Influences of Test Conditions and Mixture Proportions on Property Values of Soil Treated with Cement to Represent the Wet Method of Deep Mixing

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Abstract

A laboratory testing program was conducted on cement-treated soil mixtures fabricated to represent materials produced by the wet method of deep mixing. The testing program focused on investigating the influences that variations in laboratory testing conditions and in the mix design have on measured property values. A base soil was fabricated from commercially available soil components to produce a very soft lean clay that is relatively easy to mix and can be replicated for future research. The mix designs included a range of water-to-cement ratios of the slurries and a range of cement factors to produce a range of mixture consistencies and a range of unconfined compressive strengths after curing. Unconfined compressive strength (UCS) tests and unconsolidated-undrained (UU) triaxial compression tests were conducted. Secant modulus of elasticity were determined from bottom platen displacements, deformations between bottom platen and cross bar, and from LVDT's placed directly on the cement-treated soil specimens. Five end-face treatment methods were used for the specimens: sawing-and-hand-trimming, machine grinding, sulfur capping, neoprene pads, and gypsum capping. Key findings of this research include the following: (1) The end-face treatment method does not have a significant effect on the unconfined compressive strength and secant modulus; (2) a relationship of UCS with curing time, total-water-to-cement ratio, and dry density of the mixture; (3) the secant modulus determined by bottom platen displacements is significantly affected by slack and deformations in the load frame; (4) the secant modulus determined by local strain measurements was about 630 time the UCS; (5) typical values of Poisson's ratio range from about 0.05 to 0.25 for stress levels equal to half the UCS and about 0.15 to 0.35 at the UCS; (6) Confinement increased the strength at high strains from less than 20% the UCS to about 60% the UCS. In addition to testing the cured mixtures, the consistency of the mixtures were measured right after mixing using a laboratory miniature vane. A combination of the UCS relationship along with the mixture consistency may provide useful information for deep mixing contractors.

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General Audience Abstract

Deep mixing is a ground improvement technique that mixes cement with in-situ soil to improve the quality of the soil for supporting embankments, buildings, and other facilities. Deep mixing is also used for earth retention and to form subsurface seepage barriers. When the cement is added in dry powder form, the process is called the dry method of deep mixing, and when the cement is added in the form of cement-water slurry, the process is called the wet method of deep mixing. When using the wet method, both the water-to-cement ratio of the slurry and the amount of slurry added to the soil have important effects on the strength of the cured mixture. Laboratory mixtures are often tested in advance of field mixing to estimate the proportions of cement, water, and soil necessary to produce the desired outcomes. The laboratory test conditions influence the test results, and a wide variety of test conditions are used in practice. This research investigated different testing conditions and different mix designs to demonstrate their impacts on laboratory test results.

Dedication

This work is dedicated, first, to my family, for their unconditional love and support, regardless of where I am. To my parents, for all their love and all their support though out these years. For teaching me the value of hard work and putting my education above anything else. I am where I am today because of the sacrifices that they made, and I cannot thank them enough. To my brother and my sister because being in three separate countries cannot affect the love and the care that we have for each other. Last but not least, to my friends because a simple phone call or meeting for dinner is always a highlight in my day.

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Chapter 1: Introduction

1.1. Background

The deep mixing method is an in-situ ground improvement technique in which soil is mixed with cementitious binder. Unlike soil-cement compacted in lifts by equipment operating on the surface of each lift, the product of deep mixing is an in-place mixture of soil and binder that is not compacted in lifts, and the resulting mixture is referred to as "cement-treated soil" in this report. The deep mixing method is used to improve the strength and deformation properties of foundation soils for support of embankments, buildings, excavations, and other facilities. Deep mixing can also be used to reduce the hydraulic conductivity of soil to create seepage barriers, although seepage barriers are not a subject of this report. The deep mixing method can be performed by delivering the binder in dry form or in slurry form. In the dry method of deep mixing, dry binder is mixed with a high-water-content soil, where the water in the soil provides the water necessary for binder hydration. In the wet method of deep mixing, a binder-water slurry is prepared, and the slurry is then mixed with the soil. Common binders used for the wet method of deep mixing include Portland cement and ground granulated blast-furnace slag. This research focuses on the strength and deformation properties of cement-treated soil produced by the wet method of deep mixing using Portland cement as the binder.

1.2. Objectives, tasks, and scope

The objectives of this research were to investigate: (1) the influences of laboratory procedures and conditions on measured property values of cement-treated soil, (2) relationships between engineering property values, e.g., the relationship between unconfined compressive strength and Young's modulus, and (3) the influence of mix design proportions on cured strength and on mixture consistency immediately after mixing.

Establishing a suitable mix design is important to provide the engineering property values necessary for adequate performance of a deep mixing support system. The mix design process often includes a laboratory mixing program to identify suitable binder types and appropriate mixture proportions, i.e., the relative amounts of soil and added binder and water in the mixture, to achieve the desired properties.

For the wet method of deep mixing, laboratory mixing and specimen preparation procedures have been investigated and developed by Hodges et al. (2008), Kitazume (2012), Kitazume and Terashi (2013), and Bruce et al. (2013), among others. Specimen preparation procedures are important because they can significantly affect the measured property values (Kitazume 2012).

Variations in testing procedures also influence the measured engineering property values of cement-treated soil specimens. For example, Filz et al. (2015) report that secant modulus values based on local strain measurements can be much larger than those determined from deformations of the end platens of the loading equipment. Furthermore, relatively little published information is available regarding the influence of specimen end-face treatment method on test results or the influence of confining stress on large-strain strengths.

Mix design proportions that influence mixture strength have also been studied. Miura et al. (2001) showed that the unconfined compressive strength (UCS) of cement-treated soil decreases as the water-to-cement ratio of the mixture increases. The water-to-cement ratio is the weight of the water divided by the weight of the cement. Miller et al. (2015) proposed a 3-coefficient relationship that yields UCS as a function of curing time and total-water-to-cement ratio of the mixture for a given soil type and binder type. Applying this approach to laboratory test programs has several potential benefits: (1) it can help with interpretation of data scatter, (2) it can take advantage of all the data in a test program simultaneously, and (3) it can reduce the number of tests necessary to establish the mix designs that will achieve the desired UCS.

Mix design proportions also influence the consistency of the mixture, which influences how much mixing energy the contractor will be needed to produce a well-mixed cement-treated soil mixture. For example, a soft lean clay can be easier to mix than a stiff fat clay, especially if the mixture uses a low water-to-cement ratio of the slurry. Measures of mixture consistency are not often reported in laboratory test programs. The result is that a laboratory test program might indicate that a certain mix design might be suitable based on UCS, but the consistency of the mixture might be relatively stiff and therefore too difficult to mix in the field. Consequently, it may be beneficial to include a standardized laboratory measure of mixture consistency as part of laboratory test programs. Different types of equipment have been used to measure the mixture consistency. Szymkiewicz et al. (2012) and Szymkiewicz et al. (2013) measured the consistency of cement-treated soil mixtures using the fall cone test. Other methods to measure the undrained shear strength of the mixture immediately after mixing include laboratory miniature vanes and impellers.

The following tasks were undertaken to achieve the research objectives:

1. Five different end-face treatment methods were investigated: (1) Sawing and hand trimming, (2) machine grinding, (3) sulfur capping, (4) neoprene pads, and (5) gypsum capping. The influences of these end-face treatment methods on the unconfined compressive strength (UCS) and on the secant modulus at a strain at 50% the peak strength (E_{50}) were determined.
2. Local linear variable displacement transducers (LVDT's) were mounted directly on specimens to investigate the influence of strain measurement technique on the secant modulus and to obtain values of Poisson's ratio.
3. Unconsolidated-undrained triaxial compression tests were conducted to investigate the influence of confinement on strengths at large strains.
4. Samples were cured at different temperatures using temperature-controlled water baths to investigate the influence of curing temperature on the rate of strength gain of the mixture.
5. Cement-treated soil batches were prepared using a variety of mix designs that produced a wide range of UCS after curing to investigate and further develop the relationship among UCS, curing time, and total-water-to-cement ratio developed by Miller et al. (2015). Also, the consistency of the mixtures soon after mixing were measured using a laboratory miniature vane shear apparatus, and a relationship between this shear strength and the water content of the mixture was found. An example was developed to illustrate the potential for using both target UCS and target mixture consistency to develop an optimum mix design.

The scope of this research is subject to the following limitations:

1. Only one type of soil was used for this research. The soil was fabricated using commercially available soil components that resulted in a very soft lean clay that could be reproduced for every batch.
2. The binder used in this research was Portland cement type I/II.

3. The cement-treated soil mixtures were prepared to represent the wet method of deep mixing. Accordingly, cement-slurry was prepared, and this slurry was mixed with the soil to create the cement-treated soil mixture.

1.3. Organization of the report

This report is organized in six chapters and seven appendices. Following this introduction, Chapter 2 provides a literature review, including: factors that affect the quality of laboratory specimens, curing conditions, end-face treatment methods, influence of confining stress, and local strain measurements.

Chapter 3 presents the base soil properties and overviews of the mixing program, specimen preparation procedures, equipment descriptions, and testing procedures.

Chapter 4 is divided into eight sections that present and discuss the results of the testing program. These eight sections cover: the influence of end-face treatment methods on the measured property values of the mixtures; the influence of deformation measurement method on the UCS; correlations of UCS with curing time and mix design parameters; the influence of confinement on large-strain strengths; the influence of curing temperature on UCS; the effect of strain measurement technique on secant modulus; values of Poisson's ratio, and mixture consistency up to an hour after mixing.

Chapter 5 describes conclusions drawn from the test results. Chapter 6 presents recommendations regarding specimen preparation and test conditions, as well as recommendations for further work.

Appendices A through G present the procedures used for calculating mixture proportions, batch mixing, specimen preparation and curing, end-face treatment methods, consistency measurements, and use of the local displacement measuring devices. The detailed results of the unconfined compressive strength tests and unconsolidated-undrained triaxial compression tests are also presented in the appendices.

Chapter 2: Literature Review

This chapter presents the literature review of previous work on important factors of the laboratory procedure and test conditions affecting the measured property values of cement-treated soil mixtures prepared in the laboratory. The topics covered are the following: molding time, molding technique, curing conditions, curing temperature and maturity, end-face treatment methods, mixture consistency, confining pressure, and local strain measurements.

2.1. Molding time

The molding time is the amount of time between mixing and placing the mixture in the molds to form the specimens. After mixing, the mixture starts setting and it becomes stiffer as time passes, increasing the difficulty of placing the mixture in the molds. Molding should take place soon after mixing, which allows the procedure to be done more easily, produces better specimens, and reduces the extent of forming and breaking cementitious bonds. Kitazume et al. (2009) and Ahnberg and Andersson (2015) recommend keeping the molding time under 30 minutes, even for mixtures with high water contents, in order to avoid forming and breaking bonds in the mixture, which could affect the strength of the cured mixture. Grisolia et al. (2012) found that the mixture can be successfully placed in the molds up to 45 minutes after mixing without adversely affecting the density and the strength of the cement-treated soil specimen.

2.2. Molding technique

The molding technique is the method used for placing the mixture into the molds, and it can significantly affect the strength of the specimen. Poor or improper molding technique can result in a significant amount of air voids in the specimen, thereby affecting the density, which then affects the strength of the specimen (Kitazume 2012). The most common techniques are tapping, rodding, dynamic compaction, and static compaction. The effectiveness of these techniques is a function of the consistency of the mixtures, and they become less effective as the stiffness of the mixture increases (Kitazume et al. 2015; Marzano et al. 2015). The consistency of the mixture depends on the amount of water in the mixture either from the slurry or from soil, as well as the plasticity of the soil. As examples, a low plasticity soil with a high water content of the mixture would have a relatively fluid consistency during mixing, and a high plasticity soil with a low water content of the mixture would have a relatively stiff consistency during mixing.

The tapping technique is done by tapping the bottom of the mold against a flat and stable surface until practically no more air bubbles are expelled from the mixture. Alternatively, 50 taps can be used as a standard number. The tapping technique has proven very effective for more fluid consistencies of the mixture, often resulting in dense and uniform samples with very little or no air pockets. Rodding can be done using an 8 mm diameter steel rod, and slowly poking the mixture 30 times per layer for 3 layers in a 100-mm tall specimen mold (Kitazume 2012). This technique has proven to be very effective and applicable for mixtures over a wide range of consistencies. It can be used along with tapping for mixtures with relatively fluid or somewhat stiffer consistency to remove as much air as possible from the mixture. It has also been very effective in removing trapped air from mixtures with even stiffer consistencies, resulting in dense and uniform specimens. Dynamic compaction is done by compressing and compacting each layer with a special apparatus that has a foot attached to a rod, along which a small weight is drop a predetermined height for a total of 5 blows per lift using 3 lifts in a 100-mm tall specimen mold (Kitazume 2012). This method is more effective for mixtures that are stiff enough that the mixtures does not squeeze up out of the mold around the foot of the compaction apparatus. Specimens produced by dynamic compaction tend to have more variability in density because they can have more air pockets than specimens produced using tapping and rodding techniques. Finally, the static compaction method is done by statically compacting each layer with a determined weight to apply a pressure of 25 kPa over nearly the entire area of the specimen. This method is not as effective tapping and/or rodding for mixtures with more fluid consistencies, and it tends to produce densities similar to rodding for mixtures with stiffer consistencies (Hirabayashi et al. 2009; Marzano et al. 2012; Kitazume 2012; Grisolia et al. 2012; Grisolia et al. 2013; Kitazume et al. 2015;).

2.3. Curing conditions

Several procedures have been proposed for curing specimens. The ASTM D1632 standard requires that specimens are cured in the forming molds inside a moist room for a minimum time of 12 hours or until removal of the specimen from the mold is allowed. The moist room should have controlled temperature and controlled humidity. After the specimen is removed from the mold, the specimens should be kept in the humid room if they are not to be tested right away, but the specimens should be protected from dripping water or direct contact with water.

The laboratory mix test procedure described by Kitazume and Terashi (2013) requires that the specimens be tightly sealed and placed in a controlled temperature and controlled humidity environment, protected from access to free water. According to Kitazume and Terashi (2013), curing unsealed specimens directly under water is not representative of field conditions, where the treated soil cures underground and migration of water is negligible.

The Federal Highway Administration deep mixing design manual (Bruce et al. 2013) includes a laboratory test procedure in which specimens are tightly sealed and cured in a humid room or container at 95 to 100 percent relative humidity, or the tightly sealed specimens are placed in a water bath. Typically, the tight seal is provided by the plastic mold with a fitted cap, and plastic tape is wrapped around the cap-mold connection. In a departure from the other curing practices described here, Correia et al. (2015) opted to allow specimens to have access to free water while subjecting the specimens to different pressures during the curing period to investigate the effects of compression of the mixture during curing.

2.4. Curing time

Curing time has been demonstrated to have a significant effect on the strength of cement-treated soil. Kitazume and Terashi (2013) report several data sets illustrating the increase of strength as a function of time. Esrig (1999) shows a set of data normalized by the 28 day strength and states that the strength of the mixtures tested, except for those treated with quicklime, increased essentially at the same rate up to 28 days. For cement-treated soils, Jacobson et al. (2003) show that the increase in strength can be approximated as a logarithmic function of time.

Filz et al. (2012) proposed a curing factor, f_c, which is the ratio of unconfined compressive strength at time t to the unconfined compressive strength at 28 days by evaluating the influence of curing time on the unconfined compressive strength from several studies found in the literature. The studies included a wide variety of soil types mixed with water-binder slurries where the binder was cement or cement-slag blends.

2.5. Curing temperature and maturity

Higher temperatures have been shown to significantly increase the mixture strength at shorter curing times and have less of an effect for longer curing times (Hirabayashi et al. 2009). It has also been shown that, at very low temperatures, e.g., sub-freezing, the strength of the cement-treated soil did not increase, even with high binder contents (Kido et al. 2009). The curing temperature of the treated soil is affected by the temperature of the surrounding ground. However, the process of cement hydration results in the release of heat and raises the temperature above the temperature of the surrounding soil. The rate of heat release is also a function of the binder type and amount. By increasing the unit amount of binder in the treated soil, increasing the size of deep-mixed elements, or reducing the spacing between deep-mixed elements, the total amount of binder within a volume of soil increases, more binder hydration occurs, and the temperature of the stabilized soil increases during the curing period (Babasaki et al. 1996).

In addition, a maturity term can be applied to estimate the combined influence of curing temperature and curing time on mixture strength. The maturity concept has been applied to the strength of concrete mixtures. For cement-treated soils, maturity has been investigated by several researchers. Kitazume and Terashi (2013) reviewed this work, and they present the following expressions for maturity:

$$M = \sum (T_c - T_{c0}) \cdot t_c \qquad \textit{Equation 1}$$

$$M = 2.1^{(T_c - T_{c0})/10} \cdot t_c \qquad \textit{Equation 2}$$

$$M = \{20 + 0.5 \cdot (T_c - 20)\}^2 \cdot \sqrt{t_c} \qquad \textit{Equation 3}$$

$$M = 2 \cdot \exp\left(\frac{T_c - T_{c0}}{10}\right) \cdot t_c \qquad \textit{Equation 4}$$

Equation 1 is the general definition used for cement concrete. Equation 2 was proposed by Nakama et al. (2004), Equation 3 by Åhnberg and Holm (1984), and Equation 4 by Babasaki et al. (1996). In these equations, M is the maturity term, T_c is the curing temperature (°C), T_{c0} is the reference temperature (-10°C), and t_c is the curing time. Equation 4 has been referenced by Hirabayashi et al. (2009) and Kitazume and Nishimura (2009).

The increase in strength of the stabilized soil can be aproximated as a logarithmic function of maturity, which means that curing temperature as an environmental condition has a considerable effect on short-term strength and becomes less significant for long-term strength (Babasaki et al. 1996; Kitazume and Terashi 2013).

2.6. End-face treatment method

The end-face treatment method refers to the method used to treat the end-faces of the specimen before they are tested in compression. The end-faces require treatment to be planar and perpendicular to the height of the specimen, to allow for a uniform distribution of stress under loading. After the specimen is extracted from the mold, the end faces are often not planar and require treatment. Gonnerman (1925) investigated the influence of end-face treatment methods like grinding, sulfur mortar caps, and neat stiff cement caps on concrete. New methods like high-strength gypsum caps and neoprene pads with metal caps have been developed in more recent years for concrete testing. ASTM D1632 recommends the use of high-strength caps such as those made of sulfur mortar or gypsum, and the maximum allowable out-of-plane tolerance is 0.002 inches. Other methods found in the literature for treated soil specimens are trimming, carving, and smoothing (Jeong et al. 2009; Marzano et al. 2009; Kitazume and Terashi 2013; Le Kouby and Guimond 2015), but generally the end-treatment method is not mentioned by many authors.

2.7. Mixture consistency

The consistency of the binder-soil mixture right after mixing is important for assessing the applicability of molding techniques (Kitazume et al. 2015). Consistency has been measured with several types of apparatus, including the laboratory miniature vane shear, impellers, and the fall cone. The laboratory miniature vane shear has been used to measure the consistency of the binder-soil mixtures, as represented by the shear strength of the mixture right after mixing. Low shear strengths are indicative of fluid mixtures, and high shear strengths are indicative of mixtures with stiffer consistencies (Kitazume and Nishimura 2009; Marzano et al. 2009; Grisolia et al. 2012; Marzano et al. 2012). Commercially available impellers have been used in a similar manner by measuring the torque required to turn the impeller in the mixtures right after mixing (Grisolia et al. 2013). Finally, the fall cone apparatus has been used to measure the consistency of binder-soil mixtures right after mixing by determining the liquid limits and the plastic limits, and measuring the undrained shear strength (Szymkiewicz et al. 2012).

Grisolia et al. (2013) described consistency as workability, which is the property of the mixture to be easily mixed in the bowl and placed in the mold. Stiff and sticky mixtures are described as having low workability and fluid mixtures as having high workability. Workability is important when mixing materials with cohesive soils because these are more prone to forming clumps. Szymkiewicz et al. (2012) states that the "workability limit," which is the minimum water content of the mixture at which the mixture is considered workable, can be assumed to be almost equal to the liquid limit of the mixture. At a water content above the liquid limit, Szymkiewicz et al. (2012) states that the material is "self-compacting," which refers to a mixture that can flow and consolidate under its own weight without additional effort. At water contents close to or equal to the liquid limit, the viscosity of the mixture allows for wide distribution of the particles during mixing. Szymkiewicz et al. (2013) defined the optimum domain of workability as the water content range between the liquid limit and the flocculation limit of the treated soil. The flocculation limit is the water content at which the soil transitions from a viscous fluid to a dispersed fluid. The optimum domain of workability is very small for non-plastic materials and can be very large for plastic materials. A water contents equal to or higher than the flocculation limit, the particles in the mixture are fully dispersed and cannot be mixed properly.

2.8. Confining pressure

The confining pressure used during triaxial testing on cement-treated soil specimens can have significant effects on the peak strength of the mixture, depending on whether the test is drained or undrained. Kitazume and Terashi (2013) reported the results of a series of consolidated-undrained and consolidated-drained triaxial compression tests. The results of these tests show that the peak strength experiences significant effects when the consolidation pressure reaches a certain threshold. For the drained tests, the results show that the peak strength was affected once the confining pressure exceeded 10% of the UCS. Whereas the results of the undrained tests show that the peak strength was affected when the consolidation pressure exceeded the UCS.

Confining pressure and drainage conditions also affect post-peak strengths. The results of tests reported by Kitazume and Terashi (2013) show that the stress at 5% strain for unconfined tests was about 25% of the UCS; whereas the strength at 5% strain ranged from 50 to 80% of the UCS at consolidation pressures as low as 1% for both drained and undrained conditions.

However, the results also show that the drained strength at 5% strain increases with consolidation pressure, while the undrained strength at 5% strain did not show a similar trend. In addition, Kitazume and Terashi (2013) reported the residual strengths from unconsolidated-undrained triaxial compression tests, but the strain at which these strengths were reported is not stated. The results of these tests show that the residual strength ranged from about 50 to 80% of the UCS at confining stresses equal to or greater than 10% of the UCS.

2.9. Local strains measurements

Local strain measurements, in which transducers are mounted directly to the test specimens, can be obtained using a variety of devices. Local strains are measured during soil testing for several important reasons. Some materials are susceptible to very brittle failures, where strains below 0.05% are important, and errors arising from imperfect specimen preparation and testing can comprise a significant portion of the axial strains reported by the testing machine when the failure strains are very small. For example, some soils and rocks are difficult to trim so that the end faces are planar and perpendicular to the vertical axis of the specimen, and this affects the connection between the end-platens and the specimen end faces, which in turn affects the distribution of stresses in the sample. Also, difficulty in trimming can produce irregularities or voids in the end faces, resulting in a “bedding effect” at the ends of the specimen. These difficulties can create compliance errors and stress concentrations, particularly when testing stiff and brittle materials such as rocks and stiff soils. The irregularities at the specimen ends may deform before the full cross-section of the cylinder deforms, producing poor definition of the stress-strain relationship, particularly over the range of small strains at the early stages of loading. Furthermore, deflections originating due to deformations of the loading system and the load measuring system can disguise or increase the machine-reported strains beyond those actually experienced by the specimen (Jardine et al. 1984). Figure 1 and Table 1 show additional potential sources of errors in deformations reported by loading machines.

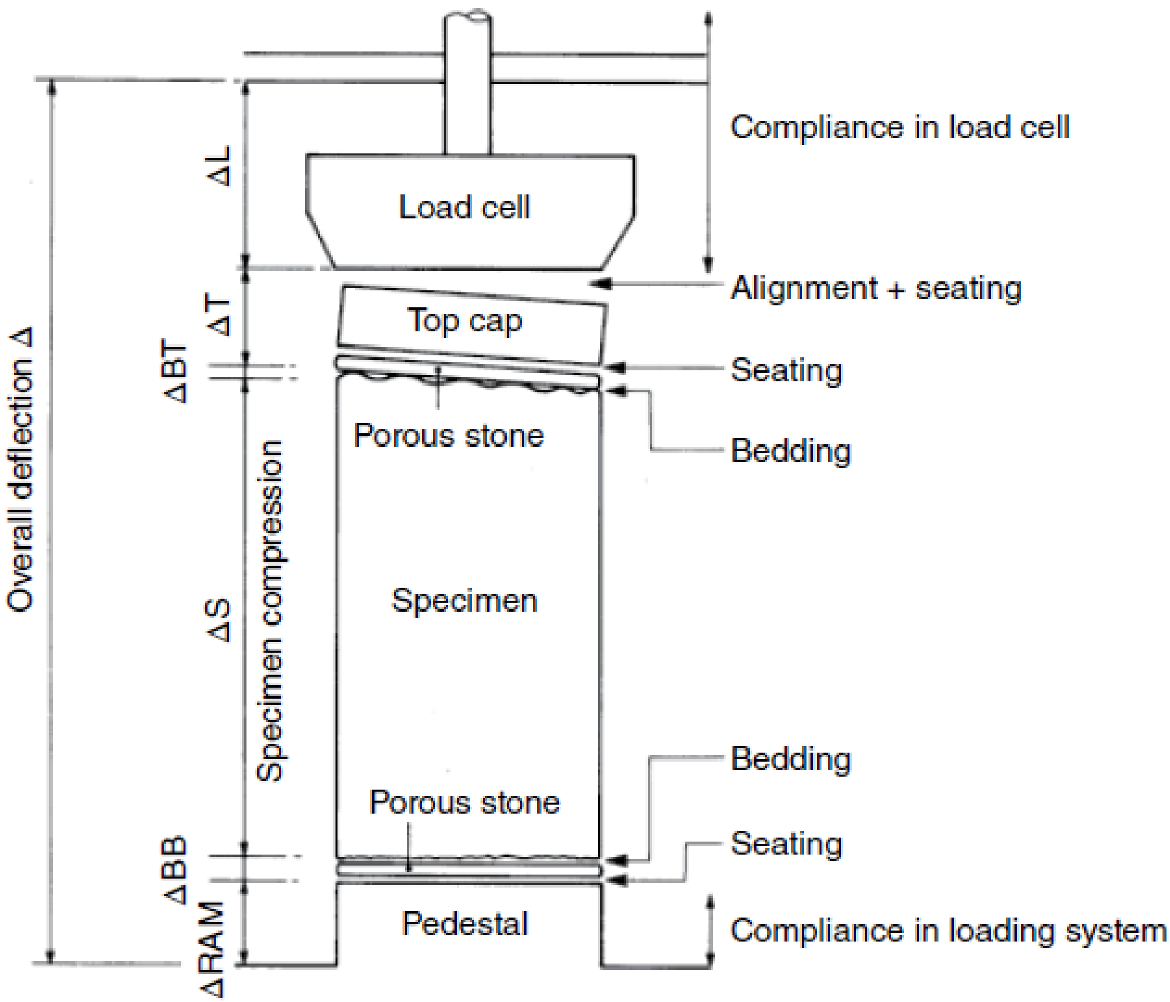

Figure 1: Sources of errors in external axial deformation measurements. Reproduced from Baldi et al. 1988 from Lade (2016).

Table 1: Sources of error in triaxial testing. Reproduced from Lade (2016)

Type of error	Caused by:
Seating errors	• Gaps closing between piston or internal load cell and specimen cap • Gaps closing between end plates and porous stones
Alignment errors	• Porous stones of nonuniform thickness • Non-verticality and eccentricity of loading ram • Non-horizontality of end platen surfaces • Tilt of specimen
Bedding errors	• Surface irregularities and poor fit at the interface between the specimen and the porous stones
Compliance errors	• The tie-rods extend and cause relative displacement of the top plate of the triaxial cell with respect to the piston • Deflection of the internal load cell • The lubricant and rubber sheets are compressed in systems using lubricated ends • The porous paper at specimen ends is compressed
Non-uniform strain errors	• Non-uniform deformations in specimen due to end restraint

Chapter 3: Testing Program

This chapter describes the testing program conducted to investigate the influences of testing conditions and mixture proportions on engineering property values of a fabricated soil treated with cement to represent a material produced by the wet method of deep mixing. First, the components, fabrication, and characteristics of the base soil are described. Second, the mixture proportions used in the testing program are presented. Third, the cement-treated soil specimen preparation method is described. Fourth, the local displacement measurement devices and set-up used to measure modulus values more precisely than can be done using displacements obtained directly from the load testing equipment are presented. Fifth, strength testing equipment and procedures used to measure the shear strength of mixtures right after mixing and to measure the compressive strength of cured specimens are described.

3.1. Base soil characterization

The base soil used in this research was fabricated from commercially available materials in proportions to satisfy the following characteristics: (1) the base soil should represent a soft soil similar to what could be encountered in practice that would be improved by the wet method of deep mixing, (2) the base soil should be relatively easy to mix so that reproducible results can be obtained, and (3) the base soil should be possible to fabricate again in the future for further research investigations.

After several initial trials, the final fabricated base soil design consists of commercially available Fine Sand, Silica Flour, Kaolin, and Bentonite. The Bentonite and the Kaolin were obtained from Highwater Clays, Inc. of Asheville, North Carolina. The Kaolin was a Tile 6 pottery clay. The Sand and Silica Flour were obtained from Short Mountain Silica Co. of Mooresburg, Tennessee. The composition of the fabricated soil by dry weight of each component is provided in Table 2.

Table 2: Base soil composition by dry weight of soil

Component	% total dry weight
Fine Sand	10
Silica Flour	65
Kaolin	20
Bentonite	5

The resulting soil classifies as a light gray lean clay (CL) using the Unified Soil Classification System (ASTM D2487). The particle size distribution was determined according to ASTM D6913 and D7928, the plastic and liquid limits were determined according to ASTM D4318, and the specific gravity of solids, G_s, was determined according to ASTM D854. The results of these tests are presented in Table 3 and Figure 2. Tap water was added to the dry mixture to produce a water content of 35 percent for the base soil, as described in more detail below. The resulting base soil was very soft in consistency. Very soft lean clays are among the soils commonly treated in the field with deep mixing. Other soils include sands, silts, and highly plastic clays. Deep mixing has also been used to treat organic and inorganic soils.

Table 3: Base soil classification tests results

USCS Classification	G_s	Atterberg Limits			% Fines
		LL	PL	PI	
CL	2.66	35	13	22	88.2

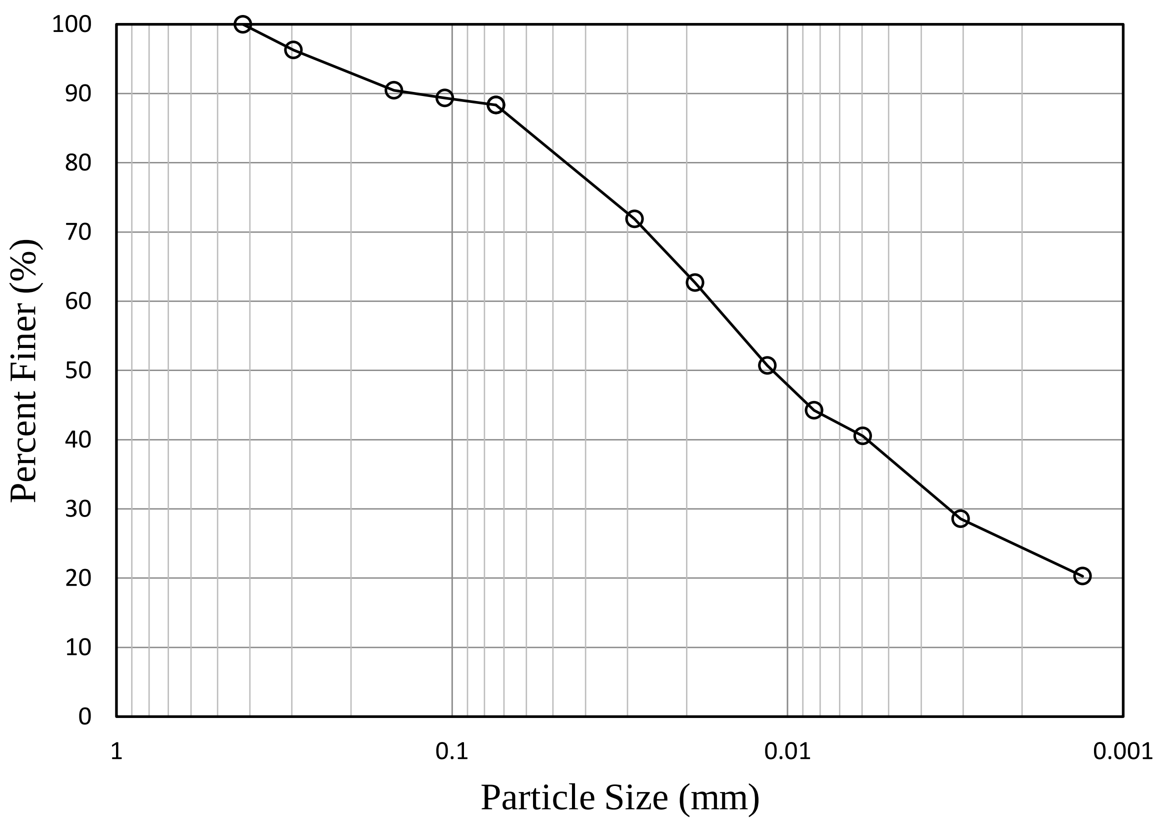

Figure 2: Particle size distribution of base soil

3.2. Mixing program

The cement factor in-place and the water-to-cement ratio of the slurry were chosen as the controlling variables for the mix designs. The cement factor in-place is defined as the weight of the cement divided by the volume of the mix. The values of cement factor in-place used for this research were 125, 200, 275, and 350 kg/m^3. The values of the water-to-cement ratio of the slurry were 0.6, 1.0, and 1.4. Both ranges are within the practical ranges used in industry and were chosen from discussions with practice experts. This range of mix design parameters produced a wide range of consistencies of the mixture immediately after mixing and a wide range unconfined compressive strengths after curing. Two of the possible combinations of cement factor in-place and water-to-cement ratio of the slurry were excluded from the test program. The mix design using a cement factor in-place of 125 kg/m^3 combined with a water-to-cement ratio of the slurry of 0.6 was excluded because the small amount of water in this mixture made mixing and specimen preparation very difficult. The mix design using a cement factor in-place of 350 kg/m^3 combined with a water-to-cement ratio of the slurry of 1.4 was excluded to avoid producing bleed water in the specimens during curing.

3.3. Cement treated soil specimen preparation method

The specimen preparation procedure developed by Hodges et al. (2008) served as the basis for the procedure used in this research. The procedure is briefly discussed in this section. The complete step-by-step procedure is presented in Appendix B.

3.3.1. Base soil properties

The dry components of the base soil were weighed and mixed using a jar mill without tumbling media. Dry mixing of the components ensures that all the components of the soil are evenly distributed before mixing them with water. The dry components were sealed in the mill and rolled for 10 minutes. The amount of soil recovered from the mill was weighed and placed in a large mixing bowl for a Hobart Legacy HL 120 (12 quarts) Kitchen Mixer.

The amount of water necessary to achieve a moisture content of 35%, equal to the liquid limit, was added to the dry soil in the mixing bowl. The dry components were mixed with water using a dough hook attachment on a speed setting of “1” for 5 minutes with periodic pauses for manual mixing to blend in the soil that would otherwise stick to the sides and the bottom of the bowl. After the dry soil and water were blended, the soil was transferred to a sealed plastic container and stored overnight in a humidity-controlled room to allow the clay particles to hydrate before mixing with the binder slurry.

3.3.2. Binder properties

The binder used in this project was type I/II Portland Cement from the commercially available brand Quikrete. Type I/II Portland Cement meets the ASTM requirements of both type 1 and type II Portland cements and it is very widely used. type I is commonly used for its strength properties, while type II is commonly used in structures exposed to soil or water containing sulfate ions because of its sulfate resistance. Portland cement type I/II has a specific gravity of solids of 3.15 and it is commonly used in civil engineering applications.

3.3.3. Mixing of binder slurry

The moist soil was mixed with the binder slurry the next day. The binder slurry was prepared using type I/II Portland Cement and tap water in different amounts depending on the desired water-to-cement ratio of the slurry. The water and dry Portland cement were blended using an Oster 14 speed blender for 3 minutes on the highest speed setting. More than the required amount of slurry to achieve the desired cement factor in-place was prepared to account for slurry that remains stuck inside the blender.

3.3.4. Mixing of soil and binder slurry

The moist base soil was also mixed while the binder slurry was being prepared. The large bowl was first dampened, and the base soil was mixed on the lowest setting for 3 minutes using the dough hook attachment. After the base soil and the binder slurry were mixed separately, they were carefully combined into the large mixing bowl. The binder slurry was added in small amounts to the mixture using the slowest speed setting to avoid sloshing of the slurry out of the bowl. Once the necessary amount of binder slurry was added, which typically took about 1-2 minutes, the mixture was bleneded on a speed setting “2” for 10 minutes. The total mixing time of the base soil and the binder slurry included occasionally stopping of the mixer and manually mixing the material with a spatula. Manual mixing was done to ensure that the base soil and the binder slurry were mixed thoroughly. Manual mixing was typically done three or more times depending on the consistency of the mix.

3.3.5. Specimen molding and curing

Specimens were quickly but carefully molded by placing the mixture into 2-inch diameter by 4-inch tall plastic cylinder molds. This procedure was done in three lifts, by tapping the mold against a hard surface between each lift until bubbles no longer breached the surface of the mixture. Excess material was removed using a straight edge spatula to produce a level top surface, and the mold was capped with a plastic lid. The molding time was restricted to 30 minutes to mold all the desired specimens. Typically, ten specimens were prepared per batch. The molds were sealed using electric tape to avoid moisture loss and then weighed to identify defective specimens. Typically, the specimens weighed close to 400 grams with the plastic cap, and any specimens that weighed less than 5 grams less than the heaviest specimen from the batch were discarded as a way to identify specimens with excessive air content. However, no specimens failed that criterion, as no specimen weighed less than 3 grams less than the heaviest specimen from the batch, so no specimens were discarded.

ASTM D1632 allows for the specimens to be extracted from the molds after 12 hours and then returned to the moist room for the remainder of the curing period. However, the specimens must be protected from dripping water during the reminder of the curing period. Kitazume and Terashi (2013) suggest sealing the mold and placing it in a humid box, and then placing the humid box in a temperature controlled room. According to Kitazume and Terashi (2013), the specimens should not be cured directly under water because it does not reflect field conditions, where the stabilized soil is cured underground and does not have access to free water.

In this research, the sealed specimens were cured by submerging them in water baths in plastic tubs with tops. The plastic tubs were stored in a room with a controlled temperature of 72 degrees Fahrenheit. The specimens used to study curing temperature were tightly sealed and cured in temperature controlled water baths. The curing periods used in this project were 3, 7, 14, and 28 days.

3.3.6. Mixture consistency measure

For selected batches, the consistency of the mixture was measured using a laboratory miniature vane shear apparatus. An excess portion of the mixture was placed in a cup immediately after forming the specimens in the plastic mold. The cup containing the mixture was tapped similarly to the molding process for the specimens to remove air bubbles. The shear strength of the mixture was then measured using the laboratory miniature vane. This process was repeated three more times to obtain the undrained shear strength as a function of time after mixing. Typically, shear strength measurements were measured at about 30, 40, 50, and 60 minutes after blending. The procedure is further described in Appendix C.

3.3.7. Sample extraction

After specimens cured for the desired period, they were extracted from the molds and prepared for testing. Extraction of the specimens was done on the day of testing with as little time between extractions and testing as practically possible to prevent moisture loss. First, the electric tape and the lid were removed from the mold. The bottom of the mold was carefully removed with a miter saw, and the mold was placed on a mold removal jig. In the jig, a utility knife was used to make a single lengthwise cut, being careful not to cut into the specimen. Once the mold had a single cut, the mold was removed carefully to avoid damaging the sample. The complete procedure, as well as the equipment used, is described in Appendix B.

3.3.8. End-face treatment methods

The end face treatments investigated in this research include several treatment methods found in the literature for compression testing of compacted soil-cement cylinders and concrete cylinders, as well as from industry experts in deep mixing. Five treatment methods were investigated: (1) Sawing-and-hand-trimming, (2) machine grinding, (3) sulfur capping, (4) neoprene pads, and (5) gypsum capping. One objective of end-face treatment is to avoid progressive failure of the specimen during loading, which can occur when the end faces of the specimen are not planar and/or parallel. In addition, bedding errors can result from surface irregularities along the ends of the specimen. Deformations of these irregularities are not representative of the deformations experienced by the main body of the specimen away from the ends. In addition, end faces that are not parallel can result in alignment errors, which produce a poor distribution of stresses on the end faces.

End-face treatment methods sometimes result in drying of the specimen due to the time necessary for the treatment. This issue was addressed by attempting to keep the preparation time as short as possible and by wrapping specimens with moist paper towels after treatment and before testing. Because end treatment may not always result in parallel end faces, a spherical bearing was used between the load cell and the end platen. The spherical bearing allows the top platen to align with the end face, reducing the level of parallelism necessary to produce good distribution of stresses in the specimen.

Sawing-and-hand-trimming

The sawing-and-hand-trimming procedure consisted of using a miter saw to remove a thin layer from both end faces of the specimen to produce planar surfaces perpendicular to the height of the sample. The end faces were then lightly hand screeded or “trimmed” using a straight edge spatula while rotating the upright specimen on a level surface to remove slight irregularities that might remain after sawing. The procedure was executed very carefully to prevent damaging the specimen or removing excessive material. Typically, hand trimming took close to 10 minutes.

Grinding

The grinding method was done using a Vinci Technologies end face grinder. Model: AP-012-001-2. The equipment met the requirements established by ASTM D4543-08 *Standard Practices for Preparing Rock Core as Cylinder Test Specimens and Verifying Conformance to Dimensional and Shape Tolerances.* The grinding method consisted of securing the specimen horizontally on a v-block and grinding the end faces with a grinding wheel to remove thin layers of material.

Sulfur mortar capping

This method was done following ASTM C617/C617M-15 *Standard Practice for Capping Cylindrical Concrete Specimens as required by ASTM D1632-07 Standard Practice for Making and Curing Soil-Cement Compression and Flexure Test Specimens in the Laboratory*. The method consists of capping the end-faces of the specimen with molten sulfur mortar that gains strength as it hardens. Sulfur caps are considered bonded caps because the cap, while in a liquid state, molds to the end-face and hardens to transfer the load to the specimen.

Neoprene pads and metal caps

This method was applied following ASTM C1231/1231M-15 *Standard Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Cylindrical Concrete Specimens.* The procedure requires the use of two neoprene pads, each inside a metal cap, as well as machine grinding or miter sawing equipment. The neoprene pads had a durometer 50 hardness, and the dimensions of the pads and the caps conformed to the ASTM C1231/1231M-15 standards.

The procedure consisted of grinding or sawing the specimen to create parallel ends and capping them with the metal caps and the neoprene pads.

In principle, the neoprene pads conform to the specimen end-faces. Once the neoprene pads deformed sufficiently to adjust to the end-faces, they are intended to provide a relatively uniform distribution of stresses on the specimen, as opposed to the concentration of stresses due to irregularities in the specimen ends acting on metal end platens.

Gypsum capping

This method was performed according to ASTM C617/C617M-15 *Standard Practice for Capping Cylindrical Concrete Specimens* required by ASTM D1632-07 *Standard Practice for Making and Curing Soil-Cement Compression and Flexure Test Specimens in the Laboratory*. Gypsum capping is an alternate to sulfur mortar caps and is classified as a bonded cap. The procedure consisted of mixing gypsum powder with water and placing it on the end faces to form the cap.

This method is relatively simple to perform and results in quality caps that can be easily removed without damaging the specimen, by simply tapping the end of the cap with a small tool lightly. The ability to remove the cap allows a sample to be re-capped as many times as necessary until a suitable end face is provided.

3.4. Local deformation measurements

For this project, equipment produced by Geotechnical Test Acquisition & Control (GEOTAC) and commonly used for rock core specimens was used to measure the local deformation of the cement-treated soil specimens. Local deformations during loading are obtained by attaching sensors directly to the specimen rather than using end-platen displacements. Local deformations were used to calculate the modulus of elasticity and the Poisson's ratio of the specimens. These measurements were taken during the investigation of end-face treatment methods.

3.4.1. Equipment and setup

The equipment consisted of two devices that used Linear Variable Differential Transducers (LVDT) to measure the radial and axial displacements of the specimen during unconfined compressive strength tests. Slight adjustments in the set-up process were necessary to accommodate the different end treatments investigated in this project, although the final attachment of the equipment to the specimen was the same throughout the project.

Radial displacement measurement device

The radial displacement measurement device consisted of a roller chain with an LVDT displacement sensor connected to the data acquisition equipment. The LVDT displacement sensor records the increase of the circumference in the middle of the specimen, and it was calibrated for a working range of 0.2 inches. As the specimen is compressed, the increase in specimen circumference pulls the rod out of the displacement sensor body.

Axial displacement measurement device

The axial displacement measurement device consists of LVDT displacement sensors, upper and lower collars with spring-loaded dowels, displacement sensor rod stems, and collar alignment posts. The measurements are made by placing the displacement sensors in diametrically opposed locations, and attaching them directly to the specimen. The bodies of the sensors are held by the collar placed near the top of the specimen and are attached to the specimen by three spring loaded dowels. The other collar is positioned near the bottom of the specimen, and the rod stems are attached to the bottom collar to receive the smaller end of the displacement sensor rods. Two collar alignment posts are used to facilitate installation of the collars parallel to each other. Additionally, an aluminum base was designed and fabricated to facilitate placing the bottom collar on the specimen.

For some tests, one or both of the sensor rods stuck inside the sensor body and did not record axial displacements. To mitigate this, alignment of each sensor body and rod was checked to ensure that the rod could move freely without binding, both before and after the sensor body was secured in the upper collar. Careful placement and checking of the sensors and rods decreased dramatically the frequency of the rods being stuck. Tests for which the LVDTs got stuck were not used in the calculations of modulus and Poisson's ratio using local measurements.

3.5. Strength testing

Three different types of strength tests were conducted during this project: the Laboratory Miniature Vane Shear Test, Unconfined Compressive Strength (UCS) Test, and Unconsolidated-Undrained (UU) Triaxial Compression Test. The vane shear test was performed on specimens of cement-treated soil before hardening, and the compression tests were performed on cured specimens.

3.5.1. Laboratory miniature vane shear test

The laboratory miniature vane shear tests were performed according to ASTM D4648/D4648M-16 *Standard Test Methods for Laboratory Miniature Vane Shear Test for Saturated Fine-Grained Clayey Soil.* The laboratory vane shear test was conducted on cement-treated soil mixtures with cement factors in-place ($\alpha_{in\text{-}place}$) of 125, 200, 275, and 350 kg/m^3, and with water-to-cement ratios of the slurry (w:c) of 0.6, 1.0, and 1.4. The vane blade had dimensions of 1.0 inch diameter by 1.0 inch tall. This blade size allowed for better determination of the torque. The following table shows the combination of water-to-cement ratios of the slurry with the in-place cement factor and the number of tests performed for each mixture.

Table 4: Mix properties of the batches used to investigate consistency

Batch	w:c	$\alpha_{in\text{-}place}$ (kg/m^3)	α (kg/m^3)	w_t:c	w_{mix}	Number of Tests
C-1	1.0	126	152	4.18	0.41	4
C-2		200	272	2.77	0.46	4
C-3		276	433	2.11	0.51	4
C-4		358	677	1.71	0.56	4
C-5	0.6	204	252	2.52	0.39	4
C-6		276	369	1.91	0.40	4
C-7		350	516	1.53	0.42	4
C-8	1.4	126	160	4.40	0.46	4
C-9		202	309	2.96	0.54	4
C-10		276	525	2.32	0.64	4

In Table 4, the cement factor, $\alpha_{in\text{-}place}$ = weight of cement divided by the volume of the soil-slurry mixture; the cement factor, α = weight of cement divided by the volume of soil to be treated; the total-water-to-cement ratio, w_t:c = the weight of water in the slurry plus the weight of water in the soil, all divided by the weight of cement; the mixture water content, w_{mix} = weight of water in the slurry plus the weight of water in the soil, all divided by the sum of the weight of cement and the weight of soil solids.

A test could be performed every ten minutes with sufficient time for a single person to carry out a test and prepare for the next specimen without any rush. The preparation included cleaning the vane blade and preparing a new testingspecimen.

Four vane shear tests, spaced at 10 minute intervals were performed for each mixture, with the first one performed 30 minutes after the end of mixing. The objective of conducting these tests was to measure the consistency of the mixtures represented by the undrained shear strength at specific times after mixing. The combination of a range of cement factors in-place and a range of water-to-cement ratios provided a broad enough range of water contents of the mixture. This range of mixtures and testing times permitted investigating relationships among the mixture consistency, the moisture content of the mix, and the time after mixing.

3.5.2. Unconfined Compressive Strength (UCS) test

The UCS tests were performed according to ASTM D2166 *Standard Test Method for Unconfined Compressive Strength of Cohesive Soil.* The tests were conducted on cement-treated soilspecimens with in-place cement factors ($\alpha_{in\text{-}place}$) of 125, 200, 275, and 350 kg/m^3 and water-to-cement ratios of the slurry of 0.6, 1.0, and 1.4. The specimens for each mix design were tested at curing periods of 3, 7, 14, and 28 days. The equipment used was a GEOTAC Sigma-1 Automated Load Test system with a data acquisition system that recorded the applied load and provided the displacement of the end platens. The tests were performed at a strain rate of 1%/min of the initial height of the specimen, and failure was defined as the maximum compressive stress applied to the sample.

The UCS testing program was divided into two main groups. The first set of testing was performed on samples with a water-to-cement ratio of the slurry equal to one. This group consisted of 12 batchesand was used to investigate the effect of the end face treatment method on the specimen. Localized displacement measurements were recorded on a large number of these tests. Table 5 shows the summary of the batches used for the investigation of the end-face treatment methods.

Table 5: Mix properties of the batches used to investigate end-face treatment methods

Batch number	w:c	$\alpha_{in\text{-}place}$ (kg/m^3)	α (kg/m^3)	w_t:c	End-face treatment method
E-1	1.0	125	150	4.21	Sawing & hand trimming / Grinding
E-2		350	651	1.74	
E-3		276	433	2.11	
E-4		203	278	2.74	
E-5		126	151	4.20	
E-6		277	435	2.11	Neoprene pads / Sulfur Capping / Gypsum Capping
E-7		353	659	1.74	
E-8		277	435	2.11	
E-9		349	648	1.74	
E-10		202	275	2.75	Sulfur Capping / Gypsum Capping
E-11		276	433	2.11	

The second group of UCS tests included water-to-cement ratios of the slurry of 0.6, 1.0, and 1.4, and values of cement factor in-place mentioned above, as shown in Table 6. This group consisted of 10 batches, and they were used to investigate further the relationship between total-water-to-cement ratio and curing time on the UCS, as previously investigated by Miller et al. 2015. Additionally, the batches with a water-to-cement ratio of one were used as a comparison to determine if the local displacement measurement equipment had any effects on the strength or the end-platen E_{50} values of the specimens from the previous group.

Table 6: Mix properties of the batches used to investigate strength relationships

Batch	w:c	$\alpha_{in\text{-}place}$ (kg/m^3)	α (kg/m^3)	w_t:c	w_{mix}	End-face treatment method
S-1	0.6	202	248	2.55	0.39	Grinding
S-2		276	369	1.91	0.40	
S-3		350	516	1.54	0.42	
S-4	1.4	127	162	4.38	0.46	
S-5		202	309	2.96	0.54	
S-6		275	520	2.33	0.64	
S-7	1.0	126	151	4.20	0.41	
S-8		275	433	2.11	0.51	
S-9		201	273	2.77	0.46	
S-10		350	650	1.74	0.56	

The UCS test data was corrected to account for the effects of poor compliance between the faces of the specimen and the end platens, as well as slack in the testing equipment. This was done by extending the tangent to the inflection point of the stress-strain curve to the horizontal axis and taking the intersection as the point of zero stress and zero strain, shifting the stress-strain curve to the left. Figure 3 shows an example of this procedure.

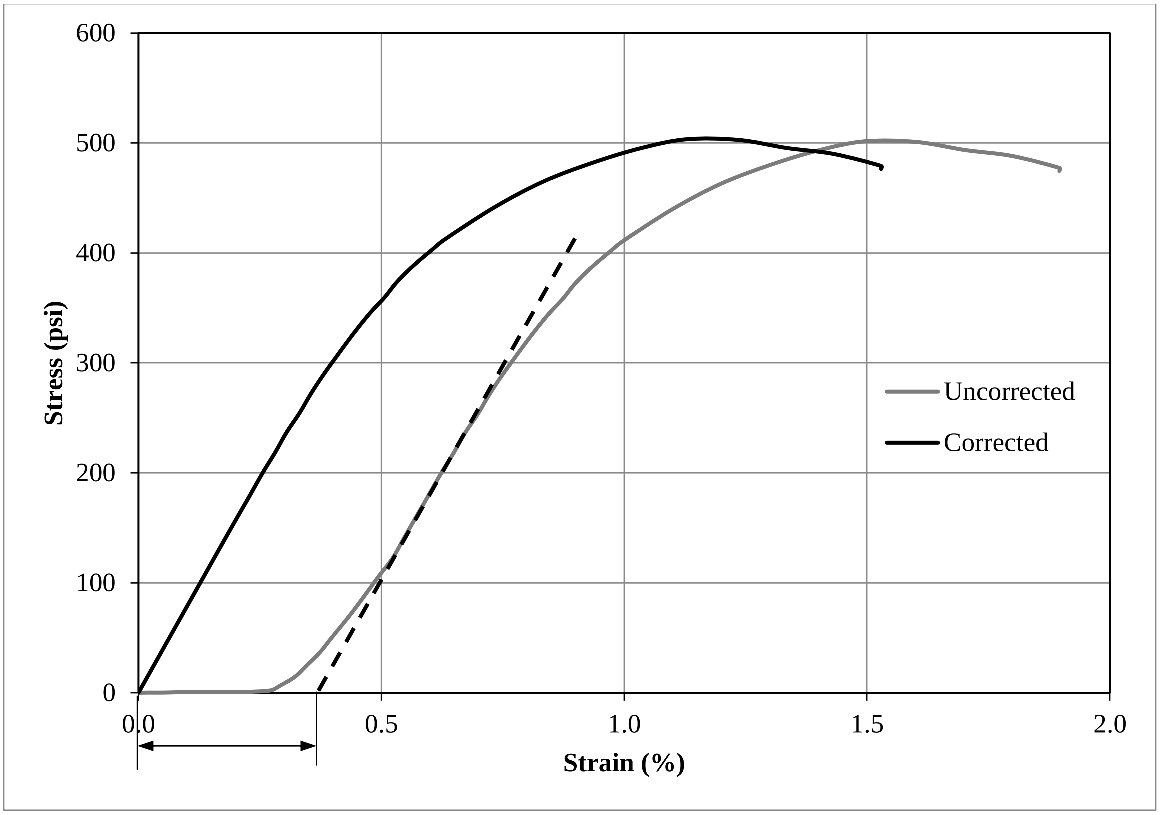

Figure 3: UCS test data correction

3.5.3. Unconsolidated-Undrained (UU) triaxial compression test

The UU tests were performed according to ASTM D2850-15 *Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils*. The equipment used was a GEOTAC Sigma-1 Automated Load Test System with a triaxial cell manufactured by GEOTAC. The tests were done on cement-treated soil specimens with water-to-cement ratios equal to one and values of cement factor in place of 125, 200, and 275 kg/m^3 tested at 28 days, as shown in Table 7.

In UU tests, the specimen is subjected to a confining stress in the triaxial cell before applying the deviator stress. The confining stresses applied on the specimen were 5, 10, 20, and 40 psi for each cement factor. A total of 25 tests were performed, with a shearing rate of 1% per minute. Failure was defined as the maximum deviator stress. Stress-strain curves and p-q plots were created with the data obtained from the UU tests.

Table 7: Mix properties of the batches used for influence of confining pressure in UU tests

Batch	w:c	$\alpha_{in\text{-}place}$ (kg/m^3)	α (kg/m^3)	w_t:c	End Treatment	Confining Stress (psi)
U-1	1.0	125	150	4.23	Grinding	5, 10, 20
U-2		199	271	2.78		5, 10, 20, 40
U-3		276	433	2.11		

Chapter 4: Results and Discussion

This chapter presents and discusses the results of the testing program described in Chapter 3. First, the influence of end-face treatment methods on the specimen strength and considerations for each method are presented. Second, the effect of using local displacement measurement devices on the UCS, and possible reasons for the observed slight influence, are discussed. Third, a study of strength relationships to predict the strength of the mixture is presented. Fourth, the influence of temperature on the rate of strength gain is presented. Fifth, the results of unconsolidated-undrained triaxial tests on three mixtures to study the influence of confinement on peak strengths and strengths at large strains are discussed. Sixth, the influence of the end-face treatment methods on the elastic modulus and the difference between strain measurement methods on the calculated value of the secant modulus are presented. Seventh, measured values of Poisson's ratio at stresses equal to half the UCS and at stresses equal to the UCS are presented. Eighth, measurements of the mixture consistency right after mixing using the laboratory miniature vane are presented, along with an example using target UCS and consistency values to establish an optimum mix design.

4.1. Influence of end-face treatment methods on specimen strength

As mentioned previously, one of the purposes of this project was to investigate the effects of end-face treatment methods, particularly on the strength of the sample. To illustrate the effects of end-face treatment on the UCS and Young's modulus, the sawing-and-hand-trimming method was chosen as the reference method due to its simplicity and wide use in practice. Direct comparisons were done by comparing the average of measured property values from specimens with the same mixture proportions and curing times, but with different end-face treatments. The direct comparisons are presented in plots with the reference values on the horizontal axis and the compared value on the vertical axis.

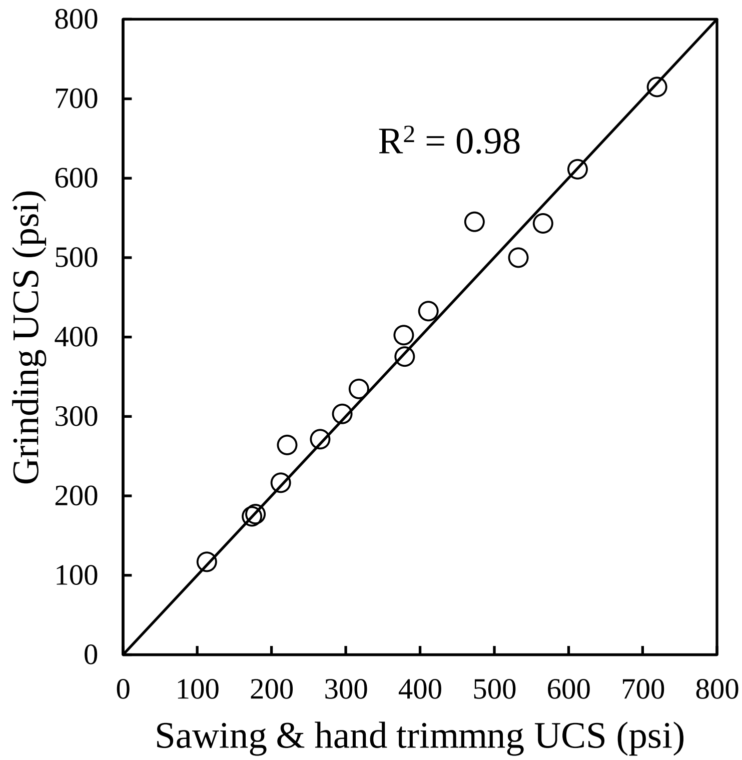

Figure 4: Effect of grinding method on UCS compared to the sawing-and-hand-trimming method

Figure 4 shows the effect of the grinding method on the UCS as compared to the sawing-and-hand-trimming method. The grinding method shows very good agreement with the sawing-and-hand-trimming method, with very little scatter. The coefficient of determination, R^2, for this set of comparison data is 0.98.

However, the equipment required for the grinding procedure is significantly more expensive than the equipment needed for the sawing-and-hand-trimming method. The large difference in costs makes the grinding method less economically effective than the sawing-and-hand-trimming method.

For both grinding and sawing-and-hand trimming methods, the end-faces of weaker specimens from lower cement factors and/or short curing ages were sometimes slightly less easy to trim than stronger specimen. Weaker specimens are softer and can be more fragile which resulted in slight chipping of very small pieces along the edges of the ends. However, the slight chipping around the edges did not occur on every weak specimen and did not cause an appreciable difference in strengths between those for which chipping occurred and those for which chipping did not occur. Additional care during hand trimming, and regular cleaning of the grinding wheel, were key components to reduce this type of damage to specimens. Nonetheless, both methods are very practical and, if done carefully, produce consistent results.

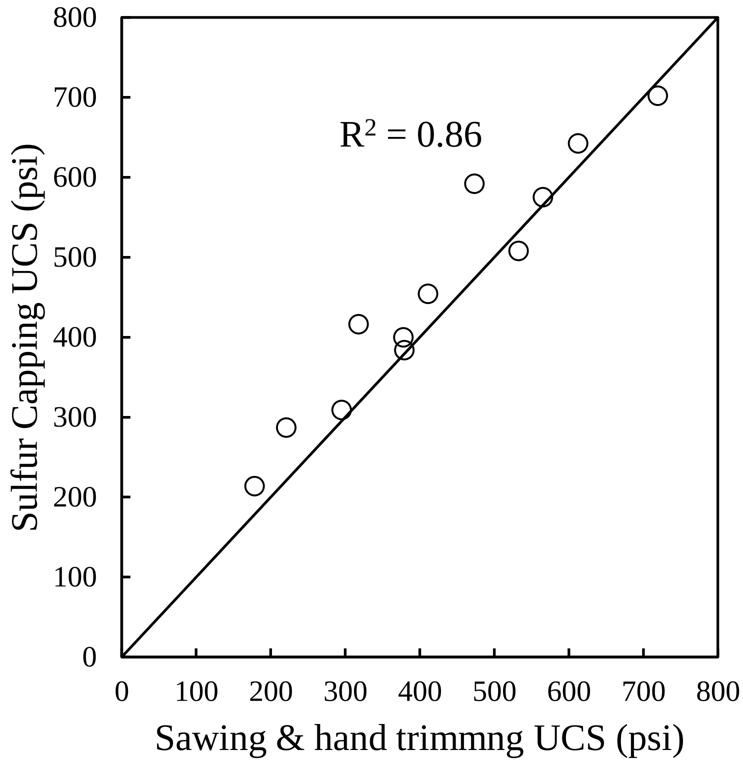

Figure 5: Effect of sulfur capping on UCS compared to the sawing-&-hand-trimming method

Figure 5 shows the direct comparison between the use of sulfur mortar caps and the sawing-and-hand-trimming method. Strengths measured using sulfur capping exhibited slightly more scatter (R^2 = 0.86) than the grinding method (R^2 = 0.98) when each method was compared to the sawing-and-hand-trimming method. In addition, sulfur capping tended to produce slightly higher strengths than sawing-and-hand-trimming over a wide range of strengths.

Sulfur capping presented some disadvantages when used on cement-treated soil specimens. When used on concrete cylinders, the sulfur caps can be removed if the cylinder does not meet parallelism requirements, thereby allowing the cylinder to be recapped. However, cement-treated soil specimens are generally softer than concrete cylinders and cannot be recapped because attempting to remove the sulfur cap can result in breaking the specimen. In addition, sulfur caps require a minimum of three hours to gain sufficient strength before the specimen can be tested. The preparation time between capping and testing can result in drying of the cement-treated soil specimen, which could compromise the results.

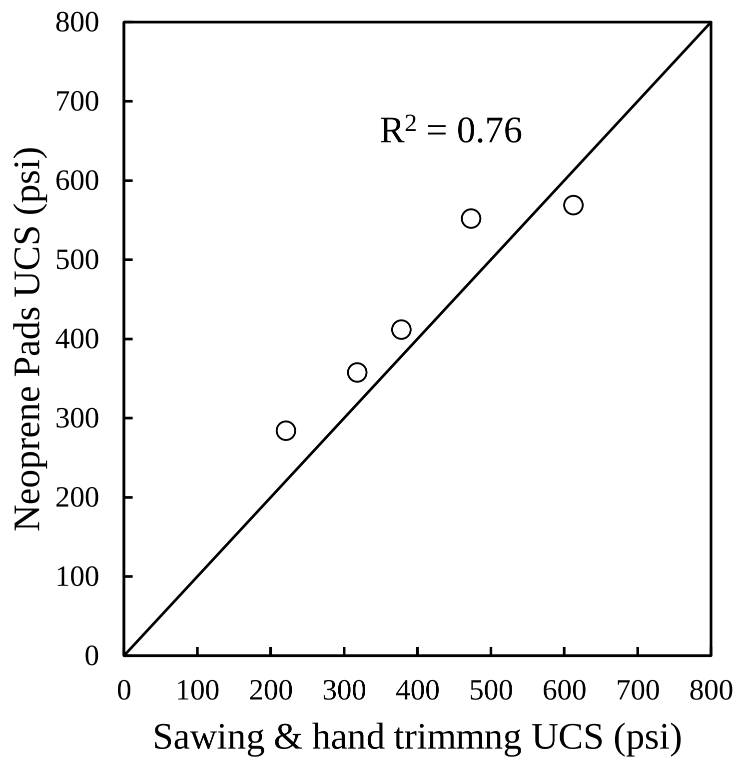

Figure 6: Use of neoprene pads on UCS compared to the sawing-and-hand-trimming method

Figure 6 shows only a few points of comparison between the use of neoprene pads and sawing-and-hand-trimming. Although the comparison shows slight scatter (R^2 = 0.76), there was not enough data to draw significant conclusions about the effect neoprene pads on the UCS as compared to the sawing-and-hand-trimming method.

Neoprene pads were very simple to use, but also presented disadvantages when used in this research. First, according to the ASTM C1231/1231M-15, the use of neoprene pads is limited to a range of compressive strengths between 1500 psi and 7000 psi. Because the cement-treated soil mixtures used in this research had strengths less than 1500 psi, this type of end treatment is not applicable according to the ASTM standard. Another drawback of this end treatment is the type of failure mechanism that it produces. According to the ASTM C39/C39M-16b, the failure mechanism observed on the cement-treated soil specimens tested with neoprene pads is similar to a type 5 fracture pattern in concrete cylinders. This type of fracture pattern is called “side fracture at top or bottom” and it occurs commonly when unbonded caps, such as neoprene pads, are used. This failure mechanism is produced by shear stresses on the face of the specimen induced by the neoprene pad attempting to deform laterally, resulting in a diagonal fracture at the edge of the face of the specimen. It is believed that the range of stresses specified by the ASTM is to avoid this type of fracture. This failure mechanism is not consistent with the failure mechanism observed for cement-treated soil specimens prepared using other end treatments, and this difference causes uncertainty in the results. Finally, it was noticed that the edges of the end face exhibited crushing, which would indicate that the neoprene pads may not be deforming sufficiently under loading to allow for a uniform distribution of stress, creating areas of stress concentration at the edges of the specimens.

Gypsum capping is an efficient end-treatment method that produced reasonable results. Figure 7 shows the correspondence between gypsum capping and the sawing-and-hand-trimming method. Gypsum capping exhibited less scatter than sulfur capping and neoprene pads. In fact, gypsum capping exhibited almost as good agreement with sawing-and-hand-trimming as grinding did. The comparison in Figure 7 has an R^2 value equal to 0.94 and shows good agreement between two methods, which indicates that there is no significant effect on UCS from using gypsum capping as end-face treatment method, for the conditions investigated in this research.

However, like sulfur caps, the preparation time is long and can result in drying of the specimen. Since both ends of the specimen are capped, it results in a period of at least one hour that the specimen is susceptible to drying. This time increases if the specimen has to be recapped, the need for which may not be noticed until the first cap attempt has set. Additional time is added if multiple specimens are capped with the same heated batch of gypsum mixture. Moreover, the gypsum cap has to be allowed to gain strength for at least a period of 3 hours before the specimen is tested in compression. As mentioned previously, specimens can be kept in a humid environment for as much of this time as practically possible.

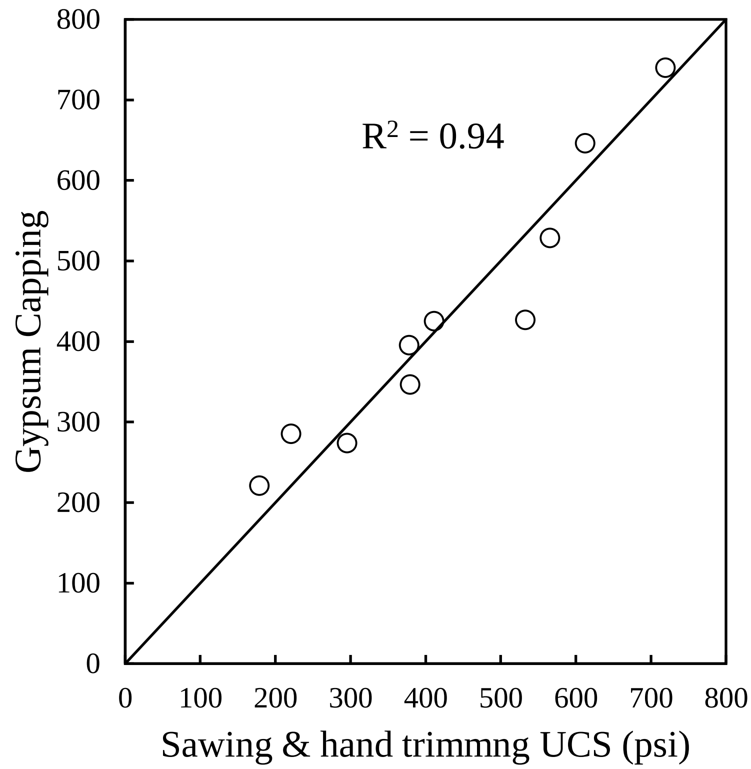

Figure 7: Effect of gypsum capping on UCS compared to the sawing-and-hand-trimming method

4.2. Effect of the use of Local Displacement Measurement Device (LDMD) on UCS determined by direct comparison

The use of LDMD raised concerns that the equipment may have affected the strength of the samples. The first concern was that the equipment is mounted directly on the specimen secured with dowels that result in indentations on the exterior of the sample, which may affect the behavior of the specimen. The indentations and the weight of the equipment may induce weak areas for failure mechanism to initiate. Alternatively, the use of the radial displacement equipment could provide some confinement that increases the strength of the specimen. Strains at failure and at 50% of peak strength could also be affected by the LDMD, affecting the secant modulus of elasticity.

A direct comparison between specimens, shown in Figure 8, was used to assess possible effects on the measured UCS of the specimens. LDMD

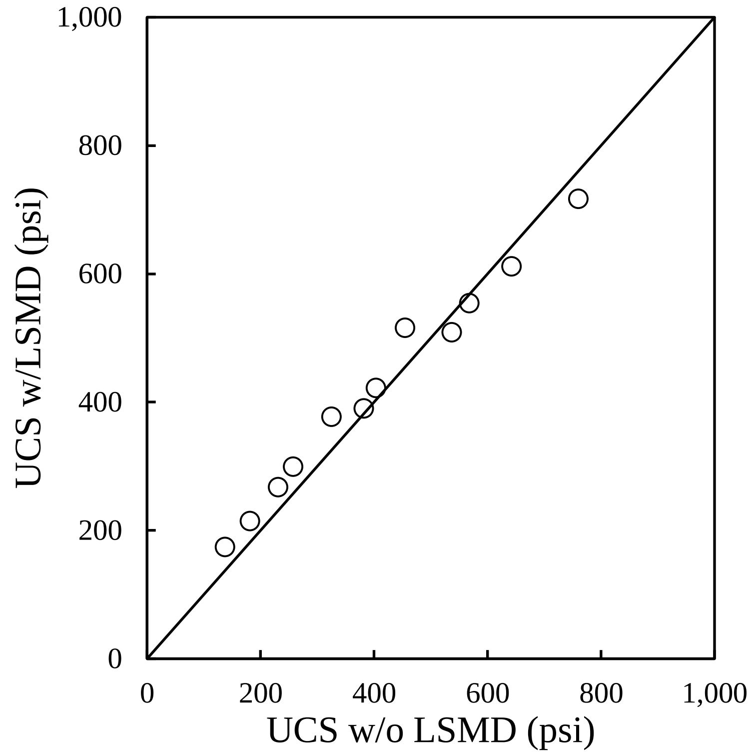

Figure 8: Effect of LDMD on UCS

As shown in Figure 8, the use of LDMD results in slightly higher strengths for specimens with peak strengths under 500 psi, where ductile behaviors were often observed. Possible slight confinement from the radial equipment may have provided additional strength to the specimens, by restricting the formation of failure planes. On the other hand, for stronger specimens, where a more brittle behavior was observed, the use of LDMD seemed to produce a slight negative effect by slightly decreasing the peak strength. Damage caused by mounting of the equipment could have resulted in fractures or weak zones for a failure plane to form. In any case, apparent effects of the LDMD on UCS are small, as shown in Figure 8.

4.3. UCS correlation with curing time and mix properties

Miller et al. (2015) proposed that UCS is a function of the total-water-to-cement ratio and curing time, for a particular soil with a particular binder type. This method assumes that the total-water-to-cement ratio and curing time have independent effects on the UCS.

First, UCS increases as a logarithmic function of the curing time (e.g., Jacobson et al. 2003), so that the effect of curing time can be characterized using a curing factor, f_c, as proposed by Filz et al. (2012). The curing factor is the UCS at any curing time, t, normalized by the UCS at 28 days, as shown in Equation 5, where a_1 and a_2 are dimensionless coefficients and t_0 is a reference time of one day, which is introduced simply to make the argument of the logarithm dimensionless.

$$f_c = \frac{UCS_t}{UCS_{28\,day}} = a_1 + a_2 \ln\left(\frac{t}{t_0}\right) \qquad \textit{Equation 5}$$

Next, Miura et al. (2001), Jacobson et al. (2003), Hodges et al. (2008), and others showed that the UCS decreases with increasing total-water-to-cement ratio. The total-water-to-cement ratio is the sum of the weight of the water in the soil plus the weight of the water in the slurry divided by the weight of the cement in the slurry. UCS can be approximated using a power function of the total-water-to-cement ratio, as shown in Equation 6, where p_a is atmospheric pressure and a_3 and a_4 are dimensionless coefficients.

$$\frac{UCS_{28\,day}}{p_a} = a_3 (w_t : c)^{a_4} \qquad \textit{Equation 6}$$

Combining the effect of curing time expressed in Equation 5 and the effect of total-water-to-cement ratio expressed in Equation 6 results in the three-coefficient Equation 7a that can be used to predict the strength of a specimen for any curing time and total-water-to-cement ratio. The dimensionless coefficients b_1, b_2, and b_3 in Equation 7aare determined through a least squares regression analysis, and they apply for the soil type and binder type tested, and for thoroughly mixed samples. Equation 7a can be re-written as Equation 7b, where $c_0 = b_1 + b_2\ln(28)$, $c_1 = b_1/c_0$, $c_2 = b_2/c_0$, and $c_3 = b_3$ are all dimensionless. Extracting the leading coefficient c_0 from coefficients b_1 and b_2 leaves the expression $c_1 + c_2\ln(t/t_0)$ in Equation 7b having the same meaning as the curing factor f_c in Equation 5. The form of Equation 7b will allows for easy comparison of the different influences of curing time and total-water-to-cement ratio on the UCS for different soils and different binder types in future investigations.

$$\frac{UCS_{pred}}{p_a} = \left[b_1 + b_2 \ln\left(\frac{t}{t_0}\right)\right] (w_t : c)^{b_3} \qquad \textit{Equation 7a}$$

$$\frac{UCS_{pred}}{p_a} = c_0 \left[c_1 + c_2\, ln\left(\frac{t}{t_0}\right)\right] (w_t : c)^{c_3} \qquad \textit{Equation 7b}$$

Figure 9 presents the correspondence between the predicted values of UCS using the best-fit of Equations 7 and the measured values of UCS for batches S-7 to S-10. It can be seen that there is very good agreement between the predicted and the measured values of UCS. The values of the coefficients for Equations 7a and 7b producing the fit shown in Figure 9 are presented in Table 8.

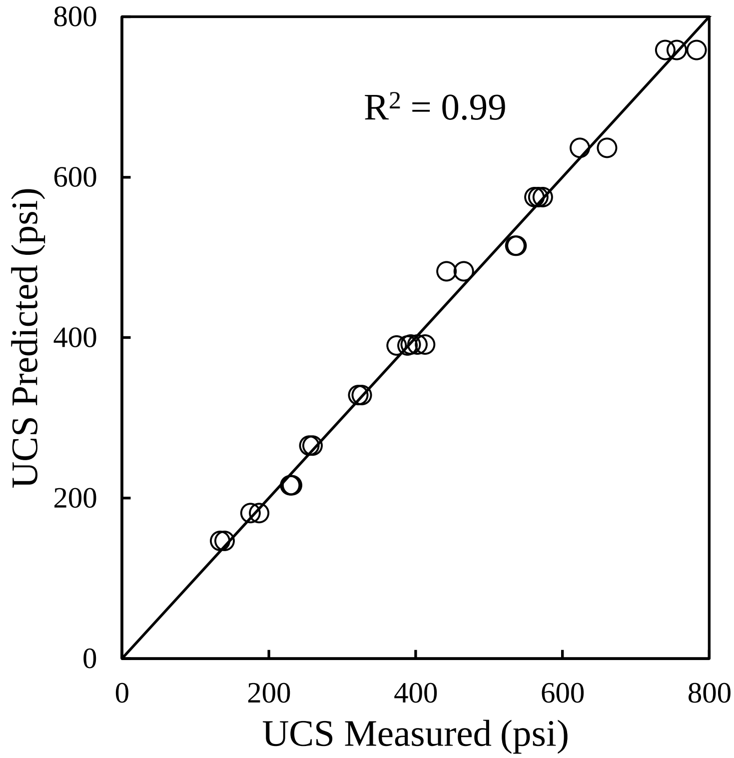

Figure 9: Relationship between predicted UCS using 3-coefficient best-fit approach and measured UCS for batches S-7 to S-10

Table 8: Coefficient values for Equations 7 from least-square regression of Figure 9

Equation 7a		Equation 7b	
Coefficient	Value	Coefficient	Value
--	--	c_0	114
b_1	25.9	c_1	0.228
b_2	26.4	c_2	0.232
b_3	-1.43	c_3	-1.43

The relationship presented by Equation 7 was investigated further by testing specimens from a wide range of mix design parameters that increased the range of unconfined compressive strengths after curing. This was done by including mixtures made with water-to-cement ratios of the slurry of 0.6, 1.0, and 1.4. The resulting values of total-water-to-cement ratios ranged from 1.54 to 4.40, and the specimens were tested at curing periods of 3, 7, 14, and 28 days. Table 6 shows a complete summary of mix designs used to study this relationship.

Figure 10 presents the comparison of the UCS predicted with the 3-coefficient best-fit Equation 7a and the UCS values measured in the laboratory. Table 9 presents the values of b_1, b_2, and b_3 obtained from the least-square regression of Equation 7a used to generate Figure 10. Table 9 also includes the corresponding values of the coefficients c_0, c_1, c_2, and c_3 for Equation 7b.

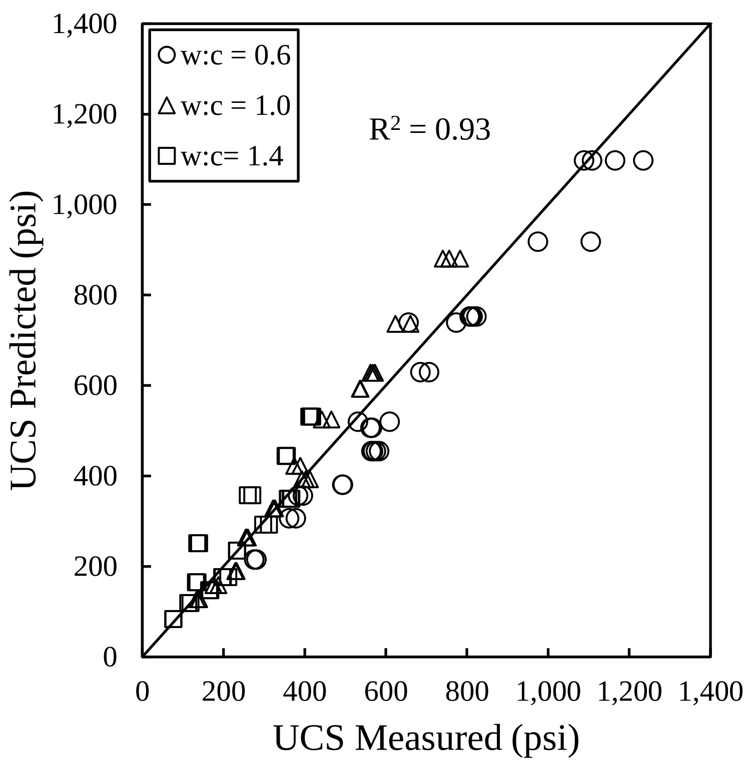

Figure 10: Relationship between predicted UCS using the 3-coefficient best-fit approach and measured UCS for batches S-1 to S-10

Table 9: Coefficient values and statistical analysis of least-square regression of Figure 10

Equation 7a					Equation 7b	
Coefficient	Value	Standard Error	t-Statistic	p-Value	Coefficient	Value
					c_0	157
b_1	34.0	6.66	5.15	1.92E-06	c_1	0.216
b_2	37.0	2.91	12.7	2.42E-21	c_2	0.235
b_3	-1.74	0.066	-26.4	1.12E-42	c_3	-1.74

Although Figure 10 shows reasonable agreement between the predicted and the measured UCS, it is evident that the level of agreement compared to Figure 9 is significantly lower. The majority of the data from mixtures with a water-to-cement ratio of the slurry equal to 0.6 are below the correlation line, which means that the measured values of UCS are higher than the predicted values. On the other hand, a significant portion of the tests from the mixtures with water-to-cement ratio of the slurry equal to 1.0 and 1.4 are above the correlation line, which means that the predicted values are higher than the measured values.

A t-test and a p-test were conducted on each coefficient to determine their influence on the regression, and the results are shown in Table 9. The t-test determines the influence of each coefficient by normalizing the coefficient by its standard error, which means that a coefficient with a t-statistic value of zero has no influence on the regression. The larger the absolute value of the t-statistic value, the larger the influence a coefficient has in the regression. The p-test determines the probability of the null hypothesis, or the probability that the variable has no effect. A small p-value means that the variable has high probability of influencing the regression. Both the t-statistic values and the p-values show that all three coefficients have significant influence on the regression, with coefficient b_3 having the largest influence and b_1 having the least influence. In addition, the root mean square error, which is the standard deviation of the differences between measured and predicted values, was calculated to be 4.89.

These statistical analyses indicate that all three coefficients b_1, b_2, and b_3 are important. However, the reduction in the degree of the correlation in Figure 10 compared to Figure 9 suggests that another factor besides curing time and total-water-to-cement ratio of the mixture may be influencing the UCS values. It was observed that using less slurry with a low water-to-cement ratio produced denser specimens than produced by more slurry with a high water-to-cement ratio to achieve similar total-water-to-cement ratios of the mixture. Figure 11 shows that the denser specimens formed using a low water-to-cement ratio of the slurry exhibited higher UCS at the same total-water-to-cement ratio of the mixture. This led to the idea that dry unit weight of the mixture could be an additional factor affecting the strength of the specimens.

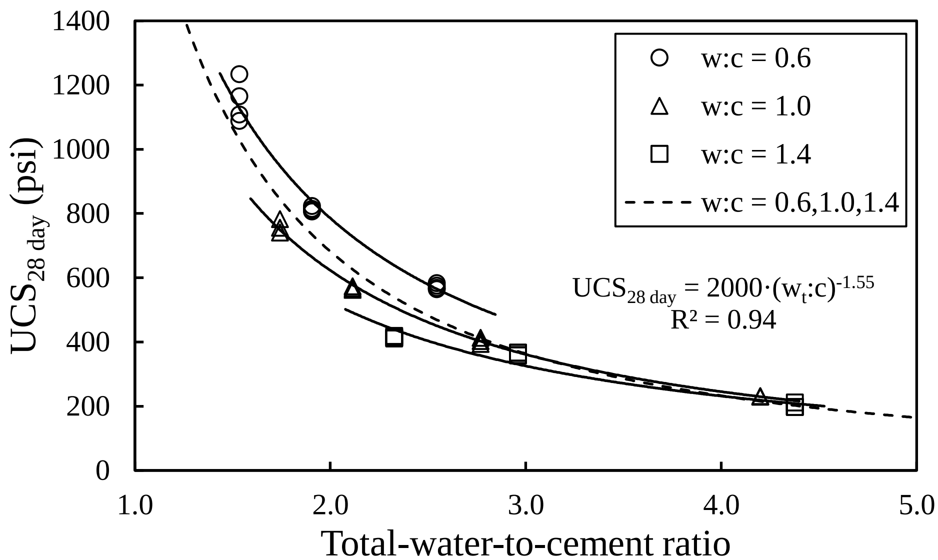

Figure 11: Relationship between UCS and w_t:c for batches S-1 to S-10 tested at 28 days

Additional literature review on the behavior of concrete showed that the compressive strength of concrete is associated with the amount of entrained air. Entrained air is the amount of air in the mixture, either by mix design or by improper compaction, and it affects the porosity of the mixture. An increase in entrained air increases the air voids and the porosity of the mixture, which reduces the strength.

Espino (1966) outlined the results of Talbolt and Richart (1923), Glanville et al. (1947), and McIntosh et al. (1956), where the compressive strength of concrete is a function of the density of the mixture. Espino (1966) also conducted a number of tests where the densities of the mixtures were varied by varying the entrained air. The results show that strength increases with density. Figure 12 shows the relationship between strength and density from McIntosh et al. (1956).

For the cement-treated soil tested in this research, parameters that affect the void ratio and dry unit weight of the mixture are the water-to-cement ratio of the slurry and the binder factor in-place. Figure 13 shows that, for a given binder factor in-place, the dry unit weight and the UCS increase as the water-to-cement ratio of the slurry decreases.

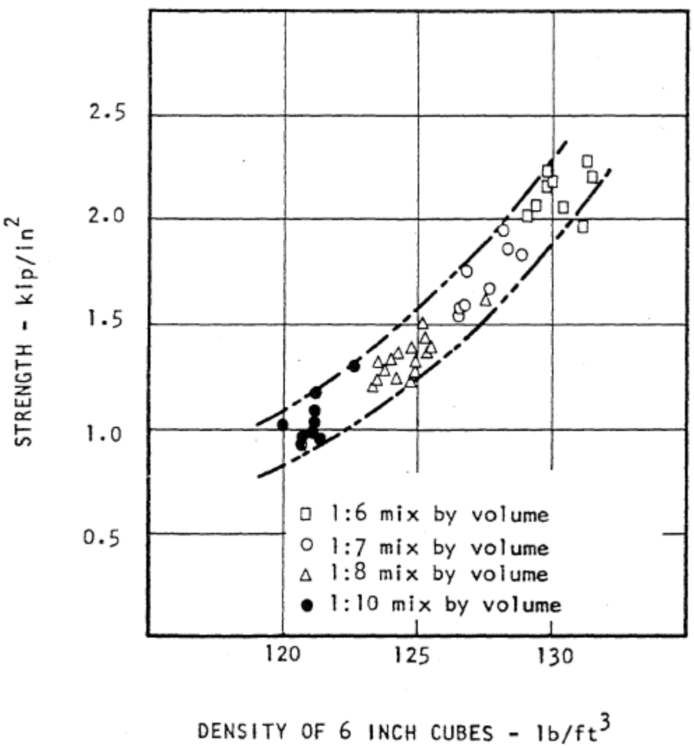

Figure 12: Relationship between the compressive strength of concrete and density (From McIntosh et al. 1956)

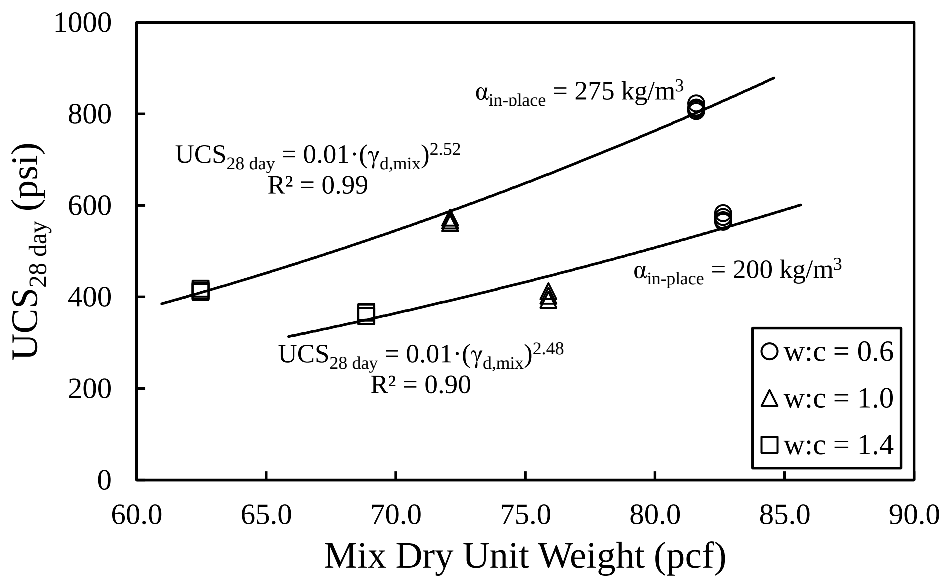

Figure 13: Relationship between 28 day UCS and dry unit weight of the mixture

Equations 8a and 8b are similar to Equations 7a and 7b, except that a power function of the dry unit weight of the mixture, $\gamma_{d,mix}$, is introduced, with $\gamma_{d,mix}$ normalized by γ_w. The values of the dimensionless coefficients d_1, d_2, d_3, and d_4 in Equation 8a are determined by least squares regression. Similar to the development for Equations 7a and 7b, Equation 8a can be re-written as Equation 8b, where $e_0 = d_1 + d_2\ln(28)$, $e_1 = d_1/e_0$, $e_2 = d_2/e_0$, and $e_3 = d_3$, and the expression $e_1 + e_2\ln(t/t_0)$ in Equation 8b has the same meaning as the curing factor f_c in Equation 5.

$$\frac{UCS_{pred}}{p_a} = \left[d_1 + d_2 \ln\left(\frac{t}{t_0}\right)\right](w_t : c)^{d_3}\left(\gamma_{d,mix} : \gamma_w\right)^{d_4}$$ *Equation 8a*

$$\frac{UCS_{pred}}{p_a} = e_0\left[e_1 + e_2\, ln\left(\frac{t}{t_0}\right)\right](w_t : c)^{e_3}\left(\gamma_{d,mix} : \gamma_w\right)^{e_4}$$ *Equation 8b*

The same data shown in Figure 10, analyzed using Equation 7a, were reanalyzed using Equation 8a, and the results are shown in Figure 14, where it can be seen that the fit in Figure 14 is better than the fit in Figure 10, with R^2 values of 0.93 and 0.99 in Figures 10 and 14, respectively.

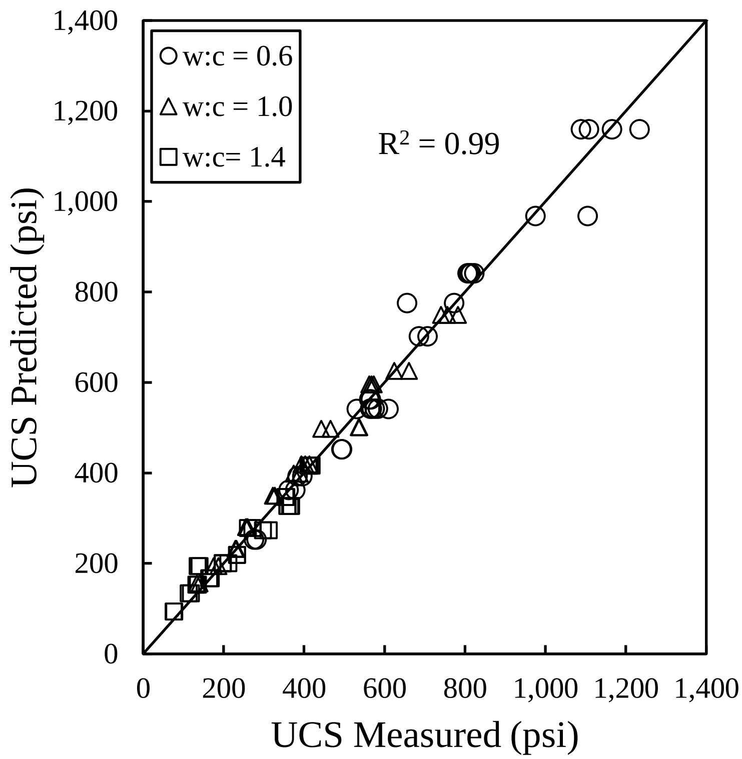

Figure 14: Relationship between predicted UCS using the 4-coefficient best-fit approach and measured UCS for batches S-1 to S-10

Table 10: Coefficient values and statistical analysis of least-square regression of Figure 14

Equation 8a					Equation 8b	
Coefficient	Value	Standard Error	t-Statistic	p-Value	Coefficient	Value
--	--	--	--	--	e_0	105
d_1	21.8	2.11	10.3	1.31E-16	e_1	0.206
d_2	25.2	1.06	23.9	3.41E-39	e_2	0.238
d_3	-1.57	0.030	-52.1	9.39E-66	e_3	-1.57
d_4	1.48	0.089	16.6	2.70E-28	e_4	1.48

Table 10 shows the values of of the coefficients d_1, d_2, d_3, and d_4 for Equation 8a obtained from a least-square regression. Table 10 also includes the corresponding values of the coefficients e_0, e_1, e_2, e_3, and e_4 for Equation 8b. Several items are worth noting about the coefficients in Tables 8, 9, and 10:

- The coefficients c_1 and c_2 in Equation 7b and e_1 and e_2 in Equation 8b represent the curing factor, f_c, and the values of these coefficients are similar in Tables 8, 9, and 10. Table 11 shows that these coefficients yield nearly the same values of f_c for curing times of 7 days and 365 days, and they all yield f_c = 1.0 at a curing time of 28 days because that is how the coefficients are defined. This outcome shows that neither introducing the additions data with *w:c* = 0.6 and 1.4, nor introducing the power function of $\gamma_{d,mix}$ in the predictive equation, produced any significant differences in how the predictive equations represent the effect of curing time on UCS.

Table 11: Effect of differences in the coefficient values for the curing factor in Equations 7b and 8b

Equation and Coefficients	Source	$f_c = c_1 + c_2\ln(t/t_0)$ or $f_c = e_1 + e_2\ln(t/t_0)$		
		t = 7 days	t = 28 days	t = 365 days
Equation 7b, c_1 and c_2	Table 8	0.68	1.00	1.60
Equation 7b, c_1 and c_2	Table 9	0.67	1.00	1.61
Equation 8b, e_1 and e_2	Table 10	0.67	1.00	1.61

Note: The data used to obtain the coefficients were based on curing times from 3 to 28 days. It would be necessary to include data for longer curing times to obtain reliable estimates of f_c for curing times longer than 28 days. The values of f_c listed in the table above for t = 365 days are only provided to illustrate the trend and to show that differences in *w:c* and $\gamma_{d,mix}$ did not significantly influence the curing factor as determined from the regressions.

- The value of the exponent, e_4, of the $\gamma_{d,mix}$ factor in Equation 8b determined from the regression results shown in Figure 14 and Table 10 is 1.42. A positive value of e_4 indicates that, at the same curing time and total-water-to-cement ratio, an increase in the amount of solids in the mixture corresponds to an increase in UCS. For a value of e_4 greater than 1.0 produces an upwards curvature in the relationship between UCS and $\gamma_{d,mix}$, which is consistent with the data shown in Figures 12 and 13.
- T-tests and p-tests were conducted on the coefficients d_1, d_2, d_3, and d_4 for Equation 8a using the same data set for which t-tests and p-tests were conducted on coefficients b_1, b_2, and b_3 for Equation 7a. Comparing the results in Tables 9 and 10, the t-statistic values are all larger and the p-values are all smaller for coefficients d_1, d_2, and d_3 than for the corresponding coefficients b_1, b_2, and b_3 for Equation 8a. In addition, the t-statistic and p-value for d4 in Table 10 indicates that the power function of dry unit weight of the mixture is significant. Finally, the root mean square error for the fitting shown in Figure 14 is 2.45, which is about half of the root mean square error of 4.89 for the fitting in Figure 10.

These results show that an additional term to account for the effects of dry unit weight of the mixture, as done in Equations 8, may be useful. To obtain reliable values of the coefficients d_1, d_2, d_3, and d_4 for Equation 8a, the data set used for the regression should include significant variations in curing time, total-water-to-cement ration, and dry unit weight of the mixture.

4.4. Effect of LDMD on UCS from correlation with curing time and mix properties

In Section 4.2, the effect of the LDMD on UCS was investigated by direct comparison of UCS measurements. In this section, the effect of the LDMD on UCS was studied using the correlations from Section 4.3 as a supplement to the direct comparison approach. The approach represented by Equations 7, i.e., UCS as a function of curing time and total-water-to-cement ratio, was used rather than the approach represented by Equations 8, which also included the dry unit weight of the mixture, because all of the tests in which the LDMD were used were mixed using a water-to-cement ratio of the slurry equal to 1.0, and Section 4.3 demonstrated that Equations 7 were adequate when the water-to-cement ratio of the slurry did not vary.

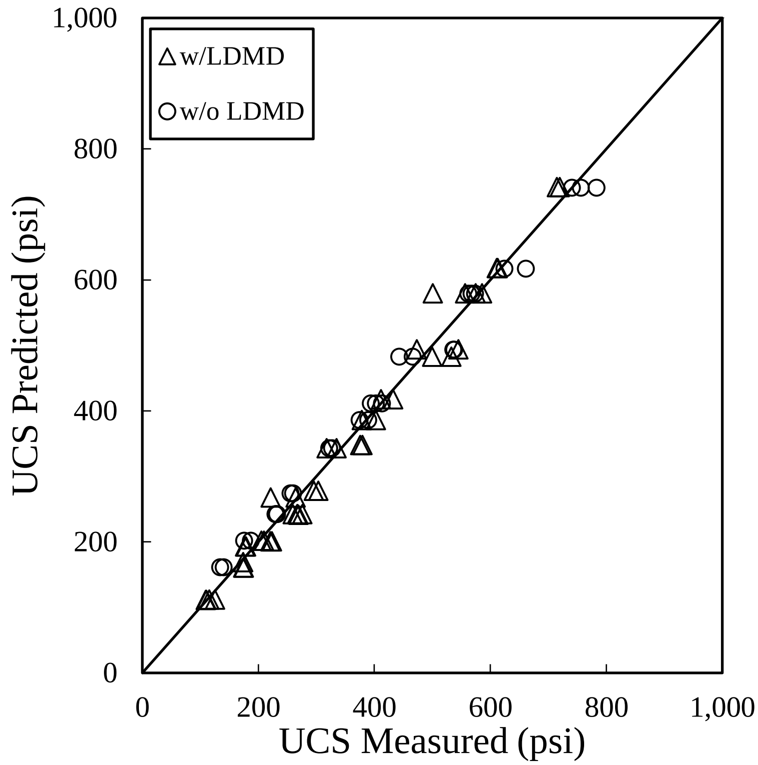

Figure 15: Effect of the use of LDMD on UCS using the 3-coefficient best-fit approach

Figure 15shows the comparison between the predicted and the measured values of UCS for the tests with w:c equal to 1.0, with and without LDMD. It can be seen that all of the data fall close to the one-to-one line. However, it is difficult to see small differences in the effects of LDMD on the UCS in Figure 15. To make such trends more visible, two trend lines of the data points in Figure 15 were determined, one for the data points representing tests with LDMD and the other for the data points representing tests without LDMD. The two trend lines are shown in Figure 16. Trend line 1 (dashed) is the trend with LDMD, and trend line 2 (solid) is the trend without LDMD.

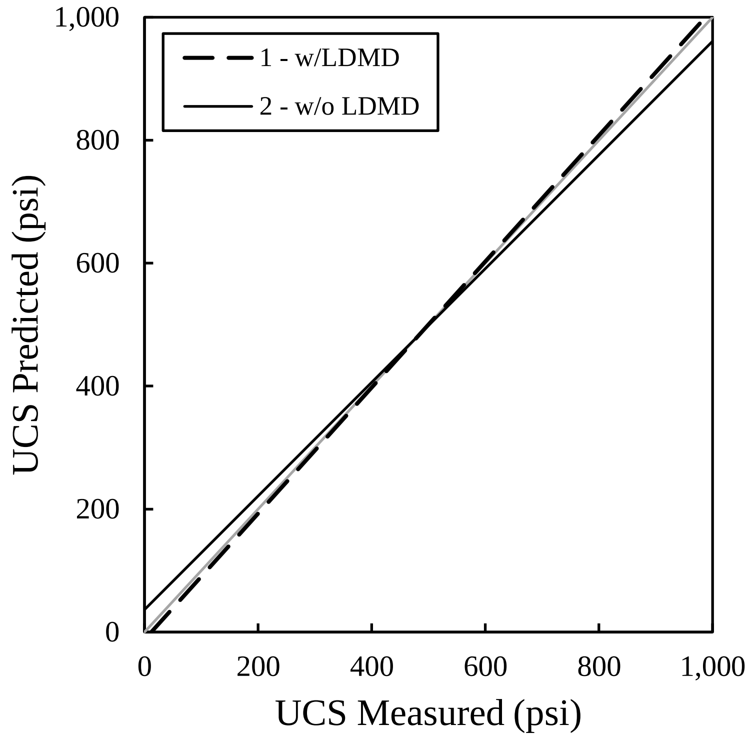

Figure 16: Effect of the use of LDMD of UCS using the 3-coefficient best fit approach (trend lines only)

Comparing the two trend lines, it can be seen that, at the same predicted UCS, the measured UCS is slightly larger with LDMD than without LDMD for UCS less than about 500 psi, and the measured UCS is slightly smaller with LDMD than without LDMD for UCS larger than about 500 psi. This finding is constituent with the direct comparisons in Section 4.2, but the comparison of trend lines in Figure 16 are based on more data because the trend line comparison does not exclude the data points for which there were not directly comparable tests with and without LDMD. As discussed in Section 4.2, the reasons for the slight impact of LDMD on UCS might be that the radial displacement sensor device produced a slight confining effect with noticeable impact for the lower UCS specimens, and the LDMD mounting locations may have produced crack initiation points that slightly reduced the UCS for the stronger and more brittle specimens with higher UCS. In any case, the effect of the LDMD does not appear to be large for mixtures designed with typical UCS values.

4.5. Influence of temperature on UCS

Two mix designs were cured at three different temperatures to study the effects of temperature on the rate of strength gain. The data in Figures 17 and 18 show that UCS increases with curing temperature time for each curing time.

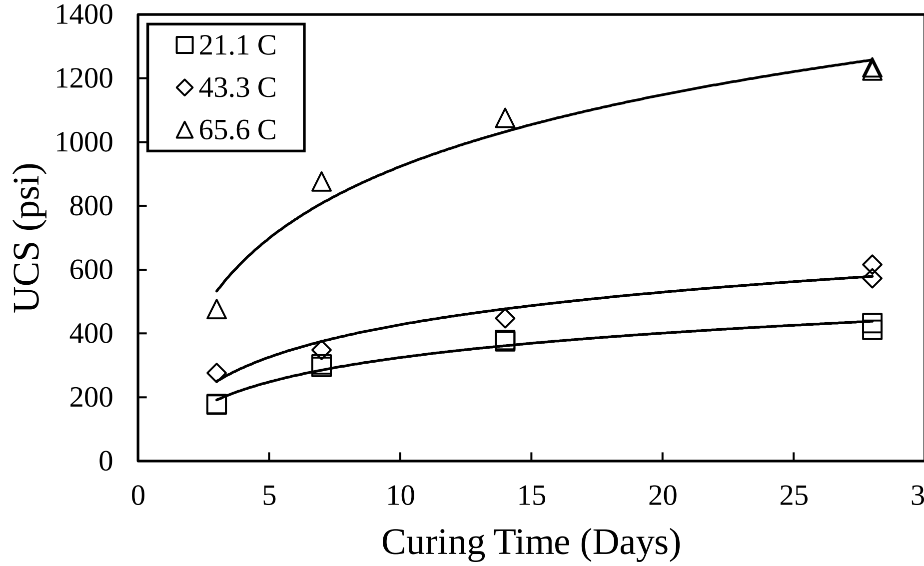

Figure 17: Relationship between UCS and curing time for $\alpha_{in\text{-}place}$ =200 kg/m^3 and w:c = 1.0 at different curing temperatures

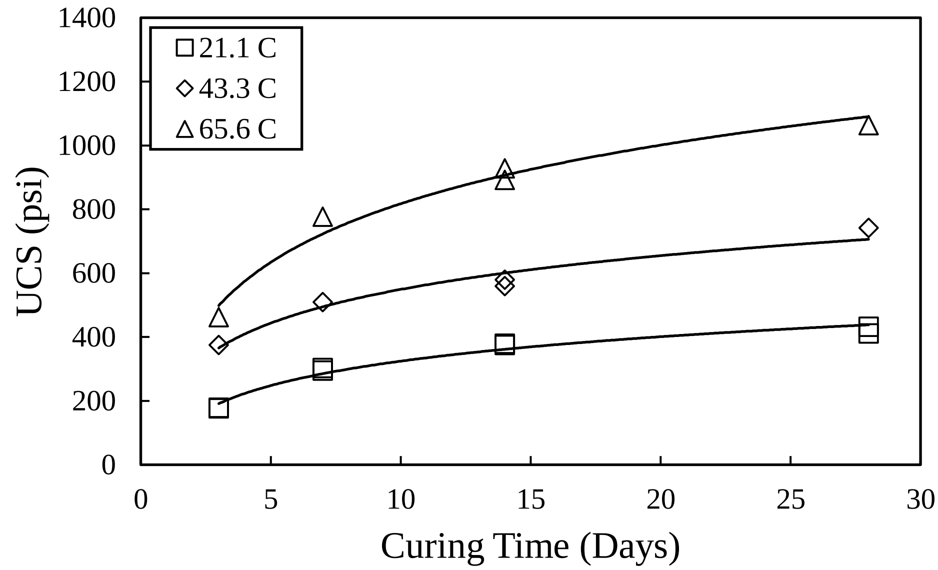

Figure 18: Relationship between UCS and curing time for $\alpha_{in\text{-}place}$ =275 kg/m^3 and w:c = 1.0 at different curing temperatures

However, these results show some irregularities. For example, the position of the strength curve for 43.3 °C is about half-way between the 21.1 °C and 65.6 °C curves in Figure 18, but the curves are far from equally spaced in Figure 17. Further, comparing the UCS values at 28-days and 65.6 °C, the strength for the mixture with a cement factor in-place of 200 kg/m^3 is higher than for the mixture with a cement factor in-place of 275 kg/m^3. It is not known whether these surprising results are due to testing errors and a relatively small data set, or whether they represent some real response of these materials.

The maturity term was calculated for each set of data using Equations 2, 3, and 4, and the results are shown in Figure 19 and Figure 20, where the maturity is plotted versus UCS. All three definitions of maturity show significant scatter when plotted against UCS for these mixtures. It is not clear that any of these definitions of maturity produce particularly good results for this data set.

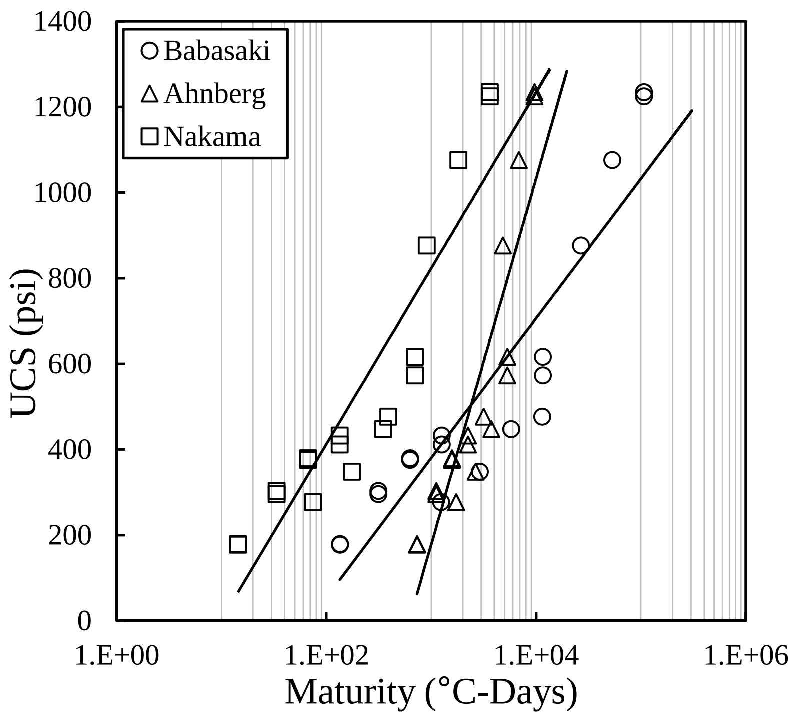

Figure 19: Relationship between UCS and maturity for $\alpha_{in\text{-}place}$ = 200 kg/m^3 and w:c = 1.0

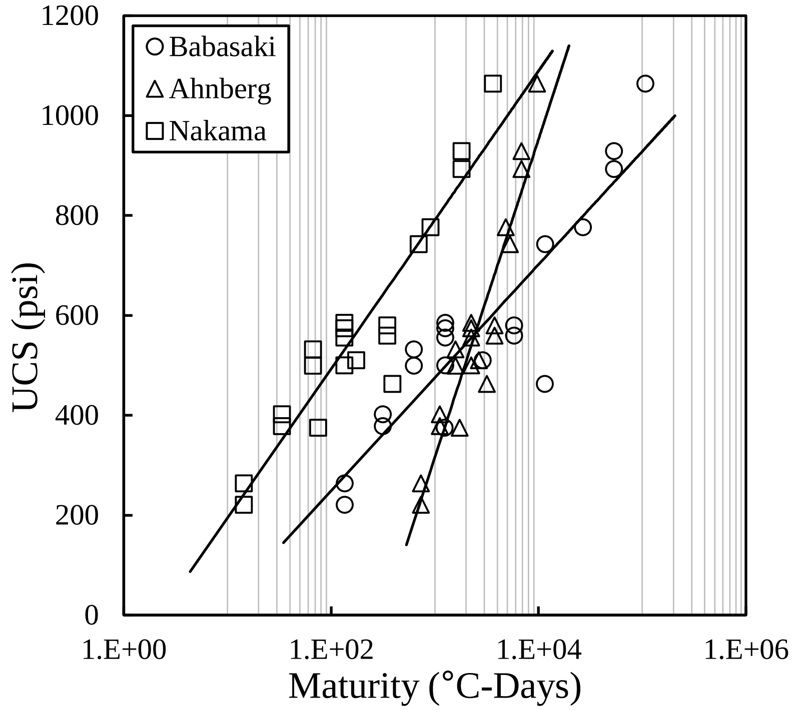

Figure 20: Relationship between UCS and maturity for $\alpha_{in\text{-}place}$ = 275 kg/m^3 and w:c = 1.0

As an alternative to the maturity expressions in Equations 2 through 4, a simple exponential function was added to Equation 7a to investigate whether it could represent the influence of curing temperature on UCS. Equation 7a was used instead of Equation 8a because all of the specimens for the temperature evaluation were mixed using a water-to-cement ratio of the slurry equal to one, so it was not necessary to include the density term that proved necessary for a wider range of mixture densities produced when the water-to-cement ratio of the slurry was expanded, as discussed previously. The exponential function of curing temperature is somewhat similar to that in Equations 2 and 4, except that logarithmic function of curing time from Equations 7 is retained. The resulting Equations 9 are the same as Equations 7, with the addition of a coefficient raised to the power of the curing temperature minus the reference temperature, T_0, normalized by the reference temperature, which is set equal to 21.1 °C for these analyses because that temperature was used for the vast majority of the specimens in this research. The base for the exponential function is designated as b_5 and c_5 in Equation 9a and 9b to avoid confusion with the coefficients that have a subscript of 4 in Equations 8. When the curing temperature, T, is equal to T_0, the exponential function of curing temperature in Equations 9 returns a value of unity. Consequently, if the exponential function were to fully capture the effects of curing temperature, the coefficients b_1, b_2, and b_3 would have the same meanings for Equations 7a and 9a, and the coefficients c_0, c_1, c_2, and c_3 would have the same meanings for Equations 7b and 9b. Just as in Equations 7, $c_0 = b_1 + b_2\ln(28)$, $c_1 = b_1/c_0$, $c_2 = b_2/c_0$, and $c_3 = b_3$ for Equations 9

$$\frac{UCS_{pred}}{p_a} = \left[b_1 + b_2 \ln\left(\frac{t}{t_0}\right)\right](w_t\colon c)^{b_3} b_5^{\frac{T-T_0}{T_0}} \qquad \textit{Equation 9a}$$

$$\frac{UCS_{pred}}{p_a} = c_0\left[c_1 + c_2\, ln\left(\frac{t}{t_0}\right)\right](w_t\colon c)^{c_3} c_5^{\frac{T-T_0}{T_0}} \qquad \textit{Equation 9b}$$

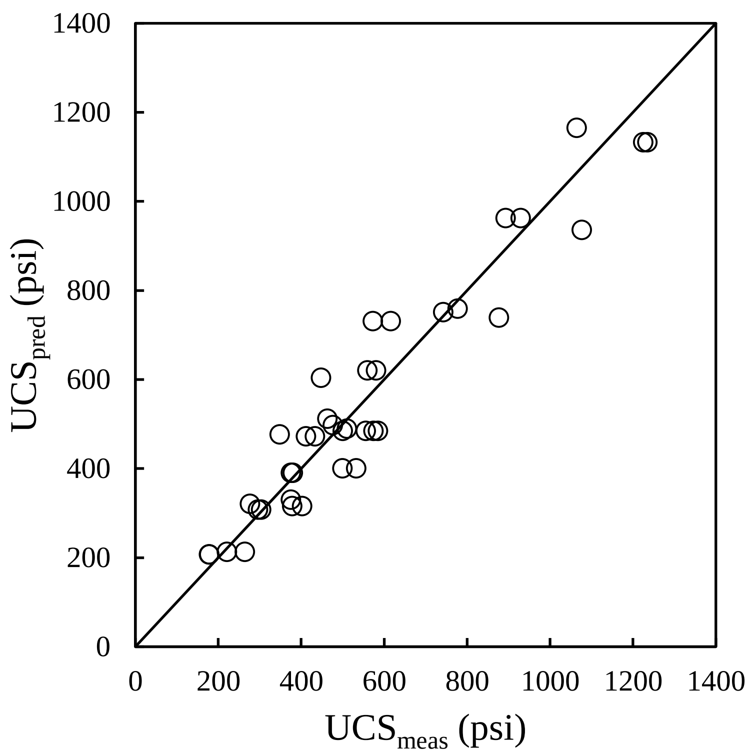

Figure 21: Relationship between predicted UCS and measured UCS

A least squares regression of Equation 9a was performed on the results of tests used to investigate the influence of curing temperature, and the results are shown in Figure 21. Considerable scatter is evident. As mentioned previously, inspection of the data for the curing temperature of 65.6 °C shows that the batch with a binder factor in-place of 200 kg/m^3 had higher strengths than the batch with a binder factor in-place of 275 kg/m^3, which was surprising.

To investigate the possibility of erroneous test results, the regression was repeated by systematically excluding the strengths of each batch for the curing temperature of 65.6 °C. First, the batch with a binder factor in-place of 200 kg/m^3 was excluded, then the 275 kg/m^3 batch was excluded, and finally both batches were excluded. Figures 22, 23, and 24 show the results from the regression analyses for each of these three cases.

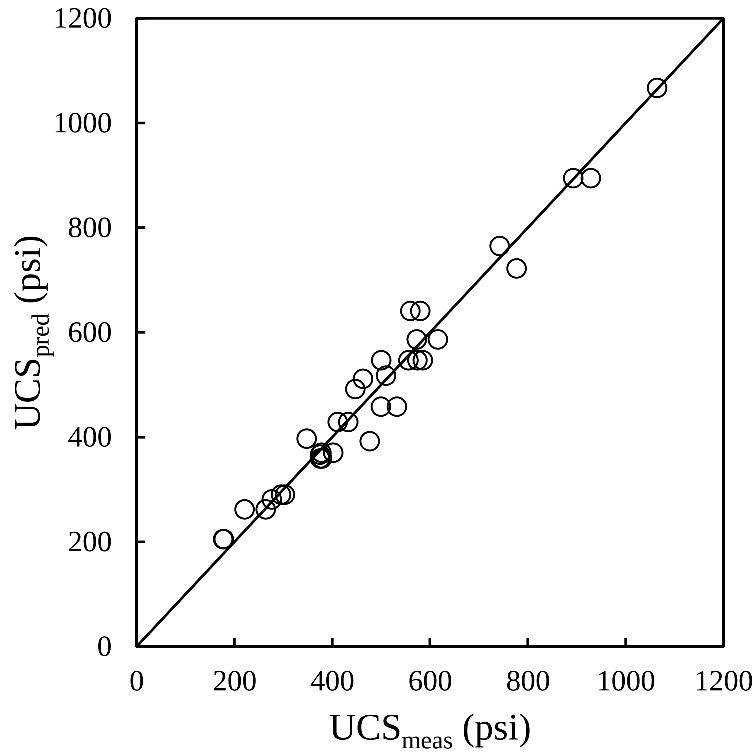

Figure 22: Relationship between predicted and measured UCS excluding $\alpha_{in\text{-}place}$ = 200 kg/m^{3}at 65.6°C

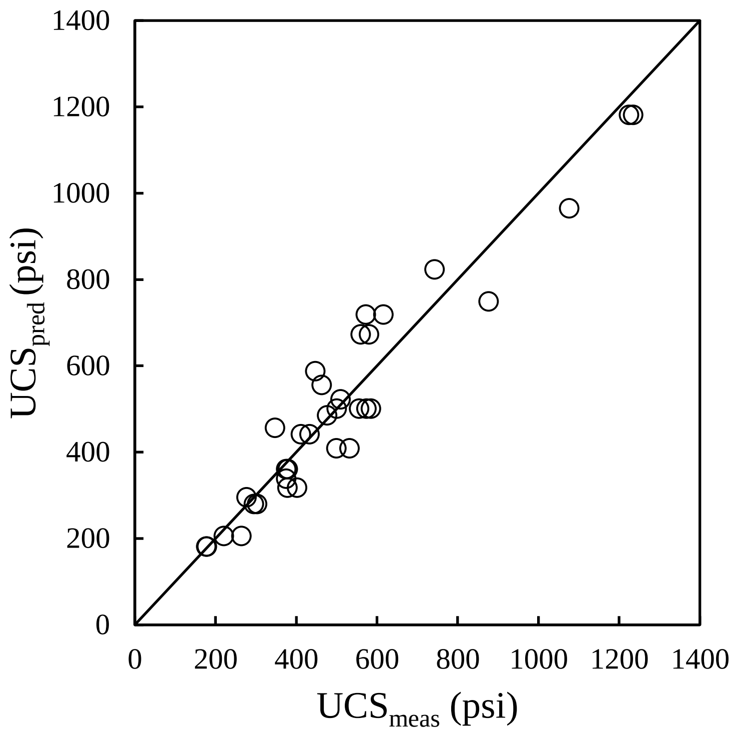

Figure 23: Relationship between predicted and measured UCS excluding $\alpha_{in\text{-}place}$ = 275 kg/m^3 at 65.6°C

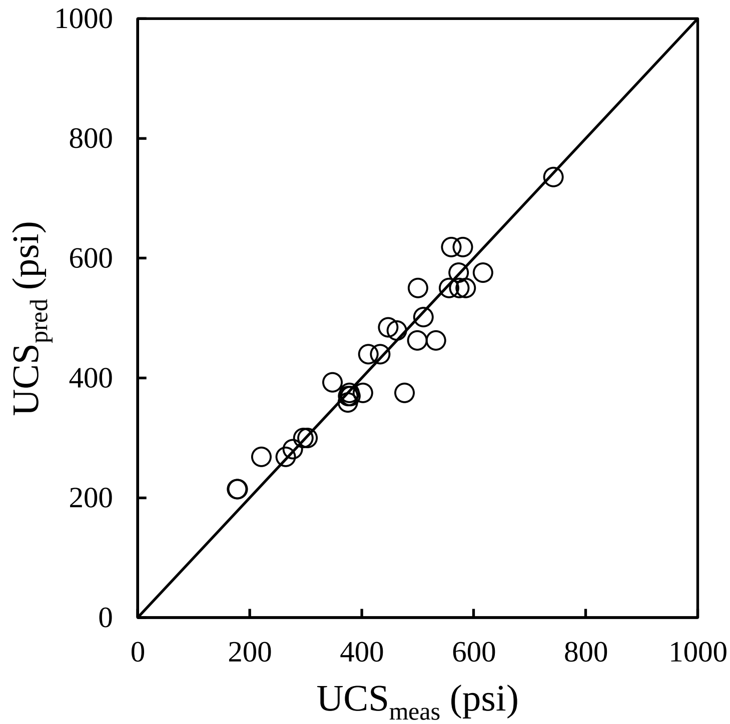

Figure 24: Relationship between predicted and measured UCS excluding $\alpha_{in\text{-}place}$ = 200 kg/m^3 and $\alpha_{in\text{-}place}$ = 275 kg/m^3 at 65.6°C

Figure 22, which excludes the strengths at 65.6 °C of the batch with a binder factor in place of 200 kg/m^3, showed the best fit with an R^2 value of 0.97. This suggests that the strengths for the 200 kg/m^3 batch at a curing temperature of 65.6 °C may have been in error in some way. However, the limited amount of data used for this investigation prevents firm conclusions.

Table 11 shows the coefficient values from the least-square regression of Equation 9a, as well as the corresponding coefficients for Equation 9b, for the specimens with curing temperature variation for the data set and fitting shown in Figure 22. For comparison, Table 11 also includes the coefficients for Equation 7b from Table 10, which is for the data set and fitting in Figure 9 without variation in curing temperature. It can be seen that the fittings with and without temperature variation produce essentially the same values of coefficients c_1 and c_2, which means that the effects of curing time are the same in both cases. Also, coefficient c_5 has a positive value, which means that increasing curing temperature increases UCS, as expected. However, Table 11 shows that the regression analysis of the data in Figure 22 using Equations 9 produces different values of c_0 and c_3 than produced by regression analysis of the data in Figure 9 using Equations 7. This could be due to errors in, or the relatively small size of, the temperature variation study in this research, or it could be due to inadequacy of Equations 9 to represent the influence of curing temperature on UCS, even though Figure 22 exhibits good correlation between predicted and measured UCS using Equations 9. Additional curing temperature data using the same base soil and binder type would be necessary to investigate whether the data used here to investigate the effects of curing temperature are flawed in some way and whether some other expression besides that shown in Equations 9 would best represent the influence of curing temperature on UCS.

Table 12: Comparison of coefficient values from Equations 9 with temperature variation to coefficient values from Equation 7 without temperature variation

Regression with Curing Temperature Variation, Data and Fitting as Shown on Figure 22				Regression without Curing Temperature Variation, Data and Fitting as Shown on Figure 9	
Equation 9a		Equation 9b		Equation 7b	
Coefficient	Value	Coefficient	Value	Coefficient	Value
--	--	c_0	78	c_0	114
b_1	17.5	c_1	0.223	c_1	0.228
b_2	18.2	c_2	0.233	c_2	0.232
b_3	-0.98	c_3	-0.98	c_3	-1.43
b_5	1.23	c_5	1.23	--	--

4.6. Effect of confinement

Unconsolidated-undrained triaxial compression tests were conducted to investigate the effects of confinement on peak and large-strain strengths. Three mixtures were investigated using a range of confining pressures. Mixture U-1 (cement factor in-place = 125 kg/m^3 and water-to-cement ratio of the slurry = 1.0) was tested at confining pressures of 5, 10, and 20 psi. Mixtures U-2 (cement factor in-place = 200 kg/m^3 and water-to-cement ratio of the slurry = 1.0) and U-3 (cement factor in-place = 275 kg/m^3 and water-to-cement ratio of the slurry = 1.0) were tested at confining pressures of 5, 10, 20, and 40 psi. Specimens from mixture U-1 were tested up to strains past 4% strain, while the specimen from mixtures U-2 and U-3 were tested up to strains past 5% strain.

Figure 25, Figure 26, and Figure 27 show typical stress-strain relationships for the three mixtures. The dashed lines represent the stress-strain relationships for UCS tests, while the solid lines represent the results for UU tests with a 5 psi confining pressure. It can be seen that the 5 psi confining pressure did not have a large impact on the peak strengths, but it did produce a significant increase in the large-strain strengths

Figure 28, Figure 29, and Figure 30 show the relationship between the deviator stress and the confining pressure at peak strength and at large-strain strengths for the UCS and UU tests conducted on each mixture. Figure 31, Figure 32, and Figure 33 show the p – q points at peak strength and at large-strain strengths for the UCS and UU tests conducted on each mixture. The p and q points are defined by the MIT stress paths where $p = (\sigma_1 + \sigma_3)/2$ and $q = (\sigma_1 - \sigma_3)/2$. In each case, the regression lines are based solely on the UU data. Although there is scatter in the data, the results show that confining pressure has much greater effect on large-strain strengths than it does on peak strengths. For the three mixtures shown in Figures 28, 29, and 30, the large-strain strengths range from 6% to 25% of the peak strengths for UCS tests, and the large-strain strengths range from 40% to 90% of the peak strengths for UU tests. The data also show trends for increasing strength with increasing confining pressure for the UU tests. Converting the p – q regression lines in Figures 31, 32, and 33 to Mohr-Coulomb cohesion intercepts and friction angles, the results are shown in Table 13.

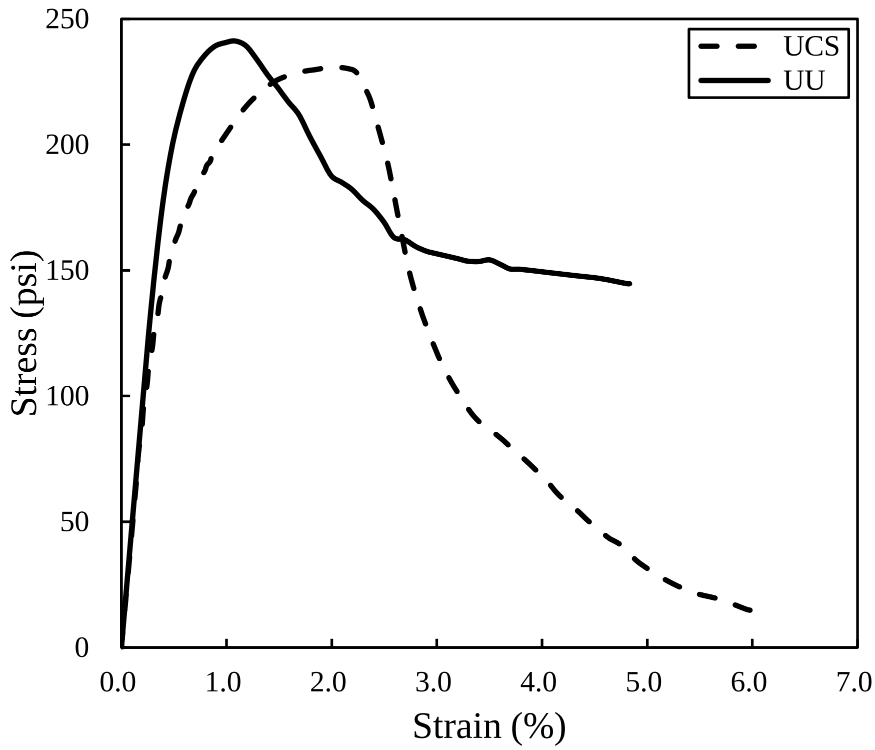

Figure 25: Stress-strain relationship for UCS test and UU tests with a 5-psi confining pressure for a cement factor in-place of 125 kg/m^3

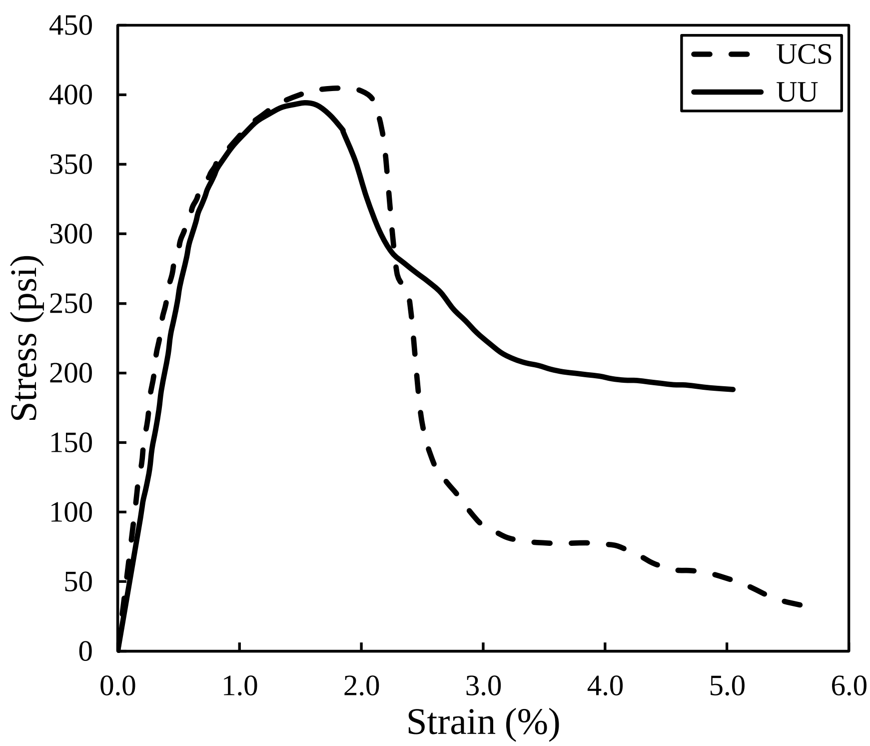

Figure 26: Stress-strain relationship for UCS test and UU tests with a 5-psi confining pressure for a cement factor in-place of 200 kg/m^3

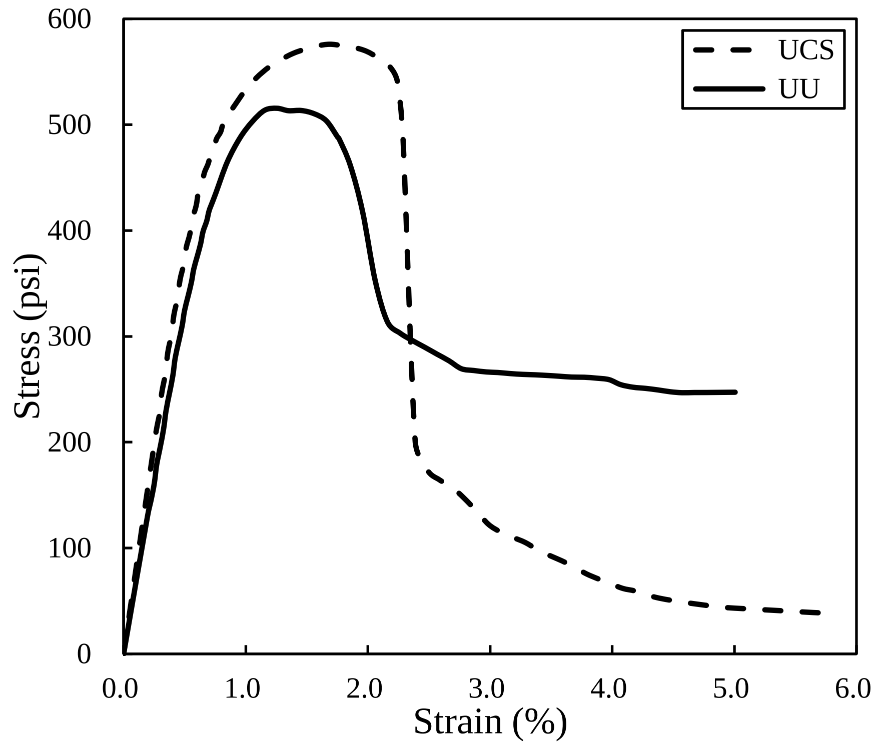

Figure 27: Stress-strain relationship for UCS test and UU tests with a 5-psi confining pressure for a cement factor in-place of 275 kg/m^3

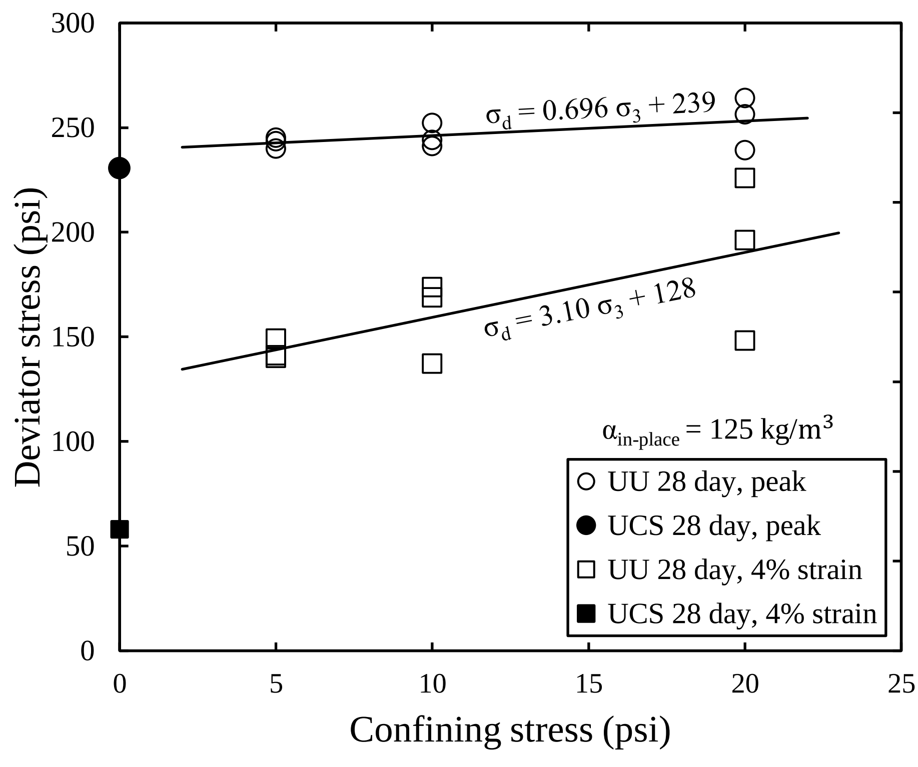

Figure 28: Relationship between deviator stress and confining stress showing peak deviator stress and deviator stress at 4% strain for a cement factor in-place of 125 kg/m^3

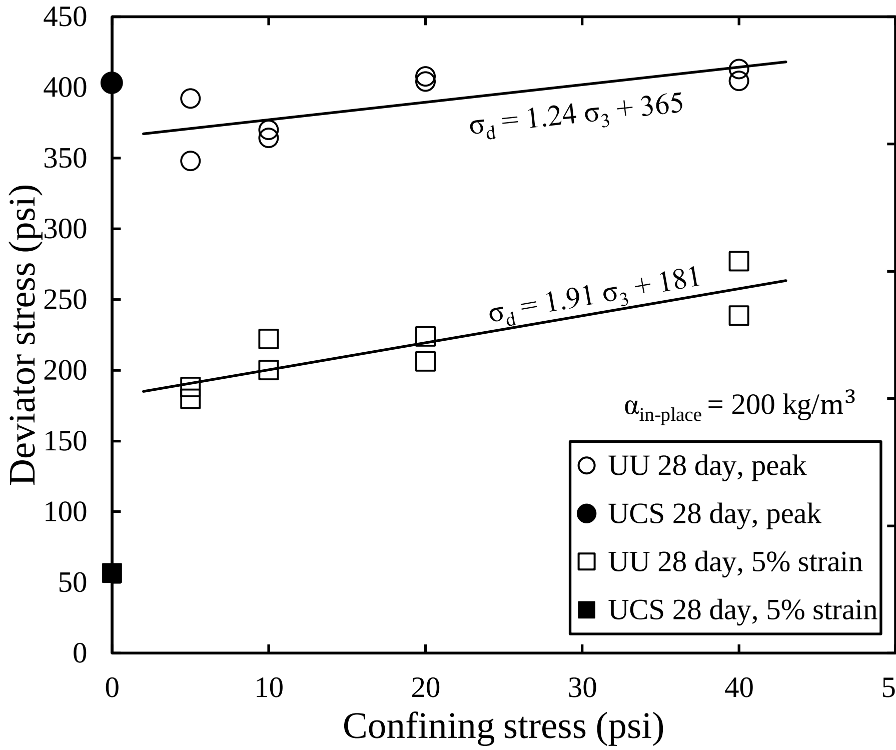

Figure 29: Relationship between deviator stress and confining stress showing peak deviator stress and deviator stress at 5% strain for a cement factor in-place of 200 kg/m^3

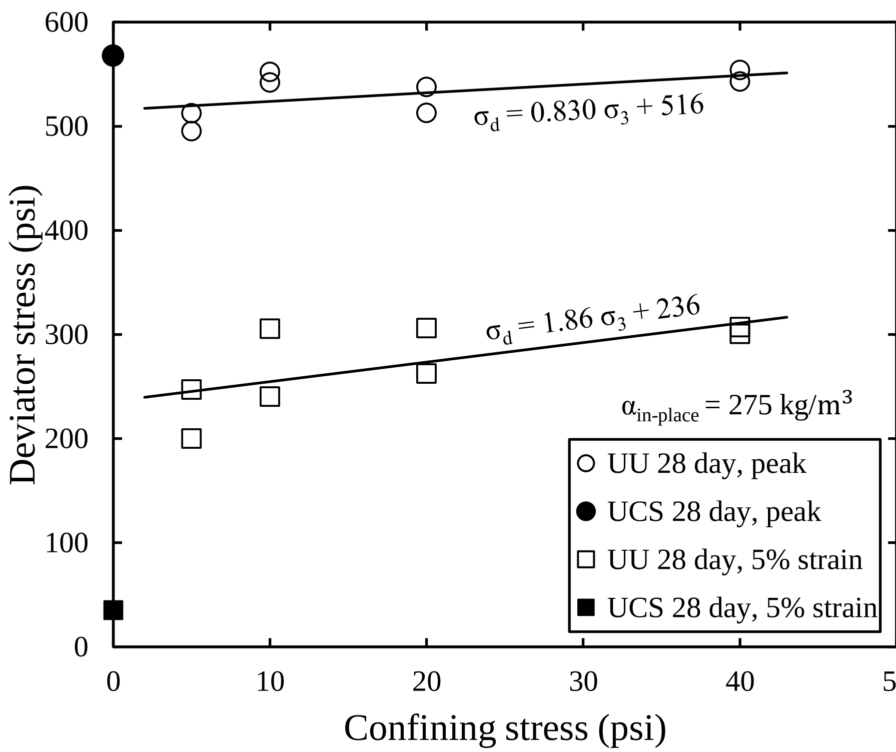

Figure 30: Relationship between deviator stress and confining stress showing peak deviator stress and deviator stress at 5% strain for a cement factor in-place of 275 kg/m^3

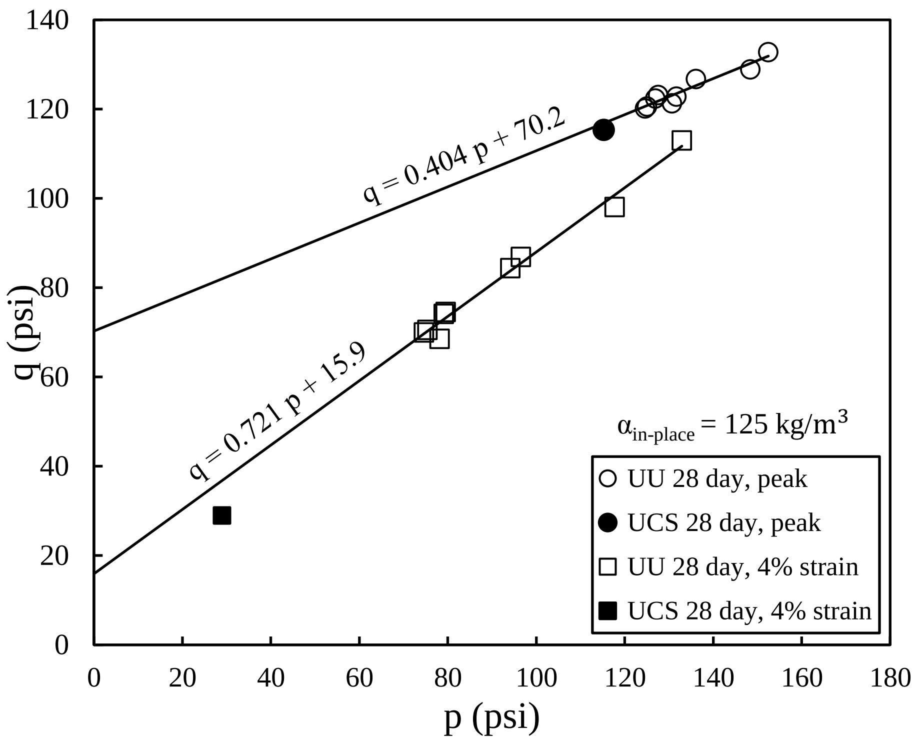

Figure 31: p-q plots showing peak total stresses and total stresses at 4% strain for a cement factor in-place of 125 kg/m³

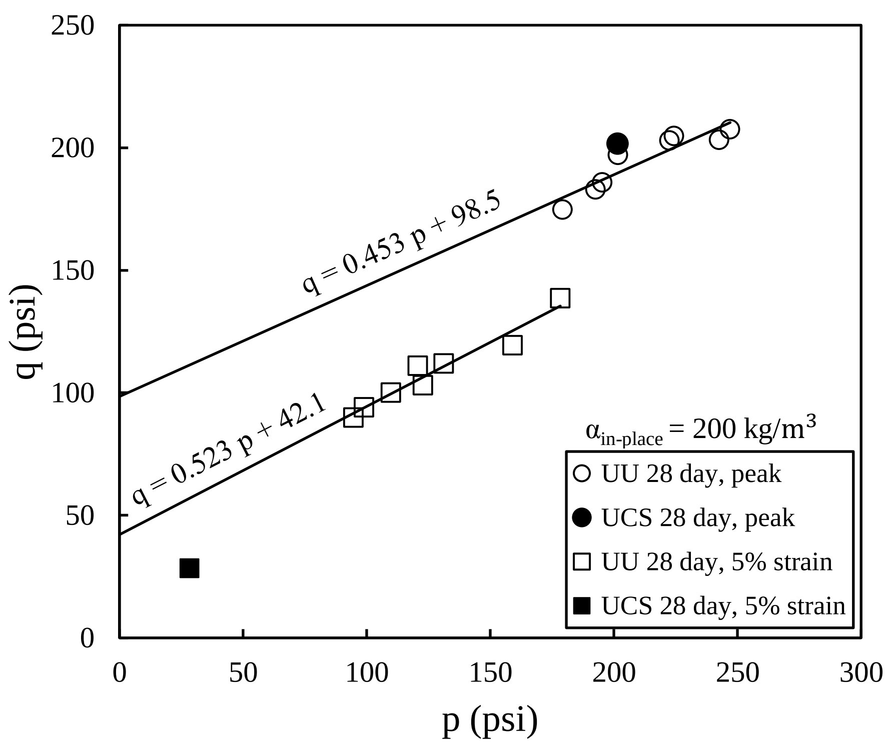

Figure 32: p-q plots showing peak total stresses and total stresses at 5% strain for a cement factor in-place of 200 kg/m³

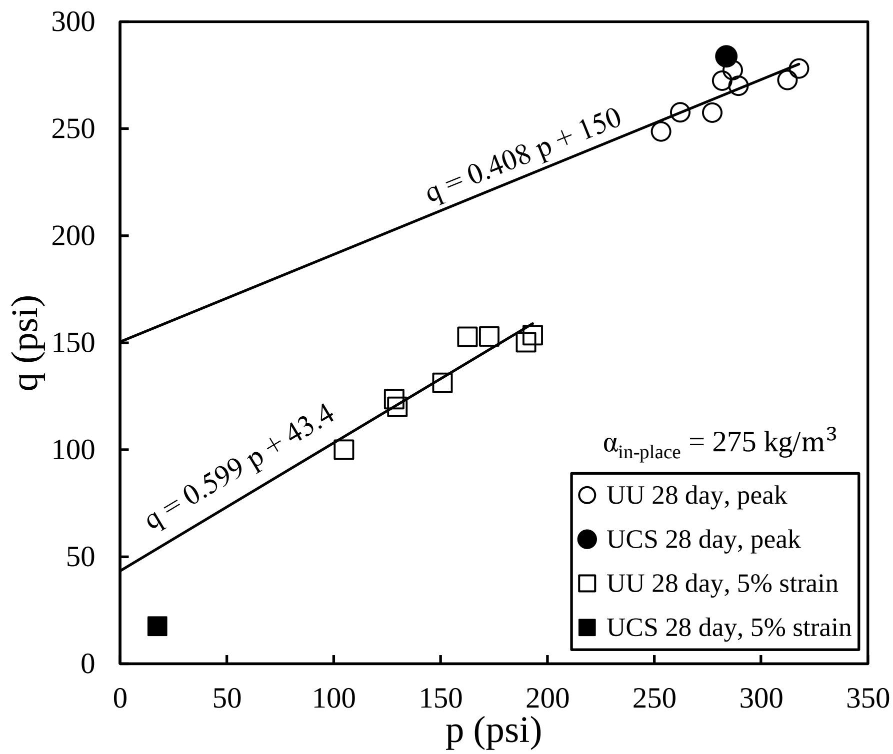

Figure 33: p-q plots showing peak total stresses and total stresses at 5% strain for a cement factor in-place of 275 kg/m³

Table 13: Mohr-Coulomb strength parameter values for soil cement mixtures from UU tests.

