Modal Analysis of Nuclear Fuel Assembly Using the Model Reduction Method

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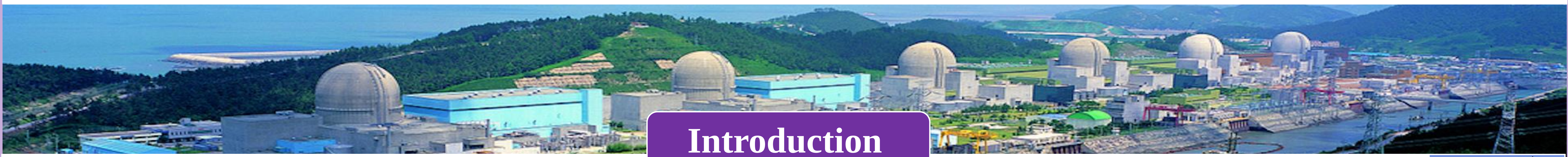
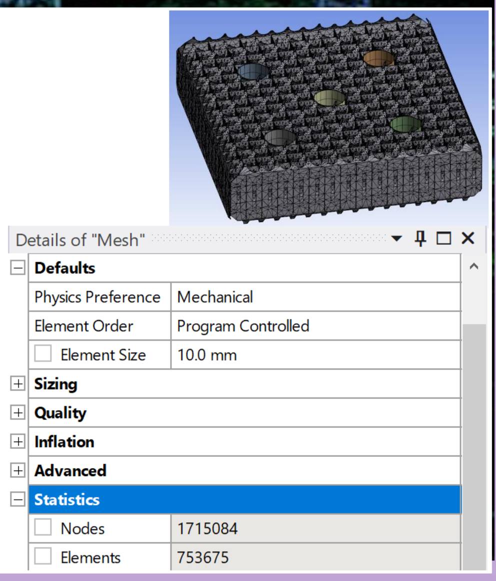
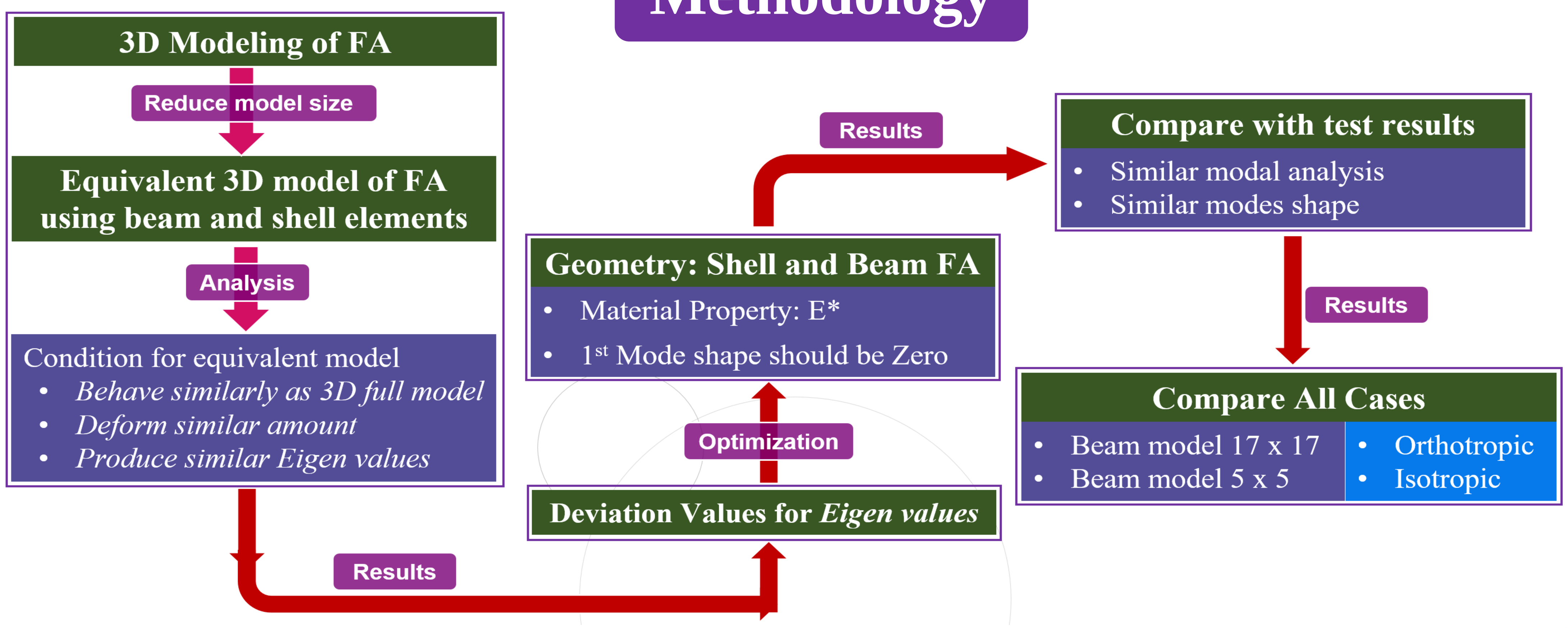


