ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

Design and Analysis of a Commercial Complex by Using Post Tension Method (Stilt+12Floors)

V.G. Kiran Kumar
PG Student,
Department of Civil Engineering,
Gurunanak Institute of Technology, JNTUH.

N.Lokeshwar Reddy
Senior Engineer at UTRACON Structural Systems Pvt Ltd.

N.Vijaya Kumar
PG Student,
Department of Civil Engineering,
KSRM Engineering College.

P.Guruswamy Goud
PG Student,
Department of Civil Engineering,
KKIT Engineering College.

Abstract:
The project deals with the Analysis and Design of High Rise Building with Post Tensioned Slabs. The structure has been analysed and designed for the typical floor. The drawings and other specifications are studied with reference to National Building (NBC).
Structural design is the primary aspect of civil engineering. In aggregates etc. on further developing we used the admixtures and plasticizers etc. So the construction materials are changing from day to day life. In ancient days, the buildings are constructed with only ground floor only. i.e. Independent house. Now a days we are constructed G+10 and G+20 floors because for scarcity of land and cost of land is heavy and other most thing is the urbanization and etc. For the construction of the multi-story buildings now a days we are moving to pretension and post tension methods. Ancient days, the like lime ,mud, jaggary and surkhi.on later the materials buildings are constructed with the help the materials we used are cement,

Keywords:
EATBS, RAPT, POST TENSION STRUCTURES.

INTRODUCTION:
In today's architecturally complex world, the "regular shape" requirement of precast pretensioned concrete is often times not possible. In order to meet these architecturally challenging applications while still providing a durable concrete structure, designers specify cast-in-place construction. Cast-in-place construction allows the engineer the flexibility to meet any geometric floor plan and to use varying section dimensions resulting in the most economical solution for the concrete application. Using post-tensioned reinforcement in cast-in-place construction affords the engineer an even moreimproved economical solution by reducing the depth of the structural elements. This reduction in depth optimizes the quantity of concrete required and also can reduce the overall weight of a structure which saves foundation costs and can reduce the overall height of a building saving in exterior cladding costs.Overall, a post-tensioned cast-in-place concrete solution for either a slab-on-ground application or a high-rise building floor system affords the owner, architect, and engineer the most cost-effective solution to meet today's challenging construction environment.

Application of post tension structures:

Apart from floor system there are many other possible applications of post tensioning in building structures that can result in significant savings. The list includes moment resisting frames, shear walls, service cores, transfer beams and plates, foundations, masonry walls, hangers and ties. In this chapter each of these applications, as well as post-tensioned floor systems are discussed in some detail.

The advantages offered by post tensioning are reviewed and some typical tendon arrangements are shown for the different applications. Since floor systems have by far the greatest impact on the cost of building structures they are treated in more depth than the other applications prepared.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

PROJECT INVETIGATION:

Our project deals with the "Design and analysis of a commercial complex". The Structure consists of a a stilt +12floors Eco friendly Design with Gold Rated Green Building specifications, for user comfort with High Energy and Floor Efficiency. Full compliance with National Building Codes and designed with international standard infrastructure facilities to suit the requirements of IT/ITES companies. Floor area of 1099 SQ.M are utilizing for different purposes.1 A BEAM SLAB OF SIZE 14 m x 7.5 m as per IS 456:2000 (Limit State Method)

Check for the limitations for the Direct Design Method

- There are one span in each direction The panels are square with span ratio : 14/7.5 = 1.86 < 2.0
- There is no offset column.
- There is no difference in successive span lengths.

Assuming

Slab thickness = 200mm

Dead Load = 12kN/m²

W_{uLL} = 5 x 1.5 = 7.5 kN/m²

$W_{u\,LL}/W_{u\,DL}$ = 7.5 / 22 = 0.34 < 3

Hence O.KHence all limitations are satisfied and Direct Design Method is applicable.

