Effectiveness of Precast Beam Column Junction Over Conventional Beam Column Junction

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Abstract- *Precast constructions are now days generally adopted in various residential and commercial projects. In this paper the RCC beam column junction is compared with precast beam column load. Initially beam-column junctions are analyzed for static linear point load which increases with time. The analysis is done by FEM tool ANSYS workbench. The stress-strain curve, load-deflection curve, normal stress and strains are compared for RCC and Precast models. In later stage time history analysis is proposed for various zones for same models. A new precast concrete beam-to- column connection for moment-resisting frames is developed in this study.*

Keywords- Precast, beam-column junction, ANSYS..

I. INTRODUCTION

High storey precast frame panel buildings performed poorly in the 1988 Spitak, Armenia earthquake due the lack of adequate seismic design considerations such as ductility in precast joints (Hadjian, 1993) [1] . A significant number of parking structures suffered extensive damage and a number of precast concrete parking structures collapsed in the 1994, Northridge earthquake. One of the reasons for the collapse was lack of proper diaphragm connections (Mitchell et al., 1995) [2]. The lessons learnt from the past earthquakes are that the connections are the weakest link. Hence more research is required in the study of connections. Many constructions are located in areas recognized to be exposed to seismic risk after erection, so that the original design takes into account only gravity loads, without any consideration of lateral loads due to earthquake [3].

Development of specific procedures for the estimation of seismic vulnerability of existing precast structures represents a key step not only when relevant structures are concerned, but also when rehabilitation and functional re-planning of large urban areas have to be carried out [4]. From a technical point of view, problems related to rehabilitation and seismic upgrading of existing precast buildings are different; first of all, aspects related to non-destructive techniques are involved for what concerns the definition of mechanical and geometrical properties of members and also of the degradation of base materials; another important point is the assessment of reinforcement (prestressing tendons, deformed and smooth rebars) [5]. Many constructions are located in areas recognized to be exposed to seismic risk after erection, so that the original design takes into account only gravity loads, without any consideration of lateral loads due to earthquake [6].

The seismic safety of precast structural systems represents a subject for investigation which is very much of a current interest worldwide [7]. In many structures, some of the structural elements are designed as seismically resistant, whereat the remaining ones sustain only gravitational loads inappropriate floor structures that don't have the capacity to transfer inertial forces to the seismically resistant vertical elements [8]. Predominant type of the precast (industrial) building in Europe consists of columns tied together with beams. Among many types of different connections between precast elements, the connection using steel dowel is most common [9] .The existing analytical and experimental investigations as well as the experience gathered from the occurred earthquakes are not sufficient enough for throwing light on their seismic behavior [10] .The following figure.1 represents general precast beam model.

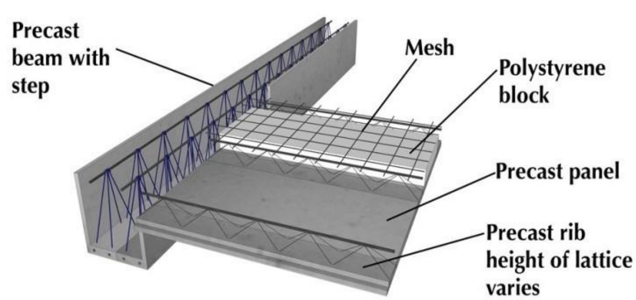


Figure 1 Precast Beam

II. SYSTEM DEVELOPMENT

2.1Methodology:

1. Collection of Data

a. Study of Time History

Time history analysis is the study of the dynamic response of the structure at every addition of time, when its base is exposed to a particular ground motion.

2. Study of Connections

a. RCC Beam Column Connection
A conventional RCC beam column is considered for the purpose of modeling which is then compared with precast beam column connections.

b. Precast Beam Column Connection
Three precast beam column connections are modeled and then results are compared with conventional RCC beam column connection.

3. Software Modeling

a. Building modeling and analysis in Staad Pro.
A G+9 RCC Commercial building is taken into consideration for analysis and design purpose in staad pro.

b. Modeling of Beam column connection in ANSYS.
The Maximum BM beam column junction is modeled in ANSYS.

