ICOSAHEDRON COMPRESSION STUDY

Introduction and Background: The project started with an initial compression model of a symmetric icosahedron array modeled after a sheet steel structure. Analysis results indicated that the compressive load carrying capacity of the structure is dominated by the connecting ligaments. That is, under compressive load, the connectors want to buckle and irreversibly deform. Once the icosahedrons touch, the load bearing capacity of the structure is significantly increased. Subsequent to these results and additional engineering meetings, a spreadsheet was developed that allowed the direct calculation of the bending load carrying capacity of the structure. The theory behind this spreadsheet is that the load is carried by the connecting ligaments that are perpendicular to the applied load and run in the direction parallel to the bending axis. In brief, in the orthogonal array of connectors, only one line or one direction of connectors carry load. The other 2/3 thirds of the connectors act to hold the structure together and allow it to behave as a "beam" like structure.

Some discussions were had whether or not the structure behaves like a cable or a beam, but at the end, it was reasoned that it behaves like a beam since it can bear transverse load while simply-supported at its ends without an axial constraint. In contrast, a cable requires axial constraint to bear a transverse load.

Lastly, a study was done on the compressive load carrying capacity of just the icosahedron. This report addresses this study. The load capacity is defined as that load the structure can carry in a linear, elastic fashion. To be linear elastic implies that upon release of the load the structure will elastically return to its original shape.

Modeling Details: A simple icosahedron having an edge length of 1.0" was used. The icosahedron was assumed to be in a densely packed array and that the deformation behavior could be modeled as if it was squeezed between two large plates. This assumption allows one to understand the basic compressive load carrying capacity of the icosahedron for design purposes.

The finite element model was based on a 1/8th symmetric section of the icosahedron and loaded via a flat plate pushing into the top of the icosahedron. Charts are provided showing the load versus deformation behavior. Two thickness and three elastic moduli were investigated, yielding six data points. The following page shows a graph of these results.

Summary: Compressive failure of the icosahedron is by buckling. For the thick (0.10" thick) icosahedron's, the buckling is along the top member while for the thinner (0.05") icosahedrons, the side members buckle. The results follow a logical trend with increasing thickness and elastic modulus providing superior compressive strength.

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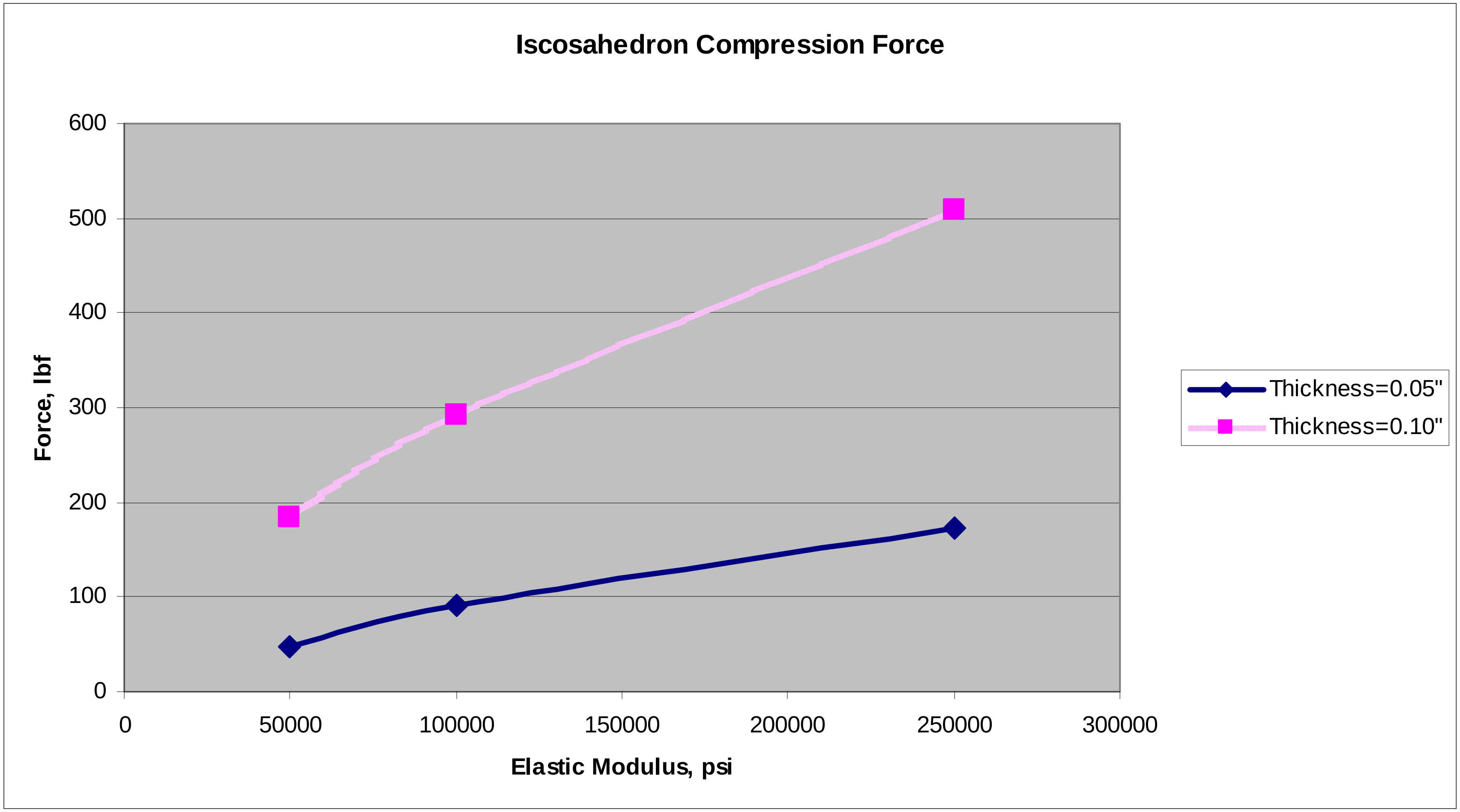

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The force values are for one (1) icosahedron.

