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Assignment

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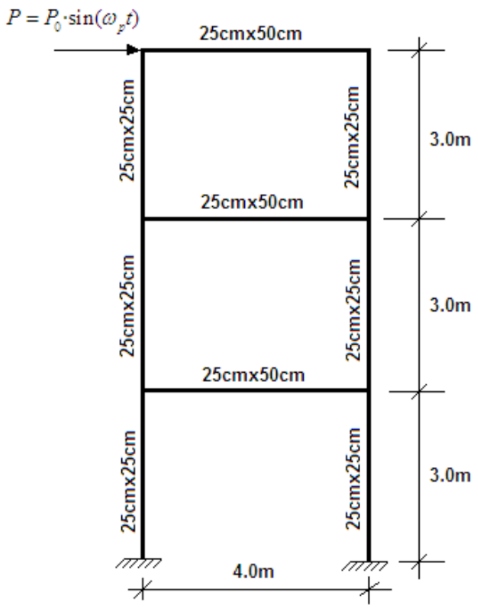
# Contents

# Task 1




*Task 1 Problem Description*

## 1.1 Pre-processing

Pre-processing steps are outlined as follow:

1- The given model represents a two dimensional frame with a variable cross section with material properties of concrete $E = 3e10\frac{N}{m^2}, v = 0.2$

2- Structure is discretised with a 2 node beam elements with a global element size of $0.03125m$ set upon mesh convergence study.

3- In the solver definition, two types of solvers are defied 1) Frequency solver: to calculate Eigen values and modal frequencies 2) Steady state dynamics solver with direct integration: To estimate the structure response under given loading.

4- Lower two ends of the frame are fixed i.e .$U_x = U_y = U_{R1} = U_{R2} = 0$.

5- Modal analysis is carried out for three cases using direct integration solver. a) Case 1 involving the dynamic load with frequency equal to 75% of the structures natural frequency b) Case 2 involving the dynamic load with frequency equal to the structures natural frequency c) Case 3 involving the dynamic load with frequency equal to 125% of the structures natural frequency. In all test cases, self weight of the structure is also considered.

## 1.2 Results and discussion

The case study is solved commercial software GiD. Result of the study are illustrated and discussed in this section. But prior to explaining the results, the mesh convergence study us explained first as follow:

### 1.2.1 Mesh convergence study

**Mesh conv**ergence study is carried out in terms natural frequency with a relative error tolerance of $10^{-4}$. Results are illustrated in figure 1.

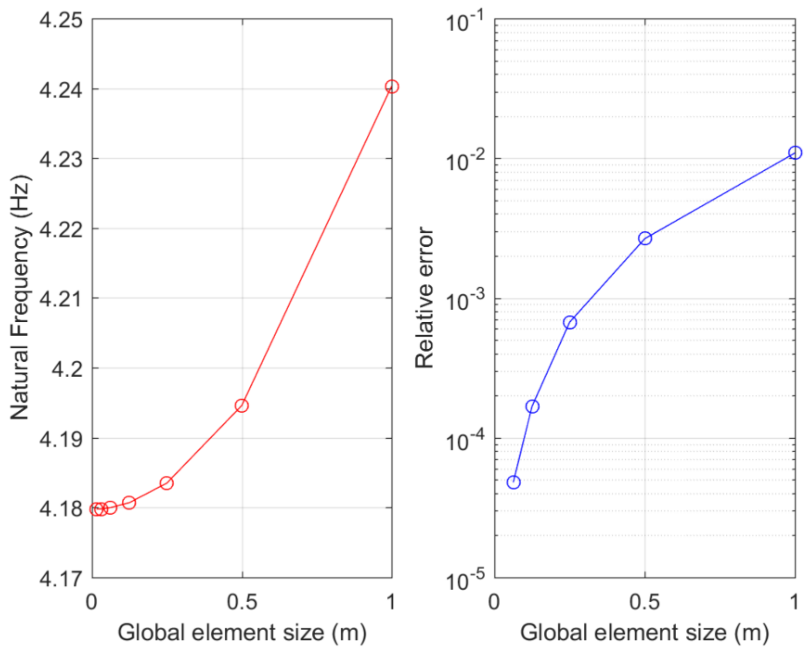



*Figure 1 Mesh Convergence Study*

### 1.2.2 Estimating frequency modes

The Eigen values and frequencies estimated for the current study are described in table 1. The estimated angular natural frequency $\omega_n$ of the structure is 26.2624 $^{radians}/_{s}$.

