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# ANALYTICAL INVESTIGATION ON PRECAST CONCRETE COLUMN TO COLUMN CONNECTION

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**Abstract -** *Precast concrete is one of the time saving ways for construction activities. It is a method of placing the precast elements such as beam, column, slabs and footing in their located area. These precast elements are manufactured in controlled environment. In precast concrete, column has a main part to withstand complete structure. In this paper the precast concrete column is studied, and different types of column are modelled using Finite Element Software. Then the analytical results are compared with monolithic column by given monotonic load.*

***Key Words***: Long bolt, End plate, welding, Coupler, Deflection.

## 1. INTRODUCTION

Prefabricated building is the recent trending in this modern culture. This technic is used in many places to complete the building in shorter duration. Assembling and dismantle is easy in this technic. Failure and crack development can be minimized in this technic. Manufacturing the precast element in closed environment can avoid unnecessary cracks. This precasting element such as beam, column, slab, footing, stairs etc., are transport and placed in site.

In prefabricated element the main element for the whole structure is column, because the column is the vertical member it will withstand the total building from top to bottom. This paper deal with developing new type of precast concrete column to column connection. Based on economic three types of connection are chosen for analytical work.

Ikhlas S.sheet, et.al., has tested four half scale interior connections with steel beams and concrete filled tubular (CFT) column. In this they used long bolts for connecting steel beams with Monolithic column. At the test result long bolts passing through the columns were effective [7].

Neeladharan, et.al., has aimed to achieve continuity load path in steel reinforcement. In order to reduce its amount of steel reinforcement. So, they had developed mechanical coupler instead of providing development length of the bars and lap weld. They have decided to check different length in coupler for suitability. Finally based on the test results (L=3D) has a better result [9].

Stency Mariam Thomas, el.al., has designed the optimal design for RC Columns. In this optimization of columns results in saving total cost of the column. Here the axial load is given, and it is validated. Finally, the result of using m20 grade of concrete gives a least cost when the column is loaded 500KN [17].

### 1.1. Research Signification

In precast concrete column to column connection, bolts and welded connection are used as a dry connection. In bolted connection, there are different types of bolts such as anchor bolt, flange bolt, machine bolt, etc., for connecting two members. In some paper long bolts are used for connecting beams and column [7]. In welded connection, if the thickness of the weld increases and the failure also decrease. In this paper different types of connection are studied and analysed based on the economical and idealistic new type of connection are developed and it is tested using monotonic load (compression).

### 1.2. Theory/calculation

#### A. Total Deformation

The deformation of the structural member, with known geometry and subjected to an axial load can be determined by using the equation.

$\delta$ = PL/EA [E = $\sigma$/ $\varepsilon$ = PL/A$\delta$]

The term EA/L is the stiffness of the member so we can rewrite the equation as

$\delta$ = PL/EA, $\delta$ = P/k.

#### B. Normal stress

Normal stress is the stress were the member is loaded by an axial force. The normal stress will occur when a member is placed in tension or compression.

$\sigma$ = P/A

$\sigma$ = Normal stress

P = Axial load

A = Cross Sectional Area

## 2. Analytical Properties and Figures

**TABLE I**
**Properties of Concrete**

| | |
|---|---|
| Density | 2300kgm$^3$ |
| Coefficient of thermal expansion | 1.4E-05 |
| Young's modulus | 3E+10Pa |
| Poisson's ratio | 0.18 |
| Bulk modulus | 1.5625E+10Pa |
| Shear modulus | 1.2712E+10Pa |
| Tensile ultimate strength | 5E+06Pa |
| Compressive ultimate strength | 4.1E+7Pa |

**TABLE II**
**Properties of Steel Structures**

| | |
|---|---|
| Density | 7850kgm$^3$ |
| Coefficient of thermal expansion | 1.2E-05 |
| Young's modulus | 2E+11Pa |
| Poisson's ratio | 0.3 |
| Bulk modulus | 1.6667E+11Pa |
| Shear modulus | 7.6923E+10Pa |
| Tensile ultimate strength | 4.6E+08Pa |
| Compressive ultimate strength | 2.5E+08Pa |
| Strength coefficient | 9.2E+08Pa |
| Ductility coefficient | 0.213 |
| Tensile yield strength | 2.5E+08Pa |

**TABLE III**
**Mechanical Properties For Plate And Bolt**

| S.NO | Material Strength of Steel | Elongation (%) | Yield strength (Mpa) | Ultimate strength (Mpa) |
|---|---|---|---|---|
| 1 | Flat end plate (Grade 250) | 29.8 | 297.58 | 431.38 |
| 2 | Bolt diameter-22 | 10.9 | 406.62 | 711.46 |

*Development length of the steel bar is 45 times the diameter of the bar as per IS456:2000

### 2.1. Preparation of Figure and Properties

Connection such as bolted connection, welded on steel bearing and coupling of reinforcing bars are taken for analytical work and it is modelled using Ansys Workbench 18.2.

