Chapter 3

Development of the Current Research

3.1 Continuation of Previous Research

As previously mentioned, an additional round of static and dynamic tests was conducted as part of this research to improve and extend results from the previous research and to better understand the behavior of the ropes during the snap loads. In the previous research, many different types of rope were tested which had various diameters, lengths, and material properties. In addition, the dynamic loading sequences were so varied that it was difficult to make any real conclusions about how the individual ropes performed. To avoid this problem, many of the variables that were present during the first round of tests were eliminated for the new tests.

For these new tests, the only ropes that were tested were nine-foot-long, ½-inch diameter Amsteel Blue and ½-inch diameter Amsteel II ropes. These ropes were chosen for this experiment based on their performance in the previous round of tests. The Amsteel Blue and Amsteel II ropes have contrasting material properties and behave differently under static and dynamic loadings. By testing these two different types of rope, it will be possible to develop an accurate idea of what properties are most essential in order to develop a SCED that dissipates a significant amount of energy, but only suffers from a limited amount of elongation.

The Amsteel Blue ropes have a low modulus of elasticity and a loose braid construction. This allows the ropes to displace more during a snap load and for more friction to occur between the individual components of the rope, hence more energy can be dissipated. As mentioned previously, for a SCED to be effective, the amount of dynamic elongation must be limited. The Amsteel Blue ropes experienced the smallest amount of elongation out all of the low modulus ropes and, therefore, were a good choice for a specimen. A photograph of an Amsteel Blue rope can be found in Figure 3.1.1.

The Amsteel II ropes have a high modulus of elasticity and a tight braid construction. This prevents the ropes from having large displacements during a snap load. The Amsteel II ropes had the smallest static displacement values of all the ropes tested in the previous research, and the energy loss values from the Follow-Up tests were very similar to those of the Amsteel Blue ropes. For these reasons, the Amsteel II ropes were also selected to be specimens. A photograph of an Amsteel II rope can be found in Figure 3.1.2.

Figure 3.1.1: ½-inch Amsteel Blue Rope
Loosely Braided

Figure 3.1.2: ½-inch Amsteel II Rope
Tightly Braided

To further simplify the new experiments, a standardized system for testing the ropes statically and dynamically was developed. This was done so that every rope would have an identical loading history and so that any trends or quantitative differences would be the result of the actual behavior of the rope and not because of any number of variables that were present during the previous tests.

3.2 Development of Current Research

The main goals of this research were to obtain an understanding of how a rope behaves during a snap load, how the properties of a rope change during a series of snap loads, and to develop a mathematical model that will characterize the behavior of a rope during the snap loads. To accomplish this, a very structured set of tests was conducted on a number of ropes of the same type. Ten ½-inch Amsteel Blue and ten ½-inch Amsteel II ropes were purchased for this purpose. Static tests were run on five ropes of each type so that half of the ropes that were tested dynamically would be precycled and a comparison could be made between the differences in performance between the precycled and new ropes.

The new static tests were conducted in the same manner and with the same setup as the static tests from the previous research. The only difference was that each rope that was precycled was loaded up to 200 pounds in six consecutive cycles. The number of cycles and maximum load were varied in the previous research. The consistency of the new data allowed for a more accurate and complete analysis of the static tests.

The new dynamic test setup was identical to that of the old test, but the manner in which the dynamic tests were conducted was slightly different. The new tests were organized so that each rope would be subjected to a sequence of 20 drop tests from a constant height and with a constant weight of 65 pounds. By conducting so many consecutive tests with identical parameters, it was possible to observe how the behavior of the rope changed throughout a loading sequence. These tests were conducted from drop heights of approximately 56, 44, 32, 20, and 8 inches, which are all lower than the drop heights used in the previous research. Therefore, the data from these tests will be more consistent. In addition, since lower drop heights were used, the initial velocities were minimized and the test data was better related to what the actual behavior of a SCED will be.

For simplification purposes, a classification system was developed to identify the ropes and explain the associated test parameters. The ropes that were precycled were paired with a new rope of the same type and both were assigned a letter identifier that corresponds to a certain drop height for the dynamic tests. The precycled ropes were given a single letter identifier and the new ropes were given a double letter identifier (i.e., the Amsteel Blue ropes were designated A – E and AA – EE, and the Amsteel II ropes were designated F – J and FF – JJ). Table 3.2.1 shows this more clearly and assigns an approximate drop height to each letter set.

