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Performance Evaluation of Dry Precast Beam Column Joints

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ABSTRACT:

The beam column joint is one of the most important considerations in the structural design of precast concrete structures. The purpose of beam column joint connection is to transfer loads, restrain movement and provide stability. Joint connections can be considered as crucial zones for the transfer of loads effectively between the connection elements in the system. In the present investigation, the details of two dry beam column connections have been presented. Two reduced scale beam column joints have been cast and tested for incremental static loads. Couplers and dowels have been used for the connections in the first and second joint respectively. Test results like deflection, failure loads have been presented and also the results are compared with a monolithic beam column joint.

INTRODUCTION:

Nowadays the concept of precast concrete is used in many countries because of its advantages over ordinary concrete.

Precast components are made in plants and later it was transported to the site locations. Precast concrete has severaladvantages like high quality, efficiency of the construction is more when compared to insite construction, time saving.

Portion of column that are common to beams at their intersections are known as beam-column joints. Joints have less force carrying capacity in the structure system. During heavy forces like earthquakes, joints are subjected to these loads and damaged severely. Joints are difficult to repair, so mostly joints damage must be avoided. It also reduces beam capacity in the structure.

So, the design of connections of the concrete members is most important considerations in the precast concrete frame structure.The purpose of connection is to restrain movement,to provide stability and load distribution of the system.Within one joint there may be several load transfers, each one must be designed for adequate strength and ductility and appropriately detailed.

OBJECTIVE OF THE PRESENT STUDY:

The obiective of the present study is to obtain efficient dry precast beam column joint by conducting experimental study on monolithic connection and a precast connectins. The load displacement behavior were compared in this paper.

LITERATURE REVIEW

Dolan and Pessiki [1] demonstrated the characteristics of a welded monotonically loaded precast concrete member connection can be simulated using models. Tests of one-quarter scale models of a single beam to column connection were conducted. Good agreement of the model and the prototype was found between the strength and the normalized moment rotation response. The effects of weld quality and design eccentricities had similar consequences in both model and prototype.

Ersoy and Tankut [2]conductedtest on precast concrete beams with dry joints which is designed for multi-storey buildingswhich located in a seismic area for reversed cyclic loading conditions. Beam consisted of two plates made of steel one at top and the other one is at the bottom, which is welded to the anchored steel plates in the column bracket and the beam. The design was later revised by adding side plates to the members. The main variables of the system is the presence of side plates and joint width. The authors concluded that the joint width is an important parameter for a structural system and therefore tolerances should be checked carefully during erection. The strength, stiffness and energy dissipation of the member with side plates were comparable to those of monolithic member.Loo and Yao [3]conducted experimental investigations on eighteen half scale interior connection models to evaluate their structural member strength and ductility properties under both static and repeated loading. It was concluded that under both loading conditions, the precast connections attained a higher flexural strength and larger energy absorbing capacities than monolithic connections.

Khaloo and Parastesh[4]carried out an experimental study to investigate for simple moment-resisting precast concrete beam-column connection of the system under cyclic inelastic loading. They have tested on the connection length of reinforcements and also on presence of transverse bars at the mid height of connection. It was concluded that the reduction in connection length reduced strength, ductility and energy absorption. The failure mode changed toward partial separation and slippage of bond between the precast concrete beam and the cast-in-place grout. The presence of transverse bars in the connection length enhanced the seismic behaviour of the precast connection system.

Li B,Kulkarani S.A, Leong C.L. [5]conducted both experimental and analytical investigations of hybrid-steel concrete connections under cyclic load reversals. The precast specimen's tested and their performanceof connections was good at exhibiting adequate ductile behaviour even under seismic loading and it was also agreed that, well with cast-in-place specimen. Embedment of the tested steel sections specimens in the joint greatly enhanced the strength of the joint core with the specimens carrying storey shears up to a ductility factor of 3.5.

EXPERIMENTAL INVESTIGATION:

The deficiencies of a structure can be associated with design, detailing, construction methods adopted and structural modification of the structure. In this experimental study, loading was applied to beam-columnjoint and the behaviour of joint is observered up to failure of the member.

Tests were carried out in Concrete laboratory.

