The Comparative Study of Linear & Non Linear Analysis of Precast & RCC Beam Column Connections Subjected To Ground Motion

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Abstract- *The current study investigates the response of combined systems, RC frame pre-cast 3D wall sandwich panels in both linear and non-linear material properties. The seismic behavior of building constructed by 3D panels is studied in details, e.g. ductility evaluation in terms of load-displacement curves, energy loops and its dissipation during applied spectrum and material nonlinearities. The results are compared with regular bending RC frames and complete box type concrete sandwich panels system and present the differences of drifts and horizontal load distribution on floors.*

Keywords- linear & non linear analysis, RCC & Precast beam-column connections, ground motion

I. INTRODUCTION

Ancient Roman builders made use of concrete and soon poured the material into moulds to build their complex network of aqueducts, culverts, and tunnels. Modern uses for pre-cast technology include a variety of architectural and structural application including individual parts, or even entire building systems. The concept of precast (also known as "prefabricated") construction includes those buildings, 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. These components are manufactured by industrial methods based on mass production in order to build a large number of buildings in a short time at low cost. Earlier Roman builders use concrete for construction of culverts, tunnels etc. Now a day's pre-cast technology include a variety of architectural and structural applications which can be used in various element of building. The process was invented by city engineer John Alexander Brodie, Actually idea was not taken up broadly in Britain Yet, it was adopted all over the world, The Precast Concrete industry focuses on utility, underground, and other non-pre-stressed products, and is represented primarily by the National Precast Concrete Association. Precast concrete elements are widely used in the construction industry. The precast elements are cast and cured in a controlled environment at a factory and then transported to the building site.

Reinforced concrete (RC) has become one of the most important building materials and is widely used in many types of engineering structures. The economy, the efficiency, the strength and the stiffness of reinforced concrete make it an attractive material for a wide range of structural applications. For its use as structural material, concrete must satisfy the conditions. The structure must be strong and safe. The proper application of the fundamental principles of analysis, the laws of equilibrium and the consideration of the mechanical properties of the component materials should result in a sufficient margin of safety against collapse under accidental overloads.The structure must be stiff and appear unblemished. Care must be taken to control deflections under service loads and to limit the crack width to an acceptable level.

Reinforced concrete interior beam-column connections are one of the least studied critical components of a building or bridge structure. It should be mentioned that a connection region comprises of the joint region along with the adjoining area within the beam and column where the inelasticity is concentrated. Reinforced concrete interior beam-column connections are one of the least studied critical components of a building or bridge structure. It should be mentioned that a connection region comprises of the joint region along with the adjoining area within the beam and column where the inelasticity is concentrated.

In precast construction, factory controlled conditions will enable the desired quality, dimension, and colored texture of precast concrete to be easily achieved. The history of precast concrete dates back to few decades ago in which several factors such as rising steel costs, material shortages during the Korean conflict, the expanded highway construction program, and the development of mass production methods to minimize labor costs have all been factors leading to the use of precast concrete. Precast concrete systems have many advantages like speed in construction, good quality due to factory production, economy in mass production. Despite many advantages of precast concrete, it is not widely used throughout the World, especially in regions of high seismic risk. Generally, the use of precast elements makes the construction phase faster and less labor intensive. The precast panels, slabs and beams, however, need to be connected by in-situ cast joints. Typically, hairpin reinforcement bars (also known as U-bars) or wire loops are extruding from the precast component sand avoid is filled with a special joint mortar or concrete.

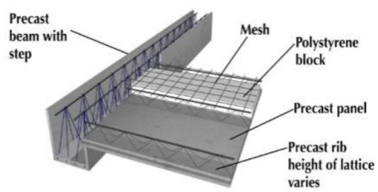

Fig1: Precast beam

Rehabilitation and protection against seismic actions concerns a large number of buildings made of precast and prestressed concrete elements, basically for industrial-manufacturing purposes. At that time the buildings were characterized by innovative and even high performance materials and by complex structural solutions exploiting new material and design approaches. The latter however were not comparable with modern regulations and technical knowledge, so that assessment of present conditions needs specific studies on local and global behavior. This circumstance is more relevant if seismic risk is analyzed; in fact, 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.

