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Effect of Span, Load Intensity, and Beam Geometry on Stress and Deflection Behavior of RCC Beams

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Abstract

This study investigates the influence of variations in beam geometry, span, load intensity, and permissible stresses on the structural behavior of reinforced concrete beams. Using classical bending and shear stress formulations, the effects of a 20% increase in key parameters were analytically evaluated. Results indicate that a 20% increase in beam span leads to a proportional 20% increase in beam depth, whereas a 20% increase in beam width or permissible compressive stress in bending results in an 8.68% reduction in beam depth. Shear stress analysis shows that an increase in load intensity of 20% raises shear stress by approximately 9.48%, while changes in span have no effect on shear stress. Increasing beam width reduces shear stress by about 8.90%, whereas higher permissible compressive stress indirectly increases shear stress due to reduced beam depth. Compressive stress at the column increases by nearly 19.85% with a 20% rise in load intensity and must remain within permissible limits. Flexural stress increases proportionally with load intensity and rises significantly (44%) with increased span for a given beam depth, while greater beam width reduces flexural stress. Tensile stress, governed by the total load and cross-sectional area, increases linearly with load intensity but decreases with increased beam width and depth. The study also highlights the interrelation between stress development and deflection, emphasizing the importance of optimized beam dimensions to ensure structural safety and serviceability under varying loading and geometric conditions.

Keywords: Beam geometry, deflection analysis, flexural stress, load intensity, permissible stress, RCC design, reinforced concrete beam, shear stress, span variation, tensile stress

INTRODUCTION

Reinforced concrete (RCC) beams, columns, and pavement layers are fundamental structural elements required to safely resist bending, shear, torsion, axial loads, and associated deflections under service and ultimate load conditions. The proper determination of member dimensions is essential to ensure structural safety, serviceability, and economy. Beam thickness, span, width, material strength, and loading intensity significantly influence the stress distribution and deflection behavior. Hence, a systematic analytical evaluation of these parameters is necessary for rational structural design [1–3].

In RCC beams, bending stresses govern the determination of beam depth, whereas shear stresses dominate near the supports owing to the combined action of compressive and reactive forces. Variations in span, width, load intensity, and permissible stress directly affect flexural, shear, compressive, and tensile stresses, which, in turn, influence the deflection characteristics. Excessive deflection can lead to failure of serviceability, even when the strength requirements are satisfied, making deflection control an essential design criterion, as per codal provisions [4, 5].

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Columns subjected to axial loads combined with bending and torsional moments require special attention owing to eccentric loading conditions. The interaction between direct stress and bending stress governs the required cross-sectional dimensions. Similarly, road pavements constructed using sand, aggregates, and soil stabilized layers must be designed to resist compressive, shear, tensile, and bending stresses induced by heavy vehicular loads, particularly when resting on weak subgrade soil.

Recent advances in strengthening techniques, such as externally bonded steel plates and composite sandwich sections, have enhanced the load-carrying capacity and stiffness of RCC beams. The use of fly ash as a partial replacement for cement improves concrete strength and sustainability. The limit state design (LSD) methodology provides a reliable framework for analyzing such composite systems by considering ultimate load conditions and safety factors [6–8].

This study presents a comprehensive analytical investigation of RCC beams, columns, composite steel-plated beams, and pavement layers under various load and geometric parameters. The effects of the bending moment, shear force, torsional moment, eccentric loading, and material properties on stress development and deflection behavior are examined. Additionally, the study highlights the dominance of cross-sectional dimensions overload magnitude in controlling tensile stress, offering valuable insights for safe, economical, and optimized structural design [9, 10].

DETERMINATION OF THICKNESS OF BEAM

Using bending formula: $\frac{M}{Z} = f$

Findings

- Due to 20% increase in span of beams the depth of beams is increased by 20%.
- Due to 20% increase in width of beam depth of beam is decreased by 8.68%.
- Owing to the 20% increase in the permissible compressive stress in bending, the depth of the beam decreased by 8.68%.

