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A Review on Non-Linear Finite Element Analysis of Precast Beam Column Connection Subjected to Time History

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ABSTRACT: Precast construction are now a days generally been adopted in various residential and commercial projects. In this paper the RCC beam column junction is compared with precast beam column load. Initially beam-column junctions are analyzed for static linear point load which increases with time. The analysis is done by FEM tool ANSYS workbench. The stress-strain curve, load-deflection curve, normal stress and strains are compared for given model. In later stage time history analysis is proposed for various zones for same models. A new precast concrete beam-to-column connection for moment-resisting frames was developed in this study. Both longitudinal bar anchoring and lap splicing were used to achieve beam reinforcement continuity. Later part validation is proposed from experimental results of literature review

KEYWORDS: Text detection, Inpainting, Morphological operations, Connected component labelling.

I. INTRODUCTION

High storey precast frame panel buildings performed poorly in the 1988 Spitak, Armenia earthquake due the lack of adequate seismic design considerations such as ductility in precast joints (Hadjian, 1993). A significant number of parking structures suffered extensive damage and a number of precast concrete parking structures collapsed in the 1994, Northridge earthquake. One of the reasons for the collapse was lack of proper diaphragm connections (Mitchell et al., 1995). The lessons learnt from the past earthquakes are that the connections are the weakest link. Hence more research is required in the study of connections. 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.

Development of specific procedures for the estimation of seismic vulnerability of existing precast structures represents a key step not only when relevant structures are concerned, but also when rehabilitation and functional re-planning of large urban areas have to be carried out. From a technical point of view, problems related to rehabilitation and seismic upgrading of existing precast buildings are different; first of all, aspects related to non-destructive techniques are involved for what concerns the definition of mechanical and geometrical properties of members and also of the degradation of base materials; another important point is the assessment of reinforcement (prestressing tendons, deformed and smooth rebars). 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.

The seismic safety of precast structural systems represents a subject for investigation which is very much of a current interest worldwide. In many structures, some of the structural elements are designed as seismically resistant, whereat the remaining ones sustain only gravitational loads inappropriate floor structures that don't have the capacity to transfer inertial forces to the seismically resistant vertical elements. Predominant type of the precast (industrial) building in Europe consists of columns tied together with beams. Among many types of different connections between

precast elements, the connection using steel dowel is most common. The existing analytical and experimental investigations as well as the experience gathered from the occurred earthquakes are not sufficient enough for throwing light on their seismic behavior.

II. LITRATURE REVIEW

Ehsan NoroozinejadFarsangi et. al. [1] studied finite element analysis on 4 types of precast connections which are pinned, rigid, semi rigid and a new proposed connection. The stiffness of the new connection was obtained from the slope of the total load versus deflection graph in the elastic range. Then the seismic loading from El Centro earthquake modified with 0.15g and 0.5g were applied to the whole structure. He concluded from the analysis results that new connection has sufficient stiffness, strength and also higher ductility. Meanwhile, the whole structure analysis results showed that the new connection behaves as semi rigid connection. LUSAS and SAP2000 were used for analysis.

R.A. HawilehLanke et al [2] Studied nonlinear finite element analysis and modeling of a precast hybrid beam–column connection subjected to cyclic loads. A detailed three-dimensional (3D) nonlinear finite element model was developed to study the response and predict the behavior of precast hybrid beam–column connection subjected to cyclic loads that was tested at the National Institute of Standards and Technology (NIST) laboratory. The model had taken into account the pre-tension effect in the post-tensioning strand and the nonlinear material behavior of concrete. The model response was compared with experimental test results and yielded good agreement at all stages of loading. Fracture of the mild-steel bars resulted in the failure of the connection. In addition, the magnitude of the force developed in the post-tensioning steel tendon was also monitored and it was observed that it did not yield during the entire loading history. He concluded that successful finite element modeling will provide a practical and economical tool to investigate the behavior of such connections.

