DESIGN AND LIFE CYCLE ANALYSIS OF POST TENSION REINFORCEMENT BUILDING BY USING ETABS

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ABSTRACT

In this project, we have seen and studied thoroughly some works on the site related to post tensioned slabs. The various sizes of tendons available, which are the materials imparting prestress to the structure were studied thoroughly. We have also understood and performed building column line staking on site. We have visited the site and taken part in the execution work under the structural engineer in-charge. The unbounded tendons are typically prefabricated at a plant and delivered to the construction site, ready to install. The tendons are laid out in the forms in accordance with installation drawings that indicate how they are to be spaced, what their profile (height above the form) should be and where they are to be stressed. After the concrete is placed(from the RMC trucks) and has reached its required strength, usually about 75% of its final strength, then the prestressing process begins. The concrete grade that was used was M35 and hence, after 7 days when it achieved the strength of 25 N/mm2, prestressing was achieved through Prestressing powerpack using a mono strand stressing jack. The principle is that when the tendons are stretched, want to return to their original length but are prevented from doing so by the anchorages. The fact that the tendons are kept in a permanently stressed (elongated) state causes a compressive force to act on the concrete. The compression that results from the post tensioning counteracts the tensile forces created by the prestress applied. This significantly increases the load-carrying capacity of the concrete.

Keywords*: post-tensioned concrete , load analysis, slab analysis.*

1.0 INTRODUCTION

The present report is based on the project work on "Detailed study and Execution work in post Tensioned Slabs". The site was a commercial complex at Kothaguda Village nearby Hi-Tech city. The building proposed is on a site with an area of 70,500 sq ft. and is a 2 basement + G + 5 building. This was taken up by the pioneer company "Crux Prestressing Systems Pvt. Ltd." for Ektha builders. The name of the building is "Ektha Pearl". Prestressed concrete is basically concrete in which internal stresses of a suitable magnitude and distribution are introduced so that the stresses resulting from external loads are counteracted to a desired degree. In Reinforced Concrete members, the prestress is commonly introduced by tensioning the steel reinforcement. The earliest examples of wooden barrel construction by force fitting of metal bands and shrink fitting of metal tyres on wooden wheels indicate that the art of prestressing has been practiced from ancient times. The tensile strength of plain concrete is only a fraction of its compressive strength and the problem of it being deficient in tensile strength appears to have been the driving factor in the development of the composite material known as "Reinforced Concrete".

The development of early cracks in reinforced concrete due to incompatibility in the strains of steel and concrete was perhaps the starting point in the development of a new material like "prestressed concrete". The application of permanent compressive stress to a material like concrete, which is strong in compression but weak in tension, increases the apparent tensile strength of that material, because the subsequent application of tensile stress must first nullify the compressive prestress.

Post tensioning: It is a method of prestressing concrete by tensioning the tendons against hardened concrete. In this method, the prestress is imparted to concrete by bearing. Post tensioned concrete may be either bonded or un-bonded.

Bonded post tensioned concrete: The term used for a method of applying compression after pouring concrete and the curing process. The concrete is cast around plastic, steel or aluminum curved duct tofollow the area where otherwise tension would occur in the concrete element. A set of tendons are fished through the duct to follow the area where otherwise tension would occur in the concrete element, and then concrete is poured. Once the concrete is hardened, the tendons are tensioned by hydraulic jacks that react (push) against the concrete member itself. When the tendons have stretched sufficiently, according to the designed specifications, they are wedged in position and maintain tension after the jack is removed, transferring pressure to the concrete. The duct is then grouted to protect the tendons from corrosion. The method is commonly used to create monolithic slabs for house construction in locations where expansive soils (such as adobe clay) create problems for the typical perimeter foundation. All stresses from seasonal expansion and contraction of the underlying soil are taken into the entire tensioned slab, which supports the building without supports the building without significant flexure. Post tensioning is also used in the construction of various bridges, both after concrete is cured, support by false work and by the assembly of prefabricated sections.

Advantages:

- ❖ Large reduction in traditional reinforcement requirements such as tendons cannot distress in accidents.
- ❖ Tendons can be easily "woven" allowing a more efficient design approach.
- ❖ Higher ultimate strength due to bond generated between the strand and concrete.
- ❖ No long term issues in maintaining the integrity of the anchor end.