Shear Stress

Compressive stress and shear stress are acting at support.

In shear stress computation, the upward reactive component at the column acting tangentially to the width of the beam and depth of the beam.

Hence, shear stress: $\frac{Upward\ Reactive\ Component}{Width\ of\ beam \times Depth\ of\ beam}$ *in N/mm²*

Findings

- Owing to the 20% increase in load intensity, the beam shear stress increased by 9.48%.
- Due to 20% increase in span of beam there is no change in shear stress.
- Due to 20% increase in width of beam shear stress decreased by 8.90%.
- Due to 20% increase in depth of beam is decreased and shear stress is increased by 9.478%.

Compressive Stress at Column

$$Load\ = \frac{wl}{2}\ taken$$

Compressive stress: $\frac{Load}{Cross\ Sectional\ Area\ of\ Column}$

This should be less than the permissible value for the given grade of concrete, that is, less than the permissible compressive stress (σcc).

- Owing to the 20% increase in load intensity, the beam compressive stress increased by 19.85%.
- Owing to the 20% increase in the load intensity, the beam flexural stress increased by 20%.
- Due to 20% increase in load intensity on beam flexural stress increased by 20% for a given depth of beam.
- Due to 20% increase in span of beam flexural stress is increased by 44% for a given depth of beam.
- Owing to the 20% increase in the width, the flexural stress decreased by 17%.
- *At mid span of beam:* bending occurs, and after bending, tension develops because the beam is designed for tensile stress.

Tensile Stress

Total load acting on beam divided by cross-sectional area of beam.

- Owing to the 20% increase in load intensity, the beam tensile stress increased by 20%.
- Due to 20% increase in width of beam tensile, stress has decreased by 16.70%.
- Due to 20% increase in depth of beam tensile stress decreased by 16.67%.

Whenever Stress is Acting There will be Deflection

Suppose flexural stress = 8 N/mm^2 (M25 grade concrete),

Span = 6 m depth of beam 581 mm.

Deflection due to flexural stress: $\delta = \frac{5}{24} \times \frac{fl^2}{ED}$

f = 8 N/mm^2 (M25 grade concrete)

l = Span of beam.

E = Modulus of elasticity of concrete $5700\sqrt{fck}$

Where, fck is the characteristic strength of concrete for M25 grade of concrete, characteristic strength = 25 N/mm^2

$$\delta = \frac{5}{24} \times \frac{8 \times (6000)^2}{28500 \times 581} = 3.623 \text{ mm}$$

Permissible value of deflection $\frac{Span}{350}$ or 20 mm whichever is less.

Hence, $\frac{6000}{350}$ = 17 mm

3.623 mm < 17 mm

Hence, O.K.

Deflection Due to Shear Stress (Computed)

Shear stress of concrete = 2 N/mm^2

2 N/mm^2 corresponds to flexural stress = 8 N/mm^2

Hence, 0.517 N/mm^2 shear stress corresponds to f= 2.068 N/mm^2

$$\delta = \frac{5}{24} \times \frac{2.068 \times (5000)^2}{28500\ x\ 484} = 0.781\ mm$$

Permissible deflection for shear stress

For flexural stress, f = 8 N/mm^2 = deflection 14 mm

$$1N/mm^2 = \frac{14}{8}$$

For 2.068 N/mm^2 (obtained for shear stress)

$$\rightarrow \frac{14 \times 2.068}{8} = 3.619\ mm > 0.781\ mm$$

Hence, O.K.

Deflection Due to Compressive Stress

5.6 N/mm^2 (σcc of M25) corresponds to f = 8 N/mm^2

$$1\ \text{N/mm}^2 = \frac{8}{5.6}$$

$$0.331\ \text{N/mm}^2 = \frac{8\ \times 0.331}{5.6} = 0.173\ \text{N/mm}^2$$

Deflection: $\delta = \frac{5}{24} \times \frac{0.473 \times (5000)^2}{28500\ x\ 484}$ = 0.179 mm

(Deflection owing to compressive stress)

Permissible Deflection for Compressive Stress

For f = 8 N/mm^2 → Permissible deflection 14 mm

$$1\ N/mm^2 = \frac{14}{8}$$

$$0.473\ N/mm^2 = \frac{8 \times 0.473}{8} = 0.828\ mm > 0.179\ \text{mm}$$

Hence, O.K.

