Design of Reinforced Concrete Beams

Reinforced concrete beam design consists primarily of producing member details which will adequately resist the ultimate bending moments, shear forces and torsional moments. At the same time serviceability requirements must be considered to ensure that the member will behave satisfactorily under working loads. It is difficult to separate these two criteria, hence the design procedure consists of a series of interrelated steps and checks. These steps are shown in detail in the flow chart in figure 7.1, but may be condensed into three basic design stages:

1. preliminary analysis and member sizing
2. detailed analysis and design of reinforcement
3. serviceability calculations.

Much of the material in this chapter depends on the theory and design specification from the previous chapters. The loading and calculation of moments and shear forces should be carried out using the methods described in chapter 3. The equations used for calculating the areas of reinforcement have been derived in chapters 4 and 5.

Full details of serviceability requirements and calculations are given in chapter 6, but it is normal practice to make use of simple rules which are specified in the Code of Practice and are quite adequate for most situations. Typical of these are the span–effective depth ratios to ensure acceptable deflections, and the rules for maximum bar spacings, maximum bar sizes and minimum quantities of reinforcement, which are to limit cracking, as described in chapter 6.

Design and detailing of the bending reinforcement must allow for factors such as anchorage bond between the steel and concrete. The area of the tensile bending reinforcement also affects the subsequent design of the shear and torsion reinforcement. Arrangement of reinforcement is
Variable loads
- Estimate self-weight
- Permanent loads
  - Preliminary analysis
    - Trial $b$
      - Estimate $d$ from
        - $M / bd^2 f_{ck} \leq K_{bal}$ singly reinforced
        - $K_{bal} < M / bd^2 f_{ck} < 8 / f_{ck}$ doubly reinforced
        - $V < \text{Max. allowable } V_{Rd2}$
          - Check basic span / effective depth

- Select $h$
  - Detailed analysis
    - BM & SF envelopes
      - Bending reinforcement design
        - Anchorage
          - Bending reinforcement details
            - Check span / effective depth

- Shear reinforcement
  - Calculate crack widths (if req'd)
  - Calculate deflections (if req'd)
  - Finish

Concrete grade
- Concrete cover
  - Minimum section
    - Durability & fire resistance

Figure 7.1 Beam design flowchart