#### 2.1.1. Column to Column Connection by Bolts

The bolted connections are referred as concentric connections (force transfer in tension & compression member), eccentric connections (in reaction transferring brackets) or moment resisting connections (in beam to column connections in frames).

In bolted connection, here using long bolt for column to column connection. In previous literatures this type of long bolted connection are given to connect the steel beams to monolithical column [7].

In this paper this long bolt is given for connecting two individual precast columns into one single column by the method of bolted two parts with end plate and then it is bolted.

**Dimension for Bolted Connection**

1) Total Height of Column: 1500mm
   (i) Top portion – 750mm
   (ii) Bottom portion – 750mm
2) Column size – 230mm x 230mm (Constant)
3) Diameter of Main bar – 16mm
4) Diameter of ties – 8mm
5) End Plate: 230mm x 500mm (four sides)
6) Thickness of End Plate – 20mm
7) Diameter of Long Bolt – 20mm
8) Diameter of Hole in Plate – 22mm
9) Inner diameter of nut – 16mm and outer diameter – 20mm
10) Dimension of nut – 20mm and Tread of nut – 1 mm
11) Length of long bolt – 350mm

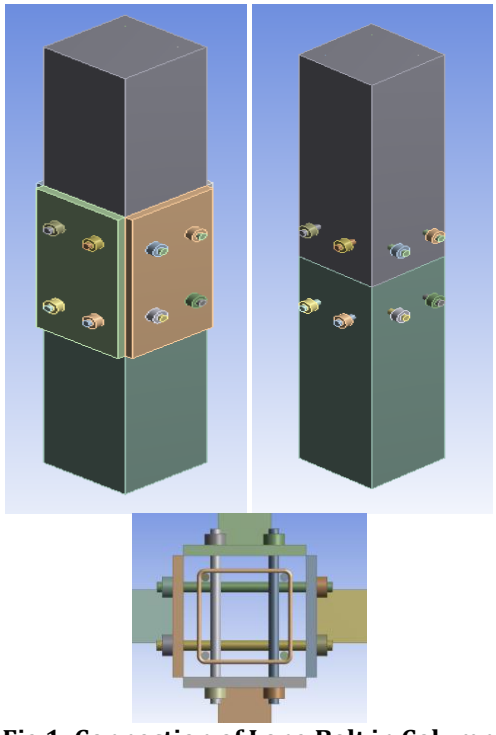


**Fig 1: Connection of Long Bolt in Column**

### *2.1.2. Column to Column Connection by Welded on Steel Bearing Face*

In this column to column connection the plate is given at the bottom of the concrete and the rods extended inside the concrete which is welded at its face and edge. This rod is given because to keep bonding between plate and concrete. Further the two individual precast concrete are places one by one and it is welded on its face with certain thickness.

In this connection the face of the plate is welded. As the thickness of welding increases and the fracture of weld will be decreases. Welding thickness as 8-10 mm as per IS 816-1969.

***Dimension for Welded on Steel Bearing Faces***

1) Total Height of Column: 1500mm
   (i) Top portion – 730mm
   (ii) Bottom portion – 730mm
2) Column size – 230mm x 230mm (Constant)
3) Diameter of Main bar – 16mm
4) Diameter of ties – 8mm
5) Thickness of bottom plate – 20mm
6) Rods extended inside the concrete - 300mm
7) Diameter of rod extended – 20mm