Deflection Due to Tensile Stress

Tensile strength of M25 grade concrete

$$= \frac{10}{100} \times 25 = 2.5\ N/mm^2$$

2.5 N/mm^2 tensile stress corresponds to flexural stress= 8 N/mm^2

$$1\ N/mm^2 = \frac{8}{2.5} = 3.2N/mm^2\ for\ tensile\ stress\ (\ 1N/mm^2\ computed)$$

Deflection due to tensile stress for f = 3.2 N/mm^2

$$\delta = \frac{5}{24} \times \frac{3.2\ \times\ (5000)^2}{28500\ \times\ 484} = 1.208\ mm$$

Permissible Value of Deflection for Tensile Stress

For flexural stress f= 8 N/mm^2 permissible deflection $\left(\frac{Span}{350}\right)$= 14 mm

$$1N/mm^2 = \frac{14}{8}$$

3.2 N/mm^2 computed from tensile stress $\frac{14 \times 3.2}{8}$ =5.60 mm greater then 1.208 mm
Hence, O.K.

Deflection in steel depends upon its modulus of elasticity. Hence,

28500 N/mm^2: 2 × 105 N/mm^2 = 14 mm

Modulus of elasticity for concrete   Modulus of Elasticity of steel   Total deflection

Hence,
28500 x + 200000 x = 14
228500 x = 14
x = 0.00006

Hence, deflection in concrete = 28500×0.00006 = 1.75 mm
Deflection in steel = 200000×0.00006 = 12 mm

Findings

Since steel is more flexible than concrete, hence, more deflection in steel takes place.

Shear Stress in Steel

Where, load = $\frac{4 \times 5}{2}$ $\left(\frac{wl}{2}\right)$ =10t acting along four bars (suppose) of 20 mm diameter steel.

$$Shear\ stress\ in\ steel = \frac{10 \times 1000 \times\ 10}{4 \times \frac{3.142}{4} \times (20)^2} = \frac{100000}{1257} = 80\ \mathrm{N}/mm^2 >\ 0.3\ \mathrm{N}/mm^2$$

= 0.3×250 = 75 N/mm^2

Hence, we must use Fe415 grade with a shear strength of = 0.3×415 = 135 N/mm^2 greater than 80 N/mm^2. Hence, O.K.

Similarly, Check for Tensile Stress of Steel

Load = 4×5 [wl] = 20 t

Tensile stress = $\frac{20 \times 1000 \times 10}{1257}$ = 159 N/mm^2 greater than 75 N/mm^2

We have to use 5 bars of 25 mm ϕ

Tensile stress = $\frac{20\ x\ 1000\ x\ 10}{5\ x\ \frac{3.142}{4}\ x\ (25)^2}$

Tensile stress= $\frac{200000}{2455}$ = 81 N/mm^2 < 0.3×415 = 135 N/mm^2

Hence, O.K.

Check for Flexural Stress for Steel

$$\mathrm{M} = \frac{wl^2}{8} = \frac{4\ x\ (5)^2}{8} = 12.50\ t - m$$

Using bending equation: $\frac{M}{Z} = f$

Sectional modulus = $\frac{I}{y_{max}\frac{\pi d 2 \pi d^3}{64 d \ 32}}$

$$= \frac{12.50 \times 1000 \ x \ 10 \ x \ 1000}{5 \times 3.142 \ x \ \frac{(25)^3}{32}}$$

5 nos. bars

25 mm ϕ bar is used

Sectional modulus: $\frac{\pi d^3}{32}$

For 5 bars of 25 mm diameter, d = 5×25 = 125 mm

$= \frac{3.142 \times (125)^3}{32} = \mathrm{Z}$

= 191772 mm^3

Hence, using bending equation: $\frac{125000000}{191772}$ = Too much.

