COMPARATIVE ANALYSIS FOR AUDITORIUM STRUCTURAL ELEMENTS BY USING POST TENSIONING METHOD AND TRADITIONAL METHOD

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Abstract - *This project "Comparative Analysis for Auditorium Structural Elements by Using Post Tensioning Method and Traditional Method". The development of pre stressing technology has one of the more important in the fields of structural construction. The economy prestressed concrete is well established or long span structures. Traditionally the construction of a building is done by RCC but in present world, construction of high rise buildings is done by Post-Tensioning. This project deals with the multi purpose auditorium so as to accommodate 900 person. The Auditorium space types are areas for large meetings, presentations, and performances. The dimension auditorium building 26 X 50 meters .Required area is calculated NBC. The shape of the auditorium is Rectangular. The drafting of auditorium planning by using Auto CADD. The project strictly in accordance with IS 456:2000 Plain and Reinforced concrete code of practices. This includes planning and designing of structural elements based on the loads coming on them dead load and live load as per IS 875: 1987 Part 1,2. SP – 16 : 1980 Design Aids for reinforcement. IS 1343 : 1080 code of practice for prestressed concrete. The structures is designed by using limit state method, adopting M20 grade of concrete and Fe 415 HYSD Bars. Conformity of style throughout a conference proceedings. Margins, column widths, line spacing, and type styles are built-in; examples of the type styles are provided throughout this document and are identified in italic type, within parentheses, following the example. Some components, such as multi-leveled equations, graphics, and tables are not prescribed, although the various table text styles are provided. The formatter will need to create these components, incorporating the applicable criteria that follow.*

***Key Words*: Slab, Beam, Column and postension structures.**

1. INTRODUCTION

1.1 AUDITORIUM

An Auditorium is a room built to enable an audience to hear and watch performances. Auditorium spaces as designed to accommodate large audience.

1.2 AUDITORIUM IS BASED ON TWO IMPORTANT FACTORS

(i) Seating Capacity
(ii) Type of Performance

1.2.1 SEATING CAPACITY:

Seating Capacity design the volume of the space.

1.2.2 TYPE OF PERFORMANCE:

Type of performance on stage deign is the width, depth and height of the stage.

1.3 PLANNING OF AUDITORIUM :

The shape of the auditorium is rectangular shape. The seating capacity of our auditorium is 900 persons & stage dimensions are 16 X 6.5 meters. The Above dimensions are followed by using NBC code . The dimensions of auditorium is 26 X 50 meters.

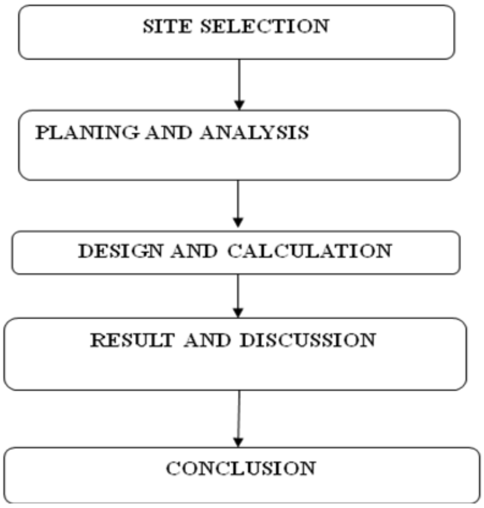
1.3.1 Load-Balancing Method

The concept of load balancing is introduced for prestressed concrete structures, as per T.Y Lin et al [3] a third approach after the elastic stress and the ultimate strength method of design and analysis. It is first applied to simple beams and cantilevers and then to continuous beams and rigid frames. This load-balancing method represents the simplest approach to prestressed design and analysis, its advantage over the elastic stress and ultimate strength methods is not significant for statically determinate structures. When dealing with statically indeterminate systems including flat slabs and certain thin shells, load-balancing method offers tremendous advantage both in calculating and visualizing. According to load-balancing method, prestressing balances a certain portion of the gravity loads so that flexural members, such as slabs, beams, and girders, will not be subjected to bending stresses under a given load condition. Thus a structure carrying transverse loads is subjected only to axial stresses.

1.3.2 Equivalent Frame Method of Analysis

The equivalent frame method of analysis is known as the beam method. This method of analysis utilizes the conventional elastic analysis assumption and models the slab or slab and columns, as a beam or as a frame, respectively. This is the most widely used and applied method of analysis for the post-tensioned flat plates.

