25-650: Applied FEA

Assignment 7

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Due: 4/22/2024

Overall Objective

1) Use the combination of modal, mode superposition harmonic, and
time transient structural analyses to address the problem of a pressure wave striking a chimney
2) Determine the maximum total displacement (absolute value in mm and to the nearest 10 mm) of the chimney structure during the time transient analysis based on the pressure wave
3) Determine if the chimney is likely to collapse and explain why or why not.

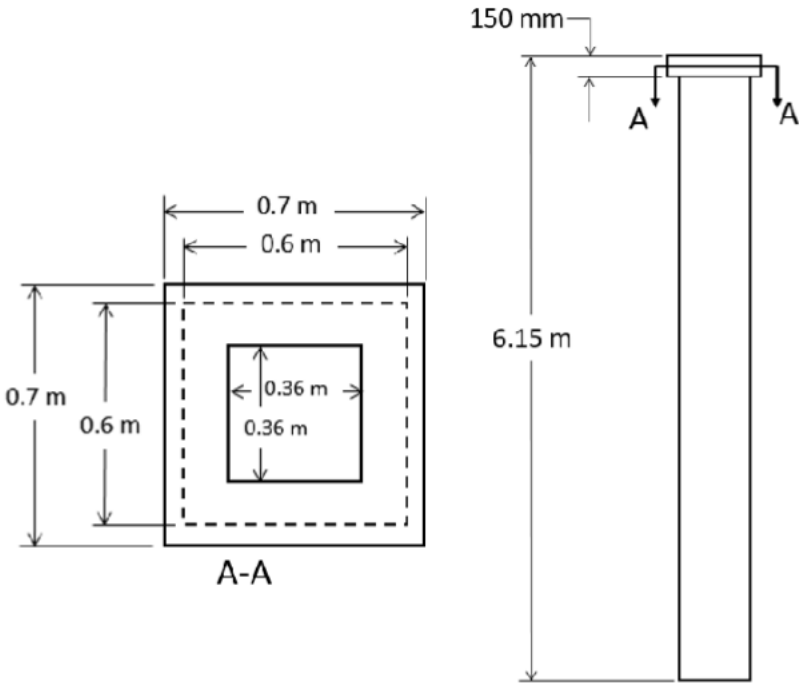
Assumptions

For all situations below, it is assumed that the bottom face of the chimney is fixed. It is also assumed that the pressure load acts along two faces as shown in the loading conditions later in this document.

Material Data

The material used was concrete from the engineering data tab within Ansys Workbench.

Geometry

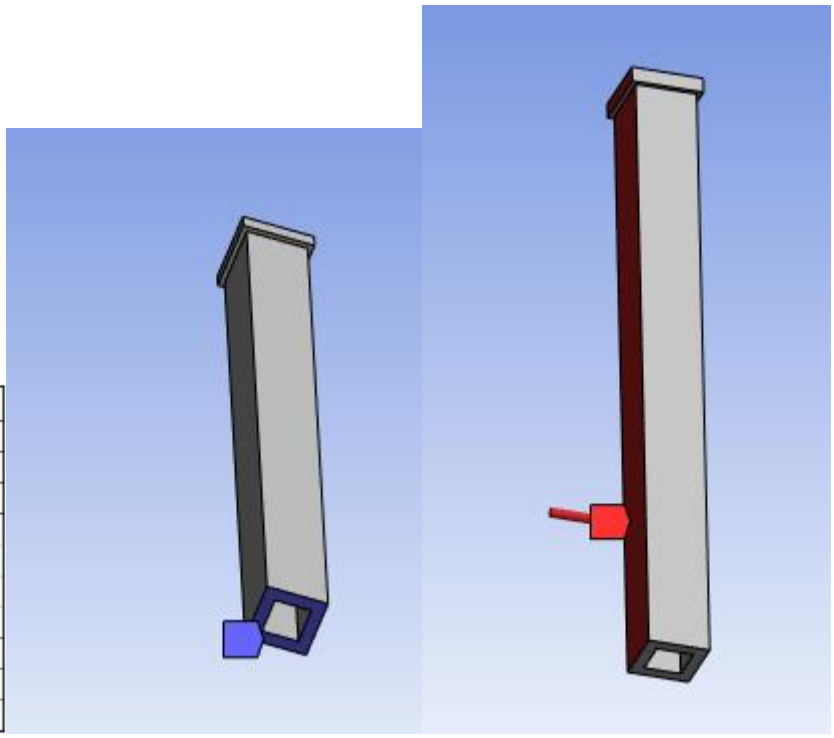


Boundary Conditions

For this analysis, the following conditions were used:

- Fixed support along the bottom face
- Pressure load along 2 faces (tabular data shown below). For transient, a constant pressure load of 2 MPa was used.

t (sec)	p (MPa)
0.0	2.00
0.1	1.36
0.2	0.78
0.3	0.32
0.4	0.10
0.5	0.00
0.6	-0.06
0.7	-0.10
0.8	-0.08
0.9	0.00