Batch	$\alpha_{in\text{-}place}$ (kg/m³)	w:c	Peak		Large Strain	
			Cohesion Intercept (psi)	Friction Angle (deg)	Cohesion Intercept (psi)	Friction Angle (deg)
U-1	125	1.0	76.8	23.8	23.0	46.1
U-2	200	1.0	110	27.0	49.4	31.5
U-3	275	1.0	165	24.1	54.1	36.8

Table 13 shows that at peak strengths, the cohesion intercept increases with increasing cement factor in-place, while the friction angle exhibits some scatter. At large strain, the strength parameters from batch U-1 are not completely comparable to the strength parameters from Batches U-2 and U-3 because the values of strain used for the large strain envelope were different. Results from batches U-2 and U-3 show an increase in both the cohesion intercept and the friction angles for large strain strengths with increasing cement factor in-place. The limitations of the results in Table 13 are: (1) the results are based on limited data, (2) confining pressures ranged from 5 to 40 psi, and (3) the strains used for the large strain envelopes were 4% for U-1 and 5% for U-2 and U-3.

4.7. Influence of strain measurement methods on the modulus of elasticity

This section presents and discusses the results of laboratory measurements of secant values of Young's modulus at 50% of the UCS, E_{50}, from unconfined compression tests. The E_{50} values were determined in three different ways:

(1) Using displacement of the bottom platen of the testing machine, as reported by the data acquisition system built into the testing machine. These values are designated $E_{50,BP-M}$, which stands for E_{50} based on Bottom Platen displacement reported by the testing Machine. During testing, the bottom platen is raised by rotation of a threaded fixture around the non-rotating threaded rod that supports the bottom platen. The bottom platen displacement is calculated from the number of rotations of the threaded fixture times the pitch of the threads.

(2) Using independent measurements of the deformation between the bottom platen and the top cross bar. These values are designated $E_{50,BP-CB}$, which stands for E_{50} based on Bottom Platen displacement relative to the fixed top Cross Bar that supports the load cell between the specimen and the top cross bar. An LVDT mounted on the top cross bar measured these displacements. Directly measuring displacements between the bottom platen and the top cross bar eliminates slack and deformations in the compression machine between the bottom platen and the top cross bar.

(3) Using displacements from LVDTs mounted directly on the specimens. These values are designated $E_{50,L}$, which stands for E_{50} based on Local displacement measurements. The local displacement measurement equipment is described in Section 3.4.

Figure 34 shows typical stress-strain curves from UCS tests resulting from the three different types of displacement measuring devices. The left-hand graph in Figure 34 shows that strains determined from displacement of the bottom platen as reported by the test machine are much larger than those determined from the LVDTs mounted directly on the specimens. The right hand graph in Figure 34 shows that strains determined from displacement of the bottom platen as reported by the test machine are slightly larger than those determined from displacement of the bottom platen relative to the cross bar.

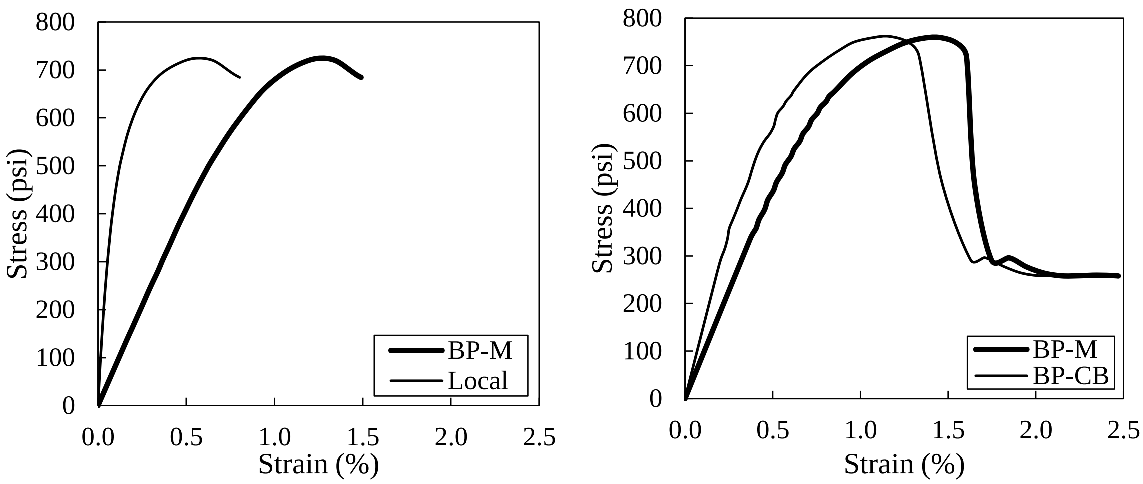

Figure 34: Typical stress-strain curves for the three different methods used to measure strain

This section includes several subsections that present and discuss the following issues: the effects of end-face treatment methods on $E_{50,BP-M}$; the effects of attaching the local displacement measurement devices (LDMD) on $E_{50,BP-M}$ and the resulting impacts on values of the ratio $E_{50,BP-M}$ to UCS for tests with and without LDMD attached; comparison of $E_{50,BP-M}$ and $E_{50,BP-CB}$ values versus UCS, including evaluation of slack and deformation in the load testing frame between the bottom platen and the top cross bar; and comparison of the $E_{50,BP-M}$ and E_{50L} values versus UCS.

4.7.1. Effect of end-face treatment on $E_{50,BP-M}$ values

The effects of end-face treatment methods on $E_{50,BP-M}$ values are shown in Figure 35, where the averages of the $E_{50,BP-M}$ results for the same curing periods and mixture proportions for four different end-face treatment methods are compared to the sawing-and-hand-trimming method. Figure 35 shows that grinding has almost no effect on the modulus of elasticity compared to sawing-and-hand-trimming. Similarly, sulfur capping and gypsum capping show little effect on the modulus of elasticity, although the data is limited and exhibits some scatter. However, the use of neoprene pads produced a significant reduction in the $E_{50,BP-M}$ values, which is logical because compression of the neoprene is included in the modulus calculation when bottom platen displacements are the basis for the strain calculation.

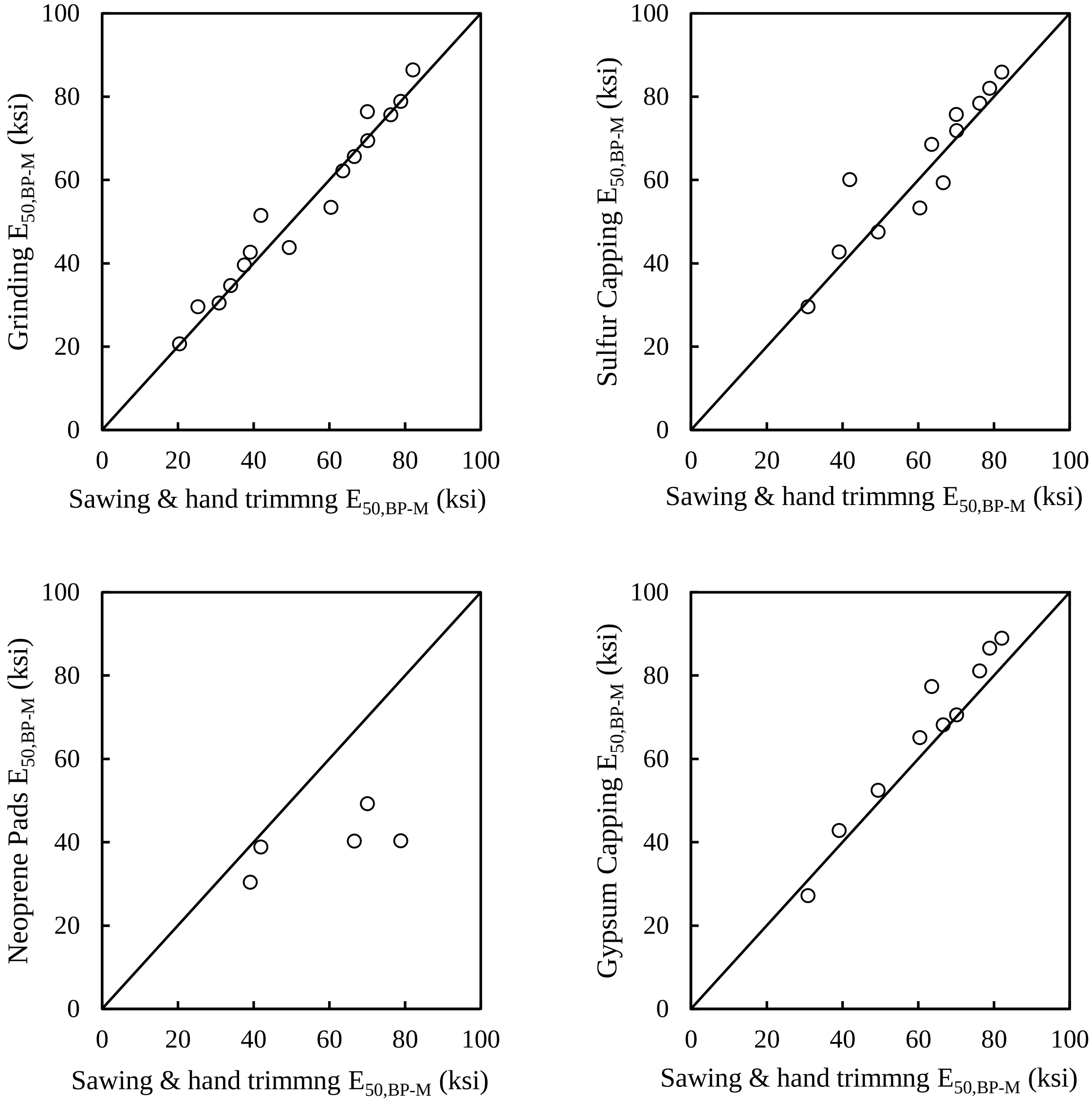

Figure 35: Effect of end-face treatment methods on $E_{50,BP-M}$

4.7.2. Effects of attaching the local strain measurement devices on $E_{50,BP-M}$ values

Figure 36 shows that attaching the local displacement measurement devices (LDMD) had essentially no impact on the $E_{50,BP-M}$ values. As discussed in Section 4.2, attaching LDMD did produce a slight increase in the UCS values, perhaps due to a slight confining effect from the radial strain measurement equipment. This produces a slight decrease in the ratio $E_{50,BP-M}$ to UCS, as shown in Figure 37.

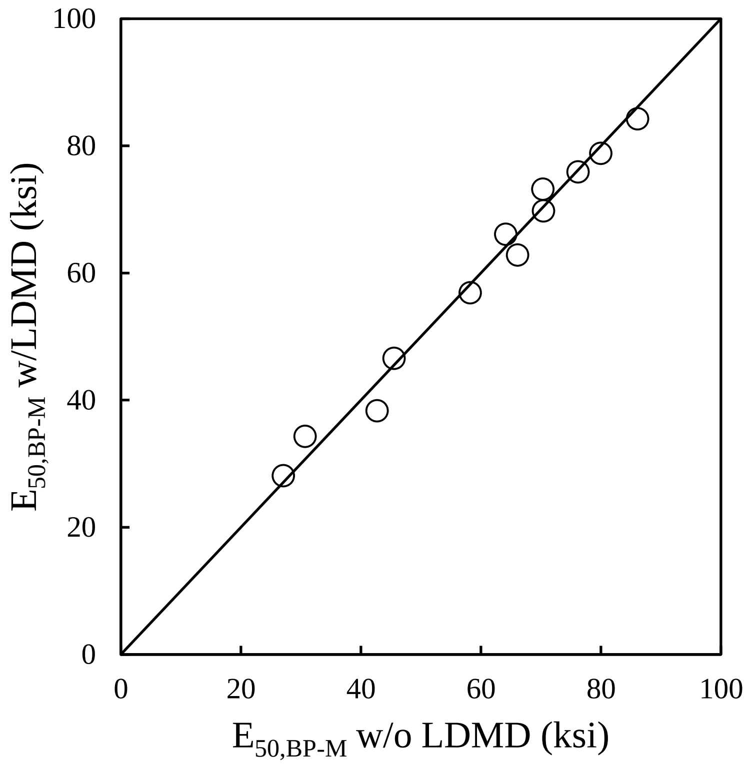

Figure 36: Effect of LDMD on $E_{50,BP-M}$

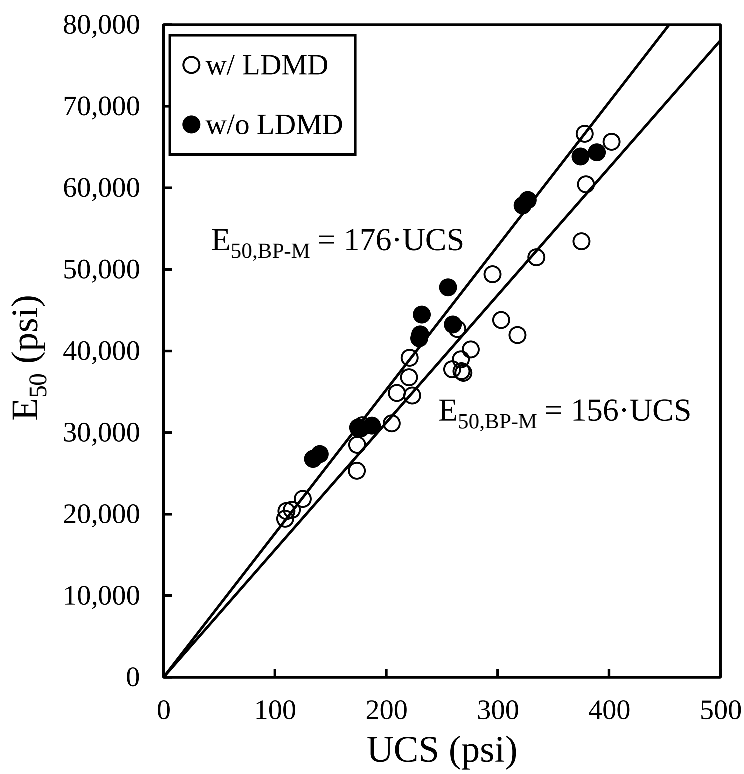

Figure 37: Effect of LDMD on the ratio of $E_{50,BP-M}$ to UCS

4.7.3. Comparison of $E_{50,BP-M}$ and $E_{50,BP-CB}$

Figure 38 shows values $E_{50,BP-M}$ and $E_{50,BP-CB}$ versus UCS. Filz et al. (2015) reported values of E_{50} ranging from 180 to 350 times the UCS for strains based on end-platen measurements. Other researchers have reported values of E_{50} ranging from 100 to 160 times the UCS (Hirabayashi et al. 2009), 35 to 150 times the UCS (Marzano et al. 2009), 40 to 170 times the UCS (Marzano et al. 2012). and 100 to 140 times the UCS (Szymkiewicz et al. 2015). The ratios of $E_{50,BP-M}$ to UCS shown in Figure 38 range from about 110 to 180 with the trend line having a value of 130, and the ratios of $E_{50,BP-CB}$ to UCS range from about 165 to about 205 with the trend line having a value of 185. These values are within the ranges reported by other researchers.

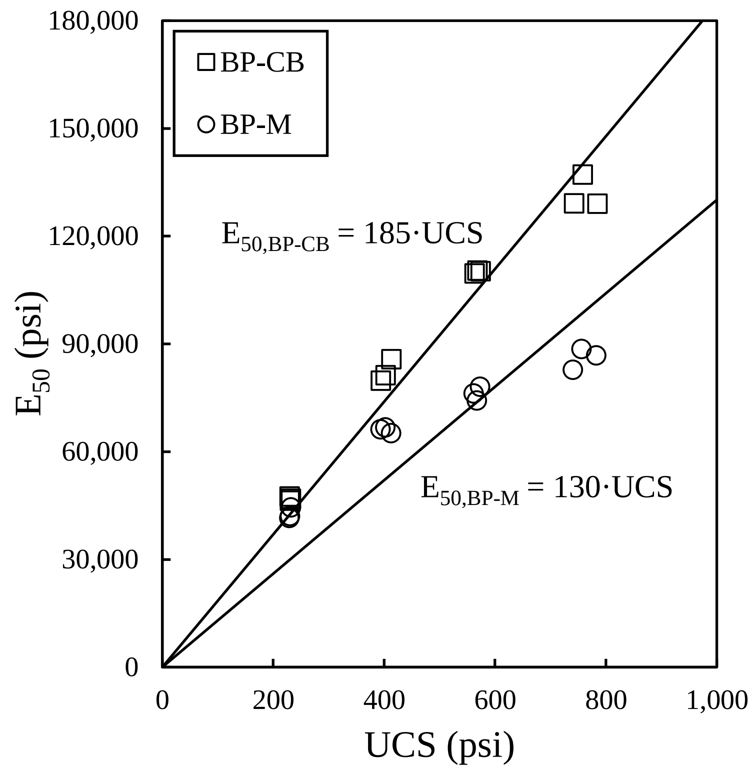

Figure 38: Effect on E_{50} determined from deformations of the cross bar

The noticeable difference between $E_{50,BP-M}$ and $E_{50,BP-CB}$ values shown in Figure 38 suggests that slack and deformation of the load-testing frame is significant, particularly for large loads, such that the difference between values of $E_{50,BP-M}$ and $E_{50,BP-CB}$ increases with UCS. Specimens with peak strengths around 200 psi exhibit very little difference between $E_{50,BP-M}$ and $E_{50,BP-CB}$, whereas specimens with peak strengths around 800 psi exhibit a significant difference between

$E_{50,BP-M}$ and $E_{50,BP-CB}$. To investigate this, deformations of the load frame were determined by subtracting the displacement of the bottom platen relative to the cross bar, as measured by an LVDT connected directly between the bottom platen and the cross bar, from the displacement of the bottom platen, as reported by the loading machine. The results are in Figure 39, which shows an initial machine slack of about 0.0014 inches, followed by machine deformation at the rate of 4.4×10^{-6} inches per pound. The procedure shown in Figure 3 removes the effects of initial slack and some initial deformation of the machine, but additional loading produces additional machine deformations, which would produce lower values of $E_{50,BP-M}$ than $E_{50,BP-CB}$ at high loads. In Figure 39, an increment in load can be considered from UCS = 200 psi, where $E_{50,BP-M}$ approximately equals $E_{50,BP-CB}$, to UCS = 800 psi, where it appears that the values of $E_{50,BP-M}$ and $E_{50,BP-CB}$ are approximately represented by 130*UCS and 185*UCS, respectively. At the 50% stress levels, this load increment is about $(800/2 - 200/2 \text{ psi})\pi(1 \text{ in.})^2$ = 943 lbs, which corresponds to machine deformation of about $(4.4 \times 10^{-6}$ in./lb)(900 lbs) = 0.00415 in., which produces an apparent strain of about 0.00106 for a 3.9-in.-long specimen. For $E_{50,BP-M}$ /UCS = 130, the strain at half the UCS is 0.00385. Subtracting the apparent strain of 0.00106, the remaining strain is 0.00279, which produces $E_{50,BP-CB}$/UCS = 180, which is close to the reported values of 185 in Figure 39.

Figure 40 shows $E_{50,BP-M}$ values over a wider range of UCS than included in Figure 39. Some of the curvature in the $E_{50,BP-M}$ versus UCS data is due to machine deformations, but other potential factors include: compression of the load cell and other components between the cross-bar and the top of the specimen; compliance at the specimen ends; and nonlinearity in this aspect of material response.

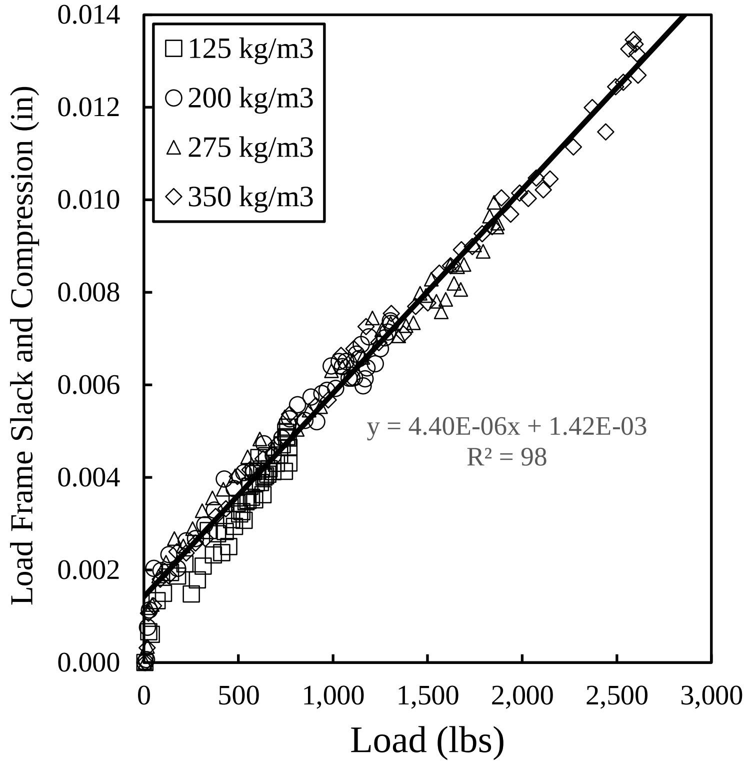

Figure 39: Slack and compression of load frame due to load

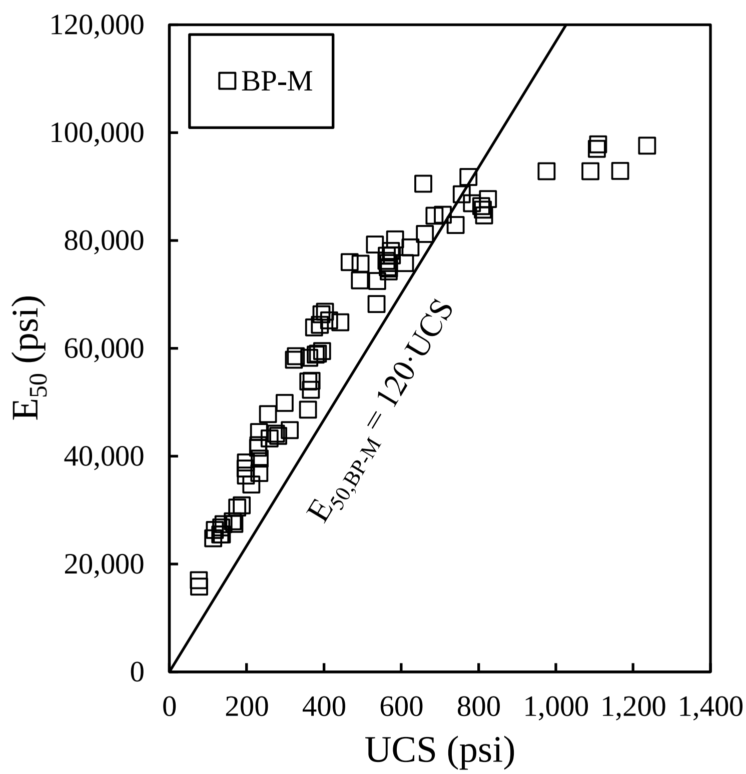

Figure 40: Relationship between $E_{50,BP\text{-}M}$ and UCS for sawing-and-hand-trimming and grinding

4.7.4. Comparison of the E_{50BP-M} and E_{50L} values to the UCS

Measured values of E_{50L} and E_{50BP-M} with LDMD attached are presented in Figure 41. Filz et al. (2015) reported values of E_{50} determined from local strain measurements ranging from 350 to 900 times the UCS. The values of E_{50} determined from local strain measurements in Figure 41 range from 450 to 720 times the UCS, with the trend line showing a value of E_{50L} equal to 630 times the UCS. These values fall within the previously reported ranges. The data sets for E_{50BP-M} in Figures 38, 40, and 41 are not the same, and the values of E_{50BP-M}/UCS are slightly different for each.

The large differences between the E_{50BP-M} and E_{50L} values in Figure 41 are believed to be due to inclusion of several deformation components that are incorporated in the E_{50BP-M} values but are not included in determining E_{50L}. These additional deformation components include machine deformations, compression of the load cell, compliance of the spherical bearing and top platen, and end-face compliance of the specimens with the end platens. Therefore, the E_{50L} values seem to be the most representative of actual material response because they do not include these additional deformations.

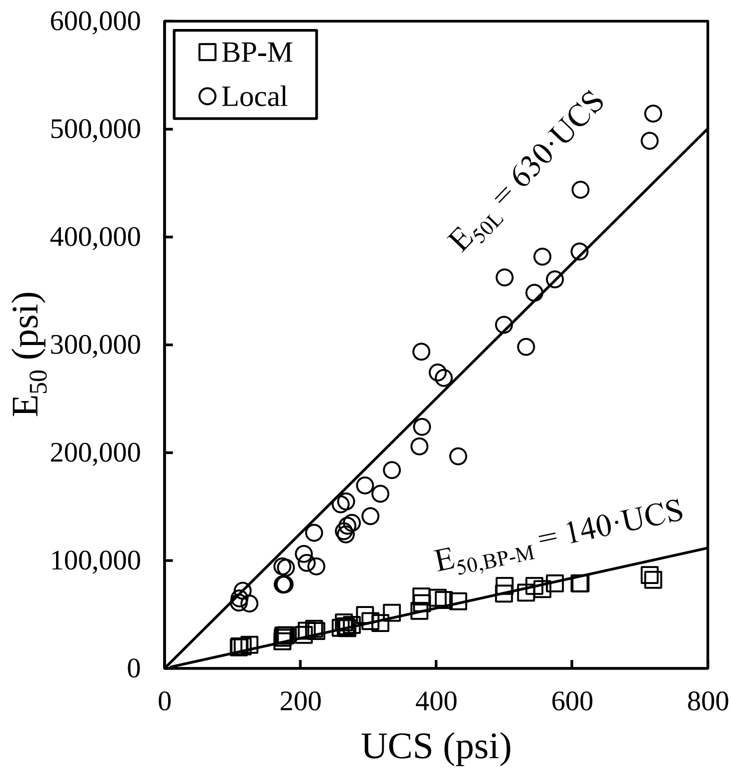

Figure 41: Relationship between E_{50} and UCS on samples with local strain measurements

4.8. Poisson's ratio

Radial deformations were obtained using the local displacement measurement device. These radial deformations can be combined with the axial deformations from the local displacement measurement device to calculate values of Poisson's ratio. Poisson's ratio is the ratio of horizontal strain to axial strain. The horizontal strain was calculated as the radial strain at the mid-height of the specimen. Figure 42 shows the resulting values of Poisson's ratio at 50% of the peak stress and at the peak stress in unconfined compression tests. The values of Poisson's ratio at 50% of the peak stress ranged from 0.05 to 0.39, with an average value of 0.14. The values of Poisson's ratio at the peak stress ranged from 0.12 to 0.45, with an average value of 0.25. The data in Figure 42 exhibit a slight trend of decreasing Poisson's ratio values as the UCS increases.

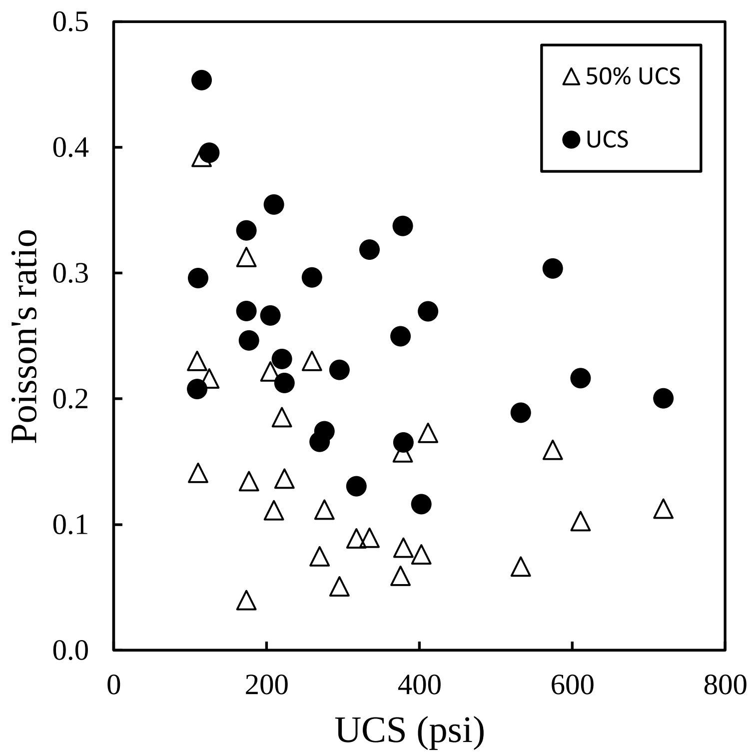

Figure 42: Relationship of Poisson's ratio with UCS

4.9. Mixture consistency soon after mixing

The consistency of the mixture immediately after blending the slurry into the soil is important because it influences whether the field mixing equipment can thoroughly blend the slurry with the soil. Different types of soil and different types of mixing equipment may require different consistencies in order to achieve thorough mixing. In typical U.S. practice, when engineers perform mix design studies during the feasibility and design stages of a project, they typically do not report a quantitative measure of the consistency of the mixture soon after mixing. This can lead to an impression that stiff mixtures which can achieve the necessary UCS may be feasible, when in reality they might not be practical because they are too stiff to thoroughly mix in the field.

This section first presents and discusses the results of laboratory measurements of mixture consistency, and then presents a procedure whereby a UCS target and a consistency target can be used in combination to select an optimum mix design.

4.9.1. Measurements of mixture consistency

The procedure employed to measure the consistency of the mixes consisted of testing four specimens at 30, 40, 50, and 60 minutes after mixing. Laboratory miniature vane shear tests were conducted on each specimen, and the undrained shear strengths, $s_{u,mix}$, measured this way were used to represent the mixture consistencies. Ten mix designs were prepared to represent a wide range of mix designs. Figure 43 presents the undrained shear strength measurements versus time for each of the ten mixtures.

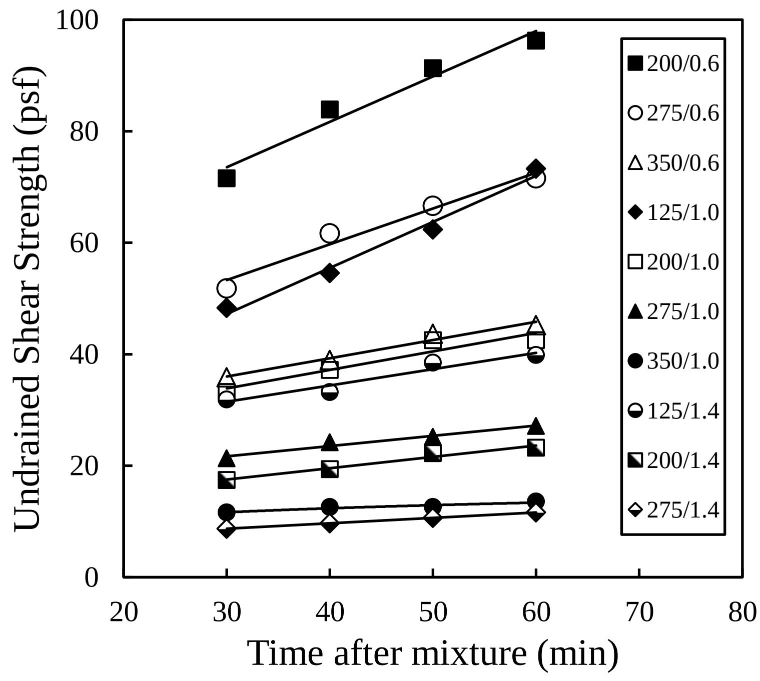

Figure 43: Relationship between undrained shear strength and time after mixing

For each mix design, the shear-strength-versus-time plots are approximately straight lines. The undrained shear strength is also significantly influenced by the mixture water content, w_{mix}, which is the weight of water in the soil plus the weight of water in the slurry divided by the weight of solids in the soil plus the weight of the dry cement in the slurry. Figure 44 shows the relationship between the undrained shear strength and the mixture water content, and the four different symbol types represent the different time periods after mixing. Both Figure 43 and Figure 44 show that mixtures with lower mixture water contents experience a larger increase in undrained shear strength with time than those with higher mixture water contents. Mixtures with lower mixture water contents show higher values of undrained shear strength because they have a stiffer consistency. Increasing the mixture water content results in the consistency of the mixture becoming more fluid, reducing the undrained shear strength. The mixture water content can be increased by increasing the cement factor and/or the water-to-cement ratio of the slurry.

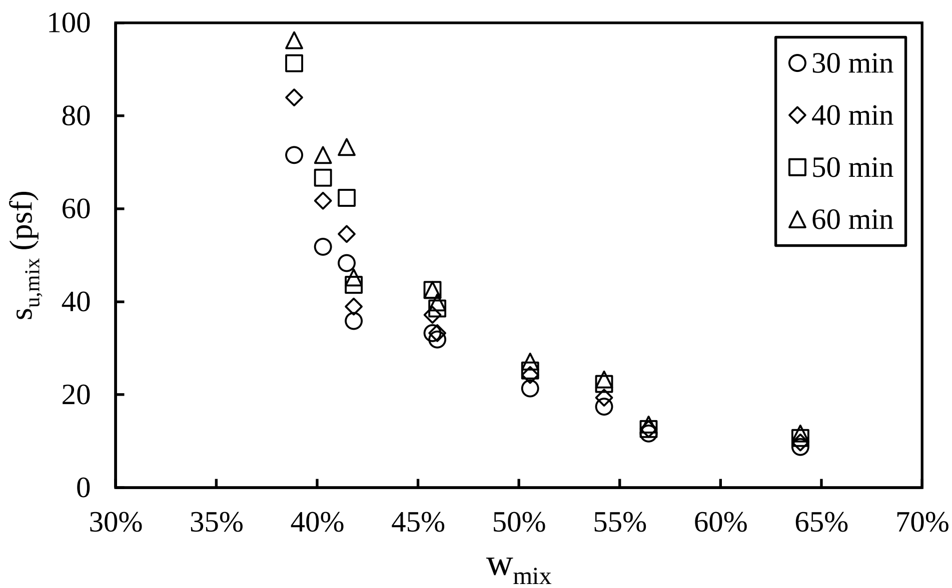

Figure 44: Relationship between undrained shear strength and mixture water content

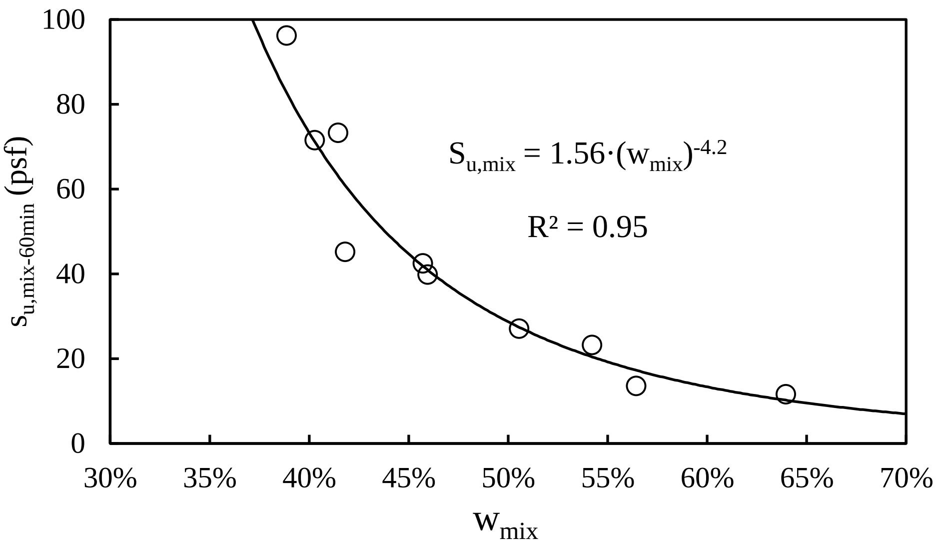

Figure 45: Relationship between undrained shear strength 60 min after mixing and mixture water content

Figure 45, which is limited to the data at 60 minutes after mixing, shows that the undrained shear strength of the mixture can be characterized as a power function of the mixture water content. Combining the linear trend with time shown in Figure 43 with the power function of the mixture water content shown in Figure 45 yields the three-coefficient expression shown in Equation 10a, where t is the time in minutes after mixing and t_{0m} is a reference time that is set equal to 60 minutes here. Values of the coefficients f_1, f_2, and f_3 can be obtained by applying a least-squares regression to fit the data to Equation 10a. Equation 10b can be obtained from Equation 10a by setting $g_0 = f_1 + f_2(60\text{ min}/t_{0m})$, $g_1 = f_1/g_0$, $g_2 = f_2/g_0$, and $g_3 = f_3$. The results are in Figure 46 and the coefficient values are listed in Table 14.

$$\frac{s_{u,pred}}{p_a} = [f_1 + f_2 t/t_{0m}](w_{mix})^{f_3}$$ *Equation 10a*

$$\frac{s_{u,pred}}{p_a} = g_0[g_1 + g_2 t/t_{0m}](w_{mix})^{g_3}$$ *Equation 10b*

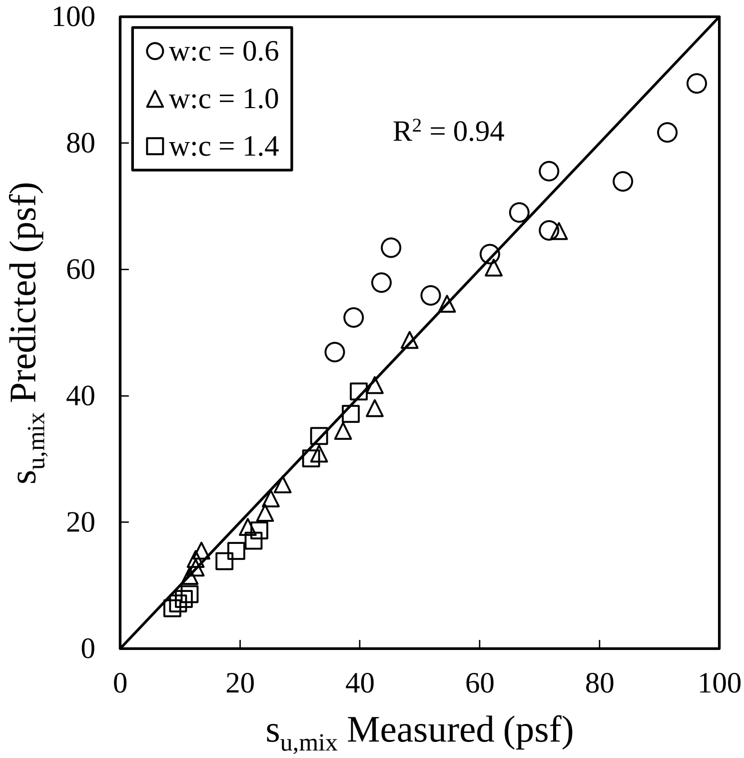

Figure 46: Relationship between the predicted $s_{u,mix}$ using Equations 8 and the measured $s_{u,mix}$

Table 14: Coefficient values determined from a least-square regression to predict $s_{u,mix}$

Equation 10a		Equation 10b	
Coefficient	Value	Coefficient	Value
--	--	g_0	0.00044
f_1	0.0002	g_1	0.455
f_2	0.00024	g_2	0.545
f_3	-4.7	g_3	-4.7

Figure 46 shows some scatter between the predicted and the measured undrained shear strengths, particularly for the mixture with a 0.6 water-to-cement ratio. This suggests that another quantity besides time and water content of the mixture may be influencing the undrained shear strength of the uncured mixture. Adding a power function of the total-water-to-cement ratio of the slurry did not improve the fit. Nevertheless, the three-coefficient expression in Equation 10 still provides a relatively good fit with the data.

4.9.2. Proposed method to select optimum design mixtures

The method proposed in this section to select optimum design mixtures makes use of the predictive models of unconfined compressive strength and undrained shear strength to find the range of mixtures that satisfy strength and consistency targets, including identifying the optimum mixture that uses the least amount of cement to satisfy these targets. In previous sections, the cement factor in-place, which is the dry weight of binder divided by the volume of soil to be treated, was used as part of the characterization of mix designs. In this section, the cement factor, which is the dry weight of binder divided by the volume of soil to be treated, is used instead because this term provides the contractor with an easy way to calculated the amount, and therefore the cost, of cement to be used on a project, i.e., simply multiply the volume of soil to be treated by the cement factor to arrive at the weight of soil needed for the project.

The proposed method proceeds according to the following steps:

1. Select a set of mix designs that encompass a relatively wide range of cement factors and water-to-cement ratios of the slurry, such that there will be substantial variations in total-water-to-cement ratio, dry density of the mixture, and mixture water contents.
2. Prepare batches of cement-treated soil using the mix designs identified in step one. Prepare sufficient UCS specimens to perform UCS tests over a range of curing times. Perform laboratory miniature shear vane tests on the mixture over a range of times, perhaps in the range from about 30 minutes to 90 minutes after mixing.
3. Perform UCS tests over a range of curing times.
4. Reduce the data as outlined below.

For the UCS test results, a least squares regression is applied to Equation 8a to obtain the best fit values of coefficients d_1 through d_4. This can be done easily using Excel®. Equation 8a can be converted to Equation 8b as a check on the reasonableness of the coefficient values by comparison to other data sets. Next, another Excel® spreadsheet is set up using Equations 11 and 12 to provide the inputs for Equation 8. All the parameters for Equations 11 and 12 are known for a given soil and binder type, except for the independent parameters cement factor, α, and water-to-cement ratio of the slurry, *w:c*. Now, decide upon a target value of UCS. A contractor may wish to select a target value of UCS that is some multiple of the specified UCS, with the multiplier depending on the rigor of the specification, the soil type, the deep mixing equipment and procedures to be employed, the contractor's prior experience, and the risks associated with low strengths from field mixed samples. For the purposes of this example, suppose that the specified 28-day UCS is 250 psi and the contractor selects a target 28-day UCS of 400 psi for mix design purposes. Next, the Excel® Solver function can be applied to obtain the value of α that satisfies Equations 8, 11, and 12 for a selected value of *w:c*. This process is repeated for different values of *w:c* to obtain the value of α for each value of *w:c*, such that the 28-day UCS equals the target value of 400 psi for each pair of α and *w:c*. The resulting curve of α versus *w:c* is plotted as Curve 1 in Figure 47. Curve 1 was generated using the soil and mixture properties for the soil tested in this research program, including using the values of the coefficients in Table 10. Any combination of α and *w:c* along Curve 1 produces a 28-day UCS of 400 psi for thorough mixtures cured at 21.1 °C, for the soil and binder used in this research, subject to the scatter in the data. Any combination of α and *w:c* above Curve 1 produces a 28-day UCS higher than 400 psi.

$$w_t : c = \frac{w\gamma_{d,soil}}{\alpha} + w : c \qquad \text{Equation 11}$$

$$\gamma_{d,mix} : \gamma_w = \frac{\gamma_{d,soil} + \alpha}{\gamma_w[1 + G_c(w : c)]} \qquad \text{Equation 12}$$

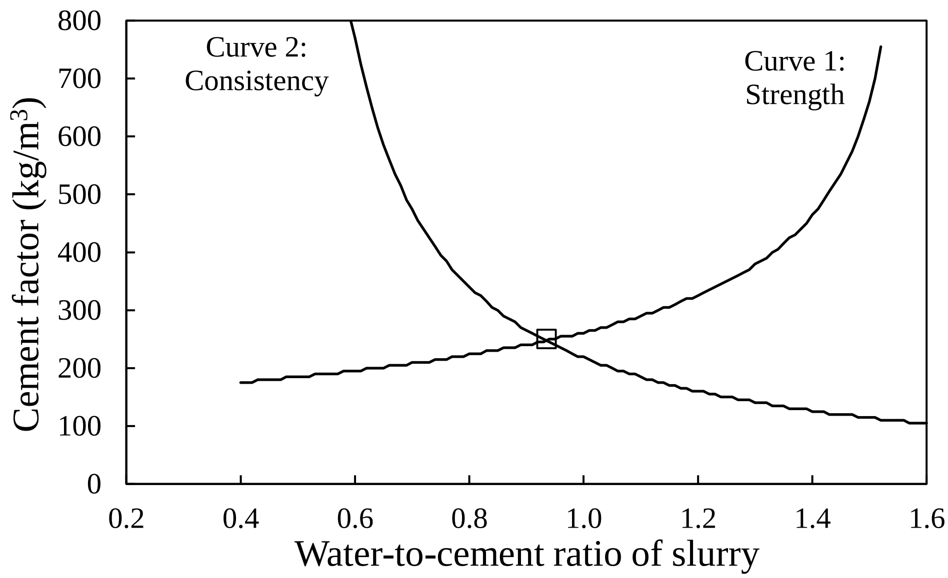

Figure 47: Relationship between cement factor and water-to-cement ratio of the slurry

For the consistency evaluation, a least squares regression is applied to Equation 10a to obtain the best fit values of coefficients f_1 through f_3. Again, this can be done easily using Excel®. Equation 10a can be converted to equation 10b if desired. Next, another Excel® spreadsheet is set up using Equation 13 to provide the input of mixture water content for Equation 10. All the parameters for Equations 13 are known for a given soil, except for the independent parameters cement factor, α, and water-to-cement ratio of the slurry, *w:c*. Now, decide upon a target value of undrained shear strength, s_u, of the mixture soon after mixing. A contractor may wish to select a target value of s_u depending on the soil type, the deep mixing equipment and procedures to be employed, and the contractor's prior experience. For the purposes of this example, suppose that the contractor selects a target s_u value of 50 psf at a time of 60 minutes after mixing. Next, the Excel® Solver function can be applied to obtain the value of α that satisfies Equations 10 and 13 for a selected value of *w:c*. This process is repeated for different values of *w:c* to obtain the value of α for each value of *w:c*, such that the s_u value equals the target value of 50 psf. The resulting curve of α versus *w:c* is plotted as Curve 2 in Figure 47. Curve 2 was generated using the soil and mixture properties for the soil tested in this research program, including the values of the coefficients in Table 14. Any combination of α and *w:c* along Curve 2 produces a 60-minute value of s_u equal to 50 psf, for the soil and binder used in this research, subject to the scatter in the data. Any combinations of α and *w:c* above Curve 2 produces 60-minute values of s_u lower than 50 psf.

$$w_{mix} = \frac{\alpha(w:c) + w\gamma_{d,soil}}{\alpha + \gamma_{d,soil}} \qquad \textit{Equation 13}$$

The optimum mix design can now be selected from Figure 47 by locating the intersection of Curves 1 and 2. For the soil, binder, and other conditions represented in Figure 47 (i.e., 28-day UCS of 400 psi for thorough mixtures cured at 21.1 °C, and a one-hour s_u of 50 psf), the optimum mix design is represented by the square symbol in Figure 47, which corresponds to a cement factor, α, of 250 kg/m^3 with a water-to-cement ratio of the slurry of 0.94. This combination represents the least amount of cement that would achieve the targets. Of course, other combinations of α and w:c that lie above both of the Curves 1 and 2 would also satisfy the targets, although with a larger quantity of cement.

Chapter 5: Conclusions

This chapter summarizes the conclusions from the results presented in Chapter 4. The order of the conclusions is presented in the same order as the results were presented.

1. A direct comparison of UCS results showed that the grinding method is in very good agreement with the sawing-and-hand-trimming method, while the sulfur capping method, the neoprene pads, and the gypsum capping method show some scatter when compared to the sawing-and-hand-trimming method. However, these comparisons showed that there is relatively little overall influence of the end-face treatment method on the measured UCS of the specimens, when each method is carefully applied. Nevertheless, the sawing-and-hand-trimming method and the grinding method are generally preferred because they produce consistent results, they do not risk drying the specimens to the same extent that sulfur capping and gypsum capping do, and they do not tend to artificially induce a splitting failure mechanism as the neoprene pad method does.

2. The use of the local displacement measurement device (LDMD) had both slight positive and slight negative effects on the measured strength. Specimens with UCS below 500 psi experienced a small increase in strength from the use of LDMD, which is believed to be due to a slight confining effect from the radial device. On the other hand, specimens with UCS above 500 psi experienced a small decrease in strength from the use of the equipment. The decrease of strength is believed to be from the attachment of the collars to the specimen, which may have caused crack initiation points to develop at the attachment locations due to the brittle behavior of those specimens.

3. The 3-coefficient best-fit approach developed by Miller et al. (2015) exhibited noticeable scatter when applied to a set of mix designs that included wide variations in the water-to-cement-ratio of the slurry. The scatter is believed to be produced by the larger range of specimen densities obtained from using a wider range of water-to-cement ratios of the slurry. The use of an additional term in the fitting equation was proposed to account for the influence of density on the predicted strength. The resulting four-coefficient equation

with the addition of the density term produced very good agreement between the predicted and measured strengths.

4. The 3-coefficient best-fit approach was applied to specimens with a single water-to-cement ratio of the slurry to study the effect of using the local displacement measurement devices on the measured UCS with and without attachment of LDMD confirmed the results obtained from the direct comparison approach, which showed that use of LDMD slightly increased the strength of low strength mixtures and slightly decreased the strength of high strength mixtures.

5. Using the best-fit approach with a temperature term to account for the influence of curing temperature on the rate of strength gain showed promising results. However, due to the limited amount of data and scatter in the data, further research on this issue is needed.

6. The results of the UCS tests show that the strength of specimens at large strains, i.e., axial strains of 4 to 5 percent, dropped below 20% of the UCS, while the UU tests under confining pressures of 5 to 40 psi exhibited large-strain strengths about 60% of the UCS. This indicates that even relatively small confining pressures produce large increases in the large strain-strength of the cement-treated soil specimens investigated in this research.

7. The grinding method, sulfur capping method, and the gypsum capping method showed no significant influence on the secant modulus at 50% of UCS determined from bottom platen displacements reported by the loading machine, $E_{50,BP\text{-}M}$, when compared to the sawing-and-hand-trimming method. However, the neoprene pads showed reduction of the secant modulus when compared to the sawing-and-hand-trimming method. The lower values of secant modulus when using neoprene pads was due to compression of the pads, which was included in the machine reported values of end-platen displacement.

8. The use of the local displacement measurement devices (LDMD) showed no significant effect on the secant modulus determined from machine reported values of end-platen displacement. However, use of LDMD did have a slight effect on UCS as discussed

above, and this resulted in a decrease in the ratio of $E_{50,BP-M}$/UCS when LDMD were applied.

9. The values of secant modulus determined from bottom platen displacements reported by the loading machine, $E_{50,BP-M}$, were significantly affected by machine slack and compliance. Direct measurement of displacements between the bottom platen and the top cross bar accounted for slack and compression of the load frame during loading, but did not account for slack in the load cell, spherical bearing between the load cell and the top platen, or compliance between the end faces of the specimens and the end platens. The values of secant modulus based on direct measurements of displacement between the bottom platen and the top cross-bar, $E_{50,BP-CB}$, were larger than the values of secant modulus based on end platen displacement reported by the loading machine, $E_{50,BP-M}$, and the differences between these two measures of secant modulus increased as the stiffness of the specimen increased.

10. The best measurement of secant modulus were obtained from local displacement measurement devices (LDMD) attached directly to the specimens, $E_{50,L}$, because this approach avoided deformations of the loading machine, the load cell, and the spherical bearing, as well as compliance at the ends of the specimens. For all the specimens for which LDMD were used, the ratio of $E_{50,L}$ to UCS was about 630, which is consistent with other values reported in the published literature.

11. Values of Poisson’s ratio ranged between 0.05 and 0.25 for 50% of UCS and between 0.15 and 0.35 at the peak strength in UCS tests. There appears to be a slight trend of decreasing Poisson's ratio with increasing UCS.

12. The consistency of a mixture right after mixing is important for the ability of field mixing equipment to thoroughly blend the slurry with the soil to be mixed. Consistency of the mixture can be measured with the laboratory miniature vane shear apparatus and is represented as the undrained shear strength of the mixture before curing. The undrained shear strength of the mixture decreases as a power function of the mixture water content

and increases as linear function of time. A 3-coefficient expression reflecting these relationships can be fit to the data to represent the uncured mixture shear strength as a function of time after mixing and water content of the mixture.

13. The predictive relationships for UCS of the cured mixture and undrained shear strength of the uncured mixture can be used to determine a range of mixtures that satisfy targets of consistency during mixing and strength after curing. This range of mix designs would allow the contractor to design a mixture that meets the strength targets of the cured cement-treated soil, but also allows for thorough mixing with the contractor's equipment. The procedure outlined in this thesis permits a contractor to select the optimum mix design that satisfies the target strength of the cured mixture and the target shear strength of the uncured mixture, where optimum in this case refers to the least amount of cement usage.

Chapter 6: Recommendations

This chapter presents recommendations from the author regarding the following: (1) the preferred end-face treatment method considering equipment availability and soil type; (2) use of the local displacement measurement device to avoid damage to the equipment; (3) requirements for the use of the 4-coefficient best-fit relationship to predict the UCS; (4) the procedure developed during this research to measure the consistency of the mixture soon after mixing; and (5) future research.

6.1. Recommendations on the end-face treatment methods

The step-by-step procedure for the application of the end-face treatment methods is presented in Appendix D. The procedure includes the five end-face treatment methods investigated in this research, as well as labeled photos of the equipment required.

The author recommends use of grinding as the preferred method from this research because it is simple to perform, produces consistent results, and the specimen preparation time is short, which prevents drying of the specimen. The alternative to grinding as a suitable end-face treatment method is the sawing-and-hand-trimming method. Sawing-and-hand-trimming has the same advantages as grinding, plus the advantage of less expensive equipment. The author recognizes that sulfur capping can also produce good and consistent results, but additional care is required to prevent the specimen from drying. Sulfur capping should be avoided on specimens that are highly sensitive to drying. Gypsum capping can also produce good results, but also requires additional care to prevent drying of the specimen. The use of a moist room during sample capping may help prevent drying of the specimen when using gypsum caps. Finally neoprene pads are not recommended as an end-face treatment methods for cement-treated soil specimens. Neoprene pads have a range of stresses in which they can be used for concrete specimens. For cement-treated soil specimens, which are typically weaker than this range, neoprene pads generally produce a splitting failure mode that is different from the failure mode typically observed for other end-face treatment methods.

6.2. Recommended use of local displacement measurement device

The local displacement measurement devices are sensitive and should be handed with extreme care at all times, especially the sensor rods since they can be damaged easily. The step-by-step procedure for placement of the equipment on cement-treated soil specimens is provided in Appendix E. When using the local displacement measurement equipment on cement-treated soil specimens, stopping the test once the load drops under 95% of the peak load is recommended. Carrying the test past this point can result in the sensor rods bending when the specimen fractures. In addition, the sensor rods should be carefully cleaned before every test to keep the insides of the LVDT's clean.

6.3. Recommended use of 4-coefficient relationship to predict the UCS

For density to have an impact on the prediction of the UCS, the test program has to cover a range of densities, which can be achieved by testing mix designs with different water-to-cement ratios of the slurry and different binder factors. This research used water-to-cement ratios of 0.6, 1.0, and 1.4 for the slurry and binder factors in-place of 125, 200, 275, and 300 kg/m^3. This range of mix designs provided a wide range of specimen densities.

6.4. Recommendations for the procedure to measure the consistency of the mixture

The step-by-step procedure to measure the consistency of the mixture using the laboratory miniature vane shear apparatus is provided in Appendix C. This procedure was developed to be done after the specimens have been molded. It is recommended to take into account the number of cement-treated soil specimens that will be prepared from the batch so there is enough mix left to conduct the procedure. Also, the number of specimens formed affects the time required to mold them, which affects the starting time of the procedure. The starting time can be delayed if necessary, but it may limit the amount of tests that can be conducted if the mixture has a stiff consistency as it may set quickly.

6.5. Recommendations for future research

The following items require further research:

(1) **Effectiveness of UCS fitting equation on different soil types:** The 4-coefficient predictive relationship presented in Section 4.3 was developed using only one type of soil and one type of binder. It is recommended that a similar study be conducted on different soils and binders. Such a study could help determine if the coefficients can be generalized or if ranges can be provided depending on the soil and binder types.

(2) **Use of UCS fitting equation that includes the influence of curing temperature:** The UCS fitting equation to account for the influence of curing temperature presented in Section 4.4 showed promising results. However, there was a small amount of data

and the results exhibited some scatter. It is recommended that a more extensive test program be conducted to investigate if the fitting approach used in this research is appropriate.

(3) **Influence of confinement on large strain strengths:** The number of tests conducted limited the results of the study of the influence of confinement. It is recommended that a more extensive triaxial compression test program be conducted to include: unconsolidated-undrained (UU) tests, isotropically consolidated-undrained (ICU) tests with back-pressure saturation and pore water pressure measurements, and anisotropically consolidated-undrained (ACU) triaxial compression tests with back-pressure saturation and pore water pressure measurements. Such tests would provide useful information about effective stress characterization of soil-cement response. It may be useful to apply confining pressures that are specific percentages of the unconfined compressive strength of the mix to facilitate comparison of the results.

(4) **Negative pore pressures:** The potential influence of negative pore water pressures on UCS and UU tests for cement-treated soil has not been well studied. Field investigations of the presence or absence negative pore water pressures of cement-treated soil above and below the groundwater level, combined with laboratory investigations of the influence of negative pore pressures on the strength of cement-treated specimen, would be informative.

(5) **Alternative methods for local strain measurements:** This research investigated the influence of using a local displacement measurement device on the strength and the secant modulus of the mixture. However, the device used was originally designed for rock core samples and not for cement-treated soil specimens, which are much softer than most rocks. It is recommended that other types of equipment be investigated. Whole body imaging equipment, such as x-ray equipment and video tracking, and non-contacting devices such as proximity transducers should also be investigated since they can produce accurate results without having to be mounted on the specimens.

(6) **Measure of mixture consistency:** The procedure and fitting equation used to measure and represent the mixture consistency soon after mixing is conducted should be further investigated, including using soils with higher and lower plasticities.

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Appendix A: Calculations for Laboratory Preparation of Cement-Treated Soil Mixtures

Laboratory Mixing Data
Batch C-1

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	8
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	125
Weight of Slurry Water, $w_{w,slurry}$ (g)	250.0
Weight of Dry Cement, w_c (g)	250.0
Weight of Moist Soil, w_{soil} (g)	3070.6
Weight of Slurry (g)	500.0
Specific Gravity of Solids	2.71
water content of mix	0.41
Dry unit wt. of mix (pcf)	79.6

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2299.7
Weight of Soil Water, $w_{w,soil}$ (g)	805
Total weight of soil used, W_t (g)	3081.5
Weight of Dry Cement, w_c (g)	251.5
Weight of Slurry Water, $w_{w,slurry}$ (g)	251.5
Soil Water Content, w (%)	35.00
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	10.93%
Cement Factor, α (kg/m3)	151.75
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	126.46
Volume Ratio, VR (%)	20.00
Total-Water-to-Cement Ratio, w_T:c	4.18

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	--
Weight of Slurry Water**, $w_{w,slurry}$ (g)	--
Volume Ratio, VR (%)	--
Total-Water-to-Cement Ratio, w_T:c	--
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	--

SAMPLE DATA: Batch C-1

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size		Cure Conditions		Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions		Strength Adjustments			total unit weight (kg/m3)	Notes
				Diam. (in)	Height (in)	Temp (C)	Humidity (%)			Peak UCS (psi)	Strain (%)	L/D ratio	Height Correction Factor	Adj. UCS (psi)		
A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
D	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
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J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	

Laboratory Mixing Data
Batch C-2

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	8
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	200
Weight of Slurry Water, $w_{w,slurry}$ (g)	400.0
Weight of Dry Cement, w_c (g)	400.0
Weight of Moist Soil, w_{soil} (g)	2707.2
Weight of Slurry (g)	800.0
Specific Gravity of Solids	2.74
water content of mix	0.46
Dry unit wt. of mix (pcf)	75.9

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2099.5
Weight of Soil Water, $w_{w,soil}$ (g)	735
Total weight of soil used, W_t (g)	2803.4
Weight of Dry Cement, w_c (g)	410.1
Weight of Slurry Water, $w_{w,slurry}$ (g)	410.1
Soil Water Content, w (%)	35.01
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	19.75%
Cement Factor, α (kg/m3)	272.01
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	200.23
Volume Ratio, VR (%)	35.85
Total-Water-to-Cement Ratio, w_T:c	2.77

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	--
Weight of Slurry Water**, $w_{w,slurry}$ (g)	--
Volume Ratio, VR (%)	--
Total-Water-to-Cement Ratio, w_T:c	--
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	--

SAMPLE DATA: Batch C-2

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
D	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
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I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	

Laboratory Mixing Data
Batch C-3

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	8
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	275
Weight of Slurry Water, $w_{w,slurry}$ (g)	550.0
Weight of Dry Cement, w_c (g)	550.0
Weight of Moist Soil, w_{soil} (g)	2343.8
Weight of Slurry (g)	1100.0
Specific Gravity of Solids	2.78
water content of mix	0.51
Dry unit wt. of mix (pcf)	72.1

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	1799.7
Weight of Soil Water, $w_{w,soil}$ (g)	630
Total weight of soil used, W_t (g)	2401.8
Weight of Dry Cement, w_c (g)	559.8
Weight of Slurry Water, $w_{w,slurry}$ (g)	559.8
Soil Water Content, w (%)	35.01
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	31.46%
Cement Factor, α (kg/m3)	433.40
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	275.83
Volume Ratio, VR (%)	57.12
Total-Water-to-Cement Ratio, w_T:c	2.11

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	--
Weight of Slurry Water**, $w_{w,slurry}$ (g)	--
Volume Ratio, VR (%)	--
Total-Water-to-Cement Ratio, w_T:c	--
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	--

SAMPLE DATA: Batch C-3

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size		Cure Conditions		Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions		Strength Adjustments			total unit weight (kg/m3)	Notes
				Diam. (in)	Height (in)	Temp (C)	Humidity (%)			Peak UCS (psi)	Strain (%)	L/D ratio	Height Correction Factor	Adj. UCS (psi)		
A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
D	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
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J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	

Laboratory Mixing Data
Batch C-4

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	8
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	350
Weight of Slurry Water, $w_{w,slurry}$ (g)	700.0
Weight of Dry Cement, w_c (g)	700.0
Weight of Moist Soil, w_{soil} (g)	1980.4
Weight of Slurry (g)	1400.0
Specific Gravity of Solids	2.82
water content of mix	0.56
Dry unit wt. of mix (pcf)	67.9

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	1500
Weight of Soil Water, $w_{w,soil}$ (g)	525
Total weight of soil used, W_t (g)	2002
Weight of Dry Cement, w_c (g)	729.2
Weight of Slurry Water, $w_{w,slurry}$ (g)	729.2
Soil Water Content, w (%)	35.00
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	49.17%
Cement Factor, α (kg/m3)	677.31
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	357.85
Volume Ratio, VR (%)	89.27
Total-Water-to-Cement Ratio, w_T:c	1.71

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	--
Weight of Slurry Water**, $w_{w,slurry}$ (g)	--
Volume Ratio, VR (%)	--
Total-Water-to-Cement Ratio, w_T:c	--
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	--

SAMPLE DATA: Batch C-4

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size		Cure Conditions		Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions		Strength Adjustments			total unit weight (kg/m3)	Notes
				Diam. (in)	Height (in)	Temp (C)	Humidity (%)			Peak UCS (psi)	Strain (%)	L/D ratio	Height Correction Factor	Adj. UCS (psi)		
A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
D	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
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J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	

Laboratory Mixing Data
Batch C-5

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	8
Water:Cement Ratio of Slurry, w:c	0.60
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	200
Weight of Slurry Water, $w_{w,slurry}$ (g)	240.0
Weight of Dry Cement, w_c (g)	400.0
Weight of Moist Soil, w_{soil} (g)	3001.5
Weight of Slurry (g)	640.0
Specific Gravity of Solids	2.74
water content of mix	0.39
Dry unit wt. of mix (pcf)	82.6

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2299.9
Weight of Soil Water, $w_{w,soil}$ (g)	808.4
Total weight of soil used, W_t (g)	3084.1
Weight of Dry Cement, w_c (g)	417.1
Weight of Slurry Water, $w_{w,slurry}$ (g)	250.2
Soil Water Content, w (%)	35.15
Water:Cement Ratio, w:c	0.60
Cement Content, a_W (%)	18.28%
Cement Factor, α (kg/m3)	251.50
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	204.34
Volume Ratio, VR (%)	23.08
Total-Water-to-Cement Ratio, w_T:c	2.52

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	--
Weight of Slurry Water**, $w_{w,slurry}$ (g)	--
Volume Ratio, VR (%)	--
Total-Water-to-Cement Ratio, w_T:c	--
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	--

SAMPLE DATA: Batch C-5

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size		Cure Conditions		Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions		Strength Adjustments			total unit weight (kg/m3)	Notes
				Diam. (in)	Height (in)	Temp (C)	Humidity (%)			Peak UCS (psi)	Strain (%)	L/D ratio	Height Correction Factor	Adj. UCS (psi)		
A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
D	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
E	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
G	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
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J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	

Laboratory Mixing Data
Batch C-6

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	8
Water:Cement Ratio of Slurry, w:c	0.60
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	275
Weight of Slurry Water, $w_{w,slurry}$ (g)	330.0
Weight of Dry Cement, w_c (g)	550.0
Weight of Moist Soil, w_{soil} (g)	2748.4
Weight of Slurry (g)	880.0
Specific Gravity of Solids	2.76
water content of mix	0.40
Dry unit wt. of mix (pcf)	81.6

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2100
Weight of Soil Water, $w_{w,soil}$ (g)	735
Total weight of soil used, W_t (g)	2807
Weight of Dry Cement, w_c (g)	557.0
Weight of Slurry Water, $w_{w,slurry}$ (g)	334.2
Soil Water Content, w (%)	35.00
Water:Cement Ratio, w:c	0.60
Cement Content, a_W (%)	26.79%
Cement Factor, α (kg/m3)	369.02
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	275.65
Volume Ratio, VR (%)	33.87
Total-Water-to-Cement Ratio, w_T:c	1.91

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	--
Weight of Slurry Water**, $w_{w,slurry}$ (g)	--
Volume Ratio, VR (%)	--
Total-Water-to-Cement Ratio, w_T:c	--
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	--

SAMPLE DATA: Batch C-6

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size		Cure Conditions		Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions		Strength Adjustments			total unit weight (kg/m3)	Notes
				Diam. (in)	Height (in)	Temp (C)	Humidity (%)			Peak UCS (psi)	Strain (%)	L/D ratio	Height Correction Factor	Adj. UCS (psi)		
A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
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Laboratory Mixing Data
Batch C-7

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	8
Water:Cement Ratio of Slurry, w:c	0.60
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	350
Weight of Slurry Water, $w_{w,slurry}$ (g)	420.0
Weight of Dry Cement, w_c (g)	700.0
Weight of Moist Soil, w_{soil} (g)	2495.3
Weight of Slurry (g)	1120.0
Specific Gravity of Solids	2.79
water content of mix	0.42
Dry unit wt. of mix (pcf)	80.4

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	1900
Weight of Soil Water, $w_{w,soil}$ (g)	665
Total weight of soil used, W_t (g)	2542.5
Weight of Dry Cement, w_c (g)	705.2
Weight of Slurry Water, $w_{w,slurry}$ (g)	423.1
Soil Water Content, w (%)	35.00
Water:Cement Ratio, w:c	0.60
Cement Content, a_W (%)	37.44%
Cement Factor, α (kg/m3)	515.80
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	350.07
Volume Ratio, VR (%)	47.34
Total-Water-to-Cement Ratio, w_T:c	1.53

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	--
Weight of Slurry Water**, $w_{w,slurry}$ (g)	--
Volume Ratio, VR (%)	--
Total-Water-to-Cement Ratio, w_T:c	--
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	--

SAMPLE DATA: Batch C-7

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size		Cure Conditions		Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions		Strength Adjustments			total unit weight (kg/m3)	Notes
				Diam. (in)	Height (in)	Temp (C)	Humidity (%)			Peak UCS (psi)	Strain (%)	L/D ratio	Height Correction Factor	Adj. UCS (psi)		
A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
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Laboratory Mixing Data
Batch C-8

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	8
Water:Cement Ratio of Slurry, w:c	1.40
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	125
Weight of Slurry Water, $w_{w,slurry}$ (g)	350.0
Weight of Dry Cement, w_c (g)	250.0
Weight of Moist Soil, w_{soil} (g)	2886.8
Weight of Slurry (g)	600.0
Specific Gravity of Solids	2.71
water content of mix	0.46
Dry unit wt. of mix (pcf)	75.3

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2199.8
Weight of Soil Water, $w_{w,soil}$ (g)	770
Total weight of soil used, W_t (g)	2948.9
Weight of Dry Cement, w_c (g)	254.5
Weight of Slurry Water, $w_{w,slurry}$ (g)	356.3
Soil Water Content, w (%)	35.00
Water:Cement Ratio, w:c	1.40
Cement Content, a_W (%)	11.65%
Cement Factor, α (kg/m3)	160.49
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	125.80
Volume Ratio, VR (%)	27.58
Total-Water-to-Cement Ratio, w_T:c	4.40

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	--
Weight of Slurry Water**, $w_{w,slurry}$ (g)	--
Volume Ratio, VR (%)	--
Total-Water-to-Cement Ratio, w_T:c	--
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	--

SAMPLE DATA: Batch C-8

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size		Cure Conditions		Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions		Strength Adjustments			total unit weight (kg/m3)	Notes
				Diam. (in)	Height (in)	Temp (C)	Humidity (%)			Peak UCS (psi)	Strain (%)	L/D ratio	Height Correction Factor	Adj. UCS (psi)		
A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
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Laboratory Mixing Data
Batch C-9

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	8
Water:Cement Ratio of Slurry, w:c	1.40
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	200
Weight of Slurry Water, $w_{w,slurry}$ (g)	560.0
Weight of Dry Cement, w_c (g)	400.0
Weight of Moist Soil, w_{soil} (g)	2413.0
Weight of Slurry (g)	960.0
Specific Gravity of Solids	2.75
water content of mix	0.54
Dry unit wt. of mix (pcf)	68.9

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	1800
Weight of Soil Water, $w_{w,soil}$ (g)	630
Total weight of soil used, W_t (g)	2410
Weight of Dry Cement, w_c (g)	400.0
Weight of Slurry Water, $w_{w,slurry}$ (g)	560.0
Soil Water Content, w (%)	35.00
Water:Cement Ratio, w:c	1.40
Cement Content, a_W (%)	22.41%
Cement Factor, α (kg/m3)	308.66
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	201.69
Volume Ratio, VR (%)	53.03
Total-Water-to-Cement Ratio, w_T:c	2.96

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	--
Weight of Slurry Water**, $w_{w,slurry}$ (g)	--
Volume Ratio, VR (%)	--
Total-Water-to-Cement Ratio, w_T:c	--
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	--

SAMPLE DATA: Batch C-9

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size		Cure Conditions		Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions		Strength Adjustments			total unit weight (kg/m3)	Notes
				Diam. (in)	Height (in)	Temp (C)	Humidity (%)			Peak UCS (psi)	Strain (%)	L/D ratio	Height Correction Factor	Adj. UCS (psi)		
A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
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Laboratory Mixing Data
Batch C-10

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	8
Water:Cement Ratio of Slurry, w:c	1.40
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	275
Weight of Slurry Water, $w_{w,slurry}$ (g)	770.0
Weight of Dry Cement, w_c (g)	550.0
Weight of Moist Soil, w_{soil} (g)	1939.2
Weight of Slurry (g)	1320.0
Specific Gravity of Solids	2.80
water content of mix	0.64
Dry unit wt. of mix (pcf)	62.6

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	1500
Weight of Soil Water, $w_{w,soil}$ (g)	525
Total weight of soil used, W_t (g)	2003.7
Weight of Dry Cement, w_c (g)	565.3
Weight of Slurry Water, $w_{w,slurry}$ (g)	791.4
Soil Water Content, w (%)	35.00
Water:Cement Ratio, w:c	1.40
Cement Content, a_W (%)	38.09%
Cement Factor, α (kg/m3)	524.66
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	275.93
Volume Ratio, VR (%)	90.15
Total-Water-to-Cement Ratio, w_T:c	2.32

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	--
Weight of Slurry Water**, $w_{w,slurry}$ (g)	--
Volume Ratio, VR (%)	--
Total-Water-to-Cement Ratio, w_T:c	--
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	--

SAMPLE DATA: Batch C-10

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
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Laboratory Mixing Data
Batch E-1

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	125
Weight of Slurry Water, $w_{w,slurry}$ (g)	340.0
Weight of Dry Cement, w_c (g)	340.0
Weight of Moist Soil, w_{soil} (g)	4222.1
Weight of Slurry (g)	680.0
Specific Gravity of Solids	2.71
water content of mix	0.41
Dry unit wt. of mix (pcf)	79.7

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	3200
Weight of Soil Water, $w_{w,soil}$ (g)	1120
Total weight of soil used, W_t (g)	4275
Weight of Dry Cement, w_c (g)	345
Weight of Slurry Water, $w_{w,slurry}$ (g)	345
Soil Water Content, w (%)	35.00
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	10.89%
Cement Factor, α (kg/m3)	150.08
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	125.29
Volume Ratio, VR (%)	19.78
Total-Water-to-Cement Ratio, w_T:c	4.21

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	345.0
Volume Ratio, VR (%)	19.78
Total-Water-to-Cement Ratio, w_T:c	4.21
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	125.3

SAMPLE DATA: Batch E-1

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	10/31 1:10 PM	7	11/7 6:07 PM	2.036	3.902	22	100	369.2	0	174.8	1.49	1.92	0.993	173.7	1773.3	
B	10/31 1:10 PM	7	11/7 7:21 PM	2.041	3.941	22	100	372.9	0	175.8	1.76	1.93	0.994	174.8	1764.6	
C	10/31 1:10 PM	28	11/28 4:13 PM	2.037	3.923	22	100	371.2	0	270.9	1.45	1.93	0.994	269.3	1771.6	
D	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
E	10/31 1:10 PM	3	11/3 7:16 PM	2.036	3.830	22	100	360.0	0	111.5	1.51	1.88	0.990	110.4	1761.7	
F	10/31 1:10 PM	3	11/3 8:21 PM	2.035	3.914	22	100	370.3	0	109.9	1.47	1.92	0.994	109	1775.0	
G	10/31 1:10 PM	14	11/14 4:12 PM	2.037	3.957	22	100	374.3	0	221.3	1.55	1.94	0.995	220.3	1771.2	
H	10/31 1:10 PM	14	11/14 5:18 PM	2.043	3.949	22	100	372.5	0	224.6	1.85	1.93	0.995	223.4	1755.7	
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Laboratory Mixing Data
Batch E-2

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	350
Weight of Slurry Water, $w_{w,slurry}$ (g)	960.0
Weight of Dry Cement, w_c (g)	960.0
Weight of Moist Soil, w_{soil} (g)	2723.1
Weight of Slurry (g)	1920.0
Specific Gravity of Solids	2.82
water content of mix	0.56
Dry unit wt. of mix (pcf)	68.3

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2100
Weight of Soil Water, $w_{w,soil}$ (g)	735
Total weight of soil used, W_t (g)	2785
Weight of Dry Cement, w_c (g)	975
Weight of Slurry Water, $w_{w,slurry}$ (g)	975
Soil Water Content, w (%)	35.00
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	47.26%
Cement Factor, α (kg/m3)	651.05
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	350.38
Volume Ratio, VR (%)	85.81
Total-Water-to-Cement Ratio, w_T:c	1.74

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	975.0
Volume Ratio, VR (%)	85.81
Total-Water-to-Cement Ratio, w_T:c	1.74
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	350.4

SAMPLE DATA: Batch E-2

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
B	11/2 1:10 PM	7	11/9 8:05 PM	2.039	3.967	22	100	358.7	0	547.2	1.39	1.95	0.996	544.9	1689.5	
C	11/2 1:10 PM	28	11/30 3:47 PM	2.040	3.918	22	100	354.1	0	724.0	1.24	1.92	0.994	719.4	1687.2	
D	11/2 1:10 PM	28	11/30 4:59 PM	2.037	3.915	22	100	353.3	0	719.1	1.16	1.92	0.994	714.6	1689.6	
E	11/2 1:10 PM	3	11/5 9:26 PM	2.035	3.933	22	100	354.5	0	319.5	1.71	1.93	0.995	317.8	1691.0	
F	11/2 1:10 PM	3	11/5 10:38 PM	2.042	3.945	22	100	355.6	0	336.4	2.01	1.93	0.995	335	1679.5	
G	11/2 1:10 PM	14	11/16 4:06 PM	2.035	3.938	22	100	355.5	0	615.6	1.19	1.94	0.995	612.4	1693.7	
H	11/2 1:10 PM	14	11/16 5:23 PM	2.041	3.955	22	100	357.3	0	614.1	1.30	1.94	0.995	611.1	1684.9	
I	11/2 1:10 PM	7	11/9 7:12 PM	2.038	3.890	22	100	351.9	0	476.7	1.39	1.91	0.993	473.2	1691.9	
J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	

Laboratory Mixing Data
Batch E-3

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	275
Weight of Slurry Water, $w_{w,slurry}$ (g)	750.0
Weight of Dry Cement, w_c (g)	750.0
Weight of Moist Soil, w_{soil} (g)	3222.8
Weight of Slurry (g)	1500.0
Specific Gravity of Solids	2.78
water content of mix	0.51
Dry unit wt. of mix (pcf)	72.1

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2400
Weight of Soil Water, $w_{w,soil}$ (g)	840
Total weight of soil used, W_t (g)	3180
Weight of Dry Cement, w_c (g)	740
Weight of Slurry Water, $w_{w,slurry}$ (g)	740
Soil Water Content, w (%)	35.00
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	31.42%
Cement Factor, α (kg/m3)	432.75
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	275.57
Volume Ratio, VR (%)	57.04
Total-Water-to-Cement Ratio, w_T:c	2.11

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	740.0
Volume Ratio, VR (%)	57.04
Total-Water-to-Cement Ratio, w_T:c	2.11
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	275.6

SAMPLE DATA: Batch E-3

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	11/5 1:10 PM	7	11/12 9:48 PM	2.036	3.941	22	100	363.2	0	380.2	1.00	1.94	0.995	378.3	1727.1	
B	11/5 1:10 PM	7	11/12 10:39 PM	2.035	3.955	22	100	364.1	0	404.2	1.22	1.94	0.995	402.4	1726.9	
C	11/5 1:10 PM	28	12/3 10:22 AM	2.038	3.941	22	100	362.6	0	577.7	1.28	1.93	0.995	574.6	1720.8	
D	11/5 1:10 PM	28	12/3 1:15 PM	2.037	3.969	22	100	365.3	0	588.0	1.57	1.95	0.996	585.6	1723.5	
E	11/5 1:10 PM	3	11/8 4:52 PM	2.036	3.941	22	100	362.6	0	222.0	1.38	1.94	0.995	220.9	1724.3	
F	11/5 1:10 PM	3	11/8 5:57 PM	2.037	3.944	22	100	363.6	0	265.2	1.56	1.94	0.995	264	1726.3	
G	11/5 1:10 PM	14	11/19 12:11 PM	2.035	3.958	22	100	364.2	0	534.9	1.92	1.94	0.996	532.6	1726.2	
H	11/5 1:10 PM	14	11/19 1:16 PM	2.037	3.950	22	100	362.2	0	502.2	1.51	1.94	0.995	499.7	1717.1	
I	11/5 1:10 PM	28	12/3 4:30 PM	2.040	3.922	22	100	361.8	0	559.8	1.26	1.92	0.994	556.4	1722.2	
J	11/5 1:10 PM	28	12/3 5:33 PM	2.038	3.940	22	100	362.5	0	503.4	1.13	1.93	0.995	500.8	1720.8	

Laboratory Mixing Data
Batch E-4

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	200
Weight of Slurry Water, $w_{w,slurry}$ (g)	550.0
Weight of Dry Cement, w_c (g)	550.0
Weight of Moist Soil, w_{soil} (g)	3722.4
Weight of Slurry (g)	1100.0
Specific Gravity of Solids	2.74
water content of mix	0.46
Dry unit wt. of mix (pcf)	75.7

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2797.6
Weight of Soil Water, $w_{w,soil}$ (g)	980
Total weight of soil used, W_t (g)	3733
Weight of Dry Cement, w_c (g)	557.7
Weight of Slurry Water, $w_{w,slurry}$ (g)	557.7
Soil Water Content, w (%)	35.03
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	20.17%
Cement Factor, α (kg/m3)	277.83
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	203.36
Volume Ratio, VR (%)	36.62
Total-Water-to-Cement Ratio, w_T:c	2.74

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	557.7
Volume Ratio, VR (%)	36.62
Total-Water-to-Cement Ratio, w_T:c	2.74
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	203.4

SAMPLE DATA: Batch E-4

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size		Cure Conditions		Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions		Strength Adjustments			total unit weight (kg/m3)	Notes
				Diam. (in)	Height (in)	Temp (C)	Humidity (%)			Peak UCS (psi)	Strain (%)	L/D ratio	Height Correction Factor	Adj. UCS (psi)		
A	11/6 1:10 PM	7	11/13 9:19 PM	2.039	3.942	22	100	366.1	0	296.9	1.75	1.93	0.995	295.3	1735.4	
B	11/6 1:10 PM	7	11/13 10:41 PM	2.034	3.956	22	100	366.9	0	304.6	2.06	1.94	0.996	303.2	1741.9	
C	11/6 1:10 PM	28	12/4 5:59 PM	2.039	3.972	22	100	372.0	0	413.1	1.31	1.95	0.996	411.4	1750.2	
D	11/6 1:10 PM	28	12/4 4:02 PM	2.045	3.947	22	100	365.9	0	435.0	1.98	1.93	0.994	432.5	1722.4	
E	11/6 1:10 PM	3	11/9 9:58 PM	2.040	3.969	22	100	370.7	0	179.3	1.76	1.95	0.996	178.5	1743.7	
F	11/6 1:10 PM	3	11/9 10:47 PM	2.039	3.975	22	100	371.0	0	177.8	1.56	1.95	0.996	177	1744.2	
G	11/6 1:10 PM	14	11/20 12:08 PM	2.034	3.920	22	100	365.6	0	381.5	1.82	1.93	0.994	379.3	1751.5	
H	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
I	11/6 1:10 PM	14	11/20 1:54 PM	2.038	3.972	22	100	369.9	0	376.9	2.05	1.95	0.996	375.3	1741.9	
J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	

Laboratory Mixing Data
Batch E-5

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	125
Weight of Slurry Water, $w_{w,slurry}$ (g)	340.0
Weight of Dry Cement, w_c (g)	340.0
Weight of Moist Soil, w_{soil} (g)	4222.1
Weight of Slurry (g)	680.0
Specific Gravity of Solids	2.71
water content of mix	0.41
Dry unit wt. of mix (pcf)	79.7

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	3199.4
Weight of Soil Water, $w_{w,soil}$ (g)	1120
Total weight of soil used, W_t (g)	4285.3
Weight of Dry Cement, w_c (g)	347.0
Weight of Slurry Water, $w_{w,slurry}$ (g)	347.0
Soil Water Content, w (%)	35.01
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	10.93%
Cement Factor, α (kg/m3)	150.57
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	125.63
Volume Ratio, VR (%)	19.84
Total-Water-to-Cement Ratio, w_T:c	4.20

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	347.0
Volume Ratio, VR (%)	19.84
Total-Water-to-Cement Ratio, w_T:c	4.20
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	125.6

SAMPLE DATA: Batch E-5

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size		Cure Conditions		Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions		Strength Adjustments			total unit weight (kg/m3)	Notes
				Diam. (in)	Height (in)	Temp (C)	Humidity (%)			Peak UCS (psi)	Strain (%)	L/D ratio	Height Correction Factor	Adj. UCS (psi)		
A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
B	1/27 10:00 AM	8	2/4 1:37 PM	2.035	3.944	22	100	371.3	0	174.7	2.58	1.94	0.995	173.8	1766.4	
C	1/27 10:00 AM	28	2/24 3:16 PM	2.038	3.955	22	100	372.9	0	260.5	1.80	1.94	0.995	259.3	1763.7	
D	1/27 10:00 AM	28	2/24 3:38 PM	2.035	3.952	22	100	371.4	0	268.2	1.97	1.94	0.995	266.9	1763.1	
E	1/27 10:00 AM	3	1/30 10:49 PM	2.030	3.944	22	100	372.0	0	115.7	1.66	1.94	0.995	115.1	1778.4	
F	1/27 10:00 AM	3	1/30 11:17 PM	2.037	3.963	22	100	375.4	0	125.6	2.78	1.95	0.996	125	1773.7	
G	1/27 10:00 AM	14	2/10 4:25 PM	2.035	3.953	22	100	372.3	0	205.8	1.67	1.94	0.995	204.9	1767.1	
H	1/27 10:00 AM	14	2/10 5:40 PM	2.037	3.912	22	100	369.1	0	210.8	1.99	1.92	0.994	209.5	1766.6	
I	1/27 10:00 AM	28	2/24 5:39 PM	2.037	3.982	22	100	377.0	0	268.4	1.76	1.95	0.996	267.4	1772.7	
J	1/27 10:00 AM	28	2/24 6:01 PM	2.036	3.943	22	100	372.7	0	277.3	2.06	1.94	0.995	275.9	1771.6	

Laboratory Mixing Data
Batch E-6

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	275
Weight of Slurry Water, $w_{w,slurry}$ (g)	750.0
Weight of Dry Cement, w_c (g)	750.0
Weight of Moist Soil, w_{soil} (g)	3222.8
Weight of Slurry (g)	1500.0
Specific Gravity of Solids	2.78
water content of mix	0.51
Dry unit wt. of mix (pcf)	72.1

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2401
Weight of Soil Water, $w_{w,soil}$ (g)	840
Total weight of soil used, W_t (g)	3206
Weight of Dry Cement, w_c (g)	750
Weight of Slurry Water, $w_{w,slurry}$ (g)	750
Soil Water Content, w (%)	34.99
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	31.60%
Cement Factor, α (kg/m3)	435.32
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	276.61
Volume Ratio, VR (%)	57.38
Total-Water-to-Cement Ratio, w_T:c	2.11

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	750.5
Volume Ratio, VR (%)	57.38
Total-Water-to-Cement Ratio, w_T:c	2.11
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	276.6

SAMPLE DATA: Batch E-6

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
B	1/16 1:27 PM	7	1/23 8:13 PM	2.036	3.972	22	100	364.7	0	390.3	1.94	1.95	0.996	388.8	1720.7	
C	1/16 1:27 PM	28	2/13 8:05 PM	2.034	3.984	22	100	366.1	0	572.8	1.92	1.96	0.997	570.9	1725.7	
D	1/16 1:27 PM	28	2/13 5:43 PM	2.032	3.984	22	100	365.4	0	568.7	1.16	1.96	0.997	566.9	1725.8	
E	1/16 1:27 PM	3	1/19 5:54 PM	2.038	3.987	22	100	362.6	0	278.6	1.84	1.96	0.997	277.7	1701.1	
F	1/16 1:27 PM	3	1/19 4:07 PM	2.035	3.992	22	100	366.9	0	285.2	2.57	1.96	0.997	284	1724.2	
G	1/16 1:27 PM	14	1/30 8:09 PM	2.033	3.983	22	100	367.3	0	483.4	1.55	1.96	0.997	481.8	1733.3	
H	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
I	1/16 1:27 PM	7	1/23 6:46 PM	2.039	3.980	22	100	367.8	0	404.7	1.64	1.95	0.996	403.1	1726.8	
J	1/16 1:27 PM	28	2/13 6:44 PM	2.030	3.986	22	100	366.0	0	489.9	0.97	1.96	0.997	488.5	1731.1	

Laboratory Mixing Data
Batch E-7

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	350
Weight of Slurry Water, $w_{w,slurry}$ (g)	960.0
Weight of Dry Cement, w_c (g)	960.0
Weight of Moist Soil, w_{soil} (g)	2723.1
Weight of Slurry (g)	1920.0
Specific Gravity of Solids	2.82
water content of mix	0.56
Dry unit wt. of mix (pcf)	68.0

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2100.1
Weight of Soil Water, $w_{w,soil}$ (g)	742.5
Total weight of soil used, W_t (g)	2818.5
Weight of Dry Cement, w_c (g)	998.2
Weight of Slurry Water, $w_{w,slurry}$ (g)	998.2
Soil Water Content, w (%)	35.36
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	47.94%
Cement Factor, α (kg/m3)	658.62
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	352.56
Volume Ratio, VR (%)	86.81
Total-Water-to-Cement Ratio, w_T:c	1.74

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	998.2
Volume Ratio, VR (%)	86.81
Total-Water-to-Cement Ratio, w_T:c	1.74
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	352.6

SAMPLE DATA: Batch E-7

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
B	1/16 3:30 PM	7	1/23 8:41 PM	2.036	3.914	22	100	353.9	0	612.1	1.95	1.92	0.994	608.3	1694.7	
C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
D	1/16 3:30 PM	28	2/13 7:18 PM	2.034	3.980	22	100	358.7	0	821.9	1.39	1.96	0.997	819.0	1692.5	
E	1/16 3:30 PM	3	1/19 5:31 PM	2.039	3.987	22	100	0.0	0	417.7	2.34	1.96	0.996	416.2	0.0	
F	1/16 3:30 PM	3	1/19 4:34 PM	2.035	3.986	22	100	361.1	0	358.9	1.43	1.96	0.997	358	1699.6	
G	1/16 3:30 PM	14	1/30 8:37 PM	2.036	3.984	22	100	361.2	0	695.7	1.48	1.96	0.997	693.2	1699.2	
H	1/16 3:30 PM	14	1/31 12:42 AM	2.037	3.930	22	100	354.9	0	572.3	1.87	1.93	0.994	569.0	1690.9	
I	1/16 3:30 PM	7	1/23 7:28 PM	2.036	3.982	22	100	0.0	0	636.9	2.20	1.96	0.996	634.6	0.0	
J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	

Laboratory Mixing Data
Batch E-8

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	275
Weight of Slurry Water, $w_{w,slurry}$ (g)	750.0
Weight of Dry Cement, w_c (g)	750.0
Weight of Moist Soil, w_{soil} (g)	3222.8
Weight of Slurry (g)	1500.0
Specific Gravity of Solids	2.78
water content of mix	0.51
Dry unit wt. of mix (pcf)	71.9

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2400
Weight of Soil Water, $w_{w,soil}$ (g)	843.8
Total weight of soil used, W_t (g)	3212.1
Weight of Dry Cement, w_c (g)	752.09
Weight of Slurry Water, $w_{w,slurry}$ (g)	752.09
Soil Water Content, w (%)	35.16
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	31.65%
Cement Factor, α (kg/m3)	435.43
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	276.65
Volume Ratio, VR (%)	57.39
Total-Water-to-Cement Ratio, w_T:c	2.11

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	752.1
Volume Ratio, VR (%)	57.39
Total-Water-to-Cement Ratio, w_T:c	2.11
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	276.7

SAMPLE DATA: Batch E-8

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size		Cure Conditions		Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions		Strength Adjustments			total unit weight (kg/m3)	Notes
				Diam. (in)	Height (in)	Temp (C)	Humidity (%)			Peak UCS (psi)	Strain (%)	L/D ratio	Height Correction Factor	Adj. UCS (psi)		
A	1/25 10:00 AM	7	2/1 8:36 PM	2.035	3.990	22	100	367.1	0	424.8	1.45	1.96	0.997	423.5	1726.2	
B	1/25 10:00 AM	7	2/1 9:57 PM	2.034	3.956	22	100	362.7	0	436.8	2.18	1.94	0.996	434.9	1721.7	
C	1/25 10:00 AM	28	2/22 8:15 PM	2.033	3.990	22	100	365.3	0	617.3	1.40	1.96	0.997	615.5	1721.0	
D	1/25 10:00 AM	28	2/22 4:32 PM	2.034	3.987	22	100	366.2	0	558.5	0.96	1.96	0.997	556.7	1724.9	
E	1/25 10:00 AM	14	2/8 9:01 PM	2.034	3.987	22	100	366.3	0	518.8	1.54	1.96	0.997	517.1	1725.3	
F	1/25 10:00 AM	14	2/8 5:09 PM	2.039	4.006	22	100	370.9	0	413.3	1.03	1.96	0.997	412	1730.1	
G	1/25 10:00 AM	14	2/8 9:29 PM	2.035	3.991	22	100	366.6	0	529.8	1.90	1.96	0.997	528.1	1723.5	
H	1/25 10:00 AM	14	2/8 5:42 PM	2.035	3.980	22	100	367.2	0	456.6	1.37	1.96	0.996	455.0	1731.1	
I	1/25 10:00 AM	28	2/22 8:43 PM	2.035	3.982	22	100	365.9	0	567.8	1.26	1.96	0.997	565.9	1723.9	
J	1/25 10:00 AM	28	2/22 5:18 PM	2.036	3.984	22	100	366.9	0	423.5	0.71	1.96	0.997	422.1	1726.1	

Laboratory Mixing Data
Batch E-9

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	350
Weight of Slurry Water, $w_{w,slurry}$ (g)	960.0
Weight of Dry Cement, w_c (g)	960.0
Weight of Moist Soil, w_{soil} (g)	2723.1
Weight of Slurry (g)	1920.0
Specific Gravity of Solids	2.82
water content of mix	0.56
Dry unit wt. of mix (pcf)	68.4

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2100
Weight of Soil Water, $w_{w,soil}$ (g)	735
Total weight of soil used, W_t (g)	2805
Weight of Dry Cement, w_c (g)	977
Weight of Slurry Water, $w_{w,slurry}$ (g)	977
Soil Water Content, w (%)	35.00
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	47.02%
Cement Factor, α (kg/m3)	647.73
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	349.42
Volume Ratio, VR (%)	85.37
Total-Water-to-Cement Ratio, w_T:c	1.74

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	977.0
Volume Ratio, VR (%)	85.37
Total-Water-to-Cement Ratio, w_T:c	1.74
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	349.4

SAMPLE DATA: Batch E-9

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	1/25 3:15 PM	7	2/1 9:03 PM	2.035	3.990	22	100	361.8	0	551.1	1.19	1.96	0.997	549.3	1701.3	
B	1/25 3:15 PM	7	2/1 10:14 PM	2.033	3.958	22	100	358.2	0	497.9	1.15	1.95	0.996	495.8	1701.0	
C	1/25 3:15 PM	28	2/22 9:11 PM	2.036	3.989	22	100	361.2	0	713.8	1.17	1.96	0.997	711.4	1697.1	
D	1/25 3:15 PM	28	2/22 5:56 PM	2.037	3.989	22	100	364.1	0	746.6	1.06	1.96	0.997	744.1	1709.1	
E	1/25 3:15 PM	14	2/8 10:31 PM	2.037	3.989	22	100	361.9	0	586.5	1.02	1.96	0.997	584.5	1698.9	
F	1/25 3:15 PM	14	2/8 6:28 PM	2.033	3.982	22	100	361.2	0	685.2	1.30	1.96	0.997	683	1705.0	
G	1/25 3:15 PM	14	2/8 11:05 PM	2.037	3.989	22	100	362.5	0	651.4	1.30	1.96	0.997	649.2	1701.5	
H	1/25 3:15 PM	14	2/8 7:06 PM	2.037	3.985	22	100	362.1	0	611.8	0.99	1.96	0.997	609.7	1701.4	
I	1/25 3:15 PM	28	2/22 9:46 PM	2.040	3.996	22	100	365.8	0	695.1	1.07	1.96	0.997	692.8	1709.0	
J	1/25 3:15 PM	28	2/22 6:51 PM	2.035	3.983	22	100	361.7	0	659.7	0.86	1.96	0.997	657.4	1703.7	

Laboratory Mixing Data
Batch E-10

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	200
Weight of Slurry Water, $w_{w,slurry}$ (g)	550.0
Weight of Dry Cement, w_c (g)	550.0
Weight of Moist Soil, w_{soil} (g)	3722.4
Weight of Slurry (g)	1100.0
Specific Gravity of Solids	2.74
water content of mix	0.46
Dry unit wt. of mix (pcf)	75.8

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2799.5
Weight of Soil Water, $w_{w,soil}$ (g)	980
Total weight of soil used, W_t (g)	3755.6
Weight of Dry Cement, w_c (g)	556.01
Weight of Slurry Water, $w_{w,slurry}$ (g)	556.01
Soil Water Content, w (%)	35.01
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	19.99%
Cement Factor, α (kg/m3)	275.32
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	202.01
Volume Ratio, VR (%)	36.29
Total-Water-to-Cement Ratio, w_T:c	2.75

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	556.0
Volume Ratio, VR (%)	36.29
Total-Water-to-Cement Ratio, w_T:c	2.75
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	202.0

SAMPLE DATA: Batch E-10

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	2/3 9:45 AM	7	2/10 6:36 PM	2.035	3.991	22	100	372.9	0	309.8	2.39	1.96	0.997	308.9	1752.9	
B	2/3 9:45 AM	7	2/10 7:58 PM	2.035	3.955	22	100	364.1	0	275.4	1.54	1.94	0.995	274.1	1726.9	
C	2/3 9:45 AM	28	3/3 9:06 PM	2.036	3.988	22	100	372.9	0	451.8	1.89	1.96	0.997	450.3	1752.5	
D	2/3 9:45 AM	28	3/3 4:46 PM	2.035	3.988	22	100	371.6	0	434.0	0.98	1.96	0.997	432.6	1748.1	
E	2/3 9:45 AM	3	2/6 6:14 PM	2.037	3.987	22	100	374.0	0	214.4	2.79	1.96	0.997	213.6	1756.2	
F	2/3 9:45 AM	3	2/6 7:58 PM	2.030	3.990	22	100	373.7	0	221.5	3.08	1.97	0.997	221	1766.0	
G	2/3 9:45 AM	14	2/17 4:43 PM	2.037	3.985	22	100	373.8	0	385.2	2.26	1.96	0.997	383.9	1756.4	
H	2/3 9:45 AM	14	2/17 6:02 PM	2.037	3.992	22	100	373.8	0	347.9	1.11	1.96	0.997	346.8	1753.3	
I	2/3 9:45 AM	28	3/3 9:37 PM	2.036	3.990	22	100	373.1	0	459.6	1.89	1.96	0.997	458.1	1752.6	
J	2/3 9:45 AM	28	3/3 5:19 PM	2.036	3.990	22	100	373.0	0	419.1	1.08	1.96	0.997	417.7	1752.1	

Laboratory Mixing Data
Batch E-11

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	275
Weight of Slurry Water, $w_{w,slurry}$ (g)	750.0
Weight of Dry Cement, w_c (g)	750.0
Weight of Moist Soil, w_{soil} (g)	3222.8
Weight of Slurry (g)	1500.0
Specific Gravity of Solids	2.78
water content of mix	0.51
Dry unit wt. of mix (pcf)	72.1

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2399.7
Weight of Soil Water, $w_{w,soil}$ (g)	840
Total weight of soil used, W_t (g)	3213.6
Weight of Dry Cement, w_c (g)	748.12
Weight of Slurry Water, $w_{w,slurry}$ (g)	748.12
Soil Water Content, w (%)	35.00
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	31.43%
Cement Factor, α (kg/m3)	432.92
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	275.64
Volume Ratio, VR (%)	57.06
Total-Water-to-Cement Ratio, w_T:c	2.11

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	748.1
Volume Ratio, VR (%)	57.06
Total-Water-to-Cement Ratio, w_T:c	2.11
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	275.6

SAMPLE DATA: Batch E-11

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	2/3 11:10 AM	7	2/10 7:05 PM	2.037	3.981	22	100	368.3	0	375.0	1.42	1.95	0.996	373.6	1732.2	
B	2/3 11:10 AM	7	2/10 8:56 PM	2.035	3.976	22	100	366.5	0	397.0	1.12	1.95	0.996	395.6	1729.3	
C	2/3 11:10 AM	28	3/3 10:17 PM	2.037	3.991	22	100	369.1	0	570.7	1.50	1.96	0.997	568.8	1731.7	
D	2/3 11:10 AM	28	3/3 6:22 PM	2.037	3.991	22	100	368.7	0	600.0	1.16	1.96	0.997	598.0	1729.8	
E	2/3 11:10 AM	3	2/6 6:41 PM	2.037	3.992	22	100	369.7	0	297.2	2.12	1.96	0.997	296.2	1733.9	
F	2/3 11:10 AM	3	2/6 8:34 PM	2.037	3.987	22	100	369.4	0	286.5	1.82	1.96	0.997	286	1734.8	
G	2/3 11:10 AM	14	2/17 5:25 PM	2.040	3.987	22	100	369.6	0	505.9	1.59	1.95	0.996	504.1	1730.6	
H	2/3 11:10 AM	14	2/17 6:36 PM	2.030	3.990	22	100	369.4	0	414.9	0.73	1.97	0.997	413.7	1745.5	
I	2/3 11:10 AM	28	3/3 10:44 PM	2.038	3.983	22	100	368.6	0	556.0	1.09	1.95	0.996	554.0	1731.1	
J	2/3 11:10 AM	28	3/3 6:52 PM	2.035	3.977	22	100	267.0	0	542.5	1.05	1.95	0.996	540.5	1259.5	

Laboratory Mixing Data
Batch S-1

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	0.60
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	200
Weight of Slurry Water, $w_{w,slurry}$ (g)	330.0
Weight of Dry Cement, w_c (g)	550.0
Weight of Moist Soil, w_{soil} (g)	4127.0
Weight of Slurry (g)	880.0
Specific Gravity of Solids	2.73
water content of mix	0.39
Dry unit wt. of mix (pcf)	82.6

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	3099.1
Weight of Soil Water, $w_{w,soil}$ (g)	1089.7
Total weight of soil used, W_t (g)	4156.5
Weight of Dry Cement, w_c (g)	554.3
Weight of Slurry Water, $w_{w,slurry}$ (g)	332.6
Soil Water Content, w (%)	35.16
Water:Cement Ratio, w:c	0.60
Cement Content, a_W (%)	18.02%
Cement Factor, α (kg/m3)	248.00
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	202.01
Volume Ratio, VR (%)	22.76
Total-Water-to-Cement Ratio, w_T:c	2.55

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	332.6
Volume Ratio, VR (%)	22.76
Total-Water-to-Cement Ratio, w_T:c	2.55
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	202.0

SAMPLE DATA: Batch S-1

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	1/31 5:30 PM	7	2/7 2:41 PM	2.038	3.981	22	100	382.1	0	379.8	1.61	1.95	0.996	378.4	1795.3	
B	1/31 5:30 PM	7	2/7 2:54 PM	2.037	3.943	22	100	377.3	0	363.6	1.31	1.94	0.995	361.7	1791.6	
C	1/31 5:30 PM	28	2/28 6:45 PM	2.038	3.962	22	100	380.1	0	571.3	1.41	1.94	0.996	568.7	1794.6	
D	1/31 5:30 PM	28	2/28 6:51 PM	2.038	3.960	22	100	379.9	0	567.5	1.37	1.94	0.995	565.0	1794.5	
E	1/31 5:30 PM	3	2/3 7:21 PM	2.038	3.908	22	100	374.0	0	283.7	2.41	1.92	0.993	281.8	1790.1	
F	1/31 5:30 PM	3	2/3 7:43 PM	2.037	3.982	22	100	382.5	0	276.8	2.20	1.95	0.996	276	1798.6	
G	1/31 5:30 PM	14	2/14 5:05 PM	2.038	3.962	22	100	380.0	0	496.8	1.79	1.94	0.996	494.5	1794.1	
H	1/31 5:30 PM	14	2/14 5:15 PM	2.034	3.956	22	100	379.8	0	495.5	2.00	1.94	0.996	493.3	1802.9	
I	1/31 5:30 PM	28	2/28 7:26 PM	2.037	3.976	22	100	381.6	0	578.1	1.46	1.95	0.996	575.9	1797.1	
J	1/31 5:30 PM	28	2/28 7:32 PM	2.037	3.973	22	100	382.2	0	586.2	1.49	1.95	0.996	583.9	1801.2	

Laboratory Mixing Data
Batch S-2

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	0.60
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	275
Weight of Slurry Water, $w_{w,slurry}$ (g)	450.0
Weight of Dry Cement, w_c (g)	750.0
Weight of Moist Soil, w_{soil} (g)	3779.0
Weight of Slurry (g)	1200.0
Specific Gravity of Solids	2.76
water content of mix	0.40
Dry unit wt. of mix (pcf)	81.6

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2799.5
Weight of Soil Water, $w_{w,soil}$ (g)	980
Total weight of soil used, W_t (g)	3748.8
Weight of Dry Cement, w_c (g)	744.4
Weight of Slurry Water, $w_{w,slurry}$ (g)	446.6
Soil Water Content, w (%)	35.01
Water:Cement Ratio, w:c	0.60
Cement Content, a_W (%)	26.81%
Cement Factor, α (kg/m3)	369.26
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	275.79
Volume Ratio, VR (%)	33.89
Total-Water-to-Cement Ratio, w_T:c	1.91

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	446.6
Volume Ratio, VR (%)	33.89
Total-Water-to-Cement Ratio, w_T:c	1.91
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	275.8

SAMPLE DATA: Batch 18

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	1/31 6:45 PM	7	2/7 3:30 PM	2.037	3.954	22	100	380.7	0	569.3	1.99	1.94	0.995	566.7	1802.7	
B	1/31 6:45 PM	7	2/7 3:45 PM	2.033	3.965	22	100	381.7	0	564.4	1.79	1.95	0.996	562.2	1809.5	
C	1/31 6:45 PM	28	2/28 8:19 PM	2.037	3.966	22	100	381.3	0	810.7	1.68	1.95	0.996	807.3	1800.2	
D	1/31 6:45 PM	28	2/28 8:25 PM	2.035	3.971	22	100	382.3	0	814.3	1.66	1.95	0.996	811.1	1806.2	
E	1/31 6:45 PM	3	2/3 8:25 PM	2.038	3.974	22	100	381.9	0	397.1	2.13	1.95	0.996	395.5	1797.4	
F	1/31 6:45 PM	3	2/3 8:54 PM	2.039	3.976	22	100	382.6	0	385.7	2.03	1.95	0.996	384	1798.2	
G	1/31 6:45 PM	14	2/14 6:11 PM	2.036	3.965	22	100	380.7	0	688.6	1.51	1.95	0.996	685.7	1799.6	
H	1/31 6:45 PM	14	2/14 6:18 PM	2.039	3.954	22	100	380.1	0	710.6	1.79	1.94	0.995	707.2	1796.4	
I	1/31 6:45 PM	28	3/1 12:24 AM	2.036	3.983	22	100	381.8	0	827.1	1.59	1.96	0.997	824.2	1796.6	
J	1/31 6:45 PM	28	3/1 12:31 AM	2.037	3.971	22	100	382.7	0	818.1	1.69	1.95	0.996	814.8	1804.5	

Laboratory Mixing Data
Batch S-3

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	0.60
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	350
Weight of Slurry Water, $w_{w,slurry}$ (g)	580.0
Weight of Dry Cement, w_c (g)	960.0
Weight of Moist Soil, w_{soil} (g)	3431.1
Weight of Slurry (g)	1540.0
Specific Gravity of Solids	2.79
water content of mix	0.42
Dry unit wt. of mix (pcf)	80.4

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2599
Weight of Soil Water, $w_{w,soil}$ (g)	910
Total weight of soil used, W_t (g)	3484
Weight of Dry Cement, w_c (g)	966.1
Weight of Slurry Water, $w_{w,slurry}$ (g)	579.6
Soil Water Content, w (%)	35.01
Water:Cement Ratio, w:c	0.60
Cement Content, a_W (%)	37.44%
Cement Factor, α (kg/m3)	515.65
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	350.00
Volume Ratio, VR (%)	47.33
Total-Water-to-Cement Ratio, w_T:c	1.54

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	579.6
Volume Ratio, VR (%)	47.33
Total-Water-to-Cement Ratio, w_T:c	1.54
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	350.0

SAMPLE DATA: Batch 18

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	2/1 10:00 AM	7	2/8 3:15 PM	2.041	3.958	22	100	379.7	0	660.0	0.97	1.94	0.995	656.7	1789.1	
B	2/1 10:00 AM	7	2/8 3:29 PM	2.040	3.950	22	100	379.4	0	777.8	1.17	1.94	0.995	773.9	1793.2	
C	2/1 10:00 AM	28	3/1 5:44 PM	2.035	3.965	22	100	380.7	0	1171.1	1.59	1.95	0.996	1166.3	1801.3	
D	2/1 10:00 AM	28	3/1 5:50 PM	2.037	3.957	22	100	380.5	0	1094.4	1.44	1.94	0.995	1089.3	1800.5	
E	2/1 10:00 AM	3	2/4 2:41 PM	2.037	3.969	22	100	380.8	0	612.5	1.58	1.95	0.996	609.9	1796.6	
F	2/1 10:00 AM	3	2/4 2:47 PM	2.036	3.946	22	100	378.6	0	534.3	0.96	1.94	0.995	532	1798.2	
G	2/1 10:00 AM	14	2/15 5:44 PM	2.037	3.945	22	100	377.7	0	980.8	1.58	1.94	0.995	975.8	1792.7	
H	2/1 10:00 AM	14	2/15 5:53 PM	2.036	3.951	22	100	378.4	0	1111.1	1.84	1.94	0.995	1105.9	1795.0	
I	2/1 10:00 AM	28	3/1 6:23 PM	2.037	3.949	22	100	378.8	0	1114.5	1.37	1.94	0.995	1109.0	1796.1	
J	2/1 10:00 AM	28	3/1 6:29 PM	2.038	3.959	22	100	380.2	0	1241.7	1.77	1.94	0.995	1236.0	1796.4	

Laboratory Mixing Data
Batch S-4

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.40
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	125
Weight of Slurry Water, $w_{w,slurry}$ (g)	480.0
Weight of Dry Cement, w_c (g)	340.0
Weight of Moist Soil, w_{soil} (g)	3969.3
Weight of Slurry (g)	820.0
Specific Gravity of Solids	2.71
water content of mix	0.46
Dry unit wt. of mix (pcf)	75.2

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2999.3
Weight of Soil Water, $w_{w,soil}$ (g)	1050
Total weight of soil used, W_t (g)	4012.9
Weight of Dry Cement, w_c (g)	349.5
Weight of Slurry Water, $w_{w,slurry}$ (g)	489.2
Soil Water Content, w (%)	35.01
Water:Cement Ratio, w:c	1.40
Cement Content, a_W (%)	11.76%
Cement Factor, α (kg/m3)	161.95
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	126.69
Volume Ratio, VR (%)	27.83
Total-Water-to-Cement Ratio, w_T:c	4.38

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	489.2
Volume Ratio, VR (%)	27.83
Total-Water-to-Cement Ratio, w_T:c	4.38
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	126.7

SAMPLE DATA: Batch S-4

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	2/1 5:15 PM	7	2/8 4:09 PM	2.036	3.943	22	100	365.8	0	113.8	1.07	1.94	0.995	113.2	1738.8	
B	2/1 5:15 PM	7	2/8 4:23 PM	2.032	3.928	22	100	365.4	0	118.5	1.46	1.93	0.995	117.9	1750.1	
C	2/1 5:15 PM	28	3/1 7:11 PM	2.038	3.911	22	100	361.2	0	213.0	1.53	1.92	0.994	211.7	1727.6	
D	2/1 5:15 PM	28	3/1 7:17 PM	2.039	3.942	22	100	365.8	0	199.2	1.07	1.93	0.995	198.2	1734.1	
E	2/1 5:15 PM	3	2/4 3:44 PM	2.036	3.952	22	100	366.5	0	77.6	1.57	1.94	0.995	77.3	1738.0	
F	2/1 5:15 PM	3	2/4 4:21 PM	2.034	3.954	22	100	367.7	0	76.3	1.27	1.94	0.996	76	1746.5	
G	2/1 5:15 PM	14	2/15 6:49 PM	2.035	3.892	22	100	359.9	0	169.3	1.96	1.91	0.993	168.1	1734.9	
H	2/1 5:15 PM	14	2/15 6:57 PM	2.033	3.926	22	100	364.1	0	165.1	1.76	1.93	0.994	164.2	1743.3	
I	2/1 5:15 PM	28	3/1 7:54 PM	2.036	3.950	22	100	366.0	0	198.8	1.07	1.94	0.995	197.9	1736.6	
J	2/1 5:15 PM	28	3/1 8:00 PM	2.036	3.947	22	100	366.8	0	198.2	1.17	1.94	0.995	197.2	1741.8	

Laboratory Mixing Data
Batch S-5

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.40
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	200
Weight of Slurry Water, $w_{w,slurry}$ (g)	770.0
Weight of Dry Cement, w_c (g)	550.0
Weight of Moist Soil, w_{soil} (g)	3317.9
Weight of Slurry (g)	1320.0
Specific Gravity of Solids	2.75
water content of mix	0.54
Dry unit wt. of mix (pcf)	68.9

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2499.5
Weight of Soil Water, $w_{w,soil}$ (g)	875
Total weight of soil used, W_t (g)	3268.8
Weight of Dry Cement, w_c (g)	543.2
Weight of Slurry Water, $w_{w,slurry}$ (g)	760.4
Soil Water Content, w (%)	35.01
Water:Cement Ratio, w:c	1.40
Cement Content, a_W (%)	22.43%
Cement Factor, α (kg/m3)	309.01
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	201.84
Volume Ratio, VR (%)	53.09
Total-Water-to-Cement Ratio, w_T:c	2.96

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	760.4
Volume Ratio, VR (%)	53.09
Total-Water-to-Cement Ratio, w_T:c	2.96
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	201.8

SAMPLE DATA: Batch S-5

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size		Cure Conditions		Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions		Strength Adjustments			total unit weight (kg/m3)	Notes
				Diam. (in)	Height (in)	Temp (C)	Humidity (%)			Peak UCS (psi)	Strain (%)	L/D ratio	Height Correction Factor	Adj. UCS (psi)		
A	2/2 1:10 PM	7	2/9 11:14 AM	2.036	3.895	22	100	355.2	0	234.8	2.14	1.91	0.993	233.1	1709.1	
B	2/2 1:10 PM	7	2/9 11:25 AM	2.037	3.931	22	100	359.1	0	234.9	2.43	1.93	0.994	233.6	1710.6	
C	2/2 1:10 PM	28	3/2 4:46 PM	2.038	3.943	22	100	359.8	0	367.8	2.04	1.93	0.995	365.9	1706.9	
D	2/2 1:10 PM	28	3/2 4:54 PM	2.036	3.938	22	100	359.0	0	369.6	1.85	1.93	0.995	367.6	1708.6	
E	2/2 1:10 PM	3	2/5 6:11 PM	2.035	3.939	22	100	360.8	0	136.8	1.77	1.94	0.995	136.1	1718.3	
F	2/2 1:10 PM	3	2/5 6:21 PM	2.035	3.946	22	100	361.5	0	132.7	1.47	1.94	0.995	132	1718.7	
G	2/2 1:10 PM	14	2/16 3:38 PM	2.037	3.949	22	100	360.1	0	299.5	1.85	1.94	0.995	298.1	1707.4	
H	2/2 1:10 PM	14	2/16 3:49 PM	2.037	3.944	22	100	359.6	0	313.4	2.34	1.94	0.995	311.8	1707.2	
I	2/2 1:10 PM	28	3/2 5:34 PM	2.038	3.932	22	100	359.4	0	360.7	1.57	1.93	0.994	358.6	1709.8	
J	2/2 1:10 PM	28	3/2 5:42 PM	2.037	3.935	22	100	359.6	0	361.3	1.75	1.93	0.995	359.3	1711.1	

Laboratory Mixing Data
Batch S-6

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.40
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	275
Weight of Slurry Water, $w_{w,slurry}$ (g)	1050.0
Weight of Dry Cement, w_c (g)	750.0
Weight of Moist Soil, w_{soil} (g)	2666.5
Weight of Slurry (g)	1800.0
Specific Gravity of Solids	2.79
water content of mix	0.64
Dry unit wt. of mix (pcf)	62.5

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2000
Weight of Soil Water, $w_{w,soil}$ (g)	707.5
Total weight of soil used, W_t (g)	2685.2
Weight of Dry Cement, w_c (g)	750.8
Weight of Slurry Water, $w_{w,slurry}$ (g)	1051.2
Soil Water Content, w (%)	35.38
Water:Cement Ratio, w:c	1.40
Cement Content, a_W (%)	37.85%
Cement Factor, α (kg/m3)	520.00
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	274.63
Volume Ratio, VR (%)	89.35
Total-Water-to-Cement Ratio, w_T:c	2.33

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	1051.2
Volume Ratio, VR (%)	89.35
Total-Water-to-Cement Ratio, w_T:c	2.33
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	274.6

SAMPLE DATA: Batch 18

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	2/2 3:10 PM	7	2/9 12:06 PM	2.036	3.898	22	100	341.4	0	273.1	2.23	1.91	0.993	271.2	1641.5	
B	2/2 3:10 PM	7	2/9 12:20 PM	2.039	3.900	22	100	343.1	0	261.9	1.65	1.91	0.993	260.0	1644.2	
C	2/2 3:10 PM	28	3/2 6:55 PM	2.037	3.912	22	100	342.4	0	416.9	1.97	1.92	0.994	414.2	1638.8	
D	2/2 3:10 PM	28	3/2 7:01 PM	2.038	3.914	22	100	343.3	0	413.8	1.69	1.92	0.994	411.2	1640.7	
E	2/2 3:10 PM	3	2/5 7:05 PM	2.036	3.905	22	100	342.5	0	141.2	2.28	1.92	0.993	140.3	1643.7	
F	2/2 3:10 PM	3	2/5 7:14 PM	2.037	3.942	22	100	346.9	0	136.1	1.76	1.94	0.995	135	1647.5	
G	2/2 3:10 PM	14	2/16 4:40 PM	2.037	3.884	22	100	339.3	0	355.8	2.30	1.91	0.993	353.1	1635.7	
H	2/2 3:10 PM	14	2/16 4:47 PM	2.038	3.905	22	100	341.2	0	358.4	2.47	1.92	0.993	356.0	1634.4	
I	2/2 3:10 PM	28	3/2 7:08 PM	2.036	3.883	22	100	340.8	0	421.9	1.67	1.91	0.993	418.7	1645.0	
J	2/2 3:10 PM	28	3/2 7:14 PM	2.036	3.894	22	100	337.8	0	416.0	1.78	1.91	0.993	413.1	1625.9	

Laboratory Mixing Data
Batch S-7

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	125
Weight of Slurry Water, $w_{w,slurry}$ (g)	340.0
Weight of Dry Cement, w_c (g)	340.0
Weight of Moist Soil, w_{soil} (g)	4222.1
Weight of Slurry (g)	680.0
Specific Gravity of Solids	2.71
water content of mix	0.41
Dry unit wt. of mix (pcf)	79.7

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	3199.8
Weight of Soil Water, $w_{w,soil}$ (g)	1120
Total weight of soil used, W_t (g)	4296
Weight of Dry Cement, w_c (g)	348.2
Weight of Slurry Water, $w_{w,slurry}$ (g)	348.2
Soil Water Content, w (%)	35.00
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	10.94%
Cement Factor, α (kg/m3)	150.71
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	125.73
Volume Ratio, VR (%)	19.86
Total-Water-to-Cement Ratio, w_T:c	4.20

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	348.2
Volume Ratio, VR (%)	19.86
Total-Water-to-Cement Ratio, w_T:c	4.20
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	125.7

SAMPLE DATA: Batch S-7

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	5/15 1:10 PM	7	5/22 4:37 PM	2.036	3.935	22	100	371.6	0	140.9	2.47	1.93	0.995	140.2	1769.9	
B	5/15 1:10 PM	14	5/29 4:59 PM	2.036	3.960	22	100	373.4	0	188.0	1.86	1.94	0.996	187.2	1767.3	
C	5/15 1:10 PM	28	6/12 5:27 PM	2.035	3.950	22	100	371.8	0	233.1	1.90	1.94	0.995	232.0	1765.9	
D	5/15 1:10 PM	7	5/22 5:08 PM	2.037	3.925	22	100	370.3	0	134.9	1.95	1.93	0.994	134.1	1766.5	
E	5/15 1:10 PM	14	5/29 5:47 PM	2.036	3.949	22	100	370.9	0	176.2	1.84	1.94	0.995	175.4	1760.3	
F	5/15 1:10 PM	28	6/12 6:44 PM	2.037	3.940	22	100	369.6	0	230.7	2.04	1.93	0.995	229	1756.5	
G	5/15 1:10 PM	28	6/12 6:01 PM	2.037	3.970	22	100	373.6	0	231.3	1.85	1.95	0.996	230.3	1762.0	
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Laboratory Mixing Data
Batch S-8

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	275
Weight of Slurry Water, $w_{w,slurry}$ (g)	750.0
Weight of Dry Cement, w_c (g)	750.0
Weight of Moist Soil, w_{soil} (g)	3222.8
Weight of Slurry (g)	1500.0
Specific Gravity of Solids	2.78
water content of mix	0.51
Dry unit wt. of mix (pcf)	72.1

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2399.4
Weight of Soil Water, $w_{w,soil}$ (g)	840
Total weight of soil used, W_t (g)	3214.1
Weight of Dry Cement, w_c (g)	747.5
Weight of Slurry Water, $w_{w,slurry}$ (g)	747.5
Soil Water Content, w (%)	35.01
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	31.40%
Cement Factor, α (kg/m3)	432.50
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	275.47
Volume Ratio, VR (%)	57.00
Total-Water-to-Cement Ratio, w_T:c	2.11

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	747.5
Volume Ratio, VR (%)	57.00
Total-Water-to-Cement Ratio, w_T:c	2.11
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	275.5

SAMPLE DATA: Batch S-8

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	5/16 3:00 PM	7	5/23 5:15 PM	2.036	3.943	22	100	363.7	0	376.2	1.43	1.94	0.995	374.3	1728.8	
B	5/16 3:00 PM	14	5/30 3:17 PM	2.036	3.914	22	100	360.7	0	445.3	1.57	1.92	0.994	442.5	1727.2	
C	5/16 3:00 PM	28	6/13 3:01 PM	2.038	3.955	22	100	365.0	0	564.6	1.50	1.94	0.995	561.9	1726.3	
D	5/16 3:00 PM	7	5/23 5:58 PM	2.036	3.919	22	100	360.6	0	391.5	1.71	1.92	0.994	389.1	1724.6	
E	5/16 3:00 PM	14	5/30 3:52 PM	2.036	3.952	22	100	365.0	0	468.3	1.61	1.94	0.995	466.1	1731.0	
F	5/16 3:00 PM	28	6/13 3:38 PM	2.037	3.930	22	100	361.8	0	570.6	1.49	1.93	0.994	567	1723.8	
G	5/16 3:00 PM	28	6/13 4:18 PM	2.037	3.959	22	100	364.5	0	576.0	1.69	1.94	0.995	573.4	1723.9	
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Laboratory Mixing Data
Batch S-9

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	200
Weight of Slurry Water, $w_{w,slurry}$ (g)	550.0
Weight of Dry Cement, w_c (g)	550.0
Weight of Moist Soil, w_{soil} (g)	3722.4
Weight of Slurry (g)	1100.0
Specific Gravity of Solids	2.74
water content of mix	0.46
Dry unit wt. of mix (pcf)	75.9

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2799.6
Weight of Soil Water, $w_{w,soil}$ (g)	980
Total weight of soil used, W_t (g)	3753.7
Weight of Dry Cement, w_c (g)	550.4
Weight of Slurry Water, $w_{w,slurry}$ (g)	550.4
Soil Water Content, w (%)	35.01
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	19.80%
Cement Factor, α (kg/m3)	272.68
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	200.59
Volume Ratio, VR (%)	35.94
Total-Water-to-Cement Ratio, w_T:c	2.77

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	550.4
Volume Ratio, VR (%)	35.94
Total-Water-to-Cement Ratio, w_T:c	2.77
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	200.6

SAMPLE DATA: Batch S-9

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	5/17 4:10 PM	7	5/24 5:26 PM	2.036	3.941	22	100	368.0	0	256.7	2.05	1.94	0.995	255.3	1750.1	
B	5/17 4:10 PM	14	5/31 7:12 PM	2.037	3.954	22	100	368.9	0	323.8	1.73	1.94	0.995	322.3	1746.9	
C	5/17 4:10 PM	28	6/14 2:48 PM	2.036	3.963	22	100	369.8	0	414.8	1.72	1.95	0.996	413.0	1748.9	
D	5/17 4:10 PM	7	5/24 6:10 PM	2.036	3.936	22	100	366.4	0	261.1	1.74	1.93	0.995	259.7	1744.7	
E	5/17 4:10 PM	14	5/31 7:50 PM	2.036	3.969	22	100	370.6	0	328.4	1.70	1.95	0.996	327.1	1750.1	
F	5/17 4:10 PM	28	6/14 3:24 PM	2.036	3.961	22	100	369.4	0	395.3	1.49	1.95	0.996	394	1747.9	
G	5/17 4:10 PM	28	6/14 4:14 PM	2.036	3.945	22	100	367.6	0	404.7	1.79	1.94	0.995	402.7	1746.4	
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Laboratory Mixing Data
Batch S-10

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	350
Weight of Slurry Water, $w_{w,slurry}$ (g)	960.0
Weight of Dry Cement, w_c (g)	960.0
Weight of Moist Soil, w_{soil} (g)	2723.1
Weight of Slurry (g)	1920.0
Specific Gravity of Solids	2.82
water content of mix	0.56
Dry unit wt. of mix (pcf)	68.3

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2099.9
Weight of Soil Water, $w_{w,soil}$ (g)	735
Total weight of soil used, W_t (g)	2810.2
Weight of Dry Cement, w_c (g)	982.0
Weight of Slurry Water, $w_{w,slurry}$ (g)	982.0
Soil Water Content, w (%)	35.00
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	47.18%
Cement Factor, α (kg/m3)	649.84
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	350.03
Volume Ratio, VR (%)	85.65
Total-Water-to-Cement Ratio, w_T:c	1.74

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	982.0
Volume Ratio, VR (%)	85.65
Total-Water-to-Cement Ratio, w_T:c	1.74
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	350.0

SAMPLE DATA: Batch S-10

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	5/18 5:10 PM	7	5/25 5:46 PM	2.037	3.953	22	100	360.0	0	538.6	1.31	1.94	0.995	536.0	1705.2	
B	5/18 5:10 PM	14	6/1 5:42 PM	2.036	3.939	22	100	357.7	0	664.4	1.69	1.93	0.995	660.9	1702.0	
C	5/18 5:10 PM	28	6/15 6:02 PM	2.037	3.935	22	100	357.6	0	744.6	1.25	1.93	0.995	740.5	1701.6	
D	5/18 5:10 PM	7	5/25 6:19 PM	2.036	3.951	22	100	359.6	0	540.2	1.81	1.94	0.995	537.7	1705.8	
E	5/18 5:10 PM	14	6/1 6:16 PM	2.037	3.962	22	100	360.1	0	626.8	1.29	1.95	0.996	624.1	1701.8	
F	5/18 5:10 PM	28	6/15 6:38 PM	2.036	3.926	22	100	356.8	0	787.4	1.85	1.93	0.994	783	1703.3	
G	5/18 5:10 PM	28	6/15 7:19 PM	2.036	3.958	22	100	360.2	0	759.4	1.45	1.94	0.996	756.0	1705.7	
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Laboratory Mixing Data
Batch T-1

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	200
Weight of Slurry Water, $w_{w,slurry}$ (g)	550.0
Weight of Dry Cement, w_c (g)	550.0
Weight of Moist Soil, w_{soil} (g)	3722.4
Weight of Slurry (g)	1100.0
Specific Gravity of Solids	2.74
water content of mix	0.46
Dry unit wt. of mix (pcf)	75.7

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2799
Weight of Soil Water, $w_{w,soil}$ (g)	986
Total weight of soil used, W_t (g)	3751
Weight of Dry Cement, w_c (g)	550.4
Weight of Slurry Water, $w_{w,slurry}$ (g)	550.4
Soil Water Content, w (%)	35.23
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	19.84%
Cement Factor, α (kg/m3)	272.88
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	200.69
Volume Ratio, VR (%)	35.97
Total-Water-to-Cement Ratio, w_T:c	2.78

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	550.4
Volume Ratio, VR (%)	35.97
Total-Water-to-Cement Ratio, w_T:c	2.78
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	200.7

SAMPLE DATA: Batch T-1

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size		Cure Conditions		Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions		Strength Adjustments			total unit weight (kg/m3)	Notes
				Diam. (in)	Height (in)	Temp (C)	Humidity (%)			Peak UCS (psi)	Strain (%)	L/D ratio	Height Correction Factor	Adj. UCS (psi)		
A	2/21 8:00 AM	7	2/28 11:54 AM	2.050	3.951	43	100	369.5	0	349.7	1.28	1.93	0.994	347.7	1728.9	
B	2/21 8:00 AM	7	2/28 11:47 AM	2.045	3.955	66	100	368.8	0	881.1	1.71	1.93	0.995	876.4	1732.4	
C	2/21 8:00 AM	28	3/21 4:38 PM	2.049	3.973	43	100	374.5	0	619.1	1.23	1.94	0.995	616.1	1744.3	
D	2/21 8:00 AM	28	3/21 5:13 PM	2.042	3.960	66	100	370.1	0	1230.7	1.89	1.94	0.995	1224.7	1741.4	
E	2/21 8:00 AM	3	2/24 7:06 PM	2.047	3.967	43	100	371.4	0	277.9	1.66	1.94	0.995	276.5	1735.9	
F	2/21 8:00 AM	3	2/24 7:13 PM	2.046	3.967	66	100	368.9	0	478.8	1.38	1.94	0.995	476	1725.9	
G	2/21 8:00 AM	14	3/7 4:19 PM	2.051	3.977	43	100	373.4	0	449.5	1.12	1.94	0.995	447.3	1734.1	
H	2/21 8:00 AM	14	3/7 4:37 PM	2.051	3.952	66	100	372.5	0	1082.5	1.94	1.93	0.994	1076.2	1740.8	
I	2/21 8:00 AM	28	3/21 8:41 PM	2.048	3.976	43	100	374.4	0	575.4	1.09	1.94	0.995	572.7	1744.3	
J	2/21 8:00 AM	28	3/21 9:13 PM	2.045	3.968	66	100	370.4	0	1240.3	1.98	1.94	0.995	1234.4	1734.2	

Laboratory Mixing Data
Batch T-2

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	275
Weight of Slurry Water, $w_{w,slurry}$ (g)	750.0
Weight of Dry Cement, w_c (g)	750.0
Weight of Moist Soil, w_{soil} (g)	3222.8
Weight of Slurry (g)	1500.0
Specific Gravity of Solids	2.78
water content of mix	0.51
Dry unit wt. of mix (pcf)	72.0

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2399.3
Weight of Soil Water, $w_{w,soil}$ (g)	842
Total weight of soil used, W_t (g)	3199.1
Weight of Dry Cement, w_c (g)	745.3
Weight of Slurry Water, $w_{w,slurry}$ (g)	745.3
Soil Water Content, w (%)	35.09
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	31.47%
Cement Factor, α (kg/m3)	433.25
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	275.77
Volume Ratio, VR (%)	57.10
Total-Water-to-Cement Ratio, w_T:c	2.12

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	745.3
Volume Ratio, VR (%)	57.10
Total-Water-to-Cement Ratio, w_T:c	2.12
Cement Factor In-Place, $\alpha_{in-place}$ (kg/m^3)	275.8

SAMPLE DATA: Batch T-2

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Peak UCS (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)	Notes
A	2/21 3:55 PM	7	2/28 5:34 PM	2.047	3.941	43	100	363.2	0	513.1	2.02	1.93	0.994	510.0	1708.8	
B	2/21 3:55 PM	7	2/28 6:02 PM	2.049	3.948	66	100	362.3	0	781.3	1.71	1.93	0.994	776.7	1698.2	
C	2/21 3:55 PM	28	3/21 5:52 PM	2.048	3.956	43	100	367.2	0	746.4	1.48	1.93	0.995	742.3	1719.4	
D	2/21 3:55 PM	28	3/21 6:14 PM	2.052	3.971	66	100	366.0	0	1069.7	1.69	1.94	0.995	1064.1	1700.6	
E	2/21 3:55 PM	3	2/24 8:08 PM	2.046	3.980	43	100	366.4	0	376.7	1.74	1.95	0.996	375.1	1708.6	
F	2/21 3:55 PM	3	2/24 8:15 PM	2.052	3.990	66	100	366.0	0	464.7	1.34	1.94	0.996	463	1692.5	
G	2/21 3:55 PM	14	3/7 4:59 PM	2.049	3.889	43	100	360.0	0	564.3	1.41	1.9	0.992	559.7	1713.0	
H	2/21 3:55 PM	14	3/7 5:20 PM	2.055	3.983	66	100	366.3	0	897.3	1.59	1.94	0.995	892.9	1691.9	
I	2/21 3:55 PM	28	3/7 8:19 PM	2.048	3.961	43	100	367.5	0	583.2	1.31	1.93	0.995	580.1	1718.6	
J	2/21 3:55 PM	28	3/7 8:19 PM	2.048	3.961	66	100	367.5	0	583.2	1.31	1.93	0.995	580.1	1718.6	

Laboratory Mixing Data
Batch U-1

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	125
Weight of Slurry Water, $w_{w,slurry}$ (g)	340.0
Weight of Dry Cement, w_c (g)	340.0
Weight of Moist Soil, w_{soil} (g)	4222.1
Weight of Slurry (g)	680.0
Specific Gravity of Solids	2.71
water content of mix	0.41
Dry unit wt. of mix (pcf)	79.7

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	3199.2
Weight of Soil Water, $w_{w,soil}$ (g)	1120
Total weight of soil used, W_t (g)	4283.1
Weight of Dry Cement, w_c (g)	344.4
Weight of Slurry Water, $w_{w,slurry}$ (g)	344.4
Soil Water Content, w (%)	35.01
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	10.85%
Cement Factor, α (kg/m3)	149.52
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	124.90
Volume Ratio, VR (%)	19.71
Total-Water-to-Cement Ratio, w_T:c	4.23

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	344.4
Volume Ratio, VR (%)	19.71
Total-Water-to-Cement Ratio, w_T:c	4.23
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	124.9

SAMPLE DATA: **Batch U-1**

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size		Cure Conditions		Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions			Strength Adjustments			total unit weight (kg/m3)
				Diam. (in)	Height (in)	Temp (C)	Humidity (%)			Conf. Stress (psi)	Peak Dev (psi)	Strain (%)	L/D ratio	Height Correction Factor	Adj. UCS (psi)	
A	1/27 11:30 AM	28	2/24 11:57 AM	2.036	3.949	22	100	372.5	0	5.0	####	1.08	1.93959	0.995	240.0	1767.9
B	1/27 11:30 AM	28	2/24 2:07 PM	2.038	3.955	22	100	372.8	0	5.0	####	1.30	1.94063	0.995	245.2	1763.2
C	1/27 11:30 AM	28	2/24 10:47 PM	2.036	3.939	22	100	371.0	0	5.0	####	1.61	1.93468	0.995	243.5	1765.3
D	1/27 11:30 AM	28	2/25 9:40 AM	2.036	3.941	22	100	371.0	0	10.0	####	1.68	1.93566	0.995	252.3	1764.4
E	1/27 11:30 AM	28	2/25 11:51 AM	2.037	3.925	22	100	371.5	0	10.0	####	1.34	1.92685	0.994	244.1	1772.2
F	1/27 11:30 AM	28	2/25 1:25 PM	2.037	3.935	22	100	371.1	0	10.0	####	1.41	1.93176	0.995	241	1765.8
G	1/27 11:30 AM	28	2/25 4:47 PM	2.036	3.933	22	100	371.2	0	20.0	####	2.32	1.93173	0.995	256.4	1768.9
H	1/27 11:30 AM	28	2/25 6:03 PM	2.038	3.941	22	100	371.7	0	20.0	####	2.64	1.93376	0.995	264.2	1764.2
I	1/27 11:30 AM	28	2/24 11:57 AM	2.036	3.955	22	100	374.4	0	20.0	####	1.10	1.94253	0.995	239.2	1774.3
J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Laboratory Mixing Data
Batch U-2

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	200
Weight of Slurry Water, $w_{w,slurry}$ (g)	550.0
Weight of Dry Cement, w_c (g)	550.0
Weight of Moist Soil, w_{soil} (g)	3722.4
Weight of Slurry (g)	1100.0
Specific Gravity of Solids	2.74
water content of mix	0.46
Dry unit wt. of mix (pcf)	75.9

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2799.5
Weight of Soil Water, $w_{w,soil}$ (g)	980
Total weight of soil used, W_t (g)	3747.9
Weight of Dry Cement, w_c (g)	545.2
Weight of Slurry Water, $w_{w,slurry}$ (g)	545.2
Soil Water Content, w (%)	35.01
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	19.64%
Cement Factor, α (kg/m3)	270.54
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	199.43
Volume Ratio, VR (%)	35.66
Total-Water-to-Cement Ratio, w_T:c	2.78

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	545.2
Volume Ratio, VR (%)	35.66
Total-Water-to-Cement Ratio, w_T:c	2.78
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	199.4

SAMPLE DATA: Batch U-2

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size: Diam. (in)	Sample Size: Height (in)	Cure Conditions: Temp (C)	Cure Conditions: Humidity (%)	Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions: Conf. Stress (psi)	Failure Conditions: Peak Dev (psi)	Failure Conditions: Strain (%)	Strength Adjustments: L/D ratio	Strength Adjustments: Height Correction Factor	Strength Adjustments: Adj. UCS (psi)	total unit weight (kg/m3)
A	1/30 11:30 AM	28	2/27 9:26 AM	2.037	3.941	22	100	367.4	0	5.0	####	1.55	1.93471	0.995	392.2	1745.6
B	1/30 11:30 AM	28	2/27 10:18 AM	2.035	3.961	22	100	369.9	0	5.0	####	1.34	1.94644	0.996	348.1	1752.0
C	1/30 11:30 AM	28	2/27 12:15 PM	2.035	3.944	22	100	367.9	0	10.0	####	1.58	1.93808	0.995	364.3	1750.0
D	1/30 11:30 AM	28	2/27 2:22 PM	2.035	3.951	22	100	369.0	0	10.0	####	1.65	1.94152	0.995	370.1	1752.2
E	1/30 11:30 AM	28	2/27 3:15 PM	2.035	3.951	22	100	368.2	0	20.0	####	1.46	1.94152	0.995	404.1	1748.4
F	1/30 11:30 AM	28	2/27 4:41 PM	2.036	3.953	22	100	368.5	0	20.0	####	1.98	1.94155	0.995	408	1747.2
G	1/30 11:30 AM	28	2/27 7:00 PM	2.035	3.936	22	100	366.5	0	40.0	####	1.86	1.93415	0.995	413.0	1746.9
H	1/30 11:30 AM	28	2/27 7:57 PM	2.038	3.950	22	100	368.4	0	40.0	####	2.07	1.93817	0.995	404.6	1744.6
I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Laboratory Mixing Data
Batch U-3

Change only black text, red is calculated

Organization	Virginia Tech
Location	Blacksburg, VA
Conducted By	Roberto Nevarez Garibaldi
Supervisor	George Filz

Soil Properties:

Soil Type	artificial
Soil Solids Specific Gravity	2.66
Soil Water Content, w (%)	0.35
Unit Weight, γ_{soil} (kg/m^3)	1859.7

Binder Properties:

Binder Type	Portland Cement (TypeI/II)
Specific Weight, G_c	3.15
Unit Weight, γ_c (kg/m3)	3148.6

Mixer Type / Model	Hobart Mixer, Dough Hook
Mixing Time (minutes) for:	
Soil	3 minutes
Soil/Cement	10 minutes
Blender Type / Model	Oster 14-Speed Blender
Mixing Time (minutes) for:	
Binder Slurry	3 minutes

Design Mix Values for Batch:

Number of Specimen, N	11
Water:Cement Ratio of Slurry, w:c	1.00
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	275
Weight of Slurry Water, $w_{w,slurry}$ (g)	750.0
Weight of Dry Cement, w_c (g)	750.0
Weight of Moist Soil, w_{soil} (g)	3222.8
Weight of Slurry (g)	1500.0
Specific Gravity of Solids	2.78
water content of mix	0.51
Dry unit wt. of mix (pcf)	72.1

Actual Mix Values for batch:

As Mixed:

Weight of Soil Solids, w_s (g)	2399.7
Weight of Soil Water, $w_{w,soil}$ (g)	840
Total weight of soil used, W_t (g)	3202.1
Weight of Dry Cement, w_c (g)	745.8
Weight of Slurry Water, $w_{w,slurry}$ (g)	745.8
Soil Water Content, w (%)	35.00
Water:Cement Ratio, w:c	1.00
Cement Content, a_W (%)	31.44%
Cement Factor, α (kg/m3)	433.14
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	275.73
Volume Ratio, VR (%)	57.09
Total-Water-to-Cement Ratio, w_T:c	2.11

As Cured:

Weight of Bleed Water*, $w_{w,bleed}$ (g)	0.0
Weight of Slurry Water**, $w_{w,slurry}$ (g)	745.8
Volume Ratio, VR (%)	57.09
Total-Water-to-Cement Ratio, w_T:c	2.11
Cement Factor In-Place, $\alpha_{in\text{-}place}$ (kg/m^3)	275.7

SAMPLE DATA: Batch U-3

Sample ID	Time Molded (date / Time)	Curing Period (Days)	Time Tested (date/time)	Sample Size		Cure Conditions		Specimen wt. after cure (g)	Bleed Water (g)	Failure Conditions			Strength Adjustments			total unit weight (kg/m3)
				Diam. (in)	Height (in)	Temp (C)	Humidity (%)			Conf. Stress (psi)	Peak Dev (psi)	Strain (%)	L/D ratio	Height Correction Factor	Adj. UCS (psi)	
A	1/30 11:30 AM	28	2/27 9:34 PM	2.037	3.923	22	100	360.6	0	5.0	####	1.26	1.92587	0.994	512.4	1721.1
B	1/30 11:30 AM	28	2/27 10:18 PM	2.038	3.961	22	100	365.1	0	5.0	####	1.15	1.94357	0.995	495.2	1724.2
C	1/30 11:30 AM	28	2/27 11:21 PM	2.036	3.957	22	100	364.4	0	10.0	####	1.55	1.94352	0.995	552.2	1726.0
D	1/30 11:30 AM	28	2/28 3:01 PM	2.037	3.939	22	100	362.3	0	10.0	####	1.45	1.93373	0.995	541.9	1722.2
E	1/30 11:30 AM	28	2/28 3:55 PM	2.037	3.960	22	100	365.5	0	20.0	####	1.54	1.94404	0.996	537.7	1728.2
F	1/30 11:30 AM	28	2/28 4:50 PM	2.037	3.951	22	100	364.0	0	20.0	####	1.37	1.93962	0.995	513	1725.0
G	1/30 11:30 AM	28	3/1 8:56 PM	2.037	3.959	22	100	364.4	0	40.0	####	1.51	1.94354	0.995	553.9	1723.4
H	1/30 11:30 AM	28	3/1 9:47 PM	2.039	3.952	22	100	364.5	0	40.0	####	1.41	1.93821	0.995	543.0	1723.6
I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
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Appendix B: Laboratory Procedure for Mixing and Curing Cement-Treated Soil Specimens

A laboratory procedure for mixing, curing, and preparing cement-treated soil specimens was developed as part of this investigation. This procedure assures consistency in the mix obtained so that the results obtained can be comparable. The soil used in this investigation was an artificial Lean Clay. Below is a list of the equipment and components of the soil used and a detailed step by step description of the laboratory procedure.