4. Result and Conclusion

As a consequence of the analysis, the results obtained from the models in ANSYS are shown in tables and graphs.

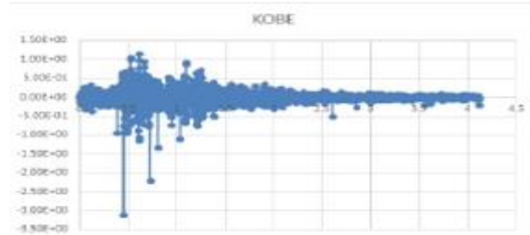
2.2 Response Spectrum Method:

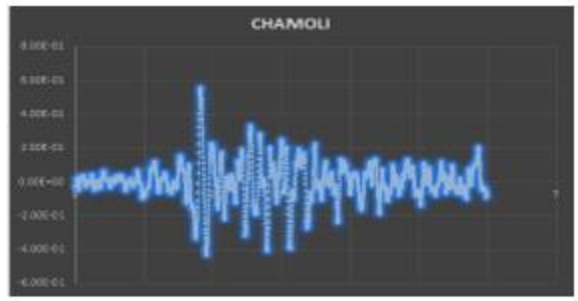
Response spectrum analysis is a procedure for computing the statistical maximum response of a structure to a base excitation. Spectra which determine the base acceleration applied to each mode according to its period (the number of seconds required for a cycle of vibration).Response spectrum analysis produces a set of results for each earthquake load case which is really in the nature of an envelope. It is apparent from the calculation, that all results will be absolute values - they are all positive. Each value represents the maximum absolute value of displacement, moment, shear, etc. that is likely to occur during the event which corresponds to the input response spectrum.

The definition of the proposed numerical model was made by using finite elements available in the ANSYS code default library.

2.3 Time History Data (e.g. of earthquake measuring in time history analysis):

Time history data of Kobe (Japan, 1995) and Chamoli (Uttarakhand, 1999) is shown in the graphs. The time history data of highest magnitude is taken for analysis in Ansys.





3. MODELING AND ANALYSIS OF MODELS:

3.1 Problem statement:

A G+9 RCC Commercial building is considered for analysis and design purpose in staad pro the details of the building considered are as follows:

Plan dimensions: 12 m x 12 m Location considered: Zone-III Soil Type considered: Hard Strata. General Data of Building:

- Grade of concrete: M 25
- Grade of steel considered: Fe 500
- Live load on roof: 2 KN/m2
- Live load on floors: 4 KN/m2
- Roof finish: 1.0 KN/m2
- Floor finish: 1.0 KN/m2
- Brick wall in longitudinal direction: 200 mm thick
- Brick wall in transverse direction: 140 mm thick
- Beam in longitudinal direction: 230X350 mm
- Column size: 300X750 mm
- Density of concrete: 25 KN/m3
- Density of brick wall including plaster: 20 KN/m3
- Plinth beam: 230X350 mm

Total of 4 models are analyzed in ANSYS:

Figure 3.4.1 is conventional RCC model, Figure 3.4.2 is precast model no. 1, Figure 3.4.3 is precast model no. 2, and Figure 3.4.4 is precast model no. 4.

3.2 Material properties:

Sr.No.	Material	Property	Value
1	Structural steel	Yield stress f_{sy}(MPa)	265
		Ultimate strength f_{su}(MPa)	500
		Young's modulus *Es*(MPa)	205×10^{3}
		Poisson's ratio µ	0.3
		Ultimate tensile strain et	0.25
3	Concrete	Compressive strength f_{sc}(MPa)	25
		Tensile strength f_{sy}(MPa)	3.5
		Young's modulus E_c(MPa)	32920
		Poisson's ratio µ	0.15
		Grade of concrete	M25

3.3 Analysis of model:

The analysis results of the G+9 RCC Commercial Building in StaadPro is shown in the figure4.3.1. The highlighted lines in the model shows the columns and beams with highest beam end forces. The beams with highest beam end forces are shown in Table 3.3.1.