Modeling Details of 1/8 Symmetry Icosahedron (1" sides)

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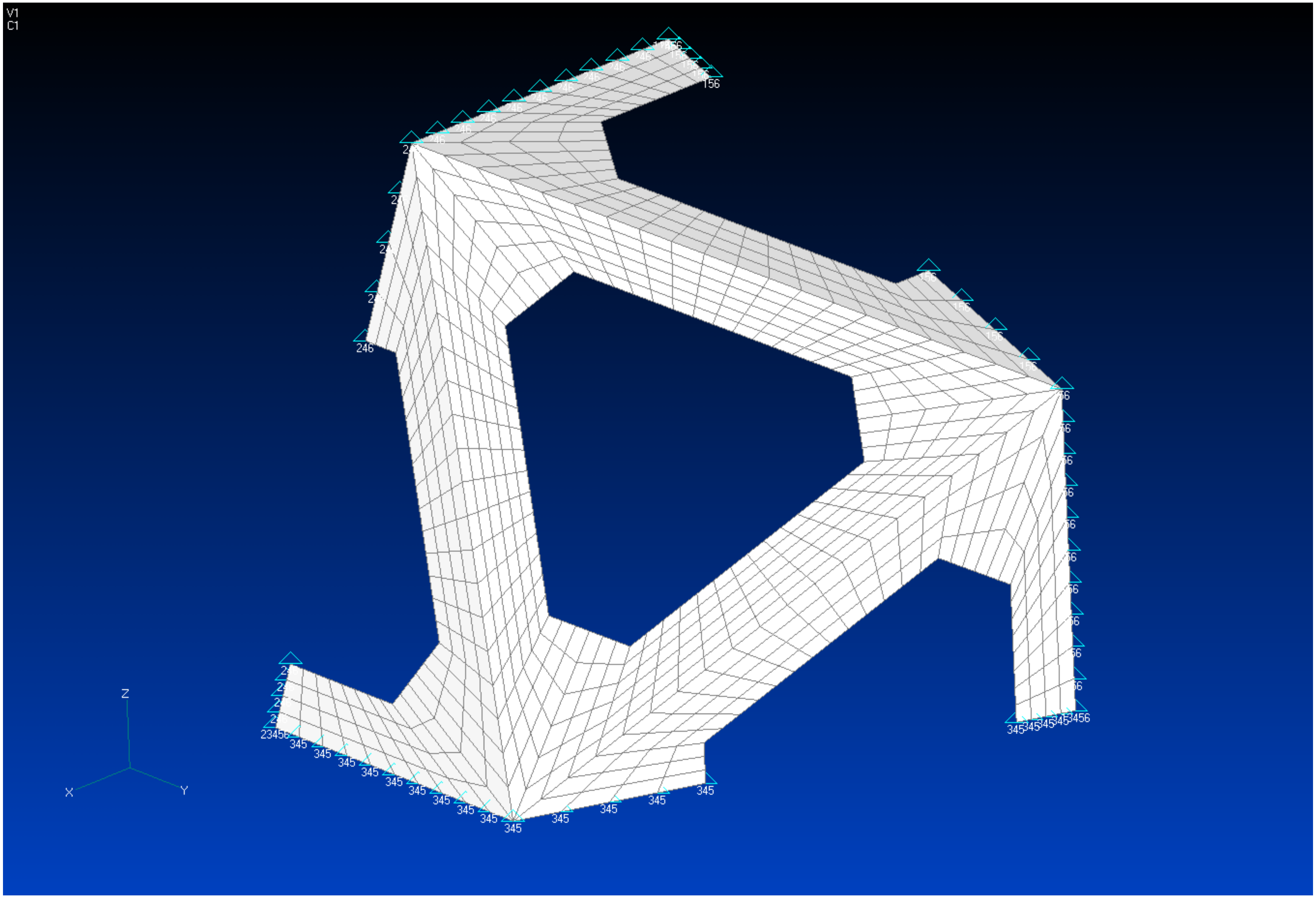

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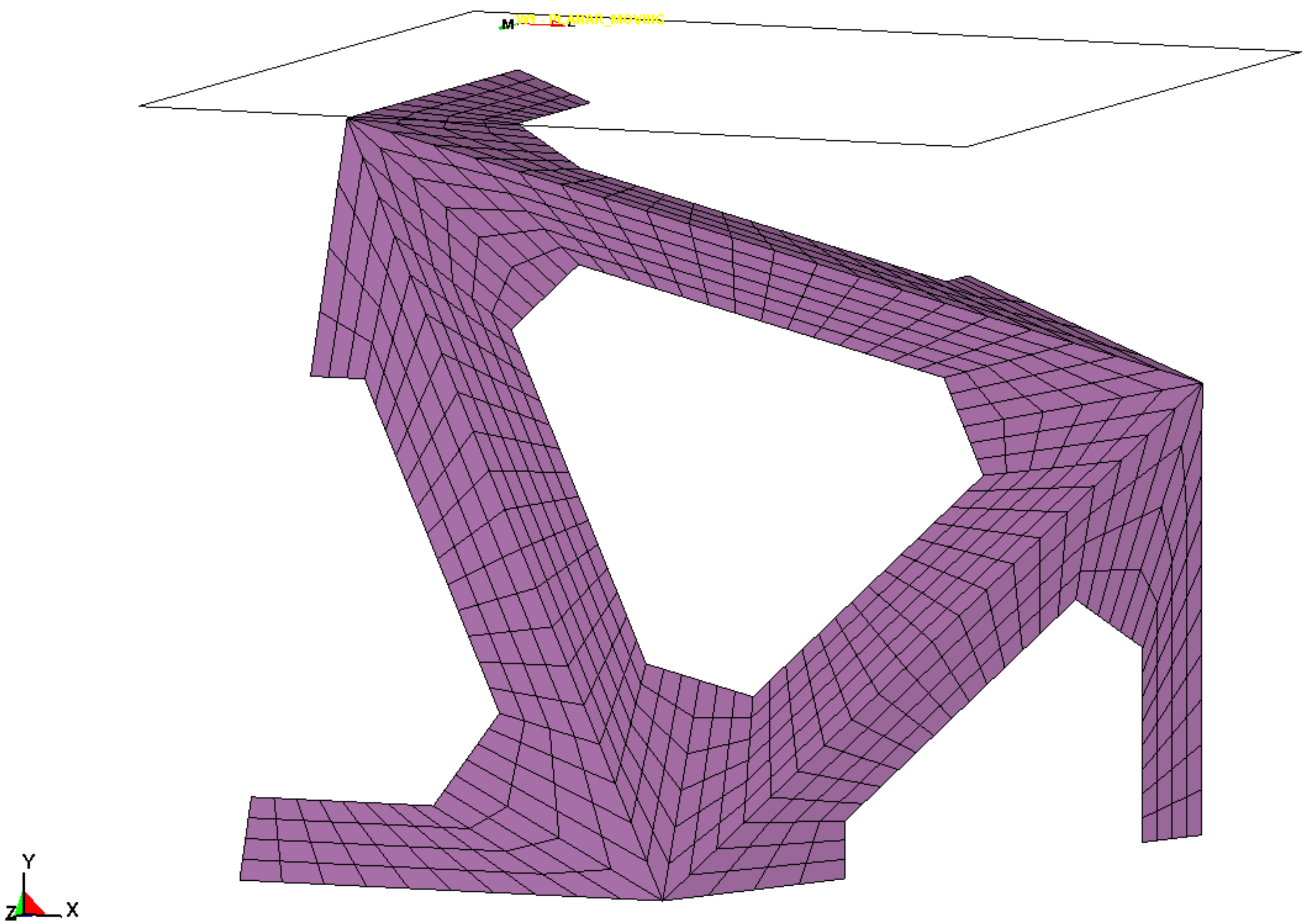
Symmetric model of the icosahedron. The triangle edge length is 1.0”. The symbols along the edges are the B.C.s to enforce symmetry.