If 7 no of bars used,

$$\frac{3.142 \times (7 \times 25)^3}{32} = 526224$$

$$= \frac{125000000}{526224} = 238 \ N/mm^2$$

If Fe 415 bar is used flexural strength = 0.6×415 = 249 N/mm^2 > 238 N/mm^2. Hence, O.K.

Also, deflection in steel is found by using formula for uniformly distributed load (U.D.L.)

$$\delta = \frac{5}{24} \frac{fl^2}{ED}$$

$$= \frac{5}{24} \times \frac{150 \times (5000)^2}{2 \times 10^5 \times 484} = 8 \, mm$$

Where,

Flexural stress of steel = 150 N/mm^2

Span of beam = 5 m

Modulus of elasticity of steel = 2×10^5 N/mm^2

Depth of beam = 484 mm.

Road

Every material used in road should have more compressive strength than load.

- If load in road = 1700 t

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Hence, depth of sand layer and aggregate for lesser strength against bending i.e. $\frac{1}{3}\times 20 = 6.667$ n/mm^2

Hence, using bending equation $\frac{47 \times 1000 \times 10 \times 1000}{\frac{1}{12} \times 1000 \times d^3 \times \frac{2}{d}} = 6.667$

Lateral load; hence, b = 1000 m

$1111\ d^2 = 470000000$
$d^2 = 423042 \therefore d = 650$ mm.

In case of soil stabilized road: Since aggregate and soil stabilized material are used.

Aggregates have 30 N/mm^2 and soil stabilized material has 5 N/mm^2 strength due to different types of material having large difference in compressive strength; hence, load on soil stabilized material is found by ratio of strength of aggregate and soil stabilized material.

Because the soil stabilized material has a strength of 5 N/mm^2, we can apply a load of a vehicle with a weight of less than 500 t/m^2.

Hence, the ratio of the strength of the aggregate and soil stabilized material related to a 400-t load.

Hence, 30 N/mm^2: 5 N/mm^2 = 400
$30\,x + 5\,x = 400$
$35\,x = 400$
$x = 11.43$ t

Hence, load on soil stabilized material $5 \times 11.43 = 57$ t

Against bending moment $w = \frac{57}{12 \times 4} = \frac{57}{48} = 1.88\ t/m^2$

Length of vehicle Width of vehicle

$$M = \frac{1.88\ x\ (4)^2}{8} = 2.38\ t - m$$

Using bending equation: $\frac{2.38 \times 1000 \times 10 \times 1000}{\frac{1}{12} \times 1000 \times d^3 \times \frac{2}{d}} = 5$ Since soil has less strength; hence, bending strength and tensile strength same as compressive strength.

$833\ d^2 = 23800000$
$d^2 = 28571$
$d = 169$ mm

Hence, depth of soil stabilized material used should be 170 mm thick.

EFFECT OF BENDING MOMENT AND TORSIONAL MOMENT

Moment amount A$\rightarrow$ 10 × [5-0.1]

= 10×4.9 – 19.6 × 2.45 – 4 × (2.5 + 2.4)

= 49– 48.02 = 0.98 t–m m=$\frac{(2.5 + 2.4)}{2}$

$M_{eccentric} = T = 20 \times (2.5 - 0.1) = 20 \times 2.4 = 48$ t–m.

$$M_{equivalent} = \frac{1}{2}\ [0.98 + \sqrt{(0.98)^2 + \ (48)^2}]$$

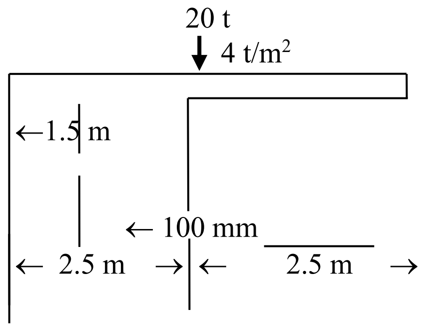
$$= \frac{1}{2}\ \left[0.98 + \sqrt{0.960 + \ 2304}\ \right]$$

