G+7 Storeyed Prefabrication Structure Design and Implementation

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Abstract- This study explains how to analyse and design precast buildings. Precast buildings react differently from cast-in-place structures. The primary goal of this research is to examine and record the behavior of precast structures under gravity and lateral stresses. For this reason, a reference project in Chennai is adopted and modelled in ETABS software to evaluate the structure. Individual precast parts, such as slab planks in Concise beam software, foundations in Safe software, and beams and columns in CSI detail, are designed separately. Assumptions are made in relation to a certain structure.

Keywords- Slab plank, Etabs, Concise, safe, CSI detail etc.

I. INTRODUCTION

- The concept of precast (also known as "prefabricated") construction includes those structures where the majority of structural components are standardized and produced in plants in a location away from the building, and then transported to the site for assembly.
- Components are manufactured by industrial methods based on mass production.
- Entire conventional construction process is to enable interaction between the design phase and production planning in order to improve and speed up the construction.
- Precast structures are sound in construction practices due to there are no restrictions on the use of skeletal framed or irregular shaped or Architectural challenging designs are more suitable for precasting.
- For Precast structures there must be conscious effort to ensure the structural continuity such as slabs, beams and columns are connected effectively.
- The overall behaviour of precast structure depends on all design forces, ductility to deformations and load distribution.
- Load distribution can be determined through structural stiffness or rigidity.
- The design, construction and performance of precast concrete structures are greatly influenced by behavior of connections between the elements.

• All structural elements forms stable structural system after the joints is connected.

II. OBJECTIVES

- To analyze and design the structure using **ETABS** software.
- To analyze individually for each precast elements like slab planks in **Concise beam** software, Foundation in **Safe** software.
- To do the detailing of beams and columns in CSI detail.

III. LITERATURE REVIEW

Nakaki (1999) - explains the experimental and analytical studies of ductile connection precast elements for frame and wall structures, a distinct 5 storeyed frame is considered for analysis. He suggested that the strong-connection in precast structures emulates monolithic reinforced concrete construction.

Habibullah (2007) - has worked on physical object-based analysis and design modeling of shear wall system using Etabs.

Capozzi et al (2008) - conducted experimental tests on beamcolumn connections of precast buildings. Both monotonic and cyclic load paths are programmed; the former ones are performed until the ultimate displacement using cyclic tests.

Patrick et al (2011) - reviewed the most appropriate type of beam-column connections to be introduced to precast concrete industry, particularly for regions of low to moderate seismicity.

Gopinathan and Subramanian (2013) - analysed the G+5 storeyed frame subjecting to lateral loading with strong connections by specially designed bolts and L angles gives that Precast structure reaches nearly the ultimate load of control frame and variation is small.

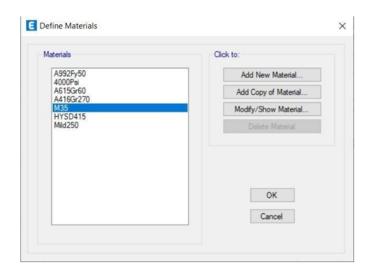
Chaitanya Kumar and Lute Venkat (2013) - analyzed G+11 storey residential building with precast reinforced concrete load bearing walls. The structural system consists of load bearing walls and one-way slabs for gravity and lateral loads have been taken for analysis using ETABS.

IV. METHODOLOGY



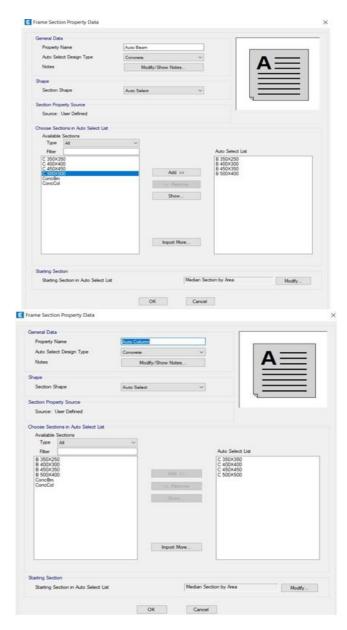
MODELLING

- First the materials in the structural members are defined.
- The grade of concrete is taken as M35.
- HYSD415 (For Longitudinal Rebar) and Mild250(For Tie Rebar) are taken.

