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Q#02

part # "A"

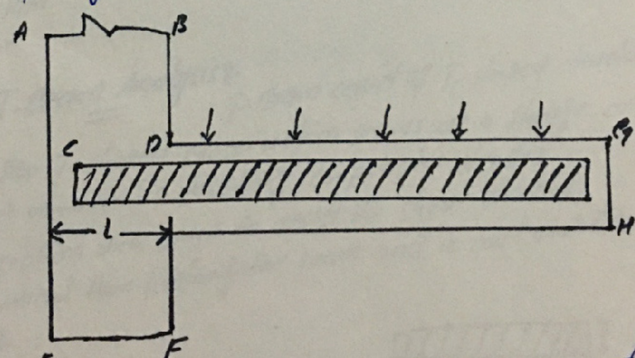
=> Bond stress:-

Def:- Bond stress is the stress produced because of the bond b/w concrete surface and the reinforcement steel. It varries depending upon the type of the concrete and reinforcement used.

=> It is like a grip. if surface is rough and less Grip and if the surface is smooth and rounded.

=> Development length:- => Development length certain minimum length of the bar required on either side of a point of maximum steel stress in order to transfer the load bar to the surrounding concrete through bond without slip to prevent bar from pulling out under tension.

Fig:-



=> In the diagram (l) represent the Development length.

⇒ part B

⇒ Doubly Reinforced Beams:- Doubly reinforcement Beam is used due to the following reason.

No # 1:- when the dimension of the beam (breth, depth) are limited for Architectrial or structure purposes.

02:- when the section such as brace in water, towers etc such as subjected to reversal bending movement.

03:- Due to high demand of local that causes movement and due to restriction in dimension, section is designed as doubly reinforced.

04:- for condition T-beam the portion of the beam are middle support has to be designed as doubly reinforced section.

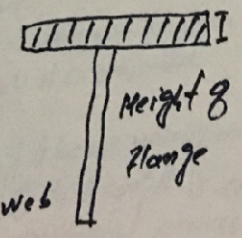
part # C"

T-Beam Analysis:- T-Beam consist of T-shaped structure the top of the T-shaped cross-section serves as a flange or compression member is resisting compression stresses. the lower section web serve to resist the shear stresses. It is economical then Rectangular beam and is cast monolithically with the slab.

∴ a > hf

→ a = depth of compression block

→ hf = slab thickness / flange - height.



=> Rectangular Beam Analysis:-

=> A rectangular beam is one which is generally used as Compression in top fiber and tension is bottom fiber.

=> Rectangular beam is more used to office / commercial buildings. these can be cost in-slice Design standard reinforcement or precast.

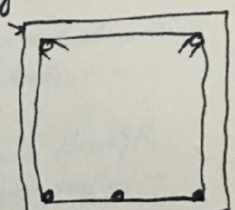
=> In rectangular beam, the stress block diagram show the top fiber are subjected to maximum compression leniently reduced tills the neutral axis.

=> Its Analysis is required when.

$a \leq h_f$

a = depth of compression block

h_f = height of flange



part # D"

=> strength Reduction factors:- It is define as the ratio of elastic strength to yield strength.

Denoted by:

ϕ

=> Effect on strength:- strength reduction factors, shows the strength in terms of percentage while designing of a section to resist the moment caused by load.

=> Basically it represent the uncertainity in determining the members behavior to the type of stress as to which it is subjected.

For example:- during the design process of a beam usually we take 0.75 for shear loads. its show that 75% of its strength is considered here and the rest of 25% is for future accidental process.

=> Designing Methods:- Two methods are used for the designing of concrete and different structure members.

1- ADS (Allowble stress Design method)

(2) USD (ultimate strength Design method)

"1" Allowble stress Design method:- ASD method is also known as working stress design method. it is based on the principle that stress developed in the structural members should not exceed a certain limit / fraction of elastic limit

=> In this method all loads are taken as service loads and no factor is applied to increase these service loads.

"2" ultimate strength Design method:- ultimate strength Design method is also known as load factor method or ultimate load factor

=> For structural subjected to large external loads the ultimate strength determined by the inelastic (non linear analysis)

=> ultimate strength design method is for designing different structural members because of the following.

#01:- As the ultimate strength of the material is considered we will get much slender section for column and beams compared to other method.

#02:- ultimate design method result is more economical design for a building with fewer special needs for constomized areas of reinforcement.