$$= \frac{1}{2}\ \left[0.98 + \sqrt{2305}\ \right]$$

$$M_{equivalent} = \frac{1}{2}\ [0.98\ +\ 48\ ]$$

= 24.50 t–m

Abstract



$$= \frac{wl}{2}$$
$$= \frac{4\ x\ 5}{2}\ =\ 10\ t$$

Introduction

When an eccentric load acts, the combined effects of the bending and torsional moments are considered, and the equivalent for the beam is 24.50 t-m.

Hence, using bending equations,

$$\frac{24.50\ \times\ 1000\ \times\ 10\ \times\ 1000}{\frac{1}{12}\ \times\ \underbrace{400}_{\text{Width of beam}}\ \times\ d^3\ \times\ \frac{2}{d}} = 10\ \sigma cbc\ for M30\ grade\ concrete$$

$667\ d^2 = 245000000$
$d^2 = 367316$
$d = 606$ mm

Results

Hence, cross-section of beam = 400 x 606 mm^2 taken

Subjected to bending moment and torsional moment due to eccentric load.

Column

Since reactive component of column = 10 t [Axial load]

Hence, direct stress $= \frac{P}{A} = \ \frac{10\ x\ 1000\ x\ 10}{500\ x\ 500}$ cross-sectional area of column

= 500 mm × 500 mm = Direct stress = 0.4 N/mm^2

Bending stress owing to the bending moment P × e = 20 × [2.5 -0.05]
= 20 × 2.45 = 49 t-m.

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Bending stress in column due to P × e = 49 t-m

Using bending equation

$$\frac{49 \times 1000 \times 10 \times 1000}{\frac{1}{12} \times d \times d^3 \times \frac{2}{d}} = 10$$

[width and depth same taken for column]

$10d^3 = 2940000000$

$d^3 = 294000000$

$b = d = [294000000]^{0.333}$

$= 661$ mm × 661 mm

Cross-sectional area of the column required against bending stress. Considering direct stress consideration, $\frac{P}{A} = \sigma cc$ (Permissible compressive stress).

$\frac{10 \times 1000 \times 10}{\boldsymbol{A}} = 8$ [for M30 grade concrete]

$8A = 100000$

$A = 12500$ mm^2

b × d = 112 mm × 112 mm [cross-sectional area of the column] against direct stress consideration.

Hence, cross-section of columns against bending stress consideration 661 mm × 661 mm taken.

RCC BEAM STRENGTHENED BY STEEL PLATE

Abstract: Span of beam = 6 m
Load intensity on beam = 4 t/m

Strengthened by steel plates in top and bottom portion of beam (RCC beam M30 grade concrete)

Introduction

Design is made by adopting LSD method for sand witch type material.
Since design is made considering LSD for sand witch material.
Strength of composite material in bending

$$\frac{0.87fy + 0.87\,fy + 0.45\,fck}{3}$$

$$= \frac{0.87 \times 250 + 0.87 \times 250 + 0.45 \times 30}{3}$$

$$\frac{218 + 218 + 13.50}{3} = 150\ N/mm^2$$

RESULTS AND ANALYSIS

Since total load of beam = 4 x 6 = 24 t

In limit state method
Load = 1.5 × 24 = 36 t acting on 6 m length.

This is a transverse load case because the width of the beam is considerably smaller than its length.

Hence, load intensity = $\frac{Load}{Length\ of\ Span} = \frac{36}{6} = 6\ t/m$

Bending in beam takes place along length of beam.

Hence, bending moment, $M = \frac{wl^2}{8} = \frac{6 \times (6)^2}{8} = \frac{6 \times 36}{8}$ = 27t–1

Using bending equation: $\frac{M}{Z}$ = f

Hence, $\frac{27 \times 1000 \times 10 \times 1000}{\frac{1}{12} \times \underbrace{400}_{\text{Width of beam}} \times d^3 \times \frac{2}{d}}$ =150

10000 d^2 = 270000000

d^2 = 27000

Hence, depth of beam 164 mm

Hence, provide 200 mm width of beam and 400 mm depth of beam.

