

# *Reinforced Concrete Structures*

*MIM 232E*



*Flanged Sections*  
*Doubly Reinforced Rectangular Beams*

**RCSD-4**

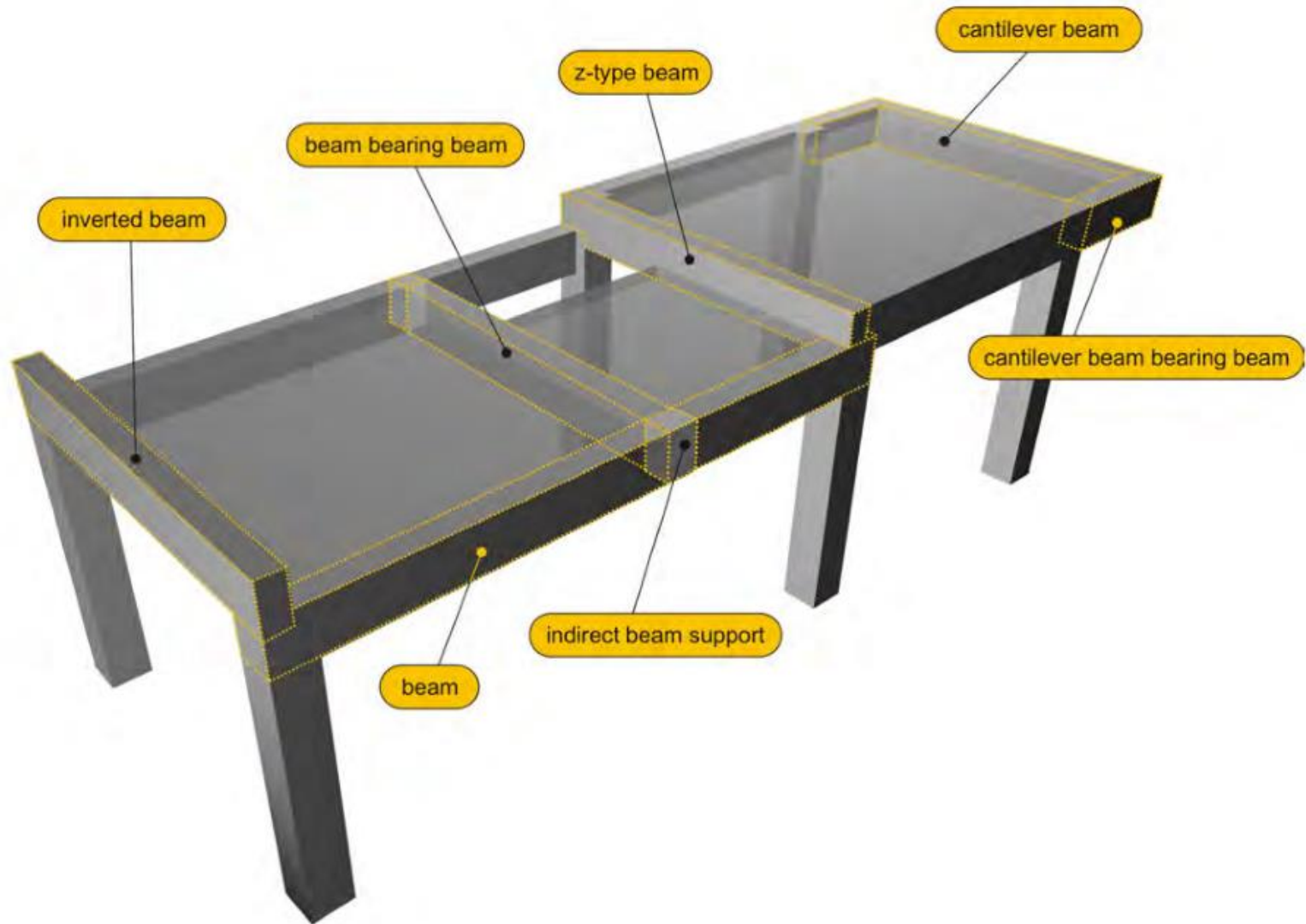
**Dr. Haluk Sesigür**

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Structural and Earthquake Engineering WG