Material Properties:

M_{40}

Steel grade, Fe_{500}

LOAD CALCULATION

Dead Load for thickness 200 mm = 0.2 x 25

= 5 kN/m²

Unit weight of concrete with reference to IS 875 (Part1)

Live Load for office building with reference of IS 875 (Part II)

Live Load = 5 kN/m²

Floor Finish thickness = 100 mm

Unit weight of P.C.C = 24 kN/m²

Reference IS 875 (Part I)

Total load, w = 22 kN/m²

Factored load, w_u = 33 kN/m²

Now let us look at typical span-to-depth ratios of post-tensioned floors. For light loading, say up to about 3.5 kN/m² and provided that punching shear is not critical. If drop panels are provided over the columns the span-depth ratio can be increased to about 45 and 35 for interior panels of post-tensioned and reinforced concrete slabs, respectively. For higher superimposed loading the span/depth ration decreases, particularly if the super-imposed load is predominantly variable in place and time. Then the amount of post-tensioning cannot simply be increased to load-balance the super-imposed load so that in order to meet the deflection limitations a greater floor thickness is required where the span/depth ratios of a number of post-tensioned flat plates and beam slabs, respectively, built in various parts of the world over the last 10 years, are plotted against the total load normalized by the slab self weight.

Slab thickness = 200 mm

Post Tensioning strand details:

Ultimate Tensile Stress = 1884 N/mm²

Nominal area of strands = 98.7 mm²

Jacking force = 75% of the Ultimate Tensile Force

Ultimate Tensile Force = 186 kN

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

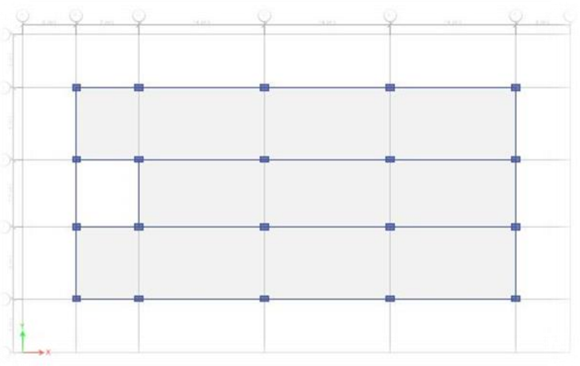

Fig1: Shows the plan of the structure.

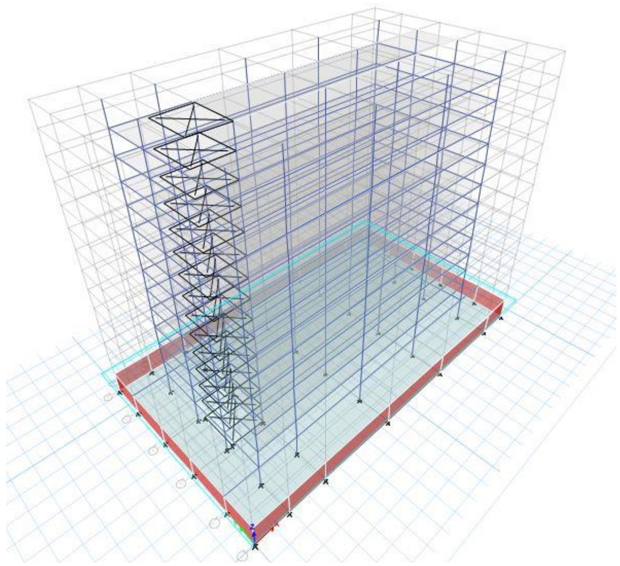

Fig2: shows the 3d diagram of the structure.

DESIGNING OF INTERNAL TYPICAL COLUMN

Size of Column = 900 x 650 mm

Material Properties:

Grade of Concrete, M_{40}

Steel grade, Fe_{415} and Fe_{500}

LOAD CALCULATION

Load due to self weight and Live load on slab of Ground floor to Terrace and Basement 1 & 2

Slab thickness from slab Ground floor and Terrace= 200 mm

Beam size 1200mm x 600mm

Beam thickness in floor Ground floor to Terrace =600 mm

Live load for Ground to Terrace 5kN/m^2

Dead load $_{s+12}$ = 0.2 x 25

= 5 kN/m^2

beam $_{s+12}$ = 10 kN/m^2

Total load $_{s+12}$ = 22 kN/m^2

Self weight of Single column:

1 – 13 = 631.8 kN

G – 1 = 58.5 kN

Total =690.3

Number of floors =12+stilt

Length along the column =7.5m

Width of the column =14m

Loading to the floors 22kN/m^2

Influence area of the column =14 x 7.5m

Therefore total load on the column is

=14 x7.5x13x22 =30030kn

WIND LOAD CALCULATION

Wind Data:

