Assignment 3 Computation and Design

Analysis/sizing of a cable dome and form-finding of a shell structure using the dynamic relaxation method (20%) - Mixed Groups

AIM: Use the dynamic relaxation method for the analysis/sizing of the Geiger dome and for the form-analysis of a (grid) shell structure.

Part I: Analysis/sizing of the Geiger dome using the dynamic relaxation method (10%)

Your report (min. 3pages) (6 %) and calculations (4%) are due on April 8th by e-mail.

The goal of this part of the assignment is to use the dynamic relaxation method to size the elements of the Geiger dome, illustrated in Figures 1 and 2. Similar to Assignment 2, although the Geiger dome is the object of this assignment, the method is applicable for the analysis of other types of pre-stressed structures. The dynamic relaxation routine is implemented in the file *DRroutine.mat* (**please do not make changes on this file**).

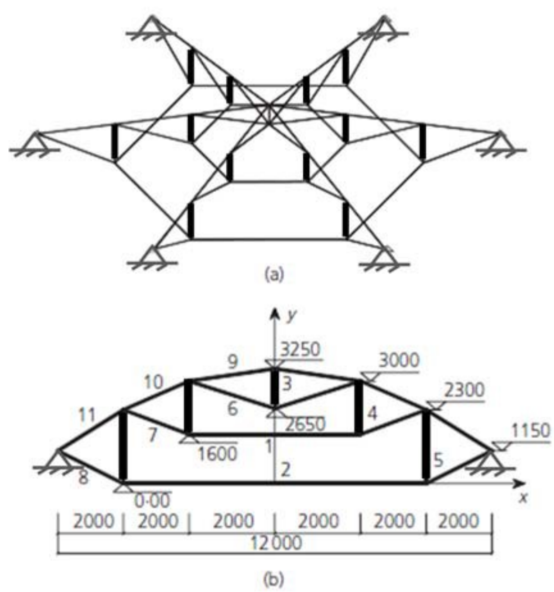

Figure 1: Illustration of the Geiger dome: (a) perspective and (b) geometry of the representative section

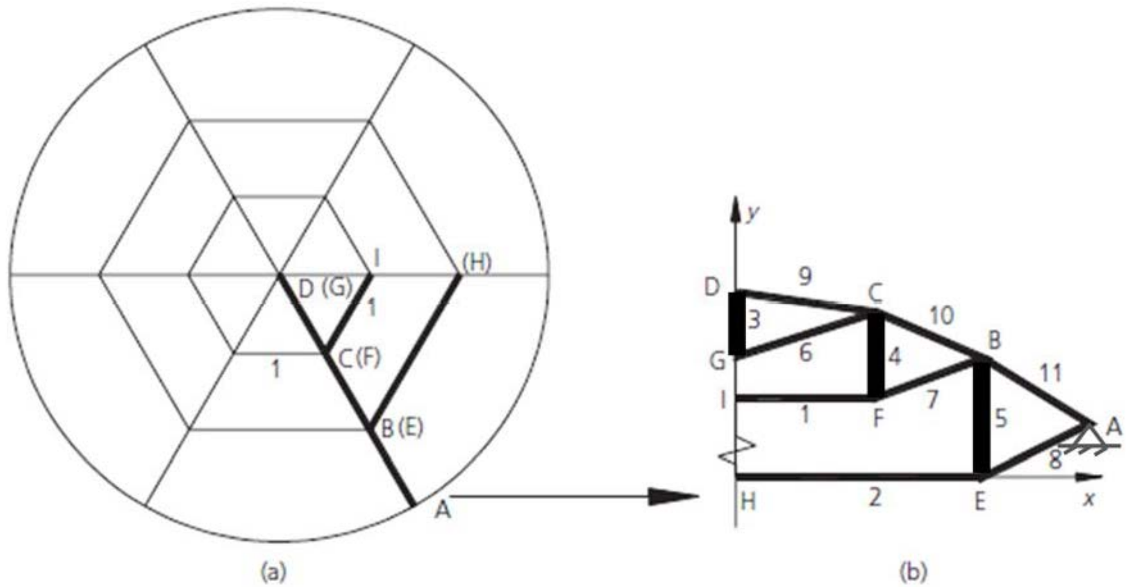

Figure 2: Illustration of a representative element group for the Geiger dome: (a) plan view, (b) representative section

The input file provided, *Input1.mat*, includes the topology for the Geiger dome as presented in Assignment 2. Use this file to make changes in your model.

