

Behaviour of Horizontal Connections in Precast Walls under Lateral Loading



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Abstract: *The design of connections is one of the most important considerations in the structural design of precast concrete structures. The purpose of the connection is to transfer loads, restrain movement and provide stability. Within one joint there may be several load transfers, each one must be designed for adequate strength and ductility and appropriately detailed. The proposed investigation aims to achieve efficient horizontal connections in precast walls with improved structural performance under various loads. HYSD reinforcement dowels are used as connectors. The arrangement of dowels is varied to achieve the efficient load transfer in the walls. The experimental investigation on three precast wall and one monolithic wall depicts that the precast wall exhibits high strength than the monolithic wall specimen and structural performance were found to be better than the monolithic wall specimen and also the efficient load transfer is achieved in the precast wall.*

Index Terms: *connections, strength, precast walls, load transfer*

I. INTRODUCTION

Today precast technology is widely used all around the world as a part of building structures particularly in developing nations. By adopting precast technology in buildings is a most beneficial way as it contributes less manpower, quality of the finished products, speedy erection of units, timely completion of projects safely, economically and thereby improving the productivity of the project day by day. The precast units can also be utilized as composite structures by combining with the structural steel sections. The shear wall stands as a lateral load resisting system in precast buildings due to their high initial stiffness and lateral load capacity and the inelastic deformation of connections offers potential for high ductility and energy dissipation capacity in concrete structures.

The design of connections is a standout amongst the most critical thought for the effective development of precast strengthened solid structures. The design of connection influences the constructability, solidness, quality, adaptability in the structure. Along these designers should

design the connection part to guarantee that strengths are exchanged between the precast wall panels adequately. Dry joints are built by blasting or welding together with steel plates. Welded connections can be utilized to interface components by warming through projecting bars or utilizing plates. It was discovered that welding through surface wetness can possibly increment smaller scale discontinuities and make noticeable splitting. In the meantime, wet joints are developed with thrown in-situ cement or grout that is poured between the precast panels. Congruity support bars can be accomplished when steel bars are put over the joints by which the shear strengths can be exchanged between the components.

The performance of the vertical connection between walls when subjected to incremental lateral load has been evaluated in terms of stress, deformation and absolute plastic strain by developing 3D finite element modeling of precast wall and its connection. From the analytical results it is evident that the crack has occurred along the bottom of the wall and along the connection part simultaneously rebars provided in the connection part experience more stresses and failure occurred near the interface of both the walls and therefore vertical connection has also low efficiency in terms of capacity against lateral loading and consequently it can be claimed that the common connection role can be ignored in the lateral in plane loading. Researchers had conducted study on connection between interior and exterior wall by using loop bars as connectors and the main purpose is to determine behavior of loop bars under shear load. The wall panels has been casted and tested under uniformly distributed load and mostly crushing and spalling of concrete occurred at the joint portion and connections were found to be ductile from the behavior of the wall panels and it is within the permissible limits.

The seismic performance of precast concrete wall with and without opening has been evaluated under quassi static horizontal loading on precast walls and tests results revealed that extensive cracking, reinforcement yielding and concrete crushing occurred in the wall panels meanwhile behavior is analyzed numerically by finite element modeling and by comparing both experimental and analytical results the precast wall with small openings dissipated more energy than wall with large openings. The relative strength and response of the commercially available ties in wall panels has been studied experimentally and analyzed and failure modes and response were quantified and from the experimental results shear ties used in wall construction have considerable variation in strength,

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stiffness and deformation and results has been used to develop trilinear relationship to approximate flexural responses of sandwiched wall panels. The potential methods such as bonded or unbonded longitudinal bars with partially reduced cross section and RC-PC hybrid wall had been proposed and four specimens were casted and tested under cyclic loading.

The experimental test moment capacity were estimated at critical section and curvature was obtained by differential strain and yield strain and maximum moment curvature had been calculated and the proposed RC wall panel prevented gap opening and shear slip at the panel joint. In the present study performance of horizontal connections on precast shear wall is evaluated by using HYSD steel reinforcement as connectors and also structural performance of the same under various loads experimentally. In the experimental study the reduced scale models of monolithic wall and three precast concrete wall has been casted and tested simultaneously under various loads to determine the structural behavior of connections and strength of the joints and the failure loads In precast wall arrangement of dowel bars has been varied accordingly to achieve efficient load transfer in the walls.