Introduction

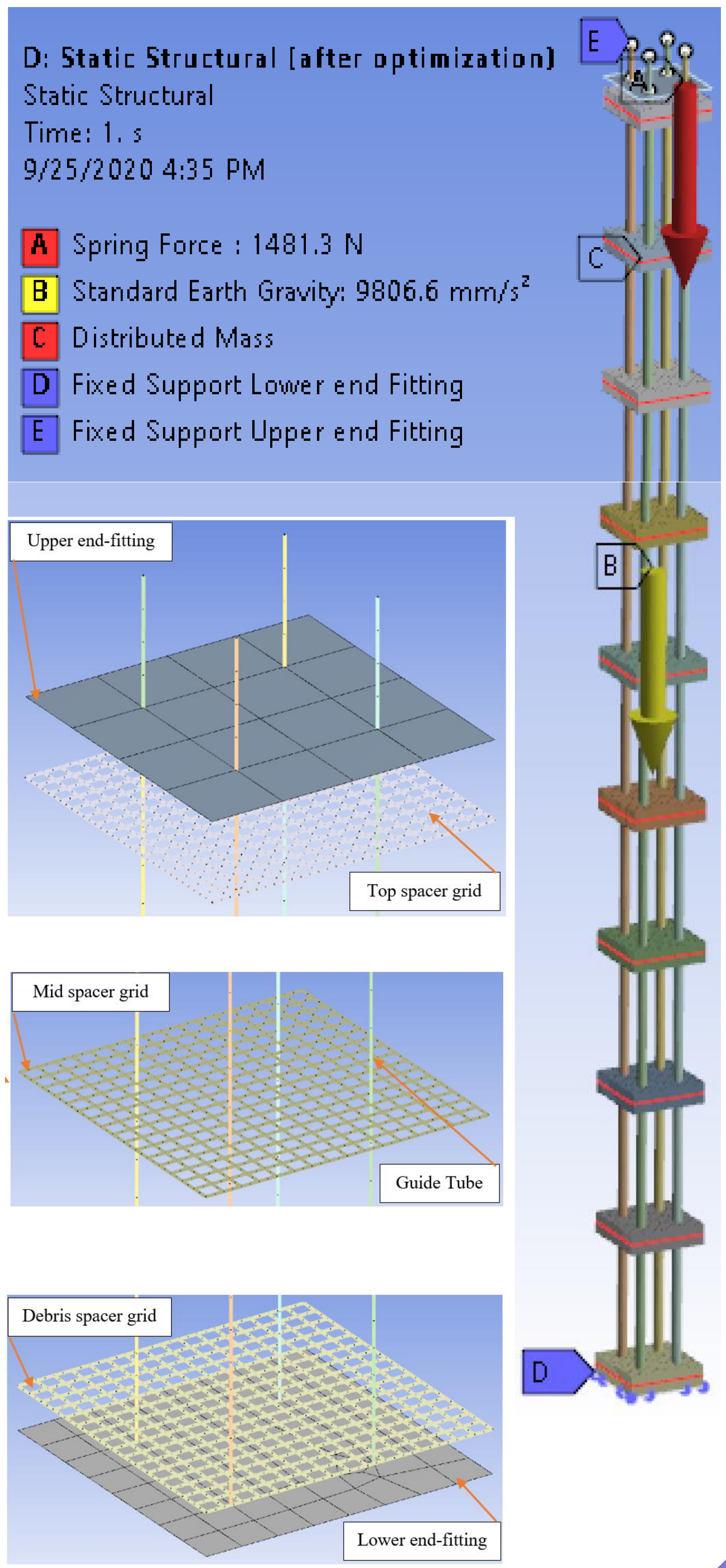
- The structure of fuel assemblies should have the capability to withstand lateral static and dynamic loads from external forces such as an earthquake.
- Currently, a lot of research has been the put in development of nuclear fuel assembly using 1D or 2D modeling and avoid the complexities of 3D modeling fuel assembly. But, in the 1D or 2D model, interaction between CEA guide tubes and twist motion of fuel assembly can not be assessed. 3D Dynamic analysis on the other hand, in the case of time history analysis, requires a lot of computing time.
- In this research, a 3D modeling approach will be introduced and proposed the method and will carry out a simple case of dynamic analysis. Beam and shell elements are used to construct fuel assembly and reduced model size using ANSYS software.
- The modal analysis of this fuel assembly gives Mode shapes and Modal values. This presents for the first time each fuel rod behavior and interaction between them, and will also show which position of the spacer grid will experience more dynamic-behavior.



