STUDY OF VARIOUS ASPECTS OF APPLICATION OF SEGMENTAL CONSTRUCTION TECHNIQUE IN BUILDINGS

A Major Thesis

Submitted in Partial Fulfillment of

The Requirement for Award of Degree of

MASTER OF ENGINEERING

In

STRUCTURAL ENGINEERING

By

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<u>CANDIDATE DECLARATION & CERTIFICATE</u>

This is certify that the project work entitled "***STUDY OF VARIOUS ASPECTS OF APPLICATION OF SEGMENTAL CONSTRUCTION TECHNIQUE IN BUILDINGS***" is a bonafide record of work done submitted me for the partial fulfillment of the requirement for the degree of **Master of Engineering, Civil Engg.** (Structural Engineering) from Delhi college of Engineering, Delhi.

This project has been carried out under the supervision of Prof. D. Goldar of my college.

I have not submitted the matter embodied in this direction for the award of any other degree.

Name	Roll No.	Signature
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CERTIFICATE:

This is to certify that above statement made by candidate is to the best of our knowledge.

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ACKNOWLEDGEMENT

It gives me great pleasure to thank my project guide **Prof. D. GOLDAR** who has been highly inspiring throughout the time I was engaged in doing my project and providing me with invaluable support and guidance without which this project would not have been completed.

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I also wish to extend my thanks to my colleagues for helping me in gathering the information required for completing the project.

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ABSTRACT

The project entitled **"STUDY OF VARIOUS ASPECTS OF APPLICATION OF SEGMENTAL CONSTRUCTION TECHNIQUE IN BUILDINGS"** developed by Ajay Gupta under the guidance of project guide **Prof. D. GOLDAR** is an attempt to study use of modernization in Civil Engineering works by introduction of "Precasting of Elements of a Building" along with development of "Fully Automatic Self Raising Launching System for Building Construction" to facilitate reduction in construction time and improvement in Quality of Construction.

The Project brings out the Goods and Bads of the Application of Segmental Construction Technique in Buildings in contrast to Normal Cast-In-Situ Construction.

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INTRODUCTION

Prefabrication of concrete structures is one of the most remarkable developments in the construction process of concrete structures in the last few decades. This prefabrication is closely related to the developments in the precasting industry, which in turn is one of the most important steps towards mechanization of building industry.

Mechanization of processes have a distinct advantage over manual processing which is reflected in the quality of the output. This advantage can be attributed to some of the inherent characteristics of mechanization mechanism i.e.

1. Mechanization necessitates establishment of the manufacturing process and a flow chart of the sequence of activities to be performed on raw material until the final product is produced.

2. The sequence of activities once defined in a manufacturing process induces a control over the product quality which can be assessed and rectified as and when required along the process sequence.

3. The sequencing reduces the decision making efforts since WHAT NEXT? can be foreseen and the solutions can be sought after and defined at various levels of malfunctioning of the process machinery/ system in advance.

4. Repetitive behavior of the process in a predefined format allows us to define the functions/ activities on the critical path and helps us in economizing by shifting the efforts from less critical zones to the zones of high criticality thus saving time and wastage of efforts on less critical activities.

5. Over all improvement in quality of product and its production time can be achieved.

6. All of the above lead to economies of scale/ scope.

The need for mechanization of the construction industry has been understood and practiced by many in past. The use of segmental construction technique by Delhi Metro Rail

Corporation (DMRC) for construction of Mass Rapid Transit System (MRTS) for Delhi stands as one of the greatest examples of all times being witnessed by us in India.

SEGMENTAL CONSTRUCTION TECHNIQUE IN BUILDINGS

The topic refers to the precasting of various elements of a building independently in a casting yard/ factory with scientifically designed quality control program and joining them on requisite site in their respective positions to get a structure incorporating all the necessary features for its intended use.

The basic definition of the topic suggests following basic requirements of the construction process

1. Design of building elements to be precast as an individual identity.

2. Adequacy of the dimensions and other properties of the precast element when placed in harmony with the other elements (cast-in-situ/ precast) in the service stage of the structure.

3. Development of a scheme for construction of the precast elements.

4. Development of scheme for transportation of the precast elements to the requisite site location.

5. Development of a scheme for lifting, positioning and connecting the precast elements with the rest of the structure.

6. Design of a launching systems incorporating all feature for erection of precast elements and performing other construction related activities.

OBJECTIVES OF RESEARCH PROGRAM

1. To study the various aspects of application of segmental construction techniques in buildings.

2. To compare the economy achieved in the design of building elements to be constructed by segmental construction technique in contrast to the design of building elements to be constructed by cast-in-situ construction technique.

3. To develop a schematic launching system for buildings.

SCOPE OF STUDY

1. A general study of the various requirements of a good construction and to perform a comparative study of various construction activities in the light of segmental construction technique and cast-in-situ construction technique.

2. To study the basic difference in the design procedure of building elements to be constructed by segmental construction technique in contrast to the design of building elements to be constructed by cast-in-situ construction technique.

3. The design of multistory buildings is a topic of research from various prospects. For the research conducted under present thesis, we have confined our study to the design of solid slabs / cellular slabs to be constructed by segmental construction technique and solid slabs / cellular slabs to be constructed by cast-in-situ construction technology and to study the comparison between the two types of construction methodology in regards to the design of slabs conducted under the present work.

4. In the development of launching system for buildings present thesis is confined to developing a schematic Launching system highlighting its essential components, their requirements, their functioning in general and making a drawing showing various functions that can be performed with the proposed launching system.

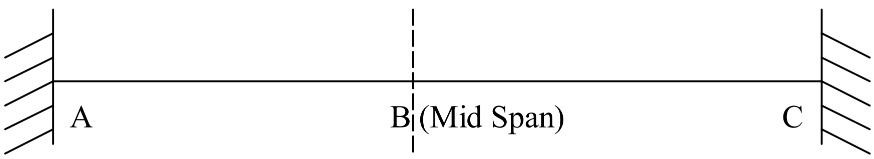
ORIGIN OF THE PROBLEM

Before selecting the present topic for research we studied the behavior of beams through a number of examples of continuous beams of varying span arrangements and observed some strange facts/ phenomenon which compelled us to do a research in this area. These analysis were performed in highly crude manner and were not preserved in any form for presenting them for any healthy discussion. However the truth behind some of our observations has been boosted by the experiences of "Delhi Metro Rail Project".

The ongoing chapter is an attempt to explain these phenomenons with some simple examples and facts available to us:

a. Change in bending moment distribution in beams with change in construction technology.

Consider a single span beam of length 5m with following loading conditions



Dead Load of beam = 0.3 t/m^2
Weight of Super Imposed Dead Load on the beam = 0.2 t/m^2
Live Load on beam = 0.2 t/m^2
Width of slab contributing to the loaded width effective for the beam = 4m
Support condition = Fixed / Built in
Effective span of the beam = 5m

<u>If the beam is constructed by cast-in-situ construction technique</u>

Bending Moment at Support = $4 \times (0.3+0.2+0.2) \times 5^2 /12$ = 5.834tm
Bending Moment at Mid Span = $4 \times (0.3+0.2+0.2) \times 5^2 /24$ = 2.917tm

If the beam is constructed by segmental construction technique

Bending Moment at Support = 0 + 4 x (0.2+0.2) x 5^2 /12 = 3.333tm

Bending Moment at Mid Span = 4 x (0.3) x 5^2 /8 + 4 x (0.2+0.2) x 5^2 /24 = 5.416tm

OBSERVATIONS:

1. In beam constructed by cast-in-situ construction technology, the bending moment distribution is such that the bending moment at support section is much higher than the bending moment at mid span section. However in contrast to this, in beam constructed by segmental construction technology, the bending moment distribution is such that the bending moment at mid span section is much higher than the bending moment at support section.

2. In general the nature of bending moment is hogging at support and sagging at mid span. Now if the beam supports a slab rigidly connected to it then the Moment Resisting Capacity at mid span is much higher than the same at support section, because the slab contributing as flange of T beam is effective only in sagging moment condition (compression at top face and tension at bottom face). If this statement is true than the beam designed to be constructed by segmental technology should have smaller dimensions and hence more economical.

3. In general for spans up to 5m the maximum bending moment at any section in the beam designed to be constructed by segmental construction technique is smaller than the bending moment at any section in the beam designed to be constructed by cast-in-situ construction technology. However the same is not true for spans larger than 10m, and a transition stage exists between 5m to 10m, i.e. the maximum bending moment at any section is nearly same or comparable in the two methods of construction.

4. If the total load transferred to the beam before continuity of the beam is established is lower than the total additional loads (including live loads) transferred to the beam after the continuity is established then the maximum bending moment developed at any section in the beams designed to be constructed by segmental construction technique will always be lesser than the same in beam designed to be constructed by

cast-in-situ construction technology irrespective of the span length. This statement is perfect for single span beams fixed at ends, and generally true for continuous beams deviating only marginally in occasional situations.

MATHEMATICAL PROOF TO THE ABOVE STATEMENT

Let us consider the following data:

Dead Load tranferred to the beam before continuty is established = W1 t/m
Dead Load tranferred to the beam after continuty is established = W2 t/m
Live Load on beam = W3 t/m
Support condition = Fixed / Built in
Effective span of the beam = L (m)

If the beam is constructed by cast-in-situ construction technique

Bending Moment at Support = (W1+W2+W3) x L^2 /12
Bending Moment at Mid Span = (W1+W2+W3) x L^2 /24
Maximum bending moment at any section in the beam = (W1+W2+W3) x L^2 /12

If the beam is constructed by segmental construction technique

Bending Moment at Support = 0 + (W2+W3) x L^2 /12
Bending Moment at Mid Span = W1 x L^2 /8 + (W2+W3) x L^2 /24
Maximum bending moment at any section in the beam = W1 x L^2/8 + (W2+W3) x L^2/24

IF $\quad$ W1 x L^2/8 + (W2+W3) x L^2/24 $\leq$ (W1+W2+W3) x L^2 /12
Then $\quad$ 3 x W1 + (W2 + W3) $\leq$ 2 x (W1 + W2 + W3)
i.e. $\quad$ 3 x W1 – 2 x W1 $\leq$ 2 x (W2+W3) – (W2 + W3)
i.e. $\quad$ W1 $\leq$ (W2 + W3)
Which is same as the condition assumed, therefore we can say that design of beams designed to be constructed by segmental construction technique will always be economical provided the said condition is achieved.

b. Better distribution of moment along the span.

The absolute maximum bending moment lies at support section in continuous beams designed to be constructed by cast-in-situ technology; and the same lies at mid span in the beams designed to be constructed by segmental construction technique. Maximum moment at mid span is a desirable condition from many considerations such as:

1. Greater Moment resisting capacity of mid span section due to T beam effect as explained earlier.

2. Since the absolute maximum bending moment lies at mid span which in turn governs the cross-sectional dimensions of the beam, therefore it results in lesser congestion of steel at support section.

3. The bending moments due to lateral loads such as wind force and earthquakes is more concentrated at support sections; than at mid span sections, therefore by concentrating the maximum moment due to basic loads (dead load) at mid span location leaves us with a safety margin at support sections for absorbing those unexpected high intensities of lateral load phenomenon's for which a normal cast-in-situ constructed structure can not be designed due to many reasons including economy of the structure.

c. Greater reserve strength.

1. The absolute maximum bending moment in continuous beams designed to be constructed by cast-in-situ technology lies at support section therefore the yielding of concrete at ultimate state of loading starts at support sections. Since the concrete is brittle in nature therefore many a times the section fails due to excessive rotation demanded by the mechanism leading to collapse much before the formation of three hinge mechanism required for collapse of the beam. In contrast to this the absolute maximum bending moment in continuous beams designed to be constructed by segmental construction technique lies at mid span section, therefore the yielding starts at mid span section, so that a single hinge is formed which can not lead to complete collapse, therefore segmental construction technique ensures that the structure does

not collapse before the complete failure mechanism is formed or collapse load is reached.

d. Control of deflections.

The simplest method of controlling deflections is to provide precamber in the structure during its casting. Practically it is difficult to provide correct precamber in shuttering arrangement during cast-in-situ construction, because the entire arrangement of shuttering is supported on staging system consisting of several hundred numbers of pipes or steel trestles, precise leveling of these steel trestles is a difficult task in general and in some cases it is absolutely impossible due to prevailing site conditions. Besides this the problem gets intensified if the structure possesses a two way behavior so that the deflection pattern resembles a dome structure which is almost impossible to achieve. It is generally observed that precamber is not provided in cast-in-situ construction.

In contrast to the above in segmental construction, the elements of the building/ structure are precasted in casting yard where the shuttering rests on a rigid concrete bed at ground level. The leveling of shuttering is therefore relatively easier. More so the big elements especially the elements having two way behavior are cast in small units each having one way behavior, these units are assembled and connected at site to form the two way behaving structure. In doing so the problem of providing precamber in a dome like pattern is completely eliminated, further reducing the required efforts.

In the light of above fact it can be concluded that by segmental construction technique, economy is guaranteed in building elements whose design governs by deflection criteria.

e. Reduced shrinkage and creep effects.

Precasting of structural elements reduces the chances of cracking due to shrinkage and creep effects. In general it has been found that the strains developed due to shrinkage and creep effects gets accumulated near joints thereby inducing internal tension at the joints so that joints fails during real time disastrous loading like wind storms and earthquakes without developing the expected resistance.

Several literatures justify this belief, study of one such literature is mentioned below:

SP: 25 – 1984 (Handbook on Causes and Prevention of Cracks in Buildings)

Clause 10.7.17 Use of Precast Components: as per this clause "judicious use of precast components can help to reduce incidence of cracking in structures since such components are pre-shrunk".

Clause 2.5.4 Measures for Controlling Cracks Due to Shrinkage: as per this clause "construction based on use of precast components has a distinct advantage over in-situ concrete job since initial shrinkage is made to take place without any restraint prior to incorporation of the components in a building, thus obviating subsequent shrinkage".

Clause 10.7.15 Pace of Construction: as per this clause " in concrete work, it is necessary that before construction of any masonry work either over it or by its side, most of drying shrinkage, creep and elastic deformation should be allowed to take place so as to avoid cracks in masonry or cracks at junction of concrete and masonry. Creep in concrete depends upon age of concrete at the time of loading: delayed loading thus reduces creep. Construction schedule should therefore be drawn and pace of construction regulated keeping these requirements in view and jobs should not be rushed through unnecessarily and unwittingly".

It can therefore be concluded that, this codal provision restricts the pace of construction to allow sufficient time for shrinkage and creep to take place in the building frame, on the contrary precasting in casting yard allows shrinkage and creep phenomenon to occur without restraint and without transferring any effect on its neighboring elements since they are scheduled to be cast at least a month in advance of their actual positioning and connection at their final position on site, thus improving the quality of construction without imposing any restriction on the pace of construction.

Some other facts related to construction activities also suggests more and more use of segmental construction technique for construction of RCC structures (Buildings)

f. Better time management and planning opportunities.

In segmental construction any sequence of precasting of structural elements can be planned without bothering about the position of the element cast in the actual structure therefore the planning of construction activities is much easier and has wide range of flexibility compared to the casting schedule planned for any cast-in-situ construction.

g. Faster Construction.

In segmental construction it is possible to plan construction sequence in such a manner that the precasting of first floor elements is completed with in the time required for casting of foundations so that the elements of first floor are ready to placed at their requisite position in the structure, similarly the elements of second floor are cast with in the time required for placing the elements of first floor in the structure so that the no time is wasted between construction of one floor and its subsequent floor on account of miscellaneous activities like fixing of scaffolding, fixing of shuttering over the scaffolding, in-situ casting, and providing sufficient time for cast concrete to gain strength good enough to hold its self weight so that de-shuttering can be done.

h. Ease in construction.

In a casting yard all the elements are cast at ground level, formwork is supported over firm ground generally paved with RCC/ PCC concrete, all the corners of the formwork are accessible, the location of casting is nearly same for all the casting activities, the hauling distance of concrete produced is kept as small as possible, proper platforms for placing vibrators and other equipments/ tools are available. Presence of all these facilities eases the process of casting of elements.

In contrast to this in cast-in-situ construction form work is supported over scaffoldings which are relatively shaky, as the height of the element to be cast increases (with floor levels) it becomes more and more difficult to provide proper platforms for supporting the equipments/tools like vibrators, psychologically also the working labor finds it difficult to work at greater heights affecting the quality of work produced, more over the hauling distance for concrete increases with increasing height of the building inducing problems in regards to the workability of concrete, thus affecting the design of the concrete mix.

i. Improved quality and durability.

The control of quality of concrete is highly improved in casting yard which in turn improves the durability of the structure finally constructed.

The improved quality control is achieved due to following major reasons:

1. General reduction in age of cement used for casting, due to continuous cycle of concreting.
2. Possibility of more frequent monitoring of quality of ingredients of concrete, i.e. water, course aggregates, fine aggregates etc due to centralization of batching plant.
3. proper mixing of concrete through automatic/semi automatic concrete mixers, and use of the same concrete product without tempering it with water or cement slurry so that the quality of concrete produced is maintained un till it is finally cast. This is possible only if the hauling distance for concrete is kept small.
4. Placing and compaction of concrete is also improved, because all the activities are performed at smaller heights so that handling of equipments is easier.
5. Better curing of concrete through use of automatic sprinkling systems.

Since all the activities are centralized therefore labor can be more easily trained which in turn improves the ratio of skilled labor to the total labor available at site. Improvement in this ratio automatically results in greater quality control than the same available at site in in-situ construction.

j. Reduced cost of construction.

In segmental construction the sizes of building elements are fixed in such manner so as to allow multiple uses of shuttering/ formwork. It results in reduction in cost of shuttering, more over since the handling of form work is controlled in a much better way it improves the reusability of the formwork by many folds.

The following data collected in this regards clearly proves this fact:

Project Name: Construction of Elevated Viaduct From km 8.0 to 14.3 on Barakhamba Road - Cannaught Place – Dwarka Section (Line No. 3) (DMRC Phase-I)
Contractor: Persys – Punj Lloyd JV
Total Length of Viaduct: 6300 m
Total Number of Spans: 252 Nos.
Number of Pier Segments: @ 2 segments per span = 504 Nos.
Number of Intermediate segments: 1702 Nos.
Number of Pier segments Moulds/ shuttering = 6Nos.
Number of repetitions per mould = 504/6 = 84 times
Number of Intermediate segments Moulds/ shuttering = 10Nos.
Number of repetitions per mould = 1702/10 = 170.2 times

These moulds/ shutters still exist in good condition and ready for casting of another set of same number of segments again if required.

Cost comparison of shuttering in segmental/ cast-in-situ construction

Segmental construction adopted in the project

Transverse Width of the segments = 10.75m
Area of Shuttering = 14.75m^2/m (approx)
Weight of Shuttering = 150kg/m^2
Cost of Fabrication = Rs 75 per kg
Cost of Shuttering = 75 x 150 = Rs 11250 per m^2

Cost of 6 moulds of Pier Segment = 6 x 14.75 x 2m (length) x 11250

= Rs 19.92 Lakhs

Cost of 2 side bulkheads for each mould = 2 x 0.75 x 19.92 = Rs 29.88 Lakhs

(Almost equal to 0.75 times the normal shutter per Bulkhead)

Cost of 10 moulds of Intermediate Segment = 10 x 14.75 x 3m (length) x 11250

= Rs 49.79 Lakhs

Cost of 1 side bulkheads for each mould = 0.75 x 49.79 = Rs 37.34 Lakhs

(Almost equal to 0.75 times the normal shutter per Bulkhead)

Total cost of Shuttering moulds = Rs 136.93 Lakhs

<u>Equivalent cost of shuttering in case of cast-in-situ construction</u>

Reusability of Shuttering in in-situ construction = 30 to 50 times depending upon handling facilities

Assuming 40 times reusability of the shuttering on an average

Total area of Shuttering required = 14.75 x 6300/40 = 2323 m^2

Total cost of Shuttering = 2323 x 11250 = Rs 261.33 Lakhs

Saving in cost = 261.33 – 136.93 = Rs 124.40 Lakhs

+ Shuttering Moulds still available in good shape and condition for casting of similar Numbers again

+ Time.

% saving = (124.40/261.33) x 100 = 47.60%

<u>Cost comparison of scaffolding segmental/ cast-in-situ construction</u>

<u>Cast-in-situ construction</u>

Total Plan area of scaffolding = (10.75+3) x 6300 = 86625 m^2

Cost of Scaffolding for 10m average height = Rs 4000 to Rs 6000 per m^2

Assuming cost of scaffolding = Rs 5000 per m^2

Reusability of scaffolding = 10 times
Total cost of scaffolding = (86625/10) x 5000 = Rs 433.10 lakhs

Segmental construction adopted in the project

Total number of Launching girders used = 4 Nos.
Weight of each Launching girder = 225 tonne
Total cost of Launching girder = 225 x 4 x 75000 = Rs 675 lakhs

The cost of scaffolding is little less than cost of Launching girders but after the project the scaffoldings are not usable or lost, on the contrary the Launching girders have been modified with an addition of another 50 tonnes (total for 4 launching girders) and are in use at present therefore average cost of launching girder for the project can be taken as 675/2 = Rs 337.5 lakhs (50% of original cost)

Saving in cost = 433.10 – 337.5 = Rs 96.25 Lakhs
+ Launching girder still available in good shape and condition for use in another project
+ Time.

% saving = (96.25/337.5) x 100 = 28.51%

The % saving in cost increases with number of reusability of both Shuttering Moulds and Launching girder.

Saving is also achieved in cost of concrete since transportation of concrete is not required.
In the similar manner savings are achieved in almost all activities related to concreting.

The only additional activity increasing the cost of construction is involved in transportation of the precast segments from the casting yard to the site which can be controlled by proper planning of casting yard near the site location.

Basic difference in the design procedure of building elements to be constructed by segmental construction technique in contrast to the design of building elements to be constructed by cast-in-situ construction technique.

In in-situ construction the various elements of a building are monolithically connected to each other unless they are intentionally designed to be connected through special connectors or bearings. For monolithically connected elements framing together to form the complete structure, the structure can be analyzed using commonly used elastic methods of analysis like slope-deflection method, moment distribution method, matrix method of analysis etc, the computer based software's like STAAD, NISA-CIVIL, STRUDL, S-CAAD, RM-2000, ANSYS etc. may be used as quick and convenient tools of analysis. The entire analysis can be done as a single stage construction.

In segmental construction the structure passes through various stages in which certain elements of the building exist as monolithically connected to each other and several elements exist as simply resting over the remaining structure and behave as simply supported. Theses simply supported precast elements are then connected to the rest of the structure though various techniques viz.

- Connection through in-situ concreting at the joints.
- Connection by welding of dowel bars left projected in the precast elements and covering the joint with cement mortar or prepackaged non shrink concrete.
- Connection by prestressing the precast elements using high tension cable strands passing through duct holes left in the precast elements during concreting.
- Connection by bolting of base plates anchored at the ends of precast element during precasting.

In all the cases the elements which are precast behave as simply supported for Dead Weight of the structural concrete before continuity of the element is established with the rest of the structure and behave as continuous members for other loads including live loads after the continuity is established with the rest of the structure.

The segmental construction technique therefore demands a two step design procedure i.e. design for simply supported condition before continuity is established and as continuous structure after continuity is established. As an example design procedure mentioned in IS 14215 -1994 has been iterated below.

IS 14215-1994

Indian Standard-**DESIGN AND CONSTRUCTION OF ROOFS AND FLOORS WITH PRECAST REINFORCED CONCRETE CHANNEL UNITS- CODE OF PRACTICE**

Clause 4: Structural design

4.1

The Channel units shall have adequate strength and stability in accordance with IS 456: 1978 during the following stages:

i) De moulding

ii) Handling, stacking, transporting and placing; and

iii) Final stage with all designs dead and imposed loads acting on the floor/roof.

4.3 Design stage I (Just after Placing of *In-situ* Concrete)

4.3.1 At the time of laying the units, the load comprises the self-weight of the channel units, the weight of *in- situ* concrete in the joint between the two units and also the incidental live load, likely to act on the structure at this stage. In absence of more accurate information, incidental load may be taken as half the imposed load likely to act on the structure at final stage as recommended in IS 875(Part 2): 1987.

4.3.2 Effective section: At this stage of loading, as in *in-situ* concrete has not attained any strength to ensure monolithicity, the effective width of channel unit shall be taken as width of flange portion only.

4.4 Design stage 2 (With full design load)

4.4.1 Loads: At this stage, the loads acting on the structure shall comprise dead load and full imposed load as per IS 875(Part 2): 1987. This shall be maximum load likely to act on the structure during its lifetime. For calculating the limit state of collapse at the critical section, a combined load factor of at least 1.5 shall be applied for calculating the limit state of collapse load.

4.4.2 Effective section: As the *In- Situ* concrete has attained strength at this stage , an effective width equal to the nominal width of the unit shall be taken for calculating the strength of section.

4.5 Design Bending Moment and Shear Force

When the floors /roofs consist of three or more continuous and approximately equal spans, the value of bending moment and shear force coefficients given in IS:456-1978 may be used. These coefficients shall be used for imposed live load as well as dead load of finishing but not for dead weight of units (incliding that of in-situ concrete) shall be added.

4.6 *In – Situ* concrete, which brings monolithic connection and continuity between pre cast units, shall be designed in accordance with IS 3935:1966.

4.7 When Pre cast units are used for the construction of buildings in high seismic zones the floor and roof shall be strengthened in accordance with **9** of IS 4326: 1993.

5.0 **STORAGE, TRANSPORTATION AND ERECTION OF PRE CAST ELEMENTS**

5.1 Handling and transportation of units: The pre cast units shall be handled by placing slings placed at about 1/5 of span from ends. Care shall be taken to see that no support is placed at the center of the span and the main reinforcement is always at the bottom of the stacked units, that is trough shall be facing downwards.

Literature Review

IS 14215: 1994

Indian Standard – DESIGN AND CONSTRUCTION OF FLOORS AND ROOFS WITH PRECAST REINFORCED CONCRETE CHANNEL UNITS – CODE OF PRACTICE

The code includes Eight Design Tables as mentioned below:

Table 1 "Design Table for 300mm Wide Channel Units Simply Supported"

The Design Table covers Effective Span Range from 2.10m to 4.50m

Table 2 "Design Table for 300mm Wide Channel Units Continuous over Two Equal Spans"

The Design Table covers Effective Span Range from 2.10m to 4.50m

Table 3 "Design Table for 300mm Wide Channel Units Continuous over Three Equal Spans, Residential building"

The Design Table covers Effective Span Range from 2.10m to 4.50m

Table 4 "Design Table for 600mm Wide Channel Units Simply Supported, Residential Building"

The Design Table covers Effective Span Range from 2.10m to 4.50m

Table 5 "Design Table for 600mm Wide Channel Units Continuous over Two Equal Spans, Residential building"

The Design Table covers Effective Span Range from 2.10m to 4.50m

Table 6 "Design Table for 600mm Wide Channel Units Continuous over Three Equal Spans, Residential building"

The Design Table covers Effective Span Range from 2.10m to 4.50m

Table 7 Limit State Moment of Resistance and Shear Capacity of 300mm wide Channel Units

Table 8 Limit State Moment of Resistance and Shear Capacity of 600mm wide Channel Units

GENERAL FINDINGS

The design tables referred in the code are valid for an effective Span Range of 2.10m to 4.50m, for larger spans the general design procedure mentioned in the code has to be followed.

This IS code does not provide any reference for deflection check however it does recommend use of provisions given in IS 456 for checks not included in this code of practice.

The arrangement of channels shown in this code indicates design of slabs as one way behavior, however concrete topping may be provided with reinforcement in longer direction to cater for two way behavior of slabs.

The stiffness of slab is much higher in effective span direction (shorter span) than in longer span direction therefore the coefficients for design of slabs spanning in two directions given in IS 456 are no longer valid, rather the bending moment coefficients for continuous beams given in IS 456 are referred in this code (which are much higher than the coefficients for two way spanning slab system).

IS 6061 (part I) – 1971

Indian Standard – CODE OF PRACTICE FOR CONSTRUCTION OF FLOOR AND ROOF WITH CONSTRUCTION OF FLOOR AND ROOF WITH JOISTS AND FILLER BLOCKS PART I: WITH HOLLOW CONCRETE FILLER BLOCKS

IS 6061 (Part II) – 1981

Indian Standard – CODE OF PRACTICE FOR CONSTRUCTION OF FLOOR AND ROOF WITH CONSTRUCTION OF FLOOR AND ROOF WITH JOISTS AND FILLER BLOCKS PART II: WITH HOLLOW CLAY FILLER BLOCKS

IS 6061 (Part III) – 1981

Indian Standard – CODE OF PRACTICE FOR CONSTRUCTION OF FLOOR AND ROOF WITH CONSTRUCTION OF FLOOR AND ROOF WITH JOISTS AND FILLER BLOCKS

PART III: WITH PRECAST HOLLOW CLAY BLOCK JOISTS AND HOLLOW CLAY FILLER BLOCKS

IS 6061 (Part IV) – 1981

Indian Standard – CODE OF PRACTICE FOR CONSTRUCTION OF FLOOR AND ROOF WITH CONSTRUCTION OF FLOOR AND ROOF WITH JOISTS AND FILLER BLOCKS PART IV: WITH PRECAST HOLLOW CLAY BLOCK AND SLAB PANELS

GENERAL FINDINGS

IS 6061 (PART I) and IS 6061 (PART II) recommends maximum effective span of 6.0m, however IS 6061 (PART III) and IS 6061 (Part IV) recommends only a general design procedure.

All these codes does not provide any reference for deflection check however it does recommend use of provisions given in IS 456 for checks not included in these codes of practice.

In Structural arrangement suggested by IS 6061 (PART I) and IS 6061 (PART II) the stiffness of slab is much higher in effective span direction (shorter span) than in longer span direction therefore the coefficients for design of slabs spanning in two directions given in IS 456 are no longer valid, and analysis as per T Girder with Slab is required. The bending moment coefficients for such a system are much higher in effective span direction than in other direction.

In Structural arrangement suggested IS 6061 (PART III) and IS 6061 (PART IV) bending moment coefficients are recommended for direct design of the slab. The coefficient mentioned in the code are close to the bending moment coefficients mentioned in IS 456 for design of continuous beams, again the coefficients are much higher than corresponding values recommended in IS 456 for two way spanning slabs.

IS 13990: 1994

Indian Standard – PRECAST REINFORCED CONCRETE PLANKS AND JOISTS FOR ROOFING AND FLOORING – SPECIFICATION.

GENERAL FINDINGS

This standard lays down the requirements for precast reinforced concrete planks and joist used for construction of roofs and floors. The plank lengths up to 1.50m long only are covered under this Indian standard specification.

IS14142: 1994

Indian Standard – DESIGN AND CONSTRUCTION OF FLOORS AND ROOFS WITH PREFABRICATED BRICK PANEL – CODE OF PRACTICE

This standard lays down recommendations of floor and roof with prefabricated brick panels (concrete brick panels of maximum length 1.1m for grade of concrete less than M-40 and maximum length 1.2m for grade of concrete more than M-40)

As per this code joists shall be designed as continuous beam, it may be designed either as simply supported or continuous T-Beam in accordance with IS 456.

Scope of Study for present work

In general the available standards deal with maximum effective span up to 4.50m and in one case up to 6.0m only. The design procedure recommends design of slab units as continuous beams i.e. in general the two way behavior of slab is superceded with one way continuous beam effect which is more appropriate for the arrangements suggested there in. However in all these cases the bending moment coefficients are much higher than a normal RCC slab.

In present study two types of slab systems have been included viz.

Type 1: Solid slab: (continuation of work started in Minor Thesis)

1. Reinforced concrete beams designed to span in one direction as simply supported for dead weight of the slab, over which structural concrete topping shall be provided with reinforcement for full continuity in both directions so that the slab behave as two way bending structure for loads transferred after continuity is achieved.

2. Span Range considered for analysis is 7.00m to 11.00m.

3. Deflection check has been considered as per Annexure C of IS 456: 2000.

4. Effect of concentrated loads placed at mid span of the slab has been analyzed using bending moment coefficients recommended by Pigeaud's curves and its supporting methodology for which the book titled 'REINFORCED CONCRETE DESIGNER'S HANDBOOK' TENTH EDITION authored by: CHARLES E. REYNOLDS AND JAMES C. STEEDMAN has been referred.

The design has been conducted for in-situ construction methodology and segmental construction technique separately and the results of the two are compared.

Type 2: Cellular slab: (New addition in Major Thesis)

1. Prestressed concrete cell beams/ similar to box girders designed to span in one direction as simply supported for dead weight of the slab, over which structural concrete topping shall be provided with reinforcement for full continuity in both directions so that the slab behave as two way bending structure for loads transferred after continuity is achieved.

2. Span considered for analysis is 30.00m x 20.00m.

3. For continuity effects grid floor analysis has been adopted

4. Deflection check has been considered as per Annexure C of IS 456: 2000.

5. Effect of concentrated loads is not considered.

The design has been conducted for in-situ construction methodology as RCC Cellar Slab/ Grid Floor and for segmental construction technique as Prestressed concrete beam simply supported in direction of effective span and full continuity at supports in shorter span as well as longer span direction provided by un-tensioned Reinforcement. The two analyses have been performed separately and the results of the two are compared.

For detailed description of design methodology refer annexure attached at the end of this report.

ANALYSIS RESULTS OF SOLID SLAB SYSTEM

INPUT INFORMATION

Density of Concrete	=	2.5	t/m^3			
Density of Flooring	=	2.0	t/m^3			
Thickness of Flooring	=	100	mm			
Grade of Concrete	=	M-	25	and	M-	40
Grade of Steel	=	Fe-	415			
fck	=	2550	t/m^2	and	4080	t/m^2
fy	=	42330	t/m^2			
Xumax/d	=	0.48				
Partial factor of safety						
Dead Load	=	1.5				
Live Load	=	1.5				
Bar dia to be used	=	8	mm			
Clear Cover in Lx Direction	=	20	mm			
Bar dia to be used	=	8	mm			
Clear Cover in Ly Direction	=	28	mm			
Self Weight of Slab	=	Varies				
Dead Load due to Floor Finishing's	=	0.2	t/m^2			
Live Load	=	0.2	t/m^2			
Type of Slab Panel considered for analysis	=	Internal Panel				
		(continuous on all edges)				

Size of Slab Panel

Lx = 7
Ly = 7
Ly/Lx = 1.000

				Slab Without Partition Wall				Slab With Partition Wall Along Lx Dir.				Slab With Partition Wall Along Ly Dir.			
				Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.	
				Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection
Bending Moments (Before continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	1.6691	1.9906	0.0000	0.0000	1.7609	2.1438	0.0000	0.0000	1.8069	2.1897
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bending Moments (After continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	1.1378	1.4729	0.8658	0.8967	1.1907	1.5170	0.8747	0.9114	1.1731	1.5082	0.8791	0.9158
			Negative Bending Moment at Support	1.5170	1.9639	1.1544	1.1956	1.5876	2.0227	1.1662	1.2152	1.5641	2.0110	1.1721	1.2211
		Along Ly Dir.	Positive Bending Moment at Mid Span	1.1378	1.4729	0.8658	0.8967	1.1907	1.5170	0.8747	0.9114	1.1731	1.5082	0.8791	0.9158
			Negative Bending Moment at Support	1.5170	1.9639	1.1544	1.1956	1.5876	2.0227	1.1662	1.2152	1.5641	2.0110	1.1721	1.2211
Total concentrated load applied including (partial safety factor)				0.0000	0.0000	0.0000	0.0000	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300
Contact Length of load				1.0000	1.0000	1.0000	1.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000
Contact Width of load				1.0000	1.0000	1.0000	1.0000	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150
Bending Moments due to Loads [other than Dead Load (self Wt. of the Slab) + Flr. Load + Live Load] After continuity of the Structure is established	Bending Moment due to concentrated loads	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.2679	0.2662	0.2678	0.2673	0.3977	0.3887	0.3965	0.3940
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.3444	0.3422	0.3443	0.3436	0.5113	0.4998	0.5098	0.5066
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.3980	0.3896	0.3976	0.3951	0.2678	0.2660	0.2676	0.2671
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.5118	0.5009	0.5111	0.5080	0.3443	0.3420	0.3440	0.3434

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	Total Bending Moment (in tm/m)	Along Lx Dir.	Positive Bending Moment at Mid Span	1.1378	1.4729	2.5349	2.8873	1.4586	1.7832	2.9034	3.3225	1.5708	1.8969	3.0825	3.4995	
			Negative Bending Moment at Support	1.5170	1.9639	1.1544	1.1956	1.9320	2.3649	1.5105	1.5588	2.0754	2.5108	1.6819	1.7277	
		Along Ly Dir.	Positive Bending Moment at Mid Span	1.1378	1.4729	0.8658	0.8967	1.5887	1.9066	1.2723	1.3065	1.4409	1.7742	1.1467	1.1829	
			Negative Bending Moment at Support	1.5170	1.9639	1.1544	1.1956	2.0994	2.5236	1.6773	1.7232	1.9084	2.3530	1.5161	1.5645	
Over all Required Thickness of Slab				0.0980	**0.1740**	0.1090	**0.1300**	0.1100	**0.1840**	0.1150	**0.1400**	0.1060	**0.1820**	0.1180	**0.1430**	
Area of Steel Required cm^2/m	Along Lx Dir.		Positive Steel at Mid Span	4.6630	**2.7501**	10.0837	**8.5381**	5.1092	**3.1279**	10.7854	**8.9146**	5.9080	**3.3802**	11.0673	**9.1544**	
			Negative Steel at Support	6.5210	**3.7074**	4.0005	**3.2258**	7.0631	**4.1963**	4.9551	**3.8626**	8.2505	**4.5307**	5.3672	**4.1869**	
	Along Ly Dir.		Positive Steel at Mid Span	5.4200	**2.9161**	3.2862	**2.5990**	6.4035	**3.5432**	4.5820	**3.4701**	6.1301	**3.3349**	3.9165	**3.0311**	
			Negative Steel at Support	7.7540	**3.9367**	4.5096	**3.5231**	9.0525	**4.7552**	6.2751	**4.6676**	8.7010	**4.4818**	5.3367	**4.0755**	M-25
Governing Thickness of the slab				**0.1740**		**0.1300**		0.1840		0.1400		0.1820		0.1430		
% Reduction in Slab Thickness due to Precasting				**25.29%**				**23.91%**				**21.43%**				

Size of Slab Panel

Lx = 7

Ly = 7

Ly/Lx = 1.000

				Slab Without Partition Wall				Slab With Partition Wall Along Lx Dir.				Slab With Partition Wall Along Ly Dir.			
				Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.	
				Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection
Bending Moments (Before continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	1.3169	1.7456	0.0000	0.0000	1.3934	1.9141	0.0000	0.0000	1.4241	1.9447
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bending Moments (After continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	1.0716	1.4729	0.8320	0.8732	1.1113	1.5126	0.8394	0.8894	1.0981	1.5038	0.8423	0.8923
			Negative Bending Moment at Support	1.4288	1.9639	1.1094	1.1642	1.4818	2.0168	1.1192	1.1858	1.4641	2.0051	1.1231	1.1897
		Along Ly Dir.	Positive Bending Moment at Mid Span	1.0716	1.4729	0.8320	0.8732	1.1113	1.5126	0.8394	0.8894	1.0981	1.5038	0.8423	0.8923
			Negative Bending Moment at Support	1.4288	1.9639	1.1094	1.1642	1.4818	2.0168	1.1192	1.1858	1.4641	2.0051	1.1231	1.1897
Total concentrated load applied including (partial safety factor)				0.0000	0.0000	0.0000	0.0000	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300
Contact Length of load				1.0000	1.0000	1.0000	1.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000
Contact Width of load				1.0000	1.0000	1.0000	1.0000	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150
Bending Moments due to Loads [other than Dead Load (self Wt. of the Slab) + Flr. Load + Live Load] After continuity of the Structure is established	Bending Moment due to concentrated loads	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.2682	0.2662	0.2682	0.2676	0.3993	0.3889	0.3989	0.3956
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.3448	0.3422	0.3449	0.3440	0.5134	0.5000	0.5129	0.5087
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.3998	0.3897	0.3999	0.3966	0.2681	0.2660	0.2680	0.2674
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.5140	0.5010	0.5141	0.5099	0.3447	0.3420	0.3446	0.3438

	Total Bending Moment (in tm/m)	Along Lx Dir.	Positive Bending Moment at Mid Span	1.0716	1.4729	2.1489	2.6188	1.3795	1.7788	2.5010	3.0711	1.4974	1.8927	2.6653	3.2326
			Negative Bending Moment at Support	1.4288	1.9639	1.1094	1.1642	1.8266	2.3590	1.4641	1.5298	1.9775	2.5051	1.6360	1.6984
		Along Ly Dir.	Positive Bending Moment at Mid Span	1.0716	1.4729	0.8320	0.8732	1.5111	1.9023	1.2393	1.2860	1.3662	1.7698	1.1103	1.1597
			Negative Bending Moment at Support	1.4288	1.9639	1.1094	1.1642	1.9958	2.5178	1.6333	1.6957	1.8088	2.3471	1.4677	1.5335
Over all Required Thickness of Slab				0.0830	**0.1740**	0.0860	**0.1140**	0.0920	**0.1830**	0.0910	**0.1250**	0.0890	**0.1810**	0.0930	**0.1270**
Area of Steel Required cm²/m	Along Lx Dir.		Positive Steel at Mid Span	5.4554	**2.7175**	11.7035	**8.7924**	6.0715	**3.1006**	12.5913	**9.1087**	7.0484	**3.3476**	13.0492	**9.4150**
			Negative Steel at Support	7.5888	**3.6473**	5.3349	**3.6677**	8.3605	**4.1408**	6.6101	**4.3032**	9.7913	**4.4644**	7.2225	**4.7000**
	Along Ly Dir.		Positive Steel at Mid Span	6.5889	**2.8772**	4.5883	**3.0059**	7.9247	**3.5054**	6.4307	**3.9267**	7.5444	**3.3013**	5.4474	**3.4443**
			Negative Steel at Support	9.4083	**3.8647**	6.3542	**4.0644**	11.2019	**4.6782**	8.9144	**5.2597**	10.7015	**4.4131**	7.4868	**4.6159**
Governing Thickness of the slab				**0.1740**		**0.1140**		0.1830		0.1250		0.1810		0.1270	
% Reduction in Slab Thickness due to Precasting				**34.48%**				**31.69%**				**29.83%**			

M-40

Size of Slab Panel

Lx = 7

Ly = 9

Ly/Lx = 1.286

				Slab Without Partition Wall				Slab With Partition Wall Along Lx Dir.				Slab With Partition Wall Along Ly Dir.			
				Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.	
				Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection
Bending Moments (Before continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	1.8069	2.3428	0.0000	0.0000	1.9141	2.4959	0.0000	0.0000	1.9600	2.5419
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bending Moments (After continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	1.7252	2.2720	1.2977	1.3736	1.7772	2.3111	1.3129	1.3953	1.8033	2.3241	1.3194	1.4018
			Negative Bending Moment at Support	2.2608	2.9774	1.7006	1.8001	2.3290	3.0286	1.7205	1.8285	2.3632	3.0457	1.7290	1.8371
		Along Ly Dir.	Positive Bending Moment at Mid Span	1.1687	1.5391	0.8791	0.9305	1.2039	1.5656	0.8894	0.9452	1.2216	1.5744	0.8938	0.9496
			Negative Bending Moment at Support	1.5582	2.0521	1.1721	1.2407	1.6052	2.0874	1.1858	1.2603	1.6288	2.0992	1.1917	1.2662
Total concentrated load applied including (partial safety factor)				0.0000	0.0000	0.0000	0.0000	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300
Contact Length of load				1.0000	1.0000	1.0000	1.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000
Contact Width of load				1.0000	1.0000	1.0000	1.0000	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150
Bending Moments due to Loads [other than Dead Load (self Wt. of the Slab) + Flr. Load + Live Load] After continuity of the Structure is established	Bending Moment due to concentrated loads	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.3172	0.3157	0.3169	0.3163	0.4948	0.4771	0.4925	0.4842
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.4078	0.4059	0.4075	0.4066	0.6362	0.6134	0.6333	0.6225
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.3632	0.3556	0.3621	0.3586	0.2883	0.2790	0.2871	0.2827
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.4670	0.4573	0.4655	0.4610	0.3707	0.3587	0.3691	0.3635

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Total Bending Moment (in tm/m)	Along Lx Dir.	Positive Bending Moment at Mid Span	1.7252	2.2720	3.1046	3.7164	2.0944	2.6268	3.5439	4.2075	2.2981	2.8012	3.7719	4.4279	
		Negative Bending Moment at Support	2.2608	2.9774	1.7006	1.8001	2.7368	3.4345	2.1280	2.2351	2.9994	3.6591	2.3623	2.4596	
	Along Ly Dir.	Positive Bending Moment at Mid Span	1.1687	1.5391	0.8791	0.9305	1.5671	1.9212	1.2515	1.3038	1.5099	1.8534	1.1809	1.2323	
		Negative Bending Moment at Support	1.5582	2.0521	1.1721	1.2407	2.0722	2.5447	1.6513	1.7213	1.9995	2.4579	1.5608	1.6297	
Over all Required Thickness of Slab			0.1050	**0.1890**	0.1180	**0.1530**	0.1130	**0.1950**	0.1250	**0.1630**	0.1170	**0.1970**	0.1280	**0.1660**	
Area of Steel Required cm²/m	Along Lx Dir.	Positive Steel at Mid Span	6.7045	**3.8914**	11.1724	**8.8252**	7.4158	**4.3553**	11.8265	**9.2388**	7.7944	**4.5998**	12.2393	**9.5286**	
		Negative Steel at Support	9.3833	**5.1687**	5.4339	**3.9945**	10.3468	**5.7778**	6.3928	**4.6215**	10.8644	**6.1004**	6.9356	**4.9950**	
	Along Ly Dir.	Positive Steel at Mid Span	4.8911	**2.7414**	2.9428	**2.1517**	5.9885	**3.3123**	3.9296	**2.8021**	5.3910	**3.1499**	3.5592	**2.5796**	
		Negative Steel at Support	6.8690	**3.6935**	4.0114	**2.8996**	8.3890	**4.4399**	5.3283	**3.7458**	7.4801	**4.2244**	4.8159	**3.4498**	M-25
Governing Thickness of the slab			**0.1890**		**0.1530**		0.1950		0.1630		0.1970		0.1660		
% Reduction in Slab Thickness due to Precasting			**19.05%**				**16.41%**				**15.74%**				