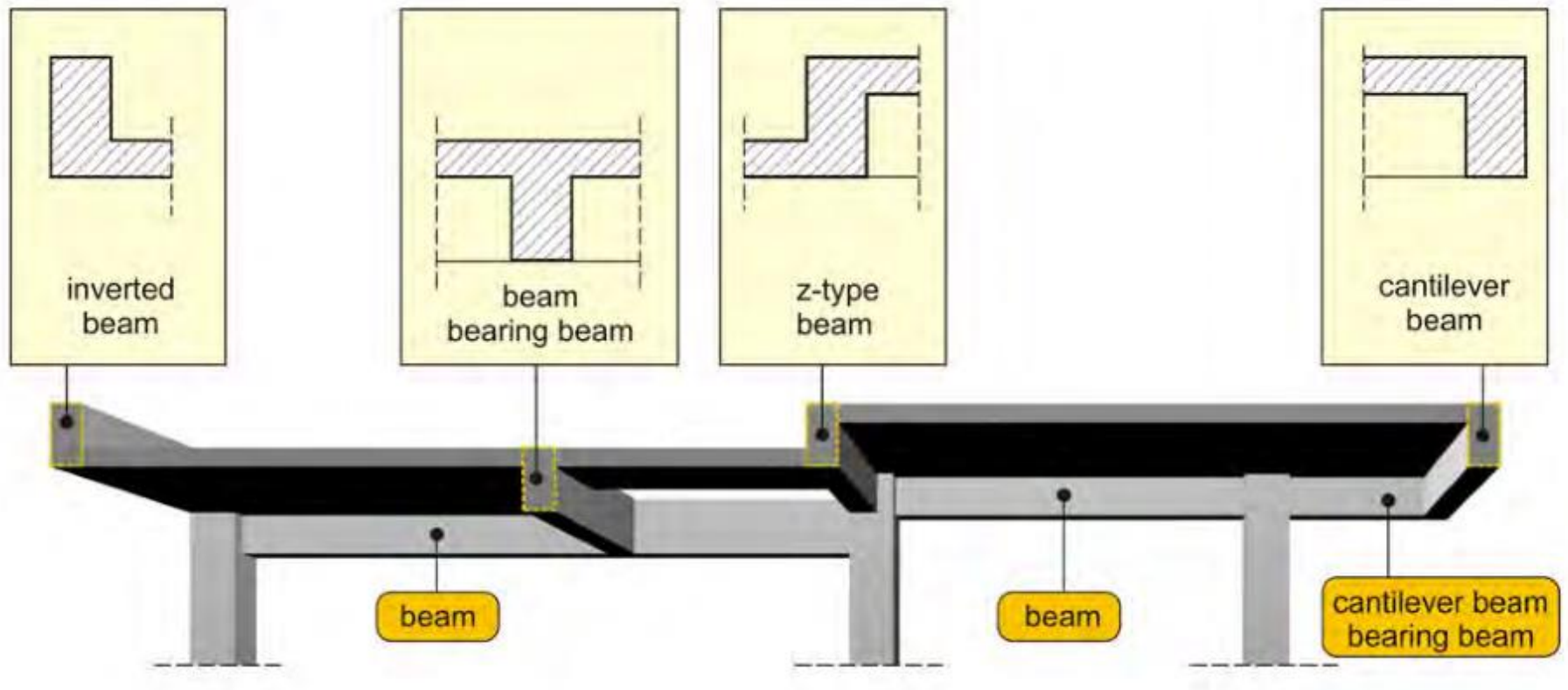
# T-section beam

## Concept



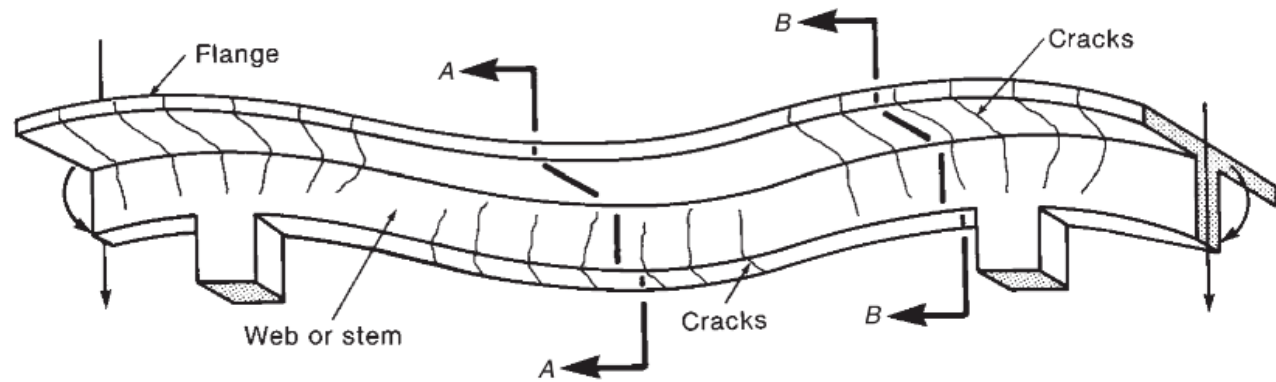
# T-section beam

## Concept

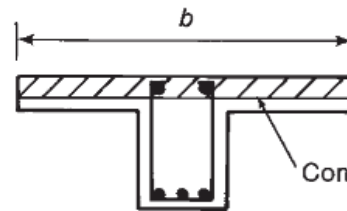


# T-section beam

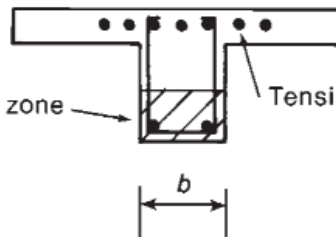
## Concept



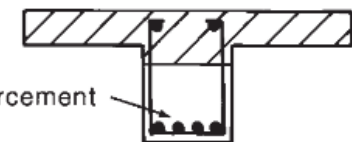
(a) Deflected beam.



(b) Section A-A  
(rectangular  
compression zone).



(c) Section B-B  
(negative moment).