Un Bonded post tensioned concrete:

It differs from bonded post tensioning by providing each individual cable permanent freedom of movement relative to the concrete. To achieve this, each individual tendon is coated with grease (generally lithium base) and covered by a plastic sheathing formed in an extrusion process. The transfer of tension to the concrete is achieved by the steel cable acting against steel anchors embedded in the perimeter of the slab. The main disadvantage over bonded post tensioning is the fact that a cable can distress itself and burst out of the slab if damaged (such as during repair on the slab

ADVANTAGES:

- ❖ The ability to individually adjust cables based on poor field conditions (For ex: shifting a group of four cables around an opening by placing two to either side.)
- ❖ The procedure of post stress grouting is eliminated.
- ❖ The ability to distress the tendons before attempting repair work.

1.3 IMPORTANT TERMINOLOGY:

1) Tendon: A stretched element used in a concrete member of structure to impart prestress to the concrete. Generally, high tensile steel wires, bars, cables or strands are used as tendons.

2) Anchorage: A device generally used to enable the tendon to impart and maintain prestress in the concrete. The commonly used anchorages are the Freyssinet (widely used in India), MagnelBlaton, Gifford-Udall.

3) Partial prestressing: The degree of prestress applied to concrete in which tensile stresses to a limited degree are permitted in concrete under working loads. In this case, in addition to tensioned steel, a considerable proportion of untensioned reinforcement is generally used to limit the width of cracks developed under service loads.

4) Transfer: This stage corresponding to the transfer of prestress to concrete. For post tensioned members, it takes place after the completion of the tensioning process.

5)Supplementary or untensioned reinforcement: It is the Reinforcement in prestressed members not tensioned with respect to the surrounding concrete before the application of loads.
6) Transmission length: It is the length of bond anchorage of the prestressing wire from the end of a pre-tensioned member to the point of full steel stress.
7) Cracking load: The load on the structural element corresponding to the first visible crack.
8) Creep in concrete: Progressive increase in the elastic deformation of concrete under sustained stress component.
9) Shrinkage of concrete: Contraction of concrete on drying.
10) Relaxation in steel: Decrease of stress in steel at constant strain.
11) Proof Stress: The tensile stress in steel which produces a residual strain of 0.2 per cent of the original gauge length on unloading.
12) Creep Co-Efficient: The ratio of the total creep strain to elastic strain in concrete.
13) Cap Cable:A short curved tendon arranged at the interior supports of a continuous beam. The anchors are the compression zone; cable is the curved portion is in the tensile zone.

LITERATURE REVIEW

[1] Richard P. Nguyen (1991) studied the feasibility of using cold-formed steel channels as reinforcement for cast-in-place concrete beams. His experimental investigation included 32 beam specimens made of thin-walled, cold-formed steel stiffened channels and concrete subjected to shear and bending both individually and combined. From the test results, the authors concluded that, the composite beams developed the same ultimate strength in bending and shear as conventional RCC beams in addition to economy and speedy construction. The composite strength of the profiled beams depended primarily on forces normal to the ribs in the side of profiled steel sheets. These normal forces are induced by the mechanical actions from flexural and shear displacements. Of secondary importance are the shear bond forces, which only increased the strength slightly. Furthermore, from theoretical studies the author suggested that the addition of side – profiled sheets substantially reduce the long term deflections due to creep and shrinkage of the concrete and the span/depth ratio is increased by about 20% since the depth of the beam is reduced.

[2] Brian. Uy and M.A. Bradford (1993) The conducted service load tests on profiled composite and reinforced concrete beams. Tests are reported on two profiled composite steel-concrete beams and two reinforced concrete beams of the same flexural strength as the profiled beams under service loads. The beams were monitored under sustained loading for a period of approximately 250 days. Time-dependent deflections and strains in the beams were measured over this period, as well as the creep co-efficient and shrinkage strains on companion specimens. The results showed that the time dependent deformations of the profiled composite steel-concrete beams are significantly less than those of the reinforced concrete beams.

[3]**Deric J. Oehlers, Howard D. Wright and J. Burnet (1994)** The reported a construction technique that uses steel decking as permanent and integral shuttering for the sides and soffits of reinforced concrete beams. The authors conducted experiments on large-scale profiled beams. The authors predicted that the behaviour of this form of composite construction can be

affected by local buckling of the steel decking and the strength of the shear bond at the interface between the decking and concrete. Simple design procedures are developed to prevent local buckling of the steel decking before the ultimate strength of the beam is reached. A new procedure based on rigid plastic analysis has been derived for determining the flexural strength of composite profiled beams.