Material Characteristics:

Ordinary portland cement of 53 grade was used for both monolithic and precast members. M50 grade concreteand Fe 500 grade steel was used for longitudinal, transverse and shear reinforcement purpose.

Details of Specimens:

For testing model, the dimension of column was 200 x 200 mm and length of column is 900 mm. dimension of beam was200 x 200 mm and length of beam is 600 mm.

Types of Connections:

Monolithic Connection:

Monolithic connection reinforcement of the beam consists of six bars, provided each corner with one bar of 10 mm diameter. Three bars provided at bottom as tension reinforcement and three bars provided at top as compression reinforcement. For shear reinforcement, provided stirrups of 8 mm diameter with 75 mm spacing with total no of 7 stirrups for beam. Provided development length of 200 mm The column reinforcement consists of eight number of 12 mm diameter bars. Lateral ties provided at 75 mm spacing and total no.of ties are 12.

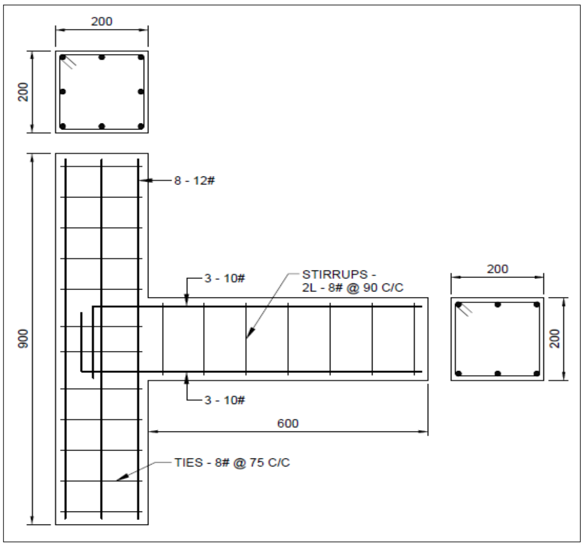

Figure 1: Monolithic Beam

Precast Connection using couplers:

In this type of connection the main connecting elements was couplers. The beams are connected to the columns by using 12 mm diameter couplers. For this type of connection beam reinforcement has 4 no of bars of 12 mm diameter provided at each corner. Column reinforcement has 12 mm diameter of 8 no of bars with 12 mm ties for shear reinforcement with spacing 75 mm total no.of ties provided were 12. Beam reinforcement bars was threaded rebars connections members was inter connected with couplers over threaded rebars.

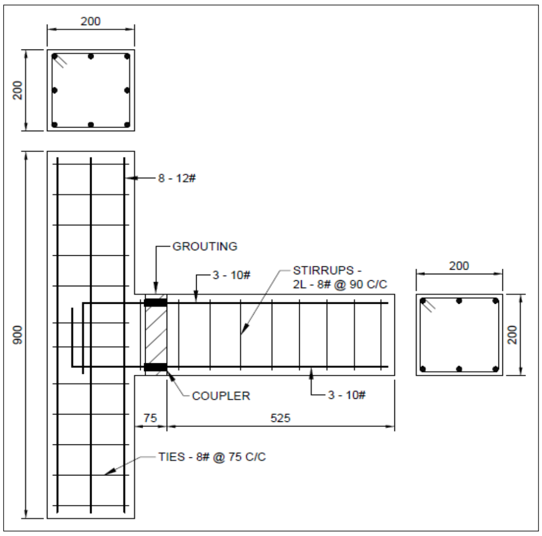

Figure 2: Precast Connection using Couplers

Precast Connection using MS Pipes:

In this type of connection the main element used was MS Pipes (Mild Steel pipes). Mild steel pipes were used in washing machine in olden days. In this type of connection, beam reinforcement has 6 bars of 10 mm diameter. For column reinforcement has 8 no.of 12 mm diameter, each side 3no .of 12 mm diameter bars. MS pipes were connected to projection bars of the precast members and later it was concreted.