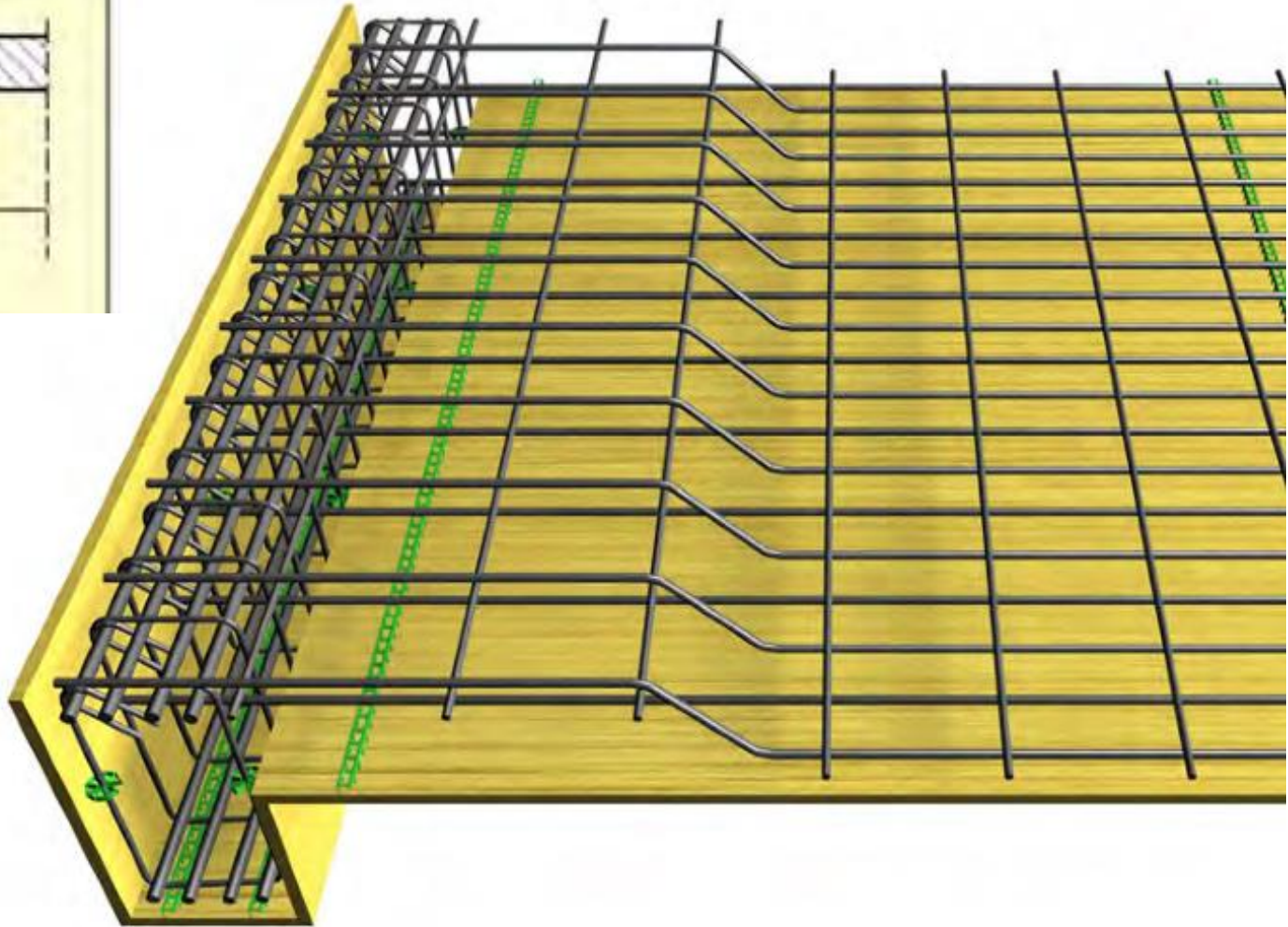
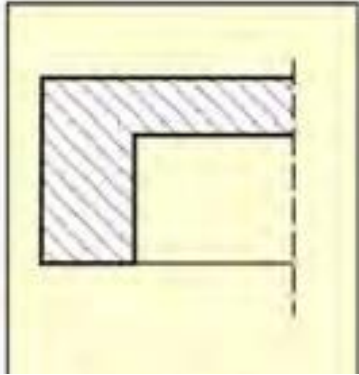
(d) Section A-A  
(T-shaped  
compression zone).

Fig. 4-37  
Positive and negative moment  
regions in a T-beam.



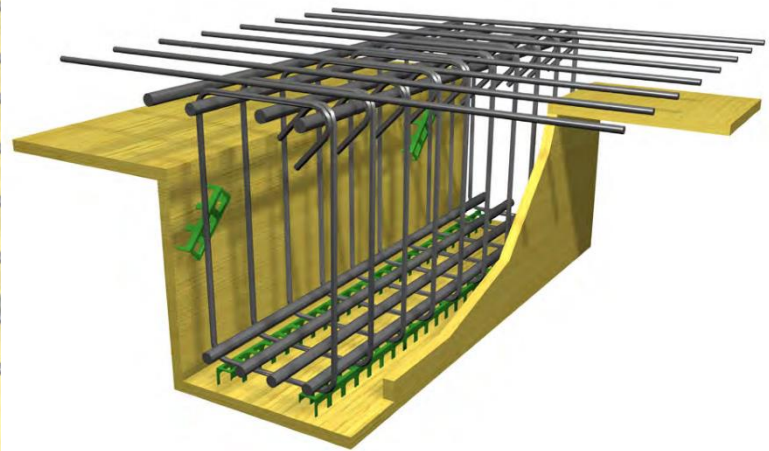
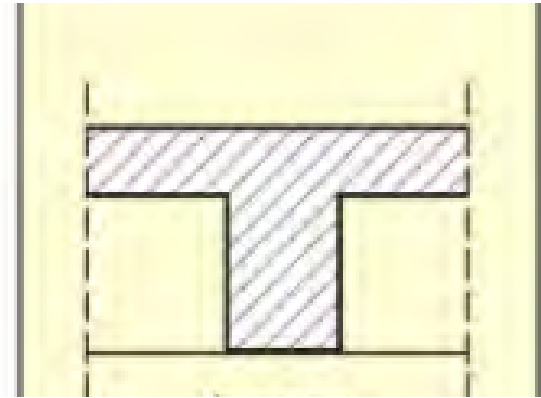
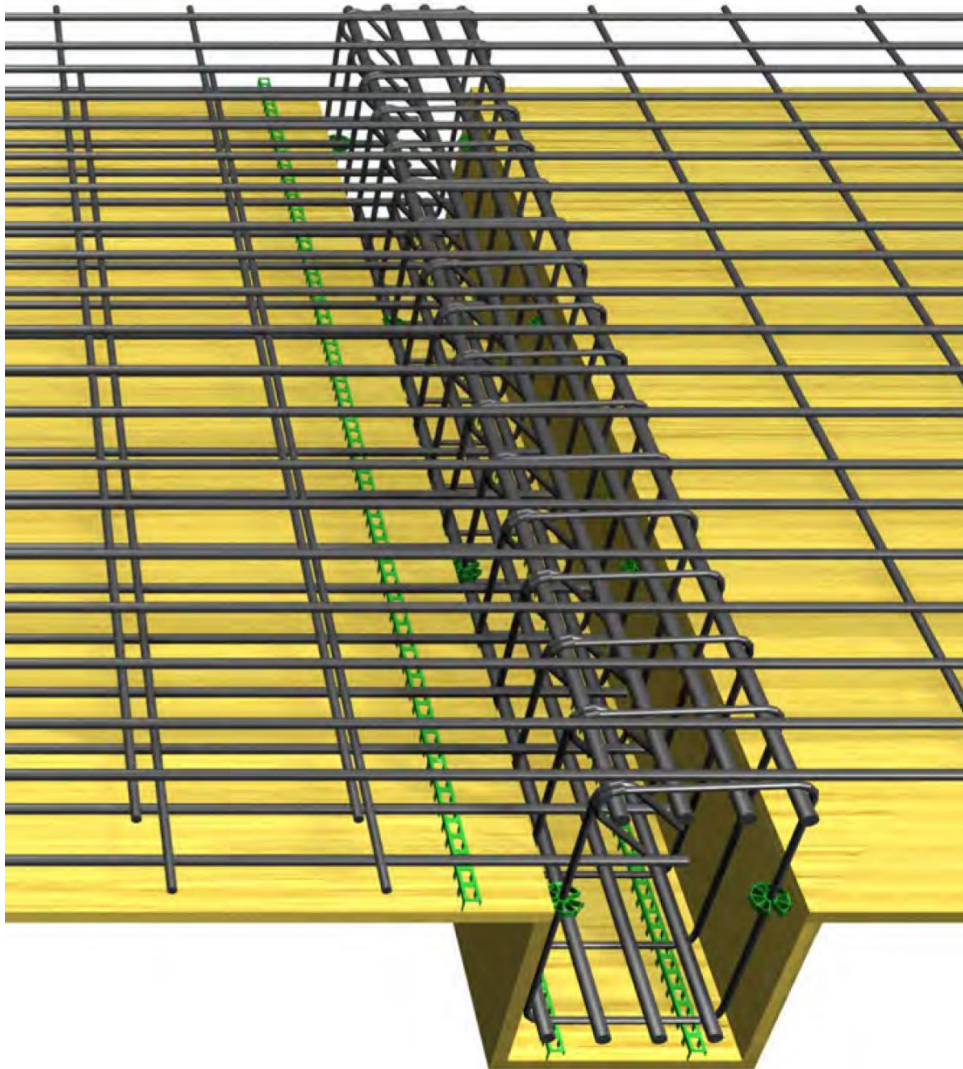
# ***L-section beam***