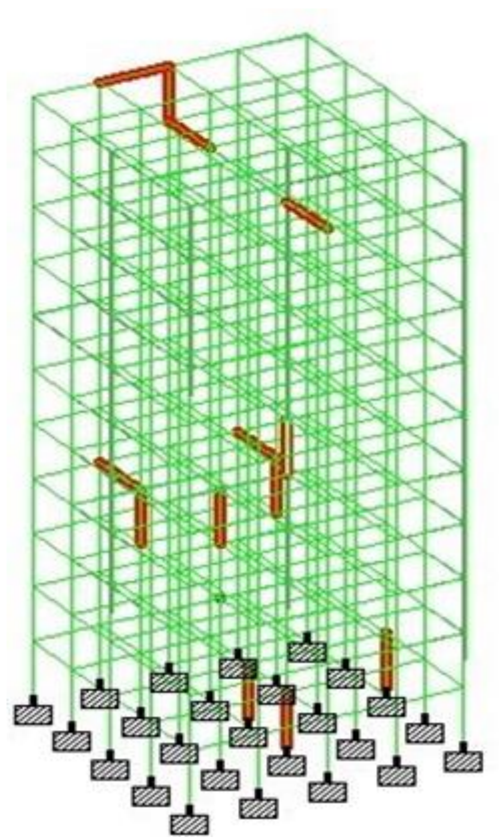


Figure 3.3.1Beams with highest beam end forces

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	289	7 DLLL	143	**2489.316**	0.000	-0.000	0.000	-0.000	0.000
Min Fx	291	2 EQ-X	145	**-156.035**	-13.317	0.000	-0.000	-0.000	-25.599
Max Fy	633	7 DLLL	53	-0.928	**55.683**	-0.000	0.000	0.000	40.543
Min Fy	828	7 DLLL	333	-0.928	**-55.683**	0.000	-0.000	0.000	40.543
Max Fz	105	7 DLLL	53	130.492	0.000	**26.883**	0.000	-34.199	0.000
Min Fz	425	10 DLEQZ	232	1113.860	-4.186	**-35.714**	-0.000	52.532	-6.084
Max Mx	602	9 DLEQ-X	22	-0.128	32.014	-0.000	**0.329**	0.001	19.826
Min Mx	604	8 DLEQX	24	-0.128	32.014	0.000	**-0.329**	-0.001	19.826
Max My	406	10 DLEQZ	213	1824.073	0.000	-27.339	-0.000	**69.948**	0.000
Min My	431	10 DLEQZ	243	965.172	0.000	-34.998	-0.000	**-54.677**	-0.000
Max Mz	186	9 DLEQ-X	92	1247.382	-32.169	5.239	-0.000	8.199	**48.422**
Min Mz	188	8 DLEQX	94	1247.382	32.169	5.239	0.000	8.199	**-48.422**

Table 3.3.1 Beams with highest beam end forces.

Maximum Bending Moment is observed at Beam No. 406 as shown in Table no. 4.3.1. The concrete design output obtained from Staad file is shown in figure 4.3.1 and 4.3.2 along with its RCC details for Column no. 406 and adjacent Beam no. 354.

Column no. 406 along with its adjoining beam B354 is taken for designing purpose.

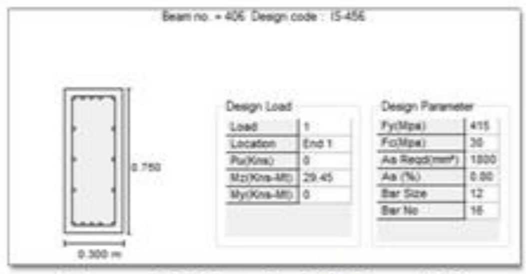
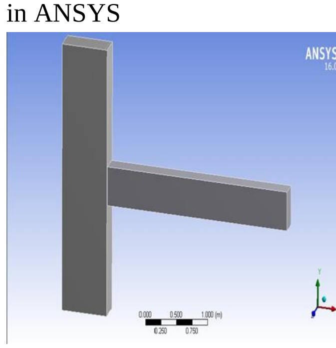