| Mode | Frequency (Hz) | Eigen values |
|---|---|---|
| 1 | 4.1798 | 689.7 |
| 2 | 12.418 | 6087.6 |
| 3 | 19.410 | 14874.0 |
| 4 | 42.712 | 72020.0 |
| 5 | 47.409 | 88731.0 |
| 6 | 51.473 | 1.04596e5 |
| 7 | 73.839 | 2.15243e5 |
| 8 | 82.837 | 2.70902e5 |
| 9 | 89.714 | 3.17749e5 |
| 10 | 92.533 | 3.38032e5 |

*Table 1 Task 1: Eigen values and frequency modes*

### 1.2.3 Modal analysis

Results of the modal analysis are illustrated in the figure 2. Figure 1.2 and 1.4 is implemented for case 1 and 3 respectively. In the figures it can see that vibration frequency of the structure is larger than for $1.25\omega_n$ but for both case the displacement amplitude does not grow with time. While for the test case 2 the structure experiences resonance and as can be seen the amplitude grow over time.

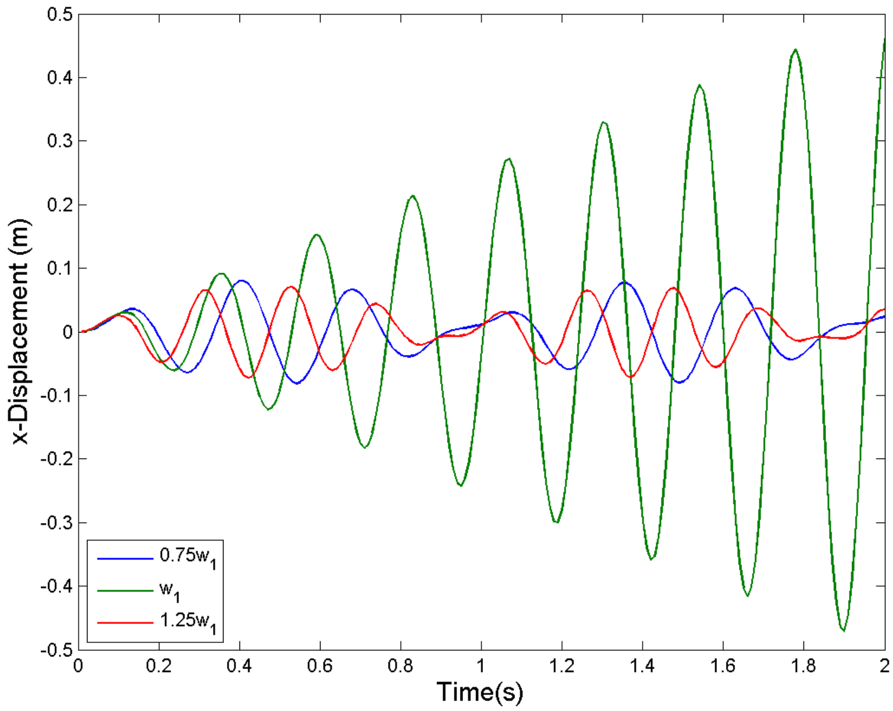



*Figure 2 Task 1: X-displacement- time plot for different loading frequencies*

Moreover from the stress response graph (figure 3) it can be seen that the for the resonance case the like displacement, the stress amplitude also grows with time. Hence for the resonance frequency the structure is deemed unsafe. On the other hand for test case 1 and 3 the stress amplitude stay within the bounds of ultimate tensile strength.

