# Simulating and Testing Ice Screw Performance in the Laboratory

Final Presentation

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# Introduction

- Project Motivation
- Statement of Problem
- Description of Experiment
- Results & Discussion
- Conclusion
- Questions

Ice screw being pulled from Specimen

# Project Motivation

- The attraction of extreme sports is aiding its rapidly increasing popularity.
- Present safety equipment ineffective → more accidents
- Project will be first step towards safer ice protection
- Very little published research available:
  - Harmston & Luebben Study, 1997

# Primary Hypothesis & Objectives

- ***Primary Hypothesis:***

  The structure and morphology of different types of ice formations can be characterized and simulated in a lab to provide a “test bed” useful for assessment of ice screws.

- ***Primary Objective:***

  To develop a repeatable means of reproducing ice in a lab and to characterize this ice using rheological data.

- ***Success Criteria:***

  a) If hypothesis 1 is true, then success is characterizing the critical properties of ice.

  b) If hypothesis 1 is false, then success is identifying why ice cannot be made successfully.

# Secondary Hypothesis and Objective

- ***Secondary Hypothesis:***

  If the first hypothesis is true, using the simulated ice, the variables affecting screw placement safety can be determined.

- ***Secondary Objective:***

  To use laboratory created ice to test simulated falls on ice screws in a manner useful to climbers.

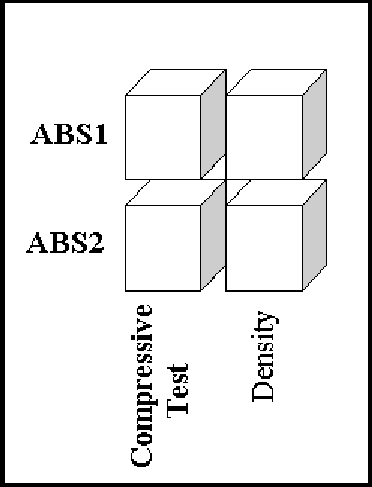
- ***Success Criteria:***

  If hypothesis 2 is true, then success is the development of a test for ice screw safety that produces consistent and repeatable data for differing ice types.

# Description of Experiment

***Stage 1: The characterization of ice***

- Produced different types of ice using different methods.
- Ice types chosen on ease of production and difference in characteristics



# Experiment (cont'd)

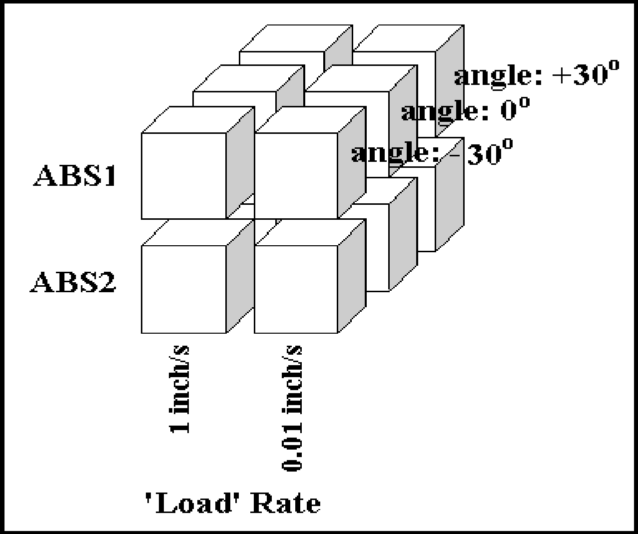
Apparatus setup for stage 1

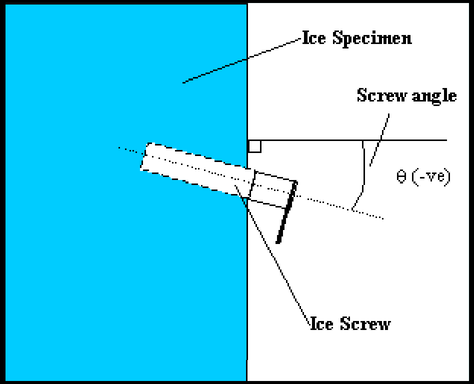
Preparing specimen for test

# Experiment (cont'd)

***Stage 2: Testing of ice screws in ice***

- Produced the two ice types on a larger scale.
- Placed ice screws at different angles into each specimen and pulled at different load rates.