Figure 3.3.2 Details of Column 406

Figure 3.3.3 Details of Beam 354

3.4 ANSYS model:

The Maximum BM beam column junction is further modeled in ANSYS



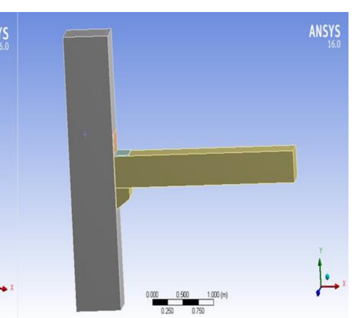
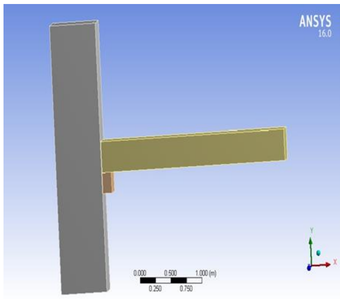


Figure 3.4.1 Conventional RCC Model Figure 3.4.2 Precast Model 1



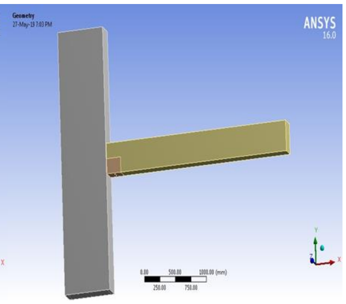


Figure 3.4.3PrecastModel2 Figure3.4.4Precast Model

Figure no. 3.4.1 shows conventions RCC model taken for analysis, and Figure no. 3.4.2, 3.4.3 and 3.4.4 shows different precast models taken for analysis.