Methodology



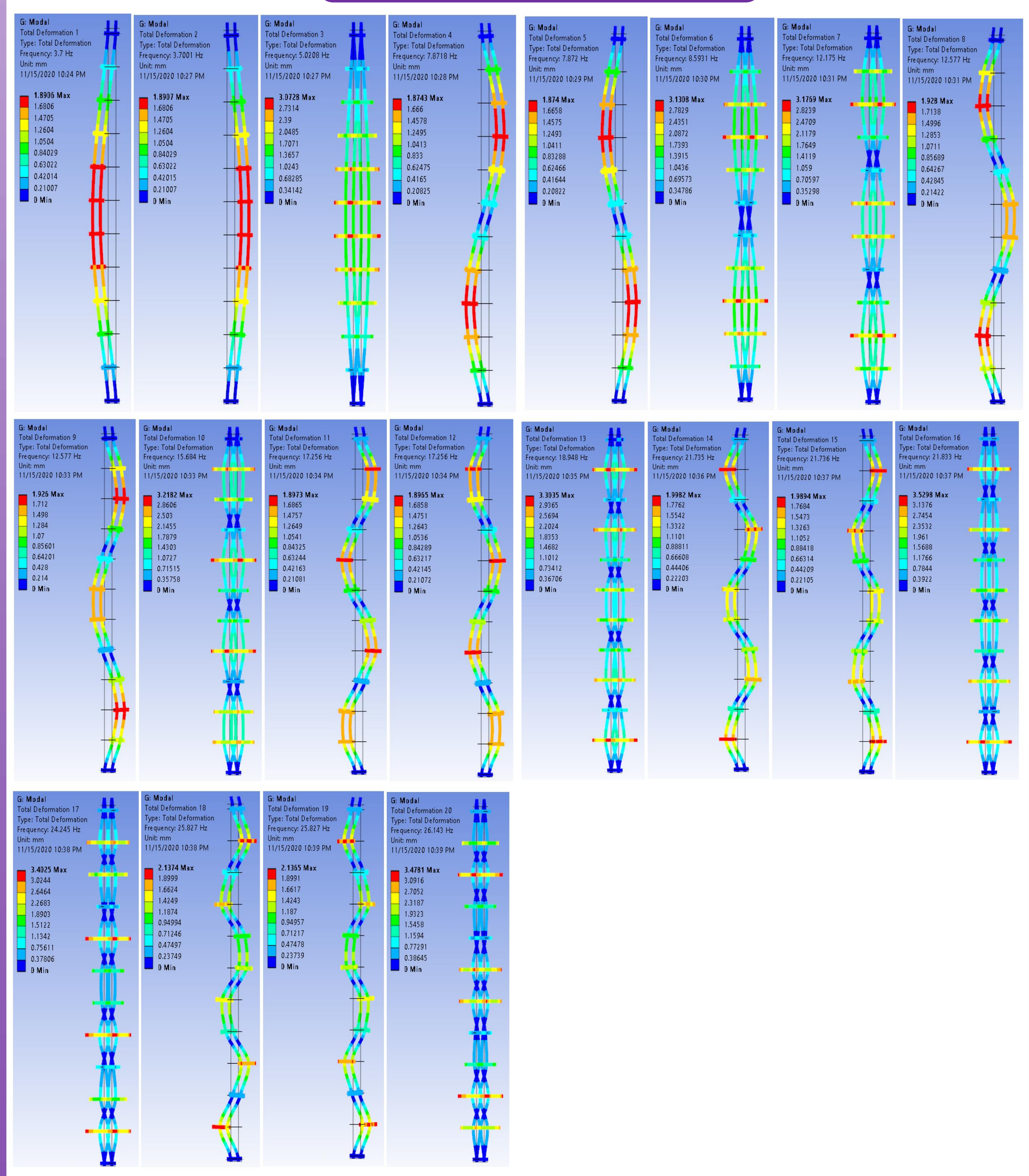
Boundary Condition



Name	Beam Profile
Guide tube	Outer diameter = 26 mm Inner diameter = 24 mm
Guide post	Outer diameter = 12 mm Inner diameter = 8 mm
Spacer Grid	Thickness = 0.45 mm Area= 53.5 x 53.5 mm High = 42 mm
Weight of 17x17 Fuel Assembly	659 kg

Loading/ condition	Value
Weight of fuel rod assembly	611.24 [kg]
F.A. hold-down spring force (approximately)	1481.3 [N]

Results



Mode	Results	Remarks
1	***3.7***	***Beam mode***
2	3.7001	*Beam mode*
3	5.0208	Twist mode
4	***7.8718***	***Beam mode***
5	7.872	*Beam mode*
6	8.5931	Twist mode
7	12.175	Twist mode
8	***12.577***	***Beam mode***
9	*12.577*	*Beam mode*
10	15.684	Twist mode
11	**17.256**	***Beam mode***
12	*17.256*	*Beam mode*
13	18.948	Twist mode
14	**21.735**	***Beam mode***
15	21.736	*Beam mode*
16	21.833	Twist mode
17	24.245	Twist mode
18	***25.827***	***Beam mode***

Conclusion

The research can give the failure loading by which buckling or structural damage to fuel assembly can occur. This maximum loading can serve as a criterion for severe accident initiation events.

- We successfully carried out modal analysis of single fuel assembly
- The 3D reduced model revealed twist modes that the lumped mass spring model cannot capture
- Due to the twist motion of the fuel assembly we can assume that there could be interaction between neighboring fuel assemblies.

Future Work

This research is first step to full core modeling using 3D reduced model of Fuel Assembly to investigate the seismic response of the full-core and interaction between Fuel Assemblies and Fuel Assemblies and reactor internals.

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