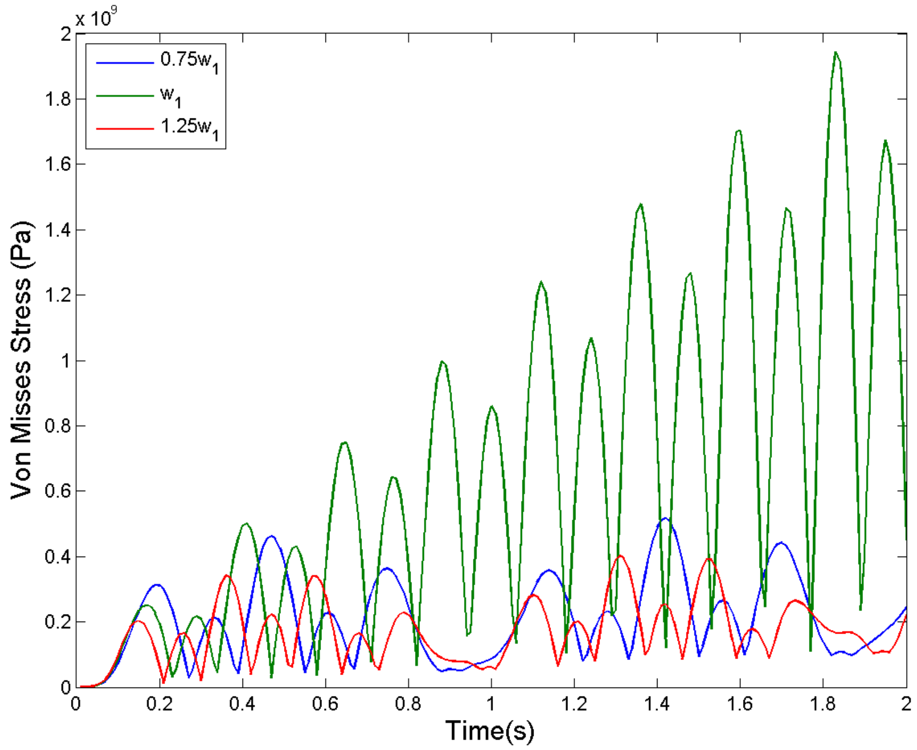
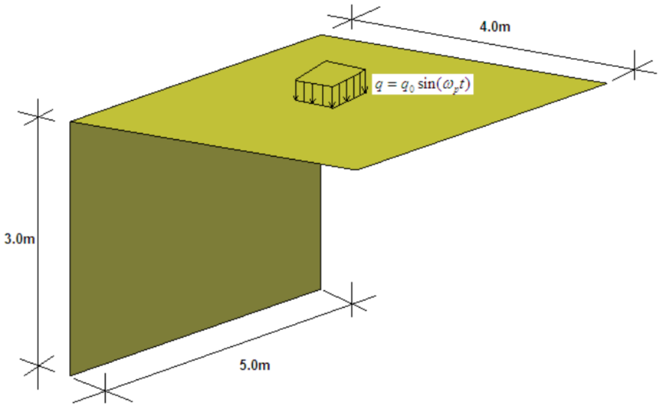



*Figure 3 Task 1: Von Mises stress response for various loading frequencies*

# Task 2




*Task 2 Task Description*

## 2.1 Prepressing

Pre-processing steps are outlined as follow:

1- The given model represents a three dimensional concrete shell structure.

2- The structure is discretised with 4 node shell reduced integration elements. A global element size of *0.125m* is set upon mesh convergence study.

3- In the solver definition, two types of solvers are defied 1) Frequency solver: to calculate Eigen values and modal frequencies 2) Steady state dynamics solver with direct integration: To estimate the structure response under given loading.

4- Lower two ends of the shell plate are fixed i.e. $U_x = U_y = U_z = U_{R1} = U_{R2} = U_{R3} = 0$.

