
COMPUTER PROJECT #1

ME/AE 6212 Advanced Finite Element Analysis

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Statement of the problem:

Use ABAQUS code to analyze the water tower shown in Figure 1. Model the tower as a beam and water tank as a lumped mass as shown in Figure 2. Determine the first three frequencies for cases (a), (b) and (c). Consider two different cross-sections of the beam shown in Figure 3. Summarize the results in a table and plot the mode shapes for case (a) with solid cross-section. Take $E = 207 \text{ GPa}$, $\nu = 0.3$, $\rho = 7.8 \times 10^3 \text{ kg/m}^3$. Use 100 beam elements.



Figure 1. Water tower

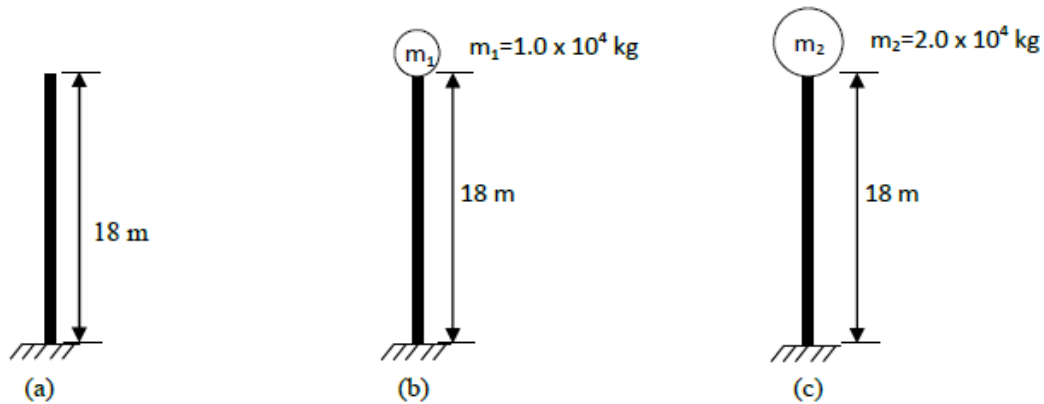


Figure 2. Beam model of water tower

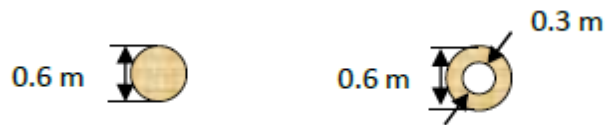




Figure 3. Cross-section of the beam

The procedures are outlined as follows:

- 1. Part:**
Create the water tower in ABAQUS using **2D Planner** -> **Deformable** -> **Wire** model.
- 2. Property:**
Set the material properties of density and elasticity;
Create section with circular or pipe profile;
Assign the created section to the part;
Assign the beam section orientation to the part.
- 3. Assembly:**
Create independent instance.
- 4. Step:**
Choose **Linear perturbation** and **Frequency** for Procedure type;
Set the **Minimum frequency** = 0.01 and **Maximum frequency** = 50.
- 5. Load:**
Create boundary condition using **Mechanical** -> **Displacement/Rotation**;
Set the boundary conditions of the fixed point as follows,
 $U1=0, U2=0, UR3 = 0$
- 6. Mesh:**
Seed edge by number of 100.
Mesh part instance.
- 7. Job:**
Submit these jobs.

Results:

The summary of the results is listed in the following table.

		Frequency(Hz)	
	Mode	0.6 m 	0.6 m 
Case (a)	1	1.3337	1.4140
	2	8.3262	8.8040
	3	23.173	24.401
Case (b)	1	0.93785	0.91935
	2	6.7480	6.9684
	3	19.940	20.769
Case (c)	1	0.76307	0.73079
	2	6.3908	6.6390
	3	19.450	20.342

The mode shapes for case (a) with solid cross-section are shown in the following figures.