Size of Slab Panel

Lx = 7

Ly = 9

Ly/Lx = 1.286

				Slab Without Partition Wall				Slab With Partition Wall Along Lx Dir.				Slab With Partition Wall Along Ly Dir.			
				Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.	
				Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection
Bending Moments (Before continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	1.4241	2.0672	0.0000	0.0000	1.5006	2.2203	0.0000	0.0000	1.5466	2.2663
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bending Moments (After continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	1.5950	2.2655	1.2434	1.3346	1.6405	2.3045	1.2543	1.3563	1.6601	2.3176	1.2608	1.3628
			Negative Bending Moment at Support	2.0902	2.9689	1.6295	1.7489	2.1500	3.0201	1.6437	1.7773	2.1755	3.0371	1.6522	1.7859
		Along Ly Dir.	Positive Bending Moment at Mid Span	1.0805	1.5347	0.8423	0.9041	1.1113	1.5611	0.8497	0.9188	1.1246	1.5700	0.8541	0.9232
			Negative Bending Moment at Support	1.4406	2.0462	1.1231	1.2054	1.4818	2.0815	1.1329	1.2250	1.4994	2.0933	1.1388	1.2309
Total concentrated load applied including (partial safety factor)				0.0000	0.0000	0.0000	0.0000	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300
Contact Length of load				1.0000	1.0000	1.0000	1.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000
Contact Width of load				1.0000	1.0000	1.0000	1.0000	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150
Bending Moments due to Loads [other than Dead Load (self Wt. of the Slab) + Flr. Load + Live Load] After continuity of the Structure is established	Bending Moment due to concentrated loads	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.3176	0.3157	0.3174	0.3166	0.4994	0.4773	0.4982	0.4883
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.4083	0.4059	0.4081	0.4070	0.6421	0.6137	0.6405	0.6278
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.3651	0.5570	0.3646	0.3602	0.2907	0.2791	0.2900	0.2849
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.4694	0.4574	0.4687	0.4632	0.3737	0.3588	0.3729	0.3663

M-40

Total Bending Moment (in tm/m)	Along Lx Dir.	Positive Bending Moment at Mid Span	1.5950	2.2655	2.6675	3.4018	1.9581	2.6202	3.0723	3.8932	2.1595	2.7949	3.3056	4.1174	
		Negative Bending Moment at Support	2.0902	2.9689	1.6295	1.7489	2.5583	3.4260	2.0518	2.1843	2.8176	3.6508	2.2927	2.4137	
	Along Ly Dir.	Positive Bending Moment at Mid Span	1.0805	1.5347	0.8423	0.9041	1.4764	2.1181	1.2143	1.2790	1.4153	1.8491	1.1441	1.2081	
		Negative Bending Moment at Support	1.4406	2.0462	1.1231	1.2054	1.9512	2.5389	1.6016	1.6882	1.8731	2.4521	1.5117	1.5972	
Over all Required Thickness of Slab			0.0850	**0.1880**	0.0930	**0.1350**	0.0920	**0.1940**	0.0980	**0.1450**	0.0950	**0.1960**	0.1010	**0.1480**	
Area of Steel Required cm^2/m	Along Lx Dir.	Positive Steel at Mid Span	8.2604	**3.8446**	13.0634	**9.0948**	9.0758	**4.2980**	14.0358	**9.5126**	9.6079	**4.5366**	14.4832	**9.2837**	
		Negative Steel at Support	11.5882	**5.0789**	7.1898	**4.4647**	12.6611	**5.6683**	8.5553	**5.1275**	13.3997	**5.9794**	9.2343	**5.5427**	
	Along Ly Dir.	Positive Steel at Mid Span	6.3167	**2.7206**	4.0251	**2.4435**	7.7097	**3.2820**	5.4651	**3.1655**	6.8792	**3.1233**	4.8572	**2.9033**	
		Negative Steel at Support	8.9482	**3.6504**	5.5171	**3.2866**	10.8757	**4.3784**	7.4655	**4.2202**	9.5872	**4.1701**	6.6049	**3.8729**	M-40
Governing Thickness of the slab			**0.1880**		**0.1350**		0.1940		0.1450		0.1960		0.1480		
% Reduction in Slab Thickness due to Precasting			**28.19%**				**25.26%**				**24.49%**				

Size of Slab Panel

Lx = 7

Ly = 11

Ly/Lx = 1.571

				Slab Without Partition Wall				Slab With Partition Wall Along Lx Dir.				Slab With Partition Wall Along Ly Dir.			
				Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.	
				Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection
Bending Moments (Before continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	1.8834	2.5266	0.0000	0.0000	1.9906	2.6797	0.0000	0.0000	2.0366	2.7409
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bending Moments (After continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	2.1140	2.7645	1.5565	1.6649	2.1760	2.8032	1.5746	1.6907	2.2070	2.8187	1.5823	1.7010
			Negative Bending Moment at Support	2.7590	3.6079	2.0314	2.1728	2.8400	3.6585	2.0549	2.2065	2.8803	3.6787	2.0650	2.2200
		Along Ly Dir.	Positive Bending Moment at Mid Span	1.2039	1.5744	0.8864	0.9482	1.2392	1.5964	0.8967	0.9629	1.2569	1.6052	0.9011	0.9687
			Negative Bending Moment at Support	1.6052	2.0992	1.1819	1.2642	1.6523	2.1286	1.1956	1.2838	1.6758	2.1403	1.2015	1.2916
Total concentrated load applied including (partial safety factor)				0.0000	0.0000	0.0000	0.0000	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300
Contact Length of load				1.0000	1.0000	1.0000	1.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000
Contact Width of load				1.0000	1.0000	1.0000	1.0000	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150
Bending Moments due to Loads [other than Dead Load (self Wt. of the Slab) + Flr. Load + Live Load] After continuity of the Structure is established	Bending Moment due to concentrated loads	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.3377	0.3363	0.3376	0.3368	0.5354	0.5191	0.5339	0.5243
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.4342	0.4324	0.4340	0.4330	0.6883	0.6674	0.6864	0.6741
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.3600	0.3532	0.3593	0.3555	0.2573	0.2508	0.2567	0.2529
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.4629	0.4541	0.4619	0.4570	0.3308	0.3224	0.3301	0.3252

M-25

	Total Bending Moment (in tm/m)	Along Lx Dir.	Positive Bending Moment at Mid Span	2.1140	2.7645	3.4399	4.1915	2.5137	3.1395	3.9028	4.7072	2.7424	3.3378	4.1528	4.9662	
			Negative Bending Moment at Support	2.7590	3.6079	2.0314	2.1728	3.2742	4.0909	2.4889	2.6395	3.5686	4.3461	2.7514	2.8941	
		Along Ly Dir.	Positive Bending Moment at Mid Span	1.2039	1.5744	0.8864	0.9482	1.5992	1.9496	1.2560	1.3184	1.5142	1.8560	1.1578	1.2216	
			Negative Bending Moment at Support	1.6052	2.0992	1.1819	1.2642	2.1152	2.5827	1.6575	1.7408	2.0066	2.4627	1.5316	1.6168	
Over all Required Thickness of Slab				0.1130	**0.1970**	0.1230	**0.1650**	0.1210	**0.2020**	0.1300	**0.1750**	0.1250	**0.2040**	0.1330	**0.1790**	
Area of Steel Required cm^2/m	Along Lx Dir.		Positive Steel at Mid Span	7.4988	**4.5367**	11.7502	**9.0325**	8.1827	**5.0250**	12.4091	**9.4457**	8.5838	**5.2937**	12.8665	**9.7101**	
			Negative Steel at Support	10.4580	**6.0095**	6.2205	**4.4139**	11.3826	**6.6536**	7.1842	**5.0242**	11.9356	**7.0094**	7.7751	**5.3802**	
	Along Ly Dir.		Positive Steel at Mid Span	4.4400	**2.6623**	2.7867	**1.9850**	5.4291	**3.2150**	3.7137	**2.5807**	4.8390	**3.0181**	3.2909	**2.3173**	
			Negative Steel at Support	6.1586	**3.5838**	3.7885	**2.6701**	7.5037	**4.3064**	5.0195	**3.4433**	6.6478	**4.0460**	4.4419	**3.0948**	M-25
Governing Thickness of the slab				**0.1970**		**0.1650**		0.2020		0.1750		0.2040		0.1790		
% Reduction in Slab Thickness due to Precasting				**16.24%**				**13.37%**				**12.25%**				

Size of Slab Panel

Lx = 7

Ly = 11

Ly/Lx = 1.571

				Slab Without Partition Wall				Slab With Partition Wall Along Lx Dir.				Slab With Partition Wall Along Ly Dir.			
				Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.	
				Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection
Bending Moments (Before continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	1.4853	2.2509	0.0000	0.0000	1.5619	2.3888	0.0000	0.0000	1.6078	2.4500
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bending Moments (After continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	1.9514	2.7568	1.4894	1.6184	1.9979	2.7955	1.5023	1.6417	2.0211	2.8187	1.5100	1.6520
			Negative Bending Moment at Support	2.5468	3.5978	1.9438	2.1122	2.6074	3.6484	1.9606	2.1425	2.6377	3.6787	1.9707	2.1560
		Along Ly Dir.	Positive Bending Moment at Mid Span	1.1113	1.5700	0.8482	0.9217	1.1378	1.5920	0.8555	0.9349	1.1510	1.6052	0.8600	0.9408
			Negative Bending Moment at Support	1.4818	2.0933	1.1309	1.2289	1.5170	2.1227	1.1407	1.2466	1.5347	2.1403	1.1466	1.2544
Total concentrated load applied including (partial safety factor)				0.0000	0.0000	0.0000	0.0000	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300	4.8300
Contact Length of load				1.0000	1.0000	1.0000	1.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000
Contact Width of load				1.0000	1.0000	1.0000	1.0000	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150
Bending Moments due to Loads [other than Dead Load (self Wt. of the Slab) + Flr. Load + Live Load] After continuity of the Structure is established	Bending Moment due to concentrated loads	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.3381	0.3364	0.3380	0.3371	0.5398	0.5191	0.5391	0.5284
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.4347	0.4325	0.4346	0.4334	0.6941	0.6674	0.6931	0.6793
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.3620	0.3533	0.3617	0.3571	0.2591	0.2508	0.2588	0.2545
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.4654	0.4542	0.4650	0.4591	0.3331	0.3224	0.3328	0.3272

M-40

Total Bending Moment (in tm/m)	Along Lx Dir.	Positive Bending Moment at Mid Span	1.9514	2.7568	2.9747	3.8693	2.3360	3.1319	3.4022	4.3676	2.5609	3.3378	3.6569	4.6304	
		Negative Bending Moment at Support	2.5468	3.5978	1.9438	2.1122	3.0421	4.0809	2.3952	2.5759	3.3318	4.3461	2.6638	2.8353	
	Along Ly Dir.	Positive Bending Moment at Mid Span	1.1113	1.5700	0.8482	0.9217	1.4998	1.9453	1.2172	1.2920	1.4101	1.8560	1.1188	1.1953	
		Negative Bending Moment at Support	1.4818	2.0933	1.1309	1.2289	1.9824	2.5769	1.6057	1.7057	1.8678	2.4627	1.4794	1.5816	
Over all Required Thickness of Slab			0.0920	**0.1960**	0.0970	**0.1470**	0.0980	**0.2010**	0.1020	**0.1560**	0.1010	**0.2040**	0.1050	**0.1600**	
Area of Steel Required cm^2/m	Along Lx Dir.	Positive Steel at Mid Span	9.0391	**4.4729**	13.7533	**9.2665**	9.9637	**4.9482**	14.7300	**9.7285**	10.5232	**5.1906**	15.2304	**10.0093**	
		Negative Steel at Support	12.5872	**5.8892**	8.1817	**4.8625**	13.8538	**6.5088**	9.5521	**5.5404**	14.6357	**6.8247**	10.2849	**5.9293**	
	Along Ly Dir.	Positive Steel at Mid Span	5.5650	**2.6437**	3.7703	**2.2208**	6.9241	**3.1880**	5.1085	**2.8996**	6.1108	**2.9839**	4.4419	**2.5902**	
		Negative Steel at Support	7.7425	**3.5455**	5.1474	**2.9820**	9.6072	**4.2514**	6.9433	**3.8598**	8.4154	**3.9838**	6.0174	**3.4519**	M-40
Governing Thickness of the slab			**0.1960**		**0.1470**		0.2010		0.1560		0.2040		0.1600		
% Reduction in Slab Thickness due to Precasting			**25.00%**				**22.39%**				**21.57%**				

Size of Slab Panel

Lx = 9

Ly = 9

Ly/Lx = 1.000

			Slab Without Partition Wall				Slab With Partition Wall Along Lx Dir.				Slab With Partition Wall Along Ly Dir.			
			Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.	
			Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection
Bending Moments (Before continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	3.6956	4.5816	0.0000	0.0000	3.8475	4.8600	0.0000	0.0000	3.9234	4.9106
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bending Moments (After continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	2.0412	2.7921	1.5212	1.6062	2.1287	2.8577	1.5358	1.6330	2.1068	2.8431	1.5431	1.6378
			Negative Bending Moment at Support	2.7216	3.7228	2.0282	2.1416	2.8382	3.8102	2.0477	2.1773	2.8091	3.7908	2.0574	2.1838
		Along Ly Dir.	Positive Bending Moment at Mid Span	2.0412	2.7921	1.5212	1.6062	2.1287	2.8577	1.5358	1.6330	2.1068	2.8431	1.5431	1.6378
			Negative Bending Moment at Support	2.7216	3.7228	2.0282	2.1416	2.8382	3.8102	2.0477	2.1770	2.8091	3.7908	2.0574	2.1838
Total concentrated load applied including (partial safety factor)				0.0000	0.0000	0.0000	0.0000	6.2100	6.2100	6.2100	6.2100	6.2100	6.2100	6.2100	6.2100
Contact Length of load				1.0000	1.0000	1.0000	1.0000	9.0000	9.0000	9.0000	9.0000	9.0000	9.0000	9.0000	9.0000
Contact Width of load				1.0000	1.0000	1.0000	1.0000	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150
Bending Moments due to Loads [other than Dead Load (self Wt. of the Slab) + Flr. Load + Live Load] After continuity of the Structure is established	Bending Moment due to concentrated loads	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.3447	0.3425	0.3443	0.3436	0.5129	0.5017	0.5104	0.5065
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.4432	0.4404	0.4427	0.4417	0.6594	0.6450	0.6562	0.6512
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.5134	0.5025	0.5114	0.5076	0.3446	0.3424	0.3441	0.3433
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.6601	0.6460	0.6576	0.6526	0.4431	0.4402	0.4424	0.4414

M-25

	Total Bending Moment (in tm/m)	Along Lx Dir.	Positive Bending Moment at Mid Span	2.0412	2.7921	5.2168	6.1878	2.4734	3.2002	5.7276	6.8366	2.6197	3.3448	5.9769	7.0549
			Negative Bending Moment at Support	2.7216	3.7228	2.0282	2.1416	3.2814	4.2506	2.4904	2.6190	3.4685	4.4358	2.7136	2.8350
		Along Ly Dir.	Positive Bending Moment at Mid Span	2.0412	2.7921	1.5212	1.6062	2.6421	3.3602	2.0472	2.1406	2.4514	3.1855	1.8872	1.9811
			Negative Bending Moment at Support	2.7216	3.7228	2.0282	2.1416	3.4983	4.4562	2.7053	2.8296	3.2522	4.2310	2.4998	2.6252
Over all Required Thickness of Slab				0.1200	**0.2230**	0.1460	**0.1810**	0.1320	**0.2320**	0.1520	**0.1920**	0.1290	**0.2300**	0.1550	**0.1940**
Area of Steel Required cm^2/m	Along Lx Dir.		Positive Steel at Mid Span	6.5054	**3.9393**	14.4538	**12.3023**	6.9643	**4.3273**	15.1124	**12.6248**	7.7161	**4.5778**	15.3905	**12.8917**
			Negative Steel at Support	9.1440	**5.3155**	4.8321	**3.8618**	9.6952	**5.8194**	5.7053	**4.4268**	10.8211	**6.1521**	6.0957	**4.7485**
	Along Ly Dir.		Positive Steel at Mid Span	7.3052	**4.1167**	3.8378	**3.0295**	8.3246	**4.7493**	4.9749	**3.7811**	7.9419	**4.5416**	4.4312	**3.4422**
			Negative Steel at Support	10.4631	**5.5614**	5.2293	**4.0893**	11.8175	**6.3891**	6.7523	**5.0693**	11.2824	**6.1161**	6.0055	**4.6189**
Governing Thickness of the slab				**0.2230**		**0.1810**		0.2320		0.1920		0.2300		0.1940	
% Reduction in Slab Thickness due to Precasting				**18.83%**				**17.24%**				**15.65%**			

M-25

Size of Slab Panel

Lx = 9

Ly = 9

Ly/Lx = 1.000

				Slab Without Partition Wall				Slab With Partition Wall Along Lx Dir.				Slab With Partition Wall Along Ly Dir.			
				Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.	
				Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection
Bending Moments (Before continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	2.8097	3.9994	0.0000	0.0000	2.9363	4.2525	0.0000	0.0000	2.9869	4.3284
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bending Moments (After continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	1.8881	2.7848	1.4361	1.5503	1.9610	2.8504	1.4483	1.5746	1.9391	2.8358	1.4531	1.5819
			Negative Bending Moment at Support	2.5175	3.7130	1.9148	2.0671	2.6147	3.8005	1.9310	2.0995	2.5855	3.7811	1.9375	2.1092
		Along Ly Dir.	Positive Bending Moment at Mid Span	1.8881	2.7848	1.4361	1.5503	1.9610	2.8504	1.4483	1.5746	1.9391	2.8358	1.4531	1.5819
			Negative Bending Moment at Support	2.5175	3.7130	1.9148	2.0671	2.6147	3.8005	1.9310	2.0995	2.5855	3.7811	1.9375	2.1092
Total concentrated load applied including (partial safety factor)				0.0000	0.0000	0.0000	0.0000	6.2100	6.2100	6.2100	6.2100	6.2100	6.2100	6.2100	6.2100
Contact Length of load				1.0000	1.0000	1.0000	1.0000	9.0000	9.0000	9.0000	9.0000	9.0000	9.0000	9.0000	9.0000
Contact Width of load				1.0000	1.0000	1.0000	1.0000	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150
Bending Moments due to Loads [other than Dead Load (self Wt. of the Slab) + Flr. Load + Live Load] After continuity of the Structure is established	Bending Moment due to concentrated loads	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.3452	0.3426	0.3450	0.3440	0.5151	0.5018	0.5140	0.5088
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.4438	0.4404	0.4436	0.4423	0.6623	0.6452	0.6608	0.6542
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.5156	0.5026	0.5149	0.5099	0.3451	0.3424	0.3448	0.3438
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.6629	0.6462	0.6620	0.6556	0.4437	0.4402	0.4434	0.4420

M-40

	Total Bending Moment (in tm/m)	Along Lx Dir.	Positive Bending Moment at Mid Span	1.8881	2.7848	4.2458	5.5497	2.3062	3.1930	4.7296	6.1711	2.4542	3.3376	4.9540	6.4191	
			Negative Bending Moment at Support	2.5175	3.7130	1.9148	2.0671	3.0585	4.2409	2.3746	2.5418	3.2478	4.4263	2.5983	2.7634	
		Along Ly Dir.	Positive Bending Moment at Mid Span	1.8881	2.7848	1.4361	1.5503	2.4766	3.3530	1.9632	2.0845	2.2842	3.1782	1.7979	1.9257	
			Negative Bending Moment at Support	2.5175	3.7130	1.9148	2.0671	3.2776	4.4467	2.5930	2.7551	3.0292	4.2213	2.3809	2.5512	
Over all Required Thickness of Slab				0.0990	**0.2220**	0.1110	**0.1580**	0.1090	**0.2310**	0.1160	**0.1680**	0.1060	**0.2290**	0.1180	**0.1710**	
Area of Steel Required cm^2/m	Along Lx Dir.		Positive Steel at Mid Span	7.6443	**3.8988**	16.4974	**12.4452**	8.1850	**4.2803**	17.3566	**12.8213**	9.1975	**4.5246**	17.8126	**13.0617**	
			Negative Steel at Support	10.6977	**5.2358**	6.4768	**4.3343**	11.3402	**5.7277**	7.6727	**4.9712**	12.8414	**6.0481**	8.2587	**5.3032**	
	Along Ly Dir.		Positive Steel at Mid Span	8.8707	**4.0704**	5.3061	**3.4385**	10.1113	**4.6899**	6.9414	**4.3033**	9.7013	**4.4868**	6.1304	**3.8740**	
			Negative Steel at Support	12.7008	**5.4699**	7.2772	**4.6315**	14.3223	**6.2728**	9.4963	**5.7535**	13.7762	**6.0087**	8.3608	**5.1847**	M-40
Governing Thickness of the slab				**0.2220**		**0.1580**		0.2310		0.1680		0.2290		0.1710		
% Reduction in Slab Thickness due to Precasting				**28.83%**				**27.27%**				**25.33%**				

Size of Slab Panel

Lx	=	9	Ly/Lx = 1.222
Ly	=	11	

				Slab Without Partition Wall				Slab With Partition Wall Along Lx Dir.				Slab With Partition Wall Along Ly Dir.			
				Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.	
				Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection
Bending Moments (Before continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	3.9488	5.2903	0.0000	0.0000	4.0753	5.5434	0.0000	0.0000	4.1766	5.6194
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bending Moments (After continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	2.8871	3.9860	2.1179	2.2944	2.9670	4.0360	2.1345	2.3277	3.0070	4.0659	2.1479	2.3377
			Negative Bending Moment at Support	3.8527	5.3192	2.8262	3.0617	3.9594	5.3858	2.8484	3.1062	4.0127	5.4258	2.8662	3.1195
		Along Ly Dir.	Positive Bending Moment at Mid Span	2.1068	2.9087	1.5455	1.6743	2.1651	2.9452	1.5576	1.6986	2.1943	2.9670	1.5674	1.7059
			Negative Bending Moment at Support	2.8091	3.8783	2.0606	2.2324	2.8868	3.9269	2.0768	2.2648	2.9257	3.9560	2.0898	2.2745
Total concentrated load applied including (partial safety factor)				0.0000	0.0000	0.0000	0.0000	6.2100	6.2100	6.2100	6.2100	6.2100	6.2100	6.2100	6.2100
Contact Length of load				1.0000	1.0000	1.0000	1.0000	9.0000	9.0000	9.0000	9.0000	9.0000	9.0000	9.0000	9.0000
Contact Width of load				1.0000	1.0000	1.0000	1.0000	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150
Bending Moments due to Loads [other than Dead Load (self Wt. of the Slab) + Flr. Load + Live Load] After continuity of the Structure is established	Bending Moment due to concentrated loads	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.3916	0.3900	0.3912	0.3904	0.6203	0.5978	0.6157	0.6035
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.5034	0.5014	0.5030	0.5019	0.7976	0.7686	0.7916	0.7759
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.4510	0.4432	0.4492	0.4450	0.3933	0.3799	0.3904	0.3832
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.5798	0.5698	0.5776	0.5722	0.5056	0.4885	0.5020	0.4927

M-25

Total Bending Moment (in tm/m)	Along Lx Dir.	Positive Bending Moment at Mid Span	2.8871	3.9860	6.0667	7.5847	3.3586	4.4260	6.6010	8.2615	3.6273	4.6637	6.9402	8.5606	
		Negative Bending Moment at Support	3.8527	5.3192	2.8262	3.0617	4.4628	5.8872	3.3514	3.6081	4.8103	6.1944	3.6578	3.8954	
	Along Ly Dir.	Positive Bending Moment at Mid Span	2.1068	2.9087	1.5455	1.6743	2.6161	3.3884	2.0068	2.1436	2.5876	3.3469	1.9578	2.0891	
		Negative Bending Moment at Support	2.8091	3.8783	2.0606	2.2324	3.4666	4.4967	2.6544	2.8370	3.4313	4.4445	2.5918	2.7672	
Over all Required Thickness of Slab			0.1290	**0.2390**	0.1560	**0.2090**	0.1370	**0.2440**	0.1610	**0.2190**	0.1410	**0.2470**	0.1650	**0.2220**	
Area of Steel Required cm^2/m	Along Lx Dir.	Positive Steel at Mid Span	8.6490	**5.2468**	15.5018	**12.5447**	9.3569	**5.7088**	16.3047	**12.9266**	9.7739	**5.9417**	16.6155	**13.2010**	
		Negative Steel at Support	12.3907	**7.1081**	6.3155	**4.6915**	13.3373	**7.7157**	7.2859	**5.2598**	13.9087	**8.0218**	7.7516	**5.6058**	
	Along Ly Dir.	Positive Steel at Mid Span	6.6559	**3.9401**	3.5534	**2.6336**	7.7038	**4.4985**	4.4830	**3.2038**	7.2456	**4.3749**	4.2194	**3.0679**	
		Negative Steel at Support	9.3644	**5.3140**	4.8240	**3.5424**	10.8139	**6.0458**	6.0601	**4.2823**	10.1024	**5.8803**	5.6966	**4.1018**	M-25
Governing Thickness of the slab			**0.2390**		**0.2090**		0.2440		0.2190		0.2470		0.2220		
% Reduction in Slab Thickness due to Precasting			**12.55%**				**10.25%**				**10.12%**				

Size of Slab Panel

Lx = 9

Ly = 11

Ly/Lx = 1.222

				Slab Without Partition Wall				Slab With Partition Wall Along Lx Dir.				Slab With Partition Wall Along Ly Dir.			
				Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.	
				Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection
Bending Moments (Before continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	3.0122	4.6322	0.0000	0.0000	3.1134	4.8853	0.0000	0.0000	3.1894	4.9866
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bending Moments (After continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	2.6274	3.9760	1.9947	2.2078	2.6973	4.0260	2.0080	2.2411	2.7273	4.0559	2.0180	2.2544
			Negative Bending Moment at Support	3.5061	5.3058	2.6618	2.9462	3.5994	5.3725	2.6796	2.9906	3.6394	5.4125	2.6929	3.0084
		Along Ly Dir.	Positive Bending Moment at Mid Span	1.9173	2.9014	1.4556	1.6111	1.9683	2.9379	1.4653	1.6354	1.9902	2.9597	1.4726	1.6451
			Negative Bending Moment at Support	2.5564	3.8686	1.9408	2.1481	2.6244	3.9172	1.9537	2.1805	2.6536	3.9463	1.9634	2.1935
Total concentrated load applied including (partial safety factor)				0.0000	0.0000	0.0000	0.0000	6.2100	6.2100	6.2100	6.2100	6.2100	6.2100	6.2100	6.2100
Contact Length of load				1.0000	1.0000	1.0000	1.0000	9.0000	9.0000	9.0000	9.0000	9.0000	9.0000	9.0000	9.0000
Contact Width of load				1.0000	1.0000	1.0000	1.0000	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150
Bending Moments due to Loads [other than Dead Load (self Wt. of the Slab) + Flr. Load + Live Load] After continuity of the Structure is established	Bending Moment due to concentrated loads	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.3919	0.3900	0.3918	0.3907	0.6259	0.5980	0.6233	0.6092
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.5039	0.5014	0.5037	0.5024	0.8047	0.7689	0.8014	0.7833
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.4530	0.4433	0.4520	0.4469	0.3966	0.3800	0.3950	0.3866
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.5824	0.5699	0.5811	0.5746	0.5099	0.4886	0.5079	0.4971

M-40

Total Bending Moment (in tm/m)	Along Lx Dir.	Positive Bending Moment at Mid Span	2.6274	3.9760	5.0069	6.8400	3.0892	4.4160	5.5132	7.5171	3.3532	4.6539	5.8307	7.8502
		Negative Bending Moment at Support	3.5061	5.3058	2.6618	2.9462	4.1033	5.8739	3.1833	3.4930	4.4441	6.1814	3.4943	3.7917
	Along Ly Dir.	Positive Bending Moment at Mid Span	1.9173	2.9014	1.4556	1.6111	2.4213	3.3812	1.9173	2.0823	2.3868	3.3397	1.8676	2.0317
		Negative Bending Moment at Support	2.5564	3.8686	1.9408	2.1481	3.2068	4.4871	2.5348	2.7551	3.1635	4.4349	2.4713	2.6906
Over all Required Thickness of Slab			0.1030	**0.2380**	0.1190	**0.1830**	0.1100	**0.2430**	0.1230	**0.1930**	0.1130	**0.2460**	0.1260	**0.1970**
Area of Steel Required cm^2/m	Along Lx Dir.	Positive Steel at Mid Span	10.4706	**5.1749**	17.7532	**12.7404**	11.2925	**5.6254**	18.8424	**13.1377**	11.8740	**5.8526**	19.3179	**13.3982**
		Negative Steel at Support	15.0102	**6.9679**	8.3742	**5.2086**	16.0726	**7.5535**	9.7216	**5.8204**	16.8810	**7.8487**	10.4032	**6.1806**
	Along Ly Dir.	Positive Steel at Mid Span	8.3519	**3.9012**	4.8201	**2.9573**	9.6738	**4.4486**	6.1527	**3.5953**	9.0503	**4.3287**	5.7614	**3.4171**
		Negative Steel at Support	11.8175	**5.2375**	6.5726	**3.9713**	13.6374	**5.9485**	8.3610	**4.7949**	12.6567	**5.7900**	7.8127	**4.5585**
Governing Thickness of the slab			**0.2380**		**0.1830**		0.2430		0.1930		0.2460		0.1970	
% Reduction in Slab Thickness due to Precasting			**23.11%**				**20.58%**				**19.92%**			

M-40

Size of Slab Panel

Lx = 11

Ly = 11

Ly/Lx = 1.000

				Slab Without Partition Wall				Slab With Partition Wall Along Lx Dir.				Slab With Partition Wall Along Ly Dir.			
				Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.	
				Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection
Bending Moments (Before continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	7.1466	9.0750	0.0000	0.0000	7.3734	9.4909	0.0000	0.0000	7.4869	9.6044
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bending Moments (After continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	3.3215	4.8896	2.4285	2.6136	3.4412	4.9767	2.4503	2.6535	3.4086	4.9550	2.4611	2.6644
			Negative Bending Moment at Support	4.4286	6.5195	3.2380	3.4848	4.5883	6.6356	3.2670	3.5380	4.5448	6.6066	3.2815	3.5526
		Along Ly Dir.	Positive Bending Moment at Mid Span	3.3215	4.8896	2.4285	3.6136	3.4412	4.9767	2.4503	2.6535	3.4086	4.9550	2.4611	2.6644
			Negative Bending Moment at Support	4.4286	6.5195	3.2380	3.4848	4.5883	6.6356	3.2670	3.5380	4.5448	6.6066	3.2815	3.5526
Total concentrated load applied including (partial safety factor)				0.0000	0.0000	0.0000	0.0000	7.5900	7.5900	7.5900	7.5900	7.5900	7.5900	7.5900	7.5900
Contact Length of load				1.0000	1.0000	1.0000	1.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000
Contact Width of load				1.0000	1.0000	1.0000	1.0000	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150
Bending Moments due to Loads [other than Dead Load (self Wt. of the Slab) + Flr. Load + Live Load] After continuity of the Structure is established	Bending Moment due to concentrated loads	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.4215	0.4184	0.4208	0.4197	0.6280	0.6123	0.6237	0.6178
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.5420	0.5380	0.5410	0.5396	0.8075	0.7872	0.8019	0.7943
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.6285	0.6131	0.6248	0.6193	0.4214	0.4183	0.4206	0.4194
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.8081	0.7882	0.8033	0.7962	0.5418	0.5378	0.5407	0.5392

M-25

	Total Bending Moment (in tm/m)	Along Lx Dir.	Positive Bending Moment at Mid Span	3.3215	4.8896	9.5751	11.6886	3.8627	5.3951	10.2445	12.5641	4.0366	5.5673	10.5717	12.8866	
			Negative Bending Moment at Support	4.4286	6.5195	3.2380	3.4848	5.1303	7.1736	3.8080	4.0776	5.3523	7.3938	4.0834	4.3469	
		Along Ly Dir.	Positive Bending Moment at Mid Span	3.3215	4.8896	2.4285	3.6136	4.0697	5.5898	3.0751	3.2728	3.8300	5.3733	2.8817	3.0838	
			Negative Bending Moment at Support	4.4286	6.5195	3.2380	3.4848	5.3964	7.4238	4.0703	4.3342	5.0866	7.1444	3.8222	4.0918	
Over all Required Thickness of Slab				0.1450	0.2890	0.1890	0.2400	0.1560	0.2970	0.1950	0.2510	0.1530	0.2950	0.1980	0.2540	
Area of Steel Required cm^2/m	Along Lx Dir.		Positive Steel at Mid Span	8.4283	5.1783	19.6371	16.8852	8.9546	5.5539	20.2474	17.1903	9.7103	5.7832	20.5118	17.3988	
			Negative Steel at Support	11.8719	6.9861	5.6499	4.5392	12.5271	7.4751	6.4509	5.0654	13.6714	7.7792	6.8157	5.3376	
	Along Ly Dir.		Positive Steel at Mid Span	9.2341	5.3512	4.4054	3.5104	10.3447	5.9495	5.4220	4.1912	9.9545	5.7569	4.9599	3.8849	
			Negative Steel at Support	13.2026	7.2256	5.9781	4.7278	14.7166	8.0089	7.3274	5.6129	14.1694	7.7561	6.7015	5.2077	M-25
Governing Thickness of the slab				0.2890		0.2400		0.2970		0.2510		0.2950		0.2540		
% Reduction in Slab Thickness due to Precasting				16.96%				15.49%				13.90%				

Size of Slab Panel

Lx	=	11	Ly/Lx = 1.000
Ly	=	11	

				Slab Without Partition Wall				Slab With Partition Wall Along Lx Dir.				Slab With Partition Wall Along Ly Dir.			
				Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.	
				Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection
Bending Moments (Before continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	5.2938	7.9028	0.0000	0.0000	5.4828	8.2809	0.0000	0.0000	5.5584	8.3944
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bending Moments (After continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	3.0165	4.8787	2.2506	2.5011	3.1145	4.9658	2.2688	2.5374	3.0819	4.9441	2.2760	2.5483
			Negative Bending Moment at Support	4.0220	6.5050	3.0008	3.3348	4.1527	6.6211	3.0250	3.3832	4.1092	6.5921	3.0347	3.3977
		Along Ly Dir.	Positive Bending Moment at Mid Span	3.0165	4.8787	2.2506	2.5011	3.1145	4.9658	2.2688	2.5374	3.0819	4.9441	2.2760	2.5483
			Negative Bending Moment at Support	4.0220	6.5050	3.0008	3.3348	4.1527	6.6211	3.0250	3.3832	4.1092	6.5921	3.0347	3.3977
Total concentrated load applied including (partial safety factor)				0.0000	0.0000	0.0000	0.0000	7.5900	7.5900	7.5900	7.5900	7.5900	7.5900	7.5900	7.5900
Contact Length of load				1.0000	1.0000	1.0000	1.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000
Contact Width of load				1.0000	1.0000	1.0000	1.0000	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150	0.1150
Bending Moments due to Loads [other than Dead Load (self Wt. of the Slab) + Flr. Load + Live Load] After continuity of the Structure is established	Bending Moment due to concentrated loads	Along Lx Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.2210	0.4185	0.4217	0.4203	0.6309	0.6124	0.6286	0.6214
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.5427	0.5380	0.5422	0.5404	0.8112	0.7874	0.8082	0.7989
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.0000	0.0000	0.0000	0.0000	0.6314	0.6132	0.6296	0.6224	0.4220	0.4183	0.4216	0.4201
			Negative Bending Moment at Support	0.0000	0.0000	0.0000	0.0000	0.8118	0.7884	0.8095	0.8003	0.5426	0.5378	0.5420	0.5401

M-40

Total Bending Moment (in tm/m)	Along Lx Dir.	Positive Bending Moment at Mid Span	3.0165	4.8787	7.5444	10.4039	3.3355	5.3843	8.1733	11.2386	3.7128	5.5565	8.4630	11.5641	
		Negative Bending Moment at Support	4.0220	6.5050	3.0008	3.3348	4.6954	7.1591	3.5672	3.9236	4.9204	7.3795	3.8429	4.1966	
	Along Ly Dir.	Positive Bending Moment at Mid Span	3.0165	4.8787	2.2506	2.5011	3.7459	5.5790	2.8984	3.1598	3.5039	5.3624	2.6976	2.9684	
		Negative Bending Moment at Support	4.0220	6.5050	3.0008	3.3348	4.9645	7.4095	3.8345	4.1835	4.6518	7.1299	3.5767	3.9378	
Over all Required Thickness of Slab			0.1170	**0.2880**	0.1400	**0.2090**	0.1260	**0.2960**	0.1450	**0.2190**	0.1230	**0.2940**	0.1470	**0.2220**	
Area of Steel Required cm^2/m	Along Lx Dir.	Positive Steel at Mid Span	9.9013	**5.1212**	21.9820	**16.8659**	10.5465	**5.4902**	22.7987	**17.2293**	11.5917	**5.7136**	23.2385	**17.4556**	
		Negative Steel at Support	13.8984	**6.8766**	7.5319	**5.0370**	14.6970	**7.3533**	8.6464	**5.6324**	16.2697	**7.6462**	9.1973	**5.9402**	
	Along Ly Dir.	Positive Steel at Mid Span	11.1555	**5.2882**	6.0050	**3.9274**	12.5630	**5.8740**	7.4782	**4.7115**	12.1341	**5.6857**	6.7849	**4.3454**	
		Negative Steel at Support	15.9564	**7.1044**	8.1890	**5.2793**	17.8630	**7.8642**	10.1625	**6.2946**	17.2881	**7.6194**	9.2107	**5.8123**	M-40
Governing Thickness of the slab			**0.2880**		**0.2090**		0.2960		0.2190		0.2940		0.2220		
% Reduction in Slab Thickness due to Precasting			**27.43%**				**26.01%**				**24.49%**				

CONCLUSION
(FOR SOLID SLAB TYPE SYSTEM)

The analysis results indicate that the design of slabs is primarily governed by deflection criteria. The result shows reduction in slab thicknesses due to precasting of the slab element in comparison to the required slab thickness in cast-in-situ construction methodology.

The reduction in slab thickness as percentage of the slab thickness required for design of slab element to be cast-in –situ lies in the range of **10% to 26%** when M-25 Grade of concrete is used along with Fe-415 HYSD reinforcement.

The reduction in slab thicknesses tends to increase with increase in Grade of Concrete primarily due to enhancement in Modulus of elasticity which helps in controlling the deflections.

The percentage reduction in slab thicknesses as compared to the Cast-in-situ construction when M-40 Grade of concrete is used along with Fe-415 HYSD reinforcement lies in the range of **20% to 34.5%**.

From the analysis it is quite clear that where ever the design of structural elements is governed by deflection criteria, the segmental construction method has tremendous potential in providing economy in the design of such elements.

Since **10% to 34.5%** economy is achieved in the design of slabs which contribute to **60% to 70%** of the total structural dead weight of the building **therefore almost 10% to 24% economy is achieved in the structural part of the building due to slab elements only** further this reduction in weights will reduce the forces on the beams and columns giving more economy to the design. **Above all reduction in average weights by 20% means that 20% more stories can be constructed over the same foundations and the ground, thus giving an option for achieving new heights in building construction**.

ANALYSIS RESULTS OF CELLULAR SLAB TYPE SYSTEM

INPUT INFORMATION

Density of Concrete	=	2.5	t/m^3
Density of Flooring	=	2.0	t/m^3
Thickness of Flooring	=	100	mm
Grade of Concrete	=	M-	40
Grade of Steel	=	Fe-	415
fck	=	4080	t/m^2
fy	=	42330	t/m^2
Xumax/d	=	0.48	
Partial factor of safety			
Dead Load	=	1.5	
Live Load	=	1.5	
Bar dia to be used	=	16	mm
Clear Cover in Lx Direction	=	20	mm
Bar dia to be used	=	16	mm
Clear Cover in Ly Direction	=	20	mm
(Clear cover in Lx and Ly direction has been taken same for siplification)			
Self Weight of Slab	=	Varies	
Dead Load due to Floor Finishing's	=	0.2	t/m^2
Live Load	=	0.2	t/m^2
Type of Slab Panel considered for analysis	=	Internal Panel (continuous on all edges)	

Size of Slab Panel

Lx	=	20	Ly/Lx = 1.500
Ly	=	30	

				Slab Without Partition Wall				Slab With Partition Wall Along Lx Dir.				Slab With Partition Wall Along Ly Dir.			
				Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.		Cast-in-situ const.		Segmental const.	
				Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection	Flexure	Deflection
Bending Moments (Before continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-
			Negative Bending Moment at Support	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-
			Negative Bending Moment at Support	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-
Bending Moments (After continuity of the Structure is established)	Bending Moment due to Dead Load (self Wt. of the Slab) + Flr Load + Live Load	Along Lx Dir.	Positive Bending Moment at Mid Span	84.86	86.07	*	*	-	-	-	-	-	-	-	-
			Negative Bending Moment at Support	165.84	168.14	60.96	60.96	-	-	-	-	-	-	-	-
		Along Ly Dir.	Positive Bending Moment at Mid Span	19.07	19.34	7.14	7.14	-	-	-	-	-	-	-	-
			Negative Bending Moment at Support	72.84	73.89	27.48	27.48	-	-	-	-	-	-	-	-
Total concentrated load applied including (partial safety factor)				0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-
Contact Length of load				1.00	1.00	1.00	1.00	-	-	-	-	-	-	-	-
Contact Width of load				1.00	1.00	1.00	1.00	-	-	-	-	-	-	-	-
Bending Moments due to Loads [other than Dead Load (self Wt. of the Slab) + Flr. Load + Live Load] After continuity of the Structure is established	Bending Moment due to concentrated loads	Along Lx Dir.	Positive Bending Moment at Mid Span	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-
			Negative Bending Moment at Support	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-
		Along Ly Dir.	Positive Bending Moment at Mid Span	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-
			Negative Bending Moment at Support	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-

	Total Bending Moment (in tm/m)	Along Lx Dir.	Positive Bending Moment at Mid Span	84.86	86.07	*	*	-	-	-	-	-	-	-	-	
			Negative Bending Moment at Support	165.84	168.14	60.96	60.96	-	-	-	-	-	-	-	-	
		Along Ly Dir.	Positive Bending Moment at Mid Span	19.07	19.34	7.14	7.14	-	-	-	-	-	-	-	-	
			Negative Bending Moment at Support	72.84	73.89	27.48	27.48	-	-	-	-	-	-	-	-	
Over all Required Thickness of Slab				0.7500	**0.8000**	0.5200	**0.5200**	-	-	-	-	-	-	-	-	
Area of Steel Required cm²/member or cell str.	Along Lx Dir.		Positive Steel at Mid Span	32.43	**31.74**	*	*	-	-	-	-	-	-	-	-	
			Negative Steel at Support	64.42	**60.85**	34.49	**34.49**	-	-	-	-	-	-	-	-	
	Along Ly Dir.		Positive Steel at Mid Span	7.21	**6.83**	3.96	**3.96**	-	-	-	-	-	-	-	-	
			Negative Steel at Support	27.96	**26.47**	15.42	**15.42**	-	-	-	-	-	-	-	-	M-40
Governing Thickness of the slab				**0.8000**		**0.5200**		-		-		-		-		
% Reduction in Slab Thickness due to Precasting				**35.00%**				-				-				
The Slab considered here is cellular type, the Average thickness of slab including RCC shuttering slab				0.2715	**0.2825**	0.2817	**0.2817**	-	-	-	-	-	-	-	-	
				0.2825		**0.2817**		-		-		-		-		
% Reduction in Slab Thickness due to Precasting				**0.28%**				-				-				
*	bending moment at mid span in Lx direction is balanced by prestressing force															
-	cases not considered for cellular slab															

CONCLUSION

(For cellular slab type system)

The analysis results indicate that although the design of cast-in-situ RCC cellular slabs still governs by deflection criteria, but the difference in the over all structural height of the slab is not much. This is because of the fact that the section in cellular structure is optimized to maximum extent by concentrating the concrete and steel reinforcement at the most desired locations thereby reducing the weight of the slab system which is normally contributing heavily towards deflection.

The design of cellular slab to be constructed by segmental construction technique, has been done as prestressed concrete beam simply supported in direction of effective span and full continuity at supports and in shorter span as well as longer span direction provided by un-tensioned Reinforcement.

The reduction in slab thickness achieved is due to the effect of prestressing otherwise the greater thickness of web demanded by the system of segmental construction for achieving continuity in both the directions may result in increase in over all weight of the slab.

The two system when compared shows nearly same average structural depth of the slab. However the use of prestressing does result in reduction in total reinforcement required.

The result of RCC cellular slab indicates that the thickness of web/ cross ribs governs by the crieteria of maximum shear stress therefore it is bound to increase with increase in span or intensity of live loads, however in prestressed system adopted in segmental construction the additional shear can be taken care off by controlling prestressing force and profiling the post tensioned cable in better manner therefore the system of segmental construction appear to have greater potential of savings in concrete for higher span lengths and higher live load intensities.