II. SCOPE OF STUDY

- To achieve mentioned objective we have decided the scope of our work as,
- To study precast element and compare its aspect with RCC.
- To study and collect data of specified ground motion for time history analysis.
- To check and compare parameters like bending stress, shear stress and maximum principal stress for linear and non-linear analysis.
- To check increase in flexural strength of precast connection as compared to RCC connection.

III. METHODOLOGY

Ground motions and linear time history analysis

Dynamic analysis using the time history analysis calculates the building responses at discrete time steps using discredited record of synthetic time history as base motion. If three or more time history analyses are performed, only the maximum responses of the parameter of interest are selected..

In linear dynamic method, the structure is modeled as a multi degree of freedom (MDOF) system with a linear elastic stiffness matrix and an equivalent viscous damping matrix. The seismic input is modeled utilizing time history analysis, the displacements and internal forces are found using linear elastic analysis. The playing point of linear dynamic procedure as for linear static procedure is that higher modes could be taken into account. In order to study the seismic behavior of structures subjected to low, intermediate, and high-frequency content ground motions, dynamic analysis is required. The STAAD Pro software is used to perform linear time history analysis.

1. Ground Motion Records

Buildings are subjected to ground motions. The ground motion has dynamic characteristics, which are peak ground acceleration (PGA), peak ground velocity (PGV), peak ground displacement (PGD), frequency content, and duration. These dynamic characteristics play predominant rule in studying the behavior of RC buildings under seismic loads. The structure stability depends on the structure slenderness, as well as the ground motion amplitude, frequency and duration. Based on the frequency content, which is the ratio of PGA/PGV the ground motion records are classified into three categories:

A. High-frequency content PGA/PGV > 1.2.
B. Intermediate-frequency content 0.8< PGA/PGV< 1.2.
C. Low-frequency content PGA/PGV < 0.8.

The ratio of peak ground acceleration in terms of acceleration of gravity (g) to peak ground velocity in unit of (m/s) is defined as the frequency content of the ground Figure 3.1 c shows the variation of 1979 Imperial Valley-06 (Holtville Post Office) H-HVP225 component ground acceleration versus time with -0.253 g PGA. The second curve is the ground velocity, obtained by integrating the acceleration-time function. The PGV is -0.488 m/s. Integration of ground velocity gives the ground displacement, displayed as the lowest trace. The peak ground displacement is 0.316 m. In the same manner, Figure 4.5-4.6 shows the variation of ground acceleration versus time with PGA, ground velocity versus time with PGV, and ground displacement versus time with PGD for corresponding ground motions. Then from the acceleration and velocity curves of the ground motion, frequency content, which is the ratio of PGA/PGV, can be obtained.

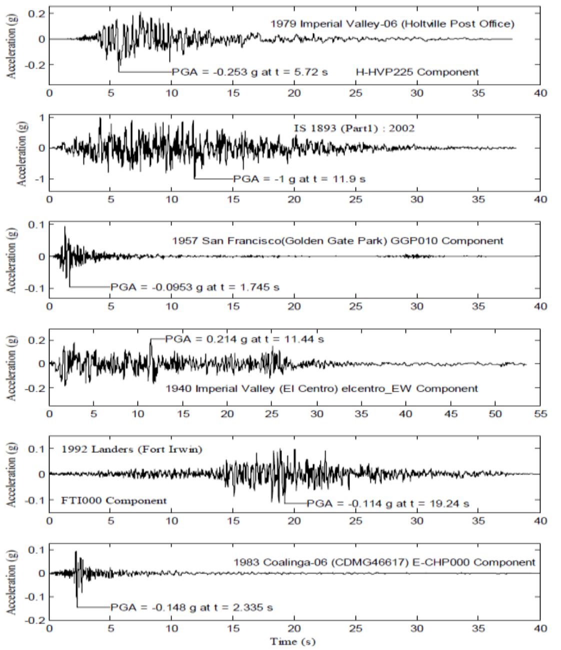

Figure 2**:** Ground motion acceleration versus time with PGA

value of 1979 Imperial Valley-06 (Holtville Post Office) H-HVP225 component, IS 1893 (Part1) : 2002, 1957 San Francisco (Golden Gate Park) GGP010 component, 1940 Imperial Valley (El Centro) elcentro_EW component, 1992 Landers (Fort Irwin) FTI000 component, and 1983 Coalinga-06 (CDMG46617) E-CHP000 component.

