Design of Precast Structure Using ETABS Software

Precast Structure

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***Abstract*: This Paper 'Design of Precast Structure Using ETABS Software' presents the design of multi storey building. The main aim of this study is to analyze the behavior of the precast structure for the applied loads. For this assignment we are using the software that name is** ETABS it **is an engineering software that completes multi-story building analysis and design. Code based load prescriptions and analysis methods or solution techniques, all coordinate with the type of grid like geometry unique to this class of structure. Either Basic or advanced systems under static or dynamic conditions evaluated using ETABS. When we start any building construction first we make a plan using by Auto CAD software doing the installation of beams and columns, testing of the stability of the building. To analyze the project ETABS software has been modeled to analyze the project.**

***Keywords*: Precast, ETABS, AutoCAD, Design Software, Multistory building.**

INTRODUCTION

The conception of precast is also known as "prefabricated". When we plan for any type of high rise building construction in the 21st century, the first thing that comes to everyone's mind is how much time taking that completion. Precast is a construction product produced by casting concrete in a reusable mold or which is then cured in a controlled environment, transported to the construction site and lifted into place. Precast is also used in exterior and interior walls. In other words precast structure includes those component where the combination of structural components produced in plants in a economical location away from the building, and then transported to the site for assemble. These components are manufactured on plant based on mass production. The benefits of using precast concrete include quality assurance, increased time efficiency, enhanced construction safety, durability, reduced wastage, and neat working areas due to reduced clutter. Precast concrete is also resistant to fire and flooding and can be easily deconstructed. The way the whole world is battling the covid-19 pandemic, we need to adopt precast technology. Precast technology saves construction time and having quality assurance, cost effective, durability, and safe construction platform.

LITERATURE REVIEW

Abraham Warszawski, M. ASCE; Head, Building Research Station-Technion, I.I.T., Haifa, Israel 32000; and Visiting Prof., Carnegie-Mellon Univ., Pittsburgh, Precast concrete components can be used in building construction within a comprehensive "closed" system, and separate elements in combination with any building method. The feasibility of this possibility was inspected within the framework of a conventional structure system and the following alternatives of elements utilization: prestressed modular floor slabs, exterior walls, and a combination of slabs and exterior walls. **Gary L. Hendershot,**

Grange, Gregory, E. Cook, and United States Patent (19) 11 Patent Number: 6,076,319 Hendershot et al. PRECAST CONCRETE CONSTRUCTION AND CONSTRUCTION METHOD. Buildings and civil engineering works are generally con Structed from Wood, metal, masonry, concrete and combi nations of these materials. The materials used depend upon cost, availability, building conditions, Structural require ments and choice.

G. Metelli 1 and P. Riva 2 1 Assistant Professor, Dept. of Civil Engineering, Architecture, Land and Environment, University of Brescia, Italy In Italy, precast concrete structures are traditionally designed as moment resisting frames with plastic hinges occurring at the column base and beams hinged to the columns. Having ductlity moment resisting connection between the column and the beam can provide the advantage of designing a seismic resisting frame which can develop plastic hinges at the beam column joints, besides those at the column base. Main aim of this paper at presenting the results of experimental tests concerning the behaviour of a particular beam and column "dry" connection for precast concrete elements.

METHDOOGY

In Etabs 2013 as moment resisting frame Precast structure is analyzed. Structural components as shear walls, core walls, slab, and beams only considered in case of balcony exists their loads are also considered. Structure with G+ 7 storeys with lift is modelled. Precast structures have minimum C35 grade of concrete, all the component and properties or sections are given to the structure. Slabs are membrane elements in Etabs; that transfer load through one-way slab.
Structure after study and the section and material property is given in Table 1 to 3.
In the analyzing of building Assumptions considered are;

a) Considered Shear walls instead of columns with 1.8x0.2 m via structure.
b) Location of the building is in raipur chhattisgarh. All types of loads and geotechnical aspects are related.
c) Building having maximum loads at the ground floor therefore foundation and slab are made cast in-situ.
d) Water table is at 2 m below the earth foundation typr is raft foundation preferred for the structure.
e) It is restricted with 0.15 m width along with precast walls using space for residential room's beams.
f) Building is assuming commercial from ground floor to 2nd floor and residential from 3rd to 7th floors.
g) At 2 locations Core walls are provided their width is 0.25 m.
h) Podium drive way for heavy cranes which are constructed as an in-situ concrete. For entire structure Structural frame system is adopted.