## ***Concept***



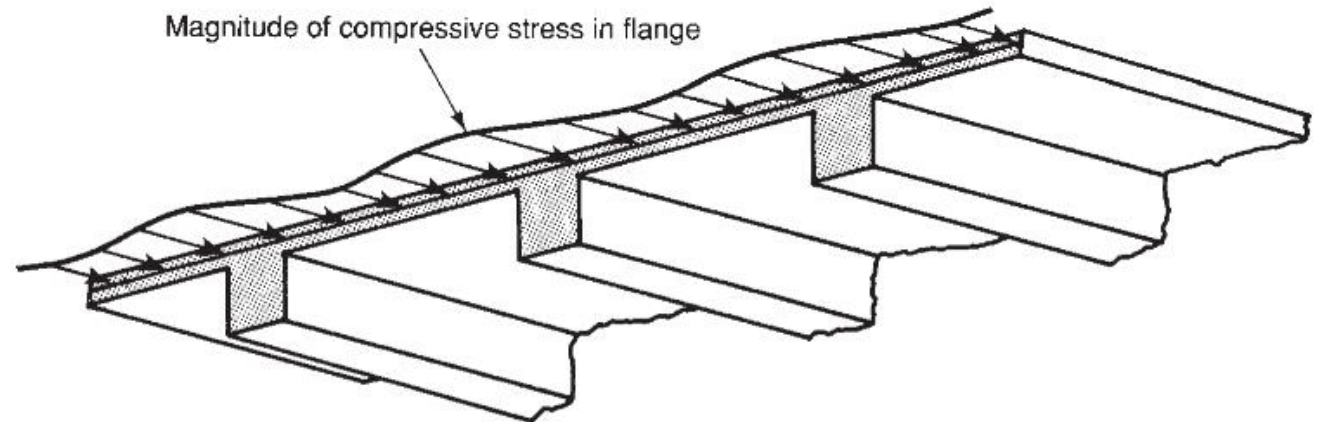
# T-section beam

## Concept



# T-section beam

## Concept



(a) Distribution of maximum flexural compressive stresses.

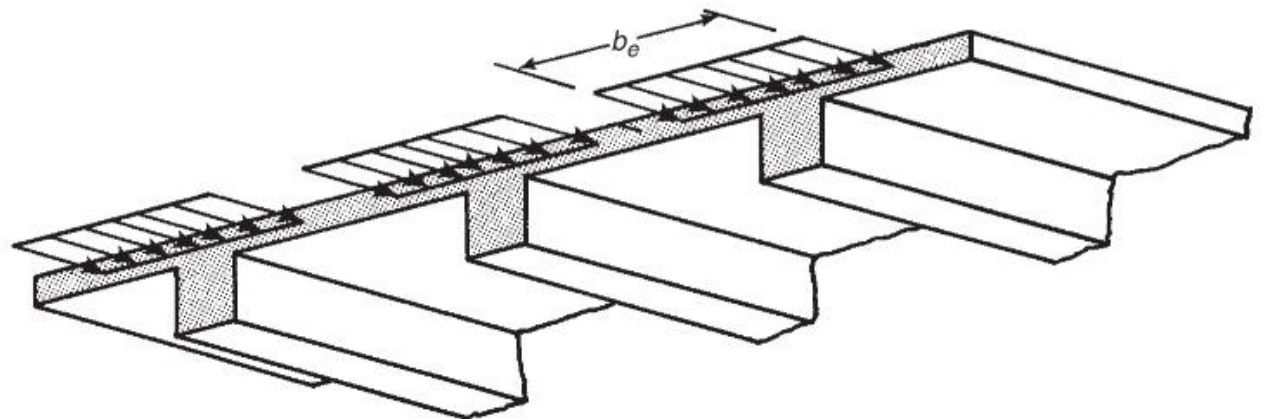


Fig. 4-40  
Effective width of T-beams.