#03:- Also better determines design for higher safety factor needs where a building is more prone to environment pressure or must behavior loads that stress a specified portion of a buildings

Q # 01

Given data:

width "b" = 10"

Height "h" = 20"

Live load = 2.47 kips/ft

Dead load. D.L = 1.05 kips/ft

span = 18'

f'_c = 4000 psi = 4 ksi

f_y = 60,000 psi = 6 ksi

Sol:

Step # 01

Effective depth "d" = h − 3 = 20 − 3 = 17"

Effective cover = d' = 2.5"

Reinforcement ratio:

$\rho_{max} = 0.85 \times \beta \times f'_c/f_y \times \left(\frac{\varepsilon_u}{\varepsilon_u + \varepsilon_y}\right)$

$\Rightarrow 0.85 \times 0.85 \times 4/60 \times \left(\frac{0.003}{0.003 + 0.005}\right)$

$\boxed{\rho_{max} = 0.0180}$

Step # 02: Finding area of steel:

$\rho_{max} = \frac{A_{st}}{b \times d}$ $\quad$ $A_{steel} = \rho_{max} \times (b \times d)$

$\Rightarrow 0.0180 \times (10 \times 17)$

$\boxed{\Rightarrow 3.06 \text{ inch}^2}$

Step # 03: By formula of design moment:

$M_{u_2} = \phi \times A_{st} \times f_y \times (d - a/2)$

$a = A_{st} \times f_y / 0.85 \times f'_c \times b \Rightarrow \frac{3.06 \times 60}{0.85 \times 4 \times 10} \Rightarrow \boxed{5.4"}$

$Mu_2 = 0.90 \times 3.06 \times 60 \times (17 - 5.4/2)$

$\Rightarrow 2362.93$ kip/inch.

moment due to given loads:

Beam selfweight $= 10/12 \times \frac{20}{12} \times 150$

$\Rightarrow 208.33$ lb/ft

Total factored load $= 1.2(1050 + 208.33) + 1.6(2470)$

$\Rightarrow 5461.99$ lb/ft

$\Rightarrow 5.46$ kips/ft

ultimate factored moment: $wl^2/8$

$\Rightarrow \frac{5.46 \times 18^2}{8} \times 12$

$Mu = 2653.56$

Now As. $Mu_2 < Mu$

$\Rightarrow 2362.92 < 2653.56$

Doubly reinforcement required.

step#04: $Mu_1 = 2653.56 - 2362.96$

$Mu_1 = 290.64$ kip-inch

Step#05: Steel area in compression zone will be

$Mu_1 = \phi \times A'st \times fy \times (d - d')$

$A'steel = \frac{Mu_1}{\phi \times fy \times (d - d')} \Rightarrow \frac{290.64}{0.90 \times 60 \times (17 - 2.5)}$

$A'st = 0.37$ inch^2

step#6:

$As = Ast + A'st = 3.06 + 0.37 = 3.43 in^2$

$As = 3.43 in^2$

step#07:

we used bar #8 — dia = 8/8 = 1"

Area = 0.785 inch²

No of bars = Ast / Area of one bar = 3.43/0.785

=> 4.36 => 5 bar

So 5 #8 bars: its for tensile zone.

Compression steel:

use #6 bars

dia (6/8) = 0.75"

Area = 0.44 inch²

No of bars = A'st / Area of one bars = 0.37/0.44 => 0.84

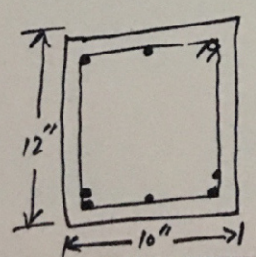
No of bars = 0.84 ≃ 1 bar

So 1 #6 bars in compression zone.

step#08: Beam minimum width:

$b_{min} = 2(1.5) + 2(3/8) + 5(8/8) + 4(8/8)$

=> 12.75 > 10" -> in multiple layer



Effective Depth

$(d) = 20 - 1.5 - 3/8 - 8/8 - 1/2\,(8/8)$

$d = 16.62''$

Effective Cover: $(d') = 1.5 + 3/8 + 1/2\,(6/8)$

$d' = 2.25''$

step #09:

Design moment is

$M_d = \phi \times [A'_{st} \times f_y \times (d - d') + A_{st} - A'_{st} \times f_y \times (d - a/2)$

$a = \dfrac{(A_{st} - A'_{st})\,f_y}{0.85 \times f'_c \times b} = \dfrac{5 \times 0.785 - 1 \times 0.44) \times 60}{0.85 \times 4 \times 10}$

$a = 6.15''$

$M_d = 0.90 \times [(1 \times 0.44) \times 60 \times (16.62 - 2.25) + (5 \times 0.785 - 1 \times 0.44 \times 60 \times (16.62 - \frac{6.15}{2})$

$M_d = 2890.46$

$M_d = 2890.46 > 2653.56$

The Design is "ok"