By conforming the building zone basic wind speed and intensity at different height is taken from IS 875-1987 (Part-3)

Basic Wind Speed 44 m/s

Terrain Category 2

Class of Structure A

Width of the Building 23.5 m

Length of the Building 49 m

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

Height of the Building 50.8m

Design Wind Speed

V_z = V_b x k1 x k2 x k3

k3 = 1.1

k2 = Varies with height

k1 = 1.07

V_z = 1 x k2 x 1 x 50

= k2 x 44 m/s

Design Wind Pressure

Pz = $0.6 \times V_z^2$

= $1609.198 \times k2^2$

3.6 SEISMIC LOADCALCULATION:

By conforming building zone, data's are calculated by referring IS 1893 – 2002.

Zone III

Z = 0.16

I = 1.5

R = 5

g = 9.81 m/s^2

A_h = $(Z / 2) \times (I / R) \times (S_a / g)$

building height h

building height h 50.8M

T 1.427

S_a/g 1

Ah 0.024

Vb 480.48

DESIGN CALCULATION

Total design moment for a span:

$M_0 = \frac{Wl_n}{12}$

where,

M_0 = total moment

w = design total load

l_n = clear span between columns

Now, $M_0 = Wl_n/12$

Total load =12.4 kn/m

Load due to the beam =10kn/m

Total load of the slab =12.4x14x7.5M

=1302KN

Total load the beam =10x1.2x14

=168KN

Therefore total load =1302+168

=1470KN

$M_0 = \frac{1470 \times 10^6 \times 14}{12}$

= 1715 kNm

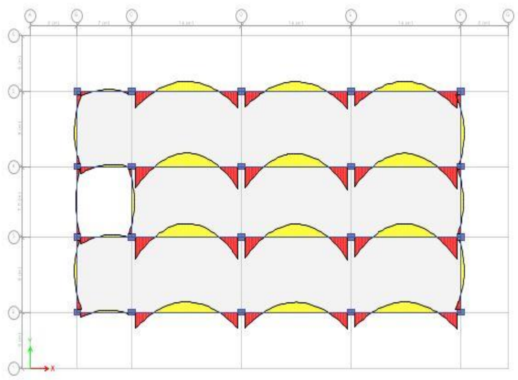

Fig3: Shows the moment diagrams.

DESIGN OF A COLMNUN:

M_X =1750 KN-M M_Y=850 KN-M

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

Eccentricity=20mm

M_u (e)=29540 x0.02 =590.8kn-m

Finally MX =1750 KN-M M Y=850 KN-M

Section is 900 x 650

Calculation of $p_u /f_{ck}bd$ =29540/40x650900

=1.3

Calculation of p /fck =1.3/40 =0.0325

Calculation of uni axial moment capacity of the column due to assumed percentage in x direction

d/D = (40+16/2)/650 =0.0738

FROM CODE BOOK SP 16 CHART NO 36 PG NO 144

M_{ux1} = $M_u /f_{ck}bd^2$ =0.38

= M_u =0.38x40x900x900x650=8002.8 kn-m

Moment carrying capacity in y direction is given by the following equation

M_{uy1} = $M_u /f_{ck}bd^2$ =0.38x40x650x650=5779.8kn-m

M_X / M_{ux1} =1750/8002.8

=0.2186

M_y / M_{uy1} =850/5779.8

=0.1470

Load carrying capacity of the column=?

P_ux z/ag is calculated. (Pgno 105 and 71 code is 456)

P_u = 20x900x650 = 11700 kn

Checking condition: (from code is456 cla39.6 pgno71)

$(M_X / M_{ux1})^{\alpha n} + (M_y / M_{uy1})^{\alpha n}$

αn value depends on the p_u/p_z values

Pu/pz =29540/11700 =2.52

if the value of αn is less than 0.2 then αn=1

αn is greater than 0.2 then αn=2

Therefore $0.218^2 + 0.147^2 =$ 0.0691

0.0691<1

Hence safe.