Flextegrity Icosahedron 0.1 Thk / E=50000



A moving rigid surface (outline) was used to deform the 1/8th symmetry FEA model.

Stress Results for Compressive Loading of Icosahedron

0.10" Thick Walls / Elastic Modulus E=50,000 psi

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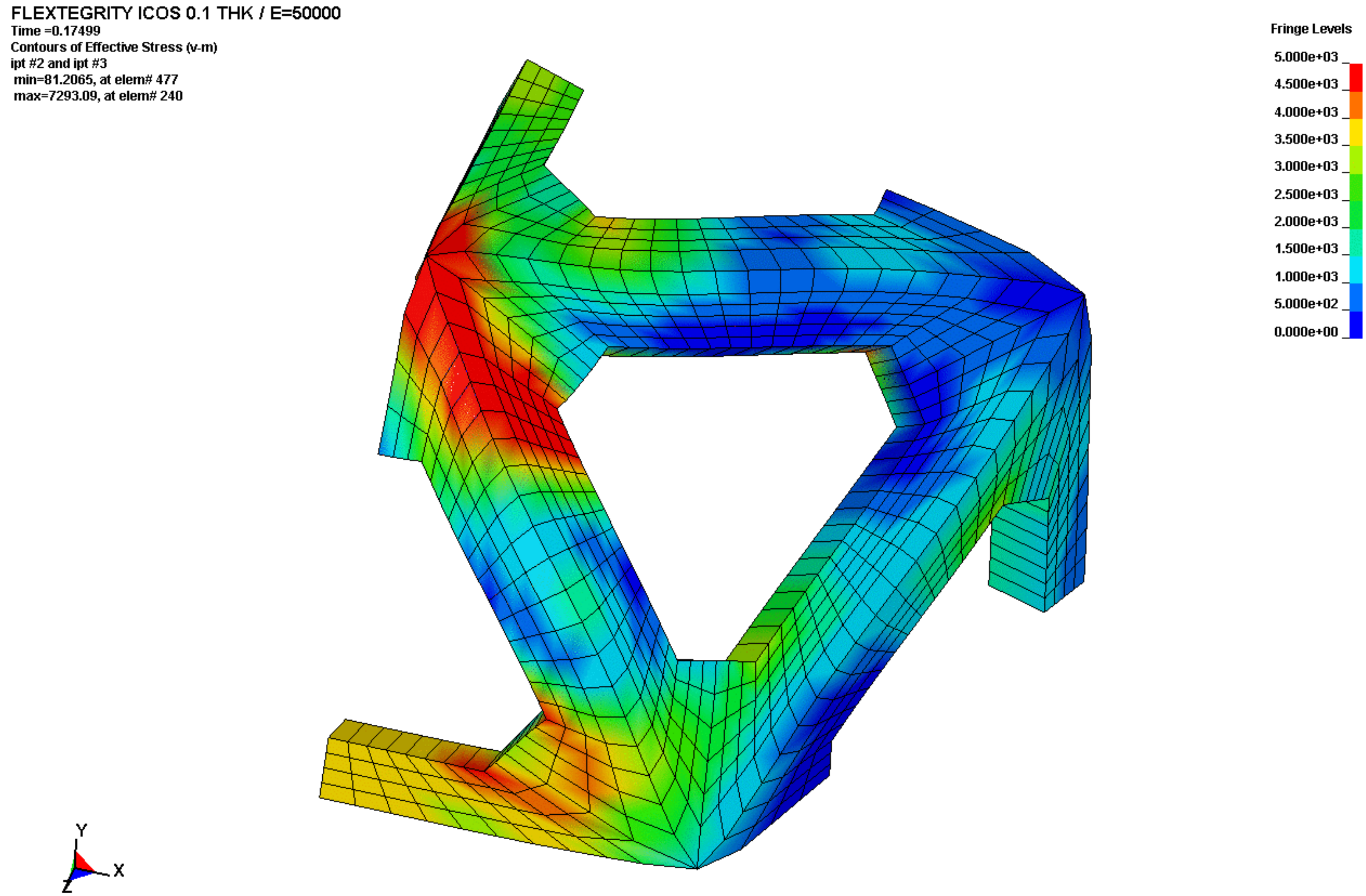

The stress results indicate the loading pattern. All results are presented with the stress legend capped at 5,000 psi to allow direct comparison with the results presented.

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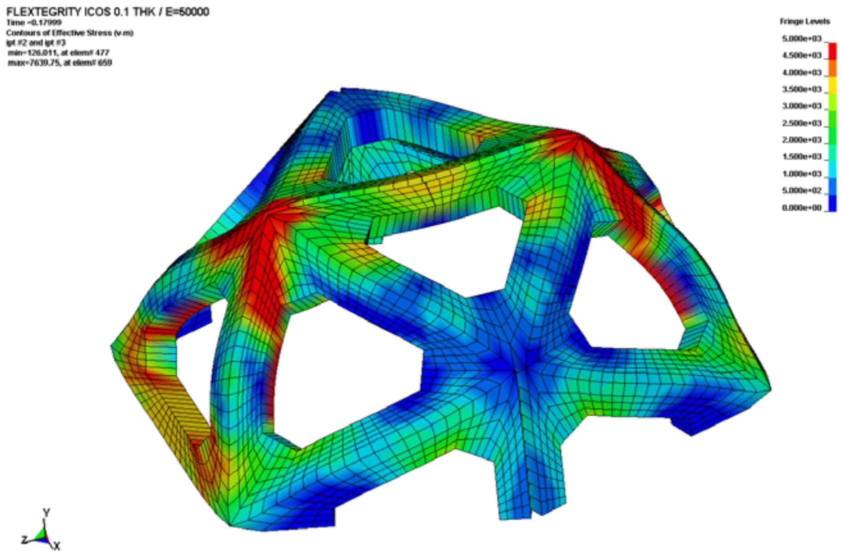