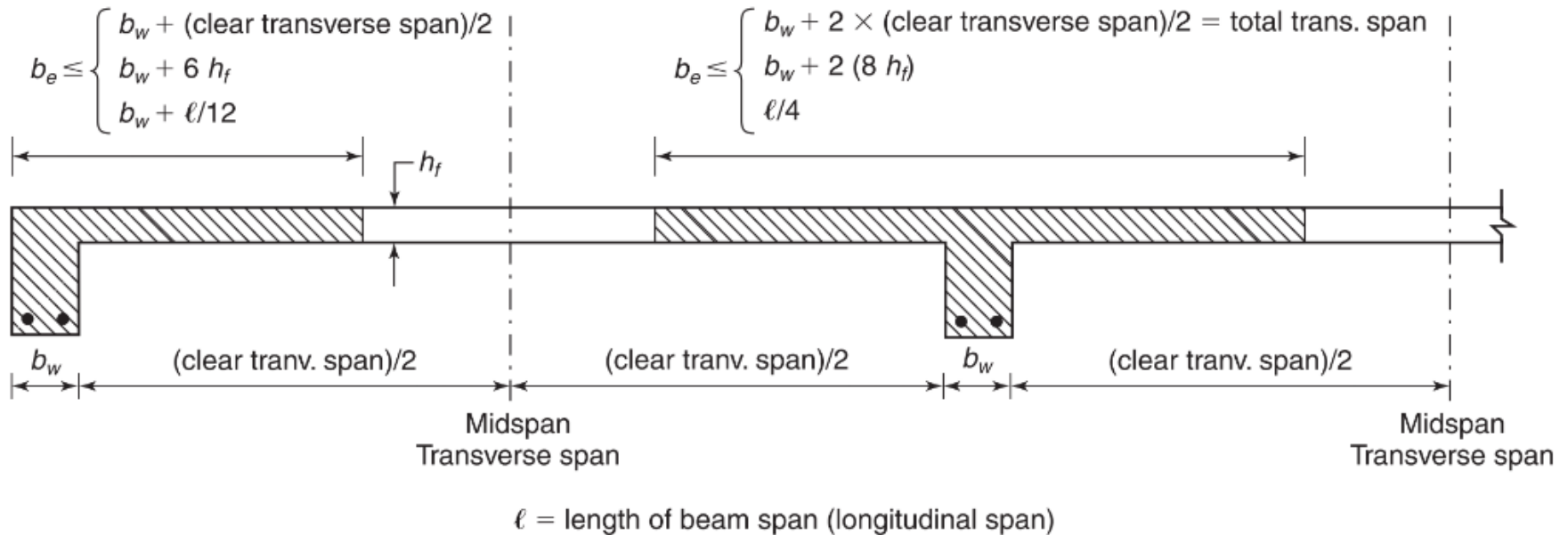
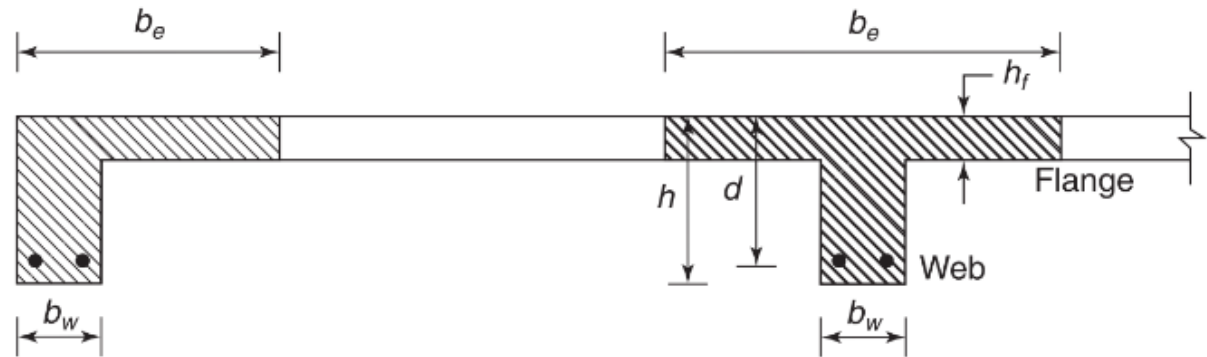
(b) Flexural compressive stress distribution assumed in design.