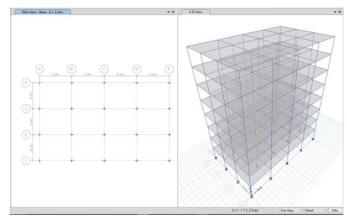


MODELLING

• For beam and column properties auto select option is selected.



3D MODEL IN ETABS

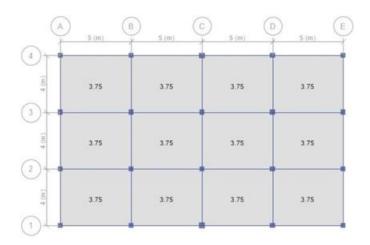


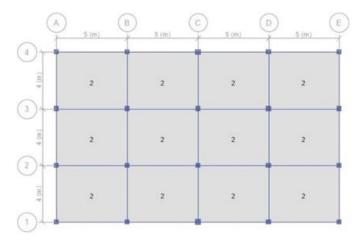
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Utility of building: Residential building. Shape of the building: Rectangular. No of storeys: G+7. Total length of the building is 20 m. Total Width is 12 m. Total height is 24 m. Floor height: 3 m. Total Built up area is 240 m²

LOAD APPLIED

Dead load = 3.75 kN/m^2 Live load = 2 kN/m^2 Wind load Seismic load





WIND LOAD

Exposure and Pressure Coefficients		Wind Coefficients	
Exposure from Extents of Diaphragms		Wind Speed, Vb (m/s)	50
Exposure from Shell Objects		Terrain Category	3 ~
		Importance Factor	1.00 ~
Wind Exposure Parameters		Risk Coefficient (k1 Factor)	1
Wind Directions and Exposure Widths	Modify/Show	Topography (k3 Factor)	1
Windward Coefficient, Cp	0.8	Exposure Height	
Leeward Coefficient, Cp	0.5	Top Story	Story8 ~
		Bottom Story	Base ~
		Include Parapet	
		Parapet Height	

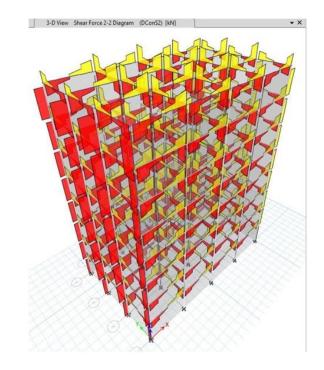
As the Location is Chennai So, wind speed is 50 m/s.

SEISMIC LOAD

Direction and Eccentricity X Dir	🗹 Y Dir	Seismic Coefficients Seismic Zone Factor, Z		
X Dir + Eccentricity	Y Dir + Eccentricity	Per Code	0.16	~
X Dir - Eccentricity	Y Dir - Eccentricity	O User Defined		
Ecc. Ratio (All Diaph.)		-		
	the second se	Site Type	11	~
Overwrite Eccentricities	Overwrite	Importance Factor, I	1	
Story Range		Time Period		
Top Story	Story8	Approximate O (m)	-	
Bottom Story	Base	Program Calculated		
	Reference of	O User Defined	*	50

As the Location is Chennai So, seismic zone is 3.

ANALYSIS



1	Story	Beam	Output case	V2 (KN)
2	Story1	B9	DConS9	46.5608
3	Story1	B8	DConS9	44.304
4	Story1	B7	DConS2	43.2052
5	Story1	B6	DConS9	42.8991
6	Story1	B5	DConS2	42.6637
7	Story1	B4	DConS2	41.5207

• ×

1	Story	Beam	Output case	M3 (kNm)
2	Story1	B9	DConS10	-35.0767
3	Story1	B8	DConS9	-34.9897
4	Story1	B6	DConS11	-33.3151
5	Story1	B7	DConS11	-32.5696
6	Story1	B5	DConS11	-32.3713
7	Story1	B4	DConS14	-27.4814