# Experiment (cont'd)

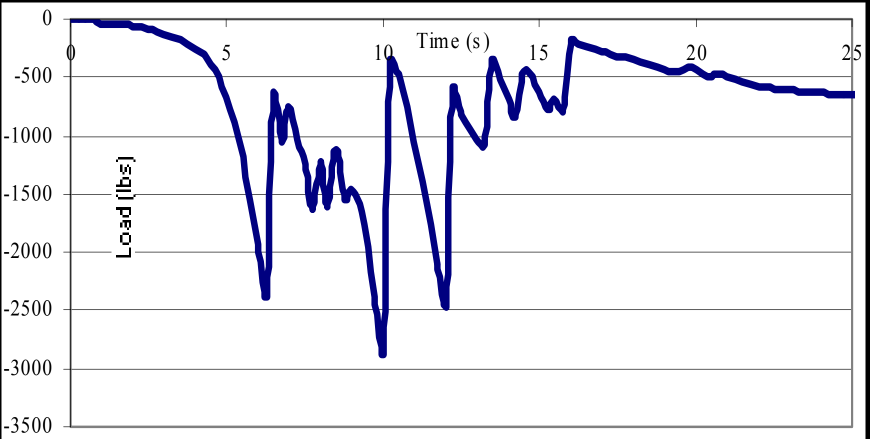
Stage 2 Test Rig

Close-up of Ice Screw/MTS interface

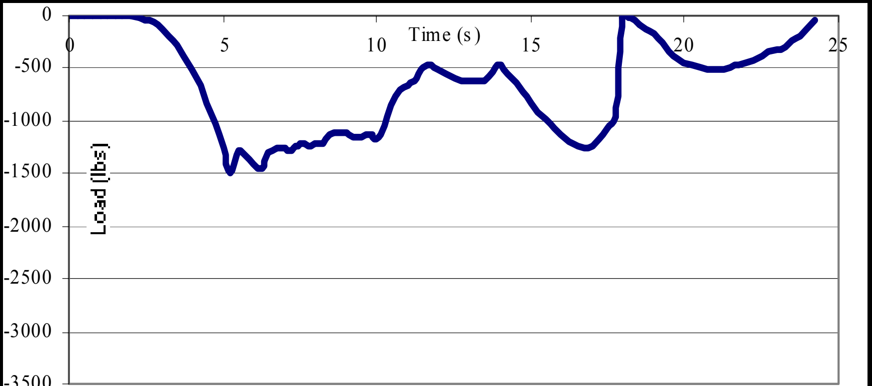
# Results – Stage 1

**Compressive Tests:**

- ABS 1:
  - Compressive strength: 2203 lbs
  - Std Dev: 638 lbs
- ABS 2:
  - Compressive strength: 1802 lbs
  - Std Dev: 618 lbs
- F-Stat: 9% chance of ABS1 being different to ABS2



Compressive load on ABS#1



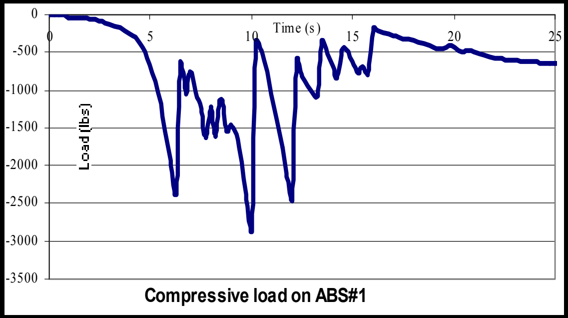
Compressive load on ABS#2

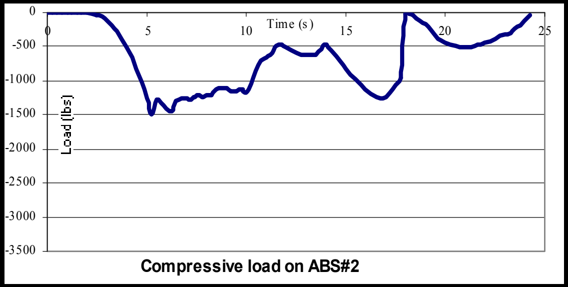
# Results – Stage 1 (cont'd)

- Density:
  - ABS1: 913 kg $m^{-3}$
  - ABS2: 804 kg $m^{-3}$
  - F-Stat: 97% chance of ABS1 being different to ABS2.