Loads from solid slab is transferred to beam and then beam loads are transferred to continuous shear walls and again shear wall transfer to foundation.
Table 1 shows slab and wall properties, table 2 shows material properties for shear walls, columns and core walls. Table 3 define auto generated wind loads and Seismic loads.

Fig 1: Structural frame modelled in ETABS

Fig 2: Typical floor with loads

Table 1: Slab and Wall Properties

Section	Material Name	Type	Membrane Thickness (m)
W200	C40	Shell-Thin	0.2
Slab85	C35	Membrane	0.085
Slab80	C35	Membrane	0.08
Head room	C35	Membrane	0.15
Ret. Wall	C35	Shell-Thin	0.10
W250	C40	Shell-Thin	0.25
GF300	C35	Shell-Thin	0.3

Table 3: Wind	Seismic	
Direction Angle = 0 & 90degrees	R = 3	
Windward Cp	= 0.8	Z = 0.16
Leeward Cp	= 0.5	Soil Type = II
Exposure: Rigid diaphragm	I = 1.25.	

Table 2: Column and Beam Properties

Section	Material Name	Shape
C 250x600	C 35	Concrete Rectangular
GB 500x150	C 40	Concrete Rectangular
GB A 900x400	C 35	Concrete Rectangular
GB B 450x250	C 35	Concrete Rectangular
HB01	C 40	Concrete Rectangular
HB02	C 40	Concrete Rectangular
PB 600x150	C 40	Concrete Rectangular
PB 600x200	C 40	Concrete Rectangular
PB 600x250	C 40	Concrete Rectangular
PB 900X150	C 40	Concrete Rectangular
PST 600x150	C 40	Concrete Rectangular

Analysis: After analysis all balcony loads, wall loads are taken on the frame. All slabs taken in one way hence planks are hollow core units are simply supported. For the frame with all the loads imposed on the structure Analysis is done. All the loads are distributed to shear walls and core walls via floor frame action. Analysis results shown in Figure 5.

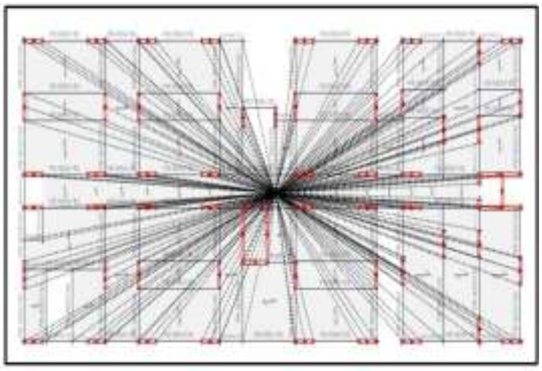


Fig 3: Rigid diaphragm for 1st floor

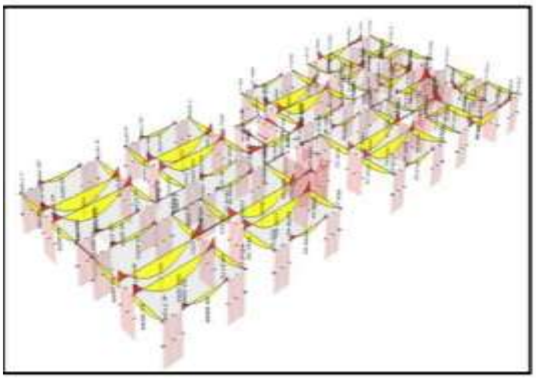


Fig 4: B.M diagram for a 5th floor plan.

