Group #07

Bridge-00

18g, 1700N

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16.7%	16.7%	16.7%
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1 Design

1.1 Assumptions

During the design process, the following assumptions have been made (Hibbeler and Yap, p. 264):

1. All loadings are applied at the joint,
2. Weight of the members neglected,
3. Joints are smooth (friction-less) pins,
4. Each member has no more than two joints.

Final bridge design can be seen in Figures 1 and 2.

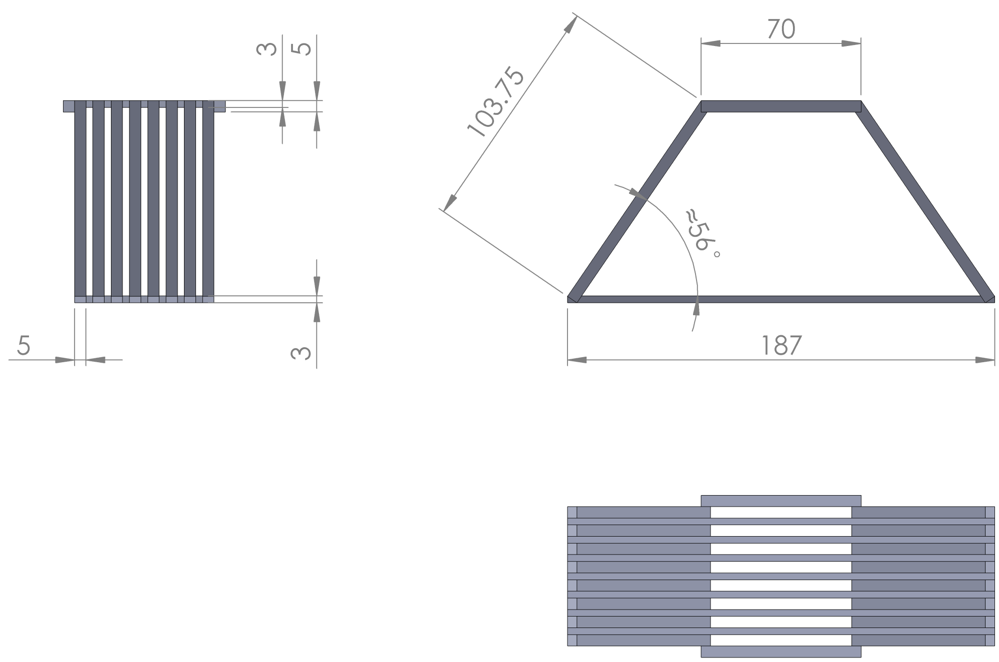

Figure 1: Dimensioned drawing.

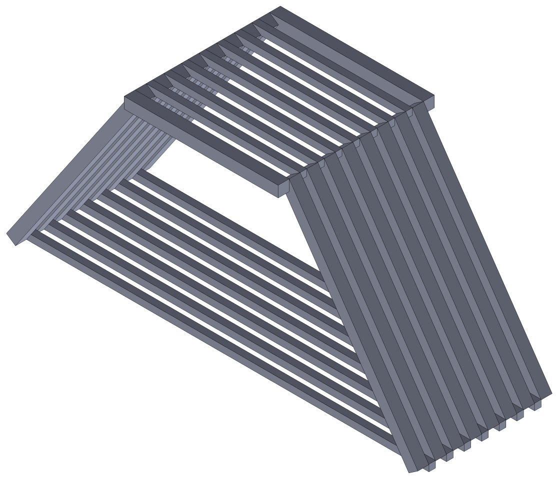

Figure 2: 3D-Projection.

1.2 Methods

2 Analysis

Due to the unconventional design, to ease the calculations during the analysis, it was assumed that the load is equally distributed between eight trapezium-shaped trusses. Thus, a single trapezium truss was analyzed, and then extended to approximate the entire bridge. Internal forces, nodes and members are labelled as per Figure 3. As the truss is symmetrical, only two nodes needed to be analyzed. For a load of 100N divided equally between nodes A

Figure 3: Trapezium truss.

and B, force equilibrium for nodes A and C are described in equation blocks 1 and 2 respectively.

$$F_s \sin 56 = 50\text{N}, \tag{1a}$$

$$F_s \cos 56 = F_t. \tag{1b}$$

$$F_s \sin 56 = F_r, \tag{2a}$$

$$F_s \cos 56 = F_b. \tag{2b}$$

The results of solving the above equations are presented in Table 1. Note that the internal force experienced by members is twice the given value, because it occurs at both ends. Maximum loads for each member were calculated

Table 1: Member loads.

70 3x3 mm (top)	33.7 N (c)
103.75 5x5 mm (side)	60.3 N (c)
187 3x3 mm (bottom)	33.7 N (t)

using the values given in the Assignment sheet. Modulus of elasticity $E = 3\text{GN/m}^2$, standard deviation $\sigma = +2.4/-2.1\text{MN/m}^2$. Tensile strength $\sigma_t = 20\text{GN/m}^2$, standard deviation $\sigma = +3.6/-3.4\text{MN/m}^2$. Compressive strength $\sigma_t = 12\text{GN/m}^2$, standard deviation $\sigma = +2.1/-2.8\text{MN/m}^2$. To calculate maximum load from strength values, equation 8 was used. The results are presented in Table 2.

$$\sigma = \frac{P}{A} \tag{3}$$

To predict the maximum load, the weakest section of the bridge had to be found. That was done by first summing up the maximum loads of all top, bottom and side members, (equation block 4), using values from Table 2, average column.

$$P_{top} = 7 \times 108 + 2 \times 300 \qquad = 1356\text{N} \tag{4a}$$

$$P_{side} = 8 \times 300 \qquad = 2400\text{N} \tag{4b}$$

$$P_{bottom} = 7 \times 180 \qquad = 1260\text{N} \tag{4c}$$

Table 2: Maximum member loads.

	average	-1σ
3x3 mm (c)	108 N	82.8 N
3x3 mm (t)	180 N	149.4 N
5x5 mm (c)	300 N	230 N

Then the safety rations (defined in equation 5) were calculated for each section (equation block 6), using values from Table 1.

$$R = \frac{P_{max}}{P} \tag{5}$$

$$R_{top} = 40.2 \tag{6a}$$

$$R_{side} = 39.8 \tag{6b}$$

$$R_{bottom} = 37.4 \tag{6c}$$

The lowest safety ratio member will break first, thus bottom was determined to be the breaking point. The actual maximum load was determined in equation block 7, where P is the load used to calculate R. The same steps were carried out in equation block 8, but the strength was assumed to be 1σ below average.

$$F = \frac{RP}{2} \tag{7a}$$

$$= 1869.4 \tag{7b}$$

$$F = \frac{R_\sigma P_\sigma}{2} \tag{8a}$$

$$= 1551.6 \tag{8b}$$

The average of the two 1710.5N, was chosen as predicted maximum load.

3 Results

References

R. C. Hibbeler and Kai Benh Yap. *Mechanics for Engineers: Statics*. Pearson.