ES 128

COMPUTATIONAL SOLID AND STRUCTURAL MECHANICS

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Problem Set 1

Due Wednesday, February 13 2019 by 4:15pm

Paper Problem **Three bars and a load (40 Points)**: Consider the three bar structure shown in Figure 1, which is subjected to the prescribed load at point C equal to $10kN$. The bars are made of a linear elastic material whose Young's modulus is $E = 100GPa$. The cross sectional area of bar (BC) is $A_{(BC)} = 200cm^2$ whereas that of (BD) and (BF) is $A_{(BD)} = A_{(BF)} = 50\sqrt{2}cm^2$. Coordinates of points shown in the figure are given in meters. *Note that point D is free to move in the x-direction*

(**a**). Construct the global stiffness matrix and load matrix
(**b**). Partition the matrices and solve for the unknown displacements at points B and D.
(**c**). Determine the stress field in each bar
(**d**). Determine the reaction forces at nodes C, D and F

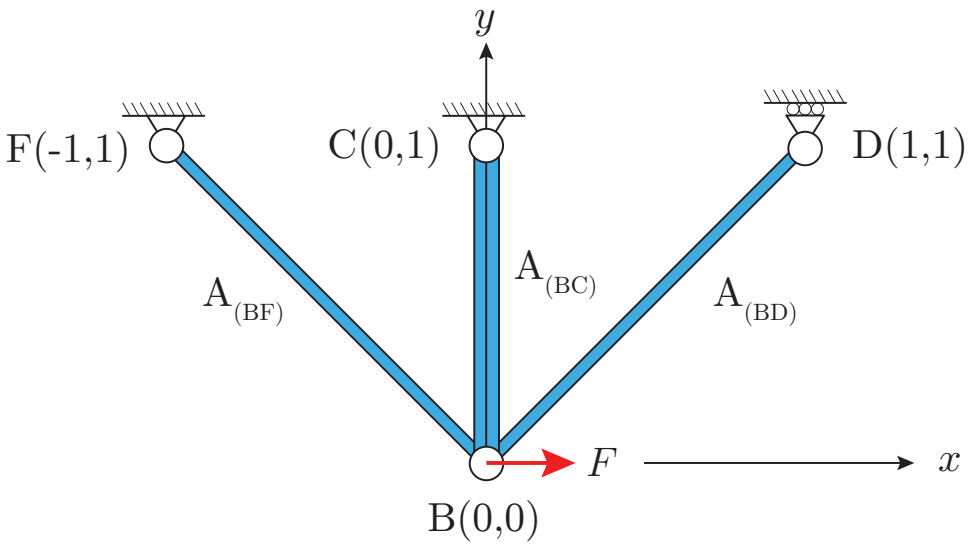

Figure 1: The three bar structure considered in problem 1

Matlab Problem **Reading Input Files and Generating the Stiffness Matrix (60 Points)**: Three input files of 2D truss structures are handed out (truss1.inp, truss2.inp and truss3.inp). The input files have the same structure as ABAQUS input files. A detailed explanation of the input files is given during class (note that truss1.inp is commented).

(**a**). You are requested to write a function in Matlab that takes as an input the name of the input file, reads the file and provides as an output the coordinates of the structure, the element connectivity matrix, the cross-sectional area of the truss elements, their Young's modulus, the nodes at which the displacements are imposed (and their corresponding values) as well as the nodes at which external forces are applied (and their corresponding values). **You should use the template** `Main.m` **which can be found in the course github** https://github.com/es128-2019/es128. You should also respect the variable naming conventions introduced and explained in the description of each function handed out to you. Useful matlab commands: `feof`, `fgetl`, `switch`, `fscanf`, `fclose`, `textscan`

(**b**). Test your function by opening and plotting all of the input files provided to you. You should be able to produce figures similar to the one shown in Figure 2

(**c**). Write a function in Matlab that generates the 4×4 stiffness matrix for an arbitrary 2D truss element. In particular your code should make use of each bar's endpoint coordinates to perform the following operations:

- Determine the length and orientation of each bar in the structure
- Construct the rotation matrix $\mathbf{T}(\theta)$
- Build the element's stiffness matrix

For this question **you should use the function** `Truss2D.m` **which is included in your template**.