5. METHODOLOGY



6. DESIGN OF SLAB

Slab are said to be deigned under the limit state method of reference of IS 456:2000. When the slab are supported in two way direction it acts as two way supported slab. A tow way slab in economical compared to one way slab.

6.1 DESIGN OF TWO WAY SLAB

Slab which are supported on unyielding supports like walls on four sides are called two – way slab. The span in the large direction is denoted by ly and that in the shorter direction by lx. The distribution of the loads in the ly and lx directions will depend on the ratio ly/lx. If the ratio ly/lx is less than 2 (ly/lx <2) then it is called two way slab. This slab is evenly distributed and will reduced bending and shifting.

Short span Length Lx = 16m

Longer span Length Ly = 3m

Fck = 20 N/mm^2

Fy = 415 N/mm^2

Unit weight of concrete = 25 kN/m^3

Check for slab

(ly / lx) =0.19 < 2

Hence its two way slab.

Depth of slab

Span / Effective depth = 26

d = 16000 / 26

= 615 say 600 mm

Assume cover (d') = 25mm

Over all depth (D) = 600+25 = 625 say 63063mm

Load calculation`:

Self weight of slab = b X D X unit weight of concrete
= 1 X 0. X 25

= 15.75 kN/m

Live load = 5 kN/m

Floor finishing load = 1 kN/m

Total load (W) = 21.75 kN/m

Ultimate design load (Wu) = 1.5 X 21.75

=21.75 kN/m

Area of Reinforcement:

Shorter span:

Mu = 0.87 X fy X Ast X d (1- (fy X Ast) / (fck X b X d))

618.142 X 10^6 = 0.87 X 415 X Ast X 600 (1- (415Ast) / (20 x 1000 x 600))

Ast = 1801 say 1800 mm^2

Provide 20 mm dia bar

Spacing = ((π/4 X d^2) / 1000) / Ast

= 565.48 say 565mm

Hance provided a spacing @ 565mm of 20 dia meter.

Area of Reinforcement:

Longer span:

Mu = 0.87 X fy X Ast X d (1- (fy X Ast) / (fck X b X d))

17.91 X 10^6 = 0.87 X 415 X Ast X 600 (1- (415Ast) / (20 x 1000 x 400))

Ast = 948.30 say 950 mm^2

Provide 12mm dia bar

Spacing = ((π/4 X d^2) / 1000) / Ast

= 113.09 say 150mm

Hance provided a spacing @ 150mm of 12 dia meter.

Check for deflection:

(l / d) max = (l / d)basic X Kt X Kc X Kf

= 20 X 1.4 X 1 X 1 = 28

Kt = 1.4 from IS 456 : 2000

(l / d) actual = 3650 + 140 / 140 = 27.07 < 28

Hance Safe.

7. DESIGN OF BEAM

7.1 BEAM

Beam is a structural member used for bearing loads it is typically use for the resisting vertical loads, shear force and bending moment.

7.2 DESIGN OF BEAM

Load on slab = 32.63kN/m

Unit weight of concrete = 25kN/m^3

Length o the beam = 16kN/m

Thickness of slab (t) = 150mm

Fck = 20N/mm^2

Fy = 415N/mm^2

Load to be consider:

Self weight of the beam = 0.2 X 0.3 X 25

= 1.5 kN/m

Load from slab per meter = 27.19kN/m

Total load (W) = 28.69 kN/m

Design load (Wu) =28.69x 1.5 = 43.04 kN/m

Bending moment & shear force:

Mu = Wu l^2 / 8

= 28.14kNm

Vu = Wu l / 2

= 43.04 X 3 /2 = 64.56 kN

Check for limitation moment:

Mu limit = 0.138 fck b d^2

= 34.5 kN/m

Mu < Mu limit

The section is under reinforced section.

Mu = 0.87 X fy X Ast X d (1- (fy X Ast) / (fck X b X d))

28.14 X 10^6 = 0.87 X 415 X Ast X 0.25 (1- (415Ast) / (20 x 200 x 230))

Ast = 366.30 say 400 mm^2

Ast = 0.12%Bd

Ast min = 0.12 / 100 X 200 X 300 = 72mm^2

Provide 12mm dia bar

No of bars = Ast / ast

= 400 / 113.09

= 3.97 say 4 bars

Provide 4 bars of 12mm dia (Ast = 452.38) and two hanger bars of 10mm dia.

Check for shear stress:

Ʈv = Vu / bd

= 0.66N/mm²

Check for deflection:

Pt = 0.90

(l / d) max = (l / d)basic X Kt X Kc X Kf

= 20 X 1.1 X 1 X 1 = 22

Kt = 1.1from IS 456 : 2000

(l / d) actual = 4190 / 250

= 16.76s< 28

Hance safe.