Depth of beam should be twice the times of width of beam so that we get more moment of inertia moment of inertia $\frac{1}{12}\ bd^3$. If moment of inertia is much more it can sustain more load.

Thickness of steel plate required → Because it is subjected to bending action, the thickness of the steel plate was determined using the bending equation.

Since, M = 27 t-m

Using bending equation $\frac{27 \times 1000 \times 10 \times 1000}{\frac{1}{12} \times 400\ x\ d^3 \times \frac{2}{d}}$ = 0.87 ×250 = 218

14533 d^2 = 270000000

d^2 = 18578

d = 136 mm.

Hence, thickness of steel plate required = 136 mm.

Check against tensile strength: After bending tension develops in beam.

Tensile stress of the composite material: $\frac{Load}{Cross\ Sectional\ Area}$ = [6 t/m for 6 m span]

= 6 x 6 = 36 t

Hence, $\frac{36 \times 1000 \times 10}{200 \times 400} = \frac{36}{8} = 4.5N/mm^2$

Tensile Strength of Composite Material

Tensile strength of composite material = $\frac{10}{100} \times 250 = 25\ N/mm^2$

Hence, tensile strength of composite material = $\frac{25 + 25 + 3}{3}$ = 18N/mm^2

Tensile strength of M30 grade concrete $\frac{10}{100} \times 30 = 3\ N/mm^2$
Hence, 4.5 N/mm^2 < 18 N/mm^2
Hence, safe.

Deflection

18 N/mm^2 tensile strength corresponds to flexural strength to flexural strength 150 N/mm^2 of composite material.

Hence, for 1 N/mm^2 corresponds to $\frac{150}{18}$

For 4.5 $N/mm^2 = \frac{150 \times 4.5}{18}$
f = 37.5 N/mm^2
Deflection of beam for flexural stress f = 37.5 N/mm^2
Deflection $= \frac{5}{24}\ \frac{fl^2}{ED}$ Since U.D.L.

For concrete

Modulus of elasticity $= \frac{2 \times 10^5 + 2 \times 10^5 + 31219}{3}$
E for composite material = 143740 N/mm^2

Hence, deflection of beam: $= \frac{5}{24} \times \frac{37.5 \times (6000)^2}{143740 \times 400} = \frac{6750000000}{1379904000} = 4.89\ mm$

Permissible deflection $= \frac{Span}{350}$ or 20 mm whichever is less
Hence, $\frac{6000}{350} = 17\ mm$

Hence, 17 mm > 4.79 mm
Hence, O.K.

We designed the structure economically using the limit state method for sandwich-type materials.

If fly ash is mixed 20% by wt. of cement.

Its strength is increased by $\frac{20}{100} \times$ 1part 0.2-part fly ash 0.2 x 10 = 2 N/mm^2 strength of M30 grade concrete is increased. Hence, strength of concrete 30 + 2 = 32 N/mm^2.

Hence, the design strength of the concrete was 0.45 × 32 = 14.40 N/mm^2.

Design strength of two steel plates provided on the top and bottom of an RCC beam glued using an adhesive epoxy material.

Hence, the design strength of the composite material considering the LSD method is 0.87 N/mm^2 = 0.87 × 250 = 218 N/mm^2

Hence, design strength of composite material for additives used in concrete.

$$\frac{218 + 218 + 14.40}{3} = 150.13\ N/mm^2$$

Hence, thickness of beam is determined by bending equation.

Since load intensity is 4 t/m for span of beam = 6 m
Total load = 4 × 6 = 24 t
For LSD load = 1.5 × 24 = 36 t

Load intensity = $\frac{36}{6} = 6\ t/m$

$$M = \frac{6 \times (6)^2}{8} = \frac{6 \times 36}{8} = 27\ t - m$$

Using bending equation: $\frac{27 \times 1000 \times 10 \times 1000}{\frac{1}{12} \times 400 \times d^3 \times \frac{2}{d}} = 150.13$

10009 d^2 = 270000000
d^2 = 26976
d = 164 mm.