Q#03 page#9

Given data:

clear cover = 10′, span = 32′, slab thickness = 6″

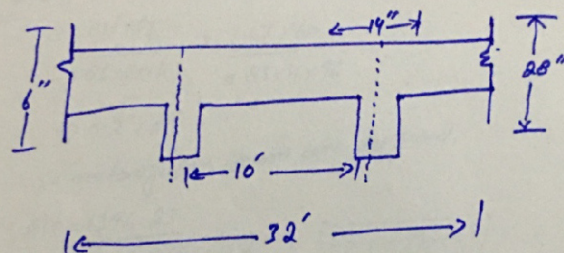
wed width = 14″, total depth = h = 28″

Effective depth = 28 − 3 = 25″

D.L = 50 lb/ft², S.S = 225 lb/ft²

fy = 60,000 psi, f′c = 4000 psi

Sol:



step#01

$Mu = \frac{Wu \times L^2}{8}$

Beam self wt per feet

wt = b×t×γc => 14/12 × 28/12 × 150 => 408.33 lb/ft

Total factored load:

=> 1.2(50 + 408.33) + 1.6(225)

=> 909.99 lb/ft => 0.909 kip/ft

Moment:

=> $wul^2/8$ => $\frac{0.909 \times (32)^2}{8} \times 12$ => 1396.23 kip-inch

=> Effective Breadth:

(1) 16(hf) + bw = 16(6) + 14 = 110″

(2) c/c distance = 10(12) = 120″

(3) span/4 = 32/4 × 12 = 96″ ∴ be = 96″

step#03:-

Rectangular or T-beam

Trial #01

let $a = h_f = 6"$

$$A_{st} = \frac{m_u}{\phi f_y \times (d - a/2)} \Rightarrow \frac{1396.23}{0.90 \times 60 (25 - 6/2)}$$

A_{steel} :- $1.17 in^2$

trial #02:-

$$a = \frac{A_{st} \times f_y}{0.85 \times f_c' \times b} \Rightarrow \frac{1.17 \times 60}{0.85 \times 4 \times 96}$$

$\Rightarrow 0.2" < 6"$

so rectangular Beam are designed.

$$A_{st} = \frac{1396.23}{0.90 \times 60 \times (25 - 0.2/2)} \Rightarrow 1.03 inch^2$$

Trial #03

$$a = \frac{1.03 \times 60}{0.85 \times 4 \times 96} \Rightarrow 0.18"$$

$$A_{steel} = \frac{1396.23}{0.90 \times 60 (25 - \frac{0.18}{2})} \Rightarrow 1.03 inch^2$$

step#4:-

check ρ_{max} and ρ_{min}

$$\rho_{max} = 0.85 \times 0.85 \times 4/60 \left(\frac{0.003}{0.003 + 0.005}\right) \Rightarrow \rho_{max} = 0.018$$

$$\rho_{min} = \frac{200}{f_y} = \frac{200}{60,000} \Rightarrow \rho_{min} = 0.003$$

$$\rho = \frac{A_{st}}{b \times d} = 1.03/14 \times 25 \Rightarrow 0.0029$$

→ $\rho_{min} < \rho < \rho_{max}$

→ $0.003 < 0.002 < 0.018$

→ As ρ is less then ρ_{min}

So, $\rho = \frac{A_{st}}{b \times d} = A_{st} = \rho_{min} \times b \times d$

$A_{steel} = 0.003 \times 14 \times 25 \Rightarrow 1.05\ in^2$

step#5:- No of and selection of bars let use #8 bars then

dia = $(8/8) = 1''$, Area = $0.785\ in^2$

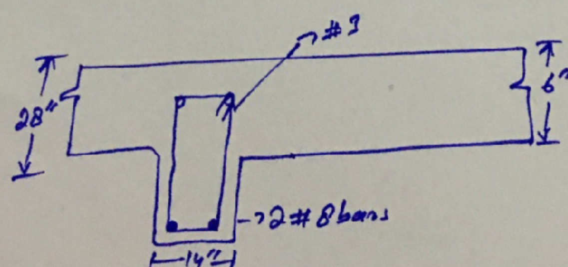
No of Bars = $\frac{1.05}{0.785} = 1.3 \approx 2$

we use 2#8 bars:.

step#6:- minimum width

$b_{min} = 2(1.5) + 2(3/8) + 2(8/8) + 1(8/8)$

$\Rightarrow 6.75'' < 14''$ → it's good in single layer or one.



Step # 7:-

Design moment

$Md = \phi \times fy \times Ast \times (d - a/2)$

Area of steel = Area of 1 bar × No of bars

$= 0.785 \times 2 = \boxed{1.57 m^2}$

$a = \frac{1.57 \times 60}{0.85 \times 4 \times 96} \Rightarrow \boxed{0.2''}$

$Md = 0.90 \times 60 \times 1.57 \times (25 - 0.2/2) \Rightarrow \boxed{2111.02 \text{ kip-inch}}$

$\boxed{As \Rightarrow 2111.02 > 1396.23}$

Result:-

The design is ok.