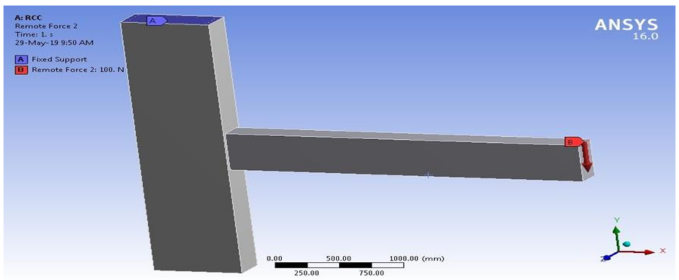


Figure 3.4.5 Column end conditions and Loading in ANSYS

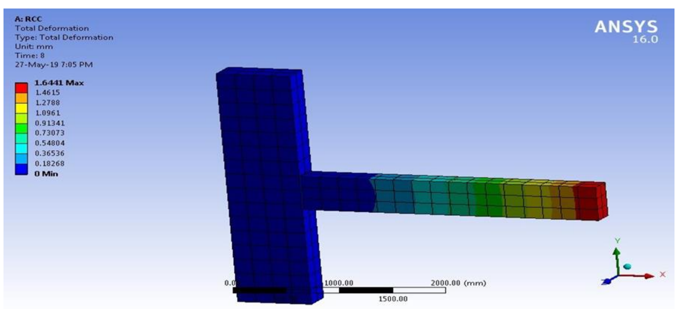


Figure 3.4.6 Total Deformation of RCC model

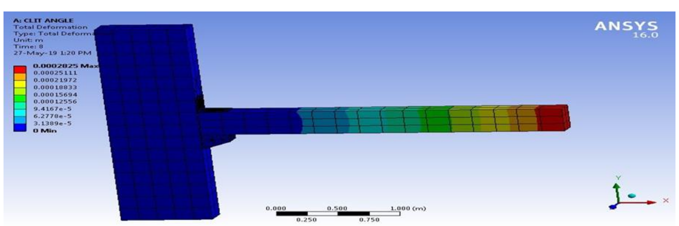


Figure 3.4.7 Total Deformation of precast model no. 1

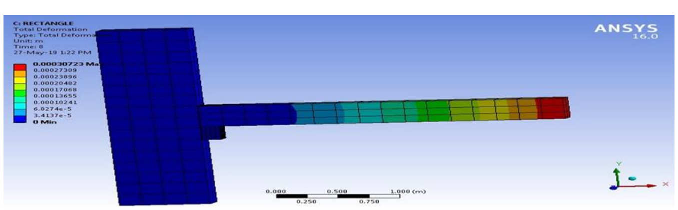


Figure 3.4.8 Total Deformation of precast model no. 2

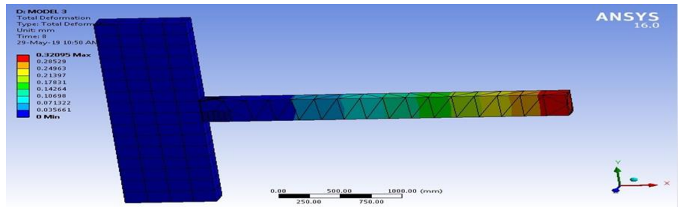


Figure 3.4.9 Total Deformation of precast model no. 3

IV. RESULTS AND DISCUSSION:

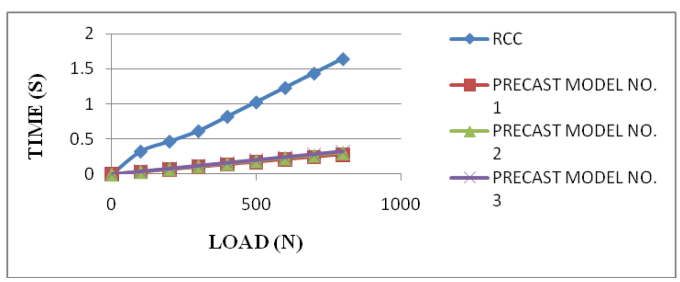
The results obtained from the analysis of models in ANSYS are shown in tables and graphs.

From Graph 4.1 it clearly shows that the total deformation in conventional RCC beam column junction is more than precast beam column junction.The normal stress, shear stresses and maximum principal stresses in precast model no. 1, 2 and 3 is more as compared to RCC beam column junction as seen in the Graphs 4.2, 4.3 and 4.4. In precast the stresses are concentrated in the connecting elements.

4.1 Maximum Deformation M25:

Table 4.1Maximum Deformation

LOAD (N) vs DEFORMATION (mm)				
LOAD (N)	RCC MODEL	PRECAST MODEL NO.1	PRECAST MODEL NO.2	PRECAST MODEL NO.3
0	0	0	0	0
100	0.32612	3.53E-02	3.84E-02	4.01E-02
200	0.46801	7.06E-02	7.68E-02	8.02E-02
300	0.61655	0.10594	0.11521	0.12036
400	0.82207	0.14125	0.15361	0.16047
500	1.0276	0.17656	0.19202	0.20059
600	1.2331	0.21187	0.23042	0.24071
700	1.4386	0.24712	0.26883	0.28083
800	1.6441	0.2825	0.30723	0.32095



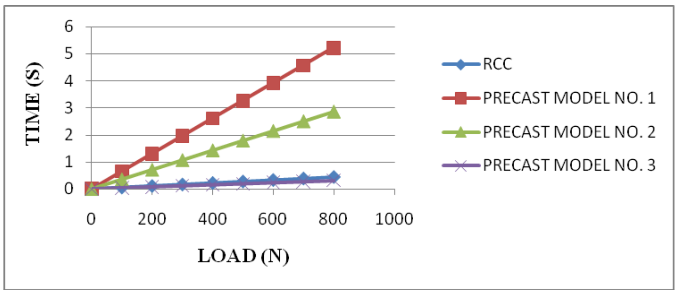
Graph 4.1 Maximum Deformation

Above graph shows the result for Maximum Deformation for all models, the results conclude that the Deformation for precast model no 1 is less than the other precast patterns and RCC model, by around 5-10% for precast models and 30-40% for RCC model.

4.2 Normal Stress M25:

Table 4.2Normal Stress

LOAD (N) vs NORMAL STRESS (MPa)				
LOAD (N)	RCC MODEL	PRECAST MODEL NO.1	PRECAST MODEL NO.2	PRECAST MODEL NO.3
0	0	0	0	0
100	0.0553226	6.53E-01	3.57E-01	4.01E-02
200	0.11064	1.31E+00	7.13E-01	8.02E-02
300	0.16597	1.9597	1.0689	0.12036
400	0.22129	2.6129	1.431	0.16047
500	0.27661	3.2662	1.7889	0.20059
600	0.33193	3.9194	2.1467	0.24071
700	0.38725	4.5715	2.5045	0.28083
800	0.44258	5.2259	2.8623	0.32095