Above all reduction in over all height of the slab from 800mm in RCC cellular cast –in-situ to 520mm in PSC cellular segmental construction has a distinct advantage in reducing the total height of the building, which is important for tall buildings.

Note: The savings in regards to shuttering and scaffolding in segmental construction will continue to provide an edge to segmental construction over cast-in-situ construction method.

DEVELOPING A LAUNCHING SYSTEM FOR ERECTION OF PRECAST ELEMENTS OF A BUILDING

The use of Launching Systems in construction of structures is not new to the world; however the use of Launching Systems is confined to specific structures in general. The use of Launching systems in buildings is a rare experience. This section highlights the use of Launching systems, and discusses features of good Launching Systems already in use.

This section also discusses the requirements of a good Launching System to be used specifically in buildings, and finally gives a schematic Launching System satisfying the basic requirements. At the very end of the project a discussion on constraints and other requirements of the successful segmental construction technique with use of launching systems deriving support from already erected structure leaves us with a number of un answered questions for us explore in future before realizing the dream of frequent use of the technique in reality.

What are Launching Systems?

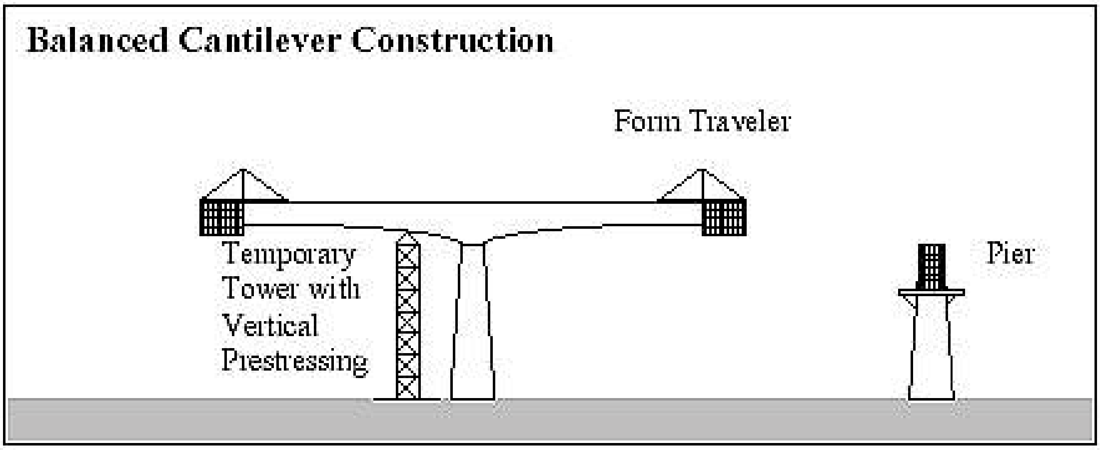
Launching Systems are machines developed for handling the precast elements of a structure.

The launching systems can be broadly classified into three categories.

a. Launching Systems deriving their support from the Ground.
b. Launching Systems deriving their support from the already erected structure.
c. Launching Systems deriving their support partly from the ground and partly from the already erected structures.

All the types of Launching Systems have been successfully used in construction industry.

The kinematics of different launching systems differs from each other so much so that the technical requirement and criteria's governing their design are altogether different. One can still visualize a fact that the final goal in each case is the same i.e. providing a technology that helps in erection of precast elements for the construction of the desired structure. These systems also helps in construction of cast in situ elements which can be placed segment by segment or casting of the entire structure in single stage as per the requirements of the design, in such a case the entire shuttering may be mounted over the launching system and the casting may be done and kept in place till the desired strength is achieved. The cantilever construction equipments used in construction of Cantilever type bridges built over rivers and marines is a perfect example of such launching systems.



As shown above the entire shuttering for the concrete element to be cast is mounted over a launching system popularly known as Form Traveler. The Same system with some minor modifications can be used for lifting of precast concrete elements, in both the cases the design philosophy need consideration for the additional weight of the launching system which is mounted over the structure to be constructed.

Fig. 1(a) : Erection of segments with shear leg segments through columns.

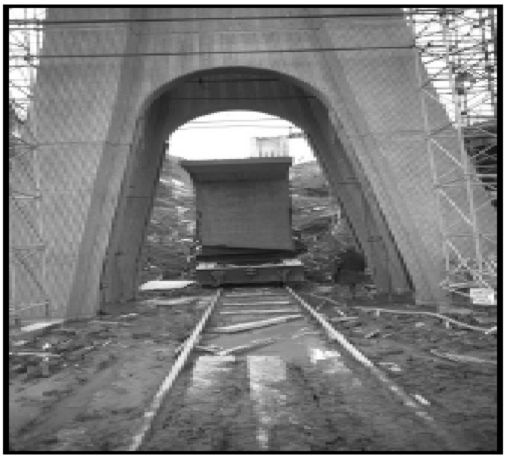


Fig. 1(b) : Delivery of segments through the piers.

Source of Information: fib Symposium 2004 on "Segmental Construction in Concrete" Organized by: The Institution of Engineers (India) Held on 26 November, 2004 at New Delhi, India.

The photographs shown above provide a view of the construction of Byker Viaduct in U.K (it is the first segmental viaduct constructed in U.K.). In this project precast segments are lifted using a Cantilever type Launching system, these segments are brought over rails passing through the pier base where space has been specifically provided for delivery of segments. **The project provides a perfect example of planning where the shape of the permanent structure is modified to facilitate the construction methodology required to suit the project site conditions.**

Form Traveler holding the Shuttering for
Cast-in-situ Segmental Construction of the Bridge

Arial View of the Site for Bridge Construction
(Showing Intermediate Stage of Bridge Construction)

The above Photograph shows the form traveler designed by VSL (Prestressing) for

Source of Information: fib Symposium 2004 on “Segmental Construction in Concrete” Organized by: The Institution of Engineers (India) Held on 26 November, 2004 at New Delhi, India.

construction of “Bras de la Plain Bridge on the Island of Revnion in the Indian Ocean (France)”. The bridge structure is 280-m long pan embedded in counter weight abutments.

The arial view of the site clearly indicates that the erection of Shuttering over staging is not at all possible because of presence of flowing water and the frightening depth of the steep cut valley. The advent of segmental construction technique and launching systems is a gift of science and technology that has made such dream projects a reality now.

Launching System for Line 3 of D.M.R.C.

The photograph shows construction of 14.6KM Stretch of Span-By-Span Construction of D.M.R.C. Line-3 Project using Launching System **exclusively designed for construction of elevated Viaduct using "Precast Segmental Construction Technique" by Arch Consultancy Services (P) Ltd.** This viaduct is now operational and stands as a record in the history as one of the fastest executed project in the world.

The examples of use of Launching systems in construction presented so far belongs to "Category b" i.e. these Launching Systems derive their support from the already erected structure.

Source of Information: Practical involvement in the DMRC line-3 Project as a member of Design Team for the Design and Planning of Launching System for Line-3 Project.

The "Category c" i.e. Launching Systems deriving their support partly from the ground and partly from the already erected structures also enjoy much use in construction of bridges.

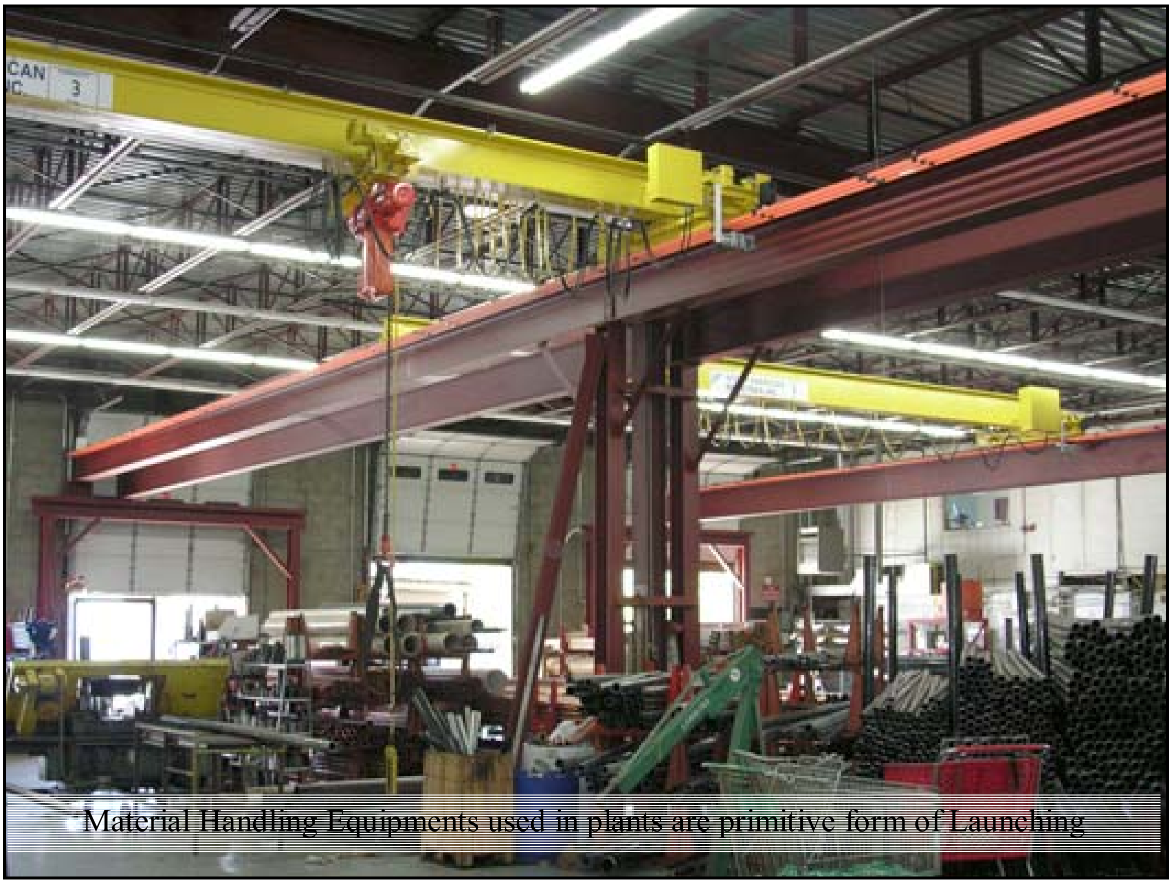
Erection of Box Girder Segments – Flyover at Anand Rao Circle.

The above photograph shows the Truss type Launching system deployed for construction of Flyover at Anand Rao Circle in Bangalore. The Front leg of the Launcher rests on rails laid on the ground and the rear leg rests over the already erected structure.

The "Category a" i.e. Launching Systems deriving their support from the Ground are the most primitive form of Launching Systems. This type of Launching Systems is generally found not suitable in complex projects where the structure posses sharp changes in vertical and horizontal gradients. Truly speaking at places where the structure is surrounded by water body like river, marine or a pond, the possibility of deriving support from ground becomes a difficult task.

Launching System deriving support from Ground

The technology used in simple material handling equipment as shown below is another example of launching system deriving their support from the ground.



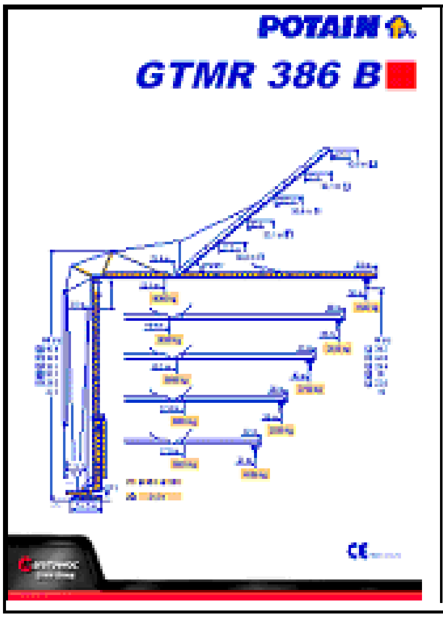
Material Handling Equipments used in plants are primitive form of Launching

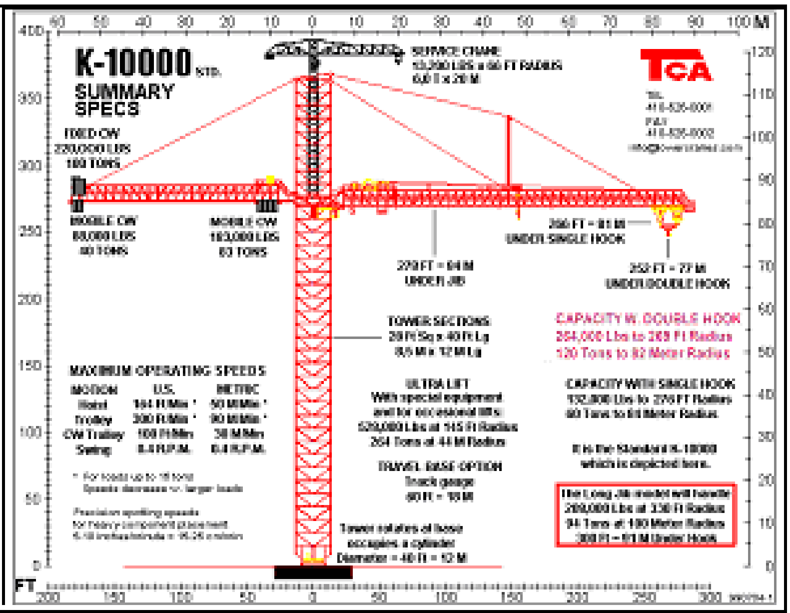
The launching systems shown above are mostly concerned with construction of bridges.

Source of Information: Web sites on cranes (Internet info media).

The use of specifically designed launching systems in buildings is a rare chance. However Tower cranes are general material handling machines that are ere extensively used for the construction of Buildings.

Tower cranes are assembled on ground. They are available in wide variety and range





The photographs shown above give general information on lifting capacities of two different brands of tower cranes. The photograph of POTAIN (Left Side) shows that the optimum lifting capacity decreases with increase in height and horizontal range. As an example at a height 42.9m and horizontal radius of 13.1m the lifting capacity is 8000Kg, which reduces to 1500Kg with same height and horizontal radius of 50.0m. In precasting the weight of precast units is generally in the range of 10tonnes to 100tonnes or more for small sub element to elements precasted as single unit such as a large wall panel or a roof slab or in some cases one complete room etc. the horizontal range of 13.1m which gives largest capacity is too small for the machine to operate from a singe point and therefore require frequent shifting.

The photograph of K-10000 (Right Side) gives a higher capacity of 120tonne at a horizontal radius of 82mand a height of 12m. The crane rotates about a cylinder of 12m diameter provided at its base. Although the crane satisfies our requirements but it is highly costly affair. The 12m dia of its rotating base is good enough to tell about its structural dimensions.

Source of Information: Web sites on cranes (Internet info media).

<u>The following pages give a schematic Launching System Developed as a part of this thesis.</u>

The Launching System has following Basis Features which have been inculcated to cater for the requirements of segmental construction in buildings. Although the system might come up with its own limitations before it actually comes in practice, but at present we have tried to introduce all the features required for a successful Launching System.

Basic features of the Launching System developed for segmental construction of a building:

a. The launching system consists of a number of supporting steel columns which holds a supporting beam in longitudinal (Longer dimension of the building) direction. A mobile gantry girder runs over the supporting beam, and the gantry girder is provided with an electrically operated movable lifting hoist.

b. The Launching System provides accessibility to practically every possible location covered with in its longitudinal supporting beam.

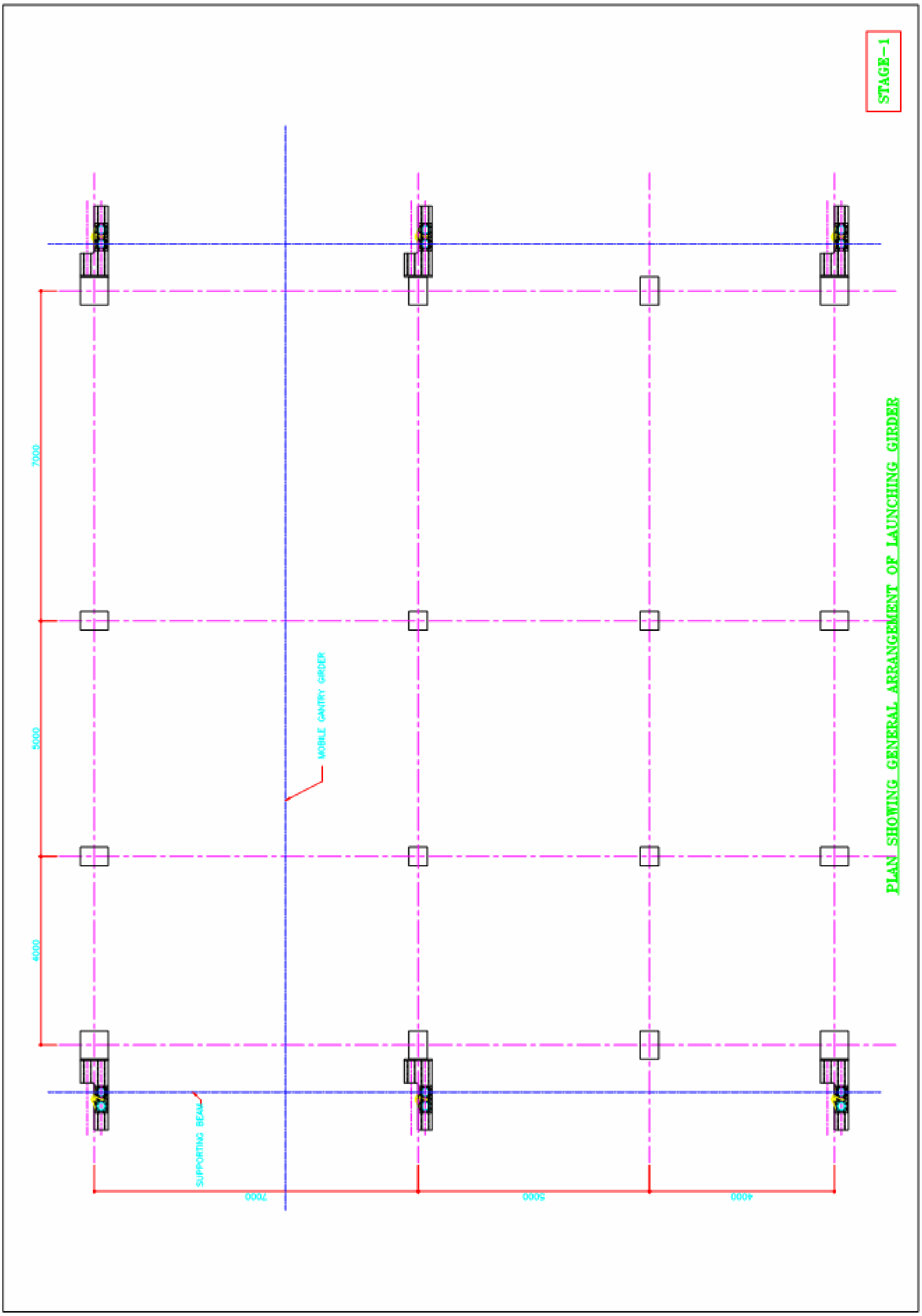
c. The Supporting Steel Columns are Telescopic legs which provide flexibility of adjustments in operating height of the Launching System.

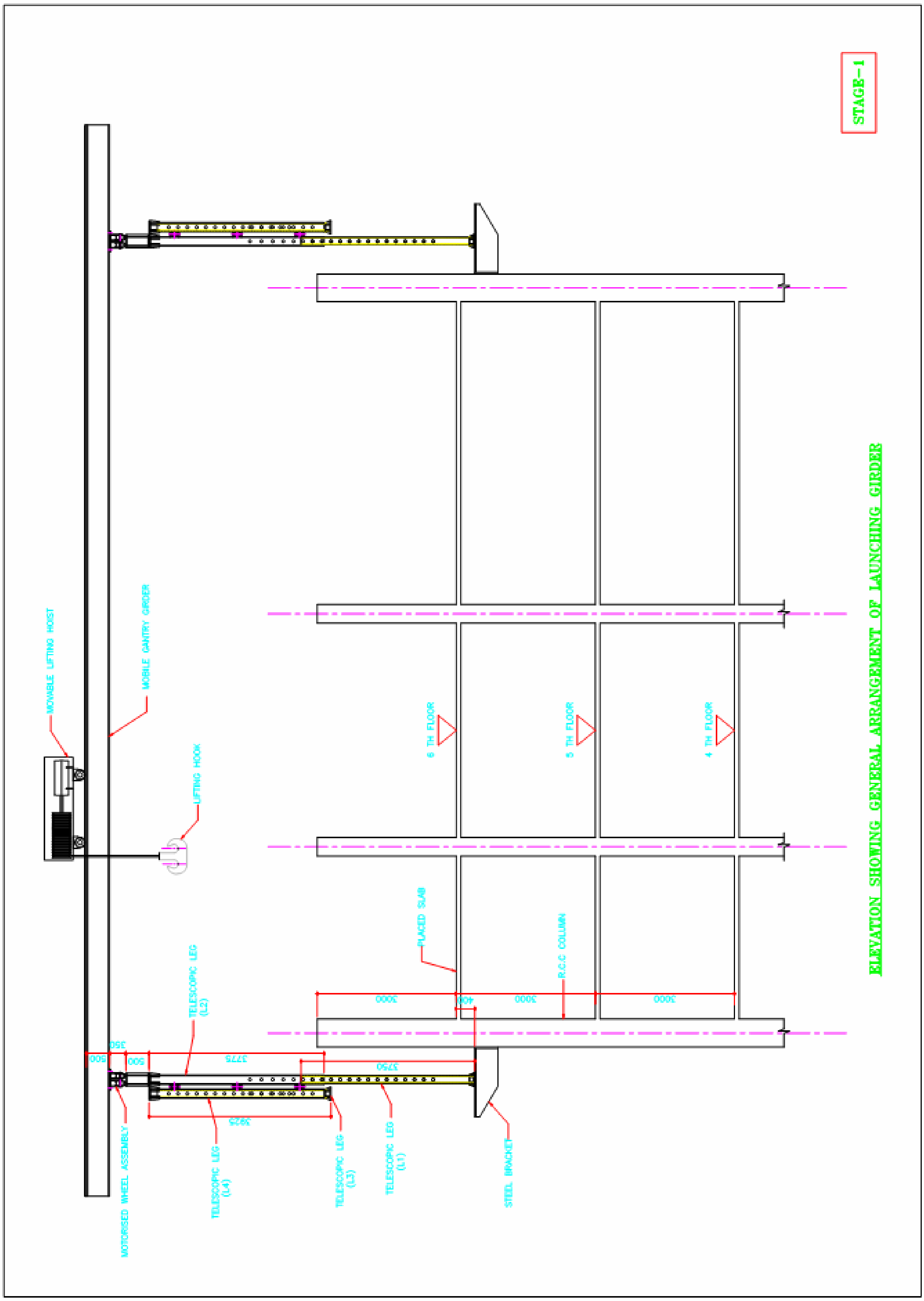
d. The entire Launching System is mounted over steel Brackets mounted over the building to be constructed so that the Height of the System required reduces to a range of 3.0m to 7.0m approximately. The ability to work at any height of the building without increasing the overall height of the Launching System makes it more efficient and economical.

e. The Visibility of all the parts of the Launching System through naked eyes from one location (possible only due to its small height) reduces the chances of accidents and hence improves operational safety in a big manner.

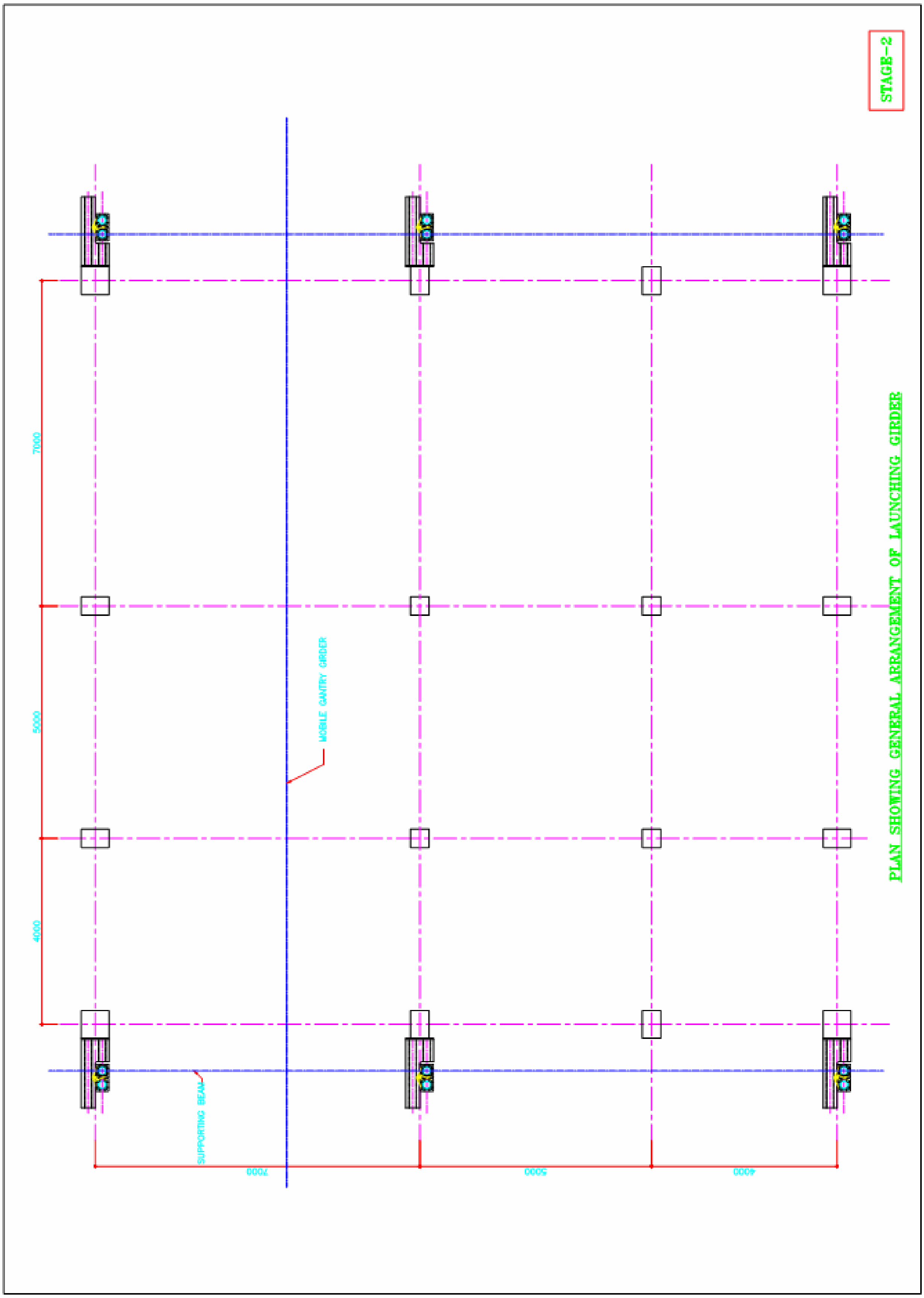
f. I envisage that all the functions of the Launching System can be automated using electronic modules which will add a sense of modernization making it one of the most versatile machines for building construction in future.

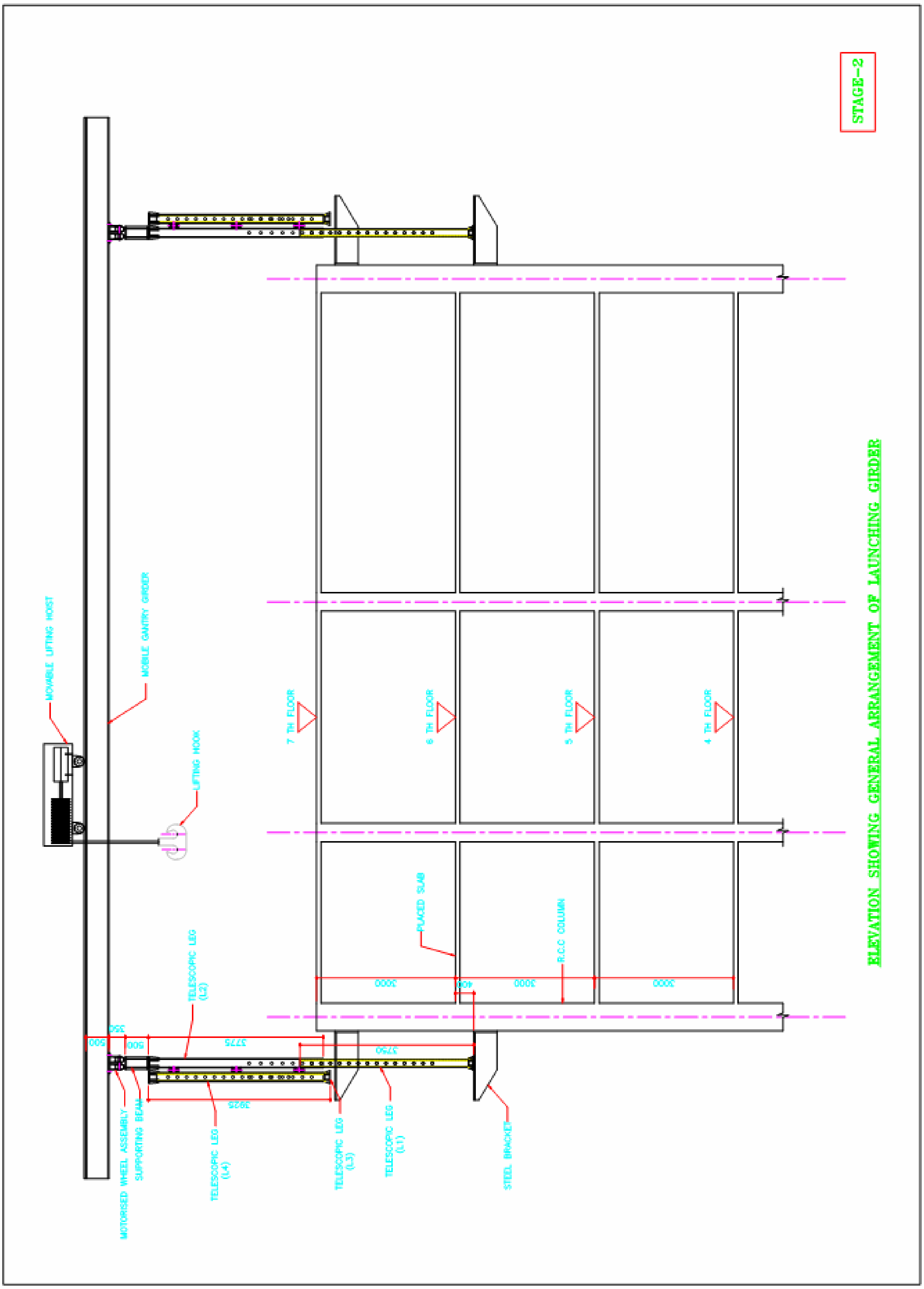
With the features discussed above, the Machine can be technically called a "**<u>Fully Automatic Self Raising Launching System for Building Construction</u>**".

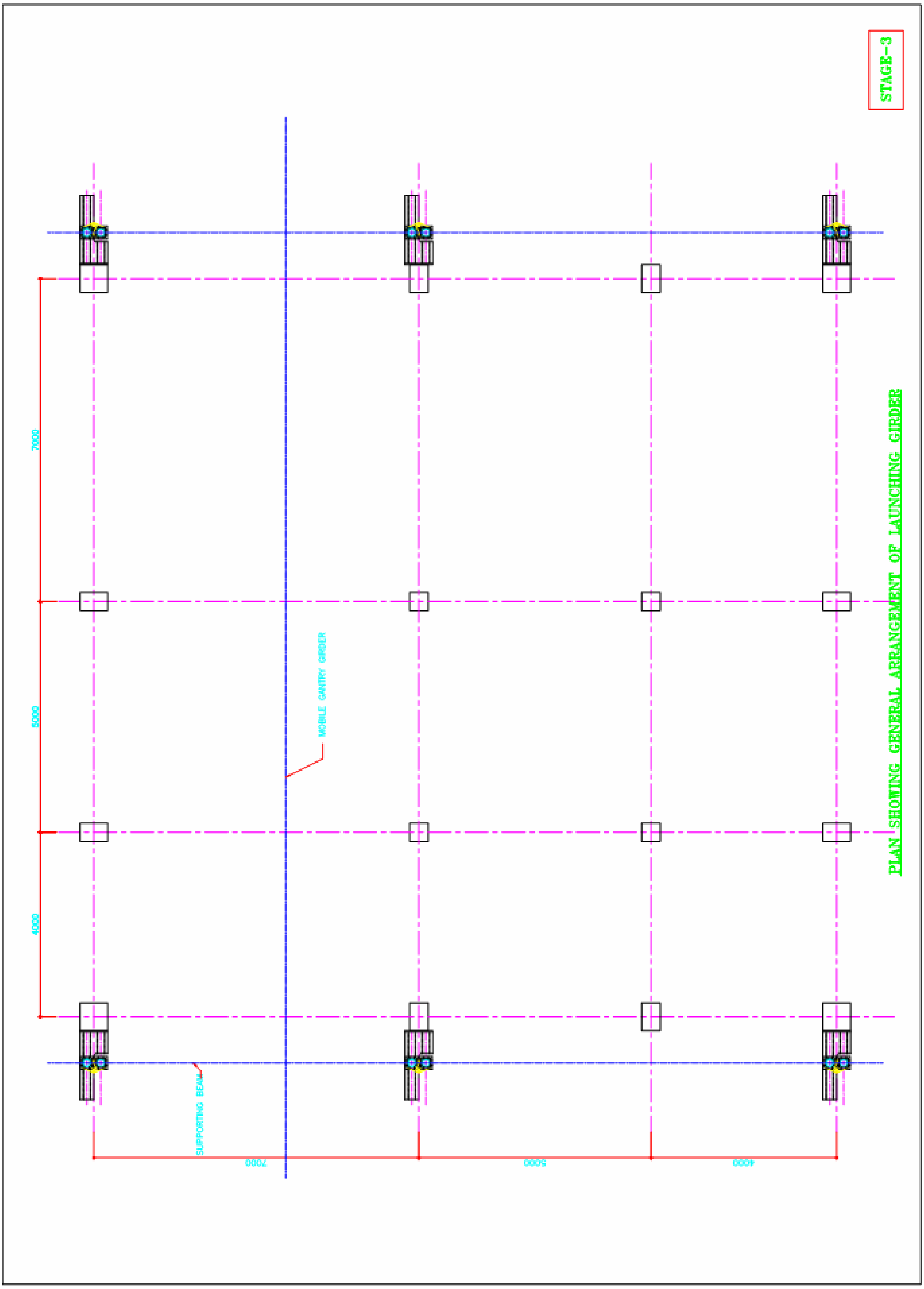

STAGE-1
PLAN SHOWING GENERAL ARRANGEMENT OF LAUNCHING GIRDER
MOBILE GANTRY GIRDER
SUPPORTING BEAM
7000
5000
4000
7000
5000
4000

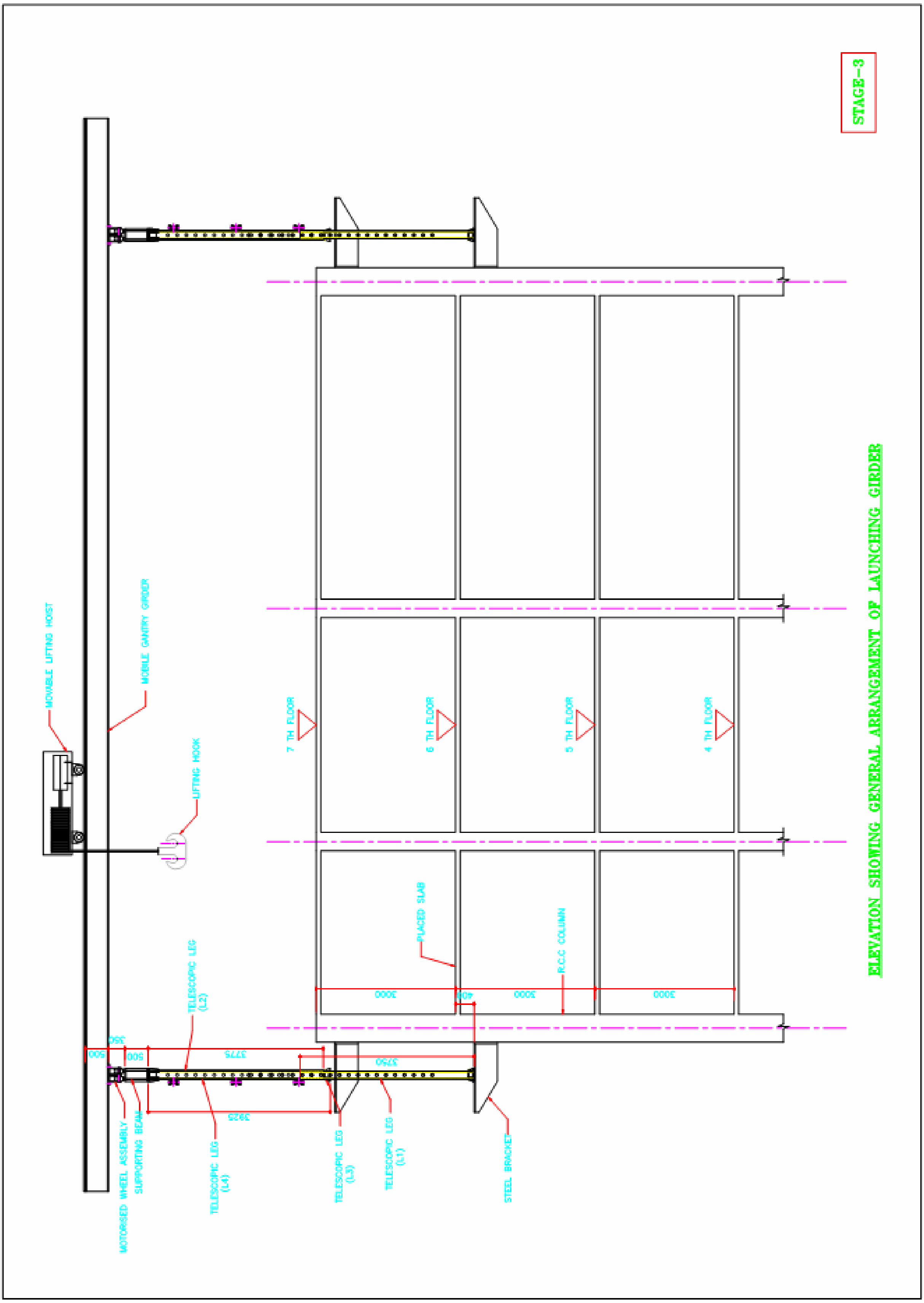


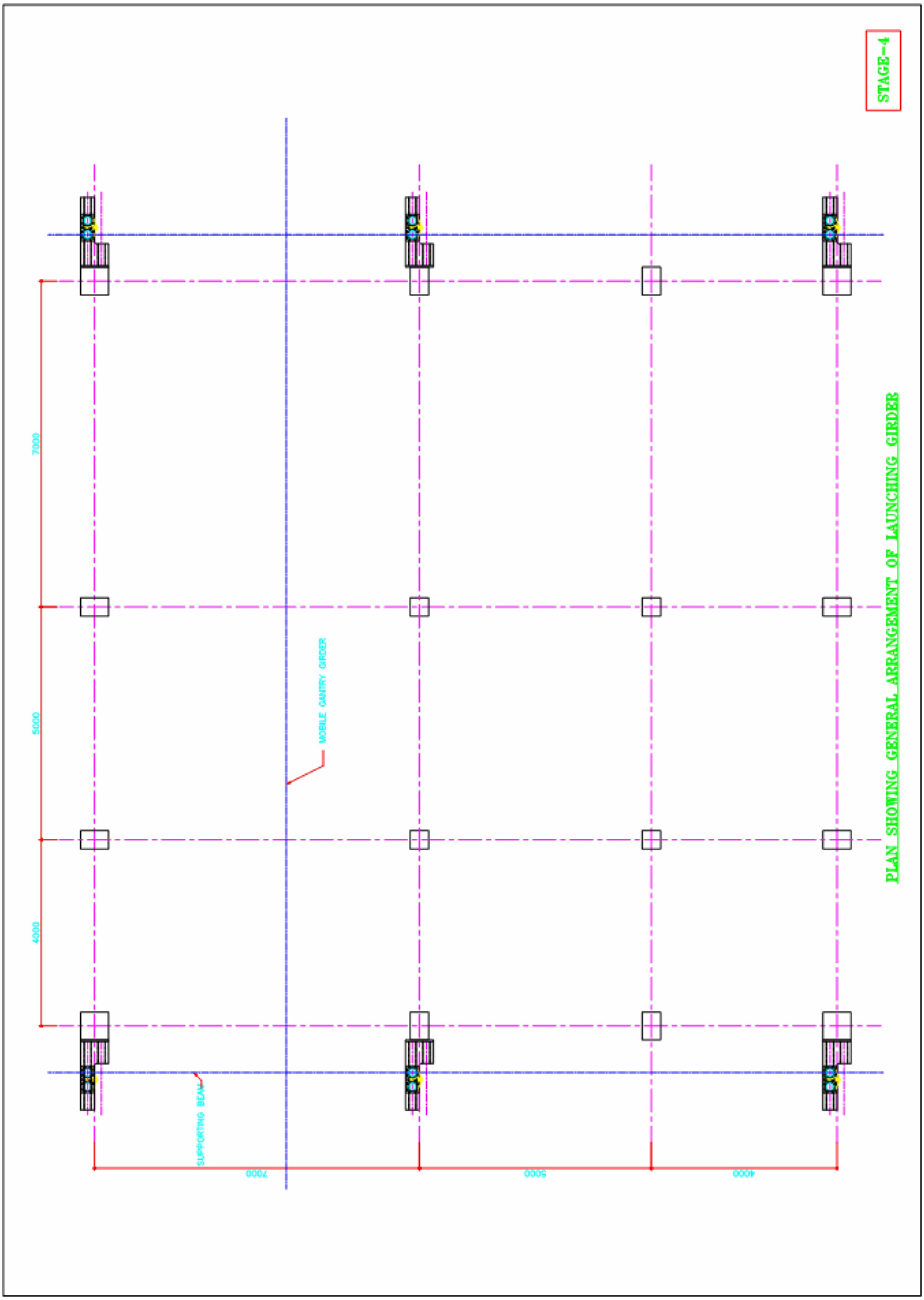
STAGE-1
MOVABLE LIFTING HOIST
MOBILE GANTRY GIRDER
LIFTING HOOK
6 TH FLOOR
5 TH FLOOR
4 TH FLOOR
PLACED SLAB
R.C.C COLUMN
TELESCOPIC LEG (L2)
MOTORISED WHEEL ASSEMBLY
TELESCOPIC LEG (L4)
TELESCOPIC LEG (L3)
TELESCOPIC LEG (L1)
STEEL BRACKET
3000
400
3000
3000
350
500
500
3775
3750
3925
ELEVATION SHOWING GENERAL ARRANGEMENT OF LAUNCHING GIRDER

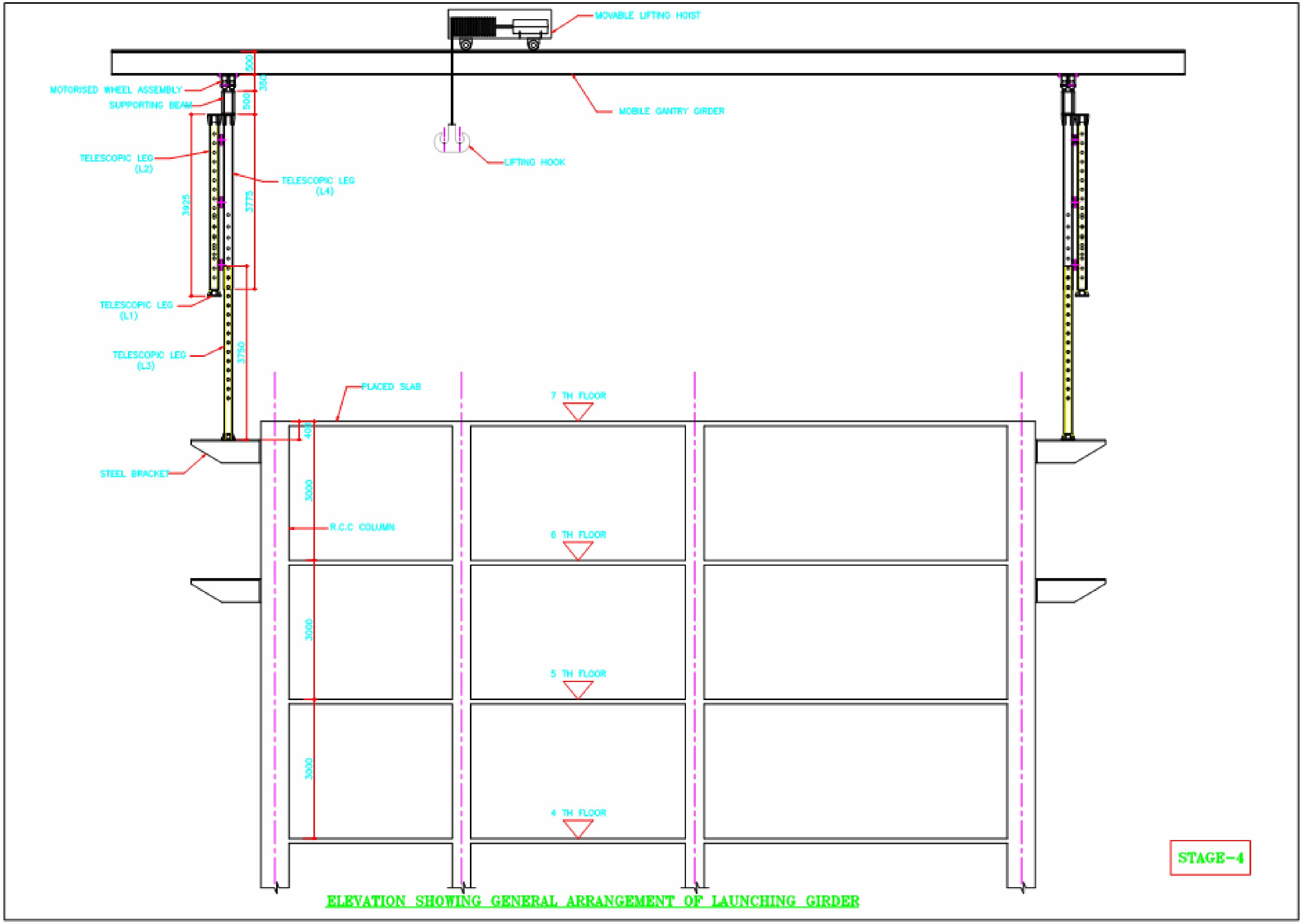

STAGE-2
PLAN SHOWING GENERAL ARRANGEMENT OF LAUNCHING GIRDER
MOBILE GANTRY GIRDER
SUPPORTING BEAM
7000
5000
4000
7000
5000
4000

