May 2, 2022

UNIVERSITY OF WATERLOO
Department of Civil and Environmental Engineering

CIV. E. 413: Structural Steel Design

Assignment 1 (Review Structural Steel Design in CivE 310)

Note: The following should be completed by providing detailed calculations evaluating member compressive resistance. Direct use of the tabulated values of member compressive resistance and section classification in the ***Handbook of Steel Construction*** is prohibited. **G40.20M- 350W (assume F_y = 350 MPa, F_u = 450 MPa, E = 200000 MPa)** steel is to be used, unless otherwise specified.

1. Figure 1 shown below is a portion of a floor plan view of the second floor in a multistorey residential building. The floor system is a one-way slab floor system in which the concrete slab is supported by steel floor joists (Joist A and Joist B), and the floor joists are supported by steel floor girders (Girder C), as shown in the Figure 1a. Both floor joists and girders are simply supported at their ends, except Joist A supports a cantilever balcony at one end. The joists are laterally supported by the slab, and the girder is laterally supported by the joists and supports. The cross-section of the joists is a welded single symmetrical I-shaped section as shown in Fig. 1b, whereas the girder and column are standard structural steel sections. The floor service dead load (including the balcony) and live load are 2.5 kPa (self-weight included) and 2.0 kPa, respectively, and the service live load of the balcony is yet to be determined. Complete the following questions based on the cross-section dimensions of the joists and cross-section properties of the girder and columns provided below.

   a) Identify the section classification of the joist. Locate the elastic and plastic neutral axis associated with the strong axis of the section, and compute the corresponding elastic and plastic section modulus (welds between flange and web can be neglected in computing section properties and resistances).

   b) Compute service dead and live loads (W_D *and* W_L) of Joist A. Note that W_L and $W_{L\text{-}can}$ may and may not be applied simultaneously. Check the adequacies of bending moment resistance based on the loads W_D *and* W_L at the ultimate load level. Determine the maximum magnitude of the service live load ($W_{L\text{-}can}$) on the balcony based on all the loads and moment resistance of Joist A.

   c) Calculate the most critical factored loads of Girder C (P_D and P_L) as W_L and $W_{L\text{-}can}$ may and may not be applied simultaneously and evaluate the adequacy of bending moment resistance.

   d) Evaluate the mid-span deflections of the joists and girder based on the most critical service live load pattern and check if the deflection serviceability requirement $L/360$ is satisfied.

   e) Compute the most critical factored axial loads and the factored compressive resistances for columns D and E, respectively. The length of the columns is 3500 mm, and there is no lateral bracing available for the column except at their ends. The column ends are pin connected.

   f) Based on the floor factored axial loads and compressive resistances for columns D and E obtained in item e), estimate how many floors the columns can support by assuming the magnitudes of the factored loads of the roof are the same as that of a floor.

Joists cross-section dimensions (Joists A and B):

Top flange: b = 150 mm, t = 12 mm; Bottom flange: b = 250 mm, t = 12 mm
Web: h = 282 mm, w = 6 mm;

Girder C (W310×86) cross-sectional properties:

b = 254 mm, t = 16.3 mm, d = 310 mm, w = 9.1 mm;
A = 11,000 mm^2; I_x = 198×10^6 mm^4, Z_x = 1420×10^3 mm^3
Max. unsupported length for the beam being considered as laterally supported: L_u = 3810 mm

Column D (HSS 254×254×7.9 Class H) cross-sectional properties:

Outside dimension = 254.0 mm, t = 7.94 mm, A = 7650 mm^2; I = 76.4 ×10^6 mm^4,

Column E (HSS 254×152×7.9 Class H) cross-sectional properties:
Outside dimension: depth = 254.0 mm, width = 152.4 mm, t = 7.94 mm,
A = 6040 mm^2; I_x = 52.0 ×10^6 mm^4, I_y = 23.5 ×10^6 mm^4

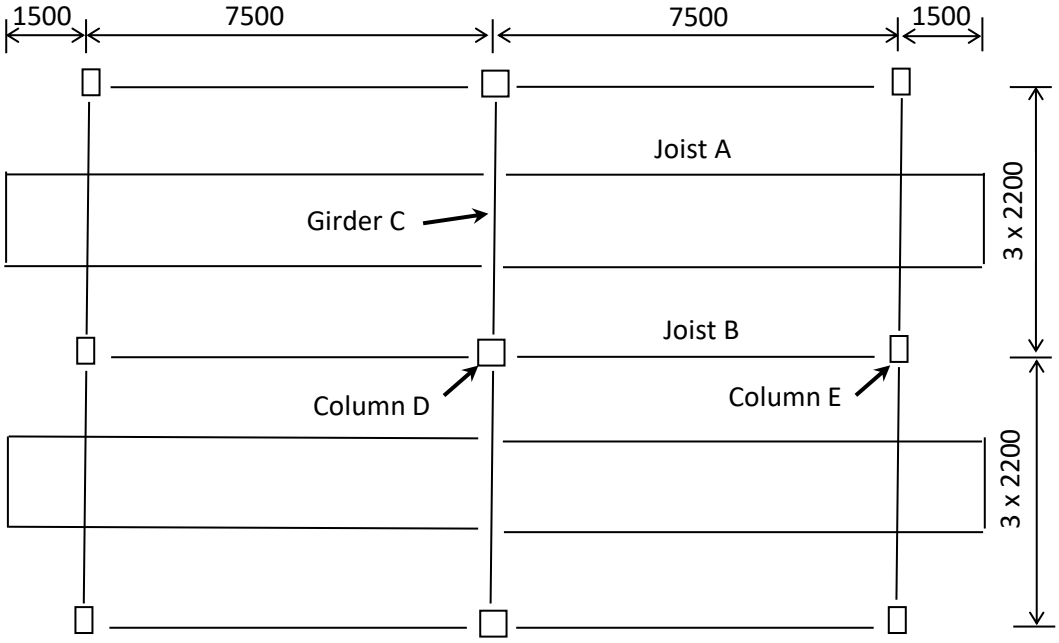

Fig. 1a. unit: mm

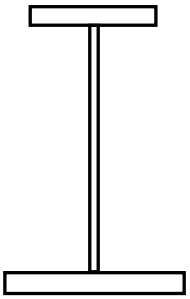

Fig. 1b.
Joists A and B

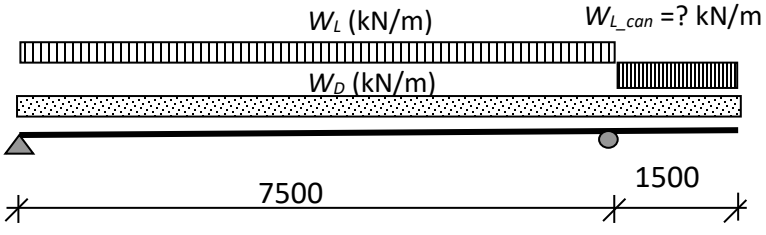

Figure 1c. Joist A

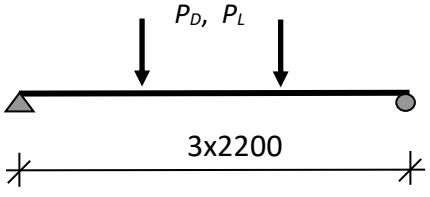

Figure 1d. Girder C