2025

Rectangular PLATE ANALYSIS

PHASE II

VIBRATIONS SPRING 1404

PREPARED BY:

ASRA MEHROLHASSANI SID: 810800024

THE CURRENT DOCUMENT IS A REPORT OF THE SECOND VIBRATIONS PROJECT REGARDING RECTANGULAR PLATE ANALYSIS

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Phase I: Rectangular Plate Analysis

Introduction

The current document is a report of the secondVibrations Project, prepared for the class Vibrations- ME 8106-116-0.

Knowledge of ‘**Dynamics**”, ‘**Vibrations**” and familiarity with “**Abaqus**” is required for understanding this document.

For further insights, the reader can study “Theory of Vibration with Applications” written by William T. Thomson.

The aim of this project is to familiarize students with Abaqus.

Model Design

Plate Creation

As stated by the project descriptions, a 0.5x1 m^2 plate is designed in the Solid modeling environment under the “Part” section in Abaqus. The width of this plate is set to be 0.01.

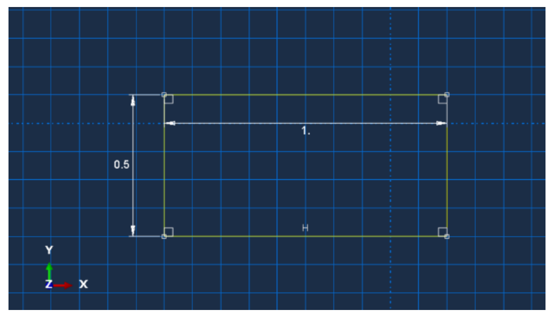


Figure 1.The 2d sketch of the plate before extrusion

Material Selection

As suggested, the material is set as steel.

Later a surface with this material is defined and matched with the part (the rectangular plate) built in the previous section. Since we are to study the vibrations of this plate, “Frequency” step is used after the initial step.

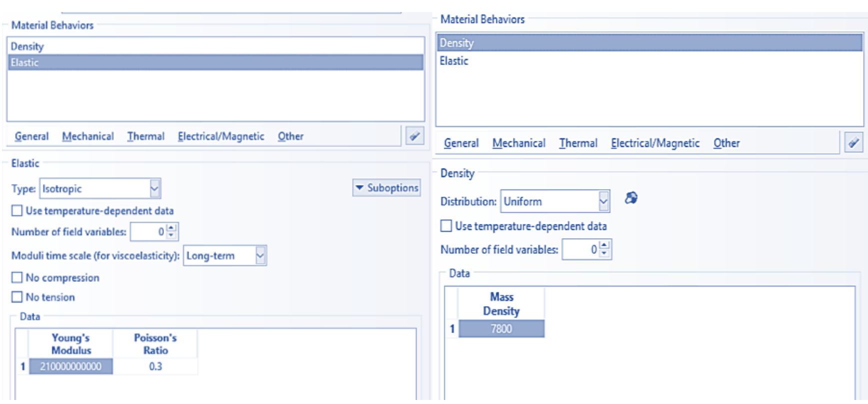


Figure 2. Material Behavious of the rectangular plate

Notice how Abaqus doesn’t provide any units settings, as it is expected that the user is consistent and careful with his/her numbers.

Boundary Conditions

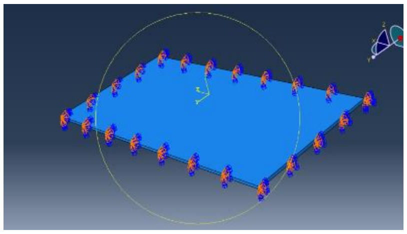
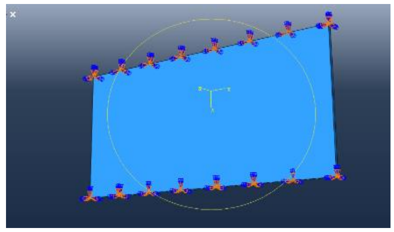
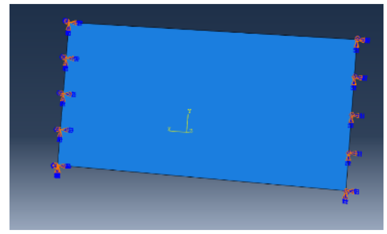
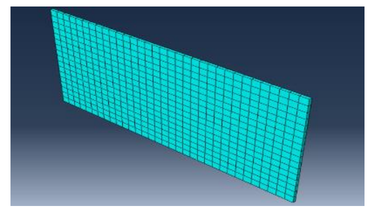
  