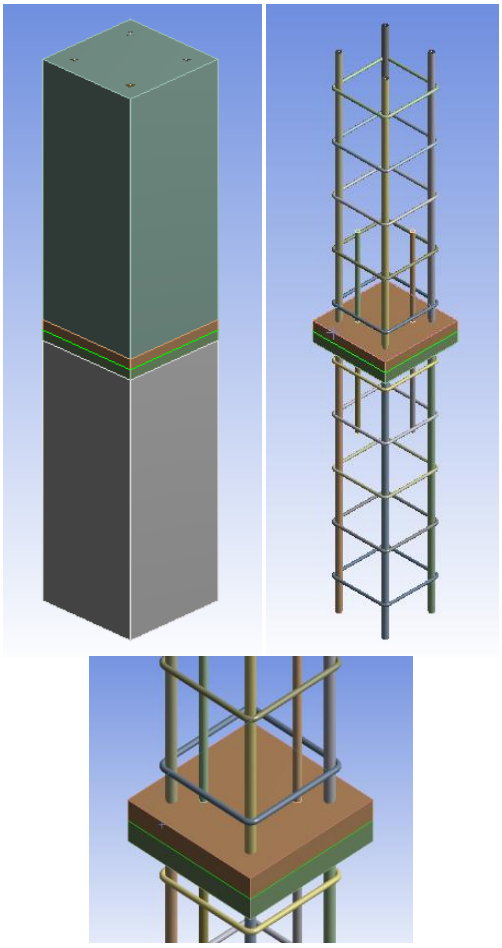


**Fig 2: Connection by Welded on Steel Bearing Face**

### *2.1.3. Column to Column Connection by Coupling of Reinforcing Bars*

Coupling of Reinforcing bars are by joining two individual reinforcing bars into single bar. It is just screwing the coupler between two bars. In precast concrete two individual column are casted with bars extended one side.

Further, the edges of the bars are coupled. Finally, the gaps of the precast concrete are filled with concrete on it. The length of the coupler is 3D as per Reference in journal can give a best performance. Coupling of reinforcing bars is the one which is used to reduce the bars from extension and welding. This coupling method gives a better result while comparing with extension bar and welded connection.

***Dimension for Coupling of Reinforcing Bars Connection***

1) Total Height of Column: 1500mm
   (i) Top portion – 650mm
   (ii) Bottom portion – 650mm
   (iii) Mid portion – 200mm
2) Column size – 230mm x 230mm (Constant)
3) Diameter of Main bar – 16mm
4) Diameter of ties – 8mm
5) Using coupler of (L=3D) length 48mm
6) External Diameter - 20mm
7) Internal Diameter – 12mm
8) Tread – 2mm and pitch as 1.2mm

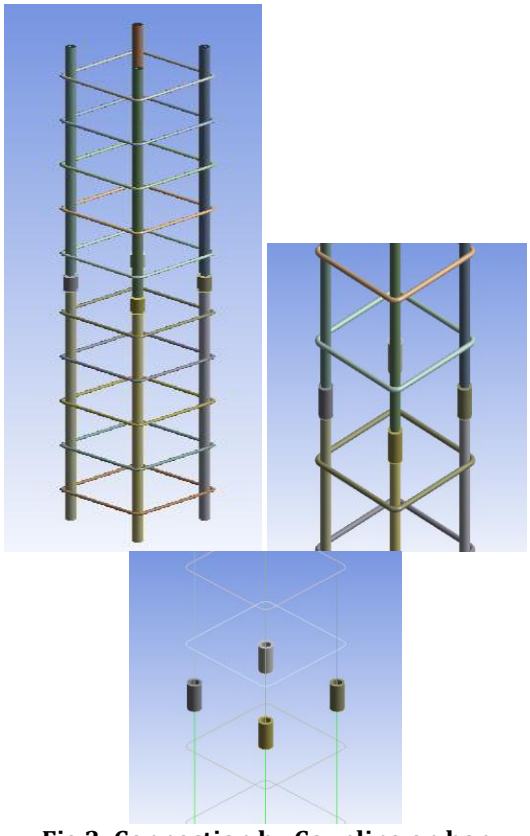


**Fig 3: Connection by Coupling on bar**

## 3. Preparation of Tables and Graphs.

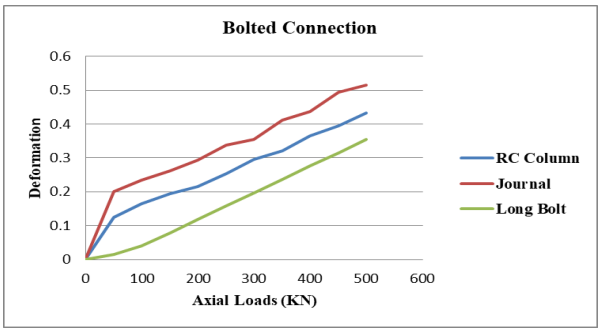
### *3.1.Description:*

In this result obtained from column to column connection by bolt, the total deformation value obtained as 0.35476mm. Then the normal stress result as 14.733 Mpa (+ve) and 16.684 (-ve). These values are within the permissible limit.