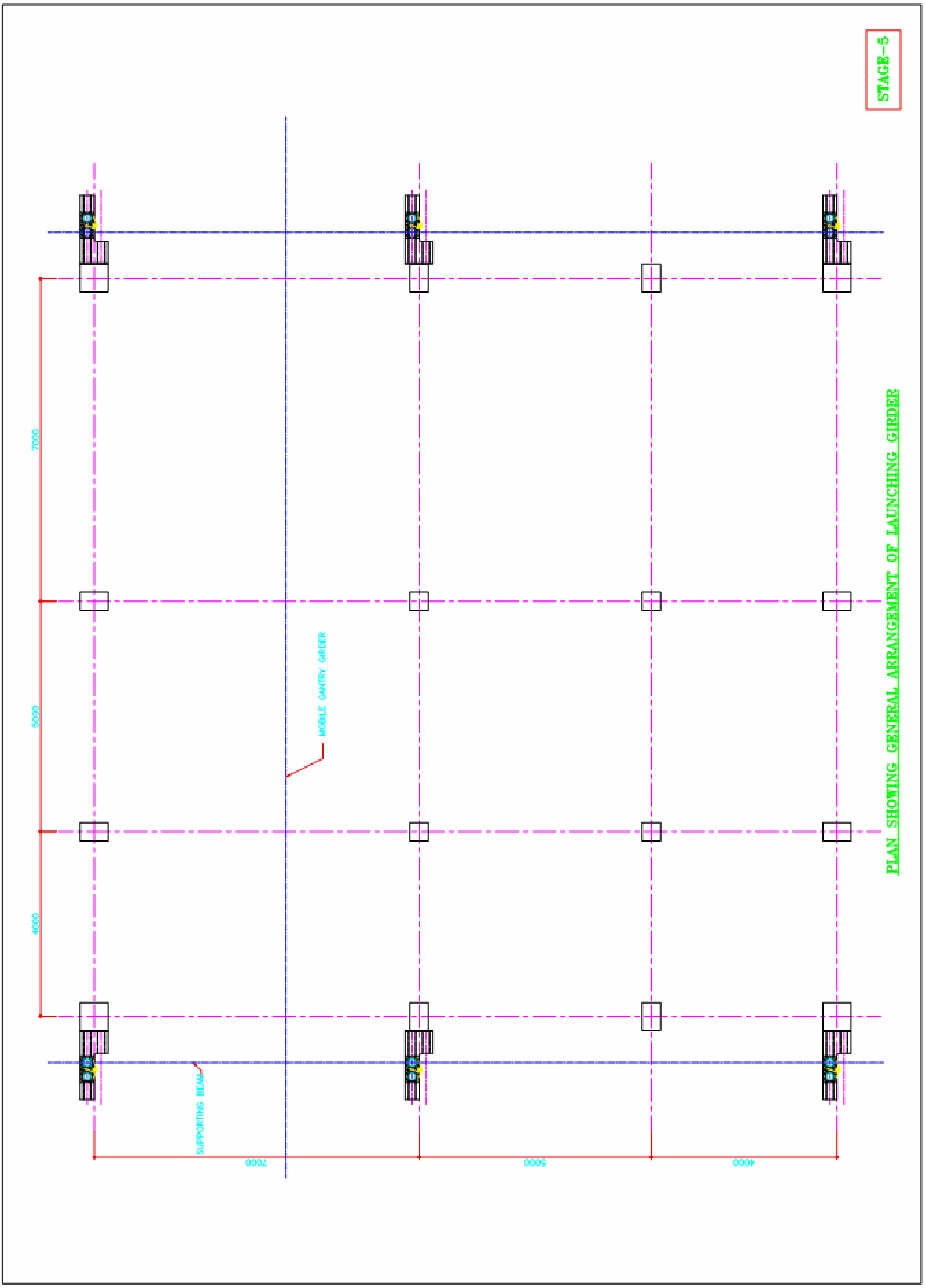

STAGE-2
MOVABLE LIFTING HOIST
MOBILE GANTRY GIRDER
LIFTING HOOK
7 TH FLOOR
6 TH FLOOR
5 TH FLOOR
4 TH FLOOR
PLACED SLAB
R.C.C COLUMN
3000
400
3000
3000
TELESCOPIC LEG (L2)
350
500
500
3775
3750
3925
MOTORISED WHEEL ASSEMBLY
SUPPORTING BEAM
TELESCOPIC LEG (L4)
TELESCOPIC LEG (L3)
TELESCOPIC LEG (L1)
STEEL BRACKET
ELEVATION SHOWING GENERAL ARRANGEMENT OF LAUNCHING GIRDER

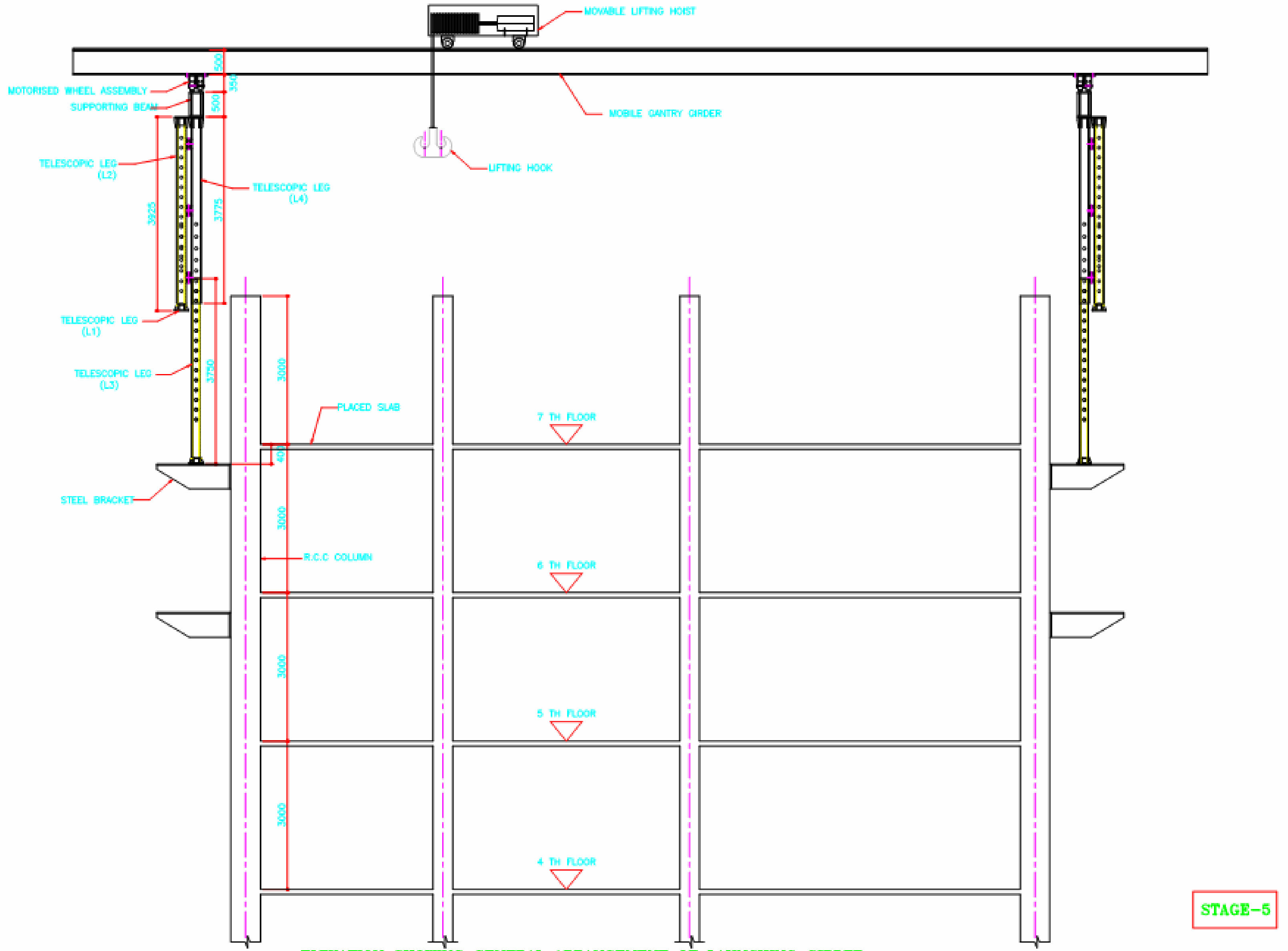

STAGE-3
7000
5000
4000
MOBILE GANTRY GIRDER
SUPPORTING BEAM
7000
5000
4000
PLAN SHOWING GENERAL ARRANGEMENT OF LAUNCHING GIRDER


STAGE-3
ELEVATION SHOWING GENERAL ARRANGEMENT OF LAUNCHING GIRDER
MOVABLE LIFTING HOIST
MOBILE GANTRY GIRDER
LIFTING HOOK
TELESCOPIC LEG (L2)
PLACED SLAB
R.C.C COLUMN
7 TH FLOOR
6 TH FLOOR
5 TH FLOOR
4 TH FLOOR
3000
400
3000
3000
350
500
500
3775
3750
3925
MOTORISED WHEEL ASSEMBLY
SUPPORTING BEAM
TELESCOPIC LEG (L4)
TELESCOPIC LEG (L3)
TELESCOPIC LEG (L1)
STEEL BRACKET

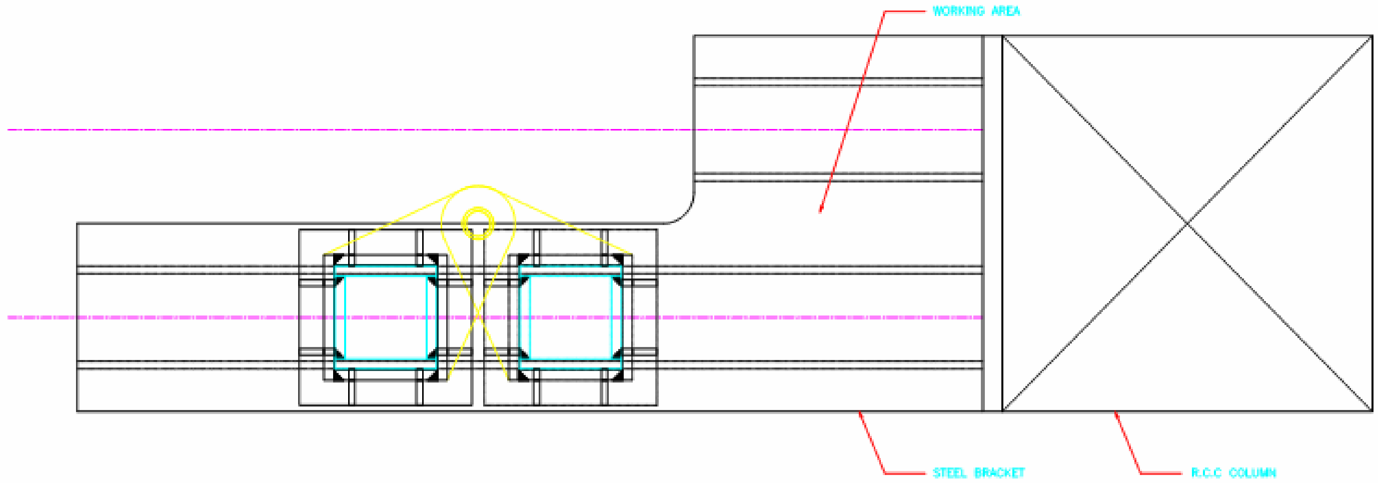

STAGE-4
7000
5000
4000
MOBILE GANTRY GIRDER
SUPPORTING BEAM
7000
5000
4000
PLAN SHOWING GENERAL ARRANGEMENT OF LAUNCHING GIRDER


MOVABLE LIFTING HOIST
MOBILE GANTRY GIRDER
LIFTING HOOK
MOTORISED WHEEL ASSEMBLY
SUPPORTING BEAM
TELESCOPIC LEG (L2)
TELESCOPIC LEG (L4)
TELESCOPIC LEG (L1)
TELESCOPIC LEG (L3)
500
350
500
3925
3775
3750
PLACED SLAB
STEEL BRACKET
400
3000
R.C.C COLUMN
3000
3000
7 TH FLOOR
6 TH FLOOR
5 TH FLOOR
4 TH FLOOR
STAGE-4
ELEVATION SHOWING GENERAL ARRANGEMENT OF LAUNCHING GIRDER

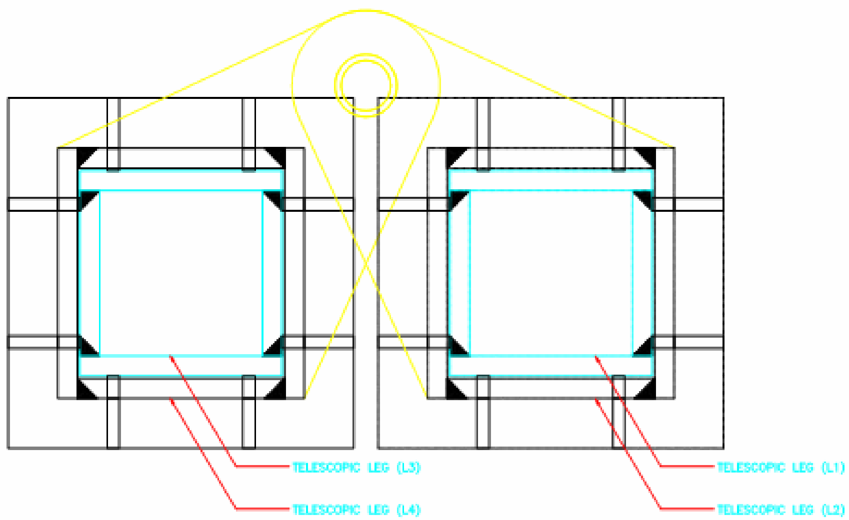

STAGE-5
PLAN SHOWING GENERAL ARRANGEMENT OF LAUNCHING GIRDER
MOBILE GANTRY GIRDER
SUPPORTING BEAM
7000
5000
4000
7000
5000
4000



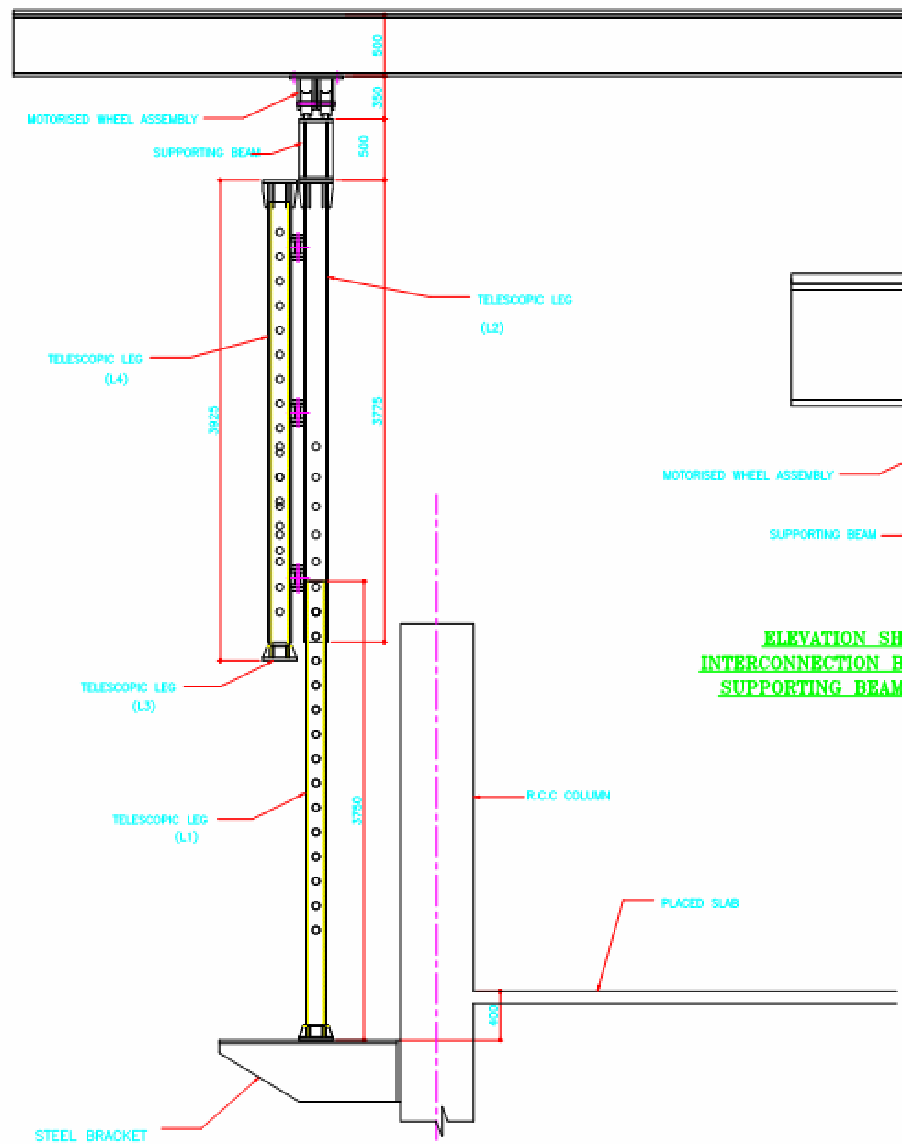
ELEVATION SHOWING GENERAL ARRANGEMENT OF LAUNCHING GIRDER



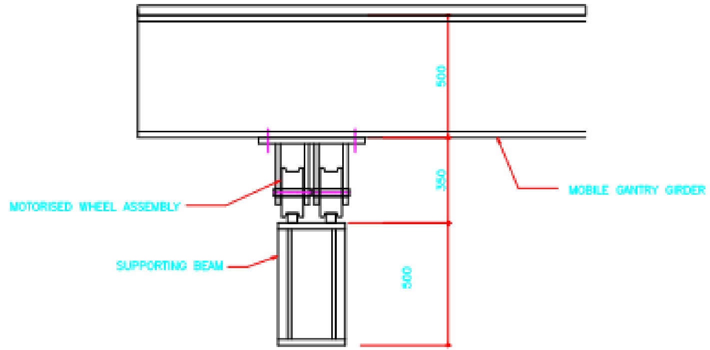
PLAN SHOWING ARRANGEMENT OF TELESCOPIC LEGS OVER STEEL BRACKET



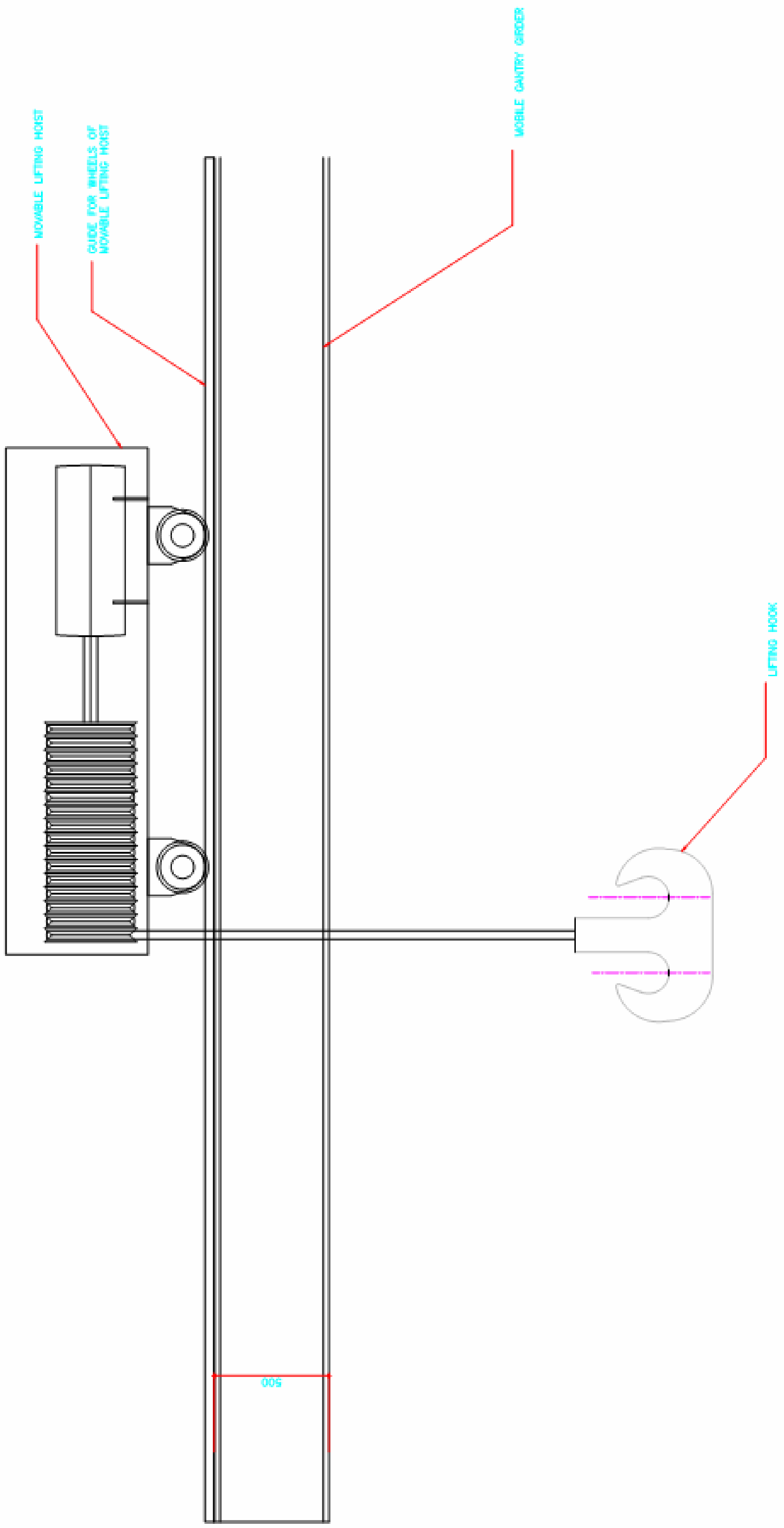
PLAN SHOWING ARRANGEMENT OF TELESCOPIC LEGS ONLY



ELEVATION SHOWING GENERAL ARRANGEMENT OF SUPPORTING SYSTEM



ELEVATION SHOWING GENERAL ARRANGEMENT OF INTERCONNECTION BETWEEN MOBILE GANTRY GIRDER AND THE SUPPORTING BEAM THROUGH MOTORISED WHEEL ASSEMBLY



ELEVATION SHOWING MOVABLE LIFTING HOIST OVER MOBILE GANTRY GIRDER

Annexure 1

Recommended design procedures and structural checks, construction related provisions as recommended by present Indian Standards (only those Standards which are studied under present work have been included)

IS 13990-1994

Indian Standard-**PRECAST REINFORCED CONCRETE PLANKS AND JOISTS FOR ROOFING AND FLOORING- SPECIFICATION**

Clause 5: Design

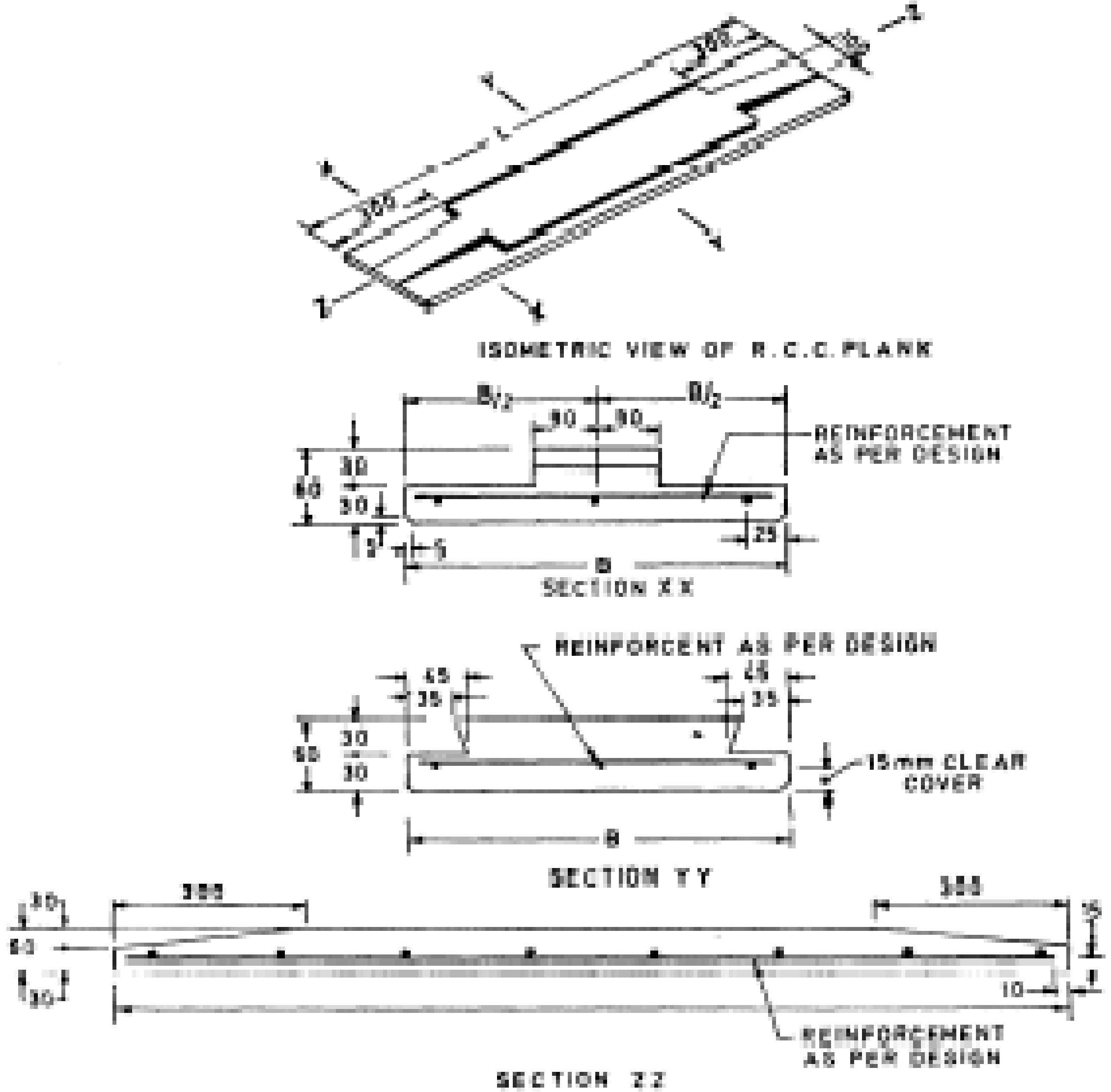
5.1 The Planks shall be designed as simply supported for self weight including *in-situ* concrete over haunches, and as a continuous slab for a load comprising live load, self weight and dead load of floor finish and/or water proofing treatment .The design shall be in accordance with the limit state method of IS 456:1978.

5.2 Reinforcement

i. Reinforcement for the planks shall comprise three equally spaced bars of required diameter along the length of planks as main reinforcement. Distribution reinforcement shall be equal to or more than the minimum recommended for slabs in IS 456:1978. The main reinforcement shall also fulfill the requirement of maximum permissible spacing given in IS 456: 1978.

ii. Reinforcement for planks for roofs and floors of residential buildings for spacing of joists at 1.5 m, shall comprise of 3 bars of 6 mm of mild steel grade I conforming to IS 432(Part 1): 1982 as main reinforcement and 6 mm dia bars, of mild steel grade I conforming to IS 432(Part 1): 1982, at 200 mm c/c as transverse reinforcement. In the absence of detailed design same reinforcement may be used for spacing of joist smaller than 1.5m.

iii. Reinforcement for RCC joist shall be provided as per design (see IS13994: 1994)



All dimensions in millimetres.

FIG. 1 PRECAST RCC PLANK

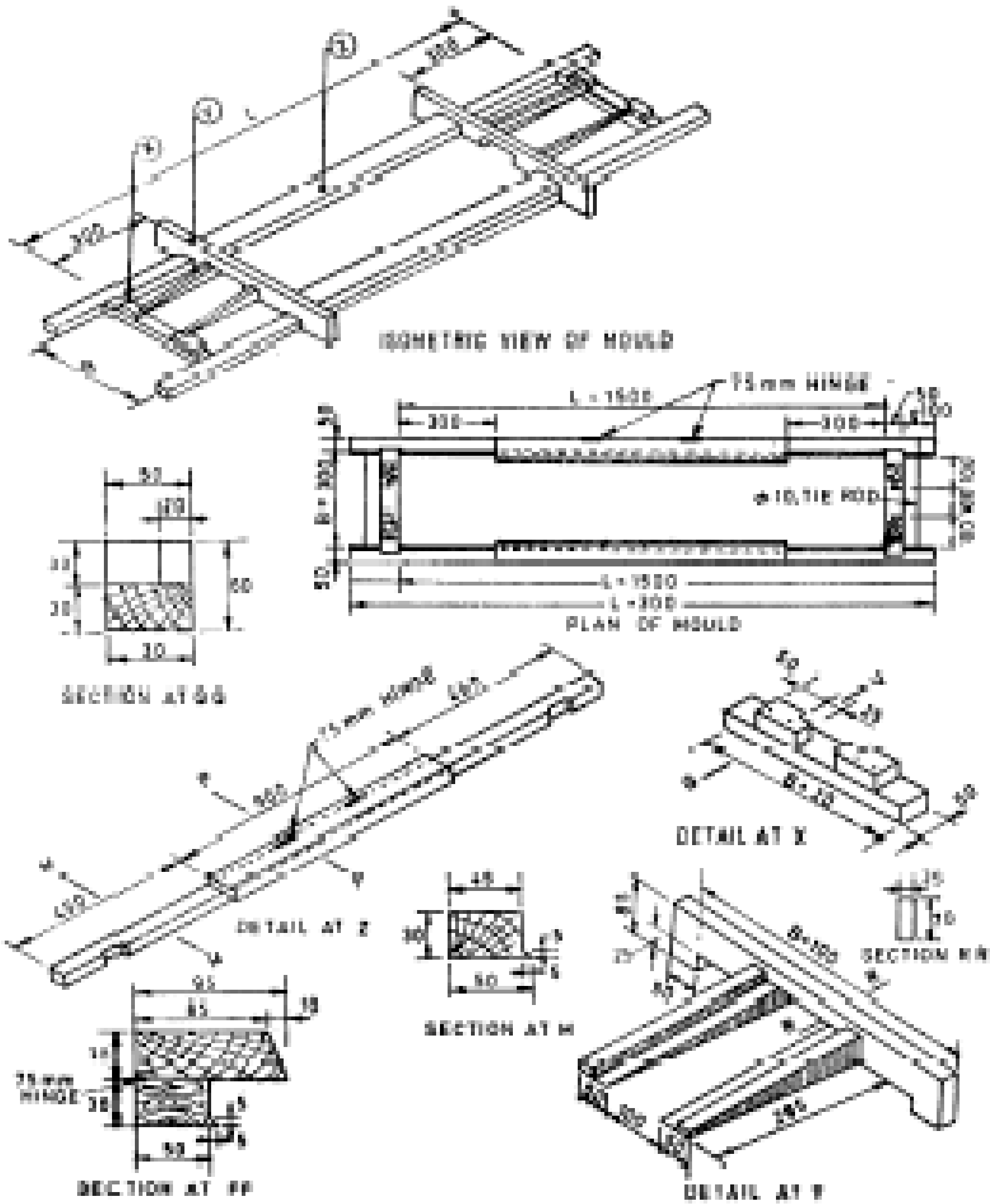
(Scanned from the Code for reference)

Clause 6: CASTING AND CURING OF PRE CAST ELEMENTS

6.1 Pre cast RC Planks

6.1.1 **Moulds**: Moulds may be made from well-seasoned good quality timber or an equivalent wood substitute. However, in case of mass production, steel, plastic or FRP mould may be used with advantage .Any material used for making moulds shall be rigid, non absorbent and non corrodible and shall maintain the dimensions within the specified limits. Typical sketches of moulds are available in the code referred. Some of those are shown below (scanned from the code).

6.1.2 Casting: Inner sides of mould shall be applied with a suitable bond release agent and it shall be kept on a smooth concrete platform coated with the bond release agent. Alternatively wrinkle free old newspaper may be used over the concrete platform. Reinforcement cage shall be placed inside the mould in such a way as to provide a cover of 15 mm. Concrete with well-graded aggregate of maximum size 10 mm shall be poured to a depth such that after compaction with a plate vibrator, shall become 30 mm. The upper side of the longitudinal members of the mould and the two tapering members shall be then placed over the mould. Concrete shall then be poured in middle and the sides and then compacted with plate vibrator. Concrete shall be finished level with the mould and the top surface shall be made rough by trowel markings. After about half an hour of casting, the two tapering members may be lifted off. The mould may be stripped off in about two hours (depending on weather). About 24 to 30 hours after casting (depending upon the weather), the cast unit shall be first slid by push and then tilted through right angles on long edge. It shall then be transported in vertical position for curing.



All dimensions in millimetres.

FIG. 2A TYPICAL SKETCH OF TIMBER MOULD FOR R/C PLANK

3

(Scanned from the Code for reference)

IS 14215-1994

Indian Standard-**DESIGN AND CONSTRUCTION OF ROOFS AND FLOORS WITH PRECAST REINFORCED CONCRETE CHANNEL UNITS- CODE OF PRACTICE**

Clause 4: Structural design

4.1 The Channel units shall have adequate strength and stability in accordance with IS 456: 1978 during the following stages:

a. De moulding
b. Handling, stacking, transporting and placing; and
c. Final stage with all designs dead and imposed loads acting on the floor/roof.

4.2 The units shall be designed either simply supported or continuous depending upon actual end conditions. Main reinforcements shall be either designed or shall be taken directly from tables 1 to 8 for residential loads.

4.3 Design stage I (Just after Placing of In-situ Concrete)

4.3.1 At the time of laying the units, the load comprises the self-weight of the channel units, the weight of in- situ concrete in the joint between the two units and also the incidental live load, likely to act on the structure at this stage. In absence of more accurate information, incidental load may be taken as half the imposed load likely to act on the structure at final stage as recommended in IS 875(Part 2): 1987.

4.3.2 Effective section: At this stage of loading, as in *In-situ* concrete has not attained any strength to ensure monolithicity, the effective width of channel unit shall be taken as width of flange portion only.

4.4 Design stage 2 (With full design load)

4.4.1 Loads: At this stage, the loads acting on the structure shall comprise dead load and full imposed load as per IS 875(Part 2): 1987. This shall be maximum load likely to act on the structure during its lifetime. For calculating the limit state of collapse at the critical section, a combined load factor of at least 1.5 shall be applied for calculating the limit state of collapse load.

4.4.2 Effective section: As the In- Situ concrete has attained strength at this stage , an effective width equal to the nominal width of the unit shall be taken for calculating the strength of section.

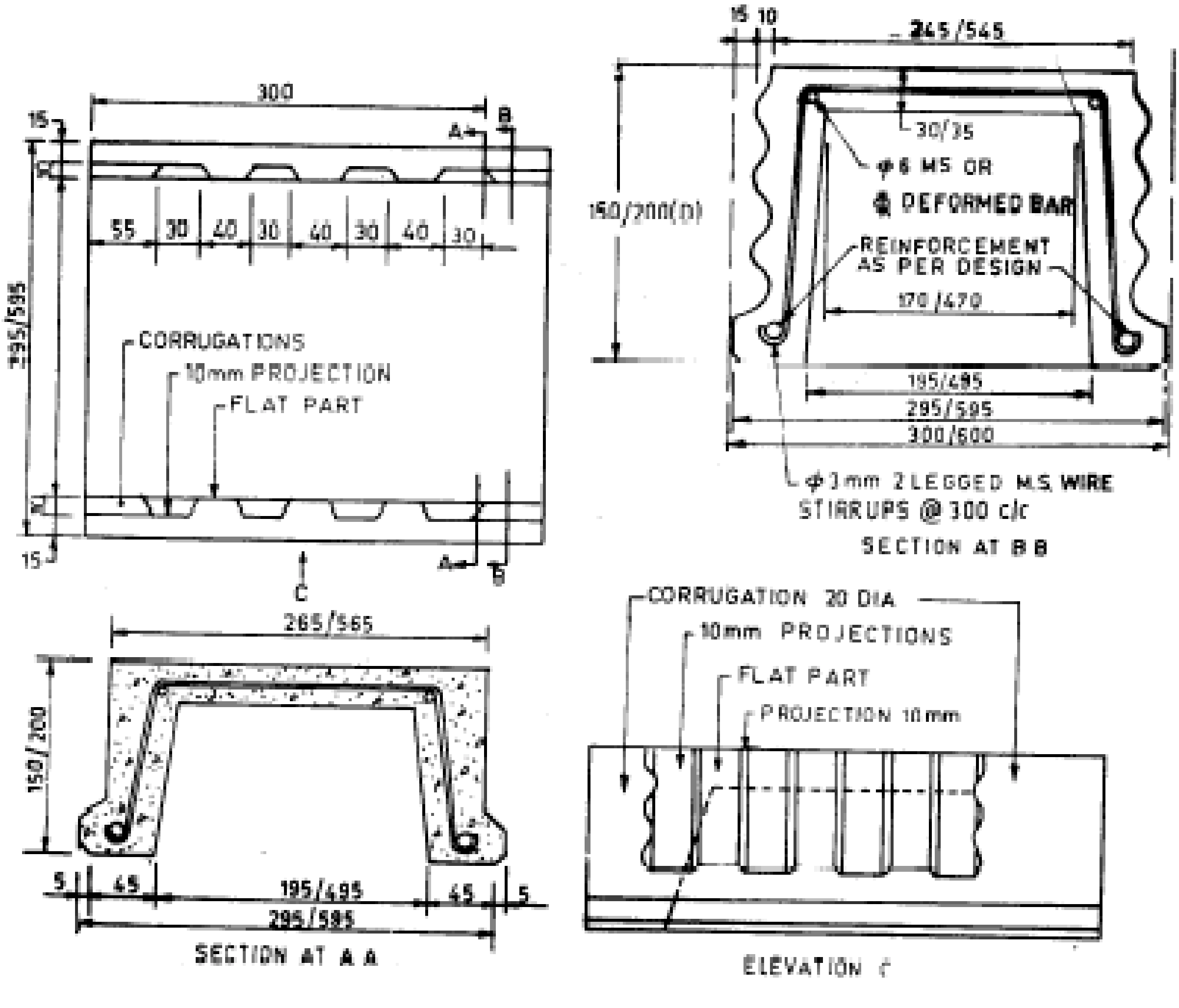


FIG. 1 A CHANNEL UNIT

5

(Scanned from the Code for reference)

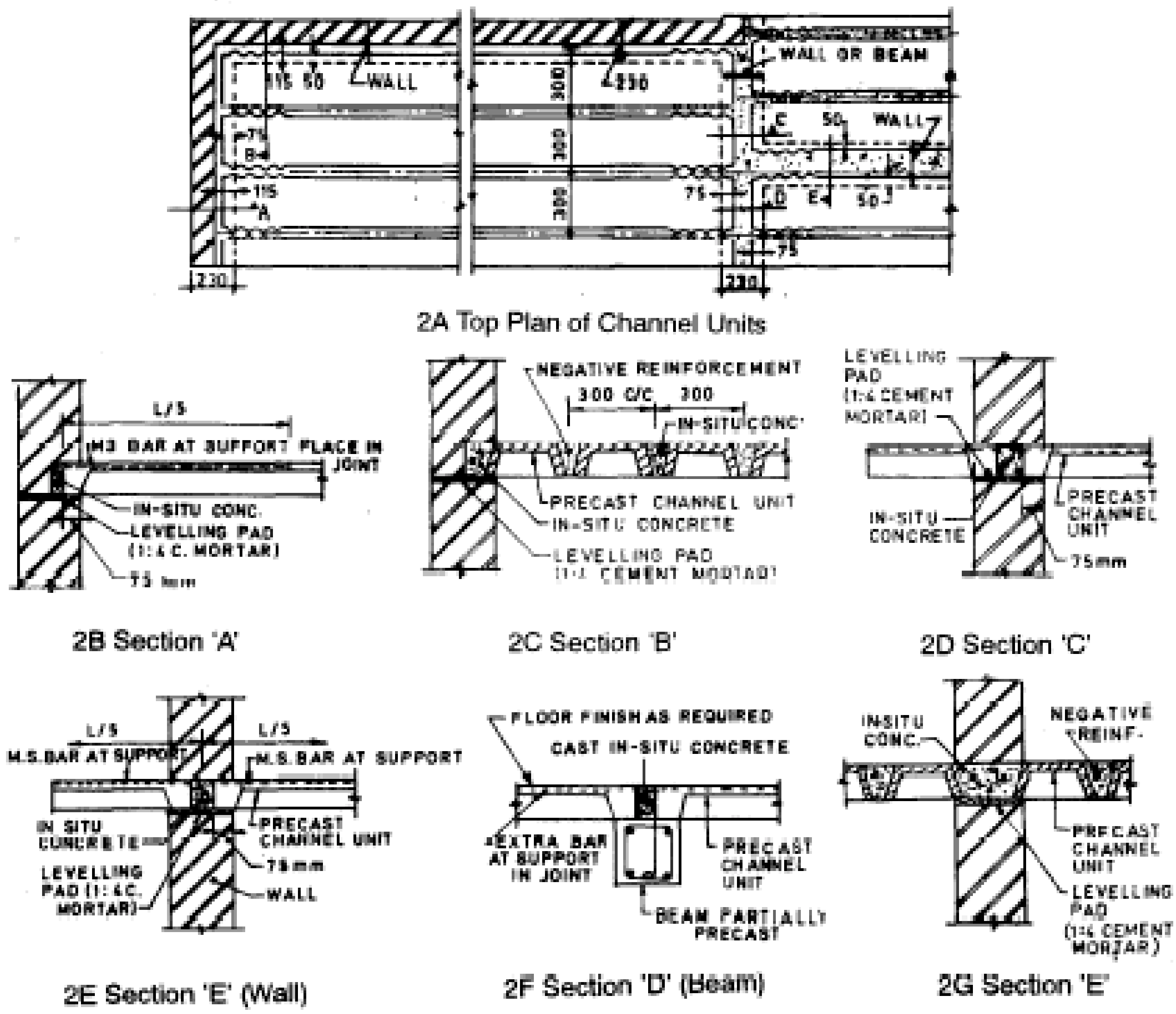


FIG. 2 DETAILS OF JOINTS IN A FLOOR WITH CHANNEL UNITS

6

(Scanned from the Code for reference)

4.5 **Design Bending Moment and Shear force:**

When the floors/roofs consist of three or more continuous and approximately equal spans, the values of bending moment and shear force coefficients given in IS 456: 1978 may be used. These coefficients shall be used for imposed live load as well as dead load of finishing but not for dead weights of units (including that of *In-situ* concrete). To the bending moment and shear forces so found out, simply supported moment and shear force due to dead weight of units (including that of *In-situ* concrete) shall be added.

4.6 *In – Situ* concrete, which brings monolithic connection and continuity between pre cast units, shall be designed in accordance with IS 3935:1966.

4.7 When Pre cast units are used for the construction of buildings in high seismic zones the floor and roof shall be strengthened in accordance with 9 of IS 4326: 1993.

5.0 STORAGE, TRANSPORTATION AND ERECTION OF PRE CAST ELEMENTS

5.1 Handling and transportation of units: The pre cast units shall be handled by placing slings placed at about 1/5 of span from ends. Care shall be taken to see that no support is placed at the center of the span and the main reinforcement is always at the bottom of the stacked units, that is trough shall be facing downwards.

5.2 Transportation: The unit shall be lifted either manually, or preferably with the help of a chain pulley block or mechanically with a hoist and placed side by side across the span to be covered.

5.3 Placing and aligning: The top surface of the wall or beam support shall be leveled so as to provide uniform bearing to the webs of the channel units. While placing the units, care shall be taken not to drag the units or apply load eccentrically, which may damage the unit. The units are to be placed should be leveled with 6 mm thick plaster (1 cement: 3 fine sand) finished with a floating coat of neat cement plaster and a thick coat of lime wash or Kraft paper. This is necessary to allow free movement of the roof over the walls/ beams so as to avoid development of thermal stress.

