the beam:

Slab ULS total UDL = $10.68 \times 7.5 \times 5 = 400.5\,\text{kN}$

Beam G_k self-weight UDL = $24 \times 0.4 \times 0.25 \times 7.5 = 18\,\text{kN}$

ULS beam UDL = $\gamma_f G_k = 1.4 \times 18 = 25.2\,\text{kN}$

Total ULS beam UDL = $400.5 + 25.2 = 425.7\,\text{kN}$

These total loads would be used to design the slab and beams for the ULSs of bending and shear.

Example 3.2

A 3 m high reinforced concrete column supports a 700 kN characteristic dead load and a 300 kN characteristic imposed load. Calculate the total ULS design load for the column if it is 300 mm × 250 mm in cross-section and the load due to the weight of concrete is $24\,\text{kN/m}^3$.

Applied dead load $G_k = 700\,\text{kN}$

Self-weight dead load $G_k = 24 \times 3 \times 0.3 \times 0.25 = 5.4\,\text{kN}$

Applied imposed load $Q_k = 300\,\text{kN}$

Total ULS design load = $\gamma_f G_k + \gamma_f Q_k$

$= 1.4 \times 700 + 1.4 \times 5.4 + 1.6 \times 300 = 1467.56\,\text{kN}$

This load would be used to design the column for the ULS of axial compression.

3.6 Material properties

The strength of the materials actually used in construction can vary from the specified strength for a number of reasons. Therefore in ULS design the basic or characteristic strength of a material is modified by a partial safety factor to give the ultimate design strength. This is explained in more detail below.

3.6.1 Characteristic strength of materials

BS 8110 adopts the criterion that no more than 5 per cent of a sample batch should have less than a specified strength. This strength is called the characteristic strength, denoted by f_{cu} for the concrete and f_y for the steel reinforcement.

The test results used for specifying the characteristic strengths of reinforced concrete materials are the cube strengths of concrete and the yield or proof strength of steel reinforcement.

Table 9 of BS 5328 'Concrete' Part 1, 'Guide to specifying concrete', reproduced here as Table 3.2, lists the characteristic strengths for various grades of concrete. These are in fact the cube strengths of the concrete at 28 days. The yield strength of reinforcement is given in BS 8110 Table 3.1, reproduced here as Table 3.3.

Table 3.2 Concrete compressive strength (BS 5328 Part 1 1990 Table 9)

Concrete grade	Characteristic compressive strength at 28 days ($N/mm^2 = MPa$)
C7.5	7.5
C10	10.0
C12.5	12.5
C15	15.0
C20	20.0
C25	25.0
C30	30.0
C35	35.0
C40	40.0
C45	45.0
C50	50.0
C55	55.0
C60	60.0

Table 3.3 Strength of reinforcement (BS 8110 Part 1 1985 Table 3.1)

Designation	Specified characteristic strength f_y (N/mm^2)
Hot rolled mild steel	250
High yield steel (hot rolled or cold worked)	460

3.6.2 Partial safety factors for materials

For the analysis of reinforced concrete elements the design strength of the concrete and the steel reinforcement is obtained by dividing their characteristic strength by a partial safety factor γ_m. This factor is to take account of differences that may occur between laboratory and on-site values. Such differences could be caused by any of the following:

Concrete

Segregation during transit
Dirty casting conditions
Inadequate protection during curing
Inadequate compaction of concrete.

Reinforcement

Wrongly positioned reinforcement
Distorted reinforcement
Corroded reinforcement.

Values of γ_m for the ULS are given in BS 8110 Table 2.2, which is reproduced here as Table 3.4.