5- Modal analysis is carried out for three cases. a) Case 1 involves the dynamic load with frequency equal to 75% of the structures natural frequency b) Case 2 involves the dynamic load with frequency equal to the structures natural frequency c) Case 3 involves the dynamic load with frequency equal to 125% of the structures natural frequency. In all test cases, self weight of the structure is also considered.

## 2.2 Results and discussion

The case study is solved commercial software GiD. Result of the study are illustrated and discussed in this section. But prior to explaining the results, the mesh convergence study us explained first as follow:

### 2.2.1 Mesh convergence study

**Mesh con**vergence study is carried out in terms natural frequency with a relative error tolerance of $10^{-4}$. Results are illustrated in figure 5.

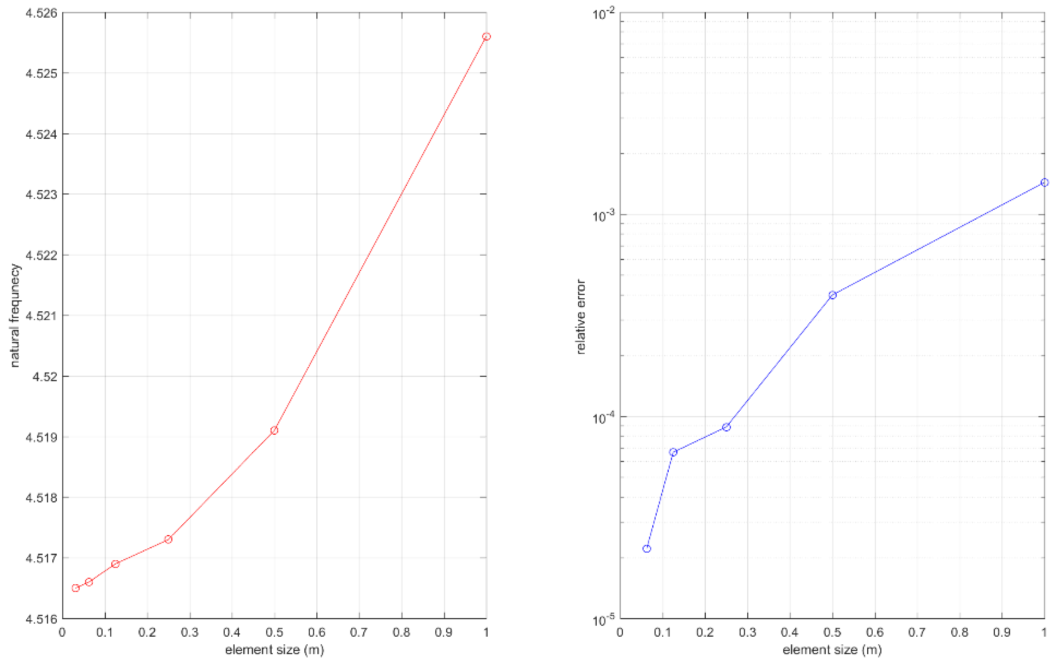



*Figure 4 Task 2: Mesh convergence study*

### 2.2.2 Estimating frequency modes

The Eigen values and frequencies estimated for the current study are described in table 2. The estimated angular natural frequency $\omega_n$ of the structure is 28.378 radians/Hz.

| Mode | Frequency (Hz) | Eigen values |
|---|---|---|
| 1 | 4.5165 | 805.32 |
| 2 | 8.5498 | 2885.8 |
| 3 | 12.523 | 6191.0 |
| 4 | 19.640 | 15229.0 |
| 5 | 50.507 | 1.00708e5 |
| 6 | 55.776 | 1.22814e5 |
| 7 | 70.492 | 1.96175e5 |
| 8 | 83.135 | 2.728502e5 |
| 9 | 99.960 | 3.94472e5 |
| 10 | 110.62 | 4.83106e5 |

*Table 2 Task 2: Eigen values and frequency modes*

### 2.2.3 Modal analysis

Results of the modal analysis are illustrated in the figure 6. In the figure it can be seen that vibration frequency of the structure is larger than for *1.25*$\omega_n$ but for both case the displacement amplitude does not grow with time. While for the test case 2 the structure experiences resonance and as can be seen the amplitude grow over time.