RESULTS AND DISCUSSION

Slabs Design: Concrete slab planks is used as permanent formwork for in-situ. Performance of planks acts to cast in-situ construction. Precast planks are usually 75 mm to 120 mm thick it is based on the load carrying capacity. It can be Analysis and Design of G+7 storeyed precast structure designed by Prestressed or ordinary reinforced with minimum grade of C35 and C45. Steel provided on topping concrete which acts as negative reinforcement in case of continuous slabs. Only in case of one way slab these can be designed and for construction 1 m wide planks are used. During the installation stage, planks are designed as simply supported about 4 m to 6m for 75 mm and thickness 100 mm. if load is more and case of longer spans deflection is more props are suggested for temporary and permanent stage Design is done. At temporary stage the weight of wet concrete (topping) [at transfer] + Live loads. Live loads are considered as permanent loads designed for service. In case of permanent conditions hardened concrete providing the resistance for flexible and compressive resistance.

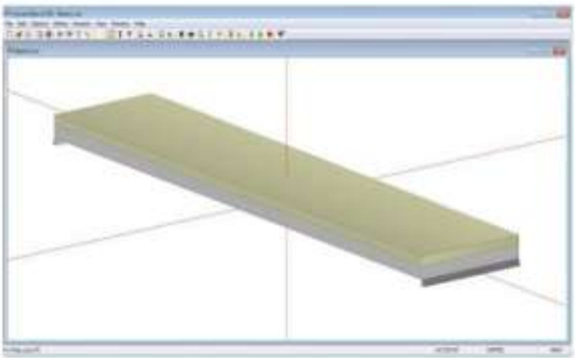


Fig 5: Precast slab plank in concise software.

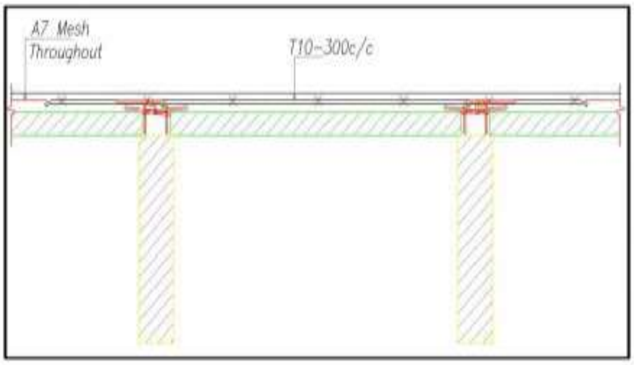


Fig 6: connection between planks for shear transfer.

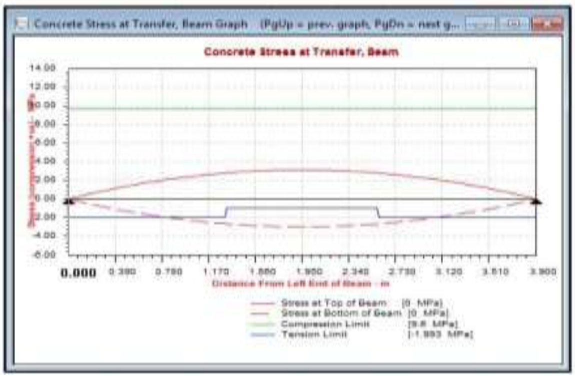


Fig 7: Concrete stresses at transfer.

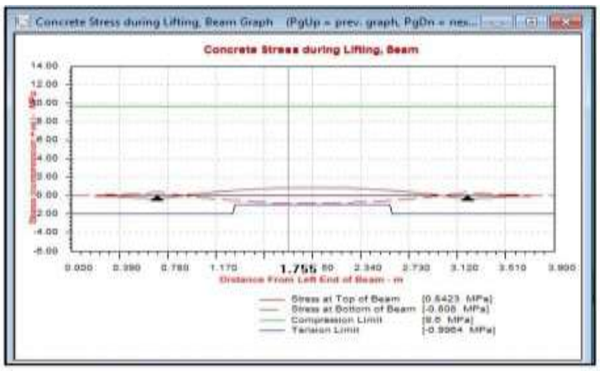


Fig 8: Concrete stresses during lifting

If deflection more than shoring is done, for negative Bending moment minimum reinforcement is provided in top of plank for lateral loads distribution Reinforcement from the plank will be blended. Topping nominal reinforcement of T 10 bars with 300 mm c/c is given.