Equipment

- Plastic bags, airtight containers, and plastic wrap
- Scale
- Hobart™ Legacy HL 120 Mixer (12 quart) with dough hook attachment
- Oster™ 14 speed blender (1.25 L)
- U.S. Stoneware Jar Mill
- Respirator
- Mixing bowls
- Moisture tins
- Rubber spatula
- Latex gloves or similar
- Large spoon
- 50 mm diameter, 100 mm tall (2" x 4") plastic molds with lids
- Drywall Spatula or straight edge spatula
- Calipers
- Miter saw with stone cutting blade
- Unconfined compression testing apparatus
- Utility knife
- Cylinder mold removal jig
- Large razor blade
- Small level

Soil Components

- Tile 6 Kaoline
- Bentonite
- Premium Play Sand
- Silica Flour SMS-200
- Portland Cement type I/II

Table 15: Soil components, selected equipment and sources

Soil Component	Source	Location	Contact
Tile 6 Kaoline	Highwater Clays	Ashville, NC	highwaterclays.com
Bentonite			
Premium Play Sand	Short Mountain Silica	Mooresburg, TN	shortmtnsilica.com
Silica Flour SMS-200			
2x4 inch test cylinder mold with lid	Paragon Products	Mt. Pleasant, IA	paragonproducts-ia.com
type I/II Portland Cement	Quikrete		quikrete.com
14 speed blender (1.25 L)	Oster		oster.com
Legacy HL 120 Mixer (12 quart) with dough hook	Hobart Corporation		hobartcorp.com
Jar Mill	U.S. Stoneware	East Palestine, OH	usstoneware.com
Sigma-1 Automated Load Test System with digiflow automated flow pumps	GeoTAC	Houston, TX	geotac.com

Dry Mixing of Base Soil

Dry mixing is first conducted to ensure a thorough mixing of the dry components. It is more difficult to obtain a thorough, uniform mix if water is added prior to dry mixing.

Inhalation of silica dust and other soil components can be harmful to the respiratory system. An appropriate half-face respirator and filter approved for silica dust should be worn whenever dry mixing is being conducted. Dust generation can be minimized with a careful technique. Careless dumping of material should be avoided. Instead, any dry soil component should be transferred with a spatula in a slow manner to reduce the generation of dust.

1. Prepare dry components
    a. Sieve the Premium Play Sand to obtain the desired gradation. The portion of the sand that passes the #40 sieve and was retained on the #200 sieve was used for this project.
    b. Air dry the sand and store in an air-tight container.
    c. Store the rest of the dry components in sealed containers away from moisture to prevent changes in moisture content between batches.
2. Weigh dry components

a. Select the amount of base soil to prepare and determine the amount needed for each component. The base soil is composed of the following proportions by dry weight of the total weight
    i. 10% Fine Sand (#40 > sand >#200)
    ii. 65% Silica Flour
    iii. 20% Tile 6 Kaoline
    iv. 5% Bentonite

3. Place the dry components in the Jar Mill and mix briefly with a spoon.

Figure 48: Placing of the dry components into the Jar Mill

4. Seal the lid.
5. Place the drum on the motorized rollers.
6. Turn on the jar mill on speed setting 30 and allow it to roll for 10 minutes. This process thoroughly mixes the dry components and produces minimum dust. In the event the amount of soil to be prepared exceeds the capacity of the jar mill, several smaller batches should be prepared and then combined.
7. Remove drum from roller and take outside.
8. Open the drum and place dry base soil in container of known mass and seal the lid of the container
    a. Well-ventilated areas can also be used during windy days to avoid losing material.
    b. Dust generation can be minimized by using a spatula to slowly transfer the material into a container.
    c. Careless dumping of the material from the drum to the container should be avoided as it produces more dust.
    d. Once the dry soil is in a closed container, the respirator is not required.
9. Weigh the dry soil recovered from the mixing drum

10. Store soil until ready for wet mixing
11. Wash mixing drum

Wet Mixing of Base Soil

The wet mixing stage further ensures the soil components are thoroughly mixed. It is recommended to prepare more wet soil than will be needed for specimen preparation since some wet soil sticks to the sides of the bowl and the container resulting in smaller amounts of wet soil available for test specimen preparation.

12. Determine the necessary weight of water corresponding to the amount of water to be added to the dry components to obtain the desired water content. For this research, a water content of 35%, which is equal to the liquid limit of the soil, was used. Mixing at this water content aided in the mixing process.
    a. Measuring the exact amount needed for the target water content results in smaller amounts being transferred to the mixture since some water stays in the bowl where it was measured. Instead of weighing the exact amount of water required for the target water content, weigh a higher amount and transfer only the necessary amount of water to the mixture.
13. Take the dry base soil in closed container, weighted water, and kitchen mixer outside or into a well-ventilated area, if possible.
14. Transfer the dry base soil into mixing bowl carefully using a spatula. Respirator should be worn during this stage due to dust generation.
15. Pour the required amount of water into the mixing bowl.
    a. Use the straight-edge spatula to manually mix the dry soil with the water, especially at the center of the bowl where the hook has limited reach. This will prevent the water from splashing to the sides of the bowl during the next step and facilitates a thorough mixing.
16. Begin mixing with kitchen stand mixer on low speed using a dough hook attachment.
    a. Mix for 5 minutes on speed setting “1”. Periodically, the mixer will need to be turned off and the soil manually mixed using a spatula. Some of the soil sticks to the sides of the bowl/mixer attachment and must be scraped off and placed in the center of the bowl so that a thorough mixing could be accomplished. The time spent manually mixing the soil should be kept to a minimum and is not included in the 5 minute mixing time.
    b. The respirator may be removed once dust is no longer generated by the mixing process.
17. Remove the wet soil and store in a sealed container in a humid environment overnight.
    a. The clay is not fully hydrated after initial wet mixing so it is allowed to continue hydrating overnight.

After the moist base soil has been allowed to hydrate, it is ready to be mixed with the binder slurry.

Moist Soil Mixing

The following procedure is modified after Hodges et al. (2008).

Mixing of the moist soil is done to moist soil mixing and binder slurry mixing should be performed simultaneously to prevent moisture loss of the base soil.

The moist soil must first be mixed prior to adding the binder slurry

18. Determine the weight of moist soil necessary for creating a particular batch of soil cement mixture
19. Wet the inside of the mixing bowl to be used with the Hobart™ stand mixer, and lightly pat dry with a paper towel. The inside of the mixing bowl should be lightly moistened, but should show no visible water beads.
20. If a different amount of moist soil is going to be used than the amount that was prepared, measure the required weight of moist soil to the nearest tenth of a gram and place it in the moistened mixing bowl. Reseal the soil samples. Record the actual weight of moist soil if different from the target weight.
    a. Some of the moist soil sticks to the container and it is good practice to weigh the container before and after transferring the moist soil into the mixing bowl to obtain the actual weight of moist soil used in the mix.
21. Place the mixing bowl onto the mixer and begin mixing at the lowest setting. Mix for 3 minutes.

Binder Slurry Mixing

It is recommended that more binder slurry is prepared than necessary. Some of the slurry sticks to the inside of the blender and cannot be removed. This results in a lower cement factor than desired if exact amounts are blended.

22. Determine the dry weight of cement and weight of water necessary for the targeted water-to-cement ratio for the mixture.
    a. The ratio of slurry water to cement should be consistent even though more slurry is being prepared.
23. Measure the required weight of slurry mixing water and add it to the mixing container of the Oster™ kitchen blender.
24. Measure the required weight of dry cement and place it in the mixing container of the kitchen blender.
25. Blend for 3 minutes on high setting. Record the total mixing time. The binder slurry should be mixed while the moist soil is being mixed.

Soil-Binder Mixing

26. After the binder slurry is mixed, turn off the blender and the mixer. Remove the pitcher from the base. Weigh the pitcher and binder slurry to determine how much should go into the moist soil, and how much should remain in the pitcher, since excess binder slurry has been prepared. Slowly add the binder slurry to the mixing bowl with wet soil. If too much

binder slurry is added at once, some may slosh out of the mixing bowl once mixing is started. It is necessary to add a portion of the binder slurry to the soil and mix on low setting until it will no longer slosh out. At this time more binder slurry may be added. Before adding more binder slurry, agitate the slurry because cement will begin to settle out as it sits.

27. Once the required amount of binder slurry has been added, record the weight of the pitcher after the binder slurry has been added to the soil to determine the amount of binder slurry that is mixed with the moist soil and mix the soil cement mixture for 10 minutes using the kitchen stand mixer and dough hook attachment. Speed setting “2” was used in this step. If other mixing equipment is used, select the medium speed setting. Use a rubber spatula to dig out the moist soil at the bottom of the bowl and to remove the mixture from the beater and sides of the bowl, and push the mixture back towards the center, stopping mixing only when necessary. Typically, the mixing will need to be stopped 3-4 times to manually mix soil that the beater does not mix well. The 10 minute mixing time is only for the kitchen stand mixing. The manual mixing time is not included and should be kept to a minimum. Record the total mixing time and mixing equipment used.

Placing the Mixture in the Molds

28. Appropriately label clean dry molds with batch number, date formed, cement factor in-place, and test to be performed. It is recommend that this is done prior to beginning the mixing process, or while the soil and binder slurry are being mixed.
29. Begin placing the mixture in the molds as soon as possible following soil-binder mixing. Using a rubber spatula, fill the spatula with a representative scoop of the mixture. Place the mixture from the spatula into a plastic mold. Exercise care to ensure that each lift placed in the mold is representative of the entire mixture. Allowing soil particles to settle out during placement will result in samples with varied mixture properties (cement content, volume ratio, etc.), thus decreasing the usefulness of the test results.
30. Fill each mold in approximately three lifts tapping the sample after each lift on a hard surface as necessary to remove air bubbles. Samples with less binder slurry will require more tapping due to their higher viscosity. Cease tapping if water begins to separate from the mixture or if bubbles no longer break the surface.
31. Finish by screeding the top of the specimen flush with the top of the mold using a straightedge spatula to produce a flat surface. Cap the specimen immediately by pressing on the sides of the lid until it clicks. Pressing the center of the lid can result in damage of the specimen.
32. After all molds have been filled and capped, clean and dry the molds. Weigh each specimen individually in its mold. If the lightest specimen is not within the desired tolerance, it should be remolded or discarded. Each testing program should set its own tolerance based on the variability of the soil being tested and the sensitivity of the cement-treated soil mixture to segregating. For this project, specimens in their molds varied at most by 3 grams. This is insignificant because the cylinder molds used in this project could vary by 2 grams themselves.
33. Discard any mix that is not satisfactorily placed in a mold within 30 minutes of completing initial mixing. No re-mixing or other disturbance of the mixture shall be allowed more than 30 minutes after completion of the initial mixing.

34. Seal the seam between the lid and mold body with a strip of electrical tape to prevent moisture loss. The molds used in this project had lids attached to them by a plastic tag. It was necessary to cut this tag off before the specimens had been capped, preferably before the start of the mixing procedure. This allowed the electric tape to make a positive seal between lid and body of the mold.

Figure 49: Sealing of the specimens with electrical tape

35. If a consistency measurement of the mixture is going to be performed, it should be started after the specimens are formed. It is recommended, however, that the consistency measurement is done when a small amount of specimens are formed. This procedure is further explained in Appendix C.

Curing

36. Store the sealed specimens at the specified humidity and temperature. If a humid room is not available, the sealed specimens may be stored under water in lieu of storing at 100% relative humidity. Specimens should be stored in the sealed cylinder molds under these controlled conditions for their specified curing period (3 to 56 days). In this research, the sealed specimens were stored submerged in a closed container inside a humid room.

Figure 50: Curing of specimens

Specimen Preparation

Specimens should be prepared for testing the day testing will occur and as close to the testing time as possible.

37. After a specimen has reached its designated curing age, remove from the water bath and dry the mold. Carefully remove the cap from the specimen to be tested. If bleed water has formed at the top the specimen, record the weight of bleed water as the difference in the weight of the specimen before and after pouring the bleed water. Correct the total-water-to-cement ratio of the cured specimen by subtracting the amount of bleed water recorded.
38. With the cap removed, use a jig to make a single cut down the length of the specimen mold with a utility knife. The jig should prevent the utility knife blade from cutting into the cement-treated soil specimen. Carefully remove the mold from the specimen. Transfer the specimen identification on the mold to the removed specimen using a pencil, being careful not to gouge the specimen.

    NOTE: Do not attempt to remove specimen from their molds using standard stripping tools for concrete specimens. Cemen-treated soil specimens are softer than standard concrete specimens and may be damaged if extreme care is not used during extraction. Alternatively, the bottom of the mold can be removed with a miter saw and the specimen will slide without any effort.

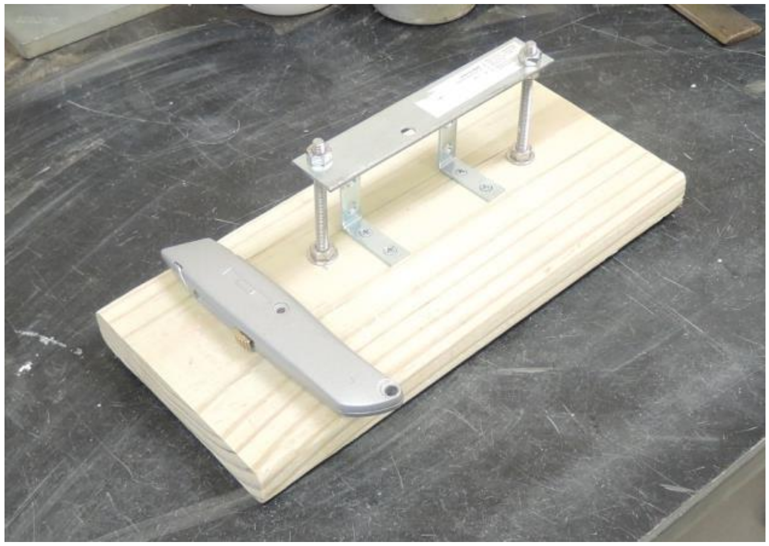


Figure 51: Jig used to demold the specimens and utility knife

Figure 52: Demolding of a specimen using the jig to make a single cut along the length

39. Perform the desired end-face treatment for testing the specimen. The procedures for the different end-face treatment methods are further detailed in Appendix D.
40. Measure and record the specimen weight to the nearest tenth of a gram. Use a caliper and/or a "pi" tape to measure and record the specimen height and diameter. Height and diameter measurements should be taken at three locations on the specimen, and then averaged.
41. Immediately conduct the desired laboratory test. If multiple tests are to be performed in relative close succession, wrap the specimens in plastic wrap and place into a sealed container to maintain their moisture contents until testing is performed. If the time between tests is over an hour, wait to prepare those specimens.

Appendix C: Laboratory Procedure for Measuring the Mixture Consistency with the Laboratory Miniature Vane Shear Apparatus

The objective of this procedure is to use the undrained shear strength of the mixture, measured using the laboratory miniature vane shear apparatus, as an indicative of the consistency at different times after mixing. The tests and the equipment should be in accordance with ASTM D4648/D4648M-16 *Standard Test Methods for Laboratory miniature Vane Shear Test for Saturated Fine-Grained Clayey Soil*

Equipment

1. 1.0" by 1.0" vane blade
2. Torque measuring device
3. Calibrated torque springs with calibration data
4. Water content cup
5. Regular toothbrush
6. Rubber spatula
7. Straight edge spatula
8. Paper towels
9. Stopwatch

Procedure

1. Select an appropriate calibrated torque spring depending on the expected undrained shear strength of the mixture. Use weaker springs for more fluid mixtures and stronger springs for thicker mixtures. During testing, the maximum rotation angle in the calibration sheet of the spring being used should not be reached.
2. Secure the vane in the equipment and check that it is not restricted from moving.
3. Mix the base soil with the slurry using the mixing procedure provided in Appendix B. Start the stopwatch at the end of mixing. The first test should be conducted 30 minutes from the end of mixing. If specimens are being molded for other tests, the specimen preparation time for this procedure should be taken into consideration when deciding the number of specimens that will be prepared. If needed, the first test can be conducted at 35 minutes to allow enough time for specimen molding.
4. Prepare the specimen in which the test will be conducted. Fill the water content cup in approximately three lifts tapping the sample after each lift on a hard surface in order to remove air bubbles. Exercise care to ensure that each lift is representative of the entire mixture.
5. Finish by screeding the top of the specimen flush with the top of the water content cup using a straightedge spatula to produce a flat surface as shown in Figure 53.

Figure 53: Screeding of the mix to make the specimen for testing

6. Conduct the first test 30 minutes after mixing the soil with the slurry.
    a. If a different amount of time for molding the specimens is used as part of the mixing procedure, conduct the firs vane shear test after the specimens have been formed
    b. Record the starting time, the change in rotation angle, and the calibrated torque spring used.

Figure 54: Sheared specimen from a mixture with stiff consistency

7. Hold the water content cup down to prevent it from moving during the test
8. Lower the vane and insert it to about half the depth of the cup.
9. Record the initial reading of the needle in the inside scale.

10. Initiate rotation of the vane at a constant rate of 60 to 90°/minute. The rate of vane rotation should be adjusted to the torque of the spring so that the specimen fails within two to three minutes. Figure 54 shows a specimen from a thick mixture that has been sheared.
    a. Failure occurs when the spring deflection does not increase, which is when the value of the inside scale does not change. Even if it is suspected that failure occurred, keep rotating the vane for 10 to 20 seconds to confirm that the value of the inner scale (spring deflection) does not change.
    b. If shearing occurs under a minute, the rate of vane rotation was too fast, which may result in higher strengths.
11. Record the final reading of the needle in the inside scale.
12. After the test, remove the vane blade from the apparatus and clean it under running water or in a bowl filled with water using the toothbrush as shown in Figure 55.

Figure 55: Cleaning of the specimen under running water using a toothbrush

13. Use a dry paper towel to dry completely the vane blade before attaching it to the equipment.
14. Remove the mixture from the water content cup and place it back in the mixing bowl.
15. Prepare a new specimen to conduct another test following the same procedure as before.
16. Conduct the next test 10 minutes after the beginning of the first test.
17. Repeat steps 3 – 10 to conduct another test for however many times it is desired. This research conducted four tests per design mix, but more tests can be conducted if desired.
18. Use the calibration data provided with the torque springs to obtain the shear strength of the mixture as detailed in ASTM D4648/D4648M-16.

Appendix D: Procedure for Application End-Face Treatment Methods

This project focused on investigating the effects of using different end-face treatment methods on the measured unconfined compressive strength as well as in the modulus of elasticity and other mechanical properties of the cement-treated soil mixtures. Some of the end-face treatment methods investigated are the same as those used for compression testing of concrete cylinders.

Sawing and Hand Trimming

This method requires the use of machine shop equipment and the appropriate training regarding equipment handling and safety should be done prior to using the equipment. Although this method is simple, it requires extreme care to avoid producing very small specimens. The efficacy of this method is a function of the mixture proportions and curing age of the specimen. Weaker specimens from lower cement factors and/or short curing ages are sometimes slightly less easy to trim than stronger specimens because weaker specimens are softer and tend to be more fragile, which can result in slight chipping of very small pieces along the edges of the ends. However, the slight chipping does not occur on every weak specimen and tests show that slight chipping does not cause an appreciable difference in strength.

Equipment

- Long razor blade or straight edge spatula
- Miter saw with stone cutting edge

Procedure

1. With the equipment off, lower the cutting edge and place the specimen on the tray of the equipment with the end-face touching the miter saw.
2. Still with the equipment off, move the miter saw up and down without cutting into the specimen to make sure it will not remove more material than needed. The amount of material removed should be kept to a minimum at all times to prevent short specimens.

Figure 56: Sawing of the end-face

3. With the blade not touching the specimen, turn on the equipment.
4. While holding firmly the side of the specimen away from the cutting edge, make a single cut down the diameter of the specimen removing a thin layer from the face of the specimen, creating a planar surface perpendicular to the long axis of the specimen.
5. Repeat Steps 1 – 4 for the other face of the specimen.
6. Place the specimen upright on a level surface.
7. Using a razor blade or a straight edge spatula longer than the diameter of the specimen, lightly scrape the end face of the specimen while rotating it on the level surface. This removes surface irregularities left from the sawing procedure. Be careful not to cut or gouge the end-face of the specimen.

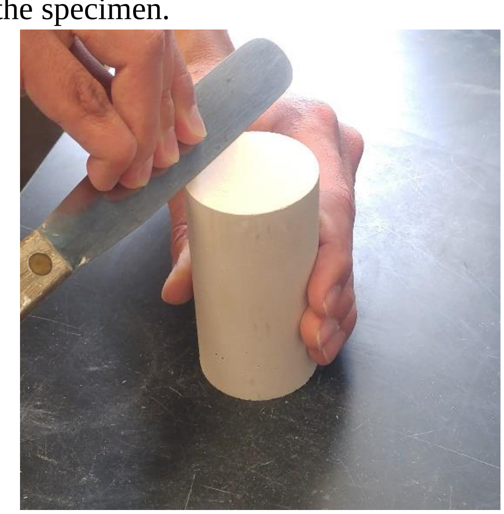


Figure 57: Hand-trimming of the specimen using a straight-edge spatula

8. Repeat step 7 for the other face of the specimen.

<u>Grinding</u>

The equipment used for this method is significantly more expensive than the equipment for sawing and hand trimming, and may not be as economically efficient. The equipment used in this project met the requirements stablished by ASTM D4543-08 *Standard Practice for Preparing Rock Core as a Cylinder Test Specimens and Verifying Conformance to Dimensional and Shape Tolerances.*

Equipment

- Vinci Technologies end face grinder. Model: AP-012-001-2 (or other rock-core grinder)

Procedure

1. Place the specimen on the v-block.
2. While holding the specimen in the v-block, adjust the location of the specimen by pushing down the hand lever and moving the specimen towards the grinding will until it touches it. Ensure the specimen goes past the v-block on the left side.

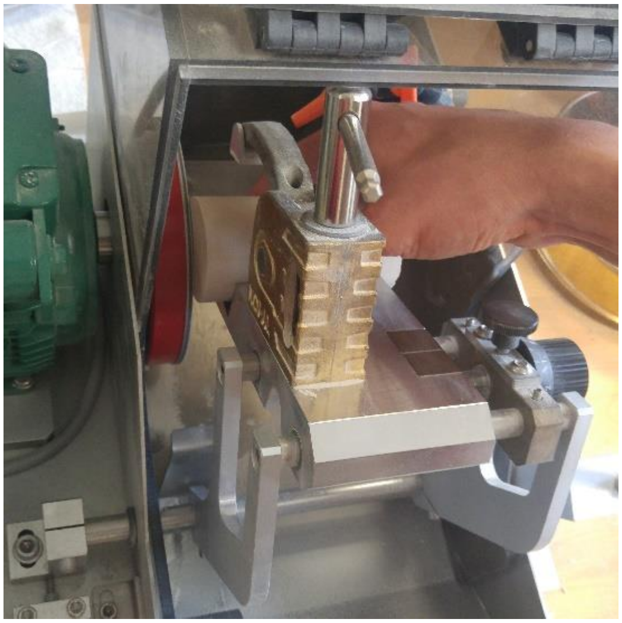


Figure 58: Placing of the specimen in the v-block touching the grinding wheel

Figure 59: Specimen secured in the v-block with the clamping device

3. Lock the specimen in place with the clamping device.
4. Confirm one more time the position of the specimen by pushing down the lever towards the grinding wheel. At the point of contact, there should be a small amount of resistance, but the grinding wheel should not cut much into the sample during the first pass.
5. Use the half-face respirator. Dust may be produced during this procedure so it is recommended to use the respirator in conjunction with the vacuum attachment in the equipment.

6. Connect vacuum to the equipment and turn the vacuum on.
7. Close the cover and turn on the equipment.
8. Gently move the hand lever down and up to grind the specimen, then use the Vernier to move the specimen closer to the grinding wheel. One full rotation of the knob moves the specimen by 1 mm. The Vernier has 10 division and 10 sub-divisions on the knob; for an adjustment of 0.05 mm per sub-division.
9. During grinding, move the hand lever gently back and forth, constituting a full cycle, while rotating the knob one or two sub-divisions every three to four cycles.
    a. The number of sub-divisions that the knob is rotated between cycles depended on the ease of the specimen to be grinded while trying to keep the total amount to under 15 divisions or 1.5 mm (0.059 inches).

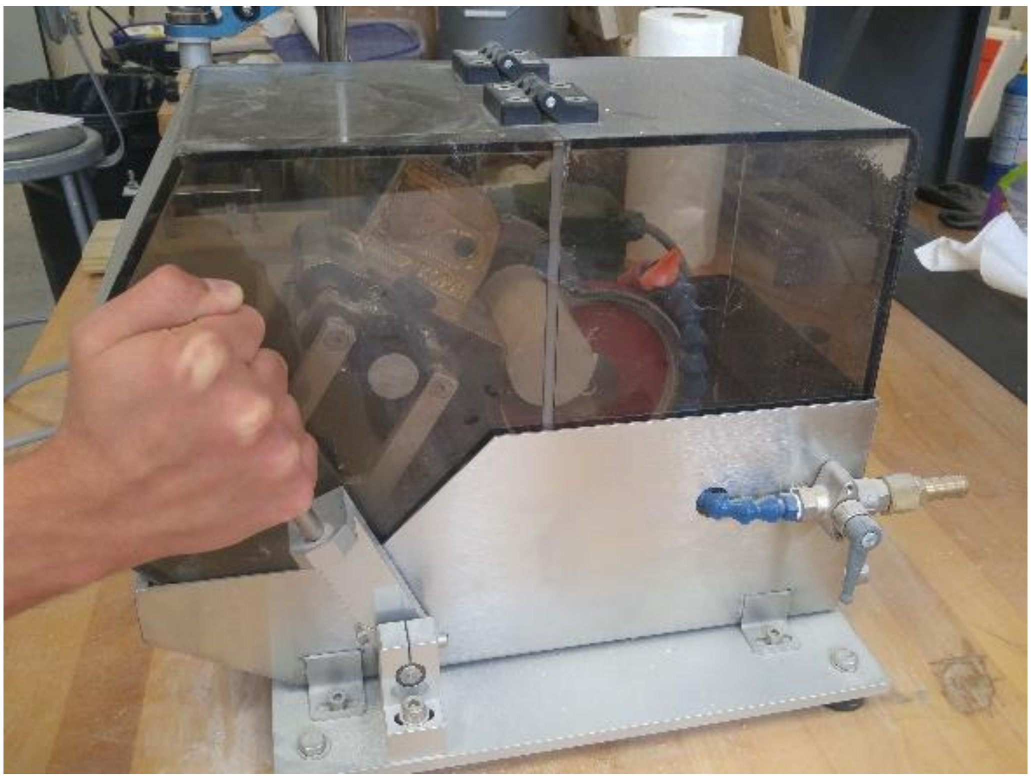


Figure 60: Grinding of the specimen by lowering the handle

Figure 61: Rotation of the Vernier to move the specimen closer to the grinding wheel

10. Turn off the equipment and unclamp the specimen.
11. Flip the specimen to grind the other end-face.
12. Repeat the procedure for the other face.

Sulfur Mortar Capping

This method requires the most equipment as well as special facilities in order to be done. The procedure was done with accordance to ASTM C617/C617M-15 Standard Practice for Capping Cylindrical Concrete Specimens as requested by ASTM D1632-07 Standard Practice for Making and Curing Soil-Cement Compression and Flexure Test Specimens in the Laboratory.

Equipment

1. Sulfur mortar
2. Compound melting pot with cover
3. Exhaust hood
4. Capping ladle
5. Vertical cylinder guide with capping plate for 2” by 4” cylinders
6. Protective eyewear and clothing
7. Heat resistant gloves
8. WD-40 or mineral oil and cloth

9. Hammer with round end
10. Paper towels/cloth

Figure 62: Equipment used for sulfur capping (from left to right): melting pot with cover, hammer with round edge, cloth, Vertical cylinder guide with capping plate for 2" by 4" cylinders, WD-40, cement-treated soil specimen, and heat resistant gloves

Procedure

1. Place the solid sulfur pieces in the compound melting pot and cover it.
2. Turn on the melting pot to a temperature between 265 and 290 °F.
3. Allow the sulfur to completely melt for three to four hours. This period of time has to be taken into consideration when using this method. For this project, the melting pot was turned on in the morning in order to be able to cap the specimens around noon.
4. Record measurements of the height and diameter of the specimen using a set of calipers or pi tape at three locations and take the average.
5. Record the weight of the specimen.
6. Use the ladle to stir the sulfur to confirm there are no chunks of solid sulfur left.
7. Place the vertical cylinder guide and the capping plate next to the melting pot to avoid spilling molten sulfur.
8. Spray a small amount of WD-40 or mineral oil on the capping plate and distribute it with a cloth or a paper towel over the whole surface of the capping plate. This will prevent adhesion between the sulfur and the capping plate, as well as making cleaning easier.
9. Place the specimen near the capping plate so it is ready to be capped. This allows the specimen to be capped while the sulfur is still in a liquid state since it becomes solid very quickly.
10. Make sure that the capping plate and the vertical cylinder guide are fully assembled.
11. Use the ladle to transfer molten sulfur onto the capping plate. Fill completely the mold in the plate. If the mold is not full, the cap may not cover the whole face of the specimen.

The transfer of the molten sulfur should be done quickly, but with extreme care to avoid spilling molten sulfur.

Figure 63: Placing of the molten sulfur into the capping plate with idle

12. Grab the specimen and pressing lightly against the vertical guide, lower the specimen into the mold so that the molten sulfur surrounds the bottom of the specimen. This also, has to be done quickly because the molten sulfur starts hardening within a minute after being placed in the mold and can result in uneven caps. When lowering the specimen into the mold, be careful to avoid splashing sulfur.

Figure 64: Capping of the cement-treated soil specimen using the capping plate and vertical cylinder guide

13. Hold the specimen tightly in place by slightly pressing down on it and against the vertical guide for 1-2 minutes.
14. Pull the capping plate away from the vertical guide as shown in Figure 65 to lift the specimen. If the capping plate is not pulled from the ensemble, the cap can break during the extrusion. The WD-40 prevents adhesion from the sulfur to the capping plate and allows to lift the specimen effortlessly.

Figure 65: Specimen with dry sulfur cap inside capping plate

15. In the case of residual sulfur hardening with the cap, remove it by lightly tapping it with the round end of a hammer, as shown in Figure 66. This should chip off the excess sulfur without damaging the cap of the specimen.

Figure 66: Removal of sulfur residual with a round tip hammer

16. Repeat steps 7-15 to cap the other face of the specimen.
17. Wet some paper towels or a cloth and squeeze them well. Wrap the specimen with the paper towels, as shown in Figure 67, and place it in a humidity room or inside a container protected from dripping water to prevent moisture loss.
18. Wait at least 3 hours before testing the specimen to allow the sulfur to gain sufficient strength.

Figure 67: Capped specimens wrapped with moist paper towel (left) and capped specimen before testing (right)

Neoprene Pads and Metal Caps

This method was done in accordance with ASTM C1231/1231M-15 Standard Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Cylindrical Concrete Specimen.

Equipment

1. Two shore A durometer 50 neoprene pads conformed to ASTM C1231/1231M-15 standards for 2” by 4” specimen cylinders.
2. Two metal caps or retainers conformed to ASTM C1231/1231M-15 standards for 2” by 4” specimen cylinders.
3. Grinding or sawing equipment
4. Record of the use life of the pads including the date the pad was first used, the durometer of the pad, and the number of uses.

Procedure

1. Examine the neoprene pad for signs of wear and tear, and check the record for the number of uses it has been subjected to. The number of maximum uses is limited to 100 uses for most neoprene pads.
2. Insert the neoprene pads in the metal caps.
5. Use the grinding or sawing equipment to produce planar surfaces perpendicular to the height of the specimen as detailed above.
3. Place a metal cap containing the neoprene pad inside, on each end-face of the specimen.

Figure 68: Specimen capped with neoprene pads inside metal caps

<u>Gypsum Capping</u>

The gypsum capping method is also adapted from compression testing of concrete cylinders and is very similar to the sulfur mortar capping method. This method was performed in accordance with ASTM C617/C617M-15 *Standard Practice for Capping Cylindrical Concrete Specimens* as requested by ASTM D1632-07 *Standard Practice for Making and Curing Soil-Cement Compression and Flexure Test Specimens in the Laboratory*.

Equipment

1. High strength gypsum powder
2. Small bowl for mixing
3. Regular spoon
4. Water
5. Wash bottle
6. Scale
7. Bullseye level
8. 4” by 4” glass squares
9. Needle
10. Mineral oil or WD-40
11. Paper towels
12. Stopwatch

Procedure

1. Determine the water-to-gypsum ratio appropriate depending on the number of specimens that are going to be capped. It is recommended that a new mixture be prepared for each face. The ratio should be between 0.26 and 0.30. Low ratios allow for high strengths, but are harder to work with. High ratios are easier to work with, but reduce the strength. For

this project, a water-to-gypsum ratio equal to 0.30 was used when capping between 1 and 4 specimens at a single time.

2. Place the specimen upright on a level surface
3. Spray mineral oil on one of the surfaces of the glass squares and spread it with a paper towel, removing any excess. A decent amount of mineral oil should be left on the surface of the glass square, making it hard to see through it. This will prevent the gypsum mixture from sticking to the glass and damaging the cap.
4. Measure the desired dry weight of gypsum powder in the mixing bowl and record it. For this project, 300 grams of dry gypsum powder were used when preparing the mixture for capping. This amount of dry gypsum powder allowed for an easy mixing process. If too little dry gypsum powder is used, the mixing process can be difficult, compromising the strength of the cap.

Figure 69: Dry gypsum inside mixing bowl and water bowl

5. Zero the scale.
6. Add water to the bowl using the wash bottle until the desired weight of water is added.
7. Start the stopwatch.
8. Mix the water and the gypsum using the spoon for 2-3 minutes. The mixing should be vigorously, almost violently to ensure the water and the gypsum are mixed thoroughly.
9. Tap the bowl against a hard surface to get bubbles out of the mixture.

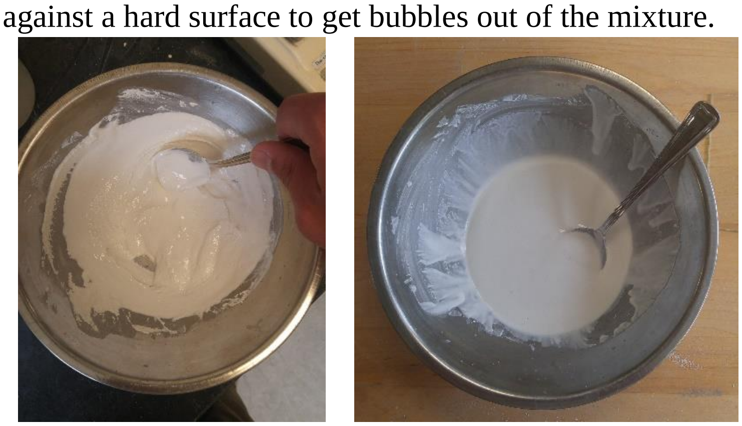


Figure 70: Mixing of the gypsum-water mixture with a spoon

10. Place a spoonful of the mixture on the end-face of the specimen.

Figure 71: Placing of the mixture on the end-face

11. Use the needle to pop any air bubbles visible in the mixture sitting on the end-face.
12. Place the surface of the glass square with mineral oil on top of the mixture.
13. Center the bullseye level on top of the glass square.
14. Press firmly on the glass square displacing evenly the mixture over the end-face until the bubble in the bullseye level is centered. This will produce a planar surface with parallel ends. The thickness of the cap should be around 0.25 inch so displacing excessive amounts of mixture should be avoided.
15. Once the cap is leveled, allow the mixture to harden for 30 minutes as shown in Figure 72.

Figure 72: Capping of the specimen with bullseye level

16. Clean the bowl to prevent the mixture hardening in it.
17. Remove the glass square from the top of the cap. As the cap hardens, they gypsum stops sticking to the glass. Grab the glass with both hands on opposite sides and using the thumbs of each hand, press on the bubble while pulling on the sides as if you were trying to bend the glass square. Be careful not to break the glass or damage the cap. This motion should increase the size of the bubble, allowing the glass to separate from the cap.
18. Clean the glass square from residue.

19. Repeat steps 1 – 18 to repeat the process for the other end of the specimen.
20. Wet some paper towels and squeeze them well. Wrap the specimen with the paper towels and place it in a humidity room away from free water as shown in Figure 73 or in a closed container.

Figure 73: Capped specimen wrapped in moist paper towels

21. Allow the gypsums caps to gain strength for 2 – 3 hours before testing the specimen as shown in Figure 74.

Figure 74: Capped specimen prior to test

Appendix E: Procedure for Placement of the Local displacement Measurement Device

This procedure was initially developed by GeoTAC and has been modified and adapted to this project.

1. Add the sensors to the data acquisition software using the calibration data provided by the manufacturer.

Radial strain measurement device

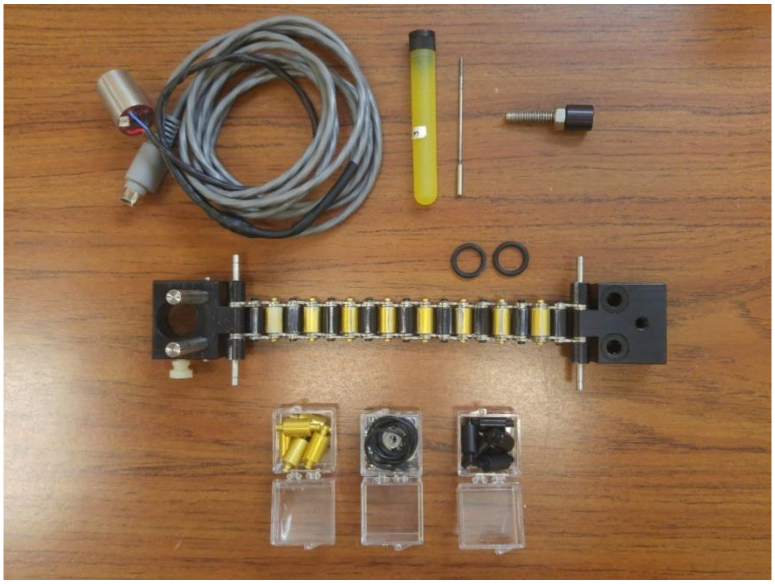


Figure 75: Components of the radial strain measuring device (from left to right, top to bottom) displacement sensor, sensor rod, positioning stem, roller chain with end blocks for the displacement sensor, additional rollers, and o-rings.

2. Adjust the length of the roller chain by placing the appropriate number of rollers to fit the diameter of the specimens. For the specimen size used in this project, the chain was adjusted to have 19 rollers, including the rollers that are part of the end-blocks of the chain. This is done only once if the equipment is only going to be used on specimens with the same dimensions.

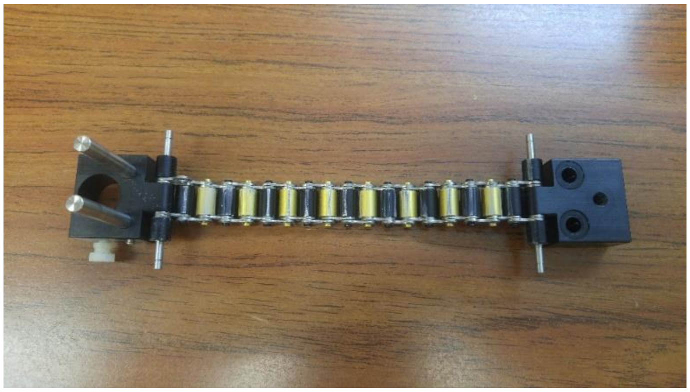


Figure 76: Roller chain and end blocks with 19 rollers (including rollers that are part of the end blocks)

3. Wrap the roller chain around the center of the specimen and insert the alignment rods of one of the end-blocks to the bearings of the other block.

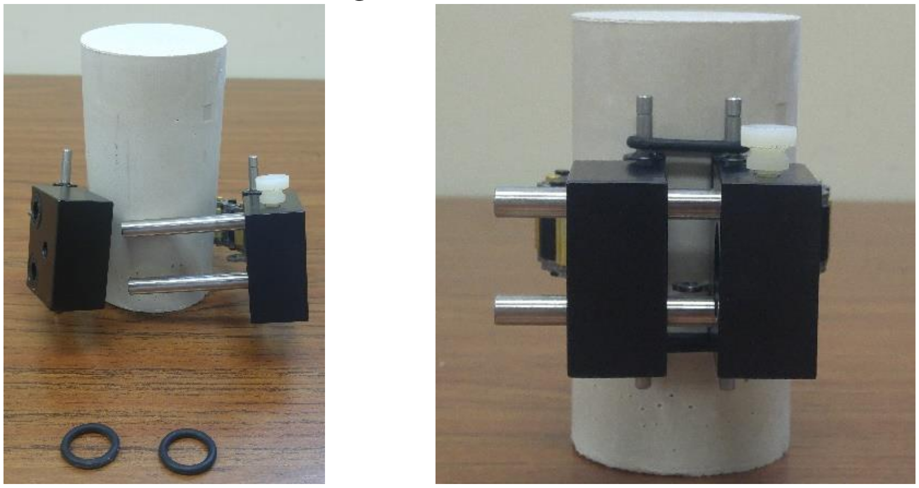


Figure 77: Securing the roller chain to the specimen with o-rings

4. Secure the roller chain using the o-rings provided with the equipment. The number of rollers and the size of the o-rings ensures enough tension in the chain to hold it in place.
5. Insert the sensor body into the block containing the two alignment pins and secure it by tightening gently the nylon screw on top of the block.

Figure 78: Displacement sensor components (left to right) positioning stem, sensor rod, and sensor body

6. Screw the threaded end of the displacement sensor rod into the positioning stem.

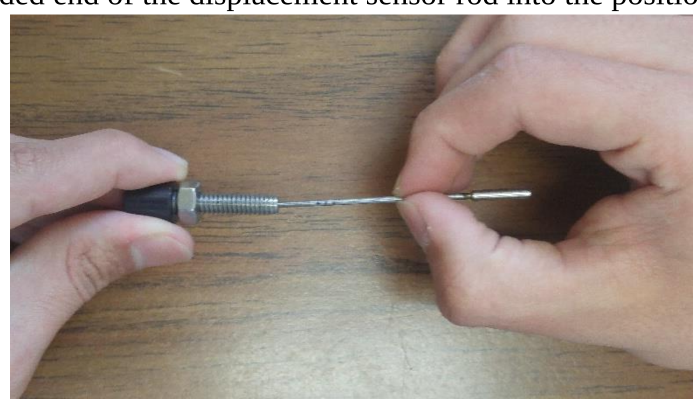


Figure 79: Insertion of sensor rod into positioning stem

7. Screw the positioning stem into the other block while carefully inserting the sensor rod into the sensor body. Three black lines are drawn on the sensor rod, marking the ends and the middle of the working range of the instrument, which for this case was ±0.1 inches. Adjust the positioning stem until the sensor body is close to covering the mark closest to the stem, covering the other two marks. As the specimen is compressed, the increase in circumference pulls the sensor rod out of the sensor body recording a change in circumference.

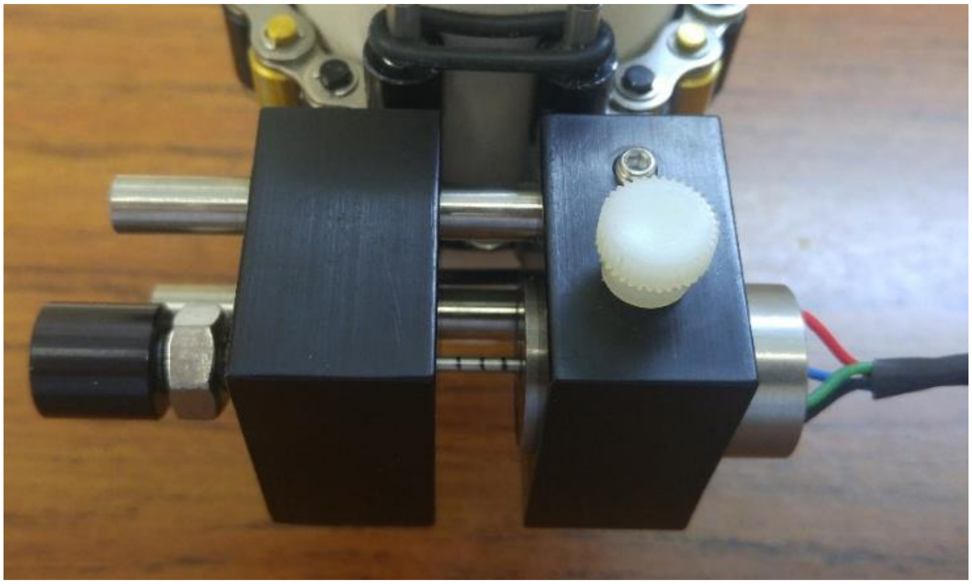


Figure 80: Displacement sensor body, rod, and positioning stem installed in end blocks showing the working range of the equipment

8. Turn the lock nut in the positioning stem towards the block to fix the stem in place.

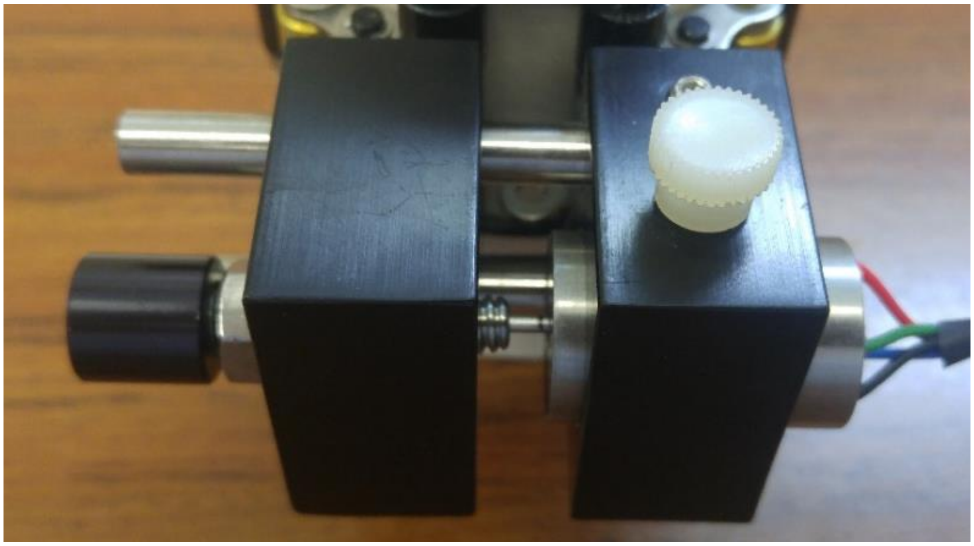


Figure 81: Rod positioning for full benefit of the sensors working range

Axial strain measurement device

Figure 82: Components of axial strain measurement device (from left to right) collar alignment posts (top left), displacement sensor rod stems (bottom left), lower and upper collars with spring loaded dowels installed, displacement sensors.

9. Set a gage length on the collar alignment posts. The gage length is adjusted by positioning the lock nuts and shoulder cylinders on the collar alignment posts such that the distance from the outside edges of the shoulder cylinders is the same on both posts.

Figure 83: Collar alignment post adjusted for a gage length of 2.9 inches

10. Screw the positioning stems into the bottom collar with the open ends sticking farther out. The close end of the stems should protrude enough so only two or three threads are visible. Use the two nuts on the other side to secure the positioning stems in place.
11. Insert the alignment posts into the bottom collar and secure them by tightening the thumbscrews. The alignment posts and the positioning stems should be facing in the same direction.
12. Place the bottom collar on top of the ring of the aluminum base, aligning the alignment posts with the squares on the outside and the positioning stems with the holes in the ring. The positioning stems should prevent the bottom collar from moving excessively.

Figure 84: Aluminum base designed for the set up of the device

13. Center the specimen inside the ring of the aluminum base.

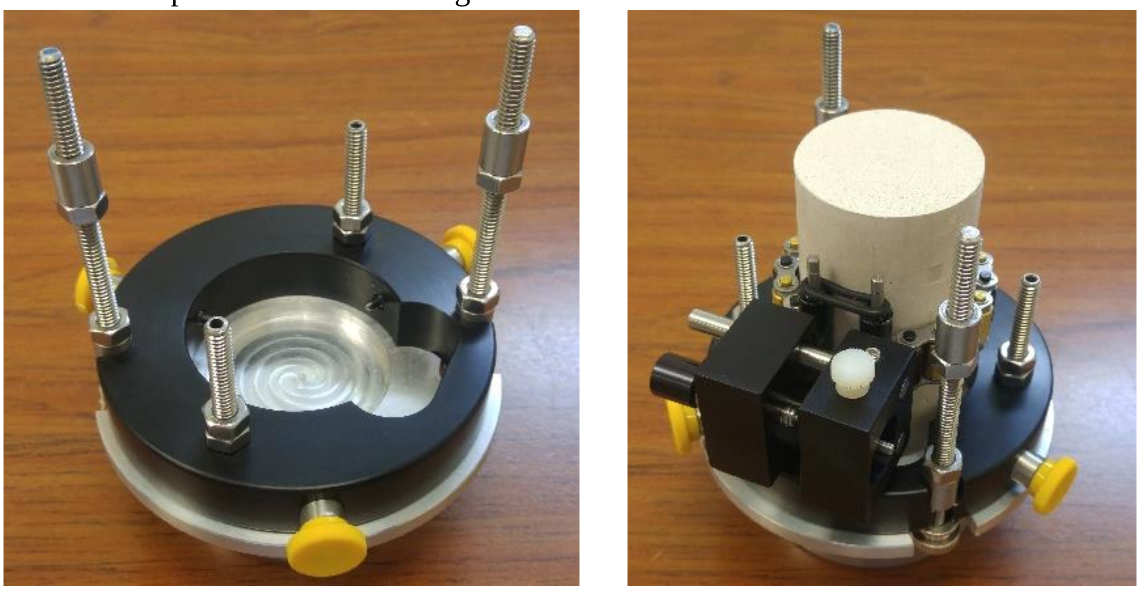


Figure 85: Set up of the bottom collar and the specimen on the aluminum base

14. Tighten the dowels so that the specimen is centered and all three are firmly attached to the specimen. The specimen and the collar may have to be held to prevent them from

moving while tightening the dowels due to the rotation of the screws. Each dowel should be tightened by alternating between dowels.

15. Remove the thumbscrews from the top of the alignment posts and place the top collar allowing it to slide down through the alignment posts. Secure the top collar to the alignment posts by placing the thumbscrews and tightening them.

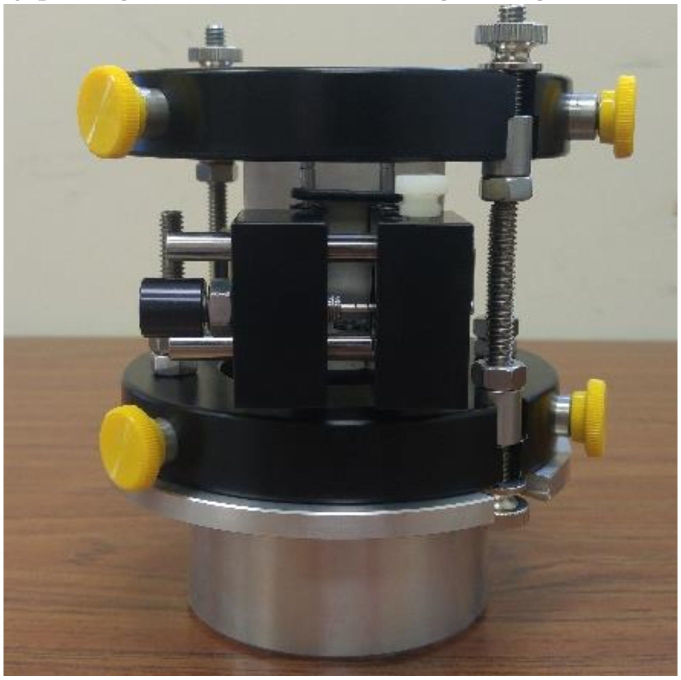


Figure 86: Top collar secured on the specimen with the dowels

16. Tighten the dowels of the top collar the same way the dowels of the bottom collar were tighten. Be careful so the specimen stays centered inside the collars, but it is not subjected to bending forces.
17. Place sensor rod inside the positioning stems.
18. Identify which sensor body corresponds to each sensor rod. All three rods are paired with a sensor body and are identified by the number of lines closer to threaded part in the rod. The sensor body is identified by the number of dots on one of the ends.
19. Insert the appropriate sensor body through one of the opening in the top collar and slide the rod into the body. The sensor body should barely cover the mark closes to it. This gives the equipment enough working range to measure compression of the specimen and guarantees the equipment is within working range at the beginning of the test. As the specimen compresses, the sensor rod moves into the body and records axial deflection.
20. Secure the sensor bodies in the top collar with the nylon screws on the sides of the collar.

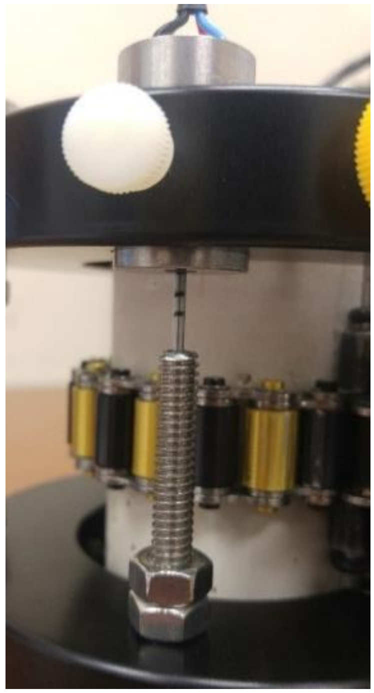


Figure 87: Close view of the sensor rod showing full working range

21. Remove the alignment posts by loosening the thumbscrews and slide the posts away from the specimen.

Figure 88: Close view of the alignment posts

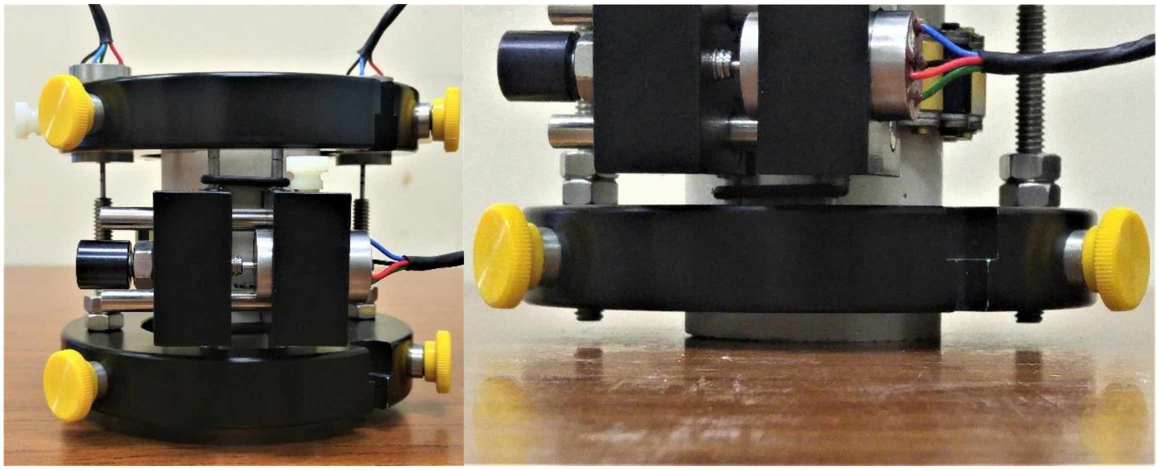


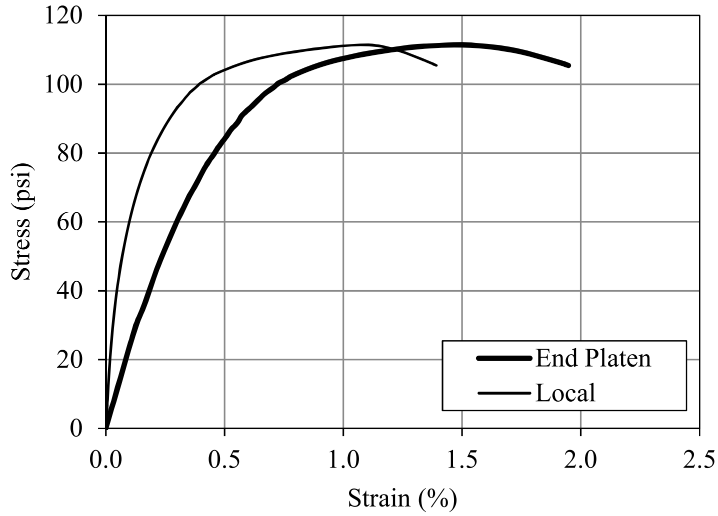
Figure 89: Final set up of the local displacement measurement device before testing with close view of the bottom

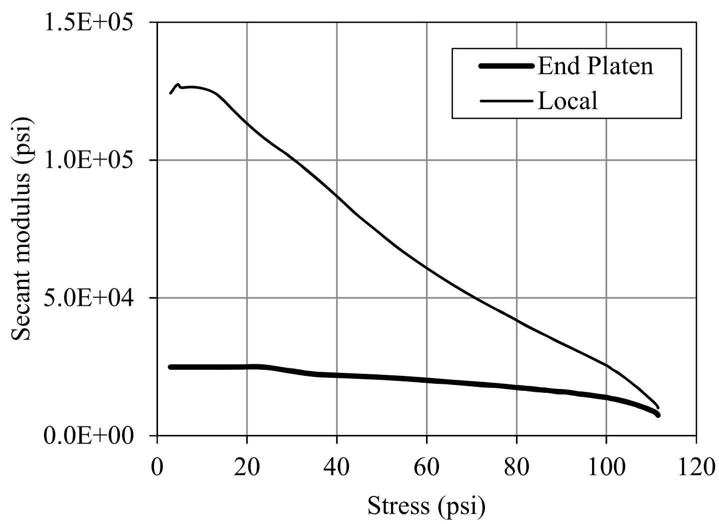
Attachment to testing equipment

22. Connect the sensor bodies to their corresponding channels in the desired ADIO.
23. Carefully place the specimen onto the loading platform. The axial displacement sensors should be positioned perpendicular to the wide axis of the S-type load cell. This prevents deformation from the load cell to influence the deflection registered by the sensors.
24. In the data acquisition software, click on the “options” tab on the top left corner and click on “sensors” to open a window showing the sensors registered.
25. Click on each of the names corresponding to the sensors of the equipment, one at the time, and click the “test” button on the window.
26. Another window showing the deflection being registered and the voltage will open.
27. Use a pair of tweezers to slightly lift each sensor rod in the axial sensors to confirm they are both connected to the right channel and they are reading changes in voltage. The rods should only be lifted a small amount. Drop them inside the stem to confirm they are not getting stuck inside the sensor body. A slight sound of metals hitting should be heard every time the rod is dropped. Repeat this step 3 – 4 times.
28. Select the name of the sensor corresponding to the radial sensor and select “test” to open the same window as before for this sensor. Confirm that the sensor is within range by checking the voltage is higher than negative ten.
29. Close the “test” and the “sensors” windows.
30. Start test.

Appendix F: Unconfined Compressive Strength Tests Data Sheets and Results

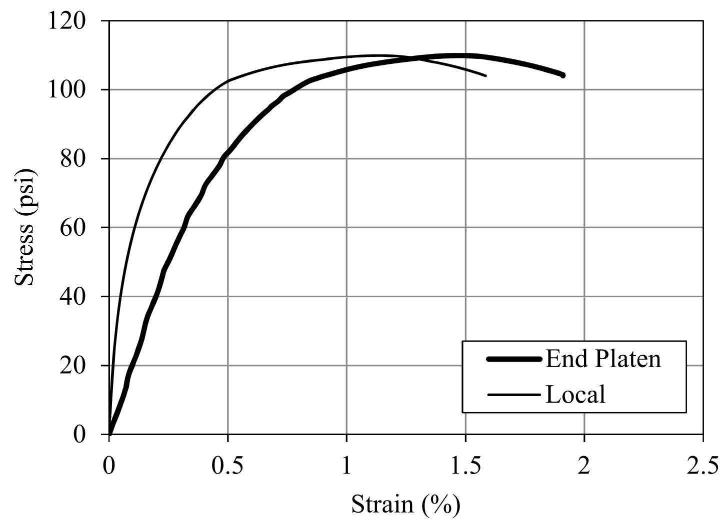
Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-1-E	
Curing Period:	3 day	
Test Date:	11/3/2016	
$\alpha_{in\text{-}place}$:	200	
$(w{:}c)_{slurry}$:	1.0	
End Treatment:	Sawing and Trimming	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.83	in
Diameter (initial):	2.036	in
Weight:	360.0	g
Unit Weight:	110	pcf
Gage Length:	2.815	in
Test Summary		
Peak Stress:	111	psi
Secant Modulus E_{50EP}:	20,559	psi
Secant Modulus E_{50L}:	65,497	psi
Poisson's Ratio ν_{50} :	0.14	
Poisson's Ratio ν_f :	0.30	
Local Strain at failure, ε_f :	1.51	%
End Platen Strain at failure, ε_f :	1.11	%

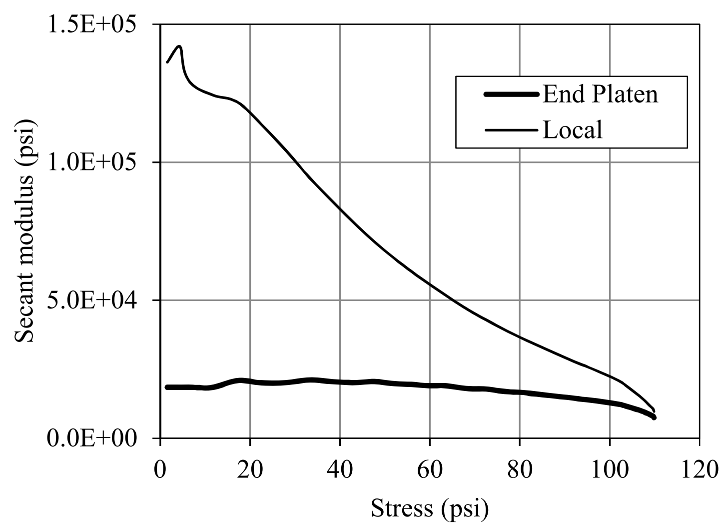


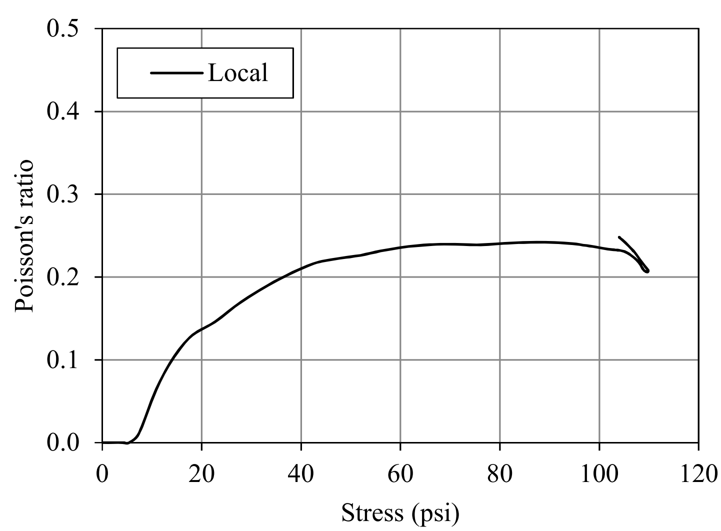


Batch E-1

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-1-F	
Curing Period:	3 day	
Test Date:	11/3/2016	
$\alpha_{in\text{-}place}$:	200	
$(w{:}c)_{slurry}$:	1.0	
End Treatment:	Grinding	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.914	in
Diameter (initial):	2.035	in
Weight:	370.3	g
Unit Weight:	111	pcf
Gage Length:	2.89	in
Test Summary		
Peak Stress:	110	psi
Secant Modulus E_{50EP}:	19,563	psi
Secant Modulus E_{50L}:	61,436	psi
Poisson's Ratio ν_{50} :	0.23	
Poisson's Ratio ν_f:	0.21	
Local Strain at failure, ε_f:	1.47	%
End Platen Strain at failure, ε_f:	1.13	%

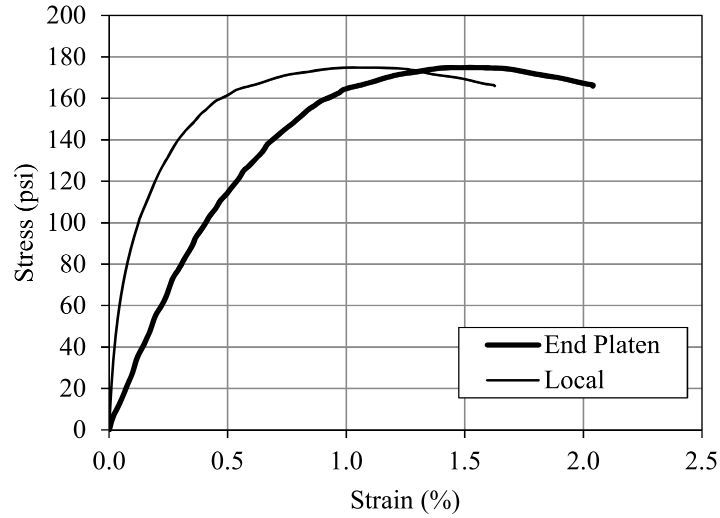


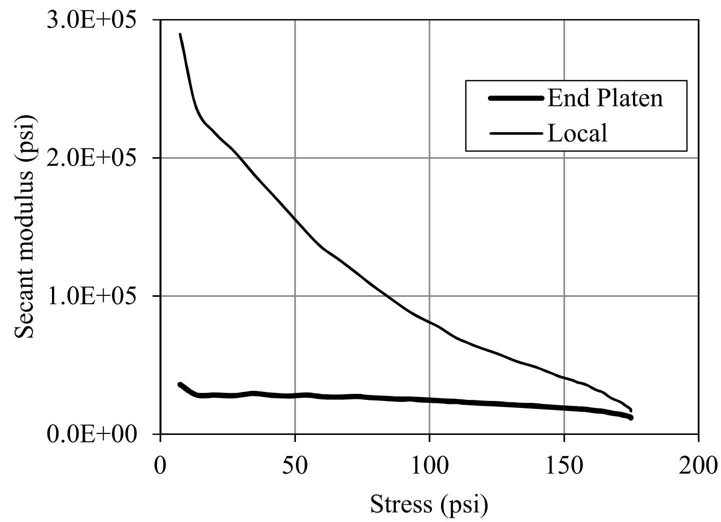


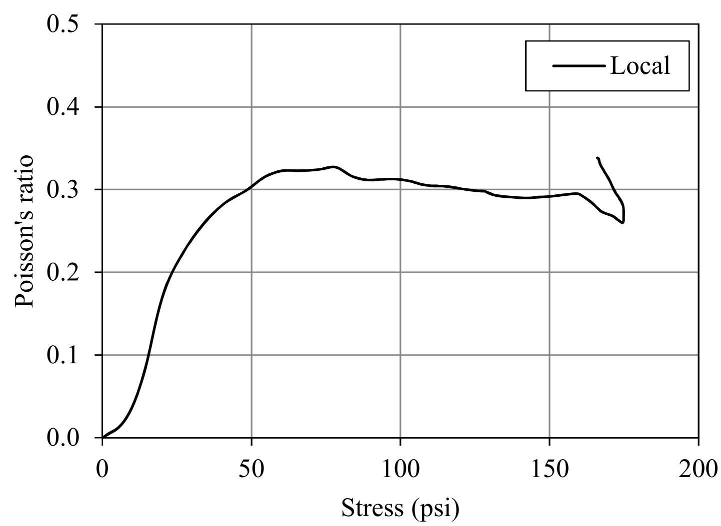


Batch E-1

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-1-A	
Curing Period:	7 day	
Test Date:	11/7/2016	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Sawing & Trimming	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.902	in
Diameter (initial):	2.036	in
Weight:	369.2	g
Unit Weight:	111	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	175	psi
Secant Modulus E_{50EP}:	25,487	psi
Secant Modulus E_{50L}:	95,338	psi
Poisson's Ratio ν_{50} :	0.31	
Poisson's Ratio ν_f :	0.27	
Local Strain at failure, ε_f :	1.49	%
End Platen Strain at failure, ε_f :	1.05	%





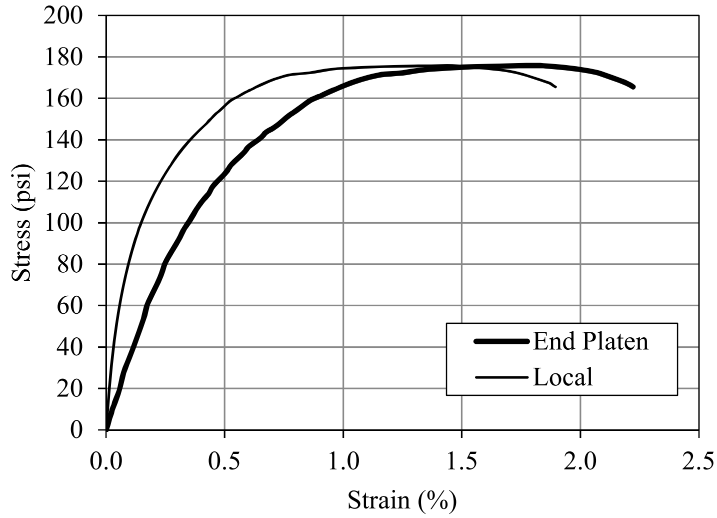


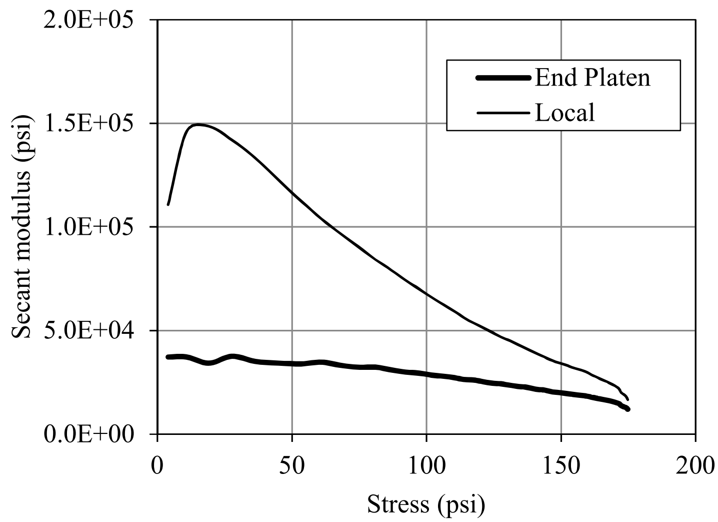
Batch E-1

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-1-B
Curing Period:	7 day
Test Date:	11/7/2016
$\alpha_{in\text{-}place}$:	125
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.941	in
Diameter (initial):	2.041	in
Weight:	372.9	g
Unit Weight:	110	pcf
Gage Length:	2.9	in

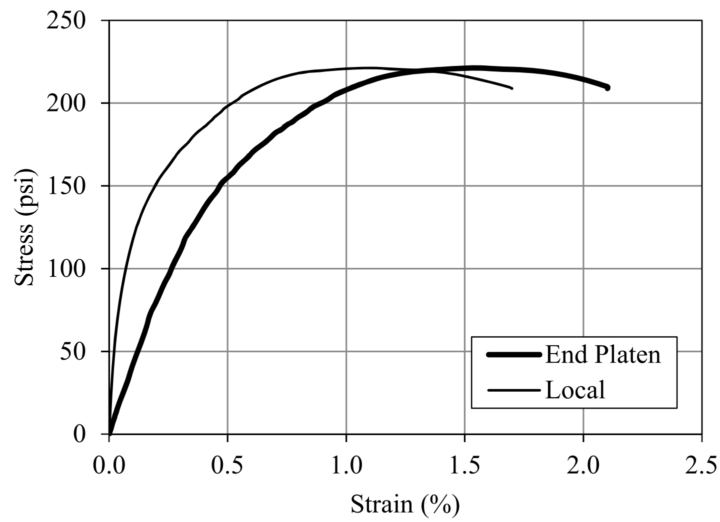
Test Summary		
Peak Stress:	176	psi
Secant Modulus E_{50EP}:	30,769	psi
Secant Modulus E_{50L}:	78,125	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	1.37	%
End Platen Strain at failure, ε_f:	1.76	%

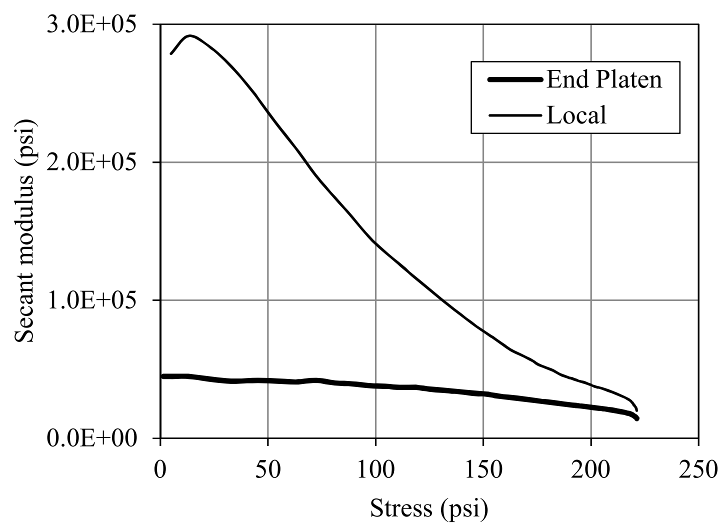


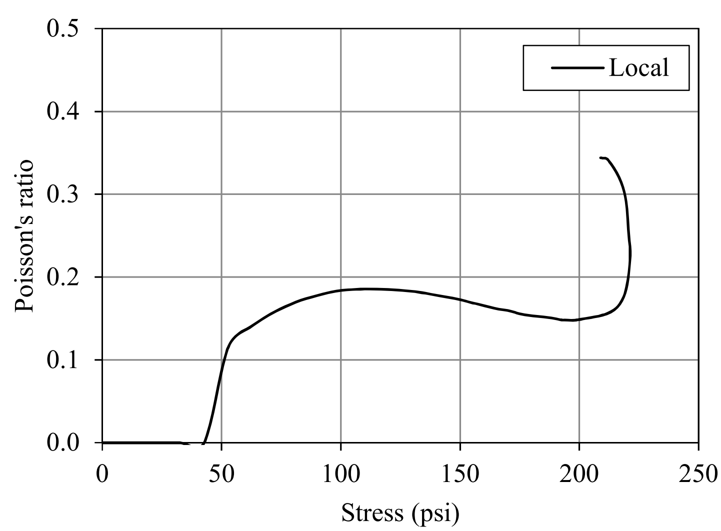


Batch E-1

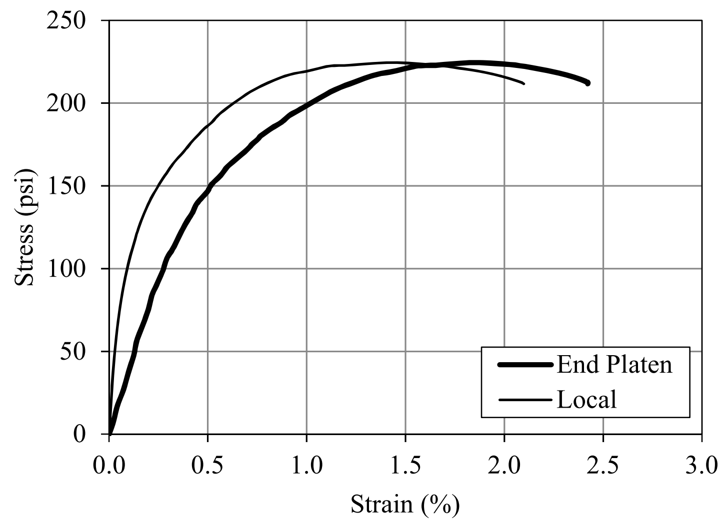
Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-1-G	
Curing Period:	14 day	
Test Date:	11/14/2016	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Sawing & Trimming	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.957	in
Diameter (initial):	2.037	in
Weight:	374.32	g
Unit Weight:	111	pcf
Gage Length:	2.9	in
Test Summary		
Peak Stress:	221	psi
Secant Modulus E_{50EP}:	36,952	psi
Secant Modulus E_{50L}:	126,440	psi
Poisson's Ratio ν_{50} :	0.19	
Poisson's Ratio ν_f:	0.23	
Local Strain at failure, ε_f:	1.55	%
End Platen Strain at failure, ε_f:	1.10	%

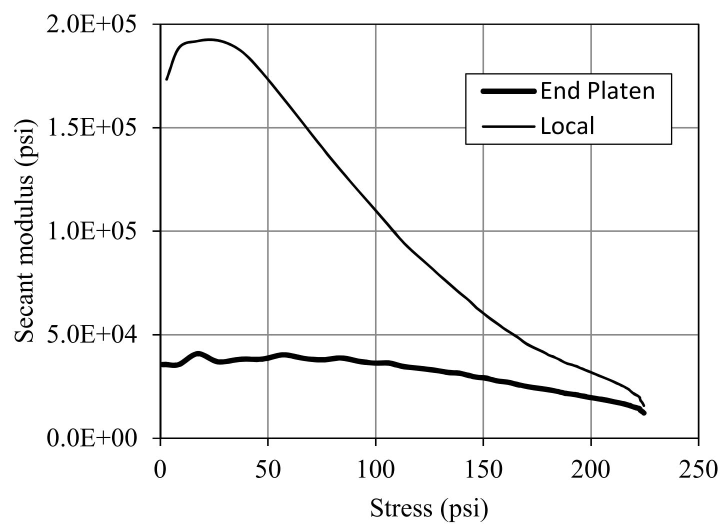


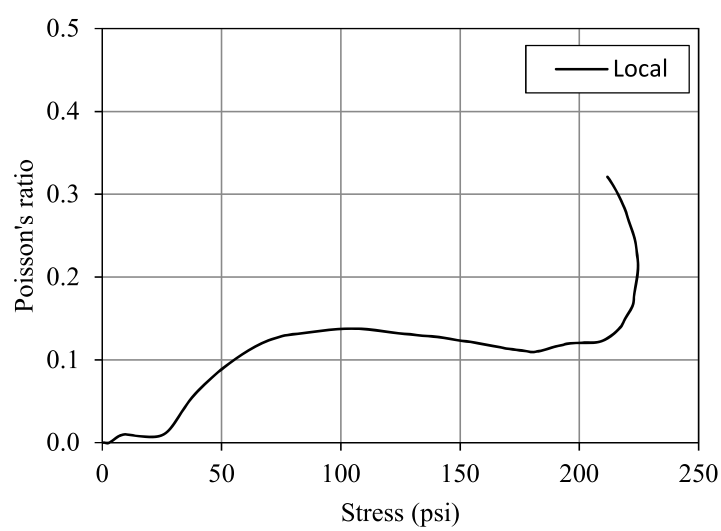




Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-1-H	
Curing Period:	14 day	
Test Date:	11/14/2016	
$\alpha_{in\text{-}place}$:	200	
$(w{:}c)_{slurry}$:	1.0	
End Treatment:	Grinding	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.949	in
Diameter (initial):	2.043	in
Weight:	372.5	g
Unit Weight:	110	pcf
Gage Length:	2.9	in
Test Summary		
Peak Stress:	225	psi
Secant Modulus E_{50EP}:	34,721	psi
Secant Modulus E_{50L}:	95,236	psi
Poisson's Ratio ν_{50} :	0.14	
Poisson's Ratio ν_f :	0.21	
Local Strain at failure, ε_f :	1.85	%
End Platen Strain at failure, ε_f :	1.43	%

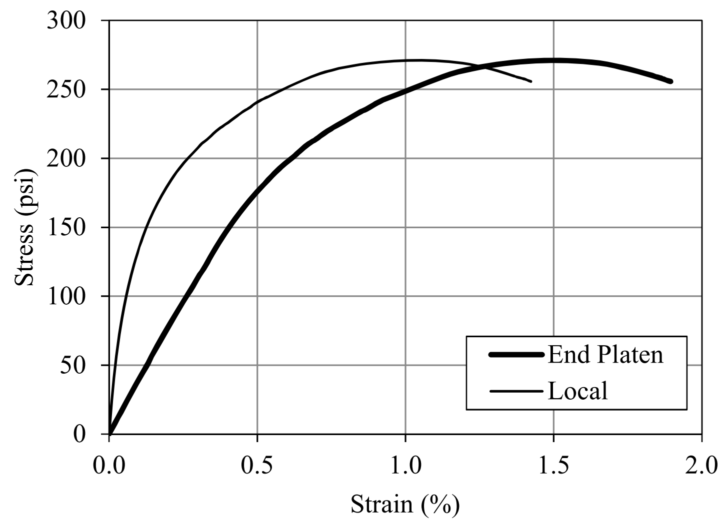


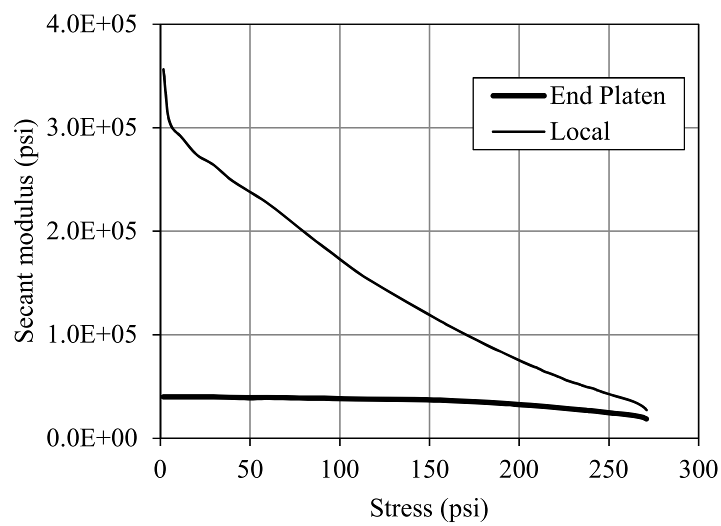


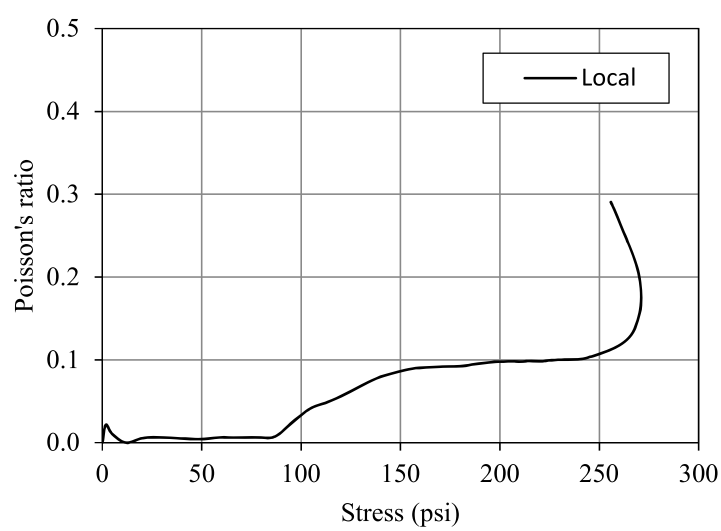


Batch E-1

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-1-C	
Curing Period:	28 day	
Test Date:	11/28/2016	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Sawing & Trimming	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.923	in
Diameter (initial):	2.037	in
Weight:	371.2	g
Unit Weight:	111	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	271	psi
Secant Modulus E_{50EP}:	37,537	psi
Secant Modulus E_{50L}:	133,179	psi
Poisson's Ratio ν_{50} :	0.07	
Poisson's Ratio ν_f :	0.17	
Local Strain at failure, ε_f :	1.45	%
End Platen Strain at failure, ε_f :	0.99	%



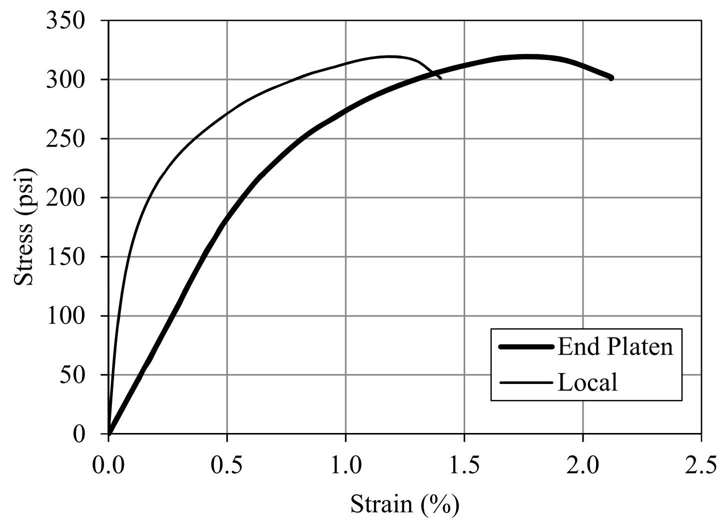


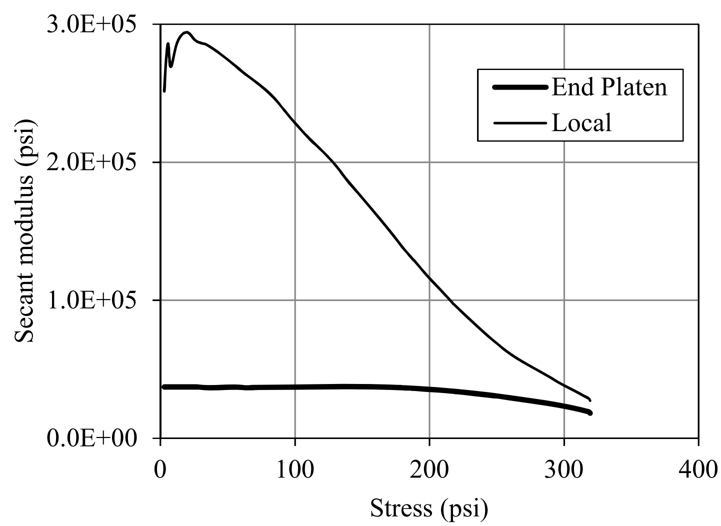


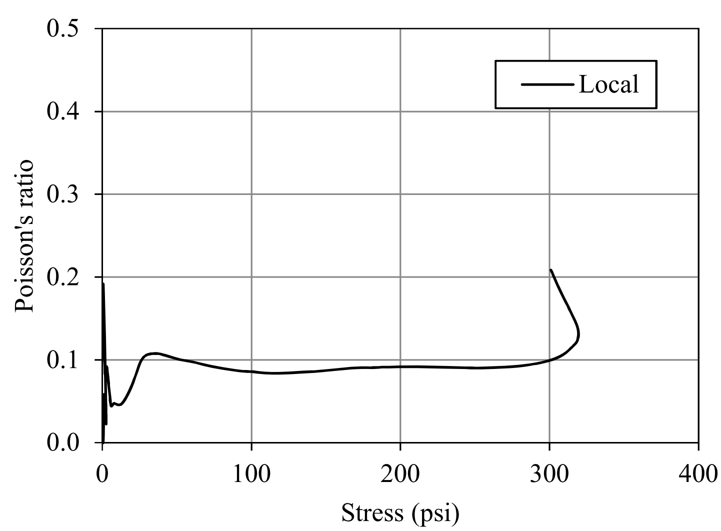
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-2-E
Curing Period:	3 day
Test Date:	11/5/2016
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sawing and Trimming
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.933	in
Diameter (initial):	2.035	in
Weight:	354.5	g
Unit Weight:	106	pcf
Gage Length:	2.9	in

Test Summary		
Peak Stress:	319	psi
Secant Modulus E_{50EP}:	37,253	psi
Secant Modulus E_{50L}:	162,772	psi
Poisson's Ratio ν_{50} :	0.09	
Poisson's Ratio ν_f:	0.13	
Local Strain at failure, ε_f:	1.76	%
End Platen Strain at failure, ε_f:	1.18	%

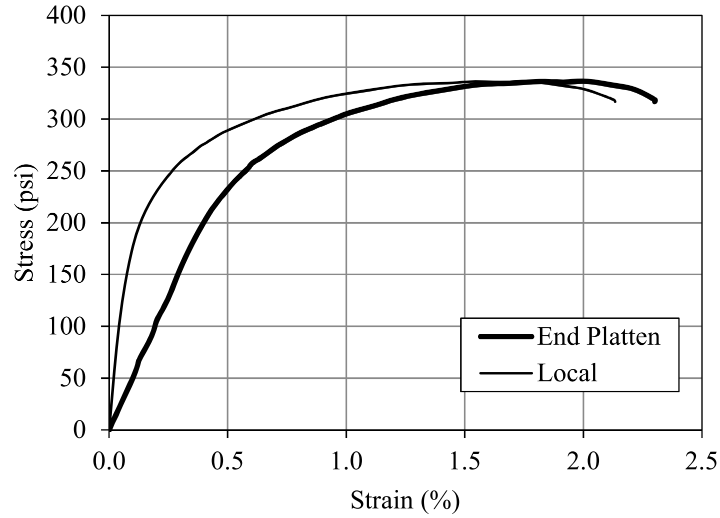


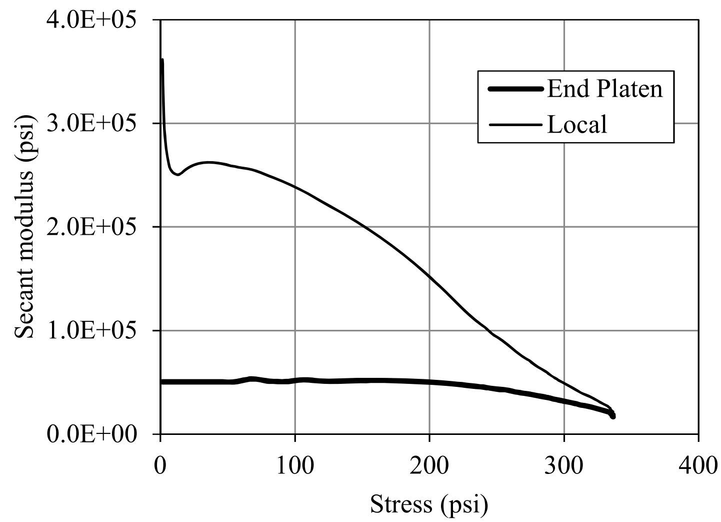


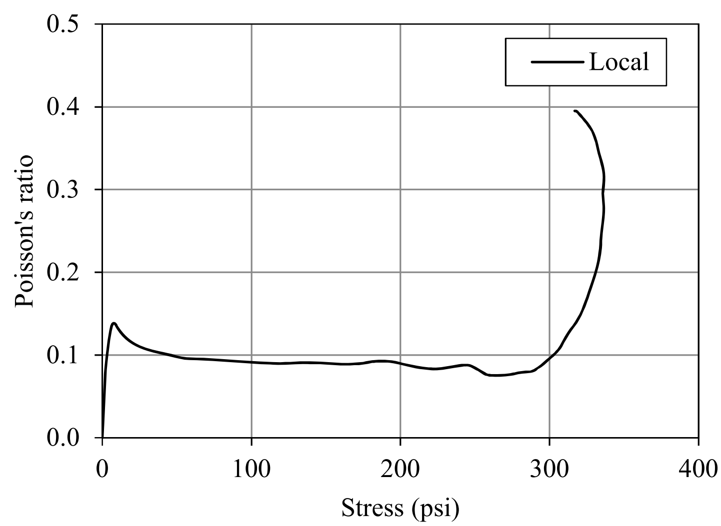


Batch E-2

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-2-F	
Curing Period:	3 day	
Test Date:	11/5/2016	
$\alpha_{in\text{-}place}$:	200	
$(w{:}c)_{slurry}$:	1.0	
End Treatment:	Grinding	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.945	in
Diameter (initial):	2.042	in
Weight:	355.6	g
Unit Weight:	105	pcf
Gage Length:	2.91	in
Test Summary		
Peak Stress:	336	psi
Secant Modulus E_{50EP}:	51,755	psi
Secant Modulus E_{50L}:	185,042	psi
Poisson's Ratio ν_{50} :	0.09	
Poisson's Ratio ν_f:	0.32	
Local Strain at failure, ε_f:	2.01	%
End Platen Strain at failure, ε_f:	1.77	%





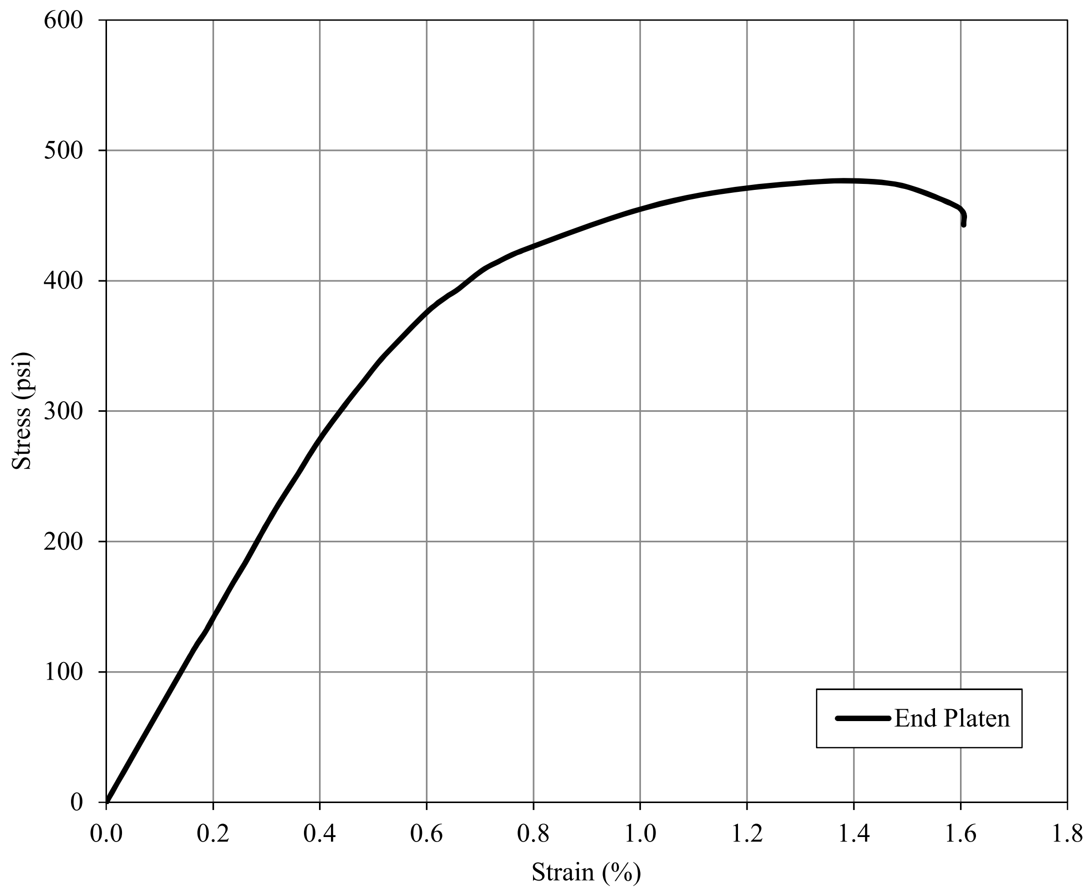


Batch E-2

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-2-I
Curing Period:	7 day
Test Date:	11/9/2016
$\alpha_{in\text{-}place}$:	350
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Sawing & Trimming
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

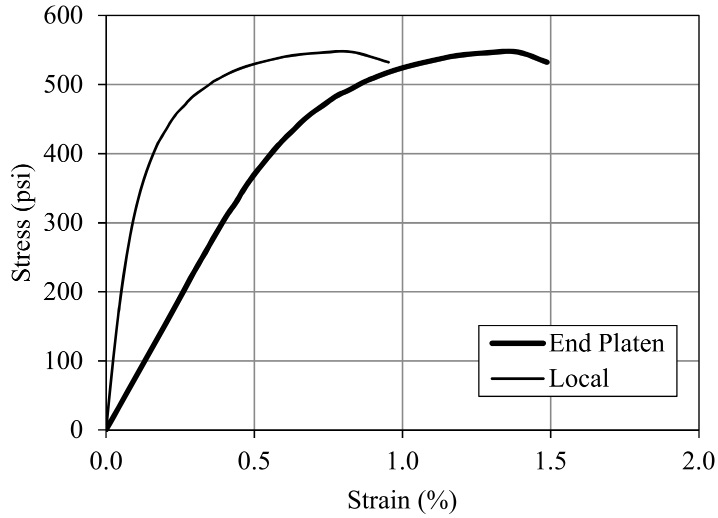
Specimen Information		
Height (initial):	3.89	in
Diameter (initial):	2.038	in
Weight:	351.9	g
Unit Weight:	106	pcf
Gage Length:	N/A	in

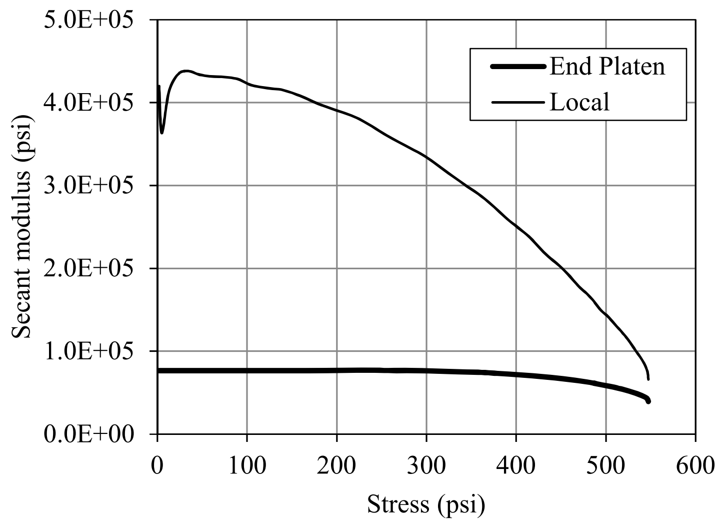
Test Summary		
Peak Stress:	477	psi
Secant Modulus E_{50EP}:	70,561	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.39	%



Batch E-2

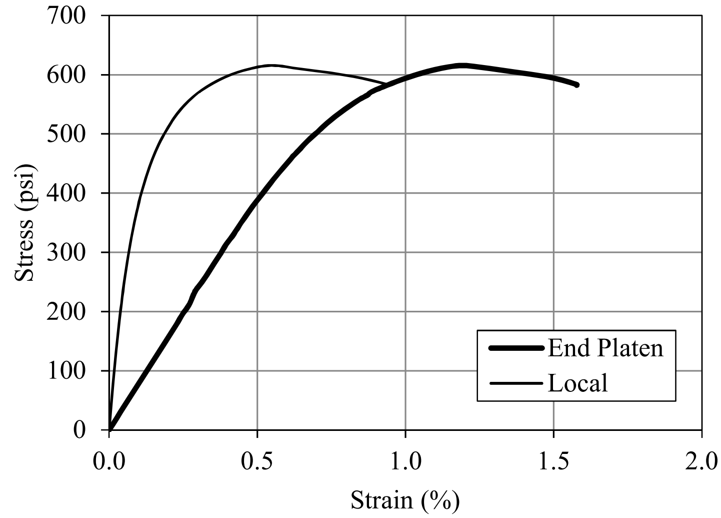
Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-2-B	
Curing Period:	7 day	
Test Date:	11/9/2016	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Grinding	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.967	in
Diameter (initial):	2.039	in
Weight:	358.7	g
Unit Weight:	105	pcf
Gage Length:	2.95	in
Test Summary		
Peak Stress:	547	psi
Secant Modulus E_{50EP}:	76,718	psi
Secant Modulus E_{50L}:	349,699	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	1.39	%
End Platen Strain at failure, ε_f:	0.83	%

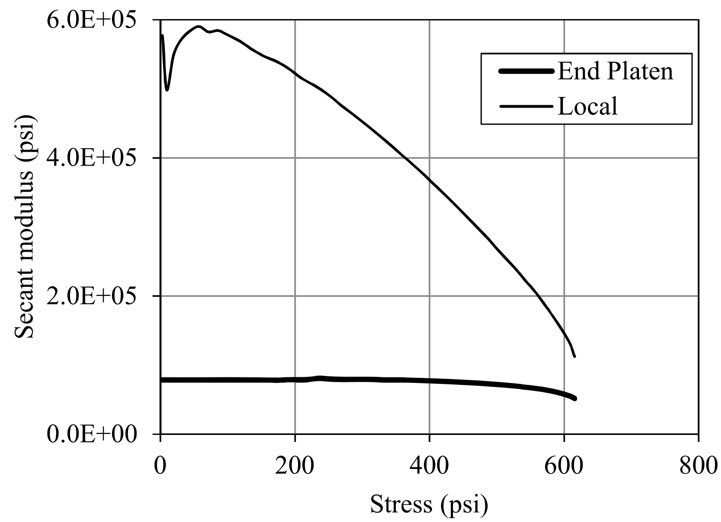




Batch E-2

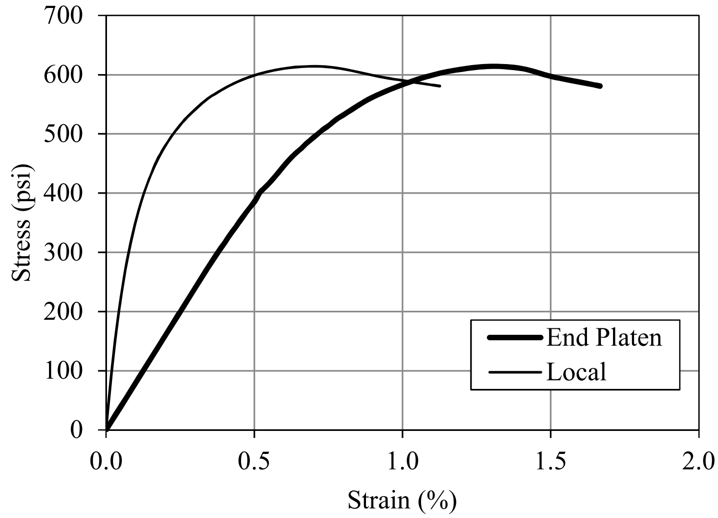
Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-2-G	
Curing Period:	14 day	
Test Date:	11/16/2016	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Sawing & Trimming	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.938	in
Diameter (initial):	2.035	in
Weight:	355.5	g
Unit Weight:	106	pcf
Gage Length:	2.9	in
Test Summary		
Peak Stress:	616	psi
Secant Modulus E_{50EP}:	79,275	psi
Secant Modulus E_{50L}:	446,165	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	1.19	%
End Platen Strain at failure, ε_f:	0.55	%

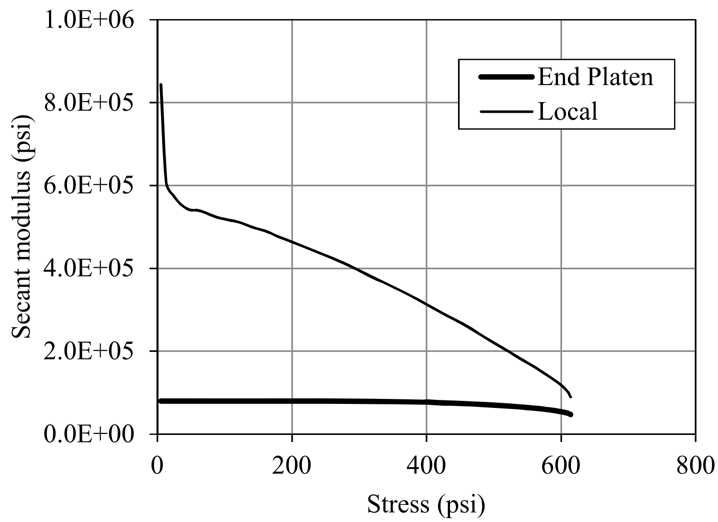


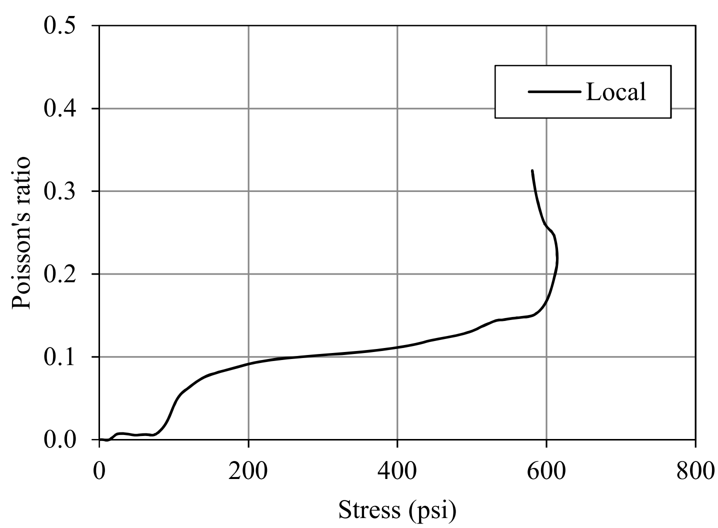


Batch E-2

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-2-H	
Curing Period:	14 day	
Test Date:	11/16/2016	
$\alpha_{in\text{-}place}$:	200	
$(w{:}c)_{slurry}$:	1.0	
End Treatment:	Grinding	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.955	in
Diameter (initial):	2.041	in
Weight:	357.3	g
Unit Weight:	105	pcf
Gage Length:	2.9	in
Test Summary		
Peak Stress:	614	psi
Secant Modulus E_{50EP}:	79,287	psi
Secant Modulus E_{50L}:	388,365	psi
Poisson's Ratio ν_{50} :	0.10	
Poisson's Ratio ν_f:	0.22	
Local Strain at failure, ε_f:	1.30	%
End Platen Strain at failure, ε_f:	0.68	%





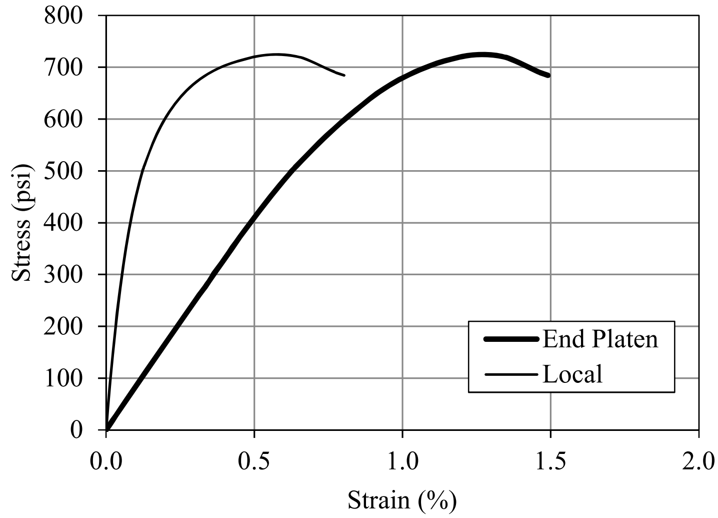


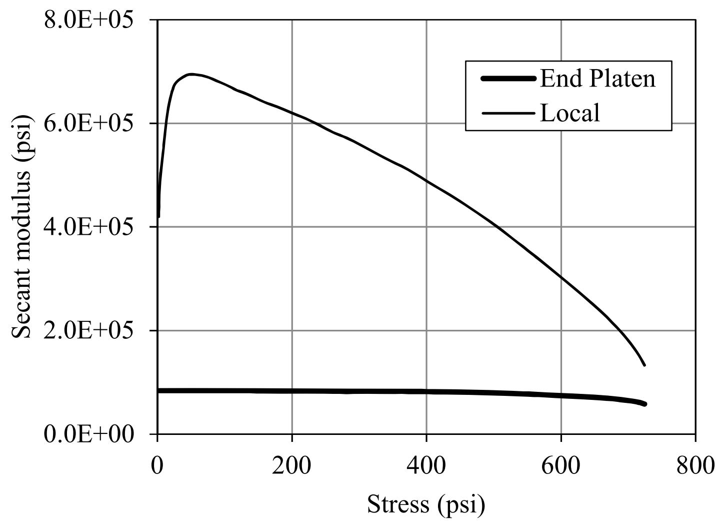
Batch E-2

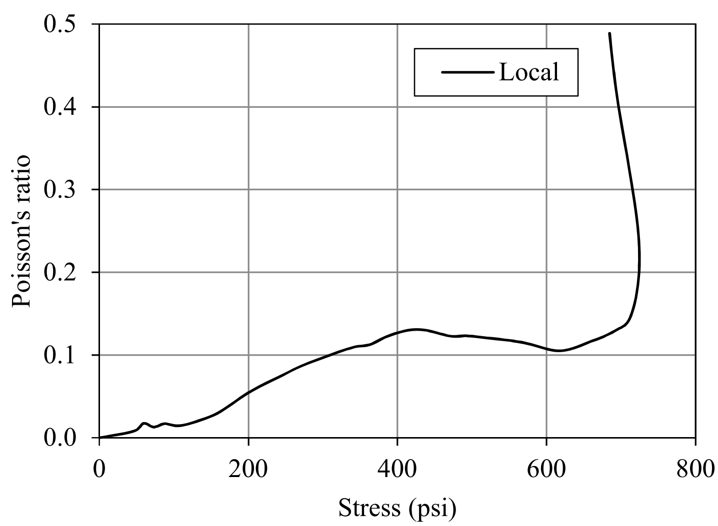
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-2-C
Curing Period:	28 day
Test Date:	11/30/2016
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sawing & Trimming
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.918	in
Diameter (initial):	2.04	in
Weight:	354.1	g
Unit Weight:	105	pcf
Gage Length:	2.85	in

Test Summary		
Peak Stress:	724	psi
Secant Modulus E_{50EP}:	82,632	psi
Secant Modulus E_{50L}:	517,817	psi
Poisson's Ratio ν_{50} :	0.11	
Poisson's Ratio ν_f:	0.20	
Local Strain at failure, ε_f:	1.24	%
End Platen Strain at failure, ε_f:	0.54	%

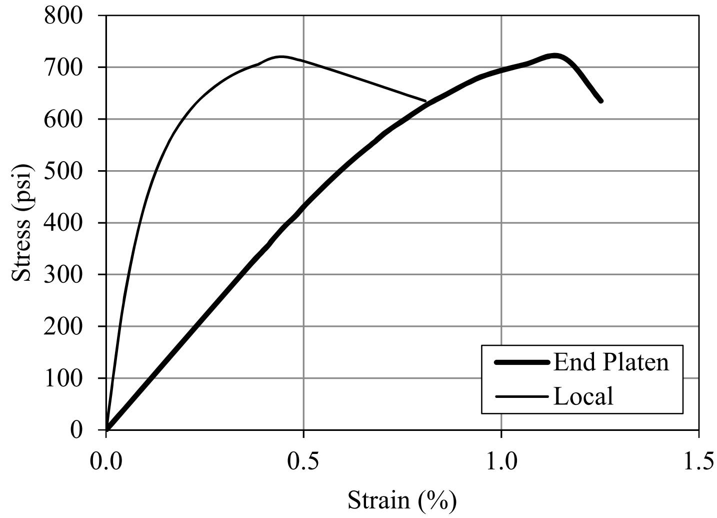


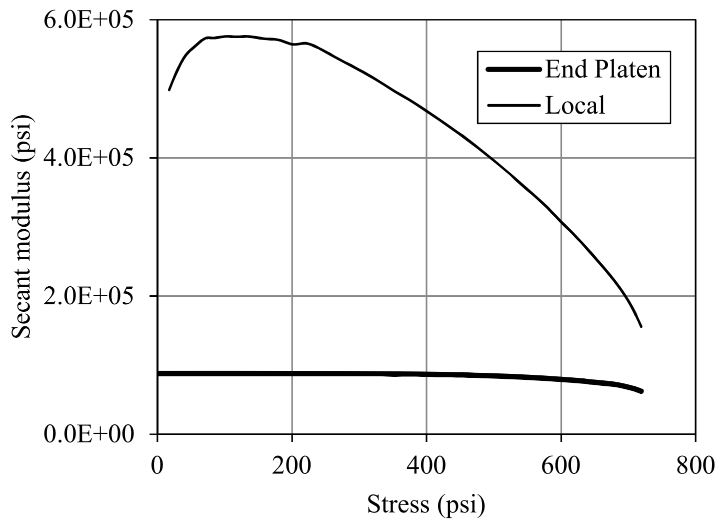


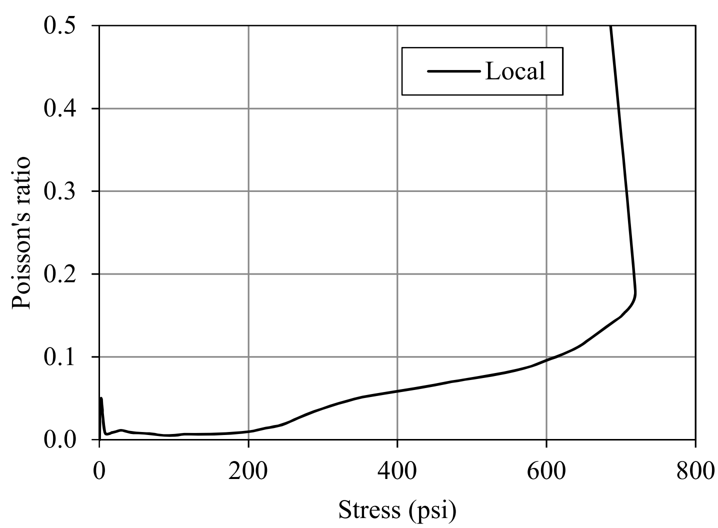


Batch E-2

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-2-D	
Curing Period:	28 day	
Test Date:	11/30/2016	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Grinding	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.915	in
Diameter (initial):	2.037	in
Weight:	353.3	g
Unit Weight:	105	pcf
Gage Length:	2.85	in
Test Summary		
Peak Stress:	719	psi
Secant Modulus E_{50EP}:	86,986	psi
Secant Modulus E_{50L}:	492,150	psi
Poisson's Ratio ν_{50} :	0.05	
Poisson's Ratio ν_f:	0.18	
Local Strain at failure, ε_f:	1.16	%
End Platen Strain at failure, ε_f:	0.46	%





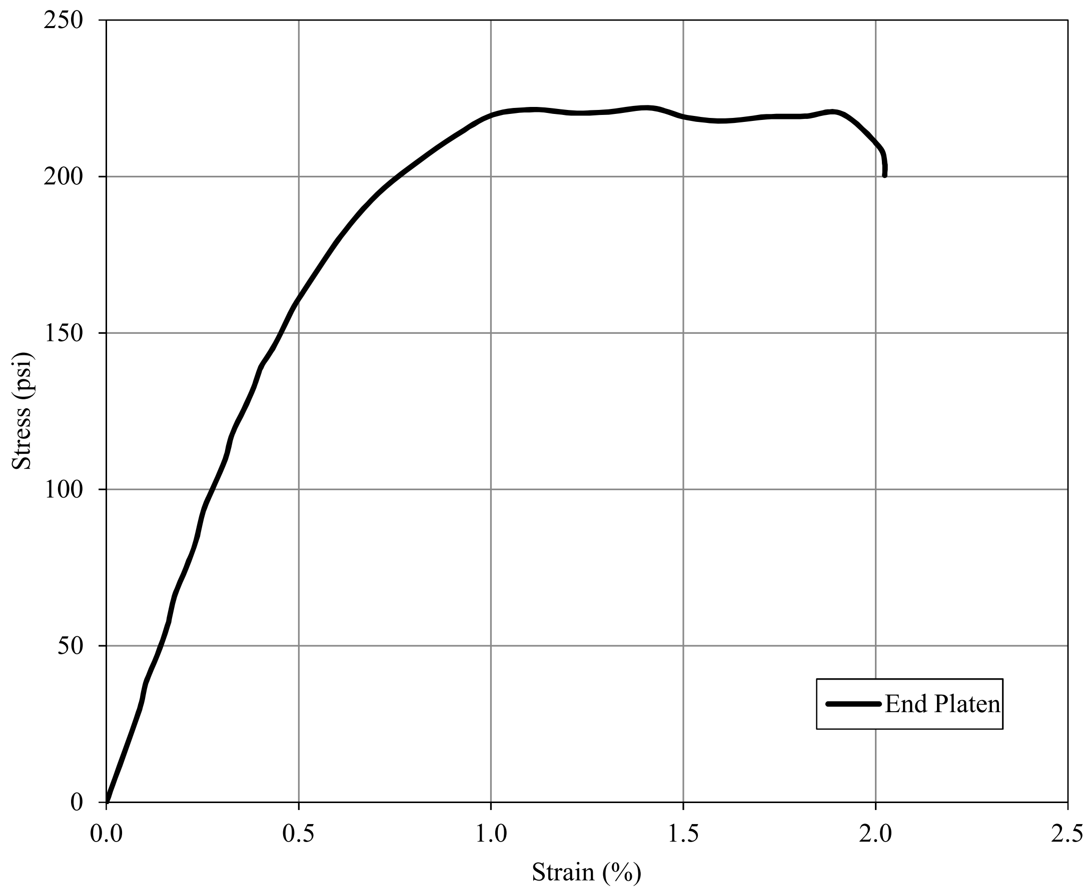


Batch E-3

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-3-E
Curing Period:	3 day
Test Date:	11/8/2016
$\alpha_{in\text{-}place}$:	275
$(w:c)_{slurry}$:	1.0
End Treatment:	Sawing and Trimming
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.941	in
Diameter (initial):	2.036	in
Weight:	362.6	g
Unit Weight:	108	pcf
Gage Length:	N/A	in

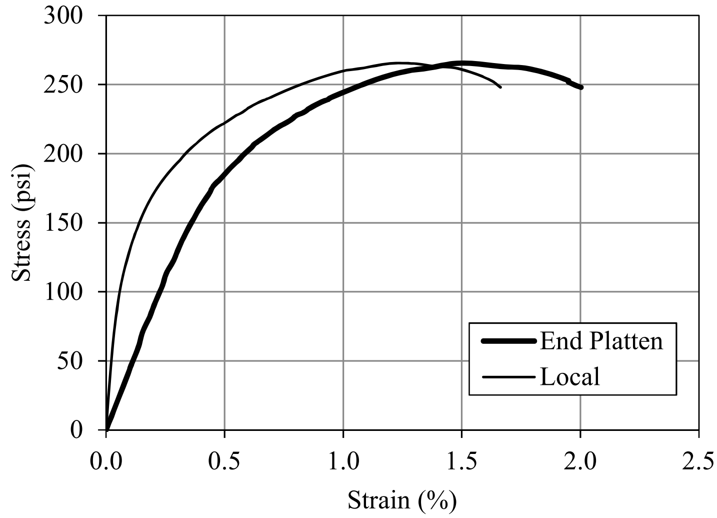
Test Summary		
Peak Stress:	222	psi
Secant Modulus E_{50EP}:	35,563	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.41	%

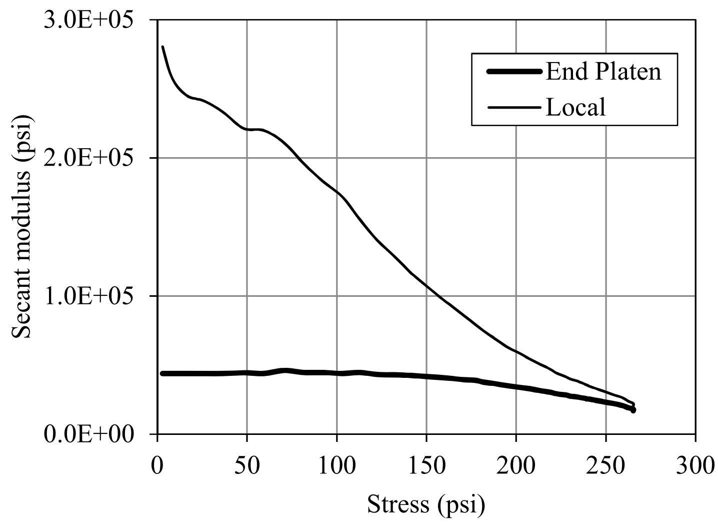


Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-3-F
Curing Period:	3 day
Test Date:	11/8/2016
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.944	in
Diameter (initial):	2.037	in
Weight:	363.6	g
Unit Weight:	108	pcf
Gage Length:	2.9	in

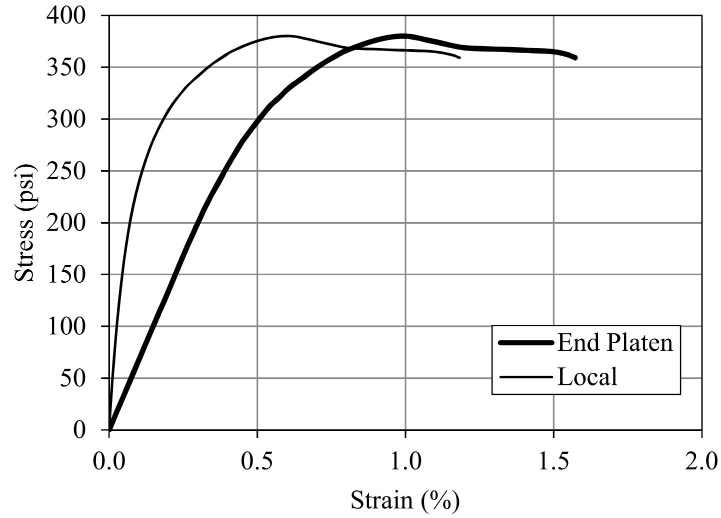
Test Summary		
Peak Stress:	265	psi
Secant Modulus E_{50EP}:	42,927	psi
Secant Modulus E_{50L}:	127,945	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	1.56	%
End Platen Strain at failure, ε_f:	1.30	%

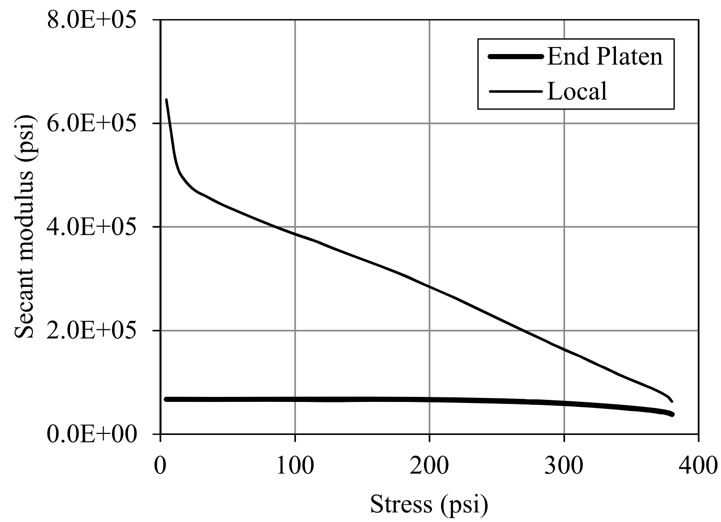


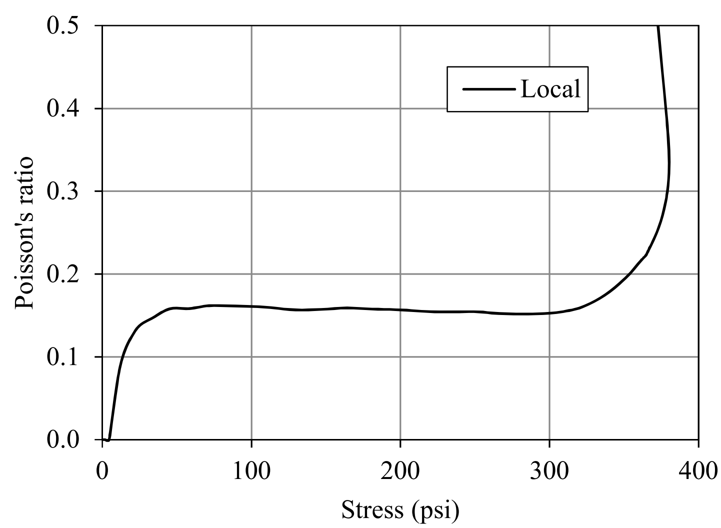


Batch E-3

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-3-A	
Curing Period:	7 day	
Test Date:	11/12/2016	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Sawing & Trimming	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.941	in
Diameter (initial):	2.036	in
Weight:	363.2	g
Unit Weight:	108	pcf
Gage Length:	2.9	in
Test Summary		
Peak Stress:	380	psi
Secant Modulus E_{50EP}:	66,978	psi
Secant Modulus E_{50L}:	295,132	psi
Poisson's Ratio ν_{50} :	0.16	
Poisson's Ratio ν_f:	0.34	
Local Strain at failure, ε_f:	1.00	%
End Platen Strain at failure, ε_f:	0.60	%



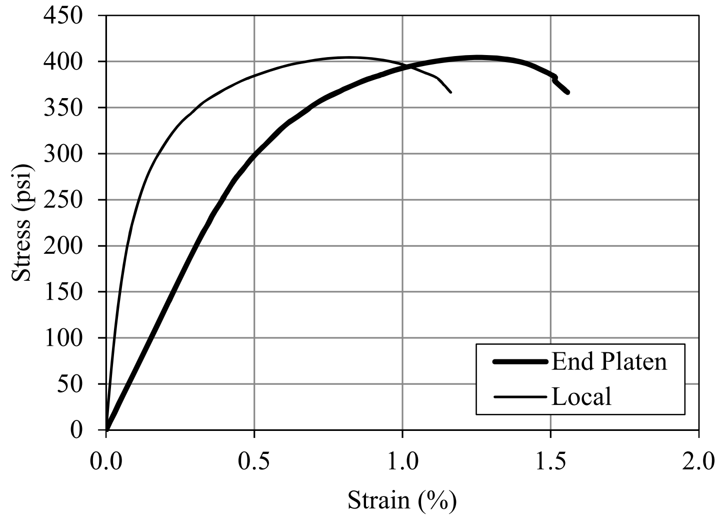


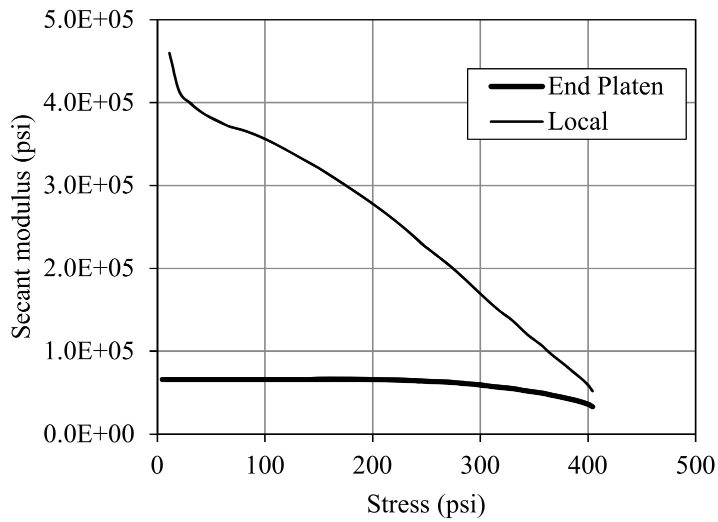


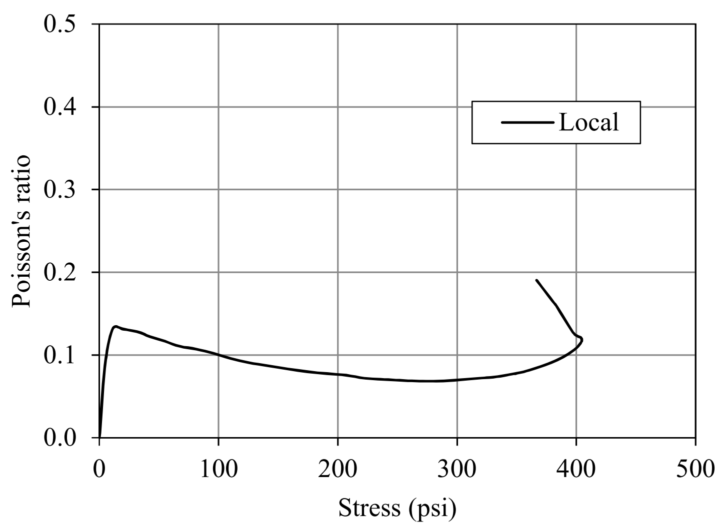
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-3-B
Curing Period:	7 day
Test Date:	11/12/2016
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.955	in
Diameter (initial):	2.035	in
Weight:	364.1	g
Unit Weight:	108	pcf
Gage Length:	2.9	in

Test Summary		
Peak Stress:	404	psi
Secant Modulus E_{50EP}:	65,953	psi
Secant Modulus E_{50L}:	275,589	psi
Poisson's Ratio ν_{50} :	0.08	
Poisson's Ratio ν_f:	0.12	
Local Strain at failure, ε_f:	1.22	%
End Platen Strain at failure, ε_f:	0.78	%

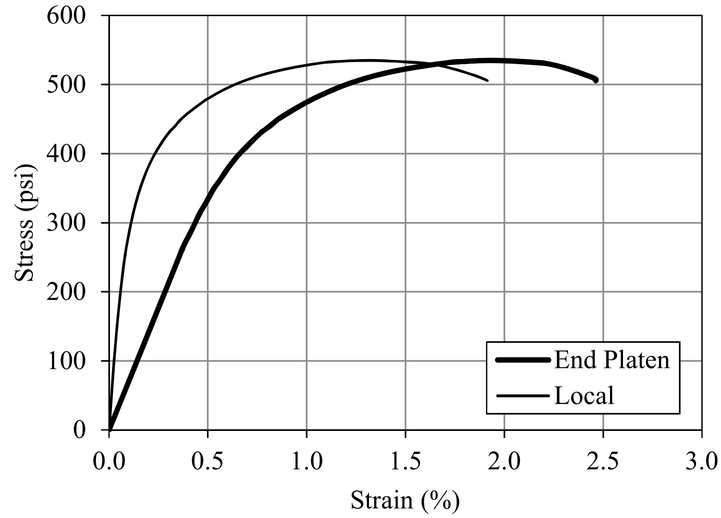


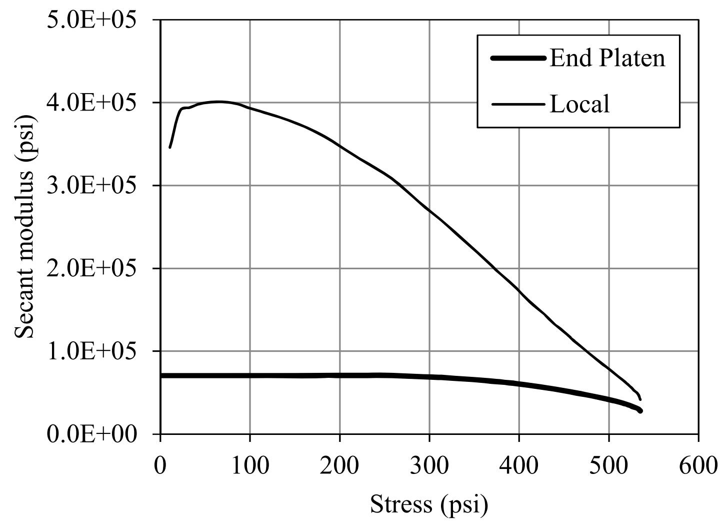


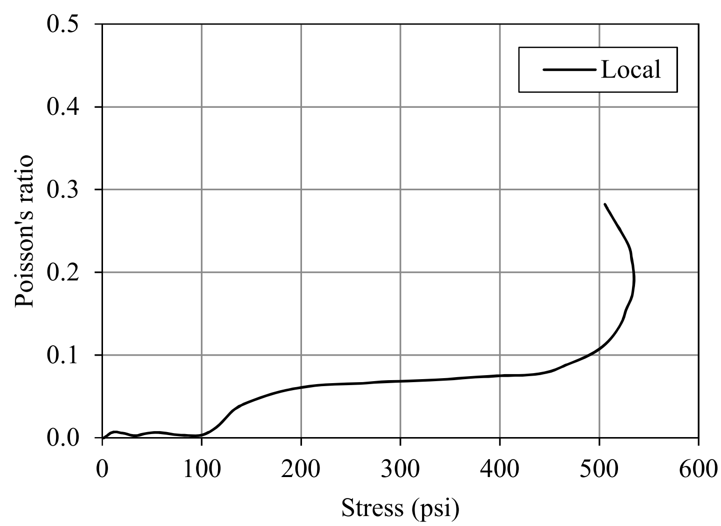


Batch E-3

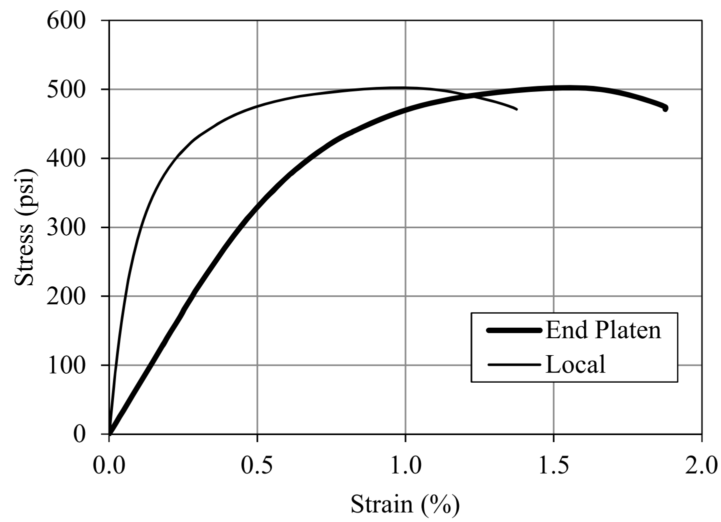
Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-3-G	
Curing Period:	14 day	
Test Date:	11/19/2016	
$\alpha_{in\text{-}place}$:	200	
$(w{:}c)_{slurry}$:	1.0	
End Treatment:	Grinding	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.958	in
Diameter (initial):	2.035	in
Weight:	364.2	g
Unit Weight:	108	pcf
Gage Length:	2.9	in
Test Summary		
Peak Stress:	535	psi
Secant Modulus E_{50EP}:	70,453	psi
Secant Modulus E_{50L}:	299,415	psi
Poisson's Ratio ν_{50} :	0.07	
Poisson's Ratio ν_f :	0.19	
Local Strain at failure, ε_f :	1.92	%
End Platen Strain at failure, ε_f :	1.28	%

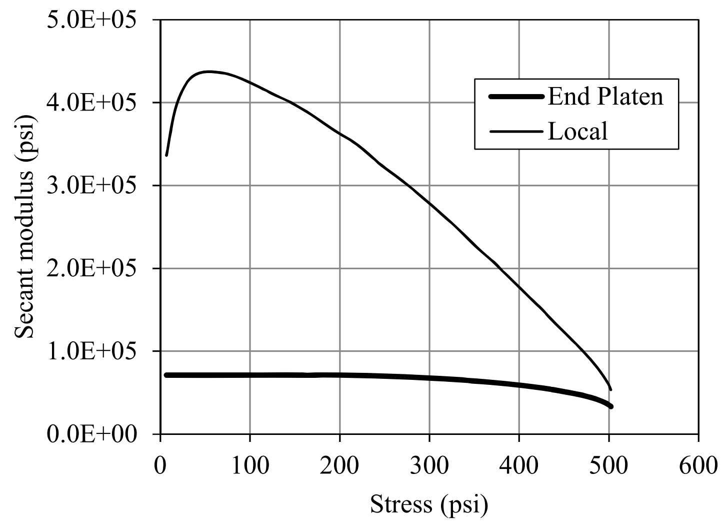






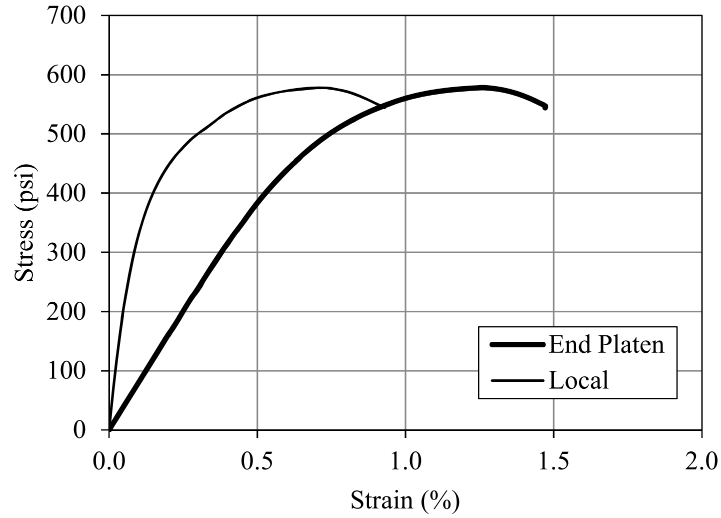
Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-3-H	
Curing Period:	14 day	
Test Date:	11/19/2016	
$\alpha_{in\text{-}place}$:	200	
$(w{:}c)_{slurry}$:	1.0	
End Treatment:	Grinding	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.95	in
Diameter (initial):	2.037	in
Weight:	362.2	g
Unit Weight:	107	pcf
Gage Length:	2.9	in
Test Summary		
Peak Stress:	502	psi
Secant Modulus E_{50EP}:	69,821	psi
Secant Modulus E_{50L}:	320,293	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	1.51	%
End Platen Strain at failure, ε_f:	0.94	%

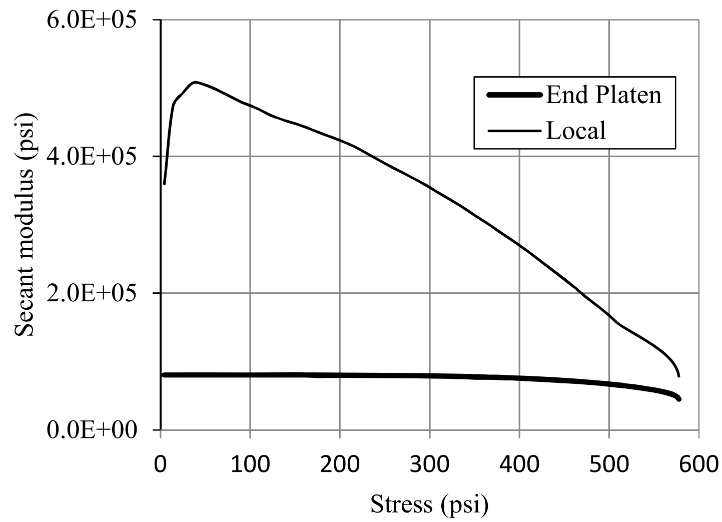


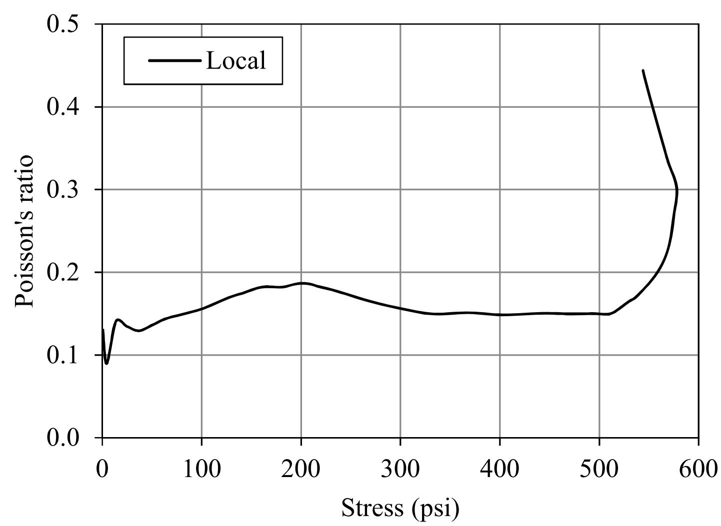


Batch E-3

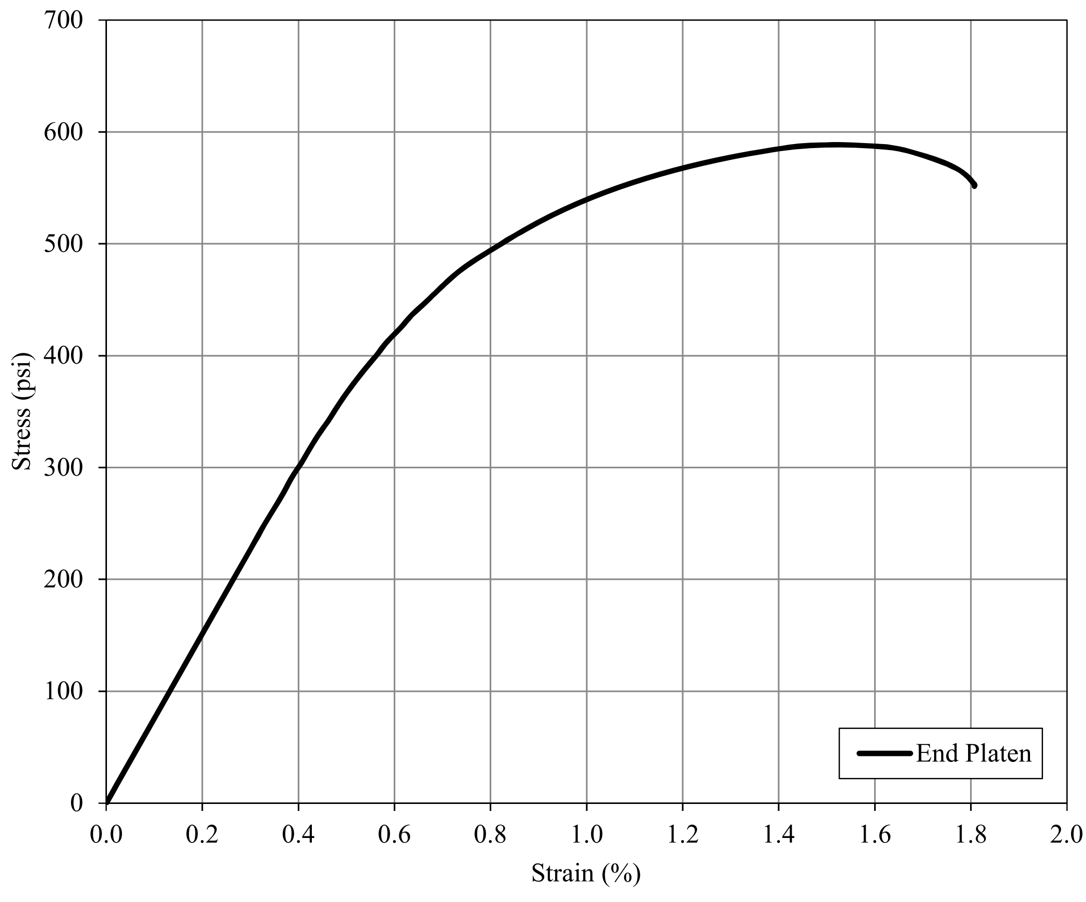
Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-3-C	
Curing Period:	28 day	
Test Date:	12/3/2016	
$\alpha_{in\text{-}place}$:	200	
$(w{:}c)_{slurry}$:	1.0	
End Treatment:	Sawing & Trimming	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.941	in
Diameter (initial):	2.038	in
Weight:	362.6	g
Unit Weight:	107	pcf
Gage Length:	2.85	in
Test Summary		
Peak Stress:	578	psi
Secant Modulus E_{50EP}:	79,417	psi
Secant Modulus E_{50L}:	362,591	psi
Poisson's Ratio ν_{50} :	0.16	
Poisson's Ratio ν_f:	0.30	
Local Strain at failure, ε_f:	1.28	%
End Platen Strain at failure, ε_f:	0.73	%







Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.969	in	Peak Stress:	588	psi
Tested by:	RNG	Diameter (initial):	2.037	in	Secant Modulus E_{50EP}:	75,222	psi
I.D. :	E-3-D	Weight:	365.34	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	108	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	12/3/2016	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.57	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