Analysis Settings

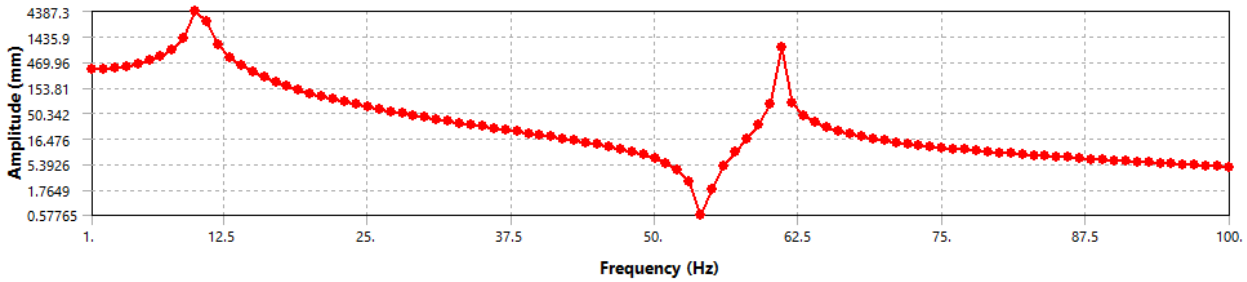
Modal:

For the modal analysis, the number of modes was selected such that the sum of the Ratio of Effective Mass to Total Mass was greater than .9 for all categories (see below). In this case, 32 modes were used for the modal analysis.

Sum		0.96251	0.9318	0.96251	0.99987	0.95836	0.99987

Harmonic:

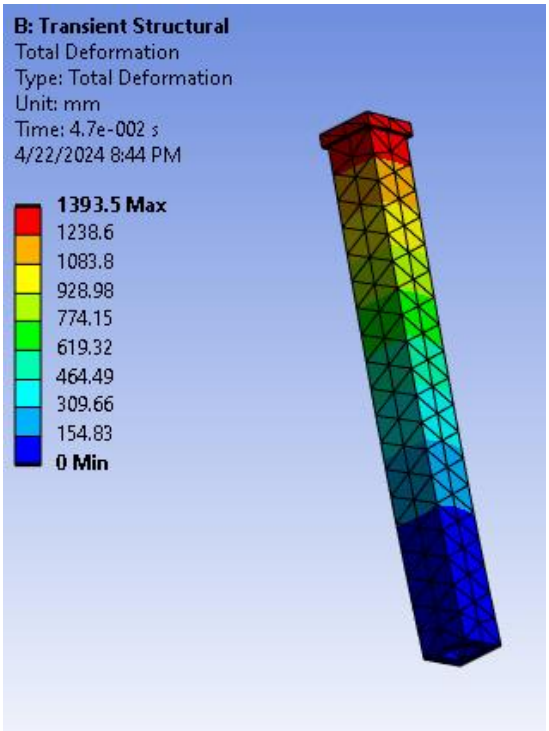
The frequency range used was 0-100Hz with 100 solution intervals. The number of intervals was increased until the curve was sufficiently defined. See frequency response below:



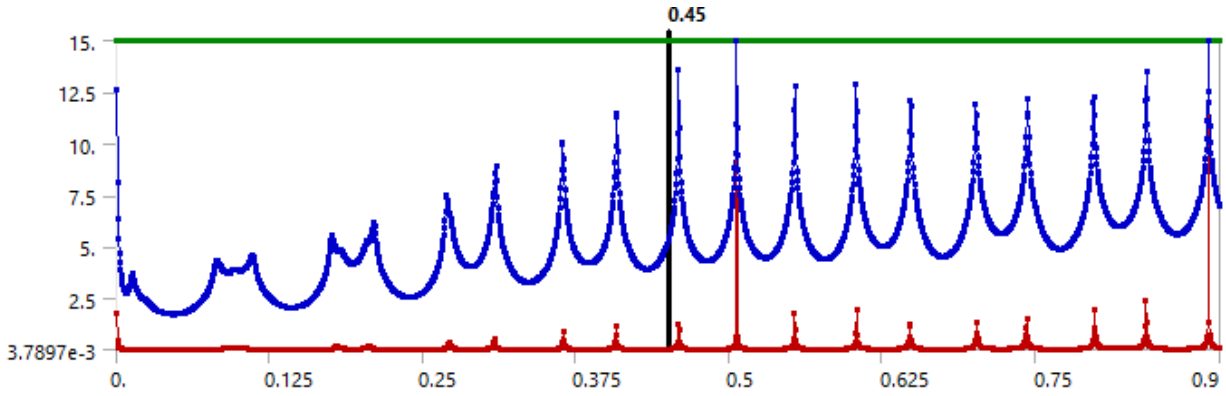
Transient:
The transient analysis settings are shown below. The time step was reduced until the results converged at 0.001s -- difference between peak total deformation results of less than 10mm. Time steps of 0.01, 0.001, and 0.0005 were used to demonstrate convergence. The stiffness coefficient was determined by dominant frequency (10.399Hz) as shown above in the harmonic analysis and a damping ratio of 3%. The pressure load was also converted from tabular to 2 MPa.

Step Controls	
Number Of Steps	1.
Current Step Number	1.
Step End Time	0.9 s
Auto Time Stepping	Off
Define By	Time
Time Step	1.e-003 s
Time Integration	On
Options	
Include Residual Vector	No
On Demand Expansion Option	Program Controlled
-- On Demand Expansion	No
Mode Selection Method	None
Output Controls	
Damping Controls	
Eqv. Damping Ratio From Modal	No
Damping Ratio	0.
Stiffness Coefficient Define By	Damping vs Frequency
-- Frequency	10.399 Hz
-- Damping Ratio	3.e-002

Full Results



The maximum total deformation of the chimney during transient analysis was shown to be **1390mm.**



The minimum safety factor of the chimney during transient analysis was shown to be **0.0038.** This extremely low safety factor strongly suggests that the chimney would **fail** during these loading conditions.

Conclusion

Overall, the results of the simulations make sense given the conditions used. It makes sense that given the enormous pressure load that the chimney would fail. Concrete without rebar or other support material should not be used under these loading conditions.