Direct Stiffness Method
Excercises

Simulation Methods in Acoustics

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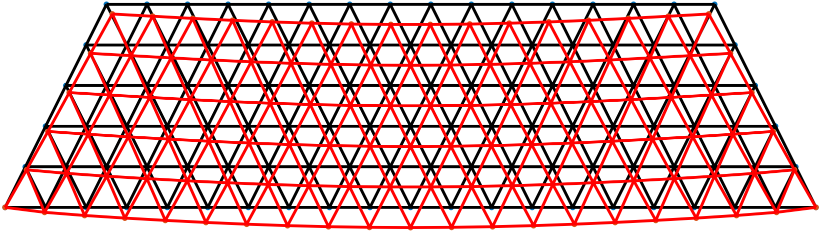

Generation and Post Processing of a 2D Bridge Model

`[nodes, elements] = create_bridge(nSpan, nFloor);`
creates the geometrical model of a 2D bridge structure

- `nSpan` – integer, number of spans on lowest level
- `nFloor` – number of levels
- `nodes` – $N \times 2$ matrix of nodal coordinates (x, y)
- `elements` – $E \times 2$ matrix of spring endpoint indices

`[hn, he] = plot_truss(nodes, elements, deformation, color);`
plots the undeformed and deformed geometry

- `deformation` – $N \times 2$ matrix of nodal displacements
- `color` – Color descriptor applied to each spring element
- `he, hn` – Handles to nodes and elements (graphic objects)

Excercise 1.

- Write a function that returns the total stiffness matrix of the truss structure

  ```
  K = truss_stiffness(nodes, elements);
  ```

  - Assume that the elements represent bars with constant Young's modulus E and cross section A.
  - Derive the stiffness of spring elements based on their lengths L.
- Investigate the sparsity structure of the stiffness matrix.

  ```
  spy(K);
  ```

  Explain the result
- Investigate the invertibility (rank) of the stiffness matrix.
  Explain the result

Excercise 2.

- Generate the displacement field $u_x(x, y) \equiv 1$, $u_y(x, y) \equiv 0$.
  Compute the nodal loading forces that can result in this displacement field.
  Explain the results

Excercise 3.

- Apply the external loading force $f_y = -1$ to each topmost node and zero force to each other DOF
- Apply homogeneous Single Degree of Freedom Constraint to the two bottom corner nodes.
  Derive the reduced system of equations (stiffness matrix and force excitation) for the unconstrained degrees of freedom.
- Solve the reduced system of equations for the displacements.
- Determine the equivalent nodal forces at the bottom corner nodes

Excercise 4.

- Apply Rigid Body Displacement constraints to the top nodes.
  - Introduce three extra DOF for the two displacements and rotation of the top plate.
  - Assemble the constraint matrix **A** that contains the previous SDFC and the rigid body constraints as well.
- Modify the force vector to asymmetric
- Solve the constrained system using the Penalty Method
- Interpret the results