International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 05, May-2019

Structural Performance of Detachable Precast Composite Column and Joints using Fea

Sona P R
PG Student
Dept. of Civil Engineering
AWH Engineering College, Kuttikkattoor
Calicut, Kerala

Mrs. Jithma T
Assistant Professor
Dept. of Civil Engineering
AWH Engineering College, Kuttikkattoor
Calicut, Kerala

***Abstract*—The seismic performance of the novel precast concrete frame with mechanical joints with or without metal plates proposed to provide moment connections was estimated by the numerical analysis verified by experimental investigations. Column plates are interconnected by high-strength bolts. It was shown that the use of the novel mechanical joints with steel plates significantly reduces construction time compared with the conventional monolithic assembly. Square, rectangular, circular columns are analysed without plates and best geometry is chosen and further analysis is done. Lateral and inclined loads are applied on columns with and without plates. Joint positions are changed and best position is taken for further analysis. Long columns are also analysed. The best column is taken for the cyclic analysis. In all cases detachable shows best result as monolithic columns. Also the construction time can be reduced in detachable column. Monolithic column can be replaced by detachable column.**

Keywords—Column joints, Precast Construction, Connections in column, Plate connections, Prefabricated construction

I. INTRODUCTION

Conventionally, sleeve connections are used for precast columns. A cylindrical steel sleeve was used as a mechanical sleeve coupler for splicing reinforcing bars to provide full tension and compression for precast column connections. The precast columns are then connected by inserting the protruding bars from the end of lower precast columns into the sleeves of the upper columns. Proper grouted steel sleeves are used to ensure the continuity of the column longitudinal reinforcements. The erection of precast columns proceeds after the grouted non-shrink high early strength mortar is cured, making the reinforcing bars continuous through the connection.

A mechanical joint is proposed illustrated in Fig.1 which is designed to transfer moments through the inter-connected components, was implemented for both precast steel-concrete composite frames and precast concrete frames. Proposed mechanical joint will reduce the construction time by reducing the curing time of concrete at the joints. The precast members are connected by end-plates with metal filler plates that are designed to transfer moments through interconnected components. The joint of the proposed connection consists of two endplates (lower and upper column plates), nuts, and high-strength bolts. The nuts were incorporated to connect the threaded end of the vertical reinforcing bars at the rear part of end-plates. High-strength bolts designed based on a bearing-type connection were used to transfer moments through both lower and upper column plates.

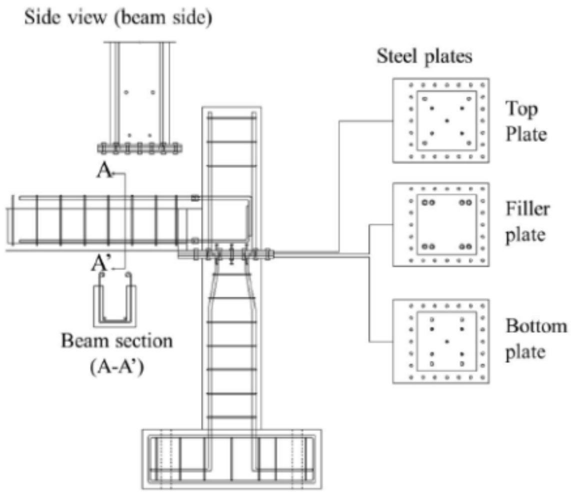

Fig.1 Proposed Mechanical Joint

II. METHODOLOGY

- Conduct literature review on structural performance of detachable precast composite column and joints.
- Modelling and analysis of column joints with or without plates, different joint positions, different loading conditions and other types of long columns using ANSYS 16.1.
- Interpretation of results

III. FINITE ELEMENNT MODELLING

Modelling of the composite column was done using ANSYS WORKBENCH 16.1. For analysis, 30 number of models was used. Monolithic and detachable columns are analysed and compared the results. 22 short columns and 8 long columns are analysed. Material properties are given in Table 1.

a) FE Model of Short columns

Twenty two short columns are analysed with height of 1700 mm. Plate size of 700 x 700 mm was used. Thickness of plates are 45 mm and there is no filler plate used. First, 3 models are analysed, circular, rectangular and square. Lateral loads are applied at top of the column. Cross sectional area of these specimen remains constant. Size of square column used was 500 x 500 mm, 564.18 mm dia circular column was used. 400 x 625 mm size rectangular column was used. Four numbers of 25 mm diameter bars are used. Stirrups of 6 mm diameter 9 numbers are used. Square columns shows best performance and Square geometry is used for the further analysis. Detachable Square column was also analysed and compared with monolithic columns.