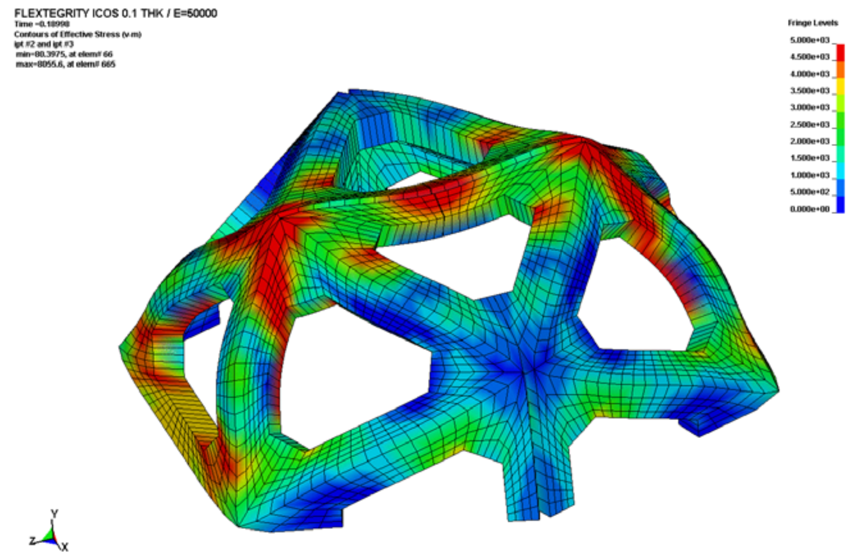

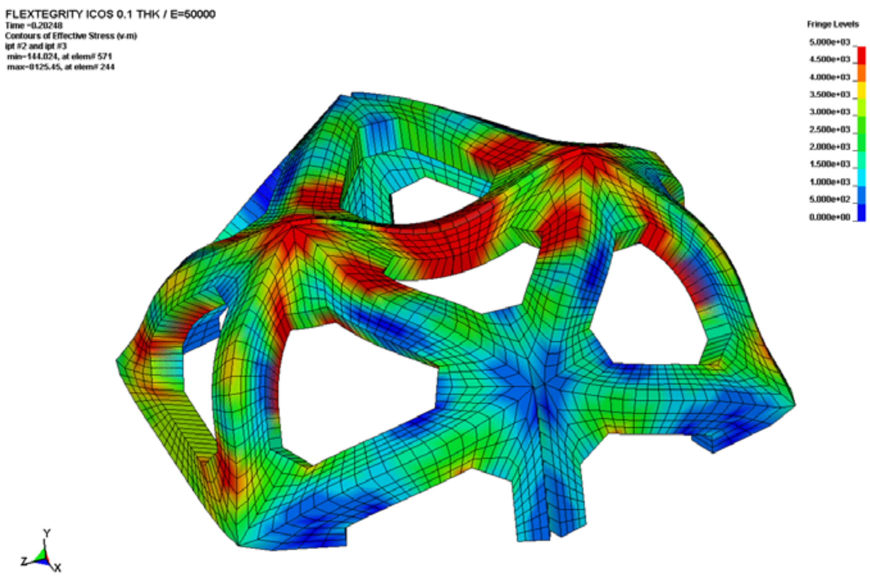

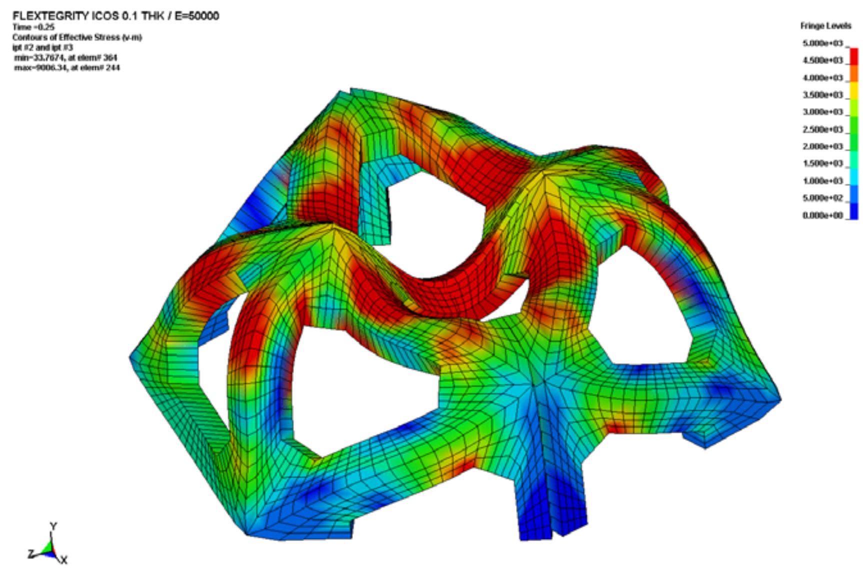

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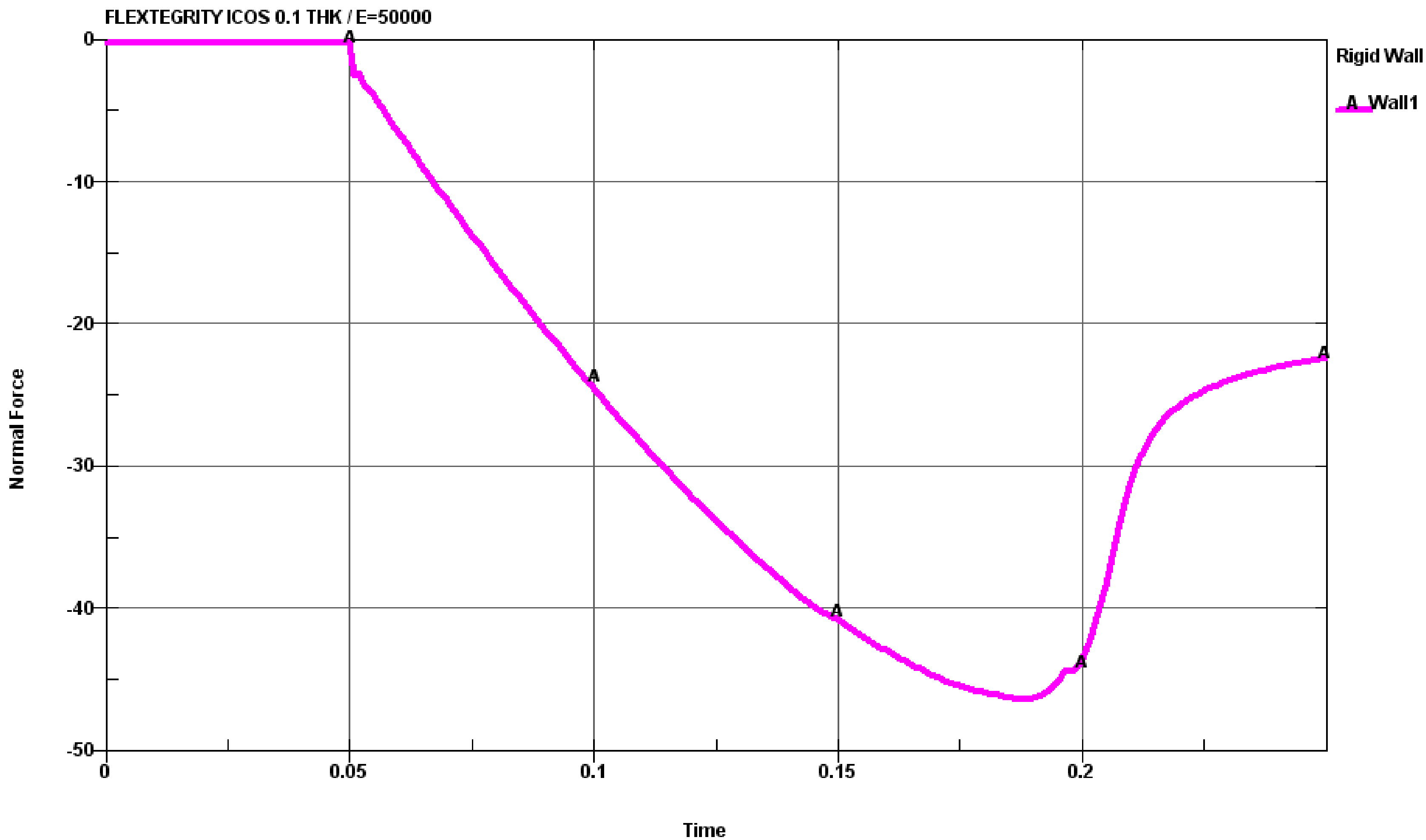
A movie file titled Flextegrity Icosahedron Compressive Thk010_E50000.avi is available that shows the deformation behavior of the structure from start to finish.