Hence, a cross-section of beam 200 mm × 400 mm is provided. Depth is twice the time of width to get more moments of inertia to sustain more load Table 1.

Tensile stress depends upon load and cross-sectional area of column.

INTERPRETATION

Due to more lateral load, we require more cross-sectional area; hence, from data, we see cross-section of column is dominant parameter as compared to load for tensile stress.

Proof

Load taken variable

Since tensile stress = $\frac{Load\ (Lateral)}{Cross\ Sectional\ Area}$

variables involved in tensile stress: Load and cross-sectional area.

Load 26 t and cross-section = 576 mm x 576 mm
Tensile stress = 0.784 N/mm^2

Load is increased by 20% (cross-section is const.)

Load = $\frac{20}{100} \times 26 = 5.2\ t$

Hence, load 26 + 5.2 = 31.20 t
Hence, tensile stress = $\frac{31.20 \times 1000 \times 10}{576 \times 576} = 0.940\ N/mm^2$

Table 1. Data analysis.

S.N.	Load (lateral) in tone	Tensile stress in N/mm^2
1	26	0.784
2	28	0.692

Increase in tensile stress of concrete due to 20% increase in load.

In a 0.784 N/mm^2 increase in tensile stress, 0.940–0.784 = 0.156 N/mm^2

$1 \rightarrow \frac{0.156}{0.784}$

$100 \quad \frac{0.156 \times 100}{0.784} = 19.90$

Findings

Due to 20% increase in load (lateral) of column there is 19.90% increase in tensile stress of concrete.

Case

Since cross-sectional area is in dominator; hence, 20% decrease in cross-sectional area taken so that there will be increase in tensile stress.

Cross-sectional area is decreased by 20% $\frac{20}{100}\ x\ 576\ x\ 576\ =\ 66355\ mm^2$

Hence, cross-sectional area decreased by 331776-66355 = 265421 mm^2

Hence, tensile stress $= \frac{26 \times 1000 \times 10\ [load\ is\ taken\ const.]}{265421} =\ 0.980N/mm^2$

In a 0.784 N/mm^2 increase in tensile stress (0.980–0.784) = 0.196 N/mm^2

$1 \quad \rightarrow \quad \frac{0.196}{0.784}$

$100 \quad \rightarrow \quad \frac{0.196 \times 100}{0.784}$ =25

Findings

Owing to the 20% decrease in the cross-sectional area of the column, the tensile stress increased by 25%.

CONCLUSION

This analytical study examined the influence of geometric parameters, loading conditions, and material properties on the structural behavior of reinforced concrete beams, columns, composite members, and pavement layers. The results demonstrate that variations in span, width, depth, and permissible stresses significantly affect flexural, shear, compressive, and tensile stresses, as well as overall deflection performance. An increase in the beam span was found to proportionally increase the bending stress and required beam depth, whereas increasing the beam width effectively reduced the flexural, shear, and tensile stresses. Shear stress was observed to be sensitive to load intensity but independent of the span length. Deflection checks under flexural, shear, compressive, and tensile stresses confirmed that all structural elements satisfied the permissible serviceability limits.

For columns subjected to axial load combined with bending and eccentricity, the study revealed that the cross-sectional area plays a more critical role than the load magnitude in controlling tensile stress. A reduction in the column cross-section resulted in a substantially higher increase in tensile stress compared to an equivalent increase in the applied load, emphasizing the importance of adequate member dimensions in the design. Strengthening RCC beams using externally bonded steel plates and composite sandwich action significantly improved the load-carrying capacity and stiffness, whereas the incorporation of fly ash enhanced concrete strength and sustainability. Overall, the study highlights that the rational selection of cross-sectional dimensions, supported by LSD principles, is essential for achieving safe, economical, and durable structural systems.

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