[4] Brian Uy and Mark Andrew Bradford (1995) Conducted experiments on ductility of profiled composite beams. The authors adopted cold-formed profiled steel sheeting as stay-in-place form for reinforced concrete beam and referred them as Profiled Composite Beams. The study includes two profiled composite beams and two reinforced concrete beams. All beams were 6m in length with their cross sections being 290 * 400 mm for profiled beams and 265 x 400mm for RCC beams. The beams were tested to failure in flexure. Load strain characteristics were measured for the beams, from which moment – curvature response was obtained.

[5] Ramajeyam.I and Swamidura.A (1997) The behavior of concrete in filled cold formed steel tubular columns stiffened with weld-mesh. The aim of the investigation is to study the effect of confinement of concrete in cold formed steel concrete composite columns with respect to strength and stiffness by conducting experiments on the different types of concrete in filled cold formed steel tubular columns and cold formed steel hollow columns.

METHODOLOGY

3.1 SITE INSPECTION:

A site investigation report is the basis for all the subsequent decisions regarding cleanup of a contaminated site. This report describes the findings of the desk study and the field work and discuss their implications with respect to the proposed development of the site. An assessment is made in terms of likelihood of the presence of contamination that may affect the feasibility of the site for the intended use.

The 3.1 consistency limits of soil are as follows:

Soil type	Liquid limit	Plastic limit
Sand	20	0
Slits	27	20
Murrum	100	45

Admixtures: Like concrete, admixtures may be used to improve workability and reduce the water required, reduce bleed, improve pumping properties or entrain air. Care must be exercised to use the correct quantities in the proper way according to manufacturer's instructions and to remainThemix properties established by qualifying laboratory tests. Calcium nitrite may help to improve corrosion resistance in some situations by bonding to the steel to form a passive layer and prevent attack by chloride ions. High range water reducer (HRWR) improves short term fluidity. However, a grout with HRWR may lose fluidity later when being injected through hoses and ducts.The minimum wall thickness should be 10mm (3/8 inch) reinforced with a minimum of four ply polyester reinforcement. Sleeves should be secured with 10mm (3/8 in) wide power seated, 316 stainless steel band clamps, using one on each end of the sleeve (boot) to seal against leaking grout. The power seating force should be between 356 and 534 N (80 and 120lbf). Alternatively, connections may be made using mechanical couplers with plastic components made of approved plastic resins meeting the same requirements as for external plastic pipes and metal components of grade 316 stainless-steel. Mechanical connections should meet the same pressure rating requirements (above) and have seals to prevent grout leaks. Steel and plastic pipe may be connected directly when the outside diameters do not vary by more than + 2mm (0.08in). A reducer or spacer should be used when outside this tolerance

Table 3.3 Main features of cables using 12.7mm diameter strands.

No. of strands	4	7	9	12
Nominal c/s area of steel Ap(mm2)	600	1050	1350	1800
Nominal mass of steel(kg/m)	467	820	1055	1758
Characteristic tensile strength(fpi) MPa	1.860	1.860	1.860	1.860
Characteristic ultimate resisting force of tendon (fpk)KN	1.116	1.953	2.511	3.348

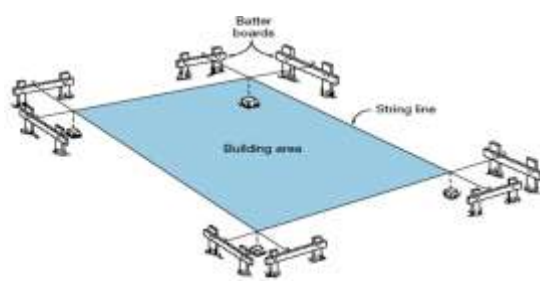


Fig 3.1 Building Staking

3.6 THE DESIGN PROCESS

This section considers the various stages of the design process. As in most reinforced and prestressed concrete design work, the customary design process is of an iterative nature following the cycle:

1. Preliminary design
2. Check design by analysis
3. Revise design as required
4. Repeat steps 2 & 3

Table 3.4 Features of mono strand stressing jacks: Types of jacks

	PT 150KN	PT 200KN	PT 250KN	PT 300KN
Capacity (KN)	150	200	250	300
Stroke (mm)	100	200	200	200
Weight (KN)	16	23	23	28
Tensioning section (cm2)	3280	4720	4720	5832
Max tensioning pressure (bar)	550	450	550	550
Max return pressure (bar)	180	180	180	180
Max locking pressure (bar)	165	165	165	165

Mix design of M35 Grade of Concrete :