IS 13994-1994

Indian Standard-**DESIGN AND CONSTRUCTION OF FLOOR AND ROOF WITH PRECAST REINFORCED CONCRETE PLANKS AND JOISTS- CODE OF PRACTICE**

Clause 4: Design requirements

4.1 Loads

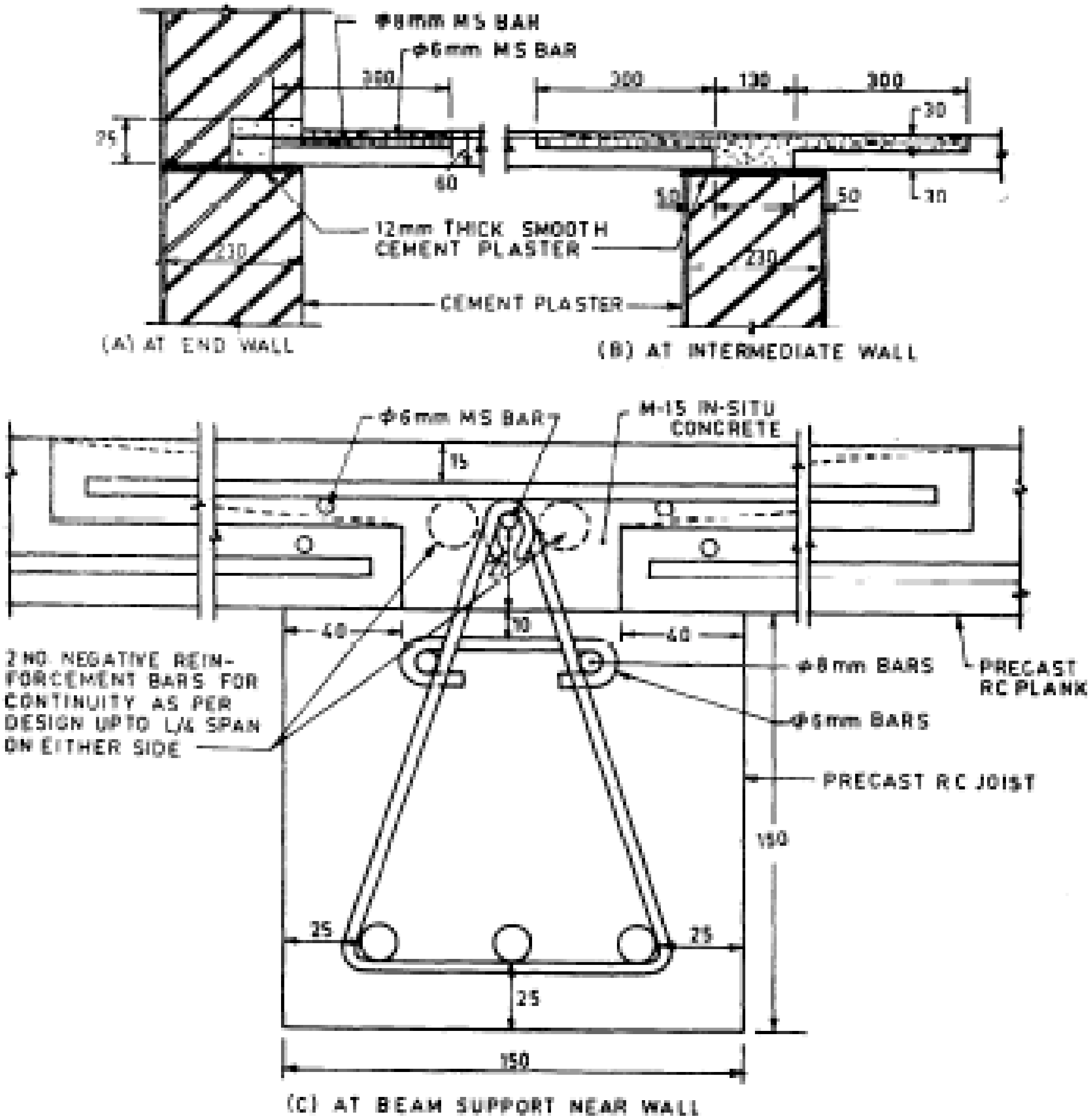
The design load on various components of the flooring/roofing shall comprise self weight , imposed load in accordance with IS 875 (Part 2):1987 and dead load due to floor finish in case of intermediate floors and dead load due to roof treatment in case of roofs in accordance with IS875(Part 1) : 1987.

4.2 Structural design of Roof/floor

4.2.1 Pre cast RC Planks: The plank shall be designed as simply supported for self weight including *in- situ* concrete over haunches, and as a continuous slab for a load comprising live load, self weight and dead load of floor finish and/or water proofing treatment. The design shall be in accordance with the limit state method of IS 456:1978

4.2.2 Partially pre cast joists

4.2.2.1 The joists shall be designed as simply supported or continuous T- beam with 60 mm flange thickness (equal to full thickness of flange with *In- situ* concrete) depending upon whether joists are having single span or continuous over adjacent span. Reinforcement shall be determined in accordance with IS 456: 1978 for the required spacing and span of the joists.



All dimensions in millimetres.

FIG. 4 TYPICAL SKETCH SHOWING DETAILS OF DIFFERENT BEARING POSITION

(Scanned from the Code for reference)

4.2.2.2 For large spans requiring high moment of resistance, either the depth of joist can be increased, or if the depth cannot be increased due to headroom requirements, the joist shall be designed as doubly reinforced beam at the support. In the latter case, the bottom reinforcement of the joist shall be kept projecting out by about 20 mm and the bottom reinforcements of joists covering adjacent spans shall be welded together for continuity. The top reinforcement to resist negative moment shall also be provided in the joists upto a distance from supports as specified in Is 456: 1978. This shall be embedded in *In-situ* concrete. The moments and shears at various sections shall be determined either theoretically or the coefficients given in IS 456: 1978 may be used, wherever applicable. Moment of resistance of T- beam with different reinforcement based on limit state methods is given in table 1 for reference.

4.2.3 Cover to reinforcement: A minimum clear cover of 15 mm for planks and 25 mm for joists shall be provided.

4.3 When the pre cast units are used for construction of buildings in high seismic zones, the roofs/ floors shall be strengthened in accordance with the provision of IS 4326: 1993.

IS 14201-1994

Indian Standard-**PRECAST REINFORCED CONCRETE CHANNEL UNITS FOR CONSTRUCTION OF FLOORS AND ROOFS- SPECIFICATION**

This standard covers the requirements for the pre cast reinforced concrete channel units having a length up to 4.5 m used for construction of roofs and floors. In general, this standard lays down dimensional specifications of pre cast reinforced concrete channel units.

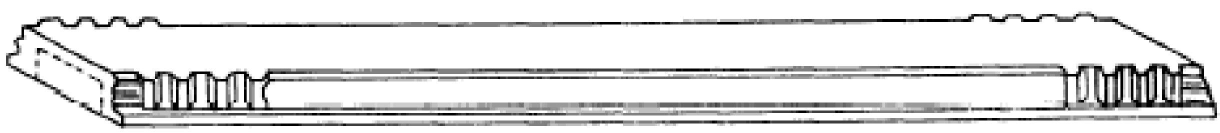


FIG. 1 A CHANNEL UNIT

1

(Scanned from the Code for reference)

Annexure 2

STUDY OF COMPARISON OF DESIGN OF ROOF SLABS CONSTRUCTED BY IN-SITU CONSTRUCTION AND ROOF SLABS CONSTRUCTED BY SEGMENTAL CONSTRUCTION TECHNIQUE

To study the comparison we have developed small software in EXCEL SPEARDSHEET (CALCULATION TOOL OF MS OFFICE A WINDOWS BASED SOFTWARE)

KEY ASPECT CONSIDERED FOR DEVELOPMENT OF THE SOFTWARE

- Analysis of slabs for uniformly distributed loads (structural dead load, floor finishing and live load) for in-situ construction of slab i.e. slab considered to be monolithically cast with the beams as support using bending moment coefficients given in ANNEX D of INDIAN STANDARD CODE OF PRACTICE FOR PLAIN AND REINFORCED CONCRETE IS 456 : 2000. The software has facility for considering all the support conditions as mentioned in the code IS 456: 2000

- Analysis of slabs for concentrated loads such as due to partition walls, other type of concentrated loads can also be considered. For analysis Pigeaud's curves has been used.

- For computerized use of Pigeaud's curves the curves as given in various references are superimposed over graphs of same scale printed on transparencies and having a finer grid using the facility of photocopying available these days. The values of bending moment coefficients for different values of ratio of U/Lx and ratio of V/Ly [ratio of loaded length i.e. contact length of the concentrated load + additional length available due to dispersion of load at 45 degrees through the effective slab thickness to the span length along the direction of loaded length] are read from these curves. Fourteen tables of values are thus generated each corresponding to a different value of Ly/Lx curve.

  Tables corresponding to Ly/Lx equal to 1.00, 1.25, 1.41, 1.67, 2.00 and 2.50 have been taken from Table 54, Table 55 and Table 56 of the book titled 'REINFORCED

CONCRETE DESIGNER'S HANDBOOK' TENTH EDITION authored by: CHARLES E. REYNOLDS AND JAMES C. STEEDMAN.

Table corresponding to Ly/Lx equal to 1.11 has been taken from chapter 12 'design of two way slabs' of the book titled 'LIMIT STATE DESIGN OF REINFORCED CONCRETE' THIRD PRINT authored by: P. C. VARGHESE.

The values so obtained from these curves are connected with the help of programming tools and values lying any where in the range of Ly/Lx greater than or equal to 1.00 and less than or equal to 2.50 are obtained by linearly interpolating values between the nearest values available in the tables.

- The partial safety factors for loads to be used in the analysis are separately mentioned in the software and can be changed if a more stringent approach with higher factor of safety is demanded by the code in future.

- The software shows a line 'Construction Methodology (Write 1 for cast-in-situ construction and 2 for precast segmental construction)'. If 1 is inserted then the software applies entire partial safety factor for loads and calculates the bending moment for dead load + Floor load + Live load, otherwise if 2 is inserted then the software calculates the bending moment due to one times the Dead load (structural weight of slab) for simply supported condition spanning along direction of effective span and marks it as Design Bending Moments (due to Loads before continuity of the structure is established) and calculates Design Bending Moments (due to Loads after continuity of the structure is established) for

  (1.5-1.0) x Dead load + 1.5 x Floor load + 1.5 x Live load

  considering the structure to be continuous in all respects (i.e. same as analyzed in the case of cast-in-situ construction). The Bending Moments due to concentrated loads (partition walls) is analyzed using Pigeaud's curves and is same in both type of construction methodologies as the slab is made continuous by in situ concreting before erection of partition walls.

- The software includes provisions for eccentrically placed concentrated loads and span ratio adjustments for various support conditions as per Pigeaud's method of analysis. Reference for these provisions has been taken from Table 56 of the book titled 'REINFORCED CONCRETE DESIGNER'S HANDBOOK' TENTH EDITION authored by: CHARLES E. REYNOLDS AND JAMES C. STEEDMAN.

- The software also considers check for deflection using span empirical relation with span depth ratio, suggested by IS 456: 2000 clause 23.2.1. The software also includes the modification factor to span depth ratio due to other factors viz. tension reinforcement, compression reinforcement, ratio of web width to flange width. Reference has been taken from clause 22.2.1 page 55 of sp: 24-1983 for the empirical formula for modification factor due to tension reinforcement for direct use in the software.

Note: modification factors due to compression reinforcement, ratio of web width to flange width has been ignored and unity (1) has been inserted for these, however provision for these modification factors has been kept in the software.

- The check for deflection using empirical relation with span depth ratio, suggested by IS 456: 2000 clause 23.2.1 is applicable to in-situ construction only. In case of segmental construction it is assumed that the slab shall be divided into number of beams spanning along effective span of the slab. These precast elements will be provided with precamber against structural weight of the slab so that the top surface of the slab will be perfectly horizontal after achieving continuity through application of in-situ concreting. Therefore the slab will deflect for
(1.5-1.0) x Dead load + 1.5 x Floor load + 1.5 x Live load + concentrated load if any.
The software also includes the calculation of deflection due to long term effects like shrinkage and creep.

  Reference for these calculations has been taken from ANNEX C of INDIAN STANDARD CODE OF PRACTICE FOR PLAIN AND REINFORCED CONCRETE IS 456: 2000.

For the calculation of basic value of deflection before cracking of concrete section ELEMENT ANALYSIS TOOL OF STAAD III has been used. The software automatically generates the input file for STAAD III by dividing the entire slab into 100 elements i.e. a grid of 10 x10 elements, these elements are considered as fixed at joints along the slab edges. The software generates the loading positions and load intensity in the required format of STAAD III. This input file can be simply copied from EXCEL SPREADSHEET and paste in the STAAD input file. The deflections so obtained are fed back into the EXCEL SPREADSHEET for calculation of modified short tem and long term deflection using the concept of effective moment of inertia of the cracked section as guided by ANNEX C of INDIAN STANDARD CODE OF PRACTICE FOR PLAIN AND REINFORCED CONCRETE IS 456: 2000.

Note: the deflections are calculated for full Dead Load taken as acting on continuous structure and later a camber already provided in the slab corresponding to one times the dead load is deducted to give the actual deflection under segmental construction technique.

- The software provides comparison of the deflections obtained and the permissible values as per clause 23.2.a and 23.2.b of IS 456: 2000. With two or three iterations depth required for satisfying deflection criteria can be obtained.

Note: the deflections check with actual calculation of effective moment of inertia of the cracked section can be used for in-situ construction method also by putting precamber values to zero. However we have not considered it here.

DEVELOPING A CONVENIENT TOOL FOR QUICK AND REASONABLY ACCURATE ANALYSIS

The following pages give an insight of how the software works and the basic inputs required?

Step 1: The SOFTWARE requires the inputs for which the slab element is to be designed

The inputs are either colored in blue color or bold font is used to differentiate the input data from the normal data getting generated through internal formulas.

Step 2: Assume suitable depth for first trial

Step 3: Define construction methodology

Write 1 for cast-in-situ construction and 2 for precast segmental construction

Step 4: In the first part of design, slab is analyzed for uniformly distributed loads using coefficients of bending moment as mentioned in ANNEX D of INDIAN STANDARD CODE OF PRACTICE FOR PLAIN AND REINFORCED CONCRETE IS 456: 2000.

In the column marked Span type use following numerals to represent the edge conditions:

101 ⟶ internal panels
102 ⟶ one short edge discontinuous
103 ⟶ one long edge discontinuous
104 ⟶ two adjacent edges discontinuous
105 ⟶ two short edges discontinuous
106 ⟶ two long edges discontinuous
107 ⟶ three edges discontinuous (one long edge continuous)
108 ⟶ three edges discontinuous (one short edge continuous)
109 ⟶ four edges discontinuous

Step 5: After marking span type use following numerals to represent the edge type in shorter and longer span directions:

1 ⟶ continuous edge

2 ⟶ discontinuous edge

As per Clause D-1.6 (ANNEX D OF IS:456 2000) at a discontinuous edge, negative moment may arise depending upon the degree of fixity at the edge of the slab, therefore 50% of the reinforcement provided at mid span should extend 0.1 L into the span. In the present SOFTWARE 50% of the moment at mid span is considered to be effective at the discontinuous edge so that the codal provision of extending 50% reinforcement is automatically taken care off while calculating the final reinforcement.

Step 6: In the second part of the design the SOFTWARE deal with analysis of slab for concentrated loads using Pigeaud's curves

Total Load ⟶ refers to the concentrated load including partial factor of safety for Loads.

aLx ⟶ refers to the length of concentrated load along the direction of shorter/ effective span.

aLy ⟶ refers to the length of concentrated load along the direction of longer span.

$\mathbf{X_{CG}}$ ⟶ refers to the Distance of the CG of the concentrated load along the direction of shorter/ effective span.

$\mathbf{Y_{CG}}$ ⟶ refers to the Distance of the CG of the concentrated load along the direction of longer span.

The distances $\mathbf{X_{CG}}$ and $\mathbf{Y_{CG}}$ should be the perpendicular from the nearest edge i.e. the shorter distance.

Load Type → refers to the position of the concentrated load with respect to the CG of the Slab Panel.

Load Type 1 → refers to concentrated load concentric with the slab CG in both Lx and Ly directions.

Load Type 2 → refers to concentrated load concentric with the slab CG in both Lx directions and eccentric in Ly direction.

Load Type 3 → refers to concentrated load concentric with the slab CG in both Ly directions and eccentric in Lx direction.

Load Type 4 → refers to concentrated load eccentric with the slab CG in both Lx and Ly directions.

The loads which can not be defined by any of the above load type can be divided into several fragments so that each fragment can be individually defined by one of the above types.

The SOFTWARE includes facility for considering five concentrated loads or load fragments. The no. of concentrated loads can be increased further if required.

Step 7: In certain cases the load can be defined by proper load type, but it changes after the effect of dispersion through the effective depth of the slab is considered. To take care of this the effect of the dispersion through the effective slab thickness can be ignored making the analysis result a bit more conservative.

The SOFTWARE asks to enter 1 for effect of dispersion to be considered and 2 for effect of dispersion to be ignored.

Step 8: In the analysis for concentrated loads the Pigeaud's method suggest modification in Ly/Lx ratio depending upon the edge conditions of the Slab Panel by multiplying it by a factor K1.

In the column marked Span type use following numerals to represent the edge conditions:

101 ⟶ internal panels -- K1 = 1
102 ⟶ one short edge discontinuous ------------------------ K1 = 9/8
103 ⟶ one long edge discontinuous ------------------------ K1 = 7/8
104 ⟶ two adjacent edges discontinuous ------------------------ K1 = 1
105 ⟶ two short edges discontinuous ------------------------ K1 = 4/3
106 ⟶ two long edges discontinuous ------------------------ K1 = 3/4
107 ⟶ three edges discontinuous (one long edge continuous) ----- K1 = 6/5
108 ⟶ three edges discontinuous (one short edge continuous) ---- K1 = 5/6
109 ⟶ four edges discontinuous -------------------------------- K1 = 1

Step 9: After marking span type use following numerals to represent the edge type in shorter and longer span directions for calculation of mid span moment, according to the edge type the actual moment is obtained by multiplying calculated moment by a factor F:

1 ⟶ edge of interior panel -------------------------------- F = 0.70
2 ⟶ edge of end panel. -------------------------------- F = 0.85

Similarly use following numerals to represent edge type in shorter and longer directions for calculation of support moment, according to the edge type the actual moment is obtained by multiplying calculated moment by a factor F:

1 ⟶ edge of interior panel ------------------------------- F = 0.90
2 ⟶ edge of end panel. ------------------------------- F = 0.25
3 ⟶ edge of penultimate panel lying towards end panel ----- F = 0.25

Step 10: Finally the SOFTWARE superimpose all the bending moments calculated for uniformly distributed loads applied before continuity of the structure is achieved/ after continuity of the structure is achieved and the moments calculated for various concentrated loads.

Step 11: The SOFTWARE directly calculates the effective depth required, ratio of depth of neutral axis to effective depth and the area of steel required using the actual effective depth considered for the analysis. The depth required can be compared with the depth assumed for the analysis and iterated accordingly; simultaneously the Xu/d ratio gives a check for ensuring that the final section is under-reinforced to ensure greater ductility as desired in all the designs.

Step 12: The SOFTWARE also gives a check for effective depth required for satisfying the check for deflection (Span- Depth ratio) as given by IS:456 200. After comparison the depth of slab required can be iterated accordingly. This check is applicable to cast-in-situ construction. For deflection check in segmental construction method a separate sheet is used where an input for STAAD III file is generated automatically. This is fed into STAAD for Analysis, the deflection results obtained is fed back to the EXCEL-SPREADSHEET and the actual deflection including long term effects due to shrinkage and creep is calculated as per IS:456 2000. after two or three iterations the deflections can be managed with in the limiting values and the corresponding depth of slab required can be found out.

Annexure 3

Part 1:

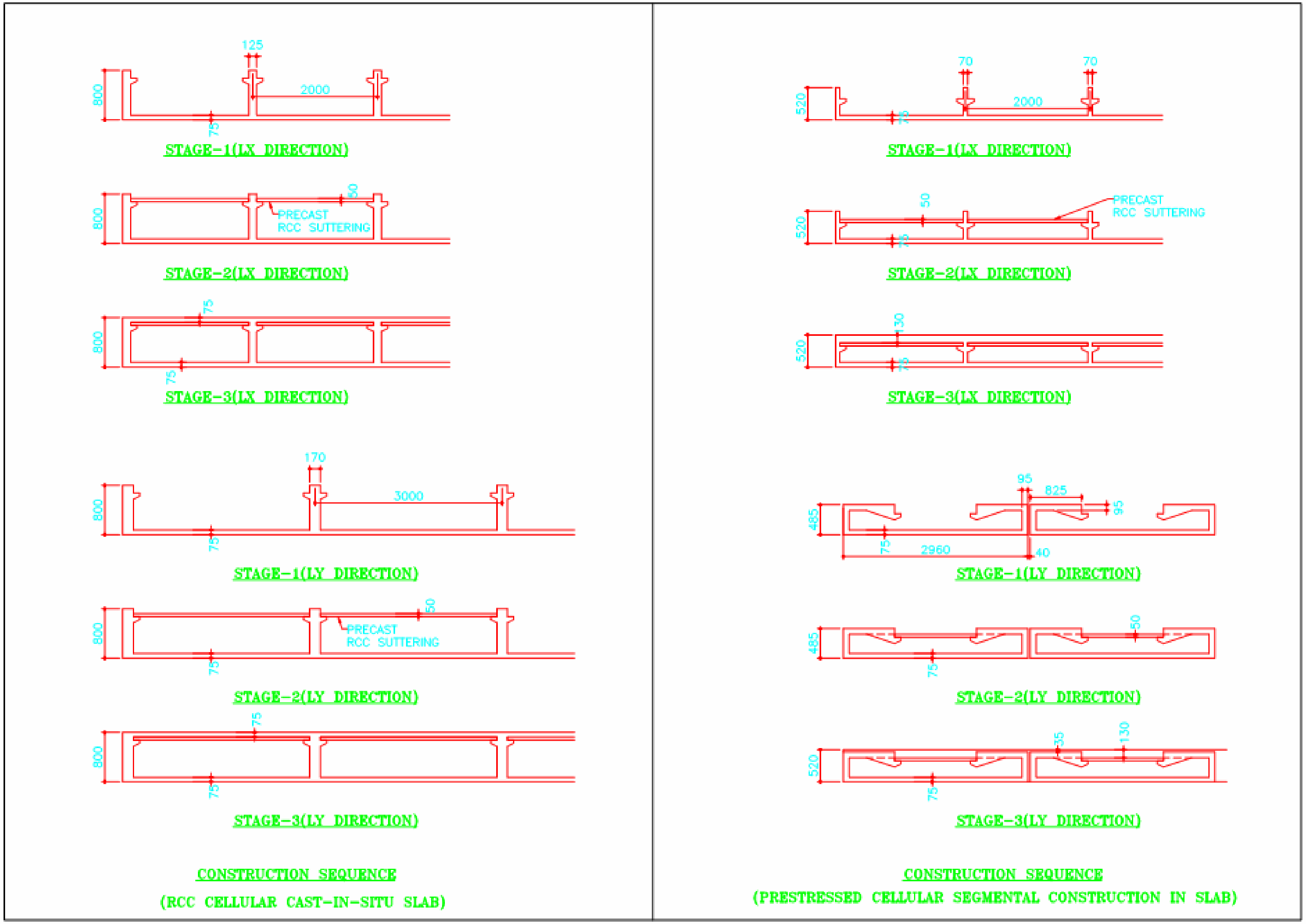
Design Calculations of RCC cellular slab cast-in-situ

Part 2:

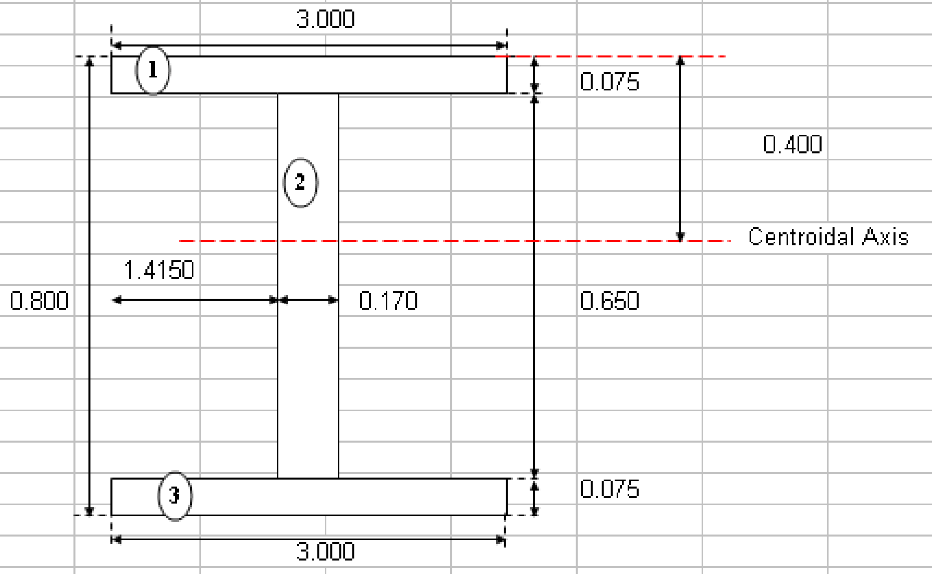
Design Calculations of PSC cellular slab design to be constructed by segmental construction technique

Part 3:

Design Calculations of RCC continuity in cellular slab design to be constructed by segmental construction technique


125
2000
800
75
STAGE-1(LX DIRECTION)
50
PRECAST
RCC SUTTERING
STAGE-2(LX DIRECTION)
75
STAGE-3(LX DIRECTION)
170
3000
STAGE-1(LY DIRECTION)
STAGE-2(LY DIRECTION)
STAGE-3(LY DIRECTION)
CONSTRUCTION SEQUENCE
(RCC CELLULAR CAST-IN-SITU SLAB)
70
520
STAGE-1(LX DIRECTION)
STAGE-2(LX DIRECTION)
130
STAGE-3(LX DIRECTION)
95
825
485
2960
40
STAGE-1(LY DIRECTION)
STAGE-2(LY DIRECTION)
35
STAGE-3(LY DIRECTION)
CONSTRUCTION SEQUENCE
(PRESTRESSED CELLULAR SEGMENTAL CONSTRUCTION IN SLAB)

Section Properties of The Internal Cell Grid Line Along Lx Direction at Mid Span Location



Calculation of Cross-Section Properties

Element	Area (A)	Z	AZ	Y	AY
1	0.225	0.038	0.0084	1.500	0.3375
2	0.1105	0.4	0.0442	1.500	0.1658
3	0.225	0.7625	0.1716	1.500	0.3375
TOTAL	**0.560500**		**0.2242**		**0.8408**

$\overline{Z}$ = 0.400 m $\overline{Y}$ = 1.500 m

I_X

Element	b	d	$\frac{bd^3}{3}$	
1	3.000	0.075	2.11E-04	<---bd³/6
2	0.650	0.170	1.06E-03	<---bd³/3
3	3.000	0.075	2.11E-04	<---bd³/6
TOTAL			0.001486	

I_X = **0.001486** m^4

I_Y

Element	Iself=db³/12	$A(Y - \overline{Y})^2$
1	0.168750	0.000000
2	0.000266	0.000000
3	0.168750	0.000000
TOTAL	0.337766	0.000000

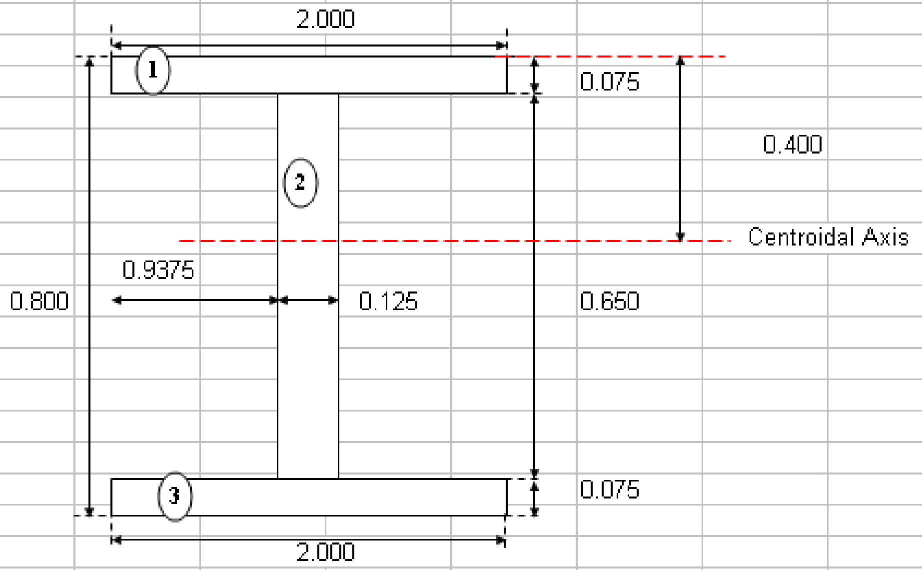
I_y = **0.337766** m^4

I_Z

Element	Iself=bd³/12	$A(X-\overline{X})^2$
1	0.000105	0.029566
2	0.003891	0.000000
3	0.000105	0.029566
TOTAL	0.004101	0.059133

I_Z = **0.063234** m^4

Section Properties of The Internal Cell Grid Line Along Ly Direction at Mid Span Location



Calculation of Cross-Section Properties

Element	Area (A)	Z	AZ	Y	AY
1	0.15	0.038	0.0056	1.000	0.1500
2	0.08125	0.4	0.0325	1.000	0.0813
3	0.15	0.7625	0.1144	1.000	0.1500
TOTAL	**0.381250**		**0.1525**		**0.3813**

$\overline{Z}$ = 0.400 m $\overline{Y}$ = 1.000 m

I_X

Element	b	d	$\frac{bd^3}{3}$	
1	2.000	0.075	1.41E-04	<---$bd^3/6$
2	0.650	0.125	4.23E-04	<---$bd^3/3$
3	2.000	0.075	1.41E-04	<---$bd^3/6$
TOTAL			0.000704	

I_X = **0.000704** m^4

I_Y

Element	Iself=$db^3/12$	$A(Y - \overline{Y})^2$
1	0.050000	0.000000
2	0.000106	0.000000
3	0.050000	0.000000
TOTAL	0.100106	0.000000

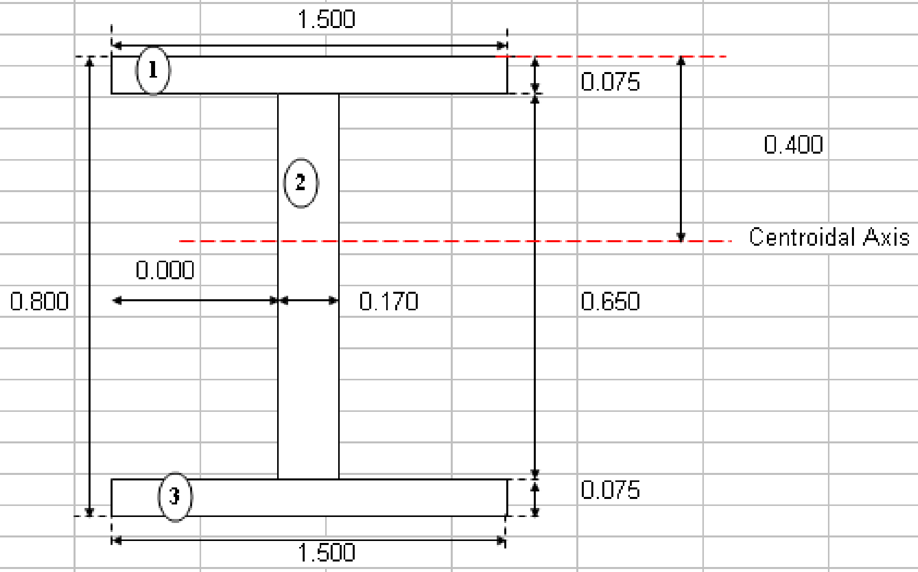
I_y = **0.100106** m^4

I_Z

Element	Iself=$bd^3/12$	$A(X - \overline{X})^2$
1	0.000070	0.019711
2	0.002861	0.000000
3	0.000070	0.019711
TOTAL	0.003001	0.039422

I_Z = **0.042423** m^4

Section Properties of The Internal Cell Grid Line Along Lx Direction at Mid Span Location



Calculation of Cross-Section Properties

Element	Area (A)	Z	AZ	Y	AY
1	0.1125	0.038	0.0042	0.750	0.0844
2	0.1105	0.4	0.0442	0.085	0.0094
3	0.1125	0.7625	0.0858	0.750	0.0844
TOTAL	**0.335500**		**0.1342**		**0.1781**

$\overline{Z}$ = 0.400 m $\overline{Y}$ = 0.531 m

I_X

Element	b	d	$\frac{bd^3}{3}$	
1	1.500	0.075	1.05E-04	<---$bd^3/6$
2	0.650	0.170	1.06E-03	<---$bd^3/3$
3	1.500	0.075	1.05E-04	<---$bd^3/6$
TOTAL			0.001275	

I_X = **0.001275** m^4

I_Y

Element	Iself=$db^3/12$	$A(Y - \overline{Y})^2$
1	0.021094	0.005397
2	0.000266	0.021978
3	0.021094	0.005397
TOTAL	0.042454	0.032771

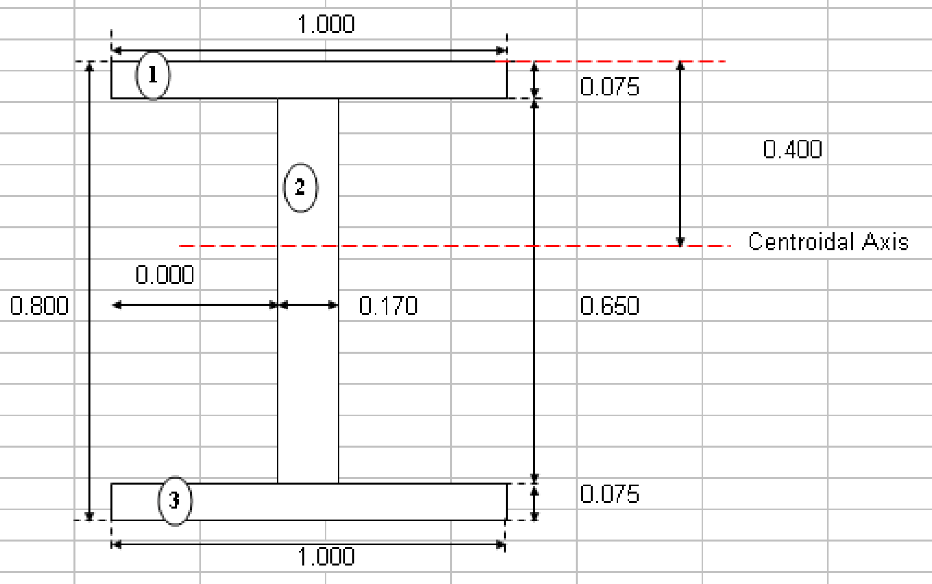
I_y = **0.075225** m^4

I_Z

Element	Iself=$bd^3/12$	$A(X - \overline{X})^2$
1	0.000053	0.014783
2	0.003891	0.000000
3	0.000053	0.014783
TOTAL	0.003996	0.029566

I_Z = **0.033562** m^4

Section Properties of The Internal Cell Grid Line Along Ly Direction at Mid Span Location



Calculation of Cross-Section Properties

Element	Area (A)	Z	AZ	Y	AY
1	0.075	0.038	0.0028	0.500	0.0375
2	0.1105	0.4	0.0442	0.085	0.0094
3	0.075	0.7625	0.0572	0.500	0.0375
TOTAL	**0.260500**		**0.1042**		**0.0844**

$\overline{Z}$ = 0.400 m $\overline{Y}$ = 0.324 m

I_X

Element	b	d	$\frac{bd^3}{3}$	
1	1.000	0.075	7.03E-05	<---$bd^3/6$
2	0.650	0.170	1.06E-03	<---$bd^3/3$
3	1.000	0.075	7.03E-05	<---$bd^3/6$
TOTAL			0.001205	

I_X = 0.001205 m^4

I_Y

Element	$I_{self}=db^3/12$	$A(Y-\overline{Y})^2$
1	0.006250	0.002324
2	0.000266	0.006310
3	0.006250	0.002324
TOTAL	0.012766	0.010958

I_y = 0.023724 m^4

I_Z

Element	$I_{self}=bd^3/12$	$A(X-\overline{X})^2$
1	0.000035	0.009855
2	0.003891	0.000000
3	0.000035	0.009855
TOTAL	0.003961	0.019711

I_Z = 0.023672 m^4

SUMMARY OF BENDING MOMENTS IN VARIOUS LOAD COMBINATIONS

COMBINATION 1

PARTIAL FACTOR OF SAFETY FOR LOADS

Please write 1 for cast-in-situ construction and 2 for segmental construction **1**

	ULS
DEAD LOAD	1.50
FLOOR FINISHES	1.50
LIVE LOAD	1.50

span of the slab

Lx	20	m
Ly	30	m

SIGN CONVENTION:

+ve means hogging
-ve means sagging

Clear Cover to Reinforcement in beams/slabs	20	mm
Clear Cover to Reinforcement in ribs	20	mm
Dia of Reinforcing Bars	16	mm
Charecteristic compressive strength of concrete	40	N/mm^2
Charecteristic tensile strength of reinforcement	415	N/mm^2

LOAD CASE →			UNFACTORED MOMENTS			Factored Moment												
Member No.	Distance		Dead Load	Floor Finishes	Live Load	Total Bending moment	Total Depth of the Member	Effective Depth	Thickness of comp-ression Flange	Xumax/d Permi-ssible	Xu for Yf= Df	MOR for which Xu = Df Muf	MOR for which Xu makes Yf=Df Mub	MOR for which Xu makes Yf>Df Muweb	Flange Width of the Member	Web Width of the Member	Xu/d Achieved	Area of Steel Required cm^2
51	0	MAX.	71.21	20.44	20.44	168.14	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.06692	**60.85**
		MIN.	71.21	20.44	20.44	168.14	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.06692	**60.85**
	1	MAX.	51.45	14.78	14.78	121.52	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.04797	**43.62**
		MIN.	51.45	14.78	14.78	121.52	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.04797	**43.62**
	2	MAX.	32.70	9.38	9.38	77.19	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.03024	**27.50**
		MIN.	32.70	9.38	9.38	77.19	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.03024	**27.50**
52	0	MAX.	32.71	9.39	9.39	77.24	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.03026	**27.52**
		MIN.	32.71	9.39	9.39	77.24	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.03026	**27.52**
	1	MAX.	17.15	4.93	4.93	40.52	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.01578	**14.35**
		MIN.	17.15	4.93	4.93	40.52	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.01578	**14.35**
	2	MAX.	2.60	0.74	0.74	6.12	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.00237	**2.15**
		MIN.	2.60	0.74	0.74	6.12	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.00237	**2.15**

UNFACTORED TORSION			Factored Moment	UNFACTORED SHEAR			Factored Shear	Equivalent Shear/Bending Moment due to Effect of Torsion				Total Shear/ Moment										
Dead Load	Floor Finish-es	Live Load	Total Torsion	Dead Load	Floor Finish-es	Live Load	Total Shear	Total Depth of the Member	Breadth of the Member	Shear	Bending moment	Shear	Bending moment	Effective Depth	Shear stress	% Tensile Reinf.	Permi-ssible Shear Stress	b1	d1	Shear Reinf. Required cm^2	Xu/d Achieved	Area of Tension Steel Required cm^2
0.00	0.00	0.00	0.00	20.22	5.73	5.73	47.52	0.80	0.170	0.00	0.00	47.52	168.14	0.77	362.1	4.64	103.02	0.114	0.744	11.96	0.07	60.85
0.00	0.00	0.00	0.00	20.22	5.73	5.73	47.52	0.80	0.170	0.00	0.00	47.52	168.14	0.77	362.1	4.64	103.02	0.114	0.744	11.96	0.07	60.85
0.00	0.00	0.00	0.00	19.26	5.53	5.53	45.48	0.80	0.170	0.00	0.00	45.48	121.52	0.77	346.5	3.32	103.02	0.114	0.744	11.24	0.05	43.62
0.00	0.00	0.00	0.00	19.26	5.53	5.53	45.48	0.80	0.170	0.00	0.00	45.48	121.52	0.77	346.5	3.32	103.02	0.114	0.744	11.24	0.05	43.62
0.00	0.00	0.00	0.00	18.29	5.33	5.33	43.43	0.80	0.170	0.00	0.00	43.43	77.19	0.77	330.9	2.10	91.23	0.114	0.744	11.06	0.03	27.50
0.00	0.00	0.00	0.00	18.29	5.33	5.33	43.43	0.80	0.170	0.00	0.00	43.43	77.19	0.77	330.9	2.10	91.23	0.114	0.744	11.06	0.03	27.50
0.00	0.00	0.00	0.00	16.02	4.53	4.53	37.62	0.80	0.170	0.00	0.00	37.62	77.24	0.77	286.7	2.10	91.23	0.114	0.744	9.02	0.03	27.52
0.00	0.00	0.00	0.00	16.02	4.53	4.53	37.62	0.80	0.170	0.00	0.00	37.62	77.24	0.77	286.7	2.10	91.23	0.114	0.744	9.02	0.03	27.52
0.00	0.00	0.00	0.00	15.06	4.33	4.33	35.58	0.80	0.170	0.00	0.00	35.58	40.52	0.77	271.1	1.09	71.56	0.114	0.744	9.21	0.02	14.35
0.00	0.00	0.00	0.00	15.06	4.33	4.33	35.58	0.80	0.170	0.00	0.00	35.58	40.52	0.77	271.1	1.09	71.56	0.114	0.744	9.21	0.02	14.35
0.00	0.00	0.00	0.00	14.09	4.13	4.13	33.53	0.80	0.170	0.00	0.00	33.53	6.12	0.77	255.4	0.16	31.42	0.114	0.744	10.34	0.00	2.15
0.00	0.00	0.00	0.00	14.09	4.13	4.13	33.53	0.80	0.170	0.00	0.00	33.53	6.12	0.77	255.4	0.16	31.42	0.114	0.744	10.34	0.00	2.15

			UNFACTORED MOMENTS			Factored Moment												
LOAD CASE →			Dead Load	Floor Finishes	Live Load	Total Bending moment	Total Depth of the Member	Effective Depth	Thickness of comp-ression Flange	Xumax/d Permi-ssible	Xu for Yf = Df	MOR for which Xu = Df Muf	MOR for which Xu makes Yf=Df Mub	MOR for which Xu makes Yf>Df Muweb	Flange Width of the Member	Web Width of the Member	Xu/d Achieved	Area of Steel Required cm^2
Member No.	Distance																	
53	0	MAX.	2.63	0.74	0.74	6.17	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.00239	**2.17**
		MIN.	2.63	0.74	0.74	6.17	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.00239	**2.17**
	1	MAX.	-8.69	-2.50	-2.50	-20.54	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.00797	**7.25**
		MIN.	-8.69	-2.50	-2.50	-20.54	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.00797	**7.25**
	2	MAX.	-19.00	-5.47	-5.47	-44.91	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.01750	**15.91**
		MIN.	-19.00	-5.47	-5.47	-44.91	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.01750	**15.91**
54	0	MAX.	-18.97	-5.46	-5.46	-44.84	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.01747	**15.89**
		MIN.	-18.97	-5.46	-5.46	-44.84	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.01747	**15.89**
	1	MAX.	-26.01	-7.47	-7.47	-61.43	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.02400	**21.83**
		MIN.	-26.01	-7.47	-7.47	-61.43	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.02400	**21.83**
	2	MAX.	-32.04	-9.22	-9.22	-75.72	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.02966	**26.97**
		MIN.	-32.04	-9.22	-9.22	-75.72	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.02966	**26.97**
55	0	MAX.	-32.03	-9.22	-9.22	-75.71	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.02965	**26.96**
		MIN.	-32.03	-9.22	-9.22	-75.71	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.02965	**26.96**
	1	MAX.	-34.73	-9.98	-9.98	-82.04	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.03217	**29.25**
		MIN.	-34.73	-9.98	-9.98	-82.04	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.03217	**29.25**
	2	MAX.	-36.42	-10.48	-10.48	-86.07	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.03377	**30.71**
		MIN.	-36.42	-10.48	-10.48	-86.07	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.03377	**30.71**
56	0	MAX.	-36.42	-10.48	-10.48	-86.07	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.03377	**30.71**
		MIN.	-36.42	-10.48	-10.48	-86.07	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.03377	**30.71**
	1	MAX.	-34.74	-9.98	-9.98	-82.05	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.03217	**29.26**
		MIN.	-34.74	-9.98	-9.98	-82.05	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.03217	**29.26**
	2	MAX.	-32.06	-9.22	-9.22	-75.75	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.02967	**26.98**
		MIN.	-32.06	-9.22	-9.22	-75.75	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.02967	**26.98**
57	0	MAX.	-32.07	-9.23	-9.23	-75.80	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.02969	**27.00**
		MIN.	-32.07	-9.23	-9.23	-75.80	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.02969	**27.00**
	1	MAX.	-26.05	-7.48	-7.48	-61.52	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.02404	**21.86**
		MIN.	-26.05	-7.48	-7.48	-61.52	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.02404	**21.86**
	2	MAX.	-19.02	-5.48	-5.48	-44.97	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.01752	**15.93**
		MIN.	-19.02	-5.48	-5.48	-44.97	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.01752	**15.93**