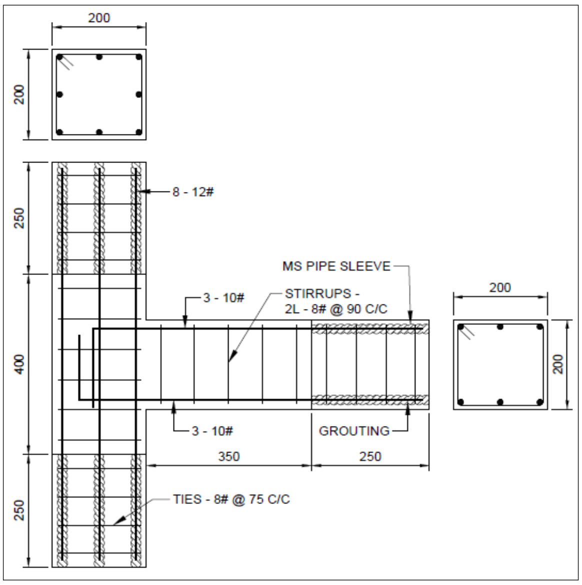

Figure 3: Precast Connection using MS pipes

Experimental setup:

The experiments of the connections were carried out on a loading frame having beam capacity of 25tonns. Hydraulic jack was fixed to the loading frame for applying loads on the structrumembers.

RESULTS AND DISCUSSIONS:

Monolithic Connection:

Figure 4: Monolithic Connection Testing set up

Figure 5: Crack formation in Monolithic Connection

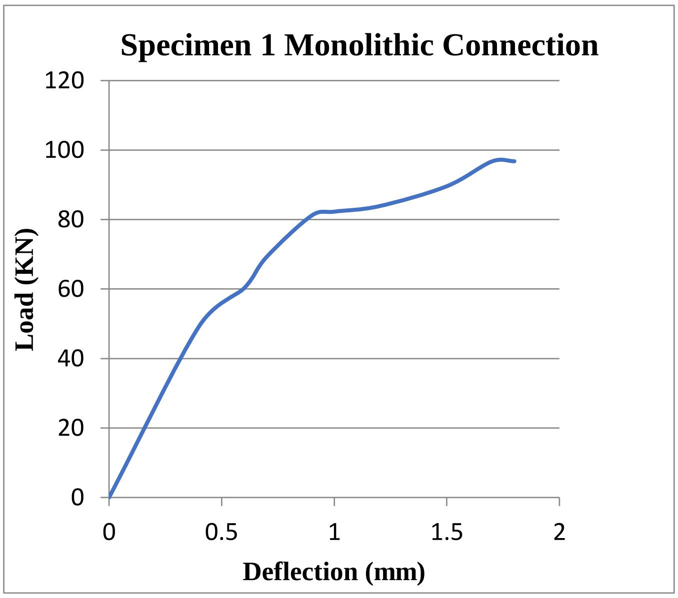

Figure 6: Load v Deflection graph for Monolithic Specimen

S.No	Ultimate Load(KN)	Deflection (mm)
1	96	1.8

Table 1: Ultimate load and Deflection for Monolithic Connection

Precast Connections using Couplers:

