Forces Generated During a Simple Ascent

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Background

In early 2007 GH designed and manufactured three load cells designed for use in testing vertical rescue systems and equipment. They were designed to measure up to 3000kg, have a failure load of around 5000kg, weighed about 100 grams[1], and were capable of recording load histories. This device would be a major step forward compared to using a crane weighing hook which are very heavy and only display the current load or peak load. GH finished building the load cells in March and calibrated them up to 440kg using calibration weights at Bishop Innovation in April.

On 28/29 April 2007 GH took this system to a V3 exercise at Bega for the first trial of the system. This report describes the testing done during this exercise.

Test Performed

To demonstrate the capabilities of this system and get some preliminary data for discussion, a load cell was secured to the roof beam of the Bega VRA shed and a rope hung off the load cell. This gave a 4m vertical ascent. All tests were done using mechanical ascenders (CMI Explorers) on 11mm Bluewater II rope. The sampling rate of the system was set to 10Hz for all tests. The load cell was found to have a sensitivity of better than 0.1kg.

Test 1 – A Typical Load History

In Figure 1 the full load history of an operator attaching to the rope, ascending using the frog technique and returning to the ground by going down on the ascenders. It can be seen the operator partially loaded the rope to about 20kg at 30s before fully loading the rope at about 35s during the setup process. The weight of the operator and equipment can be seen as about 80kg, and during the ascent the load varies approximately +/-20kg. During the descent stage the load also varies by about +/-20kg. This means that in normal use, ascending generates load spikes around 25% higher than the operator's weight due to the bouncing action of ascending.

Test 2 – Comparison of "Smooth" and "Rough" Ascending Styles

The data in the previous section is using a "smooth" ascending technique, typical of an experienced operator ascending normally but carefully. To quantify the effects poor ascending technique could have on rope loads the rope was ascended again using a "rough" ascending technique. The rough technique was marginally worse than the jerky movements of an inexperienced operator, but is indicative of what is possible with poor technique.

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[1] This was achieved by only having the strain gauge elements and minimal electronic circuitry on the load cell itself. The cell has a cable which connects to a signal conditioning module and requires a laptop computer to drive it so the full system weighs a few kilograms, but the component on the rope only weighs 100g.

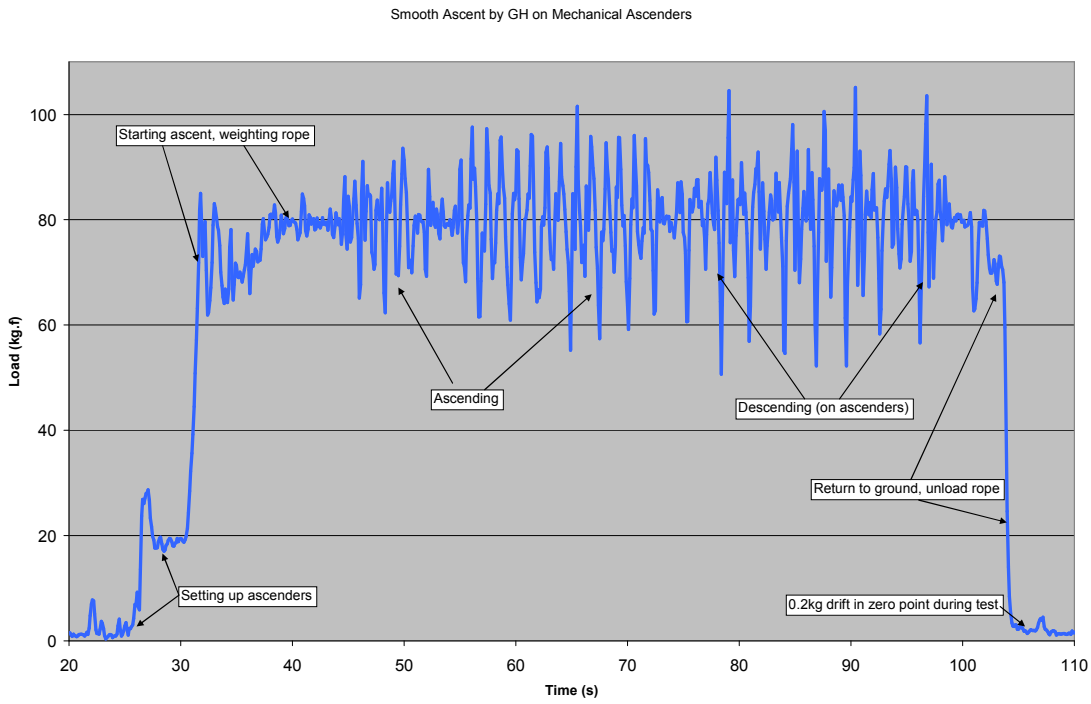

Figure 1 - Full load history of setting up, ascending, descending and leaving rope.

