Modern Structural Analysis - Introduction to Modelling

Supplementary information

Chapter 5 Section 5.7 Case study
Distribution of vertical load in a machinery support system

The purpose of this case study is to show how load is distributed in a floor system where the reactions from the slabs and the beams are all statically determinate. The demonstrated process gives the correct results if the system is statically determinate but would give only approximate results for systems with beam or slab support continuity.

Figure 1 shows a plan of a machinery support system with the following specification:

- Dimensions are in metres
- The ⟵⟶ symbol indicates the direction of the spans of the slabs
- The figures beside the direction of span symbols are the (vertical) floor loads in kN/m^2.
- All slabs are one way spanning with no continuity over any support
- The beams are all pin connected to the columns
- A beam is denoted as, for example, A-B/1. This means that the beam is on gridline1 between gridlines A and B
- A floor slab is defined by one of its diagonals. For example the top left slab is denoted as B1-C2 since one corner is at gridpoint B1 and the diagonally opposite corner is at C2

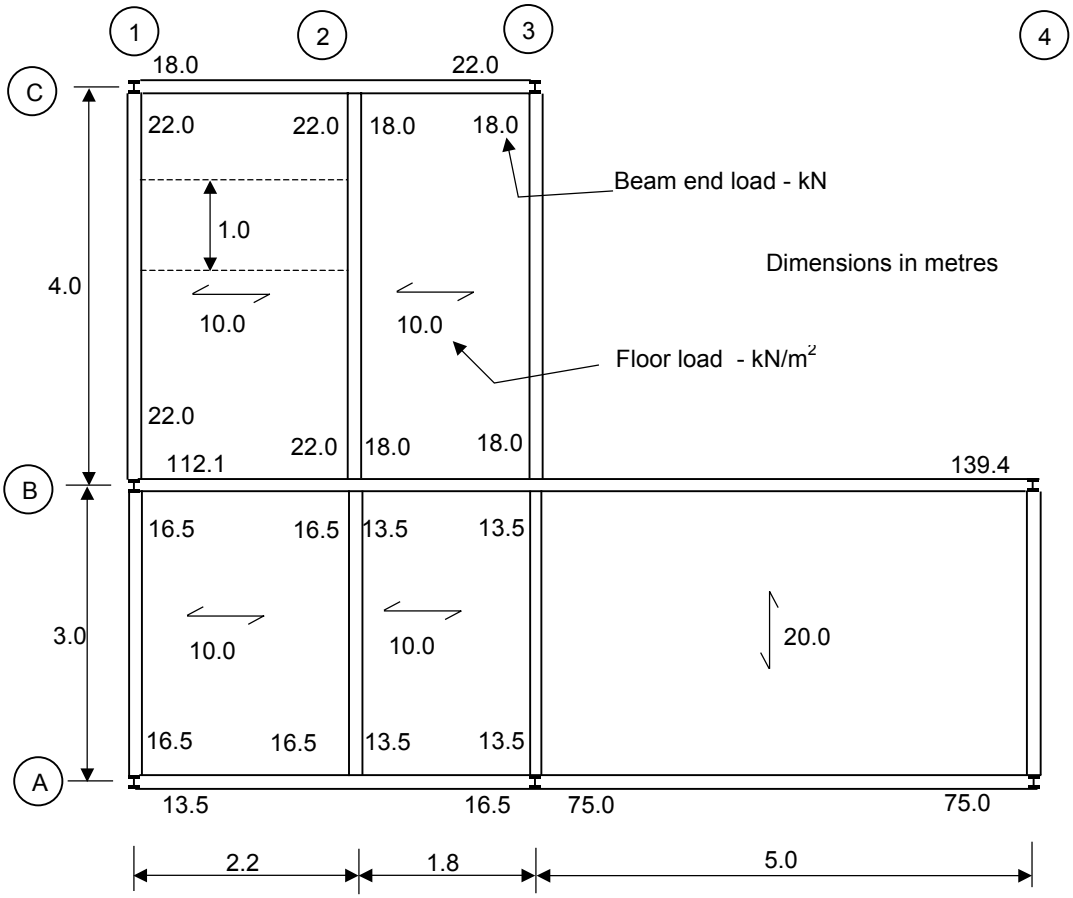

Figure 1 Plan of machinery support

It is required to calculate the loads in the columns due to the specified floor loading.

The end loads from the beams due to the adjacent floor slabs are shown beside the beams on Figure 1.