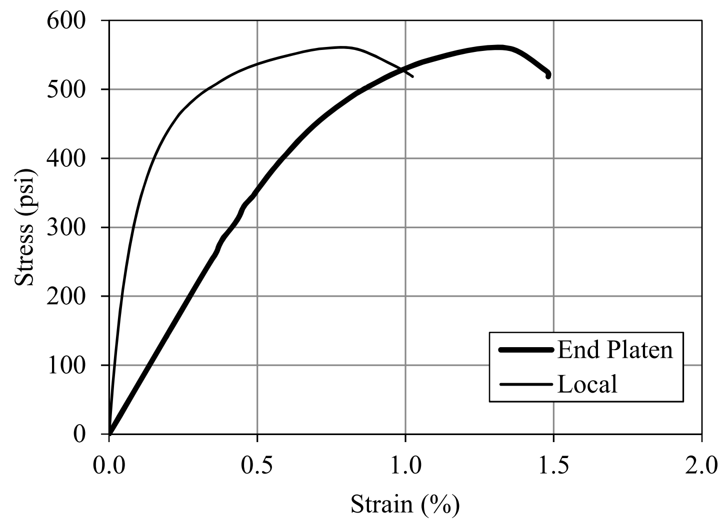


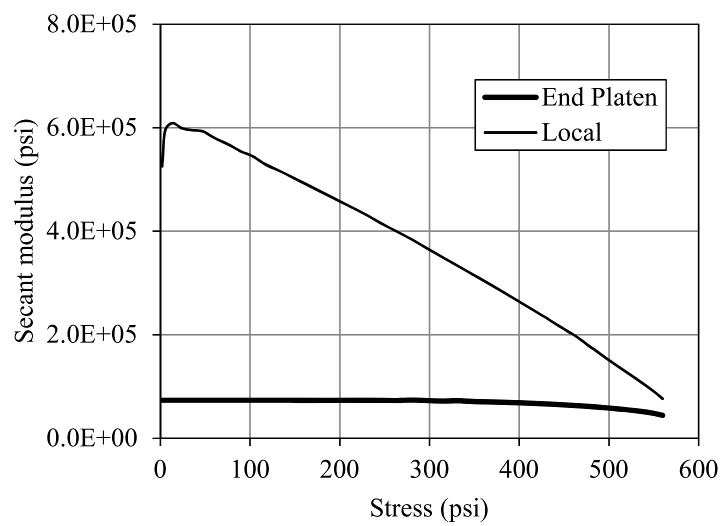
Batch E-3

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-3-I
Curing Period:	28 day
Test Date:	12/3/2016
$\alpha_{in\text{-}place}$:	200
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Sawing & Trimming
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.922	in
Diameter (initial):	2.04	in
Weight:	361.8	g
Unit Weight:	108	pcf
Gage Length:	2.85	in

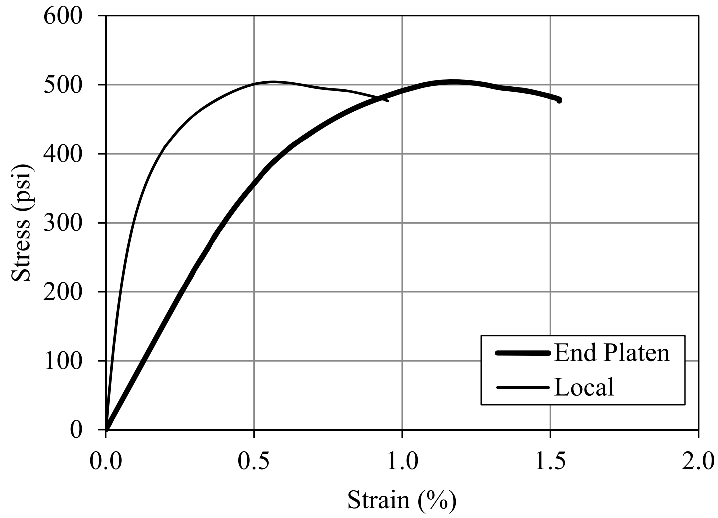
Test Summary		
Peak Stress:	560	psi
Secant Modulus E_{50EP}:	73,921	psi
Secant Modulus E_{50L}:	384,225	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	1.26	%
End Platen Strain at failure, ε_f:	0.74	%

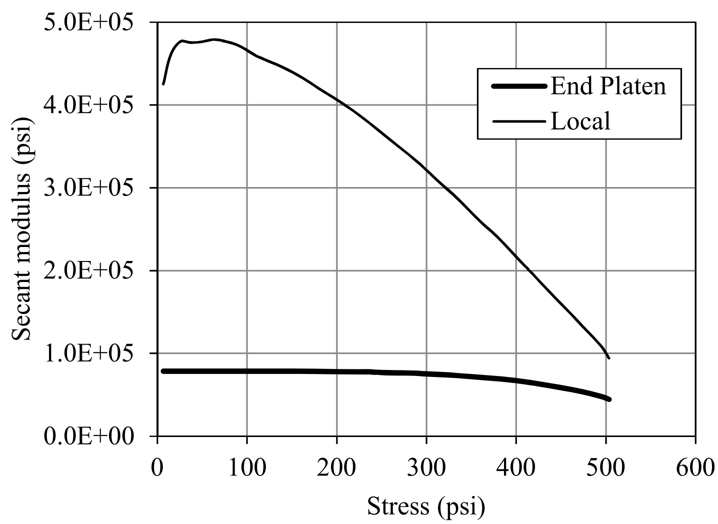




Batch E-3

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-3-J	
Curing Period:	28 day	
Test Date:	12/3/2016	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Grinding	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.94	in
Diameter (initial):	2.038	in
Weight:	362.5	g
Unit Weight:	107	pcf
Gage Length:	2.85	in
Test Summary		
Peak Stress:	503	psi
Secant Modulus E_{50EP}:	76,843	psi
Secant Modulus E_{50L}:	364,402	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	1.13	%
End Platen Strain at failure, ε_f:	0.53	%



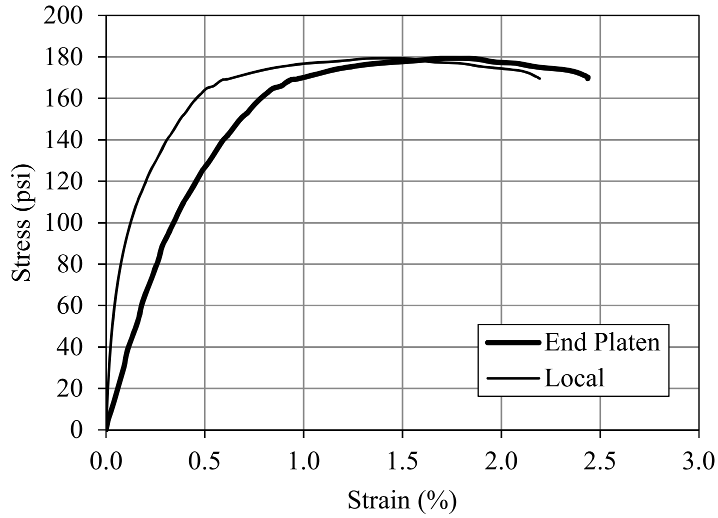


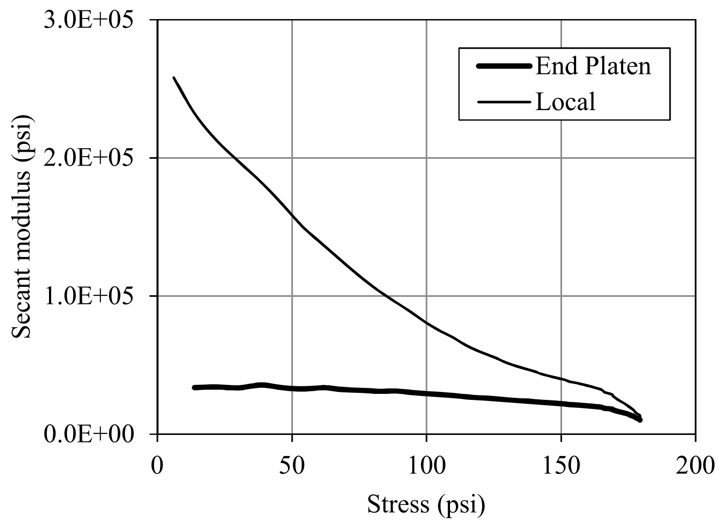
Batch E-4

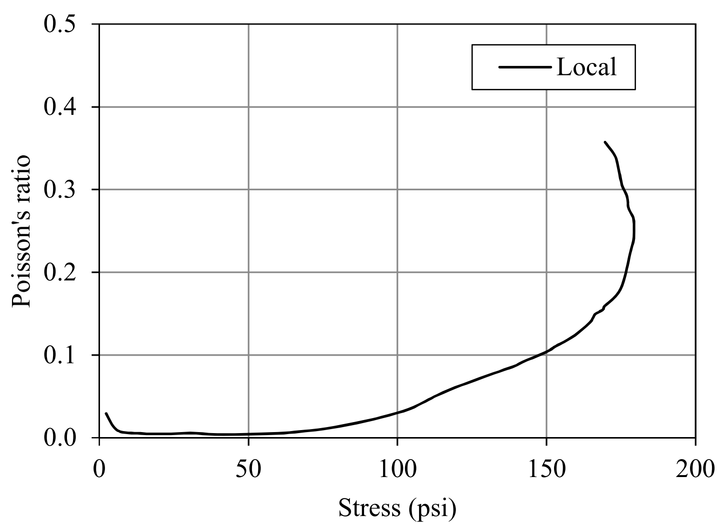
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-4-E
Curing Period:	3 day
Test Date:	11/9/2016
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sawing and Trimming
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.969	in
Diameter (initial):	2.04	in
Weight:	370.7	g
Unit Weight:	109	pcf
Gage Length:	2.9	in

Test Summary		
Peak Stress:	179	psi
Secant Modulus E_{50EP}:	31,015	psi
Secant Modulus E_{50L}:	93,931	psi
Poisson's Ratio ν_{50} :	0.02	
Poisson's Ratio ν_f:	0.25	
Local Strain at failure, ε_f:	1.76	%
End Platen Strain at failure, ε_f:	1.42	%



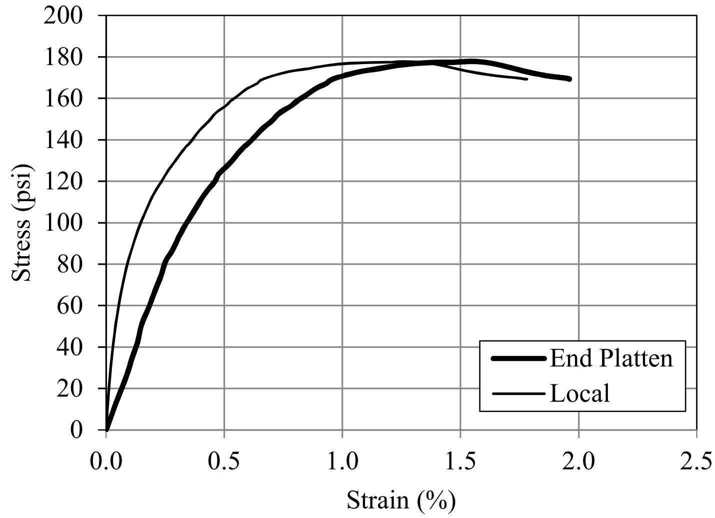


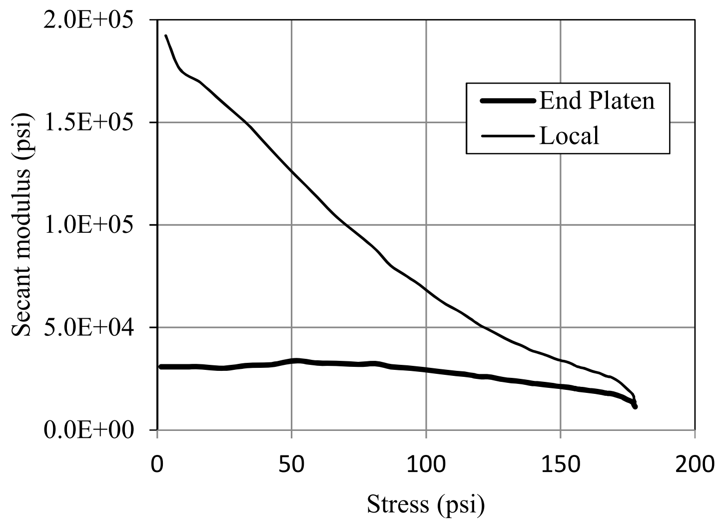


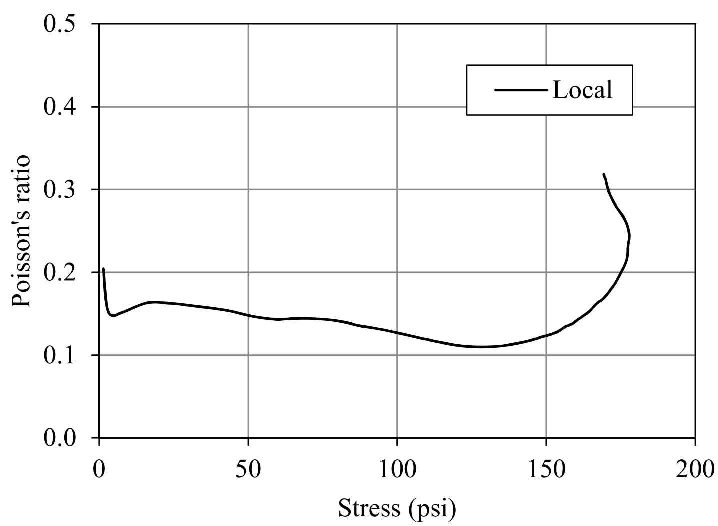
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-4-F
Curing Period:	3 day
Test Date:	11/9/2016
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.975	in
Diameter (initial):	2.039	in
Weight:	371.0	g
Unit Weight:	109	pcf
Gage Length:	2.9	in

Test Summary		
Peak Stress:	178	psi
Secant Modulus E_{50EP}:	30,636	psi
Secant Modulus E_{50L}:	78,196	psi
Poisson's Ratio ν_{50} :	0.13	
Poisson's Ratio ν_f :	0.25	
Local Strain at failure, ε_f :	1.56	%
End Platen Strain at failure, ε_f :	1.29	%

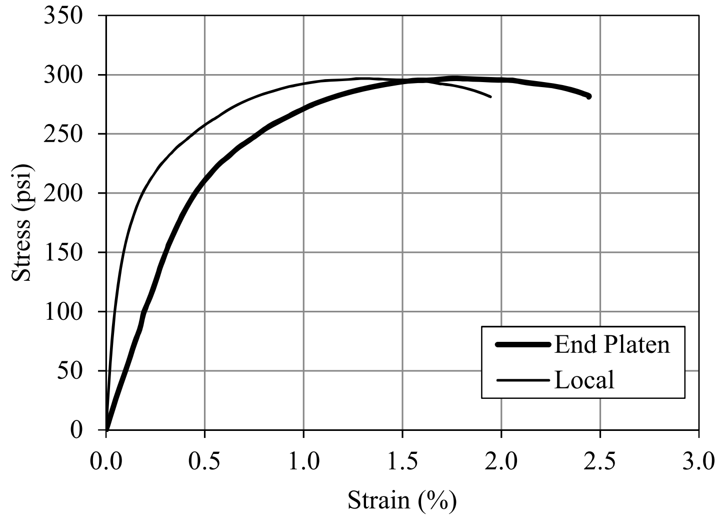


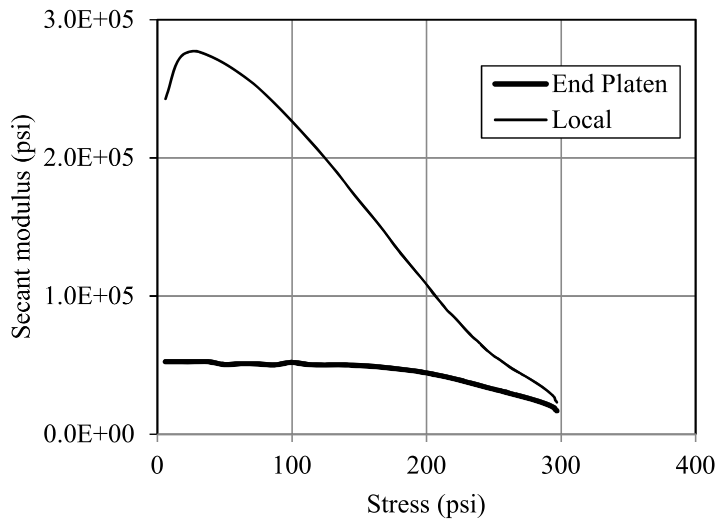


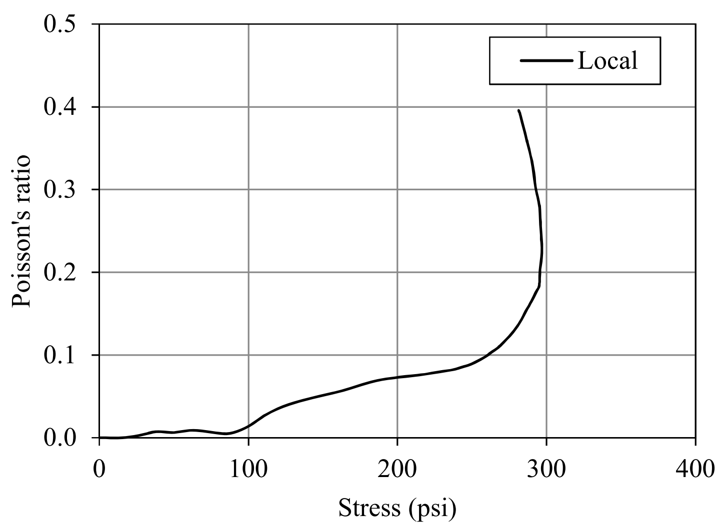


Batch E-4

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-4-A	
Curing Period:	7 day	
Test Date:	11/13/2016	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Sawing & Trimming	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.942	in
Diameter (initial):	2.039	in
Weight:	366.1	g
Unit Weight:	108	pcf
Gage Length:	2.9	in
Test Summary		
Peak Stress:	297	psi
Secant Modulus E_{50EP}:	49,694	psi
Secant Modulus E_{50L}:	170,483	psi
Poisson's Ratio ν_{50} :	0.05	
Poisson's Ratio ν_f:	0.22	
Local Strain at failure, ε_f:	1.75	%
End Platen Strain at failure, ε_f:	1.29	%

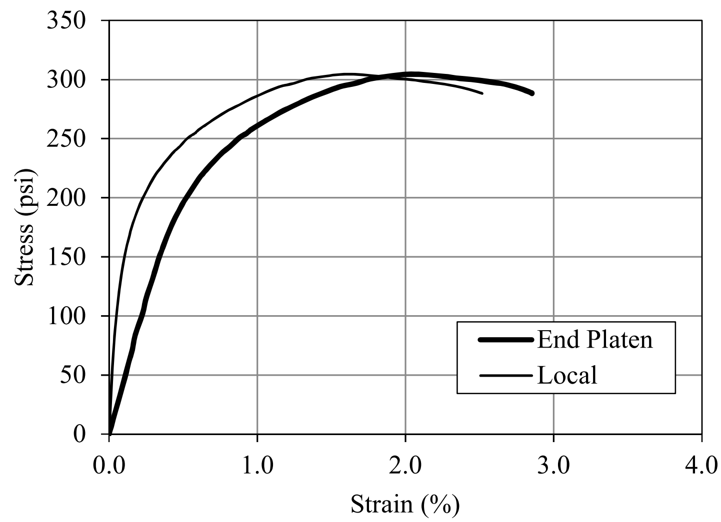


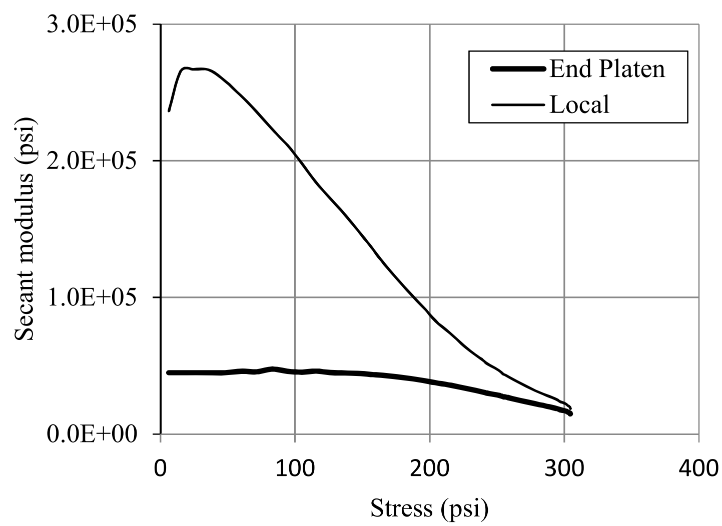


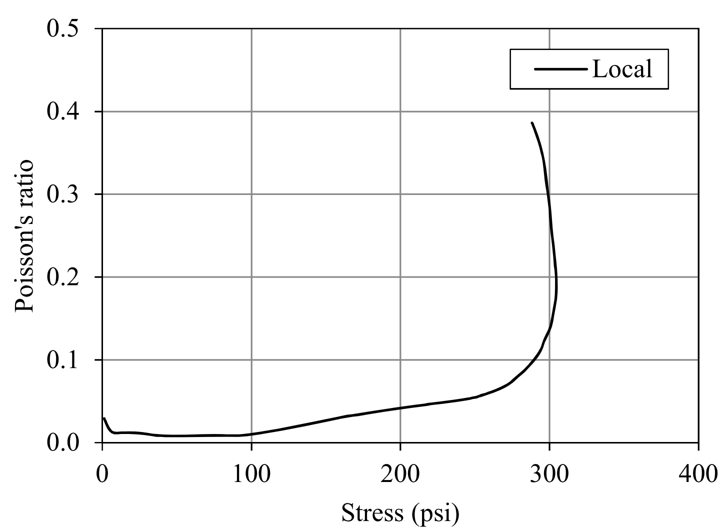


Batch E-4

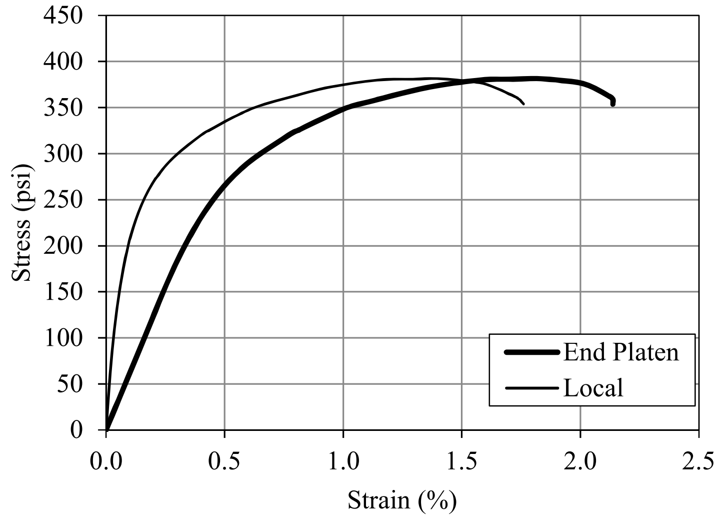
Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-4-B	
Curing Period:	7 day	
Test Date:	11/13/2016	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Grinding	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.956	in
Diameter (initial):	2.034	in
Weight:	366.9	g
Unit Weight:	109	pcf
Gage Length:	2.9	in
Test Summary		
Peak Stress:	305	psi
Secant Modulus E_{50EP}:	44,012	psi
Secant Modulus E_{50L}:	141,744	psi
Poisson's Ratio ν_{50} :	0.03	
Poisson's Ratio ν_f:	0.19	
Local Strain at failure, ε_f:	2.06	%
End Platen Strain at failure, ε_f:	1.64	%

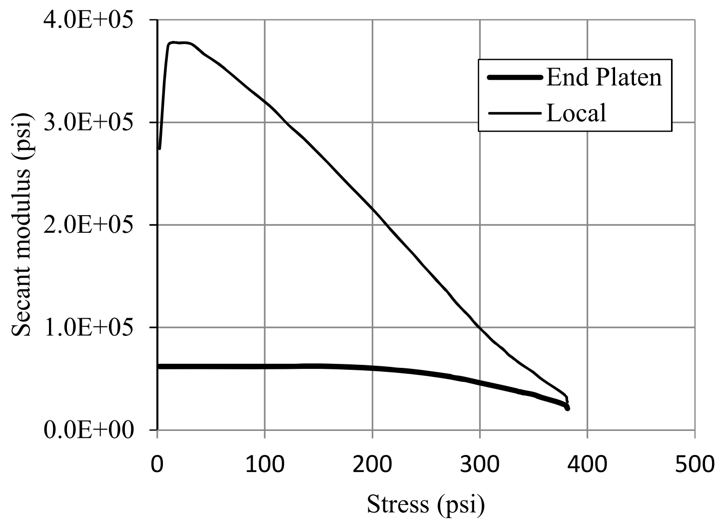


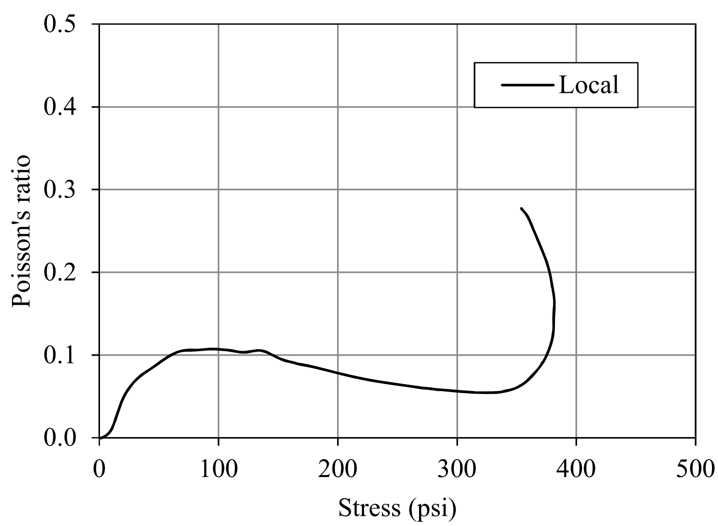




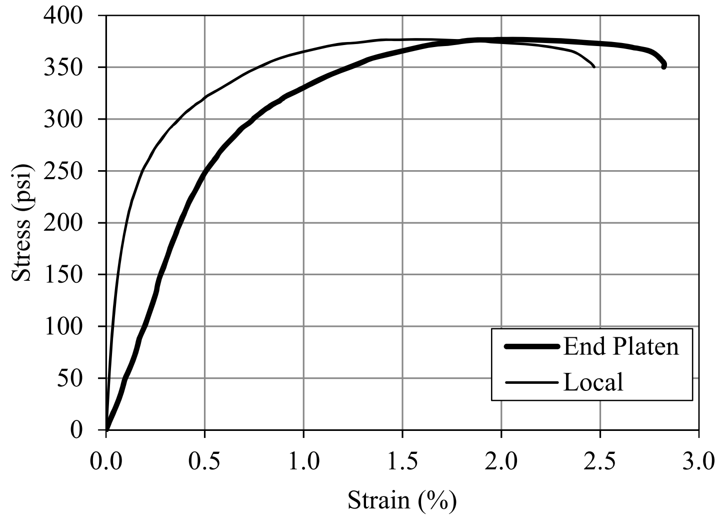
Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-4-G	
Curing Period:	14 day	
Test Date:	11/20/2016	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Sawing & Trimming	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.92	in
Diameter (initial):	2.034	in
Weight:	365.6	g
Unit Weight:	109	pcf
Gage Length:	2.9	in
Test Summary		
Peak Stress:	382	psi
Secant Modulus E_{50EP}:	60,789	psi
Secant Modulus E_{50L}:	225,207	psi
Poisson's Ratio ν_{50} :	0.08	
Poisson's Ratio ν_f:	0.17	
Local Strain at failure, ε_f:	1.82	%
End Platen Strain at failure, ε_f:	1.40	%

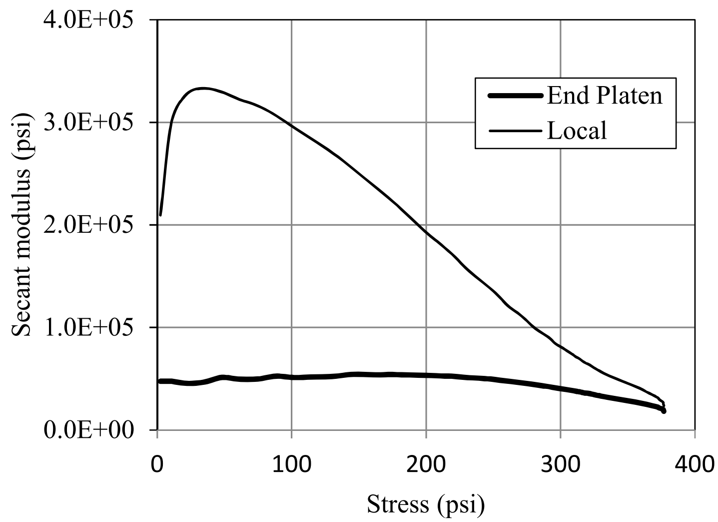


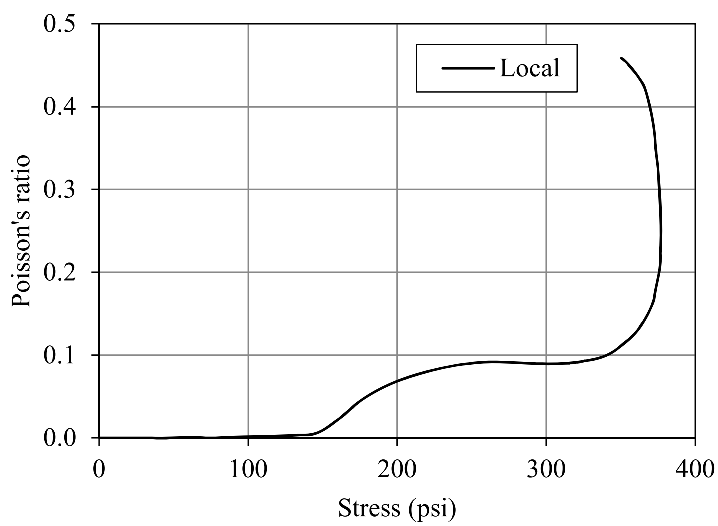




Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-4-I	
Curing Period:	14 day	
Test Date:	11/20/2016	
$\alpha_{in\text{-}place}$:	200	
$(w{:}c)_{slurry}$:	1.0	
End Treatment:	Grinding	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.972	in
Diameter (initial):	2.038	in
Weight:	369.9	g
Unit Weight:	109	pcf
Gage Length:	2.9	in
Test Summary		
Peak Stress:	377	psi
Secant Modulus E_{50EP}:	53,660	psi
Secant Modulus E_{50L}:	206,780	psi
Poisson's Ratio ν_{50} :	0.06	
Poisson's Ratio ν_f:	0.25	
Local Strain at failure, ε_f:	2.05	%
End Platen Strain at failure, ε_f:	1.59	%

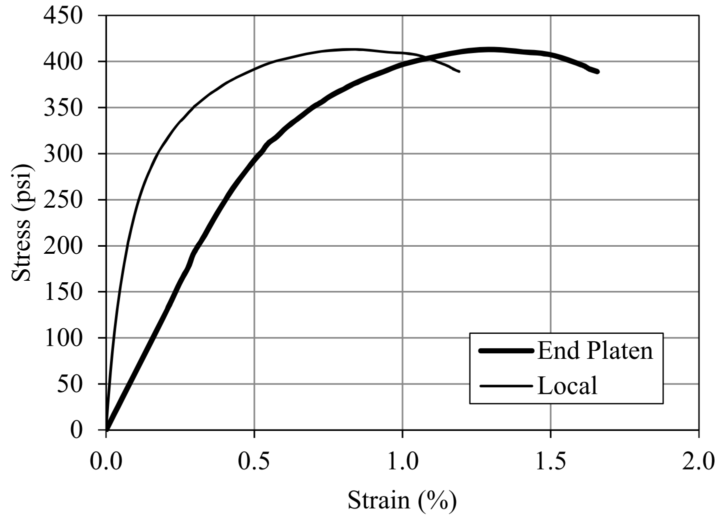


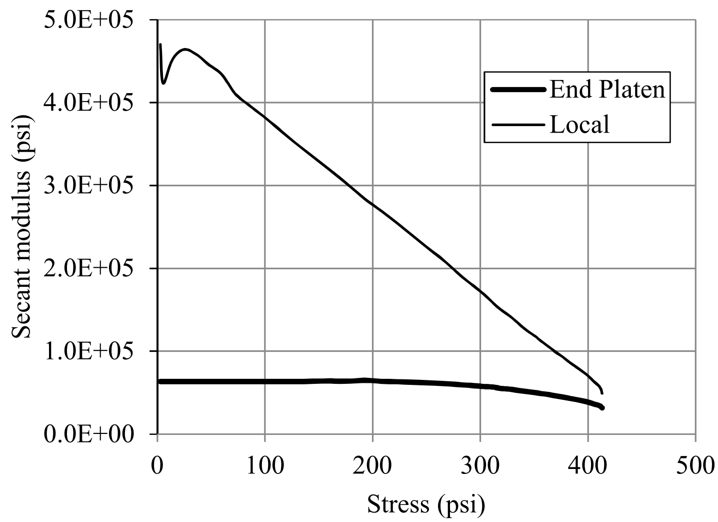


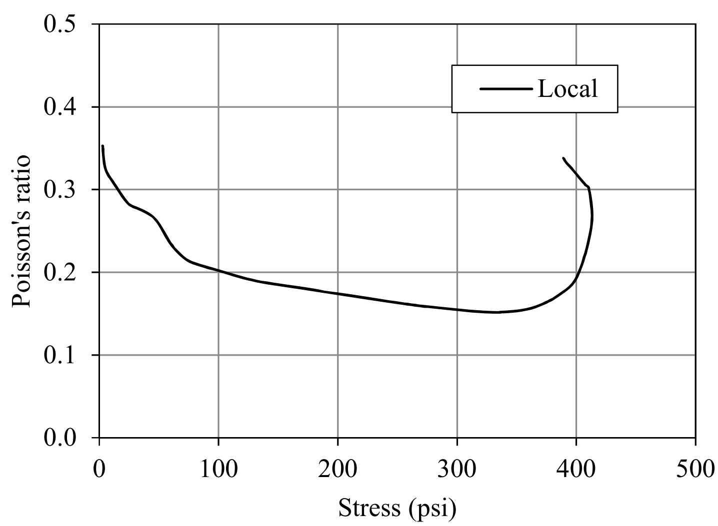


Batch E-4

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-4-C	
Curing Period:	28 day	
Test Date:	12/4/2016	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Sawing & Trimming	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.972	in
Diameter (initial):	2.039	in
Weight:	372.0	g
Unit Weight:	109	pcf
Gage Length:	2.85	in
Test Summary		
Peak Stress:	413	psi
Secant Modulus E_{50EP}:	63,829	psi
Secant Modulus E_{50L}:	270,601	psi
Poisson's Ratio ν_{50} :	0.17	
Poisson's Ratio ν_f:	0.27	
Local Strain at failure, ε_f:	1.31	%
End Platen Strain at failure, ε_f:	0.84	%

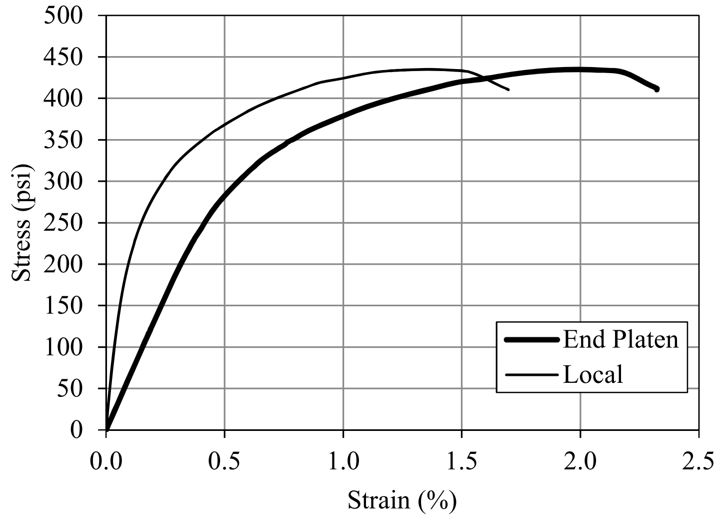


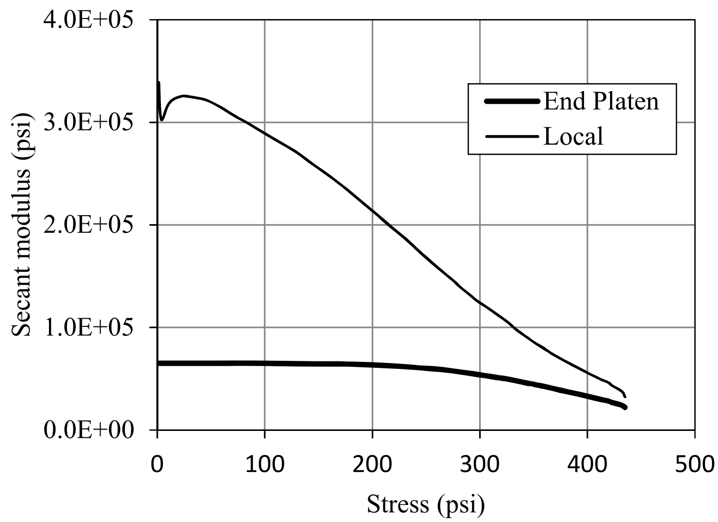




Batch E-4

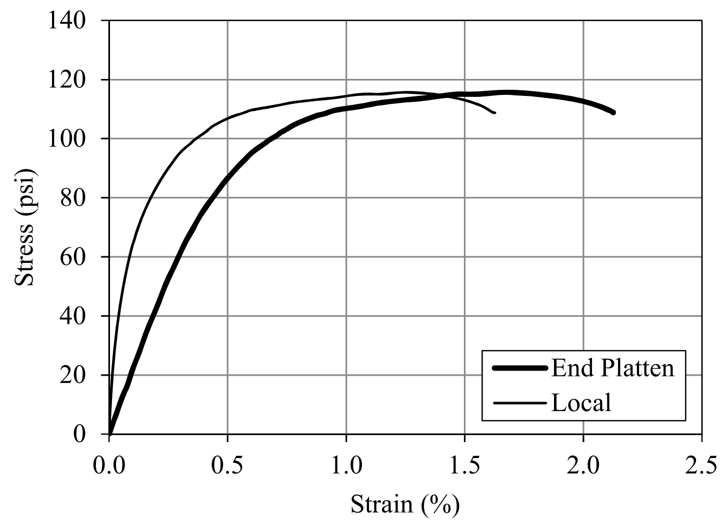
Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-4-D	
Curing Period:	28 day	
Test Date:	12/4/2016	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Grinding	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.947	in
Diameter (initial):	2.045	in
Weight:	365.9	g
Unit Weight:	108	pcf
Gage Length:	2.85	in
Test Summary		
Peak Stress:	435	psi
Secant Modulus E_{50EP}:	62,546	psi
Secant Modulus E_{50L}:	197,876	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, ε_f :	1.98	%
End Platen Strain at failure, ε_f :	1.35	%

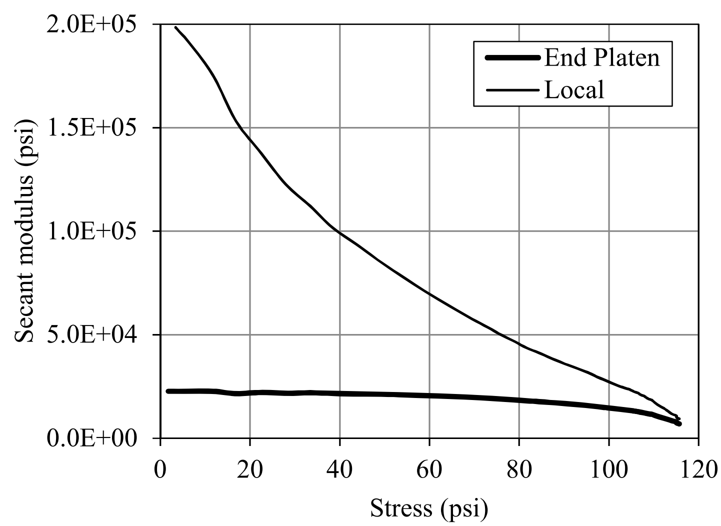


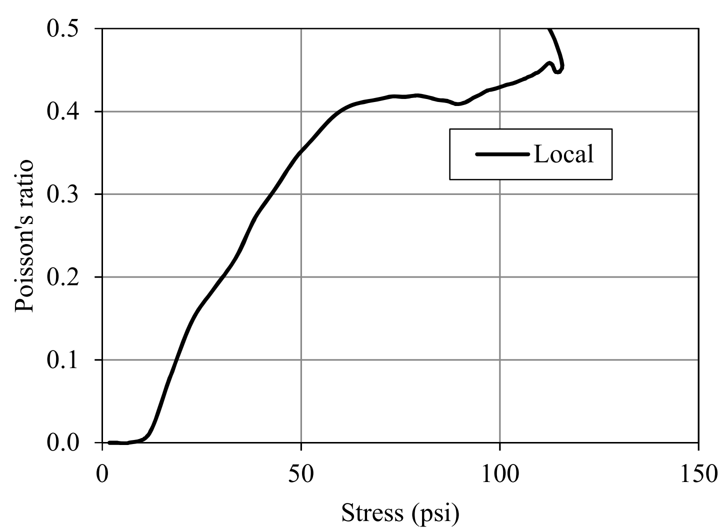


Batch E-5

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-5-E	
Curing Period:	3 day	
Test Date:	1/30/2017	
$\alpha_{in\text{-}place}$:	200	
$(w{:}c)_{slurry}$:	1.0	
End Treatment:	Sawing and Trimming	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.944	in
Diameter (initial):	2.03	in
Weight:	372.0	g
Unit Weight:	111	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	116	psi
Secant Modulus E_{50EP}:	20,618	psi
Secant Modulus E_{50L}:	72,488	psi
Poisson's Ratio ν_{50} :	0.39	
Poisson's Ratio ν_f :	0.45	
Local Strain at failure, ε_f :	1.66	%
End Platen Strain at failure, ε_f :	1.24	%



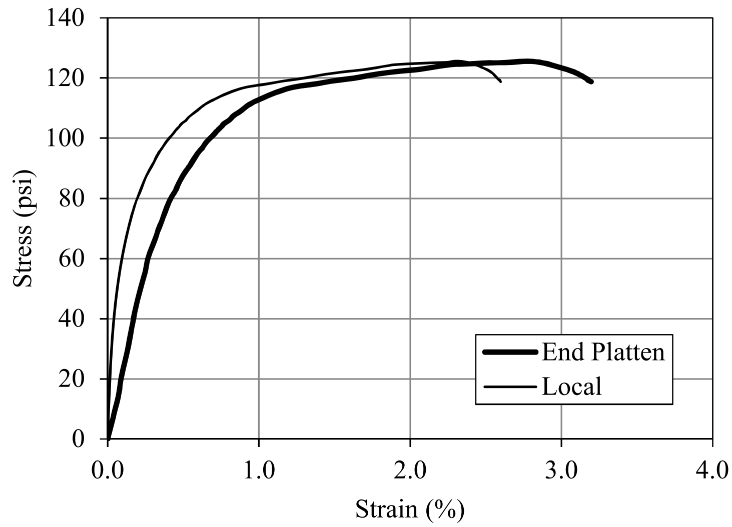


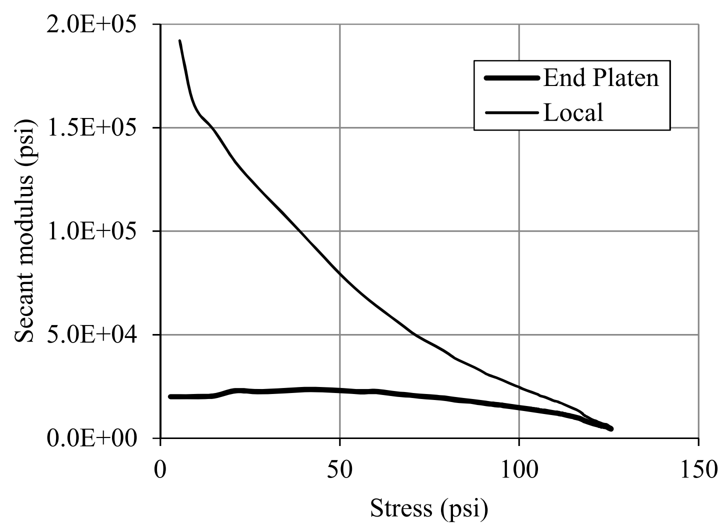


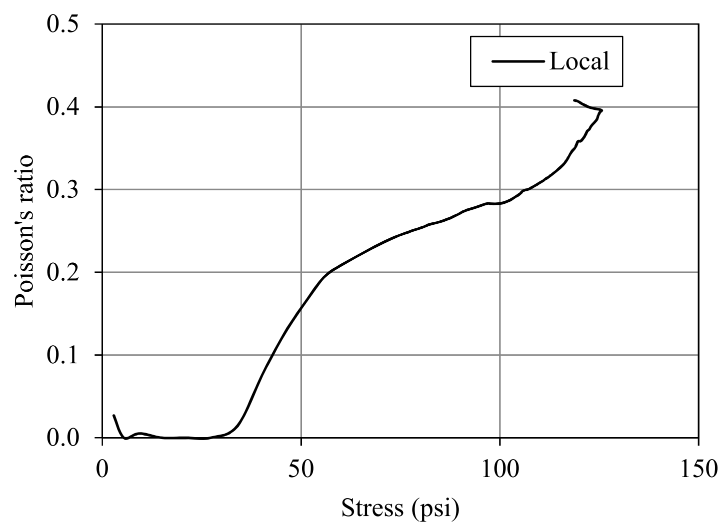
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-5-F
Curing Period:	3 day
Test Date:	1/30/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.963	in
Diameter (initial):	2.037	in
Weight:	375.4	g
Unit Weight:	111	pcf
Gage Length:	2.8	in

Test Summary		
Peak Stress:	126	psi
Secant Modulus E_{50EP}:	21,954	psi
Secant Modulus E_{50L}:	60,335	psi
Poisson's Ratio ν_{50} :	0.22	
Poisson's Ratio ν_f :	0.40	
Local Strain at failure, ε_f :	2.78	%
End Platen Strain at failure, ε_f :	2.32	%

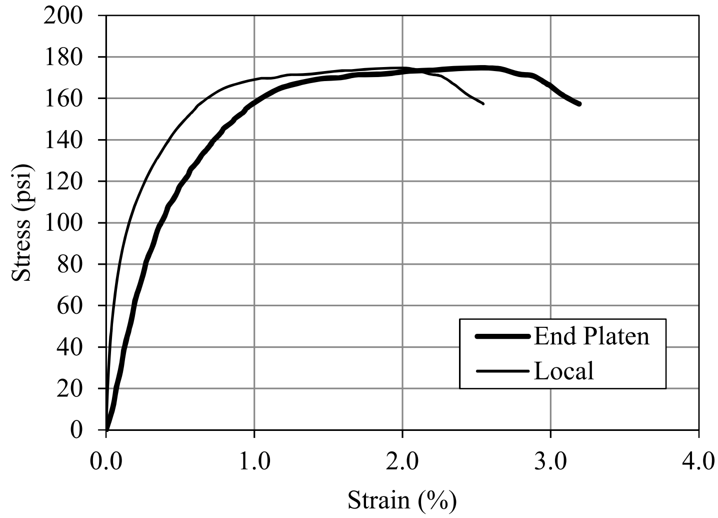


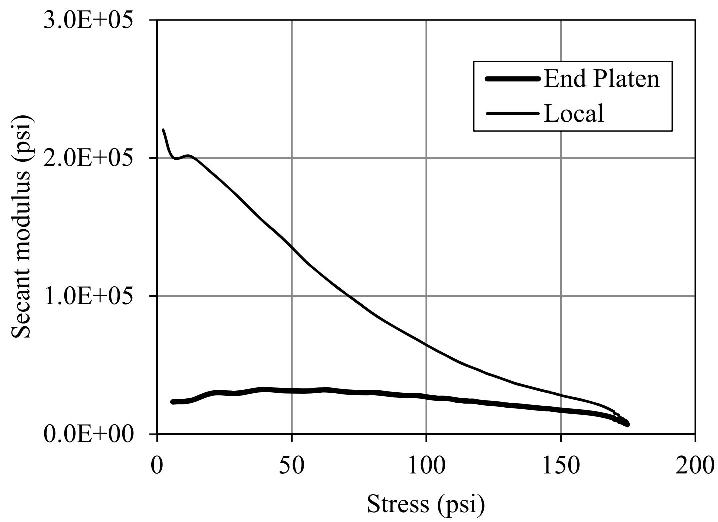


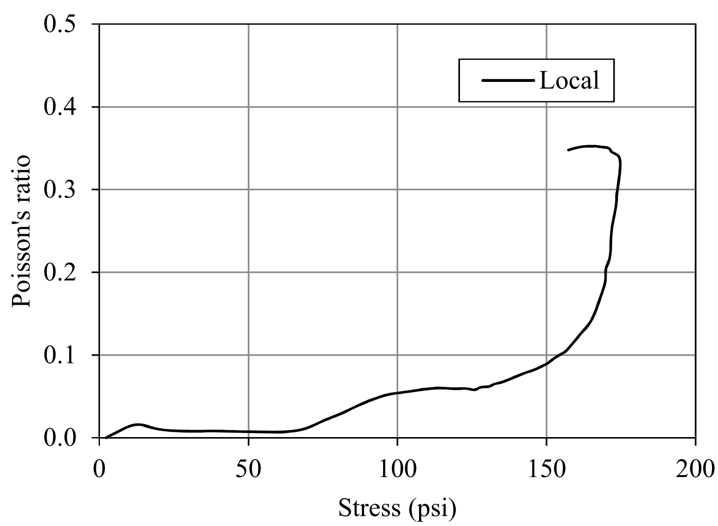


Batch E-5

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-5-B	
Curing Period:	8 days	
Test Date:	2/4/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Grinding	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.944	in
Diameter (initial):	2.035	in
Weight:	371.3	g
Unit Weight:	110	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	175	psi
Secant Modulus E_{50EP}:	28,643	psi
Secant Modulus E_{50L}:	78,496	psi
Poisson's Ratio ν_{50} :	0.04	
Poisson's Ratio ν_f :	0.33	
Local Strain at failure, ε_f :	2.58	%
End Platen Strain at failure, ε_f :	2.00	%





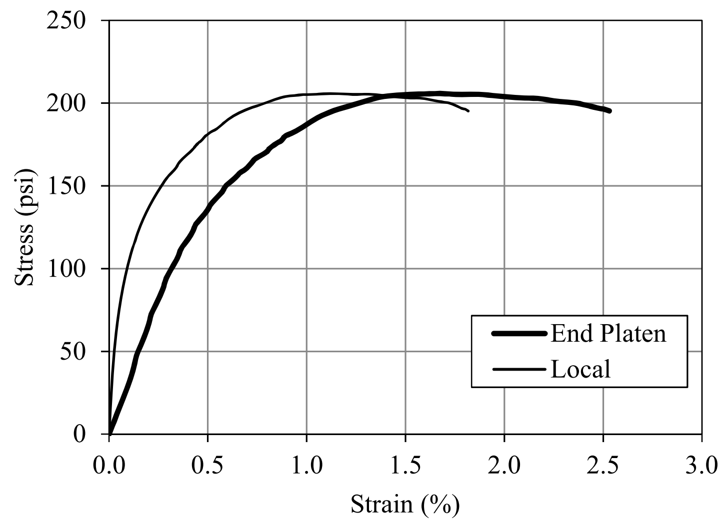


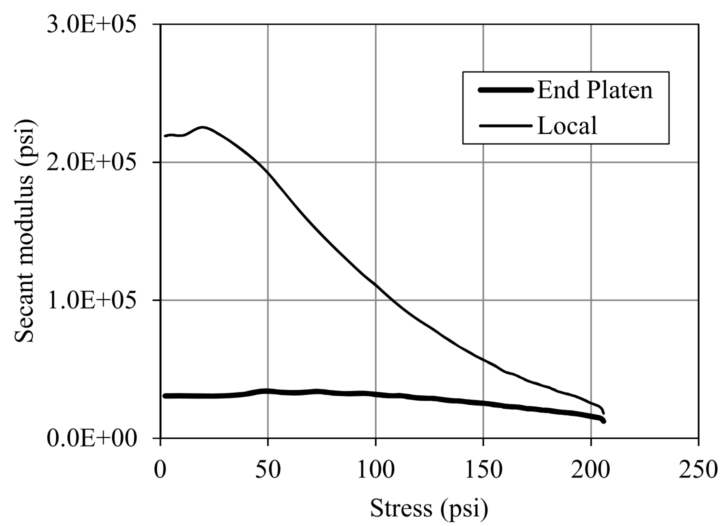
Batch E-5

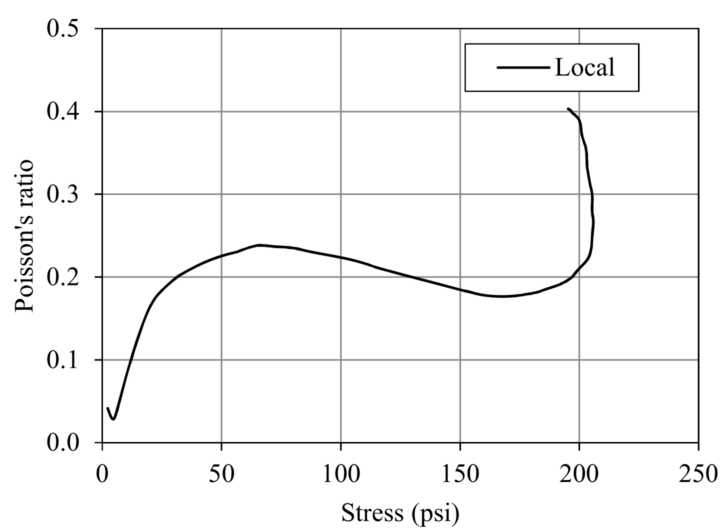
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-5-G
Curing Period:	14 day
Test Date:	2/10/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sawing and Trimming
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.953	in
Diameter (initial):	2.035	in
Weight:	372.3	g
Unit Weight:	110	pcf
Gage Length:	2.8	in

Test Summary		
Peak Stress:	206	psi
Secant Modulus E_{50EP}:	31,274	psi
Secant Modulus E_{50L}:	106,577	psi
Poisson's Ratio ν_{50} :	0.22	
Poisson's Ratio ν_f:	0.27	
Local Strain at failure, ε_f:	1.67	%
End Platen Strain at failure, ε_f:	1.14	%





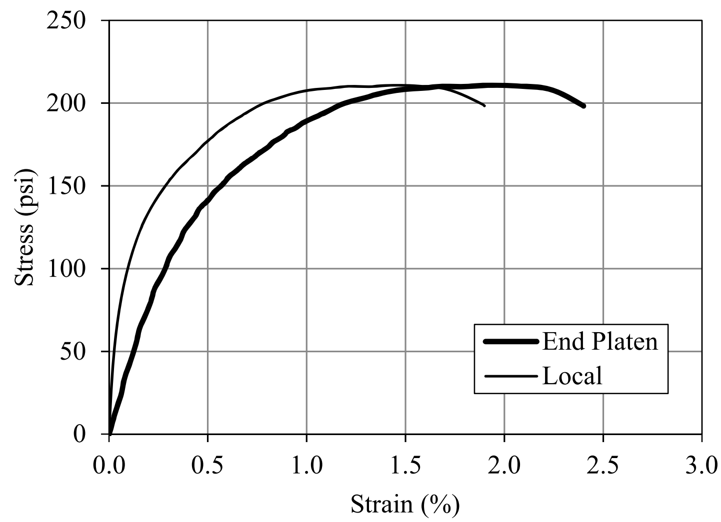


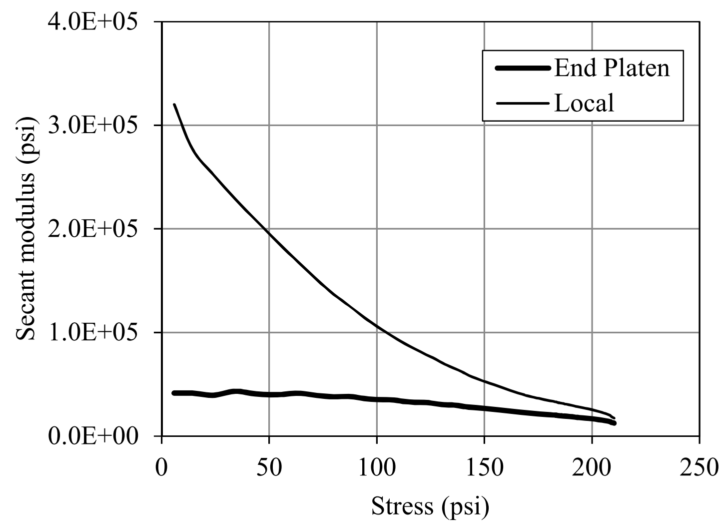
Batch E-5

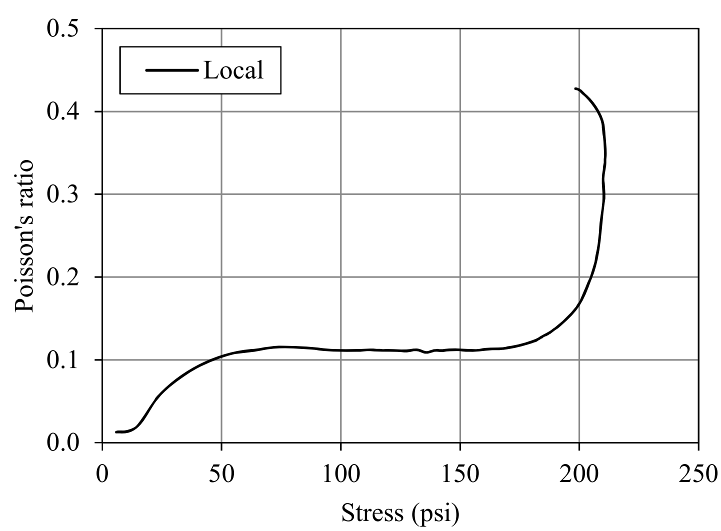
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-5-H
Curing Period:	14 day
Test Date:	2/10/2017
$\alpha_{in\text{-}place}$:	200
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.912	in
Diameter (initial):	2.037	in
Weight:	369.1	g
Unit Weight:	110	pcf
Gage Length:	2.8	in

Test Summary		
Peak Stress:	211	psi
Secant Modulus E_{50EP}:	35,070	psi
Secant Modulus E_{50L}:	98,555	psi
Poisson's Ratio ν_{50} :	0.11	
Poisson's Ratio ν_f:	0.35	
Local Strain at failure, ε_f:	1.99	%
End Platen Strain at failure, ε_f:	1.50	%



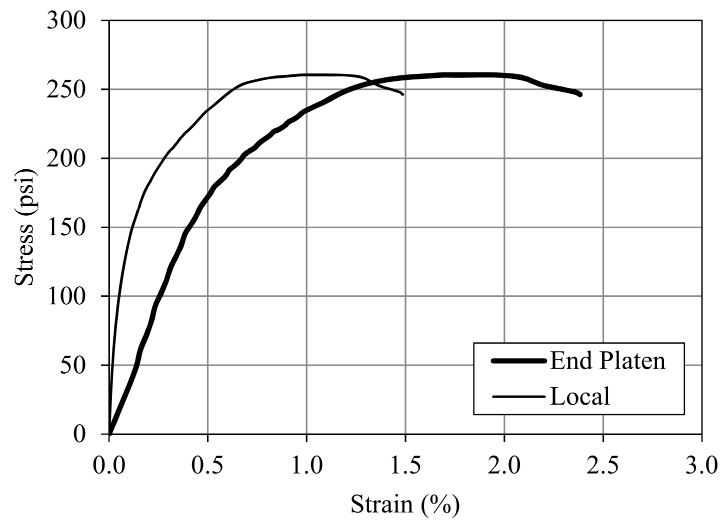


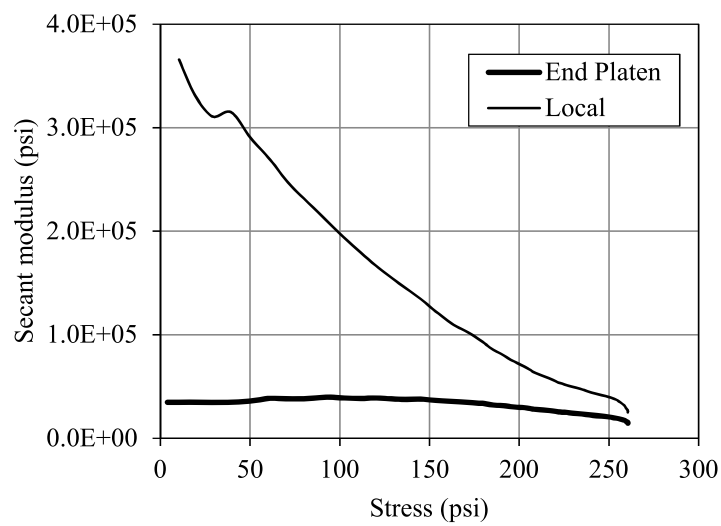


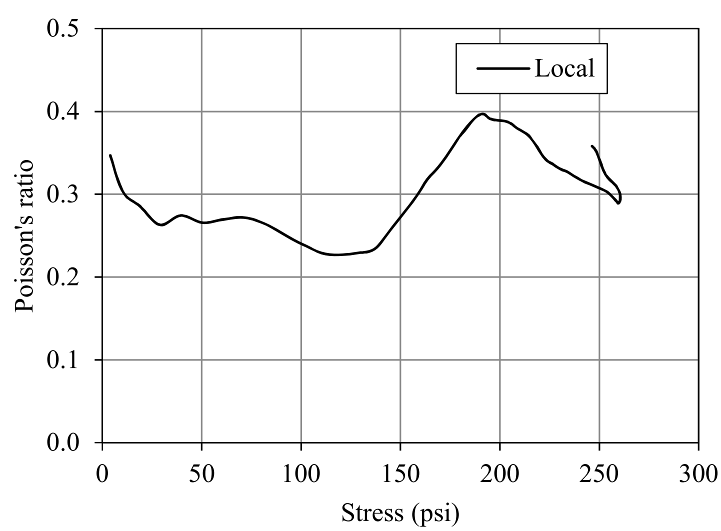
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-5-C
Curing Period:	28 day
Test Date:	2/24/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sawing & Trimming
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.955	in
Diameter (initial):	2.038	in
Weight:	372.9	g
Unit Weight:	110	pcf
Gage Length:	2.8	in

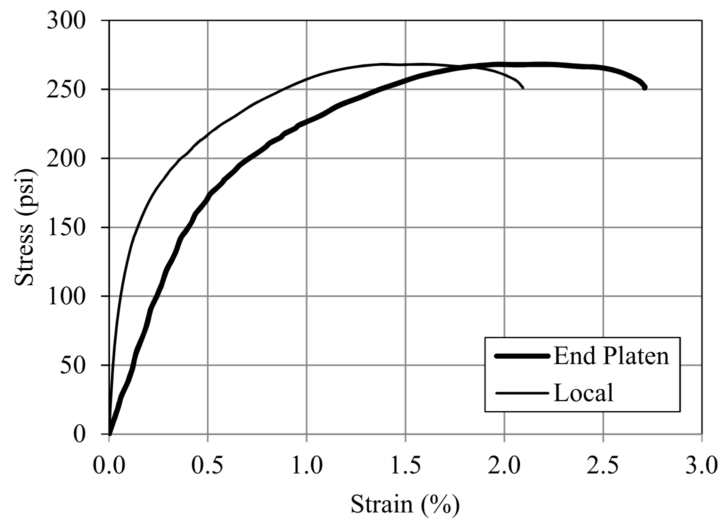
Test Summary		
Peak Stress:	261	psi
Secant Modulus E_{50EP}:	37,947	psi
Secant Modulus E_{50L}:	152,999	psi
Poisson's Ratio ν_{50} :	0.23	
Poisson's Ratio ν_f :	0.30	
Local Strain at failure, ε_f :	1.80	%
End Platen Strain at failure, ε_f :	1.05	%

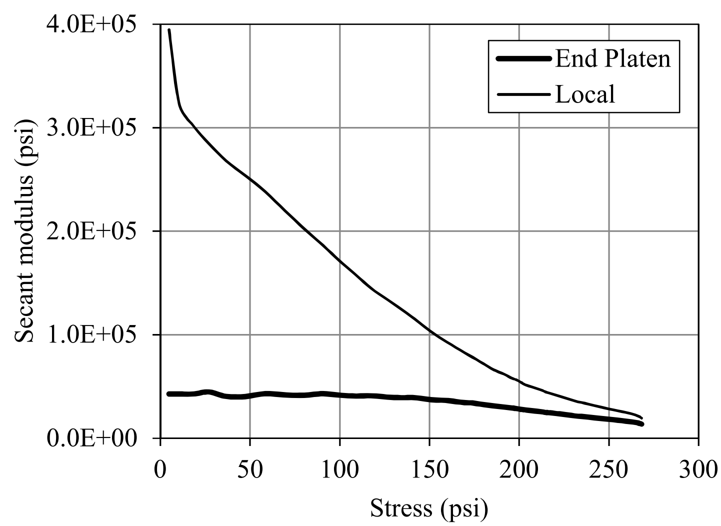


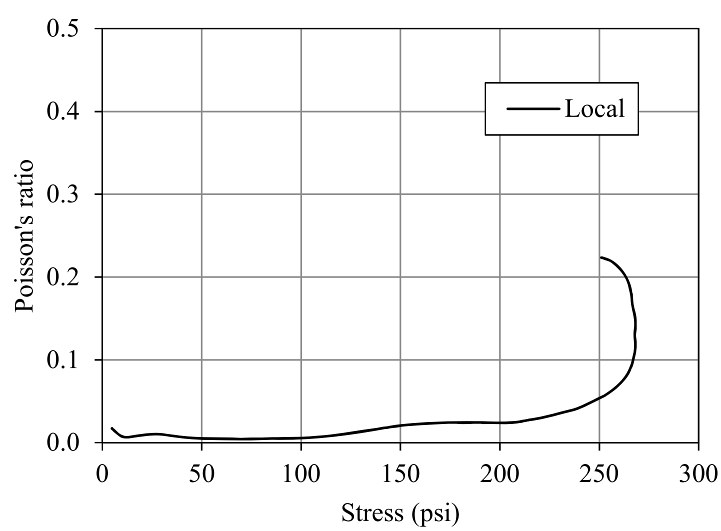




Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-5-D	
Curing Period:	28 day	
Test Date:	2/24/2017	
$\alpha_{in\text{-}place}$:	200	
$(w{:}c)_{slurry}$:	1.0	
End Treatment:	Grinding	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.952	in
Diameter (initial):	2.035	in
Weight:	371.4	g
Unit Weight:	110	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	268	psi
Secant Modulus E_{50EP}:	39,165	psi
Secant Modulus E_{50L}:	124,815	psi
Poisson's Ratio ν_{50} :	0.01	
Poisson's Ratio ν_f:	0.12	
Local Strain at failure, ε_f:	1.97	%
End Platen Strain at failure, ε_f:	1.38	%



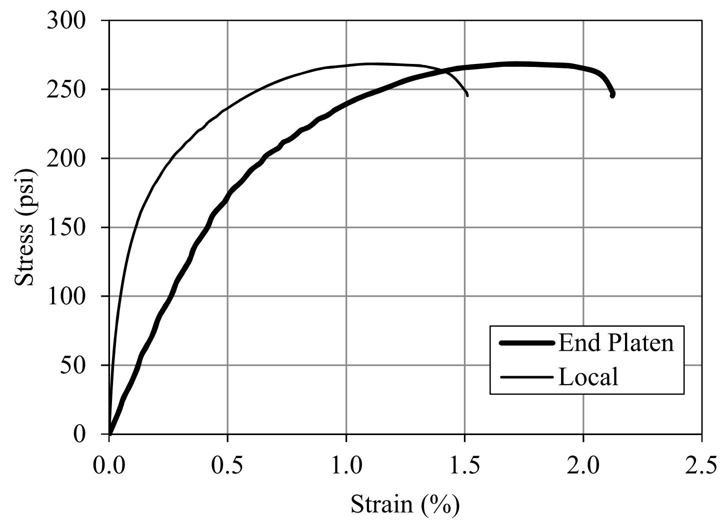


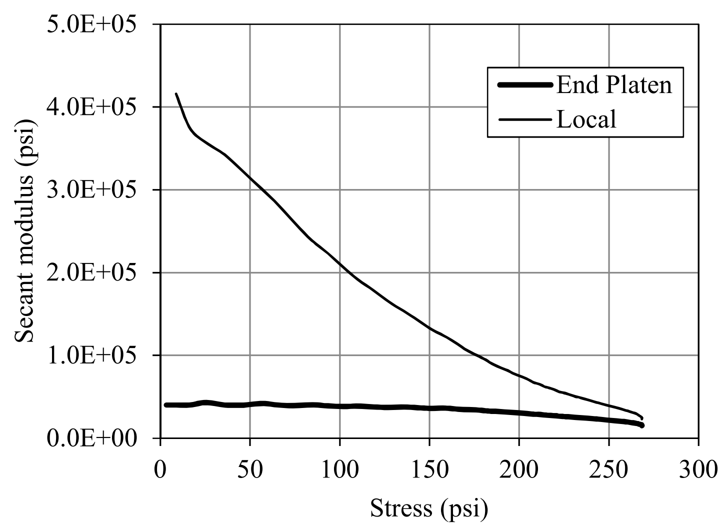


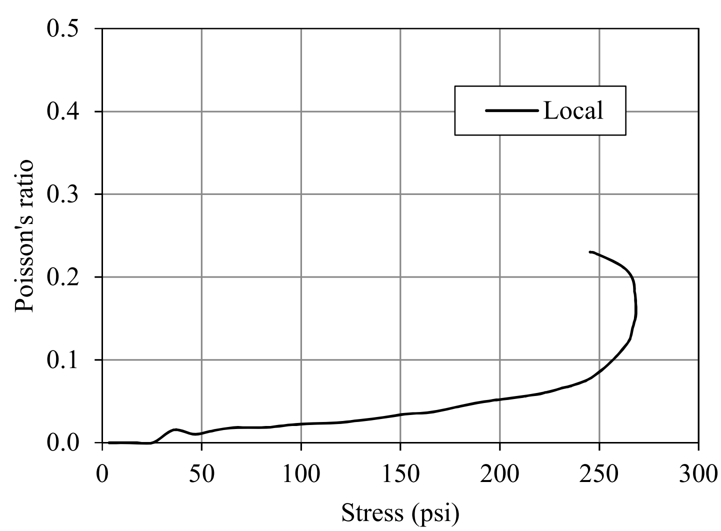
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-5-I
Curing Period:	28 day
Test Date:	2/24/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sawing & Trimming
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.982	in
Diameter (initial):	2.037	in
Weight:	377.0	g
Unit Weight:	111	pcf
Gage Length:	2.8	in

Test Summary		
Peak Stress:	268	psi
Secant Modulus E_{50EP}:	37,670	psi
Secant Modulus E_{50L}:	155,299	psi
Poisson's Ratio ν_{50} :	0.03	
Poisson's Ratio ν_f:	0.17	
Local Strain at failure, ε_f:	1.76	%
End Platen Strain at failure, ε_f:	1.15	%



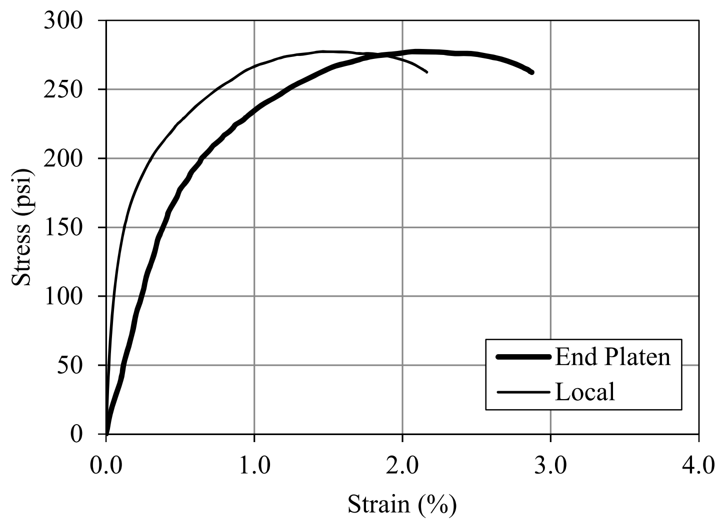


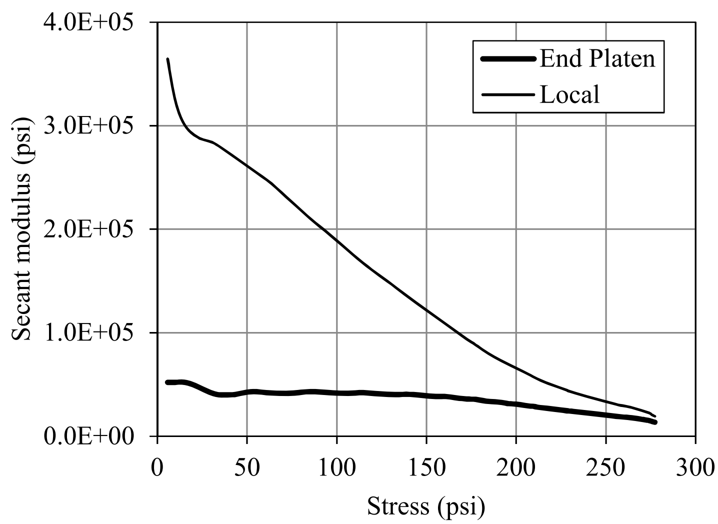


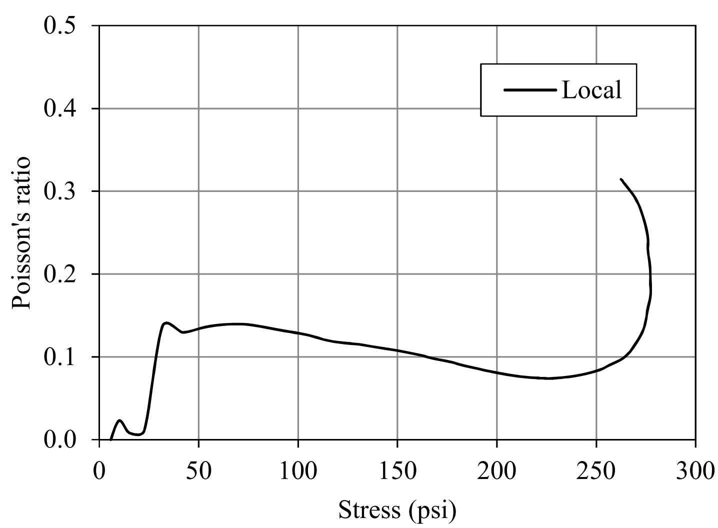
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-5-J
Curing Period:	28 day
Test Date:	2/24/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.943	in
Diameter (initial):	2.036	in
Weight:	372.7	g
Unit Weight:	111	pcf
Gage Length:	2.8	in

Test Summary		
Peak Stress:	277	psi
Secant Modulus E_{50EP}:	40,402	psi
Secant Modulus E_{50L}:	135,659	psi
Poisson's Ratio ν_{50} :	0.11	
Poisson's Ratio ν_f:	0.17	
Local Strain at failure, ε_f:	2.06	%
End Platen Strain at failure, ε_f:	1.44	%

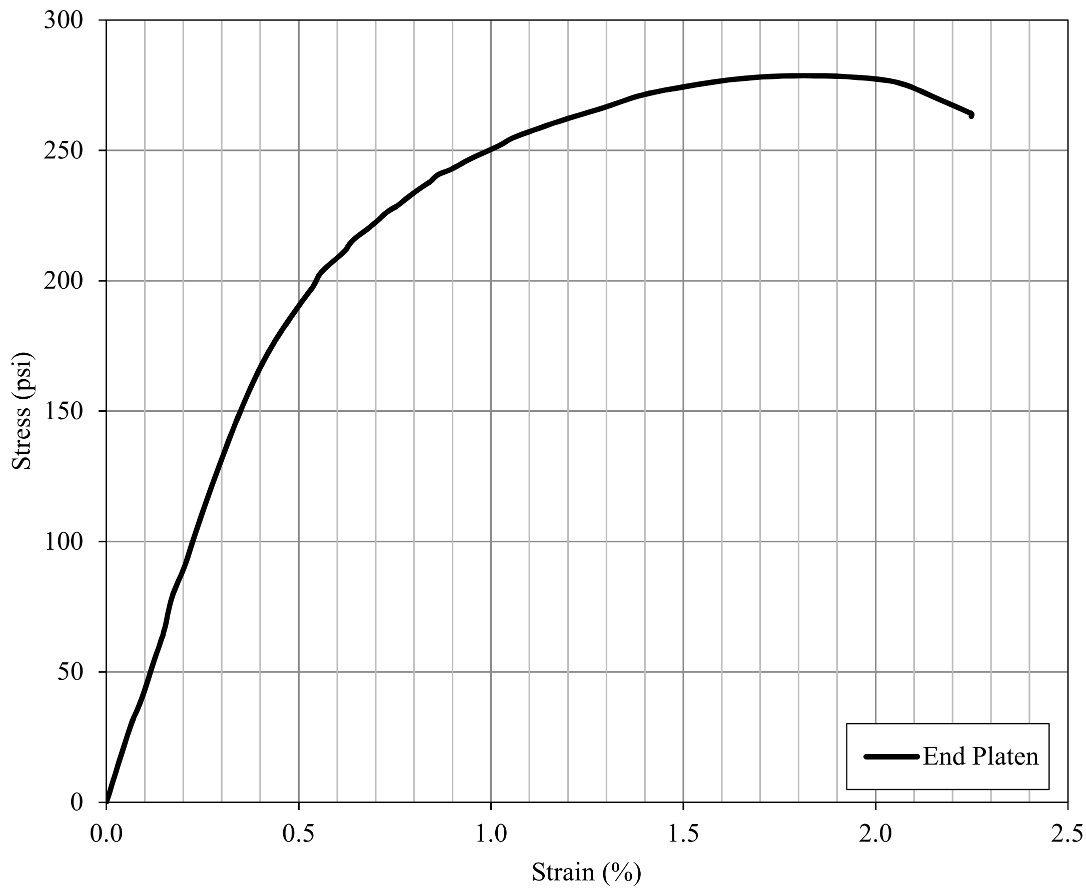






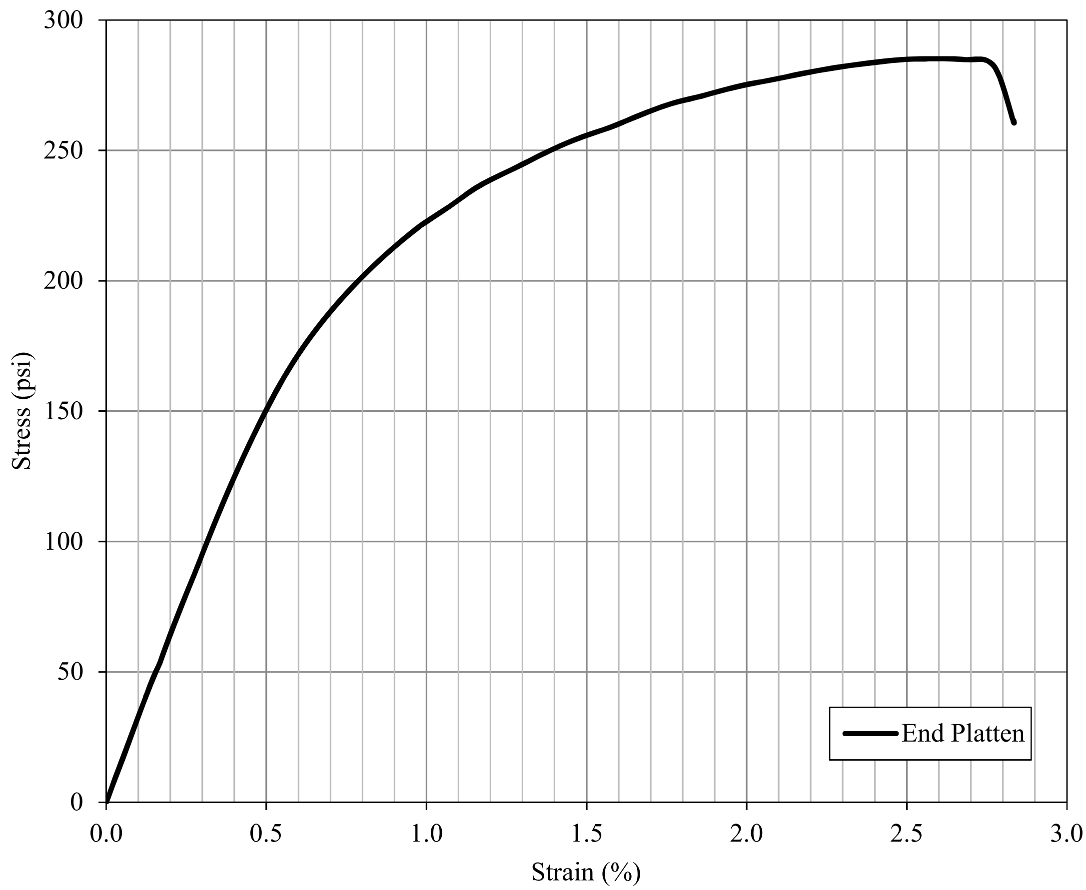
Batch E-6

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.987	in	Peak Stress:	279	psi
Tested by:	RNG	Diameter (initial):	2.038	in	Secant Modulus E_{50EP}:	43,598	psi
I.D. :	E-6-E	Weight:	362.6	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	3 day	Unit Weight:	106	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	1/19/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w{:}c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.84	%
End Treatment:	Sulfur cap						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



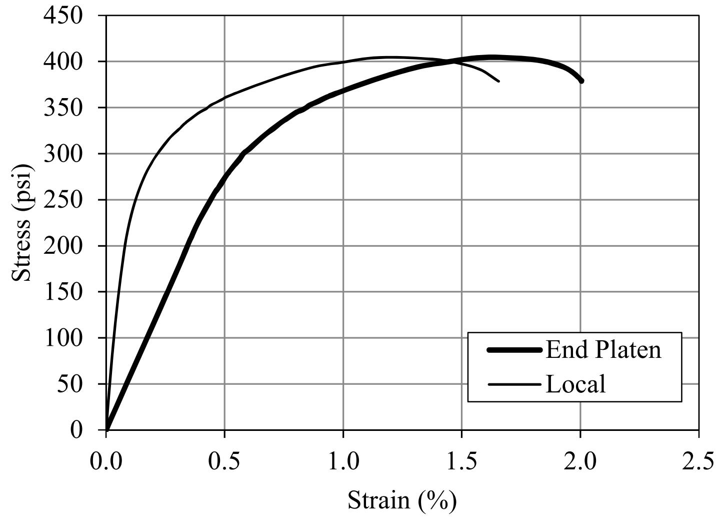
Batch E-6

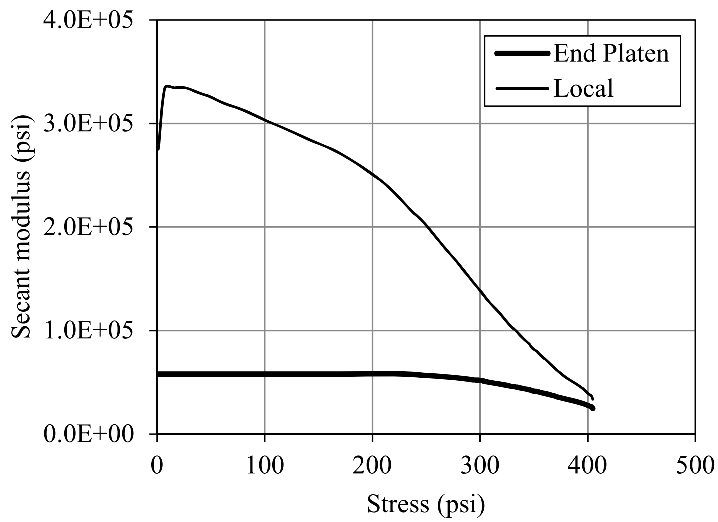
Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.992	in	Peak Stress:	285	psi
Tested by:	RNG	Diameter (initial):	2.035	in	Secant Modulus E_{50EP}:	30,502	psi
I.D. :	E-6-F	Weight:	366.9	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	3 day	Unit Weight:	108	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	1/19/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	2.57	%
End Treatment:	Neoprene pads						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



Batch E-6

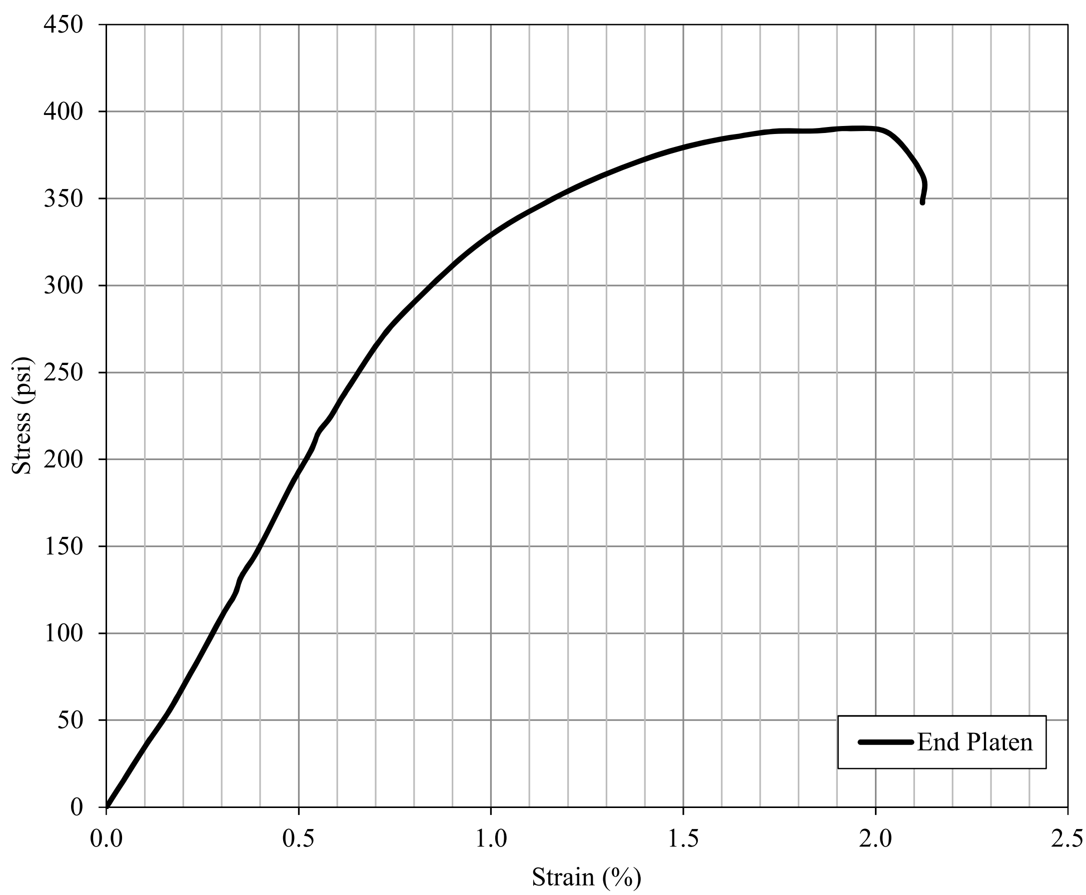
Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-6-I	
Curing Period:	7 day	
Test Date:	1/23/2017	
$\alpha_{in\text{-}place}$:	200	
$(w{:}c)_{slurry}$:	1.0	
End Treatment:	Sulfur cap	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.98	in
Diameter (initial):	2.039	in
Weight:	367.8	g
Unit Weight:	108	pcf
Gage Length:	2.85	in
Test Summary		
Peak Stress:	405	psi
Secant Modulus E_{50EP}:	58,244	psi
Secant Modulus E_{50L}:	248,397	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	1.64	%
End Platen Strain at failure, ε_f:	1.21	%



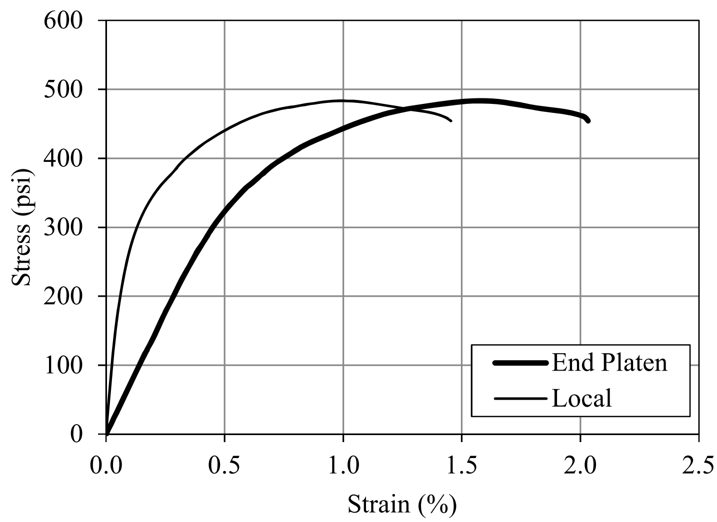


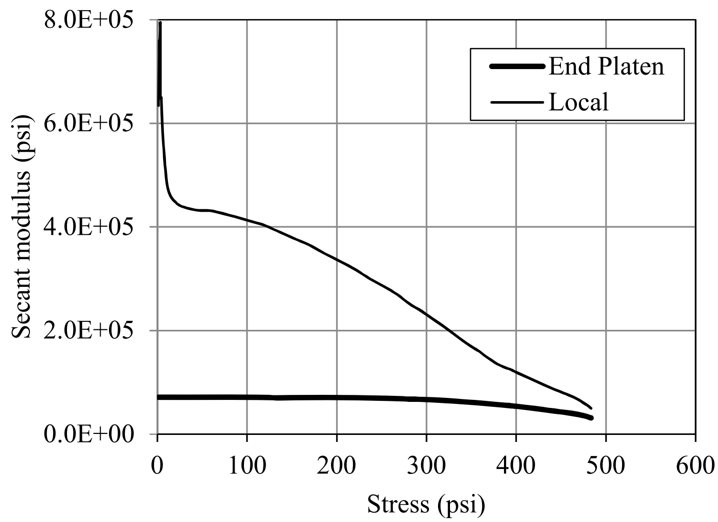
Batch E-6

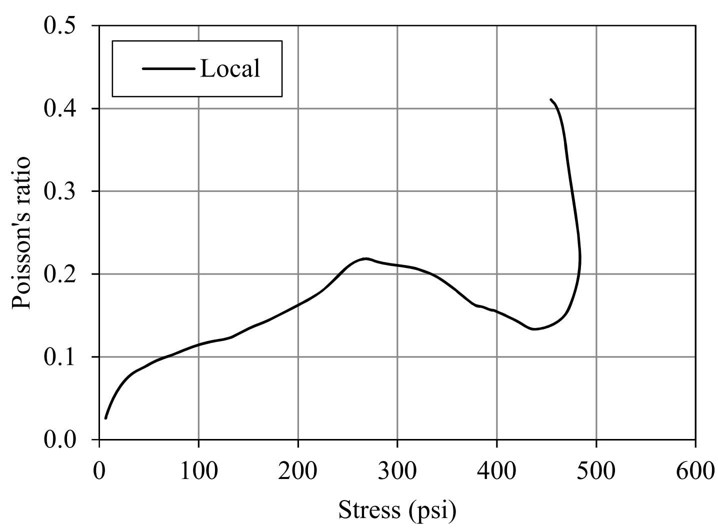
Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.972	in	Peak Stress:	390	psi
Tested by:	RNG	Diameter (initial):	2.036	in	Secant Modulus E_{50EP}:	38,548	psi
I.D. :	E-6-B	Weight:	364.7	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	7 day	Unit Weight:	107	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	1/23/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.94	%
End Treatment:	Neoprene pads						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



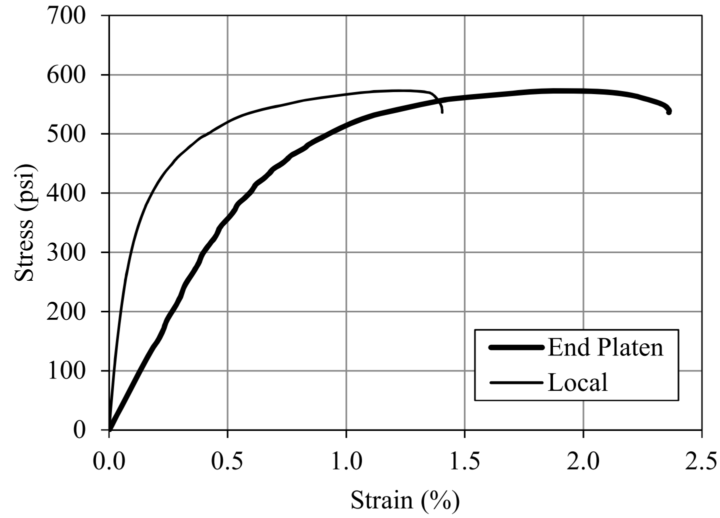
Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-6-G	
Curing Period:	14 day	
Test Date:	1/30/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Sulfur Cap	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.983	in
Diameter (initial):	2.033	in
Weight:	367.3	g
Unit Weight:	108	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	483	psi
Secant Modulus E_{50EP}:	69,594	psi
Secant Modulus E_{50L}:	294,813	psi
Poisson's Ratio ν_{50} :	0.20	
Poisson's Ratio ν_f :	0.21	
Local Strain at failure, ε_f :	1.55	%
End Platen Strain at failure, ε_f :	0.97	%

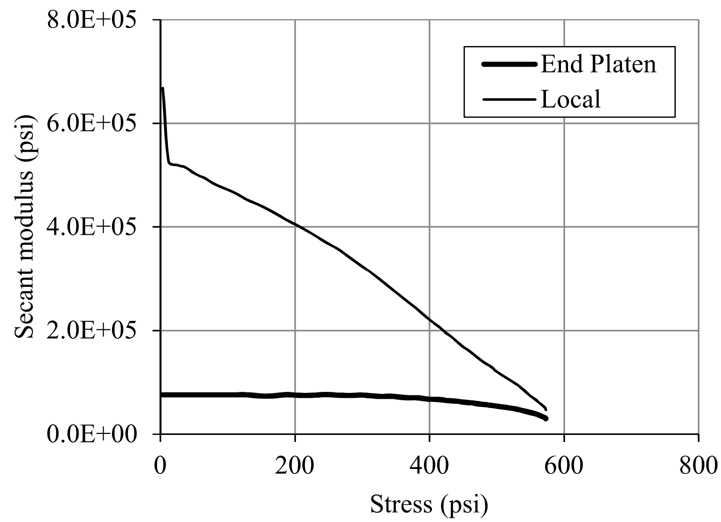


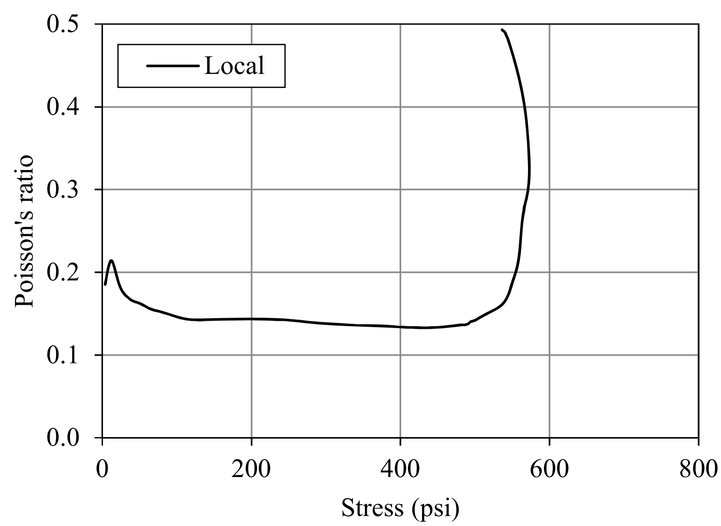




Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-6-C	
Curing Period:	28 day	
Test Date:	2/13/2017	
$\alpha_{in\text{-}place}$:	200	
$(w{:}c)_{slurry}$:	1.0	
End Treatment:	Sulfur Cap	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.984	in
Diameter (initial):	2.034	in
Weight:	366.1	g
Unit Weight:	108	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	573	psi
Secant Modulus E_{50EP}:	74,909	psi
Secant Modulus E_{50L}:	335,650	psi
Poisson's Ratio ν_{50} :	0.14	
Poisson's Ratio ν_f :	0.32	
Local Strain at failure, ε_f :	1.92	%
End Platen Strain at failure, ε_f :	1.22	%

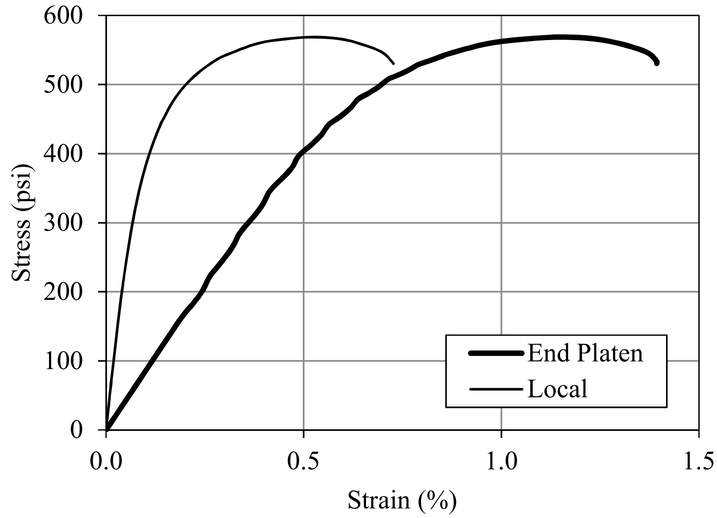


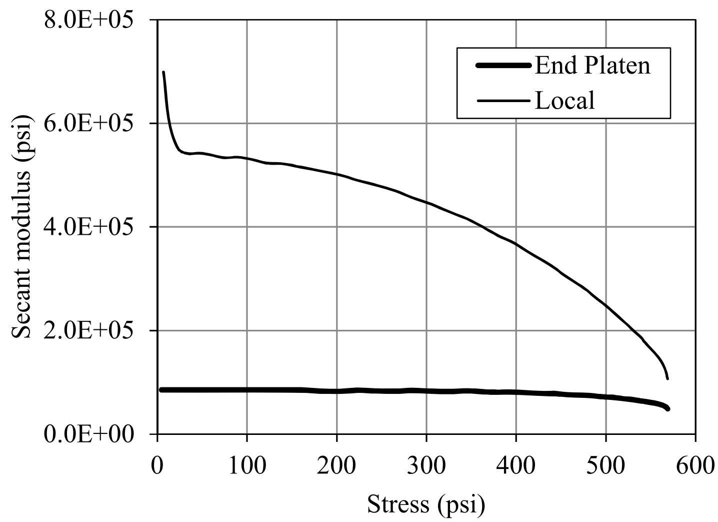




Batch E-6

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-6-D	
Curing Period:	28 day	
Test Date:	2/13/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Gypsum	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.984	in
Diameter (initial):	2.032	in
Weight:	365.4	g
Unit Weight:	108	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	569	psi
Secant Modulus E_{50EP}:	84,248	psi
Secant Modulus E_{50L}:	456,450	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	1.16	%
End Platen Strain at failure, ε_f:	0.53	%

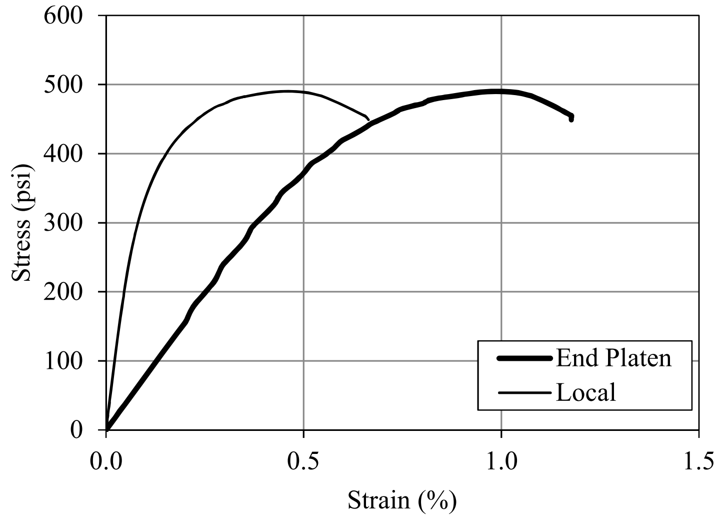


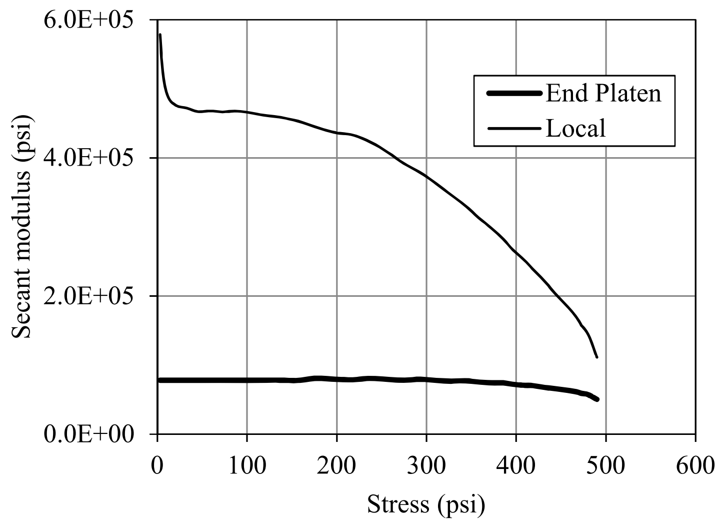


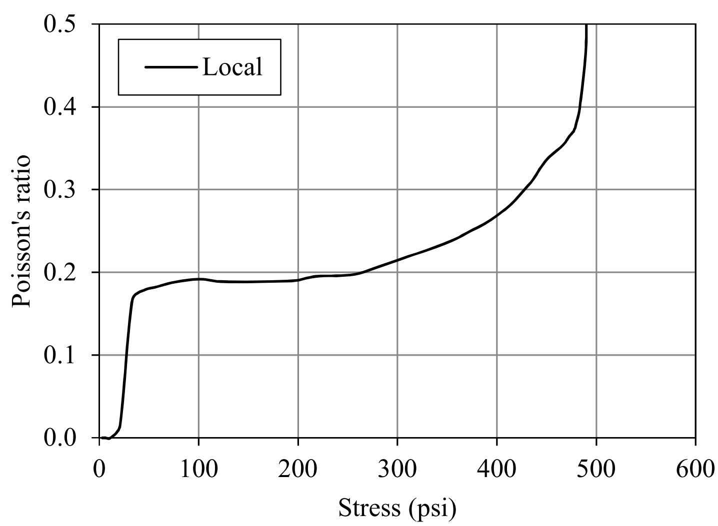
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-6-J
Curing Period:	28 day
Test Date:	2/13/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Gypsum
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.986	in
Diameter (initial):	2.03	in
Weight:	366.0	g
Unit Weight:	108	pcf
Gage Length:	2.8	in

Test Summary		
Peak Stress:	490	psi
Secant Modulus E_{50EP}:	80,170	psi
Secant Modulus E_{50L}:	416,708	psi
Poisson's Ratio ν_{50} :	0.20	
Poisson's Ratio ν_f :	0.48	
Local Strain at failure, ε_f :	0.97	%
End Platen Strain at failure, ε_f :	0.44	%





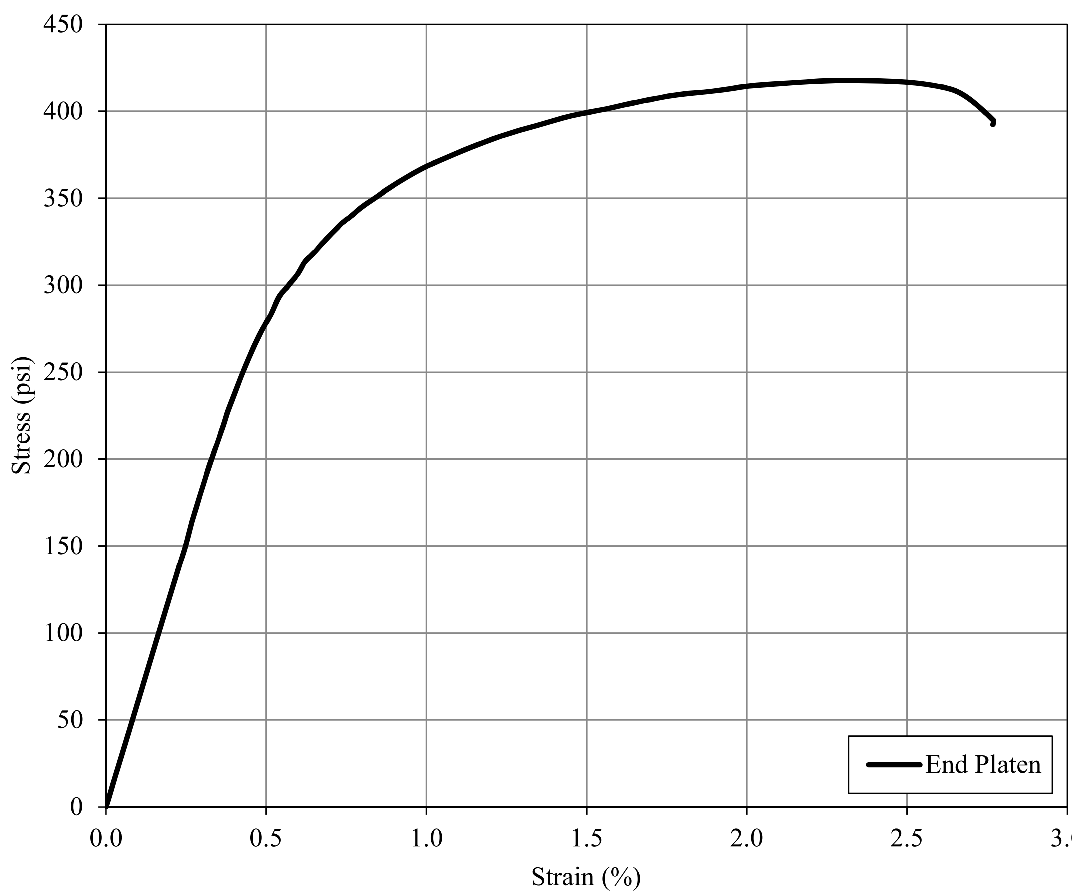


Batch E-7

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-7-E
Curing Period:	3 day
Test Date:	1/19/2017
$\alpha_{in\text{-}place}$:	350
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Sulfur cap
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.987	in
Diameter (initial):	2.039	in
Weight:	0.0	g
Unit Weight:	0	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	418	psi
Secant Modulus E_{50EP}:	60,305	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	2.34	%

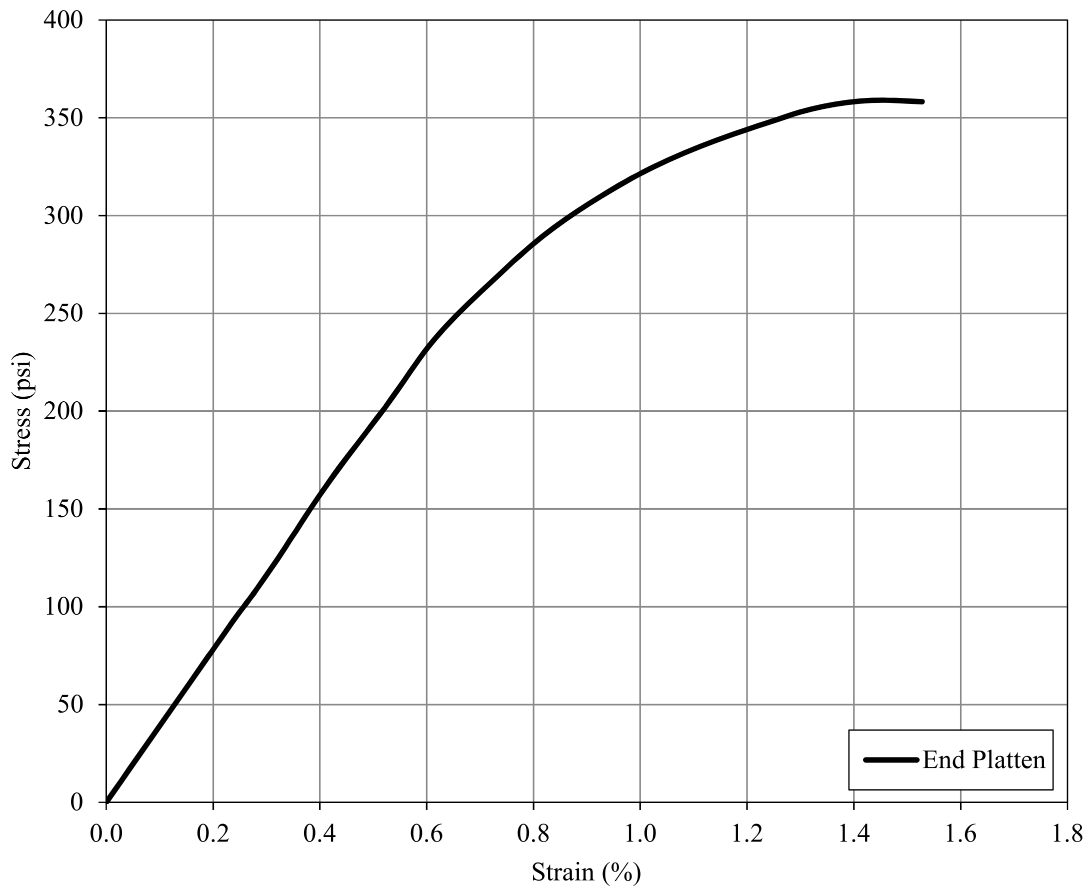


Batch E-7

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-7-F
Curing Period:	3 day
Test Date:	1/19/2017
$\alpha_{in\text{-}place}$:	350
$(w:c)_{slurry}$:	1.0
End Treatment:	Neoprene pads
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.986	in
Diameter (initial):	2.035	in
Weight:	361.1	g
Unit Weight:	106	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	359	psi
Secant Modulus E_{50EP}:	38,999	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.43	%

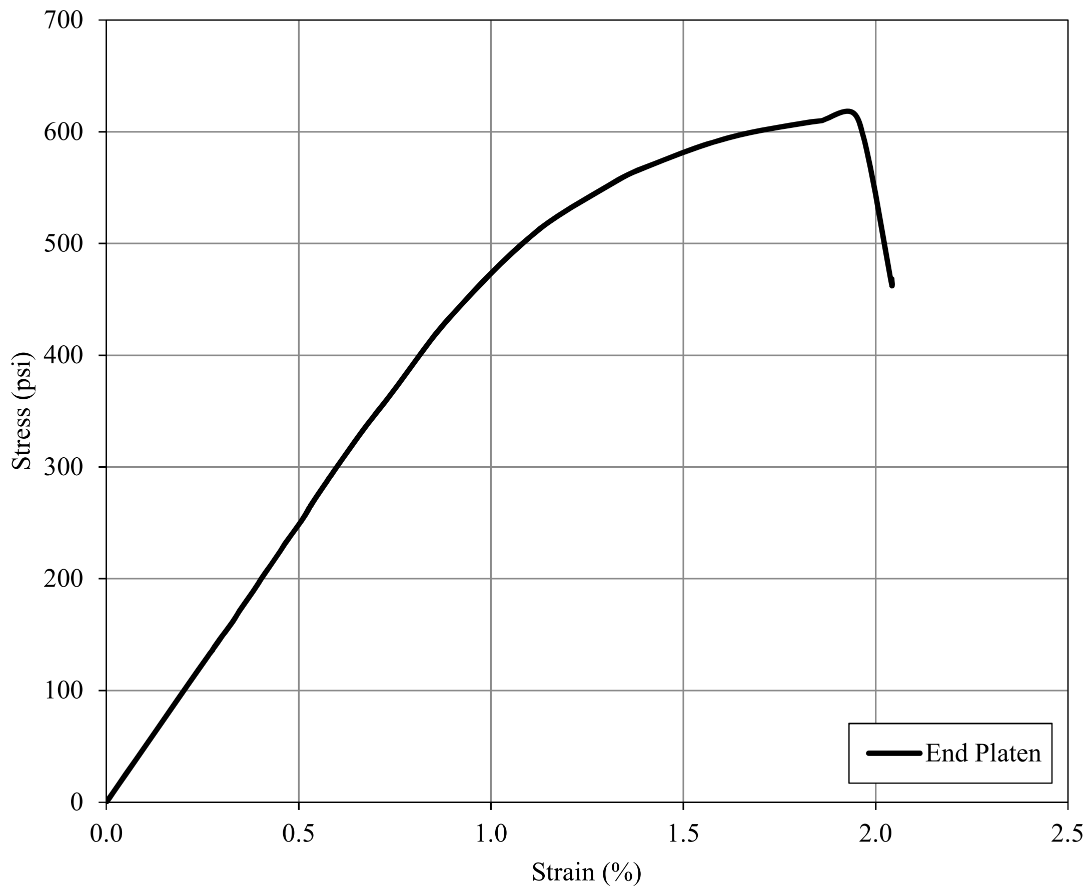


Batch E-7

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-7-B
Curing Period:	7 day
Test Date:	1/23/2017
$\alpha_{in\text{-}place}$:	350
$(w:c)_{slurry}$:	1.0
End Treatment:	Neoprene pads
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

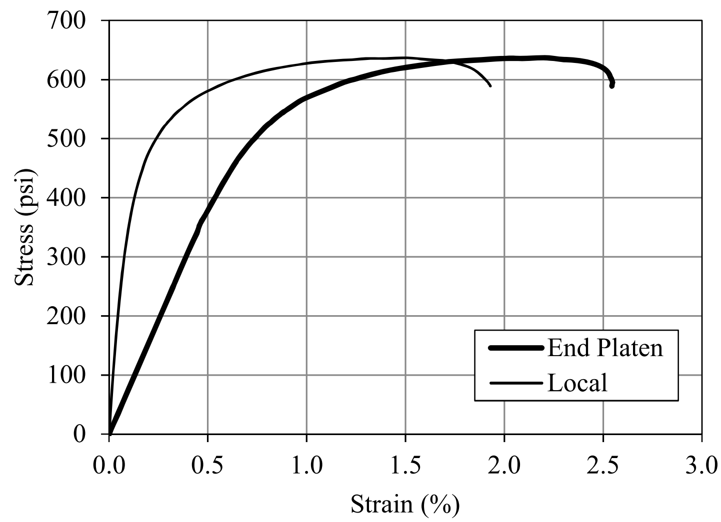
Specimen Information		
Height (initial):	3.914	in
Diameter (initial):	2.036	in
Weight:	353.9	g
Unit Weight:	106	pcf
Gage Length:	N/A	in

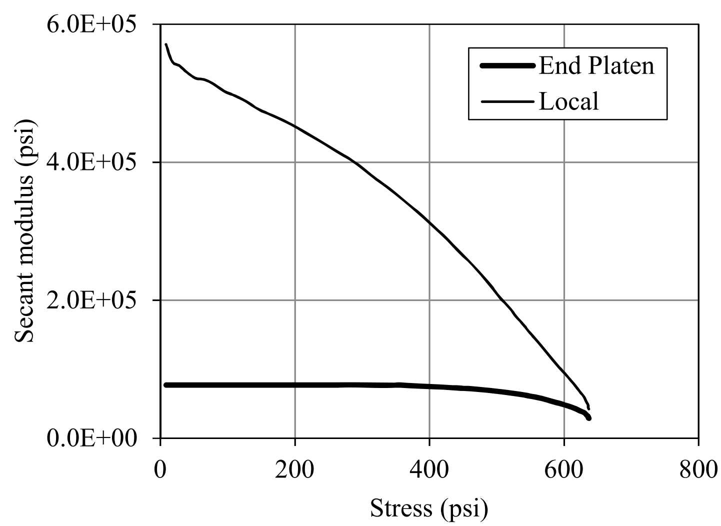
Test Summary		
Peak Stress:	612	psi
Secant Modulus E_{50EP}:	50,003	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.95	%

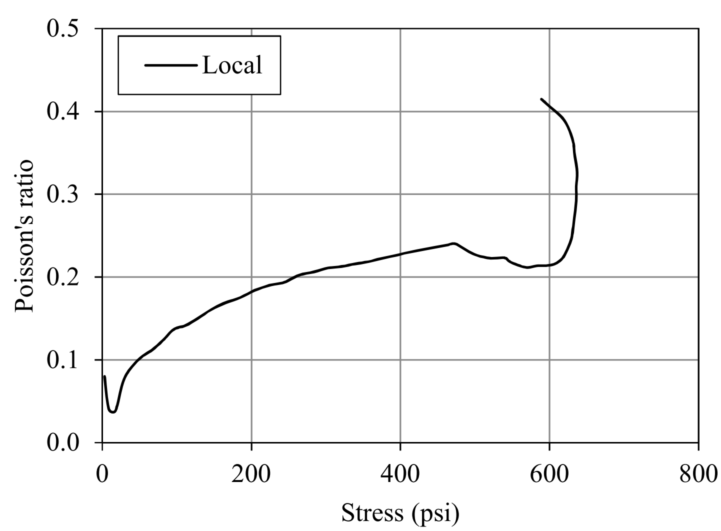


Batch E-7

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-7-I	
Curing Period:	7 day	
Test Date:	1/23/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Sulfur caps	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.982	in
Diameter (initial):	2.036	in
Weight:	0	g
Unit Weight:	0	pcf
Gage Length:	2.85	in
Test Summary		
Peak Stress:	637	psi
Secant Modulus E_{50EP}:	77,003	psi
Secant Modulus E_{50L}:	376,960	psi
Poisson's Ratio ν_{50} :	0.21	
Poisson's Ratio ν_f :	0.33	
Local Strain at failure, ε_f :	2.20	%
End Platen Strain at failure, ε_f :	1.51	%





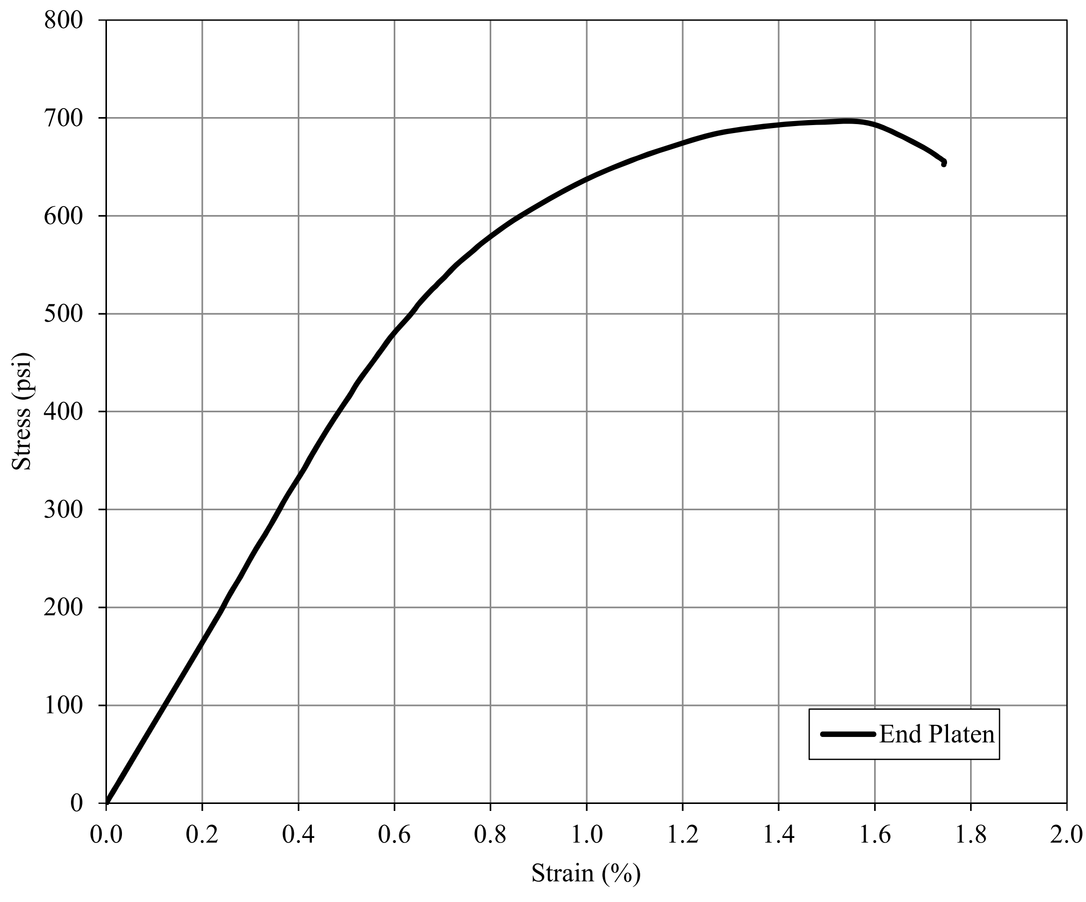


Batch E-7

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-7-G
Curing Period:	14 day
Test Date:	1/30/2017
$\alpha_{in\text{-}place}$:	350
$(w:c)_{slurry}$:	1.0
End Treatment:	Sulfur Cap
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

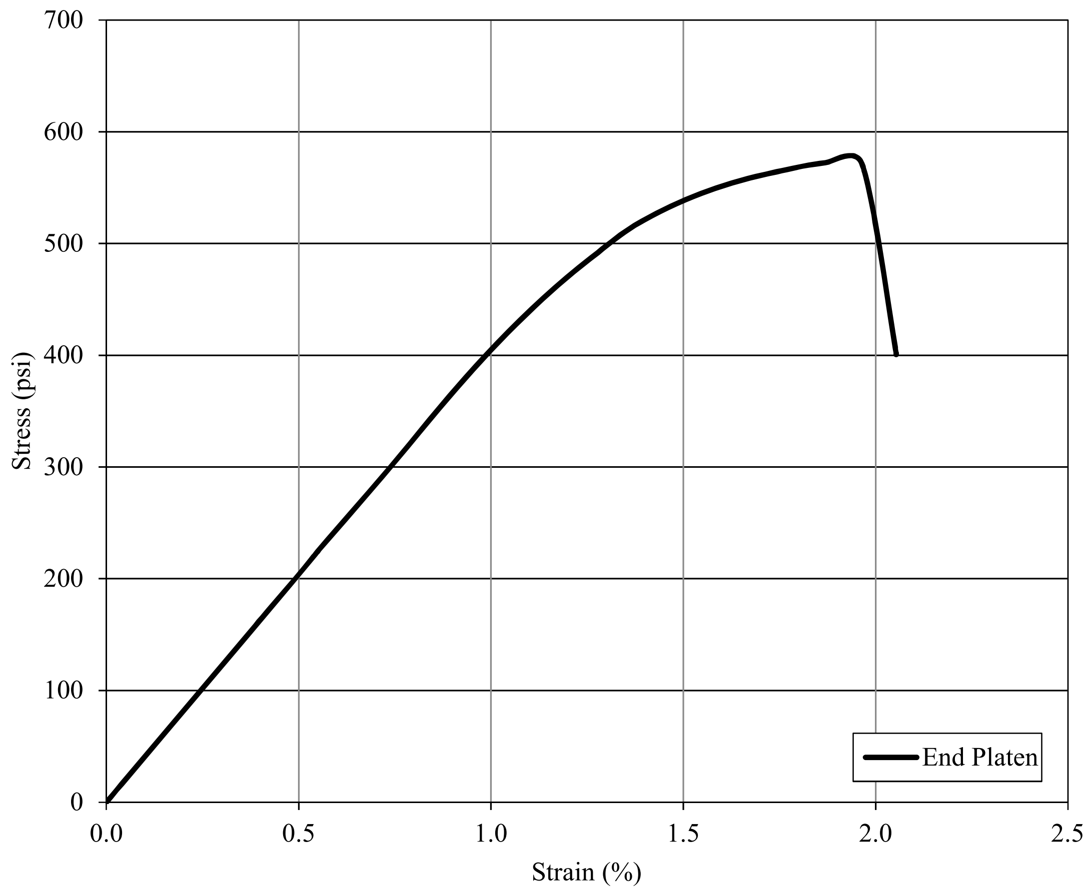
Specimen Information		
Height (initial):	3.984	in
Diameter (initial):	2.036	in
Weight:	361.2	g
Unit Weight:	106	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	696	psi
Secant Modulus E_{50EP}:	83,029	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.48	%

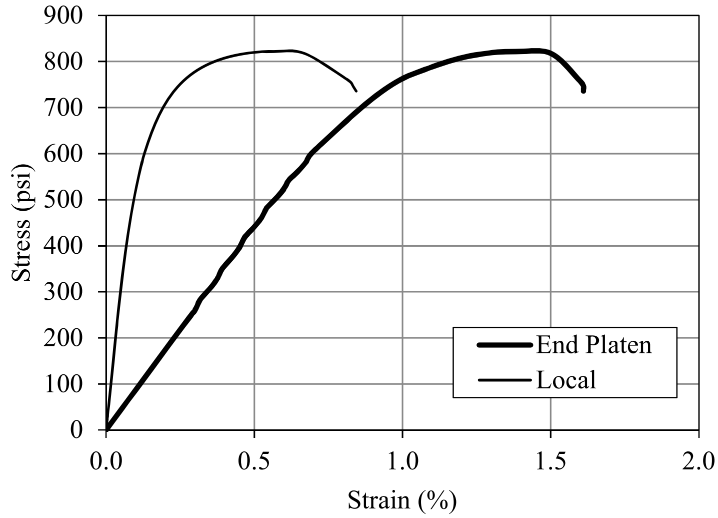


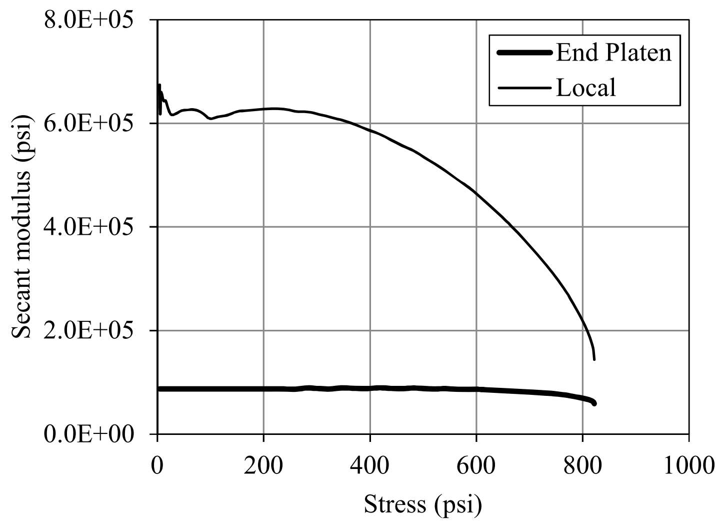
Batch E-7

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.93	in	Peak Stress:	572	psi
Tested by:	RNG	Diameter (initial):	2.037	in	Secant Modulus E_{50EP}:	40,657	psi
I.D. :	E-7-H	Weight:	354.9	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	14 day	Unit Weight:	106	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	1/30/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	350				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.87	%
End Treatment:	Neoprene Pads						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-7-D	
Curing Period:	28 day	
Test Date:	2/13/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Gypsum	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.98	in
Diameter (initial):	2.034	in
Weight:	358.7	g
Unit Weight:	106	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	822	psi
Secant Modulus E_{50EP}:	89,058	psi
Secant Modulus E_{50L}:	581,606	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	1.39	%
End Platen Strain at failure, ε_f:	0.57	%

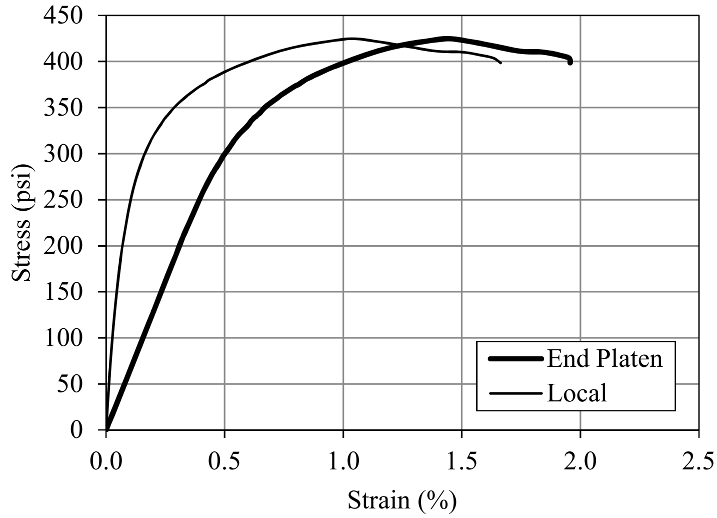


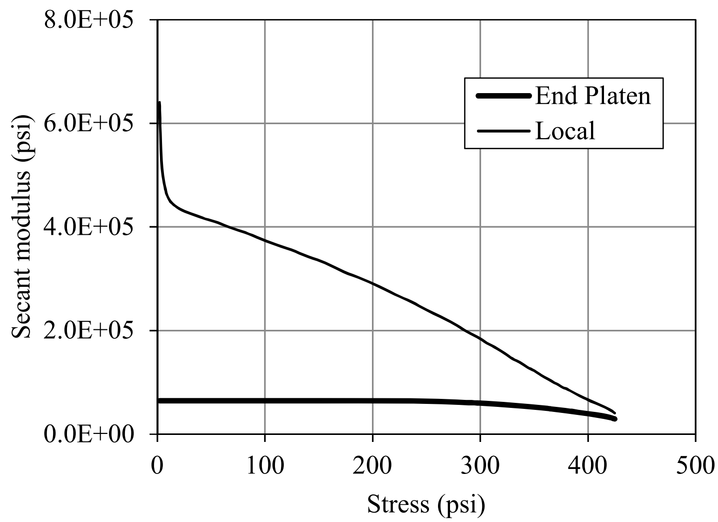


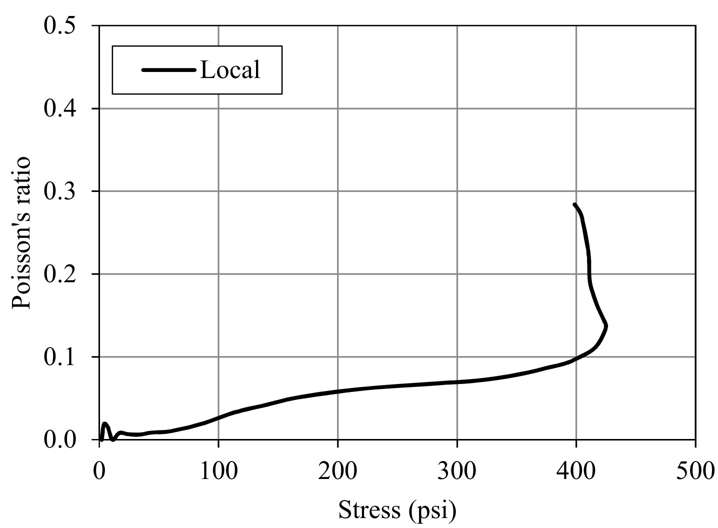
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-8-A
Curing Period:	7 day
Test Date:	2/1/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sulfur Caps
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.99	in
Diameter (initial):	2.035	in
Weight:	367.1	g
Unit Weight:	108	pcf
Gage Length:	2.8	in

Test Summary		
Peak Stress:	425	psi
Secant Modulus E_{50EP}:	64,570	psi
Secant Modulus E_{50L}:	277,836	psi
Poisson's Ratio ν_{50} :	0.06	
Poisson's Ratio ν_f :	0.14	
Local Strain at failure, ε_f :	1.45	%
End Platen Strain at failure, ε_f :	1.04	%

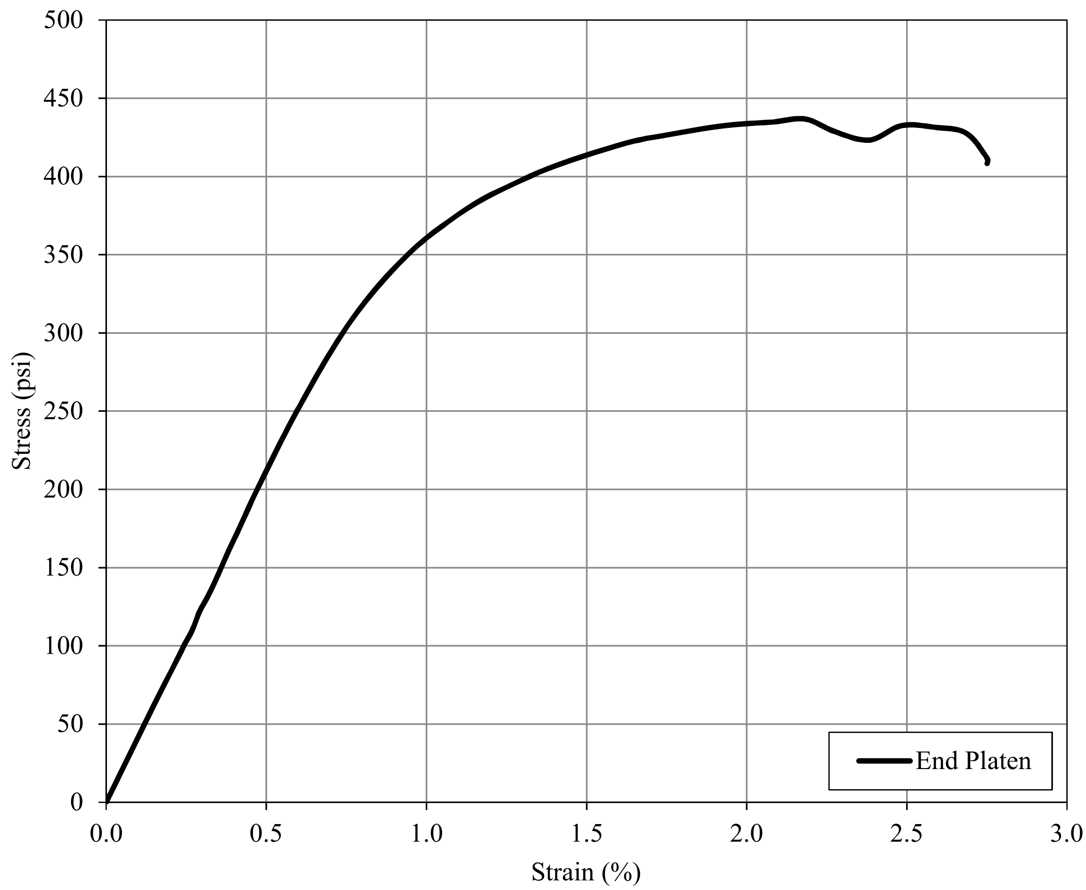






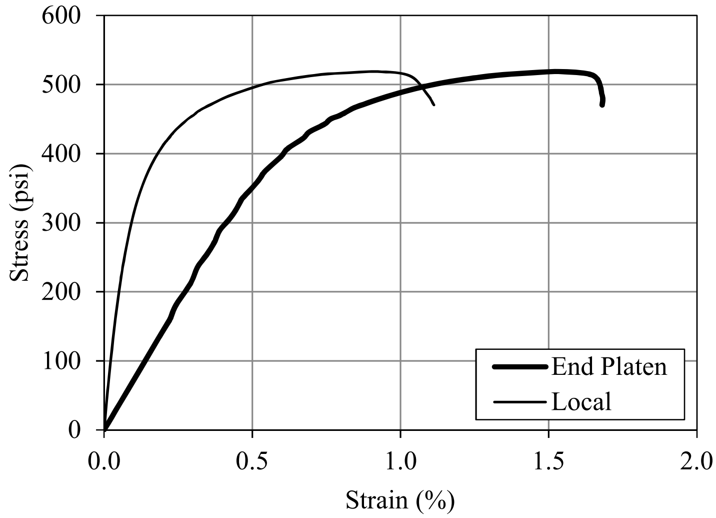
Batch E-8

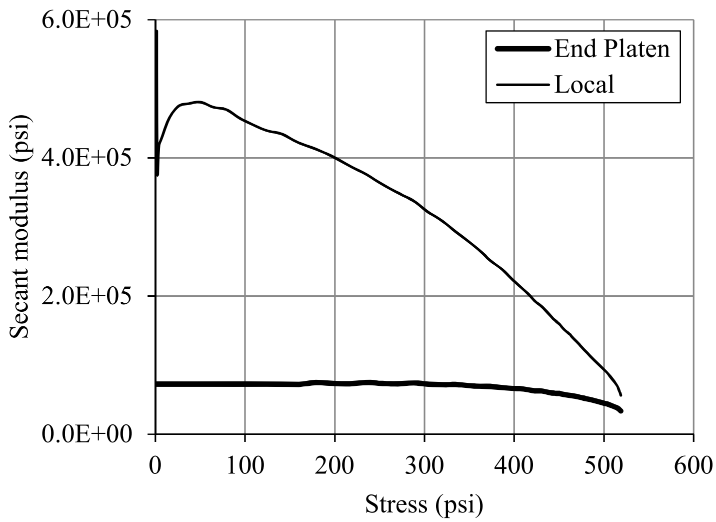
Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.956	in	Peak Stress:	437	psi
Tested by:	RNG						
I.D. :	E-8-B	Diameter (initial):	2.034	in	Secant Modulus E_{50EP}:	42,398	psi
Curing Period:	7 day						
Test Date:	2/1/2017	Weight:	362.7	g	Secant Modulus E_{50L}:	N/A	psi
$\alpha_{in\text{-}place}$:	275	Unit Weight:	107	pcf			
$(w:c)_{slurry}$:	1.0				Poisson's Ratio ν_{50} :	N/A	
End Treatment:	Neoprene pads	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
Confining Pressure (psi):	N/A				Local Strain at failure, εf :	N/A	%
Strain Rate:	1 %/min				End Platen Strain at failure, εf :	2.18	%

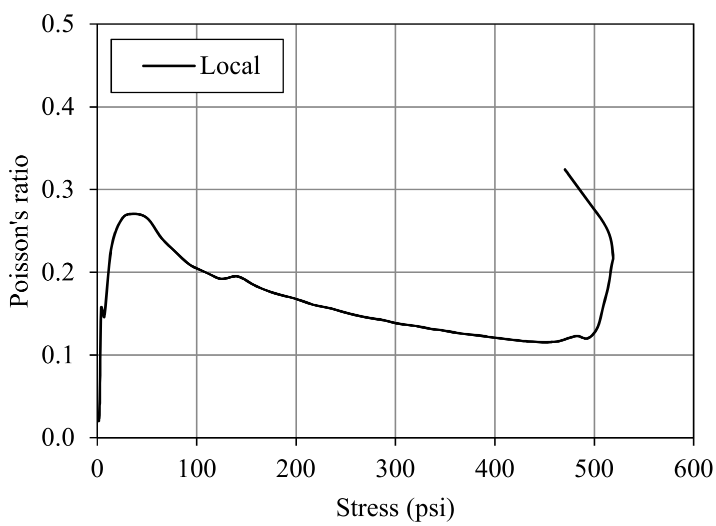


Batch E-8

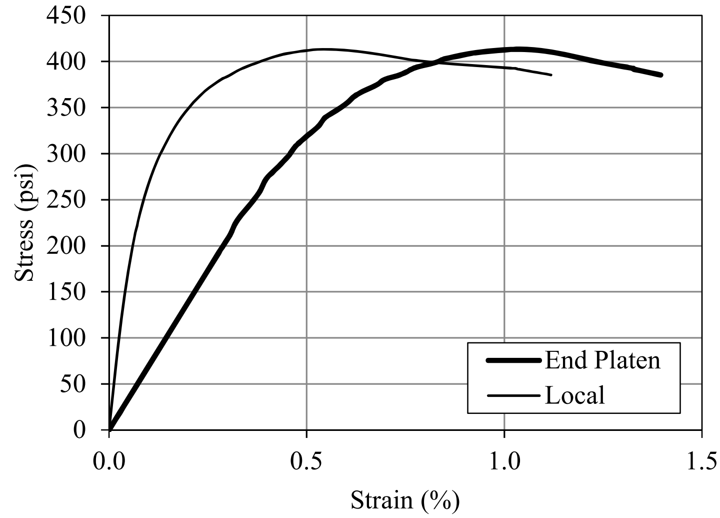
Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-8-E	
Curing Period:	14 day	
Test Date:	2/8/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Sulfur Cap	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.987	in
Diameter (initial):	2.034	in
Weight:	366.3	g
Unit Weight:	108	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	519	psi
Secant Modulus E_{50EP}:	73,242	psi
Secant Modulus E_{50L}:	356,741	psi
Poisson's Ratio ν_{50} :	0.15	
Poisson's Ratio ν_f :	0.22	
Local Strain at failure, ε_f :	1.54	%
End Platen Strain at failure, ε_f :	0.92	%

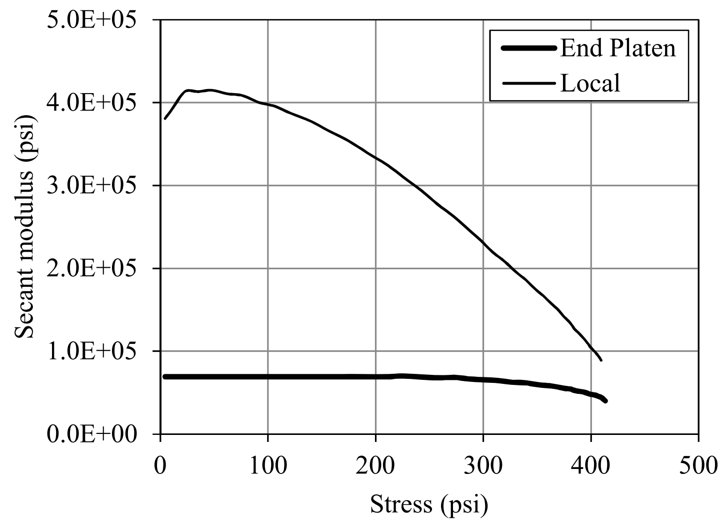


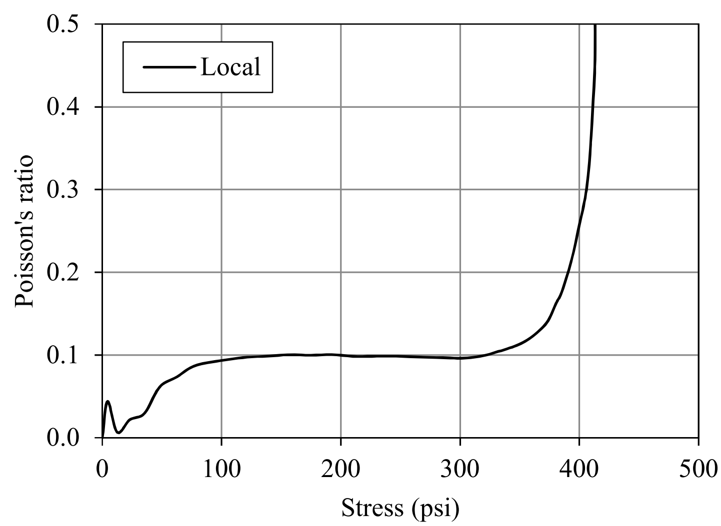




Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-8-F	
Curing Period:	14 day	
Test Date:	2/8/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Gypsum Cap	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	4.006	in
Diameter (initial):	2.039	in
Weight:	370.9	g
Unit Weight:	108	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	413	psi
Secant Modulus E_{50EP}:	69,185	psi
Secant Modulus E_{50L}:	327,792	psi
Poisson's Ratio ν_{50} :	0.10	
Poisson's Ratio ν_f:	0.47	
Local Strain at failure, ε_f:	1.03	%
End Platen Strain at failure, ε_f:	0.54	%