# Discussion – Stage 1

- Compressive Test:
  - Means are different, however this is not statistically significant
  - Qualitatively different after testing
    - ABS1 still sticks to fingers
    - ABS2 feels wet to touch
  - Graphs are different:
    - ABS1 peaks sharper
    - ABS2 peaks more rounded

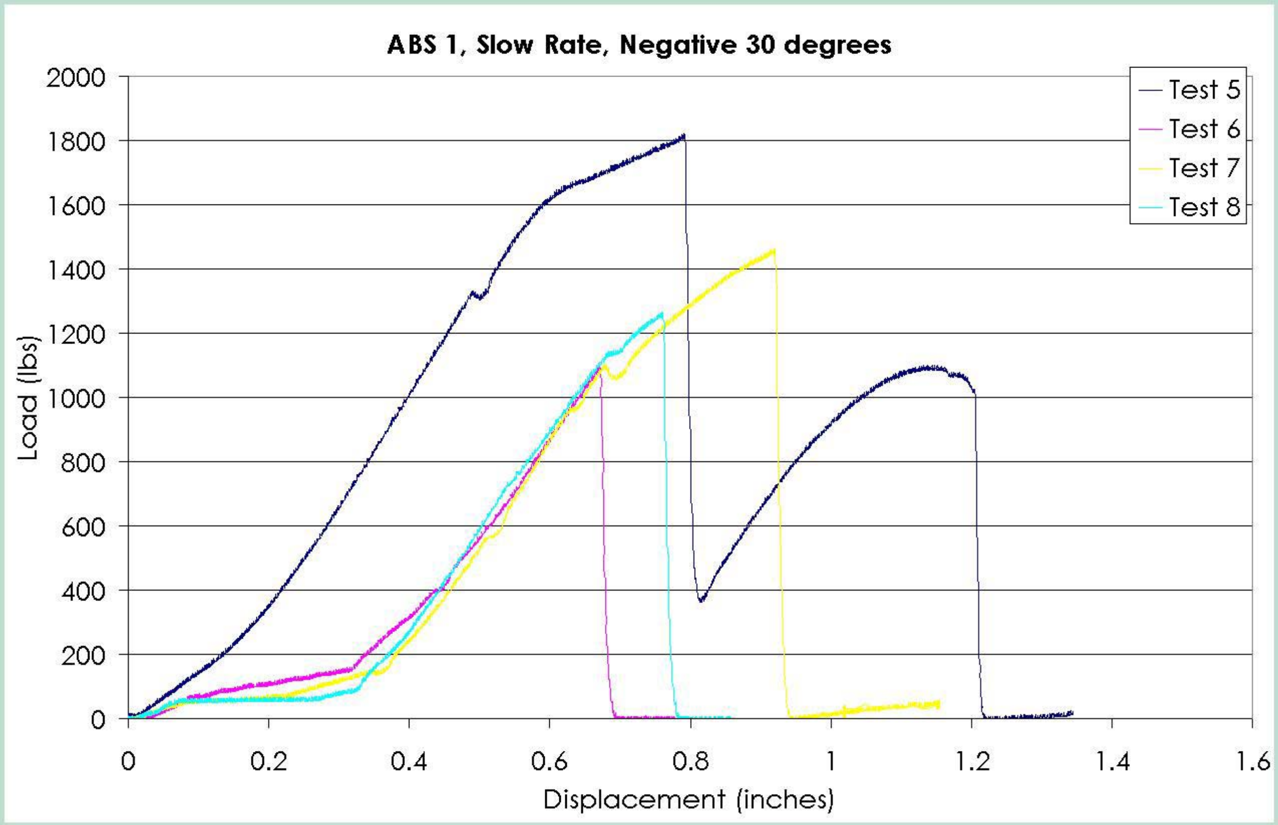


