Mechanical Hand(s):
Sample Data from Drop Testing

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Introduction:

Over the past nineteen years, Rigging for Rescue has presented data from testing projects to the ITRS gathering. A few of these test series have involved the use of a 'mechanical hand' that was used as a replacement for the human hand in tests simulating the need for a positive gripping action on behalf of the belayer.

The gripping ability setting(s) of the mechanical hand(s)[1] were based upon data from the *Gripping Ability on Rope In Motion* study conducted by Kirk and Katie Mauthner and the British Columbia Council of Technical Rescue in 1993-94.

Some questions have been raised by ITRS participants as to how well the mechanical hand(s) accurately represent dynamic gripping ability in light of the fact that the initial setting of the device(s) are representative of a static gripping ability. This test series was an attempt to answer some of those questions.

Background Information:

The method for setting a mechanical hand to a given gripping ability was by pulling on the standing end of the rope after it exited the device using a rope grab attached to a force gauge. Once the rope started to slip through the device (breaking static friction), the force was noted on the measurement gauge. If more grip was required for a given drop test, for example, the four wing nuts attached to four bolt/spring combinations mounted on to the corners of the device were tightened to increase the gripping ability.

During the *Gripping Ability on Rope In Motion* study (GARIM), the researchers examined the difference between dynamic and static gripping ability using 15 human test subjects. The authors in their report stated, "It was expected that subjects would have a higher *static* gripping ability because of the individual's ability to anticipate the grip and "lean into it" and because there is higher static friction between the glove and the rope in a dynamic state. However, for the 15 subjects tested, the average *dynamic* gripping ability was approximately 7% or 15N *(3.4 lbf)* higher than the average *static* gripping ability. It is also important to note that while the overall *dynamic* results were slightly higher, in 35% of the comparisons it was the reverse. No numerical conclusions can be drawn between the two except that the results are on the same order of magnitude."

[1] Three different versions have been used in drop testing; two of these three were measured for dynamic gripping ability in the March, 2005 testing – see force curves.

Test Set Up:

In order to accurately measure the dynamic gripping ability of the mechanical hand(s) in a drop test scenario, a 2000N load cell was used between the hand being tested and the anchor beam. All of the tests conducted included an initial static gripping ability of approximately 210N *(47.6 lbf)* which was the average gripping ability on rope in motion reported by the GARIM for a rescuer operating with a gloved hand.

The testing examined the following variables:

1. Type of Mechanical Hand:
    a) The "John McKentley" version borrowed from John and used in both the 2003 and 2004 Two Tensioned Rope Lower (TTRL) studies conducted by Rigging for Rescue.
    b) The "Two Rope" version modeled after the McKentley version but wider in order to accommodate two ropes simultaneously; also used in the TTRL study in 2004.

2. Test Mass:
    a) 200 kg[2]
    b) 80 kg

3. Rope Type:
    a) PMI EZ Bend 11mm
    b) Sterling Superstatic 11mm

4. Fall Factor:
    a) 0.33 (1m drop on 3m of rope)
    b) 0 (snug top rope)

Conclusions:

The average *dynamic* gripping ability of the mechanical hand(s) in the drops conducted was generally slightly higher than the *static* gripping ability. The results were similar in nature to the tests conducted on human subjects in the GARIM study with respect to the differences in *dynamic* versus *static* gripping ability. Essentially, the *dynamic* and *static* gripping abilities of the mechanical hands are on the same order of magnitude.

The use of similarly designed mechanical hands in research projects involving the simulation of human gripping ability is a viable alternative to the actual human test subject. By borrowing from the data in the GARIM study, researchers can more easily represent a segment of the population through the use of a mechanical hand as opposed to the gripping ability of an individual human on a given drop test. Also, because the mechanical hand has an instantaneous reaction time as opposed to the delayed reaction time of a human, the use of a mechanical hand in testing likely favors the successful arresting of a falling mass involving gripping ability. In other words, a test involving a failure to arrest a falling mass by using the mechanical hand at a given gripping ability would likely also produce a failure to arrest with a human test subject of similar gripping ability.

[2] Drop Test #59 also incorporated a brakerack between the test mass and the hand; this was eliminated on subsequent drops in order to focus on the force at the hand alone.