The peak load carrying capacity is around 46 lbf. After this load the structure buckles or collapses and the load decreases.

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Stress Results for Compressive Loading of Icosahedron

0.10" Thick Walls / Elastic Modulus E=250,000 psi

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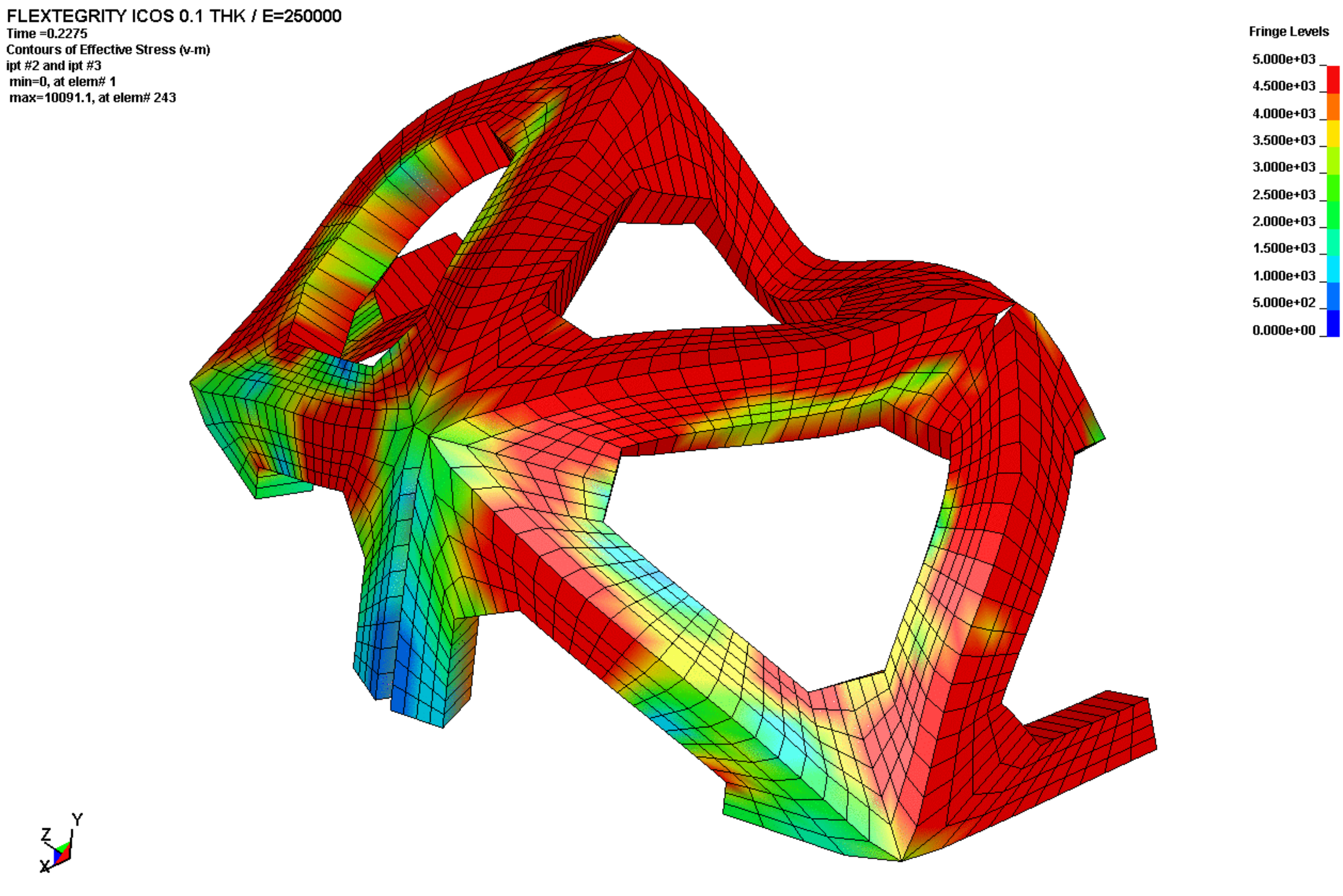

There is a movie file titled: Flextegrity_Compression_Thk010_E250000.avi that captures the complete deformation response.

