REINFORCED CONCRETE DESIGN 1

Deflection, Cracking and Detailing

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Lesson Outcome

At the end of this chapter, students should be able to:

1. Check deflection: span to depth ratio and modification factors
2. Check crack: type of cracking and bar spacing
3. Prepare structural detailing

Introduction

- In order to serve its intended purpose, a structure must be safe and serviceable
- A structure is safe, if it is able to resist without distress & with sufficient margin of safety, all forces which are likely to act on it during its lifetime
- Serviceability, implies that deformation of structures such as deflection, cracking, and other distortions under load shall not be excessive

General requirement

- Neither the efficiency nor the appearance of a structure is harmed by the deflections that will occur during its life.
- Must be considered at various stages.
- Limitations necessary to satisfy the requirements will vary considerably according to the nature of the structure & its loadings

Deflection check

- Deflection can be categorized as one of the elements that has to be checked for serviceability limit state.

- "Extreme Deflection" could cause:
  - Sagging of floors/slab
  - Defects/crushing of finishes, partitions
  - Buckling of glass enclosures
  - Ill lifting doors and windows
  - Poor drainage
  - Misalignment of machinery
  - Excessive vibration

Deflection check

For control of deflection, 2 alternatives method are described in EC2 Cl 7.4:

- Limiting span to depth ratios (Cl 7.4.2) and
- Calculation of actual deflection & check it with a limit value (Cl 7.4.3)

Definition limit:

- Final deflection of a beam, slab or cantilever ≤ span/250
- For deflection which takes place after the application of finishes or fixing of partitions ≤ span/500 (avoid damage to fixtures and fitting)

If deflection check fails...

If $(l/d)_{actual} > (l/d)_{allowable}$

Suggested solutions:

- Increase the area of tension reinforcement
- Calculate the actual value of deflection using detail calculation
- Redesign – increase the depth of beam

Cracking

- Cracks are induced in RC elements as a results of:
  - Flexural tensile stress due to bending under applied load
  - Diagonal tension stress due to shear under applie load
  - Volume changes due to shrinkage, thermal & chemica; effects
  - Splitting along reinforcement due to bond & anchorage

- Objective of crack control: to limit the width of individual cracks >> aesthetic reason, durability & corrosion protection

Crack control

2 alternatives methods are described in Eurocode 2 Clause 7.3:

- Control of cracking without direct calculation (Cl 7.3.3)
  - For normal building
- Calculation for crack widths (Cl 7.3.4)
  - For water retaining structures

Control of cracking without direct calculation

Flexural cracking generally controlled by providing a minimum area of tension reinforcement and limiting bar spacing or limiting bar sizes

- Minimum reinforcement area
- Maximum spacing of reinforcement
- Maximum bar size (slab, wall design)

Detailing

Detailing and durability requirements are to ensure that a structure has satisfactory durability and serviceability performance under normal circumstances throughout its lifetime.

- Minimum and Maximum Area of Reinforcement
- Spacing of Reinforcements
- Curtailment & Anchorage of Steel Reinforcement
- Laps in Reinforcement

Minimum & Maximum Area of Reinforcement

The minimum area of reinforcement is to:

- Control thermal and shrinkage cracking within the acceptable limits.
- Ensures that reinforcement does not yield when concrete in tension zone cracks with a sudden transfer of stress to the reinforcement.
- When minimum area is provided, then yield should not occur and cracking will then be distributed throughout the section with a greater number of cracks but of lesser width.

Example and Tutorial