8. DESIGN OF COLUMN

8.1 COLUMN

The member which are in compression are called columns. According to the loading condition the column is divided in three types.

(i) Axially loaded column
(ii) Uniaxial loaded column
(iii) Biaxial loaded column

8.2 DESIGN OF BIAXIAL COLUMN

Beam load = 43.04kN/m

Load = 14.34kN

Factored load = 1.5 X 14.34 = 21.51kN

Length = 4.5m = 4500mm

Fck = 20N/mm²

Fy = 415 N/mm²

Moment = 22.458kN/m

e_{min} = (l/500) + (D/30)

20 = (4500/500) + (D/30)

20-9 = (D/30)

11 X 30 = D

D = 330mm say 400mm

Slenderness ratio

L_{eff} = 4500 / 400

= 11.25<12

Hence design as short column

Depth (D) = 400mm

Assume breadth (B) = 400mm

Assume cover (d^1) = 40mm

d^1/D = 40 / 400 = 0.1mm

Equivalent moment

M_U = $1.15\sqrt{MuX^2 + MuX^2}$

Mux = Muy = 22.45kNm

M_U = $1.15\sqrt{22.45^2 + 22.45^2}$

= 36.51kNm

Non dimensional parameter

Pu /(fck b D) = 6.36×10^3 / (20 X 400 X 400)

= 1.98×10^{-3}

Mu /(fck b D^2) = 36.51×10^6 / (20 X 400 X 400^2)

= 0.028

Longitudinal reinforcement

Pu / fck = 0.01

P / 20 = 0.01

P = 0.01 X 20 = 0.2

Asc = Ph D / 100 (From sp 16 Pg No 102)

= (0.2 X 400 X 400) / 100 = 320 mm²

Provide 20mm dia bar

Number of bars = Asc / asc

= 320 / (π/4 X 20²)

= 1.52 say 4 bars

Area = 4 X (π/4 X 20^2)

= 1256.63 say 1260 mm^2

P = 100 Asc / bD

= 100 X 320 / 400 X 400

= 0.2%

P / fck = 0.3 / 20 = 0.015

Refer chart of 44in sp 16

Mux_1 /(fck b D^2) = 0.024

Mux_1 = 0.024 X Fck X b X D^2

= 0.024 X 20 X 400 X 400^2= 30.72kNm

Due to symmetry

Mux_1 = Muy_1 = 30kNm

Ultimate load

Puz = 0.45 fck Ac + 0.75 fy Asc

Ac = Ag – Asc

= (400 X 400) -320 = 159680

Puz = 0.45 X 20 X 159680 + 0.75 X 415 X 320

= 1536 kN

Pu / Puz = 6.36 / 1536 = 4.14 X 10^3

α_n = 2 (from sp 16 pg no 1o4)

$(Mux / Mux^1)^{\alpha n} + (Muy / Muy^1)^{\alpha n} < 1$

0.808 < 1

Hence the section is safe biaxial bending.

Lateral ties

Tie dia = (¼) X dia meter of main bar

= (¼) X 20

= 5mm provide 10mmdia tie

Tie spacing = 16 X dia meter of main bar

= 16 X 20 = 320 mm

Provide 10mm dia ties at 300 c/c spacing.

9. DESIN OF POST TENSION SLAB

Shor span length (Lx) = 16 m

Long span length(Ly) = 12m

Fck = 30 N/mm^2

Fy = 500 N/mm^2

Assume F_p = 1600 N/mm^2

E_c = 5700 √Fck From Is 1343 : 1980 (Pg No:16)

= 5700 √30 = 31.22 kN/mm^2

Ratio of Ly / Lx = 0.75 m

Thickness of Slab = Span / 50

= 1600 / 50 = 320 mm

Load Calculation:

Self weight of slab = b X D X unit weight of concrete

= 1 X 0.32X 24

= 7.68kN/m

Live Load = 5 kN/m

Finishing Load = 1 kN/m

Total Load = 13.68 kN/m

Total ultimate design load = 20.52kN/m

Refer IS 456: 2000 Table 26 (Pg . No : 91)

Working moment n the middle strip are given by

Mx = 0.062 X 13.68 X $(16)^2$ = 217 kN/m

My = 0.038 X 13.68 X $(16)^2$ = 133 kN/m

Total moment in the middle strip (X direction)

= 217 X 0.75 X 12 = 1952kNm.