M35 Characteristic Strength (Fck) : 35 Mpa Standard Deviation : 1.91 Mpa* Target Mean Strength : T.M.S.= Fck +1.65 x S.D. (from I.S 456-2000) = 35+ 1.65×1.91 = 38.15 Mpa Test Data For Material: Aggregate Type : Crushed Specific Gravity Cement : 3.15 Coarse Aggregate : 2.67 Fine Aggregate : 2.62

Water Absorption Coarse Aggregate : 0.5% Fine Aggregate : 1.0 %

Mix Design: Take Sand content as percentage of total aggregates = 36% Select Water Cement Ratio = 0.43 for concrete grade M35 Select Water Content = 172 Kg (From IS: 10262 for 20 mm nominal size of aggregates Maximum Water Content = 186 Kg/m3)
Hence, Cement Content= 172 / 0.43 = 400 Kg /m3
Formula for Mix Proportion of Fine and

Coarse Aggregate:
1000(1-a0) = {(Cement Content / Sp. Gr. Of Cement) + Water Content +(Fa / Sp. Gr.* Pf)}
1000(1-a0) = {(Cement Content / Sp. Gr. Of Cement) + Water Content +Ca / Sp. Gr.* Pc)} Where
Ca = Coarse Aggregate Content

Fa = Fine Aggregate Content

Pf = Sand Content as percentage of total Aggregates = 0.36

Pc = Coarse Aggregate Content as percentage of total Aggregates. = 0.64

a0 = Percentage air content in concrete (As per IS :10262 for 20 mm nominal size of aggregates air content is 2 %) = 0.02

Hence, 1000(1-0.02) = {(400 /3.15) + 172 +(Fa / 2.62 x 0.36)}

Fa = 642 Kg/ Cum

As the sand is of Zone II no adjustment is required for sand.

Sand Content = 642 Kg/ Cum

1000(1-0.02) = {(400 /3.15) + 172 +(Ca / 2.67 x 0.64)}

Hence, **Ca = 1165 Kg/ Cum**

From combined gradation of Coarse aggregates it has been found out that the proportion of 53:47 of 20 mm & 10 mm aggregates produces the best gradation as per IS: 383.

Hence, 20 mm Aggregates = 619 Kg

And 10 mm Aggregates = 546 Kg

To obtain slump in the range of 150-190 mm water reducing admixture brand SP430 with a dose of 0.3 % by weight of Cement shall be used.