Beams design: in precast structure beams are depend on section properties, construction methods, loads applied and beam behavior at serviceable limit state. Precast beams is designed by either complete, semi precast or shell sections based on the fabrication, joints, handling, and beams along with partition wall panels combination.

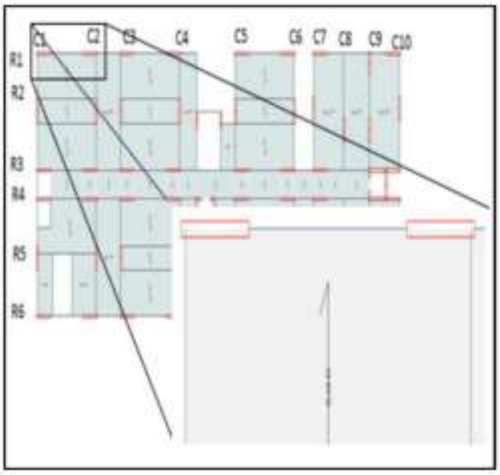


Fig 9: Connection between walls and beams.

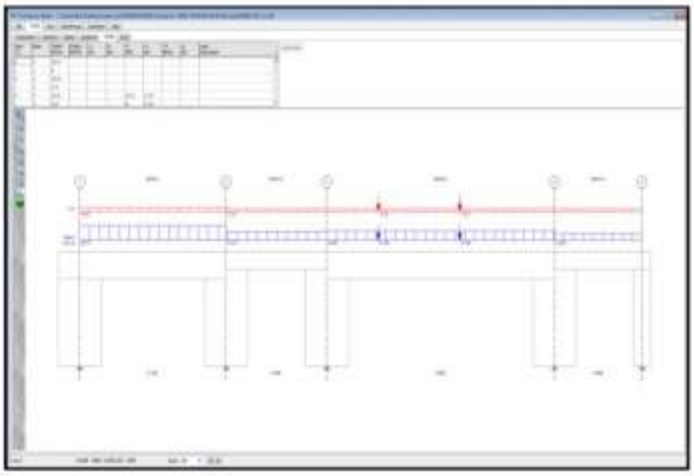


Fig 10: Loads taken in continuous frame

In Etabs design beams are connected to the exterior points of shear wall there won't be distribution of loads through walls. Therefore beams are designed by using different software, individually designing through grouping of continuous beams while designing of continuous beams in prokon software rows and columns are considered. For lateral load resistance the maximum of EQ. Wind Load in X and Y directions are considered and maximum fixed moments are taken. In Continuous beams they are designed by grouping in columns and rows; all the loads like floors constitute self-weight, imposed loads taken as uniform load. Secondary beams having self-weight and imposed loads is taken as point loads.

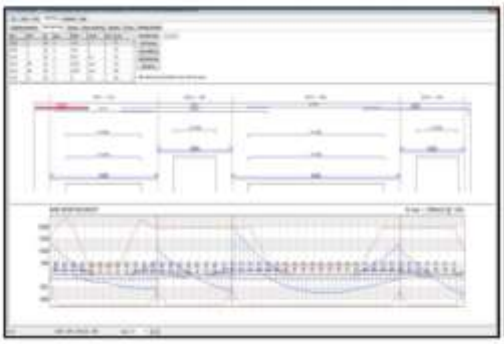


Fig 11: Design of beam for flexure.