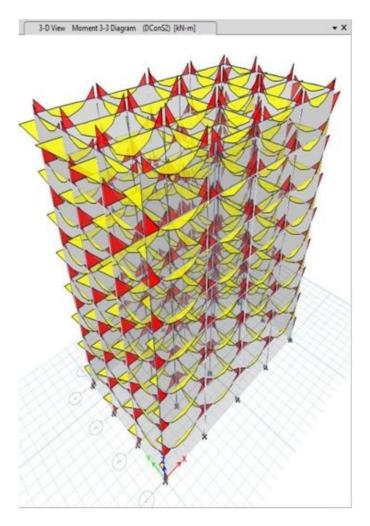
After the Analysis, this is the maximum shear force diagram we got, this are the maximum shear forces and the maximum shear force is 46.56 kN, that is on Beam 9 of storey 1.

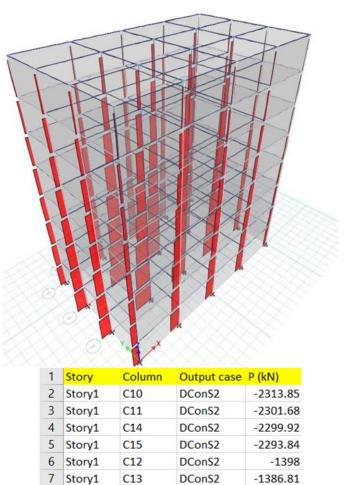
This is the Bending Moment diagram, we got after the analysis and this are the maximum bending moments.

ANALYSIS

3-D View Axial Force Diagram (DConS2) [kN]

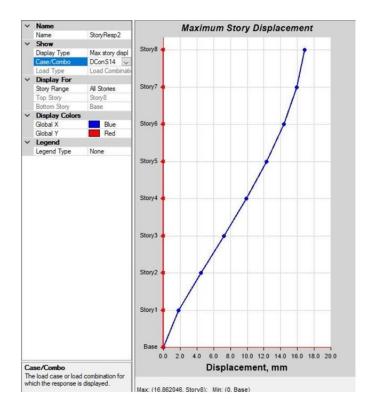
ANALYSIS



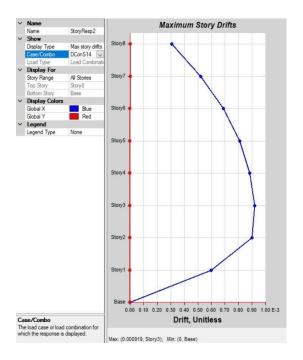


This is the Axial force diagram and this are the maximum axial force, the maximum axial force is -2313.85 kN that is on Column 10 of storey 1.

MAXIMUM STOREY DISPLACEMENT

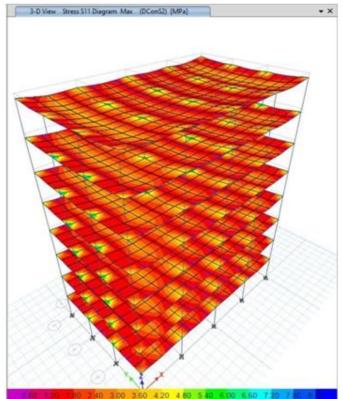


Maximum storey displacement is experienced on the topmost storey 8 and the maximum displacement we got is 16.8 mm.

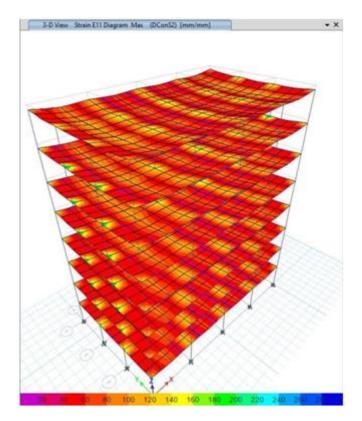


Maximum storey drift is experienced on storey 3 that is 0.000919, as per IS 1893, storey drift shall not exceed 0.004 times of storey height and our case storey height is 3 m, which gives the limit of 0.012 and the maximum storey drift is under the limit. So, it is safe.