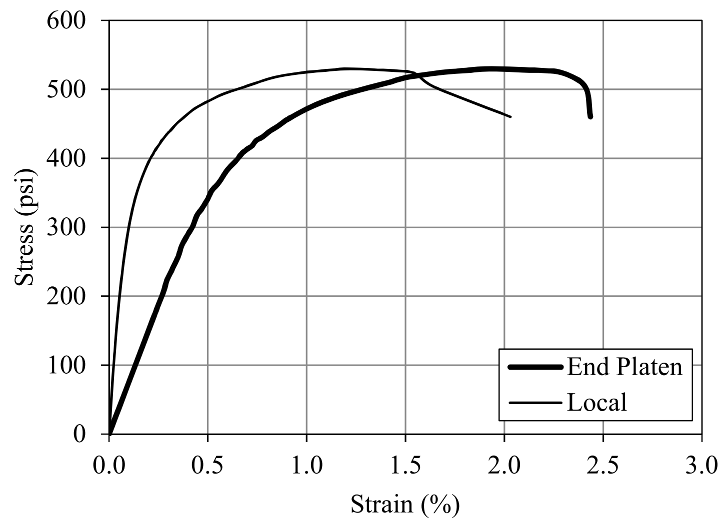


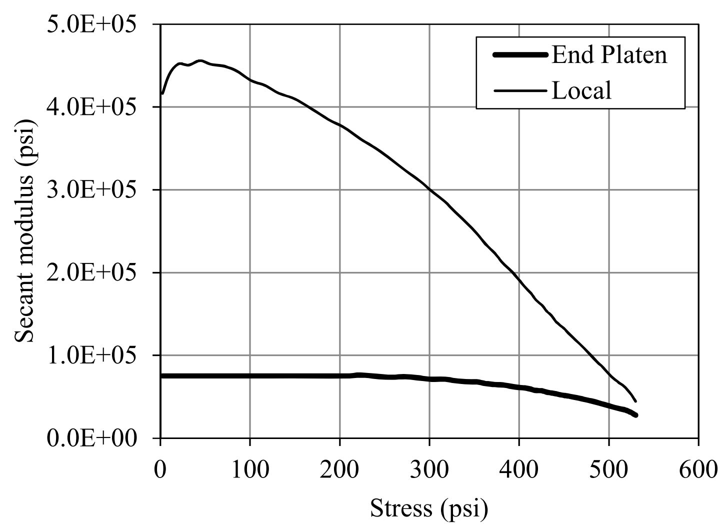


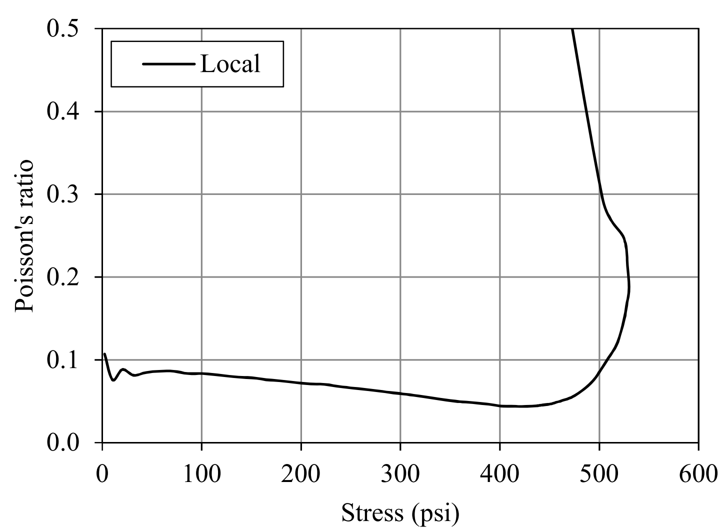
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-8-G
Curing Period:	14 day
Test Date:	2/8/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sulfur Cap
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.991	in
Diameter (initial):	2.035	in
Weight:	366.6	g
Unit Weight:	108	pcf
Gage Length:	2.8	in

Test Summary		
Peak Stress:	530	psi
Secant Modulus E_{50EP}:	73,970	psi
Secant Modulus E_{50L}:	329,870	psi
Poisson's Ratio ν_{50} :	0.06	
Poisson's Ratio ν_f :	0.18	
Local Strain at failure, ε_f :	1.90	%
End Platen Strain at failure, ε_f :	1.19	%

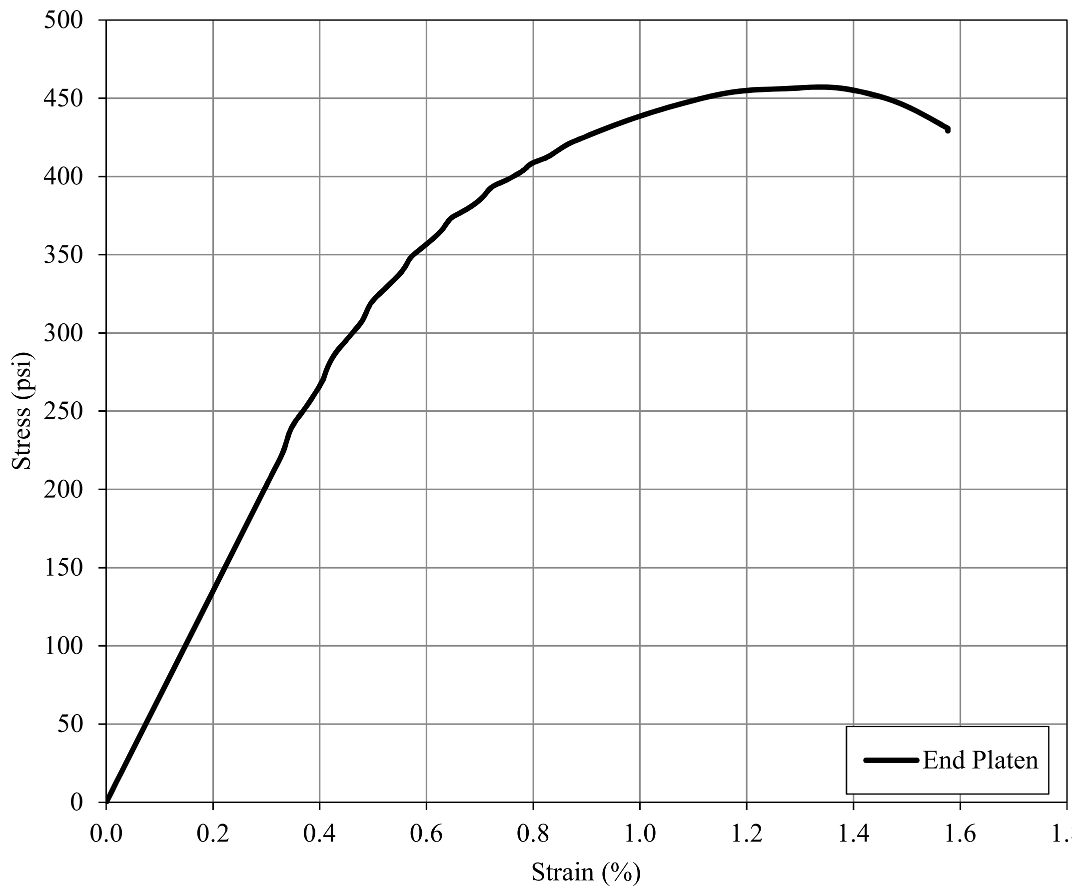






Batch E-8

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.98	in	Peak Stress:	457	psi
Tested by:	RNG						
I.D. :	E-8-H	Diameter (initial):	2.035	in	Secant Modulus E_{50EP}:	68,030	psi
Curing Period:	14 day						
Test Date:	2/8/2017	Weight:	367.2	g	Secant Modulus E_{50L}:	N/A	psi
$\alpha_{in\text{-}place}$:	275	Unit Weight:	108	pcf			
$(w:c)_{slurry}$:	1.0				Poisson's Ratio ν_{50} :	N/A	
End Treatment:	Gypsum	Gage Length:	N/A	in			
Confining Pressure (psi):	N/A				Poisson's Ratio ν_f :	N/A	
Strain Rate:	1 %/min				Local Strain at failure, εf :	N/A	%
					End Platen Strain at failure, εf :	1.37	%

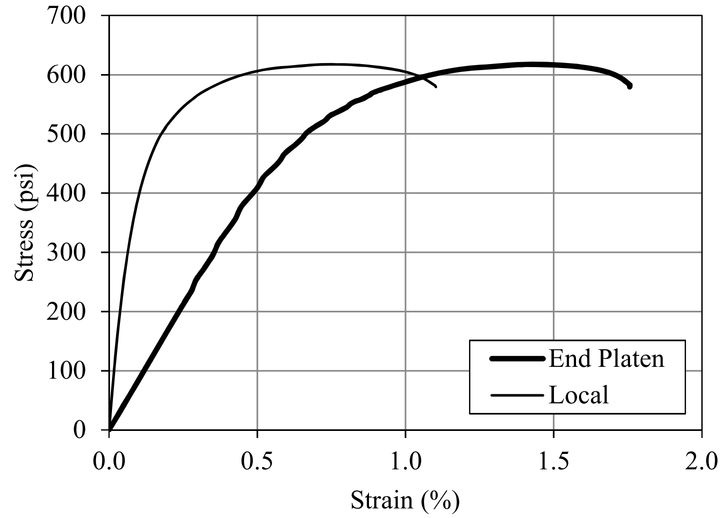


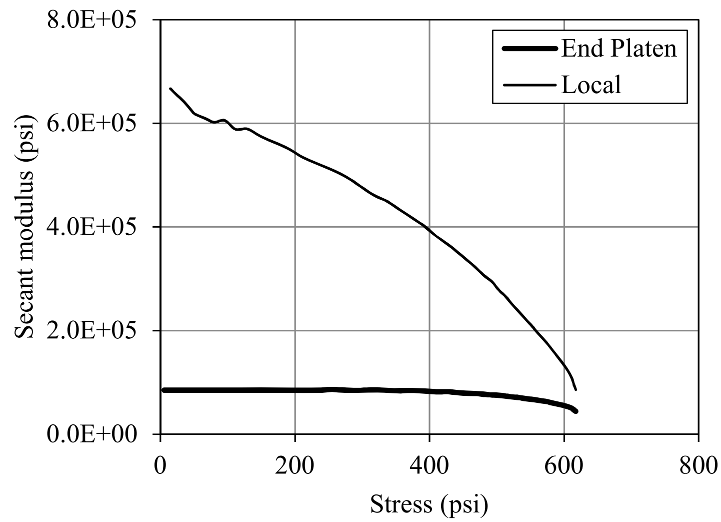
Batch E-8

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-8-C
Curing Period:	28 day
Test Date:	2/22/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sulfur Capping
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.99	in
Diameter (initial):	2.033	in
Weight:	365.3	g
Unit Weight:	107	pcf
Gage Length:	2.8	in

Test Summary		
Peak Stress:	617	psi
Secant Modulus E_{50EP}:	85,255	psi
Secant Modulus E_{50L}:	468,232	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	1.40	%
End Platen Strain at failure, ε_f:	0.72	%



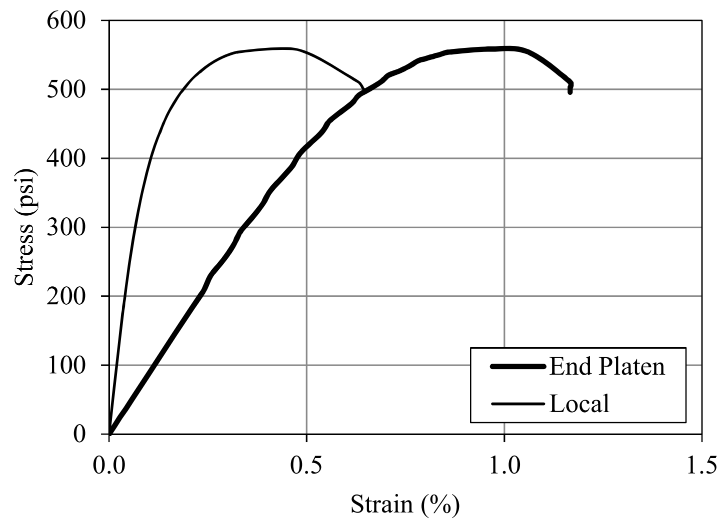


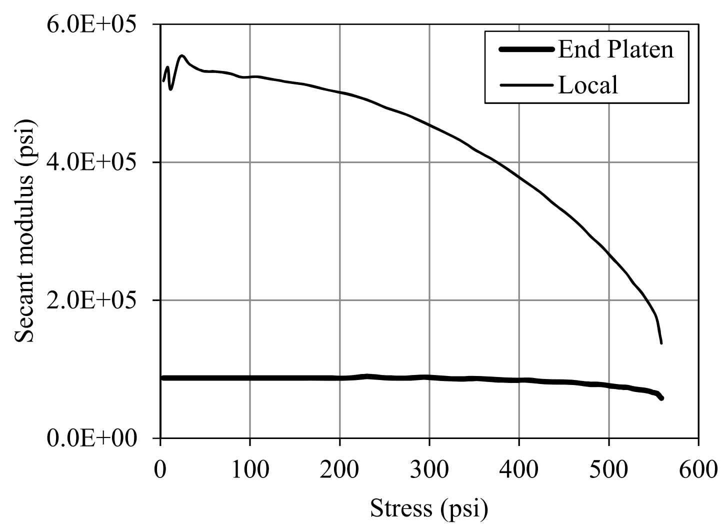
Batch E-8

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-8-D
Curing Period:	28 day
Test Date:	2/22/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Gypsum Capping
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.987	in
Diameter (initial):	2.034	in
Weight:	366.2	g
Unit Weight:	108	pcf
Gage Length:	2.8	in

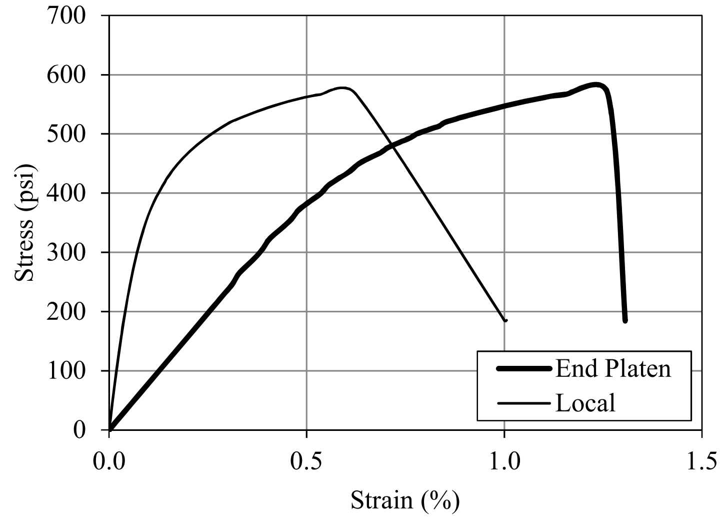
Test Summary		
Peak Stress:	559	psi
Secant Modulus E_{50EP}:	87,466	psi
Secant Modulus E_{50L}:	465,643	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	0.96	%
End Platen Strain at failure, ε_f:	0.41	%

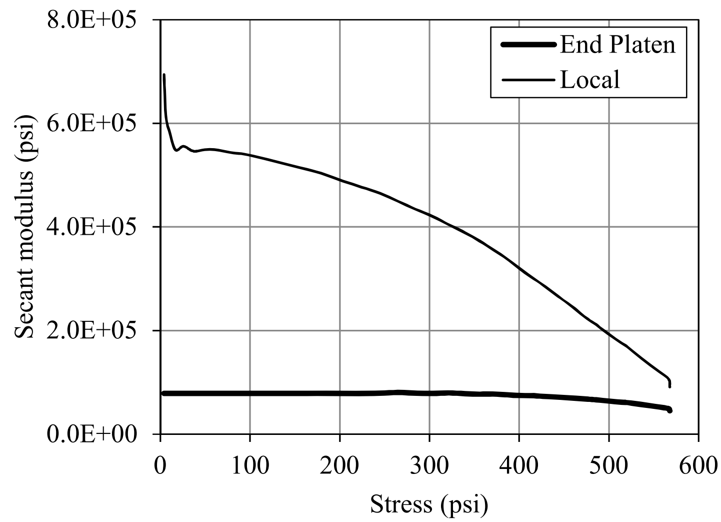


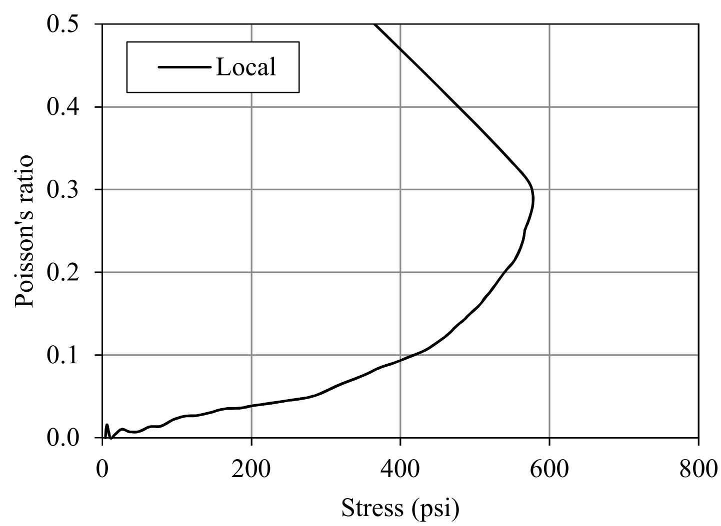


Batch E-8

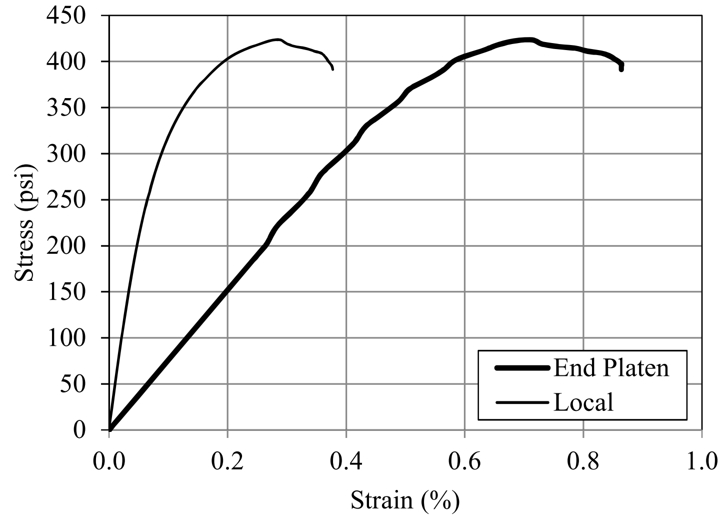
Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-8-I	
Curing Period:	28 day	
Test Date:	2/22/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Sulfur Capping	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.982	in
Diameter (initial):	2.035	in
Weight:	365.9	g
Unit Weight:	108	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	568	psi
Secant Modulus E_{50EP}:	79,165	psi
Secant Modulus E_{50L}:	434,387	psi
Poisson's Ratio ν_{50} :	0.05	
Poisson's Ratio ν_f :	0.31	
Local Strain at failure, ε_f :	1.26	%
End Platen Strain at failure, ε_f :	0.62	%

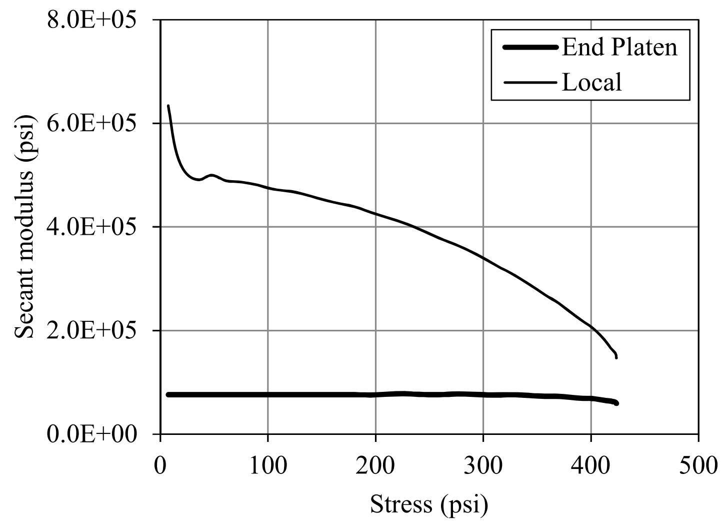






Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-8-J	
Curing Period:	28 day	
Test Date:	2/22/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Gypsum Capping	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.984	in
Diameter (initial):	2.036	in
Weight:	366.9	g
Unit Weight:	108	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	424	psi
Secant Modulus E_{50EP}:	77,189	psi
Secant Modulus E_{50L}:	416,859	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	0.71	%
End Platen Strain at failure, ε_f:	0.29	%

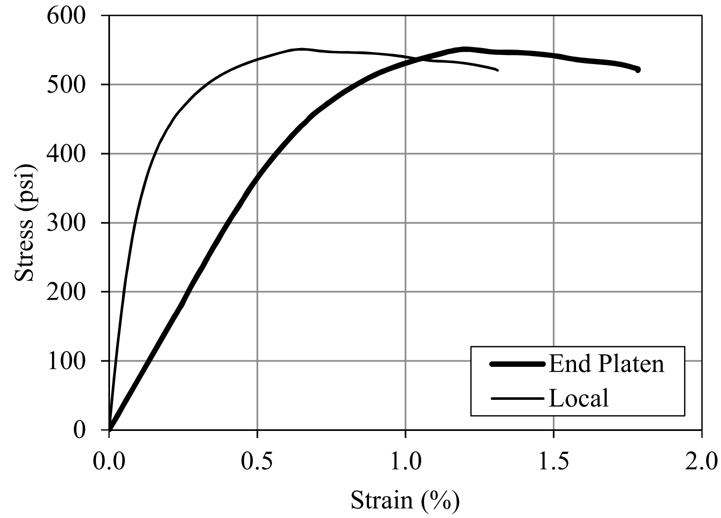


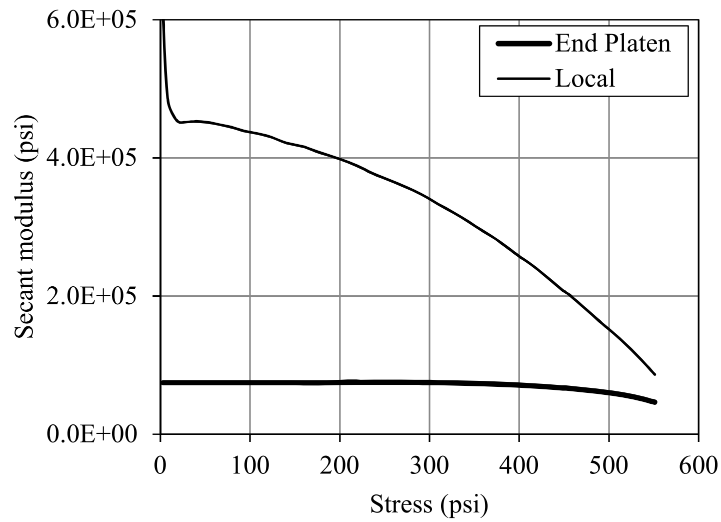


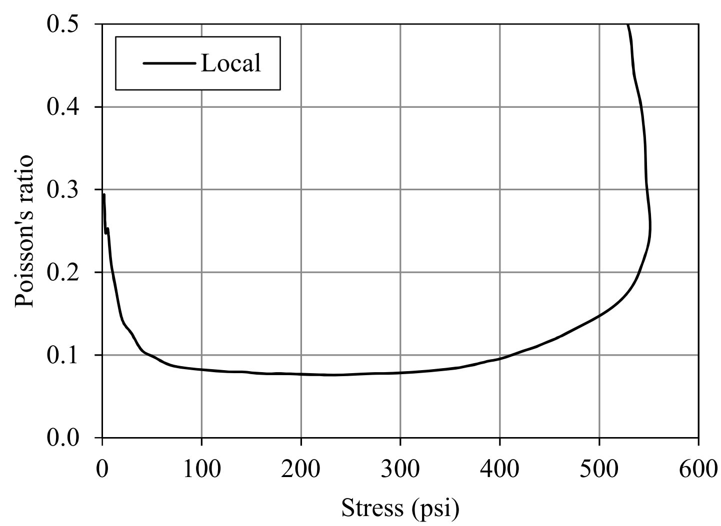
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-9-A
Curing Period:	7 day
Test Date:	2/1/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sulfur Cap
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.99	in
Diameter (initial):	2.035	in
Weight:	361.8	g
Unit Weight:	106	pcf
Gage Length:	2.8	in

Test Summary		
Peak Stress:	551	psi
Secant Modulus E_{50EP}:	74,942	psi
Secant Modulus E_{50L}:	356,376	psi
Poisson's Ratio ν_{50} :	0.08	
Poisson's Ratio ν_f :	0.25	
Local Strain at failure, ε_f :	1.19	%
End Platen Strain at failure, ε_f :	0.64	%





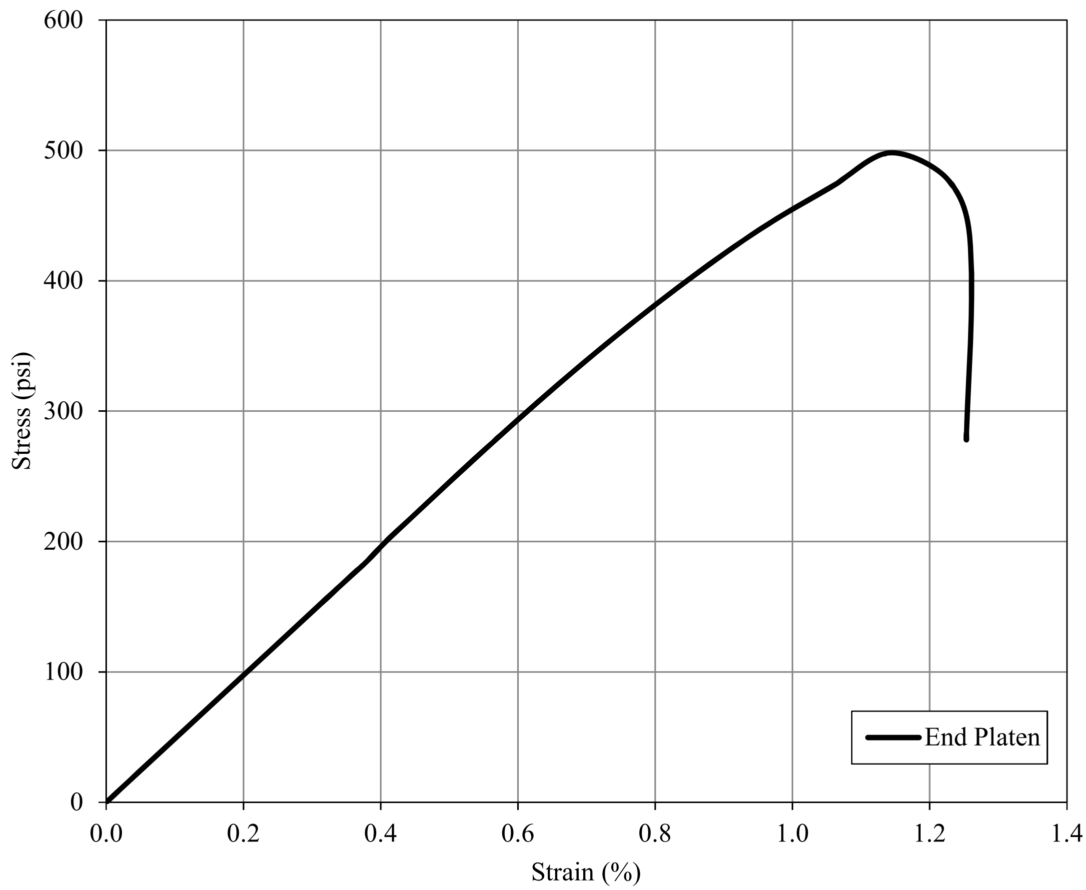


Batch E-9

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-9-B
Curing Period:	7 day
Test Date:	2/1/2017
$\alpha_{in\text{-}place}$:	350
$(w:c)_{slurry}$:	1.0
End Treatment:	Neoprene Pads
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.958	in
Diameter (initial):	2.033	in
Weight:	358.2	g
Unit Weight:	106	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	498	psi
Secant Modulus E_{50EP}:	49,098	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.15	%

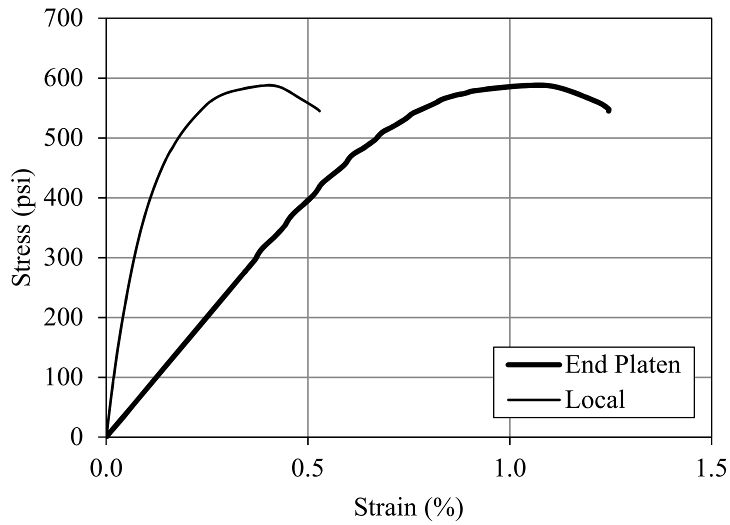


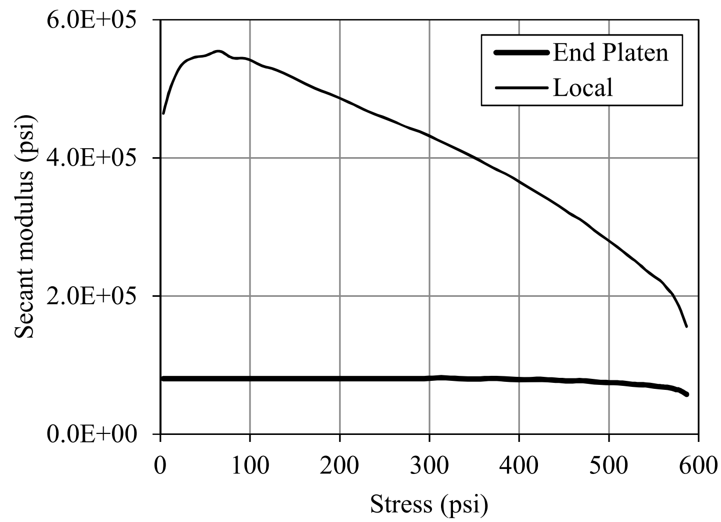
Batch E-9

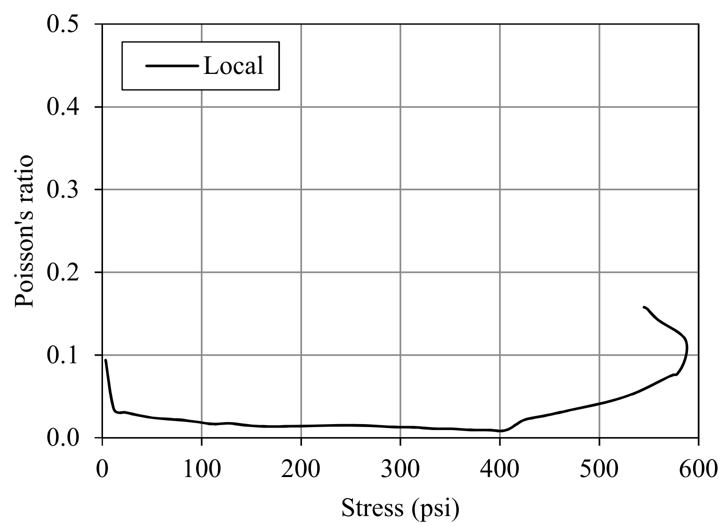
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-9-E
Curing Period:	14 day
Test Date:	2/8/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sulfur Cap
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.989	in
Diameter (initial):	2.037	in
Weight:	361.9	g
Unit Weight:	106	pcf
Gage Length:	2.8	in

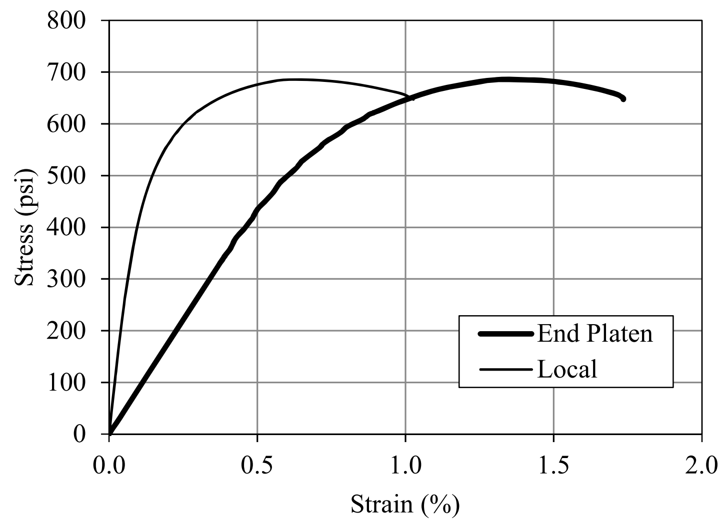
Test Summary		
Peak Stress:	587	psi
Secant Modulus E_{50EP}:	80,376	psi
Secant Modulus E_{50L}:	435,676	psi
Poisson's Ratio ν_{50} :	0.01	
Poisson's Ratio ν_f :	0.10	
Local Strain at failure, ε_f :	1.02	%
End Platen Strain at failure, ε_f :	0.38	%

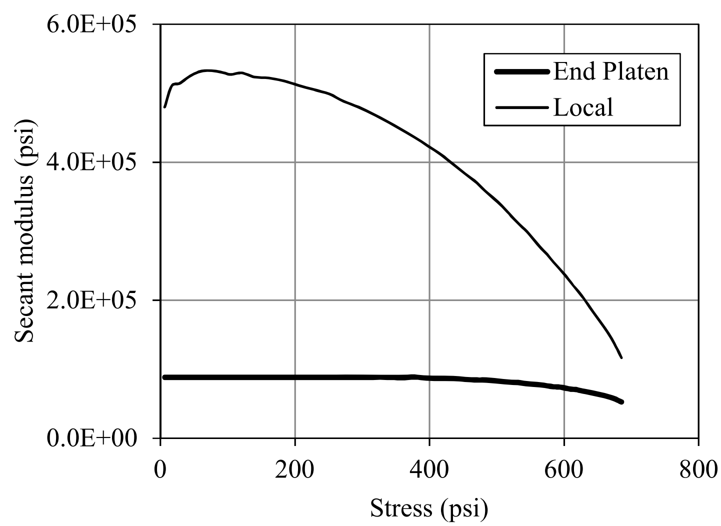


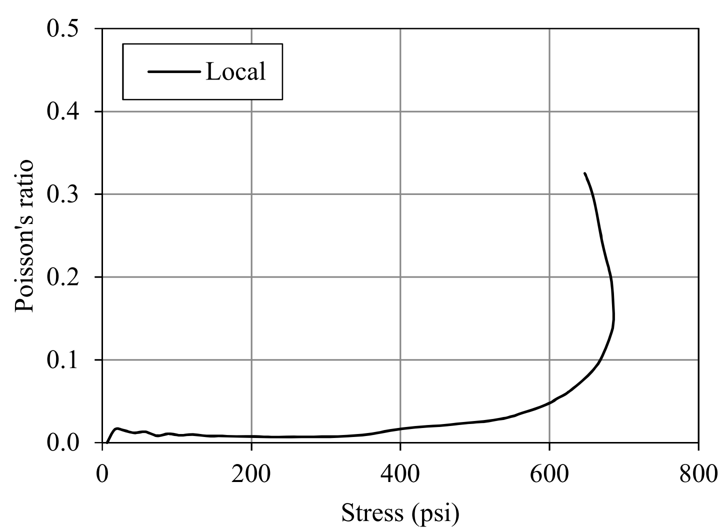




Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-9-F	
Curing Period:	14 day	
Test Date:	2/8/2017	
$\alpha_{in\text{-}place}$:	200	
$(w{:}c)_{slurry}$:	1.0	
End Treatment:	Gypsum	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.982	in
Diameter (initial):	2.033	in
Weight:	361.2	g
Unit Weight:	106	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	685	psi
Secant Modulus E_{50EP}:	88,159	psi
Secant Modulus E_{50L}:	455,801	psi
Poisson's Ratio ν_{50} :	0.01	
Poisson's Ratio ν_f :	0.14	
Local Strain at failure, ε_f :	1.30	%
End Platen Strain at failure, ε_f :	0.59	%





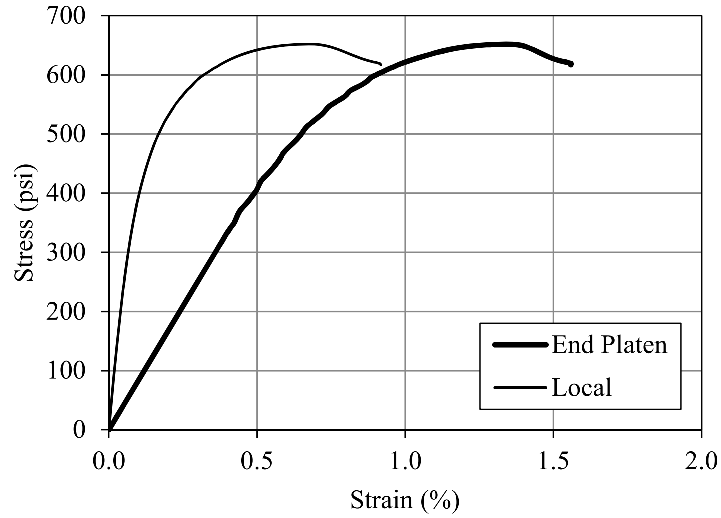


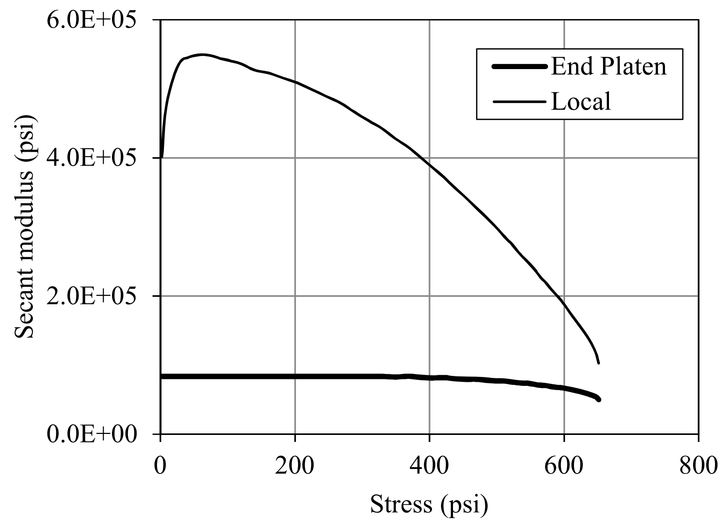
Batch E-9

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-9-G
Curing Period:	14 day
Test Date:	2/8/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sulfur Cap
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

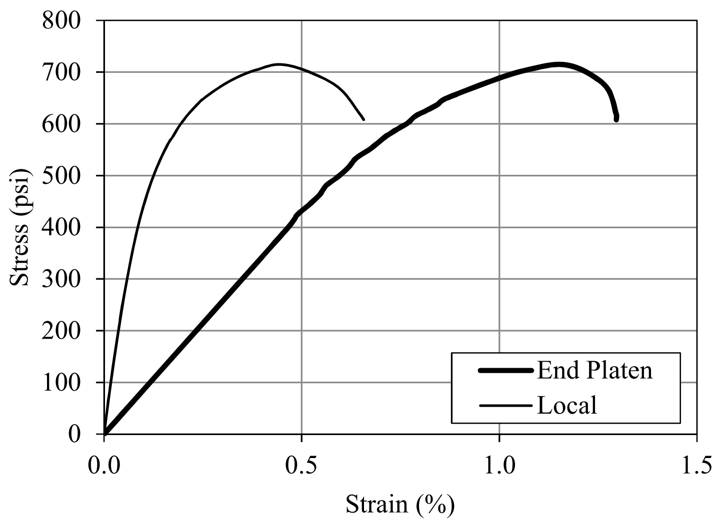
Specimen Information		
Height (initial):	3.989	in
Diameter (initial):	2.037	in
Weight:	362.5	g
Unit Weight:	106	pcf
Gage Length:	2.8	in

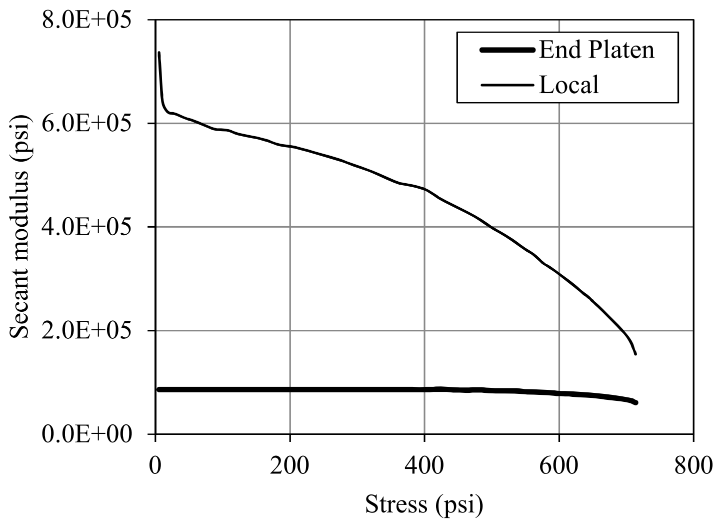
Test Summary		
Peak Stress:	651	psi
Secant Modulus E_{50EP}:	79,453	psi
Secant Modulus E_{50L}:	444,246	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	1.30	%
End Platen Strain at failure, ε_f:	0.63	%

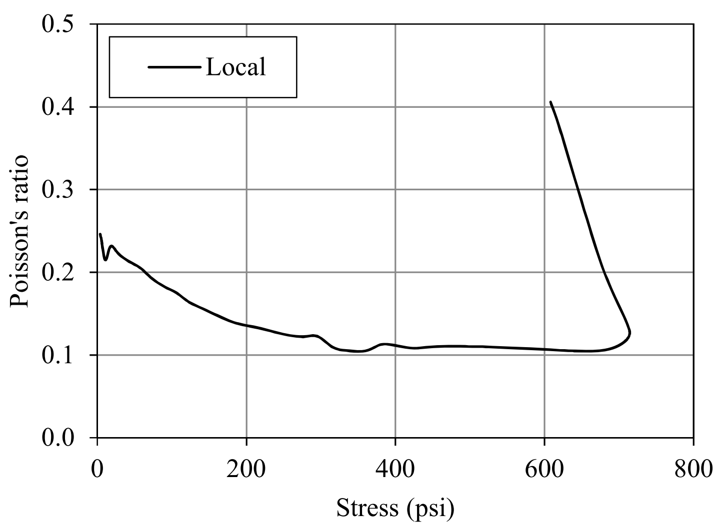




Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-9-C	
Curing Period:	28 day	
Test Date:	2/22/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Sulfur Capping	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.989	in
Diameter (initial):	2.036	in
Weight:	361.2	g
Unit Weight:	106	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	714	psi
Secant Modulus E_{50EP}:	66,197	psi
Secant Modulus E_{50L}:	486,891	psi
Poisson's Ratio ν_{50} :	0.11	
Poisson's Ratio ν_f :	0.13	
Local Strain at failure, ε_f :	1.17	%
End Platen Strain at failure, ε_f :	0.46	%





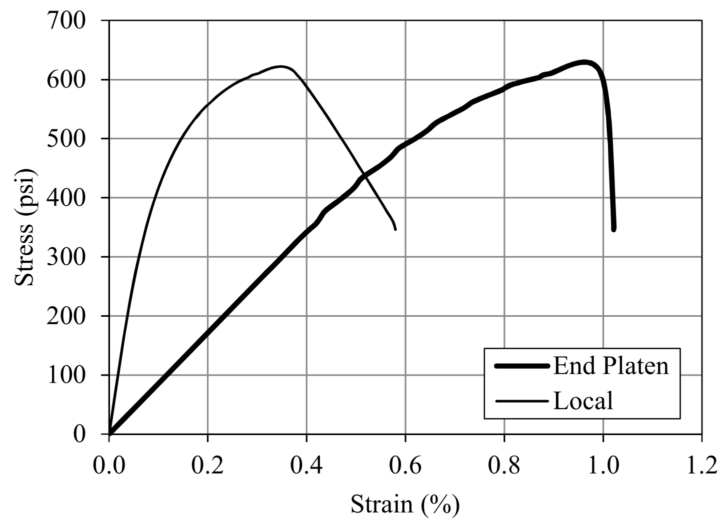


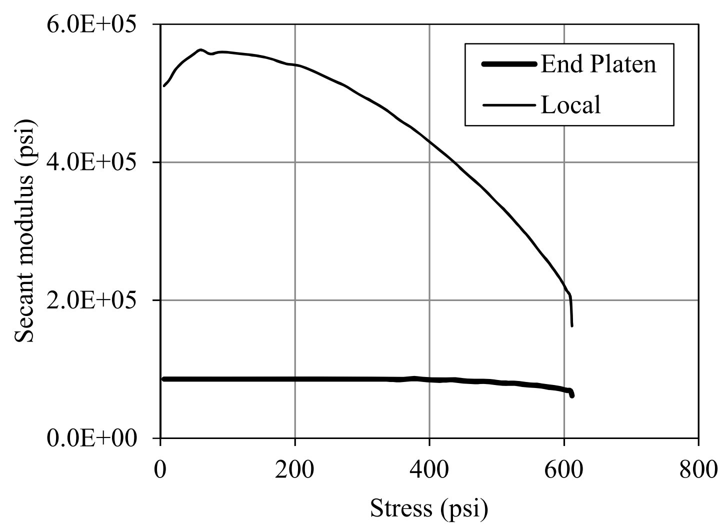
Batch E-9

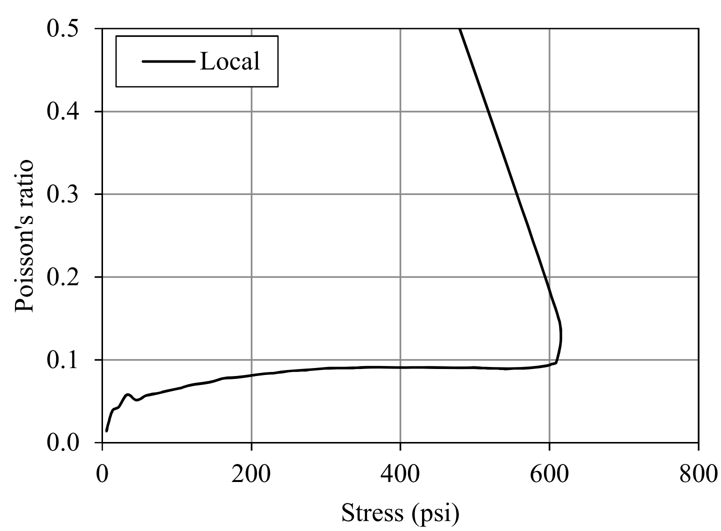
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-9-H
Curing Period:	14 day
Test Date:	2/8/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Gypsum
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.985	in
Diameter (initial):	2.037	in
Weight:	362.1	g
Unit Weight:	106	pcf
Gage Length:	2.8	in

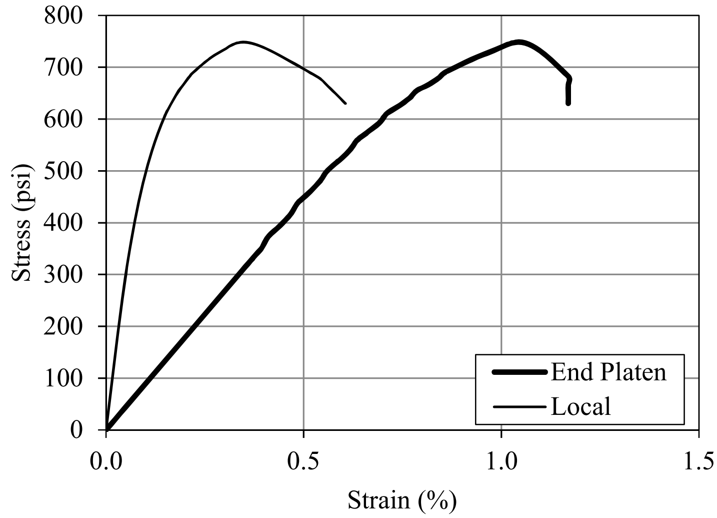
Test Summary		
Peak Stress:	612	psi
Secant Modulus E_{50EP}:	66,557	psi
Secant Modulus E_{50L}:	492,401	psi
Poisson's Ratio ν_{50} :	0.09	
Poisson's Ratio ν_f:	0.15	
Local Strain at failure, ε_f:	0.99	%
End Platen Strain at failure, ε_f:	0.38	%

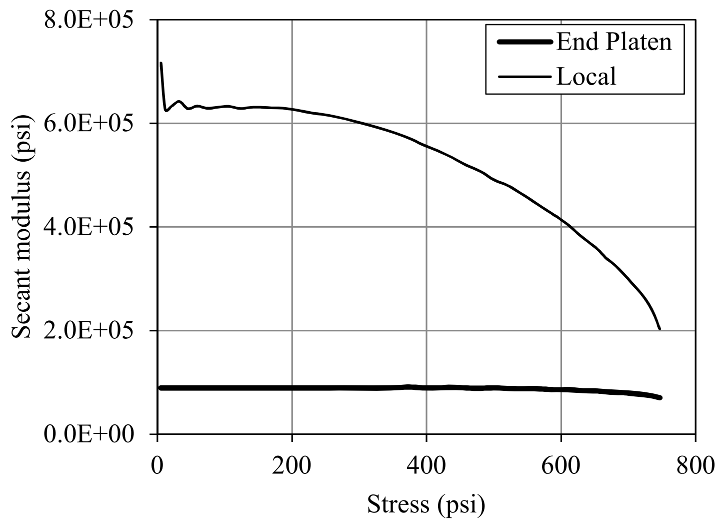


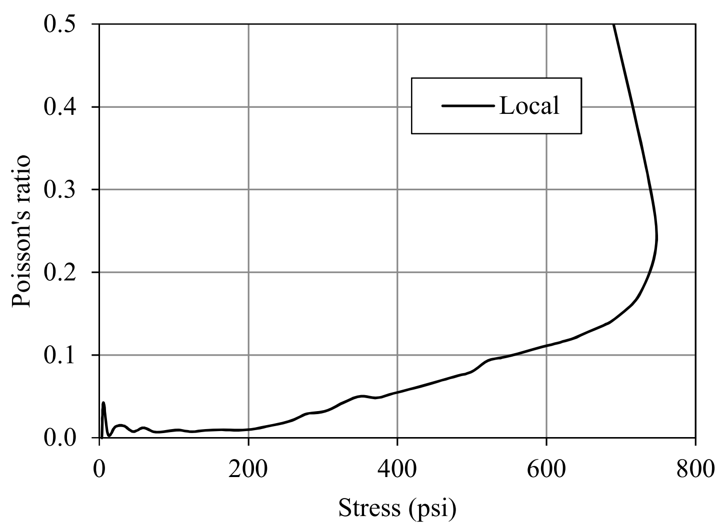




Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-9-D	
Curing Period:	28 day	
Test Date:	2/22/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Gypsum Capping	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.989	in
Diameter (initial):	2.037	in
Weight:	364.1	g
Unit Weight:	107	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	747	psi
Secant Modulus E_{50EP}:	90,898	psi
Secant Modulus E_{50L}:	571,713	psi
Poisson's Ratio ν_{50} :	0.05	
Poisson's Ratio ν_f :	0.26	
Local Strain at failure, ε_f :	1.06	%
End Platen Strain at failure, ε_f :	0.37	%



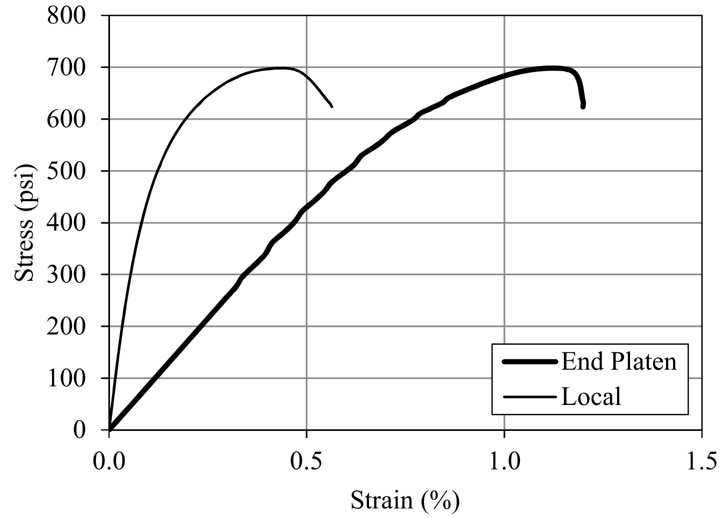


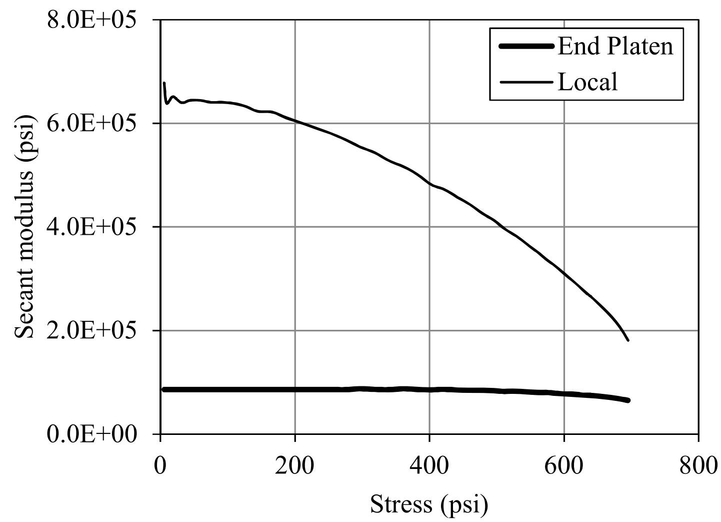


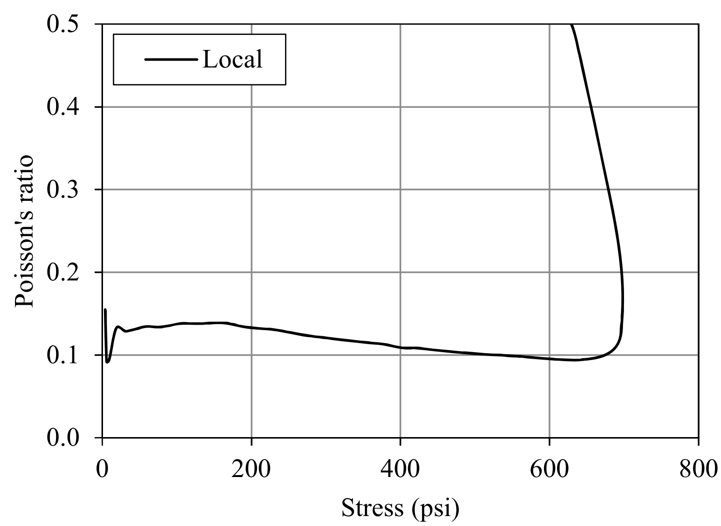
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-9-I
Curing Period:	28 day
Test Date:	2/22/2017
$\alpha_{in\text{-}place}$:	200
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Sulfur Capping
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.996	in
Diameter (initial):	2.04	in
Weight:	365.8	g
Unit Weight:	107	pcf
Gage Length:	2.8	in

Test Summary		
Peak Stress:	695	psi
Secant Modulus E_{50EP}:	86,551	psi
Secant Modulus E_{50L}:	523,329	psi
Poisson's Ratio ν_{50} :	0.12	
Poisson's Ratio ν_f :	0.12	
Local Strain at failure, ε_f :	1.07	%
End Platen Strain at failure, ε_f :	0.38	%



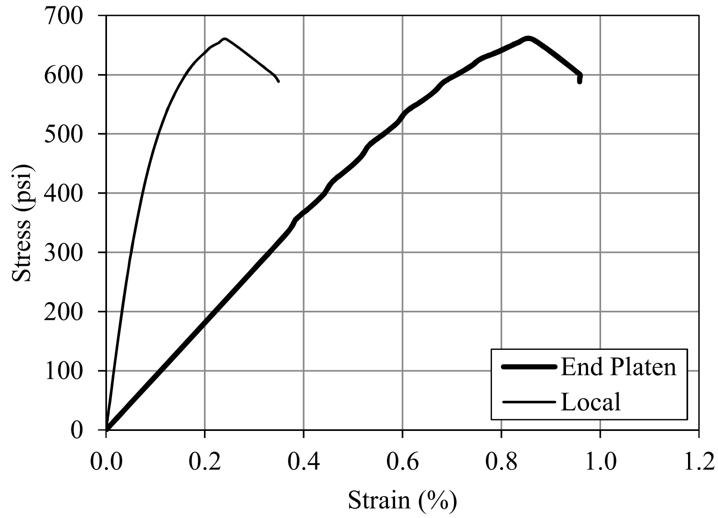


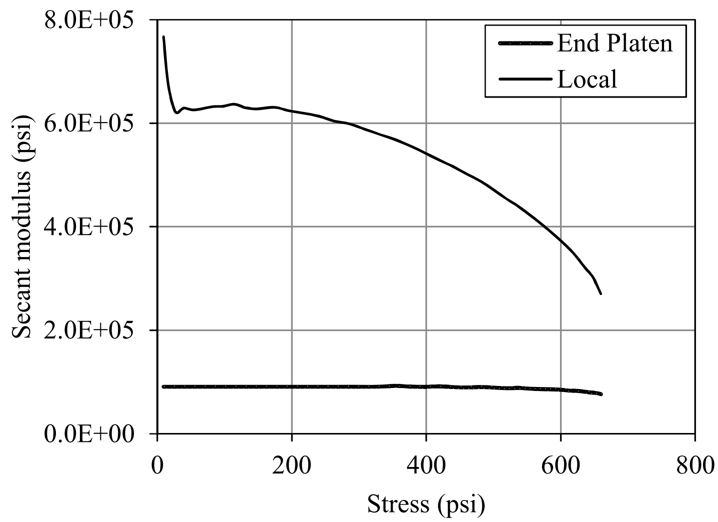


Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-9-J
Curing Period:	28 day
Test Date:	2/22/2017
$\alpha_{in\text{-}place}$:	200
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Gypsum Capping
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.983	in
Diameter (initial):	2.035	in
Weight:	361.7	g
Unit Weight:	106	pcf
Gage Length:	2.8	in

Test Summary		
Peak Stress:	660	psi
Secant Modulus E_{50EP}:	87,922	psi
Secant Modulus E_{50L}:	578,444	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, ε_f :	0.86	%
End Platen Strain at failure, ε_f :	0.24	%



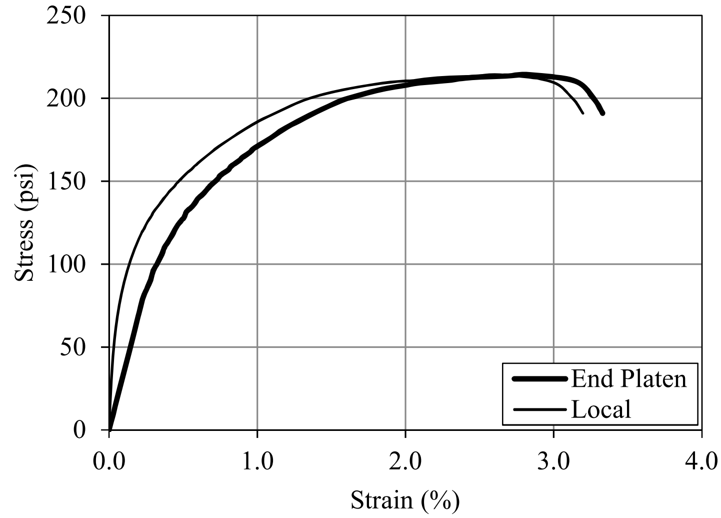


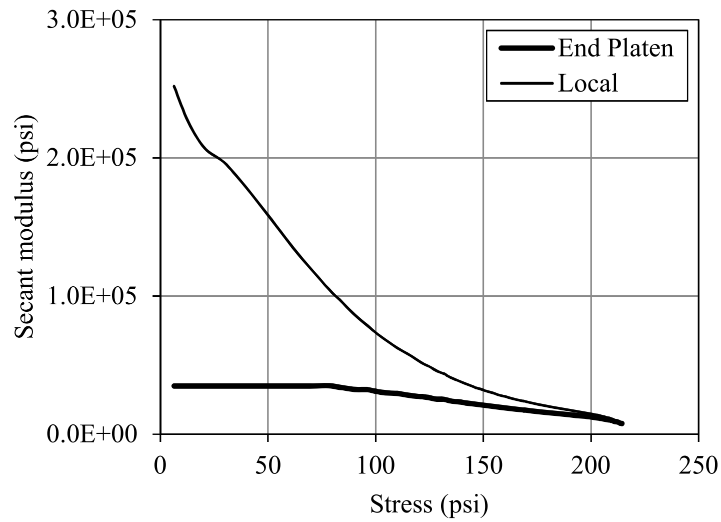
Batch E-10

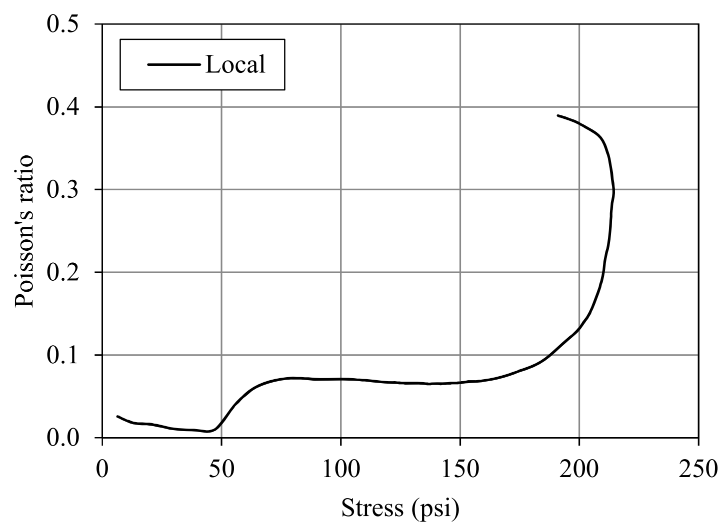
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-10-E
Curing Period:	3 day
Test Date:	2/6/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sulfur Cap
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.987	in
Diameter (initial):	2.037	in
Weight:	374.0	g
Unit Weight:	110	pcf
Gage Length:	2.8	in

Test Summary		
Peak Stress:	214	psi
Secant Modulus E_{50EP}:	29,677	psi
Secant Modulus E_{50L}:	65,310	psi
Poisson's Ratio ν_{50} :	0.07	
Poisson's Ratio ν_f:	0.30	
Local Strain at failure, ε_f:	2.79	%
End Platen Strain at failure, ε_f:	2.59	%



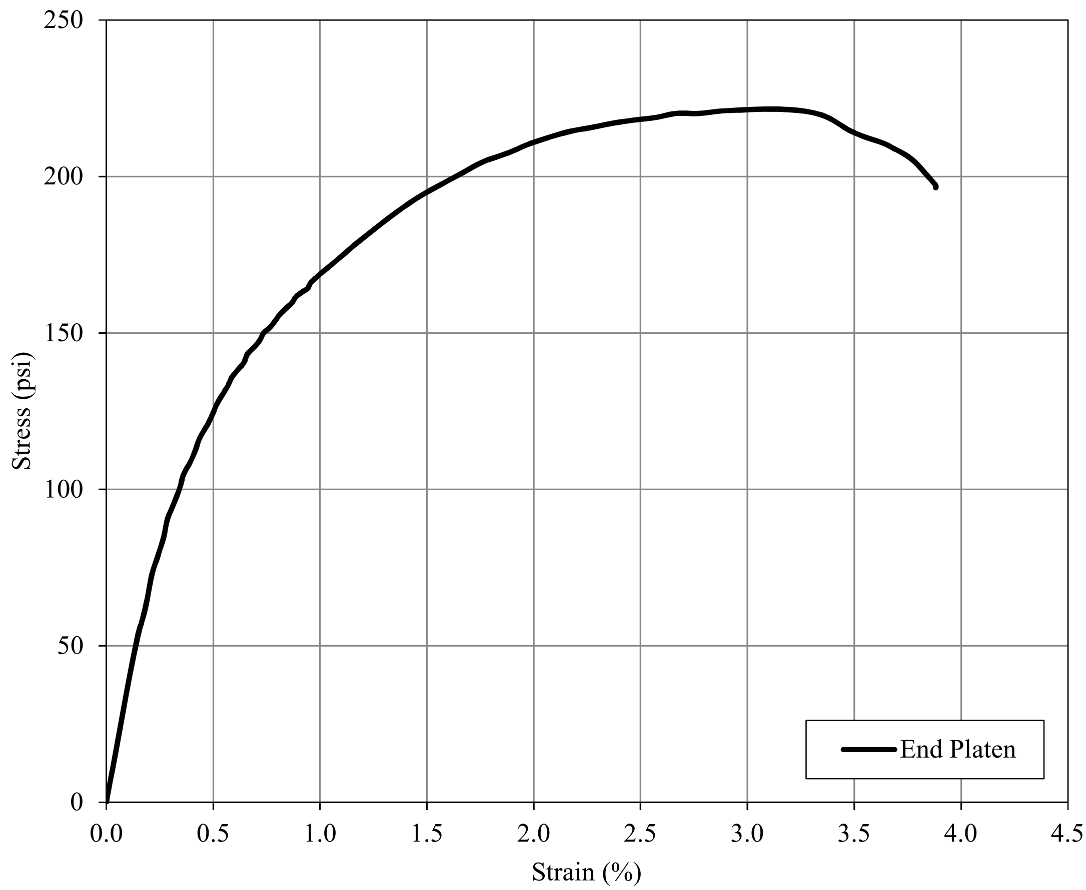




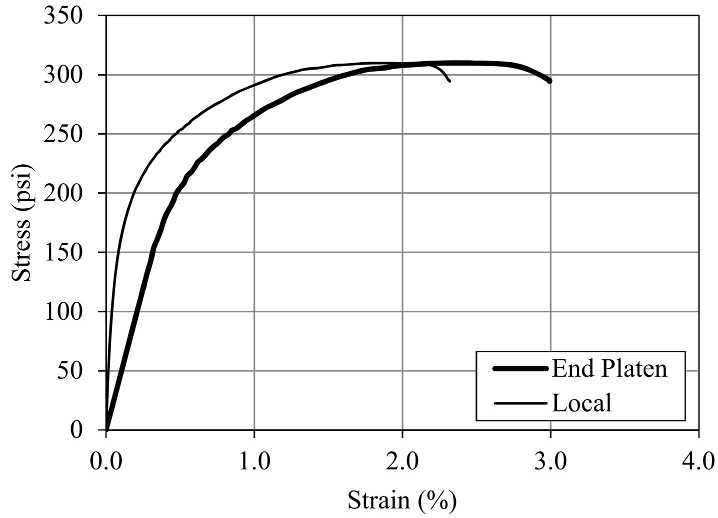
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-10-F
Curing Period:	3 day
Test Date:	2/6/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Gypsum
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

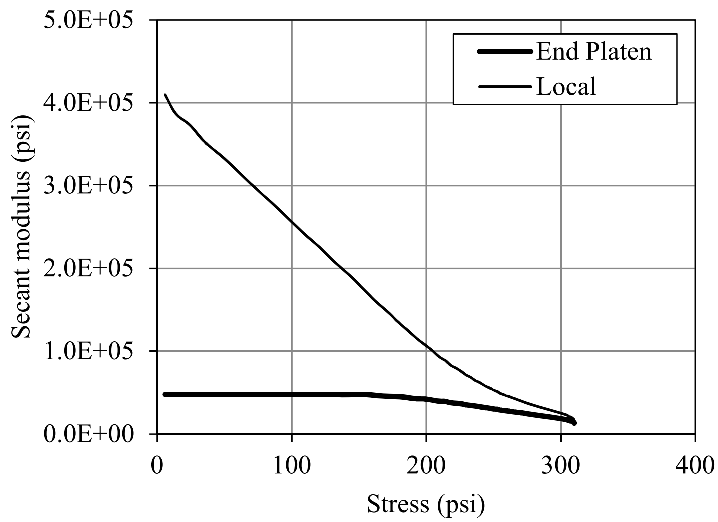
Specimen Information		
Height (initial):	3.99	in
Diameter (initial):	2.03	in
Weight:	373.7	g
Unit Weight:	110	pcf
Gage Length:	N/A	in

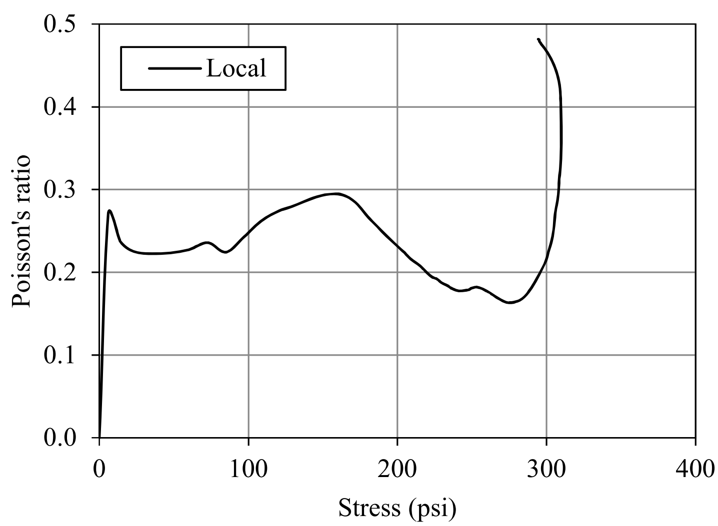
Test Summary		
Peak Stress:	222	psi
Secant Modulus E_{50EP}:	27,327	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	3.08	%



Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-10-A	
Curing Period:	7 day	
Test Date:	2/10/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Sulfur	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.991	in
Diameter (initial):	2.035	in
Weight:	372.9	g
Unit Weight:	109	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	310	psi
Secant Modulus E_{50EP}:	47,654	psi
Secant Modulus E_{50L}:	172,030	psi
Poisson's Ratio ν_{50} :	0.29	
Poisson's Ratio ν_f:	0.37	
Local Strain at failure, ε_f:	2.39	%
End Platen Strain at failure, ε_f:	1.91	%

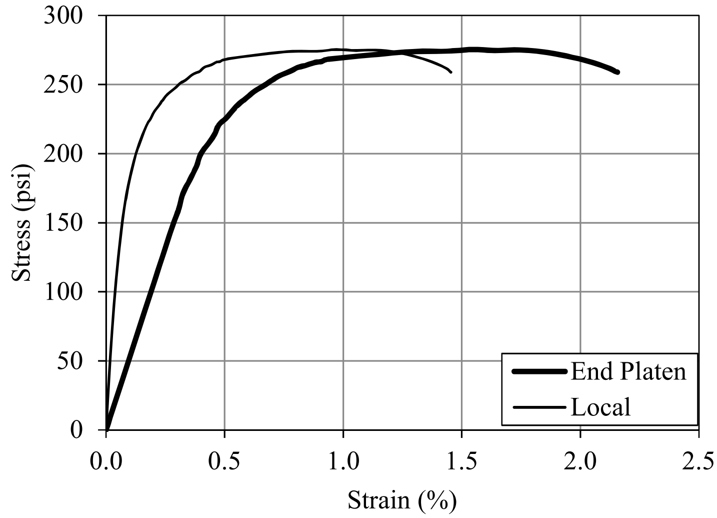


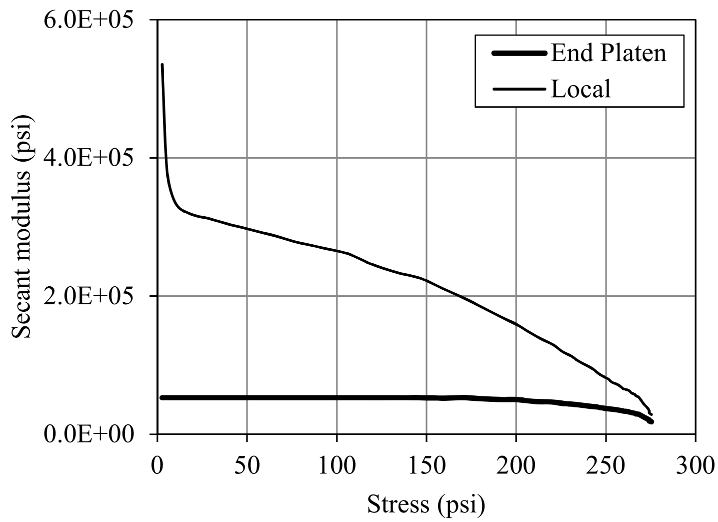




Batch E-10

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-10-B	
Curing Period:	7 day	
Test Date:	2/10/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Gypsum	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.955	in
Diameter (initial):	2.035	in
Weight:	364.1	g
Unit Weight:	108	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	275	psi
Secant Modulus E_{50EP}:	44,652	psi
Secant Modulus E_{50L}:	231,057	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	1.54	%
End Platen Strain at failure, ε_f:	0.97	%



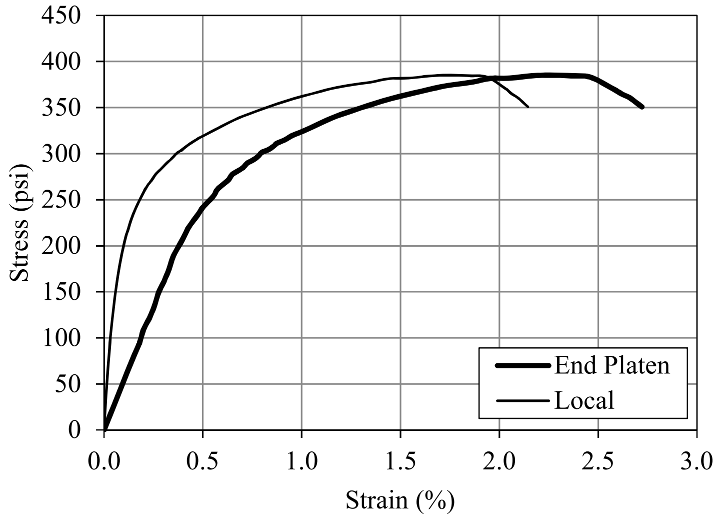


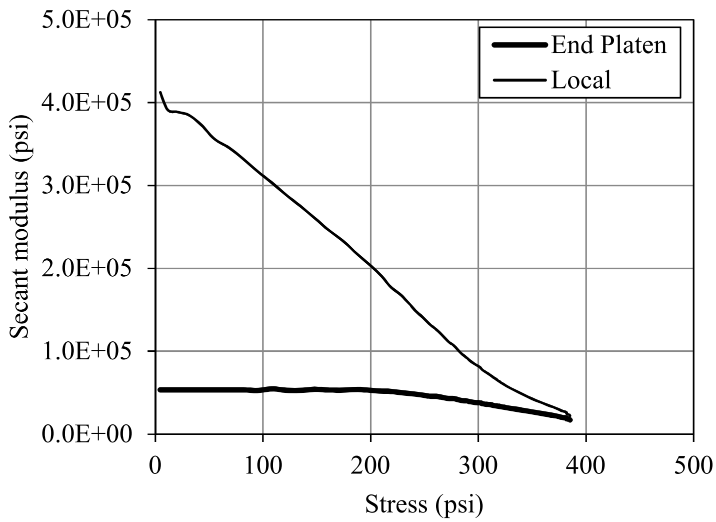
Batch E-10

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-10-G
Curing Period:	14 day
Test Date:	2/17/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sulfur
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.985	in
Diameter (initial):	2.037	in
Weight:	373.8	g
Unit Weight:	110	pcf
Gage Length:	2.8	in

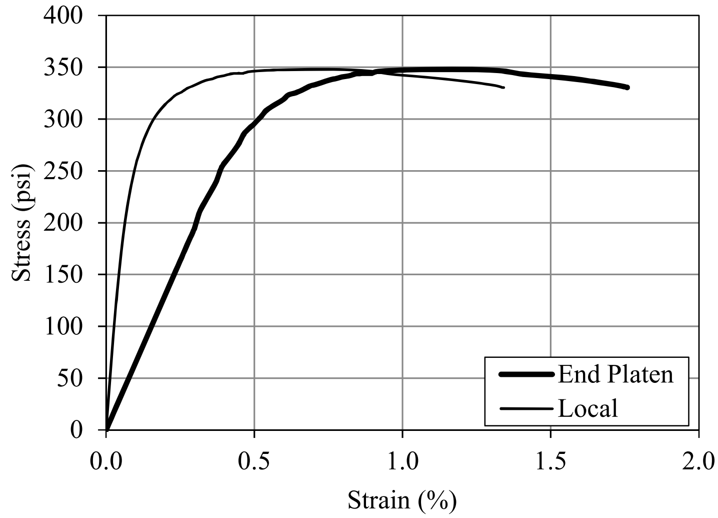
Test Summary		
Peak Stress:	385	psi
Secant Modulus E_{50EP}:	53,497	psi
Secant Modulus E_{50L}:	211,012	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	2.26	%
End Platen Strain at failure, ε_f:	1.75	%

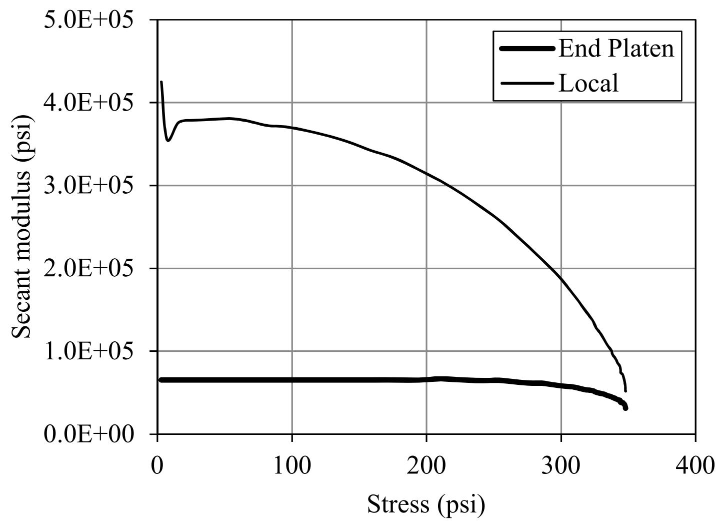




Batch E-10

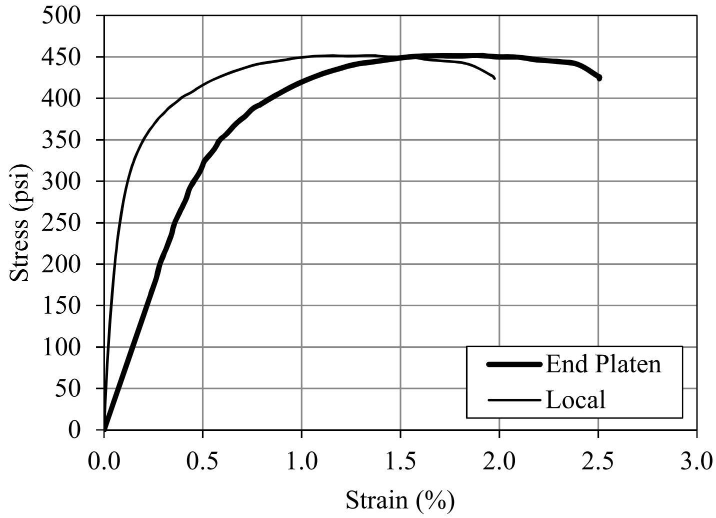
Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-10-H	
Curing Period:	14 day	
Test Date:	2/17/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Gypsum	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.992	in
Diameter (initial):	2.037	in
Weight:	373.8	g
Unit Weight:	109	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	348	psi
Secant Modulus E_{50EP}:	62,383	psi
Secant Modulus E_{50L}:	334,017	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	1.11	%
End Platen Strain at failure, ε_f:	0.67	%

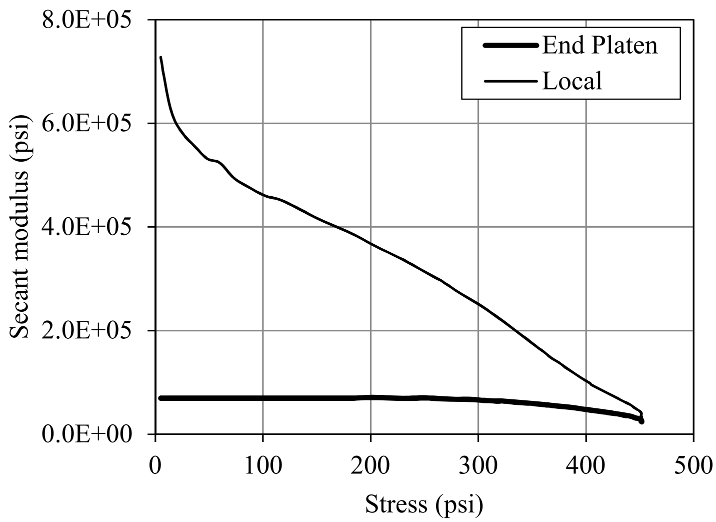


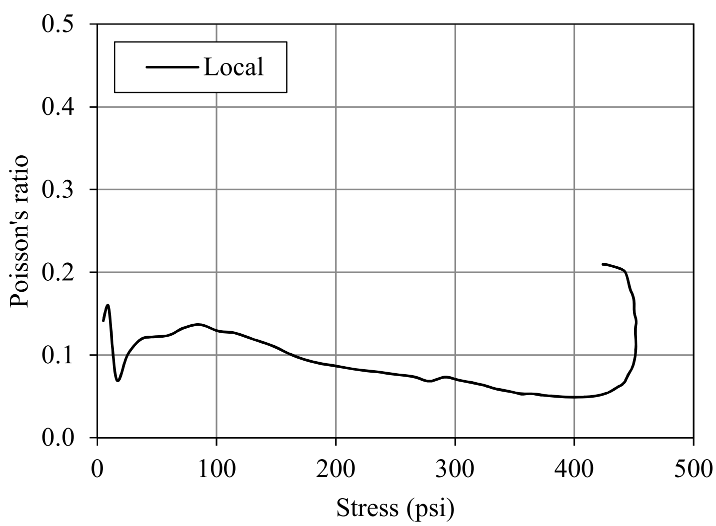


Batch E-10

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-10-C	
Curing Period:	28 day	
Test Date:	3/3/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Sulfur Capping	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.988	in
Diameter (initial):	2.036	in
Weight:	372.9	g
Unit Weight:	109	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	452	psi
Secant Modulus E_{50EP}:	69,422	psi
Secant Modulus E_{50L}:	340,267	psi
Poisson's Ratio ν_{50} :	0.08	
Poisson's Ratio ν_f:	0.14	
Local Strain at failure, ε_f:	1.89	%
End Platen Strain at failure, ε_f:	1.35	%

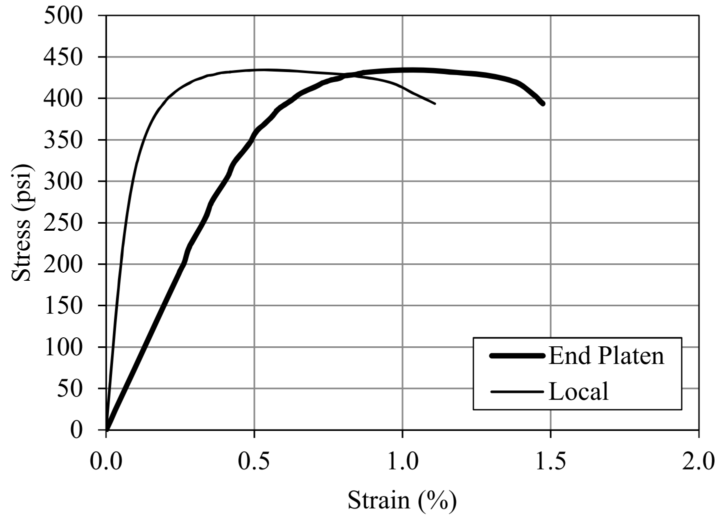


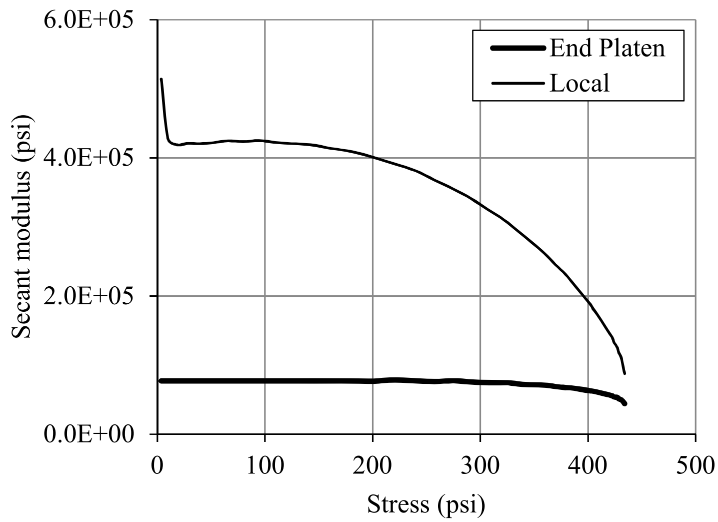


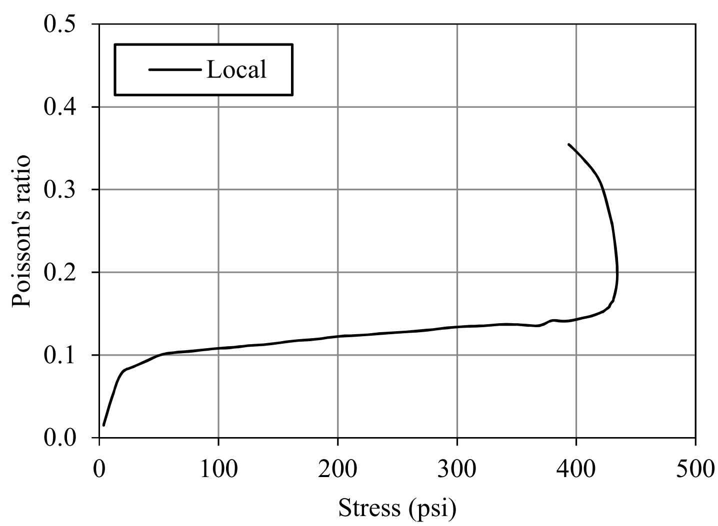


Batch E-10

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-10-D	
Curing Period:	28 day	
Test Date:	3/3/2017	
$\alpha_{in\text{-}place}$:	200	
$(w{:}c)_{slurry}$:	1.0	
End Treatment:	Gypsum Capping	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.988	in
Diameter (initial):	2.035	in
Weight:	371.6	g
Unit Weight:	109	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	434	psi
Secant Modulus E_{50EP}:	78,254	psi
Secant Modulus E_{50L}:	392,582	psi
Poisson's Ratio ν_{50} :	0.12	
Poisson's Ratio ν_f:	0.19	
Local Strain at failure, ε_f:	0.98	%
End Platen Strain at failure, ε_f:	0.50	%





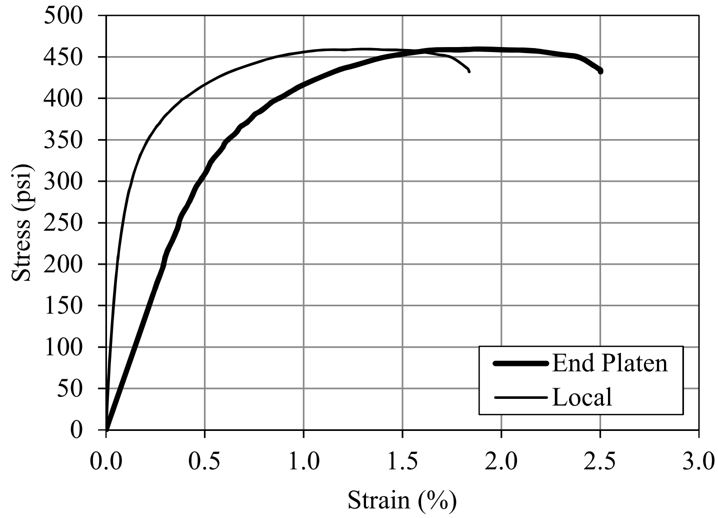


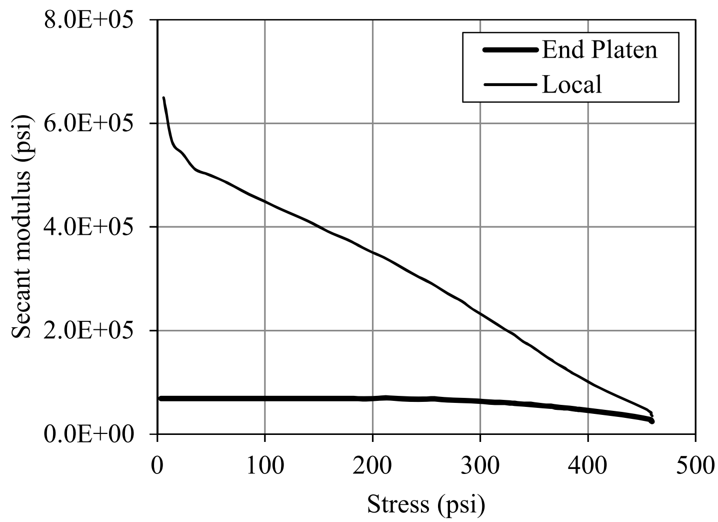
Batch E-10

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-10-I
Curing Period:	28 day
Test Date:	3/3/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sulfur Capping
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.99	in
Diameter (initial):	2.036	in
Weight:	373.1	g
Unit Weight:	109	pcf
Gage Length:	2.8	in

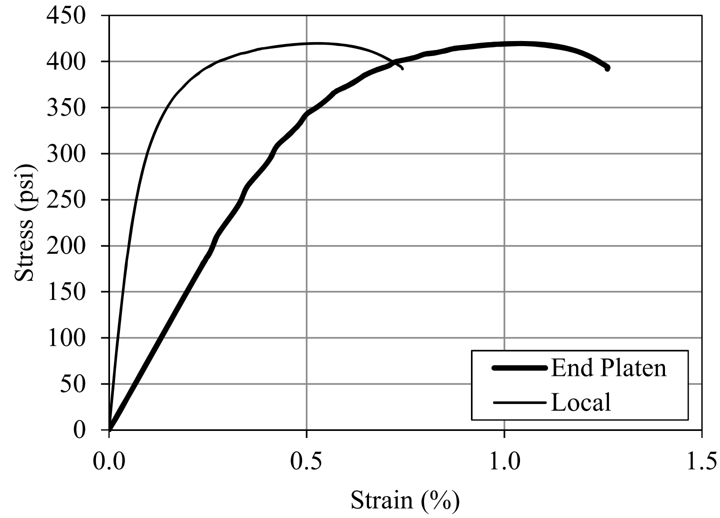
Test Summary		
Peak Stress:	460	psi
Secant Modulus E_{50EP}:	68,102	psi
Secant Modulus E_{50L}:	318,138	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	1.89	%
End Platen Strain at failure, ε_f:	1.30	%

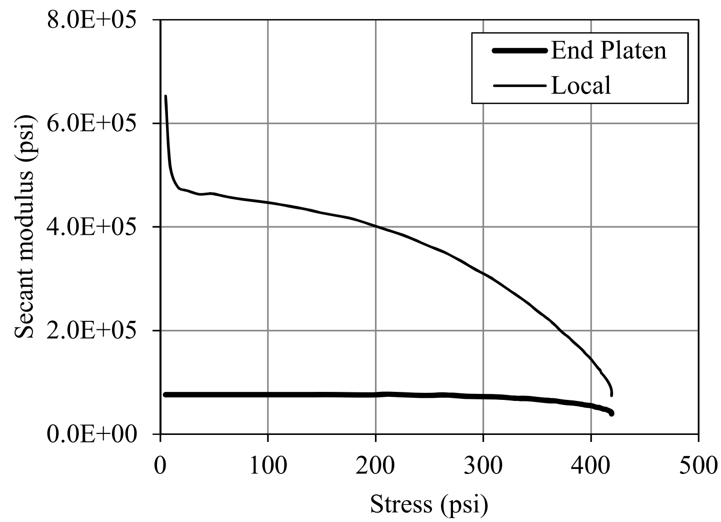


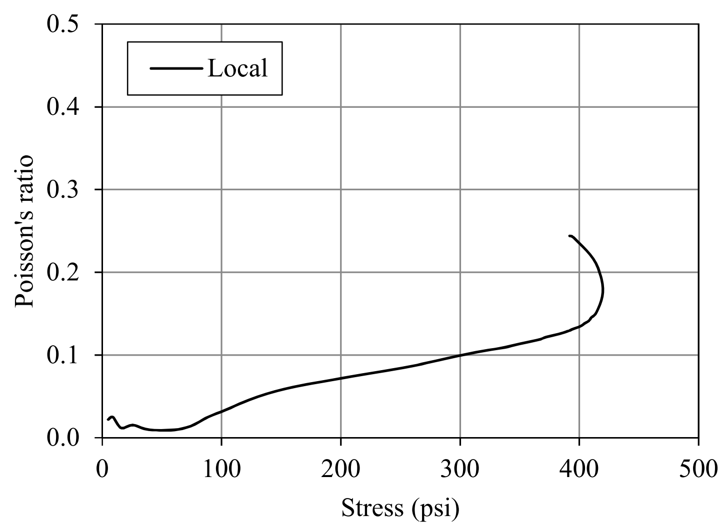


Batch E-10

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-10-J	
Curing Period:	28 day	
Test Date:	3/3/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Gypsum Capping	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.99	in
Diameter (initial):	2.036	in
Weight:	373.0	g
Unit Weight:	109	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	419	psi
Secant Modulus E_{50EP}:	77,027	psi
Secant Modulus E_{50L}:	394,838	psi
Poisson's Ratio ν_{50} :	0.07	
Poisson's Ratio ν_f:	0.19	
Local Strain at failure, ε_f:	1.08	%
End Platen Strain at failure, ε_f:	0.57	%





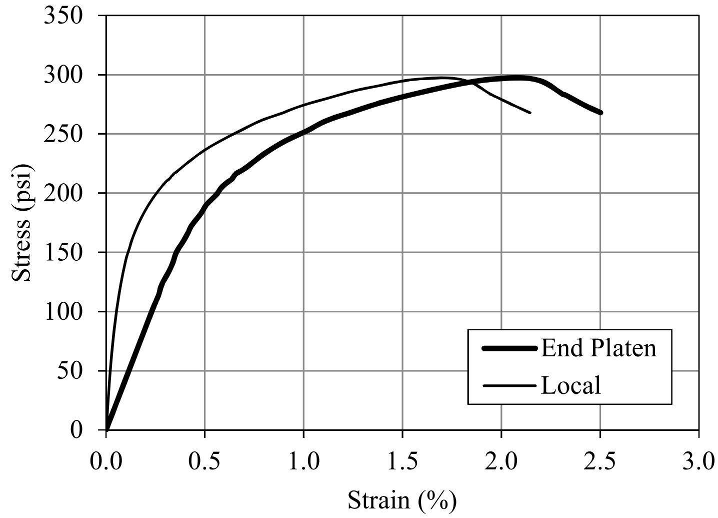


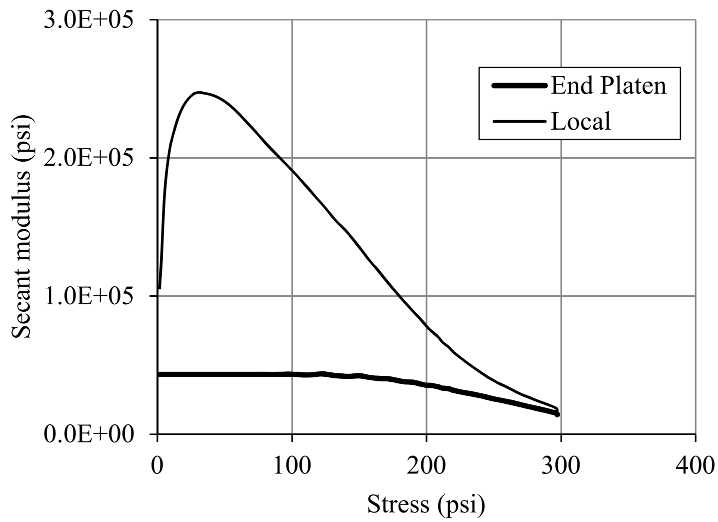
Batch E-11

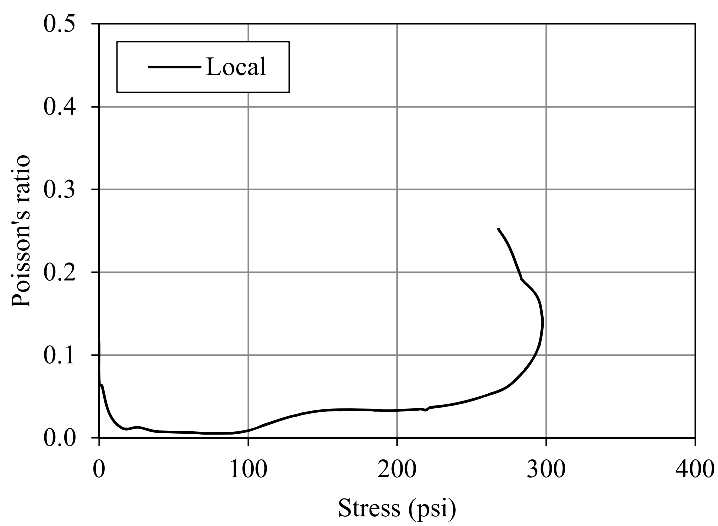
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-11-E
Curing Period:	3 day
Test Date:	2/6/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sulfur Cap
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.992	in
Diameter (initial):	2.037	in
Weight:	369.7	g
Unit Weight:	108	pcf
Gage Length:	2.8	in

Test Summary		
Peak Stress:	297	psi
Secant Modulus E_{50EP}:	42,128	psi
Secant Modulus E_{50L}:	136,789	psi
Poisson's Ratio ν_{50} :	0.03	
Poisson's Ratio ν_f:	0.15	
Local Strain at failure, ε_f:	2.12	%
End Platen Strain at failure, ε_f:	1.74	%

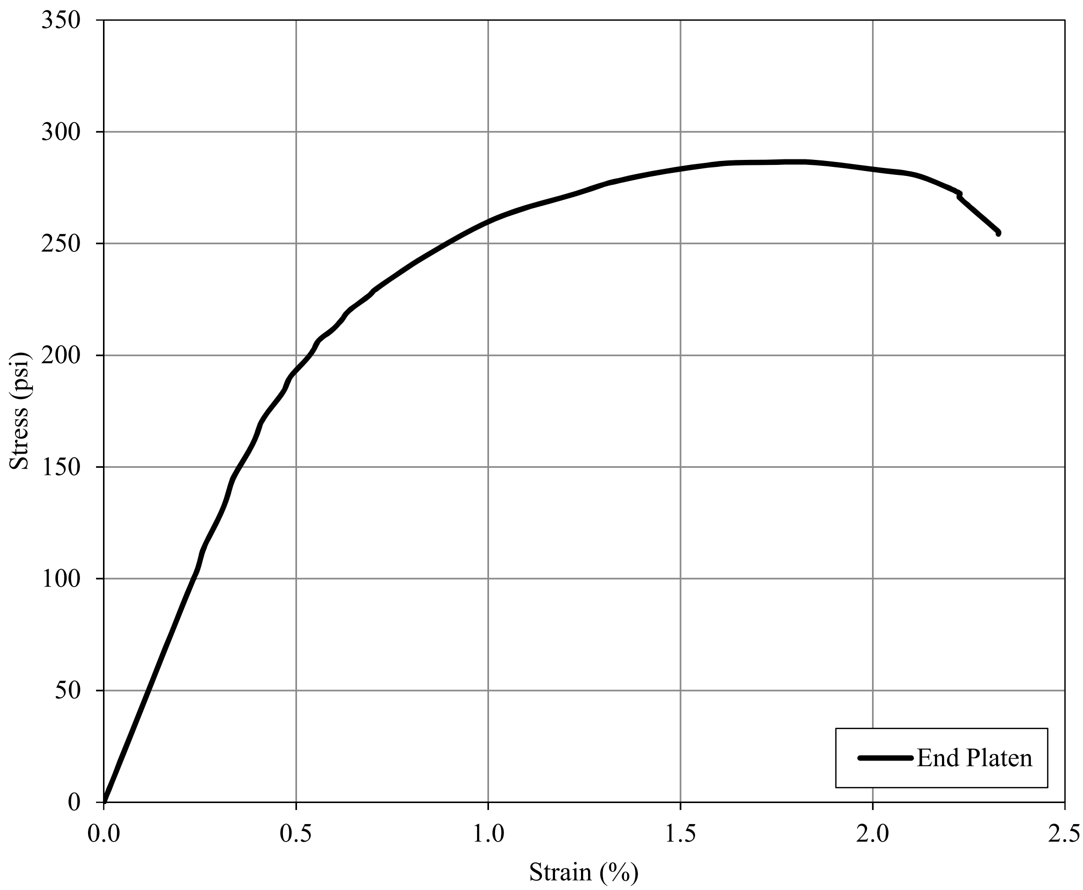




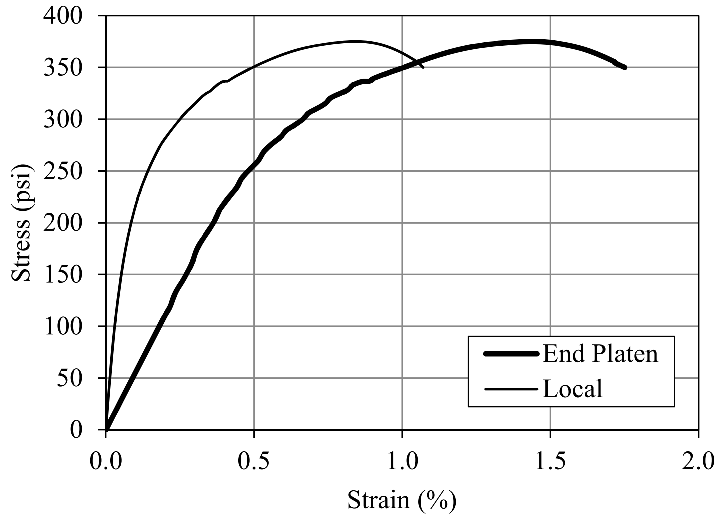


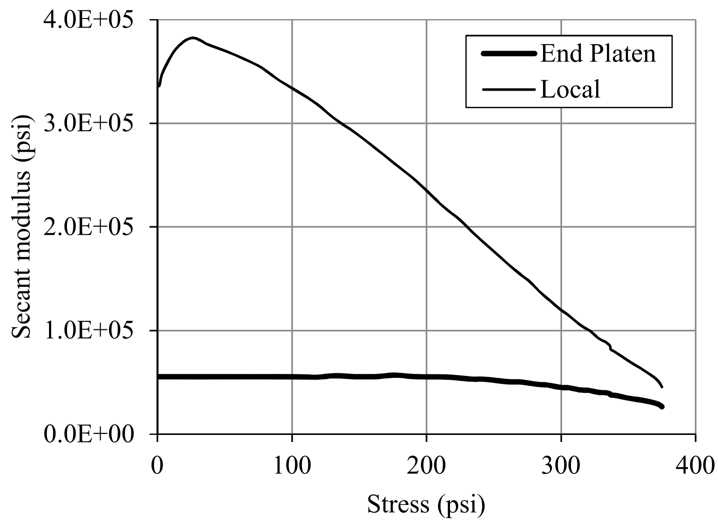
Batch E-11

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.987	in	Peak Stress:	287	psi
Tested by:	RNG	Diameter (initial):	2.037	in	Secant Modulus E_{50EP}:	43,037	psi
I.D. :	E-11-F	Weight:	369.4	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	3 day	Unit Weight:	108	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/6/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w{:}c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.82	%
End Treatment:	Gypsum						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



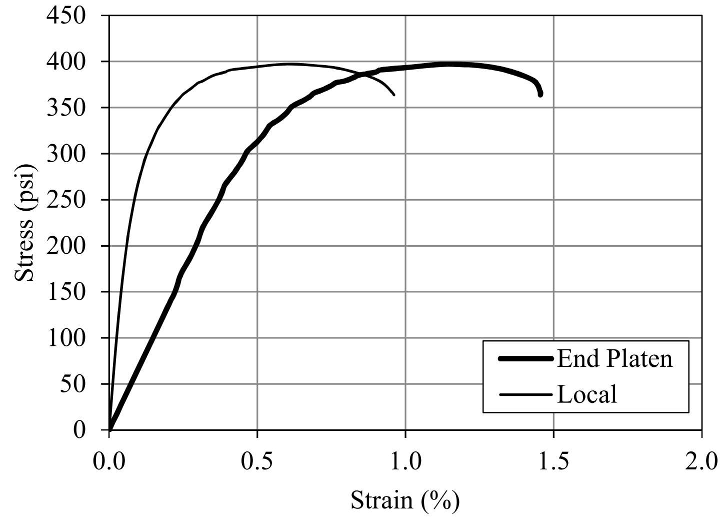
Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-11-A	
Curing Period:	7 day	
Test Date:	2/10/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Sulfur	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.981	in
Diameter (initial):	2.037	in
Weight:	368.3	g
Unit Weight:	108	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	375	psi
Secant Modulus E_{50EP}:	55,938	psi
Secant Modulus E_{50L}:	249,320	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	1.42	%
End Platen Strain at failure, ε_f:	0.83	%

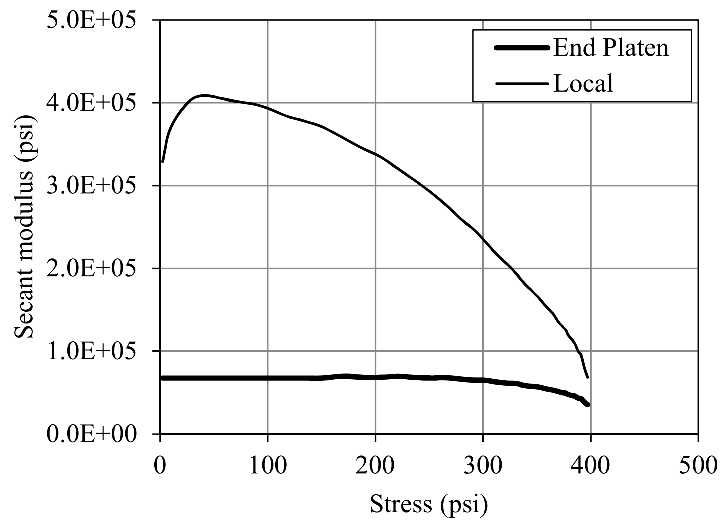


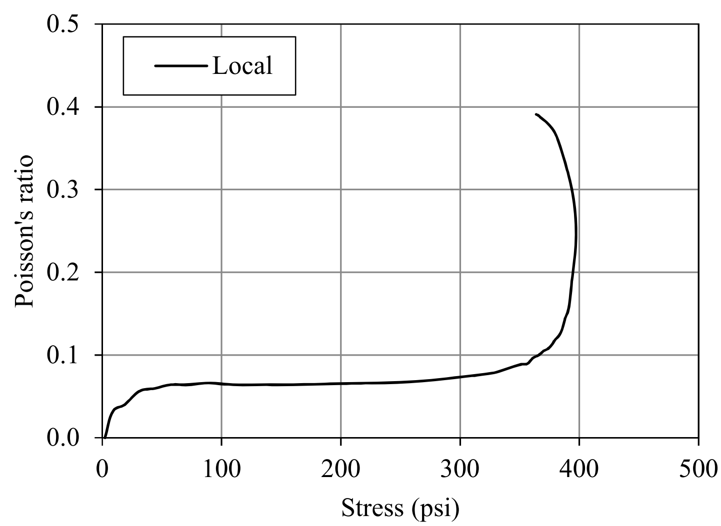


Batch E-11

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-11-B	
Curing Period:	7 day	
Test Date:	2/10/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Gypsum	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.976	in
Diameter (initial):	2.035	in
Weight:	366.5	g
Unit Weight:	108	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	397	psi
Secant Modulus E_{50EP}:	68,465	psi
Secant Modulus E_{50L}:	338,129	psi
Poisson's Ratio ν_{50} :	0.07	
Poisson's Ratio ν_f:	0.23	
Local Strain at failure, ε_f:	1.12	%
End Platen Strain at failure, ε_f:	0.58	%



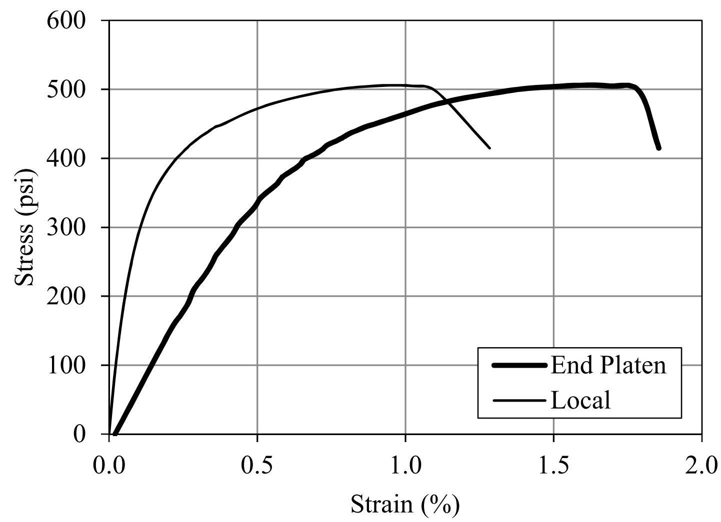


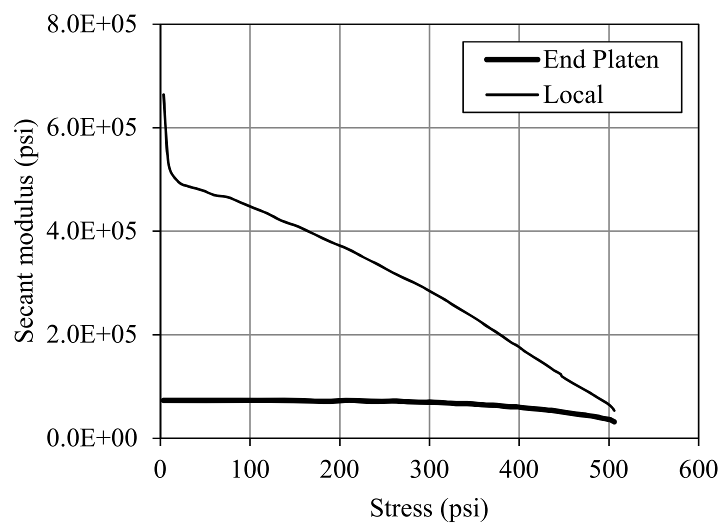


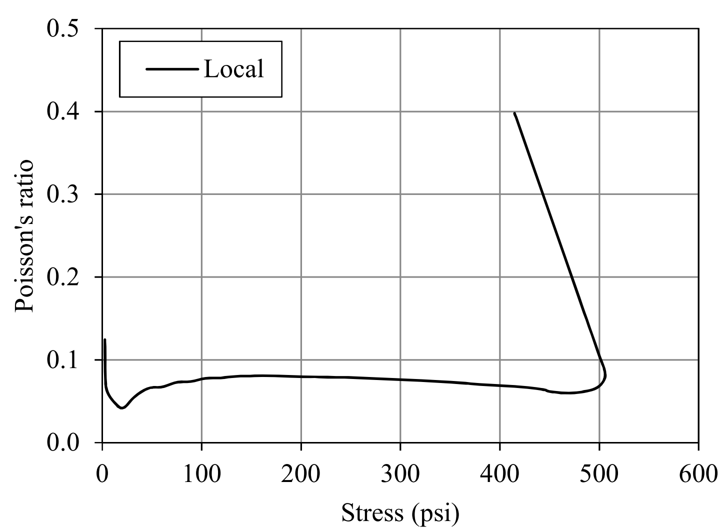
Batch E-11

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-11-G
Curing Period:	14 day
Test Date:	2/17/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sulfur
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.987	in
Diameter (initial):	2.04	in
Weight:	369.6	g
Unit Weight:	108	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	506	psi
Secant Modulus E_{50EP}:	71,634	psi
Secant Modulus E_{50L}:	325,376	psi
Poisson's Ratio ν_{50} :	0.08	
Poisson's Ratio ν_f:	0.08	
Local Strain at failure, ε_f:	1.59	%
End Platen Strain at failure, ε_f:	0.94	%



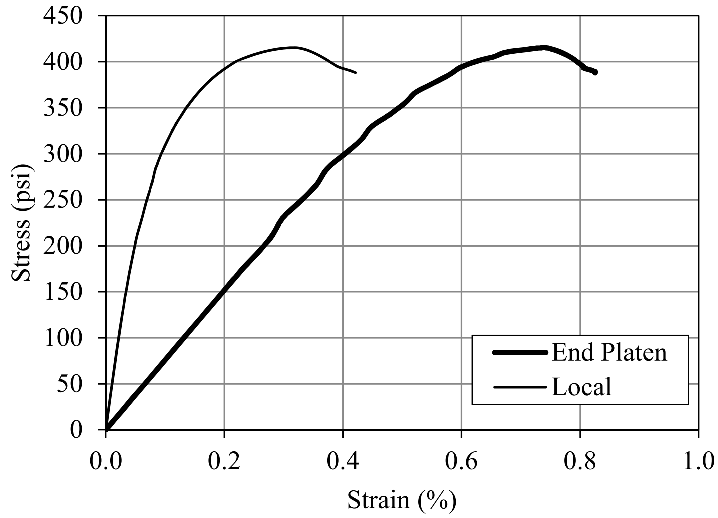


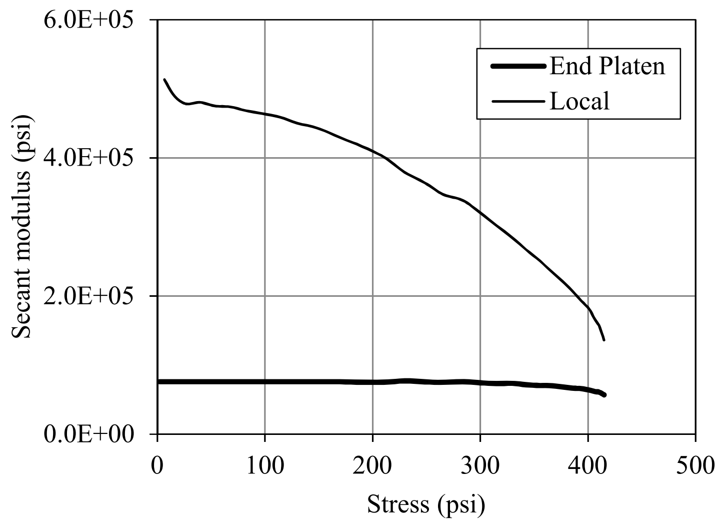


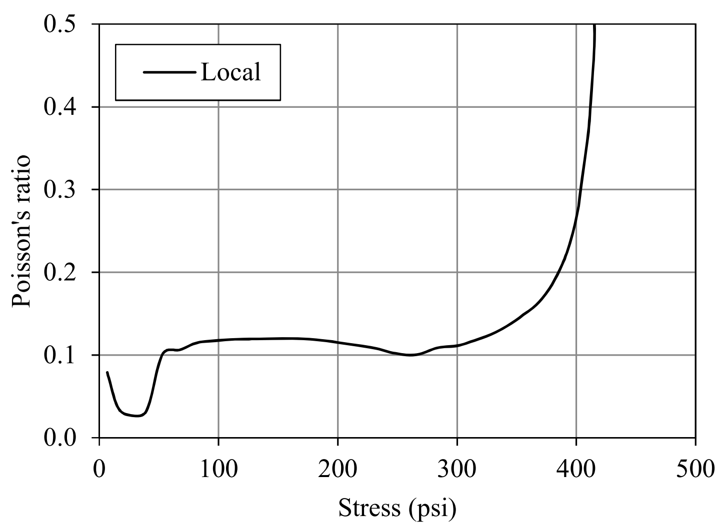
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-11-H
Curing Period:	14 day
Test Date:	2/17/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Gypsum
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.99	in
Diameter (initial):	2.03	in
Weight:	369.4	g
Unit Weight:	109	pcf
Gage Length:	2.8	in

Test Summary		
Peak Stress:	415	psi
Secant Modulus E_{50EP}:	75,197	psi
Secant Modulus E_{50L}:	403,107	psi
Poisson's Ratio ν_{50} :	0.11	
Poisson's Ratio ν_f:	0.47	
Local Strain at failure, ε_f:	0.73	%
End Platen Strain at failure, ε_f:	0.30	%





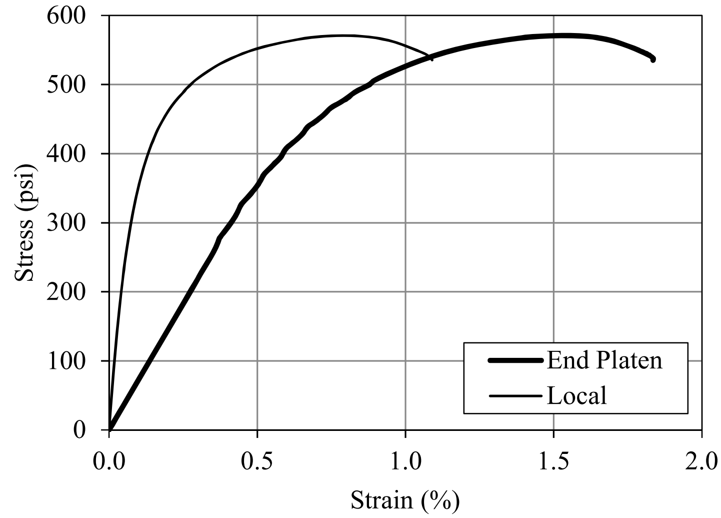


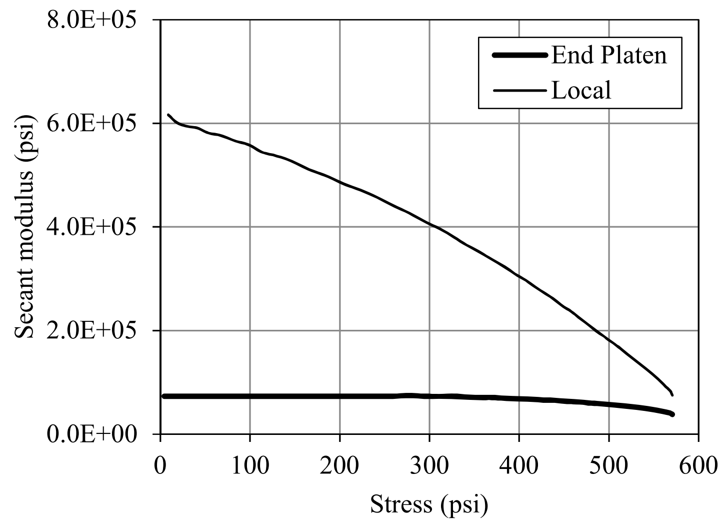
Batch E-11

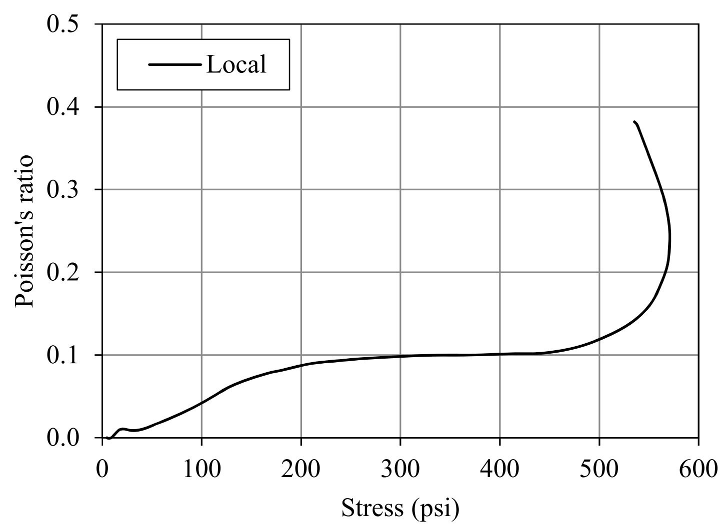
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-11-C
Curing Period:	28 day
Test Date:	3/3/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sulfur Capping
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.991	in
Diameter (initial):	2.037	in
Weight:	369.1	g
Unit Weight:	108	pcf
Gage Length:	2.8	in

Test Summary		
Peak Stress:	571	psi
Secant Modulus E_{50EP}:	73,890	psi
Secant Modulus E_{50L}:	418,733	psi
Poisson's Ratio ν_{50} :	0.10	
Poisson's Ratio ν_f :	0.23	
Local Strain at failure, ε_f :	1.50	%
End Platen Strain at failure, ε_f :	0.76	%





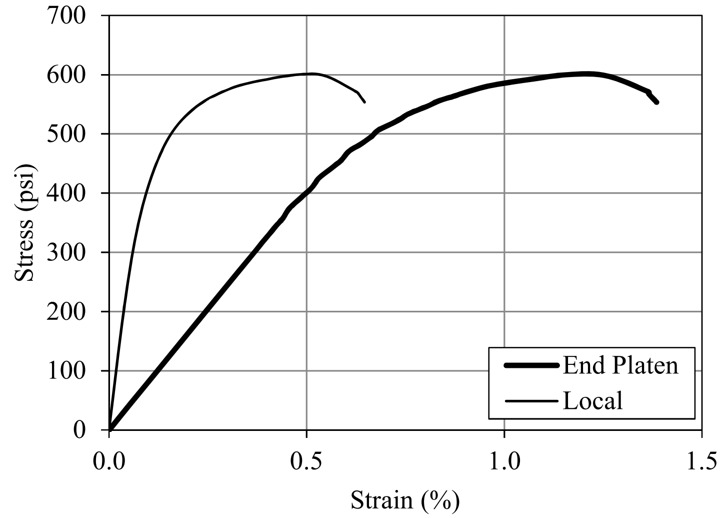


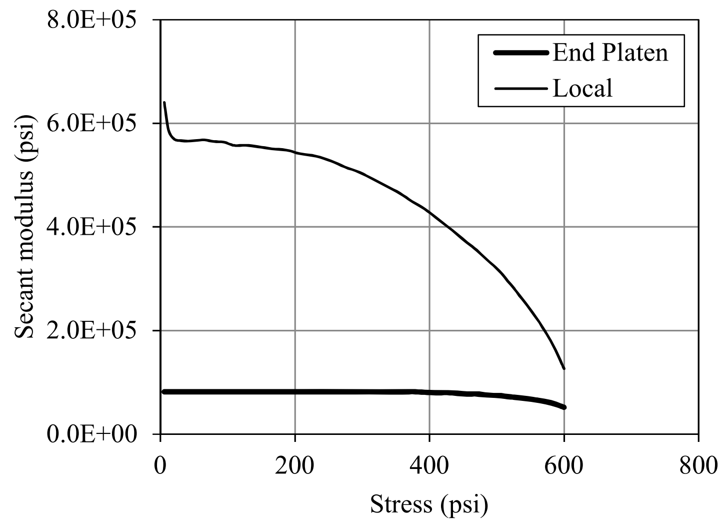
Batch E-11

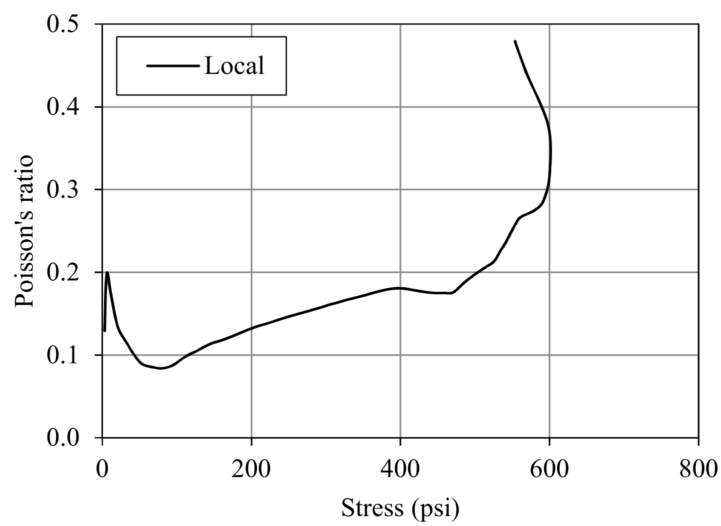
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-11-D
Curing Period:	28 day
Test Date:	3/3/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Gypsum Capping
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.991	in
Diameter (initial):	2.037	in
Weight:	368.7	g
Unit Weight:	108	pcf
Gage Length:	2.8	in

Test Summary		
Peak Stress:	600	psi
Secant Modulus E_{50EP}:	58,037	psi
Secant Modulus E_{50L}:	502,484	psi
Poisson's Ratio ν_{50} :	0.16	
Poisson's Ratio ν_f :	0.32	
Local Strain at failure, ε_f :	1.16	%
End Platen Strain at failure, ε_f :	0.48	%





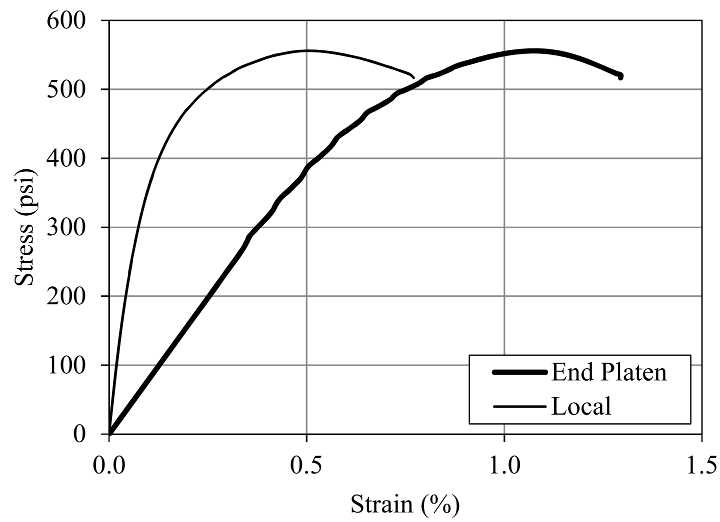


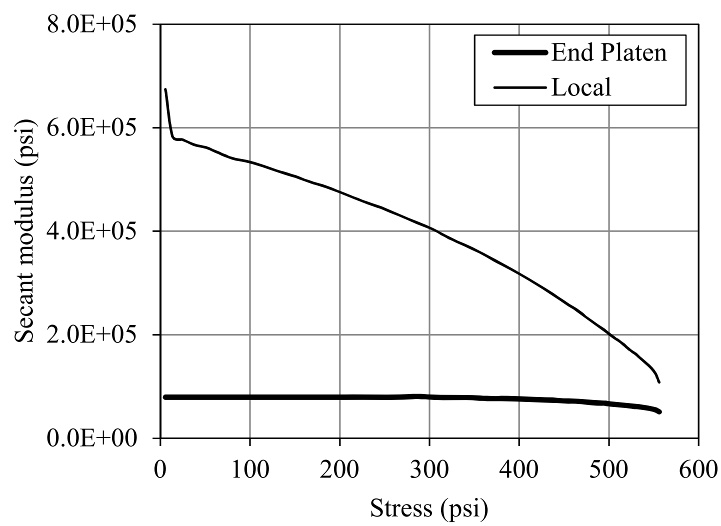
Batch E-11

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	E-11-I
Curing Period:	28 day
Test Date:	3/3/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Sulfur Capping
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.983	in
Diameter (initial):	2.038	in
Weight:	368.6	g
Unit Weight:	108	pcf
Gage Length:	2.8	in

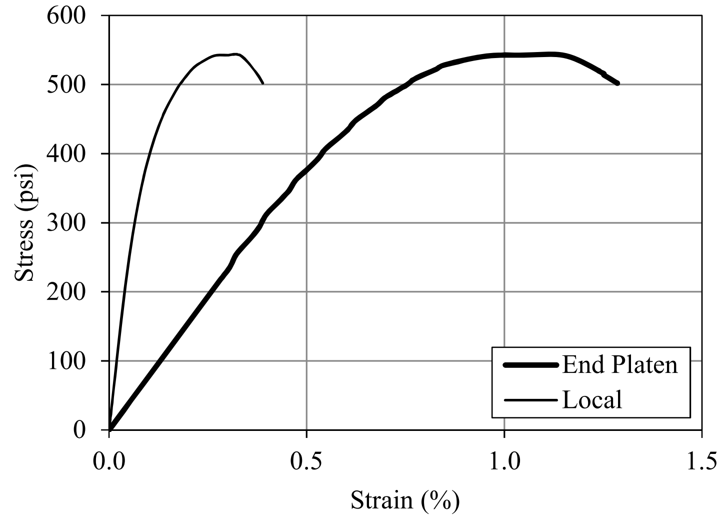
Test Summary		
Peak Stress:	556	psi
Secant Modulus E_{50EP}:	80,177	psi
Secant Modulus E_{50L}:	421,967	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f:	N/A	
Local Strain at failure, ε_f:	1.09	%
End Platen Strain at failure, ε_f:	0.51	%

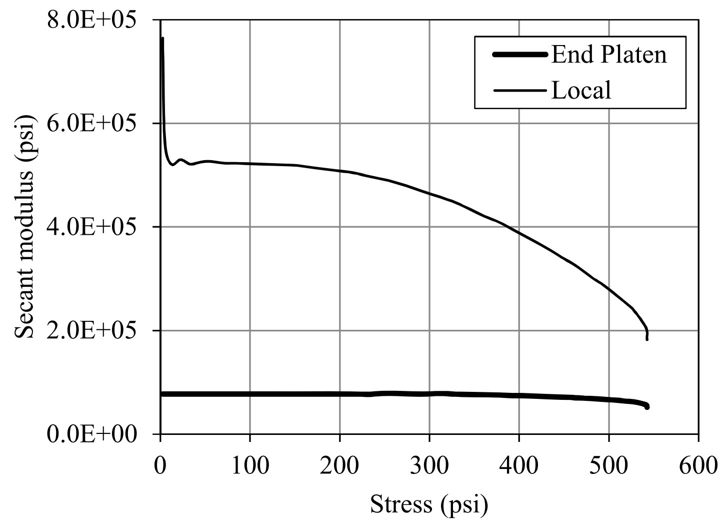


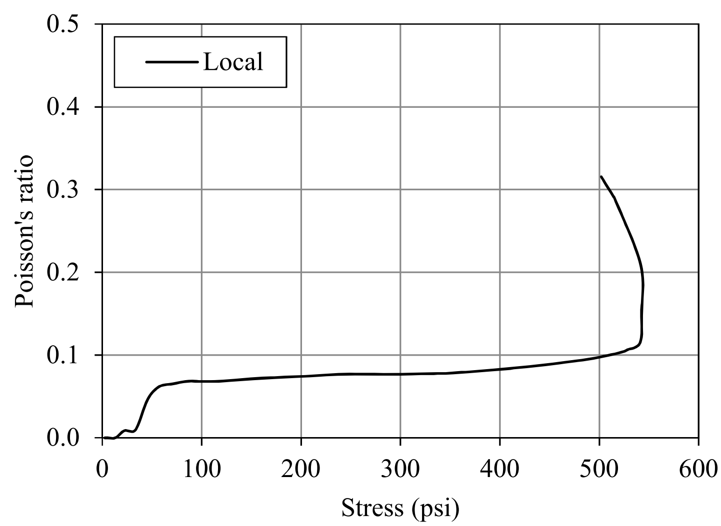


Batch E-11

Test Information		
Type of Test:	UCS Test	
Tested by:	RNG	
I.D. :	E-11-J	
Curing Period:	28 day	
Test Date:	3/3/2017	
$\alpha_{in\text{-}place}$:	200	
$(w:c)_{slurry}$:	1.0	
End Treatment:	Gypsum Capping	
Confining Pressure (psi):	N/A	
Strain Rate:	1 %/min	
Specimen Information		
Height (initial):	3.977	in
Diameter (initial):	2.035	in
Weight:	267.0	g
Unit Weight:	79	pcf
Gage Length:	2.8	in
Test Summary		
Peak Stress:	543	psi
Secant Modulus E_{50EP}:	77,929	psi
Secant Modulus E_{50L}:	480,789	psi
Poisson's Ratio ν_{50} :	0.08	
Poisson's Ratio ν_f :	0.15	
Local Strain at failure, ε_f :	1.05	%
End Platen Strain at failure, ε_f :	0.30	%





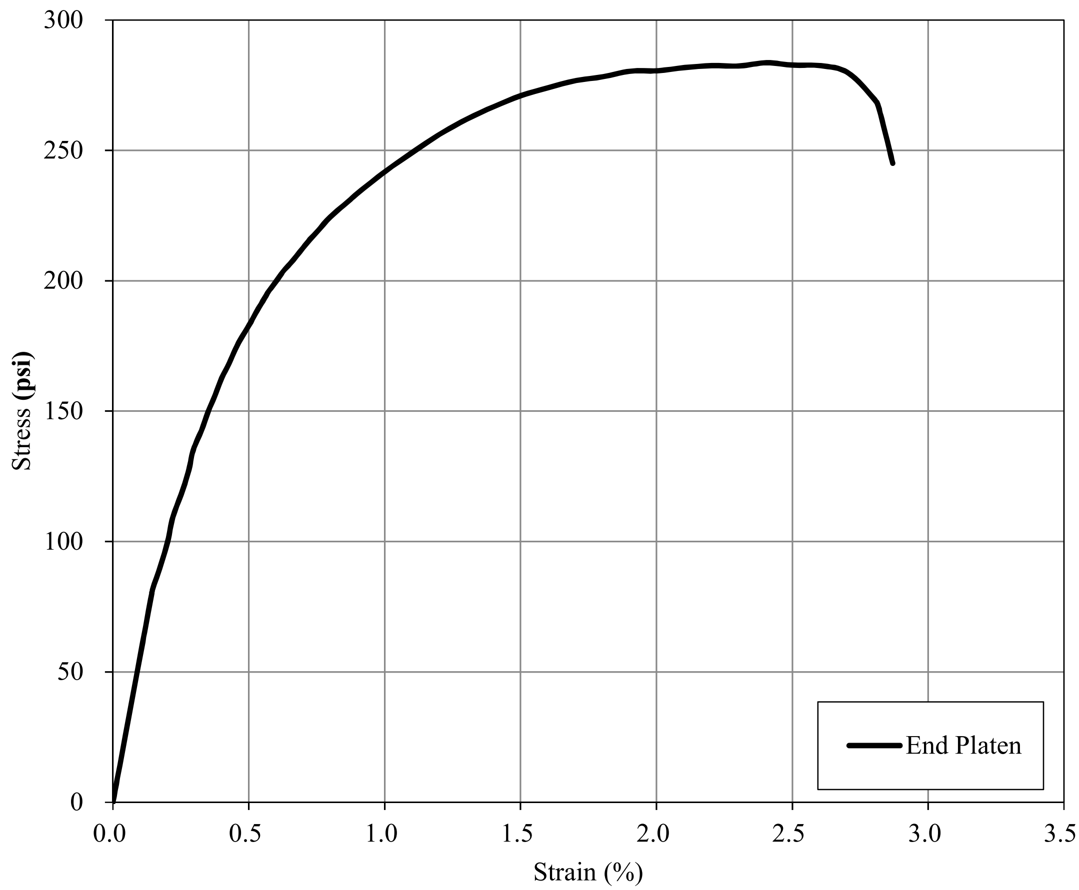


Batch S-1

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-1-E
Curing Period:	3 day
Test Date:	2/3/2017
$\alpha_{in\text{-}place}$:	200
$(w{:}c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.908	in
Diameter (initial):	2.038	in
Weight:	374.0	g
Unit Weight:	112	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	282	psi
Secant Modulus E_{50EP}:	44,000	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	2.41	%

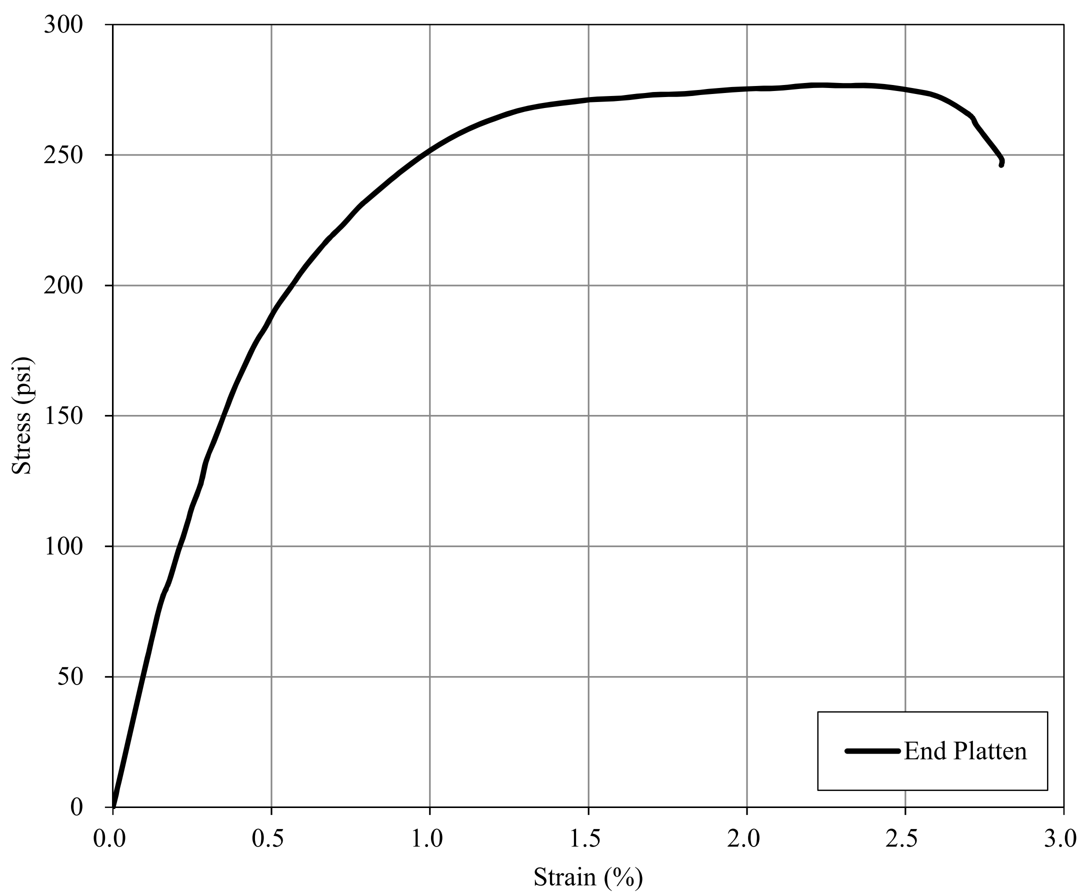


Batch S-1

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-1-F
Curing Period:	3 day
Test Date:	2/3/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.982	in
Diameter (initial):	2.037	in
Weight:	382.5	g
Unit Weight:	112	pcf
Gage Length:	N/A	in

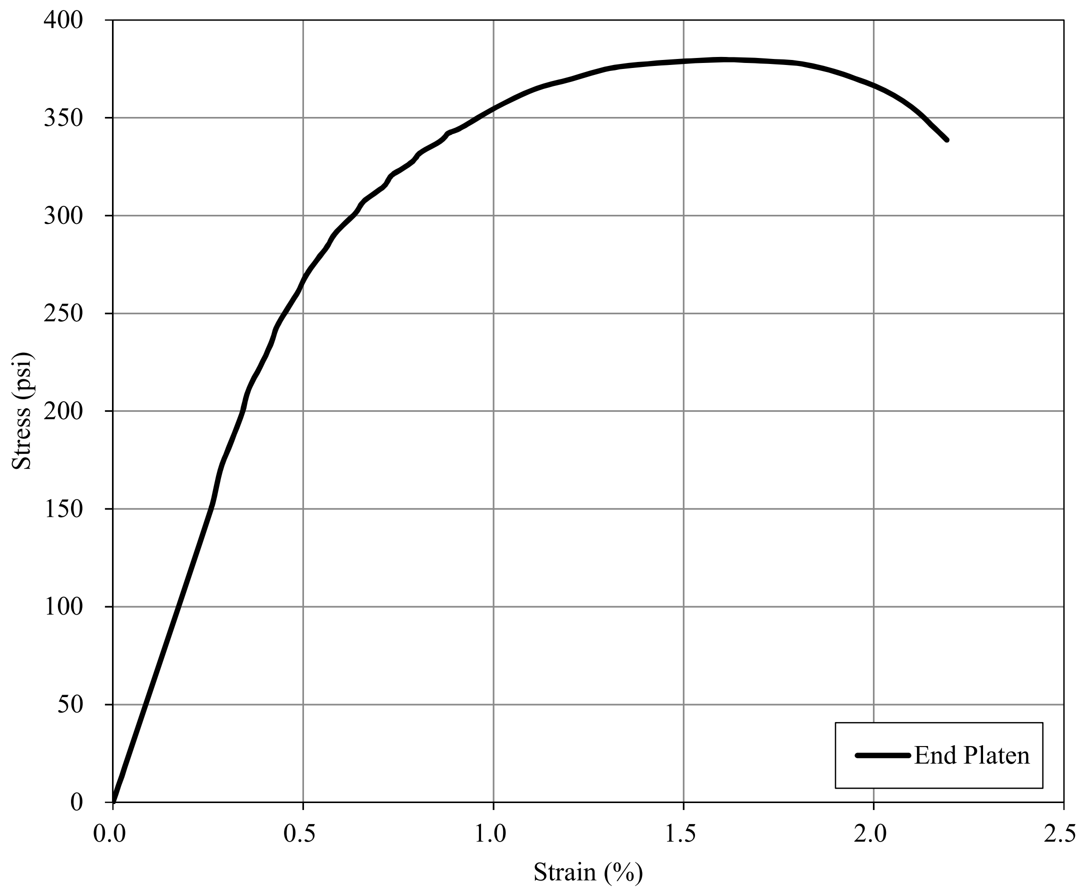
Test Summary		
Peak Stress:	276	psi
Secant Modulus E_{50EP}:	44,316	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	2.20	%



Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-1-A
Curing Period:	7 day
Test Date:	2/7/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.981	in
Diameter (initial):	2.038	in
Weight:	382.1	g
Unit Weight:	112	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	378	psi
Secant Modulus E_{50EP}:	59,057	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.61	%

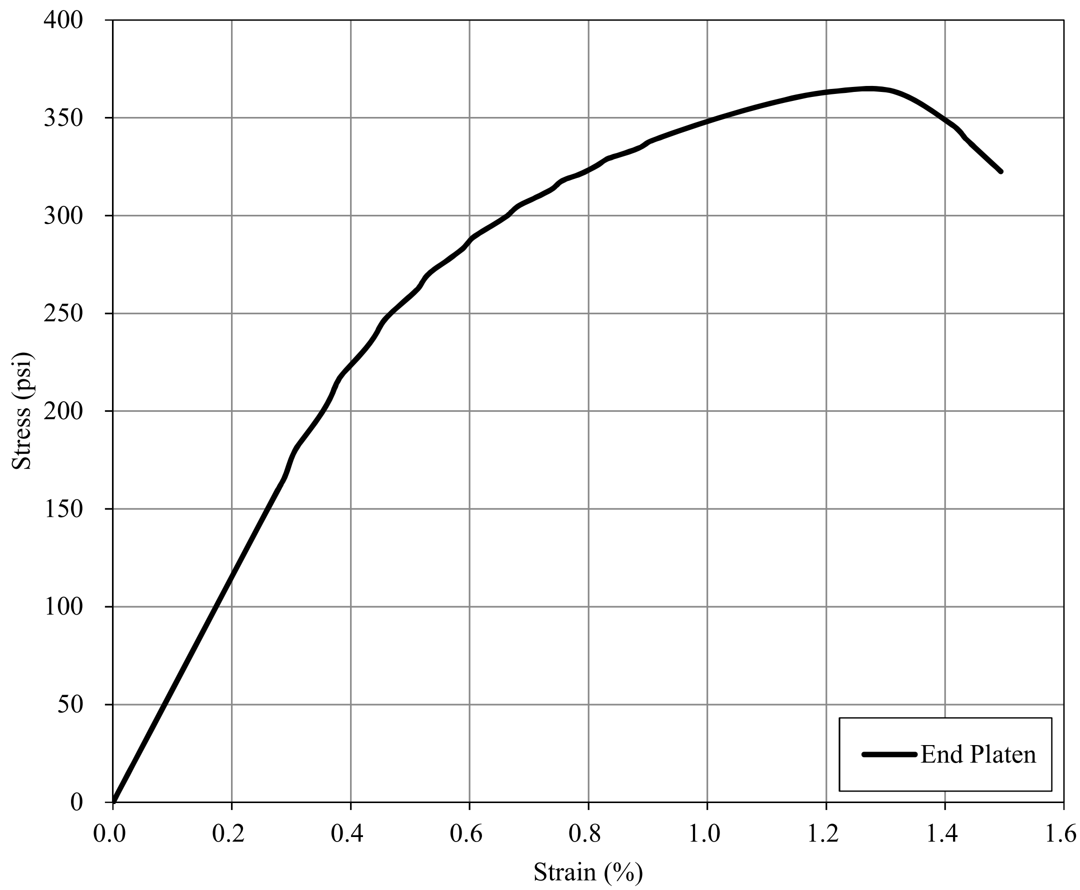


Batch S-1

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-1-B
Curing Period:	7 day
Test Date:	2/7/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