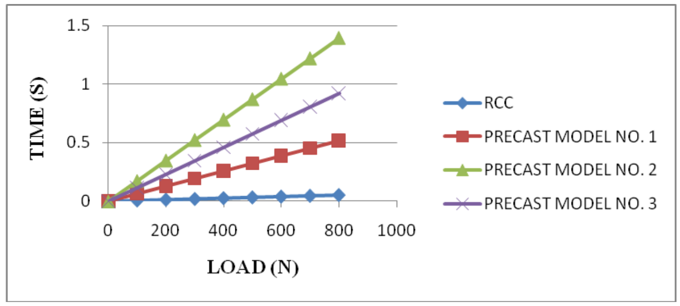
Graph 4.2 Normal Stress

Above graph shows the result for Normal Stress for all models, the results conclude that the Normal Stress for precast model no 3 is less than the other precast patterns and RCC model, by around 15- 20% for precast models and 40-50% for RCC model.

4.3 Shear Stress M25:

Table 4.3Shear Stress

LOAD (N) vs SHEAR STRESS (MPa)				
LOAD (N)	RCC MODEL	PRECAST MODEL NO.1	PRECAST MODEL NO.2	PRECAST MODEL NO.3
0	0	0	0	0
100	0.0064701	6.48E-02	1.74E-01	1.15E-01
200	0.01294	1.30E-01	3.50E-01	2.30E-01
300	0.01941	0.1944	0.52443	0.34523
400	0.02588	0.25921	0.69812	0.4603
500	0.032351	0.32401	0.87247	0.57538
600	0.038821	0.38881	1.047	0.69045
700	0.045291	0.4535	1.2214	0.80553
800	0.051761	0.51842	1.3959	0.9206



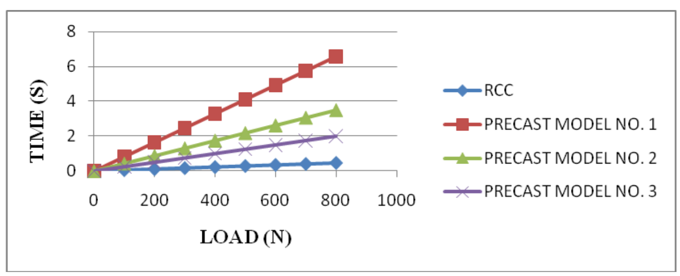
Graph 4.3Shear Stress

Above graph shows the result for Shear Stress for all models, the results conclude that the capacity of Shear Stress for RCC model is less than the other precast patterns, by around 30-35%.

4.4 MaximumPrincipal Stress M25:

Table 4.4MaximumPrincipal Stress

LOAD (N) vs MAXIMUM PRINCIPAL STRESS (MPa)				
LOAD (N)	RCC MODEL	PRECAST MODEL NO.1	PRECAST MODEL NO.2	PRECAST MODEL NO.3
0	0	0	0	0
100	0.058568	8.19E-01	4.34E-01	2.50E-01
200	0.11714	1.64E+00	8.68E-01	4.99E-01
300	0.1757	2.4575	1.3021	0.74875
400	0.23427	3.2766	1.7396	0.99834
500	0.29284	4.0958	2.1747	1.2479
600	0.35141	4.9149	2.6096	1.4975
700	0.40998	5.7327	3.0445	1.7471
800	0.46854	6.5533	3.4795	1.9967



Graph 4.4MaximumPrincipal Stress

Above graph shows the result for Maximum Principal Stress capacity for all models, the results conclude that the capacity of Maximum Principal Stress for RCC model is less than the other precast patterns, by around 40-45%.

V. CONCLUSION

In this project the comparative analysis is made for RCC and PRECAST beam column connections and following conclusions are as observed:

- The maximum deformation are reduced by 15-20 % in to Precast beam column connections as compared to RCC beam column connections.
- From the analytical study of the different shapes of beam column connection it is found that the precast connection is more effective as compared to RCC.
- The Normal Stresses, Shear Stresses, Equivalent stresses, Principal stresses are observed more at connecting elements of precast.

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