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Chapter 3, Problem 15P Bookmark Show all steps: ON Problem

In the following problem, unless otherwise noted, assume No. 3 stirrups, -in. cover for beams, and 1-in. clear space between layers of bars. In all problems, check the net tensile strain ∈t in the

extreme tension steel to ensure that it is within the allowable limits. Unless otherwise noted or shown, dt = d. Select steel for the beams of cross section shown. The positive service moments are 160 ft.-kips

live load and 100 ft.-kips dead load (this includes beam weight). Use psi and fy =
60,000 psi.

(a)

(b) PROBLEM 3–15

Step-by-step solution

a) T Beam: Determine the ultimate moment using the relation. Here, is dead load service moment and is live load service moment. Substitute 100 ft-kips for and 160 ft-kips for .
Comment

Determine the effective depth d using the relation. Here, h is total height of beam. Substitute 27.5 in. for h and 1.5 in for cover.
Comment
Determine the practical moment strength using the relation.

Here, is strength reduction factor, is compressive strength of concrete, b is effective flange width, d is effective depth, and is the height of the flange. Comment

Substitute 0.90 , 3 ksi for , 16 in for b, 5 in. for , and 24.5 in. for d.

Therefore, it is true T beam. Comment

Determine the flange couple lever arm using the relation.
Substitute 24.5 in. for d and 5 in. for .
Comment
Determine the area of the steel for flange using the relation.

Here, is tensile strength of steel. Substitute 336.6 ft-kips for , 0.9 for , 60 ksi for , and 22 in. for .

Comment

Determine the web couple height using the relation. Here, h is total height of the beam. Substitute 27.5 in. for h and 5 in. for .
Comment

Determine the web couple depth using the relation. Here, h is total height of the beam. Substitute 22.5 in. for h and 1.5 in. for cover.
Comment
Calculate required coefficient of resistance using the relation.

Here, is web width. Substitute 376 ft-kips for , 336.6 ft-kips for , 0.90 for , 10 in. for , and 19.5 in. for
.

From Table (A-8) in the textbook, the nearest reinforcement ratio is 0.0024. Therefore, net
tensile strain in the extreme tensile reinforcement is greater than 0.005. Hence, strength

reduction factor is 0.90. Comment

Calculate required area of steel for web using the relation. Substitute 0.0024 for , 10 in. for , and 19.5 in. for .

Comment
Determine the total required area of steel using the relation.
Comment
Substitute for and for .

From Table (A.2) in the textbook, the nearest highest value of area of steel is . Therefore, Use 4No. 9 bars in two layers. Comment

Check for effective depth of flange using the relation.

Here, h is total height of beam and D is diameter of #9bars. Substitute 27.5 in. for h, 1.5 in for cover, 0.38 in for #3stirrup, 0.5 in. for cover space, and 1.13 in.

for D.
Comments (3)

Calculate minimum steel area using the relation. Here, is width of web and is effective depth. Substitute 10 in. for and 24 in. for .
Comment

Calculate the total tensile force using the relation. Here, is area of steel and is characteristic strength of steel. Substitute for and 60,000 psi for .

Comment
Calculate compressive force of flange using the relation.
Substitute 3 ksi for , 5 in. for , and 16 in. for b.
Comment
Calculate depth of stress block a using formula.
Substitute 240 kips for , 204 kips for , 3 ksi for , 5 in. for , and 10 in. for .
Comment
Calculate net tensile strain in the extreme tensile reinforcement using the relation.
Substitute 25.1 in. for , and 6.41 in. for a.

The net tensile strain in the extreme tensile reinforcement is more than 0.005. Therefore, strength reduction factor is 0.90. Comment

Calculate practical moment strength using the relation.
Substitute 240 kips for , 204 kips for ,.5 in. for , 24 in. for , and 6.41 in. for a.

Hence, the design is safe. Use 4 #9 in two lavers with 1 in. clear. Comment

Draw the cross section of T beam with reinforcement details as in Figure (1).

Comment

b)

Inverted T girder: Determine the effective depth d using the relation. Here, h is total height of girder. Substitute 34 in. for h and 1.5 in for cover.
Comment
Determine the practical moment strength using the relation.
Comment

Comment

Comment

Comment

Comment

Comment

Comment

Comment

Comment
Substitute 0.90 , 3 ksi for , 8 in for b, 6 in. for , and 31 in. for d.

Therefore, it is true T beam. Determine the flange couple lever arm using the relation.

Substitute 31 in. for d and 6 in. for .
Comment
Determine the area of the steel for flange using the relation.

Here, is tensile strength of steel. Substitute 257 ft-kips for , 0.9 for , 60 ksi for , and 28 in. for .

Comment

Determine the web couple height using the relation. Here, h is total height of the beam. Substitute 34 in. for h and 6 in. for .
Comment

Determine the web couple depth using the relation. Here, h is total height of the beam. Substitute 28 in. for h and 1.5 in. for cover.
Comment
Calculate required coefficient of resistance using the relation.

Here, is web width. Substitute 376 ft-kips for , 257 ft-kips for , 0.90 for , 16 in. for , and 25 in. for
.

From Table (A-8) in the textbook, the nearest reinforcement ratio is 0.0028. Therefore, net
tensile strain in the extreme tensile reinforcement is greater than 0.005. Hence, strength

reduction factor is 0.90. Comment

Calculate required area of steel for web using the relation. Substitute 0.0028 for , 16 in. for , and 25 in. for .

Comment
Determine the total required area of steel using the relation.
Comment
Substitute for and for .
Comment

From Table (A.2) in the textbook, the nearest highest value of area of steel is . Therefore, Use 4No. 8 bars in one layer. Check for effective depth of flange using the relation. Here, h is total height of beam and D is diameter of #9bars. Substitute 34 in. for h, 1.5 in for cover, 0.38 in for #3stirrup, and 0.5 in. for cover space.
Comment

Calculate minimum steel area using the relation. Here, is width of web and is effective depth. Substitute 16 in. for and 31.6 in. for .
Comment

Calculate the total tensile force using the relation. Here, is area of steel and is characteristic strength of steel. Substitute for and 60,000 psi for .

Comment
Calculate compressive force of flange using the relation.
Substitute 3 ksi for , 6 in. for , and 8 in. for b.
Comment
Calculate depth of stress block a using the formula.
Substitute 189.6 kips for , 122.4 kips for , 3 ksi for , 6 in. for , and 16 in. for .
Comment
Calculate net tensile strain in the extreme tensile reinforcement using the relation.
Substitute 31.6 in. for and 6.75 in. for a.

The net tensile strain in the extreme tensile reinforcement is more than 0.005. Therefore, strength reduction factor is 0.90. Comment

Draw the cross section of inverted T beam with reinforcement details as in Figure (2).

Comment

Step 1 of 45

Step 2 of 45

Step 3 of 45

Step 4 of 45

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Step 45 of 45

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Chapter 3, Problem 17P

In the following problem, unless otherwise noted, assume No. 3 stirrups, -in. cover for beams, and 1-
in. clear space between layers of bars. In all problems, check the net tensile strain ∈t in the
extreme tension steel to ensure that it... View this solution

Chapter 3, Problem 13P

In the following problem, unless otherwise noted, assume No. 3 stirrups, -in. cover for beams, and 1-
in. clear space between layers of bars. In all problems, check the net tensile strain ∈t in the
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