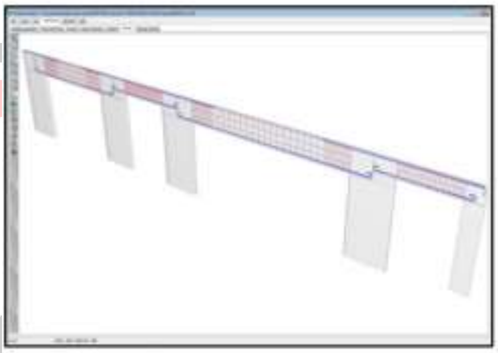


Fig 12: Reinforcement details of beam

Foundation: As per geotech study that water table is at 2 m below the earth and parking area is require raft foundation. Raft foundation is designing in Safe software. Material propertirs for foundation is C35, E=27000, u=0.2, steel Fe 500. Mat foundation with 350 mm thick is assuming and for precast storeys 900 mm is assumed. Soil sub grade are 2,50,000 kN/m³. Forces from top of the Precast and in-situ slab are given at their nodes this can be done by importing base from Etabs model. A countineously Live load 5 and 2.5 is considered for drive way and parking. Depth of slab, spreading area of 1.5 m on either sides and 1 m on top & bottom. Loads on slab like LL and water table pressure are given. For raft design gave strip layers in X and Y direction with 1 m width. Design the raft for bottom and top reinforcement bars with spacing. Designing strip layers B and A for shear and flexure. Checking is possible for reinforcement and increase if necessary. Providing additional reinforcement for punching shear if exceeds 1.

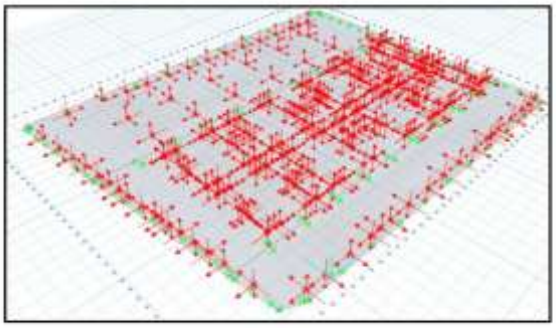


Fig 13: Forces taken for foundation design in Safe

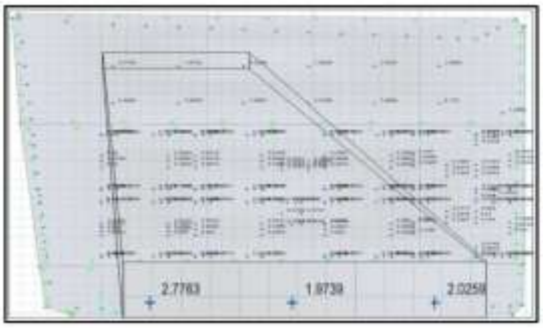
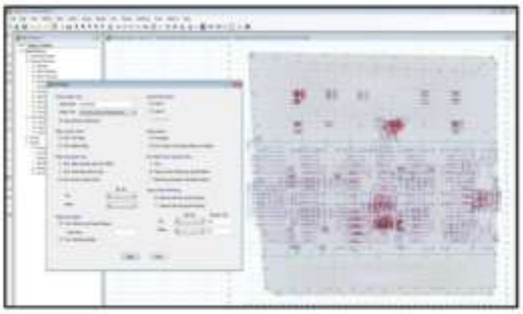


Fig 14: Punching shear values for the raft.



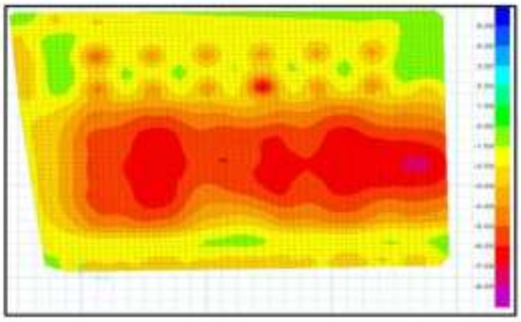


Fig 15: Slab design for reinforcement in strips	**Fig 16: Slab deflection under SLS load combination**

Shear wall Design: Design of precast columns is same as in-situ columns. Design of connections is decides the column design. While connecting the col-col, col-beam and col-foundation Dirrerent different connection methods are taken into consideration, accordingly reinforcement is placed in the column. Shear walls are taken in the building Instead of columns. Shear walls is discrete where beams are connecting to have load distribution. Therefore when coming to results these walls that having different forces hence pier is assigned to have unique identification and unique forces for the wall. Precast shear walls provide huge in plane stiffness and strength. Ultimate wind forces of the building are transferred by diaphragm action of the floor to the stability walls. Additional vertical tie reinforcement is to be modeling for the shear walls.