Loading on beam B-C/1:
A strip of slab of unit width spanning between beams B-C/1 and B-C/2 (shown in Figure 1)will transmit a total load of:
10.0*2.2 = 22.0 kN.
Since the slab is simply supported half of this will go to each beam. Therefore the load on beam B-C/1 from slab B1-C2 will be (Figure 1):
22.0/2 = 11.0 kN/m
The total load on beam B-C/1 is therefore:
11.0*4.0 = 44.0 kN
Since the loading is symmetrical, half goes to each end therefore the end beam forces are:
44.0/2 = 22.0 kN

Figure 2 shows how the 22.0 kN end load is transmitted downwards to the column and the column provides an equal and opposite reaction on the beam. It is important to distinguish between these two forces. We normally work with the former for transmission of load but with the latter when calculating the end forces on beams which are not symmetrical.

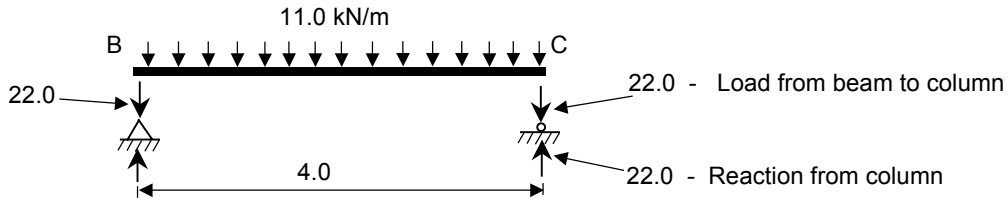

Figure 2 Loading on Beam B-C/1

Loading on beam B-C/2
Since the loading on slab B1-C2 is uniformly distributed, the end reactions on beam B-C/2 from this slab are the same as on beam B-C/1 i.e. 22.0 kN
The load from slab B2-C3 on beam B-C/2 is
10.0*1.8/2 = 9.0 kN/m
The end beam forces from slab B2-C3 are therefore 9.0*4.0/2 = 18.0 kN

Loading on beam B-C/3
Since the loading on slab B2-C3 is symmetric, the end beam forces from this slab on beam B-C/3 will also be 18.0 kN.

Loading on beam A-B/1, A-B/2, A-B/3 and 3-4/A
The process as for beams B-C/1 and B-C/2 is applied to these beams to give the end forces shown on Figure 1

Loading on beam 1-3/C
This beam takes a load of 40kN - Figure 3
Taking moments about 1 gives:
R_3*4 = 40.0*2.2
hence R_3 = 22.0 kN
and R_1 = 40.0 - 22.0 = 18.0

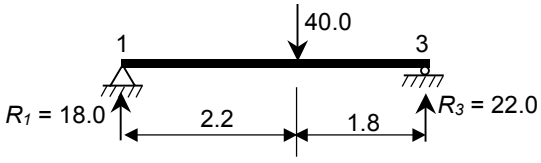

Figure 3 Beam 1-3/C

Loading on beam 1-3/A
The process as for beams 1-3/C is applied to beam 1-3/A to give the end forces shown on Figure 1

Loading on beam 1-4/B
Figure 4 shows a free body diagram of beam 1-4/B.
Taking moments about 1 gives:
R_4*9.0 = 70.0*2.2 + 31.5*4.0 +30.0*5.0*6.5
hence R_4 = 139.4 kN
the total load on the beam is 70.0 + 32.5 + 30.0*5 = 251.5 kN
hence R_1 = 251.5 - 139.4 = 112.1 kN

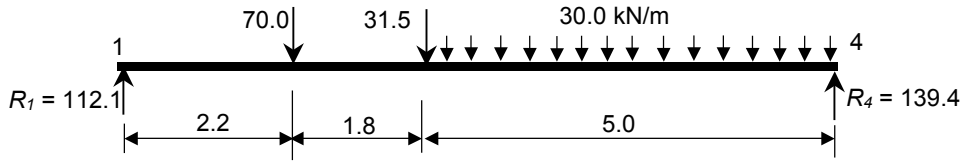

Figure 4 Beam 1-4/B

Column loads

Table 1 shows the calculated column loads

Table 1 Load summary

Column	**Beam loads** (kN)	**Column load** (kN)
C1	18.0+22.0	40.0
C3	22.0+18.0	40.0
B1	22.0+16.5+112.1	150.6
B4	139.4	139.4
A1	16.5+15.0	31.5
A2	13.5+15.0+75.0	103.5
A3	75.0	75.0
Total		580.0