II. METHODOLOGY

A. Specimens

Three specimens of reduced scale precast shear wall and one monolithic wall has been designed according to the Indian code standard. From the design of shear wall the amount of reinforcement to be provided has been founded out and thus precast wall reinforcement is detailed accordingly. The geometry of the wall specimen is 950mm in length, 400mm in width and 80mm in thickness for monolithic wall specimen and for three precast wall specimens namely PW1, PW2 and PW3 width and thickness are identical but wall is of two parts lower panel is of 300mm in length and upper part is of 650mm in length. In regarding reinforcement detailing 8mm rebar mesh is used for foundation slab provided on both top and bottom faces, 6mm rebar is used as main reinforcement for wall and same 6mm rebar is also used as distribution reinforcement for wall. In the case of precast wall PW1, PW2, PW3 same reinforcement pattern is used for foundation slab and also for the wall part, but 10mm dowel bars is provided in additional for connecting both lower and upper wall panels and it is varied accordingly as two, three and four nos in each precast wall. In order to arrive at suitable design mix ratio of concrete preliminary tests such as sieve analysis, specific gravity, bulk density, bulking of sand and aggregate impact value are conducted in laboratory to know about the physical properties of materials.

In experimental work one monolithic wall and three precast wall has been casted and tested accordingly to determine the structural integrity and behavior of horizontal connections on precast wall panels. The support condition had been considered as fixed at one end and free at other end so that it acts as a cantilever and all translational degrees of freedom are constrained at bottom. Before casting of wall specimens cutting and setting of formwork, bar bending schedule had been done to arrive at steel quantity. From the above calculations cutting, bending and tying of rebars had been done and assembled in the formwork, after assembly of

reinforcement verticality of rebars is checked accordingly.

The concrete casting had been done in two stages for monolithic wall the first being the foundation slab and then wall part is casted, meanwhile in the case of precast wall (PW1, PW2, PW3) the casting has been done in three stages first being the foundation slab part and second being lower wall panel upto 300mm height from top of the slab with projecting dowel bars that acts as an anchorage for fixing the upper panel over it. The upper wall panel had been casted separately with pipe sleeves embedment and then it is erected over the lower wall panel. During concrete casting cubes, cylinders and prisms are casted simultaneously to determine the compressive strength of the M30 concrete. All specimens are cured for a period of 28 days after which the gap in the joints and in the pipe sleeves have been sealed with help of the grouting chemical conbextra GP2 once grouted curing has been done for the next successive three days. The following figures below present the reinforcement, formwork arrangement and casted precast as well as monolithic wall specimen.



Fig 1. Monolithic wall



Fig 2. Precast Wall Dowels

B. Testing

The schematic representation of test setup is shown in figures 10 & 11. The wall specimen is fixed to the floor of the loading frame and it is held rigidly by four T section placed on either side of the slab with two on each side,

cylindrical steel beam and other support systems are provided on the either side of the slab to keep the specimen in fixed position and to prevent the lateral movement and rigid body rotation between wall specimen and floor of the loading frame under the applied static lateral load. In addition to the above side supports hydraulic bottle jack of 5ton capacity has also been provided on both left and right side to prevent wall movement.

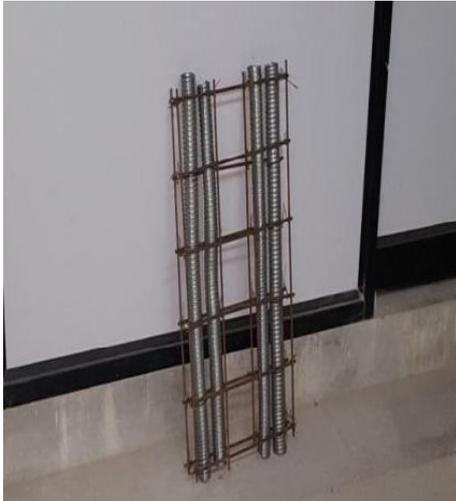


Fig 3. Precast wall – pipe sleeves



Fig 4. Precast Wall – assembly

The test frame had been provided connecting the wall specimen and the load cell for push and pull arrangement of wall. The test frame consists of two parts steel channel section on one side and hollow box steel section on another side these two sections in turn are connected by 6mm thick angle of length 580mm and 20mm diameter bolts have been used as connectors for connecting two section with the angles and thereby making an clear distance of around 400mm facilitating fixing of wall inside the test frame.



Fig 5. Test Setup

III. RESULTS & DISCUSSION

After the application of static lateral load following changes had occurred in monolithic wall the overall crack has occurred in the joint portion between wall and the slab and the sides of the wall portion near the joint had broken due to application of incremental lateral load. In the case of precast wall PW1 crack distribution had occurred near the joint between lower and upper wall panel and crack is predominant along the front side of the precast wall and few inclined cracks also appeared along with the major crack near the joint. In precast wall PW2 specimen the overall crack formation were similar to that of the above mentioned precast wall here the crack had formed only along the rear side of the wall near the precast joint along with few air line cracks and finally the precast wall PW3 few air line cracks appeared along the sides of the precast wall but after certain incrementation of load upper wall panel slightly dislocated from the lower wall panel. The following figure shows the failure pattern in monolithic wall, precast wall PW1, precast wall PW2 and precast wall PW3.