(**d**). Now write a function in Matlab that uses your function `Truss2D.m` and assembles the global stiffness matrix from the individual stiffness matrices of each element. Your code should be able to generate the global stiffness matrix for all three provided input files. For this question **you should use the function** `Assembly.m` **which is included in your template**.

(**e**). Once you are confident that the global stiffness matrix has been assembled correctly, use the Matlab command `spy` to make a sparsity plot of $\mathbf{K}$ and generate the images in figure 3 for each input file as shown below

You may download all files necessary for this assignment from the course github https://github.com/es128-2019/es128. ■

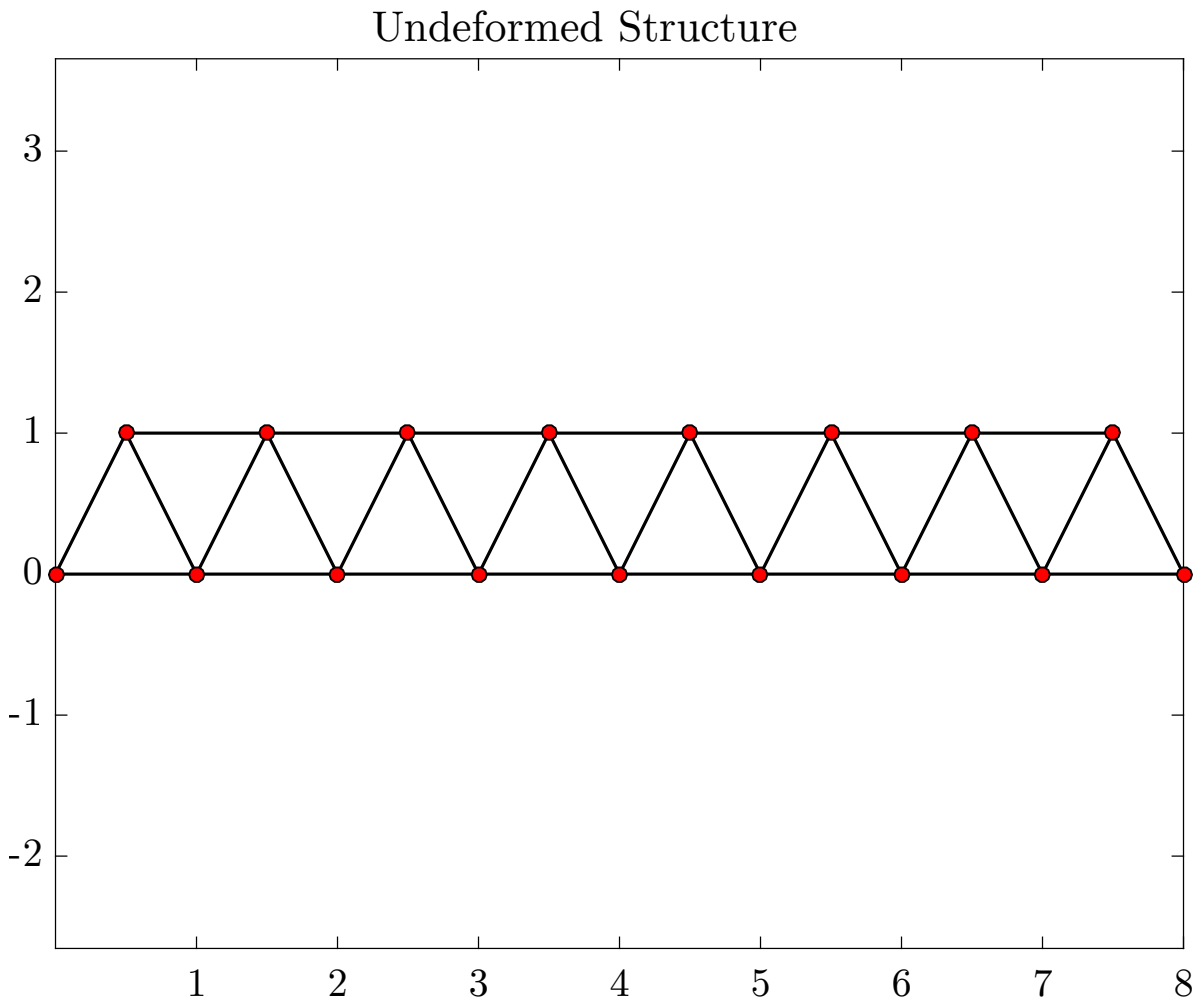

Figure 2: The figure generated from reading `truss2.inp` using the Matlab script

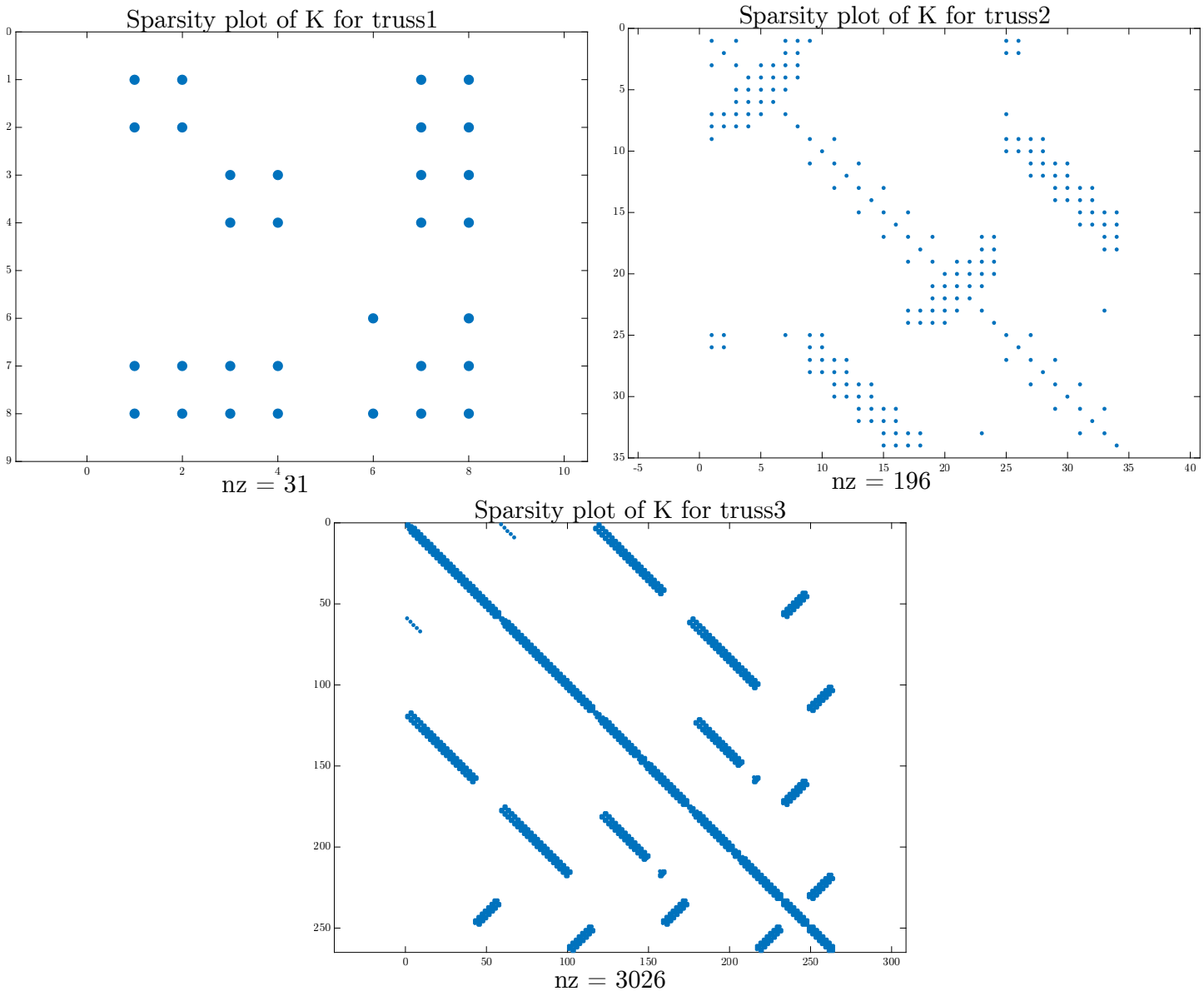

Figure 3: Sparsity plots that correspond to the global stiffness matrices for each input file