Precast Connections: modeling for precast connections is a challenge for the structure because the core wall has 250 mm width. Accommodation the connections at different joints like interior joints with four beams, exterior joints with 1 or 2 beams connecting. Connection between wall to wall and wall to beam to carry adequate moment and on the joint to resist horizontal shear and vertical shear coming from gravity and lateral loads. Loop bars and Cottering bars are provided to cast in place concrete at the joint. Cottering bars connect to loop bars with the shear wall and beam. on some locations topping bars are bent into the wall reinforcement having additional moment transfer from the beams. Fig 18 shows external wall to beam joint. Loop bars are take it at the bottom of beam and topping bars are bent to take negative moments. External joints are at the rear end of building posted in X direction hence lateral moment at the joint governs the design. The joint is critical hence moment at this joint due to gravity loads and lateral loads are higher; hence two loop bars are bent in Y direction to take in connection with cottering bars to resist the lateral loads at wall axis. Fig 19 shows the interior joint where two beams are joining. The topping bar reinforcement continuously into the next beam and that type of bar takes care of negative moment and as internal tie which has the capacity of Analysis and Design of a G+7 storeyed Precast Building Civil Engineering Systems and Sustainable Innovations ISBN: 978-93-83083-78-7 147 resisting 60 KN against progressive collapse. Bearing of 20 mm is provided. 10 mm bars are providing on both sides of beam connecting to loop bars, also at the edge of the beam to resist bearing and shear failure at the joint. Fig 20 is shows the typical internal joint where it has to resist a moment of 242 kN-m of lateral load or 93.5 kN-m due to gravity loads. Since cottering bars of 20 mm dia are provided to that protrudes from column and connecting to the loop bars from beams and peripheral bars coming in the joint. Moment of resistance is adequate for connecting the beams and lateral loads are distributed in diaphragm action.

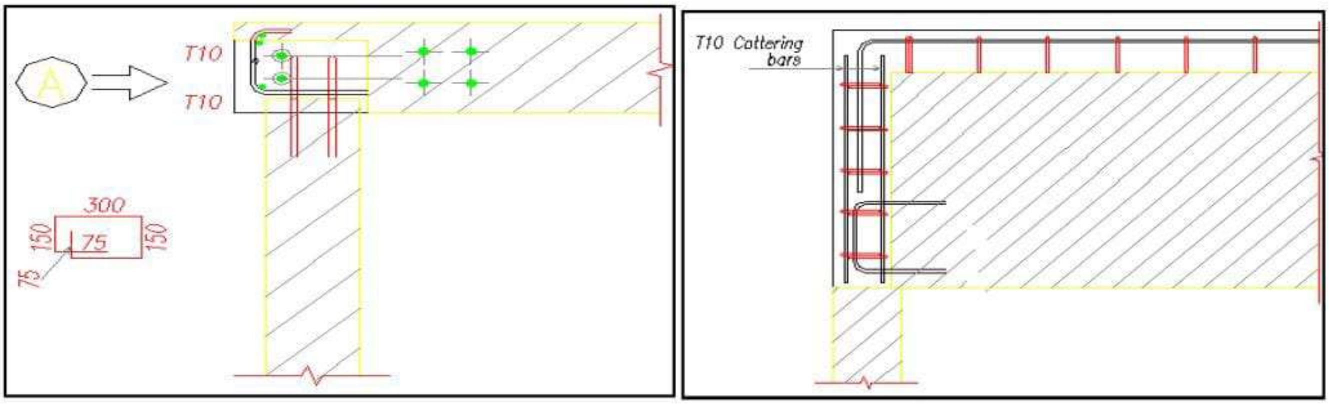


Fig 17: Exterior wall beam connections with cottering bars and topping bars connection.

