

## CHAPTER 5

### EXPERIMENTAL STUDY USING AND RESULTS OF BARE STUD TESTS

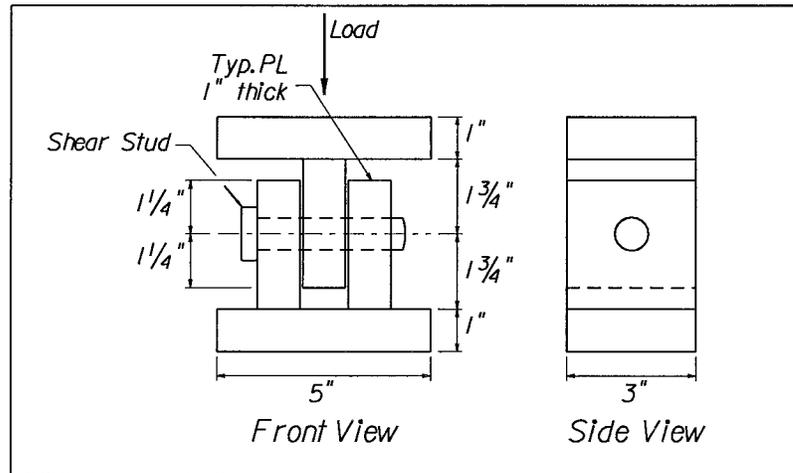
#### 5.1 Introduction

Several “bare studs” (studs not placed in concrete) were tested in shear to determine the shearing strength of a stud. According to the Von Mises’ failure criterion, the shear stress in a stud at ultimate should be approximately 60% of the ultimate tensile stress. The strength obtained from these tests should be the maximum strength allowed for a shear stud in a composite beam, if other effects such as friction are ignored.

Several tests were performed on bare studs in a combination of shear and bending. It is believed that the amount of bending that a stud in a composite slab is subjected to is determined by the deck height. For example, when the deck is made deeper, the resultant stresses due to the concrete are placed higher on the stud, farther from the base of the stud. This combination of bending and shear should decrease the stud strength. These bare stud tests will help determine the extent to which deeper deck reduces a stud’s strength.

#### 5.2 Bare Stud Specimens

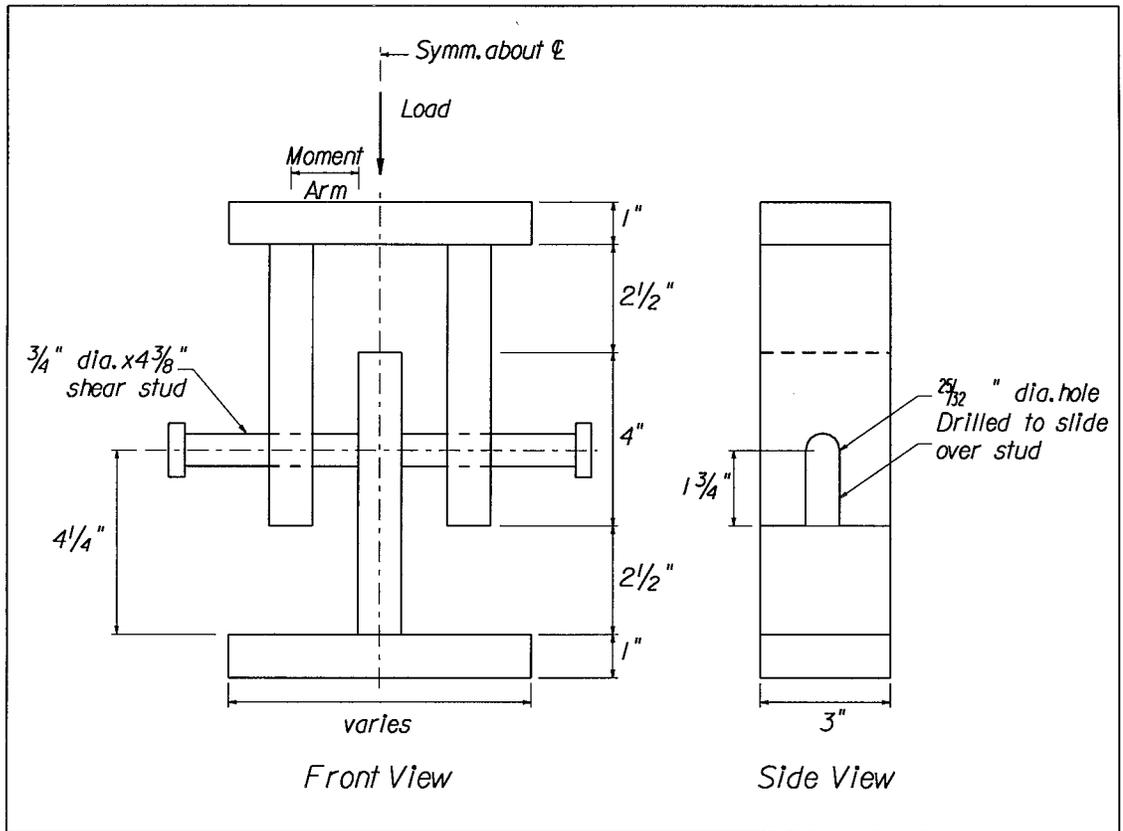
The bare stud shear tests utilized a device, made of welded 1 in. plates, that placed the studs in double shear. This device is shown in Fig. 5.1. The studs, ranging from 3/8 in. to 3/4 in. in diameter, were placed through three plates that each had a drilled hole approximately 1/32 in. to 1/16 in. larger than the stud diameter. The middle plate