Figure 7: Precast Connection using Couplers test set up

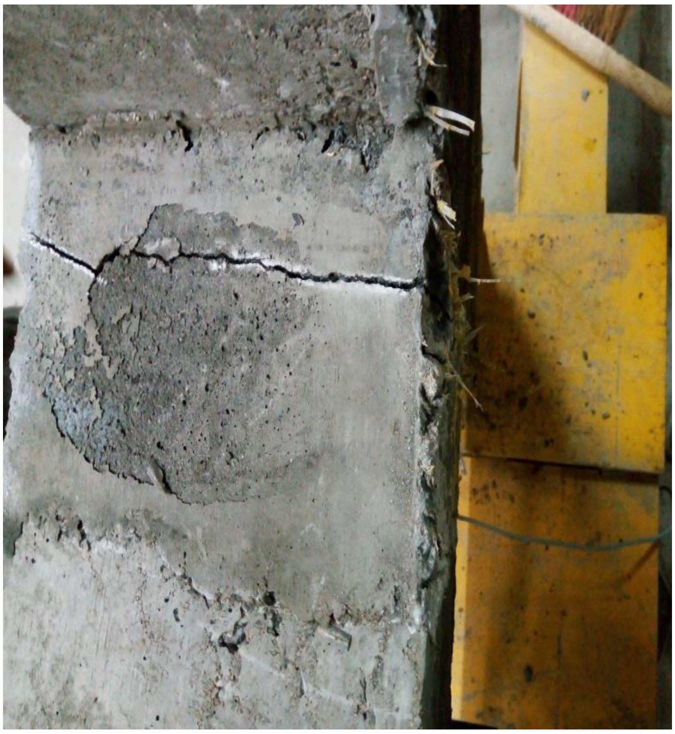

Figure 8: Precast connection using coplers

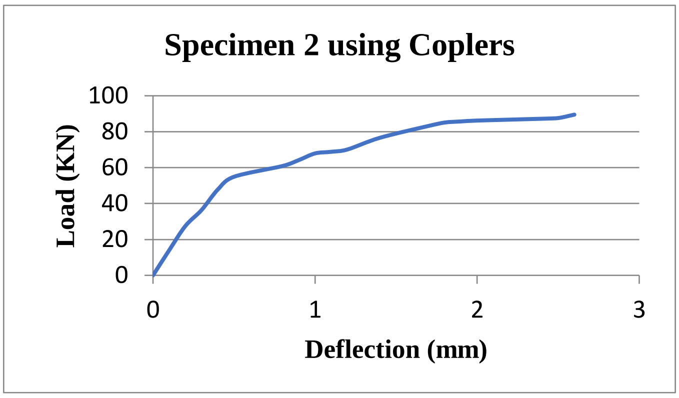

Figure9: Load v Deflection graph for precast specimen with couplers

S.No	Ultimate Load(KN)	Deflection (mm)
1	89	2.6

Table 2: Ultimate load and Deflection for precast connection using couplers

Precast Connection using MS Pipes:

Figure 10: Precast connection using MS Pipes testing set up

Figure 11: Crack formation of Precast connection

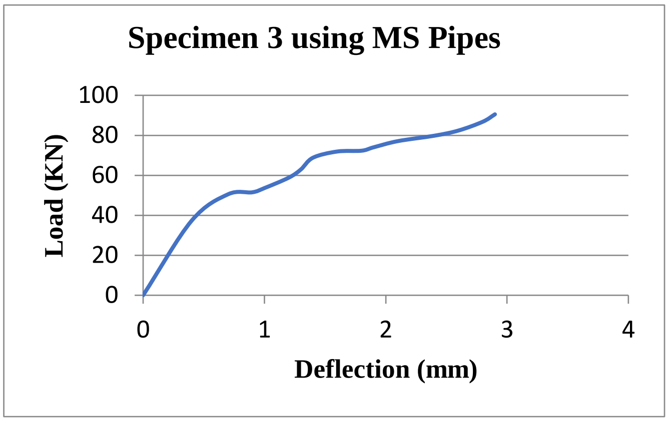

Figure 12: Load v Deflection graph for Precast Specimen with MS pipes

S.No	Ultimate Load(KN)	Deflection (mm)
1	91.5	2.9

Table 2: Ultimate load and Deflection for precast connection using MS Pipes

Ultimate Load

The above figures shows the ultimate load of the dryprecast specimens and the monolithic specimen. The ultimate load of dry precast specimen with MS pipes was found to be 4.68% less compared to the monolithic connection. This may be due to lack of space for concreting as the pipe sleeves occupied most of the space. Similarly, dry precast specimen with coupler had 7.2% less ultimate load compared to the monolithic specimen. This may be due to improper tightening of the rebars in the couplers.

Deflection

The figures 5, 7 and 9 show the load vs deflection graph for all the three specimens. The deflection of monolithic was found to be reasonable compared with the theoretical calculations. Both the dry specimens showed ductile behavior as the deflections were more for the same loads compared to the monolithic specimen.

CONCLUSIONS:

Two dry precast beam column joints which are used at sites were tested along with a monolithic specimen which showed promising results. The specimens were tested for static loads. The following conclusions were drawn from the above experimental work

1. The ultimate load carrying capacities of DC1 and DC2 were lesser than the monolithic connection by a margin of 4.68% and 7.2% respectively. The performance of the precast specimens could have been higher, if quality of work and the issues in concreting were overcome.
2. The deflections of DC1 and DC2 were 2.9 mm and 2.6 mm respectively and the monolithic specimen had a deflection of 1.8 mm. The precast specimens were found to be more ductile compared to the monolithic specimen.

The study can be extended for the cyclic behavior of joints to better understand the seismic performance.

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