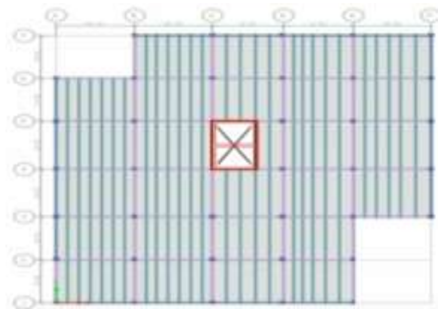


Fig 3.2 plane view of the post tension building

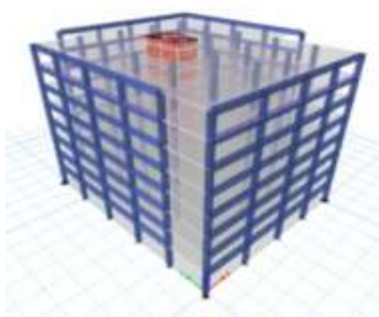


Fig 3.36^II SLAB 5000 PSI CONCRETE

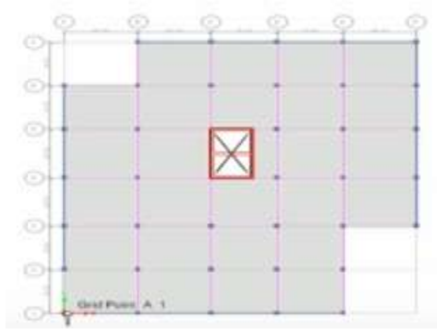


Fig 3.4 Grid A1 Plane View

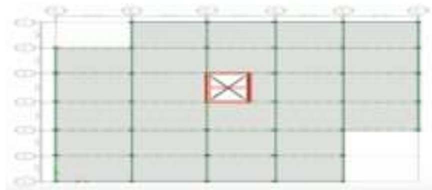


Fig 3.5 Node Point Of The Plane View

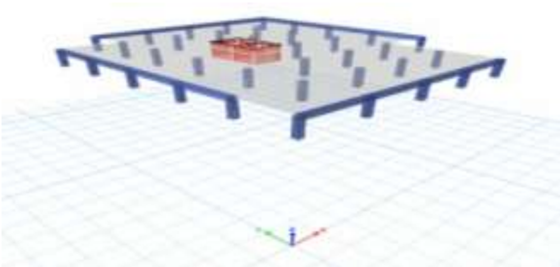


Fig 3.6 Initial View Of The 3D Model

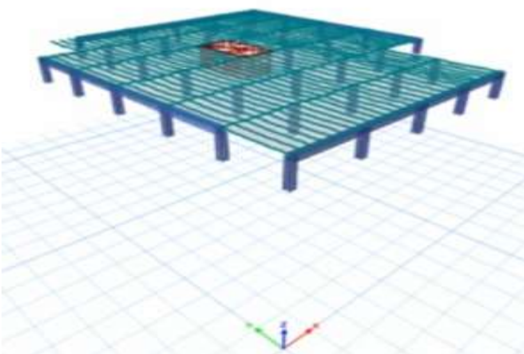


Fig 3.7 Top View Of Post Structure Building

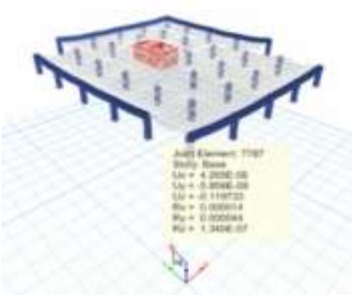


Fig 3.8 Displacement View Of The 3D Model

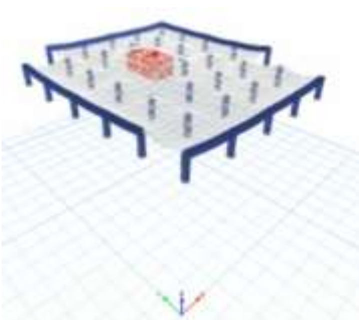


Fig 3.9 Displacement Of The Dead Loads

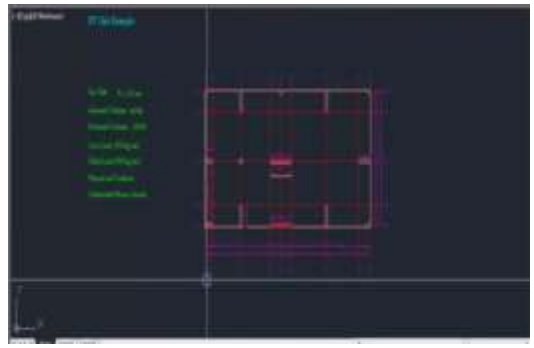


Fig 3.10 Pt Slab Model

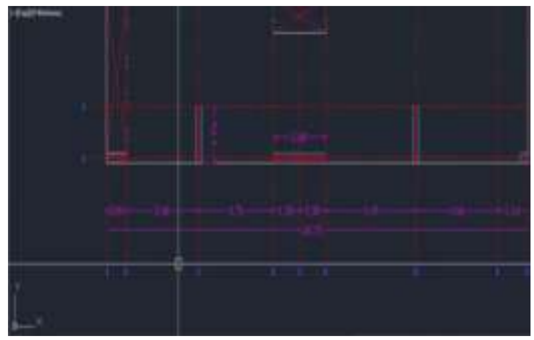


Fig 3.11 Geometric Model

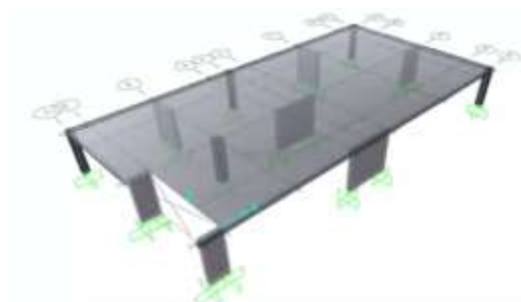


Fig 3.12 Geometric Model Of 3d View

Table 3.5 Drawing Sheet List

SR.NO	SHEET TITLE	SHEET NO	REV.NO
1	COVER SHEET	$-00	0
2	GENARAL NOTES	$-01	0
3	SLAB FRAMING PLAN	$-02	0
4	SLAB REDAR PLAN TOP-BARS	$-03	0
5	SLAB-REBAR PLAN –BOTTOM BARS	$-04	0
6	TENSION LAYOUT PLAN	$-05	0
7	SLAB SECTIONS	$-06	0

Equivalent Frame Analysis:

It is usual to divide the structure into sub-frame elements in each direction. Each frame usually comprises one line of columns together with beam/slab elements of one bay width. The frames chosen for analysis should cover all the element types of the complete structure. The use of the equivalent frame method does not take account of the two-dimensional elastic load distribution effects automatically. It will give different support reactions from the analyses in the two orthogonal directions unless the width of slab will be full panel width.