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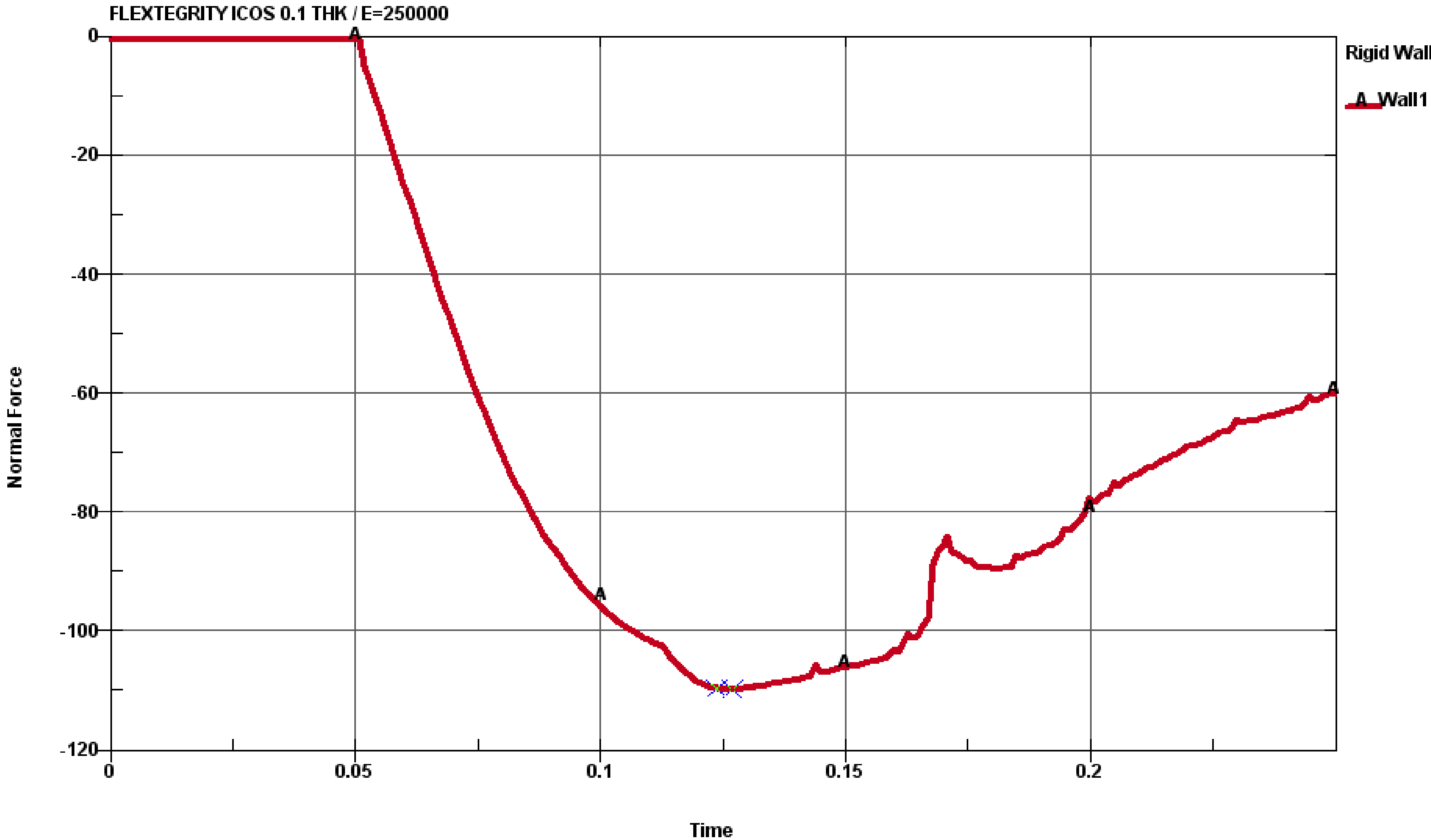

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Stress Results for Compressive Loading of Icosahedron
0.050" Thick Walls / Elastic Modulus E=250,000 psi