Figure 3. Boundry Consitions inseted on 3 models, CCCC, CFCF, FCCF respectively

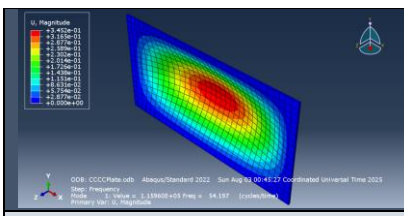
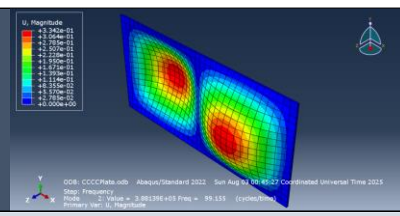
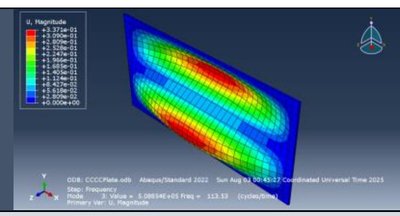
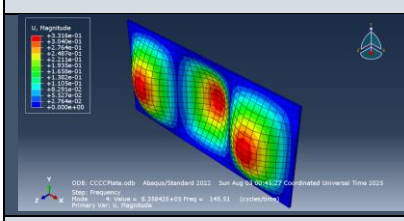
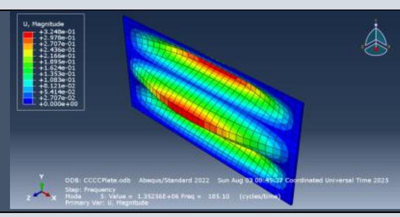
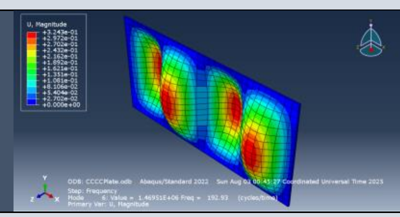
Mesh Settings



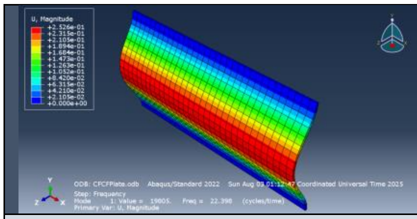
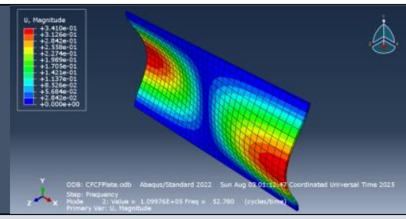
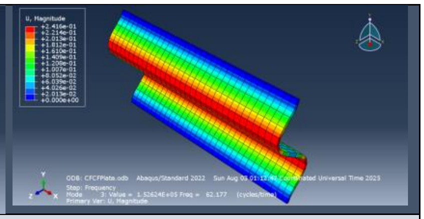
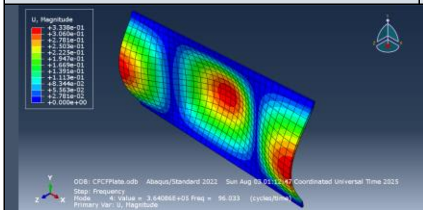
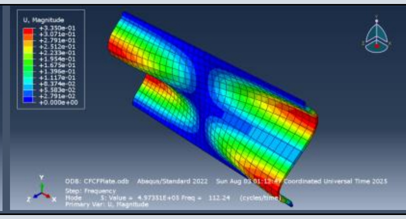
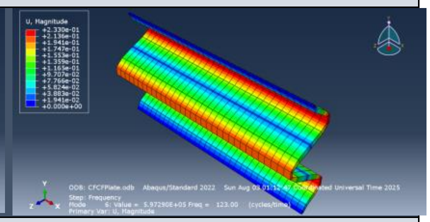
Seed: 0.03
Element Library: Standard
Geometric Order: Linear