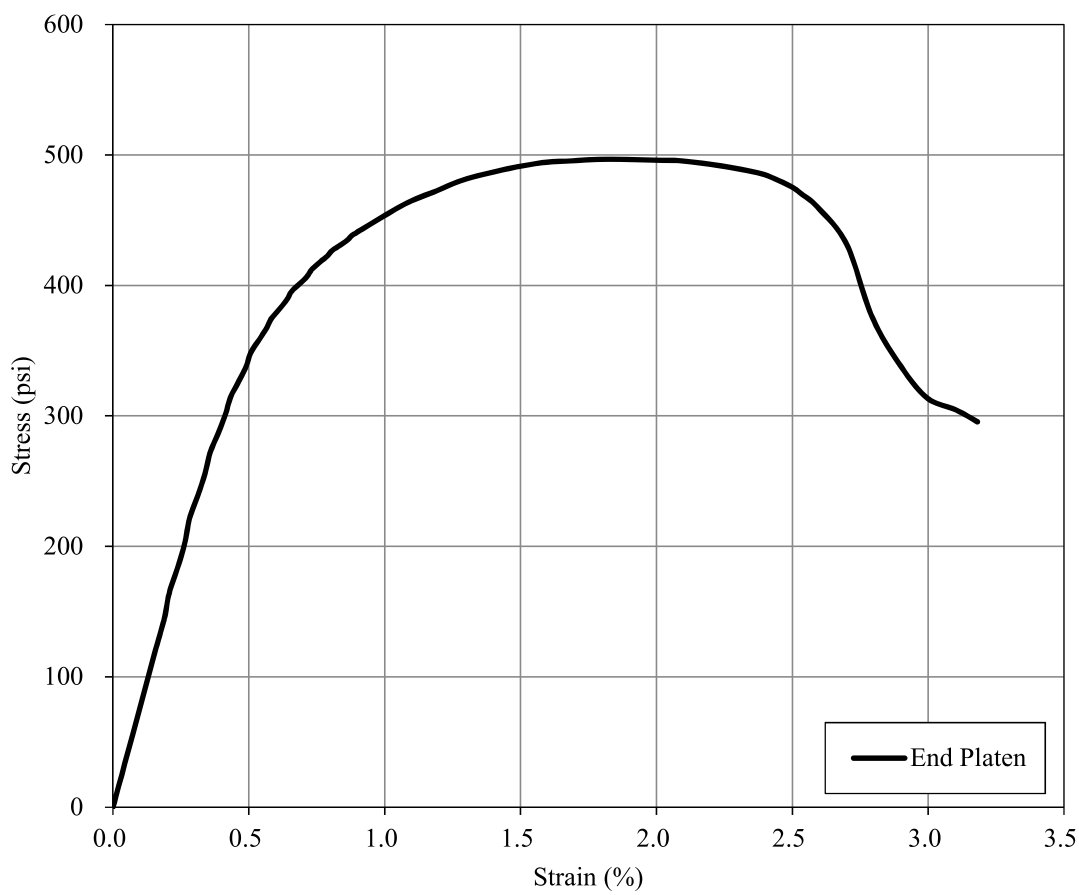
Specimen Information		
Height (initial):	3.943	in
Diameter (initial):	2.037	in
Weight:	377.3	g
Unit Weight:	112	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	362	psi
Secant Modulus E_{50EP}:	58,501	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.31	%



Batch S-1

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.962	in	Peak Stress:	495	psi
Tested by:	RNG	Diameter (initial):	2.038	in	Secant Modulus E_{50EP}:	75,993	psi
I.D. :	S-1-G	Weight:	380.0	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	14 day	Unit Weight:	112	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/14/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	200				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	0.6				End Platen Strain at failure, εf :	1.79	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

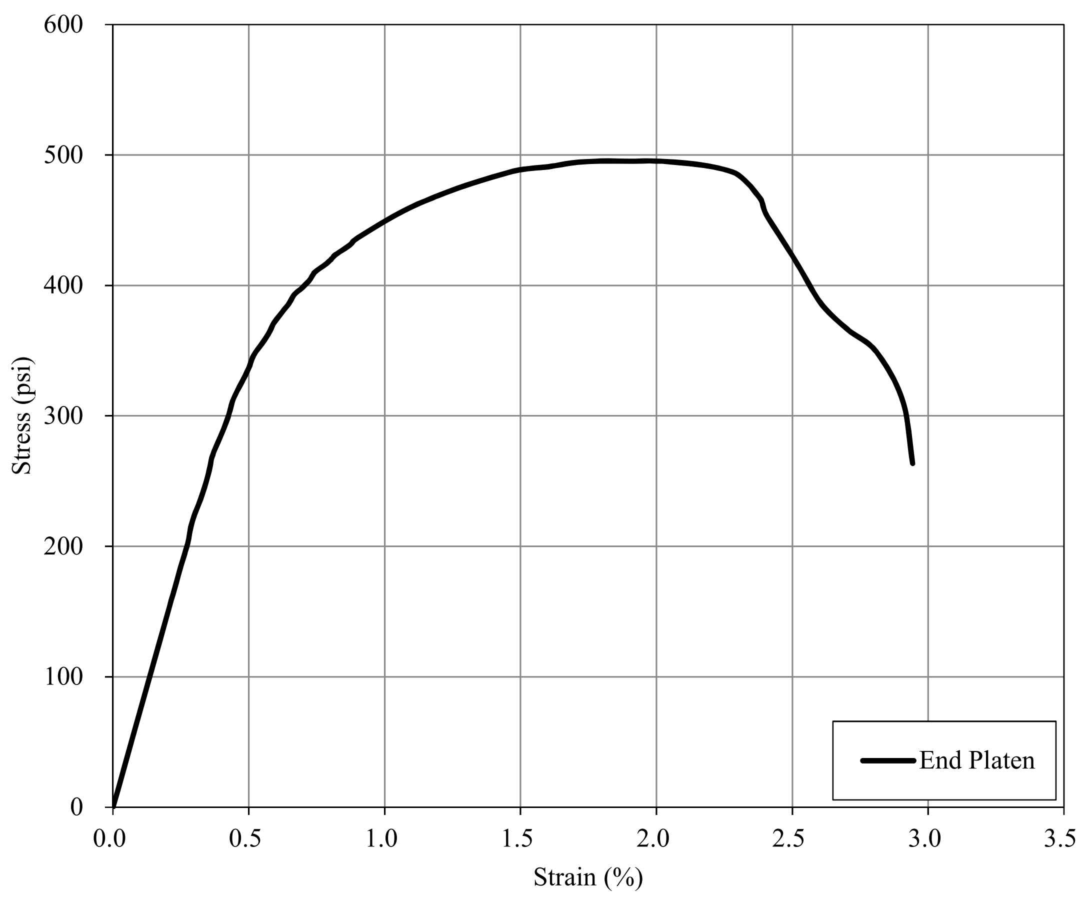


Batch S-1

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-1-H
Curing Period:	14 day
Test Date:	2/14/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.956	in
Diameter (initial):	2.034	in
Weight:	379.8	g
Unit Weight:	113	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	493	psi
Secant Modulus E_{50EP}:	72,887	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	2.00	%

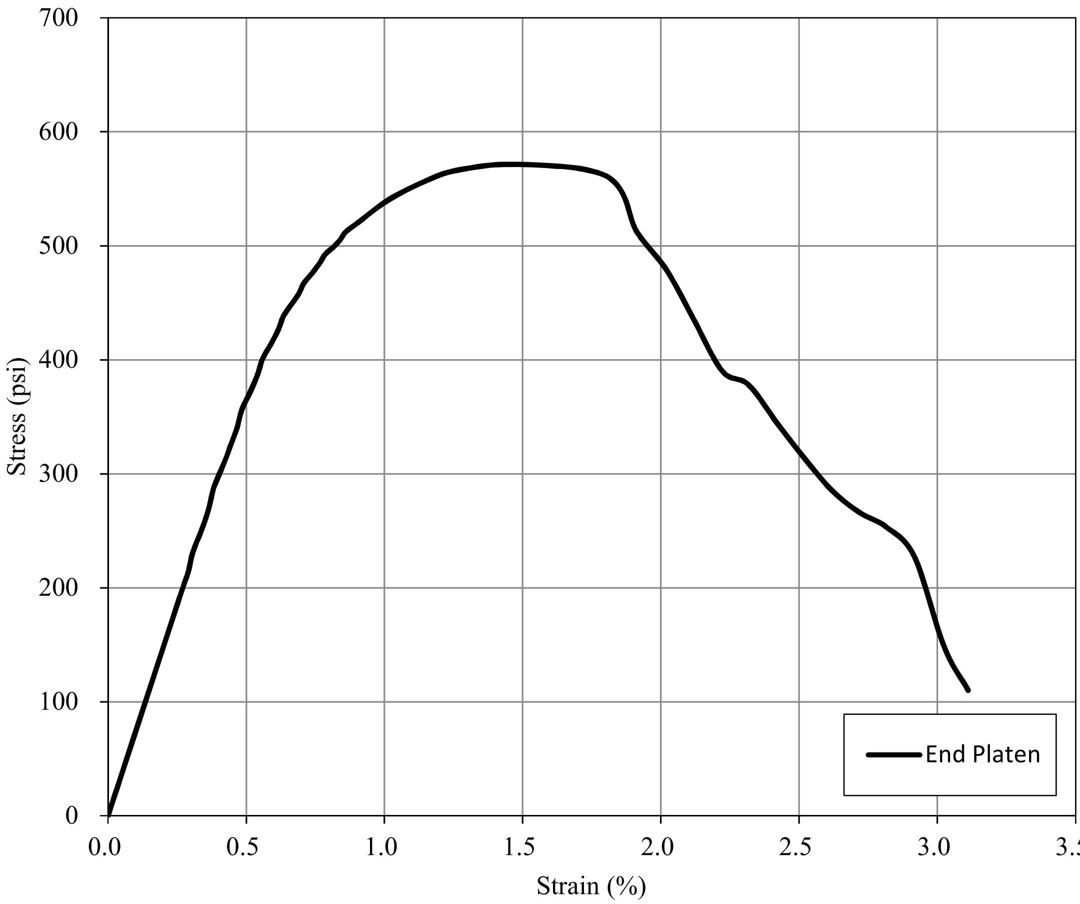


Batch S-1

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-1-C
Curing Period:	28 day
Test Date:	2/28/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.962	in
Diameter (initial):	2.038	in
Weight:	380.1	g
Unit Weight:	112	pcf
Gage Length:	N/A	in

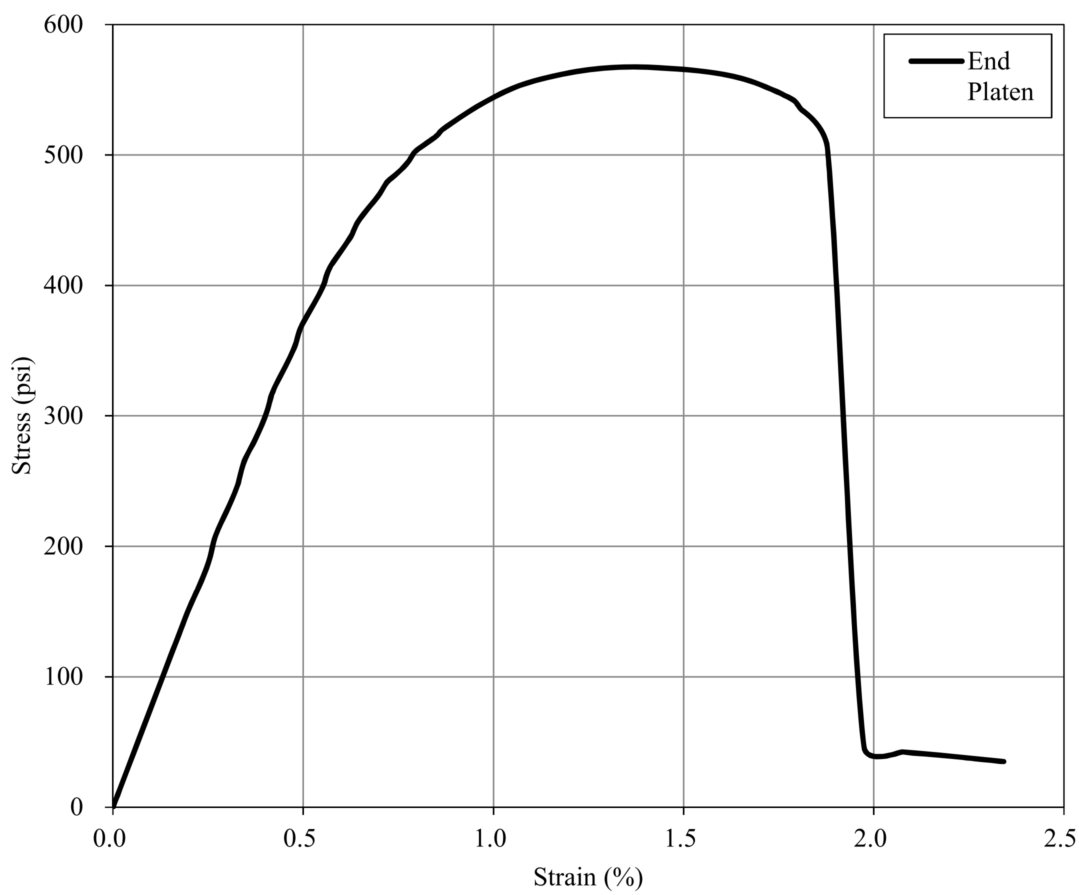
Test Summary		
Peak Stress:	569	psi
Secant Modulus E_{50EP}:	75,101	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.41	%



Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-1-D
Curing Period:	28 day
Test Date:	2/28/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.96	in
Diameter (initial):	2.038	in
Weight:	379.9	g
Unit Weight:	112	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	565	psi
Secant Modulus E_{50EP}:	75,344	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.37	%

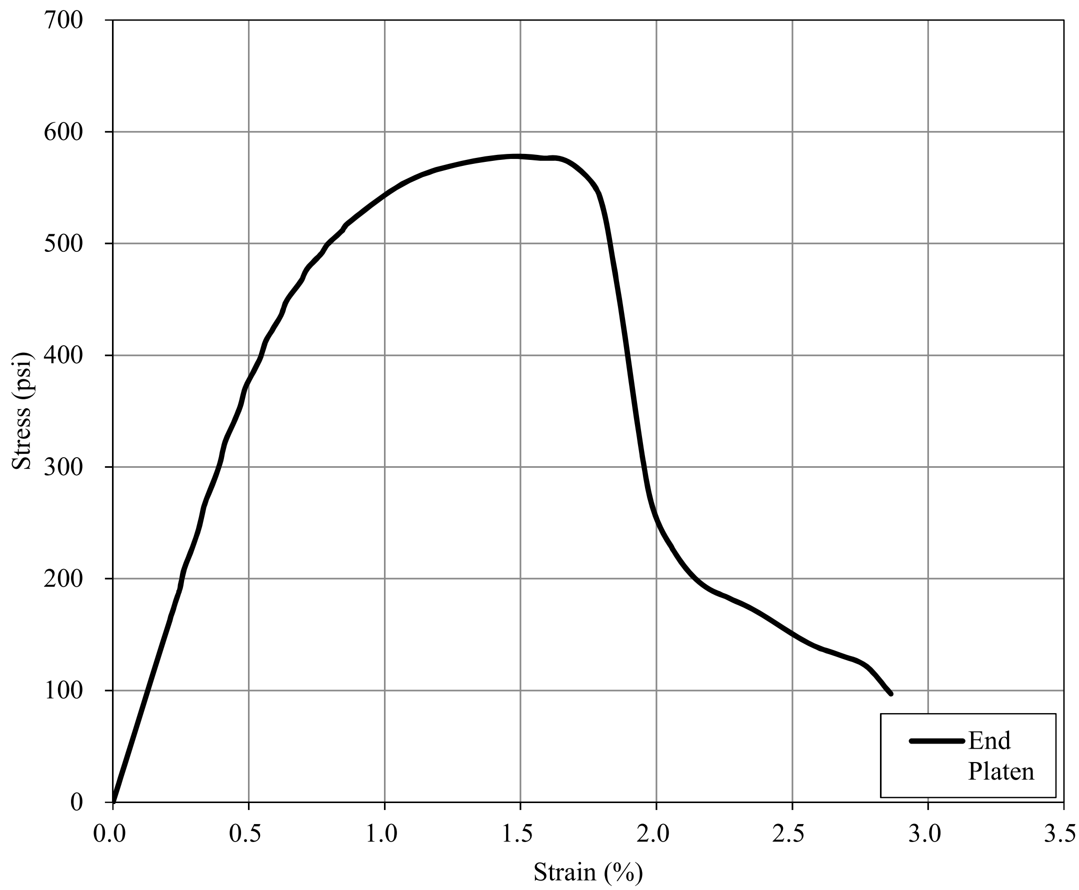


Batch S-1

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-1-I
Curing Period:	28 day
Test Date:	2/28/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.976	in
Diameter (initial):	2.037	in
Weight:	381.6	g
Unit Weight:	112	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	576	psi
Secant Modulus E_{50EP}:	77,535	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.46	%

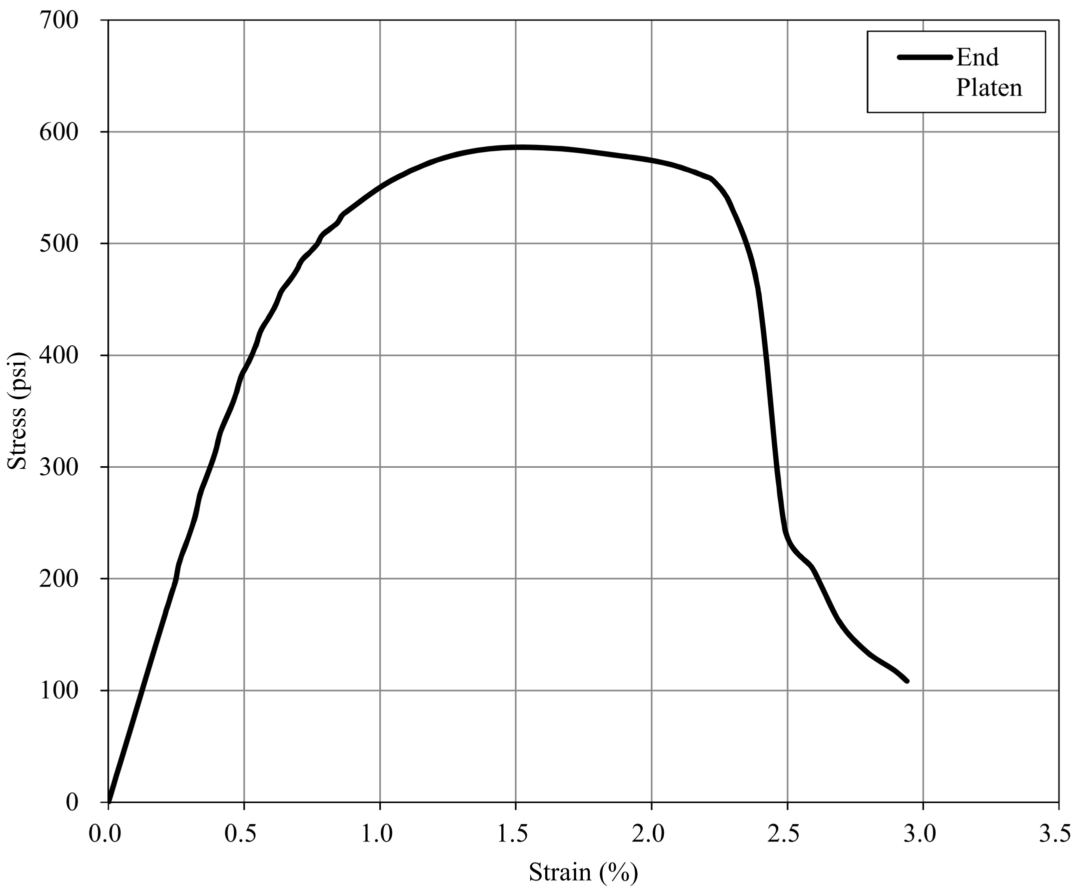


Batch S-1

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-1-J
Curing Period:	28 day
Test Date:	2/28/2017
$\alpha_{in\text{-}place}$:	200
$(w{:}c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.973	in
Diameter (initial):	2.037	in
Weight:	382.2	g
Unit Weight:	112	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	584	psi
Secant Modulus E_{50EP}:	80,465	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.49	%

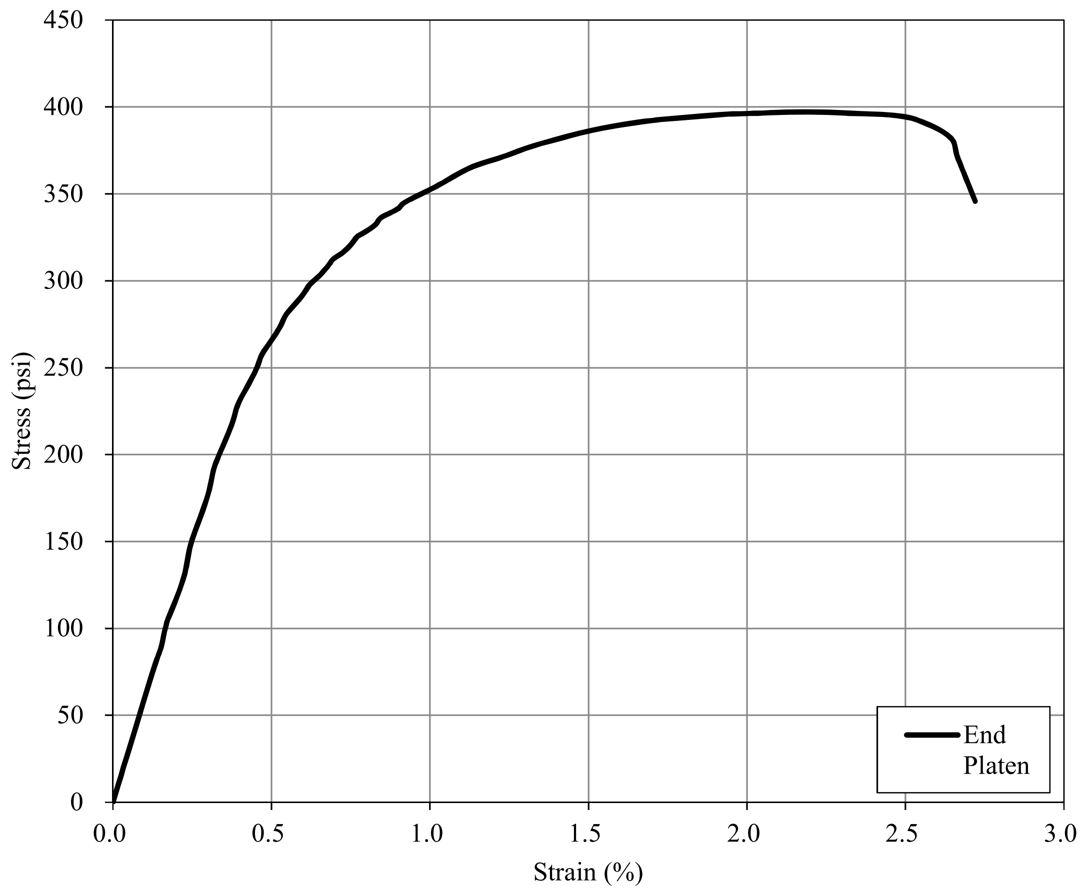


Batch S-2

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-2-E
Curing Period:	3 day
Test Date:	2/3/2017
$\alpha_{in\text{-}place}$:	275
$(w:c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

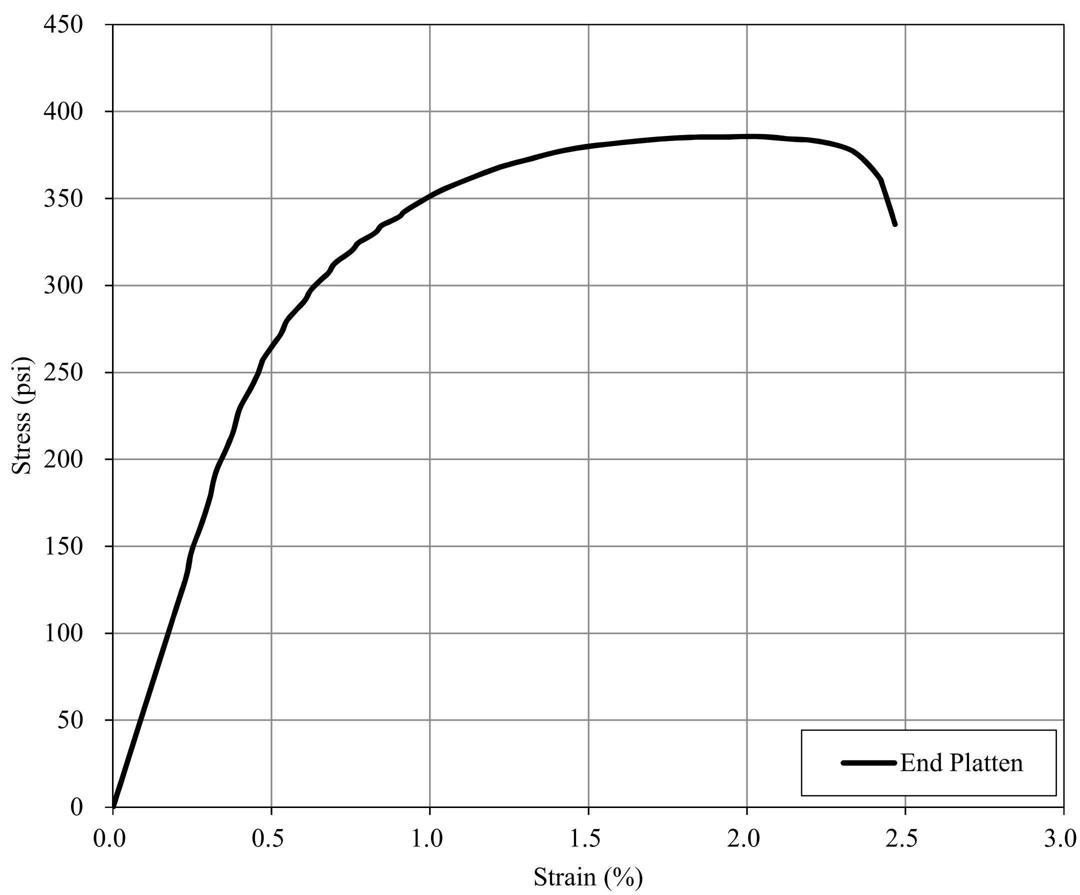
Specimen Information		
Height (initial):	3.974	in
Diameter (initial):	2.038	in
Weight:	381.9	g
Unit Weight:	112	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	395	psi
Secant Modulus E_{50EP}:	59,686	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	2.13	%



Batch S-2

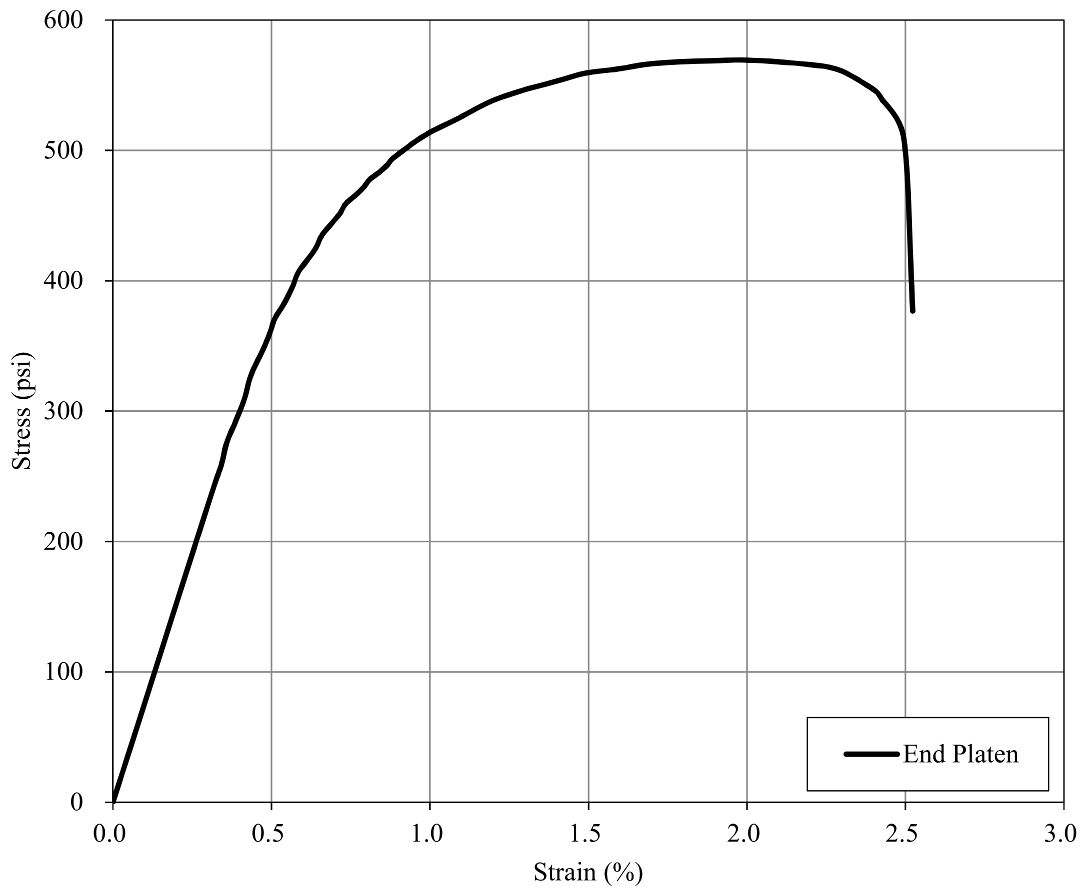
Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.976	in	Peak Stress:	384	psi
Tested by:	RNG	Diameter (initial):	2.039	in	Secant Modulus E_{50EP}:	59,227	psi
I.D. :	S-2-F	Weight:	382.6	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	3 day	Unit Weight:	112	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/3/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	0.6				End Platen Strain at failure, εf :	2.03	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-2-A
Curing Period:	7 day
Test Date:	2/7/2017
$\alpha_{in\text{-}place}$:	275
$(w:c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

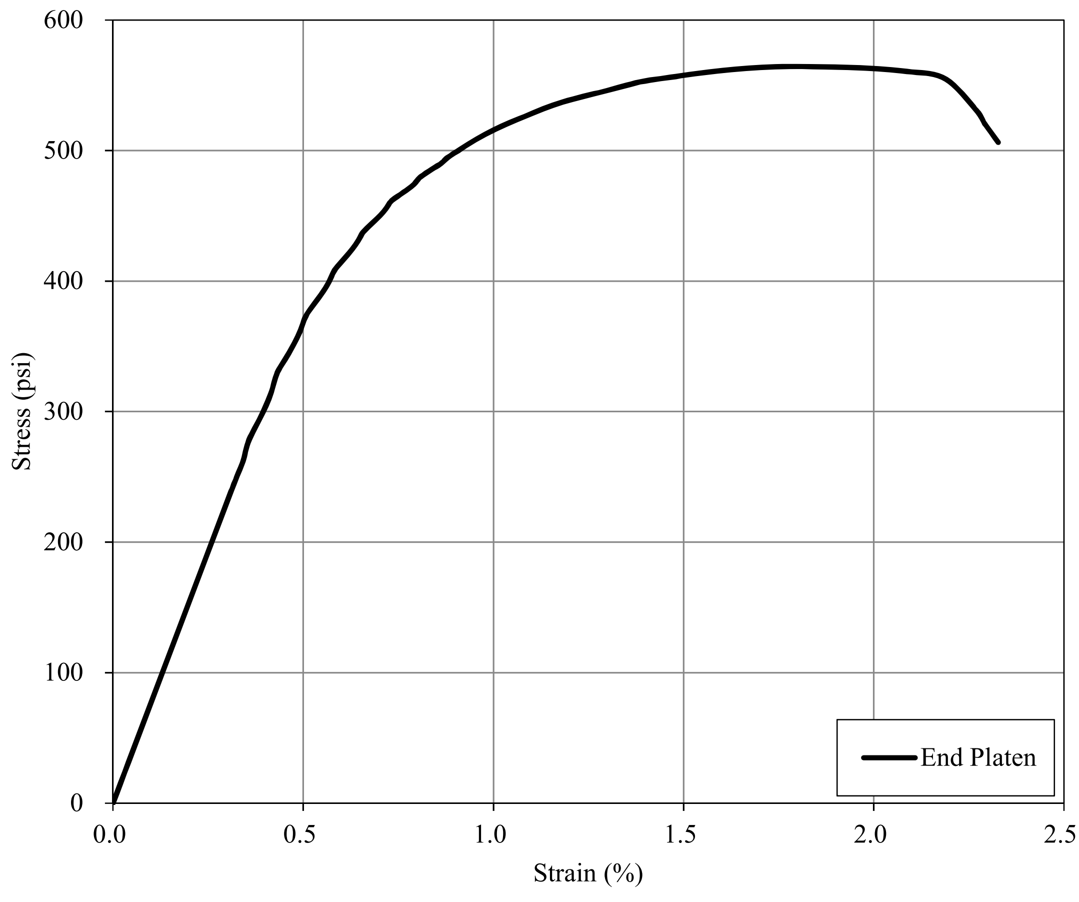
Specimen Information		
Height (initial):	3.954	in
Diameter (initial):	2.037	in
Weight:	380.7	g
Unit Weight:	113	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	567	psi
Secant Modulus E_{50EP}:	76,120	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.99	%



Batch S-2

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.965	in	Peak Stress:	562	psi
Tested by:	RNG	Diameter (initial):	2.033	in	Secant Modulus E_{50EP}:	77,460	psi
I.D. :	S-2-B	Weight:	381.7	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	7 day	Unit Weight:	113	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/7/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	0.6				End Platen Strain at failure, εf :	1.79	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

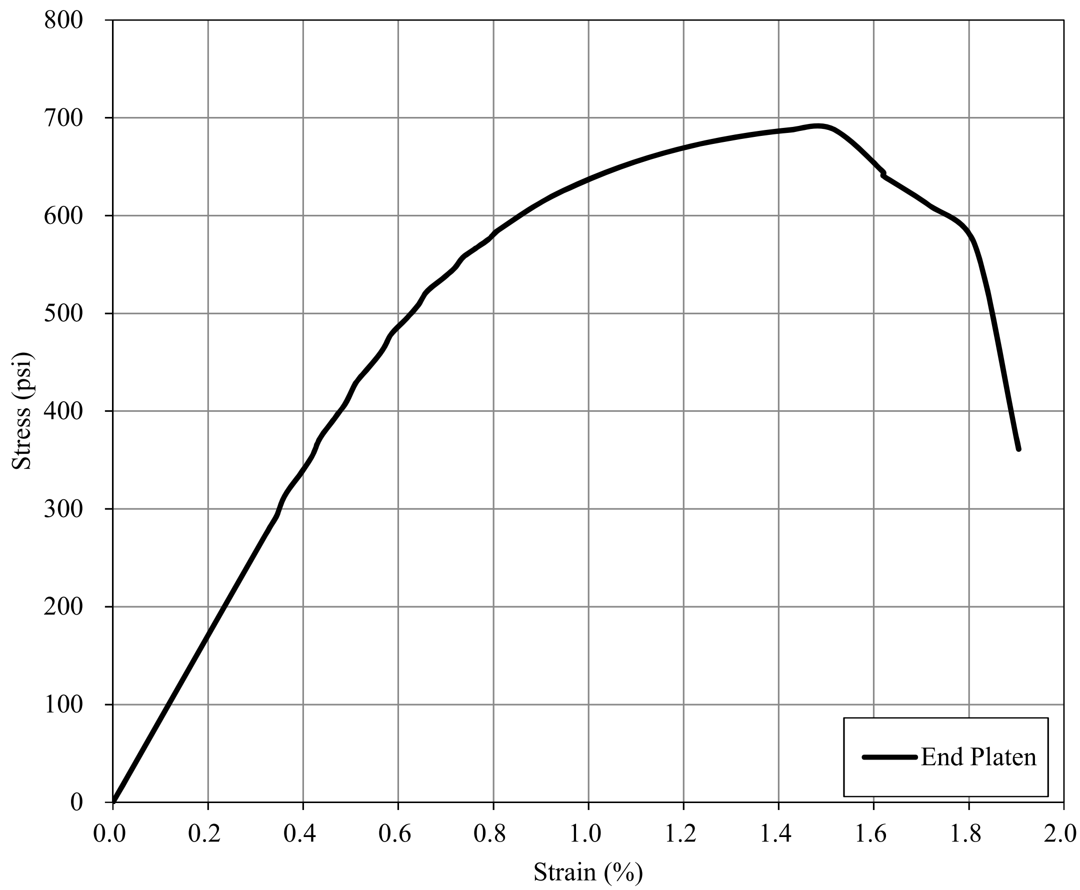


Batch S-2

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-2-G
Curing Period:	14 day
Test Date:	2/14/2017
$\alpha_{in\text{-}place}$:	275
$(w{:}c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

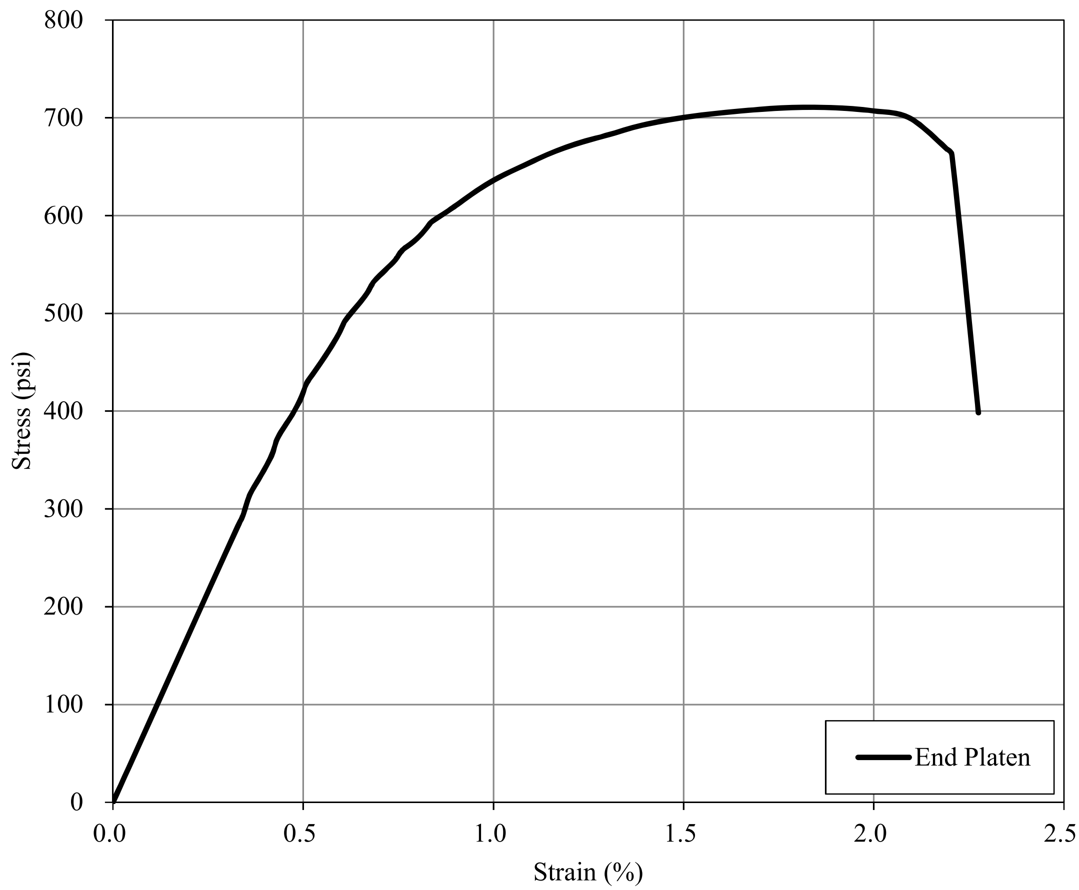
Specimen Information		
Height (initial):	3.965	in
Diameter (initial):	2.036	in
Weight:	380.7	g
Unit Weight:	112	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	686	psi
Secant Modulus E_{50EP}:	84,918	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.51	%



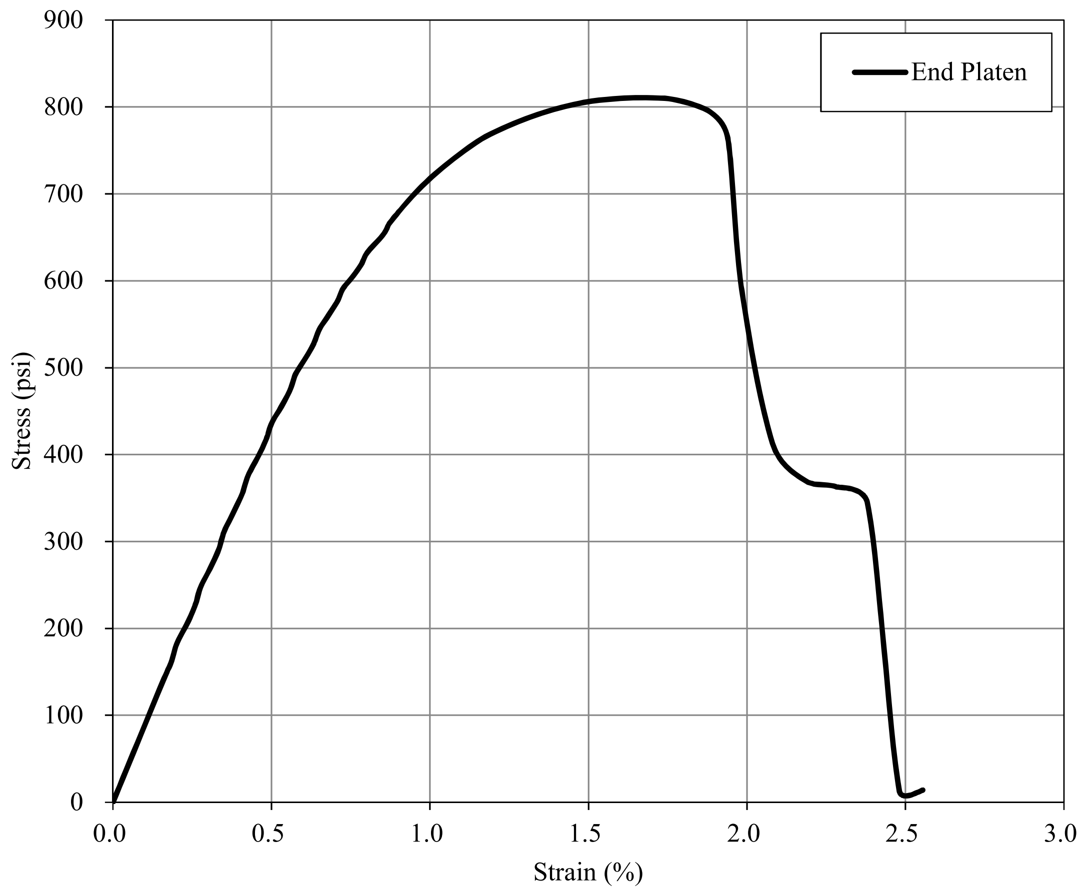
Batch S-2

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.954	in	Peak Stress:	707	psi
Tested by:	RNG	Diameter (initial):	2.039	in	Secant Modulus E_{50EP}:	85,143	psi
I.D. :	S-2-H	Weight:	380.1	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	14 day	Unit Weight:	112	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/14/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	0.6				End Platen Strain at failure, εf :	1.79	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



Batch S-2

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.966	in	Peak Stress:	807	psi
Tested by:	RNG	Diameter (initial):	2.037	in	Secant Modulus E_{50EP}:	86,716	psi
I.D. :	S-2-C	Weight:	381.3	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	112	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/28/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	0.6				End Platen Strain at failure, εf :	1.68	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

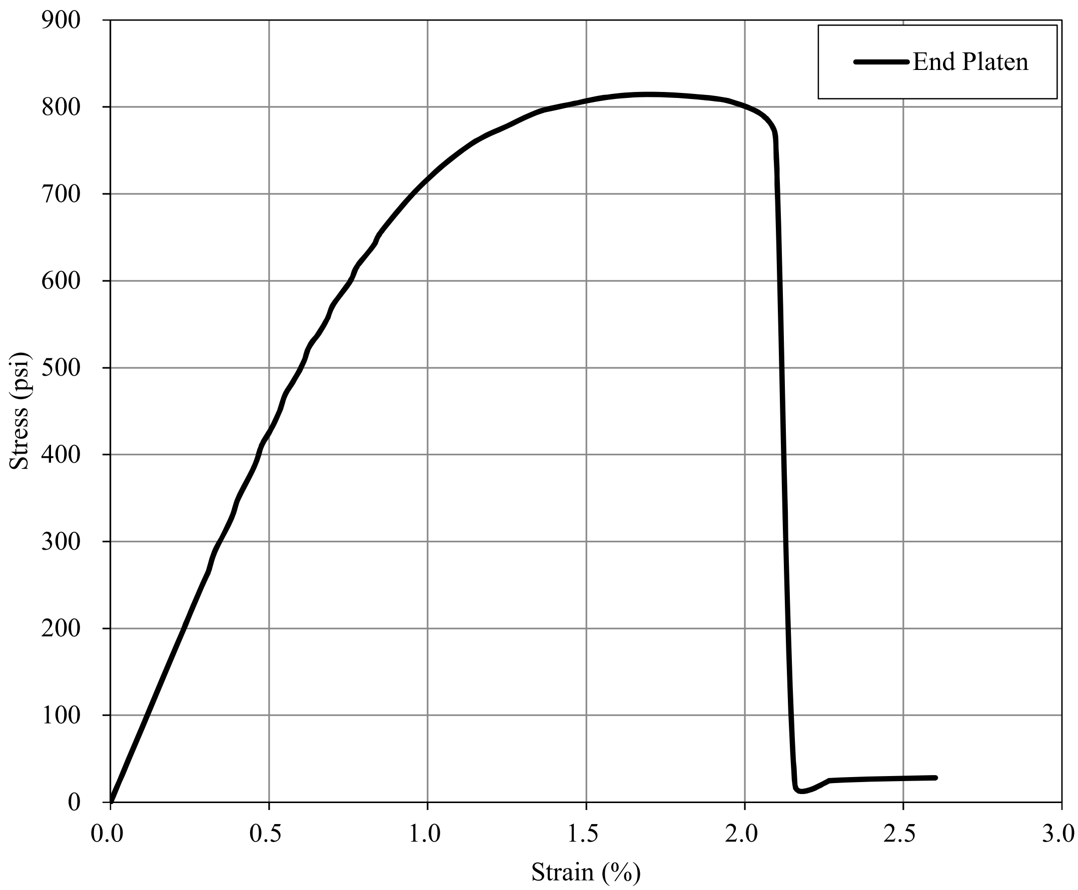


Batch S-2

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-2-D
Curing Period:	28 day
Test Date:	2/28/2017
$\alpha_{in\text{-}place}$:	275
$(w{:}c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

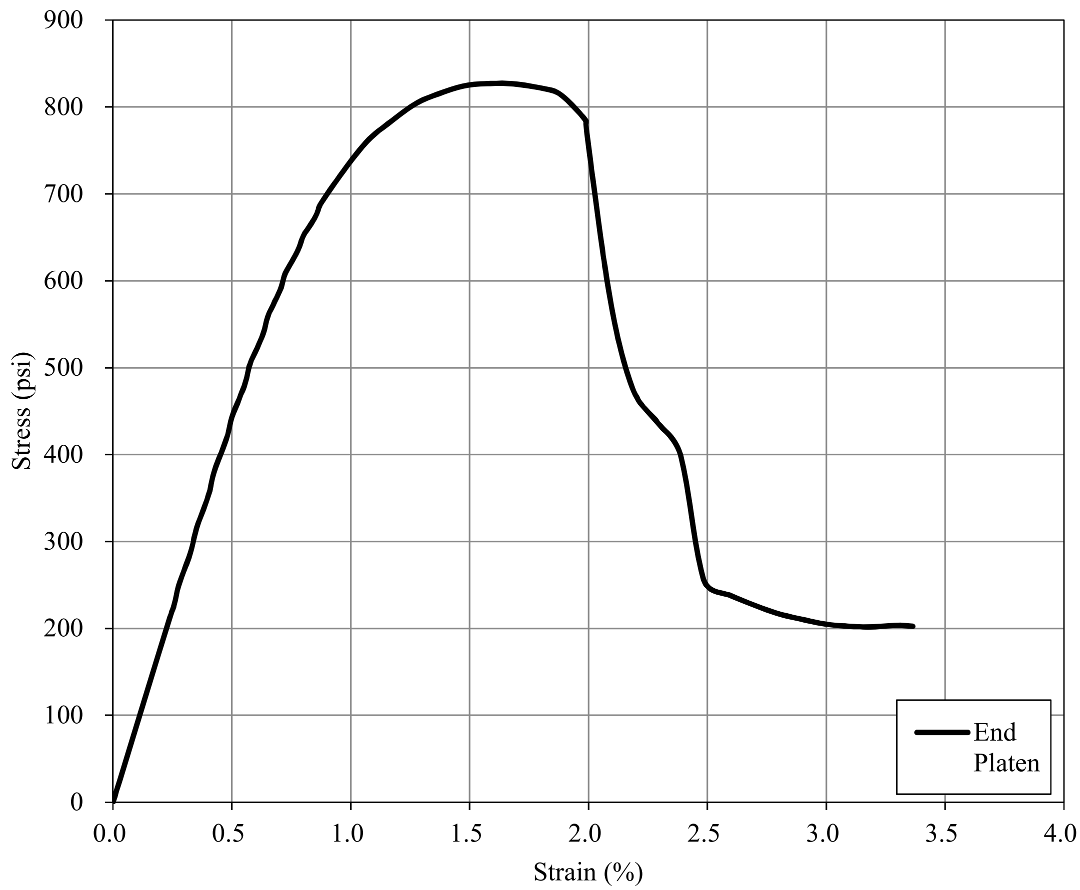
Specimen Information		
Height (initial):	3.971	in
Diameter (initial):	2.035	in
Weight:	382.3	g
Unit Weight:	113	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	811	psi
Secant Modulus E_{50EP}:	86,036	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.66	%



Batch S-2

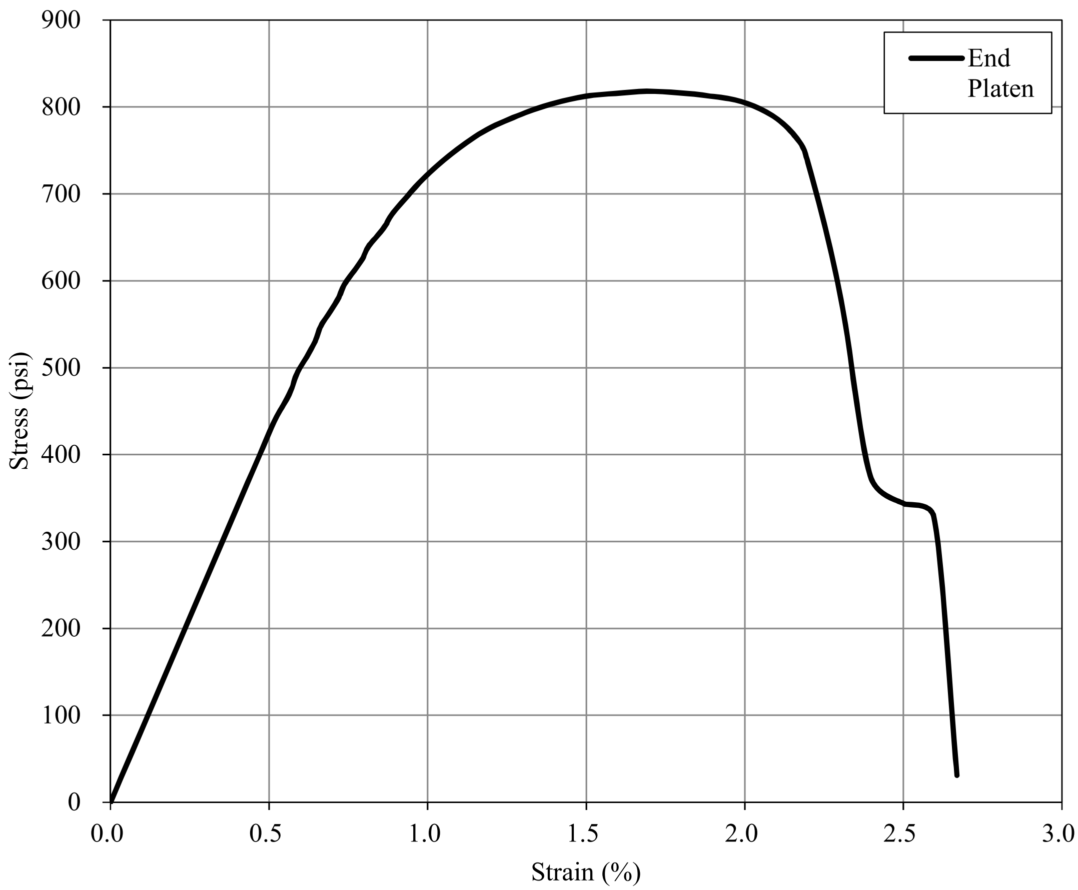
Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.983	in	Peak Stress:	824	psi
Tested by:	RNG	Diameter (initial):	2.036	in	Secant Modulus E_{50EP}:	87,941	psi
I.D. :	S-2-I	Weight:	381.8	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	112	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/28/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	0.6				End Platen Strain at failure, εf :	1.59	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-2-J
Curing Period:	28 day
Test Date:	2/28/2017
$\alpha_{in\text{-}place}$:	275
$(w{:}c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.971	in
Diameter (initial):	2.037	in
Weight:	382.7	g
Unit Weight:	113	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	815	psi
Secant Modulus E_{50EP}:	84,973	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.69	%

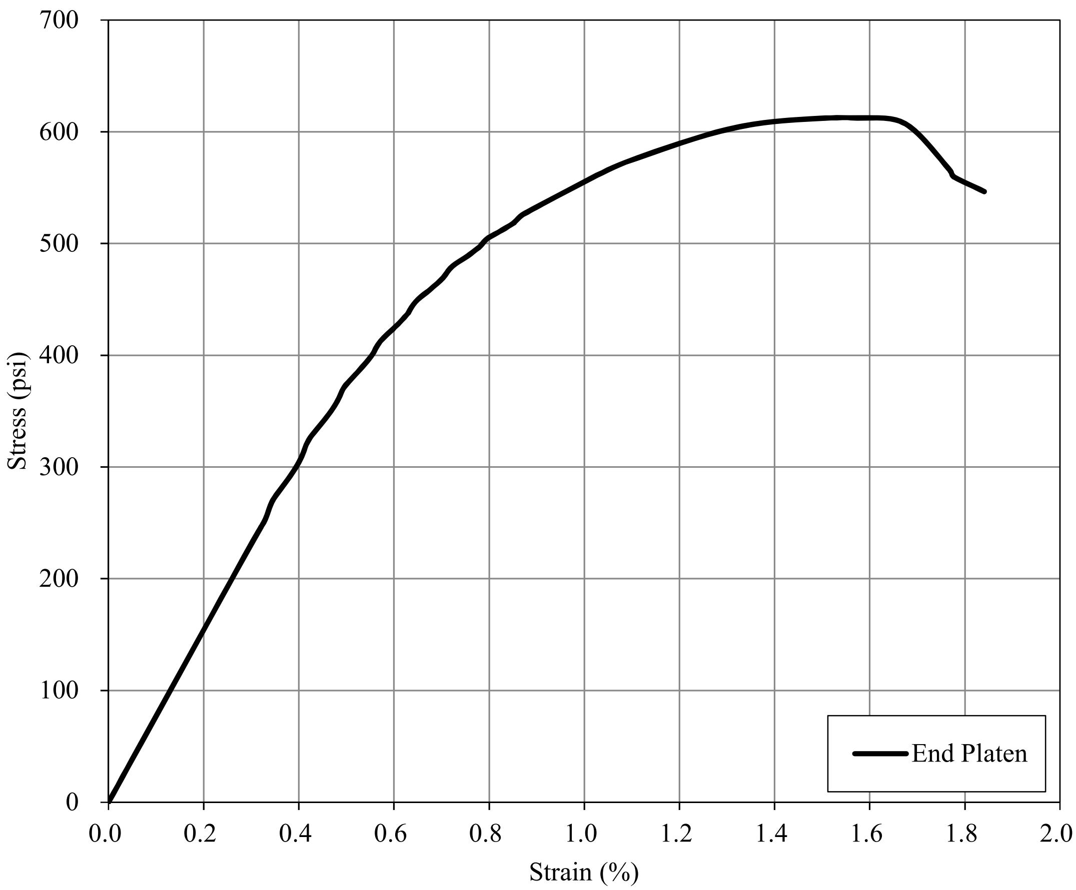


Batch S-3

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-3-E
Curing Period:	3 day
Test Date:	2/4/2017
$\alpha_{in\text{-}place}$:	350
$(w:c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

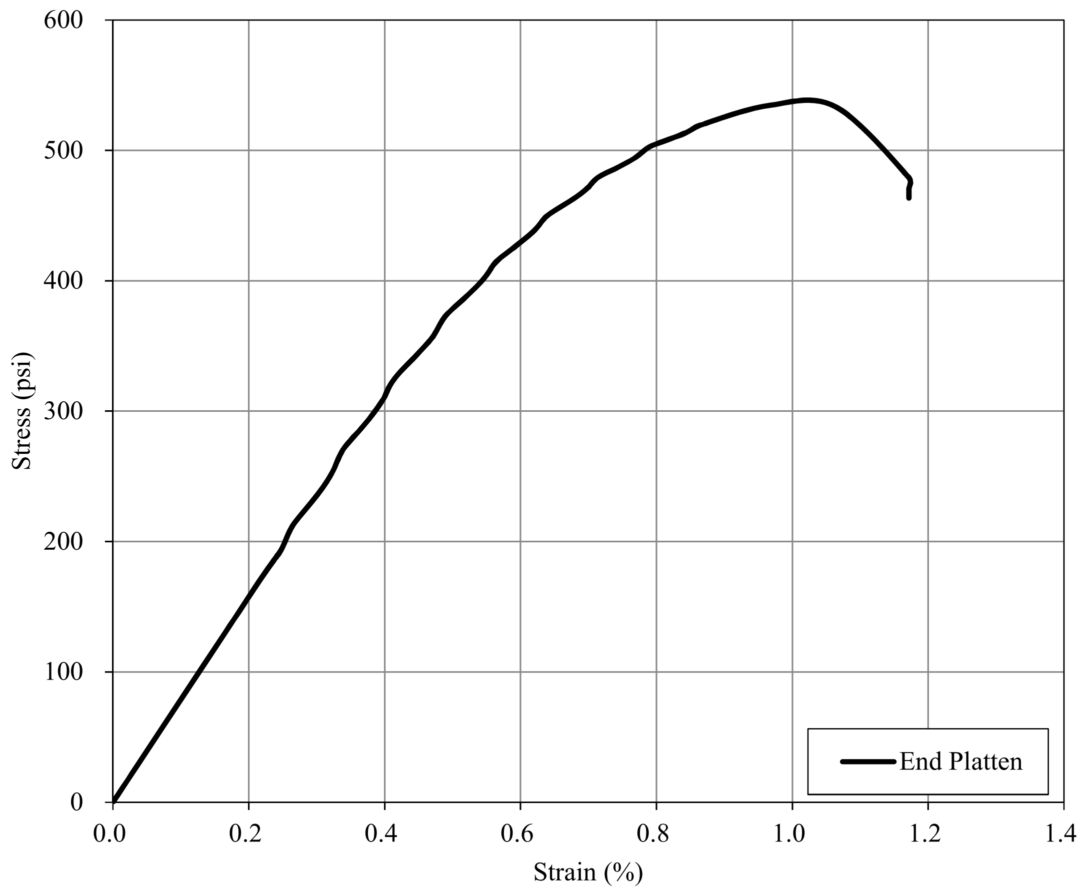
Specimen Information		
Height (initial):	3.969	in
Diameter (initial):	2.037	in
Weight:	380.8	g
Unit Weight:	112	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	610	psi
Secant Modulus E_{50EP}:	76,081	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.58	%

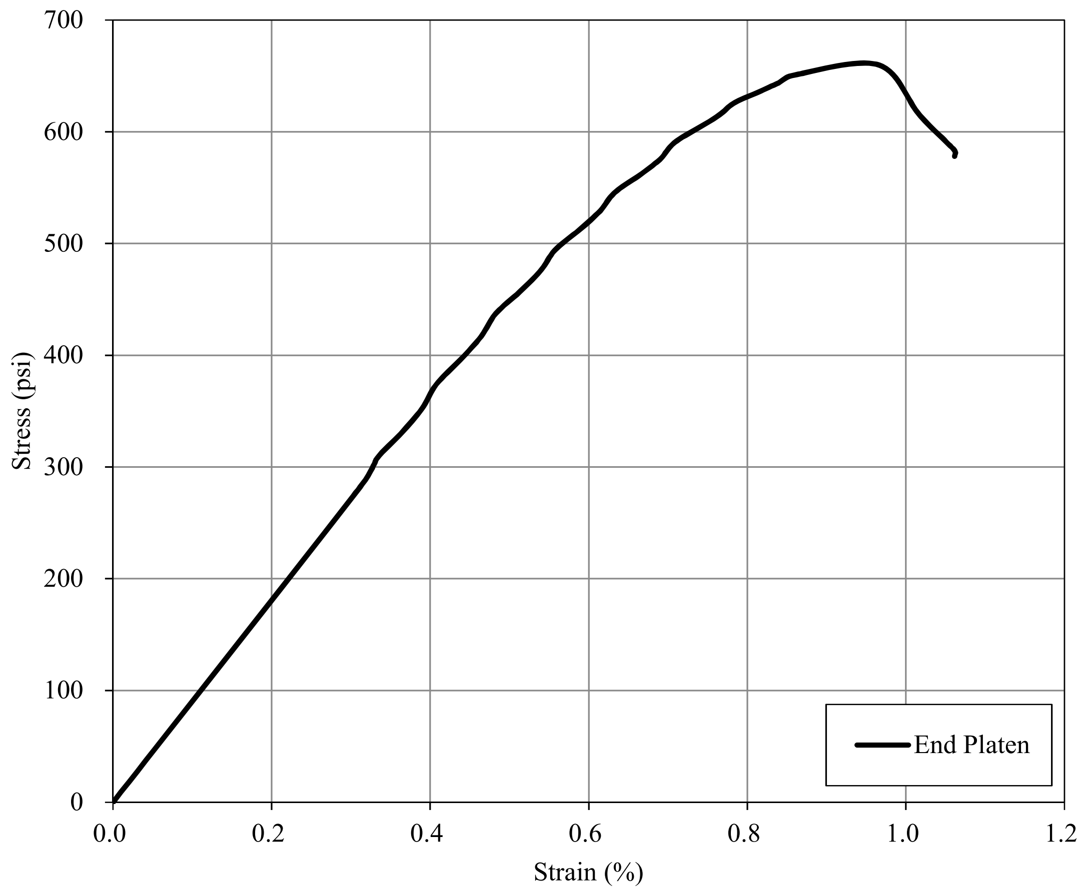


Batch S-3

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.946	in	Peak Stress:	532	psi
Tested by:	RNG	Diameter (initial):	2.036	in	Secant Modulus E_{50EP}:	79,615	psi
I.D. :	S-3-F	Weight:	378.6	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	3 day	Unit Weight:	112	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/4/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	350				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	0.6				End Platen Strain at failure, εf :	0.96	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

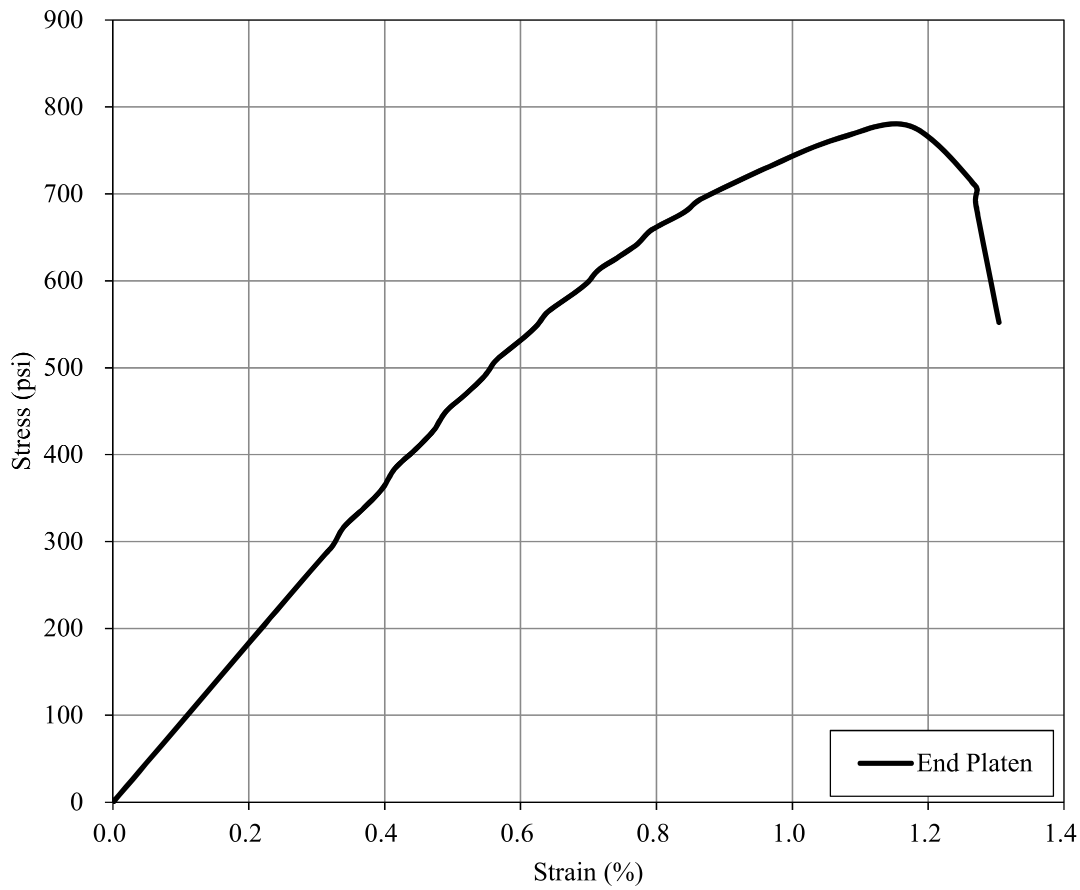


Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.958	in	Peak Stress:	657	psi
Tested by:	RNG						
I.D. :	S-3-A	Diameter (initial):	2.041	in	Secant Modulus E_{50EP}:	90,928	psi
Curing Period:	7 day						
Test Date:	2/8/2017	Weight:	379.7	g	Secant Modulus E_{50L}:	N/A	psi
$\alpha_{in\text{-}place}$:	350	Unit Weight:	112	pcf			
$(w:c)_{slurry}$:	0.6				Poisson's Ratio ν_{50} :	N/A	
End Treatment:	Grinding	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
Confining Pressure (psi):	N/A				Local Strain at failure, εf :	N/A	%
Strain Rate:	1 %/min				End Platen Strain at failure, εf :	0.97	%



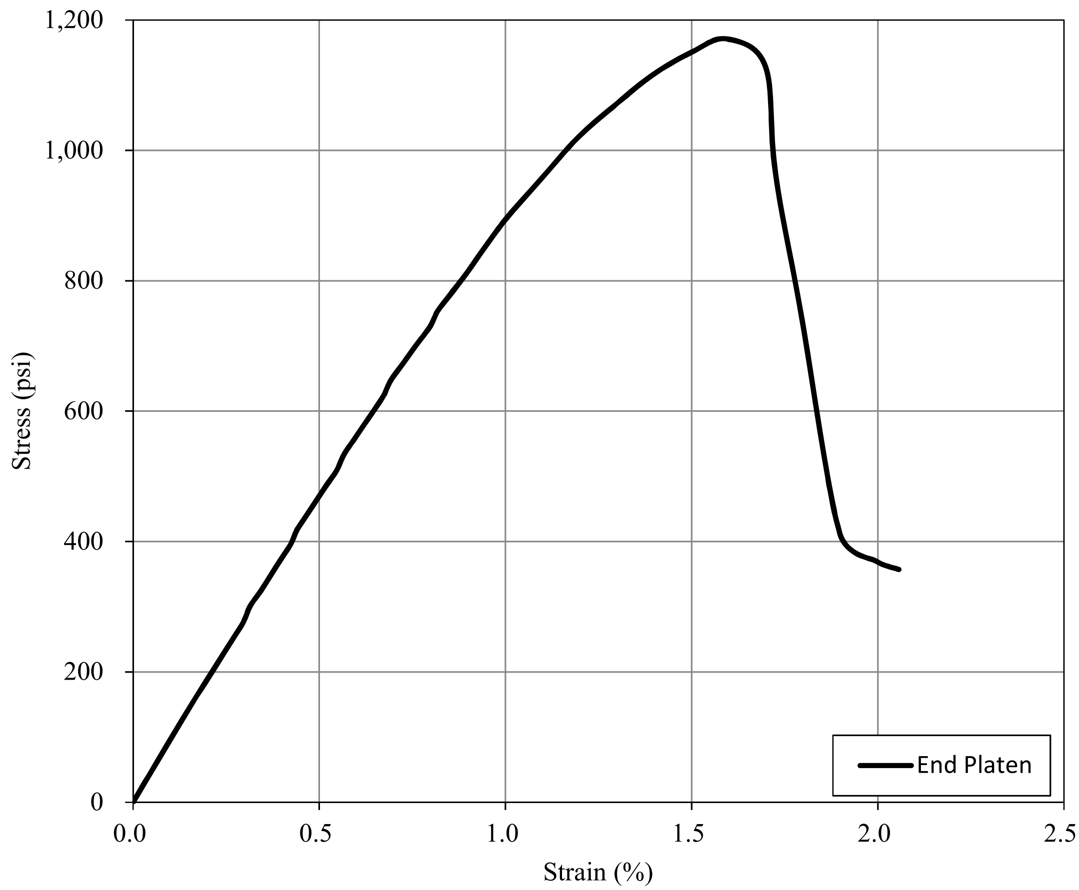
Batch S-3

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.95	in	Peak Stress:	774	psi
Tested by:	RNG	Diameter (initial):	2.04	in	Secant Modulus E_{50EP}:	92,202	psi
I.D. :	S-3-B	Weight:	379.4	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	7 day	Unit Weight:	112	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/8/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	350				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	0.6				End Platen Strain at failure, εf :	1.17	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



Batch S-3

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.965	in	Peak Stress:	1,166	psi
Tested by:	RNG	Diameter (initial):	2.035	in	Secant Modulus E_{50EP}:	93,236	psi
I.D. :	S-3-C	Weight:	380.7	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	112	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	3/1/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	350				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	0.6				End Platen Strain at failure, εf :	1.59	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

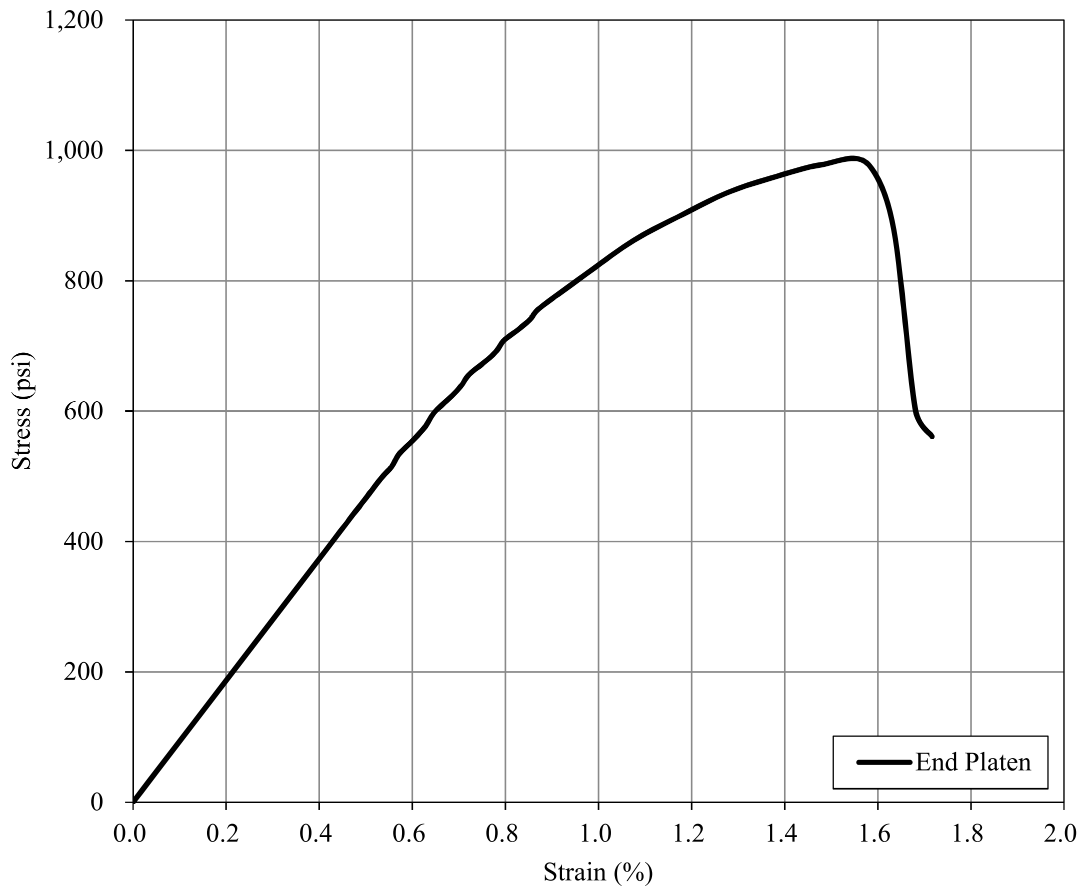


Batch S-3

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-3-G
Curing Period:	14 day
Test Date:	2/15/2017
$\alpha_{in-place}$:	350
$(w{:}c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.945	in
Diameter (initial):	2.037	in
Weight:	377.7	g
Unit Weight:	112	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	976	psi
Secant Modulus E_{50EP}:	93,275	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.58	%

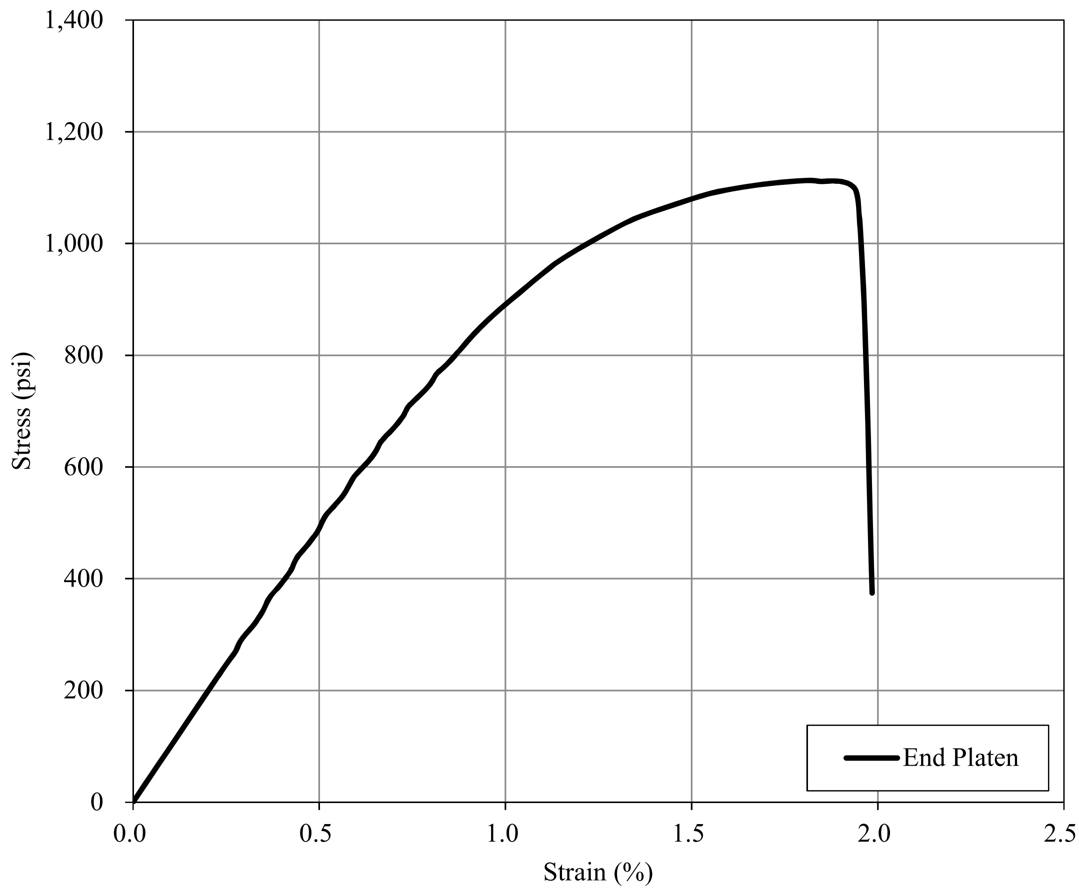


Batch S-3

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-3-H
Curing Period:	14 day
Test Date:	2/15/2017
$\alpha_{in\text{-}place}$:	350
$(w:c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.951	in
Diameter (initial):	2.036	in
Weight:	378.4	g
Unit Weight:	112	pcf
Gage Length:	N/A	in

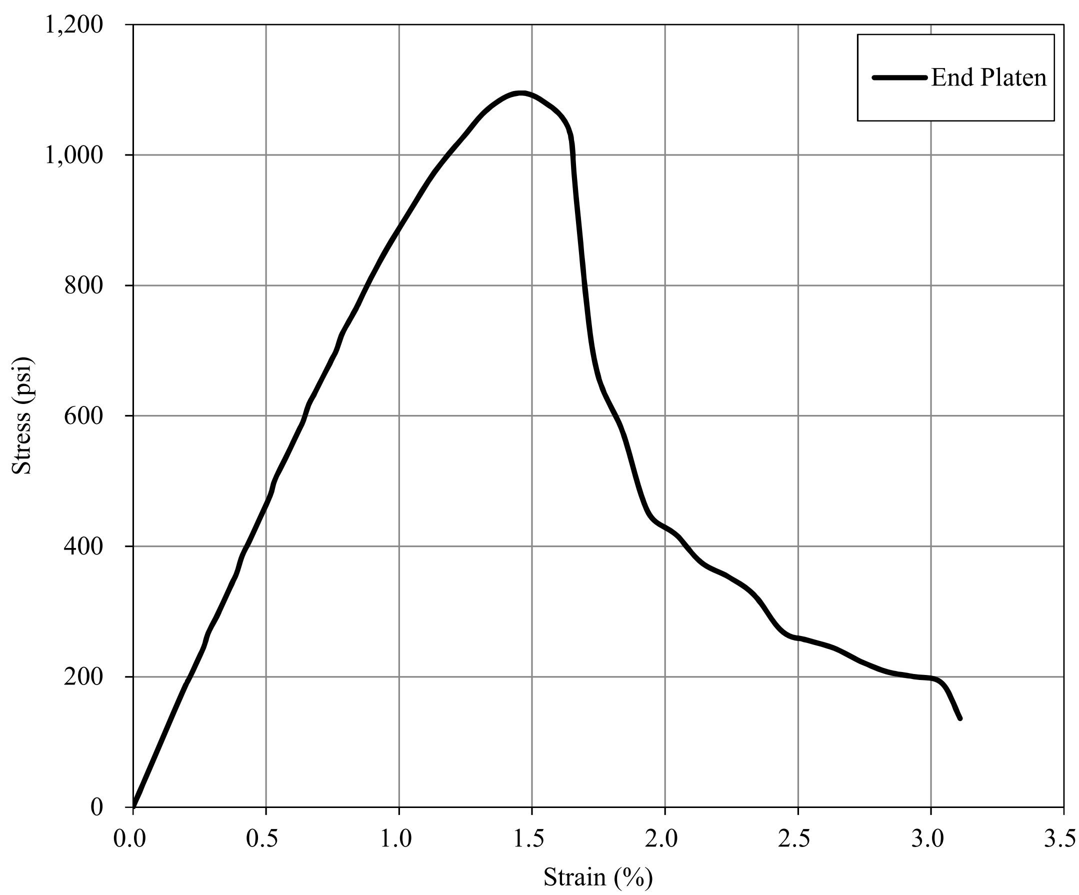
Test Summary		
Peak Stress:	1,106	psi
Secant Modulus E_{50EP}:	97,418	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.84	%



Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-3-D
Curing Period:	28 day
Test Date:	3/1/2017
$\alpha_{in-place}$:	350
$(w:c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.957	in
Diameter (initial):	2.037	in
Weight:	380.5	g
Unit Weight:	112	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	1,089	psi
Secant Modulus E_{50EP}:	93,258	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.44	%

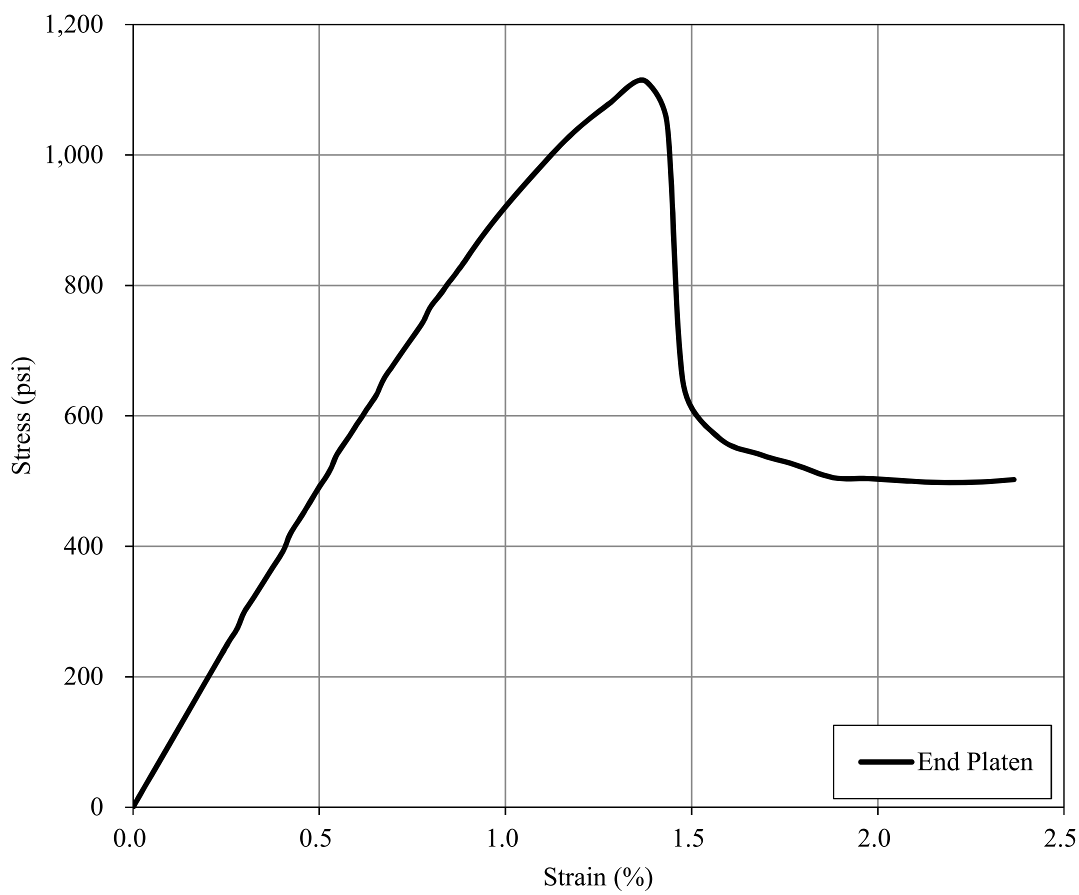


Batch S-3

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-3-I
Curing Period:	28 day
Test Date:	3/1/2017
$\alpha_{in\text{-}place}$:	350
$(w:c)_{slurry}$:	0.6
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

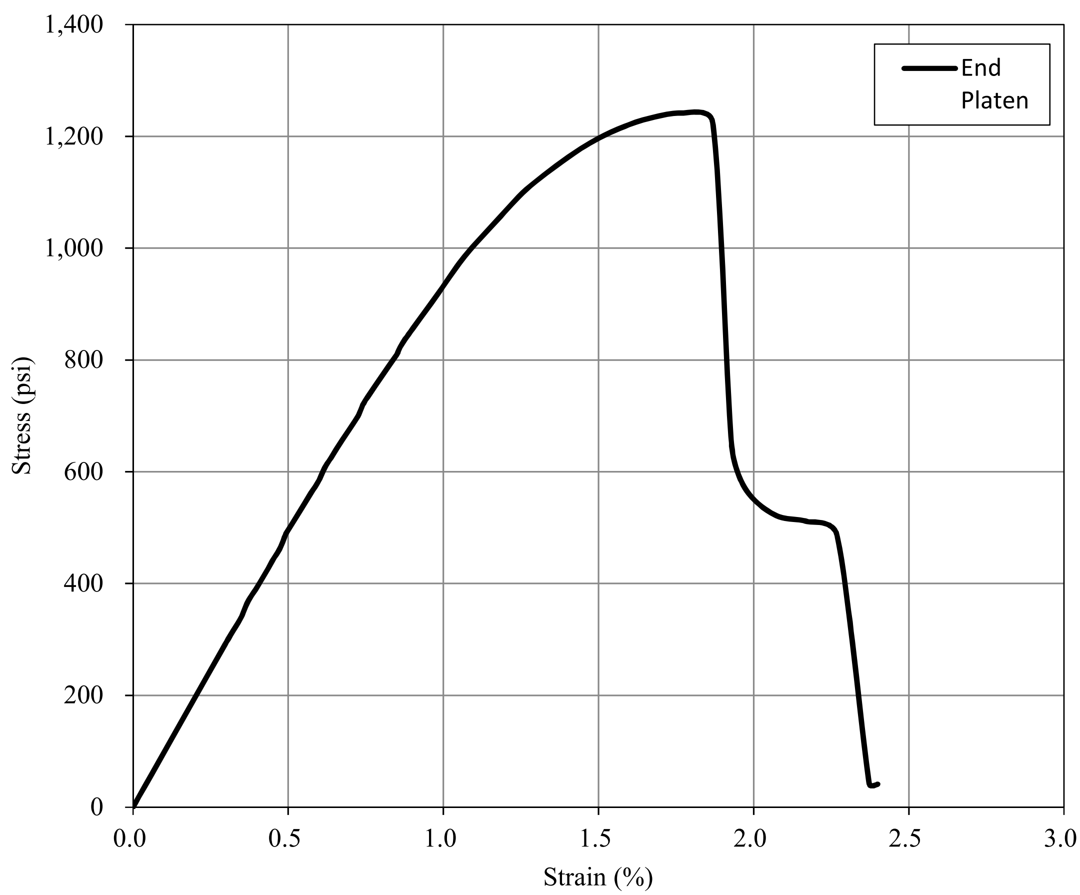
Specimen Information		
Height (initial):	3.949	in
Diameter (initial):	2.037	in
Weight:	378.8	g
Unit Weight:	112	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	1,109	psi
Secant Modulus E_{50EP}:	98,296	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.37	%



Batch S-3

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.959	in	Peak Stress:	1,236	psi
Tested by:	RNG	Diameter (initial):	2.038	in	Secant Modulus E_{50EP}:	98,033	psi
I.D. :	S-3-J	Weight:	380.2	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	112	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	3/1/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	350				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	0.6				End Platen Strain at failure, εf :	1.77	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

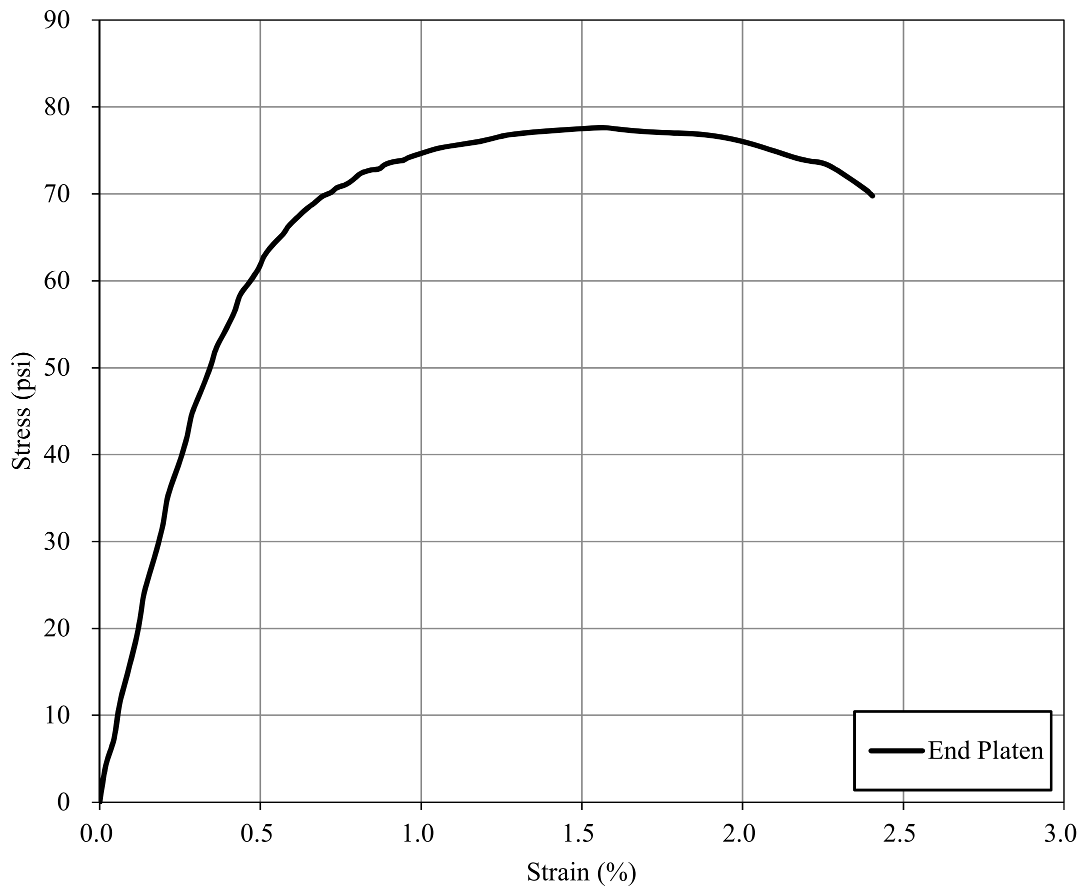


Batch S-4

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-4-E
Curing Period:	3 day
Test Date:	2/4/2017
$\alpha_{in\text{-}place}$:	125
$(w{:}c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

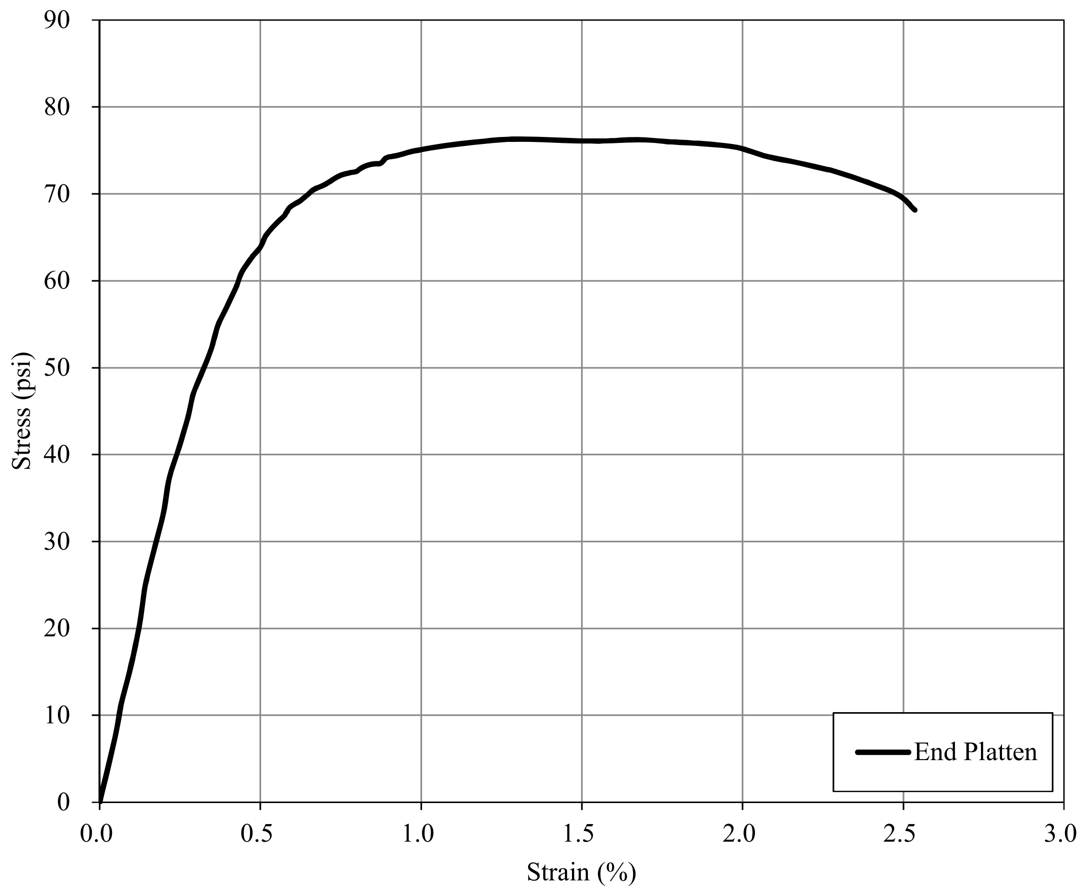
Specimen Information		
Height (initial):	3.952	in
Diameter (initial):	2.036	in
Weight:	366.5	g
Unit Weight:	109	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	77	psi
Secant Modulus E_{50EP}:	15,838	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.57	%



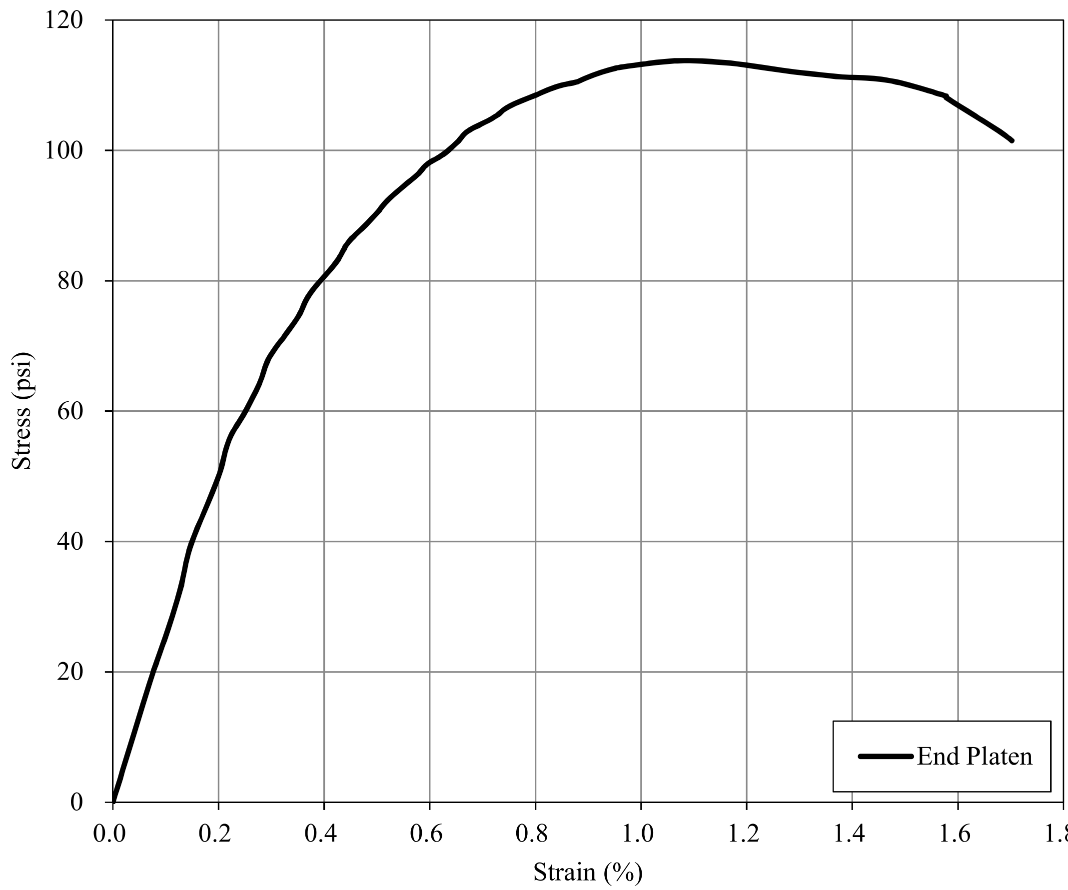
Batch S-4

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.954	in	Peak Stress:	76	psi
Tested by:	RNG	Diameter (initial):	2.034	in	Secant Modulus E_{50EP}:	17,055	psi
I.D. :	S-4-F	Weight:	367.7	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	3 day	Unit Weight:	109	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/4/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	125				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.4				End Platen Strain at failure, εf :	1.27	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



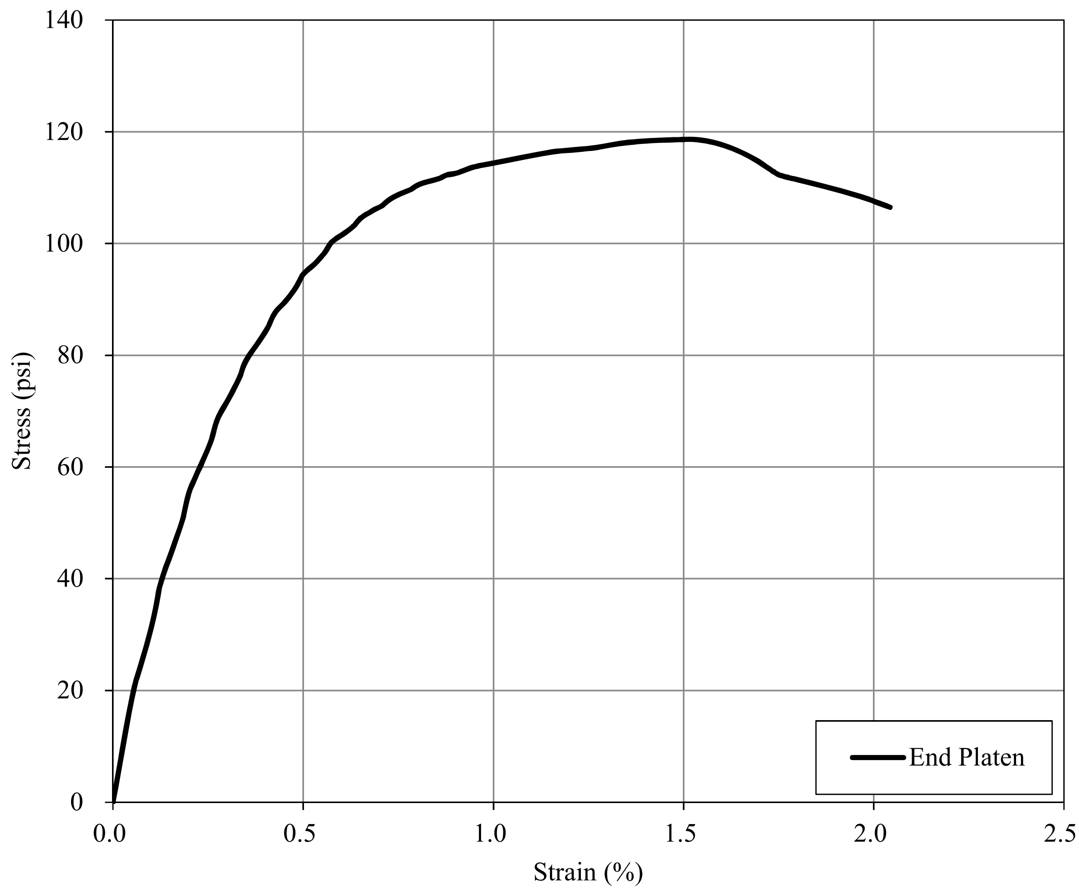
Batch S-4

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.943	in	Peak Stress:	113	psi
Tested by:	RNG	Diameter (initial):	2.036	in	Secant Modulus E_{50EP}:	24,856	psi
I.D. :	S-4-A	Weight:	365.8	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	7 day	Unit Weight:	109	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/8/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	125				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.4				End Platen Strain at failure, εf :	1.07	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



Batch S-4

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.928	in	Peak Stress:	118	psi
Tested by:	RNG	Diameter (initial):	2.032	in	Secant Modulus E_{50EP}:	26,445	psi
I.D. :	S-4-B	Weight:	365.4	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	7 day	Unit Weight:	109	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/8/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	125				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.4				End Platen Strain at failure, εf :	1.46	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

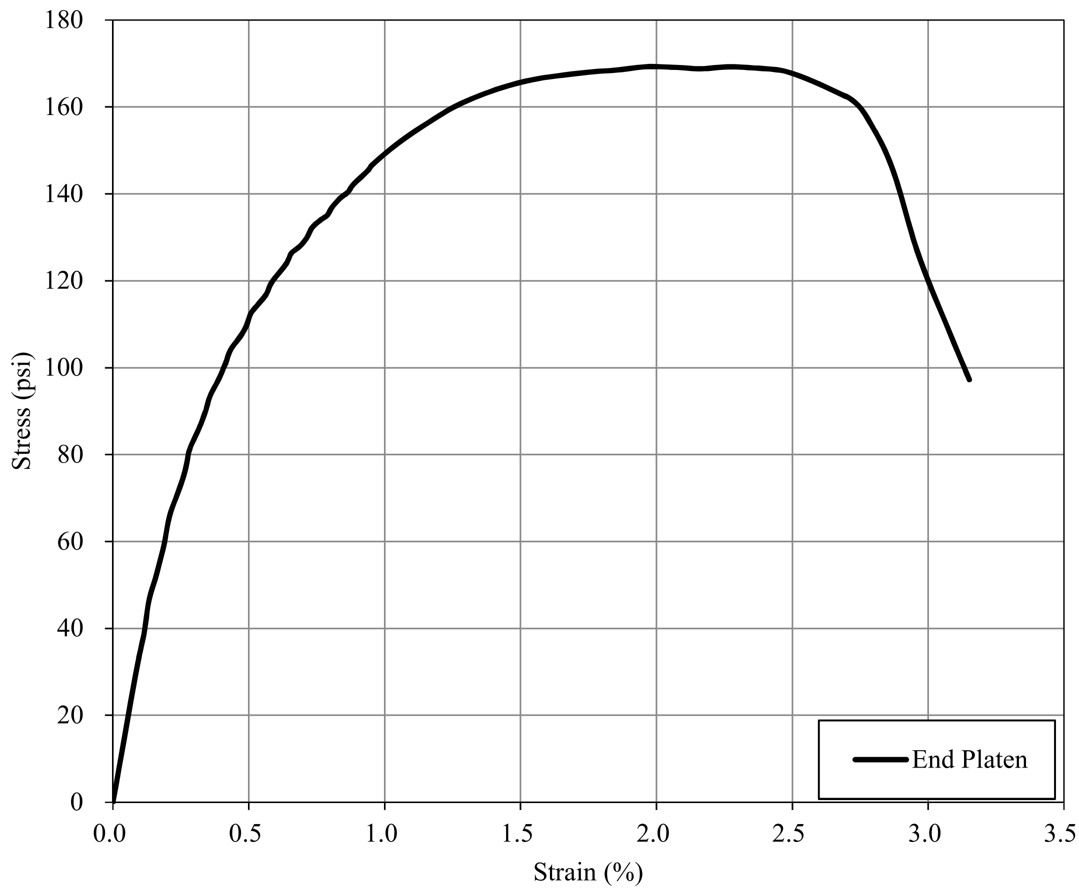


Batch S-4

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-4-G
Curing Period:	14 day
Test Date:	2/15/2017
$\alpha_{in\text{-}place}$:	125
$(w{:}c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.892	in
Diameter (initial):	2.035	in
Weight:	359.9	g
Unit Weight:	108	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	168	psi
Secant Modulus E_{50EP}:	27,613	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.96	%

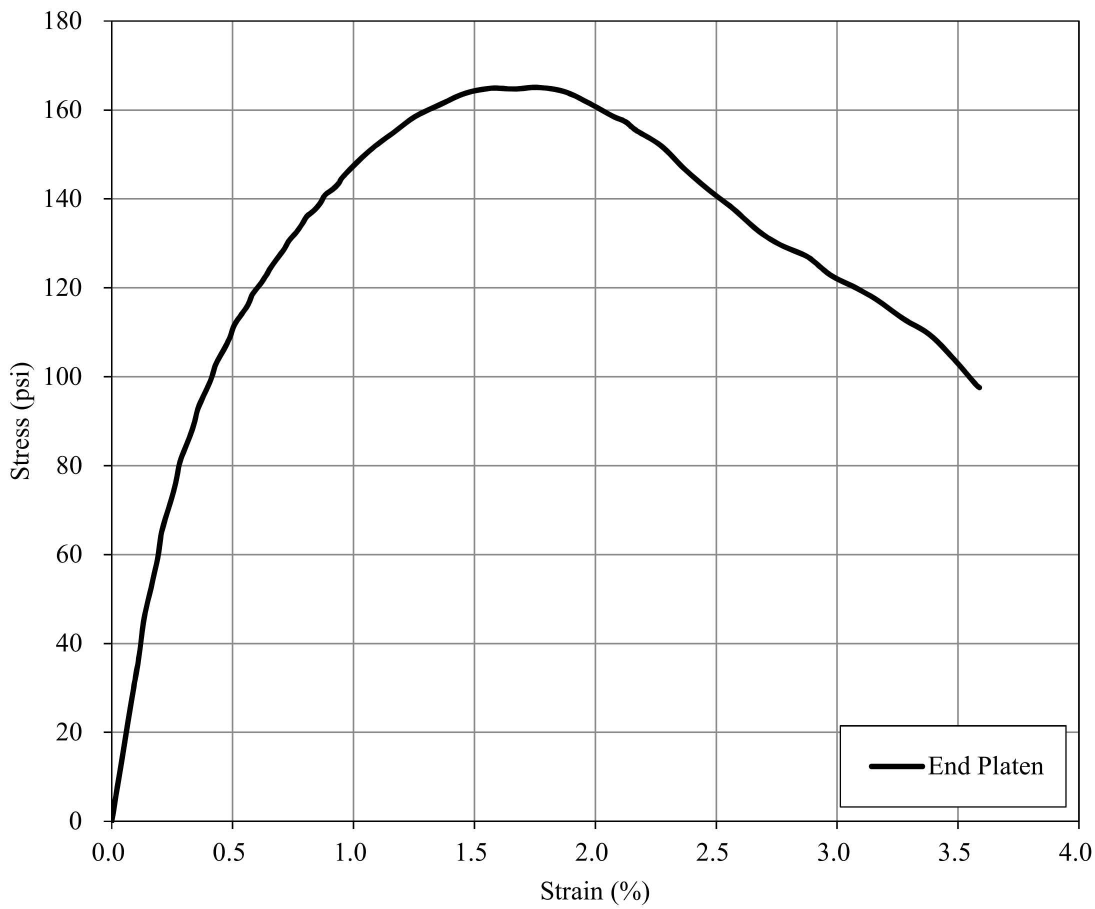


Batch S-4

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-4-H
Curing Period:	14 day
Test Date:	2/15/2017
$\alpha_{in\text{-}place}$:	125
$(w:c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.926	in
Diameter (initial):	2.033	in
Weight:	364.1	g
Unit Weight:	109	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	164	psi
Secant Modulus E_{50EP}:	28,060	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.76	%

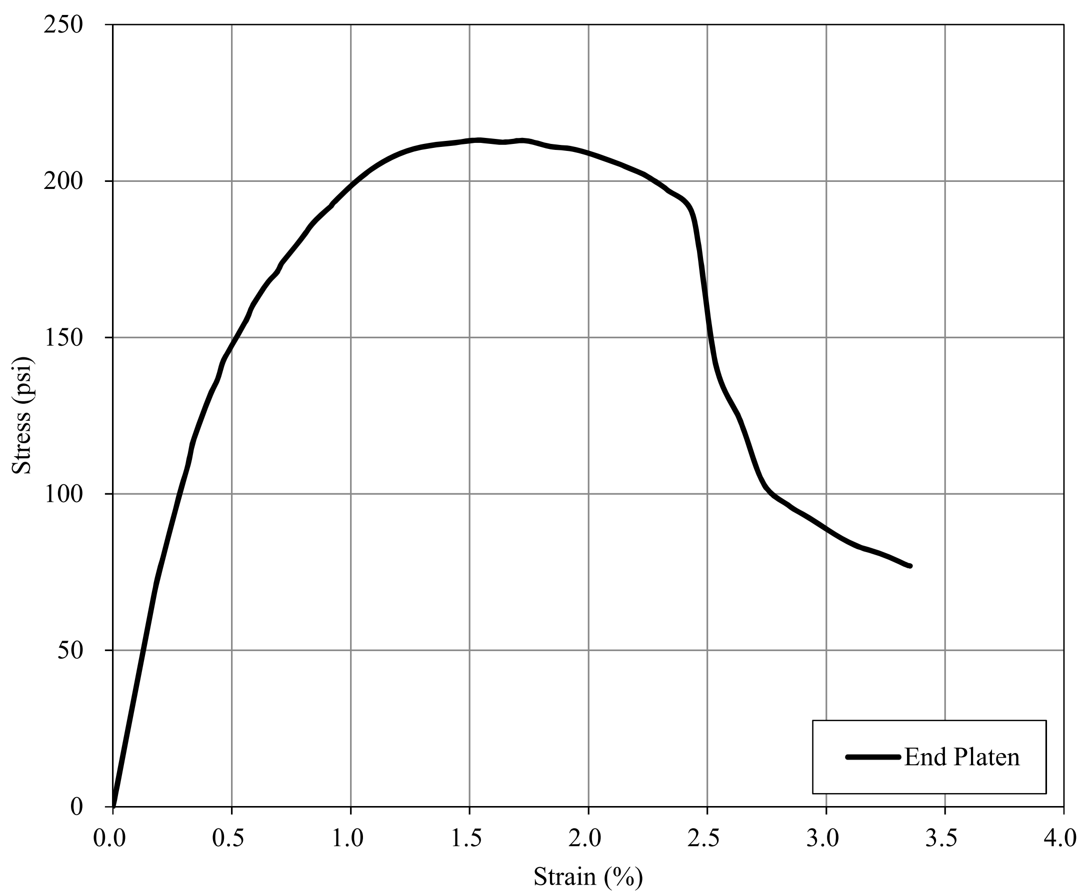


Batch S-4

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-4-C
Curing Period:	28 day
Test Date:	3/1/2017
$\alpha_{in\text{-}place}$:	125
$(w:c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.911	in
Diameter (initial):	2.038	in
Weight:	361.2	g
Unit Weight:	108	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	212	psi
Secant Modulus E_{50EP}:	34,935	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.53	%

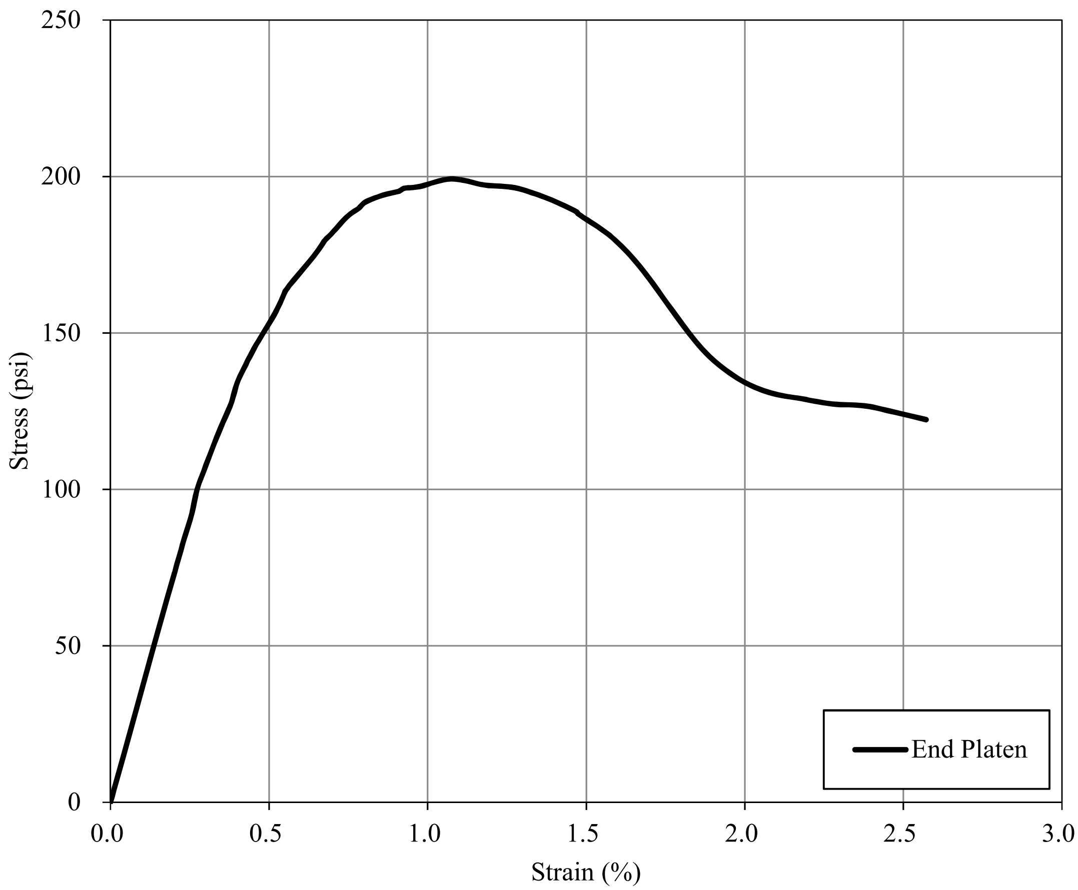


Batch S-4

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-4-D
Curing Period:	28 day
Test Date:	3/1/2017
$\alpha_{in\text{-}place}$:	125
$(w:c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

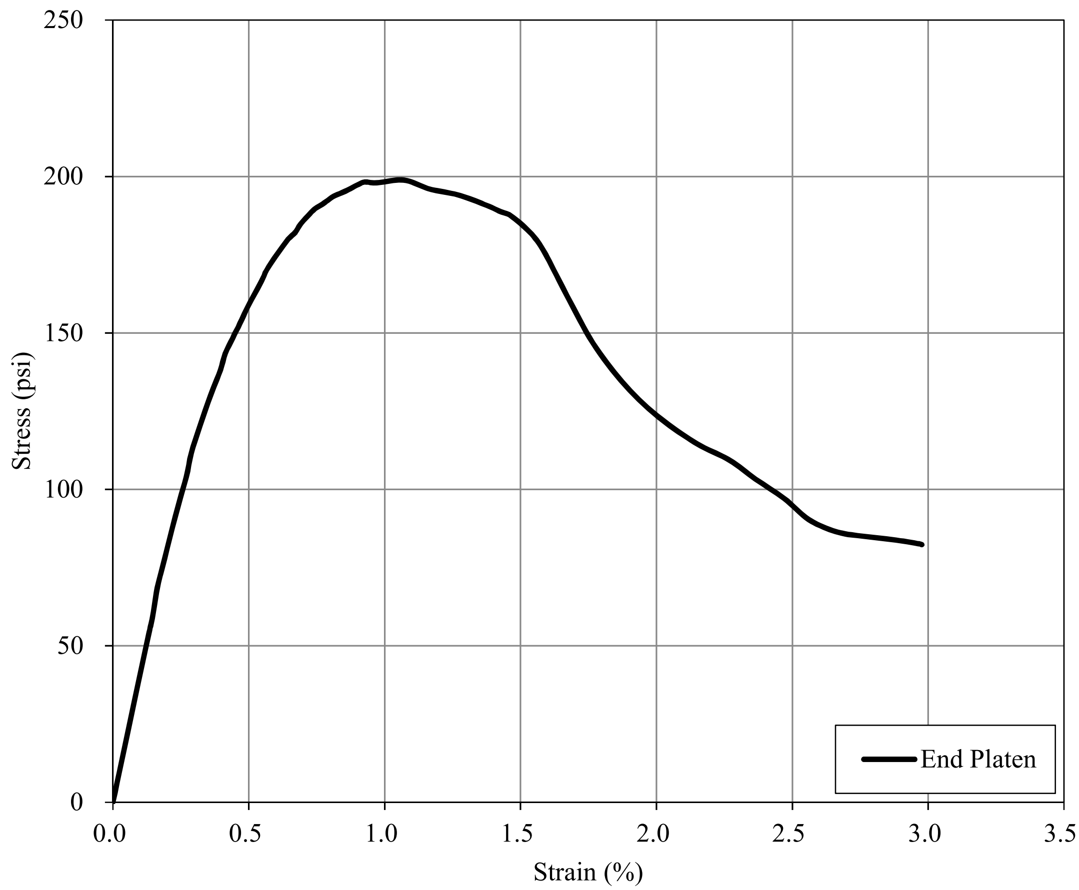
Specimen Information		
Height (initial):	3.942	in
Diameter (initial):	2.039	in
Weight:	365.8	g
Unit Weight:	108	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	198	psi
Secant Modulus E_{50EP}:	36,574	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.07	%



Batch S-4

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.95	in	Peak Stress:	198	psi
Tested by:	RNG	Diameter (initial):	2.036	in	Secant Modulus E_{50EP}:	39,001	psi
I.D. :	S-4-I	Weight:	366.0	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	108	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	3/1/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	125				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.4				End Platen Strain at failure, εf :	1.07	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

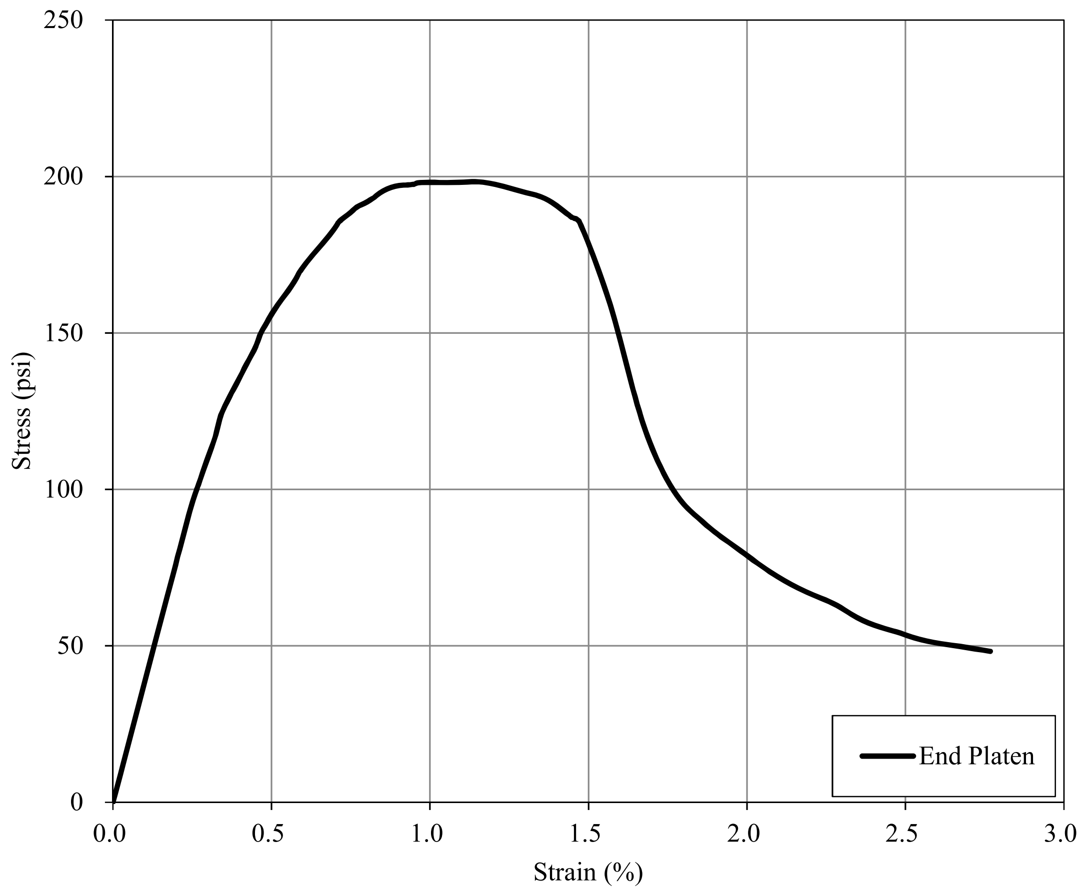


Batch S-4

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-4-J
Curing Period:	28 day
Test Date:	3/1/2017
$\alpha_{in\text{-}place}$:	125
$(w{:}c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

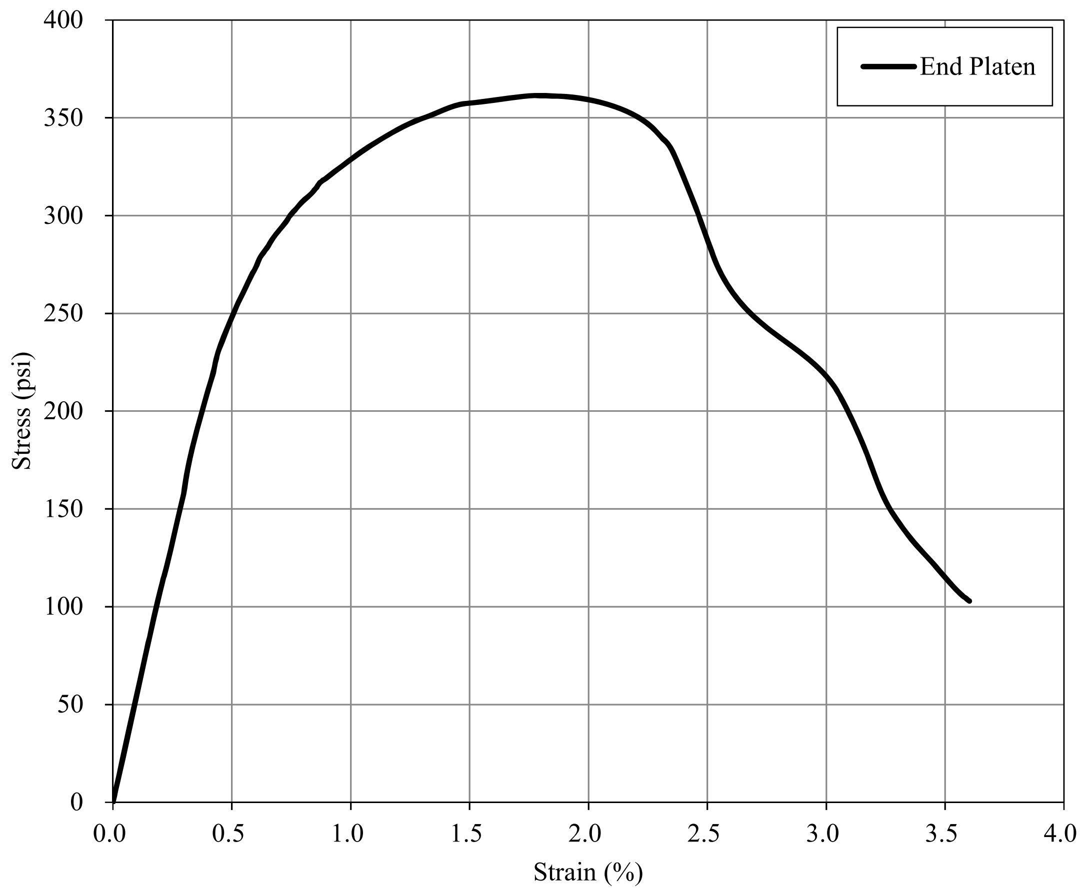
Specimen Information		
Height (initial):	3.947	in
Diameter (initial):	2.036	in
Weight:	366.8	g
Unit Weight:	109	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	197	psi
Secant Modulus E_{50EP}:	37,872	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.17	%



Batch S-5

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.935	in	Peak Stress:	359	psi
Tested by:	RNG	Diameter (initial):	2.037	in	Secant Modulus E_{50EP}:	54,147	psi
I.D. :	S-5-E	Weight:	359.6	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	107	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	3/2/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	200				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.4				End Platen Strain at failure, εf :	1.75	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

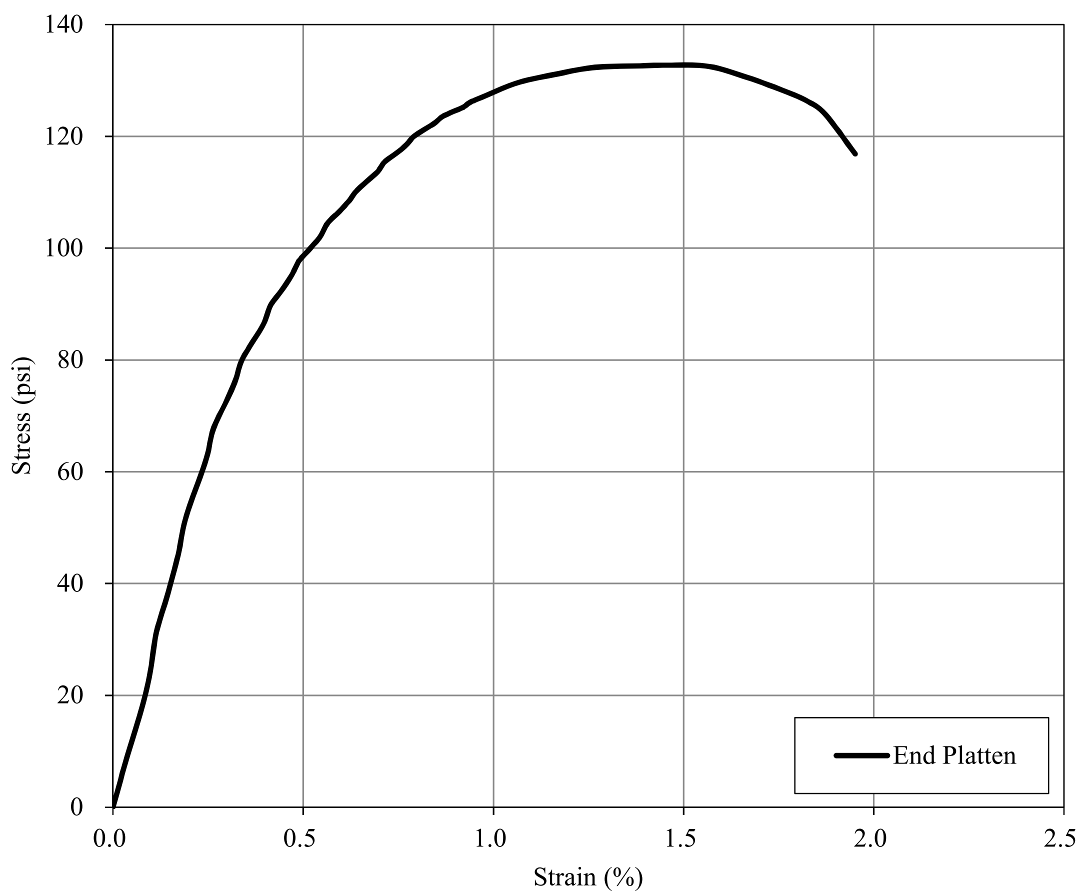


Batch S-5

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-5-F
Curing Period:	3 day
Test Date:	2/5/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.946	in
Diameter (initial):	2.035	in
Weight:	361.5	g
Unit Weight:	107	pcf
Gage Length:	N/A	in

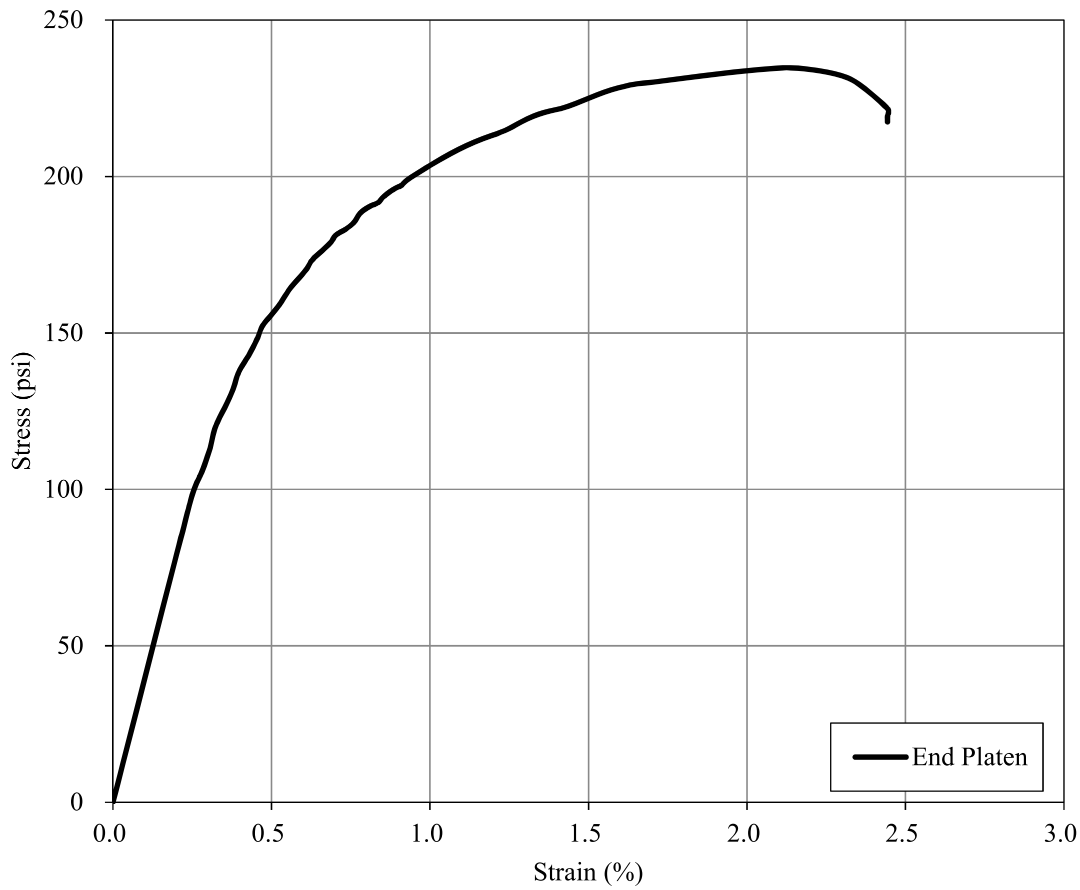
Test Summary		
Peak Stress:	132	psi
Secant Modulus E_{50EP}:	25,599	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.47	%



Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-5-A
Curing Period:	7 day
Test Date:	2/9/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.895	in
Diameter (initial):	2.036	in
Weight:	355.2	g
Unit Weight:	107	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	233	psi
Secant Modulus E_{50EP}:	37,092	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	2.14	%

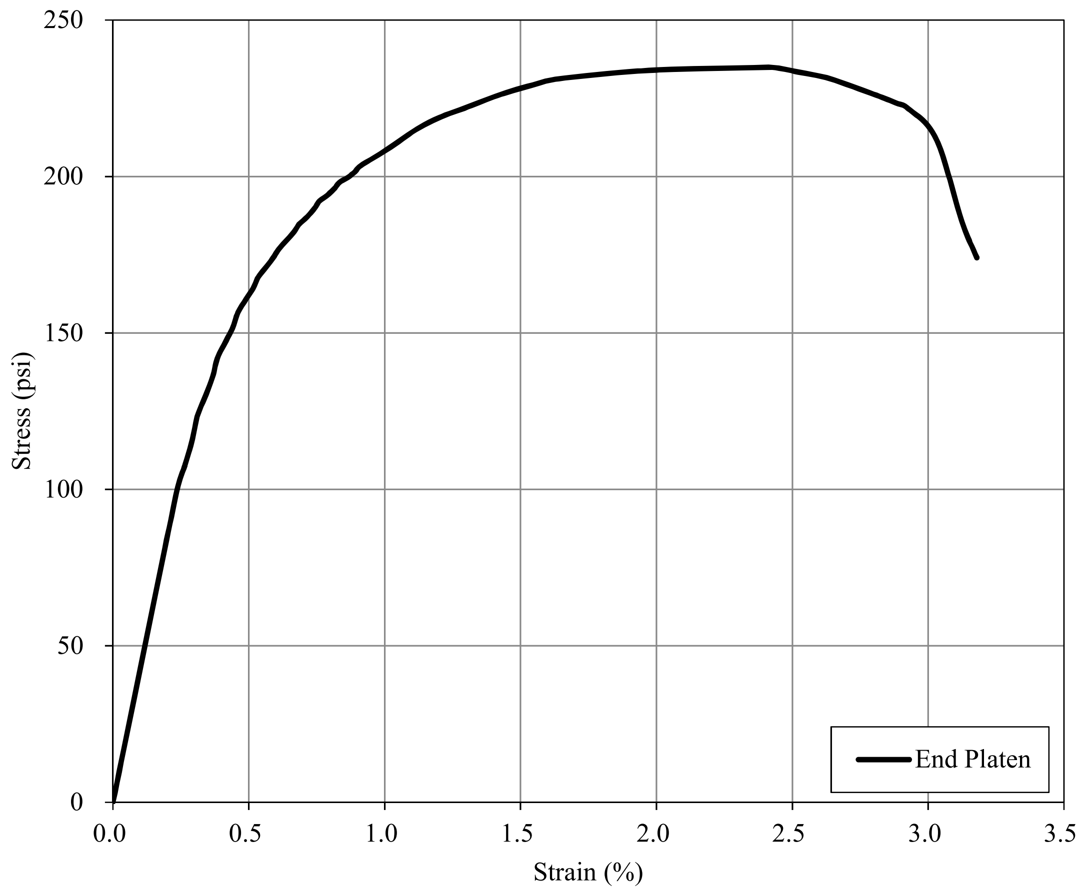


Batch S-5

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-5-B
Curing Period:	7 day
Test Date:	2/9/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.931	in
Diameter (initial):	2.037	in
Weight:	359.1	g
Unit Weight:	107	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	234	psi
Secant Modulus E_{50EP}:	39,735	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	2.43	%

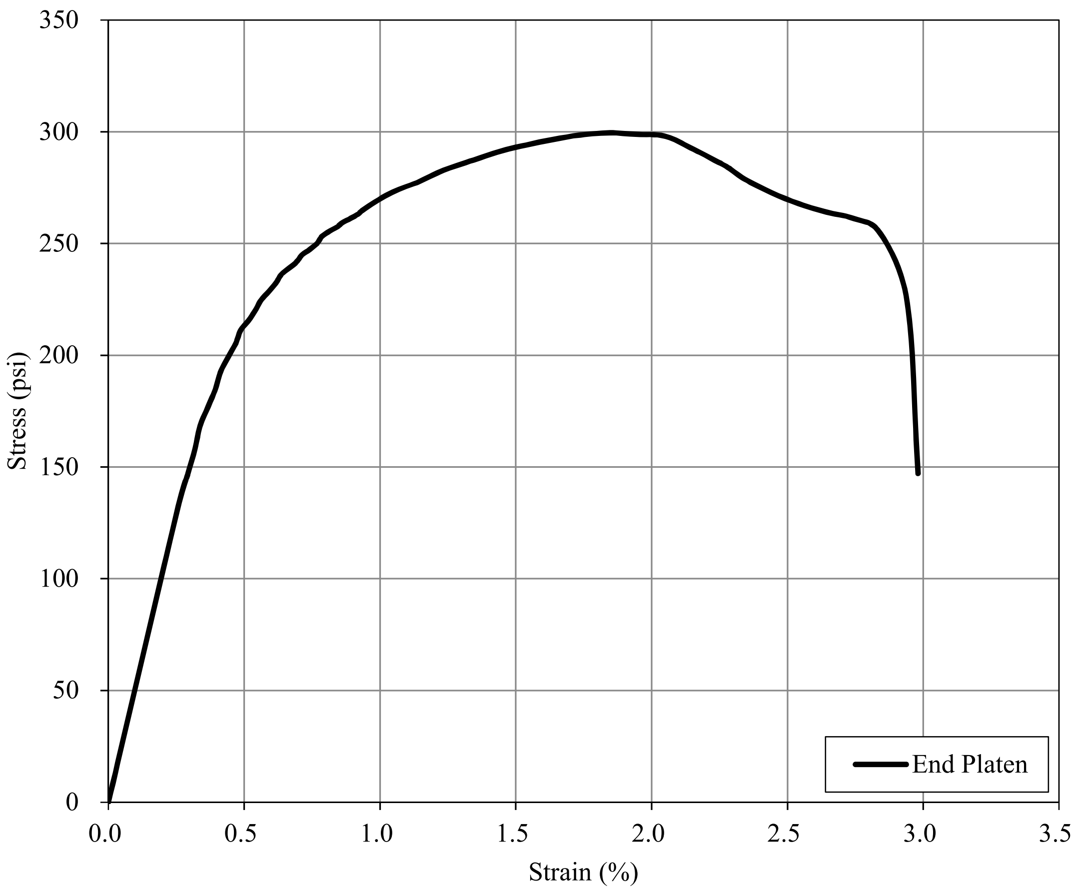


Batch S-5

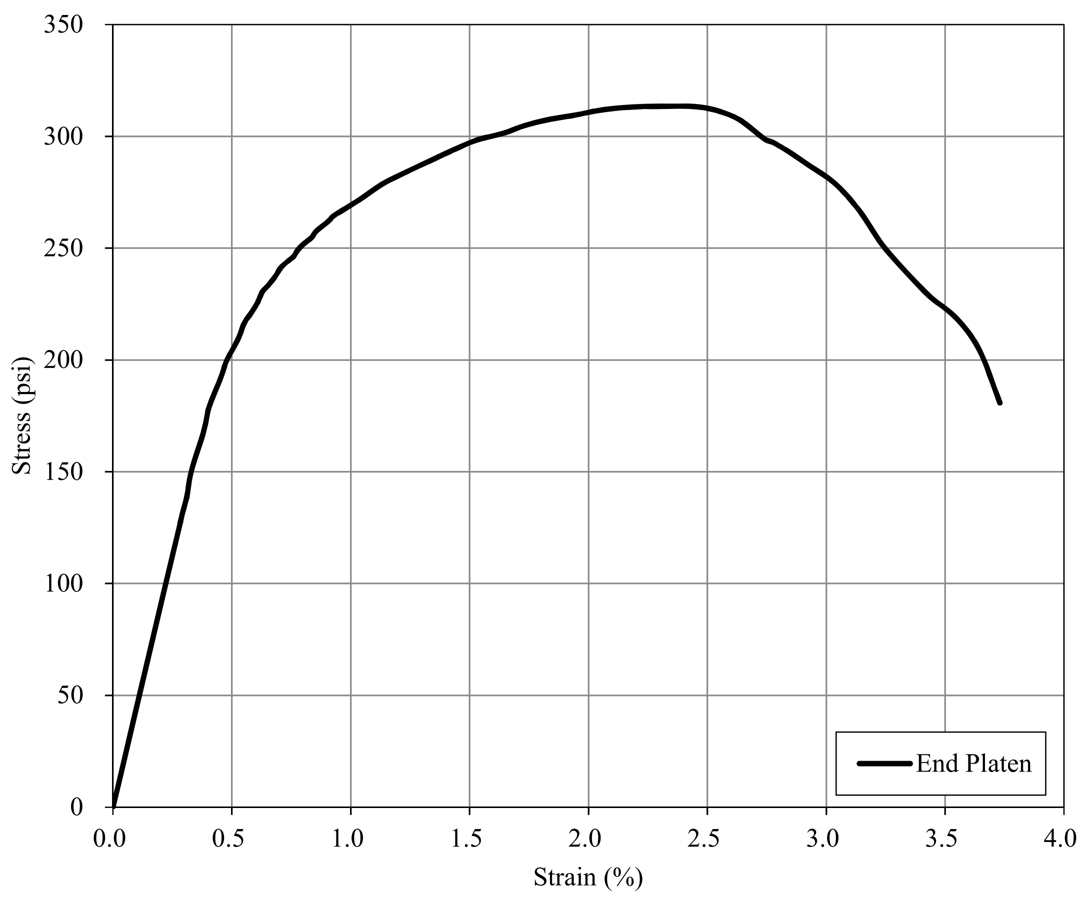
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-5-G
Curing Period:	14 day
Test Date:	2/16/2017
$\alpha_{in\text{-}place}$:	200
$(w{:}c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.949	in
Diameter (initial):	2.037	in
Weight:	360.1	g
Unit Weight:	107	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	298	psi
Secant Modulus E_{50EP}:	50,079	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.85	%

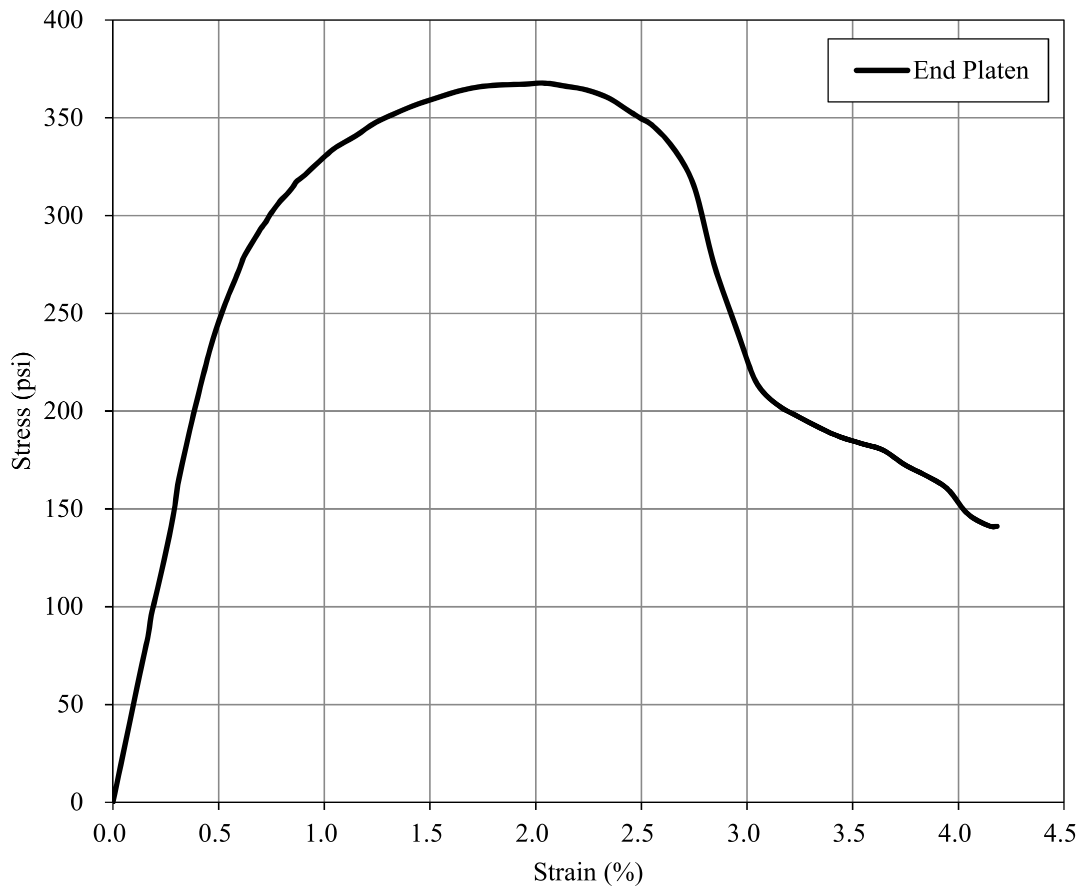


Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.944	in	Peak Stress:	312	psi
Tested by:	RNG	Diameter (initial):	2.037	in	Secant Modulus E_{50EP}:	45,025	psi
I.D. :	S-5-H	Weight:	359.6	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	14 day	Unit Weight:	107	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/16/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	200				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.4				End Platen Strain at failure, εf :	2.34	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



Batch S-5

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.943	in	Peak Stress:	366	psi
Tested by:	RNG						
I.D. :	S-5-C	Diameter (initial):	2.038	in	Secant Modulus E_{50EP}:	52,564	psi
Curing Period:	28 day						
Test Date:	3/2/2017	Weight:	359.8	g	Secant Modulus E_{50L}:	N/A	psi
$\alpha_{in\text{-}place}$:	200	Unit Weight:	107	pcf			
$(w:c)_{slurry}$:	1.4				Poisson's Ratio ν_{50} :	N/A	
End Treatment:	Grinding	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
Confining Pressure (psi):	N/A				Local Strain at failure, εf :	N/A	%
Strain Rate:	1 %/min				End Platen Strain at failure, εf :	2.04	%