The comparison is shown in Figure 2. The top figure shows the ascent part of the data presented in the previous section, from 55 to 70s in the data file. As discussed in the previous section the load varies +/-25% due to the bouncing action of ascending.

The bottom figure in Figure 2 shows the load measured during the "rough" ascent. Here a peak load of over 160kg was measured and a minimum load of almost 20kg. The operator's weight was approximately 80kg, so this indicates this poor technique can generate load spikes which are approximately double the operator's weight.

Conclusion

- GH has made a set of load cells suitable for measuring loads in vertical rescue systems. The load cells overcome many of the problems with using crane weighing hooks.
- Ascending a rope smoothly generates load spikes approximately 25% higher than the operator's weight.
- Ascending a rope roughly generates load spikes of approximately double the operator's weight.

Acknowledgements

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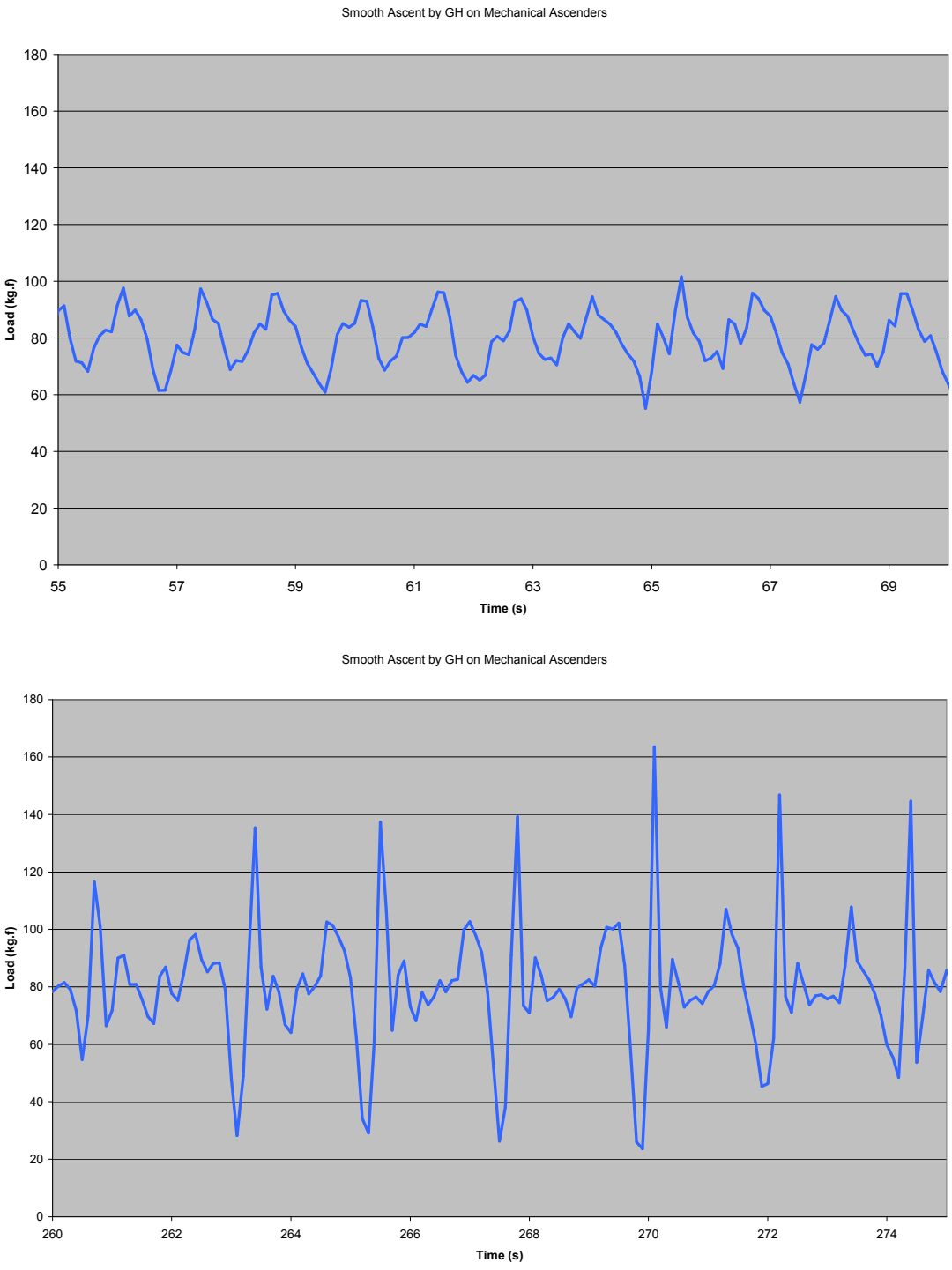

Figure 2 - Comparison of "smooth" ascending technique (top) and "rough" ascending technique (bottom).