CIHAN UNIVERSITY

COLLEGE OF ENGINEERING

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SULAIMANI

CONCRETE DESIGN I

CHAPTER 3

Analysis and Design of Doubly Reinforced Beams

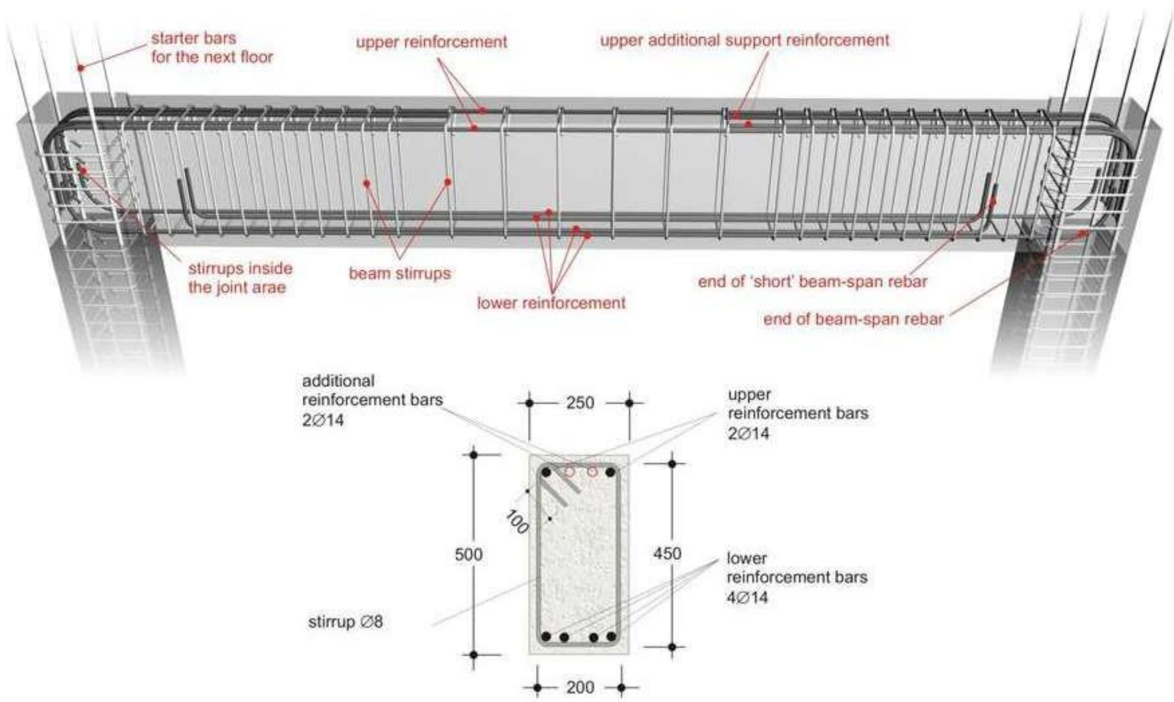
Diyari B. Hussein

M.Sc. Structural Engineering

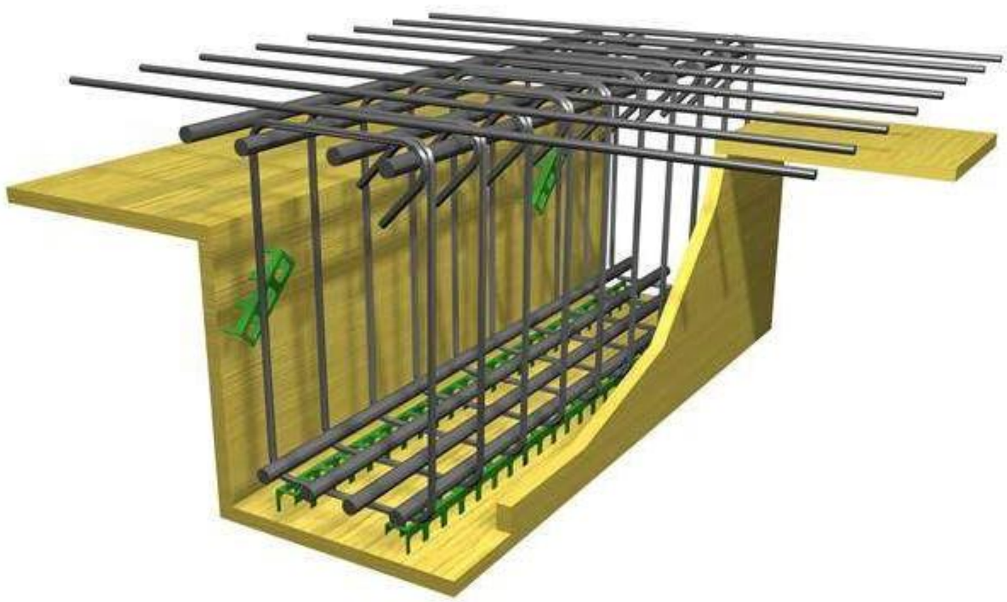
CHAPTER 3 DOUBLY REINFORCED BEAMS

4.1 Introduction [6]

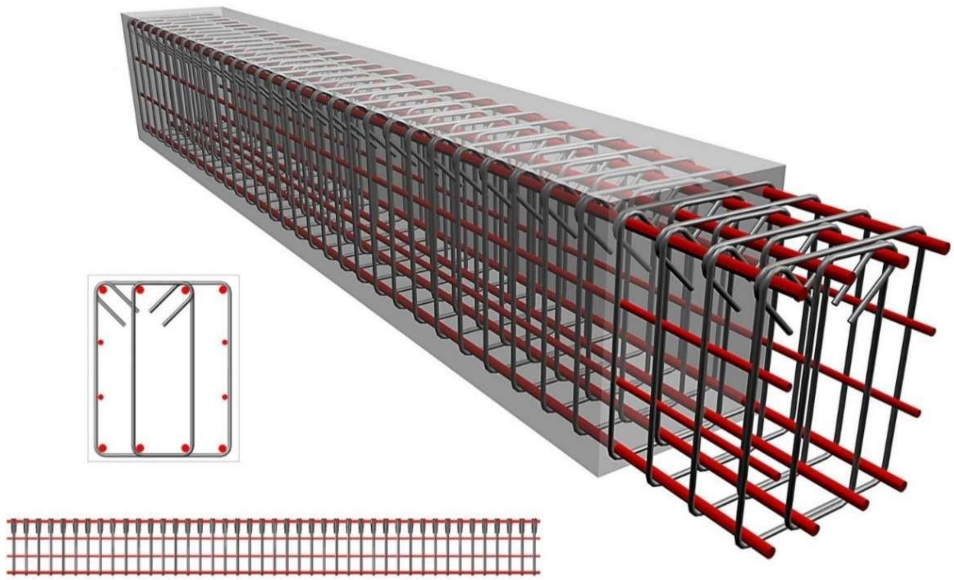
- The steel that is occasionally used on the compression sides of beams is called **compression steel**
- Beams with both tensile and compressive steel are referred to as **doubly reinforced beams**
- In some circumstances, space or aesthetic requirements limit beams to such small sizes that compression steel is needed in addition to tensile steel.
- To increase the moment capacity of a beam beyond that of a singly reinforced beam with the minimum tensile strain of (0.004), it is necessary to introduce another resisting couple in the beam.
- This is done by adding steel in both the compression and tensile sides of the beam.