Fig 6. MW Cracking

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Fig 7. PW1 Cracking



Fig 8. PW2 Cracking



Fig 9. PW3 Cracking

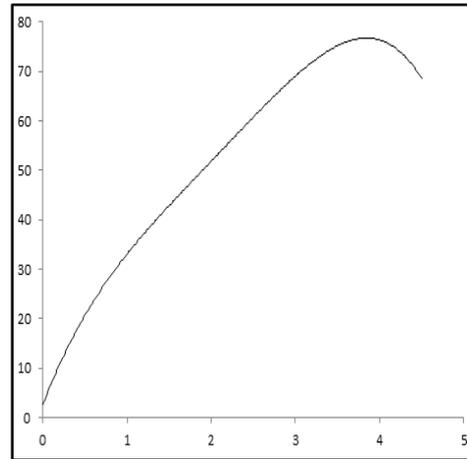


Fig 10. MW Load vs Def.

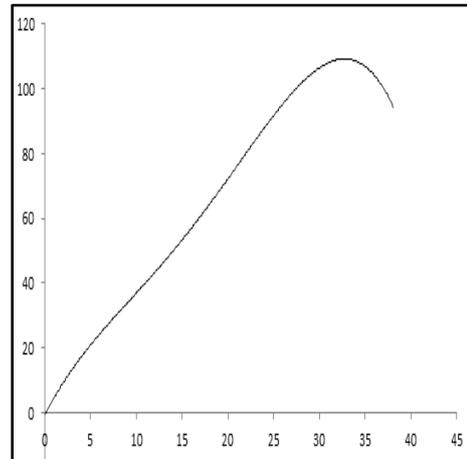


Fig 11. PW1 Load vs Def.

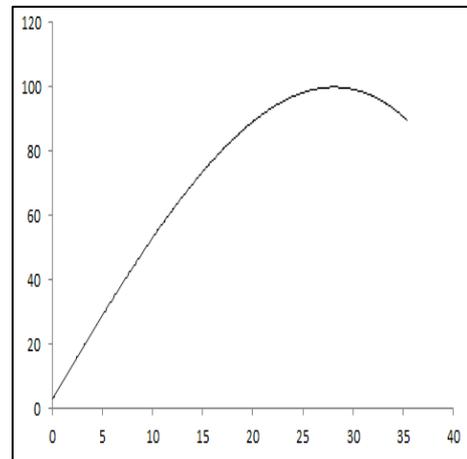


Fig 12. PW2 Load vs Def.

From the collected data of monolithic wall, precast wall PW1, precast wall PW2 and precast wall PW3 graph has been plotted between load and deflection with deflection on x-axis and load on y-axis for each wall and failure load were determined. The following graphs shows the load and deflection behavior of the above mentioned walls and table below shows the maximum deflection and ultimate loads of above mentioned walls.

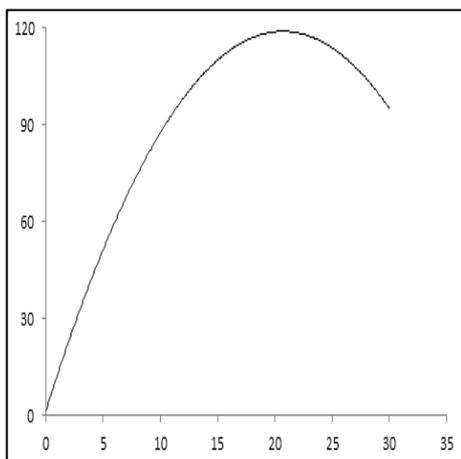


Fig 13. PW1 Load vs Def.

Table 1: Ultimate load and deflection

Wall Type	Ultimate Load	Deflection
MW	77.4 kN	3.4 mm
PW1	107.4 kN	32.3 mm
PW2	100.1 kN	27.54 mm
PW3	114.5 kN	23.4 mm

From the above graphs failure load for each wall had been determined and it is found to be for monolithic wall it is 77.4 KN, precast wall PW1 it is 107.4 KN, precast wall PW2 it is 100.1 KN and finally for precast wall PW3 it is 114.5 KN. When compared to the monolithic wall load had been increased apparently for precast wall PW1 by 38.75%, precast wall PW2 by 29.32% and precast wall PW3 by 47.93%. Comparing the percentage increase of three precast wall PW3 had founded to be higher than the other precast walls. From average of the percentage increase it precast wall strength is 38.67% more than that of monolithic wall and therefore it is recommended that precast wall provides more strength and higher stiffness than that of monolithic wall.

IV. CONCLUSION

From carried out experimental investigations on three precast wall specimen namely PW1, PW2&PW3 by varying the dowel bar arrangement in each wall following research results have been found when compared to monolithic wall specimen the precast wall specimen are found to exhibit high strength and stiffness than monolithic wall specimen. The increase in cross section area of dowels bar in precast wall contributes to increase in strength and stiffness. Therefore the structural performance of precast wall was found to be better when compared to monolithic wall.

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