# Discussion – Stage 1

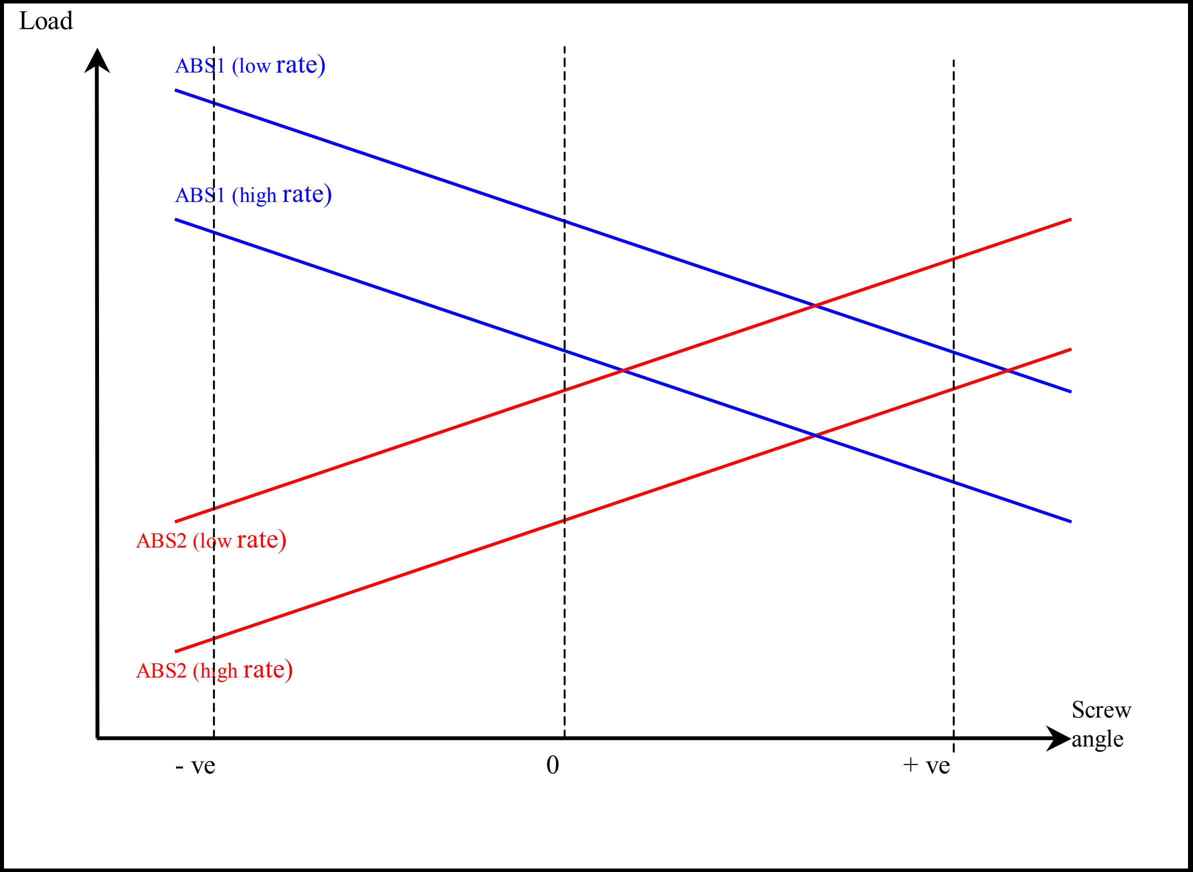
- Density:
  - Shows definite difference between ABS1 and ABS2.
- Differentiated appearance between ABS1 and ABS2
- Relation to Hypothesis 1:
  - Valid hypothesis.  Structure and morphology of different ice types were simulated and characterized in the lab successfully.