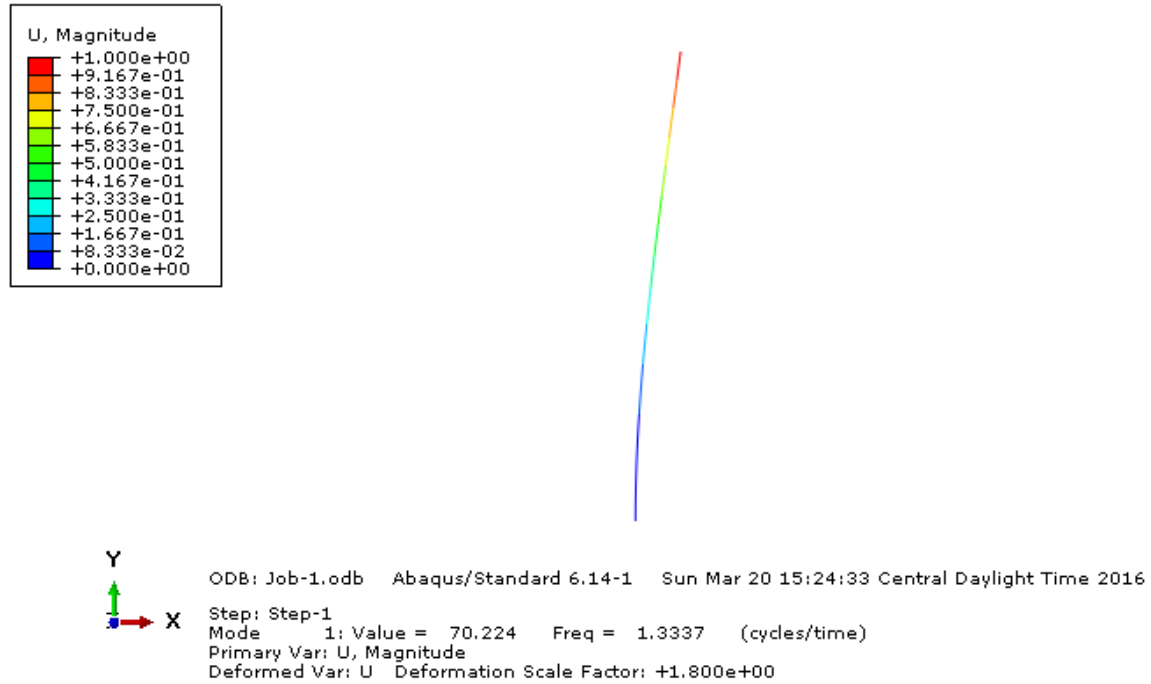


Figure 4. The 1st mode shape for case (a) with solid cross-section

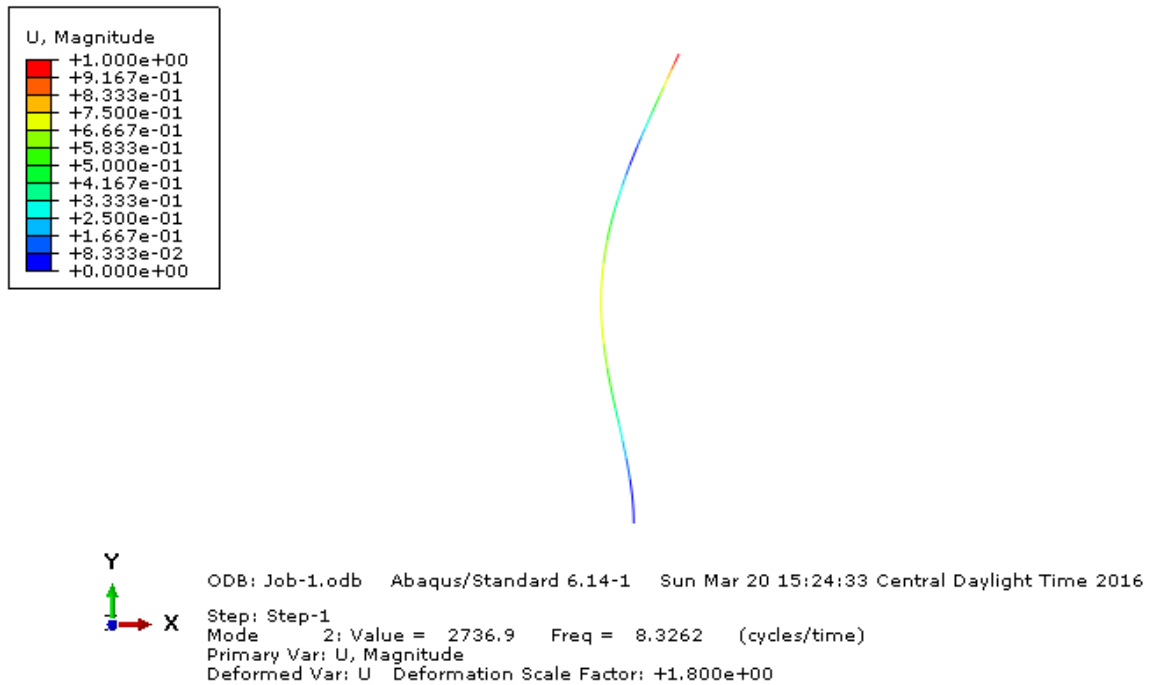


Figure 5. The 2nd mode shape for case (a) with solid cross-section

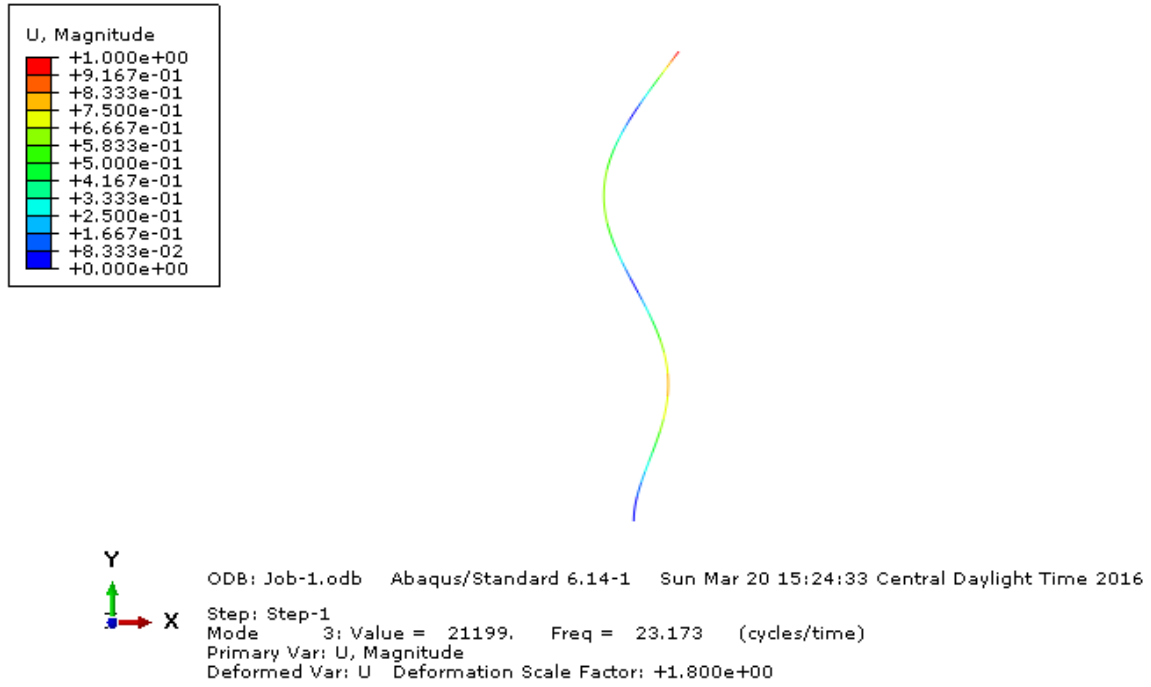


Figure 6. The 3rd mode shape for case (a) with solid cross-section

Sample output:

The outputs from ABAQUS are listed as follows,
Solid cross-section, case(a)

Index	Description			
0	Increment	0: Base State		
1	Mode	1: Value =	70.224	Freq = 1.3337 (cycles/time)
2	Mode	2: Value =	2736.9	Freq = 8.3262 (cycles/time)
3	Mode	3: Value =	21199.	Freq = 23.173 (cycles/time)
4	Mode	4: Value =	80011.	Freq = 45.019 (cycles/time)

Solid cross-section, case (b)

Index	Description			
0	Increment	0: Base State		
1	Mode	1: Value =	34.724	Freq = 0.93785 (cycles/time)
2	Mode	2: Value =	1797.7	Freq = 6.7480 (cycles/time)
3	Mode	3: Value =	15697.	Freq = 19.940 (cycles/time)
4	Mode	4: Value =	63594.	Freq = 40.135 (cycles/time)

Solid cross-section, case (c)

Index	Description			
0	Increment	0: Base State		
1	Mode	1: Value =	22.987	Freq = 0.76307 (cycles/time)
2	Mode	2: Value =	1612.4	Freq = 6.3908 (cycles/time)
3	Mode	3: Value =	14935.	Freq = 19.450 (cycles/time)
4	Mode	4: Value =	61875.	Freq = 39.589 (cycles/time)
5	Mode	5: Value =	94582.	Freq = 48.947 (cycles/time)

Pipe cross-section, case (a)