UNFACTORED TORSION			Factored Moment	UNFACTORED SHEAR			Factored Shear	Equivalent Shear/Bending Moment due to Effect of Torsion				Total Shear/ Moment										
Dead Load	Floor Finish-es	Live Load	Total Torsion	Dead Load	Floor Finish-es	Live Load	Total Shear	Total Depth of the Member	Breadth of the Member	Shear	Bending moment	Shear	Bending moment	Effective Depth	Shear stress	% Tensile Reinf.	Permi-ssible Shear Stress	b1	d1	Shear Reinf. Required cm^2	Xu/d Achieved	Area of Tension Steel Required cm^2
0.00	0.00	0.00	0.00	11.78	3.31	3.31	27.60	0.80	0.170	0.00	0.00	27.60	6.17	0.77	210.3	0.17	31.42	0.114	0.744	8.26	0.00	2.17
0.00	0.00	0.00	0.00	11.78	3.31	3.31	27.60	0.80	0.170	0.00	0.00	27.60	6.17	0.77	210.3	0.17	31.42	0.114	0.744	8.26	0.00	2.17
0.00	0.00	0.00	0.00	10.81	3.11	3.11	25.55	0.80	0.170	0.00	0.00	25.55	20.54	0.77	194.6	0.55	53.86	0.114	0.744	6.50	0.01	7.25
0.00	0.00	0.00	0.00	10.81	3.11	3.11	25.55	0.80	0.170	0.00	0.00	25.55	20.54	0.77	194.6	0.55	53.86	0.114	0.744	6.50	0.01	7.25
0.00	0.00	0.00	0.00	9.84	2.91	2.91	23.49	0.80	0.170	0.00	0.00	23.49	44.91	0.77	179.0	1.21	74.50	0.114	0.744	4.82	0.02	15.91
0.00	0.00	0.00	0.00	9.84	2.91	2.91	23.49	0.80	0.170	0.00	0.00	23.49	44.91	0.77	179.0	1.21	74.50	0.114	0.744	4.82	0.02	15.91
0.00	0.00	0.00	0.00	7.50	2.08	2.08	17.49	0.80	0.170	0.00	0.00	17.49	44.84	0.77	133.3	1.21	74.50	0.114	0.744	2.71	0.02	15.89
0.00	0.00	0.00	0.00	7.50	2.08	2.08	17.49	0.80	0.170	0.00	0.00	17.49	44.84	0.77	133.3	1.21	74.50	0.114	0.744	2.71	0.02	15.89
0.00	0.00	0.00	0.00	6.53	1.88	1.88	15.44	0.80	0.170	0.00	0.00	15.44	61.43	0.77	117.6	1.66	83.84	0.114	0.744	2.25	0.02	21.83
0.00	0.00	0.00	0.00	6.53	1.88	1.88	15.44	0.80	0.170	0.00	0.00	15.44	61.43	0.77	117.6	1.66	83.84	0.114	0.744	2.25	0.02	21.83
0.00	0.00	0.00	0.00	5.57	1.68	1.68	13.40	0.80	0.170	0.00	0.00	13.40	75.72	0.77	102.1	2.05	90.58	0.114	0.744	1.96	0.03	26.97
0.00	0.00	0.00	0.00	5.57	1.68	1.68	13.40	0.80	0.170	0.00	0.00	13.40	75.72	0.77	102.1	2.05	90.58	0.114	0.744	1.96	0.03	26.97
0.00	0.00	0.00	0.00	3.16	0.83	0.83	7.23	0.80	0.170	0.00	0.00	7.23	75.71	0.77	55.1	2.05	90.58	0.114	0.744	Not Required	0.03	26.96
0.00	0.00	0.00	0.00	3.16	0.83	0.83	7.23	0.80	0.170	0.00	0.00	7.23	75.71	0.77	55.1	2.05	90.58	0.114	0.744	Not Required	0.03	26.96
0.00	0.00	0.00	0.00	2.19	0.63	0.63	5.18	0.80	0.170	0.00	0.00	5.18	82.04	0.77	39.4	2.23	93.35	0.114	0.744	Not Required	0.03	29.25
0.00	0.00	0.00	0.00	2.19	0.63	0.63	5.18	0.80	0.170	0.00	0.00	5.18	82.04	0.77	39.4	2.23	93.35	0.114	0.744	Not Required	0.03	29.25
0.00	0.00	0.00	0.00	1.23	0.43	0.43	3.14	0.80	0.170	0.00	0.00	3.14	86.07	0.77	23.9	2.34	94.82	0.114	0.744	Not Required	0.03	30.71
0.00	0.00	0.00	0.00	1.23	0.43	0.43	3.14	0.80	0.170	0.00	0.00	3.14	86.07	0.77	23.9	2.34	94.82	0.114	0.744	Not Required	0.03	30.71
0.00	0.00	0.00	0.00	-1.21	-0.43	-0.43	-3.11	0.80	0.170	0.00	0.00	3.11	86.07	0.77	23.7	2.34	94.82	0.114	0.744	Not Required	0.03	30.71
0.00	0.00	0.00	0.00	-1.21	-0.43	-0.43	-3.11	0.80	0.170	0.00	0.00	3.11	86.07	0.77	23.7	2.34	94.82	0.114	0.744	Not Required	0.03	30.71
0.00	0.00	0.00	0.00	-2.18	-0.63	-0.63	-5.16	0.80	0.170	0.00	0.00	5.16	82.05	0.77	39.3	2.23	93.35	0.114	0.744	Not Required	0.03	29.26
0.00	0.00	0.00	0.00	-2.18	-0.63	-0.63	-5.16	0.80	0.170	0.00	0.00	5.16	82.05	0.77	39.3	2.23	93.35	0.114	0.744	Not Required	0.03	29.26
0.00	0.00	0.00	0.00	-3.14	-0.83	-0.83	-7.20	0.80	0.170	0.00	0.00	7.20	75.75	0.77	54.9	2.06	90.58	0.114	0.744	Not Required	0.03	26.98
0.00	0.00	0.00	0.00	-3.14	-0.83	-0.83	-7.20	0.80	0.170	0.00	0.00	7.20	75.75	0.77	54.9	2.06	90.58	0.114	0.744	Not Required	0.03	26.98
0.00	0.00	0.00	0.00	-5.56	-1.68	-1.68	-13.38	0.80	0.170	0.00	0.00	13.38	75.80	0.77	102.0	2.06	90.58	0.114	0.744	0.53	0.03	27.00
0.00	0.00	0.00	0.00	-5.56	-1.68	-1.68	-13.38	0.80	0.170	0.00	0.00	13.38	75.80	0.77	102.0	2.06	90.58	0.114	0.744	0.53	0.03	27.00
0.00	0.00	0.00	0.00	-6.53	-1.88	-1.88	-15.44	0.80	0.170	0.00	0.00	15.44	61.52	0.77	117.6	1.67	83.84	0.114	0.744	1.56	0.02	21.86
0.00	0.00	0.00	0.00	-6.53	-1.88	-1.88	-15.44	0.80	0.170	0.00	0.00	15.44	61.52	0.77	117.6	1.67	83.84	0.114	0.744	1.56	0.02	21.86
0.00	0.00	0.00	0.00	-7.49	-2.08	-2.08	-17.48	0.80	0.170	0.00	0.00	17.48	44.97	0.77	133.2	1.21	74.50	0.114	0.744	2.71	0.02	15.93
0.00	0.00	0.00	0.00	-7.49	-2.08	-2.08	-17.48	0.80	0.170	0.00	0.00	17.48	44.97	0.77	133.2	1.21	74.50	0.114	0.744	2.71	0.02	15.93

LOAD CASE →			UNFACTORED MOMENTS			Factored Moment												
Member No.	Distance		Dead Load	Floor Finishes	Live Load	Total Bending moment	Total Depth of the Member	Effective Depth	Thickness of comp-ression Flange	Xumax/d Permi-ssible	Xu for Yf = Df	MOR for which Xu = Df Muf	MOR for which Xu makes Yf=Df Mub	MOR for which Xu makes Yf>Df Muweb	Flange Width of the Member	Web Width of the Member	Xu/d Achieved	Area of Steel Required cm^2
58	0	MAX.	-19.04	-5.48	-5.48	-45.00	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.01754	**15.95**
		MIN.	-19.04	-5.48	-5.48	-45.00	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.01754	**15.95**
	1	MAX.	-8.72	-2.50	-2.50	-20.58	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.00799	**7.26**
		MIN.	-8.72	-2.50	-2.50	-20.58	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.00799	**7.26**
	2	MAX.	2.61	0.74	0.74	6.14	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.00238	**2.16**
		MIN.	2.61	0.74	0.74	6.14	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.00238	**2.16**
59	0	MAX.	2.58	0.73	0.73	6.06	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.00235	**2.13**
		MIN.	2.58	0.73	0.73	6.06	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.00235	**2.13**
	1	MAX.	17.15	4.93	4.93	40.52	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.01578	**14.35**
		MIN.	17.15	4.93	4.93	40.52	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.01578	**14.35**
	2	MAX.	32.73	9.39	9.39	77.27	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.03027	**27.53**
		MIN.	32.73	9.39	9.39	77.27	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.03027	**27.53**
60	0	MAX.	32.71	9.38	9.38	77.21	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.03025	**27.51**
		MIN.	32.71	9.38	9.38	77.21	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.03025	**27.51**
	1	MAX.	51.48	14.79	14.79	121.59	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.04800	**43.65**
		MIN.	51.48	14.79	14.79	121.59	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.04800	**43.65**
	2	MAX.	71.26	20.46	20.46	168.27	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.06697	**60.90**
		MIN.	71.26	20.46	20.46	168.27	0.800	0.772	0.075	0.48	0.1750	240.9	312.0	338.5	2.953	0.170	0.06697	**60.90**
116	0	MAX.	31.06	9.10	9.10	73.89	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.04298	**26.47**
		MIN.	31.06	9.10	9.10	73.89	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.04298	**26.47**
	1.5	MAX.	18.98	5.40	5.40	44.67	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.02579	**15.88**
		MIN.	18.98	5.40	5.40	44.67	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.02579	**15.88**
	3	MAX.	8.43	2.47	2.47	20.06	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.01151	**7.09**
		MIN.	8.43	2.47	2.47	20.06	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.01151	**7.09**
127	0	MAX.	8.49	2.49	2.49	20.21	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.01160	**7.14**
		MIN.	8.49	2.49	2.49	20.21	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.01160	**7.14**
	1.5	MAX.	1.70	0.42	0.42	3.81	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00218	**1.34**
		MIN.	1.70	0.42	0.42	3.81	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00218	**1.34**
	3	MAX.	-3.29	-0.88	-0.88	-7.58	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00433	**2.67**
		MIN.	-3.29	-0.88	-0.88	-7.58	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00433	**2.67**

UNFACTORED TORSION			Factored Moment	UNFACTORED SHEAR			Factored Shear	Equivalent Shear/Bending Moment due to Effect of Torsion				Total Shear/ Moment										
Dead Load	Floor Finish-es	Live Load	Total Torsion	Dead Load	Floor Finish-es	Live Load	Total Shear	Total Depth of the Member	Breadth of the Member	Shear	Bending moment	Shear	Bending moment	Effective Depth	Shear stress	% Tensile Reinf.	Permi-ssible Shear Stress	b1	d1	Shear Reinf. Required cm^2	Xu/d Achieved	Area of Tension Steel Required cm^2
0.00	0.00	0.00	0.00	-9.86	-2.91	-2.91	-23.52	0.80	0.170	0.00	0.00	23.52	45.00	0.77	179.2	1.21	74.50	0.114	0.744	4.83	0.02	15.95
0.00	0.00	0.00	0.00	-9.86	-2.91	-2.91	-23.52	0.80	0.170	0.00	0.00	23.52	45.00	0.77	179.2	1.21	74.50	0.114	0.744	4.83	0.02	15.95
0.00	0.00	0.00	0.00	-10.83	-3.11	-3.11	-25.58	0.80	0.170	0.00	0.00	25.58	20.58	0.77	194.9	0.55	53.86	0.114	0.744	6.51	0.01	7.26
0.00	0.00	0.00	0.00	-10.83	-3.11	-3.11	-25.58	0.80	0.170	0.00	0.00	25.58	20.58	0.77	194.9	0.55	53.86	0.114	0.744	6.51	0.01	7.26
0.00	0.00	0.00	0.00	-11.79	-3.31	-3.31	-27.62	0.80	0.170	0.00	0.00	27.62	6.14	0.77	210.4	0.16	31.42	0.114	0.744	8.26	0.00	2.16
0.00	0.00	0.00	0.00	-11.79	-3.31	-3.31	-27.62	0.80	0.170	0.00	0.00	27.62	6.14	0.77	210.4	0.16	31.42	0.114	0.744	8.26	0.00	2.16
0.00	0.00	0.00	0.00	-14.10	-4.13	-4.13	-33.54	0.80	0.170	0.00	0.00	33.54	6.06	0.77	255.6	0.16	31.42	0.114	0.744	10.35	0.00	2.13
0.00	0.00	0.00	0.00	-14.10	-4.13	-4.13	-33.54	0.80	0.170	0.00	0.00	33.54	6.06	0.77	255.6	0.16	31.42	0.114	0.744	10.35	0.00	2.13
0.00	0.00	0.00	0.00	-15.07	-4.33	-4.33	-35.60	0.80	0.170	0.00	0.00	35.60	40.52	0.77	271.2	1.09	71.56	0.114	0.744	9.22	0.02	14.35
0.00	0.00	0.00	0.00	-15.07	-4.33	-4.33	-35.60	0.80	0.170	0.00	0.00	35.60	40.52	0.77	271.2	1.09	71.56	0.114	0.744	9.22	0.02	14.35
0.00	0.00	0.00	0.00	-16.04	-4.53	-4.53	-37.65	0.80	0.170	0.00	0.00	37.65	77.27	0.77	286.9	2.10	91.23	0.114	0.744	9.03	0.03	27.53
0.00	0.00	0.00	0.00	-16.04	-4.53	-4.53	-37.65	0.80	0.170	0.00	0.00	37.65	77.27	0.77	286.9	2.10	91.23	0.114	0.744	9.03	0.03	27.53
0.00	0.00	0.00	0.00	-18.31	-5.34	-5.34	-43.49	0.80	0.170	0.00	0.00	43.49	77.21	0.77	331.3	2.10	91.23	0.114	0.744	11.08	0.03	27.51
0.00	0.00	0.00	0.00	-18.31	-5.34	-5.34	-43.49	0.80	0.170	0.00	0.00	43.49	77.21	0.77	331.3	2.10	91.23	0.114	0.744	11.08	0.03	27.51
0.00	0.00	0.00	0.00	-19.28	-5.54	-5.54	-45.54	0.80	0.170	0.00	0.00	45.54	121.59	0.77	347.0	3.33	103.02	0.114	0.744	11.26	0.05	43.65
0.00	0.00	0.00	0.00	-19.28	-5.54	-5.54	-45.54	0.80	0.170	0.00	0.00	45.54	121.59	0.77	347.0	3.33	103.02	0.114	0.744	11.26	0.05	43.65
0.00	0.00	0.00	0.00	-20.24	-5.74	-5.74	-47.58	0.80	0.170	0.00	0.00	47.58	168.27	0.77	362.5	4.64	103.02	0.114	0.744	11.98	0.07	60.90
0.00	0.00	0.00	0.00	-20.24	-5.74	-5.74	-47.58	0.80	0.170	0.00	0.00	47.58	168.27	0.77	362.5	4.64	103.02	0.114	0.744	11.98	0.07	60.90
0.00	0.00	0.00	0.00	8.50	2.61	2.61	20.58	0.80	0.125	0.00	0.00	20.58	73.89	0.77	213.3	2.74	99.84	0.069	0.744	3.85	0.04	26.47
0.00	0.00	0.00	0.00	8.50	2.61	2.61	20.58	0.80	0.125	0.00	0.00	20.58	73.89	0.77	213.3	2.74	99.84	0.069	0.744	3.85	0.04	26.47
0.00	0.00	0.00	0.00	7.55	2.21	2.21	17.96	0.80	0.125	0.00	0.00	17.96	44.67	0.77	186.1	1.65	83.44	0.069	0.744	3.48	0.03	15.88
0.00	0.00	0.00	0.00	7.55	2.21	2.21	17.96	0.80	0.125	0.00	0.00	17.96	44.67	0.77	186.1	1.65	83.44	0.069	0.744	3.48	0.03	15.88
0.00	0.00	0.00	0.00	6.59	1.81	1.81	15.32	0.80	0.125	0.00	0.00	15.32	20.06	0.77	158.7	0.73	60.47	0.069	0.744	3.33	0.01	7.09
0.00	0.00	0.00	0.00	6.59	1.81	1.81	15.32	0.80	0.125	0.00	0.00	15.32	20.06	0.77	158.7	0.73	60.47	0.069	0.744	3.33	0.01	7.09
0.00	0.00	0.00	0.00	5.05	1.52	1.52	12.14	0.80	0.125	0.00	0.00	12.14	20.21	0.77	125.8	0.74	60.83	0.069	0.744	2.20	0.01	7.14
0.00	0.00	0.00	0.00	5.05	1.52	1.52	12.14	0.80	0.125	0.00	0.00	12.14	20.21	0.77	125.8	0.74	60.83	0.069	0.744	2.20	0.01	7.14
0.00	0.00	0.00	0.00	3.93	1.12	1.12	9.26	0.80	0.125	0.00	0.00	9.26	3.81	0.77	95.9	0.14	30.60	0.069	0.744	2.22	0.00	1.34
0.00	0.00	0.00	0.00	3.93	1.12	1.12	9.26	0.80	0.125	0.00	0.00	9.26	3.81	0.77	95.9	0.14	30.60	0.069	0.744	2.22	0.00	1.34
0.00	0.00	0.00	0.00	2.80	0.72	0.72	6.36	0.80	0.125	0.00	0.00	6.36	7.58	0.77	65.9	0.28	39.82	0.069	0.744	0.93	0.00	2.67
0.00	0.00	0.00	0.00	2.80	0.72	0.72	6.36	0.80	0.125	0.00	0.00	6.36	7.58	0.77	65.9	0.28	39.82	0.069	0.744	0.93	0.00	2.67

Member No.	Distance	LOAD CASE →	UNFACTORED MOMENTS Dead Load	Floor Finishes	Live Load	Factored Moment Total Bending moment	Total Depth of the Member	Effective Depth	Thickness of comp-ression Flange	Xumax/d Permi-ssible	Xu for Yf = Df	MOR for which Xu = Df Muf	MOR for which Xu makes Yf=Df Mub	MOR for which Xu makes Yf>Df Muweb	Flange Width of the Member	Web Width of the Member	Xu/d Achieved	Area of Steel Required cm^2
138	0	MAX.	-3.22	-0.86	-0.86	-7.41	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00424	**2.61**
		MIN.	-3.22	-0.86	-0.86	-7.41	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00424	**2.61**
	1.5	MAX.	-6.05	-1.79	-1.79	-14.45	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00828	**5.10**
		MIN.	-6.05	-1.79	-1.79	-14.45	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00828	**5.10**
	3	MAX.	-7.09	-1.96	-1.96	-16.52	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00947	**5.83**
		MIN.	-7.09	-1.96	-1.96	-16.52	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00947	**5.83**
149	0	MAX.	-7.03	-1.95	-1.95	-16.40	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00940	**5.79**
		MIN.	-7.03	-1.95	-1.95	-16.40	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00940	**5.79**
	1.5	MAX.	-8.05	-2.36	-2.36	-19.16	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.01099	**6.77**
		MIN.	-8.05	-2.36	-2.36	-19.16	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.01099	**6.77**
	3	MAX.	-7.28	-2.01	-2.01	-16.95	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00972	**5.99**
		MIN.	-7.28	-2.01	-2.01	-16.95	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00972	**5.99**
160	0	MAX.	-7.25	-2.00	-2.00	-16.88	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00968	**5.96**
		MIN.	-7.25	-2.00	-2.00	-16.88	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00968	**5.96**
	1.5	MAX.	-8.01	-2.34	-2.34	-19.04	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.01092	**6.73**
		MIN.	-8.01	-2.34	-2.34	-19.04	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.01092	**6.73**
	3	MAX.	-6.98	-1.92	-1.92	-16.23	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00931	**5.73**
		MIN.	-6.98	-1.92	-1.92	-16.23	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00931	**5.73**
171	0	MAX.	-6.98	-1.92	-1.92	-16.23	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00931	**5.73**
		MIN.	-6.98	-1.92	-1.92	-16.23	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00931	**5.73**
	1.5	MAX.	-8.03	-2.35	-2.35	-19.10	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.01096	**6.75**
		MIN.	-8.03	-2.35	-2.35	-19.10	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.01096	**6.75**
	3	MAX.	-7.29	-2.01	-2.01	-16.97	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00973	**5.99**
		MIN.	-7.29	-2.01	-2.01	-16.97	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00973	**5.99**
182	0	MAX.	-7.32	-2.02	-2.02	-17.04	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00977	**6.02**
		MIN.	-7.32	-2.02	-2.02	-17.04	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00977	**6.02**
	1.5	MAX.	-8.13	-2.38	-2.38	-19.34	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.01110	**6.83**
		MIN.	-8.13	-2.38	-2.38	-19.34	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.01110	**6.83**
	3	MAX.	-7.15	-1.98	-1.98	-16.67	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00956	**5.89**
		MIN.	-7.15	-1.98	-1.98	-16.67	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00956	**5.89**

UNFACTORED TORSION			Factored Moment	UNFACTORED SHEAR			Factored Shear	Equivalent Shear/Bending Moment due to Effect of Torsion				Total Shear/ Moment										
Dead Load	Floor Finish-es	Live Load	Total Torsion	Dead Load	Floor Finish-es	Live Load	Total Shear	Total Depth of the Member	Breadth of the Member	Shear	Bending moment	Shear	Bending moment	Effective Depth	Shear stress	% Tensile Reinf.	Permi-ssible Shear Stress	b1	d1	Shear Reinf. Required cm^2	Xu/d Achieved	Area of Tension Steel Required cm^2
0.00	0.00	0.00	0.00	2.41	0.77	0.77	5.93	0.80	0.125	0.00	0.00	5.93	7.41	0.77	61.4	0.27	39.82	0.069	0.744	0.86	0.00	2.61
0.00	0.00	0.00	0.00	2.41	0.77	0.77	5.93	0.80	0.125	0.00	0.00	5.93	7.41	0.77	61.4	0.27	39.82	0.069	0.744	0.86	0.00	2.61
0.00	0.00	0.00	0.00	1.29	0.37	0.37	3.05	0.80	0.125	0.00	0.00	3.05	14.45	0.77	31.6	0.53	52.75	0.069	0.744	Not Required	0.01	5.10
0.00	0.00	0.00	0.00	1.29	0.37	0.37	3.05	0.80	0.125	0.00	0.00	3.05	14.45	0.77	31.6	0.53	52.75	0.069	0.744	Not Required	0.01	5.10
0.00	0.00	0.00	0.00	0.17	-0.03	-0.03	0.17	0.80	0.125	0.00	0.00	0.17	16.52	0.77	1.7	0.60	55.69	0.069	0.744	Not Required	0.01	5.83
0.00	0.00	0.00	0.00	0.17	-0.03	-0.03	0.17	0.80	0.125	0.00	0.00	0.17	16.52	0.77	1.7	0.60	55.69	0.069	0.744	Not Required	0.01	5.83
0.00	0.00	0.00	0.00	1.21	0.42	0.42	3.08	0.80	0.125	0.00	0.00	3.08	16.40	0.77	31.9	0.60	55.32	0.069	0.744	Not Required	0.01	5.79
0.00	0.00	0.00	0.00	1.21	0.42	0.42	3.08	0.80	0.125	0.00	0.00	3.08	16.40	0.77	31.9	0.60	55.32	0.069	0.744	Not Required	0.01	5.79
0.00	0.00	0.00	0.00	0.08	0.02	0.02	0.18	0.80	0.125	0.00	0.00	0.18	19.16	0.77	1.9	0.70	59.36	0.069	0.744	Not Required	0.01	6.77
0.00	0.00	0.00	0.00	0.08	0.02	0.02	0.18	0.80	0.125	0.00	0.00	0.18	19.16	0.77	1.9	0.70	59.36	0.069	0.744	Not Required	0.01	6.77
0.00	0.00	0.00	0.00	-1.04	-0.38	-0.38	-2.70	0.80	0.125	0.00	0.00	2.70	16.95	0.77	28.0	0.62	56.43	0.069	0.744	Not Required	0.01	5.99
0.00	0.00	0.00	0.00	-1.04	-0.38	-0.38	-2.70	0.80	0.125	0.00	0.00	2.70	16.95	0.77	28.0	0.62	56.43	0.069	0.744	Not Required	0.01	5.99
0.00	0.00	0.00	0.00	1.03	0.37	0.37	2.66	0.80	0.125	0.00	0.00	2.66	16.88	0.77	27.5	0.62	56.06	0.069	0.744	Not Required	0.01	5.96
0.00	0.00	0.00	0.00	1.03	0.37	0.37	2.66	0.80	0.125	0.00	0.00	2.66	16.88	0.77	27.5	0.62	56.06	0.069	0.744	Not Required	0.01	5.96
0.00	0.00	0.00	0.00	-0.09	-0.03	-0.03	-0.23	0.80	0.125	0.00	0.00	0.23	19.04	0.77	2.3	0.70	59.00	0.069	0.744	Not Required	0.01	6.73
0.00	0.00	0.00	0.00	-0.09	-0.03	-0.03	-0.23	0.80	0.125	0.00	0.00	0.23	19.04	0.77	2.3	0.70	59.00	0.069	0.744	Not Required	0.01	6.73
0.00	0.00	0.00	0.00	-1.21	-0.43	-0.43	-3.11	0.80	0.125	0.00	0.00	3.11	16.23	0.77	32.2	0.59	55.32	0.069	0.744	Not Required	0.01	5.73
0.00	0.00	0.00	0.00	-1.21	-0.43	-0.43	-3.11	0.80	0.125	0.00	0.00	3.11	16.23	0.77	32.2	0.59	55.32	0.069	0.744	Not Required	0.01	5.73
0.00	0.00	0.00	0.00	1.23	0.43	0.43	3.14	0.80	0.125	0.00	0.00	3.14	16.23	0.77	32.5	0.59	55.32	0.069	0.744	Not Required	0.01	5.73
0.00	0.00	0.00	0.00	1.23	0.43	0.43	3.14	0.80	0.125	0.00	0.00	3.14	16.23	0.77	32.5	0.59	55.32	0.069	0.744	Not Required	0.01	5.73
0.00	0.00	0.00	0.00	0.10	0.03	0.03	0.24	0.80	0.125	0.00	0.00	0.24	19.10	0.77	2.5	0.70	59.00	0.069	0.744	Not Required	0.01	6.75
0.00	0.00	0.00	0.00	0.10	0.03	0.03	0.24	0.80	0.125	0.00	0.00	0.24	19.10	0.77	2.5	0.70	59.00	0.069	0.744	Not Required	0.01	6.75
0.00	0.00	0.00	0.00	-1.02	-0.37	-0.37	-2.64	0.80	0.125	0.00	0.00	2.64	16.97	0.77	27.4	0.62	56.43	0.069	0.744	Not Required	0.01	5.99
0.00	0.00	0.00	0.00	-1.02	-0.37	-0.37	-2.64	0.80	0.125	0.00	0.00	2.64	16.97	0.77	27.4	0.62	56.43	0.069	0.744	Not Required	0.01	5.99
0.00	0.00	0.00	0.00	1.07	0.39	0.39	2.78	0.80	0.125	0.00	0.00	2.78	17.04	0.77	28.8	0.62	56.43	0.069	0.744	Not Required	0.01	6.02
0.00	0.00	0.00	0.00	1.07	0.39	0.39	2.78	0.80	0.125	0.00	0.00	2.78	17.04	0.77	28.8	0.62	56.43	0.069	0.744	Not Required	0.01	6.02
0.00	0.00	0.00	0.00	-0.05	-0.01	-0.01	-0.11	0.80	0.125	0.00	0.00	0.11	19.34	0.77	1.1	0.71	59.36	0.069	0.744	Not Required	0.01	6.83
0.00	0.00	0.00	0.00	-0.05	-0.01	-0.01	-0.11	0.80	0.125	0.00	0.00	0.11	19.34	0.77	1.1	0.71	59.36	0.069	0.744	Not Required	0.01	6.83
0.00	0.00	0.00	0.00	-1.18	-0.41	-0.41	-3.00	0.80	0.125	0.00	0.00	3.00	16.67	0.77	31.1	0.61	55.69	0.069	0.744	Not Required	0.01	5.89
0.00	0.00	0.00	0.00	-1.18	-0.41	-0.41	-3.00	0.80	0.125	0.00	0.00	3.00	16.67	0.77	31.1	0.61	55.69	0.069	0.744	Not Required	0.01	5.89

			UNFACTORED MOMENTS			Factored Moment												
LOAD CASE →			Dead Load	Floor Finishes	Live Load	Total Bending moment	Total Depth of the Member	Effective Depth	Thickness of comp-ression Flange	Xumax/d Permi-ssible	Xu for Yf= Df	MOR for which Xu = Df Muf	MOR for which Xu makes Yf=Df Mub	MOR for which Xu makes Yf>Df Muweb	Flange Width of the Member	Web Width of the Member	Xu/d Achieved	Area of Steel Required cm^2
Member No.	Distance																	
193	0	MAX.	-7.21	-2.00	-2.00	-16.82	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00964	**5.94**
		MIN.	-7.21	-2.00	-2.00	-16.82	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00964	**5.94**
	1.5	MAX.	-6.13	-1.82	-1.82	-14.66	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00840	**5.17**
		MIN.	-6.13	-1.82	-1.82	-14.66	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00840	**5.17**
	3	MAX.	-3.26	-0.88	-0.88	-7.53	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00431	**2.65**
		MIN.	-3.26	-0.88	-0.88	-7.53	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00431	**2.65**
204	0	MAX.	-3.34	-0.90	-0.90	-7.71	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00441	**2.72**
		MIN.	-3.34	-0.90	-0.90	-7.71	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00441	**2.72**
	1.5	MAX.	1.73	0.42	0.42	3.86	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00220	**1.36**
		MIN.	1.73	0.42	0.42	3.86	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.00220	**1.36**
	3	MAX.	8.58	2.51	2.51	20.40	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.01171	**7.21**
		MIN.	8.58	2.51	2.51	20.40	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.01171	**7.21**
215	0	MAX.	8.52	2.50	2.50	20.28	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.01164	**7.17**
		MIN.	8.52	2.50	2.50	20.28	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.01164	**7.17**
	1.5	MAX.	19.03	5.42	5.42	44.81	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.02587	**15.93**
		MIN.	19.03	5.42	5.42	44.81	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.02587	**15.93**
	3	MAX.	31.08	9.11	9.11	73.95	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.04302	**26.49**
		MIN.	31.08	9.11	9.11	73.95	0.800	0.772	0.075	0.48	0.1750	163.1	212.1	231.6	2.000	0.125	0.04302	**26.49**

UNFACTORED TORSION			Factored Moment	UNFACTORED SHEAR			Factored Shear	Equivalent Shear/Bending Moment due to Effect of Torsion				Total Shear/ Moment							b1	d1			
Dead Load	Floor Finish-es	Live Load	Total Torsion	Dead Load	Floor Finish-es	Live Load	Total Shear	Total Depth of the Member	Breadth of the Member	Shear	Bending moment	Shear	Bending moment	Effective Depth	Shear stress	% Tensile Reinf.	Permi-ssible Shear Stress	b1	d1	Shear Reinf. Required cm^2	Xu/d Achieved	Area of Tension Steel Required cm^2
0.00	0.00	0.00	0.00	-0.19	0.03	0.03	-0.20	0.80	0.125	0.00	0.00	0.20	16.82	0.77	2.0	0.62	56.06	0.069	0.744	Not Required	0.01	5.94
0.00	0.00	0.00	0.00	-0.19	0.03	0.03	-0.20	0.80	0.125	0.00	0.00	0.20	16.82	0.77	2.0	0.62	56.06	0.069	0.744	Not Required	0.01	5.94
0.00	0.00	0.00	0.00	-1.32	-0.37	-0.37	-3.09	0.80	0.125	0.00	0.00	3.09	14.66	0.77	32.0	0.54	53.12	0.069	0.744	Not Required	0.01	5.17
0.00	0.00	0.00	0.00	-1.32	-0.37	-0.37	-3.09	0.80	0.125	0.00	0.00	3.09	14.66	0.77	32.0	0.54	53.12	0.069	0.744	Not Required	0.01	5.17
0.00	0.00	0.00	0.00	-2.44	-0.77	-0.77	-5.97	0.80	0.125	0.00	0.00	5.97	7.53	0.77	61.9	0.27	39.82	0.069	0.744	0.75	0.00	2.65
0.00	0.00	0.00	0.00	-2.44	-0.77	-0.77	-5.97	0.80	0.125	0.00	0.00	5.97	7.53	0.77	61.9	0.27	39.82	0.069	0.744	0.75	0.00	2.65
0.00	0.00	0.00	0.00	-2.85	-0.74	-0.74	-6.50	0.80	0.125	0.00	0.00	6.50	7.71	0.77	67.3	0.28	40.35	0.069	0.744	0.91	0.00	2.72
0.00	0.00	0.00	0.00	-2.85	-0.74	-0.74	-6.50	0.80	0.125	0.00	0.00	6.50	7.71	0.77	67.3	0.28	40.35	0.069	0.744	0.91	0.00	2.72
0.00	0.00	0.00	0.00	-3.97	-1.14	-1.14	-9.38	0.80	0.125	0.00	0.00	9.38	3.86	0.77	97.2	0.14	30.60	0.069	0.744	2.26	0.00	1.36
0.00	0.00	0.00	0.00	-3.97	-1.14	-1.14	-9.38	0.80	0.125	0.00	0.00	9.38	3.86	0.77	97.2	0.14	30.60	0.069	0.744	2.26	0.00	1.36
0.00	0.00	0.00	0.00	-5.10	-1.54	-1.54	-12.27	0.80	0.125	0.00	0.00	12.27	20.40	0.77	127.2	0.75	60.83	0.069	0.744	2.25	0.01	7.21
0.00	0.00	0.00	0.00	-5.10	-1.54	-1.54	-12.27	0.80	0.125	0.00	0.00	12.27	20.40	0.77	127.2	0.75	60.83	0.069	0.744	2.25	0.01	7.21
0.00	0.00	0.00	0.00	-6.57	-1.81	-1.81	-15.29	0.80	0.125	0.00	0.00	15.29	20.28	0.77	158.4	0.74	60.83	0.069	0.744	3.31	0.01	7.17
0.00	0.00	0.00	0.00	-6.57	-1.81	-1.81	-15.29	0.80	0.125	0.00	0.00	15.29	20.28	0.77	158.4	0.74	60.83	0.069	0.744	3.31	0.01	7.17
0.00	0.00	0.00	0.00	-7.52	-2.21	-2.21	-17.91	0.80	0.125	0.00	0.00	17.91	44.81	0.77	185.6	1.65	83.64	0.069	0.744	3.46	0.03	15.93
0.00	0.00	0.00	0.00	-7.52	-2.21	-2.21	-17.91	0.80	0.125	0.00	0.00	17.91	44.81	0.77	185.6	1.65	83.64	0.069	0.744	3.46	0.03	15.93
0.00	0.00	0.00	0.00	-8.47	-2.61	-2.61	-20.54	0.80	0.125	0.00	0.00	20.54	73.95	0.77	212.8	2.75	99.84	0.069	0.744	3.83	0.04	26.49
0.00	0.00	0.00	0.00	-8.47	-2.61	-2.61	-20.54	0.80	0.125	0.00	0.00	20.54	73.95	0.77	212.8	2.75	99.84	0.069	0.744	3.83	0.04	26.49

Check for Deflection

Calculation of Effective Moment of Inertia as per IS:456 Annex C

$$I_{eff} = \frac{Ir}{1.2 - (Mr/M)\,(Z/d)\,(1\text{-}x/d)\,(bw/b)}$$

I_{eff}	is the effective moment of inertia for the entire Beam or Slab in the direction of effective span	
Ir	is the moment of inertia of the cracked section	
Mr	is the cracking moment, equal to (Fcr Igr)/Yt	
	Where	
	Fcr	is the modulus of rupture of concrete = 0.7 $\sqrt{Fck}$
	[Clause 6.2.2 of IS 456 : 2000 also reiterated in Example 12 of SP 16 :1980 (Tenth reprint June 1997)]	
	Igr	is the moment of inertia of the gross section neglecting the reinforcement
	Yt	is the distance of centroidal axis of the gross section to the extreme fibre in tension
M	is the maximum moment under service loads	
Z	is the lever arm	
d	is the effective depth	
x	is the depth of the neutral axis	
bw	is the breadth of the web	
b	is the breadth of the compression face	
Ec	is the modulus of elasticity of concrete = 5000 $\sqrt{Fck}$	
	[Clause 6.2.3.1 of IS 456 : 2000]	
Es	is the modulus of elasticity of steel = 200 KN/mm^2	
	[Clause 5.6.3 of IS 456 : 2000 also reiterated in Example 12 of SP 16 :1980 (Tenth reprint June 1997)]	
m	modular ratio = Es/Ec	

Note : for the deflection check of the slabs both bw and b are taken as 1m

Check for Deflection Along Lx Direction

Ir	=	9.790E-03	
Mr	=	71.387263	
Fcr	=	451.57	
Igr	=	6.323E-02	
Yt	=	0.4000	
M	=	57.38	
Z	=	0.7611	
d	=	0.7720	
x	=	0.0338	
bw	=	0.170	
b	=	3.000	
Ec	=	31622.78	mpa
Es	=	200000	mpa
m	=	6.3245553	
CG cracked section	=	0.1185	m
I_{eff}	=	8.636E-03	

$I_r \le I_{eff} \le Igr$

Governing value of I_{eff} = 6.323E-02

Maximum Deflection with Gross M.O.I. of the Element (i.e. gross section,neglecting the reinforcement)

Deflection due to Dead Load

Self Weight of the Slab	=	4.4040	mm
Floor Finishing	=	1.2650	mm
Partition Wall/ any other Concentrated Load	=	0.0000	mm
Deflection due to Live Load	=	1.2650	mm

Coefficient of permanent part of Live Load for loag term deflection effects 0.7
(Refer 35.4.1 page 114 of SP :-1983 First Reprint December 1985)

Total Short Term Deflection (with Gross M.O.I)	=	6.9340	mm
Modified Value of Short Term Deflection (With Ieff Calculated above)	=	6.93	mm

Deflection due to Shrinkage

a_{cs}	=	$K_3\ \psi_{cs}\ L^2$	=	2.50	mm	
K_3	=	is a constant depending upon the support condition =			0.063	for fully continuous
ψ_{cs}	=	$K_4\ \varepsilon_{cs}/D$	=	9.91E-05		
where						
	K_4	=	$0.72(Pt\text{-}Pc)/(\sqrt{Pt})$	for $0.25 \le Pt\text{-}Pc < 1.0$		
		and	$0.65(Pt\text{-}Pc)/(\sqrt{Pt})$	for $Pt\text{-}Pc > 1.0$		
	Pt	=	0.134692	%		
	Pc	=	0	(effect ignored if any)		
	K_4	=	0.264243			
	ε_{cs}	=	0.0003			
	D	=	0.8			
L	=	20.000	m	(Effective span considered)		

Deflection due to Creep

Elasticity modulus of concrete for creep effects 12162.61 mpa
Age at loading = 28 days
Please write one of the following in age at loading (other values are not allowed in the and will cause errors)

	creep coefficient
7 days	2.2
28 days	1.6
1year	1.1

Deflection due to creep = 10.11 mm

Total Deflection including all effects	=	19.54	mm	
Precamber Provided if any	=	0.00	mm	
Net Total Deflection including all effects	=	19.54	mm	
Permissible limit for deflection	=	20.00	mm	OK
Total Deflection including all effects after erection of partitions and application of finishes	=	13.87	mm	
Permissible limit for deflection	=	20.00	mm	OK

calculation of cable forces

No of Prestressing Cables =		33	
Type of cable =	Post-tensioned Cables 4no.s 0.5 inch dia Stands	**4**	**05** Pre-tensioned Cables 0.5 inch dia Stands
Type of Sheathing =		Oval Corrugated Sheet Metal Duct	
X-sectional area of each cable, A_s =		3.948	cm^2
Modulus of elasticity of prestressing steel, E_s =		1.989E+07	t/m^2
		$(1.95 \times 10^5$ MPa)	
Grade of concrete =		M-	40
Modulus of elasticity of concrete, Ec =		3.677E+06	t/m^2
Effective span =		20.000	m
Wobble coefficient k =		0.0046	
Friction coefficient μ =		0.2500	
Expected slip, s =		6.0	mm
Half slip area (= 0.5 x A_s x E_s x s) =		23.56	tm
Grip length inside the jack =		0.350	m
Extra length of cable required for jack attachment =		0.750	m
UTS of Cable =	(Post-tensioned cables)	74.90	t
Jacking End Force =	(Post-tensioned cables)	75	% of UTS
	(Pre-tensioned cables)	75	% of UTS
Duct Size =	64 X	20	mm

CABLE PROFILE

CABLE	a (Vert L) (m)	b (Vert L) (m)	c (Vert) (m)	b (Vert R) (m)	a (Vert R) (m)	a (Plan L) (m)	b (Plan L) (m)	c (Plan) (m)	b (Plan R) (m)	a (Plan R) (m)	H (Left) (m)	h3 (Left) (m)	H (Right) (m)	h3 (Right) (m)	m (Left) (m)	m (Right) (m)	Stress-ing stage
1	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
2	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
3	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
4	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
5	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
6	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
7	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
8	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
9	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
10	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
11	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
12	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
13	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
14	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
15	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
16	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
17	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
18	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
19	1.000	9.000	0.000	9.000	1.000	1.000	9.000	0.000	9.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
20	1.000	6.000	0.000	6.000	1.000	1.000	6.000	0.000	6.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
21	1.000	6.000	0.000	6.000	1.000	1.000	6.000	0.000	6.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
22	1.000	6.000	0.000	6.000	1.000	1.000	6.000	0.000	6.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
23	1.000	6.000	0.000	6.000	1.000	1.000	6.000	0.000	6.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
24	1.000	6.000	0.000	6.000	1.000	1.000	6.000	0.000	6.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
25	1.000	6.000	0.000	6.000	1.000	1.000	6.000	0.000	6.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
26	1.000	6.000	0.000	6.000	1.000	1.000	6.000	0.000	6.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
27	1.000	6.000	0.000	6.000	1.000	1.000	6.000	0.000	6.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
28	1.000	6.000	0.000	6.000	1.000	1.000	6.000	0.000	6.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
29	1.000	6.000	0.000	6.000	1.000	1.000	6.000	0.000	6.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
30	1.000	6.000	0.000	6.000	1.000	1.000	6.000	0.000	6.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
31	1.000	6.000	0.000	6.000	1.000	1.000	6.000	0.000	6.000	1.000	0.026	0.026	0.026	0.026	0.000	0.000	1
32	1.000	2.000	14.000	2.000	1.000	1.000	9.000	0.000	9.000	1.000	0.310	0.062	0.310	0.062	0.000	0.000	1
33	0.200	0.200	0.200	2.200	0.200	0.500	1.000	0.000	1.000	0.500	0.040	0.040	0.185	0.040	0.000	0.000	2

Tens-ioning Type	Cable Length from Vert. Prof.	Cable Length from Plan Prof.	Stress-ing End	Dist. of start of cable @ start of the str.	Dist. of end of cable @ end of the str.	H and h3 measured from
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	20.000	20.000	Both	0.000	0.000	Bottom
pre	14.000	14.000	Both	3.000	-3.000	Bottom
pre	14.000	14.000	Both	3.000	-3.000	Bottom
pre	14.000	14.000	Both	3.000	-3.000	Bottom
pre	14.000	14.000	Both	3.000	-3.000	Bottom
pre	14.000	14.000	Both	3.000	-3.000	Bottom
pre	14.000	14.000	Both	3.000	-3.000	Bottom
pre	14.000	14.000	Both	3.000	-3.000	Bottom
pre	14.000	14.000	Both	3.000	-3.000	Bottom
pre	14.000	14.000	Both	3.000	-3.000	Bottom
pre	14.000	14.000	Both	3.000	-3.000	Bottom
pre	14.000	14.000	Both	3.000	-3.000	Bottom
pre	14.000	14.000	Both	3.000	-3.000	Bottom
post	20.000	20.000	Both	3.000	3.000	Bottom
post	3.000	3.000	right	0.000	-17.000	Top

Calculation of Total Length of Cable Between Critical Sections of vertical profile (Including the Effect of Horizontal Profile/ Bending of Cable in Plan)

CABLE	Lengths Measured From Left End					Total Length	Lengths Measured From Right End					Total Length
	Sec 1-2	Sec 2-3	Sec 3-4	Sec 4-5	Sec 5-6		Sec 5-6	Sec 4-5	Sec 3-4	Sec 2-3	Sec 1-2	
1	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
2	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
3	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
4	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
5	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
6	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
7	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
8	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
9	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
10	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
11	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
12	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
13	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
14	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
15	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
16	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
17	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
18	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
19	1.000	9.000	0.000	9.000	1.000	20.000	1.000	9.000	0.000	9.000	1.000	20.000
20	1.000	6.000	0.000	6.000	1.000	14.000	1.000	6.000	0.000	6.000	1.000	14.000
21	1.000	6.000	0.000	6.000	1.000	14.000	1.000	6.000	0.000	6.000	1.000	14.000
22	1.000	6.000	0.000	6.000	1.000	14.000	1.000	6.000	0.000	6.000	1.000	14.000
23	1.000	6.000	0.000	6.000	1.000	14.000	1.000	6.000	0.000	6.000	1.000	14.000
24	1.000	6.000	0.000	6.000	1.000	14.000	1.000	6.000	0.000	6.000	1.000	14.000
25	1.000	6.000	0.000	6.000	1.000	14.000	1.000	6.000	0.000	6.000	1.000	14.000
26	1.000	6.000	0.000	6.000	1.000	14.000	1.000	6.000	0.000	6.000	1.000	14.000
27	1.000	6.000	0.000	6.000	1.000	14.000	1.000	6.000	0.000	6.000	1.000	14.000
28	1.000	6.000	0.000	6.000	1.000	14.000	1.000	6.000	0.000	6.000	1.000	14.000
29	1.000	6.000	0.000	6.000	1.000	14.000	1.000	6.000	0.000	6.000	1.000	14.000
30	1.000	6.000	0.000	6.000	1.000	14.000	1.000	6.000	0.000	6.000	1.000	14.000
31	1.000	6.000	0.000	6.000	1.000	14.000	1.000	6.000	0.000	6.000	1.000	14.000
32	1.008	2.005	14.000	2.005	1.008	20.026	1.008	2.005	14.000	2.005	1.008	20.026
33	0.200	0.200	0.200	2.205	0.201	3.006	0.201	2.205	0.200	0.200	0.200	3.006