Analysis & Results

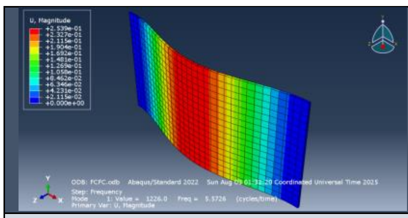
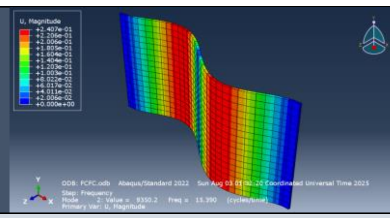
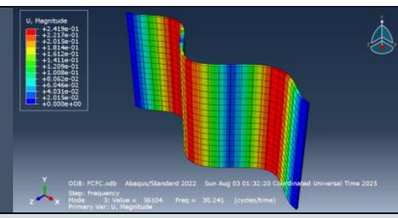
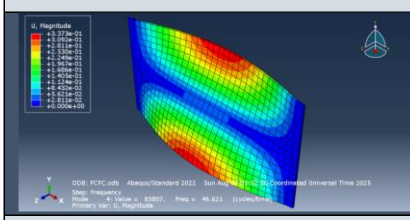
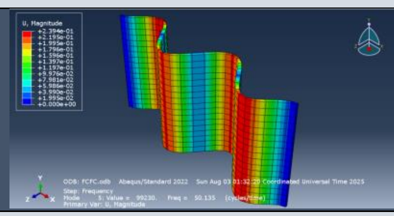
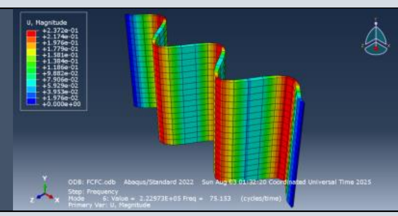
Model 1: CCCC Plate

		
54 cycles/*time*	99 cycles/time	113 cycles/Time
		
145 cycles/ Time	185 cycles/time	192 cycles/time

Model 2: FCCF Plate

		
22 Cycles/time	52 cycles/time	62 cycles/time
		
96 cycles/time	112 cycles/time	123 cycles/time

Model 3: CFCF Plate

		
5 cycles/time	15 cycles/time	30 cycles/time
		
46 cycles/time	50 cycles/time	75 cycles/time

Interpretation & Comparison

Notice how the natural frequencies of the first model (**CCCC Plate**) is **higher** than the other two models. A CCCC plate has all edges clamped, fully restricting translation and rotation. This creates maximum stiffness, especially against bending and lateral deformation. Because all edges are fixed, the plate cannot easily deform, especially in lower modes (like bending or twisting). So, the mode shapes that do occur correspond to **higher energy (higher frequency)**.

Similarly FCCF's natural frequencies are higher than CFCF, the same analogy can be applied here.

Boundary conditions heavily influence the stiffness of a structure, and natural frequency is proportional to the square root of stiffness over mass:

$$f_n = \sqrt{\frac{k}{m}}$$

Mode Shape Comparison Table

Mode Shape Aspect	CFCF	FCCF	CCCC
Edge Constraint	asymmetric stiffness	asymmetric stiffness	Fully symmetric, maximum stiffness
First Mode Shape	shows large bending across the **free edges**, with a node line near center	shows large bending across the **free edges**, with a node line near center	Smooth, symmetric central bulge (domed), minimal edge movement
Symmetry	Typically **symmetric** about the axis connecting clamped edges	Typically **symmetric** about the axis connecting clamped edges	Highly **symmetric** in both axes
Deformation Location	Concentrated near the **free edges**	Concentrated near the **free edges**	**More distributed**, uniform shape
Torsional Modes	May occur earlier due to lower constraints	May occur earlier due to lower constraints	Occur at **higher modes due to high stiffness**
Frequency Magnitude	**Low** due to 50% free edges	**Low** due to 50% free edges(higher than CFCF)	**High**, due to all clamped edges

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Practical Implications

- **CFCF**: Often used in modeling bridges or panels with partial support. Modes highlight flexibility.
- **CCCC**: Reference model for fully supported structures like metal sheets in frames.