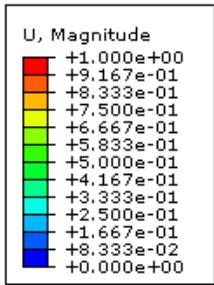
Index	Description			
0	Increment	0: Base State		
1	Mode	1: Value =	78.931	Freq = 1.4140 (cycles/time)
2	Mode	2: Value =	3060.0	Freq = 8.8040 (cycles/time)
3	Mode	3: Value =	23507.	Freq = 24.401 (cycles/time)
4	Mode	4: Value =	87699.	Freq = 47.132 (cycles/time)

Pipe cross-section, case (b)

Index	Description			
0	Increment	0: Base State		
1	Mode	1: Value =	33.367	Freq = 0.91935 (cycles/time)
2	Mode	2: Value =	1917.0	Freq = 6.9684 (cycles/time)
3	Mode	3: Value =	17029.	Freq = 20.769 (cycles/time)
4	Mode	4: Value =	68911.	Freq = 41.780 (cycles/time)

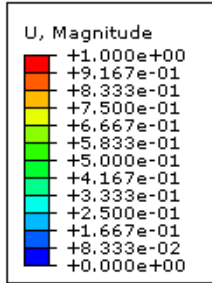
Pipe cross-section, case (c)

Index	Description			
0	Increment	0: Base State		
1	Mode	1: Value =	21.084	Freq = 0.73079 (cycles/time)
2	Mode	2: Value =	1740.1	Freq = 6.6390 (cycles/time)
3	Mode	3: Value =	16337.	Freq = 20.342 (cycles/time)
4	Mode	4: Value =	67401.	Freq = 41.319 (cycles/time)
5	Mode	5: Value =	79607.	Freq = 44.905 (cycles/time)



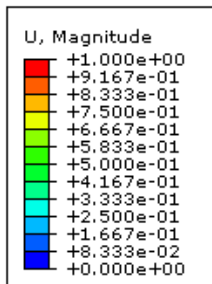
ODB: case_b.odb Abaqus/Standard 6.14-1 Sun Mar 20 15:44:01 Central Daylight Time 2016

Step: Step-1
Mode 1: Value = 34.724 Freq = 0.93785 (cycles/time)
Primary Var: U, Magnitude
Deformed Var: U Deformation Scale Factor: +1.800e+00



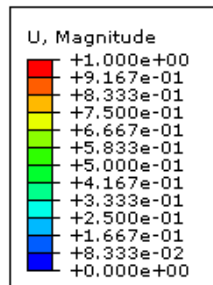
ODB: case_b.odb Abaqus/Standard 6.14-1 Sun Mar 20 15:44:01 Central Daylight Time 2016

Step: Step-1
Mode 2: Value = 1797.7 Freq = 6.7480 (cycles/time)
Primary Var: U, Magnitude
Deformed Var: U Deformation Scale Factor: +1.800e+00



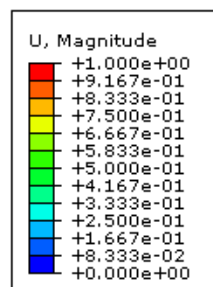
ODB: case_b.odb Abaqus/Standard 6.14-1 Sun Mar 20 15:44:01 Central Daylight Time 2016

Step: Step-1
Mode 3: Value = 15697. Freq = 19.940 (cycles/time)
Primary Var: U, Magnitude
Deformed Var: U Deformation Scale Factor: +1.800e+00



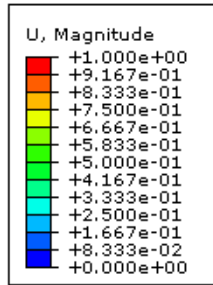
ODB: case_c.odb Abaqus/Standard 6.14-1 Sun Mar 20 15:48:05 Central Daylight Time 2016

Step: Step-1
Mode 1: Value = 22.987 Freq = 0.76307 (cycles/time)
Primary Var: U, Magnitude
Deformed Var: U Deformation Scale Factor: +1.800e+00



ODB: case_c.odb Abaqus/Standard 6.14-1 Sun Mar 20 15:48:05 Central Daylight Time 2016

Step: Step-1
Mode 2: Value = 1612.4 Freq = 6.3908 (cycles/time)
Primary Var: U, Magnitude
Deformed Var: U Deformation Scale Factor: +1.800e+00



ODB: case_c.odb Abaqus/Standard 6.14-1 Sun Mar 20 15:48:05 Central Daylight Time 2016

Step: Step-1
Mode 3; Value = 14935. Freq = 19.450 (cycles/time)
Primary Var: U, Magnitude
Deformed Var: U Deformation Scale Factor: +1.800e+00