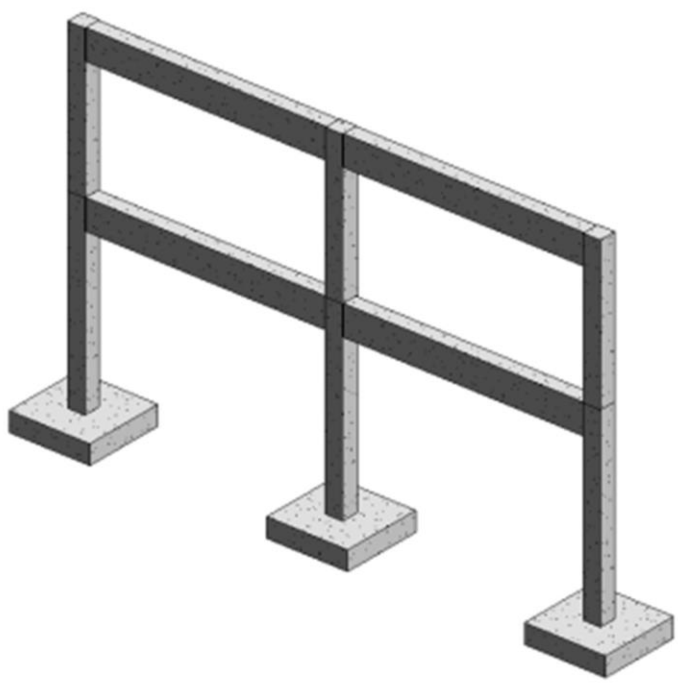


- Compressive steel increases not only the resisting moments of concrete sections but also the amount of curvature that a member can take before flexural failure.
- This means that the ductility of such sections will be appreciably increased.
- Compression steel makes beams tough and ductile, enabling them to withstand large moments, deformations, and stress reversals such as might occur during earthquakes.
- Many building codes for earthquake zones require that certain minimum amounts of compression steel be included in flexural members.
- Compression steel is very effective in reducing long-term deflections due to shrinkage and plastic flow.

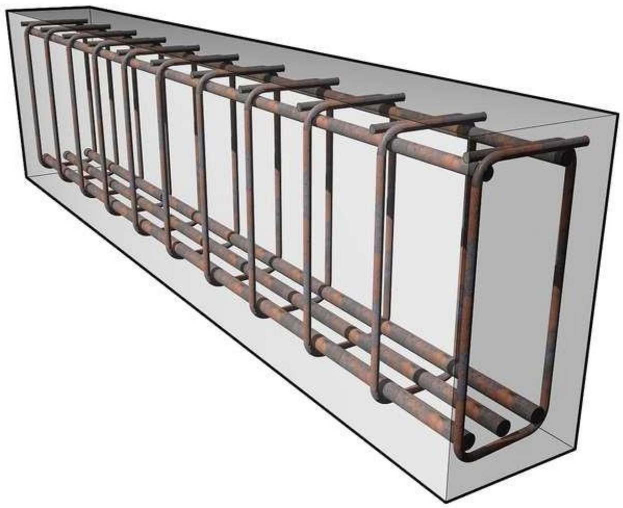


- Continuous compression bars are also helpful for positioning stirrups (by tying them to the compression bars) and keeping them in place during concrete placement and vibration.
- Tests of doubly reinforced concrete beams have shown that even if the compression concrete crushes, the beam may very well not collapse if the compression steel is enclosed by stirrups.





- Once the compression concrete reaches its crushing strain, the concrete cover spalls or splits off the bars, much as in columns (Next chapters).If the compression bars are confined by closely spaced stirrups, the bars will not buckle until additional moment is applied.
- ACI Code states that compression steel in beams must be enclosed by ties or stirrups or by welded wire fabric of equivalent area.



4.2 Notations

T_s : $Tensile\ force\ required\ to\ balance\ the\ compression\ reinforcement$

T_c : $Tensile\ force\ required\ to\ balance\ the\ concrete\ compression\ block\ force$

A_{ss} : $Reinforcement\ required\ to\ create\ the\ force\ (T_s)$

A_{sc} : $Reinforcement\ required\ to\ create\ the\ force\ (T_c)$

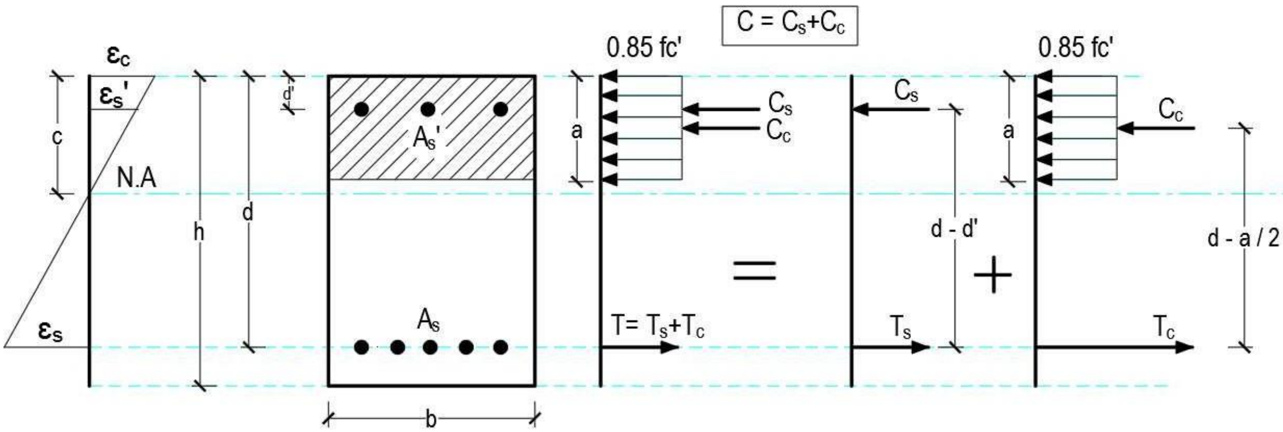
A_s : $Summation\ of\ A_{ss}\ and\ A_{sc}$