MAXIMUM SHELL STRESS & STRAIN



The Maximum principle shell stress value recorded is 6 MPa.

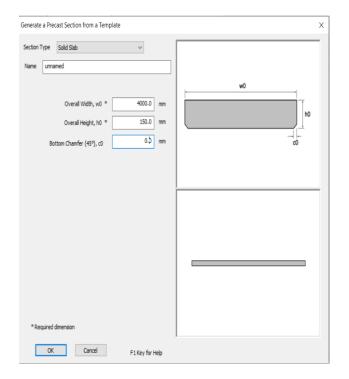


The Maximum principle shell strain value recorded is 200.

PRECAST SOLID SLAB ANALYSIS USING CONCISE BEAM SOFTWARE

Prestress Loss Cal	culation Met	hod	Concrete Parame	eters		Construction Schedule		
ACI 209 Detaile	ed Method (CPCI)	Slump	50	m	Precast Concrete is Placed	i at day 0.	
PCI Simplified M AS3600 Method			Cement	410	kg/m^3	Transfer/Stripping	0.75	days
S6 Simplified Mr	ethod		Air	5	5	Inital Lift	0.75	days
Predefined Losses			Fine/Total Aggregate	0.4]	Transport/Erection Lift	40	days
nitital Losses	18 9	ç I	Aggregate Size	20	mm	Cast-in-Place Pour	50	days
Total Losses	21 9		Basic Shrinkage Strain	780	×10 -6			
Vary Losses Alc	ing Beam		Service Environm		1.0	Composite Action	53	days days
Curing Method			Relative Humidit	·	1000			
Moist Cured			Ambient Temp.	20				
⊖ Heat Cured Ø.	e. Steam)		Exposure	Interior	Y			
e					e			
Save a	ie Settings a	is Dera	Kes	tore the Default	settings	Restore to the Factor	y settings	11
Go To Next	Define Pr	estres	sing Specify C	oncrete				
	Define Pr			tore the Default	Settings	Restore to the Factor	y Settings	

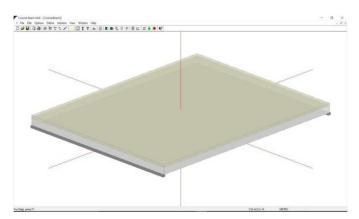
SLAB DIMENSION



opping/Slab Thickness, t1								
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ppingrado micalicada ca	50	m						
opping/Slab Width, b1	400þ	mm						
opping/Slab Lateral Offset (±), z1	0	m			4000	mm		
aunch Height (±), t2	0	mm		+	4000	1		
aunch Width, b2	0	mm		_				T
aunch Lateral Offset (±), z2	0	mm						T ²⁰⁰
ertical Offset (±), y *	0	m						
idth of Composite Interface	4000	nn						
ffset of Composite Interface (±)	0	mm						
* from top of precast beam								
			Add/Modify	Clear				
in Place Pour Segment List						Transa and	STOLEN I	
Beam Segment *	1	11 (mm)	b1 (mm)	z1 (mm)	t2 (mm)	b2 (mm)	z2 (mm)	y (mm)
unnamed		0	0	0	0	0	0	0
* user-defined segments it in Place Pour Options Too hot Include Cast in Place Pour			m segments will be -in-Place Pour Is No		ected in the cast	-	appropriate. Shoring Options	1
Account for Torsion due to Offsets		-	of Precast is Consid		Roughened		anoring options	8
To Next	-							
Define Loading	Define	Rebar	Define P	restressing				

Width of the slab is 4m. Overall height is 0.15m. Length of the slab is 5m.