Using minimum cover of 30mm for the tendon at the centre of slab the distance between the top kern and the centroid of cable

= 230-30-20

Assume cable of 5 wires of 5mm diameter.

P = Total pre stressing force required I the X – direction.

(P X 10) = (19.01 X 10^6)

= 1901 kN

Force in each cable = 100 kN

Number of cable in X direction.

Middle strip = 1952 / 100

$= 19.01 \approx 19$

Spacing of cables = (0.75 X 12X 1000) / 19

$= 473.68 \approx 173$mm

Adopt a spacing of 156mm (four cable per meter).

Total moment in the middle strip (Y direction)

= 133X 0.75 X 16 = 1596 kNm

Provide cover 30mm to cable in Y direction distance between cable and top kern.

= 73-30-20= 23mm

Prestressing force required = $1956 \times 10^6 / 29 \times 10^3$

= 550kN

Number of able in X direction middle strip = 550/ 100

Spacing of cable = 0.75 X 3.65 X 1000 / 4

$= 484.37 \approx 450$ mm

The cable profile is parabolic with more eccentricity at the centre and concentric at the supports.

Check for limit state of collapse:

Ultimate moment (X direction) = $0.075 \times 13.68 \times (16)^2$

= 262.65 kNm/m

Ap = 280 mm^2

Ap X fp / b d fck = (280 X 1600)/ (1000 X 60 X 30)

= 0.248

Refer IS 1343: 1980 table -11 (Pg No 59)

Fck / 0.87 X fp = 1.0

fpu = 1.0 X 0.87 X 1600

= 1392 N/mm^2

Refer IS 1343 : 1980 table -12

(X_u / d) = 0.054

X_u = 0.451 X d

= 0.451 X 60 = 27.06mm

Mu = fpu X Ap X (d- 0.42 X_u)

= 1392 X 280 X (60 – 042 X 27.06) = 18.95 kNm.

The ultimate moment capacity of the slab is higher than the minimum value required. A similar check may be made in the y – direction also.

Check for deflection under service loads:

The tendons following a parabolic profile in x and y direction induce uniformly distributed loads acting upward which are give by,

Equivalent load (X direction) = 8Pe / Lx^2

= $8 \times 500 \times 0.03 / (16)^2$

= 0.458 kNm

Unbalance service load = 9 – 3.65-0.468

= 2.53kN/m^2

= 0.0025 N/mm^2

The deflection is given by

α (Coefficient) = 0.00772

q = 0.0025 N/mm^2

D = (Eh^2) / 12 ((1-V_c^2)

= 31220 X 80^2 / 12 (1- 0.125^2)

= 1.5 X 10^9

a_{max} = 0.0072 X (0.0026 X $(365)^4$ / 1.35 X 10^9

= 0.000263mm

Maximum permissible long term deflection = 16000 / 156

= 100mm

Check for Stresses:

Unbalance service load = 2.53kN/m^2

Moment due to this load (X- direction) = 0.09 X 0.468 X $(16)^2$ = 10.78 kNm

Stresses developed = $10.78 \times 10^6 / ((1000 \times 80^2) / 6)$

= 10.10 N/mm^2

Compression at top and tension of soffit of slab.

Direct stress due to pre stressing force = 500 X 1000 / 1000 X 80

=6.25(Compression)

Max compressive stress in concrete at the top of slab

= 3.028 + 6.25 = 9.278 N/mm^2

Which is less than the permissible stress of 13 N/mm^2

The max shear stress under ultimate load is

$$= (0.424 \times 11.88 \times 1600) / 1000 \times 60$$

$$= 1.34 \text{ N/mm}^2$$

RESULT:

The thickness of Post Tension slab = 320mm

Self weight of Slab = 7.68 kN/m

COMPARATIVE ANALYSIS:

REINFORCED CEMENT CONCRETE SLAB	POST TENSION SLAB
Thickness of slab = 630mm	Thickness of slab = 320mm
Self weight of the slab = 15.75kN/m	Self weight of the slab = 7.68kN/m
Area of steel = 1800mm^2	Area of prestressing in steel = 280mm^2
Moment of resistance = 618.142kNm	Moment of resistance = 18.95kNm

We have Designed the post tension slab reduce the slab thickness, self weight of the slab, area of steel and moment of resistance compare to the reinforced cement concrete slab.

10. CONCLUSION

Design of beam slab is done by post tensioning method and hence the slab thickness is reduced. The post tensioned flat slab is designed by manually. In our project we have applied Post-Tensioning method for designing the Slab and hence the thickness of the slab is reduced.

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BIOGRAPHIES

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