M_{ns} : $internal\ moment\ due\ to\ compression\ reinforcement\ and\ part\ of$ $the\ tension\ reinforcement$

M_{nc} : $internal\ moment\ due\ to\ concrete\ compression\ block\ and\ the\ otehr\ part\ of$ $the\ tension\ reinforcement$

M_n : $Nominal\ internal\ moment\ and\ it\ is\ the\ summation\ of\ M_{ns}\ and\ M_{nc}$

4.3 Moment Resistance of Doubly Reinforced Beams



The strain in the compressive reinforcement

$$\varepsilon_s' = \frac{c - d'}{c}\, 0.003$$

4.3.1 CASE 1: Both Tension and Compression Reinforcement Yielded

4.3.2 CASE 2: Tension Reinforcement Yielded but Compression Reinforcement Not Yielded

4.3.3 CASE 3:

Not Permitted by ACI318

4.3.4 CASE 4:

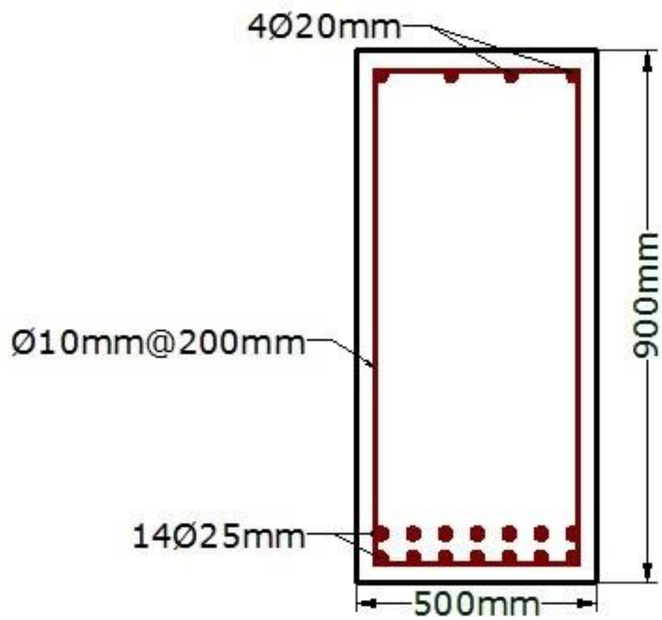
Not Permitted by ACI318

4.4 Analysis of doubly Reinforced Beams

4.5 Example 7

Compute the design moment capacity of the beam section shown.

$f'_c = 21\, MPa\ ;\ f_y = 420\, MPa$

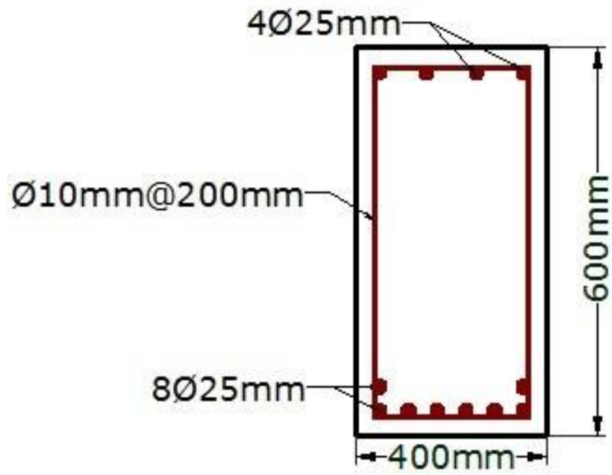


SOLUTION

4.6 Example 8

Compute the design moment capacity of the following beam using the given data.