Tendon Profile & balanced Load

Ideally the tendon profile is one which will produce a bending moment diagram of similar shape, but opposite sign, to the moments from the applied loads. This is not always possible because of varying loading conditions and geometric limitations. It should be noted that for bonded systems the centroid of the strands will not coincide with centroid of the duct. This is particularly true in the case of circular ducts. In the simplest case, for a uniformly loaded simply-supported beam, the bending moment is parabolic, as is the ideal tendon profile. The total 'sag' in the parabola is referred to as the tendon 'drape' and is limited by the section depth and minimum cover to the tendon 'drape' & is limited by the section depth and minimum cover to the tendon

ANALYSIS

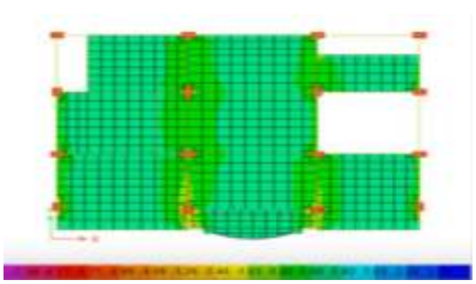


Fig 4.1 Plane View Of The Post Tension Building

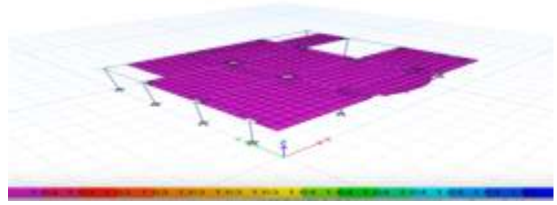


Fig 4.2 Resultant M1 Grade

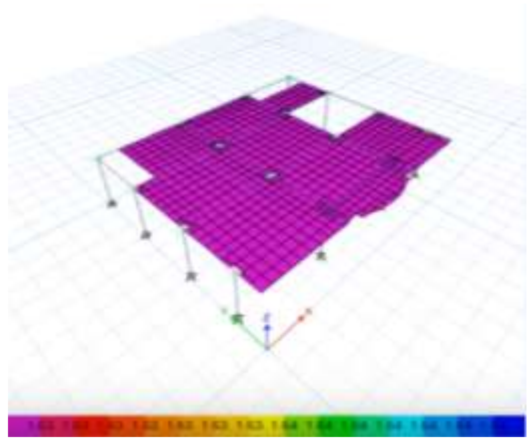


Fig 4.3 Resultant M11 Grade

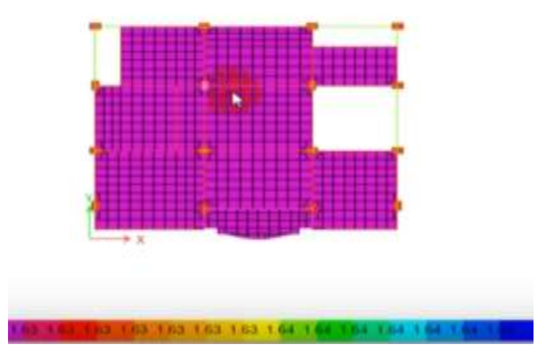
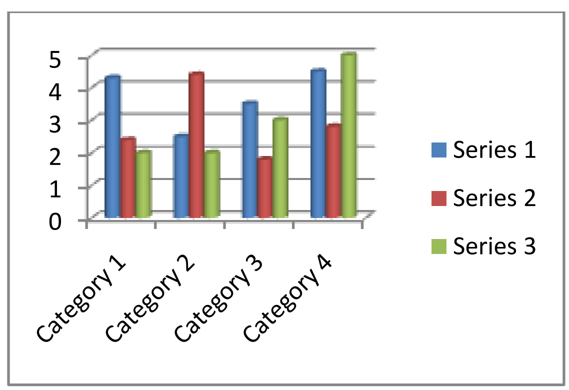


