TMM4250 Project work, Fall 2022, v1

September 2022

The term project is performed by groups of 2 or 3 students. The students form the groups themselves. Term project grade accounts for 1/3 of the final grade in the course.

Corotational nonlinear FEM code

One wish to implement a 2-D solution to primary path of a deep circular arch. This problem is described in Section 8.2.3 of Haugen's thesis [1]. The work can be performed using the following outline:

Nonlinear analysis of cantilever with end moment

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1. Model a cantilever with end moment and perform linear analysis.
2. Implement a nonlinear formulation of a beam element using a co-rotational formulation from the lecture nodes. This is described in further detail in Chapter 2 of [1]. Section 2.3.4 and 2.8.2 are of particular relevance here. *Note that only material stiffness is necessary for this problem to converge*
3. Implement Newton iterations with a load control.
4. Perform nonlinear analysis and bend the beam into a full loop. (Several loops are also possible)

Nonlinear analysis of deep arch model

1. Model the deep arch model and perform a linear analysis.
2. Implement the geometric stiffness for the element if this was not done in the previous section.
3. Implement the arc-length algorithm described in Section 3.2 of [1]
4. Perform nonlinear analysis for the arch

Document and report the code and results.

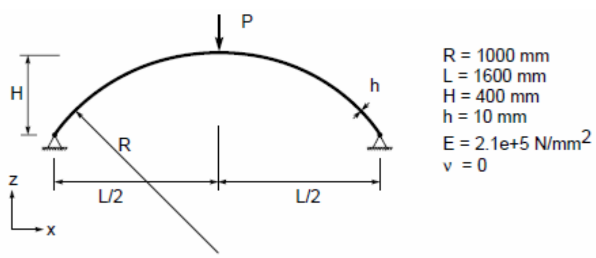

Figure 1: Deep arch geometry and material properties

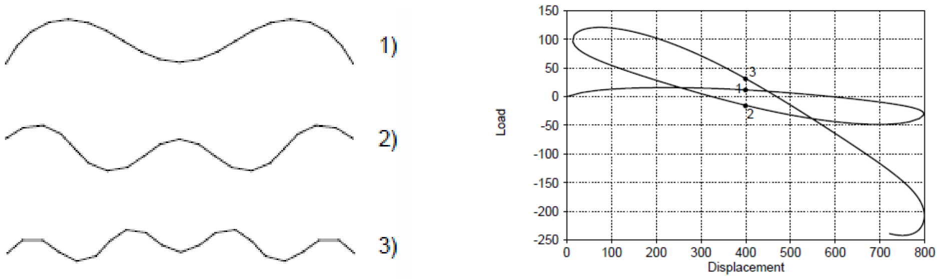

Figure 2: Deep arch displacements and load-deflection response

Scissor lift simulation in ABAQUS

Figure 3: Example of scissor-lift table

Design and analyze a scissor lift table as illustrated in the Figure 3. The primary use is lifting a rather "beefy" Harley Davidson motorcycle.

Overall requirements

Lift range 200-1000mm, i.e.

a. Maximum height at lowest position 200mm

b. Minimum height at highest position is 1000mm

Basic assessments

For you selected actuator (hydraulic cylinder or similar) establish the following;

1. Lift capacity as a function of lift height
2. Buckling load as a function of lift height
3. Estimate sensitivity with respect to eccentric loading. Loading inside support surface should not give failure.
4. Eigen-frequencies as a function of lift height and lift load (mass).

Idle speed of a Harley Davidson is in the range 800-1200 rpm. Eigen-frequencies in this range should be avoided.

Local design solutions *(Optional)*

Table top or working surface should be designed with concentrated forces in mind. What is necessary area in order to avoid

1. Permanent deformation
2. Penetration/failure.

Suggested designs to evaluate:

a. Plywood (cross-ply laminated wood) with or without thin metal surfacing.

b. Solid or stiffened metal plate in steel or aluminum.

c. GRP/sandwich panel.

Detailed design of joints *(Optional)*

Perform necessary 3D detailed analysis of the joints and compare with the simplified connectors from the global analyses.

Reporting

The work should be reported as technical report. Document choices with respect to element types, analysis types etc. The report should have sufficient level of detail so that other engineers would be able to reproduce and verify your results.