Calculation of Total Angle Traversed by the Cable Between Critical Sections of vertical profile (Including the Effect of Horizontal Profile/ Bending of Cable in Plan)

CABLE	Lengths Measured From Left End					Total θ (deg)	Lengths Measured From Right End					Total θ (deg)
	Sec 1-2	Sec 2-3	Sec 3-4	Sec 4-5	Sec 5-6		Sec 5-6	Sec 4-5	Sec 3-4	Sec 2-3	Sec 1-2	
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
32	0.000	7.069	0.000	7.069	0.000	14.137	0.000	7.069	0.000	7.069	0.000	14.137
33	0.000	0.000	0.000	6.364	0.000	6.364	0.000	6.364	0.000	0.000	0.000	6.364

Calculation of Forces in Cable After Friction Loss

CABLE	Tension-ing Type	Stress-ing stage	Friction Coeff. m	Wobble Coeff. K	Type of Cable		Area of Cable cm^2	Tensile Strength N/mm^2	UTS of Cable	Jacking Force % of UTS	Jacking force (t)	Expect-ed slip, S (in mm)	Half slip area (0.5xAsx EsxS)
1	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
2	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
3	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
4	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
5	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
6	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
7	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
8	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
9	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
10	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
11	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
12	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
13	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
14	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
15	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
16	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
17	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
18	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
19	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
20	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
21	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
22	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
23	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
24	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
25	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
26	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
27	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
28	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
29	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
30	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
31	pre	1	0.2500	0.0046	1	O5	0.987	1860	18.73	75.00	14.04	0	0.00
32	post	1	0.2500	0.0046	8	O5	7.896	1860	149.80	75.00	112.35	6	47.12
33	post	2	0.2500	0.0046	8	O5	7.896	1860	149.80	75.00	112.35	6	47.12

Section 1

Calculation of Forces in Cable After Friction and Slip Loss

Distance of section from start of structure under consideration = 10.000 m

CABLE	Distance of Section From Start of Cable	Distance of Section From End of Cable	Column 4	Column 5	Column 6	Column 7	Column 8	Column 10	Column 11	Column 12	Column 13	Stress-ing Stage
1	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
2	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
3	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
4	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
5	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
6	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
7	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
8	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
9	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
10	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
11	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
12	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
13	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
14	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
15	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
16	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
17	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
18	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
19	10.000	10.000	10.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
20	7.000	7.000	7.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
21	7.000	7.000	7.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
22	7.000	7.000	7.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
23	7.000	7.000	7.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
24	7.000	7.000	7.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
25	7.000	7.000	7.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
26	7.000	7.000	7.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
27	7.000	7.000	7.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
28	7.000	7.000	7.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
29	7.000	7.000	7.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
30	7.000	7.000	7.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
31	7.000	7.000	7.000	0.00	0.00	0.00	0.00	14.04	0.03	0.000	0.03	1
32	7.000	13.000	7.013	7.07	0.00	0.00	7.07	102.61	0.06	0.000	0.06	1
33	10.000	-7.000	10.049	6.36	0.00	0.00	6.36	0.00	0.97	0.000	0.97	2

CABLE	P	θ vertical	P Cosθ	P Sinθ	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20
					Lengths Measured From Right End						
1	14.04	0.00	14.04	0.00	**0.52**	0.03	**0.21**	0.18	2.53	14.04	2.53
2	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	28.09	5.06
3	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	42.13	7.58
4	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	56.18	10.11
5	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	70.22	12.64
6	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	84.26	15.17
7	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	98.31	17.70
8	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	112.35	20.22
9	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	126.40	22.75
10	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	140.44	25.28
11	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	154.48	27.81
12	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	168.53	30.34
13	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	182.57	32.86
14	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	196.62	35.39
15	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	210.66	37.92
16	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	224.70	40.45
17	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	238.75	42.97
18	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	252.79	45.50
19	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	266.84	48.03
20	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	280.88	50.56
21	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	294.92	53.09
22	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	308.97	55.61
23	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	323.01	58.14
24	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	337.06	60.67
25	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	351.10	63.20
26	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	365.14	65.73
27	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	379.19	68.25
28	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	393.23	70.78
29	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	407.28	73.31
30	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	421.32	75.84
31	14.04	0.00	14.04	0.00	0.52	0.03	0.21	0.18	2.53	435.36	78.37
32	102.61	0.00	102.61	0.00	0.52	0.06	0.21	0.14	14.78	537.97	93.14
33	0.00	6.39	0.00	0.00	0.52	-0.45	0.21	0.65	0.00	537.97	93.14
			537.97						93.142		
			0.00						0.00		
			0.00						0.00		

Shrinkage Model 1		
As per IS:1343-1980		
Residual Shrinkage Strain		
pre-tensioned =		0.0003
Days	% loss	Residual Strain
0	0	0.0003
30	50	0.00015
180	75	7.5E-05
> 180	100	0
post-tensioned =		.0002/(Log10(t+2))
where: t age of concrete in days		

Shrinkage Model 2	
As per IRC:18-2000	
Residual Shrinkage Strain	
Days	Residual Strain
0	4.3E-04
3	4.3E-04
7	3.5E-04
10	3.0E-04
14	2.5E-04
21	2.0E-04
28	1.9E-04
90	1.5E-04

Relaxation Model 1	
As per IS:1343-1980	
Initial Stress	Relaxation Loss N/mm^2
0.5fp	0
0.6fp	35
0.7fp	70
0.8fp	90
Values are given at 1000hours at 27°C	
It is assumed to follow same pattern upto 1000h as given in IRC:18 Model i.e. in the % sequence specified with time	

Relaxation Model 2		
As per IRC:18-2000		
Initial Stress	Relaxation Loss N/mm^2	
0.5fp	0	%
0.6fp	1.25	%
0.7fp	2.5	%
0.8fp	4.5	%
Values are given at 1000hours at 20°C		
Values shall be taken as 3 times at infinity		

Variation of Relaxation Loss with Time			
Hours	% Loss		
1	15		
5	25		
20	35		
100	55		
200	65		
500	85		
1000	100		

Creep Model 1			
As per IS:1343-1980			
Age at Loading		Creep Coefficient	
7	days	2.2	
28	days	1.6	
365	days	1.1	
Days	% loss		
0	0		
30	50		
180	75		
> 180	100		

Creep Model 2 (As per IRC:18-2000)					
%Maturity of concrete at the time of stressing					Creep Strain per 10mpa
40	% of fck				9.4E-04
50	% of fck				8.3E-04
60	% of fck				7.2E-04
70	% of fck				6.1E-04
75	% of fck				5.6E-04
80	% of fck				5.1E-04
90	% of fck				4.4E-04
100	% of fck				4.0E-04
110	% of fck				3.6E-04

Section 1 Calculation of Elastic Shortening Loss

Age at Stage 1 Stressing =		7	days	
Age at Stage 2 Stressing =		28	days	
Age at Stage 3 =		10000	days	
Age at Stage 4 =		10000	days	
%maturity of concrete at stage 1 =		80	%	
%maturity of concrete at stage 2 =		100	%	
%maturity of concrete at stage 3 =		100	%	
%maturity of concrete at stage 4 =		100	%	
Shrinkage Model =	1			
atmospheric condition	dry			
Relaxation Model =	1			
Creep Model =	1			

Stage 1&2

M1	59.02
M2	0
A1	0.4416
Iz	0.0155
Yt	0.279
Yb	0.206
Zt1	0.0557
Zb1	0.0755

Stage 3

M1	39.18
M2	0
A1	0.6875
Iz	0.0264
Yt	0.225
Yb	0.295
Zt1	0.1175
Zb1	0.0897

Stage 4

M1	20.72
M2	0
A1	0.6875
Iz	0.0264
Yt	0.225
Yb	0.295
Zt1	0.1175
Zb1	0.0897

Page 1

CABLE	Stage 1																		
	column 21	column 22	column 23	column 24	column 25	column 26	column 27	column 28	column 29	column 30	column 31	column 32	column 33	column 34		Pcosθ	Pcosθ x ecc.	sum Pcosθ	sum Pcosθ x ecc.
1	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32	640.32	1500.1	1454	0.60	12.31	0.50		11.81	2.13	11.81	2.13
2	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	23.62	4.25
3	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	35.43	6.38
4	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	47.24	8.50
5	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	59.05	10.63
6	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	70.86	12.76
7	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	82.67	14.88
8	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	94.48	17.01
9	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	106.29	19.13
10	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	118.10	21.26
11	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	129.91	23.38
12	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	141.72	25.51
13	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	153.53	27.64
14	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	165.34	29.76
15	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	177.15	31.89
16	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	188.96	34.01
17	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	200.77	36.14
18	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	212.58	38.27
19	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	224.39	40.39
20	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	236.20	42.52
21	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	248.01	44.64
22	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	259.82	46.77
23	31.8	31.8	31.8	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	271.63	48.89
24	2.2	53.7	50.9	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	283.45	51.02
25	-13.6	65.3	61.1	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	295.26	53.15
26	-13.6	65.3	61.1	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	307.07	55.27
27	-13.6	65.3	61.1	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	318.88	57.40
28	-13.6	65.3	61.1	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	330.69	59.52
29	-13.6	65.3	61.1	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	342.50	61.65
30	-13.6	65.3	61.1	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	354.31	63.78
31	-13.6	65.3	61.1	0.861	13.18	0.275	12.91	2.32			1454	0.60	12.31	0.50		11.81	2.13	366.12	65.90
32	-32.8	428.0	369.1	0.000	102.61	1.522	101.09	14.56			1390	4.57	96.52	3.46		93.05	13.40	459.17	79.30
33	0.0	0.0	0.0	0.000	0.00	0.000	0.00	0.00			0	0.00	0.00	0.00		0.00	0.00	459.17	79.30
	605.8	1670.1	1578.8	26.70	511.28		501.24	86.58					478.14			459.17	79.30		

CABLE	Stage 2																		
	column 21	column 22	column 23	column 24	column 25	column 26	column 27	column 28	column 29	column 30	column 31	column 32	column 33	column 34		Pcosθ	Pcosθ x ecc.	sum Pcosθ	sum Pcosθ x ecc.
1	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10	713.33	1247.7	1219	0.93	10.75	0.03		10.72	1.93	10.72	1.93
2	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	21.44	3.86
3	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	32.16	5.79
4	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	42.88	7.72
5	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	53.60	9.65
6	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	64.32	11.58
7	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	75.04	13.51
8	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	85.76	15.44
9	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	96.49	17.37
10	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	107.21	19.30
11	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	117.93	21.23
12	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	128.65	23.16
13	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	139.37	25.09
14	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	150.09	27.02
15	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	160.81	28.95
16	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	171.53	30.88
17	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	182.25	32.80
18	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	192.97	34.73
19	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	203.69	36.66
20	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	214.41	38.59
21	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	225.13	40.52
22	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	235.85	42.45
23	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	246.57	44.38
24	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	257.29	46.31
25	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	268.01	48.24
26	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	278.73	50.17
27	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	289.46	52.10
28	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	300.18	54.03
29	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	310.90	55.96
30	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	321.62	57.89
31	70.0	-361.7	-338.6	-0.181	11.99	0.314	11.68	2.10			1219	0.93	10.75	0.03		10.72	1.93	332.34	59.82
32	70.0	-361.7	-306.6	-1.309	94.36	2.012	92.35	13.30			1179	7.20	85.15	0.29		84.86	12.22	417.20	72.04
33	0.0	0.0	0.0	0.000	0.00	3.534	-3.53	-2.30			0	0.00	-3.53	0.00		-3.53	-2.30	413.67	69.74
					466.08		450.80	76.15					414.75			413.67	69.74		

Summary of Stress Check

Stage 1

1	The girder is cast on the casting bed with prestressing steel strands pre-tensioned against Stressing Abutments
2	The per-tensioned tendons cast into the concrete are released to transfer the prestress to the concrete
3	Some post tensioning tendons may be stressed while the girder still rests on the casting bed

Note: Age of concrete at the time of transfer of prestress is taken as 7 days

Bending moment at the section considered due to self weight of the girder	=	59.02	tm
Total prestressing force applied in stage 1	=	547.72	t

Stress Check After Friction and Slip Loss

Total prestressing force left in the stressed cables after friction and slip loss	=	537.97	t
Total bending effect due to this prestressing force ΣPCosθ x eccentricity	=	93.14	tm

The girder will Hogg up so that the bending effect of the girder is generated at the section

The stress generated at top fibre of the precast section	=	605.80	t/m^2
The stress generated at bottom fibre of the precast section	=	1670.10	t/m^2

Stress Check After Elastic Shortening Loss

Total prestressing force left in the stressed cables after elastic shortening loss	=	511.28	t
Total bending effect due to this prestressing force ΣPCosθ x eccentricity	=	88.34	tm

The girder will Hogg up so that the bending effect of the girder is generated at the section

The stress generated at top fibre of the precast section	=	631.60	t/m^2
The stress generated at bottom fibre of the precast section	=	1546.01	t/m^2

Stress Check After Shrinkage Loss

Total prestressing force left in the stressed cables after shrinkage loss	=	501.24	t
Total bending effect due to this prestressing force ΣPCosθ x eccentricity	=	86.58	tm

The girder will Hogg up so that the bending effect of the girder is generated at the section

The stress generated at top fibre of the precast section	=	640.32	t/m^2
The stress generated at bottom fibre of the precast section	=	1500.06	t/m^2

Stress Check After Creep Loss

Total prestressing force left in the stressed cables after creep loss	=	478.14	t
Total bending effect due to this prestressing force ΣPCosθ x eccentricity	=	82.59	tm

The girder will Hogg up so that the bending effect of the girder is generated at the section

The stress generated at top fibre of the precast section	=	659.68	t/m^2
The stress generated at bottom fibre of the precast section	=	1394.86	t/m^2

Stress Check After Relaxation Loss			
Total prestressing force left in the stressed cables after relaxation loss	=	459.17	t
Total bending effect due to this prestressing force ΣPCosθ x eccentricity	=	79.30	tm
The girder will Hogg up so that the bending effect of the girder is generated at the section			
The stress generated at top fibre of the precast section	=	675.77	t/m^2
The stress generated at bottom fibre of the precast section	=	1308.36	t/m^2

Stage 2

1	The girder is lifted up from the casting bed and transferred to staking yard where it rests over stacking padestals running perpendicular to it so that it spans between them
2	Some post tensioning tendons may be stressed in the stacking yard
Note:	Age of concrete at the time of transfer of prestress is taken as 28 days

Bending moment at the section considered due to self weight of the girder	=	59.02	tm
Total prestressing force applied in stage 1 and 2	=	660.07	t
Stress Check After Friction and Slip Loss			
Total prestressing force left in the stressed cables after friction and slip loss	=	537.97	t
Total bending effect due to this prestressing force ΣPCosθ x eccentricity	=	93.14	tm
The girder will Hogg up so that the bending effect of the girder is generated at the section			
The stress generated at top fibre of the precast section	=	605.80	t/m^2
The stress generated at bottom fibre of the precast section	=	1670.10	t/m^2
Stress Check After Elastic Shortening Loss			
Total prestressing force left in the stressed cables after elastic shortening loss	=	466.08	t
Total bending effect due to this prestressing force ΣPCosθ x eccentricity	=	80.50	tm
The stress generated at top fibre of the precast section	=	669.94	t/m^2
The stress generated at bottom fibre of the precast section	=	1339.87	t/m^2
Stress Check After Shrinkage Loss			
Total prestressing force left in the stressed cables after shrinkage loss	=	450.80	t
Total bending effect due to this prestressing force ΣPCosθ x eccentricity	=	76.15	tm
The stress generated at top fibre of the precast section	=	713.33	t/m^2
The stress generated at bottom fibre of the precast section	=	1247.72	t/m^2
Stress Check After Creep Loss			
Total prestressing force left in the stressed cables after creep loss	=	414.75	t
Total bending effect due to this prestressing force ΣPCosθ x eccentricity	=	69.92	tm
The stress generated at top fibre of the precast section	=	743.51	t/m^2
The stress generated at bottom fibre of the precast section	=	1083.56	t/m^2

Stress Check After Relaxation Loss

Total prestressing force left in the stressed cables after relaxation loss	=	413.67	t
Total bending effect due to this prestressing force ΣPCosθ x eccentricity	=	69.74	tm
The stress generated at top fibre of the precast section	=	744.37	t/m^2
The stress generated at bottom fibre of the precast section	=	1078.67	t/m^2

Stage 3

1 The girder is transported to its intended destination on the site and placed at its position in the structure

2 The remaining part of the dead load is cast

However since the self weight of new concrete is transferred to the old section of the girder before the new cast attains any strength for structural purpose therefore the old section properties will be effective for the purpose of stress check

Note: Age of concrete at the time of transfer of prestress is taken as 100 days
(all time dependent losses have been assumed to have completely occurred in stage 2)

Bending moment at the section considered due to self weight of the girder	=	39.18	tm
additional stress at the top fibre of new cast	=	0.00	t/m^2
additional stress at the interface of new cast and old section	=	703.23	t/m^2
additional stress at the bottom fibre of old section	=	-518.85	t
Total stress at the top fibre of new cast	=	0.00	t/m^2
Total stress at the interface of new cast and old section	=	1447.61	t/m^2
Total stress at the bottom fibre of old section	=	559.82	t

<u>Stage 4</u>				
1	The new cast concrete attains its strength and become effective for stresses due to further loads			
2	The floor is cast over the slab			
Note:	Age of concrete at the time of transfer of prestress is taken as more than 100 days			
	(all time dependent losses have been assumed to have completely occurred in stage 2)			
Bending moment at the section considered due to floor load		=	10.36	tm
additional stress at the top fibre of new cast		=	88.20	t/m^2
additional stress at the interface of new cast and old section		=	74.49	t/m^2
additional stress at the bottom fibre of old section		=	-115.55	t
Total stress at the top fibre of new cast		=	88.20	t/m^2
Total stress at the interface of new cast and old section		=	1522.09	t/m^2
Total stress at the bottom fibre of old section		=	444.27	t
Bending moment at the section considered due to live load		=	10.36	tm
additional stress at the top fibre of new cast		=	88.20	t/m^2
additional stress at the interface of new cast and old section		=	74.49	t/m^2
additional stress at the bottom fibre of old section		=	-115.55	t
Total stress at the top fibre of new cast		=	176.40	t/m^2
Total stress at the interface of new cast and old section		=	1596.580	t/m^2
Total stress at the bottom fibre of old section		=	328.72	t/m^2

DESCRIPTION OF COLUMNS

Column 1	Length of cable from vertical profile consideration up to the desired section
Column 2	Length of cable from horizontal profile consideration up to the desired section
Column 3	Horizontal projection of cable length from horizontal profile consideration at the desired section
Column 4	Total length of the cable up to the desired section
Column 5	Angle traversed by cable in vertical plane up to the desired section
Column 6	Angle traversed by cable in horizontal plane up to the desired section
Column 7	Additional angle in cable due to any other miscellaneous reason such as slope in the profile of tension face
Column 8	Total angle traversed by cable up to the desired section
Column 9	Force in the cable after friction loss
Column 10	Force in the cable after slip loss
Column 11	Cable coordinate from tension face of the section
Column 12	Additional height of cable due to any other miscellaneous reason such as slope in the profile of tension face
Column 13	Total height of cable from tension face including effect of slope of tension face if any
Column 14	Total Depth of the X-section
Column 15	Distance of CG of cable from Battom Face
Column 16	CG of the Section from the Bottom Face
Column 17	Eccentricity of the Cable (+ve towards Bottom Face from CG of the Section, -ve towards Top Face from CG of the Section)
Column 18	P Cosθ x Eccentricity of the cable
Column 19	Summation of P Cosθ
Column 20	Summation of P Cosθ x Eccentricityof the cable
Column 21	Stress at Top Fibre
Column 22	Stress at Bottom Fibre
Column 23	Stress at CG of Cables
Column 24	Elastic shortening loss
Column 25	Force in Cables after Elastic Shortening Losss
Column 26	Loss due to Shrinkage of Concrete
Column 27	Force in Cables after Shrinkage Losss
Column 28	P Cosθ x Eccentricity of the cable
Column 29	Stress at Top Fibre after losses
Column 30	Stress at Bottom Fibre after losses
Column 31	Stress at CG of Cables after losses
Column 32	Creep loss
Column 33	Force in cable after Creep loss
Column 34	Relaxation loss

Check for Shear (AT SUPPORT SECTION)

Partial Safety factors for loads

	* ULS
Dead Load	1.50
Floor Finishes	1.50
Live Load	1.50

* Ultimate Limit State

* Serviceability Limit State

Summary of Ultimate Shear

Load case	Bending Moment	Shear Force	Factored Bending Moment	Factored Shear Force
Dead Load	0.05	19.84	0.08	29.76
Floor Finishes	20.32	5.72	30.48	8.58
Live Load	20.32	5.72	30.48	8.58
Total	40.69	31.28	61.04	46.92

Stage 1 & Stage 2

Ultimate Shear Resistance of Section Uncracked in Flexure

Vco = $0.67\ b\ D\sqrt{(ft^2 + 0.8\ fcp\ ft)}$ = 21.97 t/m^2

b = 0.19 m

D = 0.485 m

Grade of concrete = M- 40

ft = $0.24\sqrt{fck}$ = 154.83 t/m^2

Area of cross Section = 0.44 m^2

fcp = 828.35 t/m^2

Ultimate Shear Resistance of Section Cracked in Flexure

Vcr = (1 - 0.55 fpe/fp) ζc b d + Mo V/M = 8771.65 t/m^2

or $0.1\ b\ d\sqrt{fck}$ = 5.63 t/m^2

Governing Value of Vcr = 8771.65 t/m^2

fpe = maximum of 0.6fp or effective prestress after all losses

= 365.80 t

fp = 880.09 t

area of prestressing tendon = 46.389 cm^2

% area of prestressing tendon = 5.319 %

ζc = 103.02 t/m^2

Mo = 0.8 fpt (I/y) = 22.09 t/m^2

The section is uncracked in flexure

Vertical component of prestress at the section = 11.95 t

Shear capacity of the section = 33.91 t/m^2

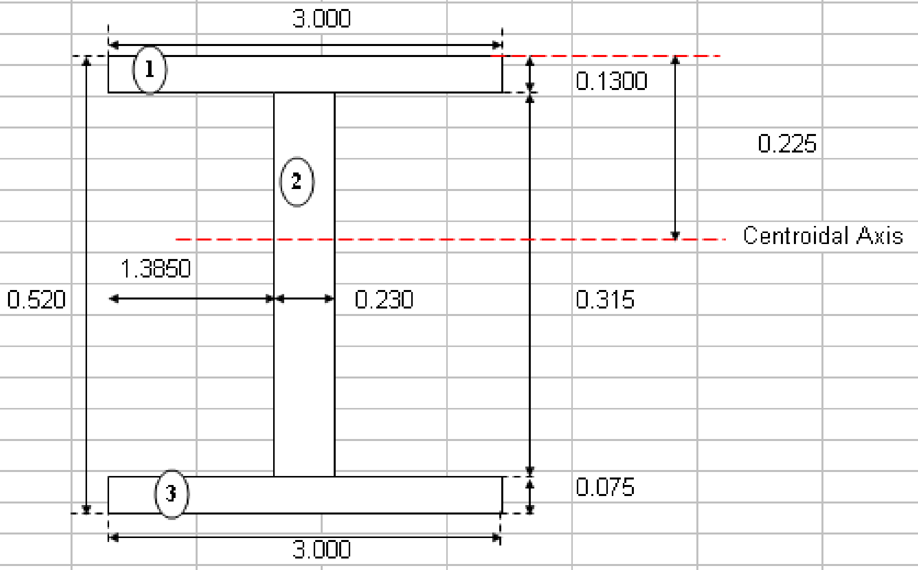
or 2.96 t

Shear reinforcement = 15.85615

Page 1

Service Stage							
Ultimate Shear Resistance of Section Uncracked in Flexure							
Vco	=	$0.67\ b\ D \sqrt{(ft^2 + 0.8\ fcp\ ft)}$			=	25.56	t/m^2
b	=	0.23	m				
D	=	0.52	m				
Grade of concrete				=	M-	40	
ft	=	$0.24 \sqrt{fck}$		=	154.83	t/m^2	
Area of cross Section				=	0.58	m^2	
fcp	=	628.03	t/m^2				
Ultimate Shear Resistance of Section Cracked in Flexure							
Vcr	=	(1 - 0.55 fpe/fp) ζc b d + Mo V/M			=	27.49	t/m^2
	or	$0.1\ b\ d \sqrt{fck}$			=	5.63	t/m^2
Governing Value of Vcr					=	27.49	t/m^2
fpe	=	maximum of 0.6fp or effective prestress after all losses					
	=	365.80	t				
fp	=	880.09	t				
area of prestressing tendon			=	46.389	cm^2		
% area of prestressing tendon			=	4.083	%		
ζc	=	103.02	t/m^2				
Mo	=	0.8 fpt (I/y)		=	24.01	t/m^2	
The section is	uncracked	in flexure					
Vertical component of prestress at the section				=	11.95	t	
Shear capacity of the section				=	37.51	t/m^2	
				or	4.26	t	
Shear reinforcement		=	23.45	cm^2/m			
Check for Ultimate Shear							
Net ultimate Shear force				=	42.66	t	
Net ultimate Shear stress				=	375.45	t/m^2	

Section Properties of The Internal Cell Grid Line Along Lx Direction at Mid Span Location



Calculation of Cross-Section Properties

Element	Area (A)	Z	AZ	Y	AY
1	0.39	0.065	0.0254	1.500	0.5850
2	0.07245	0.2875	0.0208	1.500	0.1087
3	0.225	0.4825	0.1086	1.500	0.3375
TOTAL	**0.687450**		**0.1547**		**1.0312**

$\overline{Z}$ = 0.225 m $\overline{Y}$ = 1.500 m

I_X

Element	b	d	$\frac{bd^3}{3}$	
1	3.000	0.130	1.10E-03	<---$bd^3/6$
2	0.315	0.230	1.28E-03	<---$bd^3/3$
3	3.000	0.075	2.11E-04	<---$bd^3/6$
TOTAL			0.002587	

I_X = **0.002587** m^4

I_Y

Element	$Iself=db^3/12$	$A(Y - \overline{Y})^2$
1	0.292500	0.000000
2	0.000319	0.000000
3	0.168750	0.000000
TOTAL	0.461569	0.000000

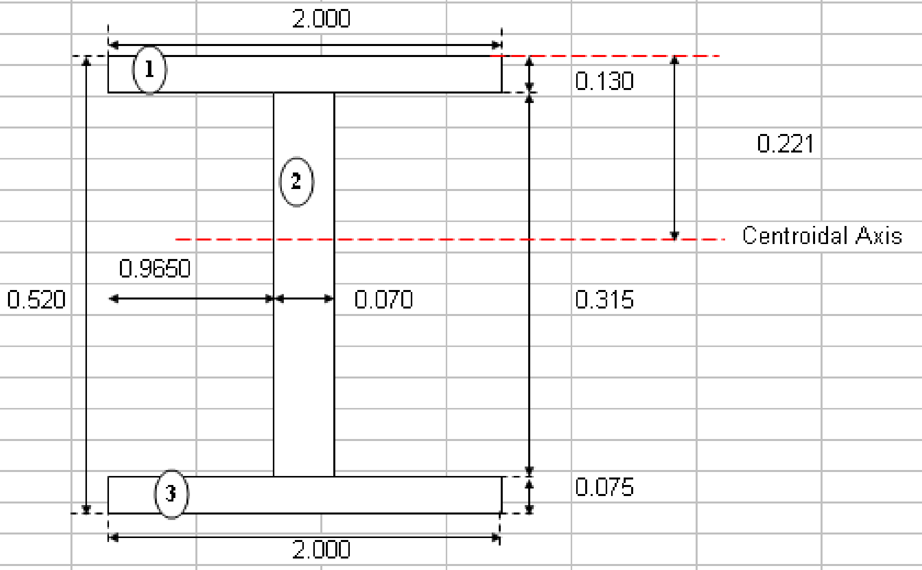
I_y = **0.461569** m^4

I_Z

Element	$Iself=bd^3/12$	$A(X-\overline{X})^2$
1	0.000549	0.009996
2	0.000599	0.000282
3	0.000105	0.014908
TOTAL	0.001254	0.025186

I_Z = **0.026440** m^4

Section Properties of The Internal Cell Grid Line Along Lx Direction at Mid Span Location



Calculation of Cross-Section Properties

Element	Area (A)	Z	AZ	Y	AY
1	0.26	0.065	0.0169	1.000	0.2600
2	0.02205	0.2875	0.0063	1.000	0.0221
3	0.15	0.4825	0.0724	1.000	0.1500
TOTAL	**0.432050**		**0.0956**		**0.4321**

$\overline{Z}$ = 0.221 m $\overline{Y}$ = 1.000 m

I_X

Element	b	d	$\frac{bd^3}{3}$	
1	2.000	0.130	7.32E-04	<---$bd^3/6$
2	0.315	0.070	3.60E-05	<---$bd^3/3$
3	2.000	0.075	1.41E-04	<---$bd^3/6$
TOTAL			0.000909	

I_X = **0.000909** m^4

I_Y

Element	$Iself=db^3/12$	$A(Y - \overline{Y})^2$
1	0.086667	0.000000
2	0.000009	0.000000
3	0.050000	0.000000
TOTAL	0.136676	0.000000

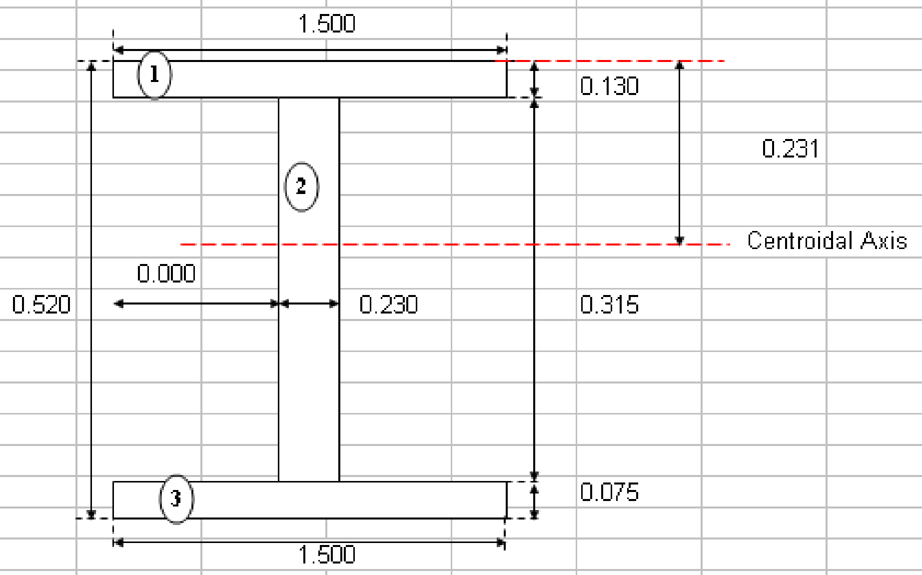
I_y = **0.136676** m^4

I_Z

Element	$Iself=bd^3/12$	$A(X-\overline{X})^2$
1	0.000366	0.006352
2	0.000182	0.000097
3	0.000070	0.010234
TOTAL	0.000619	0.016682

I_Z = **0.017301** m^4

Section Properties of The Internal Cell Grid Line Along Lx Direction at Mid Span Location



Calculation of Cross-Section Properties

Element	Area (A)	Z	AZ	Y	AY
1	0.195	0.065	0.0127	0.750	0.1463
2	0.07245	0.2875	0.0208	0.115	0.0083
3	0.1125	0.4825	0.0543	0.750	0.0844
TOTAL	**0.379950**		**0.0878**		**0.2390**

$\overline{Z}$ = 0.231 m $\overline{Y}$ = 0.629 m

I_X

Element	b	d	$\frac{bd^3}{3}$	
1	1.500	0.130	5.49E-04	<---$bd^3/6$
2	0.315	0.230	1.28E-03	<---$bd^3/3$
3	1.500	0.075	1.05E-04	<---$bd^3/6$
TOTAL			0.001932	

I_X = **0.001932** m^4

I_Y

Element	$I_{self}=db^3/12$	$A(Y-\overline{Y})^2$
1	0.036563	0.002859
2	0.000319	0.019135
3	0.021094	0.001649
TOTAL	0.057976	0.023643

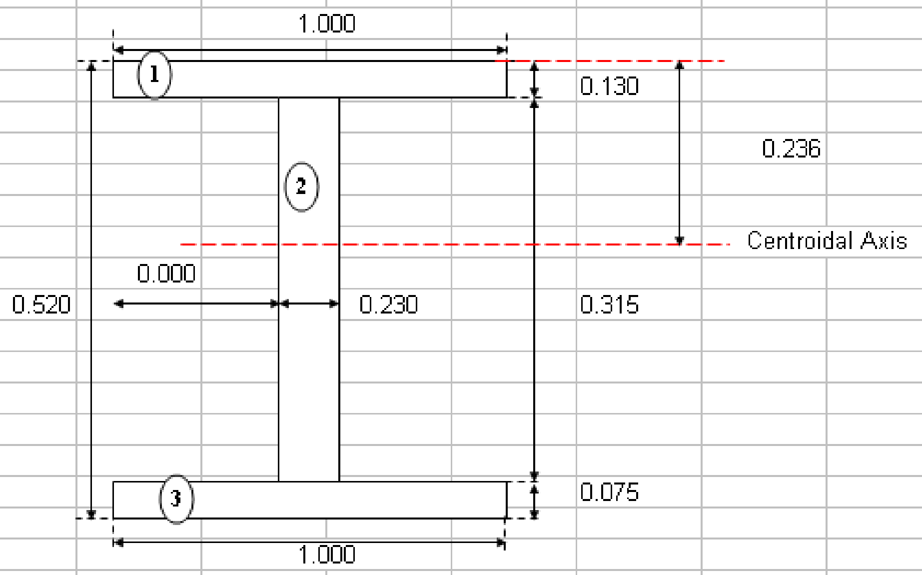
I_y = **0.081619** m^4

I_Z

Element	$I_{self}=bd^3/12$	$A(X-\overline{X})^2$
1	0.000275	0.005376
2	0.000599	0.000231
3	0.000053	0.007113
TOTAL	0.000926	0.012721

I_Z = **0.013647** m^4

Section Properties of The Internal Cell Grid Line Along Lx Direction at Mid Span Location



Calculation of Cross-Section Properties

Element	Area (A)	Z	AZ	Y	AY
1	0.13	0.065	0.0085	0.500	0.0650
2	0.07245	0.2875	0.0208	0.115	0.0083
3	0.075	0.4825	0.0362	0.500	0.0375
TOTAL	**0.277450**		**0.0655**		**0.1108**

$\bar{Z}$ = 0.236 m $\bar{Y}$ = 0.399 m

I_X

Element	b	d	$\frac{bd^3}{3}$	
1	1.000	0.130	3.66E-04	<---$bd^3/6$
2	0.315	0.230	1.28E-03	<---$bd^3/3$
3	1.000	0.075	7.03E-05	<---$bd^3/6$
TOTAL			0.001714	

I_X = **0.001714** m^4

I_Y

Element	$Iself=db^3/12$	$A(Y-\bar{Y})^2$
1	0.010833	0.001314
2	0.000319	0.005863
3	0.006250	0.000758
TOTAL	0.017403	0.007935

I_y = **0.025337** m^4

I_Z

Element	$Iself=bd^3/12$	$A(X-\bar{X})^2$
1	0.000183	0.003800
2	0.000599	0.000192
3	0.000035	0.004559
TOTAL	0.000817	0.008551

I_Z = **0.009368** m^4

SUMMARY OF BENDING MOMENTS IN VARIOUS LOAD COMBINATIONS

COMBINATION 1

PARTIAL FACTOR OF SAFETY FOR LOADS

Please write 1 for cast-in-situ construction and 2 for segmental construction 2

	ULS
DEAD LOAD	0.00
FLOOR FINISHES	1.50
LIVE LOAD	1.50

span of the slab

Lx 20 m

Ly 30 m

SIGN CONVENTION:

+ve means hogging

-ve means sagging

Clear Cover to Reinforcement in beams/slabs	20 mm
Clear Cover to Reinforcement in ribs	20 mm
Dia of Reinforcing Bars	16 mm
Charecteristic compressive strength of concrete	40 N/mm^2
Charecteristic tensile strength of reinforcement	415 N/mm^2

LOAD CASE → Member No.	Distance		UNFACTORED MOMENTS Dead Load	Floor Finishes	Live Load	Factored Moment Total Bending moment	Total Depth of the Member	Effective Depth	Thickness of comp-ression Flange	Xumax/d Permi-ssible	Xu for Yf = Df	MOR for which Xu = Df Muf	MOR for which Xu makes Yf=Df Mub	MOR for which Xu makes Yf>Df Muweb	Flange Width of the Member	Web Width of the Member	Xu/d Achieved	Area of Steel Required cm^2
51	0	MAX.	80.34	20.32	20.32	60.96	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.05859	**34.49**
		MIN.	80.34	20.32	20.32	60.96	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.05859	**34.49**
	1	MAX.	57.94	14.66	14.66	43.98	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.04197	**24.71**
		MIN.	57.94	14.66	14.66	43.98	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.04197	**24.71**
	2	MAX.	36.66	9.27	9.27	27.81	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.02636	**15.52**
		MIN.	36.66	9.27	9.27	27.81	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.02636	**15.52**
52	0	MAX.	36.80	9.30	9.30	27.90	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.02645	**15.57**
		MIN.	36.80	9.30	9.30	27.90	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.02645	**15.57**
	1	MAX.	19.20	4.86	4.86	14.58	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.01375	**8.09**
		MIN.	19.20	4.86	4.86	14.58	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.01375	**8.09**
	2	MAX.	2.72	0.68	0.68	2.04	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.00191	**1.13**
		MIN.	2.72	0.68	0.68	2.04	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.00191	**1.13**

UNFACTORED TORSION			Factored Moment	UNFACTORED SHEAR			Factored Shear	Equivalent Shear/Bending Moment due to Effect of Torsion				Total Shear/ Moment											
Dead Load	Floor Finish-es	Live Load	Total Torsion	Dead Load	Floor Finish-es	Live Load	Total Shear	Total Depth of the Member	Breadth of the Member	Shear	Bending moment	Shear	Bending moment	Effective Depth	Shear stress	% Tensile Reinf.	Permi-ssible Shear Stress	b1	d1	Shear Reinf. Required cm^2	Xu/d Achieved	Area of Tension Steel Required cm^2
0.00	0.00	0.00	0.00	22.92	5.72	5.72	17.16	0.52	0.230	0.00	0.00	17.16	60.96	0.49	151.6	3.05	103.02	0.174	0.464	4.02	0.06	34.49
0.00	0.00	0.00	0.00	22.92	5.72	5.72	17.16	0.52	0.230	0.00	0.00	17.16	60.96	0.49	151.6	3.05	103.02	0.174	0.464	4.02	0.06	34.49
0.00	0.00	0.00	0.00	21.84	5.52	5.52	16.56	0.52	0.230	0.00	0.00	16.56	43.98	0.49	146.3	2.18	92.70	0.174	0.464	3.88	0.04	24.71
0.00	0.00	0.00	0.00	21.84	5.52	5.52	16.56	0.52	0.230	0.00	0.00	16.56	43.98	0.49	146.3	2.18	92.70	0.174	0.464	3.88	0.04	24.71
0.00	0.00	0.00	0.00	20.76	5.32	5.32	15.96	0.52	0.230	0.00	0.00	15.96	27.81	0.49	141.0	1.37	77.93	0.174	0.464	3.94	0.03	15.52
0.00	0.00	0.00	0.00	20.76	5.32	5.32	15.96	0.52	0.230	0.00	0.00	15.96	27.81	0.49	141.0	1.37	77.93	0.174	0.464	3.94	0.03	15.52
0.00	0.00	0.00	0.00	18.12	4.51	4.51	13.53	0.52	0.230	0.00	0.00	13.53	27.90	0.49	119.6	1.38	77.93	0.174	0.464	3.17	0.03	15.57
0.00	0.00	0.00	0.00	18.12	4.51	4.51	13.53	0.52	0.230	0.00	0.00	13.53	27.90	0.49	119.6	1.38	77.93	0.174	0.464	3.17	0.03	15.57
0.00	0.00	0.00	0.00	17.04	4.31	4.31	12.93	0.52	0.230	0.00	0.00	12.93	14.58	0.49	114.3	0.72	59.73	0.174	0.464	3.41	0.01	8.09
0.00	0.00	0.00	0.00	17.04	4.31	4.31	12.93	0.52	0.230	0.00	0.00	12.93	14.58	0.49	114.3	0.72	59.73	0.174	0.464	3.41	0.01	8.09
0.00	0.00	0.00	0.00	15.96	4.11	4.11	12.33	0.52	0.230	0.00	0.00	12.33	2.04	0.49	109.0	0.10	30.60	0.174	0.464	4.89	0.00	1.13
0.00	0.00	0.00	0.00	15.96	4.11	4.11	12.33	0.52	0.230	0.00	0.00	12.33	2.04	0.49	109.0	0.10	30.60	0.174	0.464	4.89	0.00	1.13

			UNFACTORED MOMENTS			Factored Moment												
LOAD CASE →			Dead Load	Floor Finishes	Live Load	Total Bending moment	Total Depth of the Member	Effective Depth	Thickness of comp-ression Flange	Xumax/d Permi-ssible	Xu for Yf = Df	MOR for which Xu = Df Muf	MOR for which Xu makes Yf=Df Mub	MOR for which Xu makes Yf>Df Muweb	Flange Width of the Member	Web Width of the Member	Xu/d Achieved	Area of Steel Required cm^2
Member No.	Distance																	
53	0	MAX.	2.92	0.73	0.73	2.19	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.00205	**1.21**
		MIN.	2.92	0.73	0.73	2.19	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.00205	**1.21**
	1	MAX.	-9.85	-2.49	-2.49	-7.47	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.00702	**4.13**
		MIN.	-9.85	-2.49	-2.49	-7.47	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.00702	**4.13**
	2	MAX.	-21.50	-5.45	-5.45	-16.35	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.01543	**9.08**
		MIN.	-21.50	-5.45	-5.45	-16.35	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.01543	**9.08**
54	0	MAX.	-21.32	-5.40	-5.40	-16.20	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.01529	**9.00**
		MIN.	-21.32	-5.40	-5.40	-16.20	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.01529	**9.00**
	1	MAX.	-29.24	-7.40	-7.40	-22.20	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02100	**12.36**
		MIN.	-29.24	-7.40	-7.40	-22.20	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02100	**12.36**
	2	MAX.	-36.05	-9.13	-9.13	-27.39	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02596	**15.28**
		MIN.	-36.05	-9.13	-9.13	-27.39	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02596	**15.28**
55	0	MAX.	-35.94	-9.11	-9.11	-27.33	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02590	**15.25**
		MIN.	-35.94	-9.11	-9.11	-27.33	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02590	**15.25**
	1	MAX.	-38.97	-9.86	-9.86	-29.58	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02806	**16.52**
		MIN.	-38.97	-9.86	-9.86	-29.58	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02806	**16.52**
	2	MAX.	-40.87	-10.36	-10.36	-31.08	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02950	**17.37**
		MIN.	-40.87	-10.36	-10.36	-31.08	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02950	**17.37**
56	0	MAX.	-40.87	-10.36	-10.36	-31.08	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02950	**17.37**
		MIN.	-40.87	-10.36	-10.36	-31.08	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02950	**17.37**
	1	MAX.	-38.98	-9.87	-9.87	-29.61	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02809	**16.54**
		MIN.	-38.98	-9.87	-9.87	-29.61	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02809	**16.54**
	2	MAX.	-35.97	-9.11	-9.11	-27.33	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02590	**15.25**
		MIN.	-35.97	-9.11	-9.11	-27.33	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02590	**15.25**
57	0	MAX.	-36.08	-9.14	-9.14	-27.42	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02599	**15.30**
		MIN.	-36.08	-9.14	-9.14	-27.42	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02599	**15.30**
	1	MAX.	-29.28	-7.41	-7.41	-22.23	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02103	**12.38**
		MIN.	-29.28	-7.41	-7.41	-22.23	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.02103	**12.38**
	2	MAX.	-21.36	-5.42	-5.42	-16.26	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.01534	**9.03**
		MIN.	-21.36	-5.42	-5.42	-16.26	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.01534	**9.03**