# T-section beam

## Concept

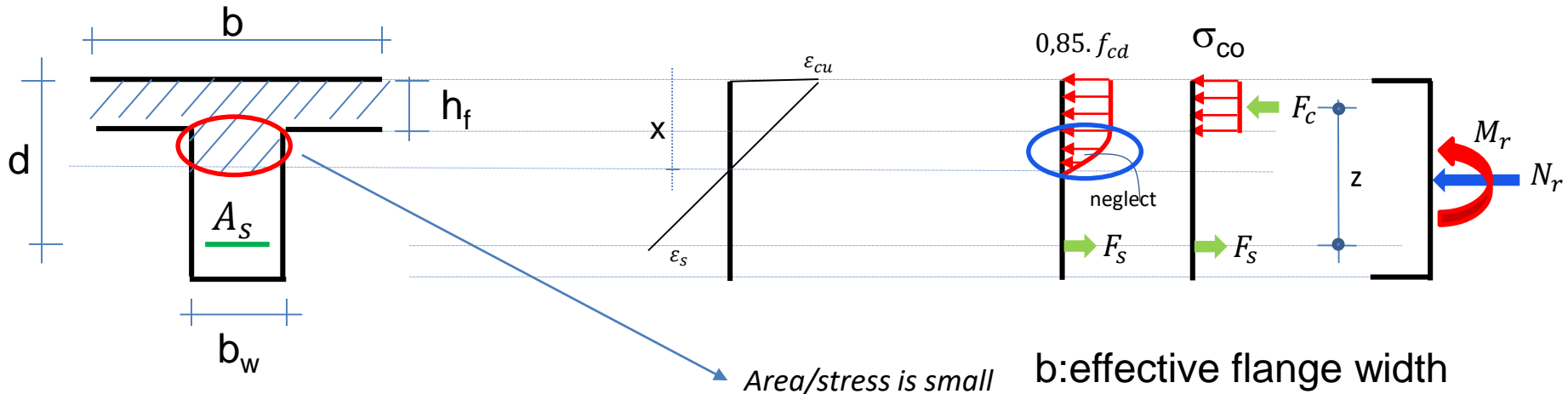
Fig. 4-41  
Typical beam sections in concrete floor systems.





# T-section beam

## calculation method



$$F_c = \sigma_{co} \cdot h_f \cdot b + (\text{neglect})$$

Assumptions:

1. N.A is assumed as at the body
2.  $\epsilon_s \geq \epsilon_y$ ,  $\sigma_{sy} = f_{yd}$

$b$ : effective flange width  
 $d$ : effective height  
 $h_f$ : slab thickness  
 $b_w$ : beam web width  
 $z$ : moment arm  
 $\sigma_{co}$ : average compressive stress in concrete

$$z \cong d - \frac{h_f}{2}, \quad F_s = A_s \cdot f_{yd} \quad , \text{ from horizontal equilibrium } , F_c = F_s$$

$$M_{sr} = Mr + Nr \cdot y_s$$

Comp. (+)  
Tens. (-)

$$M_{sr} = Fs \cdot z = As \cdot f_{yd} \cdot z = As \cdot f_{yd} \cdot \left(d - \frac{h_f}{2}\right) = Fc \cdot z$$

If also N is available;

$$A_s = \frac{M_{sr}}{\left(d - \frac{h_f}{2}\right) \cdot f_{yd}}$$

(N=0)



$$A_s = \frac{M_{sr}}{\left(d - \frac{h_f}{2}\right) \cdot f_{yd}} - \frac{N_r}{f_{yd}}$$

# T-section beam

## calculation method

$$M_{sr} = Fc.z = \sigma_{co} \cdot h_f \cdot b \cdot z$$

If  $\sigma_{co}$  (average compressive stress in concrete) is developed;

$$\sigma_{co} = \frac{M_{sr}}{b \cdot h_f \cdot z}$$

Flange area of T section

$$\sigma_{co} = \frac{M_{sr}}{b \cdot h_f \cdot (d - \frac{h_f}{2})} \leq 0,85 \cdot f_{cd}$$

### Reasons for Providing Compression Reinforcement

There are four primary reasons for using compression reinforcement in beams:

**1. Reduced sustained-load deflections.** First and most important, the addition of compression reinforcement reduces the long-term deflections of a beam subjected to sustained loads. Figure 4-30 presents deflection–time diagrams for beams with and

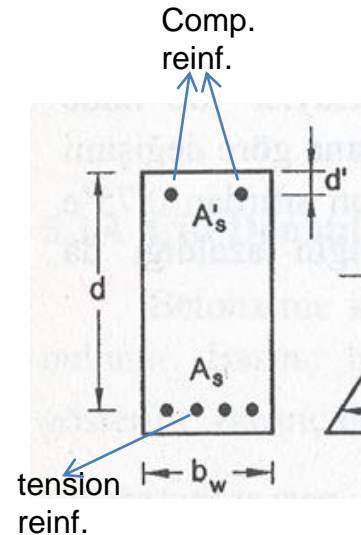
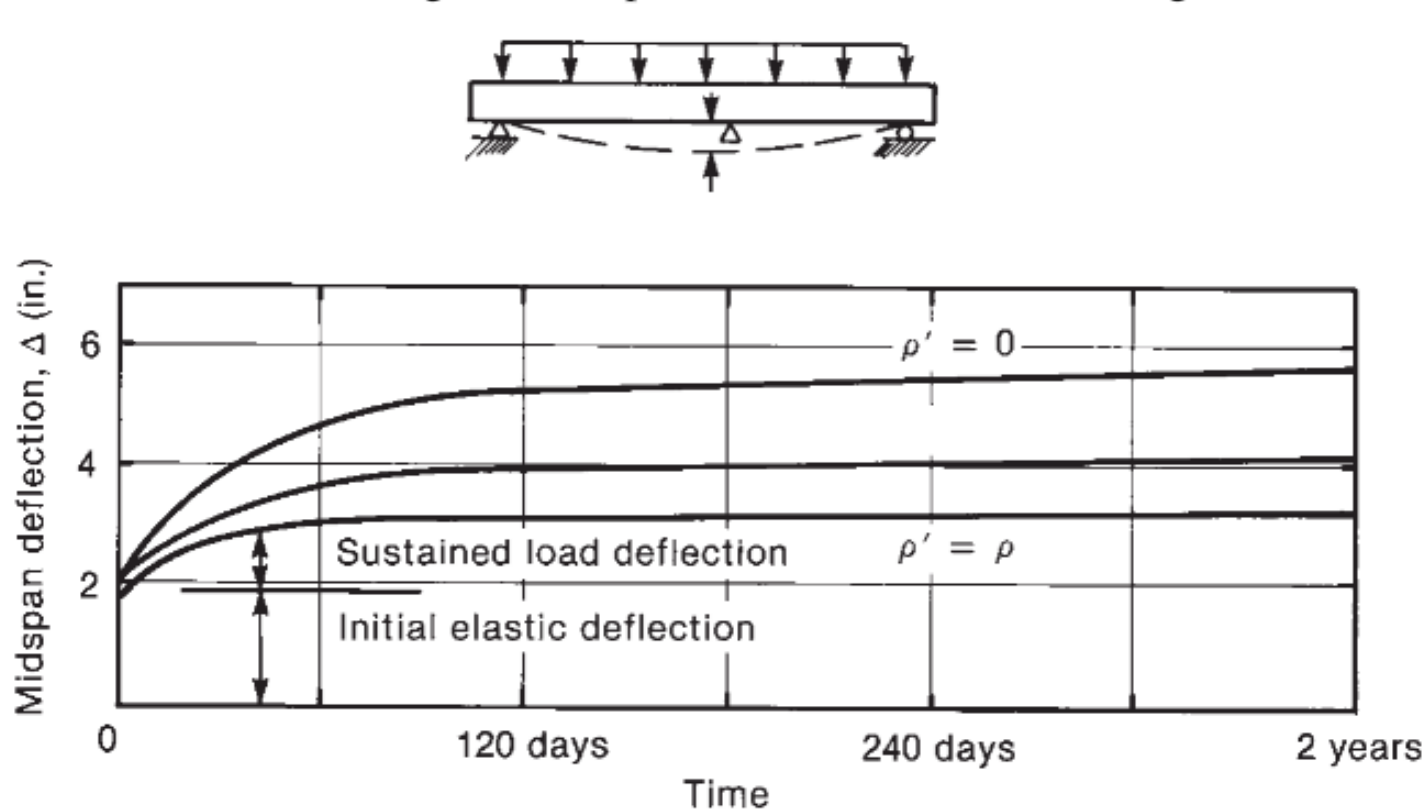