SLAB 3D VIEW

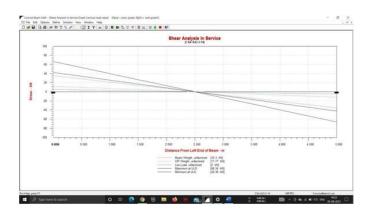


LOAD ASSIGN ON THE SLAB

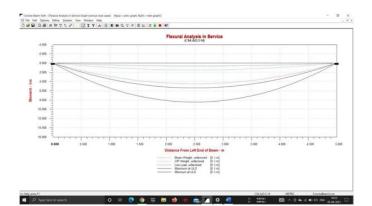
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oad Group Details										
Load Group Label		Pirst Stag	pe Load Group is Apply	ed	Load Form			Left	Right	
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LL, General		Final Ser	nice	~	Segment #0	Ecor	entricity	0	0	*
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Loads in Group a		Transito	ry .	· •	* downward gravity loads a	re positive				
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io To Next		nam based on	model (cannot be edi			Rodify Current Load Gro	up with Loa	da in Group (hanges	>

Live load is given as 2 kN/m^2 The software is calculating the beam self-weight.

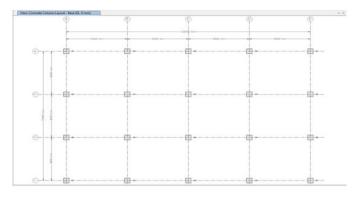
SHEAR ANALYSIS



FLEXURAL ANALYSIS



COLUMN LAYOUT



This is the column layout, spacing between the column is 5 m in x-direction, and 4 m in y direction.

MATERIAL QUANTITY OF COLUMN

SR. NO.	ITEM	QUANTITY	UNIT
1	TOTAL VOLUME, V	174.960	CU M
2	TOTAL REBARS WEIGHT, W	38,750	KG
3	REBARS RATIO, W/V	221.4784	KGICU M

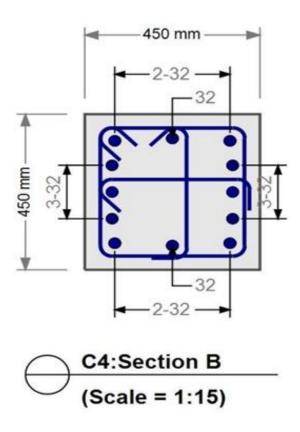
REBAR USED

REBAR QUANTITIES: CONCRETE COLUMN

SR. NO.	BAR SIZE	LENGTH (M)	WEIGHT (KG)
1	10	17,726.5	10,992
2	16	5,184.0	8,179
3	18	648.0	1,297
4	20	900.0	2,218
5	22	648.0	1,933
6	25	1,296.0	4,995
7	28	1,044.0	5,048
8	32	648.0	4,089

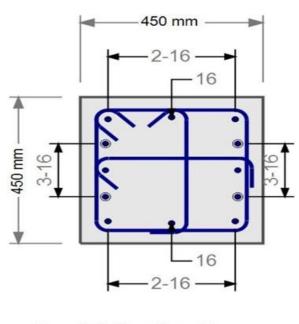
These are the Bar used, Maximum size of the bar is 32 mm, and the total length of bar used is 648 m.

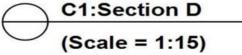
MAXIMUM REINFORCED COLUMN



This is the critical column where the column experienced the maximum force, 12 numbers of 32 mm dia bars are used, the stirrups is of 10 mm dia, at the corner the spacing of stirrups is 100 mm, and at the middle it is 150 mm.

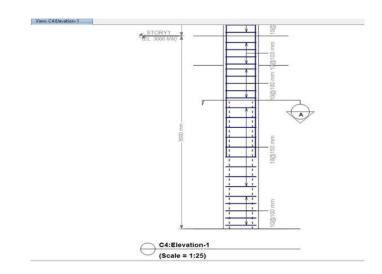
MINIMUM REINFORCED COLUMN





This is the minimum reinforced column when compare to all others column, 12 numbers of 16 mm dia bars are used, the stirrups are of 10 mm dia, at the corner the spacing of stirrups is 100 mm, and at the middle it is 150 mm.

COLUMN ELEVATION



This is the column elevation for C4 column 1st storey.