Rope Letter Code Assignments				
Drop	1/2 in. Amsteel Blue		1/2 in. Amsteel II	
Heights (in.)	Pre-cycled	New	Pre-cycled	New
56	A	AA	F	FF
44	B	BB	G	GG
32	C	CC	H	HH
20	D	DD	I	II
8	E	EE	J	JJ

Table 3.2.1: Rope Classification Method

In all, four ropes were dynamically tested from each of the five drop heights. This allowed for comparisons to be made between the two types of ropes and between the precycled and new ropes at various heights. In all, 60 static cycles and 400 drop tests were conducted. During the dynamic tests, data readings were taken at a rate of 2000 readings per second, or one reading every 0.0005 seconds.

3.3 Drop Tower Modifications

Before the new tests were conducted, it was necessary to modify the drop tower in order to reduce the amount it shook during the snap loads. This was done by installing two types of braces. These braces can be seen in Figure 3.3.1 and Figure 3.3.2.

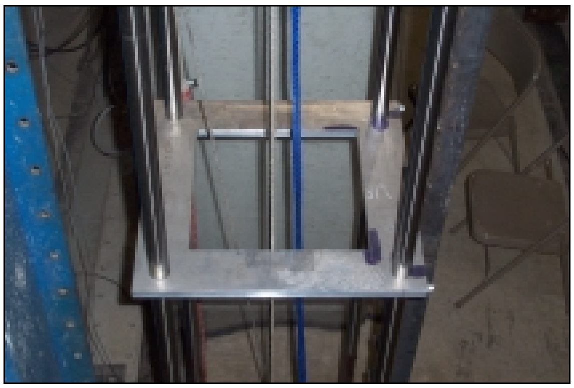

Figure 3.3.1: Mid-tower Brace

Figure 3.3.2: Top-of-tower Brace

The first bracing apparatus was cut from a ½-inch thick aluminum plate. It fits tightly around the steel rods and is placed slightly above the mid-height of the tower, so that it does not interfere with the new drop tests. It was designed to reduce the amount that the individual steel rods shook in relation to each other. The second set of braces consists of two pieces of angle material that are welded together and bolted on one side to the top plate of the drop tower and at the other to a large, wide-flange column that is located in the laboratory. This reduced the amount that the top of the tower swayed during a drop test. With these two bracing additions, the tower was very rigid and an agreeable data series was produced. Figure 3.3.3 shows a raw data series from the Follow-Up tests in which the bracing was not present, and Figure 3.3.4 shows a raw data series from the new tests where the bracing system is in place. As can be seen, there is still some shaking present, but the data looks better than it did before.