DESIGN OF THE TYPICAL FOOTING:

Axial load p_u= 29540 kn

Column size 900 x 650

Safe bearing capacity of the soil=750kn/m^2

Area of the footing=(load/safe bearing capacity of the soil)

=19693.33/750

=26.2577

=5.12m x5.12m

Depth of the footing D= 6feet=1830mm

d=1830-50-(20/2) =1770 mm

check for two way shear:

net upward preassure on the footing q=(load /area provided)

=19693.33/5.1242x5.1242

=750.010kn/m^2

Calculation of the sheer force:

V=crictical sectional area x q

=((5.1242x5.1242)-(2.6740x2.420)) x750.010

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

Design Code	List India - BS 8110*SAVED*
Material	India - USSI default Indian List Material*SAVED*
Reinforcement Type	List Bonded Post-Tensioned
Member Type	List Slab
Panel Type	List Internal
Strip Type	List One way - Full Width
Column Stiffness	List Equivalent Column
Concrete - Spanning Members	List 40MPa
Concrete - Columns	List 40MPa
Top Reinforcement Cover	mm 45
Bottom Reinforcement Cover	mm 35
Self Weight Definition	List Program Calculated
Pattern Live Load	Y/N Y
Earthquake Design	List None
Moment Redistribution %	0
Design Surface Levels	List Extreme Surfaces

=14847.19kn

Nominal shear stress:

T_v $=v_u/bd$ =14847.19x10 ^{3} x1.5/((2(2670+2420)x750.01))

=1.23

Permissible stress:

Tc =0.25x (squre root of f_c)

= 0.25x (squre root of 40)

=1.58.**Tv< Tc , Hence safe**

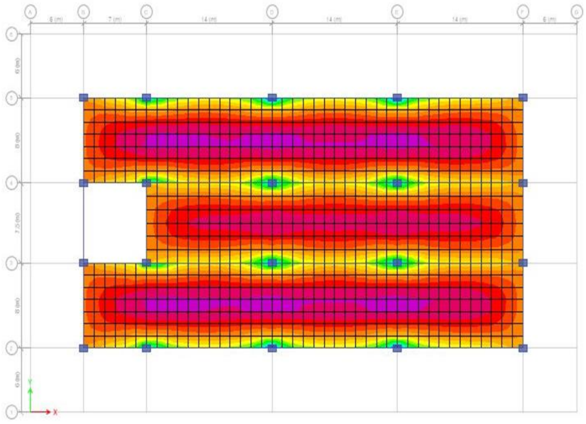

Fig4:.Shows the beam stress of the structure.

Post tension slab details in the RAPT report.

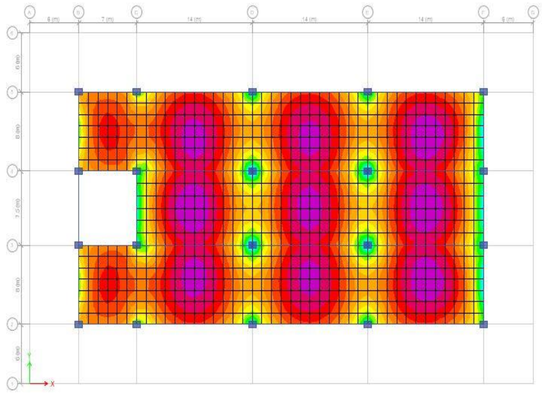

Fig5: Shows The Slab Stress In The Structure.

POST TENSION BEAM DETAILS FROM RAPT REPORT

Design Code	List	India - BS 8110*SAVED*
Material	List	India - USSI default Indian Material*SAVED*
Reinforcement Type	List	Bonded Post-Tensioned
Member Type	List	Beam
Panel Type	List	Internal
Strip Type	List	One way - Nominal Width
Column Stiffness	List	Equivalent Column
Concrete - Spanning Members	List	40MPa
Concrete - Columns	List	40MPa
Top Reinforcement Cover	mm	65
Bottom Reinforcement Cover	mm	50
Self Weight Definition	List	Program Calculated
Pattern Live Load	Y/N	Y
Earthquake Design	List	None
Moment Redistribution	%	0
Design Surface Levels	List	Extreme Surfaces

Manual calculations for pre stressed concrete:

Project: **Commerical Building**

Floor : **TYPICAL**

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

Location:

Calculation of Moment Resisting Capacity

According to IS:1343- 1980 the Moment of Resistance of a section due to tendons can be

calculated as follows.