IV. MODELING & MATERIAL PROPERTIES

The definition of the proposed numerical model was made by using finite elements available in the ANSYS code default library. SOLID186 is a higher order 3-D 20-node solid element that exhibits quadratic displacement behavior. The element is defined by 20 nodes having three degrees of freedom per node: translations in the nodal x, y, and z directions. The element supports plasticity, hyper elasticity, creep, stress stiffening, large deflection, and large strain capabilities. It also has mixed formulation capability for simulating deformations of nearly incompressible elastoplastic materials, and fully incompressible hyper elastic materials. The geometrical representation of is show in SOLID186.

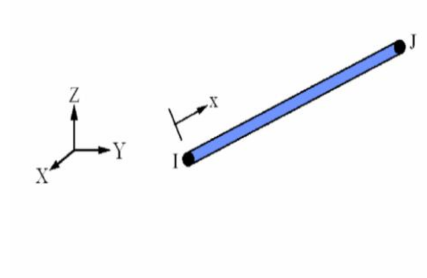

Fig.no.3: Beam

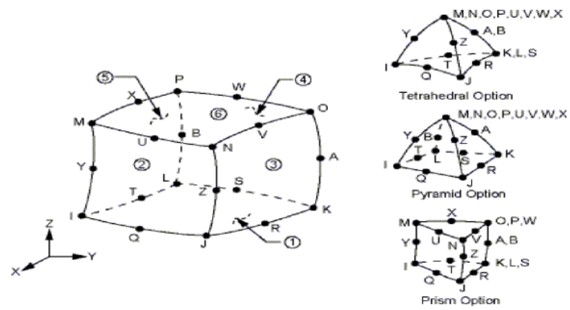

Fig no 4 : SOLID 186

This SOLID186 3-D 20-node homogenous/layered structural solid were adopted to discrete the concrete slab, which are also able to simulate cracking behavior of the concrete under tension (in three orthogonal directions) and crushing in compression, to evaluate the material non-linearity and also to enable the inclusion of reinforcement (reinforcement bars scattered in the concrete region).The element SHELL43 is defined by four nodes having six degrees of freedom at each node. The deformation shapes are linear in both in-plane directions. The element allows for plasticity, creep, stress stiffening, large deflections, and large strain capabilities. Which allow for the consideration of non-linearity of the material and show linear deformation on the plane in which it is present. The modeling of the shear connectors was done by the BEAM 189 elements, which allow for the configuration of the cross section, enable consideration of the non-linearity of the material and include bending stresses as shown in fig 3. CONTA174 is used to represent contact and sliding between 3-D "target" surfaces (TARGE170) and a deformable surface, defined by this element. The element is applicable to 3-D structural and coupled field contact analyses. The geometrical representation of CONTA174 is show in fig 6 Contact pairs couple general ax symmetric elements with standard 3-D elements. A node-to-surface contact element represents contact between two surfaces by specifying one surface as a group of nodes.

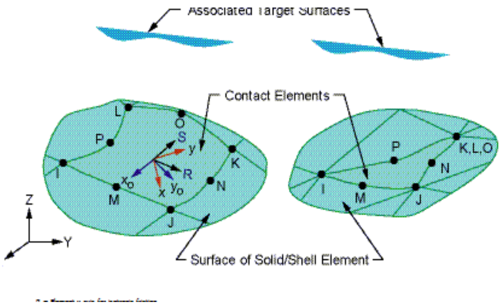

Fig no 5: TARGET

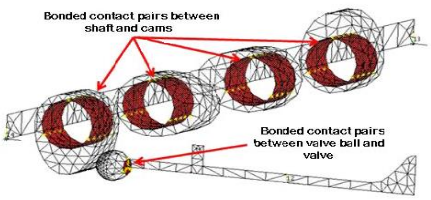

Fig no 6: CONTA

The TARGET 170 and C0NTA 174 elements were used to represent the contact slab-beam interface. These elements are able to simulate the existence of pressure between them when there is contact, and separation between them when there is not. The two material contacts also take into account friction and cohesion between the parties.