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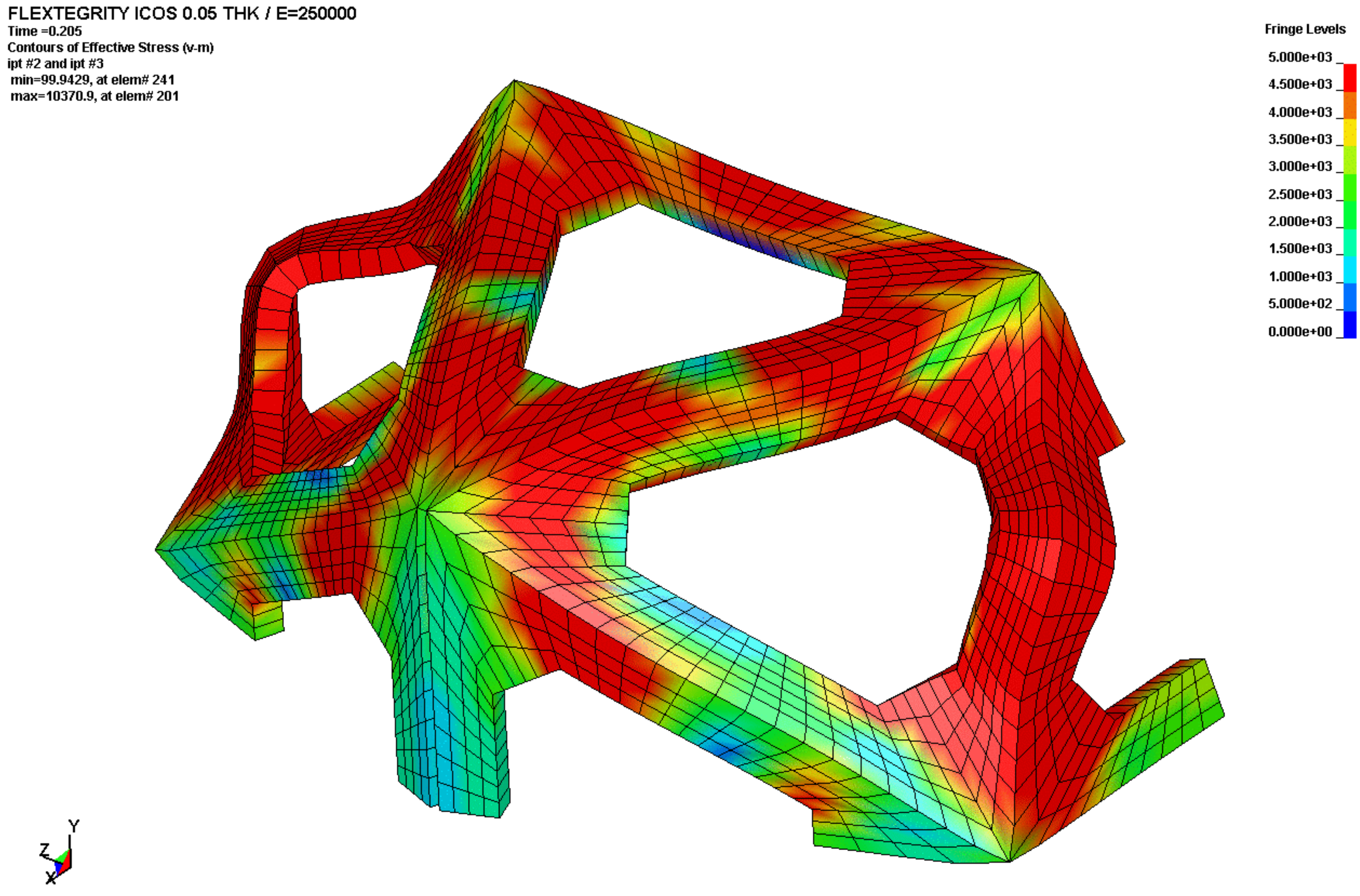
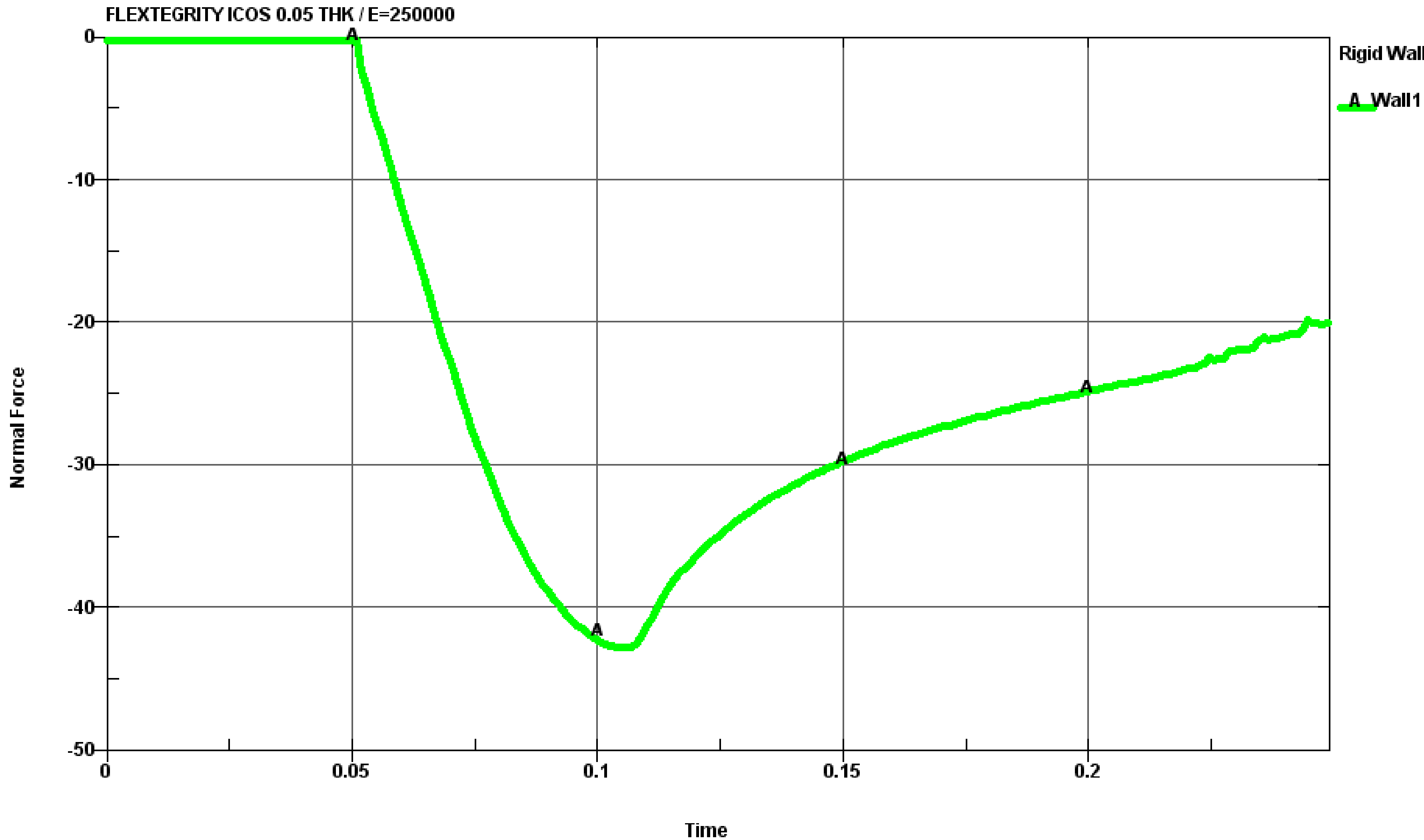


A movie file titled: Flextegrity_Compression_Thk005_E250000 is available that covers the complete deformation behavior.



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Stress Results for Compressive Loading of Icosahedron