$f'_c = 25\,MPa$; $f_y = 420\,MPa$



SOLUTION

4.7 Design of doubly Reinforced Beams

4.7.1 Example 9

Design the cantilever beam shown in the following plan using the given data.

Given:

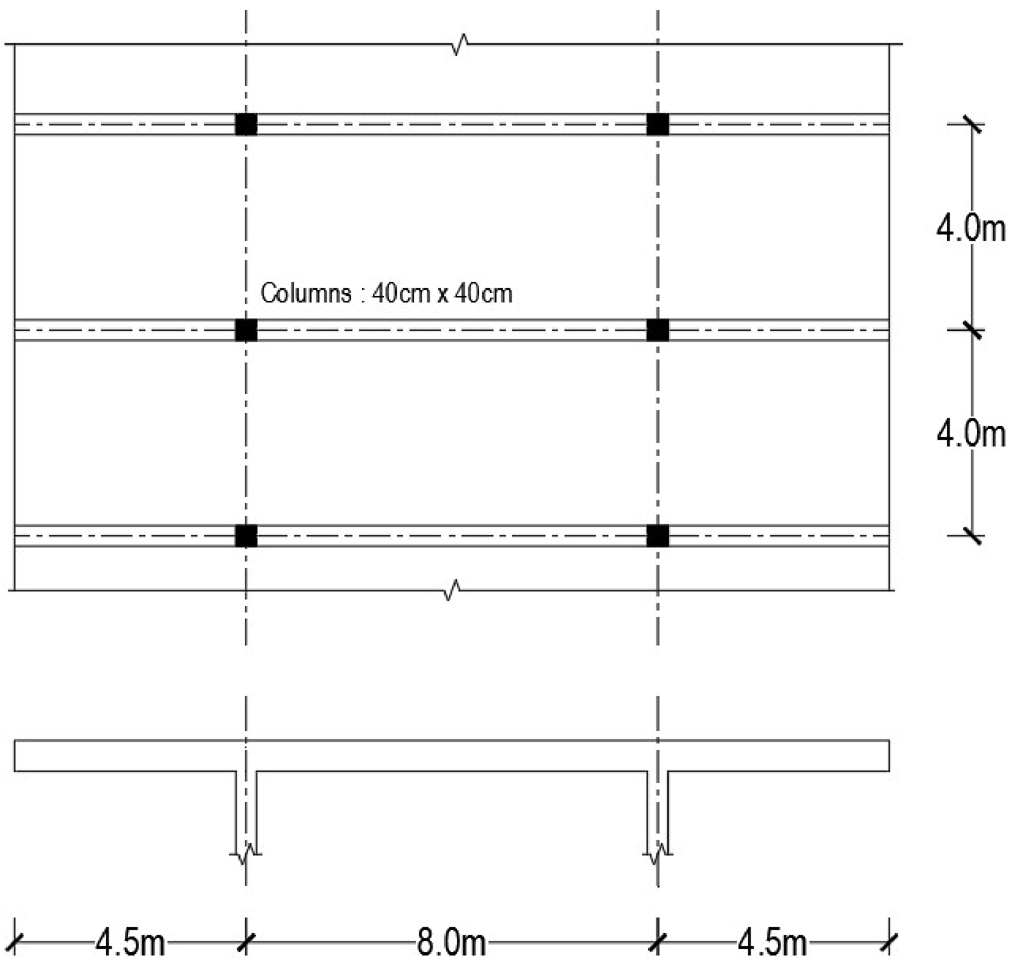
$f'_c = 21\ MPa$; $f_y = 420\ MPa$; $Slab\ thickness: 22\ cm$

$Thickness\ of\ (tiles + mortar)\ 10\ cm$

$Density\ of\ (tiles + mortar):\ 20\ kN/m3$

$Additional\ DL:\ 1.0\ kN/m^2$; $Live\ Load:\ 5.0\ kN/m^2$

***Note**: Due to architectural limitations, the depth should not be deeper than 60cm*



SOLUTION

4.8 References

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