Table 1. Material Properties

Properties	Concrete	Steel	Bolt	Rebar	Steel Plate
Density (kg/m^3)	2400	7860	2860	7860	7860
Yield Strength (MPa)	30	350	900	550	350
Poisson's ratio	0.15	0.3	0.3	0.3	0.3
Young's Modulus (MPa)	27386	$2x10^5$	$2x10^5$	$2x10^5$	$2x10^5$

Monolithic and detachable columns with inclined loads are analysed. Inclined loads of 30°,45°,60° are applied at the top of the column and 6 models are analysed. The results are compared.

To obtain the best position, columns with different joint positions are studied. In previous studies, joint position is set at 300 mm from the bottom. Joint positions with 50%, 25%, 75% of column height is modelled with lateral load. Above joint positions with inclined loads of 30°,45°, 60° to x axis are provided are also analysed and 12 detachable columns are modelled.

a) FE Model of long columns

Eight long columns are studied. Monolithic and detachable columns are compared to study the performance of long columns. Four types of long columns are analysed, RCC Long Column, Steel Long Column, Composite Encased Long Column, CFST Encased Long Column. Above columns with and without plates are analysed and compared. Height of long column was taken as 6000 mm.

In steel long column, steel I section is only used. ISWB500 steel is chosen for the analysis. 500 x 250 mm size I section is used. Thickness of flange is 14.7 mm and thickness of web is 9.9 mm.

In composite encased long column, steel I section, concrete, reinforcement are used. Total height of column is 6000 mm and joint position is 25% of column height. Thickness of plates is 45 mm and no filler plate is provided. Outer dimension is 500 x 500 mm. composite encased long columns with or without plates are analysed. And also cyclic analysis is done with these two models.

In CFST encased long column 5 mm plates are used and concrete also used. There is no other reinforcements are provided. Total height of column is 6000 mm and 45 mm plates are used. CFST with or without plates are analysed.

In RCC long column, reinforcement bars and concrete are only used. Here I section is not provided. Four numbers of 25 mm bars are used.

IV. RESULTS AND DISCUSSION

a) Short Column

Here the maximum loads are obtained in square column. So the further modeling can be done in square column. Square column has 17%, 5% increase in load than circular and rectangular columns. Deflection is lower in the case of square column. So, square geometry is used for further analysis. Maximum loads and corresponding deflections are given in Table 2. Deformed shape of square column is shown in Fig 2.

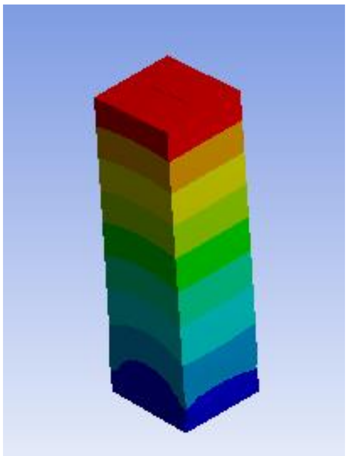

Fig. 2. Deformed Shape of Square Column

Square Detachable column was analysed and square detachable column shows good results as square monolithic column and 0.5% increase in load obtain than monolithic column. Comparison of Load-Deflection graph is shown in Fig.3.