Fig 4.4 Resultant M 22 Grades



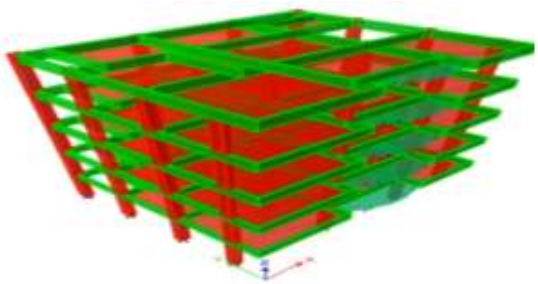


Fig 4.5 3d View Of Post Structure Building

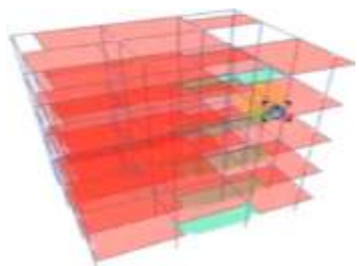


Fig 4.5 Live Loads Of Post Structure Building

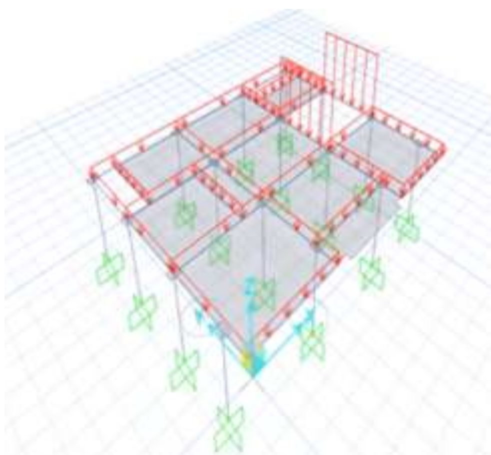


Fig 4.6 Global Beam Force Loads

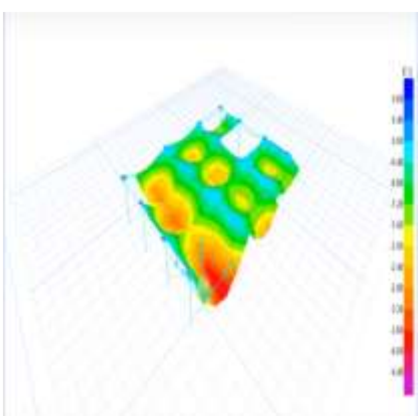


Fig 4.7 Minimum Deformation Shape Of Displacements

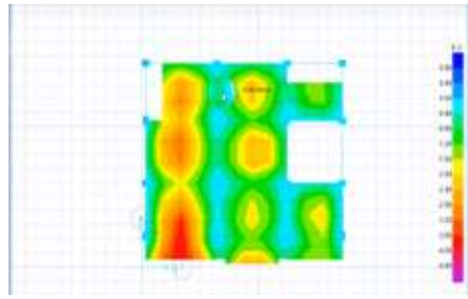


Fig 4.8 Maximum Deformation Shape Of Displacements

Fig 4.9 3D View Of Frame Plane Gravity

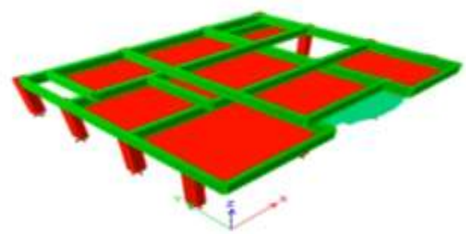


Fig 4.10 Area Draw Mode

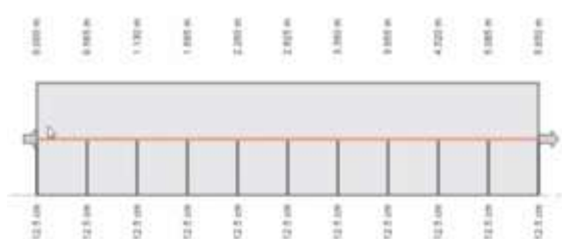


Fig 4.11 Post Tension Building Development Evolution

Table 4.2 Post Tension Building Distance And Levels

	Distance-x	level
1	0.00M	12.5CM
2	0.565M	12.5 CM
3	1.130M	12.5 CM
4	1.695 M	12.5 CM
5	2.260M	12.5 CM
6	2.825 M	12.5 CM
7	3.390M	12.5 CM
8	4.520M	12.5 CM
9	5.085M	12.5 CM