# Results – Stage 2



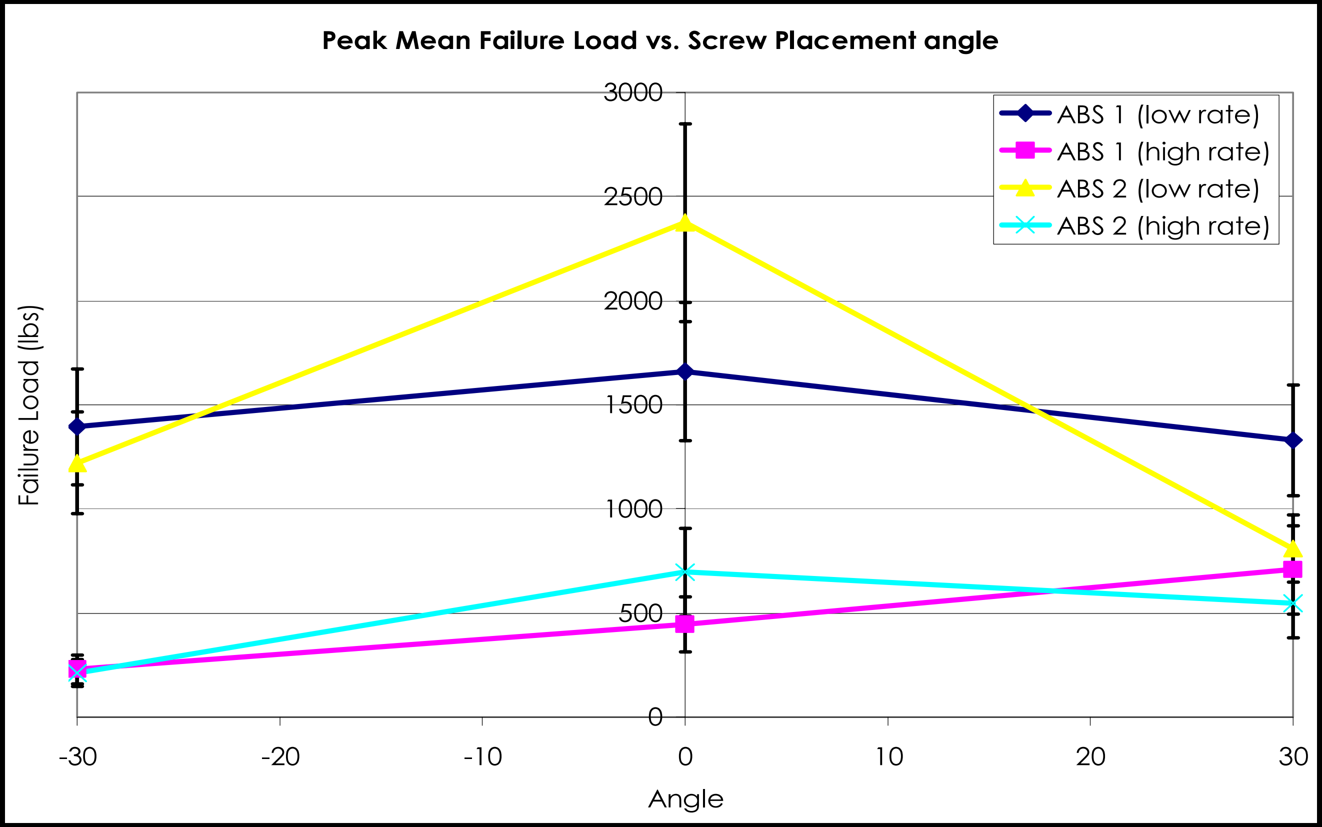

- Typical ice screw test data set.

# Results – Stage 2




Previous study's claim.

# Results – Stage 2



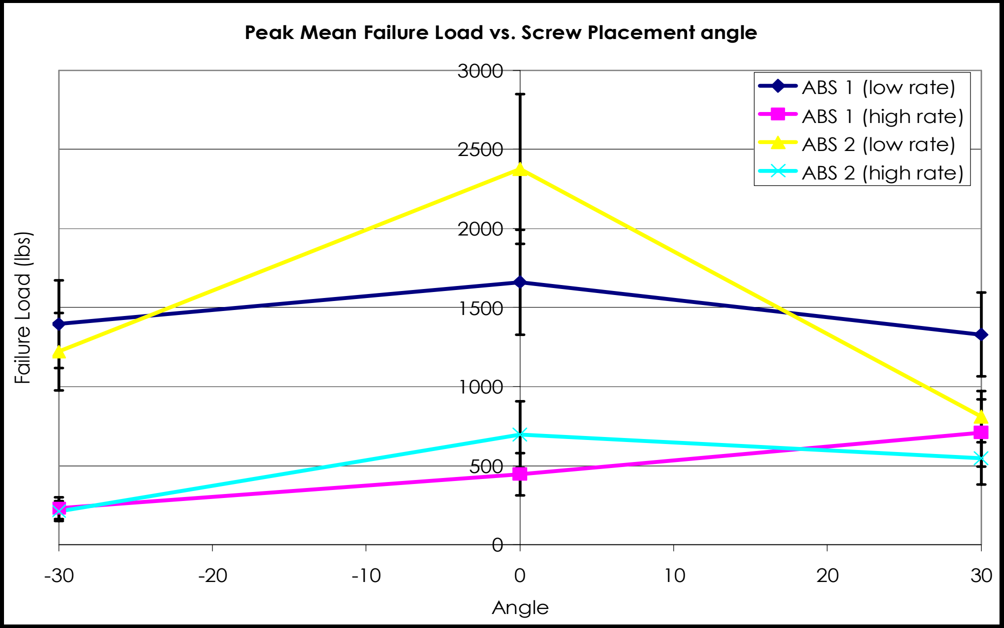

Results from the experiment.