**Fig. 5.1 Bare Stud Shear Test Device**

was welded perpendicular to another plate, to which load was applied. The outer two plates were welded perpendicular to a plate, which served as the base (or reaction) of the device.

The bare studs tested in combined shear and bending also utilized a device made of 1 in. plates. This device is shown in Fig. 5.2. For each test, two 3/4 in. studs were welded on opposite sides of a 1 in. plate. This plate was welded perpendicular to another plate, which served as the base (or reaction) of the device. A set of two plates was used to load the studs. The two plates were welded perpendicular to another plate, to which load was applied. The distance between the plates varied, depending on the amount of bending moment desired. The moment arm, or the distance from the base of the stud to the center of the loading plate, varied from 0.5 in. to 3.5 in. Each plate had a slot that slid over the diameter of the stud, making contact with half the stud's circumference.



**Fig. 5.2 Bare Stud Shear and Bending Test Device**

### 5.3 Test Procedure

The bare stud specimens were loaded with a universal testing machine. The loads measured by the machine were observed throughout testing; only the maximum load reached in each test was recorded.

In the bare stud shear tests, load was added until shank shearing occurred. In the combined shear and bending tests, load was added until significant deformations, along with a loss of load carrying capacity, were observed.

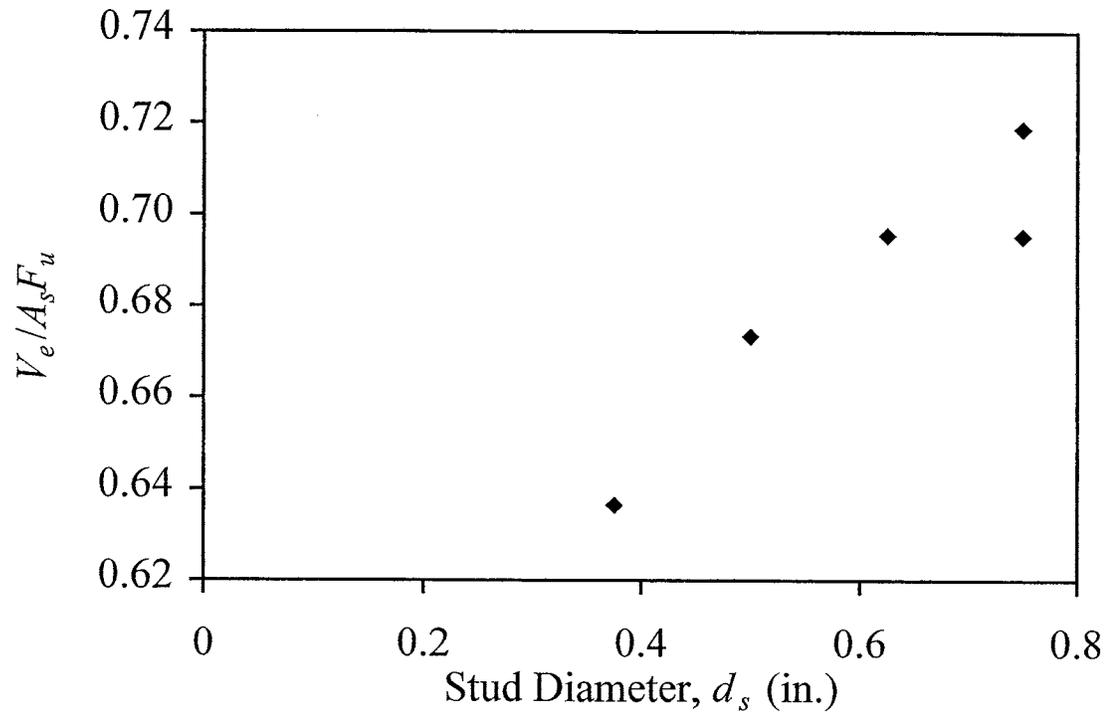
#### 5.4 Test Results

The bare stud shear test results are shown in Table 5.1 and plotted in Fig. 5.3.