UNFACTORED TORSION			Factored Moment	UNFACTORED SHEAR			Factored Shear	Equivalent Shear/Bending Moment due to Effect of Torsion				Total Shear/ Moment										
Dead Load	Floor Finish-es	Live Load	Total Torsion	Dead Load	Floor Finish-es	Live Load	Total Shear	Total Depth of the Member	Breadth of the Member	Shear	Bending moment	Shear	Bending moment	Effective Depth	Shear stress	% Tensile Reinf.	Permi-ssible Shear Stress	b1	d1	Shear Reinf. Required cm^2	Xu/d Achieved	Area of Tension Steel Required cm^2
0.00	0.00	0.00	0.00	13.29	3.29	3.29	9.87	0.52	0.230	0.00	0.00	9.87	2.19	0.49	87.2	0.11	30.60	0.174	0.464	3.54	0.00	1.21
0.00	0.00	0.00	0.00	13.29	3.29	3.29	9.87	0.52	0.230	0.00	0.00	9.87	2.19	0.49	87.2	0.11	30.60	0.174	0.464	3.54	0.00	1.21
0.00	0.00	0.00	0.00	12.21	3.09	3.09	9.27	0.52	0.230	0.00	0.00	9.27	7.47	0.49	81.9	0.37	44.59	0.174	0.464	2.33	0.01	4.13
0.00	0.00	0.00	0.00	12.21	3.09	3.09	9.27	0.52	0.230	0.00	0.00	9.27	7.47	0.49	81.9	0.37	44.59	0.174	0.464	2.33	0.01	4.13
0.00	0.00	0.00	0.00	11.13	2.89	2.89	8.67	0.52	0.230	0.00	0.00	8.67	16.35	0.49	76.6	0.80	62.83	0.174	0.464	2.03	0.02	9.08
0.00	0.00	0.00	0.00	11.13	2.89	2.89	8.67	0.52	0.230	0.00	0.00	8.67	16.35	0.49	76.6	0.80	62.83	0.174	0.464	2.03	0.02	9.08
0.00	0.00	0.00	0.00	8.44	2.06	2.06	6.18	0.52	0.230	0.00	0.00	6.18	16.20	0.49	54.6	0.80	62.51	0.174	0.464	Not Required	0.02	9.00
0.00	0.00	0.00	0.00	8.44	2.06	2.06	6.18	0.52	0.230	0.00	0.00	6.18	16.20	0.49	54.6	0.80	62.51	0.174	0.464	Not Required	0.02	9.00
0.00	0.00	0.00	0.00	7.36	1.86	1.86	5.58	0.52	0.230	0.00	0.00	5.58	22.20	0.49	49.3	1.09	71.56	0.174	0.464	Not Required	0.02	12.36
0.00	0.00	0.00	0.00	7.36	1.86	1.86	5.58	0.52	0.230	0.00	0.00	5.58	22.20	0.49	49.3	1.09	71.56	0.174	0.464	Not Required	0.02	12.36
0.00	0.00	0.00	0.00	6.29	1.66	1.66	4.98	0.52	0.230	0.00	0.00	4.98	27.39	0.49	44.0	1.35	77.52	0.174	0.464	Not Required	0.03	15.28
0.00	0.00	0.00	0.00	6.29	1.66	1.66	4.98	0.52	0.230	0.00	0.00	4.98	27.39	0.49	44.0	1.35	77.52	0.174	0.464	Not Required	0.03	15.28
0.00	0.00	0.00	0.00	3.55	0.83	0.83	2.49	0.52	0.230	0.00	0.00	2.49	27.33	0.49	22.0	1.35	77.32	0.174	0.464	Not Required	0.03	15.25
0.00	0.00	0.00	0.00	3.55	0.83	0.83	2.49	0.52	0.230	0.00	0.00	2.49	27.33	0.49	22.0	1.35	77.32	0.174	0.464	Not Required	0.03	15.25
0.00	0.00	0.00	0.00	2.47	0.63	0.63	1.89	0.52	0.230	0.00	0.00	1.89	29.58	0.49	16.7	1.46	79.56	0.174	0.464	Not Required	0.03	16.52
0.00	0.00	0.00	0.00	2.47	0.63	0.63	1.89	0.52	0.230	0.00	0.00	1.89	29.58	0.49	16.7	1.46	79.56	0.174	0.464	Not Required	0.03	16.52
0.00	0.00	0.00	0.00	1.39	0.43	0.43	1.29	0.52	0.230	0.00	0.00	1.29	31.08	0.49	11.4	1.53	81.19	0.174	0.464	Not Required	0.03	17.37
0.00	0.00	0.00	0.00	1.39	0.43	0.43	1.29	0.52	0.230	0.00	0.00	1.29	31.08	0.49	11.4	1.53	81.19	0.174	0.464	Not Required	0.03	17.37
0.00	0.00	0.00	0.00	-1.37	-0.42	-0.42	-1.26	0.52	0.230	0.00	0.00	1.26	31.08	0.49	11.1	1.53	81.19	0.174	0.464	Not Required	0.03	17.37
0.00	0.00	0.00	0.00	-1.37	-0.42	-0.42	-1.26	0.52	0.230	0.00	0.00	1.26	31.08	0.49	11.1	1.53	81.19	0.174	0.464	Not Required	0.03	17.37
0.00	0.00	0.00	0.00	-2.45	-0.62	-0.62	-1.86	0.52	0.230	0.00	0.00	1.86	29.61	0.49	16.4	1.46	79.76	0.174	0.464	Not Required	0.03	16.54
0.00	0.00	0.00	0.00	-2.45	-0.62	-0.62	-1.86	0.52	0.230	0.00	0.00	1.86	29.61	0.49	16.4	1.46	79.76	0.174	0.464	Not Required	0.03	16.54
0.00	0.00	0.00	0.00	-3.53	-0.82	-0.82	-2.46	0.52	0.230	0.00	0.00	2.46	27.33	0.49	21.7	1.35	77.32	0.174	0.464	Not Required	0.03	15.25
0.00	0.00	0.00	0.00	-3.53	-0.82	-0.82	-2.46	0.52	0.230	0.00	0.00	2.46	27.33	0.49	21.7	1.35	77.32	0.174	0.464	Not Required	0.03	15.25
0.00	0.00	0.00	0.00	-6.28	-1.66	-1.66	-4.98	0.52	0.230	0.00	0.00	4.98	27.42	0.49	44.0	1.35	77.52	0.174	0.464	Not Required	0.03	15.30
0.00	0.00	0.00	0.00	-6.28	-1.66	-1.66	-4.98	0.52	0.230	0.00	0.00	4.98	27.42	0.49	44.0	1.35	77.52	0.174	0.464	Not Required	0.03	15.30
0.00	0.00	0.00	0.00	-7.36	-1.86	-1.86	-5.58	0.52	0.230	0.00	0.00	5.58	22.23	0.49	49.3	1.09	71.56	0.174	0.464	Not Required	0.02	12.38
0.00	0.00	0.00	0.00	-7.36	-1.86	-1.86	-5.58	0.52	0.230	0.00	0.00	5.58	22.23	0.49	49.3	1.09	71.56	0.174	0.464	Not Required	0.02	12.38
0.00	0.00	0.00	0.00	-8.43	-2.06	-2.06	-6.18	0.52	0.230	0.00	0.00	6.18	16.26	0.49	54.6	0.80	62.51	0.174	0.464	Not Required	0.02	9.03
0.00	0.00	0.00	0.00	-8.43	-2.06	-2.06	-6.18	0.52	0.230	0.00	0.00	6.18	16.26	0.49	54.6	0.80	62.51	0.174	0.464	Not Required	0.02	9.03

			UNFACTORED MOMENTS			Factored Moment												
LOAD CASE →			Dead Load	Floor Finishes	Live Load	Total Bending moment	Total Depth of the Member	Effective Depth	Thickness of comp-ression Flange	Xumax/d Permi-ssible	Xu for Yf = Df	MOR for which Xu = Df Muf	MOR for which Xu makes Yf=Df Mub	MOR for which Xu makes Yf>Df Muweb	Flange Width of the Member	Web Width of the Member	Xu/d Achieved	Area of Steel Required cm^2
Member No.	Distance																	
58	0	MAX.	-21.55	-5.46	-5.46	-16.38	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.01546	**9.10**
		MIN.	-21.55	-5.46	-5.46	-16.38	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.01546	**9.10**
	1	MAX.	-9.88	-2.50	-2.50	-7.50	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.00705	**4.15**
		MIN.	-9.88	-2.50	-2.50	-7.50	0.520	0.492	0.130	0.48	0.3033	250.6	319.7	294.8	3.000	0.230	0.00705	**4.15**
	2	MAX.	2.90	0.73	0.73	2.19	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.00205	**1.21**
		MIN.	2.90	0.73	0.73	2.19	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.00205	**1.21**
59	0	MAX.	2.70	0.67	0.67	2.01	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.00189	**1.11**
		MIN.	2.70	0.67	0.67	2.01	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.00189	**1.11**
	1	MAX.	19.19	4.86	4.86	14.58	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.01375	**8.09**
		MIN.	19.19	4.86	4.86	14.58	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.01375	**8.09**
	2	MAX.	36.81	9.30	9.30	27.90	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.02645	**15.57**
		MIN.	36.81	9.30	9.30	27.90	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.02645	**15.57**
60	0	MAX.	36.67	9.27	9.27	27.81	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.02636	**15.52**
		MIN.	36.67	9.27	9.27	27.81	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.02636	**15.52**
	1	MAX.	57.97	14.67	14.67	44.01	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.04200	**24.73**
		MIN.	57.97	14.67	14.67	44.01	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.04200	**24.73**
	2	MAX.	80.40	20.33	20.33	60.99	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.05862	**34.51**
		MIN.	80.40	20.33	20.33	60.99	0.520	0.492	0.075	0.48	0.1750	152.2	198.1	204.7	3.000	0.230	0.05862	**34.51**
116	0	MAX.	35.09	9.16	9.16	27.48	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.03929	**15.42**
		MIN.	35.09	9.16	9.16	27.48	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.03929	**15.42**
	1.5	MAX.	21.56	5.41	5.41	16.23	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.02305	**9.05**
		MIN.	21.56	5.41	5.41	16.23	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.02305	**9.05**
	3	MAX.	9.51	2.42	2.42	7.26	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.01025	**4.02**
		MIN.	9.51	2.42	2.42	7.26	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.01025	**4.02**
127	0	MAX.	9.79	2.50	2.50	7.50	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.01059	**4.16**
		MIN.	9.79	2.50	2.50	7.50	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.01059	**4.16**
	1.5	MAX.	1.94	0.40	0.40	1.20	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.00169	**0.66**
		MIN.	1.94	0.40	0.40	1.20	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.00169	**0.66**
	3	MAX.	-3.85	-0.93	-0.93	-2.79	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00393	**1.54**
		MIN.	-3.85	-0.93	-0.93	-2.79	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00393	**1.54**

UNFACTORED TORSION			Factored Moment	UNFACTORED SHEAR			Factored Shear	Equivalent Shear/Bending Moment due to Effect of Torsion				Total Shear/ Moment										
Dead Load	Floor Finish-es	Live Load	Total Torsion	Dead Load	Floor Finish-es	Live Load	Total Shear	Total Depth of the Member	Breadth of the Member	Shear	Bending moment	Shear	Bending moment	Effective Depth	Shear stress	% Tensile Reinf.	Permi-ssible Shear Stress	b1	d1	Shear Reinf. Required cm^2	Xu/d Achieved	Area of Tension Steel Required cm^2
0.00	0.00	0.00	0.00	-11.15	-2.89	-2.89	-8.67	0.52	0.230	0.00	0.00	8.67	16.38	0.49	76.6	0.80	62.83	0.174	0.464	0.86	0.02	9.10
0.00	0.00	0.00	0.00	-11.15	-2.89	-2.89	-8.67	0.52	0.230	0.00	0.00	8.67	16.38	0.49	76.6	0.80	62.83	0.174	0.464	0.86	0.02	9.10
0.00	0.00	0.00	0.00	-12.22	-3.09	-3.09	-9.27	0.52	0.230	0.00	0.00	9.27	7.50	0.49	81.9	0.37	44.59	0.174	0.464	2.33	0.01	4.15
0.00	0.00	0.00	0.00	-12.22	-3.09	-3.09	-9.27	0.52	0.230	0.00	0.00	9.27	7.50	0.49	81.9	0.37	44.59	0.174	0.464	2.33	0.01	4.15
0.00	0.00	0.00	0.00	-13.30	-3.29	-3.29	-9.87	0.52	0.230	0.00	0.00	9.87	2.19	0.49	87.2	0.11	30.60	0.174	0.464	3.54	0.00	1.21
0.00	0.00	0.00	0.00	-13.30	-3.29	-3.29	-9.87	0.52	0.230	0.00	0.00	9.87	2.19	0.49	87.2	0.11	30.60	0.174	0.464	3.54	0.00	1.21
0.00	0.00	0.00	0.00	-15.98	-4.11	-4.11	-12.33	0.52	0.230	0.00	0.00	12.33	2.01	0.49	109.0	0.10	30.60	0.174	0.464	4.89	0.00	1.11
0.00	0.00	0.00	0.00	-15.98	-4.11	-4.11	-12.33	0.52	0.230	0.00	0.00	12.33	2.01	0.49	109.0	0.10	30.60	0.174	0.464	4.89	0.00	1.11
0.00	0.00	0.00	0.00	-17.05	-4.31	-4.31	-12.93	0.52	0.230	0.00	0.00	12.93	14.58	0.49	114.3	0.72	59.73	0.174	0.464	3.41	0.01	8.09
0.00	0.00	0.00	0.00	-17.05	-4.31	-4.31	-12.93	0.52	0.230	0.00	0.00	12.93	14.58	0.49	114.3	0.72	59.73	0.174	0.464	3.41	0.01	8.09
0.00	0.00	0.00	0.00	-18.13	-4.51	-4.51	-13.53	0.52	0.230	0.00	0.00	13.53	27.90	0.49	119.6	1.38	77.93	0.174	0.464	2.60	0.03	15.57
0.00	0.00	0.00	0.00	-18.13	-4.51	-4.51	-13.53	0.52	0.230	0.00	0.00	13.53	27.90	0.49	119.6	1.38	77.93	0.174	0.464	2.60	0.03	15.57
0.00	0.00	0.00	0.00	-20.79	-5.33	-5.33	-15.99	0.52	0.230	0.00	0.00	15.99	27.81	0.49	141.3	1.37	77.93	0.174	0.464	3.96	0.03	15.52
0.00	0.00	0.00	0.00	-20.79	-5.33	-5.33	-15.99	0.52	0.230	0.00	0.00	15.99	27.81	0.49	141.3	1.37	77.93	0.174	0.464	3.96	0.03	15.52
0.00	0.00	0.00	0.00	-21.86	-5.53	-5.53	-16.59	0.52	0.230	0.00	0.00	16.59	44.01	0.49	146.6	2.19	92.70	0.174	0.464	3.37	0.04	24.73
0.00	0.00	0.00	0.00	-21.86	-5.53	-5.53	-16.59	0.52	0.230	0.00	0.00	16.59	44.01	0.49	146.6	2.19	92.70	0.174	0.464	3.37	0.04	24.73
0.00	0.00	0.00	0.00	-22.94	-5.73	-5.73	-17.19	0.52	0.230	0.00	0.00	17.19	60.99	0.49	151.9	3.05	103.02	0.174	0.464	3.05	0.06	34.51
0.00	0.00	0.00	0.00	-22.94	-5.73	-5.73	-17.19	0.52	0.230	0.00	0.00	17.19	60.99	0.49	151.9	3.05	103.02	0.174	0.464	3.05	0.06	34.51
0.00	0.00	0.00	0.00	9.44	2.65	2.65	7.95	0.52	0.070	0.00	0.00	7.95	27.48	0.49	230.8	4.48	103.02	0.014	0.464	2.43	0.04	15.42
0.00	0.00	0.00	0.00	9.44	2.65	2.65	7.95	0.52	0.070	0.00	0.00	7.95	27.48	0.49	230.8	4.48	103.02	0.014	0.464	2.43	0.04	15.42
0.00	0.00	0.00	0.00	8.53	2.25	2.25	6.75	0.52	0.070	0.00	0.00	6.75	16.23	0.49	196.0	2.63	98.37	0.014	0.464	1.86	0.02	9.05
0.00	0.00	0.00	0.00	8.53	2.25	2.25	6.75	0.52	0.070	0.00	0.00	6.75	16.23	0.49	196.0	2.63	98.37	0.014	0.464	1.86	0.02	9.05
0.00	0.00	0.00	0.00	7.62	1.85	1.85	5.55	0.52	0.070	0.00	0.00	5.55	7.26	0.49	161.1	1.17	73.28	0.014	0.464	1.67	0.01	4.02
0.00	0.00	0.00	0.00	7.62	1.85	1.85	5.55	0.52	0.070	0.00	0.00	5.55	7.26	0.49	161.1	1.17	73.28	0.014	0.464	1.67	0.01	4.02
0.00	0.00	0.00	0.00	5.84	1.54	1.54	4.62	0.52	0.070	0.00	0.00	4.62	7.50	0.49	134.1	1.21	74.26	0.014	0.464	1.14	0.01	4.16
0.00	0.00	0.00	0.00	5.84	1.54	1.54	4.62	0.52	0.070	0.00	0.00	4.62	7.50	0.49	134.1	1.21	74.26	0.014	0.464	1.14	0.01	4.16
0.00	0.00	0.00	0.00	4.55	1.14	1.14	3.42	0.52	0.070	0.00	0.00	3.42	1.20	0.49	99.3	0.19	33.86	0.014	0.464	1.24	0.00	0.66
0.00	0.00	0.00	0.00	4.55	1.14	1.14	3.42	0.52	0.070	0.00	0.00	3.42	1.20	0.49	99.3	0.19	33.86	0.014	0.464	1.24	0.00	0.66
0.00	0.00	0.00	0.00	3.25	0.74	0.74	2.22	0.52	0.070	0.00	0.00	2.22	2.79	0.49	64.5	0.45	48.84	0.014	0.464	0.52	0.00	1.54
0.00	0.00	0.00	0.00	3.25	0.74	0.74	2.22	0.52	0.070	0.00	0.00	2.22	2.79	0.49	64.5	0.45	48.84	0.014	0.464	0.52	0.00	1.54

Member No.	Distance	LOAD CASE →	UNFACTORED MOMENTS Dead Load	Floor Finishes	Live Load	Factored Moment Total Bending moment	Total Depth of the Member	Effective Depth	Thickness of comp-ression Flange	Xumax/d Permi-ssible	Xu for Yf = Df	MOR for which Xu = Df Muf	MOR for which Xu makes Yf=Df Mub	MOR for which Xu makes Yf>Df Muweb	Flange Width of the Member	Web Width of the Member	Xu/d Achieved	Area of Steel Required cm^2
138	0	MAX.	-3.51	-0.84	-0.84	-2.52	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00355	**1.39**
		MIN.	-3.51	-0.84	-0.84	-2.52	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00355	**1.39**
	1.5	MAX.	-6.85	-1.80	-1.80	-5.40	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00762	**2.99**
		MIN.	-6.85	-1.80	-1.80	-5.40	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00762	**2.99**
	3	MAX.	-8.14	-1.99	-1.99	-5.97	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00843	**3.31**
		MIN.	-8.14	-1.99	-1.99	-5.97	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00843	**3.31**
149	0	MAX.	-7.88	-1.92	-1.92	-5.76	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00813	**3.19**
		MIN.	-7.88	-1.92	-1.92	-5.76	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00813	**3.19**
	1.5	MAX.	-9.14	-2.35	-2.35	-7.05	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00996	**3.91**
		MIN.	-9.14	-2.35	-2.35	-7.05	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00996	**3.91**
	3	MAX.	-8.34	-2.03	-2.03	-6.09	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00860	**3.37**
		MIN.	-8.34	-2.03	-2.03	-6.09	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00860	**3.37**
160	0	MAX.	-8.21	-1.99	-1.99	-5.97	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00843	**3.31**
		MIN.	-8.21	-1.99	-1.99	-5.97	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00843	**3.31**
	1.5	MAX.	-9.11	-2.34	-2.34	-7.02	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00991	**3.89**
		MIN.	-9.11	-2.34	-2.34	-7.02	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00991	**3.89**
	3	MAX.	-7.97	-1.93	-1.93	-5.79	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00817	**3.21**
		MIN.	-7.97	-1.93	-1.93	-5.79	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00817	**3.21**
171	0	MAX.	-7.97	-1.93	-1.93	-5.79	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00817	**3.21**
		MIN.	-7.97	-1.93	-1.93	-5.79	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00817	**3.21**
	1.5	MAX.	-9.13	-2.35	-2.35	-7.05	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00996	**3.91**
		MIN.	-9.13	-2.35	-2.35	-7.05	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00996	**3.91**
	3	MAX.	-8.25	-2.00	-2.00	-6.00	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00847	**3.32**
		MIN.	-8.25	-2.00	-2.00	-6.00	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00847	**3.32**
182	0	MAX.	-8.38	-2.03	-2.03	-6.09	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00860	**3.37**
		MIN.	-8.38	-2.03	-2.03	-6.09	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00860	**3.37**
	1.5	MAX.	-9.22	-2.38	-2.38	-7.14	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.01008	**3.96**
		MIN.	-9.22	-2.38	-2.38	-7.14	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.01008	**3.96**
	3	MAX.	-8.00	-1.95	-1.95	-5.85	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00826	**3.24**
		MIN.	-8.00	-1.95	-1.95	-5.85	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00826	**3.24**

UNFACTORED TORSION			Factored Moment	UNFACTORED SHEAR			Factored Shear	Equivalent Shear/Bending Moment due to Effect of Torsion				Total Shear/ Moment										
Dead Load	Floor Finish-es	Live Load	Total Torsion	Dead Load	Floor Finish-es	Live Load	Total Shear	Total Depth of the Member	Breadth of the Member	Shear	Bending moment	Shear	Bending moment	Effective Depth	Shear stress	% Tensile Reinf.	Permi-ssible Shear Stress	b1	d1	Shear Reinf. Required cm^2	Xu/d Achieved	Area of Tension Steel Required cm^2
0.00	0.00	0.00	0.00	2.84	0.78	0.78	2.34	0.52	0.070	0.00	0.00	2.34	2.52	0.49	67.9	0.40	46.72	0.014	0.464	0.55	0.00	1.39
0.00	0.00	0.00	0.00	2.84	0.78	0.78	2.34	0.52	0.070	0.00	0.00	2.34	2.52	0.49	67.9	0.40	46.72	0.014	0.464	0.55	0.00	1.39
0.00	0.00	0.00	0.00	1.54	0.38	0.38	1.14	0.52	0.070	0.00	0.00	1.14	5.40	0.49	33.1	0.87	64.79	0.014	0.464	Not Required	0.01	2.99
0.00	0.00	0.00	0.00	1.54	0.38	0.38	1.14	0.52	0.070	0.00	0.00	1.14	5.40	0.49	33.1	0.87	64.79	0.014	0.464	Not Required	0.01	2.99
0.00	0.00	0.00	0.00	0.25	-0.02	-0.02	-0.06	0.52	0.070	0.00	0.00	0.06	5.97	0.49	1.7	0.96	68.05	0.014	0.464	Not Required	0.01	3.31
0.00	0.00	0.00	0.00	0.25	-0.02	-0.02	-0.06	0.52	0.070	0.00	0.00	0.06	5.97	0.49	1.7	0.96	68.05	0.014	0.464	Not Required	0.01	3.31
0.00	0.00	0.00	0.00	1.45	0.43	0.43	1.29	0.52	0.070	0.00	0.00	1.29	5.76	0.49	37.5	0.93	66.75	0.014	0.464	Not Required	0.01	3.19
0.00	0.00	0.00	0.00	1.45	0.43	0.43	1.29	0.52	0.070	0.00	0.00	1.29	5.76	0.49	37.5	0.93	66.75	0.014	0.464	Not Required	0.01	3.19
0.00	0.00	0.00	0.00	0.16	0.03	0.03	0.09	0.52	0.070	0.00	0.00	0.09	7.05	0.49	2.6	1.13	72.54	0.014	0.464	Not Required	0.01	3.91
0.00	0.00	0.00	0.00	0.16	0.03	0.03	0.09	0.52	0.070	0.00	0.00	0.09	7.05	0.49	2.6	1.13	72.54	0.014	0.464	Not Required	0.01	3.91
0.00	0.00	0.00	0.00	-1.14	-0.37	-0.37	-1.11	0.52	0.070	0.00	0.00	1.11	6.09	0.49	32.2	0.98	68.38	0.014	0.464	Not Required	0.01	3.37
0.00	0.00	0.00	0.00	-1.14	-0.37	-0.37	-1.11	0.52	0.070	0.00	0.00	1.11	6.09	0.49	32.2	0.98	68.38	0.014	0.464	Not Required	0.01	3.37
0.00	0.00	0.00	0.00	1.22	0.38	0.38	1.14	0.52	0.070	0.00	0.00	1.14	5.97	0.49	33.1	0.96	68.05	0.014	0.464	Not Required	0.01	3.31
0.00	0.00	0.00	0.00	1.22	0.38	0.38	1.14	0.52	0.070	0.00	0.00	1.14	5.97	0.49	33.1	0.96	68.05	0.014	0.464	Not Required	0.01	3.31
0.00	0.00	0.00	0.00	-0.08	-0.02	-0.02	-0.06	0.52	0.070	0.00	0.00	0.06	7.02	0.49	1.7	1.13	72.30	0.014	0.464	Not Required	0.01	3.89
0.00	0.00	0.00	0.00	-0.08	-0.02	-0.02	-0.06	0.52	0.070	0.00	0.00	0.06	7.02	0.49	1.7	1.13	72.30	0.014	0.464	Not Required	0.01	3.89
0.00	0.00	0.00	0.00	-1.38	-0.42	-0.42	-1.26	0.52	0.070	0.00	0.00	1.26	5.79	0.49	36.6	0.93	67.08	0.014	0.464	Not Required	0.01	3.21
0.00	0.00	0.00	0.00	-1.38	-0.42	-0.42	-1.26	0.52	0.070	0.00	0.00	1.26	5.79	0.49	36.6	0.93	67.08	0.014	0.464	Not Required	0.01	3.21
0.00	0.00	0.00	0.00	1.39	0.42	0.42	1.26	0.52	0.070	0.00	0.00	1.26	5.79	0.49	36.6	0.93	67.08	0.014	0.464	Not Required	0.01	3.21
0.00	0.00	0.00	0.00	1.39	0.42	0.42	1.26	0.52	0.070	0.00	0.00	1.26	5.79	0.49	36.6	0.93	67.08	0.014	0.464	Not Required	0.01	3.21
0.00	0.00	0.00	0.00	0.09	0.02	0.02	0.06	0.52	0.070	0.00	0.00	0.06	7.05	0.49	1.7	1.13	72.54	0.014	0.464	Not Required	0.01	3.91
0.00	0.00	0.00	0.00	0.09	0.02	0.02	0.06	0.52	0.070	0.00	0.00	0.06	7.05	0.49	1.7	1.13	72.54	0.014	0.464	Not Required	0.01	3.91
0.00	0.00	0.00	0.00	-1.20	-0.38	-0.38	-1.14	0.52	0.070	0.00	0.00	1.14	6.00	0.49	33.1	0.96	68.05	0.014	0.464	Not Required	0.01	3.32
0.00	0.00	0.00	0.00	-1.20	-0.38	-0.38	-1.14	0.52	0.070	0.00	0.00	1.14	6.00	0.49	33.1	0.96	68.05	0.014	0.464	Not Required	0.01	3.32
0.00	0.00	0.00	0.00	1.17	0.37	0.37	1.11	0.52	0.070	0.00	0.00	1.11	6.09	0.49	32.2	0.98	68.38	0.014	0.464	Not Required	0.01	3.37
0.00	0.00	0.00	0.00	1.17	0.37	0.37	1.11	0.52	0.070	0.00	0.00	1.11	6.09	0.49	32.2	0.98	68.38	0.014	0.464	Not Required	0.01	3.37
0.00	0.00	0.00	0.00	-0.13	-0.03	-0.03	-0.09	0.52	0.070	0.00	0.00	0.09	7.14	0.49	2.6	1.15	72.79	0.014	0.464	Not Required	0.01	3.96
0.00	0.00	0.00	0.00	-0.13	-0.03	-0.03	-0.09	0.52	0.070	0.00	0.00	0.09	7.14	0.49	2.6	1.15	72.79	0.014	0.464	Not Required	0.01	3.96
0.00	0.00	0.00	0.00	-1.42	-0.43	-0.43	-1.29	0.52	0.070	0.00	0.00	1.29	5.85	0.49	37.5	0.94	67.40	0.014	0.464	Not Required	0.01	3.24
0.00	0.00	0.00	0.00	-1.42	-0.43	-0.43	-1.29	0.52	0.070	0.00	0.00	1.29	5.85	0.49	37.5	0.94	67.40	0.014	0.464	Not Required	0.01	3.24

			UNFACTORED MOMENTS			Factored Moment												
LOAD CASE →			Dead Load	Floor Finishes	Live Load	Total Bending moment	Total Depth of the Member	Effective Depth	Thickness of comp-ression Flange	Xumax/d Permi-ssible	Xu for Yf = Df	MOR for which Xu = Df Muf	MOR for which Xu makes Yf=Df Mub	MOR for which Xu makes Yf>Df Muweb	Flange Width of the Member	Web Width of the Member	Xu/d Achieved	Area of Steel Required cm^2
Member No.	Distance																	
193	0	MAX.	-8.28	-2.02	-2.02	-6.06	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00855	**3.36**
		MIN.	-8.28	-2.02	-2.02	-6.06	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00855	**3.36**
	1.5	MAX.	-6.94	-1.82	-1.82	-5.46	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00770	**3.02**
		MIN.	-6.94	-1.82	-1.82	-5.46	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00770	**3.02**
	3	MAX.	-3.56	-0.85	-0.85	-2.55	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00359	**1.41**
		MIN.	-3.56	-0.85	-0.85	-2.55	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00359	**1.41**
204	0	MAX.	-3.91	-0.94	-0.94	-2.82	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00397	**1.56**
		MIN.	-3.91	-0.94	-0.94	-2.82	0.520	0.492	0.130	0.48	0.3033	167.0	208.1	193.1	2.000	0.070	0.00397	**1.56**
	1.5	MAX.	1.97	0.41	0.41	1.23	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.00173	**0.68**
		MIN.	1.97	0.41	0.41	1.23	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.00173	**0.68**
	3	MAX.	9.89	2.52	2.52	7.56	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.01068	**4.19**
		MIN.	9.89	2.52	2.52	7.56	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.01068	**4.19**
215	0	MAX.	9.61	2.45	2.45	7.35	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.01038	**4.07**
		MIN.	9.61	2.45	2.45	7.35	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.01038	**4.07**
	1.5	MAX.	21.63	5.43	5.43	16.29	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.02313	**9.08**
		MIN.	21.63	5.43	5.43	16.29	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.02313	**9.08**
	3	MAX.	35.12	9.17	9.17	27.51	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.03934	**15.44**
		MIN.	35.12	9.17	9.17	27.51	0.520	0.492	0.075	0.48	0.1750	101.5	128.3	130.3	2.000	0.070	0.03934	**15.44**

UNFACTORED TORSION			Factored Moment	UNFACTORED SHEAR			Factored Shear	Equivalent Shear/Bending Moment due to Effect of Torsion				Total Shear/ Moment										
Dead Load	Floor Finish-es	Live Load	Total Torsion	Dead Load	Floor Finish-es	Live Load	Total Shear	Total Depth of the Member	Breadth of the Member	Shear	Bending moment	Shear	Bending moment	Effective Depth	Shear stress	% Tensile Reinf.	Permi-ssible Shear Stress	b1	d1	Shear Reinf. Required cm^2	Xu/d Achieved	Area of Tension Steel Required cm^2
0.00	0.00	0.00	0.00	-0.28	0.01	0.01	0.03	0.52	0.070	0.00	0.00	0.03	6.06	0.49	0.9	0.97	68.38	0.014	0.464	Not Required	0.01	3.36
0.00	0.00	0.00	0.00	-0.28	0.01	0.01	0.03	0.52	0.070	0.00	0.00	0.03	6.06	0.49	0.9	0.97	68.38	0.014	0.464	Not Required	0.01	3.36
0.00	0.00	0.00	0.00	-1.57	-0.39	-0.39	-1.17	0.52	0.070	0.00	0.00	1.17	5.46	0.49	34.0	0.88	65.12	0.014	0.464	Not Required	0.01	3.02
0.00	0.00	0.00	0.00	-1.57	-0.39	-0.39	-1.17	0.52	0.070	0.00	0.00	1.17	5.46	0.49	34.0	0.88	65.12	0.014	0.464	Not Required	0.01	3.02
0.00	0.00	0.00	0.00	-2.87	-0.79	-0.79	-2.37	0.52	0.070	0.00	0.00	2.37	2.55	0.49	68.8	0.41	46.72	0.014	0.464	0.42	0.00	1.41
0.00	0.00	0.00	0.00	-2.87	-0.79	-0.79	-2.37	0.52	0.070	0.00	0.00	2.37	2.55	0.49	68.8	0.41	46.72	0.014	0.464	0.42	0.00	1.41
0.00	0.00	0.00	0.00	-3.30	-0.75	-0.75	-2.25	0.52	0.070	0.00	0.00	2.25	2.82	0.49	65.3	0.45	49.37	0.014	0.464	0.30	0.00	1.56
0.00	0.00	0.00	0.00	-3.30	-0.75	-0.75	-2.25	0.52	0.070	0.00	0.00	2.25	2.82	0.49	65.3	0.45	49.37	0.014	0.464	0.30	0.00	1.56
0.00	0.00	0.00	0.00	-4.60	-1.15	-1.15	-3.45	0.52	0.070	0.00	0.00	3.45	1.23	0.49	100.2	0.20	33.86	0.014	0.464	1.26	0.00	0.68
0.00	0.00	0.00	0.00	-4.60	-1.15	-1.15	-3.45	0.52	0.070	0.00	0.00	3.45	1.23	0.49	100.2	0.20	33.86	0.014	0.464	1.26	0.00	0.68
0.00	0.00	0.00	0.00	-5.89	-1.55	-1.55	-4.65	0.52	0.070	0.00	0.00	4.65	7.56	0.49	135.0	1.22	74.50	0.014	0.464	1.15	0.01	4.19
0.00	0.00	0.00	0.00	-5.89	-1.55	-1.55	-4.65	0.52	0.070	0.00	0.00	4.65	7.56	0.49	135.0	1.22	74.50	0.014	0.464	1.15	0.01	4.19
0.00	0.00	0.00	0.00	-7.59	-1.84	-1.84	-5.52	0.52	0.070	0.00	0.00	5.52	7.35	0.49	160.3	1.18	73.77	0.014	0.464	1.64	0.01	4.07
0.00	0.00	0.00	0.00	-7.59	-1.84	-1.84	-5.52	0.52	0.070	0.00	0.00	5.52	7.35	0.49	160.3	1.18	73.77	0.014	0.464	1.64	0.01	4.07
0.00	0.00	0.00	0.00	-8.50	-2.24	-2.24	-6.72	0.52	0.070	0.00	0.00	6.72	16.29	0.49	195.1	2.64	98.49	0.014	0.464	1.84	0.02	9.08
0.00	0.00	0.00	0.00	-8.50	-2.24	-2.24	-6.72	0.52	0.070	0.00	0.00	6.72	16.29	0.49	195.1	2.64	98.49	0.014	0.464	1.84	0.02	9.08
0.00	0.00	0.00	0.00	-9.41	-2.64	-2.64	-7.92	0.52	0.070	0.00	0.00	7.92	27.51	0.49	230.0	4.48	103.02	0.014	0.464	2.41	0.04	15.44
0.00	0.00	0.00	0.00	-9.41	-2.64	-2.64	-7.92	0.52	0.070	0.00	0.00	7.92	27.51	0.49	230.0	4.48	103.02	0.014	0.464	2.41	0.04	15.44

Check for Deflection

Calculation of Effective Moment of Inertia as per IS:456 Annex C

$$I_{eff} = \frac{Ir}{1.2 - (Mr/M)\ (Z/d)\ (1-x/d)\ (bw/b)}$$

I_{eff}	is the effective moment of inertia for the entire Beam or Slab in the direction of effective span
Ir	is the moment of inertia of the cracked section
Mr	is the cracking moment, equal to (Fcr Igr)/Yt

Where

Fcr	is the modulus of rupture of concrete = 0.7 $\sqrt{Fck}$
	[Clause 6.2.2 of IS 456 : 2000 also reiterated in Example 12 of SP 16 :1980 (Tenth reprint June 1997)]
Igr	is the moment of inertia of the gross section neglecting the reinforcement
Yt	is the distance of centroidal axis of the gross section to the extreme fibre in tension

M	is the maximum moment under service loads
Z	is the lever arm
d	is the effective depth
x	is the depth of the neutral axis
bw	is the breadth of the web
b	is the breadth of the compression face
Ec	is the modulus of elasticity of concrete = 5000 $\sqrt{Fck}$
	[Clause 6.2.3.1 of IS 456 : 2000]
Es	is the modulus of elasticity of steel = 200 KN/mm^2
	[Clause 5.6.3 of IS 456 : 2000 also reiterated in Example 12 of SP 16 :1980 (Tenth reprint June 1997)]
m	modular ratio = Es/Ec

Note : for the deflection check of the slabs both bw and b are taken as 1m

Check for Deflection Along Lx Direction

Ir	=	3.469E-03	
Mr	=	45.921	
Fcr	=	451.57	
Igr	=	2.644E-02	
Yt	=	0.2600	
M	=	20.72	
Z	=	0.4859	
d	=	0.4920	
x	=	0.0295	
bw	=	0.230	
b	=	3.000	
Ec	=	31622.78	mpa
Es	=	200000	mpa
m	=	6.3245553	
CG cracked section	=	0.0828	m

I_{eff} = 3.328E-03

$I_r \leq I_{eff} \leq Igr$

Type of structure = PSC

Governing value of I_{eff} = 2.644E-02

Maximum Deflection with Gross M.O.I. of the Element (i.e. gross section.neglecting the reinforcement)

Deflection due to Dead Load

Self Weight of the Slab	=	11.8410	mm
Floor Finishing	=	2.9970	mm
Partition Wall/ any other Concentrated Load	=	0.0000	mm
Deflection due to Live Load	=	2.9970	mm

Coefficient of permanent part of Live Load for loag term deflection effects 0.7
(Refer 35.4.1 page 114 of SP :-1983 First Reprint December 1985)

Total Short Term Deflection (with Gross M.O.I) = 17.8350 mm

Modified Value of Short Term Deflection = 17.84 mm
(With Ieff Calculated above)

Deflection due to Shrinkage

a_{cs} = $K_3\ \psi_{cs}\ L^2$ = 0.90 mm

K_3 = is a constant depending upon the support condition = 0.063 for fully continuous

ψ_{cs} = $K_4\ \varepsilon_{cs}/D$ = 3.56229E-05

where

K_4 = $0.72(Pt-Pc)/(\sqrt{Pt})$ for $0.25 \le Pt-Pc < 1.0$

and $0.65(Pt-Pc)/(\sqrt{Pt})$ for $Pt-Pc > 1.0$

Pt = 0.11767313 %

Pc = 0 (effect ignored if any)

K_4 = 0.24698532

ε_{cs} = 0.000075

D = 0.52

L = 20.000 m (Effective span considered)

Deflection due to Creep

Elasticity modulus of concrete for creep effects 17568.21 mpa

Age at loading = 58 days

Please write one of the following in age at loading (other values are not allowed in the and will cause errors)

	creep coefficient
7 days	2.2
28 days	1.6
1year	1.1
days as sp	0.8

Deflection due to creep = 12.65 mm

Total Deflection including all effects	=	31.38	mm	
Precamber Provided if any	=	11.84	mm	
Net Total Deflection including all effects	=	19.54	mm	
Permissible limit for deflection	=	20.00	mm	OK
Total Deflection including all effects after erection of partitions and application of finishes	=	16.54	mm	
Permissible limit for deflection	=	20.00	mm	OK

DILEMMA FOUND IN INDIAN STANDARD

Determination of creep effects

As per IS:456-2000 clause 6.2.5.1

In absence of experimental data and detailed information on the effect of the variables, the ultimate creep strain may be estimated from the following values of creep coefficients.

Age at loading	creep coefficients
7 days	2.2
28 days	1.6
1 year	1.1

Observation

No method of interpolation of the creep coefficients is suggested specifically. As a general understanding the values can be linearly interpolated to get values corresponding to age at loading not considered in the data table.

As per SP:24-1983 (Explanatory Handbook to IS:456-1978)

Clause 5.2.5.1

Appropriate values of creep coefficient, for an age of loading different from that given in the code can be obtained by an interpolation, assuming that the creep coefficients decreases linearly with the logarithm of time in days.

Observation

A method of interpolation to obtain values of creep coefficients for age of loading not included in the data table has been established. This code also refers to reference 7 (CEB/FIP, 'international recommendations for the design and construction of concrete structures' 1970) for further detailed information on this topic.

As per IS:1343-1980 Clause 5.2.5.1

In absence of experimental data and detailed information on the effect of the variables, the ultimate creep strain may be estimated from the following values of creep coefficients.

Age at loading	creep coefficients
7 days	2.2
28 days	1.6
1 year	1.1

Clause 5.2.5.2

For calculation of deformation at some stage before the total creep is reached, it may be assumed that about **half the total creep takes place in the first month** after loading and that **three-quarters of the total creep takes place in first six months** after loading.

Observation

A method of interpretation of creep effect is suggested which is still different from the above mentioned codes.

As per IRC:18-2000 Clause 11.2

The strain due to creep of concrete shall be taken as specified in Table 2.

Maturity of concrete at the time of stressing as a % of fck	creep strain per 10mpa
40	9.4×10^{-4}
50	8.3×10^{-4}
60	7.2×10^{-4}

(Table not shown completely)

Observation

A creep effect definition is based on maturity of concrete and the present value of stress due to permanent effects at that time.

General Observation

The method of estimation of creep effects differ in different codes although all the codes are of Indian origin. The problem need immediate concern for clarity.

More over the term "Age at Loading " is misleading since it is not defined in any of the 'IS' series of codes properly. I understand that since it is applicable to long term deformations in RCC structures therefore it can not be the age at prestressing of concrete which is generally assumed.

REFERENCES

1. "Handbook of Concrete Engineering" Second Edition – Edited by: Mark Fintel
2. "Design Principles and Detailing of Concrete Structures" Edited by: D. S. Prakash Rao
3. "Reinforced Concrete Designer's Handbook" Tenth Edition –
   Edited by: Charles E. Reynolds and James C. Steedman
4. "Limit State Design of Reinforced Concrete" Tenth Print - Edited by: P. C. Varghese
5. "Design of Reinforced Concrete Structures" 2003 Reprint – Edited by: Ashok Kumar Gupta
6. IS 456: 2000 "Indian Standard Plain and Reinforced Concrete Code of Practice - (Fourth Revision)
7. SP-16 : 1980 "Design Aids for Reinforced Concrete to IS : 456 -1978"
8. IS: 875 (Part 2) -1987 "Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures – Part 2 Imposed Loads – (Second Revision).
9. SP-24: 1983 "Explanatory Handbook on Indian Standard Code of Practice for Plain and Reinforced Concrete (IS: 456-1978)" First Reprint 1985.
10. "Design of Reinforced Concrete Structures" Fourth Edition -
    Edited by: P. Dayaratnam.
11. "Construction Planning, Equipment, and Methods" Fifth Edition –
    Edited by: R. L. Peurifoy, P.E.
    W. B. Ledbetter, P. E.
    C. J. Schexnayder, P.E.
12. "Concrete Technology" International Student Edition – First ISE Reprint 1999 – Edited by: A. M. Neville and J. J. Brooks
13. "Design and Construction Failures (Lessons From Forensic Investigations)" First Published in India-2001 – Edited by: Dov Kaminetzky, M.S., P.E.
14. BS 8110: Part 1: 1985 "British Standard Structural Use of Concrete" Part 1. Code of Practice for Design and Construction.
15. BS 8110: Part 2: 1985 "British Standard Structural Use of Concrete" Part 2. Code of Practice for Special Circumstances.

16. Paper Presentation Reports of - fib Symposium 2004 on “Segmental Construction in Concrete” Organized by: The Institution of Engineers (India) Held on 26 November, 2004 at New Delhi, India.
17. IS 14215: 1994 “Indian Standard – Design And Construction Of Floors And Roofs With Precast Reinforced Concrete Channel Units – Code Of Practice”.
18. IS 6061 (part I) – 1971 “Indian Standard – Code Of Practice For Construction Of Floor And Roof With Construction Of Floor And Roof With Joists And Filler Blocks (Part I: With Hollow Concrete Filler Blocks)”.
19. IS 6061 (Part II) – 1981 “Indian Standard – Code Of Practice For Construction Of Floor And Roof With Construction Of Floor And Roof With Joists And Filler Blocks (Part Ii: With Hoolow Clay Filler Blocks)”.
20. IS 6061 (Part III) – 1981 “Indian Standard – Code Of Practice For Construction Of Floor And Roof With Construction Of Floor And Roof With Joists And Filler Blocks (Part Iii: With Precast Hollow Clay Block Joists And Hollow Clay Filler Blocks)”.
21. IS 6061 (Part IV) – 1981 “Indian Standard – Code Of Practice For Construction Of Floor And Roof With Construction Of Floor And Roof With Joists And Filler Blocks (Part Iv: With Precast Hollow Clay Block And Slab Panels)”.
22. IS 13990: 1994 “Indian Standard – Precast Reinforced Concrete Planks And Joists For Roofing And Flooring – Specification”.
23. IS14142: 1994 “Indian Standard – Design And Construction Of Floors And Roofs With Prefabricated Brick Panel – Code Of Practice”.
24. IS 13994-1994 “Indian Standard-Design And Construction Of Floor And Roof With Precast Reinforced Concrete Planks And Joists- Code Of Practice”.
25. IS 14201-1994 “Indian Standard-Precast Reinforced Concrete Channel Units For Construction Of Floors And Roofs- Specification”.
26. Web sites on cranes (Internet Info Media)
27. **Experience from Practical involvement in the DMRC line-3 Project as a member of Design Team for the Design and Planning of Launching System for Line-3 Project (Barakhamba to Dwarka Section).**