09/05/2019

Civil Engineering I
- Introduction to structural mechanics-
Design of simply supported truss structure 2

Exercises 4

Consider designing a simply supported Warren truss shown in Fig.1. To assemble the truss, we use the bars of length l having a uniform circular cross section of diameter d as illustrated in Fig.2-(a). When completed, the truss is going to be used to support two straight pipes (pipe 1 and 2) crossing over a canal of width $3l$. In performing the structural analysis necessary for the design, we will assume the followings.

Assumptions

1. The two pipes are identical and are both completely filled with water.
2. The the truss member (round bars) are so thin that their weight is negligible.
3. The weight of the water-filled pipes are supported evenly at the lower nodal points (joints) of the truss.
4. Due to the symmetry of the structure, the vertical downward force of magnitude F applied to the nodes A, B, C and D comes only from pipe 1.
5. Although the pipes are infinitely long, the length of the pipe that needed to be supported by the truss is $4l$ (Imagine that the reminder of the weight goes to the supports on the ground that are not shown in Fig.1.)
6. A structural member breaks (yields) if the axial stress (axial force/area) exceeds a certain value called an "allowable stress".

Problems

With the assumptions made above, determine the minimum value of d for which the truss can safely support the pipes without damaging (breaking) any of its members.

1. Determine the vertical reaction forces supplied to the truss by the supports at A and D.
2. Determine the axial forces of truss member No.1 through 11.
3. Determine the maximum tensile and compressional axial forces that arise in the truss members.
4. Write the magnitude F of the force using the dimensions l, D, t of the bars and pipes, gravitiy constant g, and the mass densities of water ρ_w and steel ρ_s as indicated in Fig.2.
5. For given allowable stress σ_a, determine the minimum cross sectional area A_{min} and the the corresponding diameter d_{min}. Note that the axial stress is given by N/A where N is the axial force and $A = \pi d^2/4$ is the cross sectional area of the bar.
6. Evaluate d_{min} numerically when
   D=500.0[mm], t=10.0[mm], ρ_s =7.9[g/cm^3], ρ_w =1.0[g/cm^3], l = 3.0[m], σ_a=20.0[kgf/mm^2], g=10.0[m/s^2]
   You may use a scientific calculator, but the use of Excel is recommended.

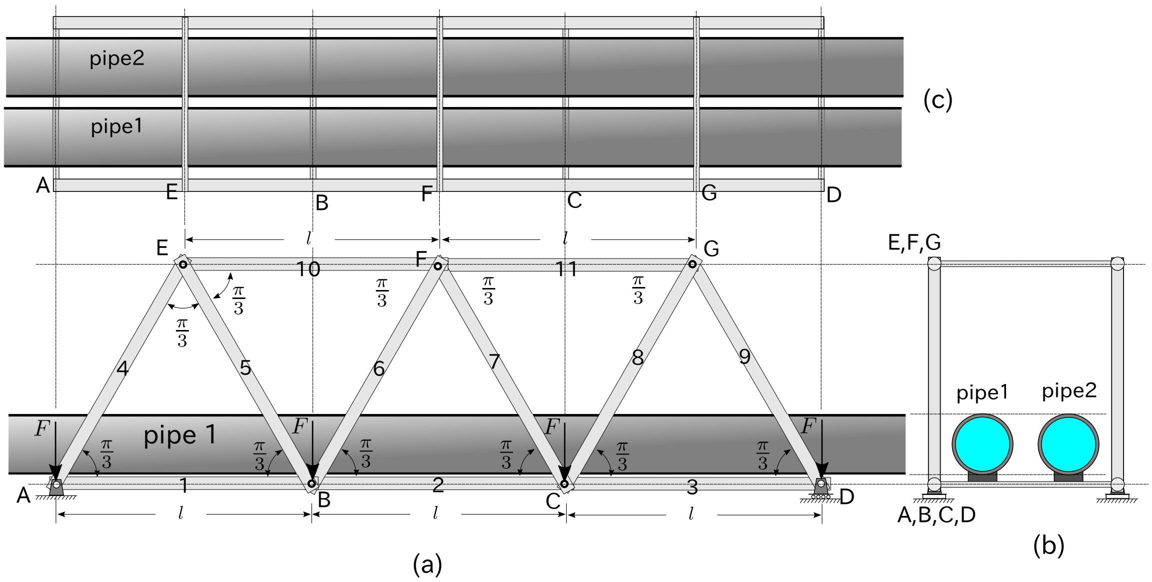

Figure 1: (a)A front, (b) side, and (c) top views of a simply supported Warren truss made of round bars of uniform circular cross section. The truss truss bears the weight of two identical, symmetrically placed, water filled pipes. The weight is distributed evenly to the nodal points (joints) on the lower level applying the downward vertical load of magnitude F to the nodes A, B, C and D.

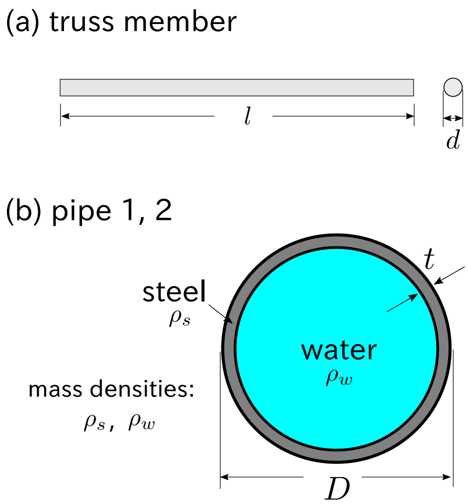

Figure 2: The cross sections of (a) a truss member (round bar) and (b) the pipe.