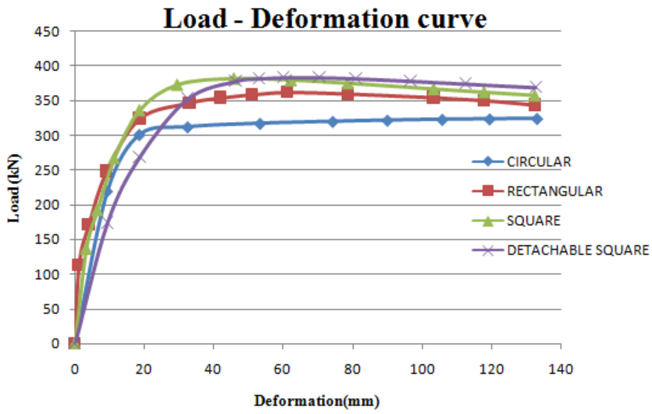

Fig. 3. Load Deformation graphs of different geometry

Monolithic and detachable column with inclined load 30°, 45° ,60° to x axis are analysed. Comparing monolithic and detachable, detachable with 30° inclined load has an increase in load of 5.71 than monolithic with 30° inclined load. Detachable with 45° inclined load has an increase in load of 4.46% than monolithic with 45° inclined load. Detachable with 60° inclined load has an increase in load of 7.22% than monolithic with 60° inclined load.

Table 2. Maximum Loads and corresponding Deflections

Type	Deflection (mm)	Load (kN)
Circular	133.15	324.35
Rectangular	61.307	362.26
Square	45.86	381.81
Square Detachable	59.974	383.59
Monolithic (30°inclined)	44.052	465.3
Monolithic (45°inclined)	52.068	617.88
Monolithic (60°inclined)	54.223	904.31
Detachable (30°inclined)	70.37	491.91
Detachable (45°inclined)	68.546	645.47
Detachable (60°inclined)	70.643	969.64

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 05, May-2019

Position of joint does not influence much, only slight change in loads are obtained, but deflection changes in each positions. Maximum loads and corresponding deflections are given in Table 3.

Table 3. Maximum Loads and corresponding Deflections of columns with different joint positions

Joint Positions with % column height	Load (kN)	Deflection (mm)
75%	383.9	63.52
50%	382.17	62.223
25%	384.46	68.96
75% with 45° inclination	640.2	67.831
50% with 45° inclination	639.1	62.719
25% with 45° inclination	640.86	71.636
75% with 30° inclination	488.24	55.322
50% with 30° inclination	485.09	62.99
25% with 30° inclination	488.67	67.167
75% with 60° inclination	964.12	57.08
50% with 60° inclination	960.23	52.423
25% with 60° inclination	964.47	60.939

In lateral loads, 25% column height has higher deflection, and also 0.2%, 0.14% increase in loads than 50%, 75% of column height. So, Change in position does not influence in load carrying capacity. In the case of deflection, 25% column height is having maximum deflection in lateral loading. 10.8%,8.5% increase in load than 50%, 75% of column height. In inclined loads also the deflection is higher in 25% and maximum load is slightly the same. 25% of column height can be used for the further analysis.

a) Long Columns

In RCC Long column, maximum load in RCC detachable column has 1.8% increase in load than RCC detachable column. But deflection is lower in detachable column. RCC detachable shows good results as RCC monolithic column. Maximum loads and corresponding deflections are given in Table 4. Comparison of Load-Deflection graph is shown in Fig.4-7.

Table 4. Maximum Loads and corresponding Deflections of Long columns

Type	Deflection (mm)	Load (kN)
RCC Monolithic	440.37	69.829
RCC Detachable	369.1	71.148
Steel Monolithic	187038	139.8
Steel Detachable	209.93	140.53
CFST Monolithic	633.32	154.41
CFST Detachable	602.92	154.18
Composite Encased Monolithic	402.34	110.76
Composite Encased Detachable	489.75	112.29