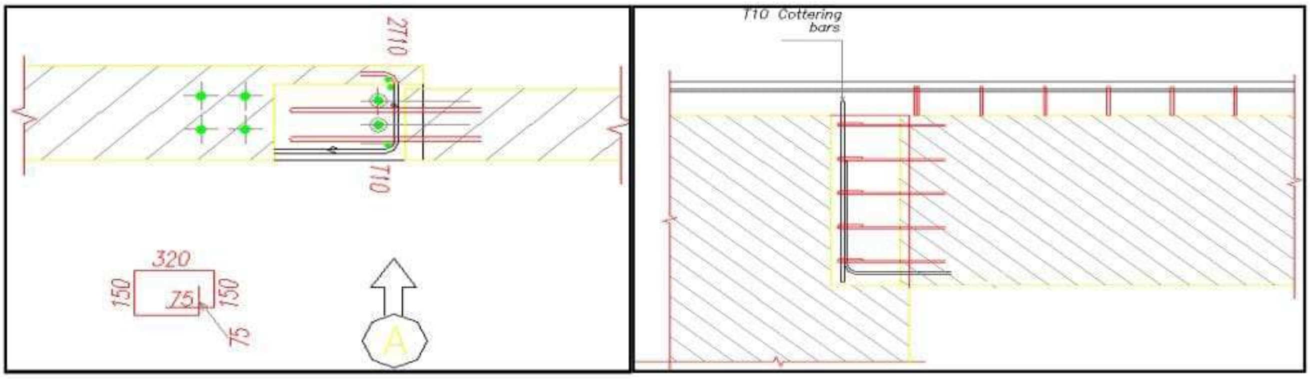


Fig 18: Detailing Interior wall to beam connection having loop bars with cottering bars.

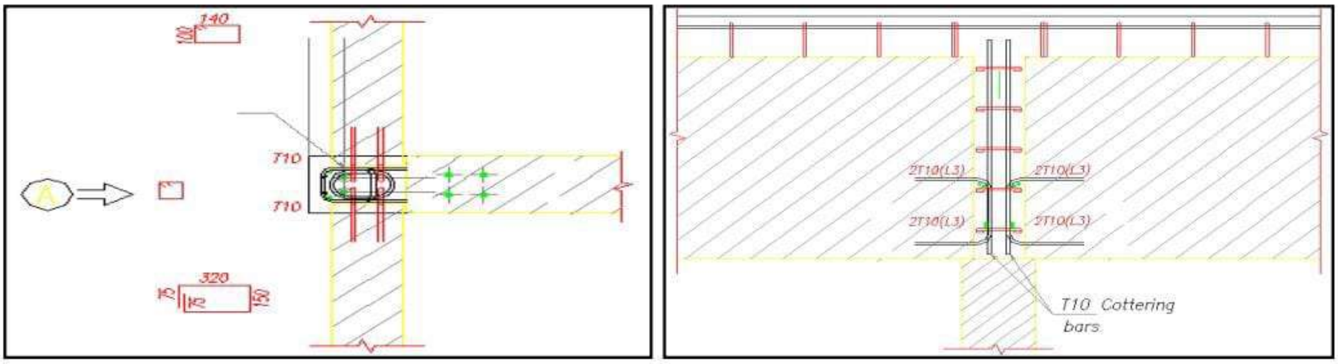


Fig 19: Typical Connection details

CONCLUSION

Precast buildings having challenges in modelling of elements, coordinates to meet the requirement. Connection details are most challenging for the cramped in their sizes. Design of multistorys building is done for the precast planks in concise beam, it is most compulsory of shoring for the 5 m spanning slab plank hence deflection criteria control the design. Beams are semi-precast and individually designed by considering transverse reinforcement for 900 mm depth. For pier forces Shear walls are designed. Foundation should be rafted as the water table is at 2m depth which bring to bear pressure on the slab. Connection details are put up for 900 mm deep beam in the combination of 200 mm shear wall with cottering bars, loop bars to counter the lateral and gravity moment by offering resistance to the design moment. Since the entire structure is designed for lateral and gravity loads.

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