For the analysis of the dome, you will need to define the characteristics and prestress in the elements as well as the loading on the structure. To run the analysis execute the file *MainProgram.mat*. The analysis will provide you the nodal displacements, the new element lengths, internal forces in the elements, the bending elements (in this assignment there are no bending elements) and the boundary reactions.

Note: To change the cross-section area, modify the value in the vector *A* in the inputfile.
To change the material, modify the value in the vector *Young* in the input file.
To change the prestress, modify the value in the parameter *prestress* in the input file.

For the sizing of the dome, make sure that the strength of the elements you employ is larger than the internal forces.

Part II: Form-finding and design of a (grid) shell structure using the dynamic relaxation method

Your poster (1 large portrait poster 30 x 40 inches hardcopy) with mostly images are due on April 8th by e-mail.

The goal of this part of the assignment is to use the dynamic relaxation method to find the form of a (grid) shell structure.

Brief

PU Engineering Quadrangle has recently celebrated its 50th Anniversary. Since its construction, the school has expanded tremendously in terms of disciplines and students. With its new focus on the integration of "Engineering and the Arts", the School is interested in developing a large "Tinker Space" (tables, tools, machinery) which could also be used for holding lectures. You, as a design team, have been asked to participate in a competition to propose a new (grid) shell roof over the Engineering Courtyard. The School has specified a number of requirements for the roof:

- This iconic roof geometry (and grid) needs to present the School and its focus on the integration of engineering and the arts;
- The offices that look onto the courtyard, rely on the courtyard for daylight. This should be respected;
- The roof and the courtyard should work together to connect the buildings surrounding the courtyard;
- The E-Café should be kept but could be integrated;
- The current courtyard is a planned garden that is part of the Andlinger planning: provision for a garden or the keeping of the current trees is crucial;
- Consideration of acoustics and natural ventilation are a bonus.

Figure 1: the Engineering Courtyard, 50 years after its construction

Methodology

1. The following tutorial (see below) will make you familiarize with how to manipulate the DR Code for PART II.

2. Study the brief boundary conditions and requirements and develop 1 or 2 designs for the courtyard roof at full scale.

3. The code will also provide you the points of the deformed grid in a .dxf file that can be imported into AutoCad or any other geometric modeler.

Tutorial

The input file provided, *Input2.mat*, includes the topology, element characteristics and loading for a rectangular grid supported at its four corners with a uniformly distributed vertical load. Use this file to make changes in your model.

- Run dynamic relaxation by executing the file, *MainProgram.mat* (do not forget to change the name of the file in line 45 of the MainProgram file), to find the equilibrium shape under the default configuration.

  Note: To change the input file for the analysis, modify the name of the file in line 45 of the MainProgram file.

- Assuming that the shell is too high for the site constraints, how can you generate a lower shell? Use dynamic relaxation to generate new form-found shapes by implementing the changes you suggest in your dynamic relaxation model.

  Note: To change the cross-section area, modify the value in the vector *A* in the input file.
  To change the material, modify the value in the vector *Young* in the input file.
  To change the prestress, modify the value in the parameter *prestress* in the input file.

- Generate a new input grid with the same nodal coordinates but with the grid rotated 45° compared to the previous one and find the new equilibrium shape (element characteristics and loading stay the same). What can you say about the two shapes?

  Note: To change the connectivity, modify the values (node numbers) in the vector *Link* in the input file.