The bare stud combined shear and bending test results are shown in Table 5.2 and plotted in Fig. 5.4.

**Table 5.1 Bare Stud Shear Test Results**

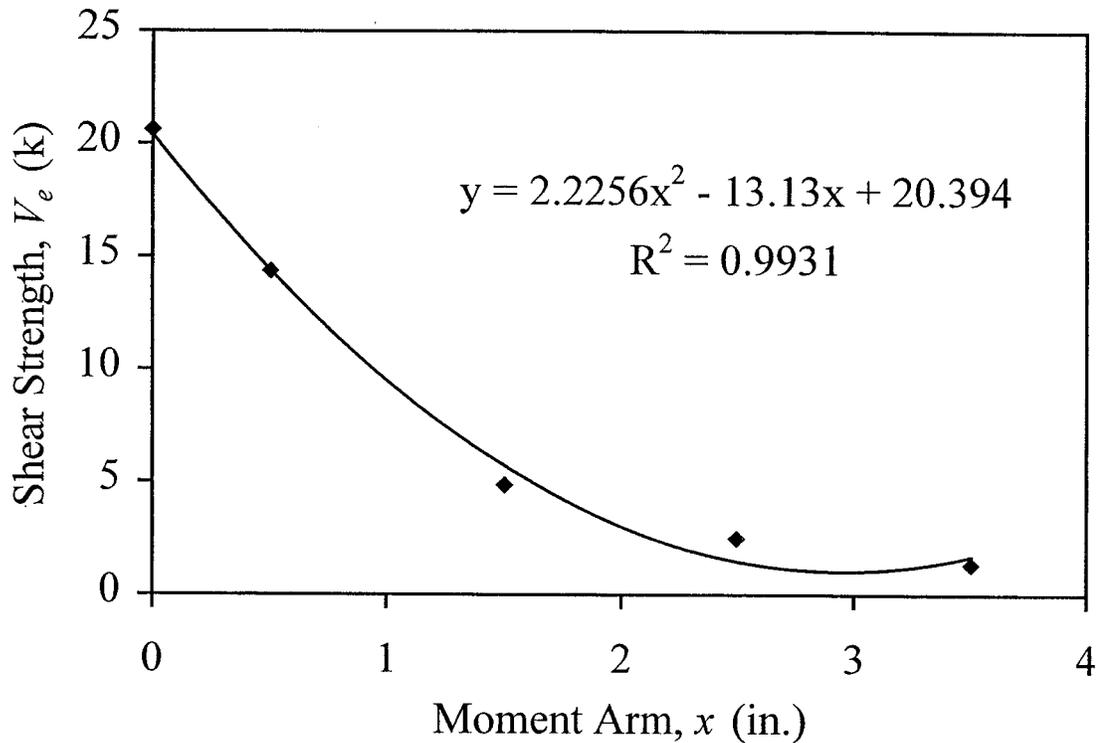
Stud Dia. (in.)	$F_u$ (ksi)	$V_e^*$ (k)	$V_e/A_s F_u$
0.375	77.238	5.43	0.637
0.5	74.049	9.79	0.673
0.625	72.635	15.5	0.696
0.75	64.868	20.6	0.719
0.75	67.377	20.7	0.695



**Fig. 5.3 Shear Strength, as a Fraction of Tensile Strength, vs. Stud Diameter**

**Table 5.2 Bare Stud Shear and Bending Test Results**

Stud Dia. (in.)	x (in.)	V <sub>e</sub> (k)	M <sub>e</sub> (k-in.)	V <sub>e</sub> /V <sub>e x=0</sub>
0.75	0	20.60	0.00	1.00
0.75	0.5	14.37	7.18	0.70
0.75	1.5	4.86	7.30	0.24
0.75	2.5	2.50	6.26	0.12
0.75	3.5	1.34	4.68	0.06



**Fig. 5.4 Shear Strength vs. Moment Arm**

The shear strength of the bare studs ranged from about 64% to 72% of the measured tensile strength provided by the manufacturer. However, there was a drastic

reduction in stud strength when the studs were tested in combined shear and bending. When the force was applied to the stud only 0.5 in. from its base, the strength reduced to 70% of the bare stud shear strength, which equates to 50% of its tensile strength. The strength decreased almost linearly with an increase in the moment arm of the applied force until the moment arm was about 1.5 in.

These test results cannot be compared exactly to push-out tests because the studs are restrained differently in the two types of tests. The failure surface of a bare stud placed in shear is similar to the failure surface of a stud in a push-out test, so these bare stud tests can be used as evidence that the maximum strength that a stud may have is about 70% of its tensile strength. Any strength beyond this amount that is obtained from push-out tests should not be relied upon in design. This “extra” strength probably arises from friction, the effects of which are discussed in Sections 3.3.2 and 3.3.3 for solid slabs and Section 6.11 for composite slabs.