10	5.650M	12.5 CM

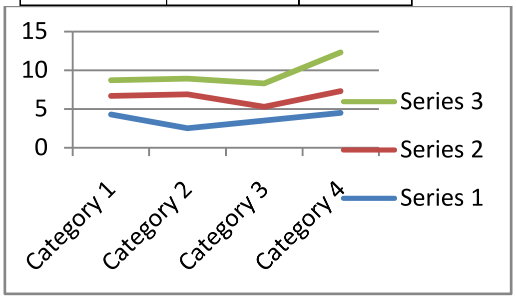
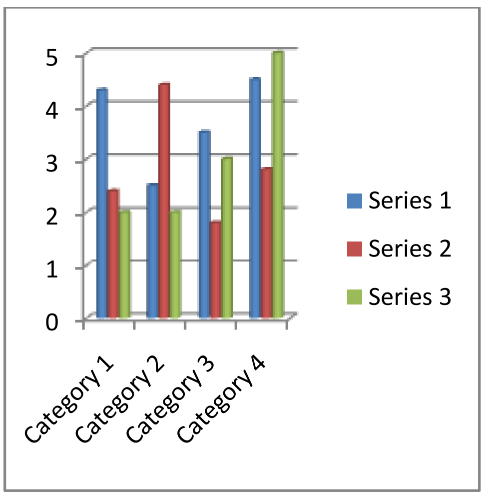
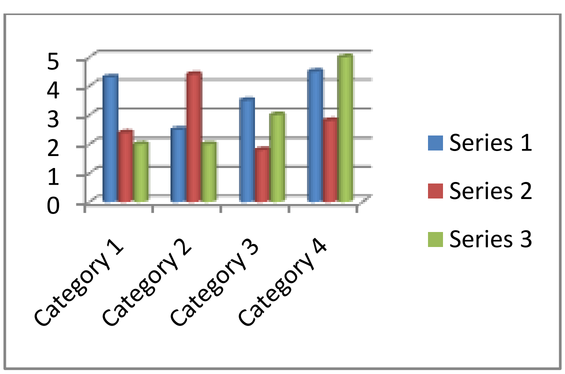


Table 4.3 Tendon Bill Of Quanties

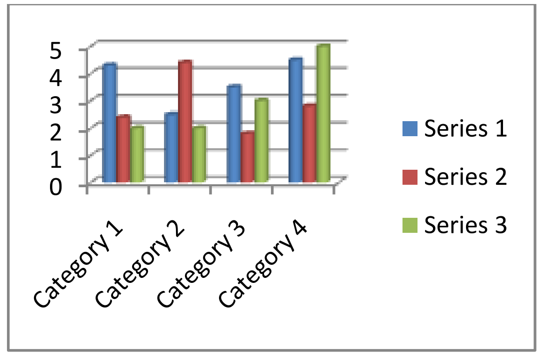
	ITEM	QUANTITY
1	TENDON1	188.840
2	SHEETH	188.840
3	JACKING ENDS	14
4	ANCHOR ENDS	14



The Graph Shows Thatfeatures Of Mono Stand Stressing Jacks



The Graph Show That Ducts Thickness Varies For 0.3mm To 0.6mm. Technical Features Of Duct



CONCLUSIONS

Prestressed concrete offers great technical advantages in comparison with otherforms of construction such as reinforced concrete and steel. They possess improved resistance to shearing forces, due to the effect of compressive prestress, which reduces the principles tensile stress. The use of curved cables, particularly in long span members helps to reduce shear forces developed at the support sections. A prestressed concrete flexural member is stiffer under working loads than a RCC member of the same depth.

However, after the onset of cracking, the flexure behavior is similar to that of RCC, The use of high strength concrete and steel in prestressed member result in lighter and slender members than is possible with reinforced concrete. These two structural features contribute to the improved durability of the structure under aggressive environmental conditions. Prestressing of concrete helps in improving the ability of the material for energy absorption under impact loads. The economy of prestressed concrete is well established for long span structures. Standardized precast bridge beams between 10m and 30 m long and precast prestressed piles have proved to be more economical than steel and reinforced concrete. Precast prestressed concrete is economical for floors, roofs and bridges of spans up to 30m and for cast *in situ* work, up to 100m. In the long-span range, prestressed concrete is generally more economical than reinforced concrete and steel and machine foundations. Due to utilization of concrete in the tension zone, an extra saving of 15 to 30% in concrete is possible in comparison with reinforced concrete. The savings in steel are even higher, 60 to 80% mainly due to the high permissible stresses allowed in the high tensile wires. Although there is considerable saving on the quantity of materials used in prestressed concrete members in comparison with RCC, it is not much significant due to the additional costs incurred for the high strength concrete, high tensile steel, anchorages and other hardware required for production of prestressed members. However, there is an overall economy in using prestressed concrete, as the decrease in dead weight reduces the design loads and the cost of foundations.

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