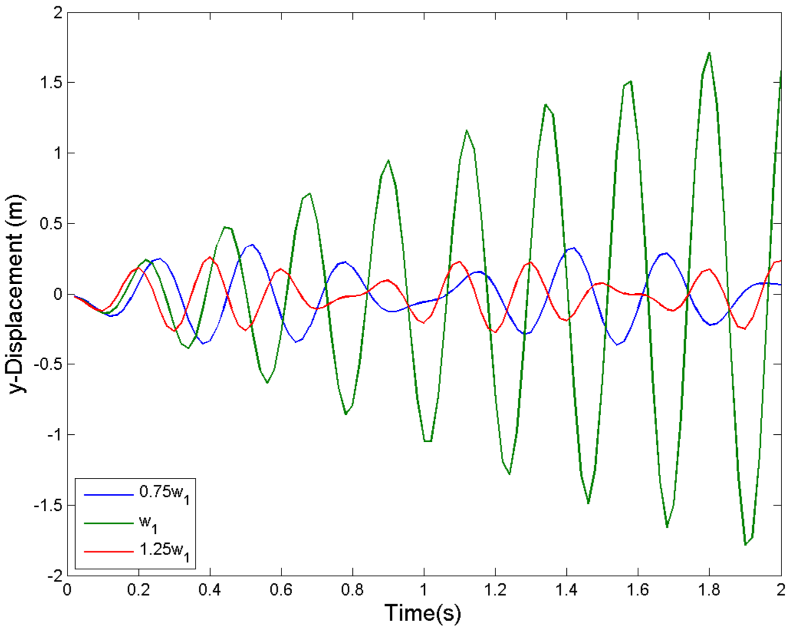



*Figure 5 Task 2: y-displacement- time plot for different loading frequencies*

Moreover from the stress response graph (figure 7) it can be seen that the for the resonance case the like displacement amplitude the stress amplitude also grows with time. Hence for the resonance frequency the structure is deemed unsafe. On the other hand for test case 1 and 3 the stress amplitude stay within the bounds of ultimate tensile strength. **Note that for a thorough safety and long term durability analysis, a fatigue study should be carried out.**

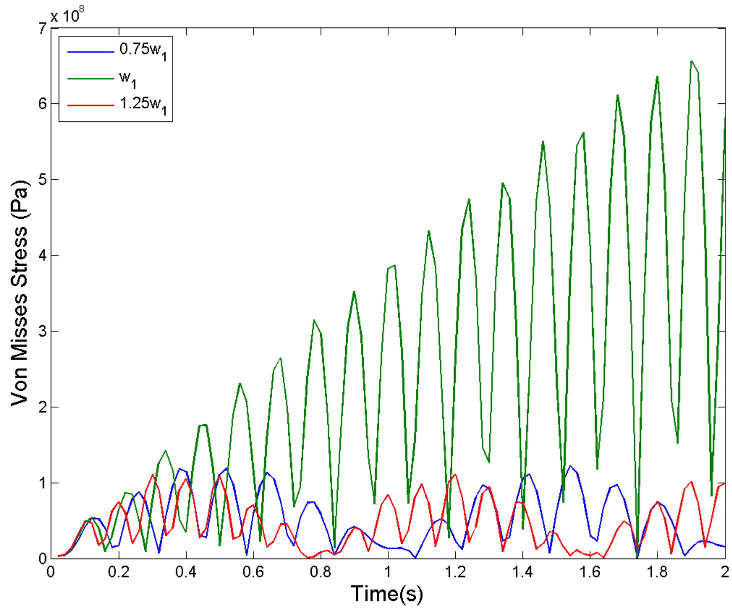



*Figure 6 Task 2: Von Mises stress response for various loading frequencies*