Method for Multi-Error Analysis and Simulation of Future Space Station Truss Application

Mizuki Abe1,2, Ying Zhang3, Hanshu Zhang4, Pol D Spanos3,4

1Department of Mechanical and Aerospace Engineering, Tohoku University, Sendai, Miyagi, Japan
2Nakatani RIES: Research & International Experiences for Students, Rice University, Houston, Texas, U.S.A.
3Department of Mechanical Engineering, Rice University, Houston, Texas, U.S.A.
4Department of Civil and Environmental Engineering, Rice University, Houston, Texas, U.S.A.

Challenges of Private sectors in Space

- The rise of private sectors in aerospace field
- Needs for building space station in a low effort
- Safety assessment and Uncertainty quantification
- The advance of private sectors into space station business
- Engineers should design space station considering the effort and safety

Analytical Approximation

\[
E[g(d, E)] = g(d_{m, E_{m}}) + \frac{1}{2} \frac{\partial^2 g(d_{m, E_{m}})}{dE^2} \sigma_{E}^2 + \frac{1}{2} \frac{\partial^2 g(d_{m, E_{m}})}{dE^2} \sigma_{d}^2 \quad \text{eq(3)}
\]

\[
V[g(d, E)] = g(d_{m, E_{m}})^2 + \left( \frac{\partial g(d_{m, E_{m}})}{dE} + g(d_{m, E_{m}}) \right) \frac{\partial^2 g(d_{m, E_{m}})}{dE^2} \sigma_{E}^2 + \left( \frac{\partial g(d_{m, E_{m}})}{dd} + g(d_{m, E_{m}}) \right) \frac{\partial^2 g(d_{m, E_{m}})}{dd^2} \sigma_{d}^2 - E[g(d, E)]^2 \quad \text{eq(4)}
\]

- To ensure that this simulation method is appropriate
- Calculate the analytical mean using Taylor expansion of \(g(d, E)\)

Simulation and Analysis Result

Path to more reliable space truss system

- Consider analysis method more for mean and variance
- Change the study target for different products and the error parameter
- Change the method to calculate the deflection or think other value to evaluate the performance
- Consider other way to assess the performance and reliability in low effort

Table 2 mean and variance of simulation and analysis

<table>
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<th></th>
<th>Warren</th>
<th>Pratt</th>
<th>Howe</th>
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<tbody>
<tr>
<td>m [m]</td>
<td>(\sigma^2)</td>
<td>m [m]</td>
<td>(\sigma^2)</td>
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<tr>
<td>Simulation</td>
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<td>Analysis</td>
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<td>1.35e-7</td>
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</tbody>
</table>

Discussion and Conclusion

- All of the deflection can be fitted by Normal distribution
- Howe truss has the smallest value both in mean and variance This indicates that Howe truss is hard to bend and tolerant to errors compared to other two trusses
- Means from simulation and analysis are in good agreement This indicates that this simulation method is reliable in consideration of the performance with slight difference in rigidity However, the variations are relatively big We need further analysis
- Considering the mean and variance might be effective in assessing the performance and reliability of product
- More consideration is needed in order to assess the reliability and performance in low manufacturing effort and encourage the movement of private sectors’ space development and utilization in space technology

Acknowledgement

This research project was conducted as a part of the Nakatani Foundation’s 2018 Nakatani RIES Fellowship for Japanese Students For more information, visit http://nakatani-ries.rice.edu/ Special thanks to the Spanos Lab at Rice University for their research mentorship and to Prof Kono, Sarah Phillips, Kenji Ogawa and Aki Shimada for their help and support

Reference