0.050" Thick Walls / Elastic Modulus E=50,000 psi

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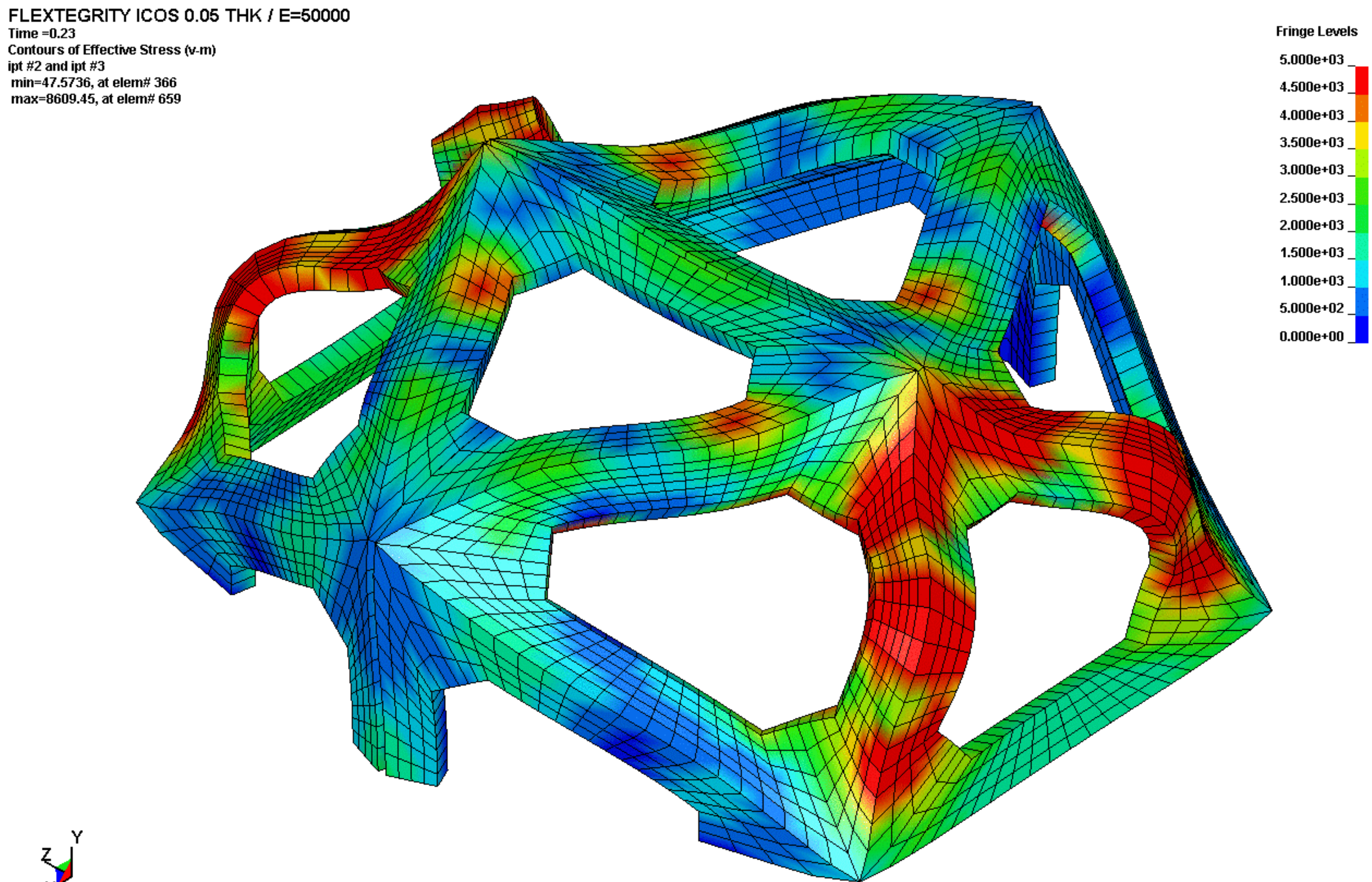

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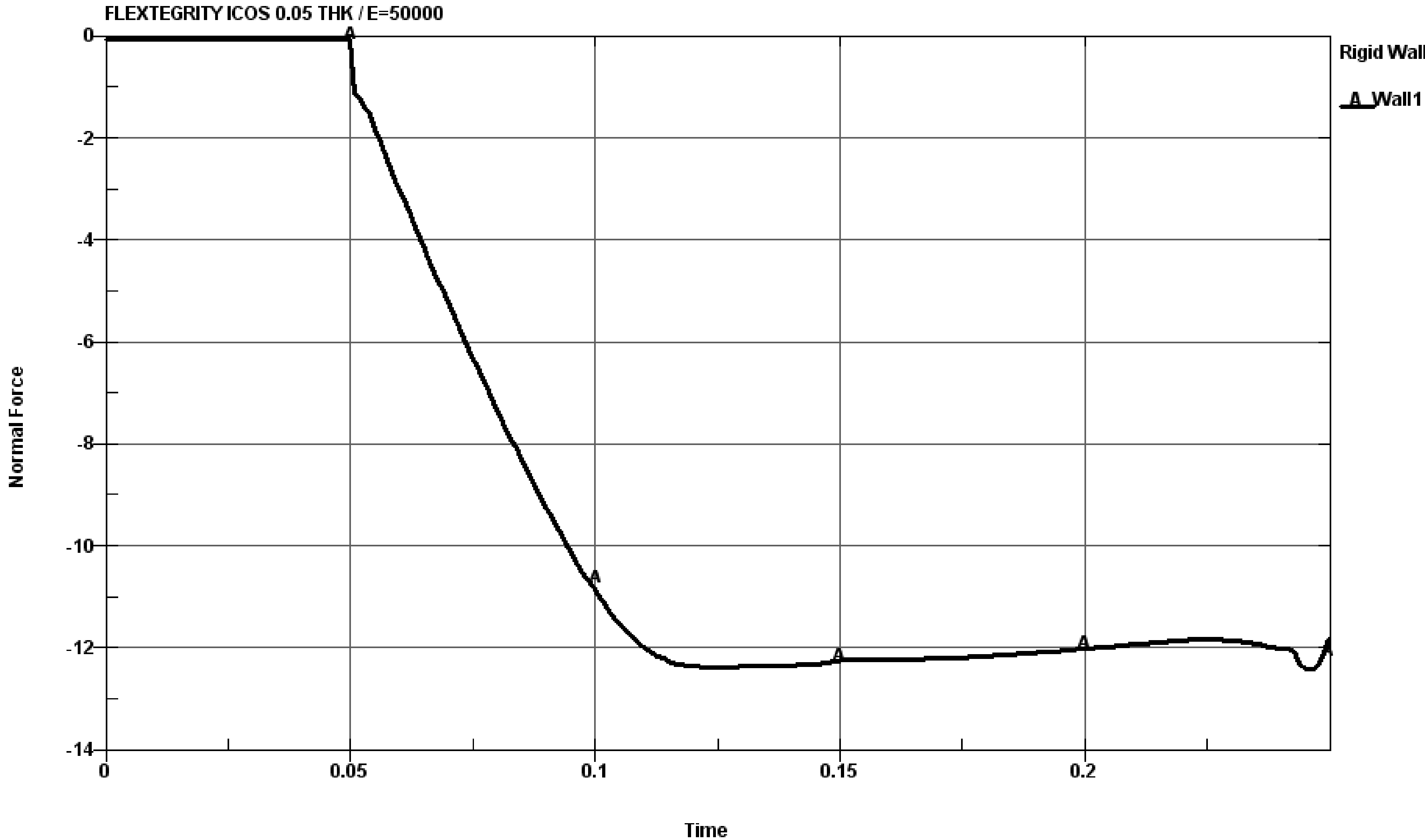
A movie file titled: Flextegrity_Compression_Thk005_E50000.avi is available to show the complete deformation process.



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Appendix

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GEORGE LAIRD II

Registered As	Cert. #	Status	Expires
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All work within this report was done under best industry practices and was executed by George Laird, Ph.D., P.E.

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