Fig. 4-30  
Effect of compression reinforcement on deflections under sustained loading.



**2. Increased ductility.** The addition of compression reinforcement causes a reduction in the depth of the compression stress block,  $a$ . As  $a$  decreases, the strain in the tension reinforcement at failure increases, as shown in Fig. 4-29c, resulting in more ductile behavior, as was shown in Fig. 4-12 for  $A'_s = 0.5 A_s$ . Figure 4-31 compares moment–curvature diagrams for three beams with  $\rho < \rho_b$ , as defined in Eq. (4-25), and varying amounts of compression reinforcement,  $\rho'$ . The moment at first yielding of the tension reinforcement

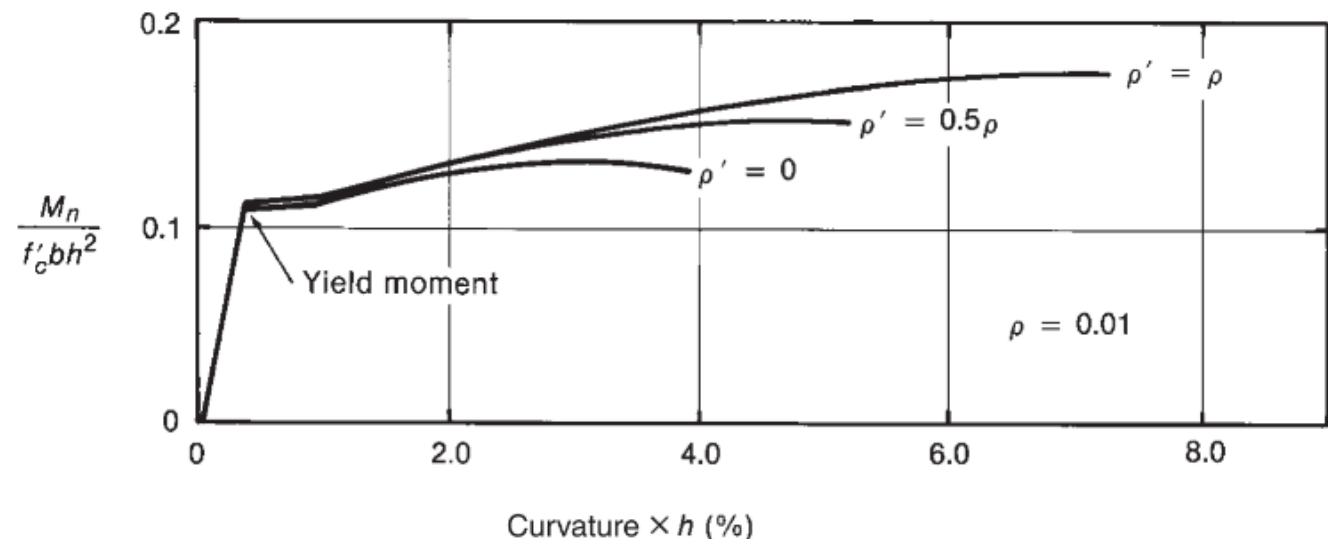


Fig. 4-31  
Effect of compression reinforcement on strength and ductility of under-reinforced beams. (From [4-16].)