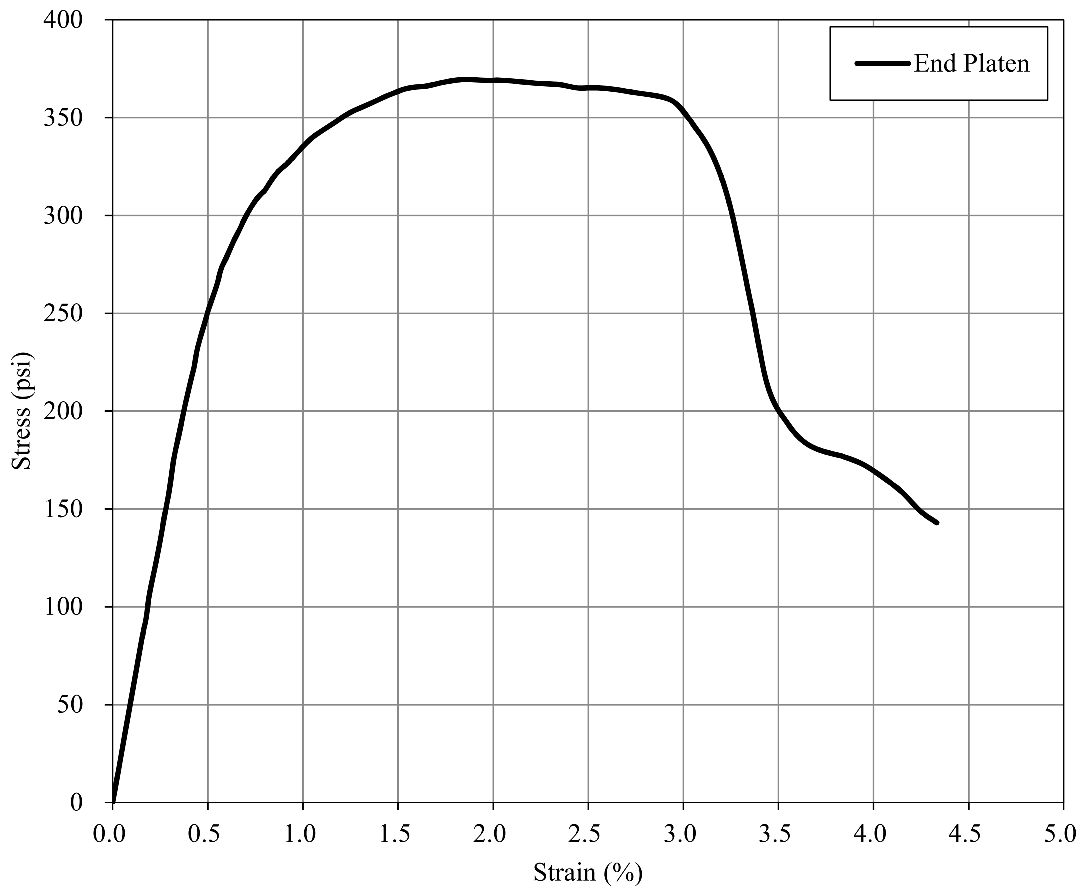


Batch S-5

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-5-D
Curing Period:	28 day
Test Date:	3/2/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

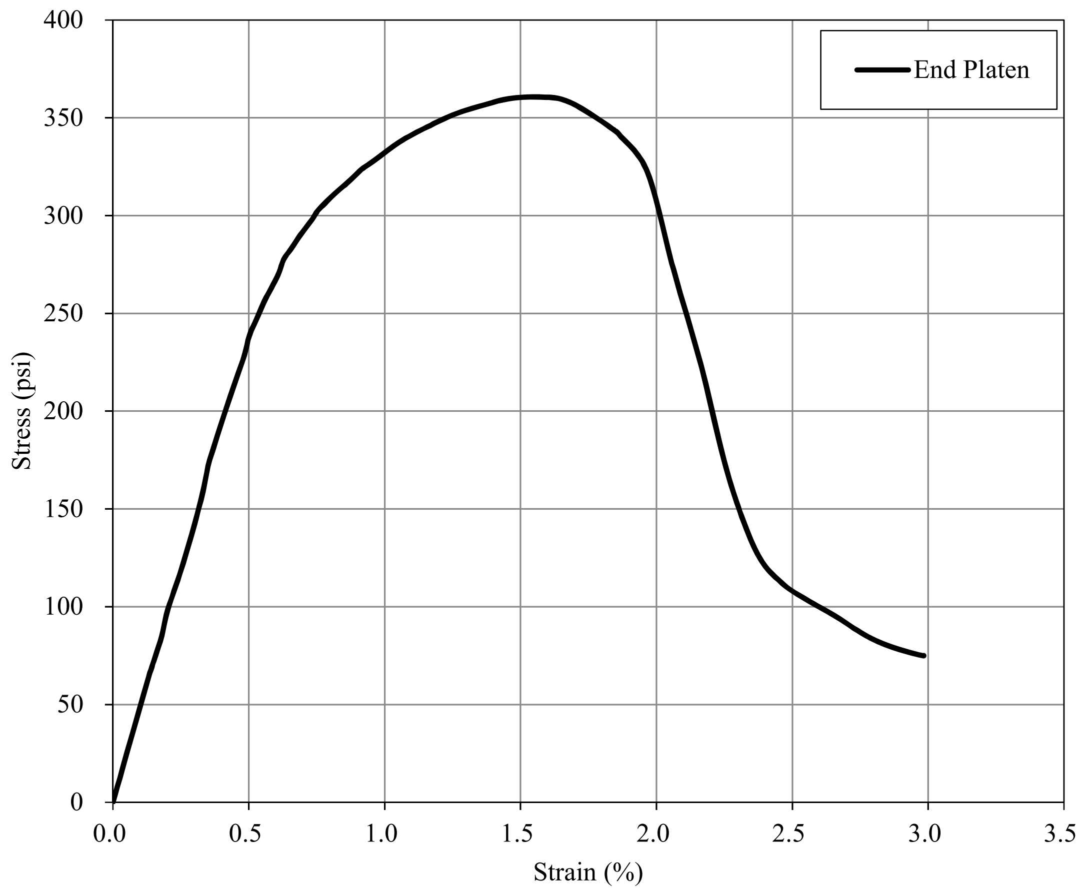
Specimen Information		
Height (initial):	3.938	in
Diameter (initial):	2.036	in
Weight:	359.0	g
Unit Weight:	107	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	368	psi
Secant Modulus E_{50EP}:	54,238	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.85	%



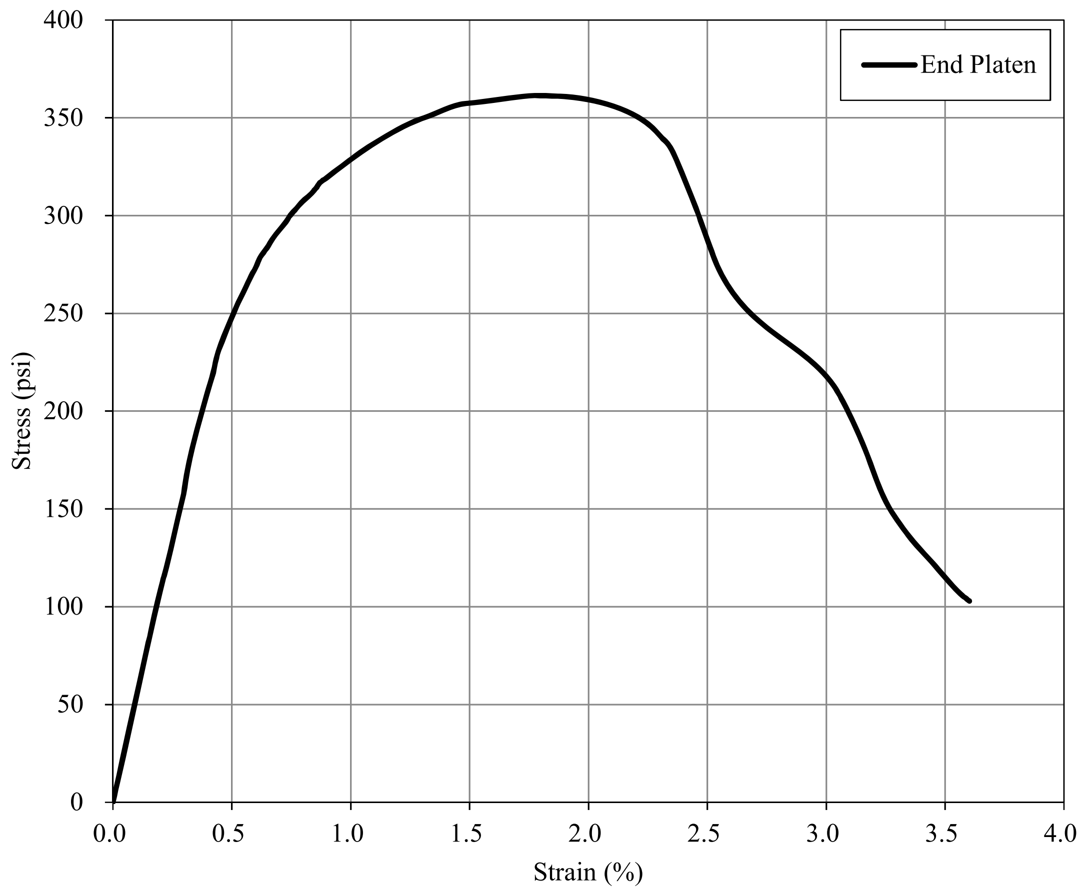
Batch S-5

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.932	in	Peak Stress:	359	psi
Tested by:	RNG	Diameter (initial):	2.038	in	Secant Modulus E_{50EP}:	48,902	psi
I.D. :	S-5-I	Weight:	359.4	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	107	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	3/2/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	200				Local Strain at failure, εf :	N/A	%
$(w{:}c)_{slurry}$:	1.4				End Platen Strain at failure, εf :	1.57	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



Batch S-5

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.935	in	Peak Stress:	359	psi
Tested by:	RNG	Diameter (initial):	2.037	in	Secant Modulus E_{50EP}:	54,147	psi
I.D. :	S-5-J	Weight:	359.6	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	107	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	3/2/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	200				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.4				End Platen Strain at failure, εf :	1.75	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

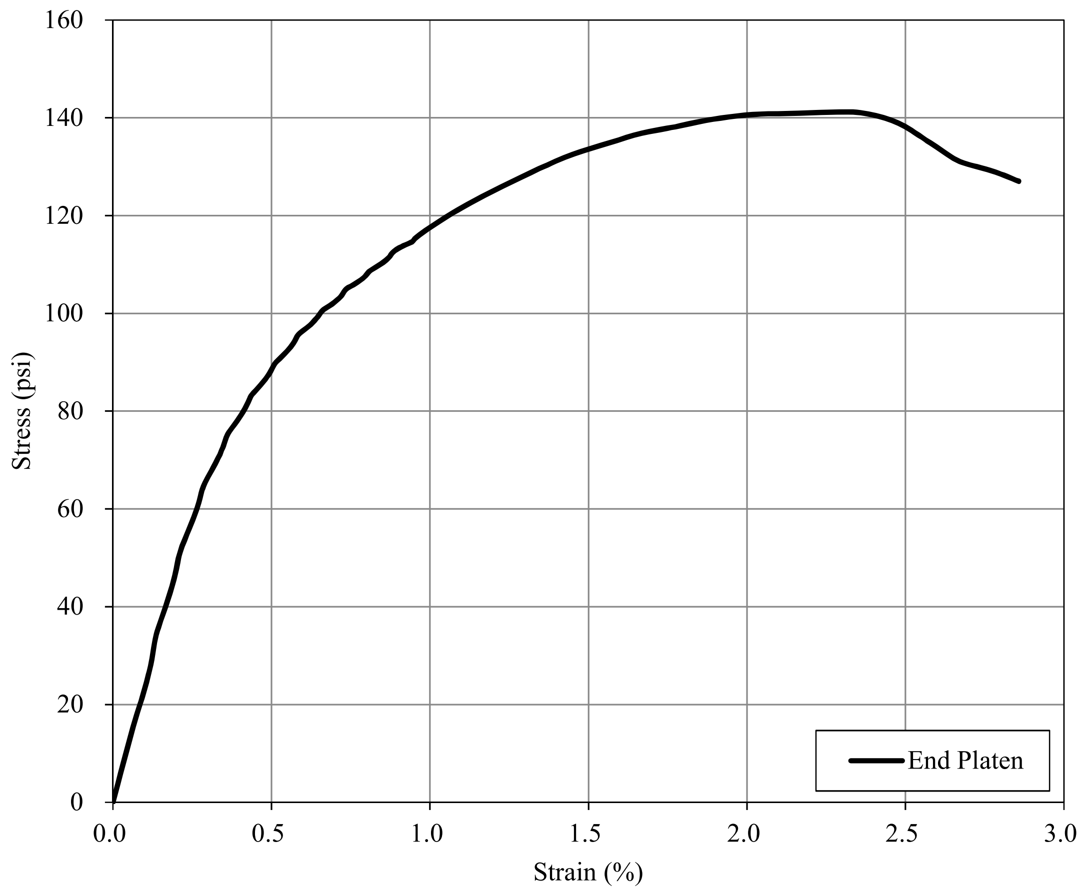


Batch S-6

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-6-E
Curing Period:	3 day
Test Date:	2/5/2017
$\alpha_{in-place}$:	275
$(w:c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.905	in
Diameter (initial):	2.036	in
Weight:	342.5	g
Unit Weight:	103	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	140	psi
Secant Modulus E_{50EP}:	21,247	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	2.28	%

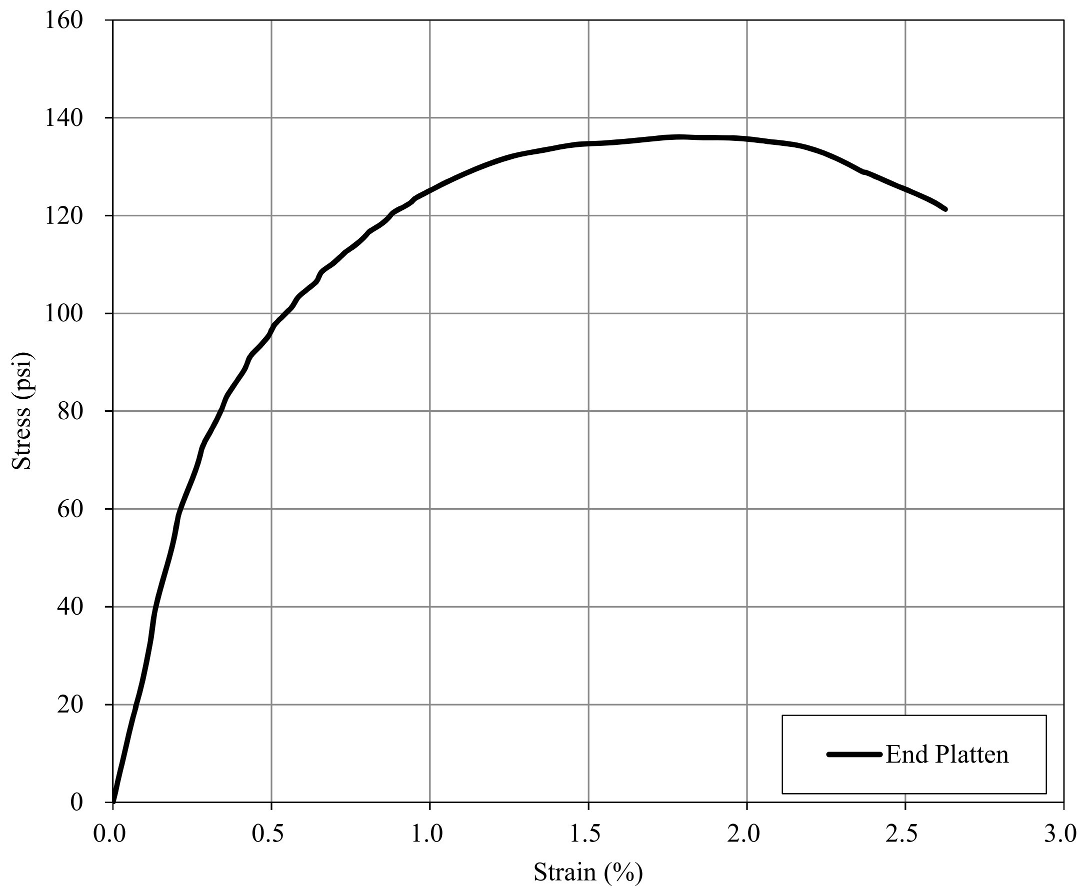


Batch S-6

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-6-F
Curing Period:	3 day
Test Date:	2/5/2017
$\alpha_{in\text{-}place}$:	275
$(w:c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.942	in
Diameter (initial):	2.037	in
Weight:	346.9	g
Unit Weight:	103	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	135	psi
Secant Modulus E_{50EP}:	26,101	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.76	%

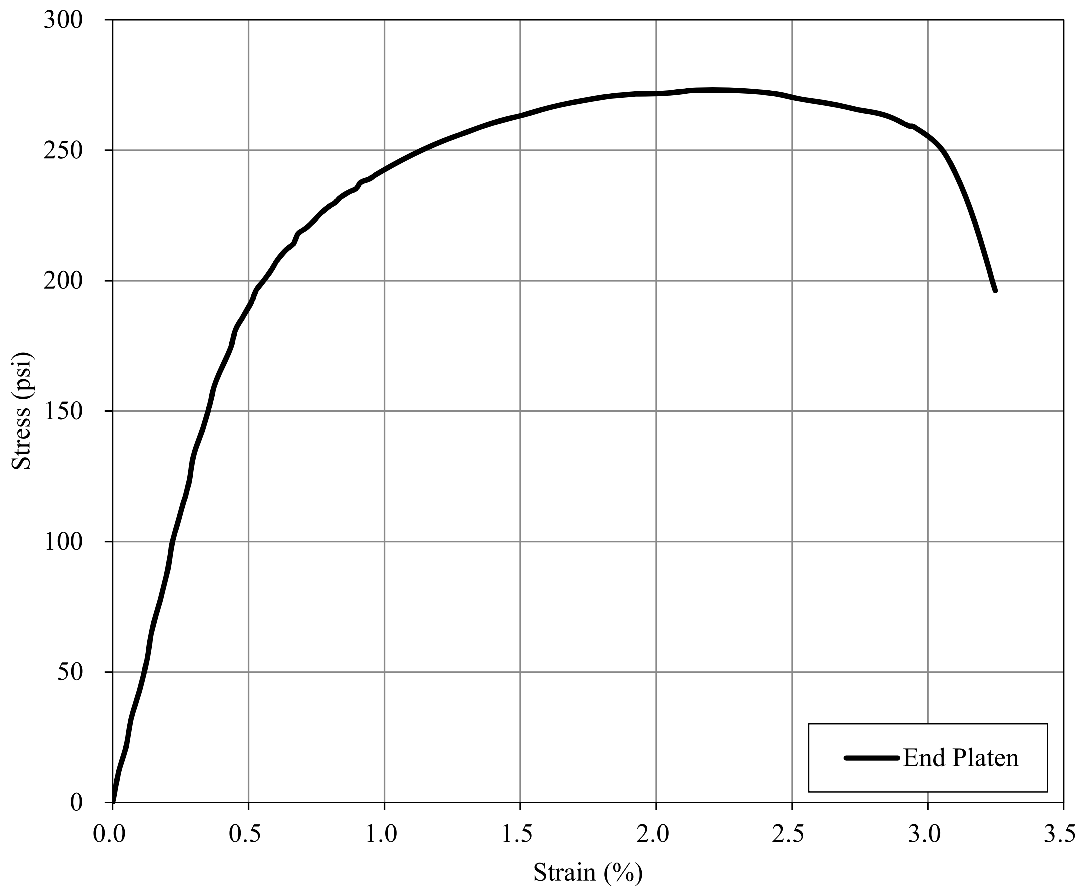


Batch S-6

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-6-A
Curing Period:	7 day
Test Date:	2/9/2017
$\alpha_{in\text{-}place}$:	275
$(w:c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.898	in
Diameter (initial):	2.036	in
Weight:	341.4	g
Unit Weight:	102	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	271	psi
Secant Modulus E_{50EP}:	44,173	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	2.23	%

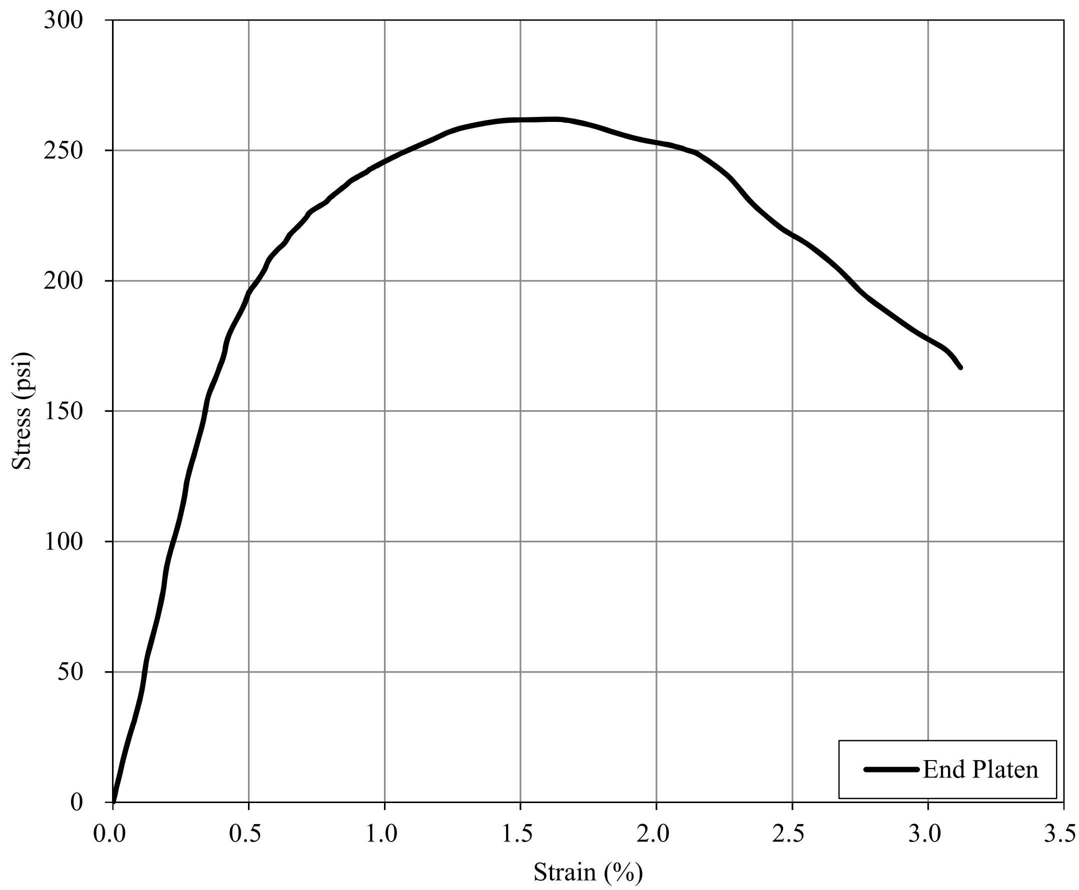


Batch S-6

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-6-B
Curing Period:	7 day
Test Date:	2/9/2017
$\alpha_{in\text{-}place}$:	275
$(w:c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

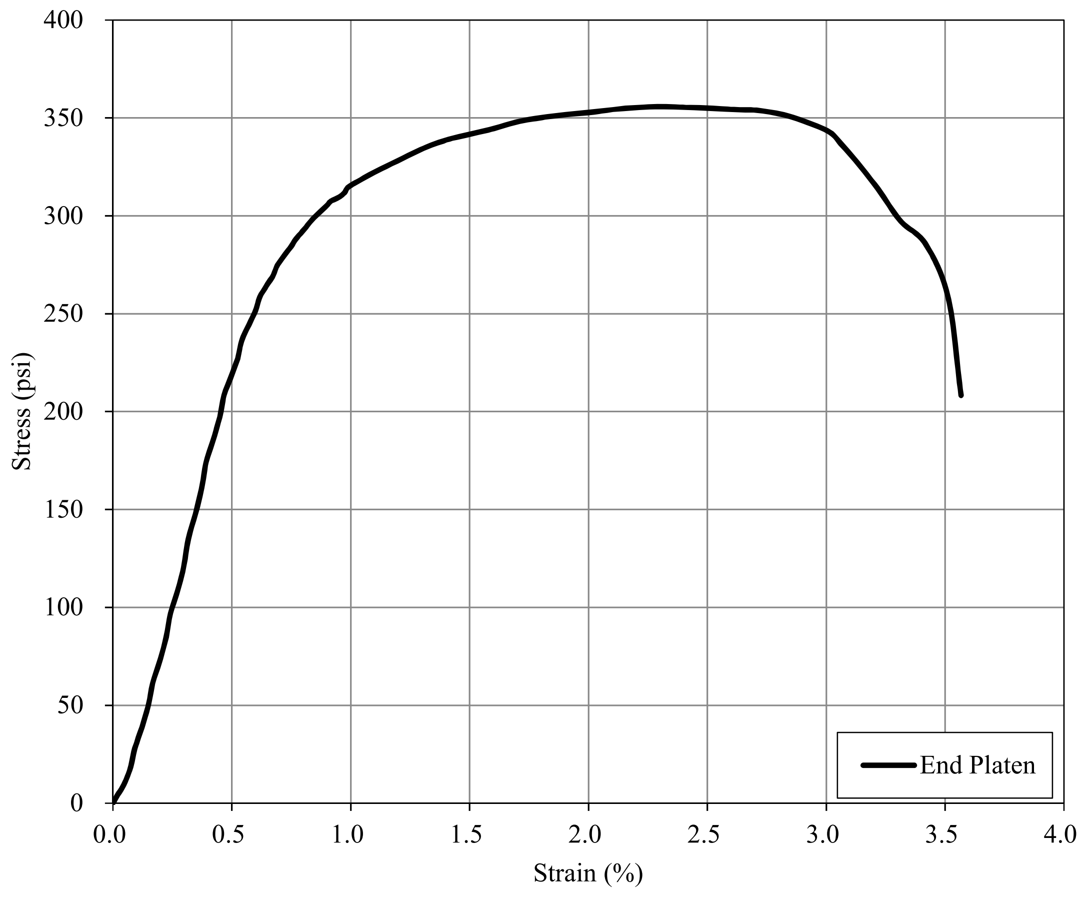
Specimen Information		
Height (initial):	3.9	in
Diameter (initial):	2.039	in
Weight:	343.1	g
Unit Weight:	103	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	260	psi
Secant Modulus E_{50EP}:	44,777	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.65	%



Batch S-6

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.884	in	Peak Stress:	353	psi
Tested by:	RNG	Diameter (initial):	2.037	in	Secant Modulus E_{50EP}:	44,291	psi
I.D. :	S-6-G	Weight:	339.3	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	14 day	Unit Weight:	102	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/16/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.4				End Platen Strain at failure, εf :	2.30	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

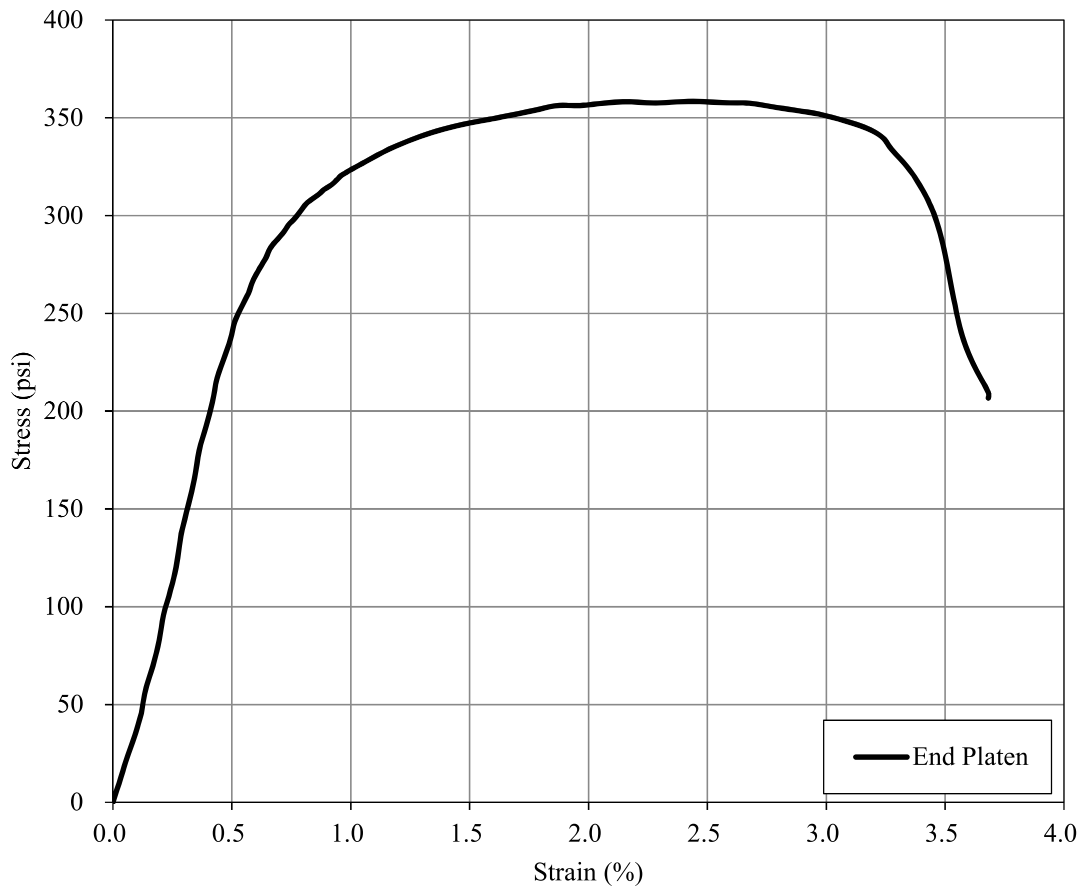


Batch S-6

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-6-H
Curing Period:	14 day
Test Date:	2/16/2017
$\alpha_{in\text{-}place}$:	275
$(w:c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.905	in
Diameter (initial):	2.038	in
Weight:	341.2	g
Unit Weight:	102	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	356	psi
Secant Modulus E_{50EP}:	49,589	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	2.47	%

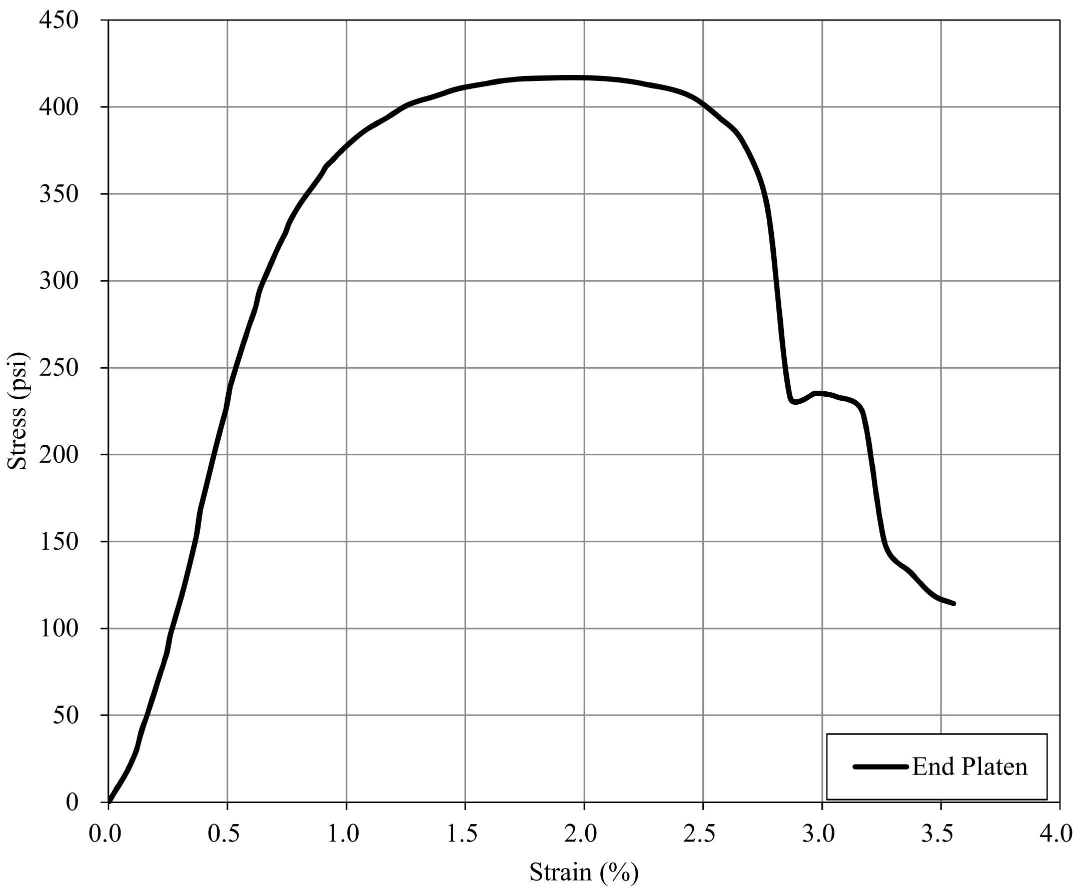


Batch S-6

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-6-C
Curing Period:	28 day
Test Date:	3/2/2017
$\alpha_{in\text{-}place}$:	275
$(w:c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.912	in
Diameter (initial):	2.037	in
Weight:	342.4	g
Unit Weight:	102	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	414	psi
Secant Modulus E_{50EP}:	45,419	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.97	%

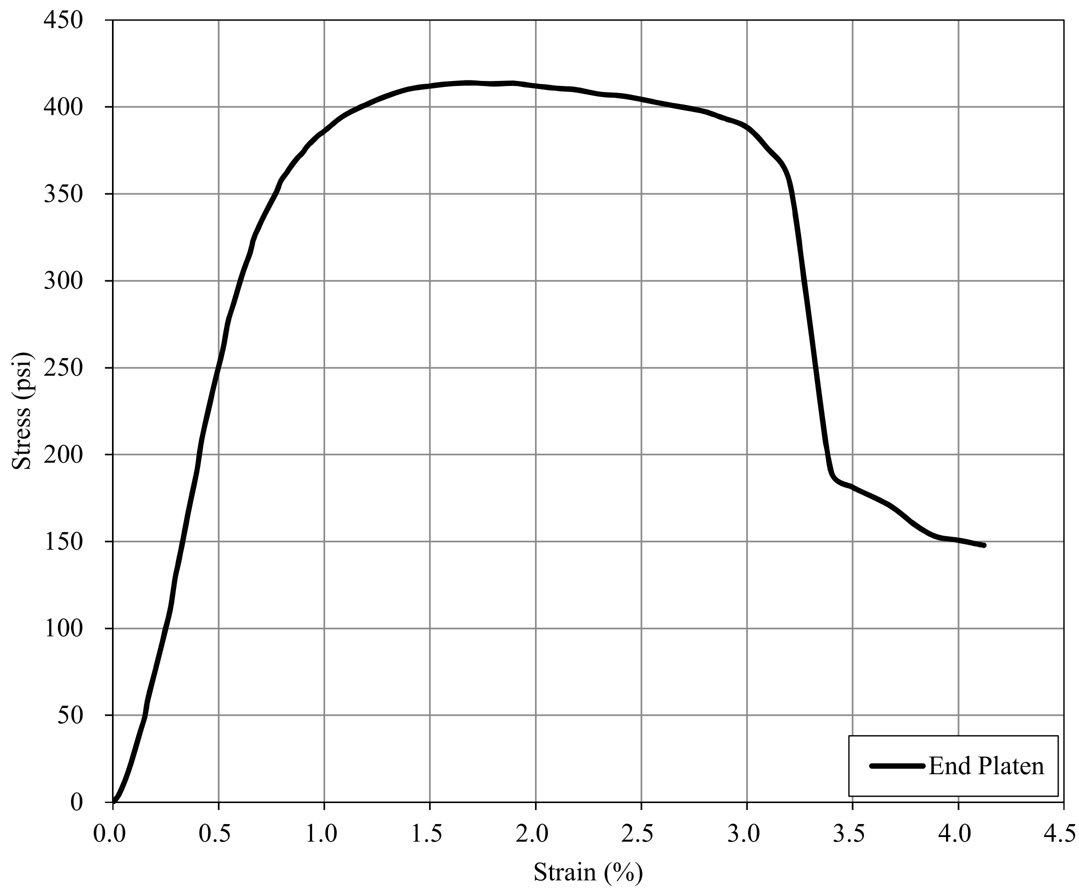


Batch S-6

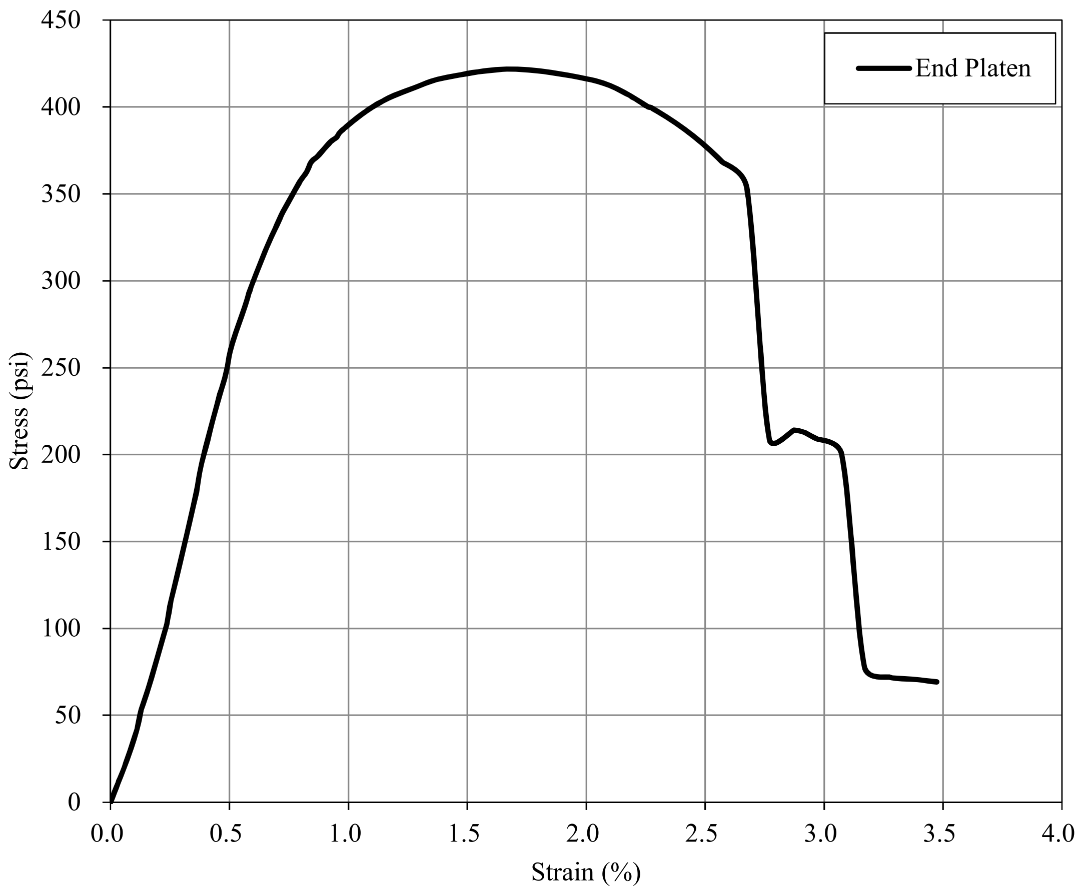
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-6-D
Curing Period:	28 day
Test Date:	3/2/2017
$\alpha_{in\text{-}place}$:	275
$(w:c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.914	in
Diameter (initial):	2.038	in
Weight:	343.3	g
Unit Weight:	102	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	411	psi
Secant Modulus E_{50EP}:	49,615	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.69	%



Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.883	in	Peak Stress:	419	psi
Tested by:	RNG	Diameter (initial):	2.036	in	Secant Modulus E_{50EP}:	51,036	psi
I.D. :	S-6-I	Weight:	340.8	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	103	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	3/2/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.4				End Platen Strain at failure, εf :	1.67	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

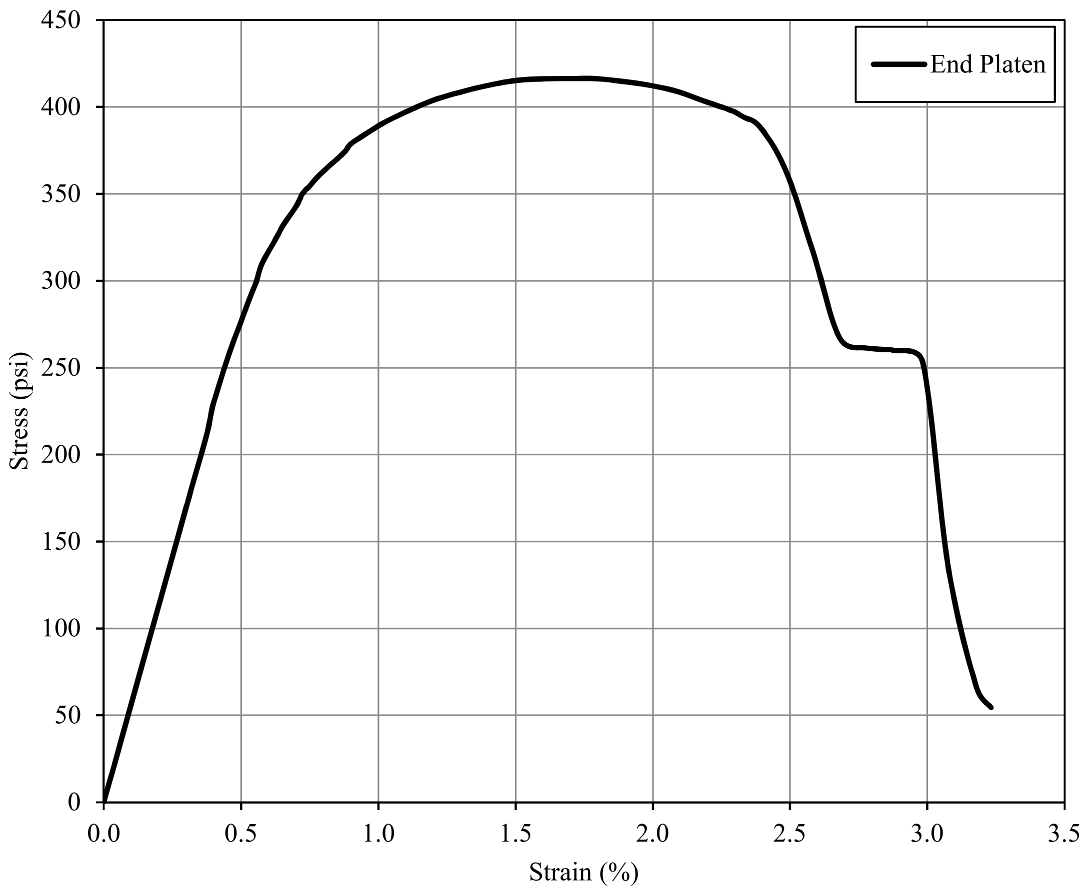


Batch S-6

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-6-J
Curing Period:	28 day
Test Date:	3/2/2017
$\alpha_{in\text{-}place}$:	275
$(w{:}c)_{slurry}$:	1.4
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.894	in
Diameter (initial):	2.036	in
Weight:	337.8	g
Unit Weight:	102	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	413	psi
Secant Modulus E_{50EP}:	45,345	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.78	%

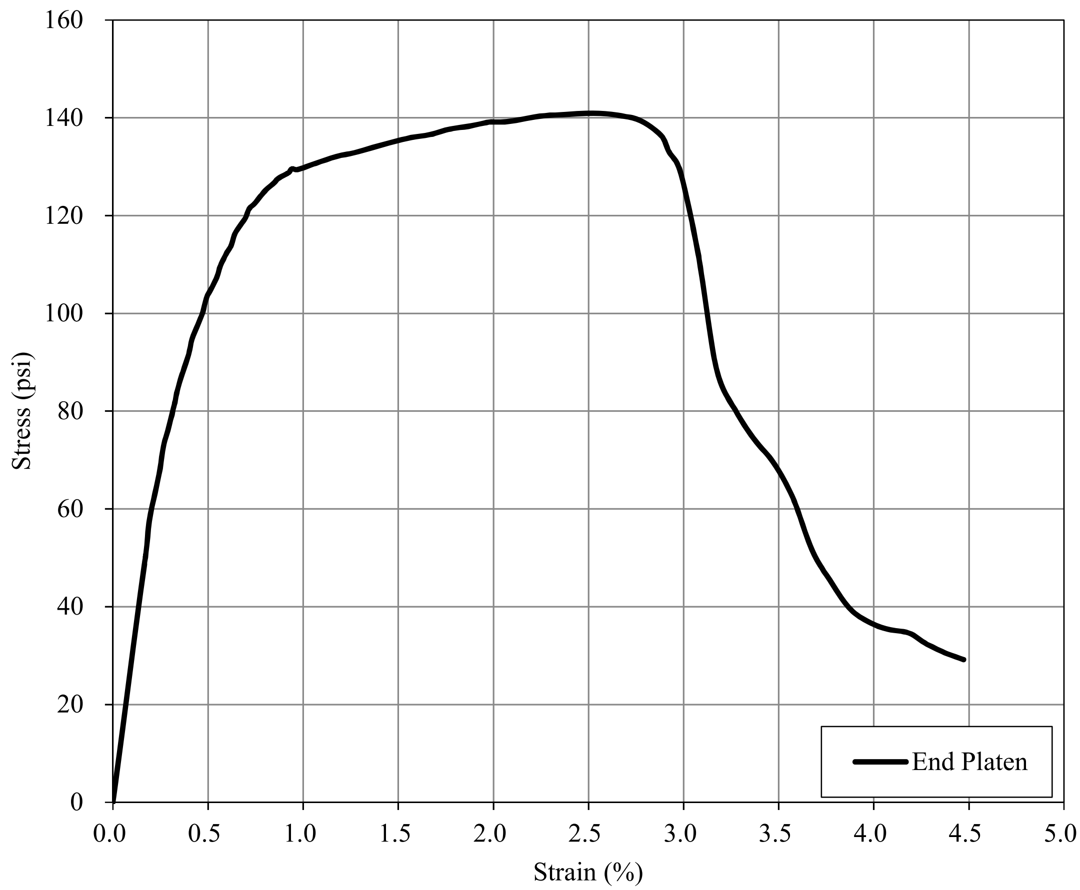


Batch S-7

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-7-A
Curing Period:	7 day
Test Date:	5/22/2017
$\alpha_{in\text{-}place}$:	125
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.935	in
Diameter (initial):	2.036	in
Weight:	371.6	g
Unit Weight:	111	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	140	psi
Secant Modulus E_{50EP}:	27,510	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	2.47	%

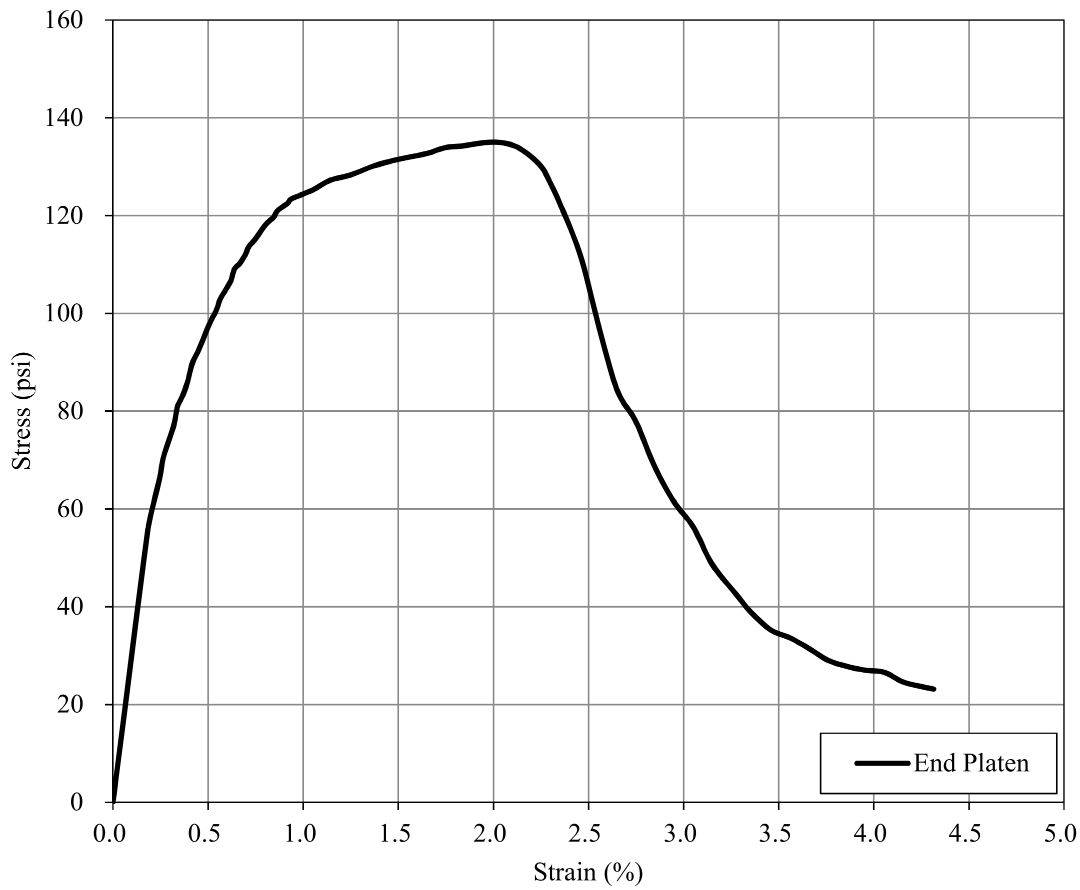


Batch S-7

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-7-D
Curing Period:	7 day
Test Date:	5/22/2017
$\alpha_{in\text{-}place}$:	125
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

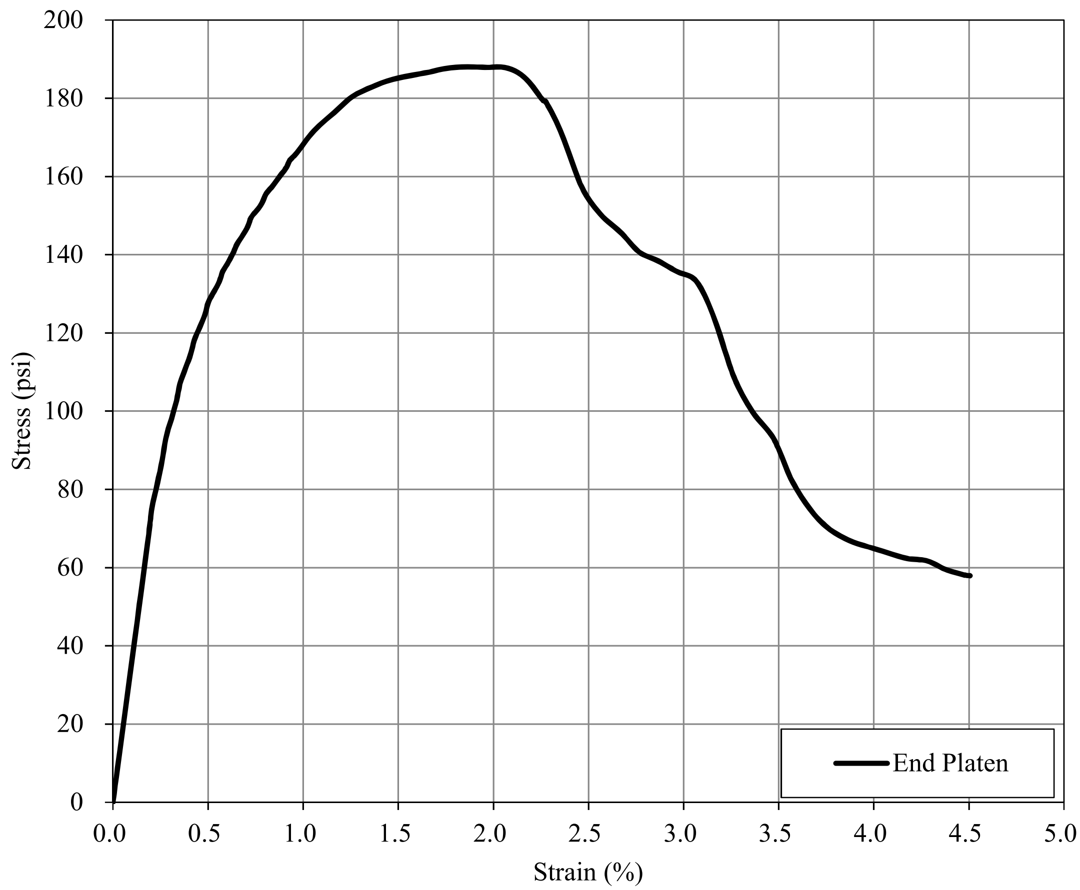
Specimen Information		
Height (initial):	3.925	in
Diameter (initial):	2.037	in
Weight:	370.3	g
Unit Weight:	110	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	134	psi
Secant Modulus E_{50EP}:	26,944	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.95	%

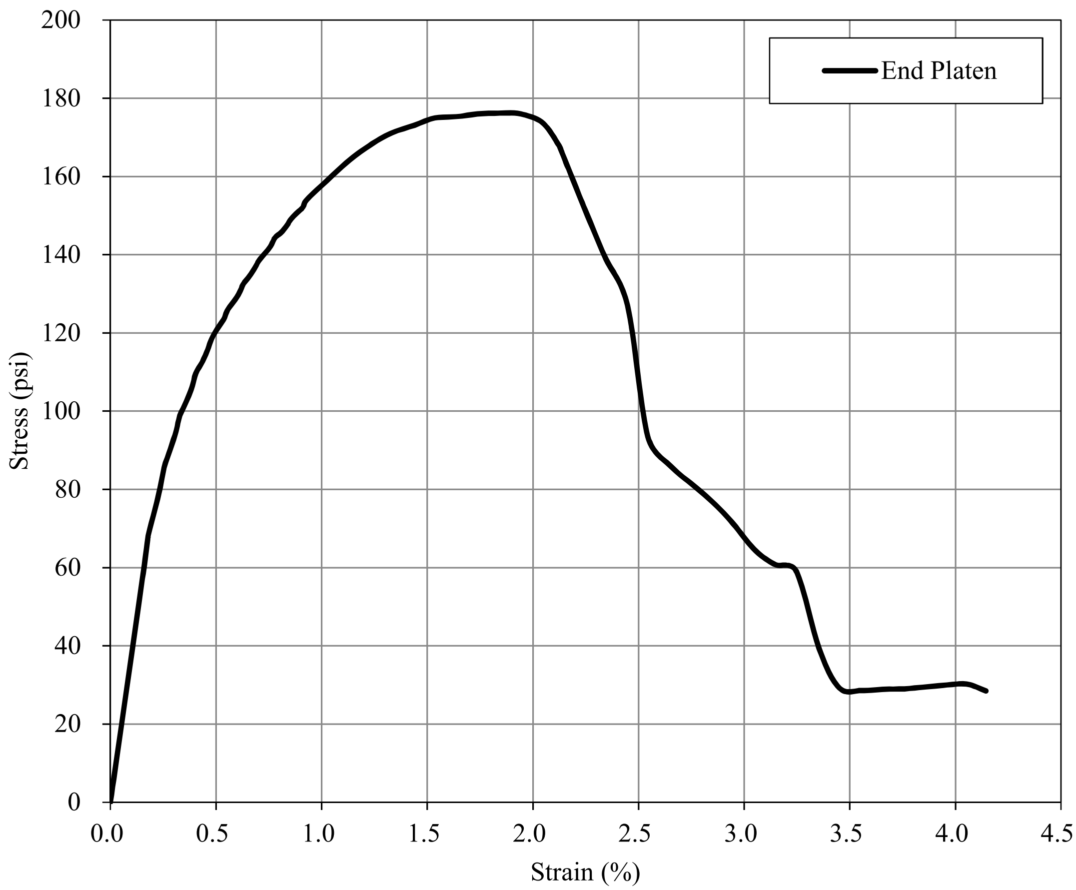


Batch S-7

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.960	in	Peak Stress:	187	psi
Tested by:	RNG	Diameter (initial):	2.036	in	Secant Modulus E_{50EP}:	33,179	psi
I.D. :	S-7-B	Weight:	373.4	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	14 day	Unit Weight:	110	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	5/29/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	125				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.86	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.949	in	Peak Stress:	175	psi
Tested by:	RNG						
I.D. :	S-7-E	Diameter (initial):	2.036	in	Secant Modulus E_{50EP}:	32,675	psi
Curing Period:	14 day						
Test Date:	5/29/2017	Weight:	370.9	g	Secant Modulus E_{50L}:	N/A	psi
$\alpha_{in\text{-}place}$:	125	Unit Weight:	110	pcf			
$(w:c)_{slurry}$:	1.0				Poisson's Ratio ν_{50} :	N/A	
End Treatment:	Grinding	Gage Length:	N/A	in			
Confining Pressure (psi):	N/A				Poisson's Ratio ν_f :	N/A	
Strain Rate:	1 %/min				Local Strain at failure, εf :	N/A	%
					End Platen Strain at failure, εf :	1.84	%

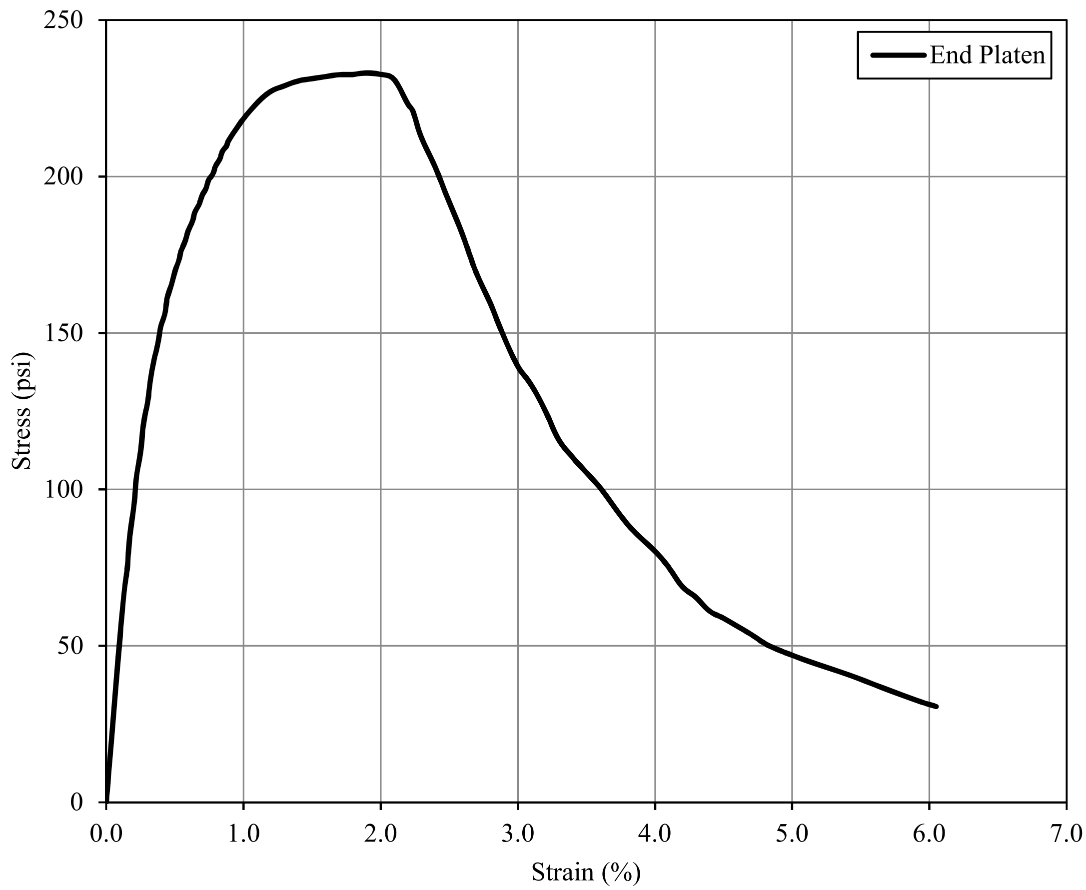


Batch S-7

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-7-C
Curing Period:	28 day
Test Date:	6/12/2017
$\alpha_{in\text{-}place}$:	125
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.95	in
Diameter (initial):	2.035	in
Weight:	371.8	g
Unit Weight:	110	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	233	psi
Secant Modulus E_{50EP}:	44,683	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.90	%

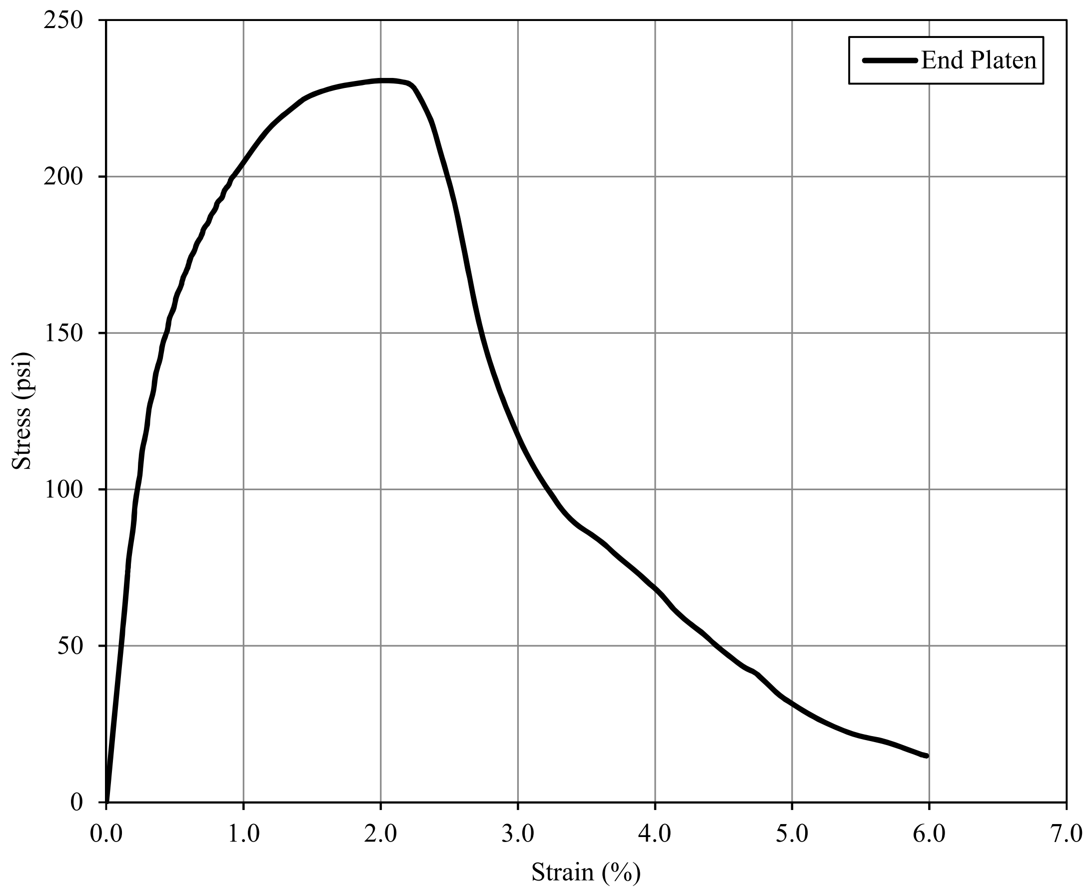


Batch S-7

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-7-F
Curing Period:	28 day
Test Date:	6/12/2017
$\alpha_{in\text{-}place}$:	125
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

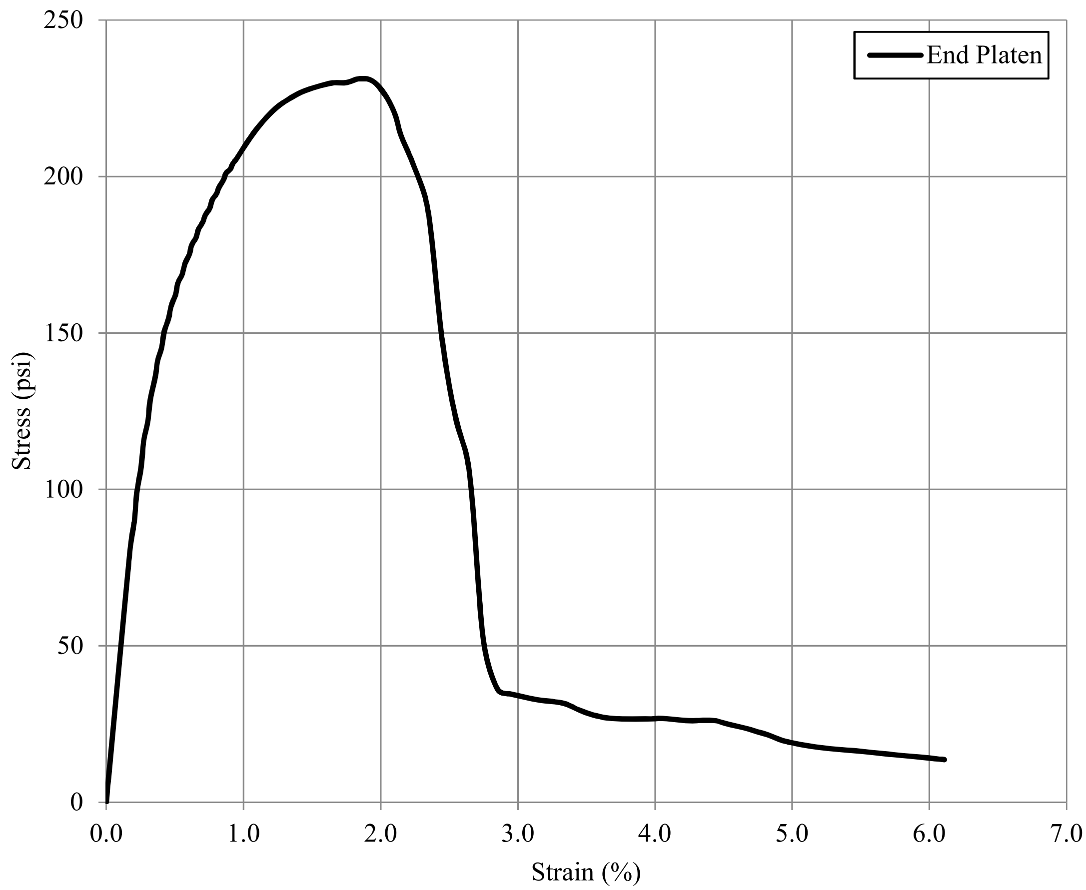
Specimen Information		
Height (initial):	3.94	in
Diameter (initial):	2.037	in
Weight:	369.6	g
Unit Weight:	110	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	231	psi
Secant Modulus E_{50EP}:	41,784	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	2.04	%



Batch S-7

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.97	in	Peak Stress:	231	psi
Tested by:	RNG	Diameter (initial):	2.037	in	Secant Modulus E_{50EP}:	42,215	psi
I.D. :	S-7-G	Weight:	373.6	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	110	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	6/12/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	125				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.85	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

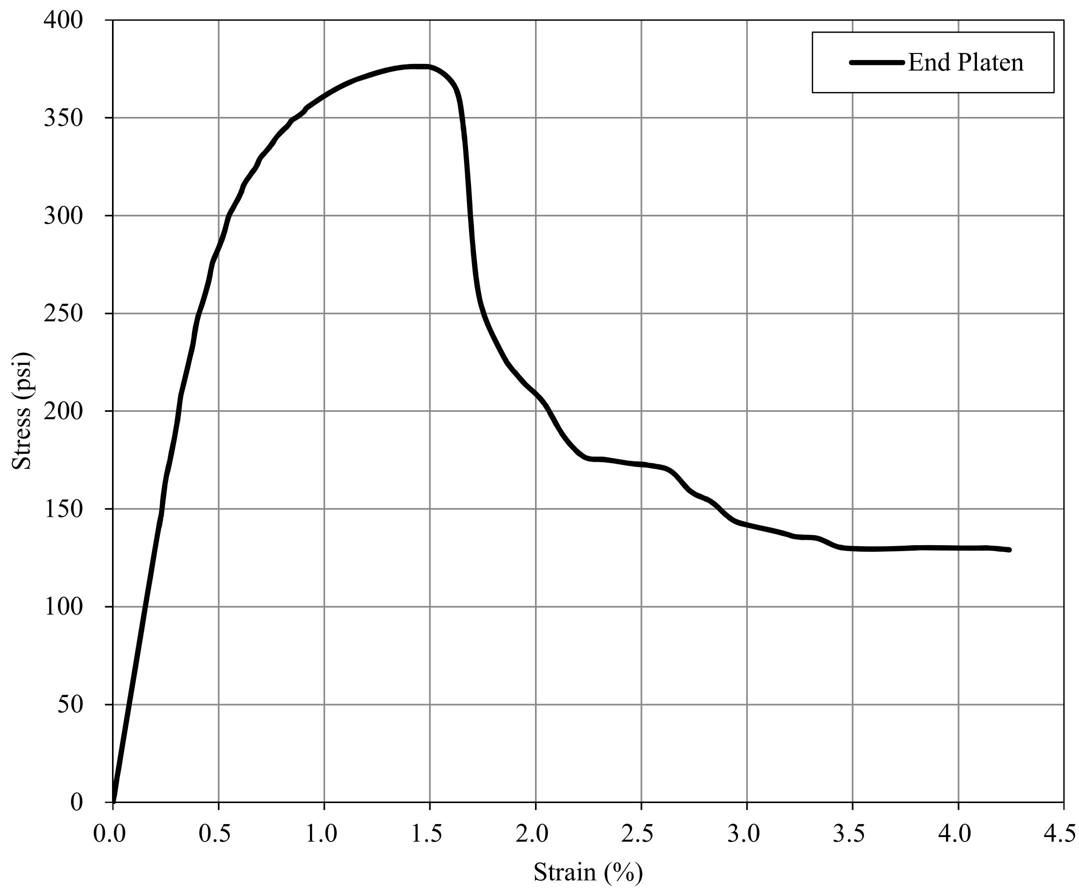


Batch S-8

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-8-A
Curing Period:	7 day
Test Date:	5/23/2017
$\alpha_{in\text{-}place}$:	275
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

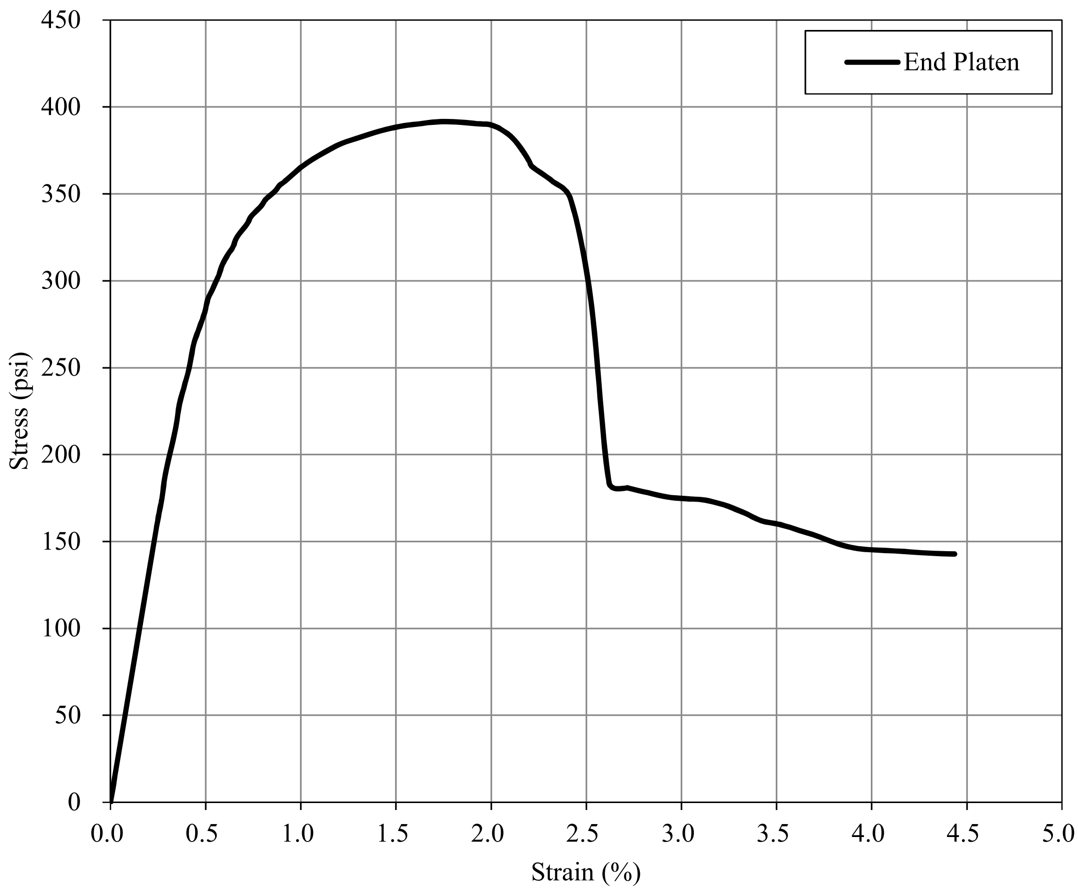
Specimen Information		
Height (initial):	3.943	in
Diameter (initial):	2.036	in
Weight:	363.7	g
Unit Weight:	108	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	374	psi
Secant Modulus E_{50EP}:	64,189	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.43	%

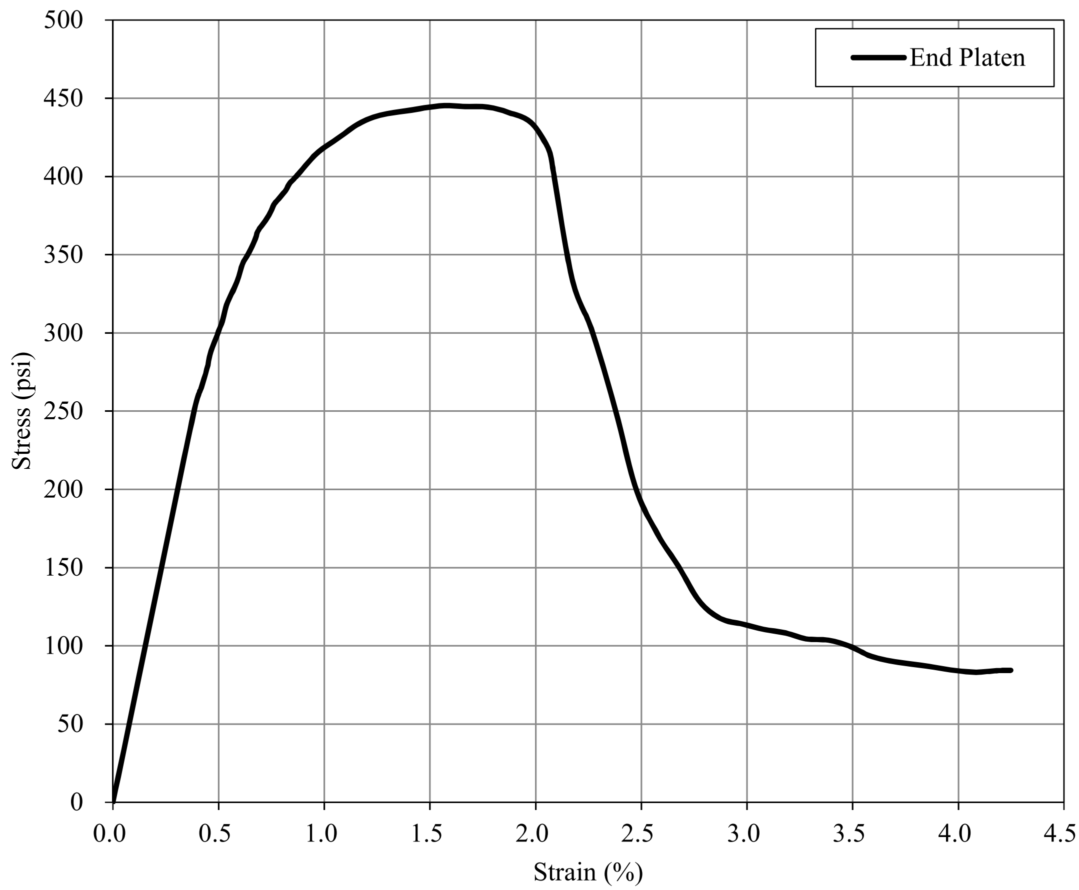


Batch S-8

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.919	in	Peak Stress:	389	psi
Tested by:	RNG						
I.D. :	S-8-D	Diameter (initial):	2.036	in	Secant Modulus E_{50EP}:	64,735	psi
Curing Period:	7 day						
Test Date:	5/23/2017	Weight:	360.6	g	Secant Modulus E_{50L}:	N/A	psi
$\alpha_{in\text{-}place}$:	275	Unit Weight:	108	pcf			
$(w:c)_{slurry}$:	1.0				Poisson's Ratio ν_{50} :	N/A	
End Treatment:	Grinding	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
Confining Pressure (psi):	N/A				Local Strain at failure, εf :	N/A	%
Strain Rate:	1 %/min				End Platen Strain at failure, εf :	1.71	%



Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.914	in	Peak Stress:	443	psi
Tested by:	RNG	Diameter (initial):	2.036	in	Secant Modulus E_{50EP}:	65,196	psi
I.D. :	S-8-B	Weight:	360.7	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	4 day	Unit Weight:	108	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	5/30/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.57	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

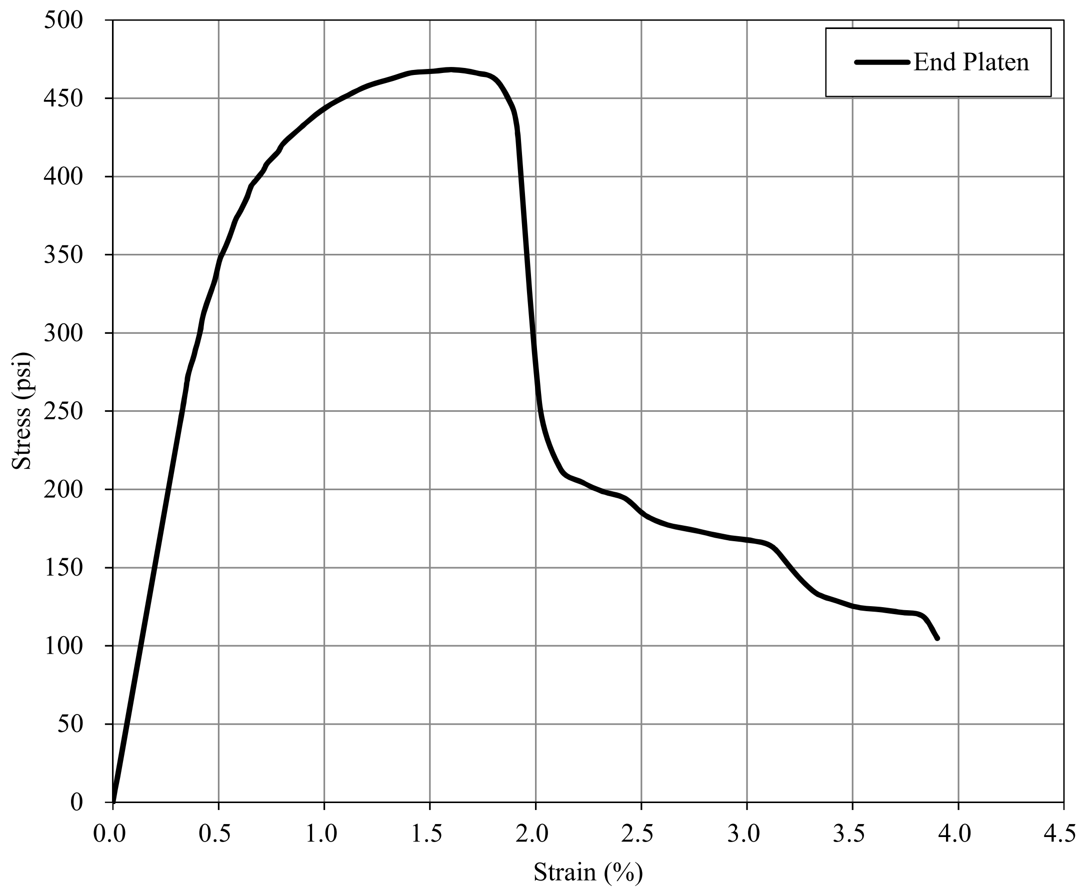


Batch S-8

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-8-E
Curing Period:	14 day
Test Date:	5/30/2017
$\alpha_{in\text{-}place}$:	275
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.952	in
Diameter (initial):	2.036	in
Weight:	365.0	g
Unit Weight:	108	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	466	psi
Secant Modulus E_{50EP}:	76,341	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.61	%

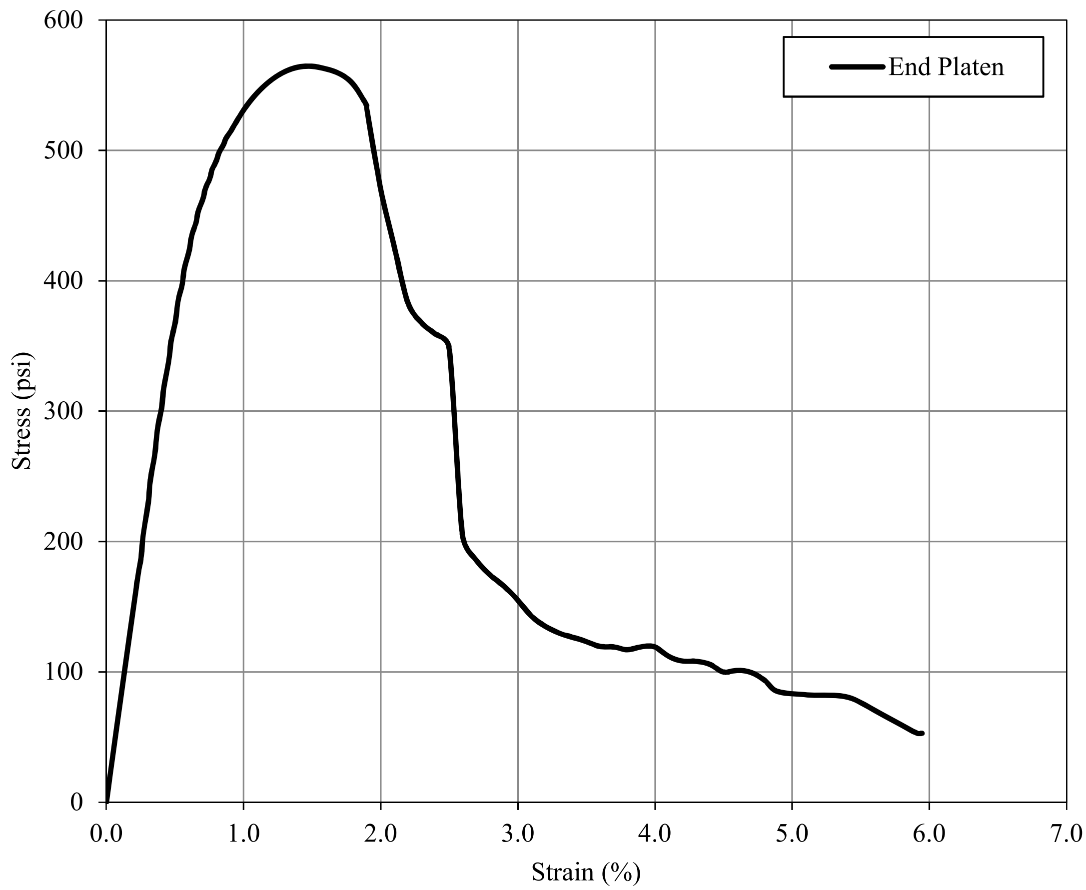


Batch S-8

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-8-C
Curing Period:	28 day
Test Date:	6/13/2017
$\alpha_{in\text{-}place}$:	275
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

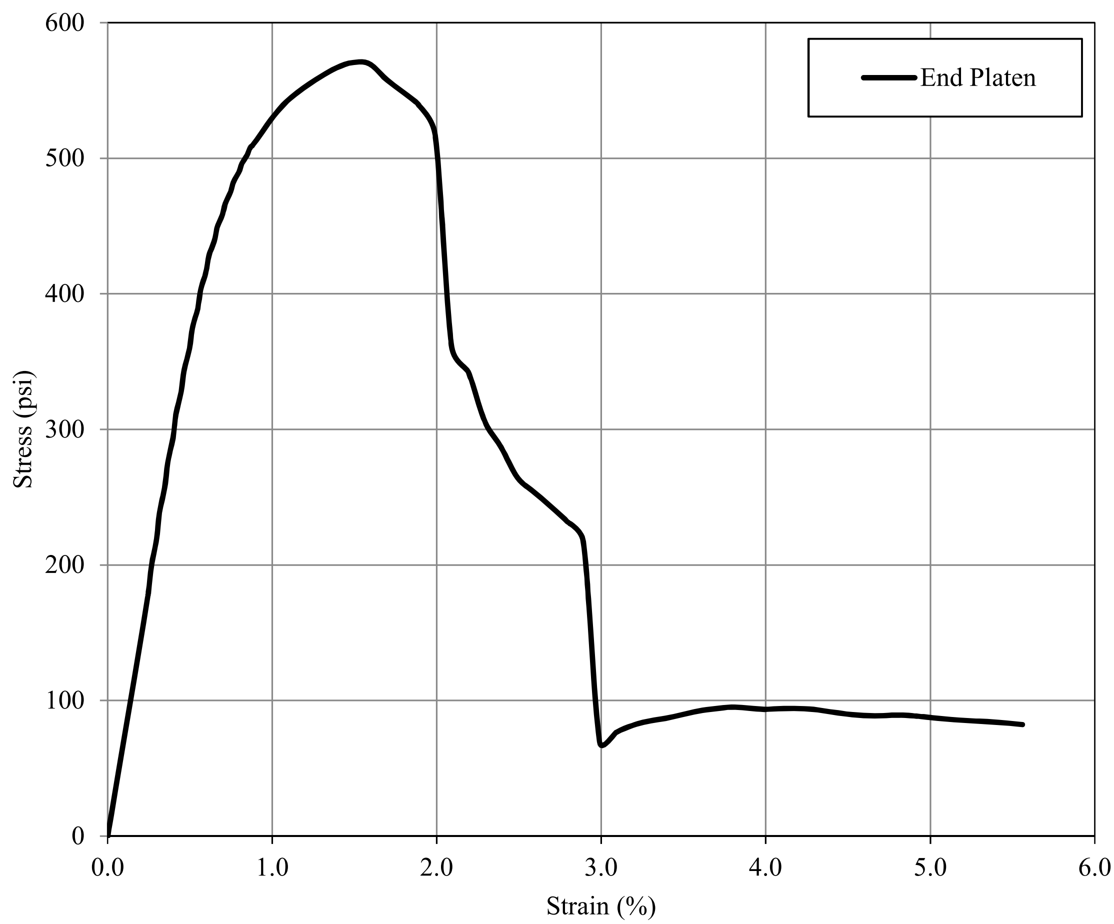
Specimen Information		
Height (initial):	3.955	in
Diameter (initial):	2.038	in
Weight:	365	g
Unit Weight:	108	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	565	psi
Secant Modulus E_{50EP}:	76,569	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.50	%



Batch S-8

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.93	in	Peak Stress:	571	psi
Tested by:	RNG	Diameter (initial):	2.037	in	Secant Modulus E_{50EP}:	74,670	psi
I.D. :	S-8-F	Weight:	361.8	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	108	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	6/13/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.49	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

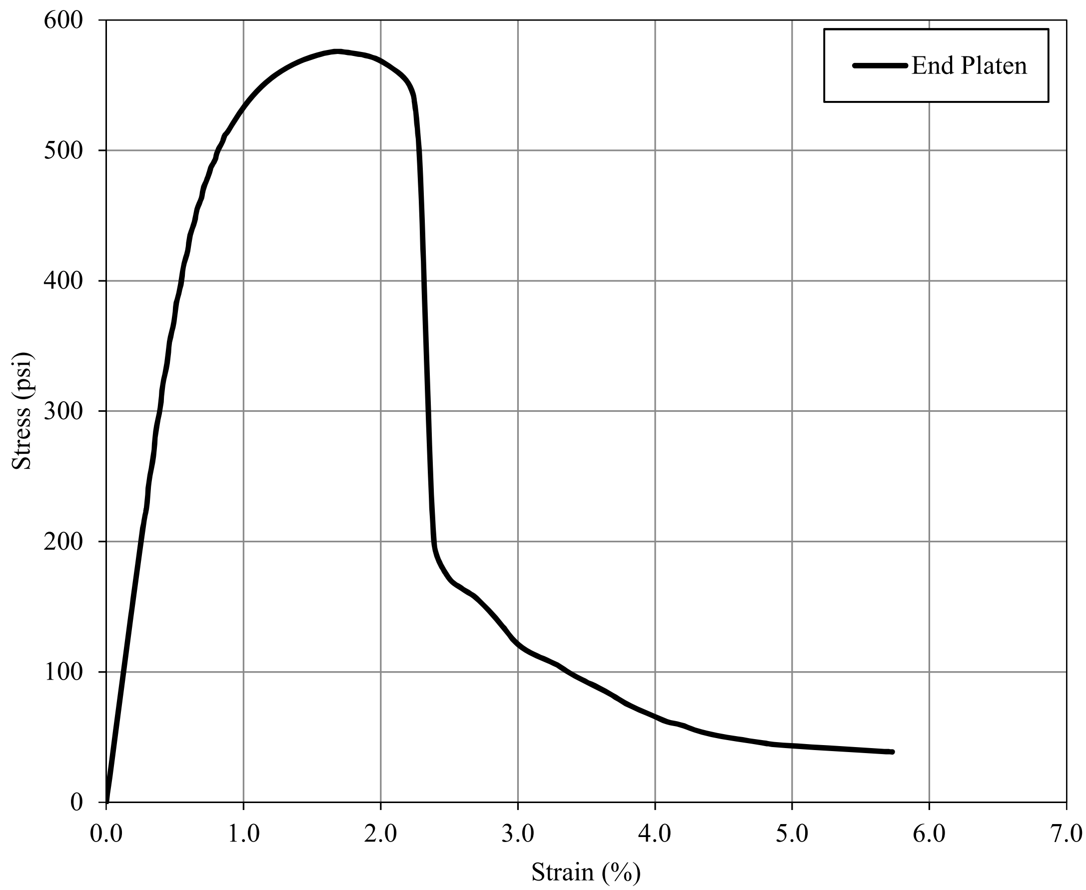


Batch S-8

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-8-G
Curing Period:	28 day
Test Date:	6/13/2017
$\alpha_{in\text{-}place}$:	275
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.959	in
Diameter (initial):	2.037	in
Weight:	364.5	g
Unit Weight:	108	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	576	psi
Secant Modulus E_{50EP}:	78,388	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.69	%

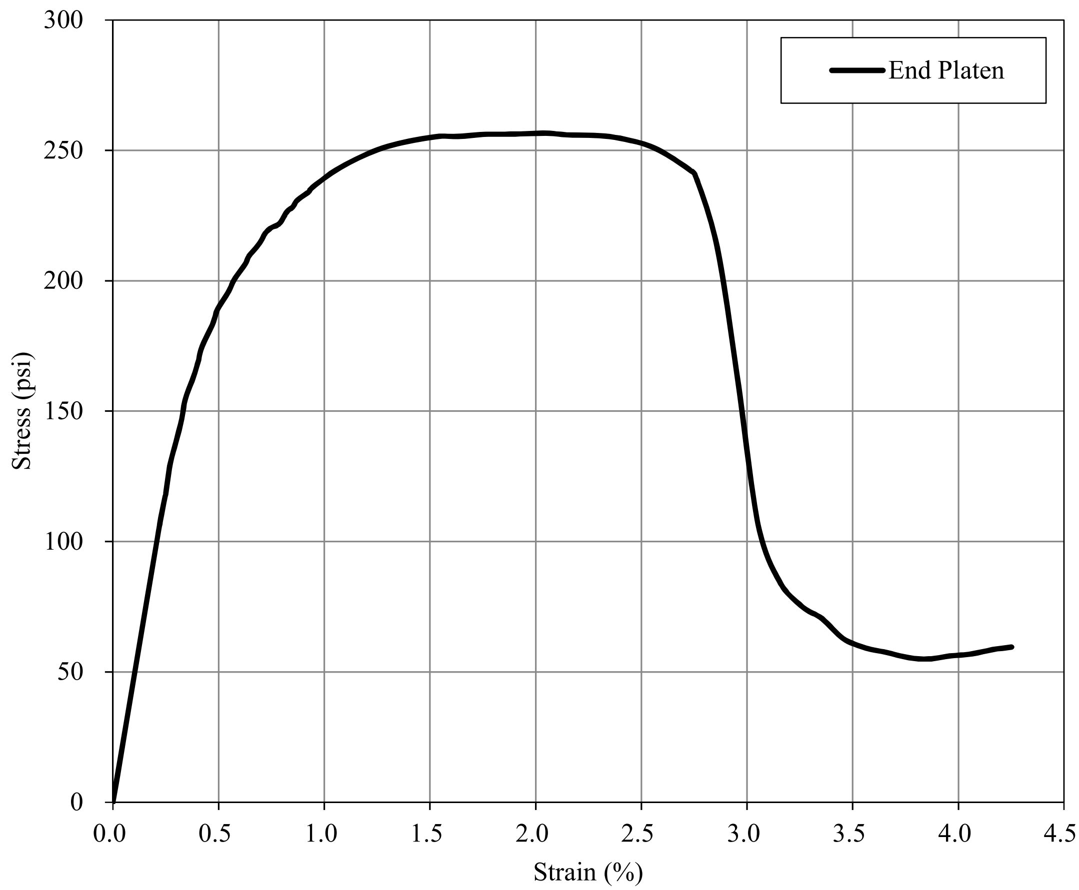


Batch S-9

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-9-A
Curing Period:	7 day
Test Date:	5/24/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

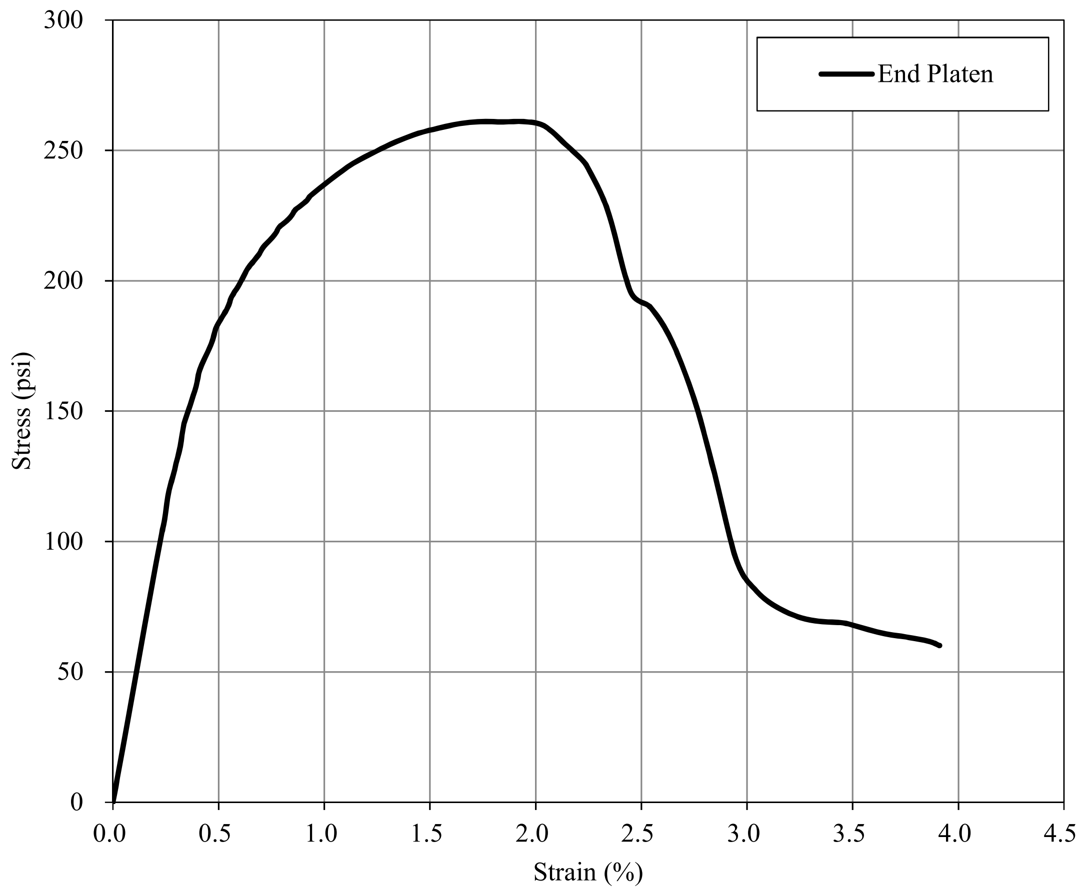
Specimen Information		
Height (initial):	3.941	in
Diameter (initial):	2.036	in
Weight:	368.0	g
Unit Weight:	109	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	255	psi
Secant Modulus E_{50EP}:	48,034	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	2.05	%



Batch S-9

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.936	in	Peak Stress:	260	psi
Tested by:	RNG	Diameter (initial):	2.036	in	Secant Modulus E_{50EP}:	43,475	psi
I.D. :	S-9-D	Weight:	366.4	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	7 day	Unit Weight:	109	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	5/24/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	200				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.74	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

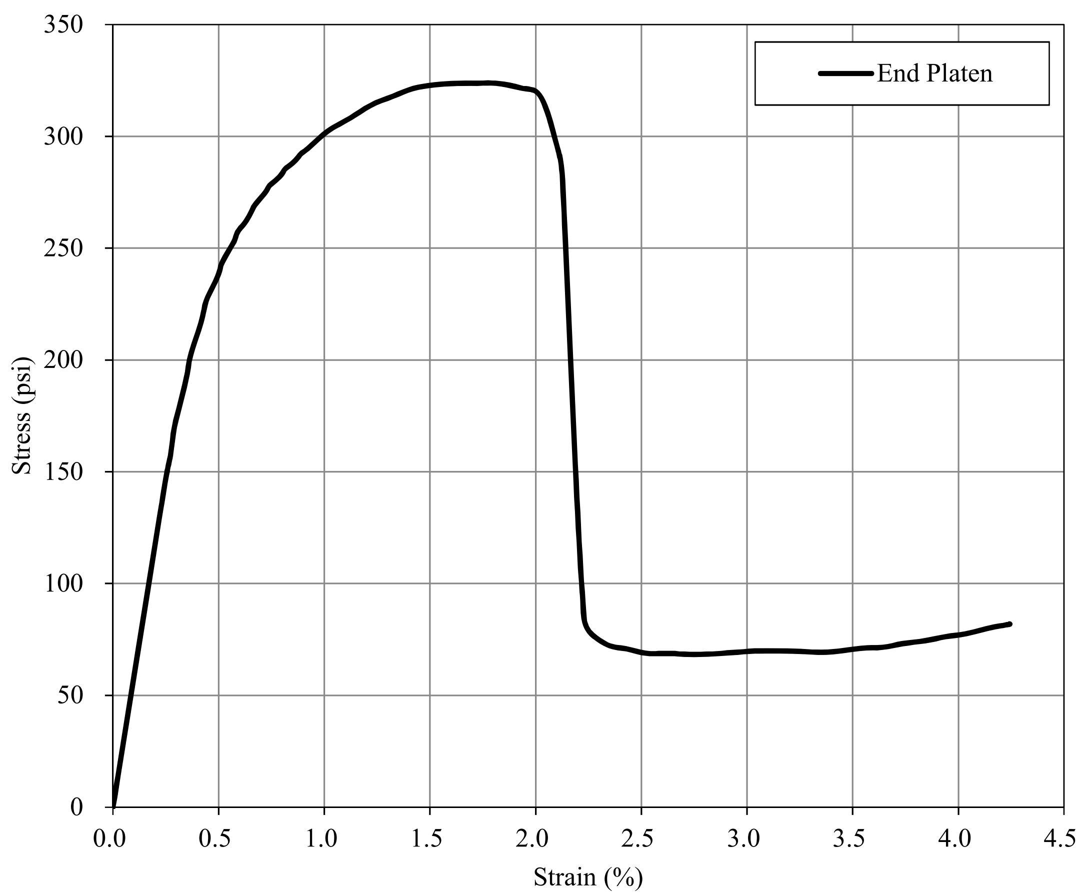


Batch S-9

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-9-B
Curing Period:	14 day
Test Date:	5/31/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

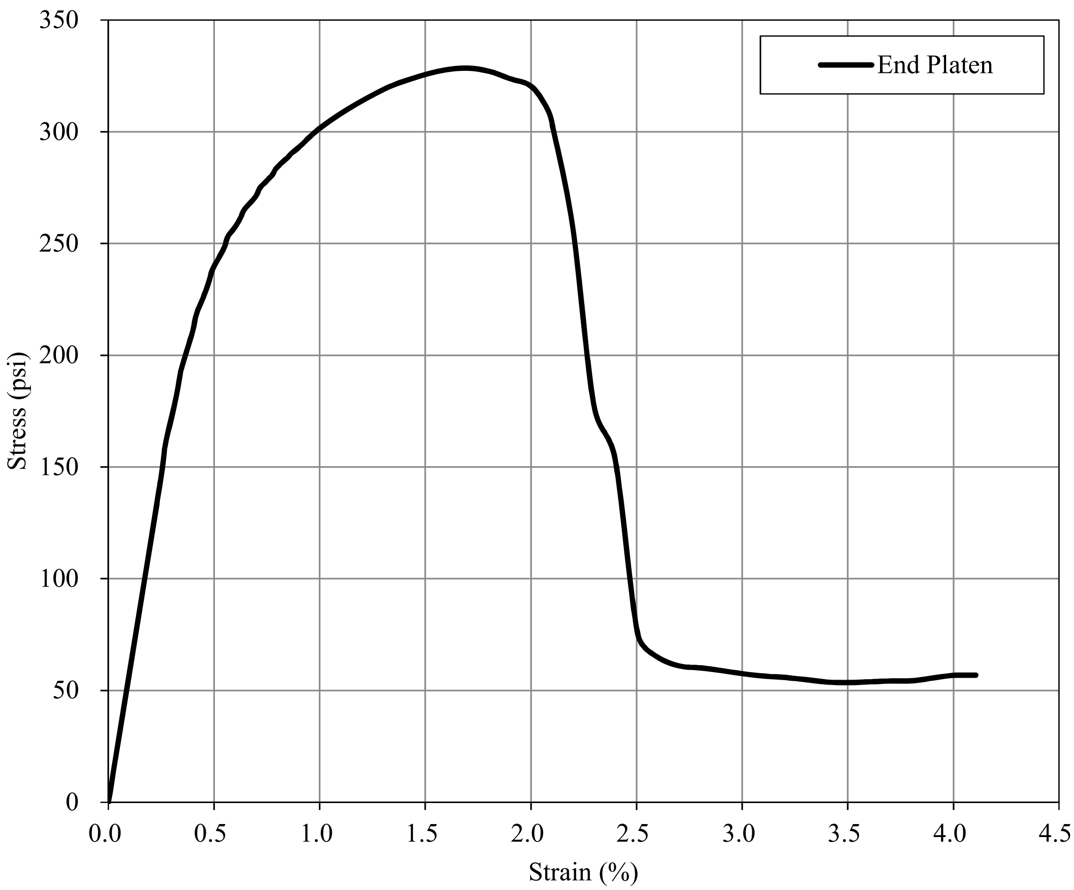
Specimen Information		
Height (initial):	3.954	in
Diameter (initial):	2.037	in
Weight:	368.9	g
Unit Weight:	109	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	322	psi
Secant Modulus E_{50EP}:	58,116	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.73	%



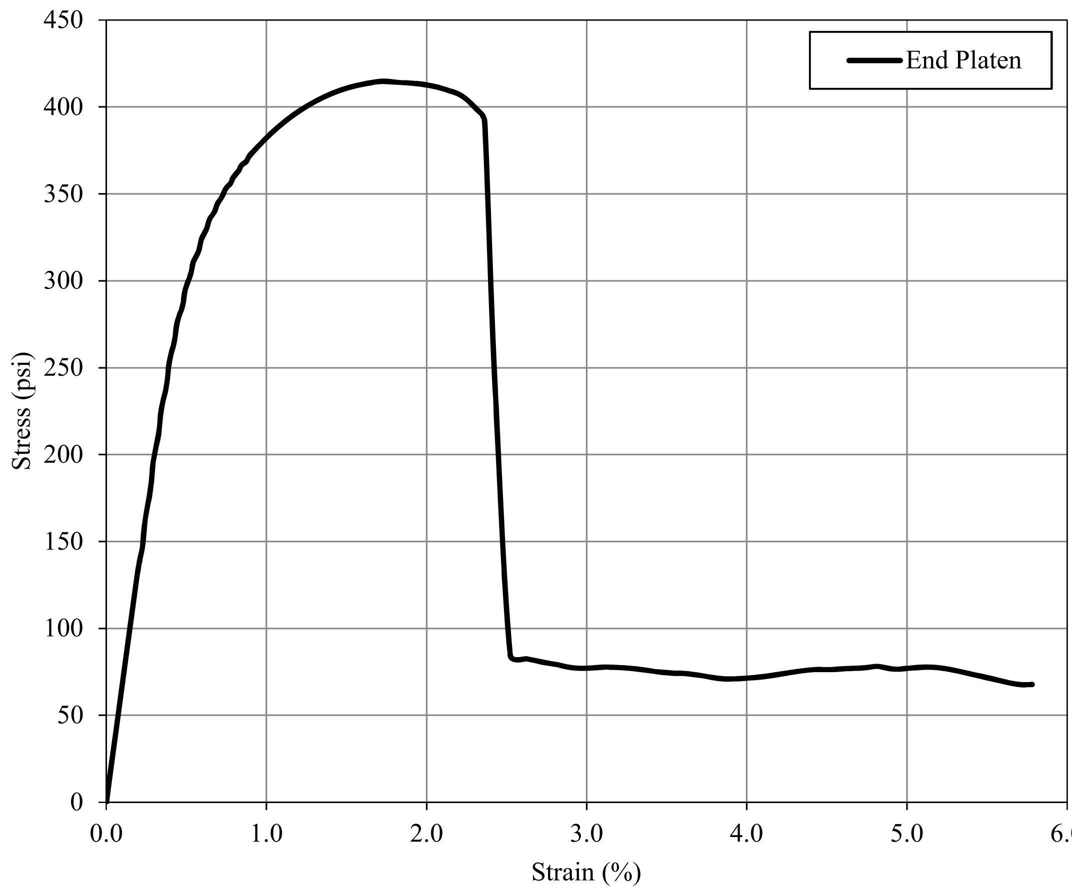
Batch S-9

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.969	in	Peak Stress:	327	psi
Tested by:	RNG						
I.D. :	S-9-E	Diameter (initial):	2.036	in	Secant Modulus E_{50EP}:	58,757	psi
Curing Period:	14 day						
Test Date:	5/31/2017	Weight:	370.6	g	Secant Modulus E_{50L}:	N/A	psi
$\alpha_{in\text{-}place}$:	200	Unit Weight:	109	pcf			
$(w:c)_{slurry}$:	1.0				Poisson's Ratio ν_{50} :	N/A	
End Treatment:	Grinding	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
Confining Pressure (psi):	N/A				Local Strain at failure, εf :	N/A	%
Strain Rate:	1 %/min				End Platen Strain at failure, εf :	1.70	%



Batch S-9

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.963	in	Peak Stress:	415	psi
Tested by:	RNG	Diameter (initial):	2.036	in	Secant Modulus E_{50EP}:	65,446	psi
I.D. :	S-9-C	Weight:	369.8	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	109	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	6/14/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	200				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.7224	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

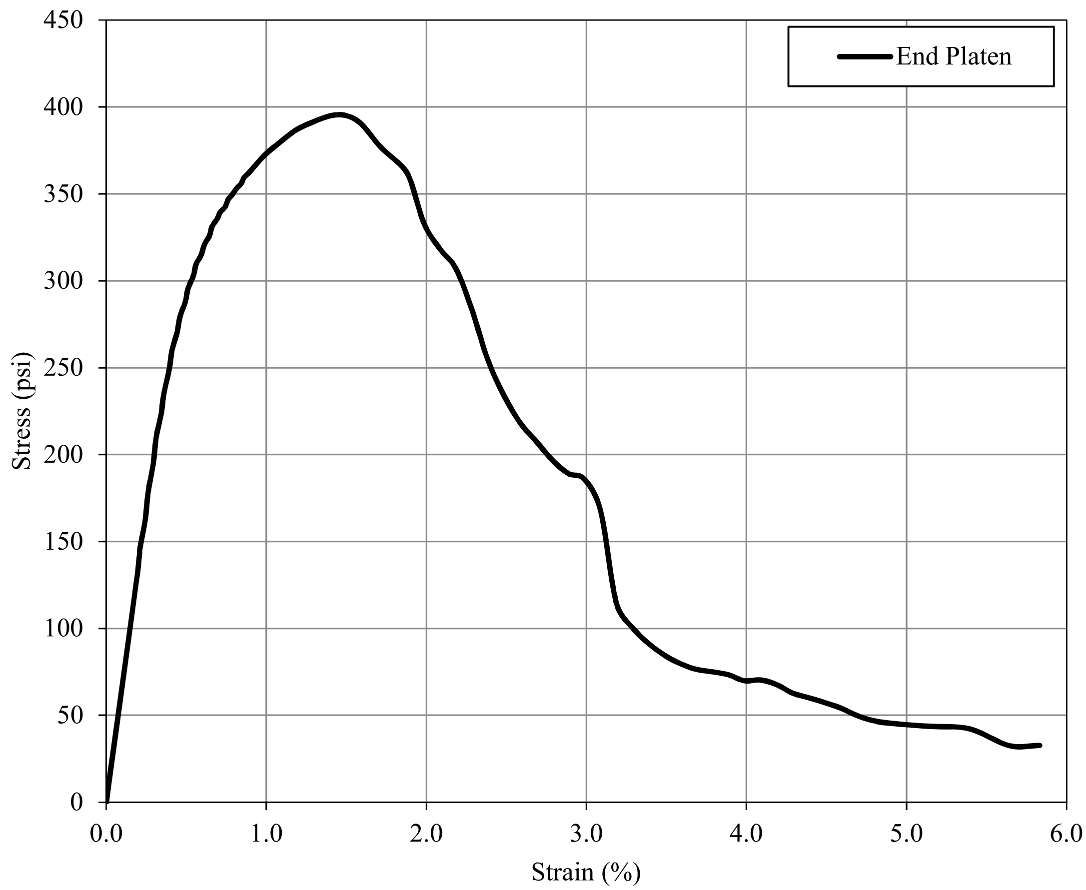


Batch S-9

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-9-F
Curing Period:	28 day
Test Date:	6/14/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.961	in
Diameter (initial):	2.036	in
Weight:	369.4	g
Unit Weight:	109	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	395	psi
Secant Modulus E_{50EP}:	66,559	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.4867	%

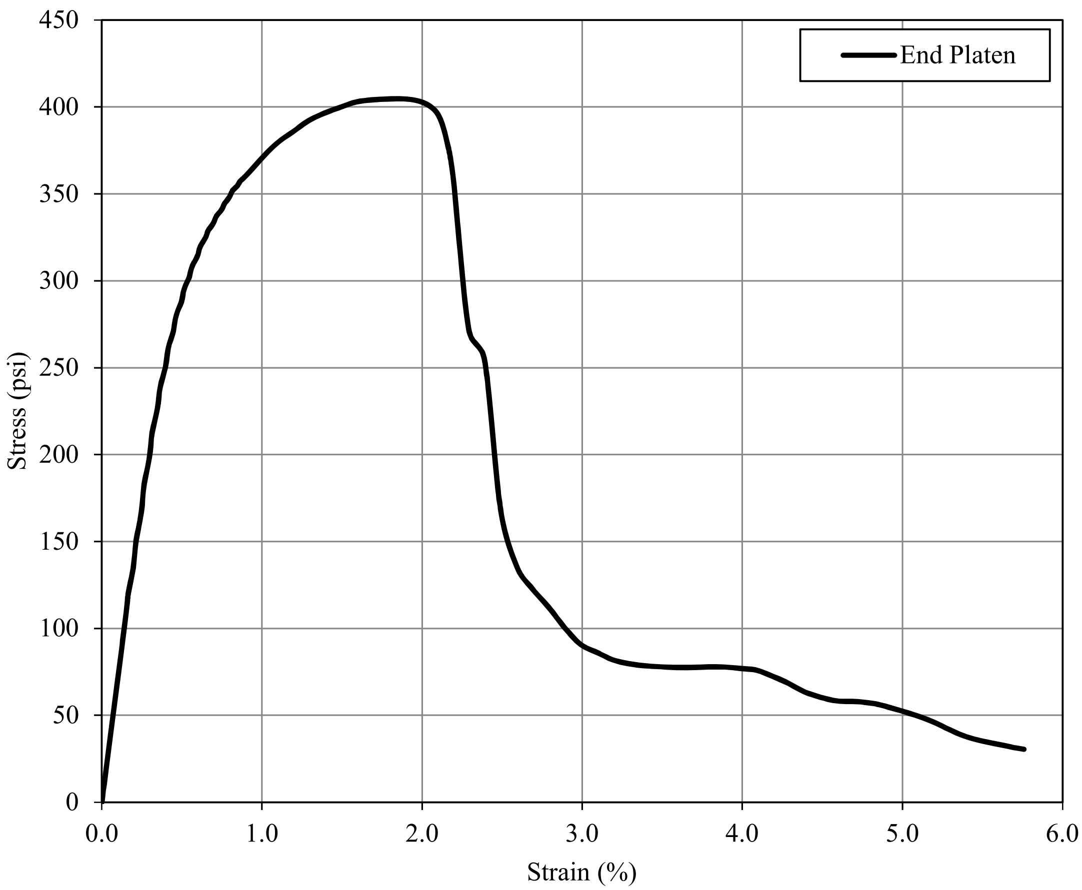


Batch S-9

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-9-G
Curing Period:	28 day
Test Date:	6/14/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.945	in
Diameter (initial):	2.036	in
Weight:	367.6	g
Unit Weight:	109	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	405	psi
Secant Modulus E_{50EP}:	67,099	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.79	%

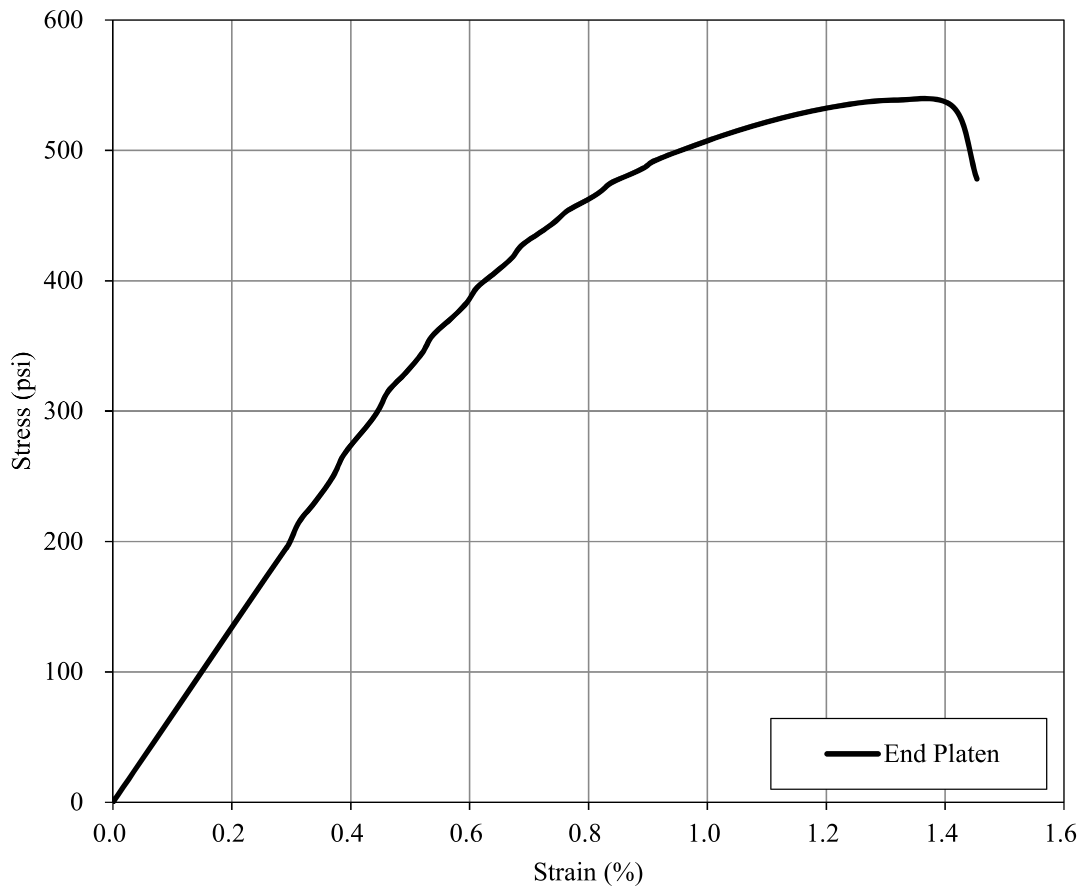


Batch S-10

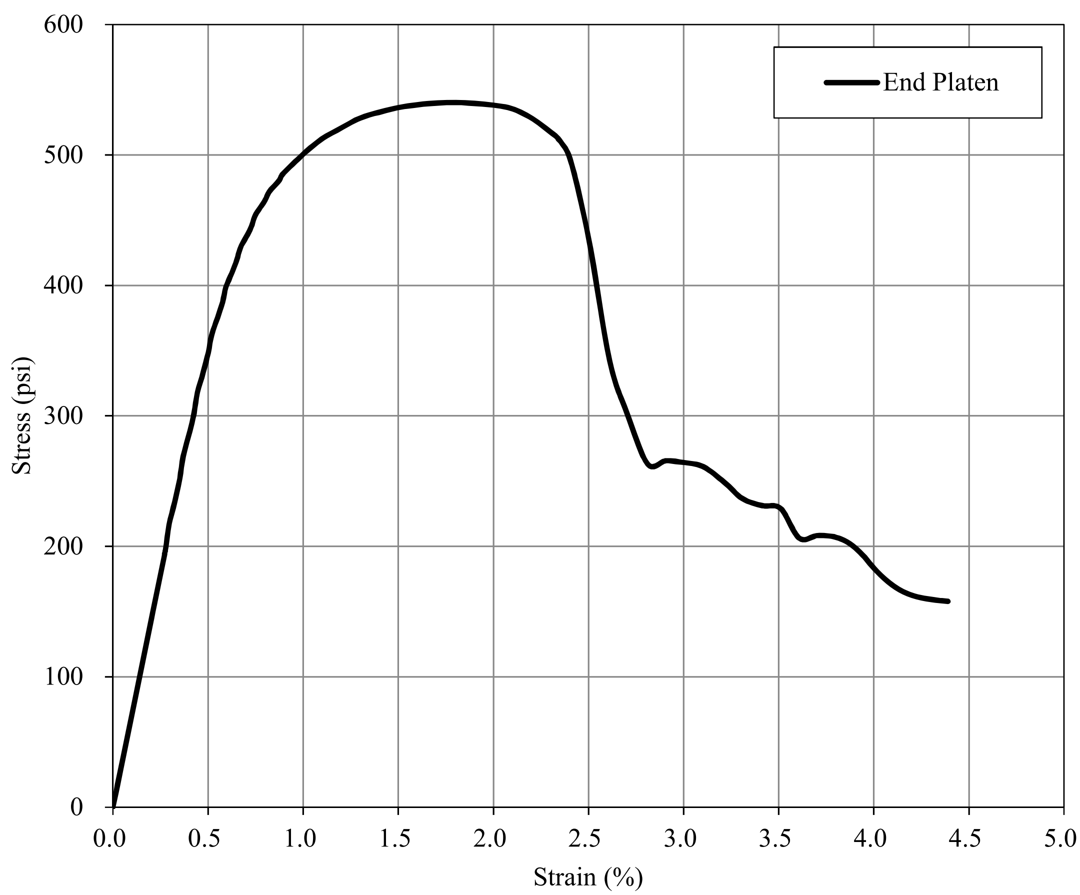
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	S-10-A
Curing Period:	7 day
Test Date:	5/25/2017
$\alpha_{in\text{-}place}$:	350
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.953	in
Diameter (initial):	2.037	in
Weight:	360.0	g
Unit Weight:	106	pcf
Gage Length:	N/A	in

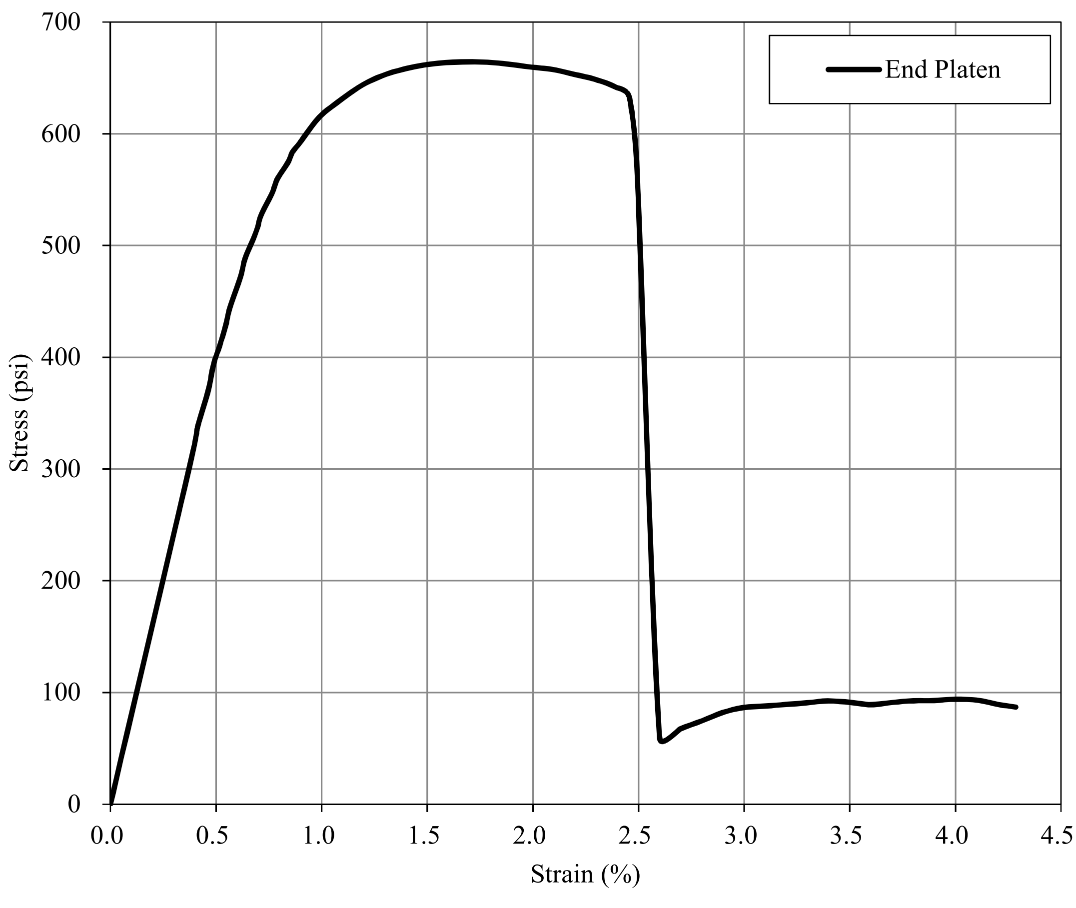
Test Summary		
Peak Stress:	536	psi
Secant Modulus E_{50EP}:	68,517	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.31	%



Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.951	in	Peak Stress:	538	psi
Tested by:	RNG	Diameter (initial):	2.036	in	Secant Modulus E_{50EP}:	72,789	psi
I.D. :	S-10-D	Weight:	359.6	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	7 day	Unit Weight:	106	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	5/25/2027	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	350				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.81	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

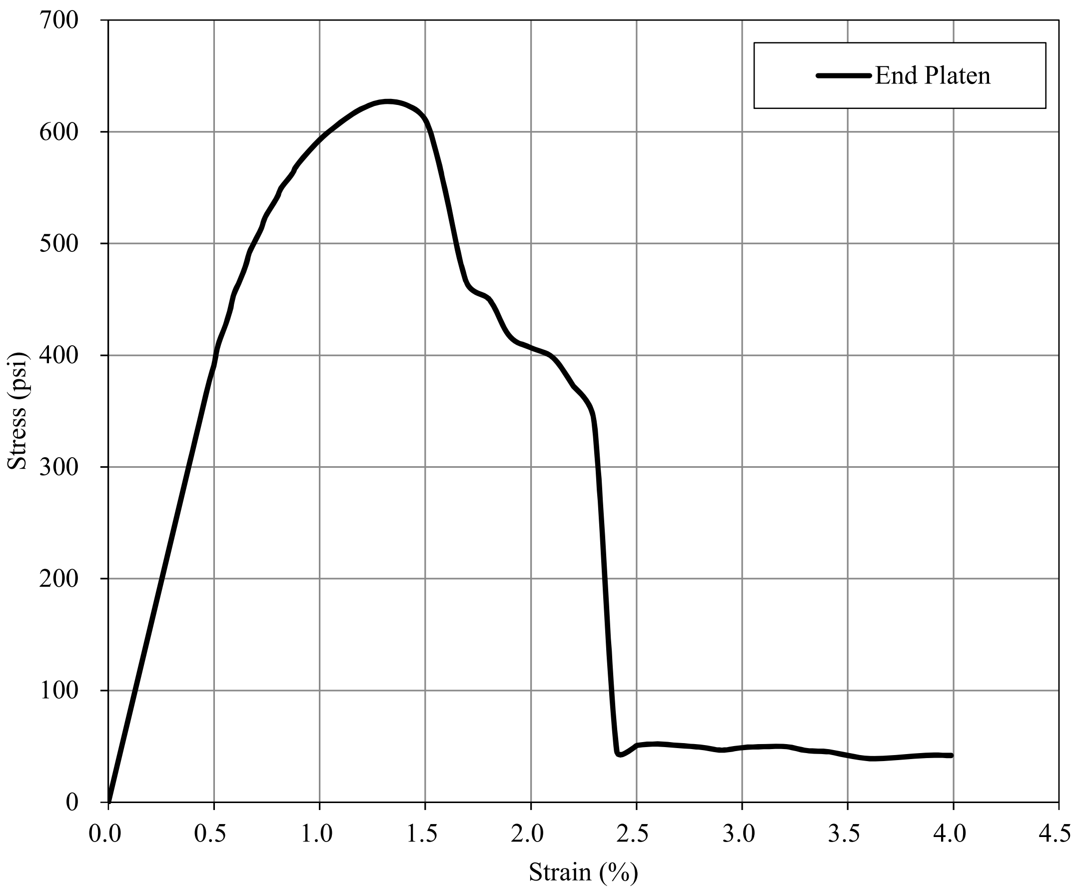


Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.939	in	Peak Stress:	661	psi
Tested by:	RNG	Diameter (initial):	2.036	in	Secant Modulus E_{50EP}:	81,633	psi
I.D. :	S-10-B	Weight:	357.7	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	14 day	Unit Weight:	106	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	6/1/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	350				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.69	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



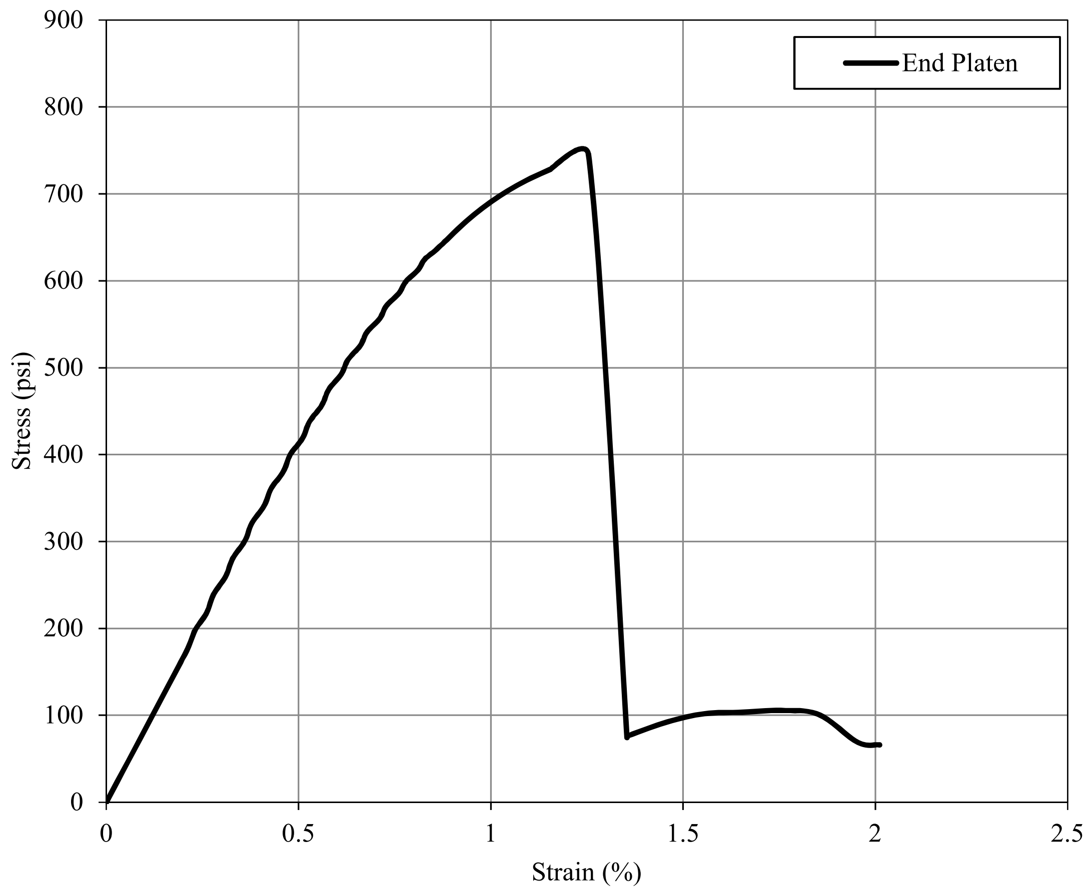
Batch S-10

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.962	in	Peak Stress:	624	psi
Tested by:	RNG	Diameter (initial):	2.037	in	Secant Modulus E_{50EP}:	79,014	psi
I.D. :	S-10-E	Weight:	360.1	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	14 day	Unit Weight:	106	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	6/1/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	350				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.29	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



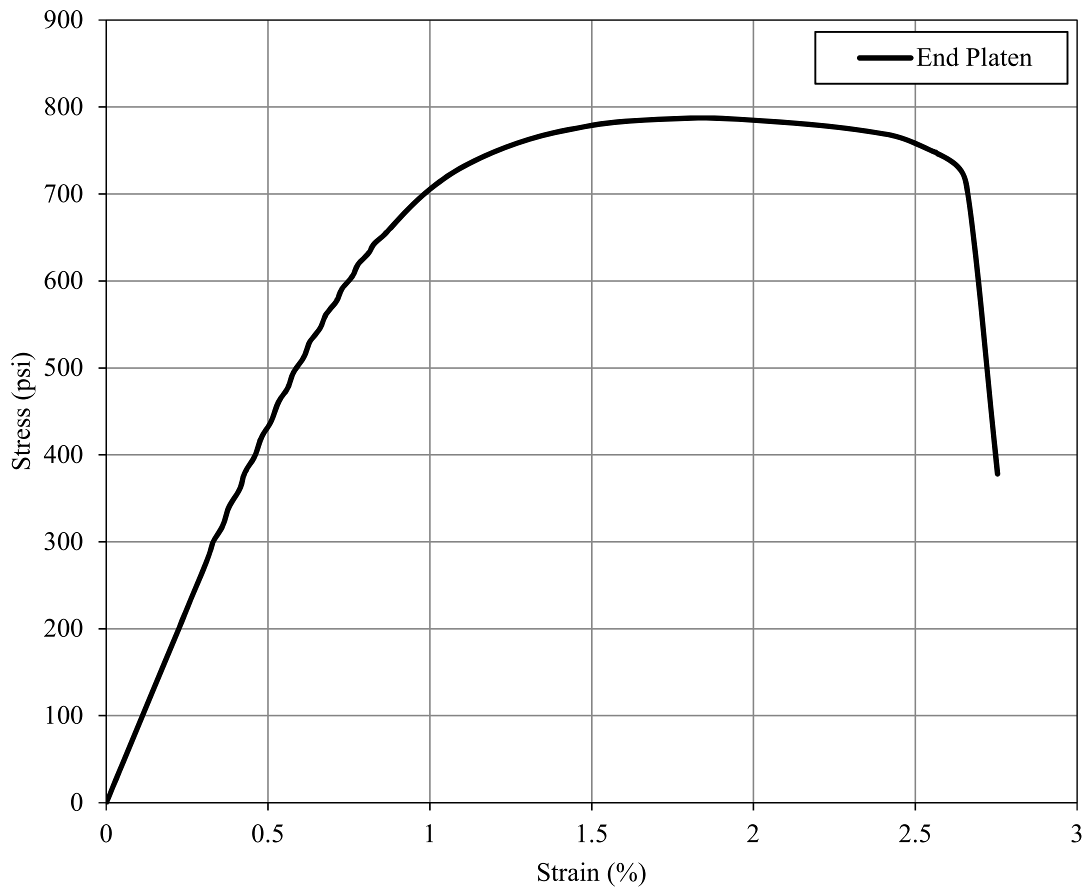
Batch S-10

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.935	in	Peak Stress:	745	psi
Tested by:	RNG	Diameter (initial):	2.037	in	Secant Modulus E_{50EP}:	83,285	psi
I.D. :	S-10-C	Weight:	357.6	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	106	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	6/15/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	350				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.25	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



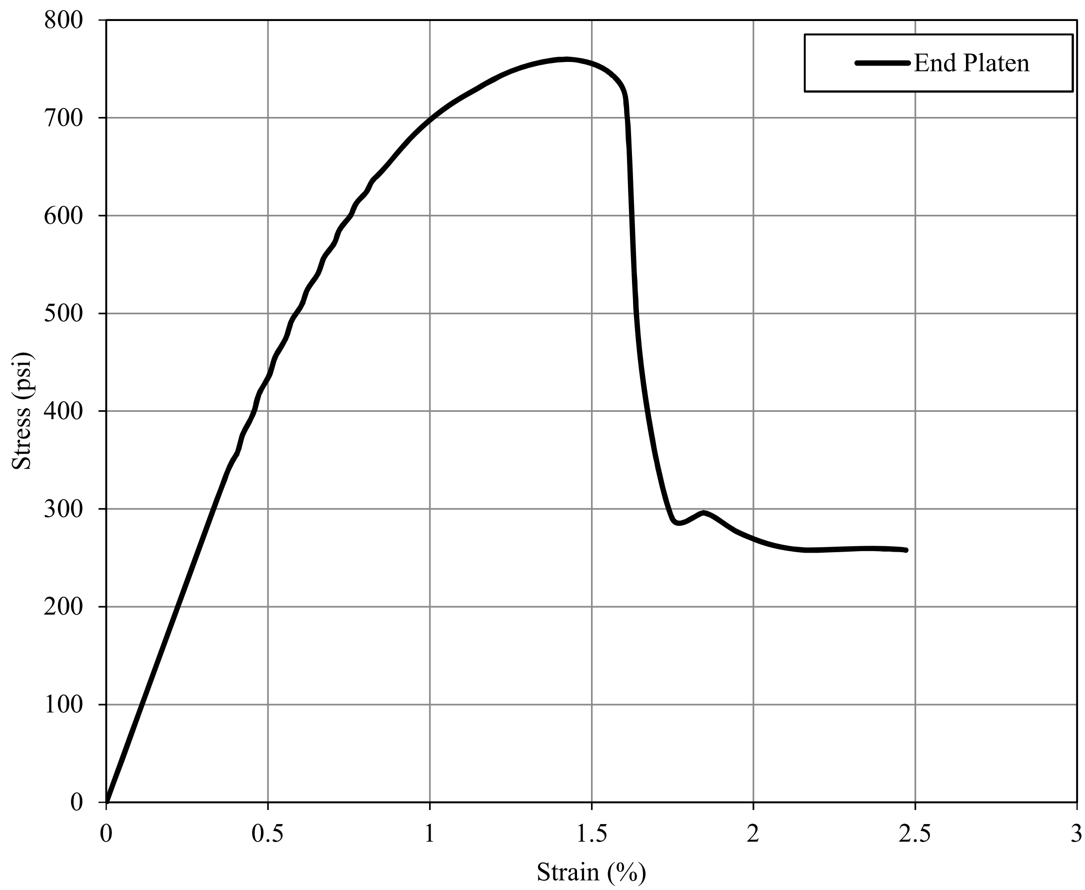
Batch S-10

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.926	in	Peak Stress:	787	psi
Tested by:	RNG	Diameter (initial):	2.036	in	Secant Modulus E_{50EP}:	87,352	psi
I.D. :	S-10-F	Weight:	356.8	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	106	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	6/15/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	350				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.85	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



Batch S-10

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.958	in	Peak Stress:	759	psi
Tested by:	RNG	Diameter (initial):	2.036	in	Secant Modulus E_{50EP}:	88,959	psi
I.D. :	S-10-G	Weight:	360.2	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	106	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	6/15/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	350				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.45	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

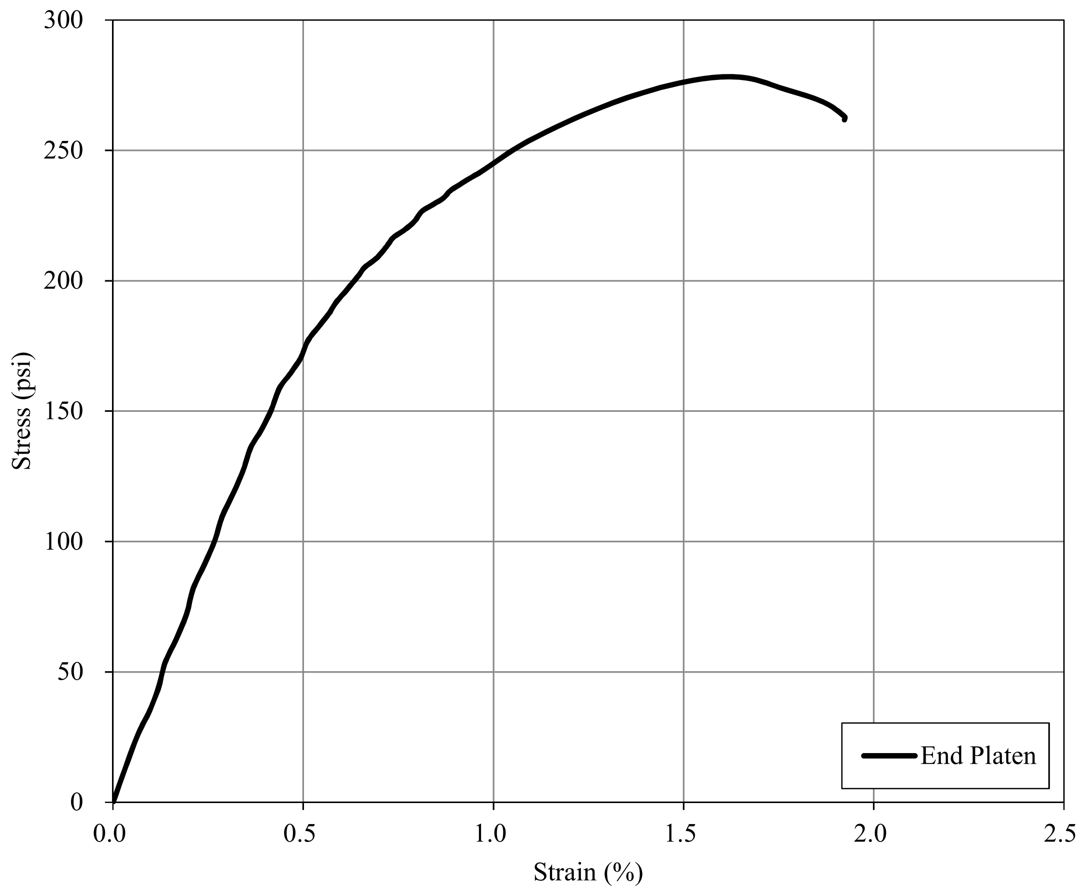


Batch T-1

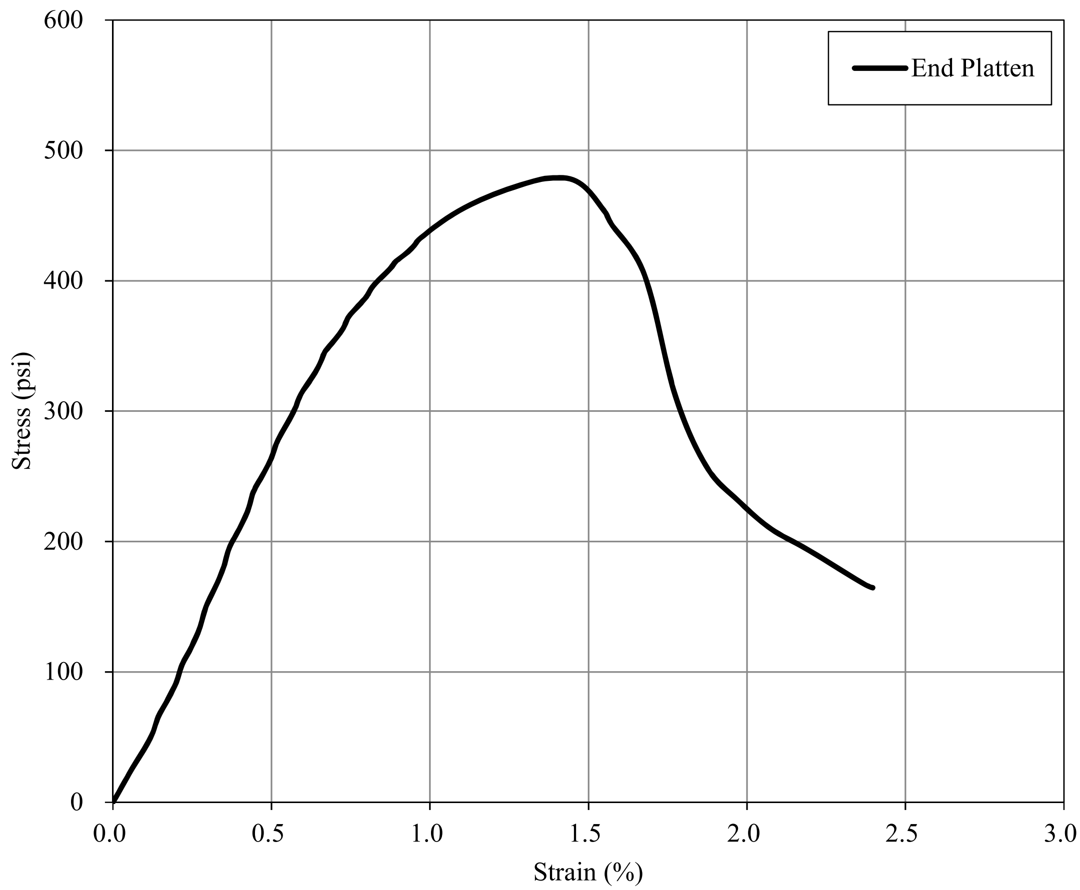
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	T-1-E
Curing Period:	3 day
Test Date:	2/24/2017
$\alpha_{in\text{-}place}$:	200
Cur. Temp (F) :	110.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.967	in
Diameter (initial):	2.047	in
Weight:	371.4	g
Unit Weight:	108	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	276	psi
Secant Modulus E_{50EP}:	37,152	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.66	%