**TABLE IV**

| Load | Axial load ( KN) | Deformation (mm) | Normal stress (Mpa) | |
|---|---|---|---|---|
| | | | +ve | -ve |
| Conventional column | 500 | 0.43159 | 2.84 | 2.81 |
| Column from Journal | 500 | 0.51547 | 13.36 | 17.37 |
| Column with Bolted connection | 500 | 0.35487 | 14.73 | 16.68 |

***All values are in below permissible limit**




**Graph-1**

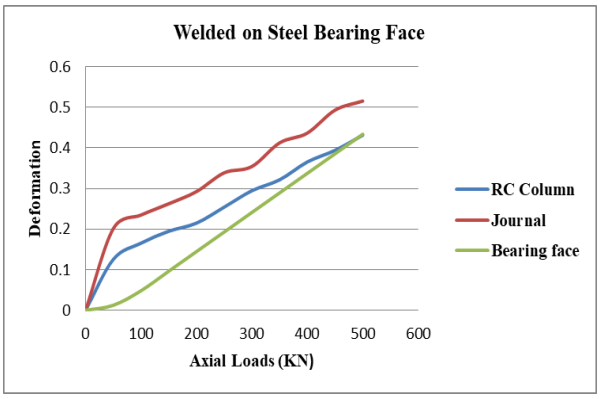
### *3.2. Description:*

In this result obtained from column to column connection by welded on steel bearing face, the total deformation value obtained as 0.43395mm. Then the normal stress result as 5.876 Mpa (+ve) and 5.85 (-ve). These values are within the permissible limit.

**TABLE V**

| Load | Axial load ( KN) | Deformation (mm) | Normal stress (Mpa) | |
|---|---|---|---|---|
| | | | +ve | -ve |
| Conventional column | 500 | 0.43159 | 2.84 | 2.81 |
| Column from Journal | 500 | 0.51547 | 13.36 | 17.37 |
| Column with Welded on steel bearing face | 500 | 0.43395 | 5.876 | 5.85 |

***All values are in below permissible limit**




**Graph-2**

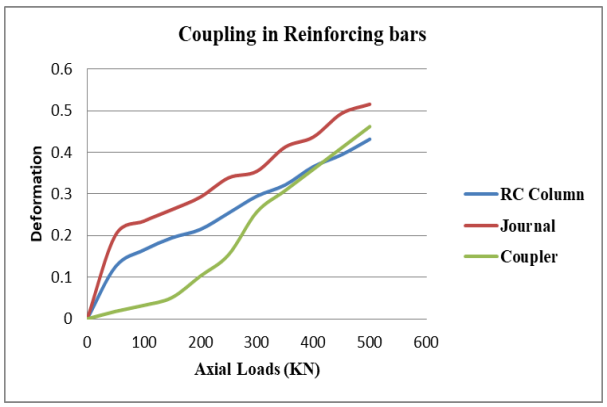
### *3.3. Description:*

In this result obtained from column to column connection by coupling in reinforcing bars, the total deformation value obtained as 0.46195mm. Then the normal stress result as 18.871 Mpa (+ve) and 5.6342 (-ve). These values are within the permissible limit.

**TABLE VI**

| Load | Axial load ( KN) | Deformation (mm) | Normal stress (Mpa) | |
|---|---|---|---|---|
| | | | +ve | -ve |
| Conventional column | 500 | 0.43159 | 2.84 | 2.81 |
| Column from Journal | 500 | 0.51547 | 13.36 | 17.37 |
| Column with Coupling of Reinforcing Bars | 500 | 0.46195 | 18.87 | 5.634 |

***All values are in below permissible limit**




**Graph-3**

## 4. DISCUSSION

Based on the Analytical tests results the following are obtained:

- The result for bolted connection has a less deformation comparing to other connection.
- The results for steel bearing face have close result comparing with conventional RC Column.
- The results for the coupler have an intermediate result.

## 5. CONCLUSIONS

1) The mechanical connection method is relatively easy and quick to implement and configure.
2) Constant Axial force is given to all connection as per journal.
3) In coupling connection 3 x Diameter of the rod is perfect to joining two bars.
4) In long bolted connection, two individual precast concrete columns are easily connected with end plates by screwing nuts into bolt. It saves on reducing steel plates.
5) For coupling method, the cost is relatively low because it saves some quantities of reinforcing bars.
6) As the thickness of the weld increases the failure criteria also reduced in steel bearing face.

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