Material properties

Sr.No.	Material	Property	Value
1	Structural steel	Yield stress f_y(MPa)	265
		Ultimate strength f_u(MPa)	410
		Young's modulus Es(MPa)	205×10^3
		Poisson's ratio μ	0.3
		Ultimate tensile strain et	0.25
2	Reinforcing bar	Yield stress f_y(MPa)	250
		Ultimate strengthf_u (MPa)	350
		Young's modulus Es(MPa)	200×10^3
		Poisson's ratio μ	0.3
		Ultimate tensile strain et	0.25
3	Concrete	Compressive strengthf_c(MPa)	42.5
		Tensile strengthf_t(MPa)	3.553
		Young's modulus E_c(MPa)	32920
		Poisson's ratio μ	0.15
		Ultimate compressive strain e_s	0.045

V. PROBLEM STATEMENT

A G+14 RCC and Precast residential building.
Plan dimensions: 20 m x 20 m
Location considered: Zone-IV
Soil Type considered: Hard Strata.
General Data of Building:
Grade of concrete: M 20
Grade of steel considered: Fe 250, Fe 500
Live load on roof: 2 KN/m2 (Nil for earthquake)
Live load on floors: 4 KN/m2
Roof finish: 1.0 KN/m2
Floor finish: 1.0 KN/m2
Brick wall in longitudinal direction: 240 mm thick
Brick wall in transverse direction: 140 mm thick
Beam in longitudinal direction: 230X350 mm
Beam in transverse direction: 230X350 mm
Column size: 300X750 mm
Density of concrete: 25 KN/m3
Density of brick wall including plaster: 20 KN/m3
Plinth beam (PB1): 350X270 mm
Plinth beam (PB2): 270X300 mm
Beam column joint detail
Span of beam: 3m

Main bar: 4# 12mm
Stirrup: 8 @mm 200mmc/c
Span of column : 3.5m
Main bar:4# 16mm
Stirrup: 8 @mm 300mmc/c.

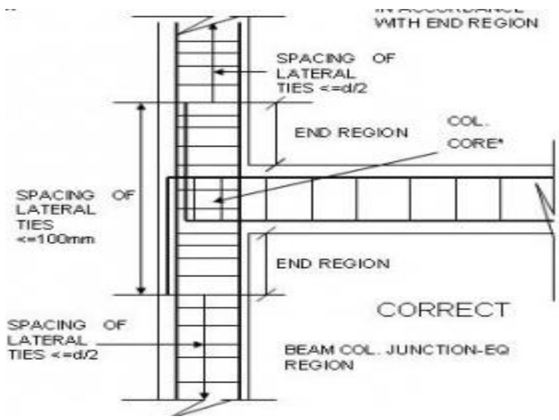

Fig no 7: Detailing of Beam Column Joint

We have to show the both system types of connection in ANSYS software with their detailing and using materials. We have to known about the connections of beam and column of RCC and Precast system. The using material in connections is also important for their taking load and also they are shown their strength and loading capacity. The connection of beam to column is male and female connections or joints. They become joint in different material parameters like in RCC they are used reinforced concrete and steel material with high grade. In precast beam to column connection is different in different format like using bolted connections, with or without corbel connection, seismic resistance connection etc. The geometry of beam to column connection of RCC and Precast system has been show below.