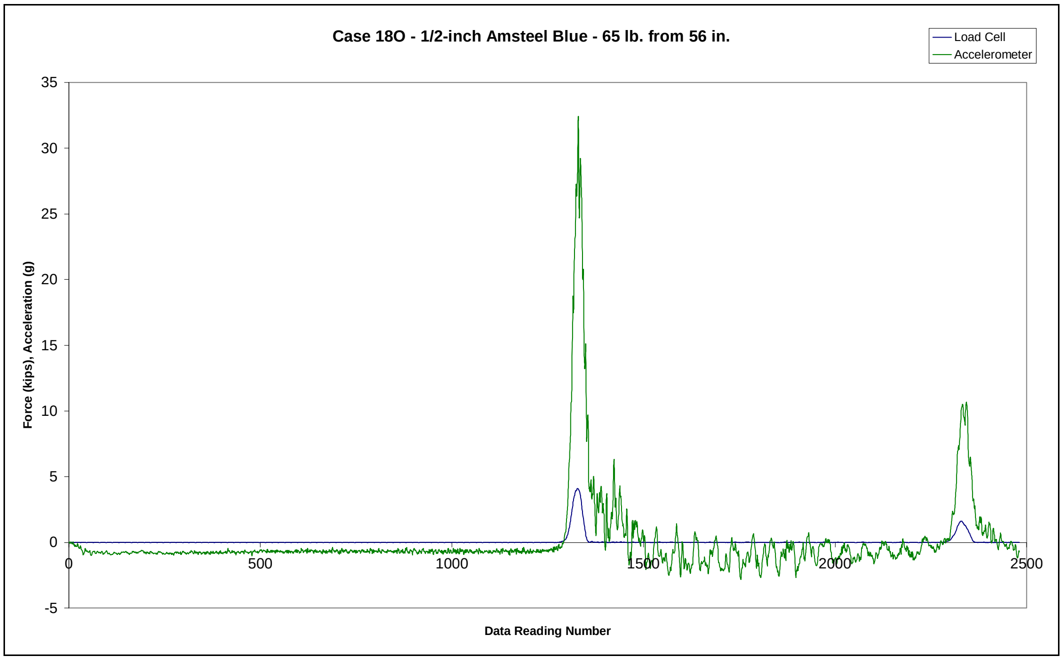

Figure 3.3.3: Force and Acceleration Data from a Dynamic Test without Bracing

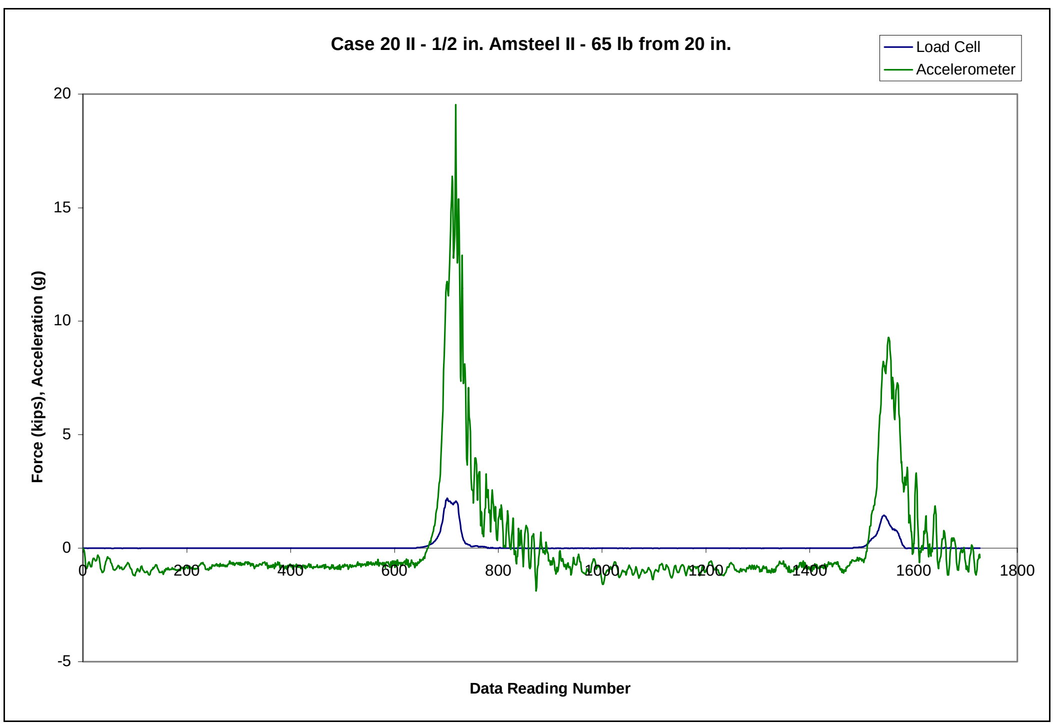

Figure 3.3.4: Force and Acceleration Data from a Dynamic Test with Bracing

After these modifications were completed, the static and dynamic tests were conducted. It became apparent after two of the Amsteel Blue ropes were tested that the drop tower was not tall enough to carry out the dynamic tests. The Amsteel Blue ropes experienced a large amount of elongation due to the dynamic tests, and after several dynamic tests the drop plate began impacting the rubber stoppers at the bottom of the tower before the ropes could become taut. This was unexpected because all of the sequences in the previous research used larger drop heights and some of them used more weight. However, none of those sequences consisted of as many drop tests and therefore did not stretch the ropes as much. The data from those two Amsteel Blue ropes was essentially ruined, but as a result of this error, the steel rods on which the drop plate slides were lengthened to allow the other tests to be run. This was done by threading four, one-foot-long rods of the same size and attaching them between the original steel rods and the top plate. This provided an additional foot of clear space to run the tests. These extensions can be seen in Figure 3.3.5.

Figure 3.3.5: Tower Rod Extensions