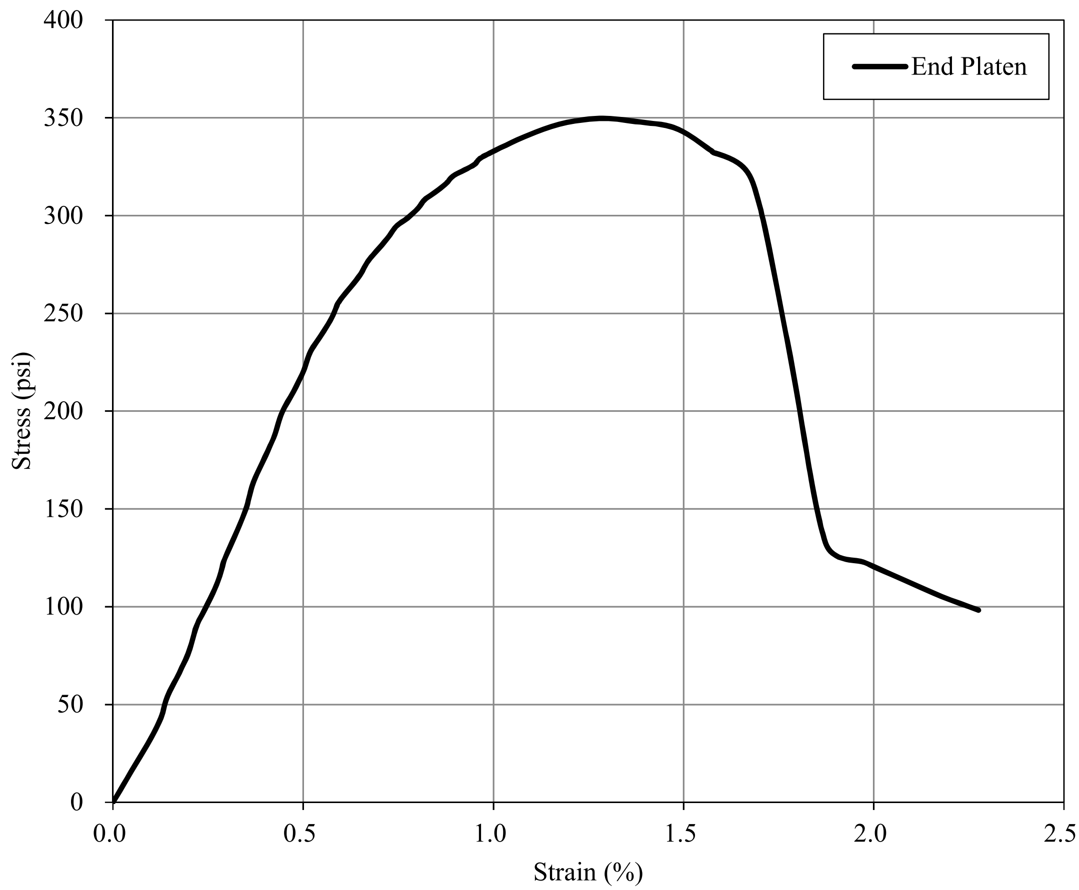


Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.967	in	Peak Stress:	476	psi
Tested by:	RNG	Diameter (initial):	2.046	in	Secant Modulus E_{50EP}:	53,677	psi
I.D. :	T-1-F	Weight:	368.9	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	3 day	Unit Weight:	108	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/24/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	200				Local Strain at failure, εf :	N/A	%
Cur. Temp (F) :	150.0				End Platen Strain at failure, εf :	1.38	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



Batch T-1

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.951	in	Peak Stress:	348	psi
Tested by:	RNG	Diameter (initial):	2.05	in	Secant Modulus E_{50EP}:	44,203	psi
I.D. :	T-1-A	Weight:	369.5	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	7 day	Unit Weight:	108	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/28/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	200				Local Strain at failure, εf :	N/A	%
Cur. Temp (F) :	110.0				End Platen Strain at failure, εf :	1.28	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

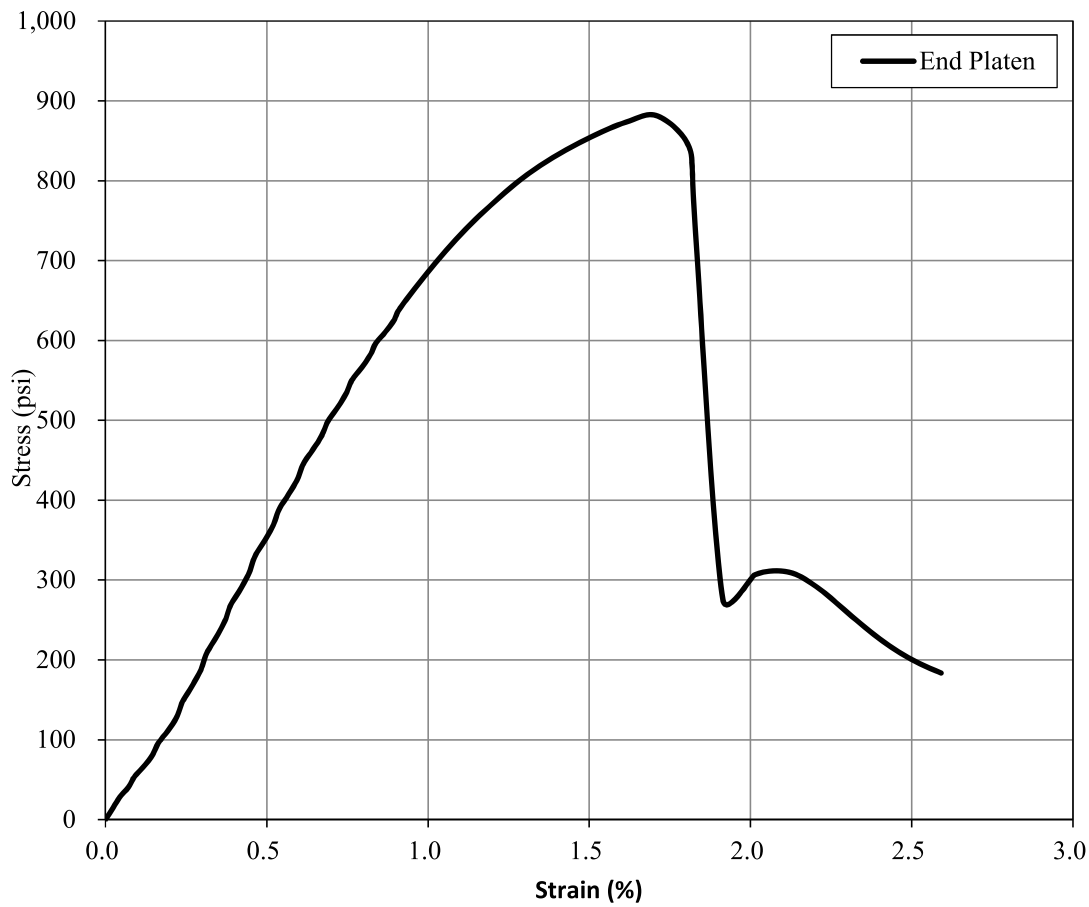


Batch T-1

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	T-1-B
Curing Period:	7 day
Test Date:	2/28/2017
$\alpha_{in\text{-}place}$:	200
Cur. Temp (F) :	150.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

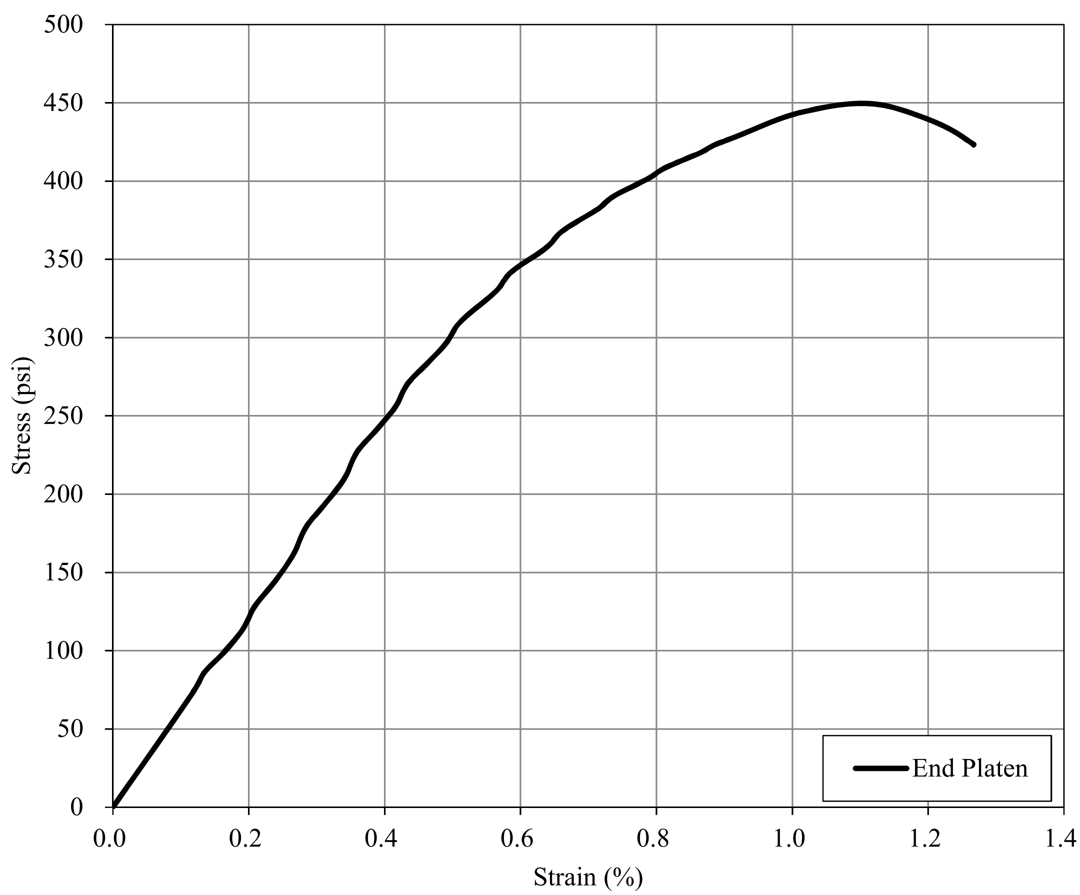
Specimen Information		
Height (initial):	3.955	in
Diameter (initial):	2.045	in
Weight:	368.8	g
Unit Weight:	108	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	876	psi
Secant Modulus E_{50EP}:	72,387	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.71	%



Batch T-1

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.977	in	Peak Stress:	447	psi
Tested by:	RNG	Diameter (initial):	2.051	in	Secant Modulus E_{50EP}:	63,006	psi
I.D. :	T-1-G	Weight:	373.4	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	14 day	Unit Weight:	108	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	3/7/2007	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	200				Local Strain at failure, εf :	N/A	%
Cur. Temp (F) :	110.0				End Platen Strain at failure, εf :	1.12	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

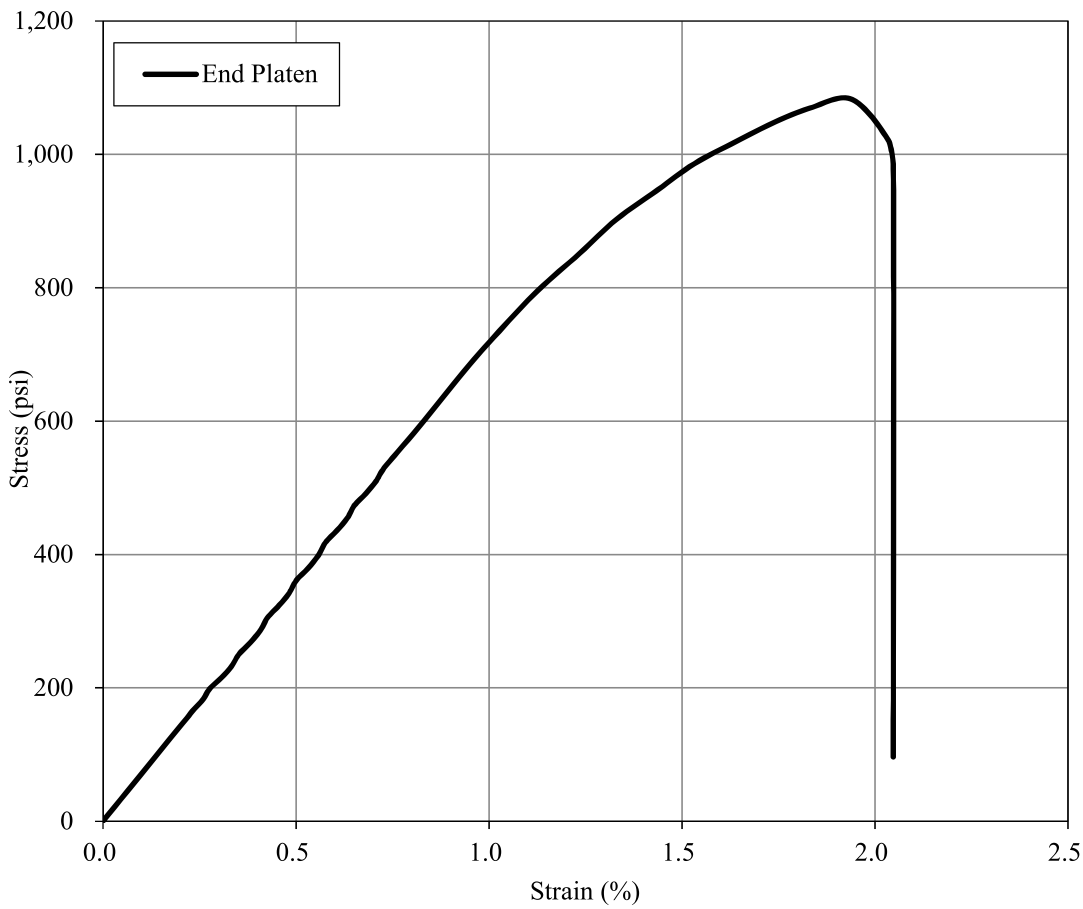


Batch T-1

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	T-1-H
Curing Period:	14 day
Test Date:	3/7/2007
$\alpha_{in\text{-}place}$:	200
Cur. Temp (F) :	150.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.952	in
Diameter (initial):	2.051	in
Weight:	372.5	g
Unit Weight:	109	pcf
Gage Length:	N/A	in

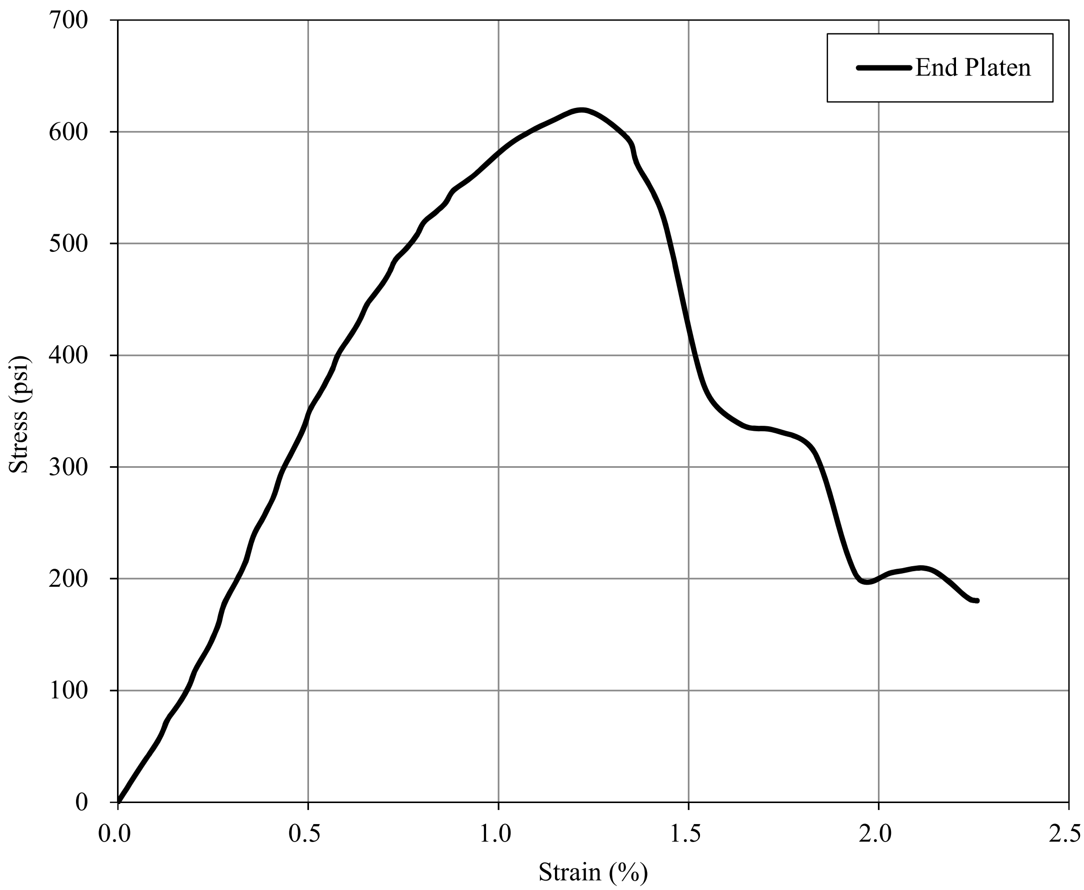
Test Summary		
Peak Stress:	1,076	psi
Secant Modulus E_{50EP}:	72,637	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.94	%



Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	T-1-C
Curing Period:	28 day
Test Date:	3/21/2017
$\alpha_{in\text{-}place}$:	200
Cur. Temp (F) :	110.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.973	in
Diameter (initial):	2.049	in
Weight:	374.5	g
Unit Weight:	109	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	616	psi
Secant Modulus E_{50EP}:	68,526	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.23	%

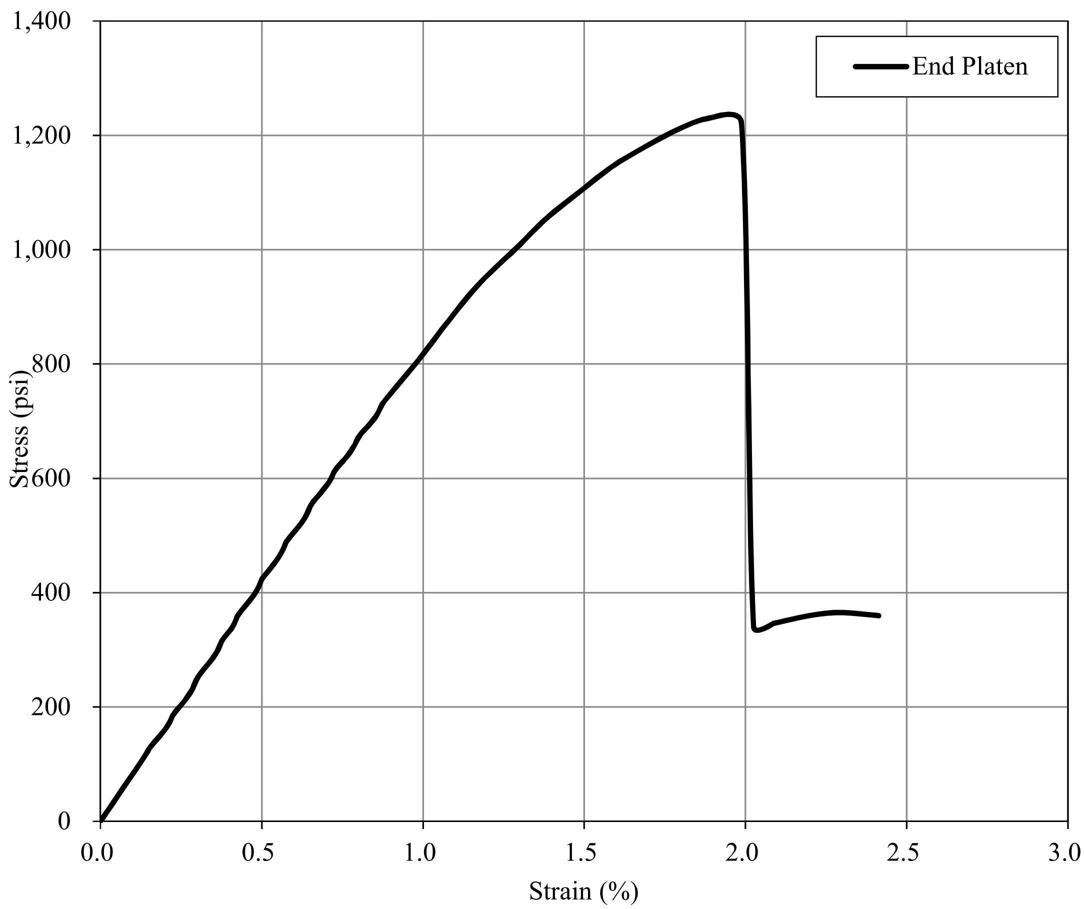


Batch T-1

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	T-1-D
Curing Period:	28 day
Test Date:	3/21/2017
$\alpha_{in\text{-}place}$:	200
Cur. Temp (F) :	150.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

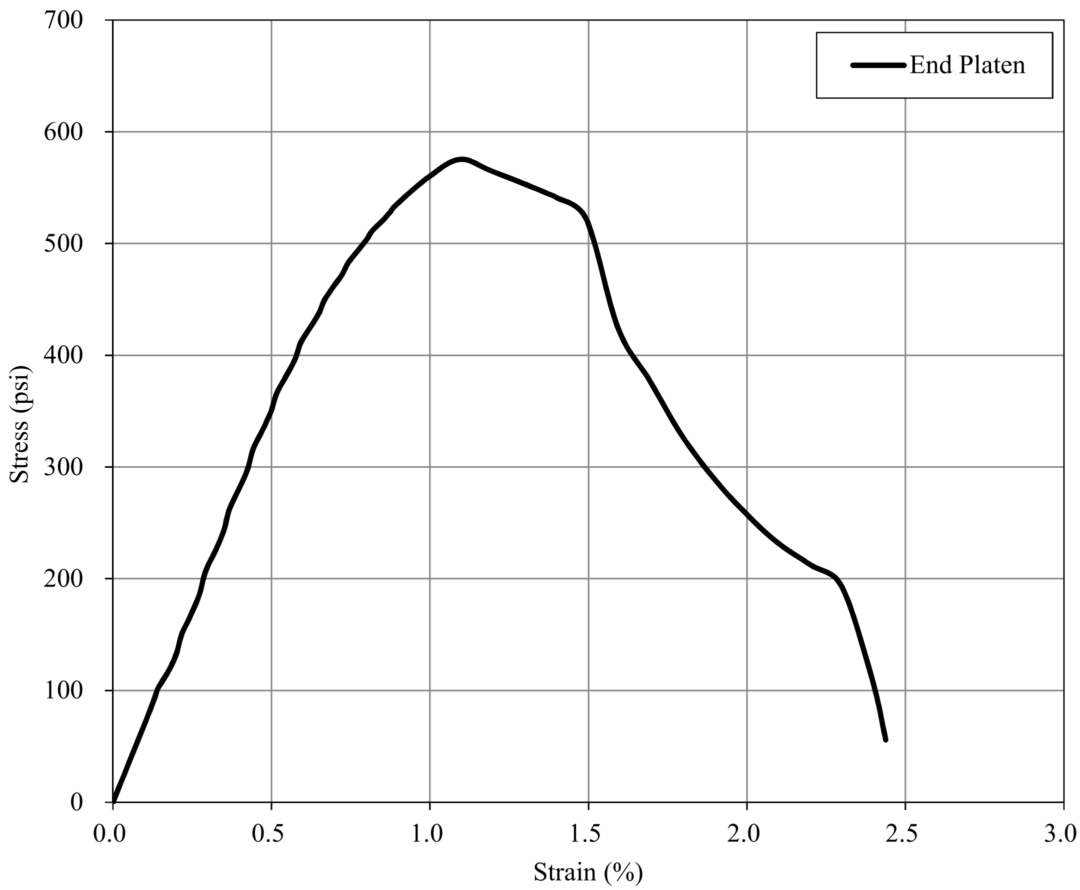
Specimen Information		
Height (initial):	3.96	in
Diameter (initial):	2.042	in
Weight:	370.1	g
Unit Weight:	109	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	1,225	psi
Secant Modulus E_{50EP}:	84,381	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.89	%



Batch T-1

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.976	in	Peak Stress:	573	psi
Tested by:	RNG	Diameter (initial):	2.048	in	Secant Modulus E_{50EP}:	70,415	psi
I.D. :	T-1-I	Weight:	374.4	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	109	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	3/21/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	200				Local Strain at failure, εf :	N/A	%
Cur. Temp (F) :	110.0				End Platen Strain at failure, εf :	1.09	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

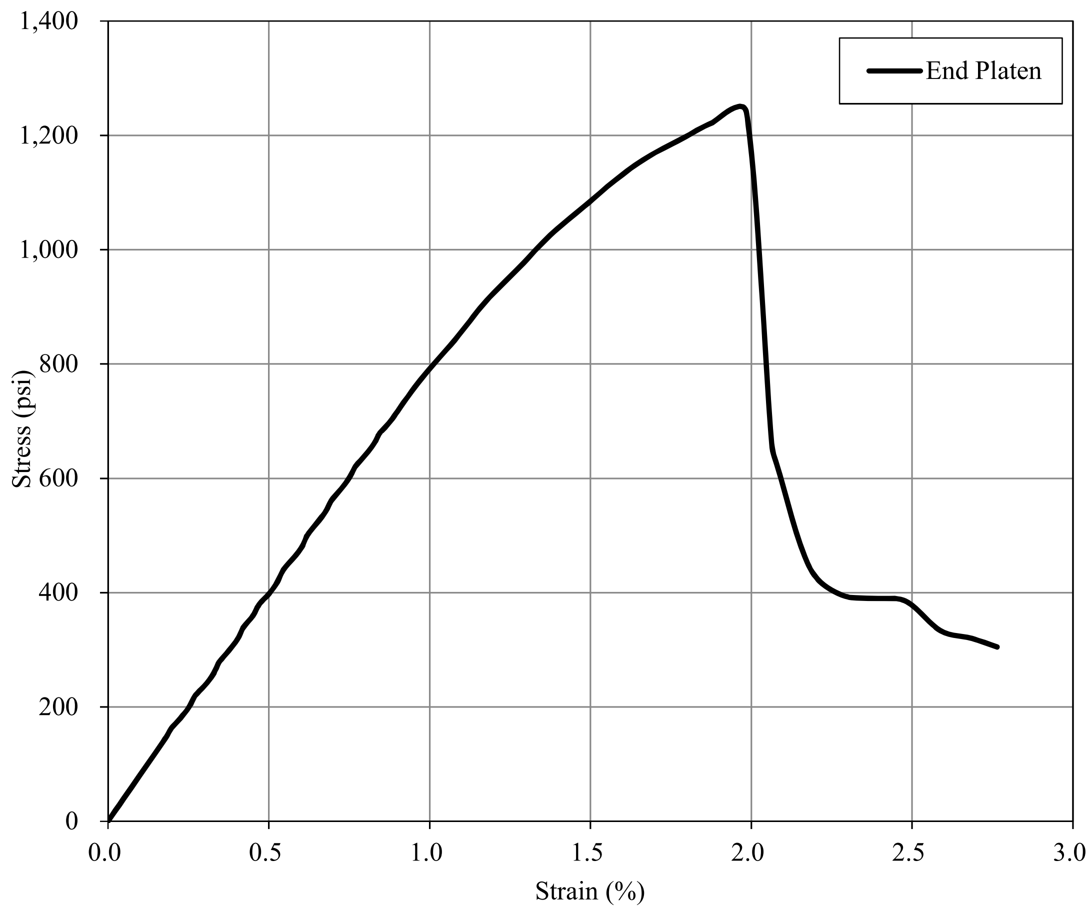


Batch T-1

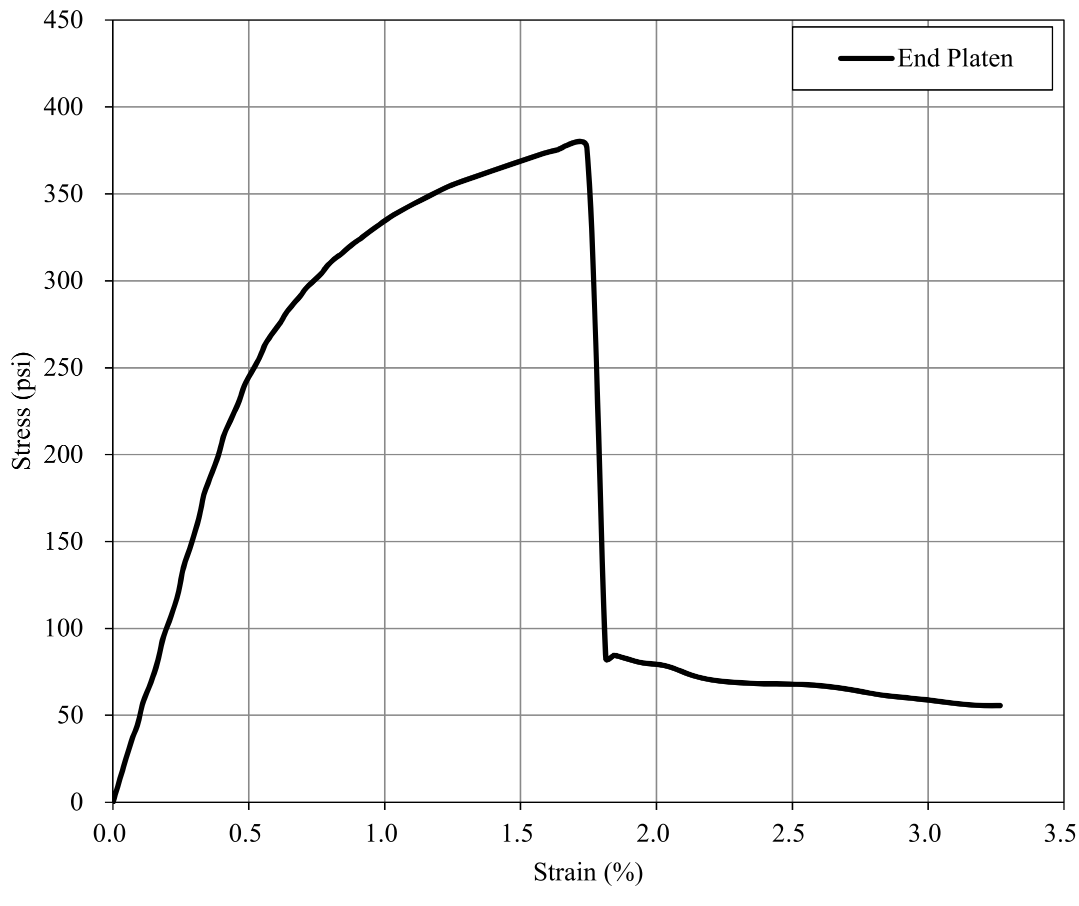
Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	T-1-J
Curing Period:	28 day
Test Date:	3/21/2017
$\alpha_{in\text{-}place}$:	200
Cur. Temp (F) :	150.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.968	in
Diameter (initial):	2.045	in
Weight:	370.4	g
Unit Weight:	108	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	1,234	psi
Secant Modulus E_{50EP}:	80,662	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.98	%

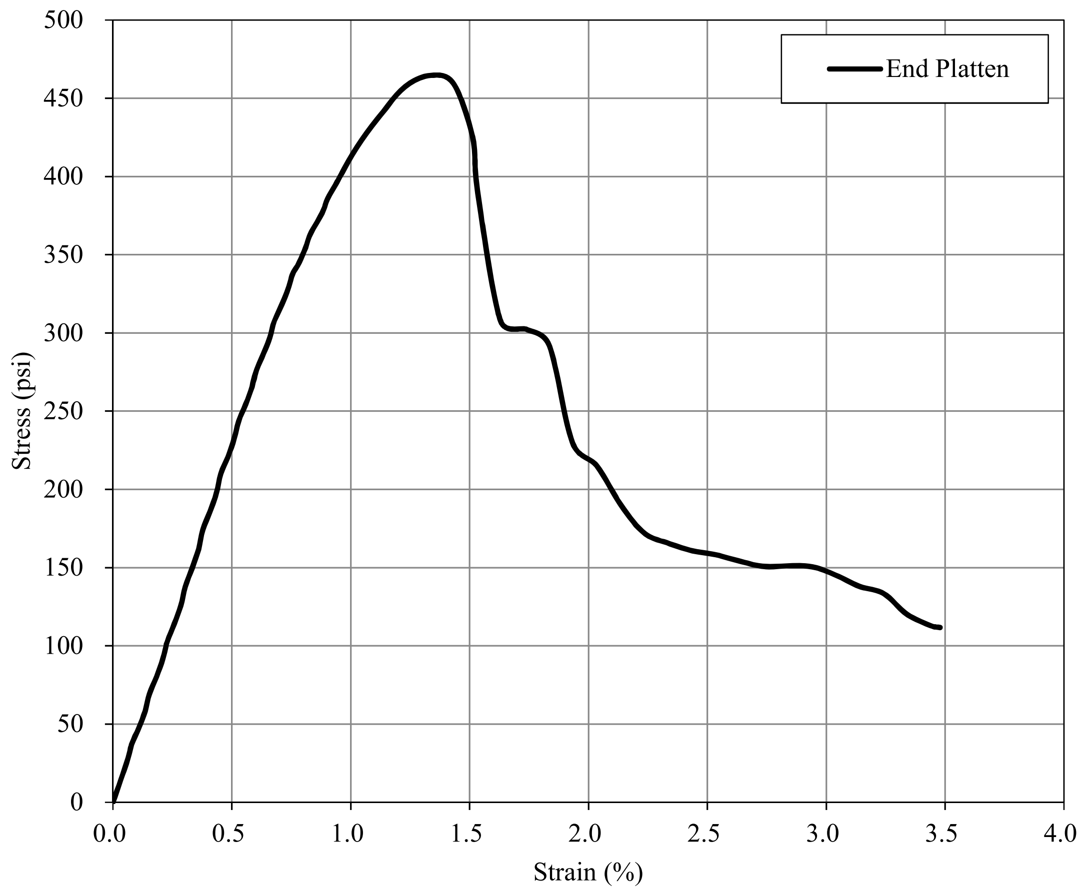


Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.980	in	Peak Stress:	375	psi
Tested by:	RNG						
I.D. :	T-2-E	Diameter (initial):	2.046	in	Secant Modulus E_{50EP}:	52,125	psi
Curing Period:	3 day						
Test Date:	2/24/2017	Weight:	366.4	g	Secant Modulus E_{50L}:	N/A	psi
$\alpha_{in\text{-}place}$:	275	Unit Weight:	107	pcf			
$(w:c)_{slurry}$:	110.0				Poisson's Ratio ν_{50} :	N/A	
End Treatment:	Grinding	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
Confining Pressure (psi):	N/A				Local Strain at failure, εf :	N/A	%
Strain Rate:	1 %/min				End Platen Strain at failure, εf :	1.74	%



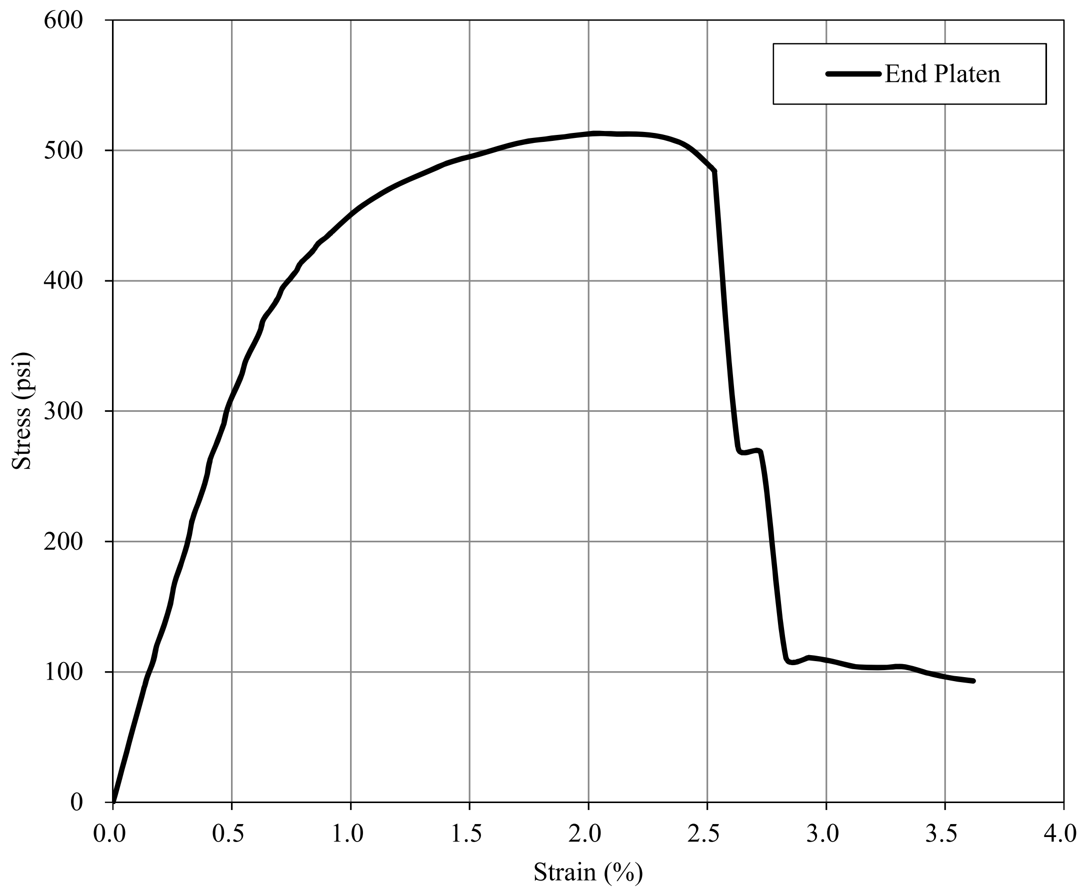
Batch T-2

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.990	in	Peak Stress:	463	psi
Tested by:	RNG	Diameter (initial):	2.052	in	Secant Modulus E_{50EP}:	45,636	psi
I.D. :	T-2-F	Weight:	366.0	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	3 day	Unit Weight:	106	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/24/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in-place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	150.0				End Platen Strain at failure, εf :	1.34	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



Batch T-2

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.941	in	Peak Stress:	510	psi
Tested by:	RNG	Diameter (initial):	2.047	in	Secant Modulus E_{50EP}:	63,899	psi
I.D. :	T-2-A	Weight:	363.2	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	7 day	Unit Weight:	107	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/28/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	110.0				End Platen Strain at failure, εf :	2.02	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

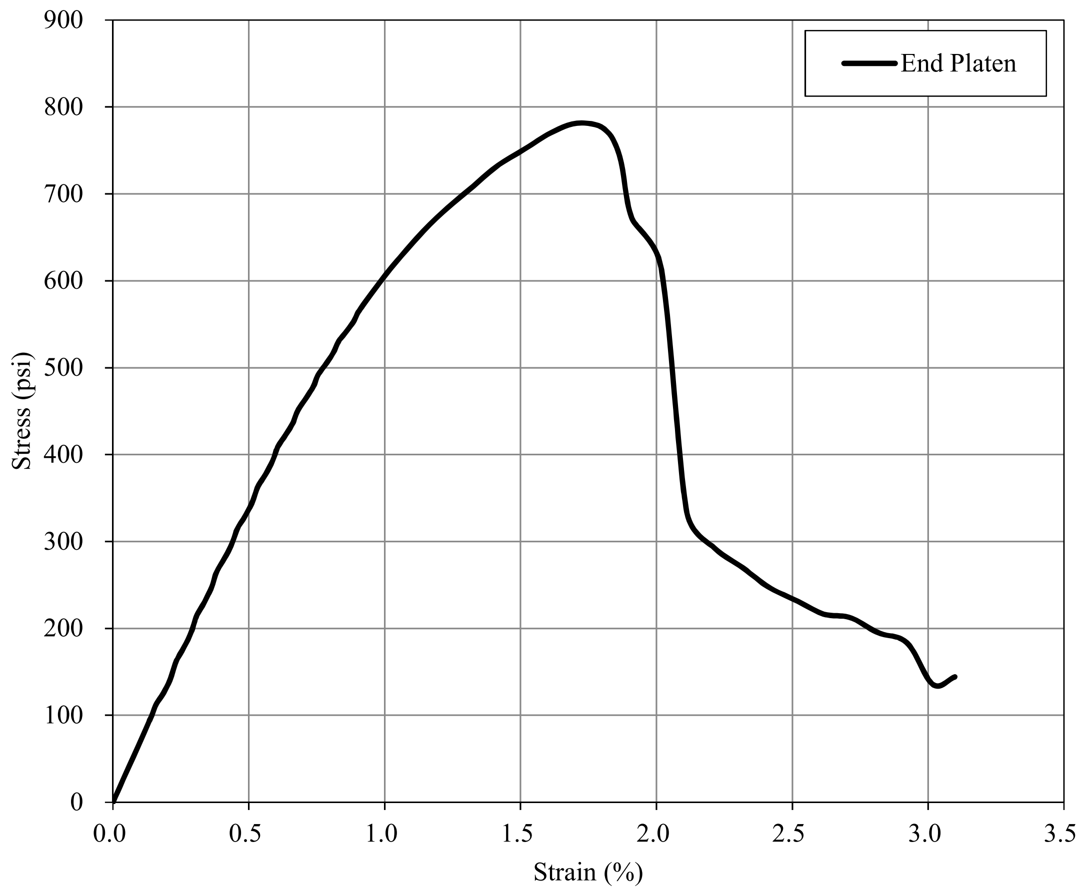


Batch T-2

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	T-2-B
Curing Period:	7 day
Test Date:	2/28/2017
$\alpha_{in-place}$:	275
$(w:c)_{slurry}$:	150.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.948	in
Diameter (initial):	2.049	in
Weight:	362.3	g
Unit Weight:	106	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	777	psi
Secant Modulus E_{50EP}:	66,913	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.71	%

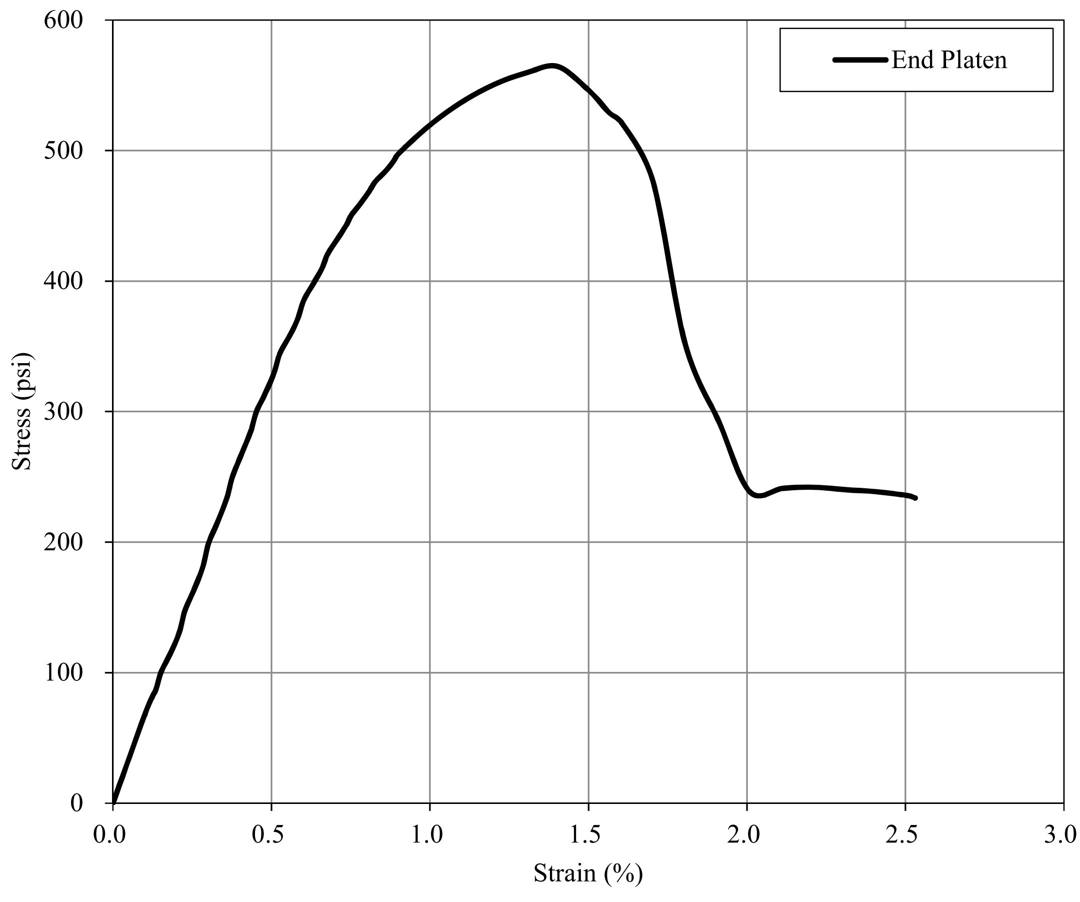


Batch T-2

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	T-2-G
Curing Period:	14 day
Test Date:	3/7/2007
$\alpha_{in\text{-}place}$:	275
$(w:c)_{slurry}$:	110.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.889	in
Diameter (initial):	2.049	in
Weight:	360.0	g
Unit Weight:	107	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	560	psi
Secant Modulus E_{50EP}:	65,617	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.41	%

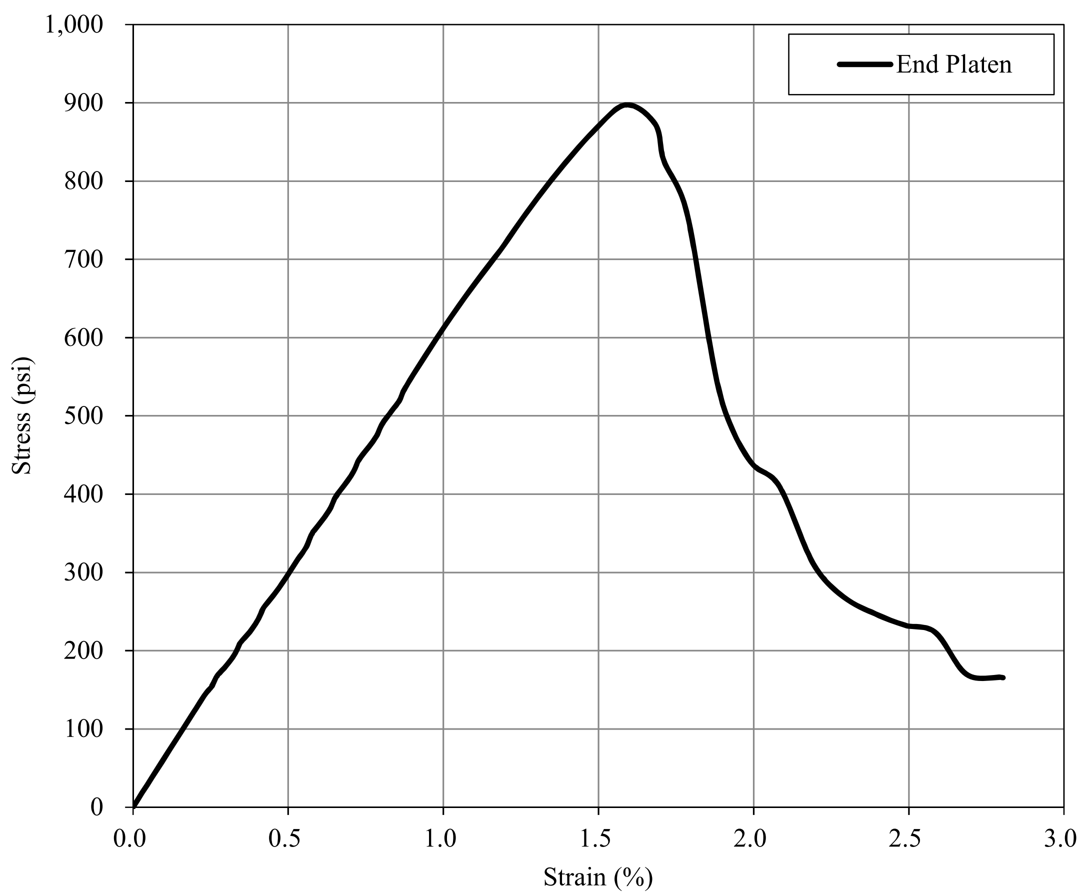


Batch T-2

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	T-2-H
Curing Period:	14 day
Test Date:	3/7/2007
$\alpha_{in\text{-}place}$:	275
$(w:c)_{slurry}$:	150.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.983	in
Diameter (initial):	2.055	in
Weight:	366.3	g
Unit Weight:	106	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	893	psi
Secant Modulus E_{50EP}:	60,866	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.59	%

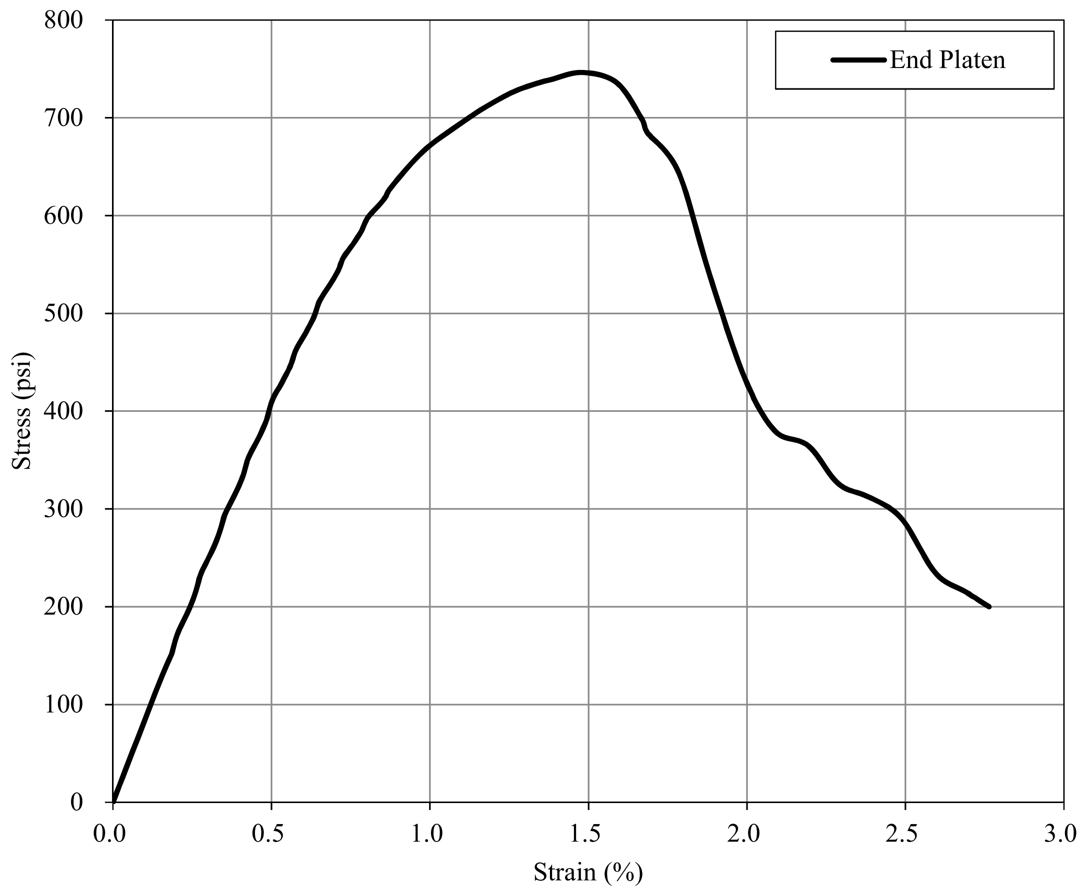


Batch T-2

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	T-2-C
Curing Period:	28 day
Test Date:	3/21/2017
$\alpha_{in\text{-}place}$:	275
$(w{:}c)_{slurry}$:	110.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

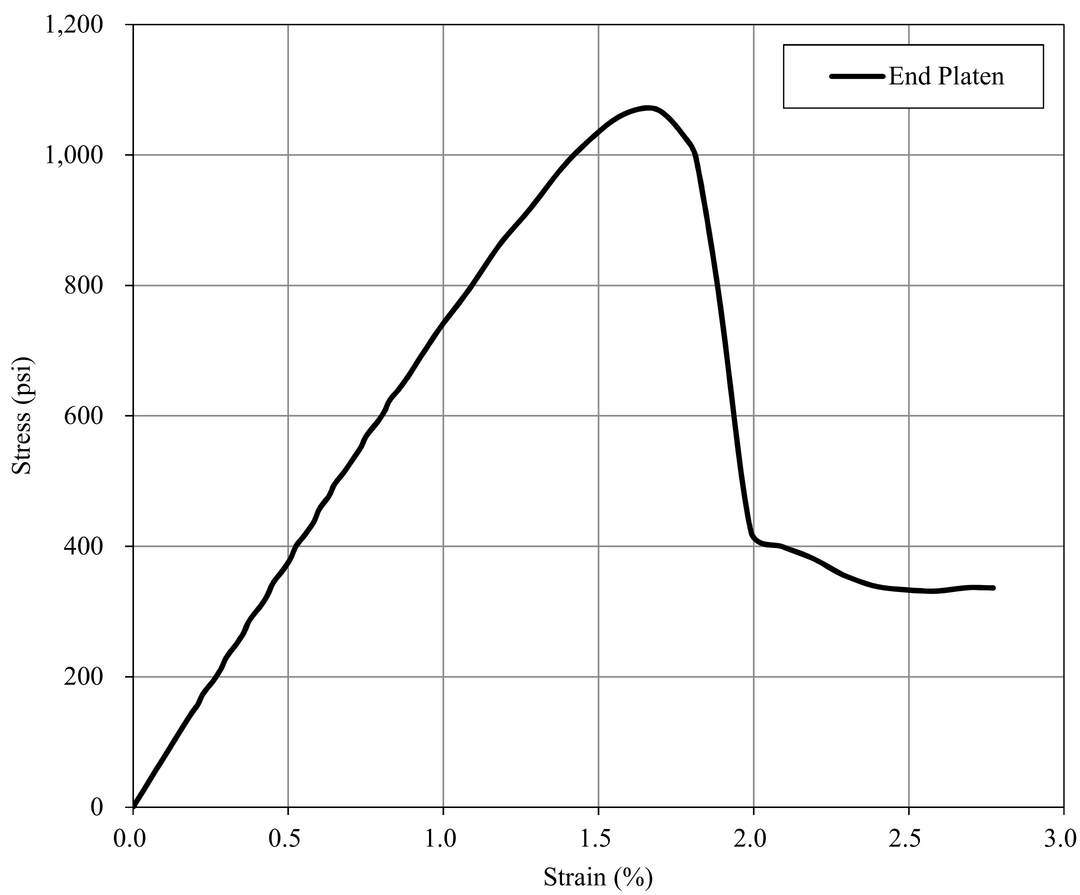
Specimen Information		
Height (initial):	3.956	in
Diameter (initial):	2.048	in
Weight:	367.2	g
Unit Weight:	107	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	742	psi
Secant Modulus E_{50EP}:	81,163	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.48	%



Batch T-2

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.971	in	Peak Stress:	1,064	psi
Tested by:	RNG	Diameter (initial):	2.052	in	Secant Modulus E_{50EP}:	75,290	psi
I.D. :	T-2-D	Weight:	366.0	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	106	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	3/21/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	150.0				End Platen Strain at failure, εf :	1.69	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						

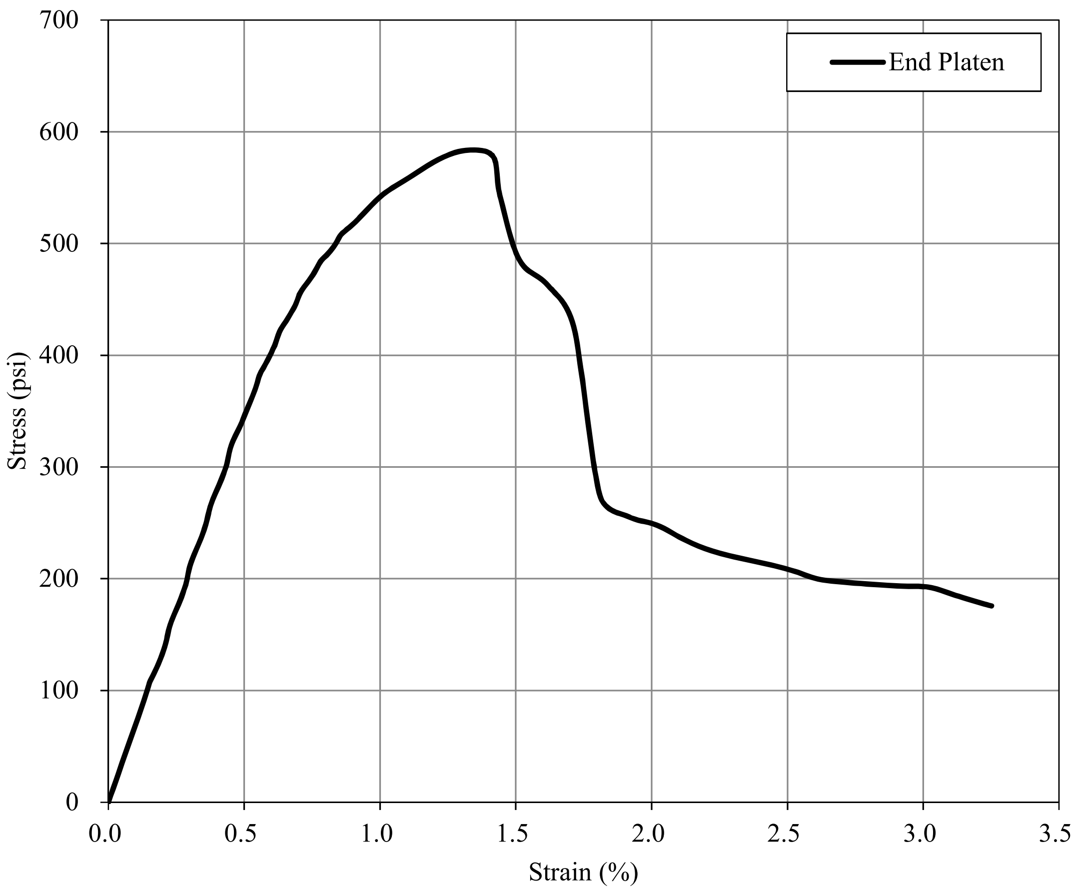


Batch T-2

Test Information	
Type of Test:	UCS Test
Tested by:	RNG
I.D. :	T-2-I
Curing Period:	14 day
Test Date:	3/7/2007
$\alpha_{in\text{-}place}$:	275
$(w:c)_{slurry}$:	110.0
End Treatment:	Grinding
Confining Pressure (psi):	N/A
Strain Rate:	1 %/min

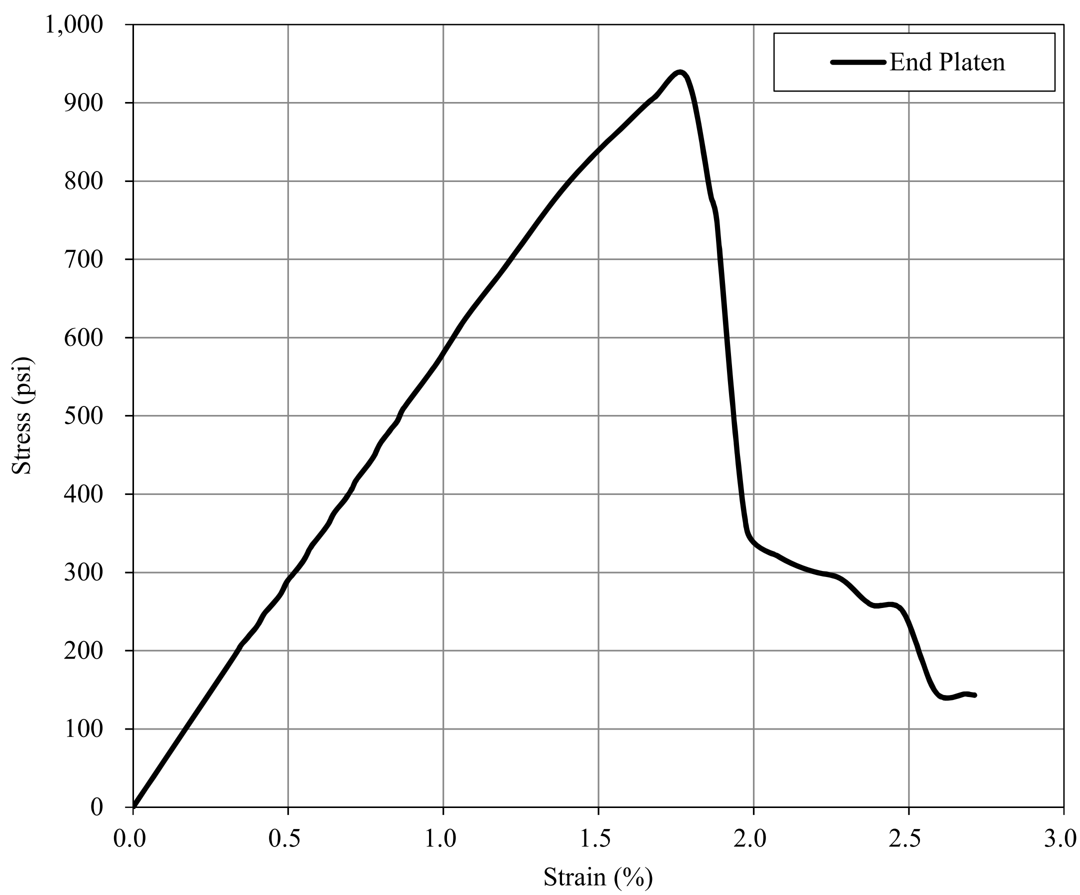
Specimen Information		
Height (initial):	3.961	in
Diameter (initial):	2.048	in
Weight:	367.5	g
Unit Weight:	107	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	580	psi
Secant Modulus E_{50EP}:	69,578	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.31	%



Batch T-2

Test Information		Specimen Information			Test Summary		
Type of Test:	UCS Test	Height (initial):	3.979	in	Peak Stress:	929	psi
Tested by:	RNG	Diameter (initial):	2.050	in	Secant Modulus E_{50EP}:	58,310	psi
I.D. :	T-2-J	Weight:	366	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	14 day	Unit Weight:	106	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	3/7/2007	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	150.0				End Platen Strain at failure, εf :	1.78	%
End Treatment:	Grinding						
Confining Pressure (psi):	N/A						
Strain Rate:	1 %/min						



Appendix G: Unconsolidated-Undrained Triaxial Tests Data Sheets and Results

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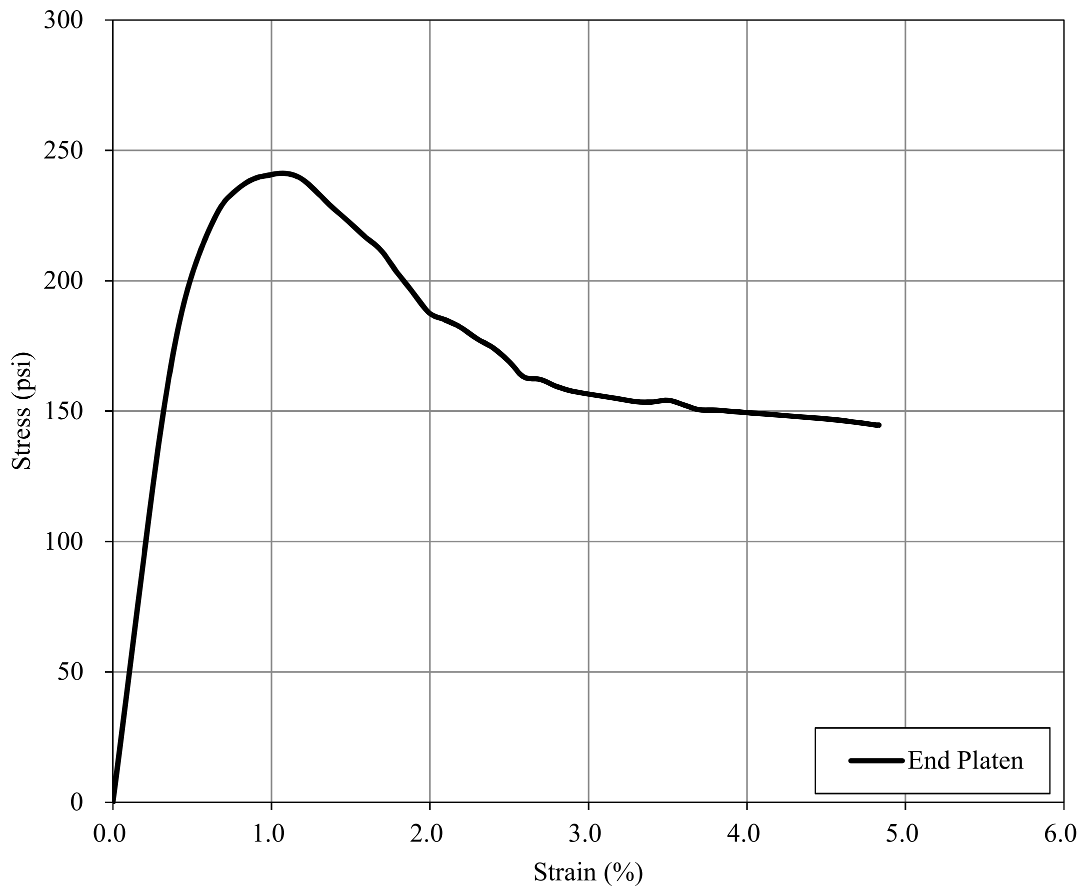
Batch U-1

Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-1-A
Curing Period:	28 day
Test Date:	2/24/2017
$\alpha_{in\text{-}place}$:	125
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	5
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.949	in
Diameter (initial):	2.036	in
Weight:	372.5	g
Unit Weight:	110	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	241	psi
Secant Modulus E_{50EP}:	47,891	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.08	%

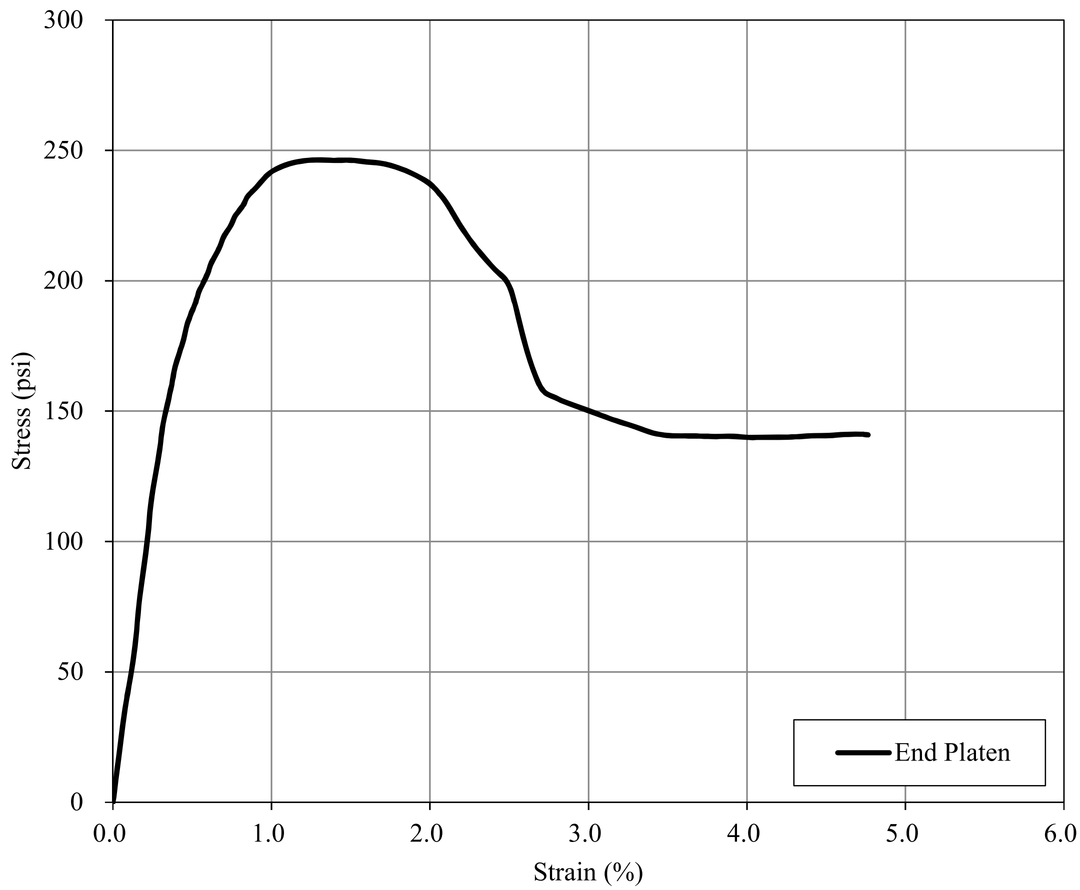


Batch U-1

Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-1-B
Curing Period:	28 day
Test Date:	2/24/2017
$\alpha_{in\text{-}place}$:	125
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	5
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.955	in
Diameter (initial):	2.038	in
Weight:	372.8	g
Unit Weight:	110	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	246	psi
Secant Modulus E_{50EP}:	47,103	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.30	%

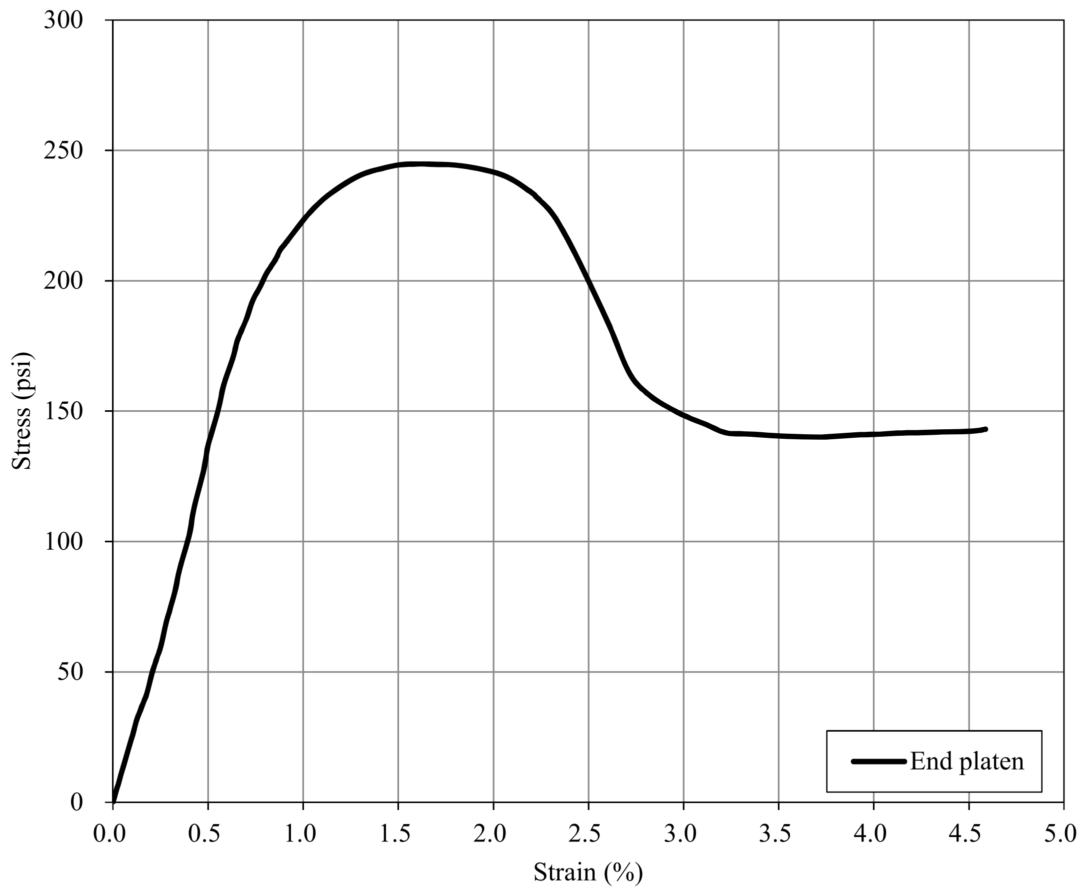


Batch U-1

Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-1-C
Curing Period:	28 day
Test Date:	2/24/2017
$\alpha_{in\text{-}place}$:	125
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	5
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.939	in
Diameter (initial):	2.036	in
Weight:	371.0	g
Unit Weight:	110	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	245	psi
Secant Modulus E_{50EP}:	26,656	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.61	%

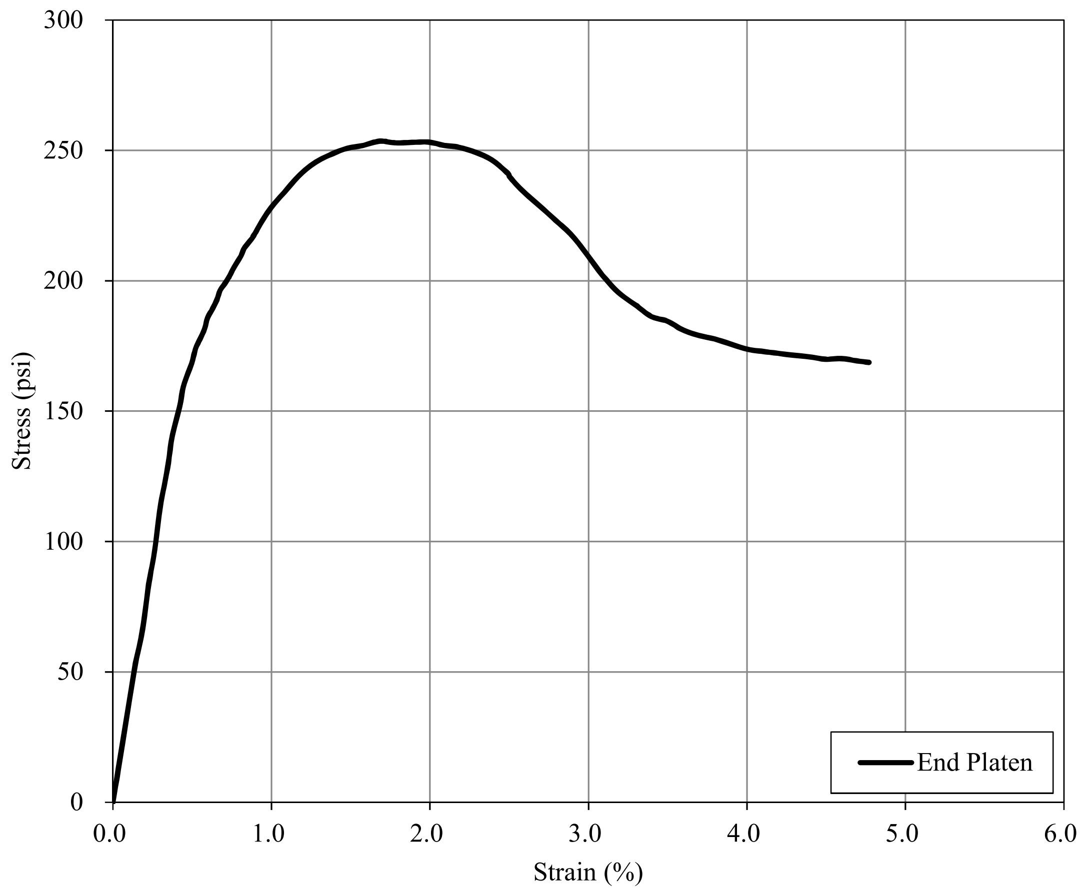


Batch U-1

Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-1-D
Curing Period:	28 day
Test Date:	2/24/2017
$\alpha_{in\text{-}place}$:	125
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	10
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.941	in
Diameter (initial):	2.036	in
Weight:	371.0	g
Unit Weight:	110	pcf
Gage Length:	N/A	in

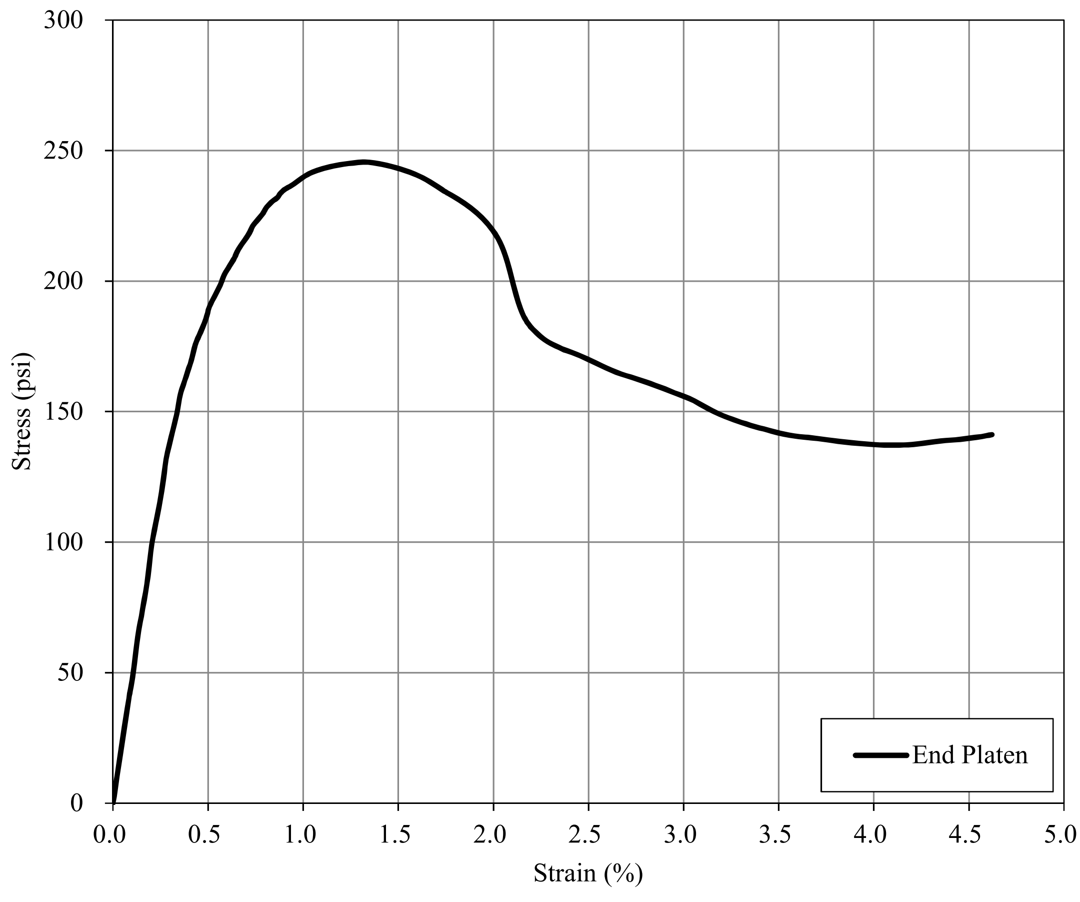
Test Summary		
Peak Stress:	254	psi
Secant Modulus E_{50EP}:	37,349	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.68	%



Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-1-E
Curing Period:	28 day
Test Date:	2/24/2017
$\alpha_{in\text{-}place}$:	125
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	10
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.925	in
Diameter (initial):	2.037	in
Weight:	371.5	g
Unit Weight:	111	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	246	psi
Secant Modulus E_{50EP}:	46,760	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.34	%

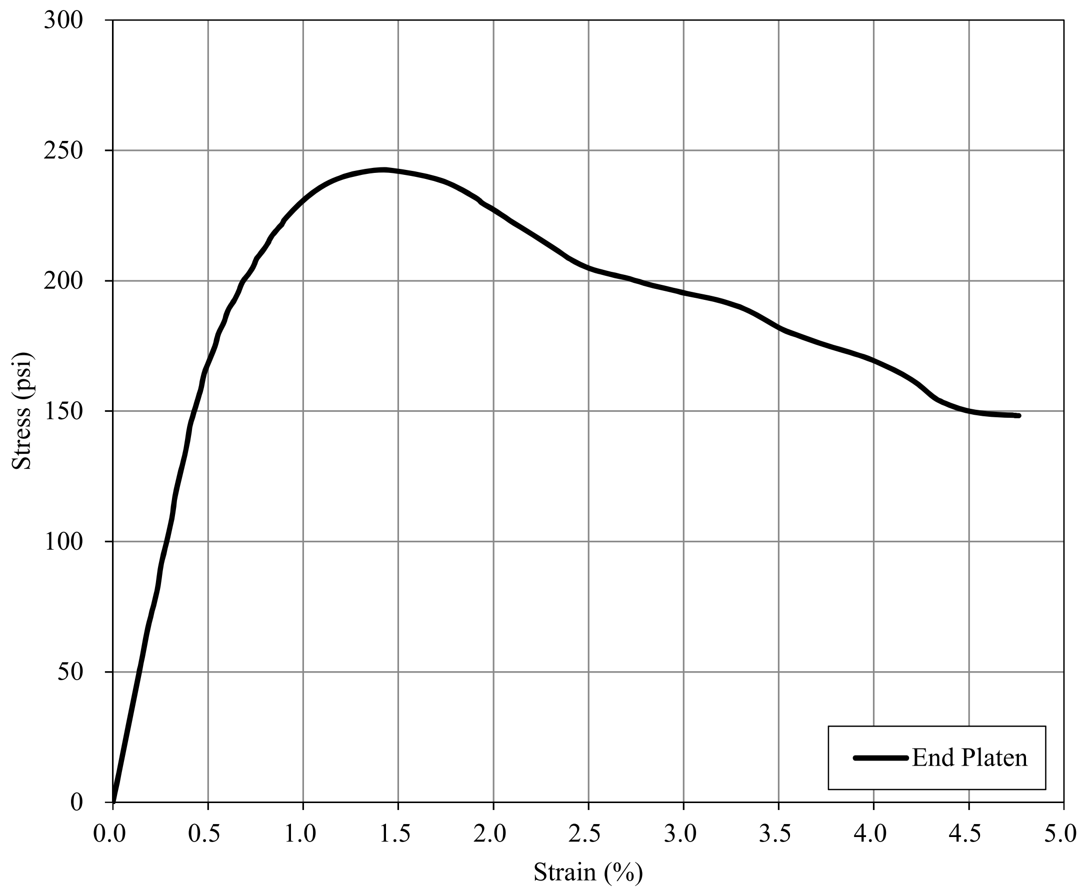


Batch U-1

Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-1-F
Curing Period:	28 day
Test Date:	2/24/2017
$\alpha_{in\text{-}place}$:	125
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	10
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.935	in
Diameter (initial):	2.037	in
Weight:	371.1	g
Unit Weight:	110	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	243	psi
Secant Modulus E_{50EP}:	35,837	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.41	%

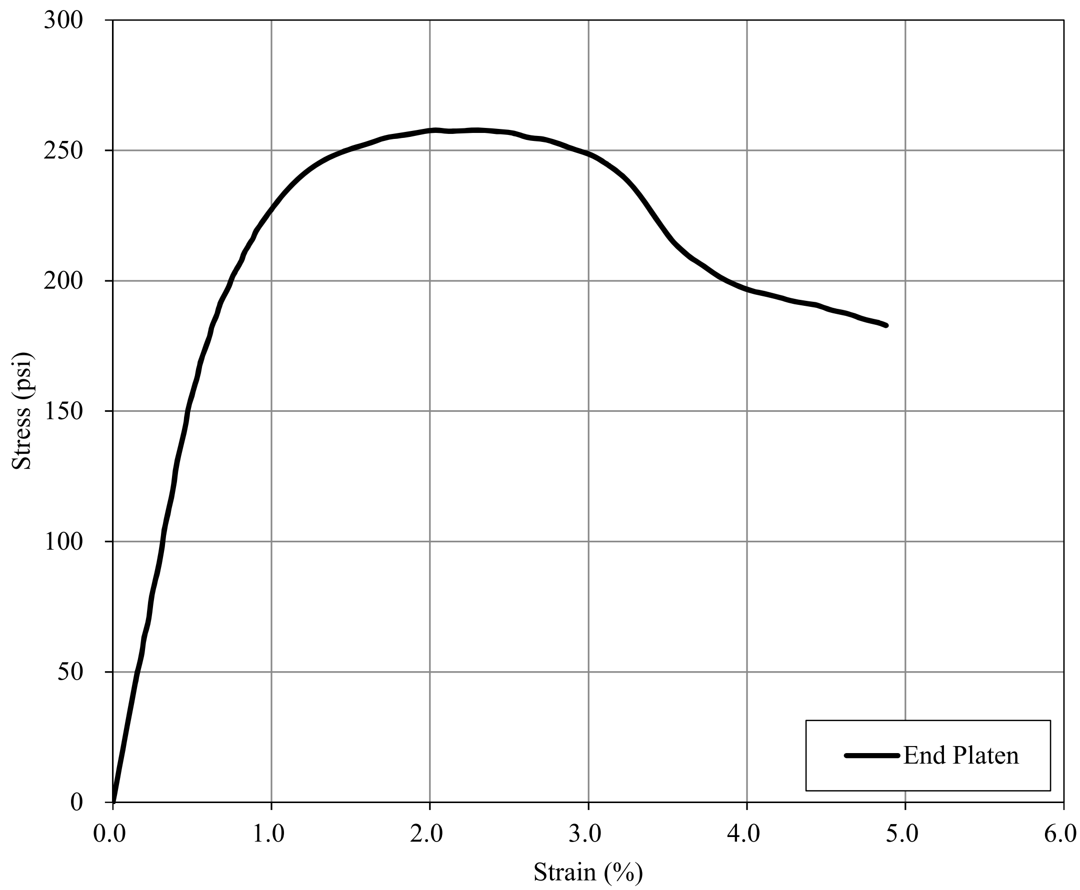


Batch U-1

Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-1-G
Curing Period:	28 day
Test Date:	2/24/2017
$\alpha_{in\text{-}place}$:	125
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	20
Strain Rate:	1 %/min

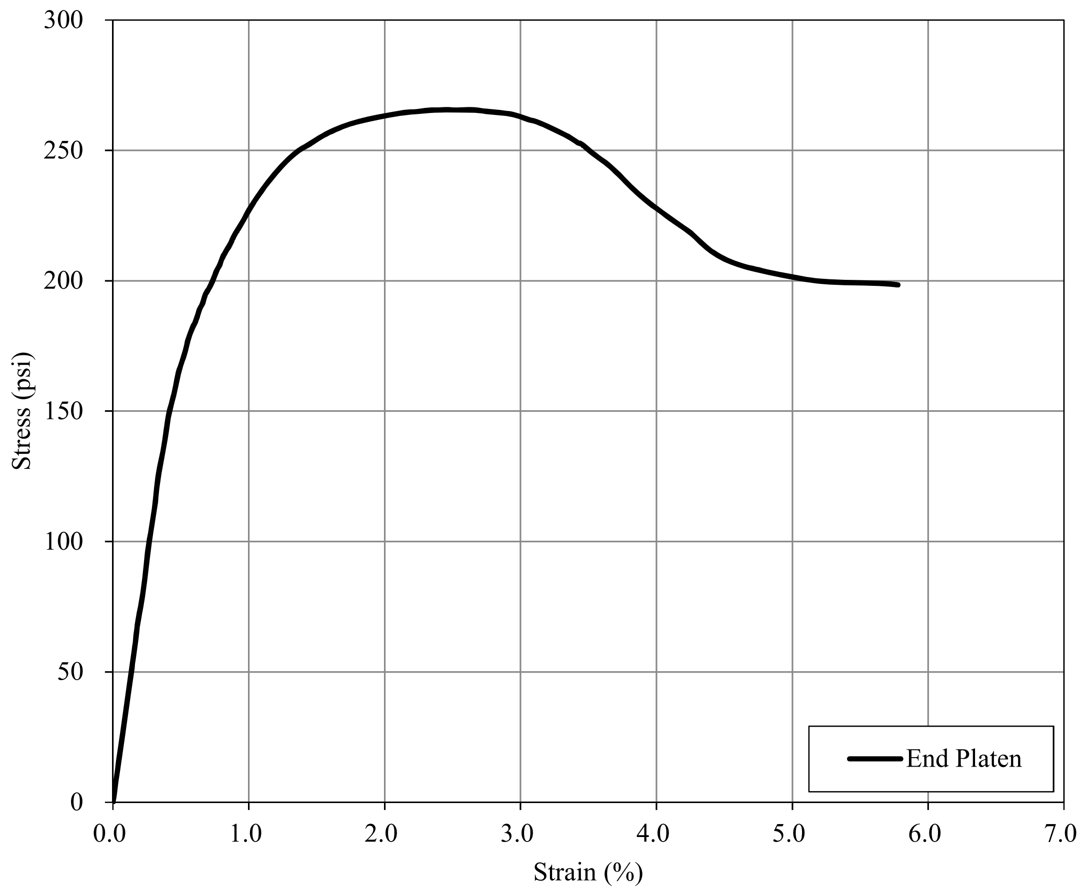
Specimen Information		
Height (initial):	3.933	in
Diameter (initial):	2.036	in
Weight:	371.2	g
Unit Weight:	110	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	258	psi
Secant Modulus E_{50EP}:	32,273	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	2.32	%



Batch U-1

Test Information		Specimen Information			Test Summary		
Type of Test:	UU Test	Height (initial):	3.941	in	Peak Stress:	266	psi
Tested by:	RNG	Diameter (initial):	2.038	in	Secant Modulus E_{50EP}:	36,895	psi
I.D. :	U-1-H	Weight:	371.7	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	110	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/24/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	125				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	2.64	%
End Treatment:	Grinding						
Confining Pressure (psi):	20						
Strain Rate:	1 %/min						

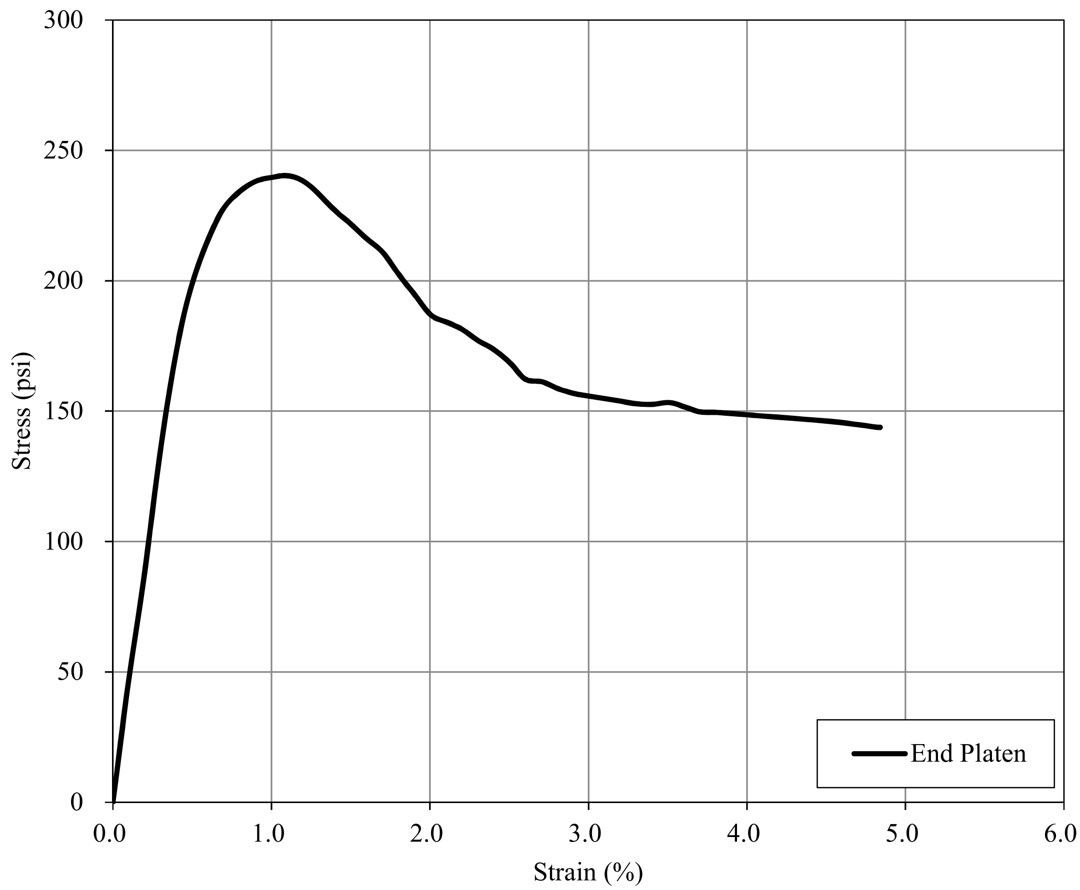


Batch U-1

Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-1-I
Curing Period:	28 day
Test Date:	2/24/2017
$\alpha_{in\text{-}place}$:	125
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	20
Strain Rate:	1 %/min

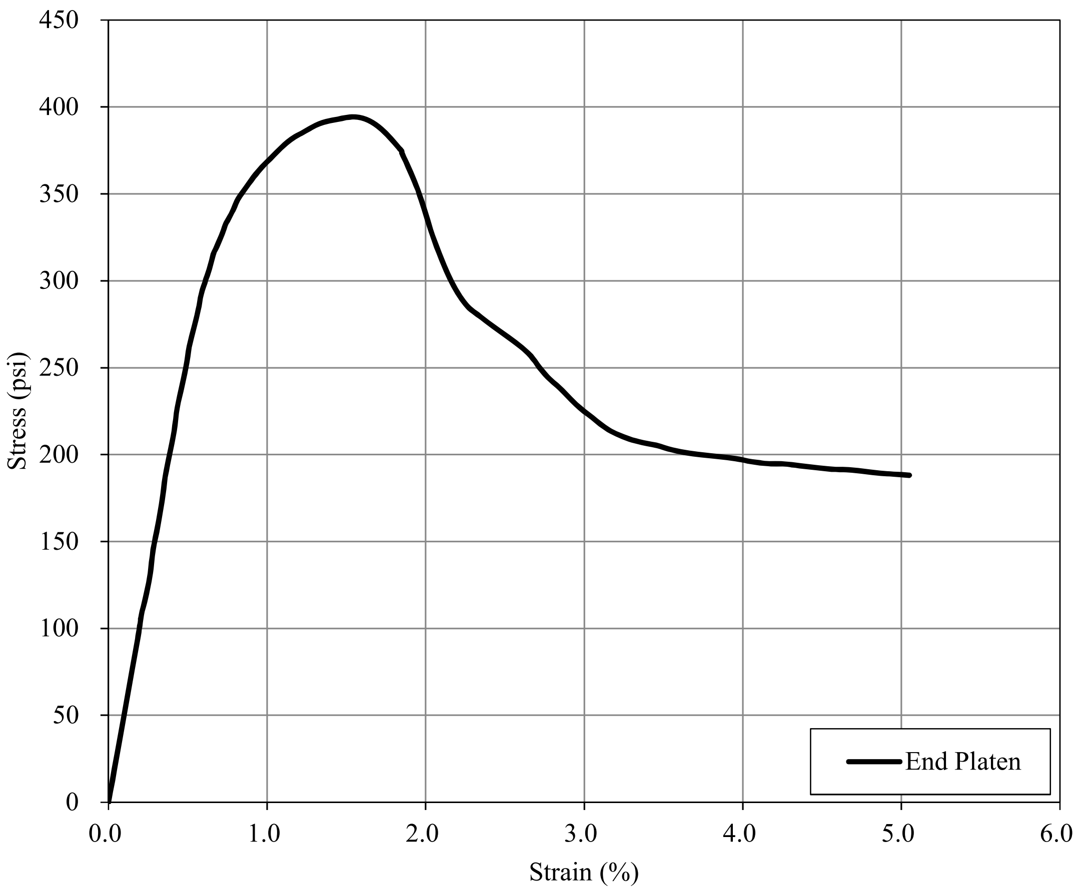
Specimen Information		
Height (initial):	3.955	in
Diameter (initial):	2.036	in
Weight:	374.4	g
Unit Weight:	111	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	240	psi
Secant Modulus E_{50EP}:	44,908	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.10	%



Batch U-2

Test Information		Specimen Information			Test Summary		
Type of Test:	UU Test	Height (initial):	3.941	in	Peak Stress:	394	psi
Tested by:	RNG	Diameter (initial):	2.037	in	Secant Modulus E_{50EP}:	52,079	psi
I.D. :	U-2-A	Weight:	367.4	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	109	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/27/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	200				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.55	%
End Treatment:	Grinding						
Confining Pressure (psi):	5						
Strain Rate:	1 %/min						

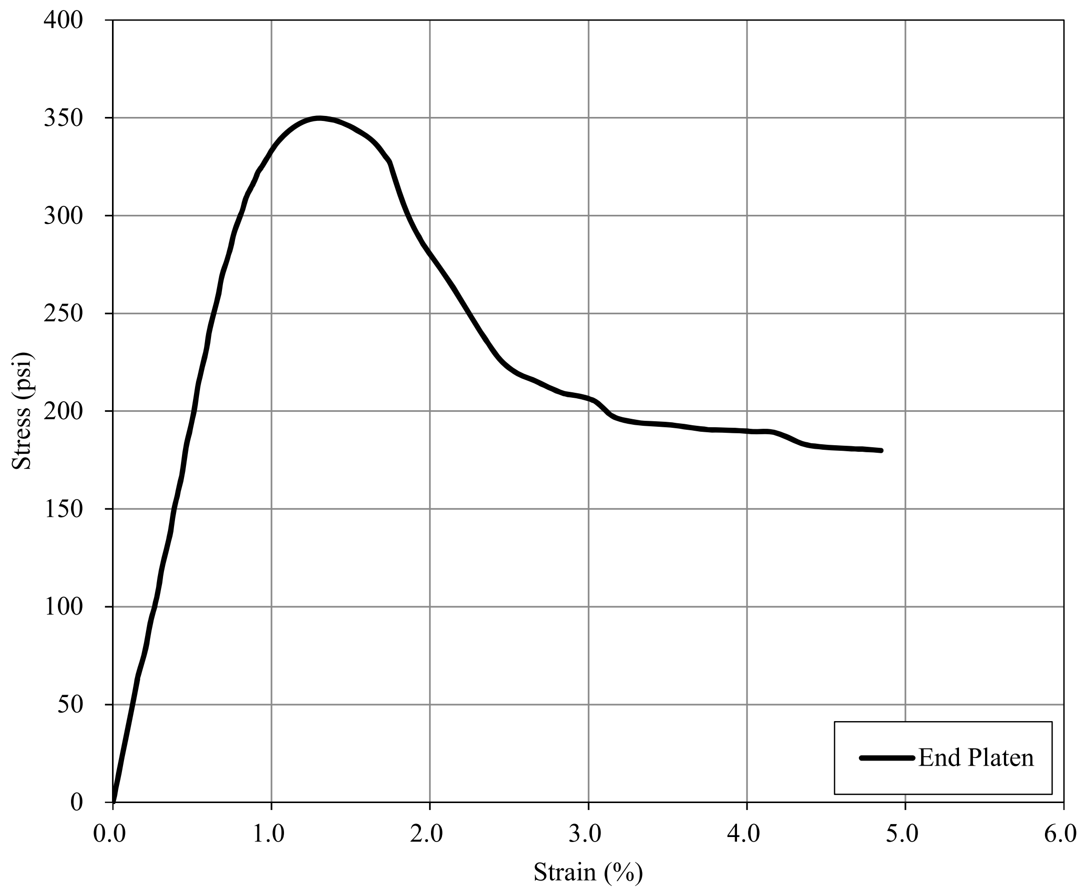


Batch U-2

Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-2-B
Curing Period:	28 day
Test Date:	2/27/2017
$\alpha_{in\text{-}place}$:	200
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	5
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.961	in
Diameter (initial):	2.035	in
Weight:	369.9	g
Unit Weight:	109	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	350	psi
Secant Modulus E_{50EP}:	38,983	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.34	%

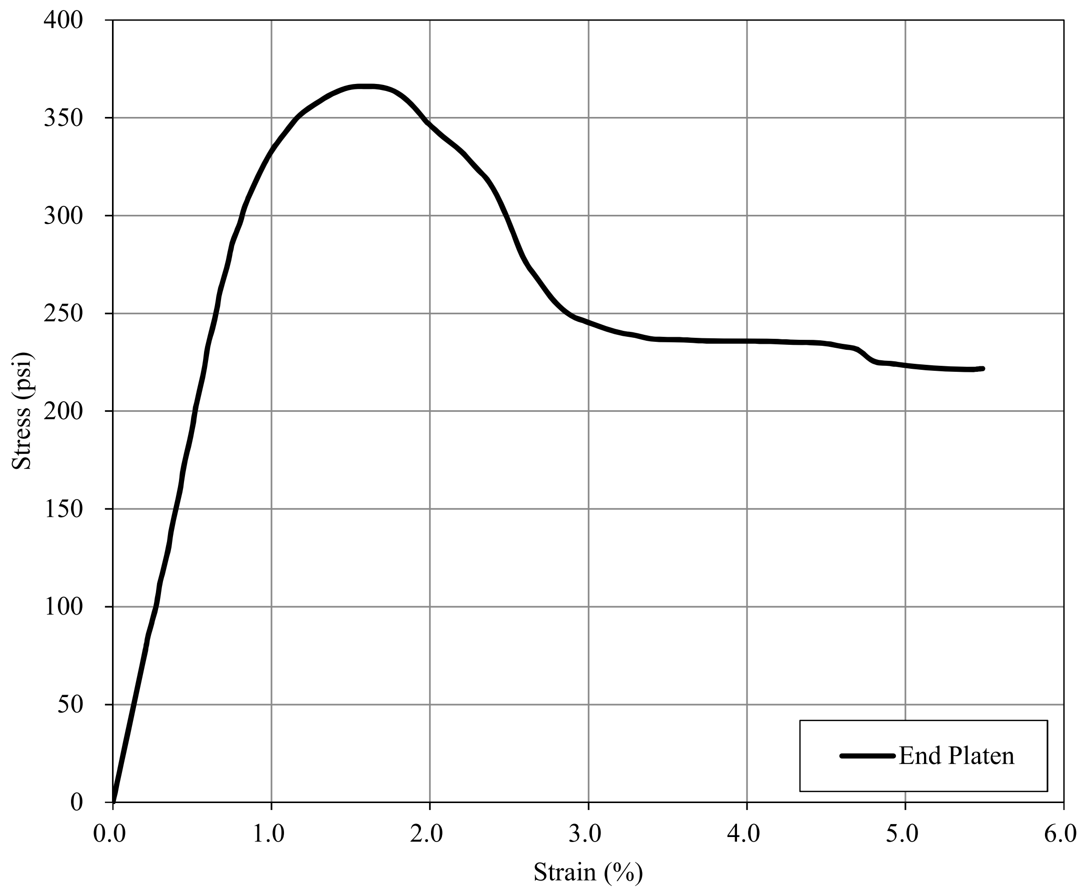


Batch U-2

Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-2-C
Curing Period:	28 day
Test Date:	2/27/2017
$\alpha_{in\text{-}place}$:	200
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	10
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.944	in
Diameter (initial):	2.035	in
Weight:	367.9	g
Unit Weight:	109	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	366	psi
Secant Modulus E_{50EP}:	38,267	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.58	%

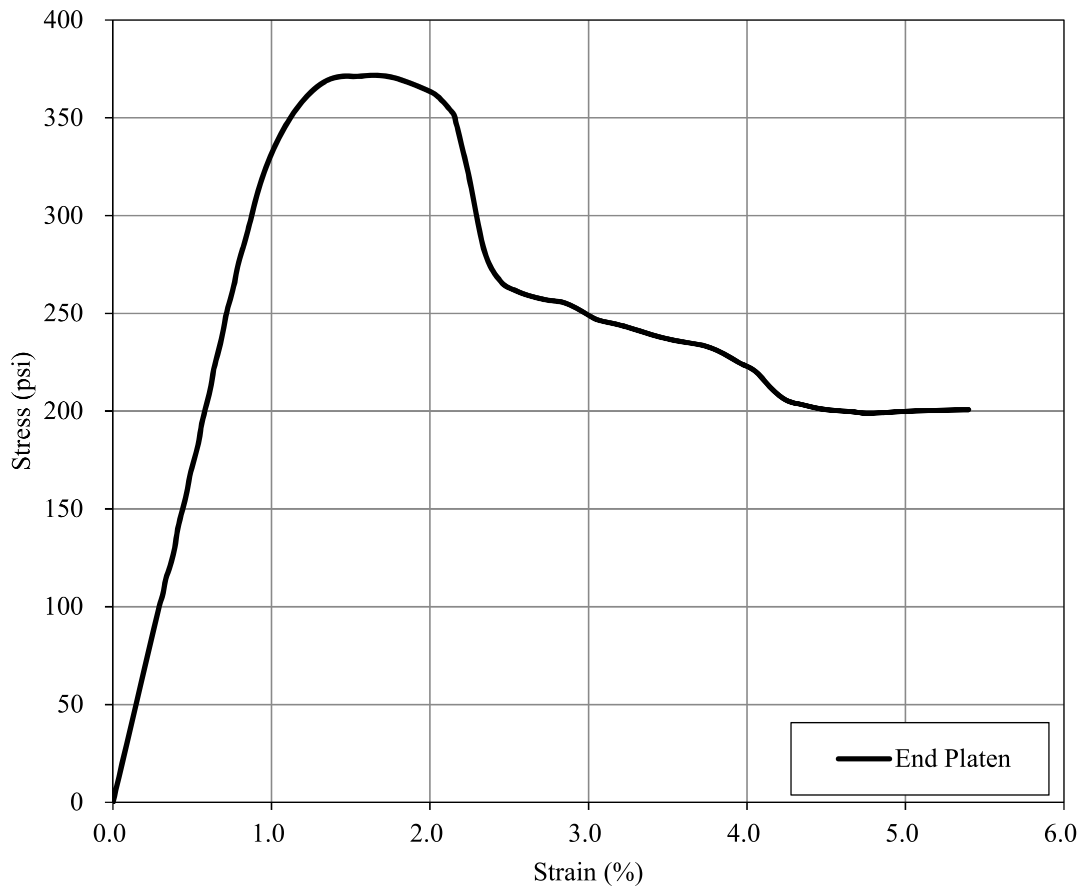


Batch U-2

Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-2-D
Curing Period:	28 day
Test Date:	2/27/2017
$\alpha_{in\text{-}place}$:	200
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	10
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.951	in
Diameter (initial):	2.035	in
Weight:	369.0	g
Unit Weight:	109	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	372	psi
Secant Modulus E_{50EP}:	34,177	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.65	%

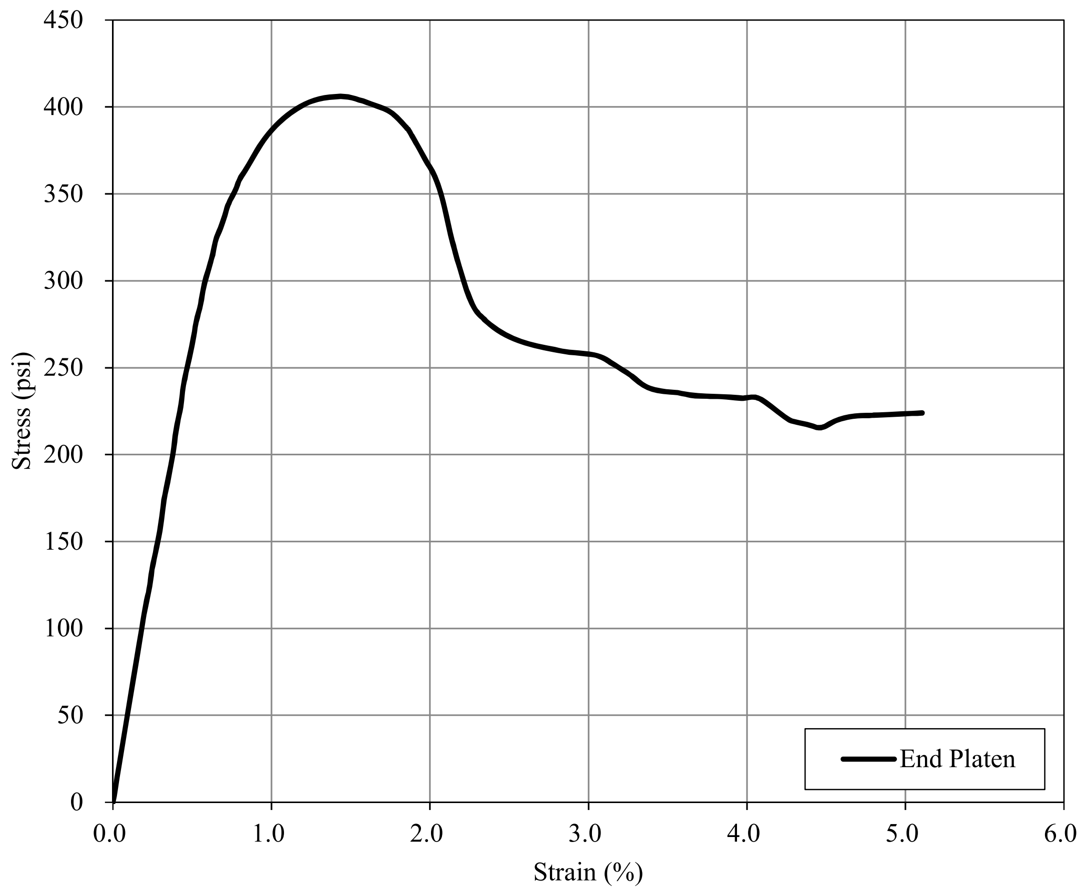


Batch U-2

Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-2-E
Curing Period:	28 day
Test Date:	2/27/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	20
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.951	in
Diameter (initial):	2.035	in
Weight:	368.2	g
Unit Weight:	109	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	406	psi
Secant Modulus E_{50EP}:	53,174	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.46	%

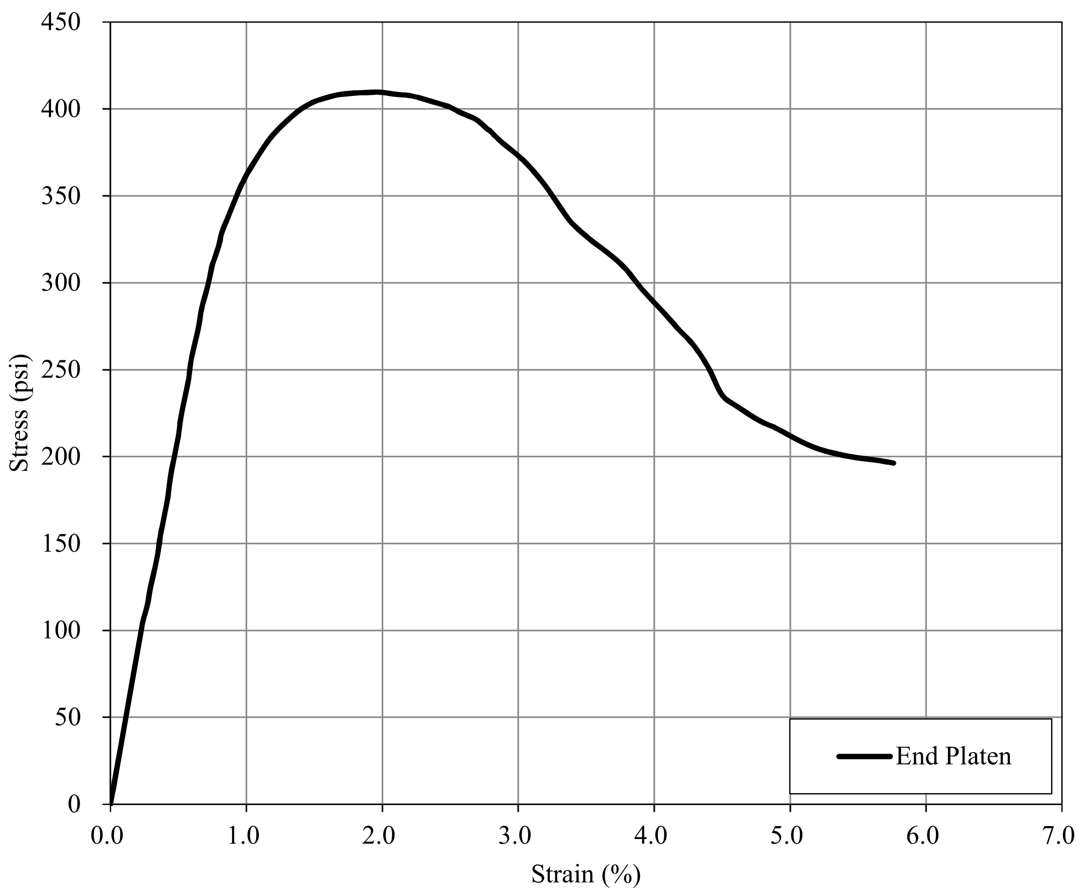


Batch U-2

Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-2-F
Curing Period:	28 day
Test Date:	2/27/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	20
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.953	in
Diameter (initial):	2.036	in
Weight:	368.5	g
Unit Weight:	109	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	410	psi
Secant Modulus E_{50EP}:	42,516	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.98	%

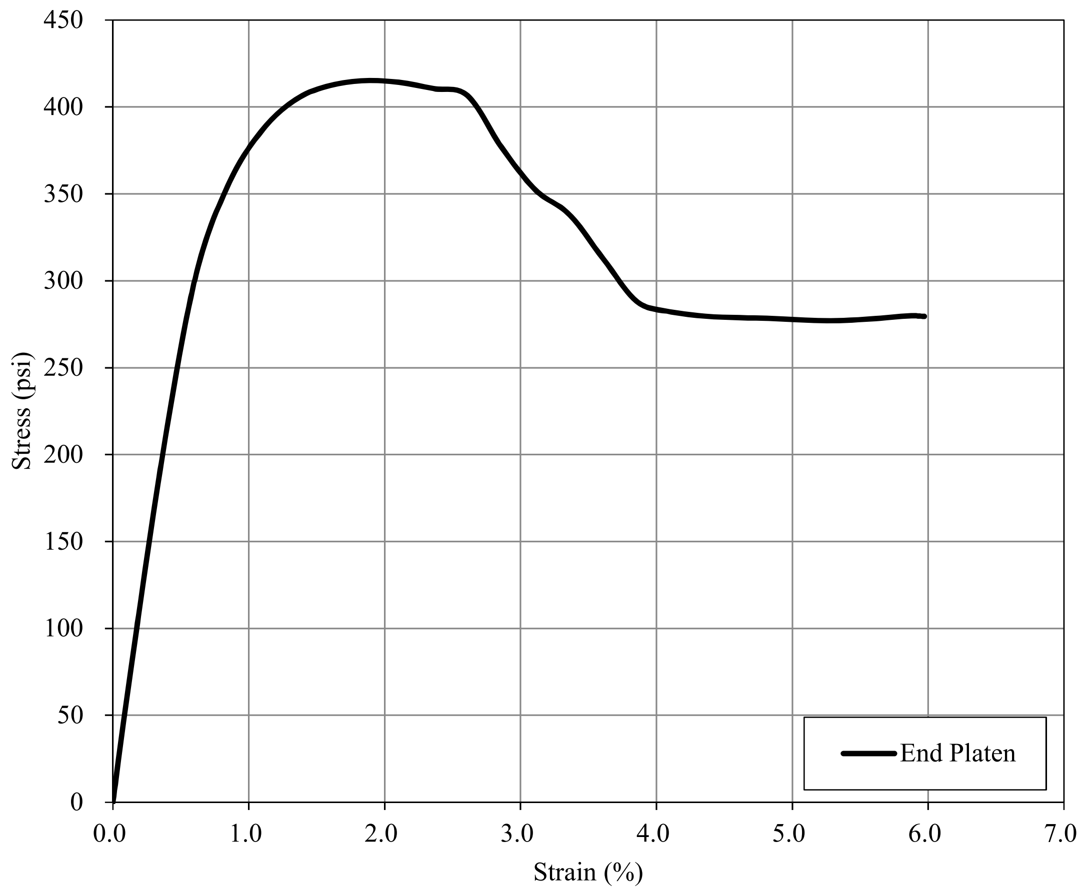


Batch U-2

Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-2-G
Curing Period:	28 day
Test Date:	2/27/2017
$\alpha_{in\text{-}place}$:	200
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	40
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.936	in
Diameter (initial):	2.035	in
Weight:	366.5	g
Unit Weight:	109	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	415	psi
Secant Modulus E_{50EP}:	53,953	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.86	%

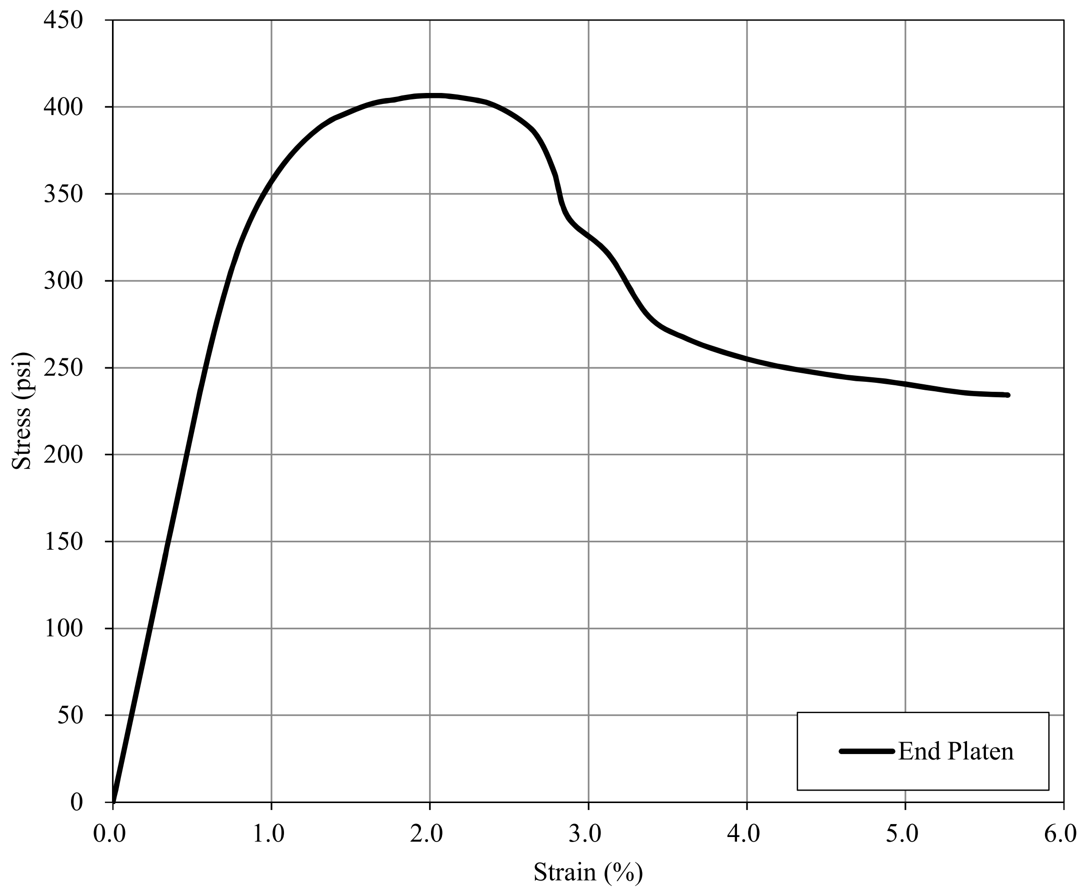


Batch U-2

Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-2-H
Curing Period:	28 day
Test Date:	2/27/2017
$\alpha_{in\text{-}place}$:	200
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	40
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.95	in
Diameter (initial):	2.038	in
Weight:	368.4	g
Unit Weight:	109	pcf
Gage Length:	N/A	in

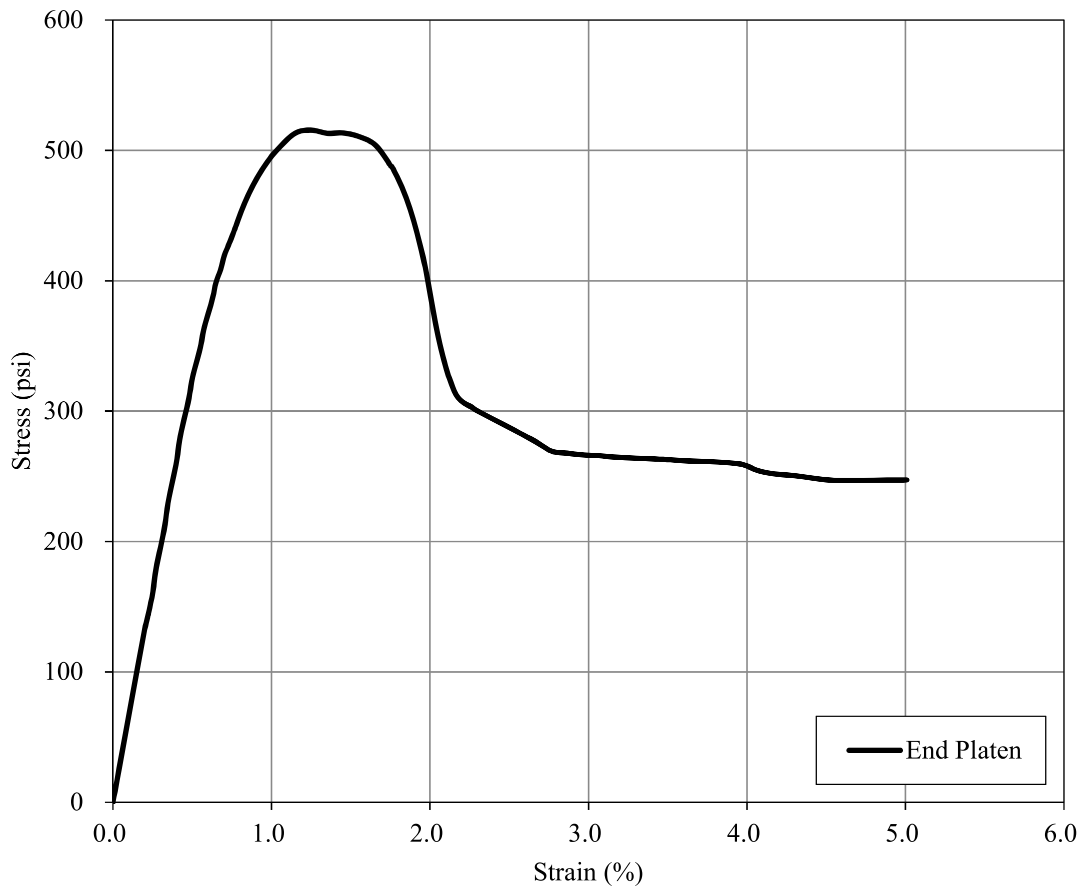
Test Summary		
Peak Stress:	407	psi
Secant Modulus E_{50EP}:	42,965	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	2.07	%



Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-3-A
Curing Period:	28 day
Test Date:	2/27/2017
$\alpha_{in\text{-}place}$:	275
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	5
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.923	in
Diameter (initial):	2.037	in
Weight:	360.6	g
Unit Weight:	107	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	515	psi
Secant Modulus E_{50EP}:	65,351	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.26	%

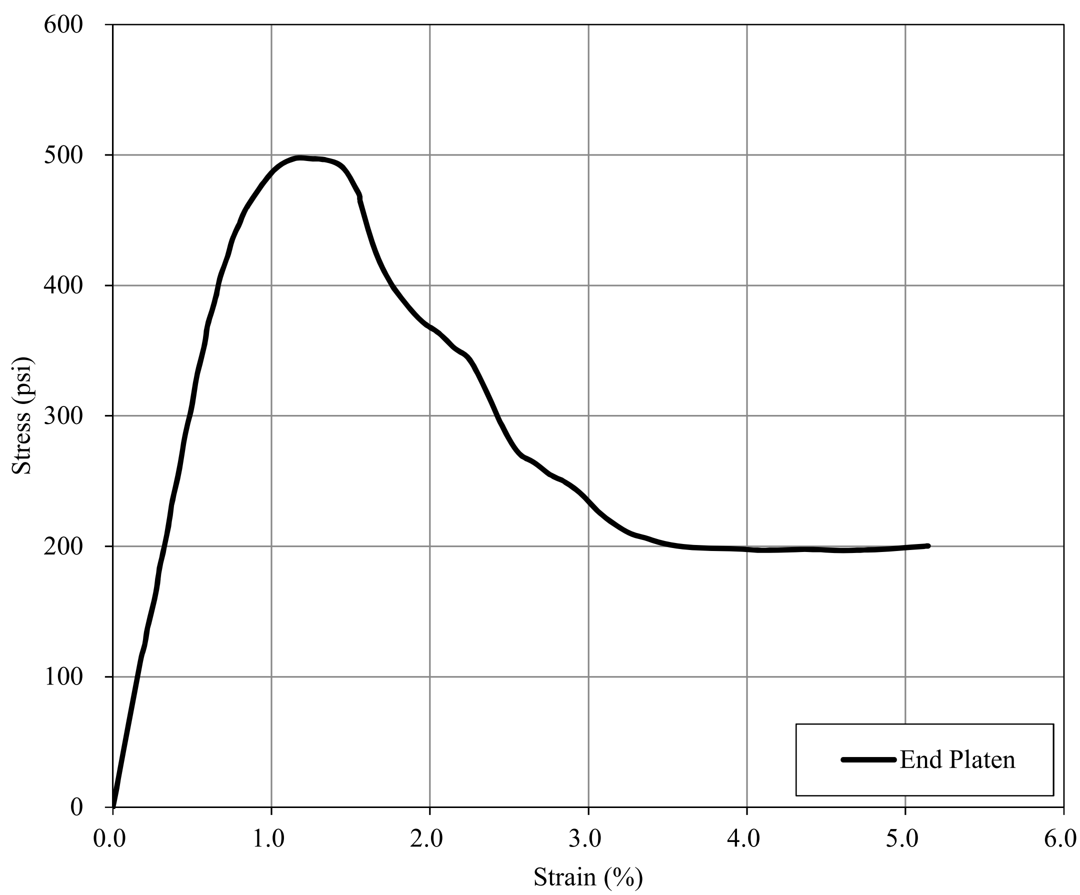


Batch U-3

Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-3-B
Curing Period:	28 day
Test Date:	2/27/2017
$\alpha_{in\text{-}place}$:	275
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	5
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.961	in
Diameter (initial):	2.038	in
Weight:	365.1	g
Unit Weight:	108	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	497	psi
Secant Modulus E_{50EP}:	62,184	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.15	%

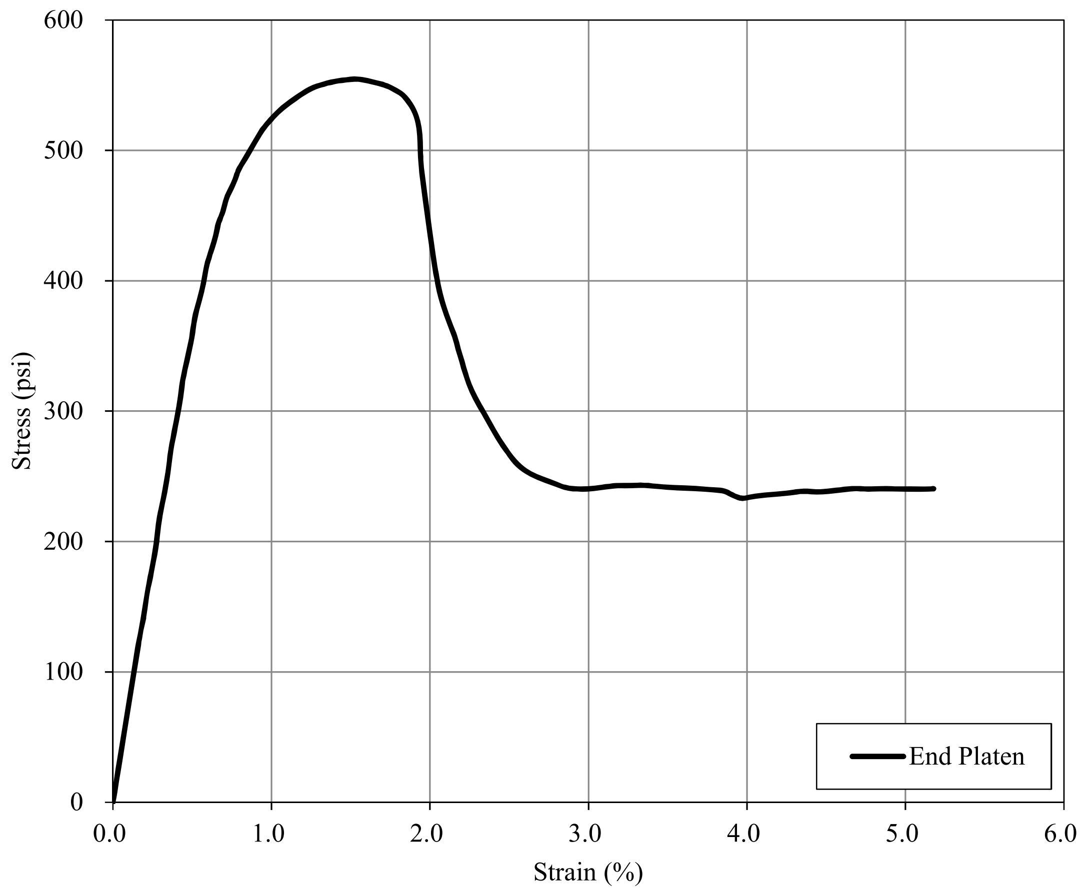


Batch U-3

Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-3-C
Curing Period:	28 day
Test Date:	2/27/2017
$\alpha_{in\text{-}place}$:	275
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	10
Strain Rate:	1 %/min

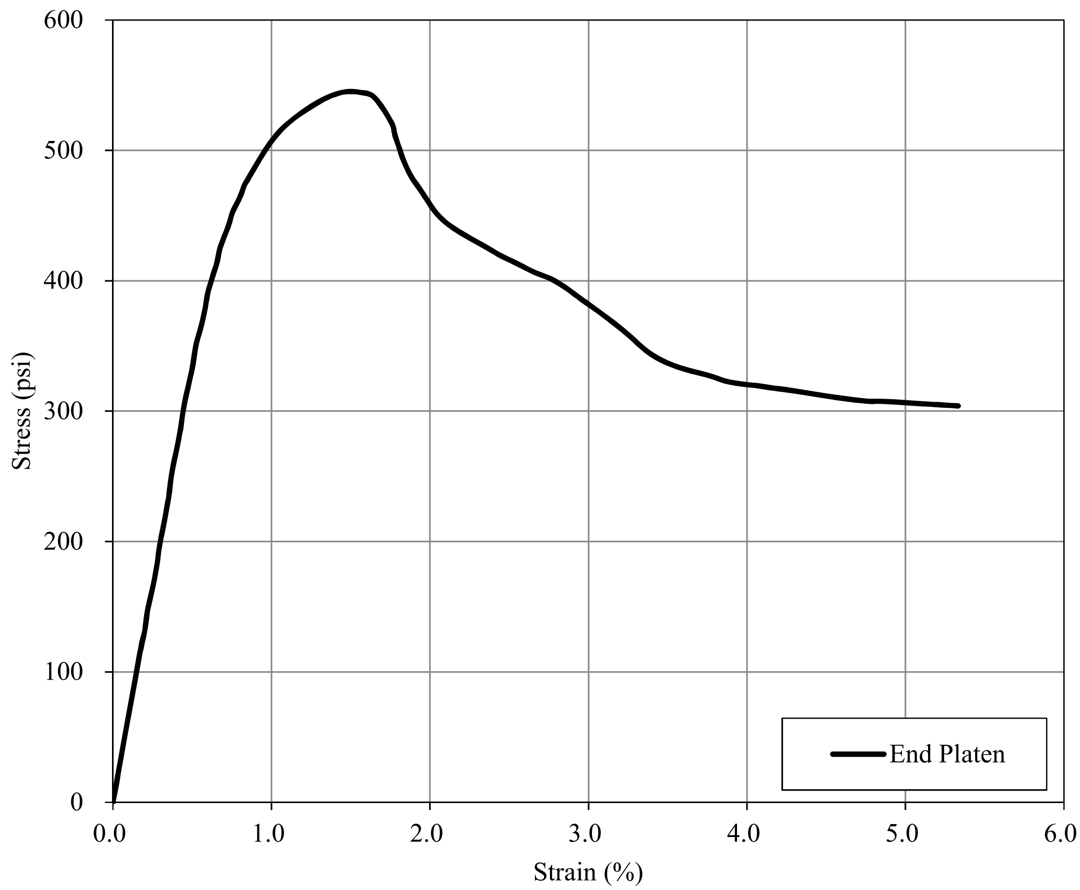
Specimen Information		
Height (initial):	3.957	in
Diameter (initial):	2.036	in
Weight:	364.4	g
Unit Weight:	108	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	555	psi
Secant Modulus E_{50EP}:	73,765	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.55	%

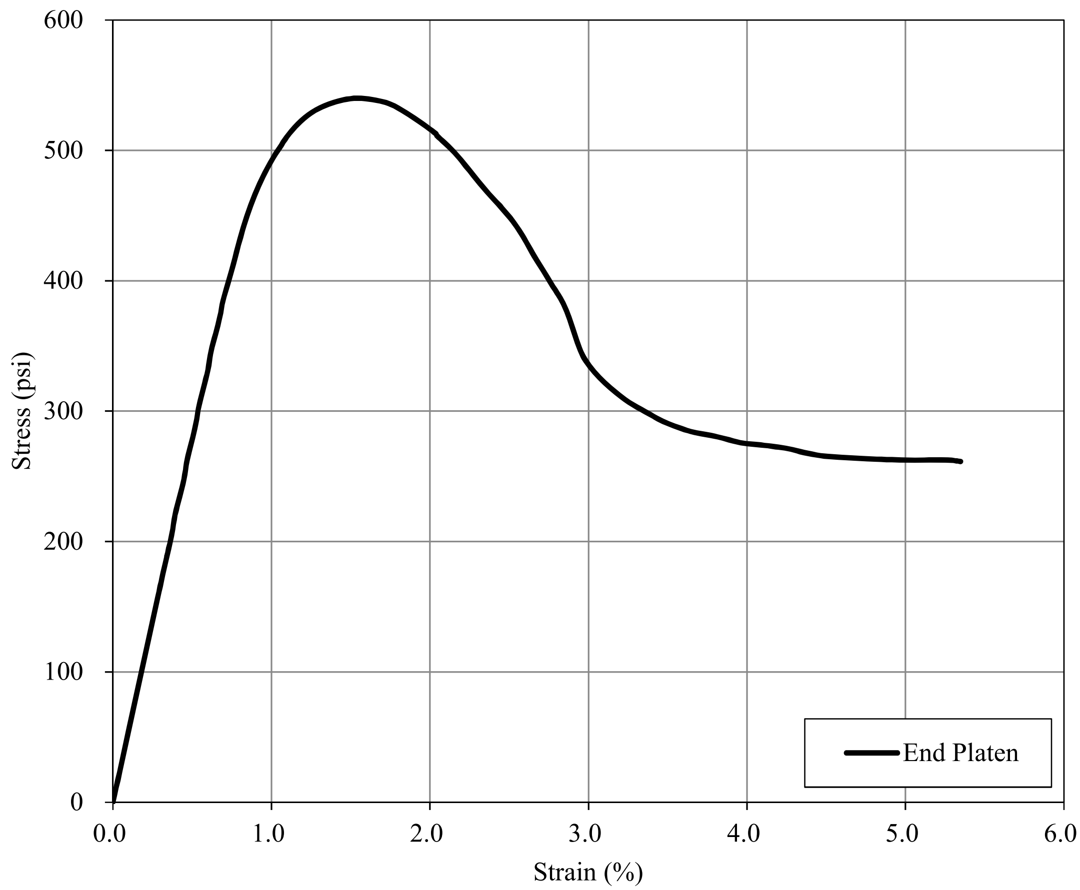


Batch U-3

Test Information		Specimen Information			Test Summary		
Type of Test:	UU Test	Height (initial):	3.939	in	Peak Stress:	545	psi
Tested by:	RNG	Diameter (initial):	2.037	in	Secant Modulus E_{50EP}:	67,470	psi
I.D. :	U-3-D	Weight:	362.3	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	108	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/27/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.45	%
End Treatment:	Grinding						
Confining Pressure (psi):	10						
Strain Rate:	1 %/min						



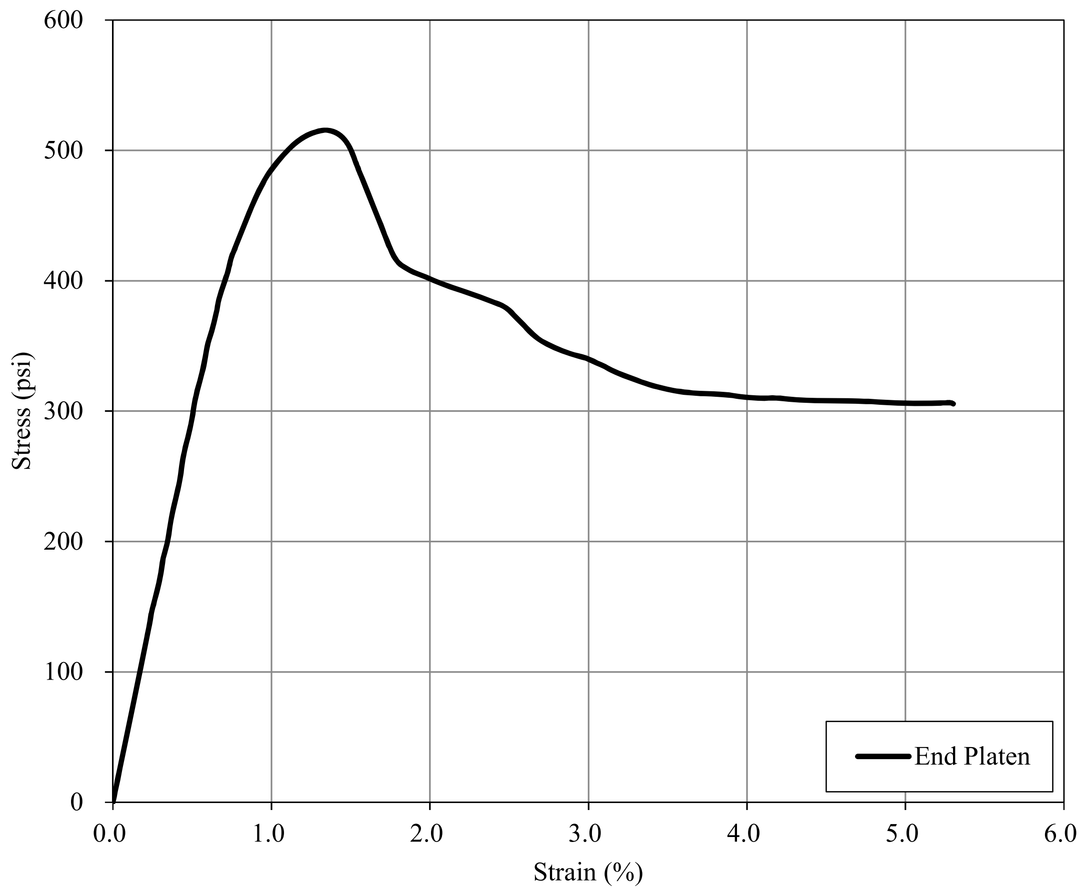
Test Information		Specimen Information			Test Summary		
Type of Test:	UU Test	Height (initial):	3.96	in	Peak Stress:	540	psi
Tested by:	RNG						
I.D. :	U-3-E	Diameter (initial):	2.037	in	Secant Modulus E_{50EP}:	55,918	psi
Curing Period:	28 day						
Test Date:	2/27/2017	Weight:	365.5	g	Secant Modulus E_{50L}:	N/A	psi
$\alpha_{in\text{-}place}$:	275						
$(w:c)_{slurry}$:	1.0	Unit Weight:	108	pcf	Poisson's Ratio ν_{50} :	N/A	
End Treatment:	Grinding	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
Confining Pressure (psi):	20				Local Strain at failure, εf :	N/A	%
Strain Rate:	1 %/min				End Platen Strain at failure, εf :	1.54	%



Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-3-F
Curing Period:	28 day
Test Date:	2/27/2017
$\alpha_{in\text{-}place}$:	275
$(w:c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	20
Strain Rate:	1 %/min

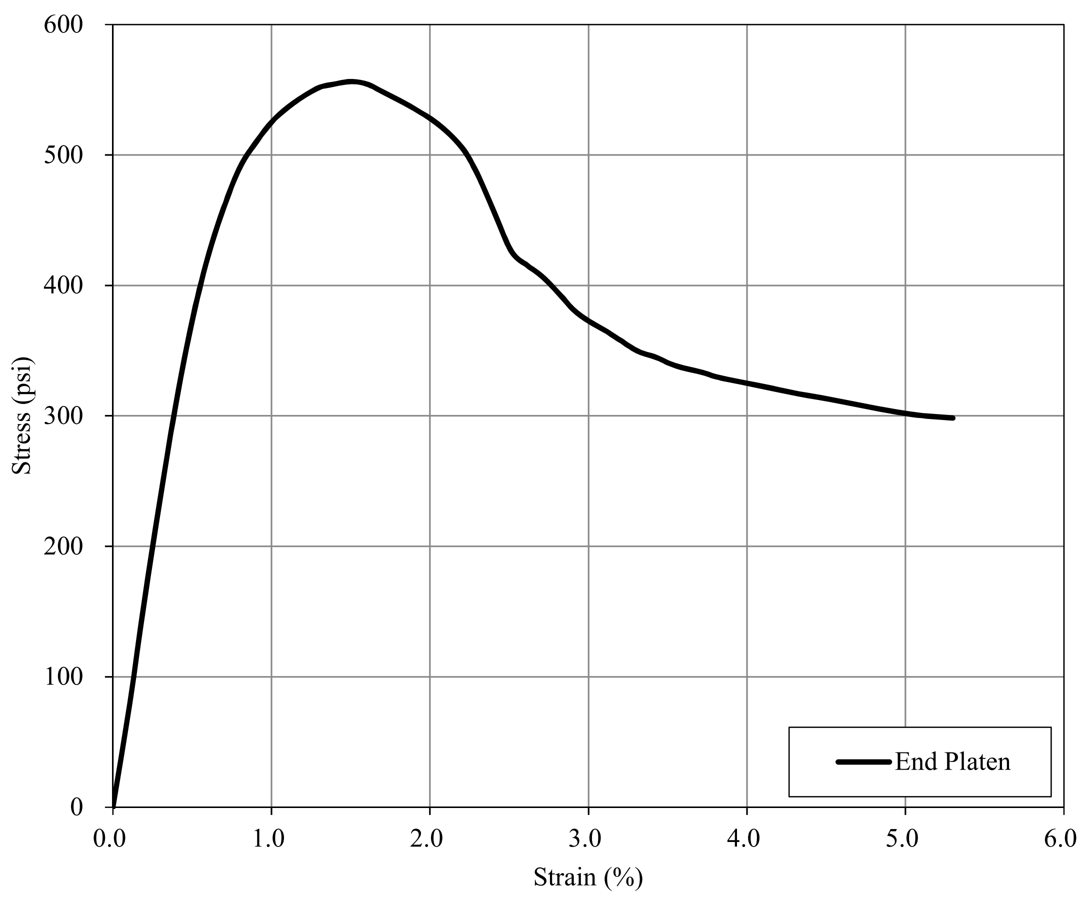
Specimen Information		
Height (initial):	3.951	in
Diameter (initial):	2.037	in
Weight:	364.0	g
Unit Weight:	108	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	515	psi
Secant Modulus E_{50EP}:	59,375	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.37	%



Batch U-3

Test Information		Specimen Information			Test Summary		
Type of Test:	UU Test	Height (initial):	3.959	in	Peak Stress:	556	psi
Tested by:	RNG	Diameter (initial):	2.037	in	Secant Modulus E_{50EP}:	78,439	psi
I.D. :	U-3-G	Weight:	364.4	g	Secant Modulus E_{50L}:	N/A	psi
Curing Period:	28 day	Unit Weight:	108	pcf	Poisson's Ratio ν_{50} :	N/A	
Test Date:	2/27/2017	Gage Length:	N/A	in	Poisson's Ratio ν_f :	N/A	
$\alpha_{in\text{-}place}$:	275				Local Strain at failure, εf :	N/A	%
$(w:c)_{slurry}$:	1.0				End Platen Strain at failure, εf :	1.51	%
End Treatment:	Grinding						
Confining Pressure (psi):	40						
Strain Rate:	1 %/min						



Batch U-3

Test Information	
Type of Test:	UU Test
Tested by:	RNG
I.D. :	U-3-H
Curing Period:	28 day
Test Date:	2/27/2017
$\alpha_{in\text{-}place}$:	275
$(w{:}c)_{slurry}$:	1.0
End Treatment:	Grinding
Confining Pressure (psi):	40
Strain Rate:	1 %/min

Specimen Information		
Height (initial):	3.952	in
Diameter (initial):	2.039	in
Weight:	364.5	g
Unit Weight:	108	pcf
Gage Length:	N/A	in

Test Summary		
Peak Stress:	546	psi
Secant Modulus E_{50EP}:	76,233	psi
Secant Modulus E_{50L}:	N/A	psi
Poisson's Ratio ν_{50} :	N/A	
Poisson's Ratio ν_f :	N/A	
Local Strain at failure, εf :	N/A	%
End Platen Strain at failure, εf :	1.41	%