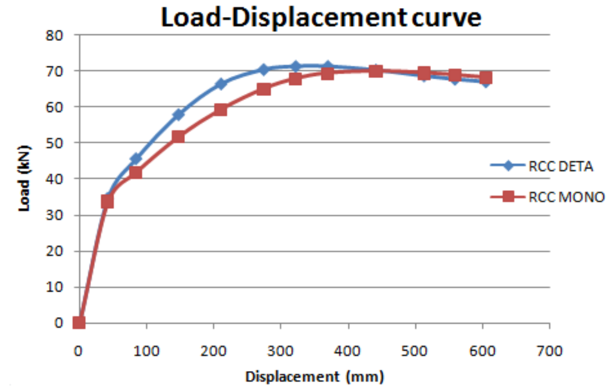

Fig. 4. Load Deformation graphs of RCC long column

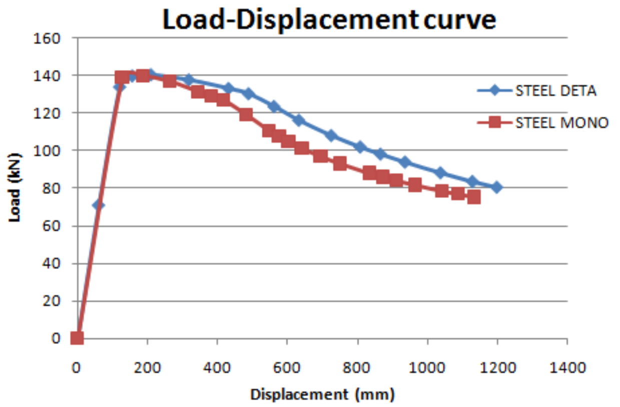

Fig. 5. Load Deformation graphs of Steel long columns

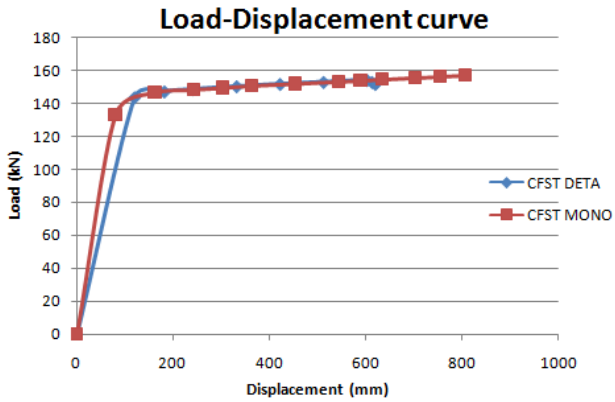

Fig. 6. Load Deformation graphs of CFST long columns

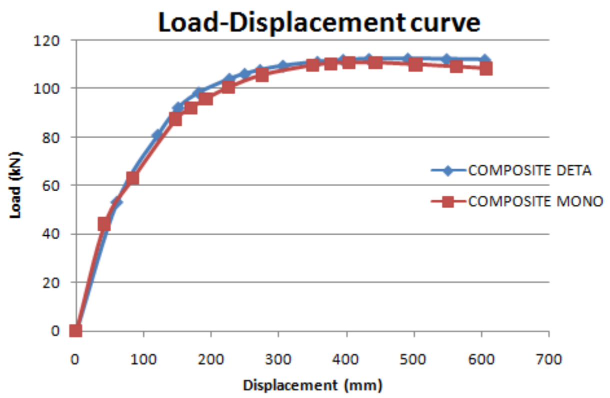

Fig. 7. Load Deformation graphs of Composite Encased long columns

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 05, May-2019

Steel long column is lighter in weight than concrete columns. Detachable column is having 12% increase in deflection and nearly same load carrying capacity as monolithic column. So, detachable shows same performance as monolithic but ductility of detachable increases.

In CFST encased long column, monolithic and detachable shows same performance. Deflection of CFST encased long columns is higher than other types of columns. But in detachable CFST encased long column, deflection decreases. In composite encased long columns load carrying capacity and deflection is higher than monolithic column. In detachable column 21.7% increase in deflection obtained than monolithic column, also 2.38% increase in load than monolithic column. Detachable shows good results than monolithic column. Cyclic analysis is also done in detachable and monolithic composite encased long columns. Maximum loads and corresponding deflections are given in Table 5.

Table 5. Maximum Loads and corresponding Deflections of Composite Encased Long Column by Cyclic Loading

Type	Cycle	Deflection (mm)	Load (kN)
Cyclic Composite monolithic	27	346.15	109.9
	29	-396	-108.97
Cyclic Composite detachable	27	350	110.01
	29	-400	-110.01

Comparison of Load-Deflection graphs are shown in Fig.8-9.