# Doubly Reinforced Beam

## Concept

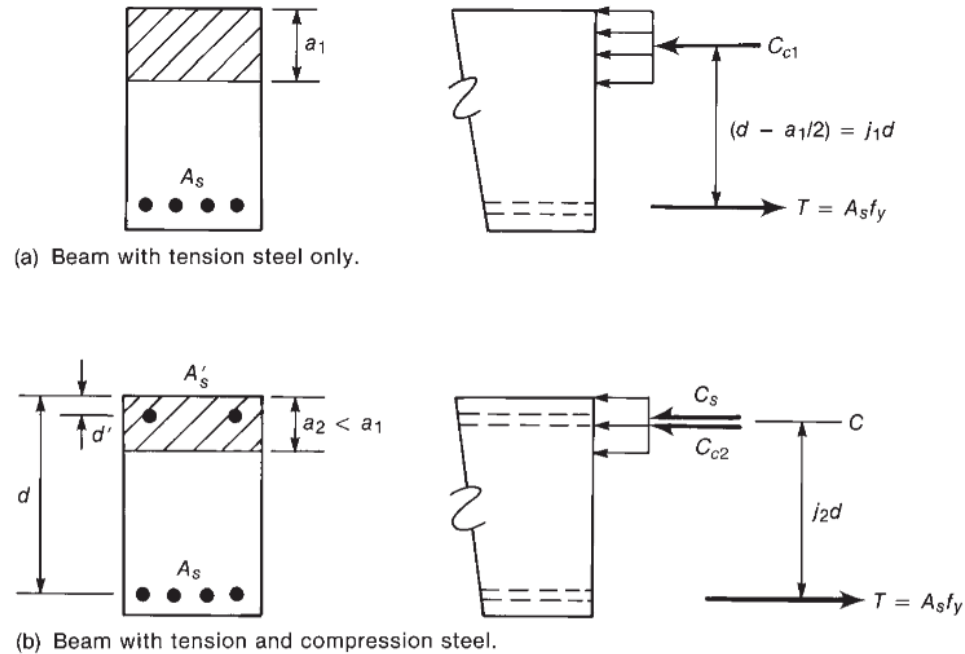
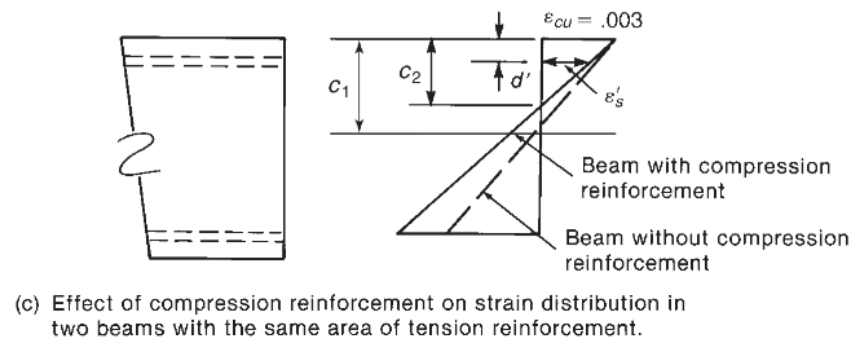


Fig. 4-29  
Effect of compression reinforcement on moment strength.



**3. Change of mode of failure from compression to tension.** When  $\rho > \rho_b$ , a beam fails in a brittle manner through crushing of the compression zone before the steel yields. A moment–curvature diagram for such a beam is shown in Fig. 4-32 ( $\rho' = 0$ ). When enough compression steel is added to such a beam, the compression zone is strengthened sufficiently to allow the tension steel to yield before the concrete crushes. The beam then displays a ductile mode of failure. For earthquake-resistant design, all beam sections are required to have  $\rho' \geq 0.5\rho$ .

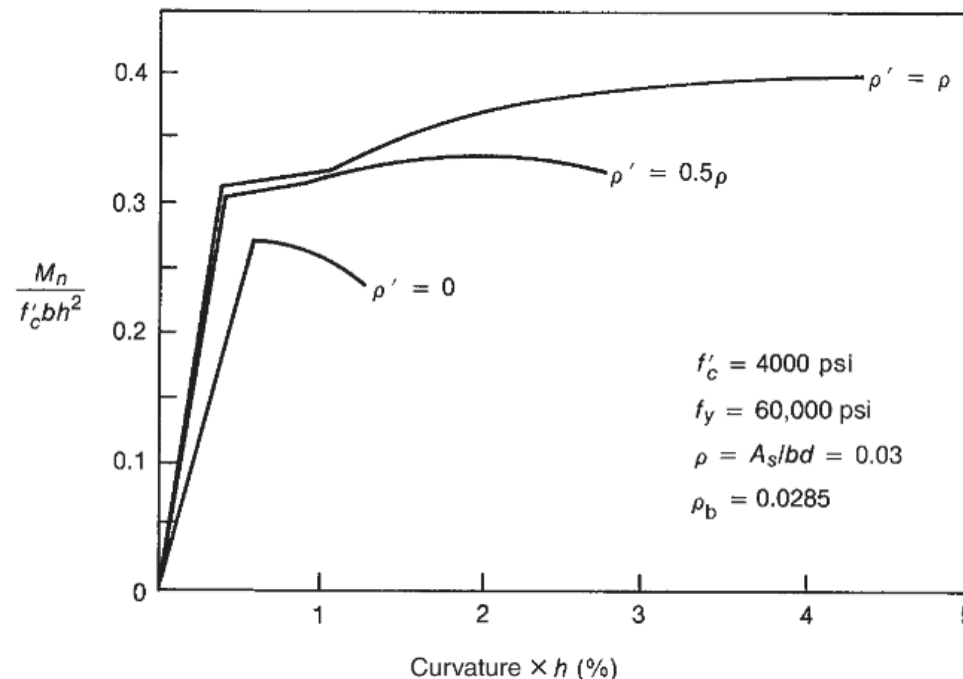


Fig. 4-32  
Moment–curvature diagram  
for beams, with and without  
compression reinforcement.  
(From [4-16].)

**4. Fabrication ease.** When assembling the reinforcing cage for a beam, it is customary to provide small bars in the corners of the stirrups to hold the stirrups in place in the form and also to help anchor the stirrups. If developed properly, these bars in effect are compression reinforcement, although they generally are disregarded in design, because they have only a small affect on the moment strength.