# Discussion – Stage 2

- Loading rate:
  - Loading rate more significant than screw placement angle or ice type.
    - Very useful for climbers.
    - loading rate can be controlled, using ropes that can stretch more and/or using a friction device for slowing fall.
  - No ice screw broken. Possibly due to:
    - development in ice screws over last six years
    - the length of screw
    - Temperature of the ice Screws
    - Loading rate of MTS machine not sufficient for breakage

# Discussion – Stage 2

- Screw placement:
  - Not much of an influence on the load taken. In general, zero angle is the one that will hold the most.



# Discussion – Stage 2

- Relation to Hypothesis:
  - Hypothesis proved.
    - Variables affecting screw placement safety identified and tested.
    - Ice type, loading rate and screw placement angle all affect safety.

# Conclusion

- Compressive Testing is not necessarily a valid test to differentiate between ice types.
- Fall Rate significantly affects failure load
- Screws safest at zero degrees
  - Previous work not supported by study

# Further work

- A test for assessing ice screw performance has been developed.  Further improvements and developments possible:
  - Research on methods for making more different ice types.
  - Determination of other tests that can characterize ice
  - Research on the effect of screw length on load.

# Acknowledgements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  – Earl Murman, Ed Greitzer & Jennifer Pixley.

- Lab staff:
  – Dick Perdichizzi, John Kane, Don Wiener, Dave Robertson & Paul Bauer.

# Questions


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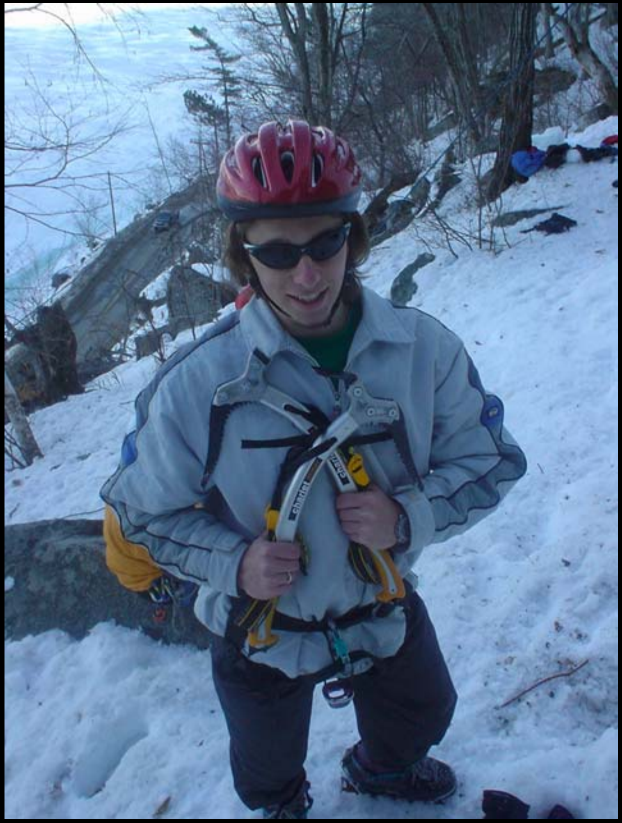

# Results – Stage 2

| Ice Type | Rate | Angle | Mean | Std. Dev. | SD/ mean |
|---|---|---|---|---|---|
| ABS1 | 0.01 | -30 | 1394 | 309 | 22% |
| ABS1 | 0.01 | 0 | 1660 | 294 | 18% |
| ABS1 | 0.01 | +30 | 1329 | 322 | 24% |
| ABS2 | 0.01 | -30 | 1220 | 410 | 34% |
| ABS2 | 0.01 | 0 | 2375 | 75 | 3% |
| ABS2 | 0.01 | +30 | 810 | 243 | 30% |
| ABS1 | 1.0 | -30 | 229.75 | 47 | 21% |
| ABS1 | 1.0 | 0 | 446 | 142 | 32% |
| ABS1 | 1.0 | +30 | 708 | 481 | 68% |
| ABS2 | 1.0 | -30 | 211 | 142 | 68% |
| ABS2 | 1.0 | 0 | 697 | 25 | 4% |
| ABS2 | 1.0 | +30 | 547 | 276 | 51% |