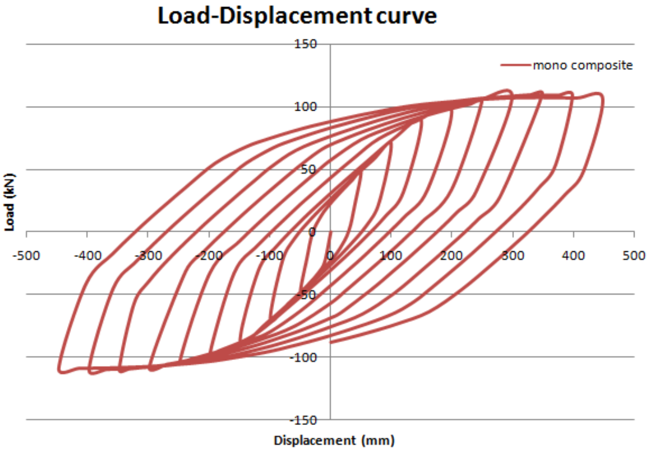

Fig. 8 Load deformation curve for cyclic analysis of Monolithic Composite encased long columns

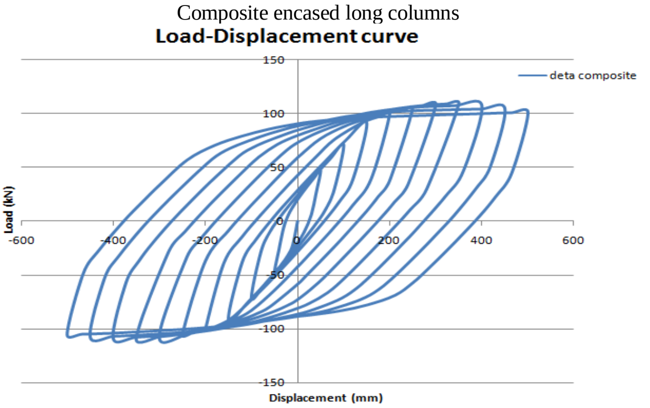

Fig. 9 Load deformation curve for cyclic analysis of Detachable Composite encased long columns

From Table 5, it is shown than maximum and minimum loads are at 27 and 29 cycles. Total no. of cycles are 36 for monolithic and 40 for detachable. The deflections are higher in detachable than monolithic. Maximum positive and negative loads are increased by 0.1%, 0.9% in detachable column. It shows good results, nearly same performance as monolithic.

V. CONCLUSIONS

- Detachable column reduces the construction time by eliminating curing time of concrete at the joints.
- Semi- Rigid connection is obtained.
- Detachable column is more Ductile. So it can be used in earthquake prone areas.
- Joints never affect the load carrying capacity of structure

ACKNOWLEDGEMENT

I would like to express my special thanks of gratitude to my Project guide Mrs. Jithma T, as well as our principal Dr. Sabeena M.V who gave me the golden opportunity to do this wonderful project which also helped me in doing a lot of Research and came to know about so many new things I am really thankful to them.

REFERENCES

[1] J.D. Nzabonimpa and Won-Kee Hong (2018) "Structural performance of detachable precast composite column joints with mechanical metal plates" *Department of Architectural Engineering*, 446-701

[2] J. D. Nzabonimpa and Jisoon Kim (2017) "Mechanical connections of the precast concrete columns with detachable metal plates"*Struct Design Tall Spec Build.* 449-70

[3] J. D. Nzabonimpa and Won-Kee Hong (2018) "Use of laminated mechanical joints with metal and concrete plates for precast concrete columns" *Materials and Structures* 51:76

[4] C. Shim et al. (2015) "Enhanced design of precast concrete columns by optimal axial steels" *WIT Transactions on The Built Environment* Vol 152 ISSN 1743-3509

[5] Do Hak Kim et al. (2015) "Experimental test and seismic performance of partial precast concrete segmental bridge column with cast-in-place base" *GS E&C Research Institute, GS Engineering and Construction* 110-130

[6] Nzabonimpa JD et al. (2017) "Nonlinear finite element model for the novel mechanical beam-column joints of precast concrete-based frames" *Comput Struct* ,189:31–48

[7] Mashaly E et al. (2011) "Finite element analysis of beam-to-column joints in steel frames under cyclic loading". *Alexandria Eng* 91–104.

[8] Chen X, Shi G. (2016) "Finite element analysis and moment resistance of ultra-large capacity end-plate joints" *J Constr Steel Res* 126:153–62.