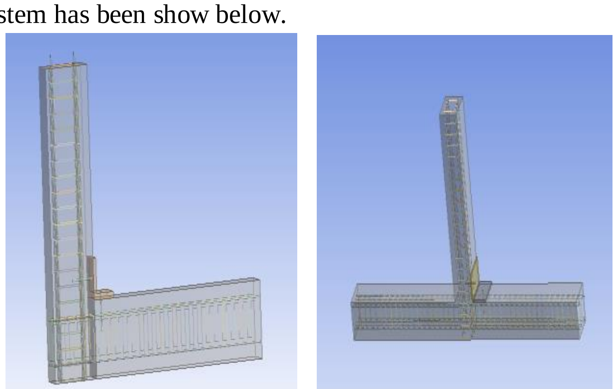

Fig no 8: Internal & External Precast beam column connection using steel pate

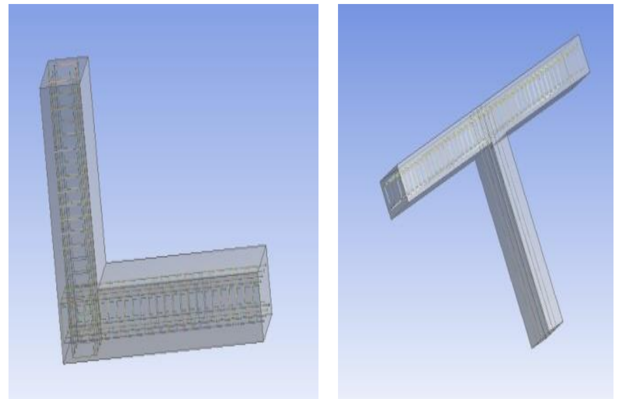

Fig no 9: Internal & External RCC beam column connection

From that geometry the shape of beam to column connections are in two formats like L shape and T shape. In the case of precast we have to using steel plate having 30 mm thick plate and 16 and 20 mm bar is used to connect the connection. In that case they are using the bolted connections like J bolted, Tie bolted, cleat angle etc and in the case of RCC connection using the reinforced concrete and steel material to join the sectional part. The connection of precast system is shown below. In this system they have to show the actual loading capacity about using materials. From that we have to taking a different material as compared to required then what happen will there and where is the deflect and bend to it that can be check. We are taking a lot of load (total building load from super structure to sub structure).

VI. RESULTS AND DISCUSSION

In the study of the topic then they have to get some different result about beam to column connections in different connections. In the RCC and Precast connection they have to show the parameters like deformations, normal and shear stress with equivalent stress and also show the mesh property is applied on whole structure. They have also shown in them. We have to taking a beam column connections with loading conditions applied on it (dead load, live load, floor finish load, roof finish load, etc). When we are applied on it then what will changes in the geometry and how will deform and where will bucking and also which portion will fall down that all point should be taking. In the same case the loads are applied on the structural component then will get to the stress parameters like shear stress, normal stress, maximum and minimum principal stress, equivalent stress etc. they all are shown in graphical format. The graphs are shown below.