M = ƒpuAp (d - 0.42 xu)

Where,

M - Moment Resisting Capacity of section

ƒpu- Ultimate Tensile stress in Tendon

Ap- Area of prestressing steel

d- Effective depth of section

Design Data:

xu- Depth of neutral axis

Grade of concrete ƒck = **40** N/mm2

Grade of steel ƒy = **500** N/mm2

Grade of prestressing strand ƒp = **1860** N/mm2

Depth of beam D = **600** mm

Web width bw = **1200** mm

Depth of slab Df = **200** mm

Effective flange width bf = **3160** mm

Dia of strand used = **12.7** mm

Tendon Arrangement

First Layer Duct **-5S** ,

Total Number of strands = **20** nos.

Totl Number of strands = **20** nos.

Clear cover from soffit of tendon to soffit of slab (1sta Layer) = **525** mm

Clear cover from soffit of tendon to soffit of slab (2nd Layer) = **0** mm

Clear cover from soffit of tendon to soffit of slab (3rd Layer) = **0** mm

Clear cover from soffit of tendon to soffit of slab (4th Layer) = **0** mm

DESIGN OF POST TENSIONED SLAB

Area of prestressing steel Ap = **1974** mm2

Effective depth of section with respect to 1st Layer tendon = **534**

Effective depth of section with respect to 2nd Layer tendon = **0**

Effective depth of section with respect to 3rd Layer tendon = **0**

Effective depth of section with respect to 4th Layer tendon = **0**

Effective depth (d) = **534.0** mm

Effective reinforcement ratio (Ap * ƒp / (b * d * ƒck) = **0.143**

From Table -11 of code

Stress in Tendon as a proportion of the design strength

ƒpu / (0.87 * ƒp) = **1.00**

ƒpu = **1618.2**

Ratio of the depth of Neutral Axis to that of the centroid of the tendon in the tension zone

xu / d = **0.303**

xu = **161.62**

Moment resisting capacity of section by Tendons = **1489** kN-m

Reinforcement Provided = **6Y16+5Y32**

Ast = **5226** mm2

Cover to Main Reinforcement = **40** mm

Effective depth to reinforcement = **560** mm

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

Moment resisting capacity of section by rebar = 87 * fy * Ast * d *

(1-((Ast * fy)/($f$ck * b * d *)))

= **1149** kN-m

Design Moment at critical section = **1850** kN-m

Total Flexural capacity of section = **2638** kN-m

Calculation of stress @ Service:-

Area of Gross cross section A = **1E+06** mm2

Area of flange = **632000**

Area of web = **480000**

Y1 = **100**

Y2 = **400**

Depth of Neutral axis from top fiber yt = **229.5**

Depth of Neutral axis from bottom fiber yb = **370.5**

Moment of Inertia of T section Ixx =

Section modulaszt = **1E+08**

Section modulaszb = **9E+07**

Eccentricity e = **163.5** mm

Available tendon force at service (1st Layer) = **108** kN

Available tendon force at service (2nd Layer) = **0** kN

Available tendon force at service (3rd Layer) = **0** kN

Available tendon force at service (4th Layer) = **0** kN

Effective force per strand = **108** kN

Total effective force @ Service P = **2160** kN

Moment due to self weight = **705** kN-m

Moment due to super imposed dead load = **220** kN-m

Moment due to Live load = **549** kN-mSecondary Moment = **-358** kN-m

Moment due to Earthquake load = **0** kN-m

Combination for Limit state of serviceability =

Service Moment = **1116** kN-m

1.0 (DL + LL + PT)

33059184652

Stress due to direct prestress = P/A

= **1.94**

Stress due to tendon eccentricity @ Top fiber = Pe/zt

= **2.45**

Stress due to tendon eccentricity @ Bottom fiber = Pe/zb

= **3.96**

Stress due to Applied loads @ Top fiber = M/Zt

= **7.75**

Stress due to Applied loads @ Bottom fiber = M/Zb

= **12.51**

Stress at extreme top fiber ft = **-3.35** N/mm2

Stress at extreme bottom fiber fb = **10.49** N/mm2

Negative sign indicates Tensile stress.

RESULTS:

In our design project we have found the following results:

We have designed the POST TENSION BEAM SLAB .the reduction in the slab depth is achieved by designing as Post-Tensioned beam Slab. By the reduction of thickness in slab, it reduces the self weight, height of the building and the materials.