MATERIAL QUANTITY OF BEAM

SR. NO.	ITEM	QUANTITY	UNIT
1	TOTAL VOLUME, V	166.250	CU M
2	TOTAL REBARS WEIGHT, W	28,099	KG
3	REBARS RATIO, W/V	169.0178	KGICU M

REBAR QUANTITIES

REBAR QUANTITIES: CONCRETE BEAMS

SR. NO.	BAR SIZE	LENGTH (M)	WEIGHT (KG)
1	10	19,815.9	12,287
2	14	4,684.9	5,663
3	16	3,018.0	4,761
4	18	864.3	1,730
5	20	1,484.1	3,658

These are the Bar used, Maximum size of the bar is 20 mm, and the total length of bar used is 1484.1 m.

REINFOREMENT DETAILING OF BEAM

?

kN/m3

×

(1)	
	Soil Subgrade Property Data
2.204-2.148	General Data
• 335 mm	Property Name SOIL1
10@75 mm	
2.16 ²	Display Color Change
	Property Notes Modify/Show Notes
182:Section A	Property
(Scale = 1:16)	Subgrade Modulus (Compression Only) 2E+04
CMBER PROPERTY	Nonlinear Option (Nonlinear Cases Only)
	O None (Linear)
ilab Property Data ? 🗙	O Tension Only
	Compression Only
General Data	O Basto-Plastic
Property Name Mat	
Slab Material M30 🗸	Compression Stiffness
Display Color Change	Compression Strength
Property Notes Modify/Show	Tension Stiffness
nalysis Property Data	Tension Strength
Type Mat ~	
hickness 200 mm	OK Cancel
Thick Plate Otthotropic	= <u></u>
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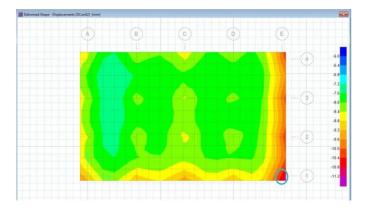
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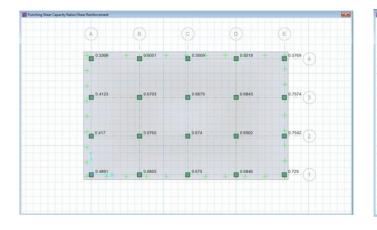
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DISPLACEMENT OF THE FOUNDATION



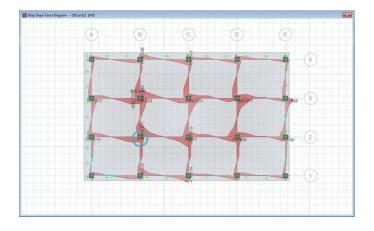
Maximum displacement is 10.74 mm this is within the permissible limit (75mm) so it is save.



All the punching shear capacity are below 1. So, it is save.

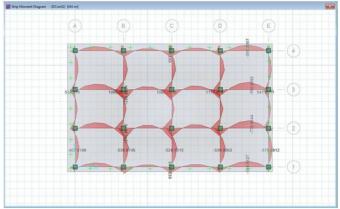
STRIP SHEAR FORCE DIAGRAM

PUNCHING SHEAR CAPACITY



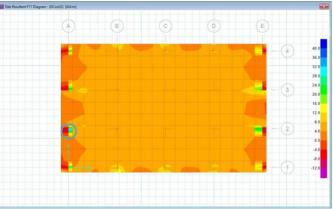
The maximum strip shear force is 2665 kN.

STRIP MOMENT DIAGRAM



The maximum strip moment is 1240 kNm.

RESULTANT STRESS



The maximum resultant stress is 32 GPa.

V. CONCLUSION

The Analysis and design methodology of precast building is different in comparison of cast in place building systems.

After analysing the G+7 storey building structure, concluded that structure is safe in loading like dead load, live load, wind load and seismic load.

All precast elements are designed considering forces during handling in addition to forces due to gravity load and lateral loading.

Member dimensions (Beam, Column, Slab, Footing) are changed by calculating the load type and its quantity applied on it.

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The results give min. diameter of bars, thickness of slab and same for column, footing.

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