1. For L shape beam column connections result

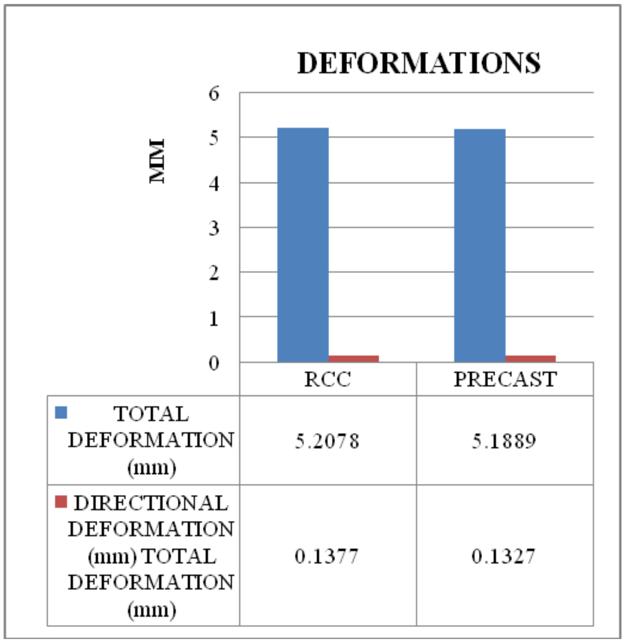

Fig no 10: Total and Directional Deformation

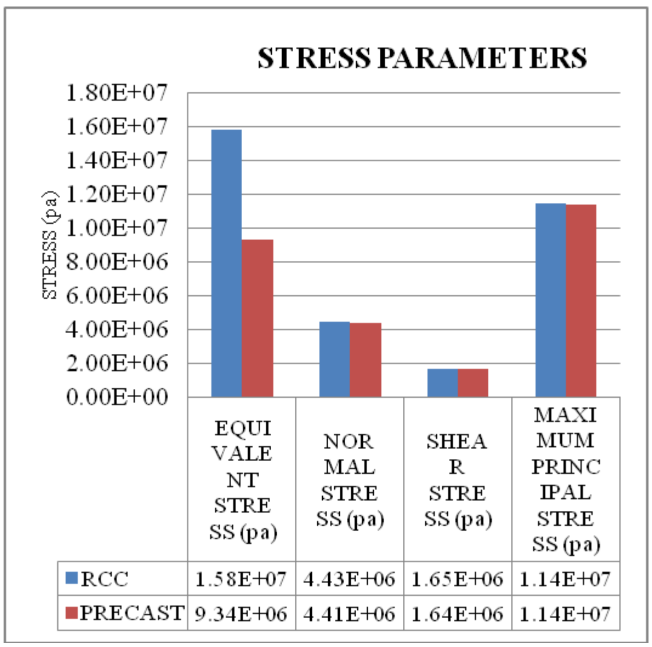

Fig no 11: Normal, Shear, Equivalent, maximum principal Stress

2. For T shape beam column connections result

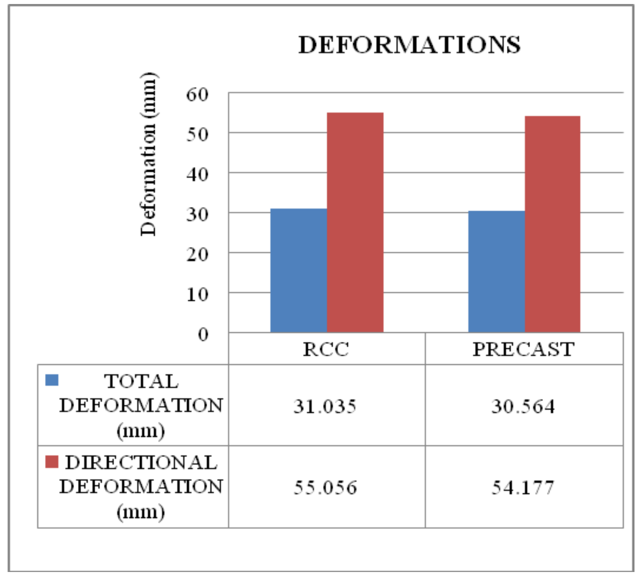

Fig no 12: Total and Directional Deformation

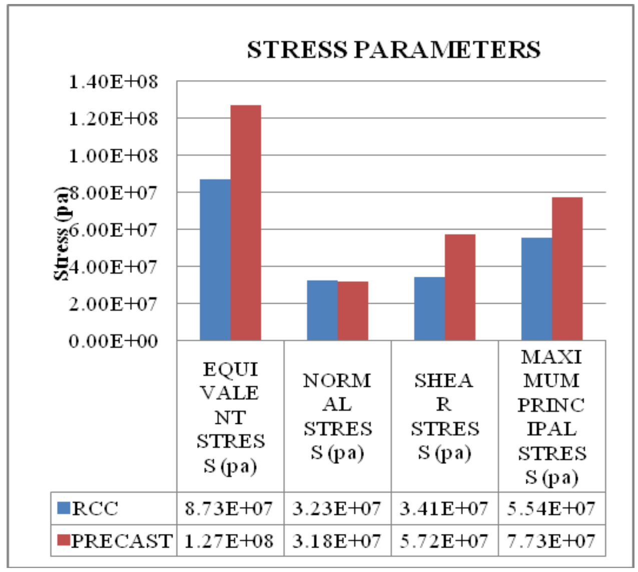

Fig no133: Normal, Shear, Equivalent, maximum principal Stress

From that graph they have to show the actual reading about the structures. In that graph we are taking this value from the mechanical model in Workbench 16.0. In RCC and Precast connections have been show that the actual load carrying capacity of precast beam column connection is stronger than RCC. The stress parameter has been shown that the precast system is more loads taking as compared to RCC. Also the deformation graph they have to show the total and directional deformation of RCC system is more as compared to precast system.

VII. CONCLUSION

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

1. The maximum deformation, stress parameters are reduced by 15-20 % in to Precast beam column connections as compared to RCC beam column connections.
2. From the analytical study of the different shape of the beam column connection has been shown that the Precast system is more as compared to RCC.
3. Deformation (Total and Directional) of precast connection system is more than RCC.

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