Thickness of Post-Tensioned beam slab = 200 mm In SLAB strip we are providing one tendon at every 1.2 meters.By considering the slab weight, live load and other loads we have designed the column for its Biaxial Moment and Axial load carrying capacity. we have derived the column size as 900mm x 650mm.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

In critical column the reinforcement provided is 16 numbers of 25 mm diameter bars.By considering the slab weight, live load and other loads we have designed the post tensioned beam and we have got the beam size as

Breadth= 1200mm

Depth = 600

SUMMARY AND CONCLUSION

Design of beam slab is done by post tensioning method and hence the slab thickness is reduced.The post tensioned flat slab is analyzed and also designed by using software package RAPT.The columns are analyzed by using software package ETABS and designed manually.In our project we have applied Post-Tensioning method for designing the Slab and hence the thickness of the slab is reduced. Post-Tensioning can also be applied for Beams and Column designing and hence the self weight of the structure can be considerably reduced.If we reduce the slab thickness and the number of columns and beams we are reducing the materials and the economical cost of the structure .if we reduce the building materials we will save the environment .our construction will be on the eco friendly.

FIG6: SHOWS THE TENDON LAYOUT READY FOR THE CONCRETING.

FIG7: SHOWS THE AFTER COMPLETING OF THE STRESS.

REFERENCES

1. Bijan O Aalami (2005) "Time-dependent analysis of post-tensioned concrete structures" Progress in Structural Engineering and Material, Vol. 1, No. 4, pp. 384-391.

2. Ebead. U. A and Marzouk. H (2005) "Tension-Stiffening model for FRP-strengthened RC concrete Two-way Slabs", Journal of Materials and Structures, Vol. 38, No. 2, pp. 193-200.

3. Iraj Noorany, E. David Colbaugh, Ronald J. Lejman and Michael J. Miller (2005) "Levelness of Newly Constructed Post-Tensioned Slabs for Residential Structures", Journal of Performance of Constructed Facilities, Vol. 19, No. 1, pp. 49-55.

4. Randall W. Poston, Gerard C. Feldmannand Mario G. Suarez (1991) "Evaluation of L'Ambiance Plaza Post-Tensioned Floor Slabs", Journal of Performance of Constructed Facilities, Vol. 5, No. 2, pp. 75-91.

5. Ricardo J. C. Silva, Paul E. Regan, and Guilherme S. S. A. Melo (2007) "Punching of Post-Tensioned Slabs - Tests and Codes", Structural Journal, Vol. 104, No. 2, pp. 123-132.

6. Robert W. Day (1998) "Settlement Behavior of Post-Tensioned slabs-on-grade", Journal of Performance of Constructed Facilities, Vol. 12, No. 2, pp. 56-61.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

7.Scollard. C. R. and Bartlett. F. M. (2004) "Rehabilitation criteria for Post-Tensioned voided-slab Bridges", Journal of Civil Engineering, Vol. 31, No. 6, pp. 977-987.

8.Stephen Horn and Garrison Kost (1983) "Investigation and Repair of Post-Tensioned Concrete Slabs - A Case History" Concrete International, Vol. 5, No. 7, pp. 44-49.

9.YoungMook Yun (2005) "Evaluation of Ultimate Strength of Post-Tensioned Anchorage Zones", Journal of Advanced Concrete Technology, Vol. 3, No. 1, pp. 149-159.

BIBLIOGRAPHY:

1.Reinforced Concrete Design 2nd Edition by **S.UNNIKRISHNA PILLAI**

2.Design of Reinforced Concrete Structures by **S.RAMAMRUTHAM**

3.Prestressed Concrete Structure by **KRISHNARAJU**

4.Design of Prestressed Concrete Structures by **T.Y.LIN**

5. PracticalPrestress Concrete Design by **B.J. BELL**

6. Prestressed Concrete Design and Construction **R.J. LIBBY**

CODE BOOKS:

1. IS 456-2000 Indian Standard Code of Practice for Plain and Reinforced Concrete.
2. IS 875 (Part 1)-1987 Code of practice for Design Dead Loads.
3. IS 875 (Part 2)-1987 Code of practice for Design Live Loads.
4. IS 875 (Part 3)-1987 Code of practice for Design Wind loads.
5. IS 1343-1980 Indian Standard Code of Practice for Prestress Concrete Structure.
6. IS 1893-2002 Code of Practice for Seismic Load.
7. Sp: 16(S&T) (1980), Design aids to Reinforced Concrete IS: 456-1978
8. British Standards (BS:8110-1997)