Vidjeapriya. R et al [3] Developed a 3-D nonlinear FE model to study the response of an exterior precast beam to column connection subjected to reverse cyclic loading. Tests of a one-third scale exterior beam column precast concrete connections was conducted. Two types of connections were compared. The connections included a monolithic connection and two precast beam - column connections (i) using J-bolt (ii) using Cleat Angle. ANSYS finite element software was used for the non-linear analysis of the precast beam column connection. For the nonlinear analysis, one-third scale model was developed. Two types of elements were used including solid elements and contact elements. The finite element analysis results compared well with the experimental data. It is concluded that if the material constitutive relation and failure criterion can be selected suitably, the finite element model can accurately predict the overall seismic behavior and the inelastic performance of these two kinds of joints.

De-Cheng Feng et al [4] developed a finite element modeling approach for the analysis of the cyclic behavior of precast beam-to-column connections. The modeling takes into account the compression-softening of concrete, the bond-slip effect in the critical regions and the representation of the post-cast concrete interface. A newly developed softened damage-plasticity model, which can reproduce the typical cyclic behavior of reinforced concrete, was adopted for concrete. Meanwhile, to reflect the significant bond-slip effect between concrete and reinforcement bars, the M-P stress-strain model is modified to account for the slippage by assuming the bar strain was the sum of the bar deformation and the slip, while the anchorage slip is theoretically derived and validated through benchmarking the pull-out tests. Additionally, a concrete layer between the precast concrete and the cast-in-situ concrete was incorporated to reflect the features of the interface. The proposed numerical modeling approach was validated through simulation of both interior and exterior precast beam-to-column connection tests. The validated models were subsequently employed to investigate the influences of key factors such as the compression-softening and the bond-slip effect on the analysis of the cyclic behavior of the precast beam-to-column connections. Results demonstrated that the proposed model was capable of reproducing the typical behavior of precast beam-to-column connections and can serve as an effective tool for the seismic performance analysis and investigation of design parameters of precast connections.

Sadik Can Girginaet al [5] studied the seismic performance factors for precast buildings with hybrid beam-column connections. Hybrid connections were constructed by welding of corbel plates to beam end plates where beam longitudinal re bars were welded, and casting of concrete through the designated gaps in beam tops and column elements at site. Their study presents the development of a numerical model for hybrid connections to be used to assess seismic performance of multi-storey precast concrete structures. The numerical model included truss-based elements for beam-column connections and fiber-based elements for beams and columns. Lateral load-drift ratio relations for the

measured and computed cyclic responses of a precast connection were compared. In addition, two-dimensional three- and five- storey precast concrete frames were designed for seismic performance evaluation. Frame models were analyzed by performing nonlinear static pushover analyses and incremental dynamic analyses with representative ground motions. Response modification factors were obtained and evaluated for seismic design of precast concrete buildings.

Shao-Bo Kang et al [6] studied behavior of precast concrete beam-column sub-assemblages subject to column removal. The behavior of precast concrete sub-assemblages which comprised two precast beams and a precast column joining together by cast-in-place concrete topping above the two beams and the beam-column joint. The top longitudinal reinforcement in the structural topping of precast beams passed through the beam-column joint continuously. However, the bottom beam longitudinal reinforcement was either lap-spliced or anchored as a 90° bend within the cast-in-place joint. Due to discontinuity of bottom beam longitudinal reinforcement, the ability of such an assemblage to develop compressive arch action (CAA) and subsequent catenary action has to be investigated, in particular, the effect of the top and bottom beam longitudinal reinforcement ratios. Test results showed that significant CAA and catenary action developed in the beams under column removal scenarios, with pull-out failure of the bottom beam reinforcement in the joint. The effectiveness of horizontal shear transfer between concretes cast at different times was examined at large deformation stage. Finally, practical suggestions were given to enhance structural resistance of a similar type of precast concrete sub-assemblages.

Liu Jin et al [7] studied shear failure, behavior of reinforced concrete (RC) beam-to-column joints having different structural sizes, especially full-scale joints, and to evaluate the possibility of the existence of size effect on the corresponding nominal shear strength of the RC joints. The test results of geometrically similar interior RC beam-to-column joints with the joint width ranging from 300mm to 900mm under both monotonic and cyclic vertical loadings were reported in their study. The effects of stirrup ratio and loading type on the seismic shear failure behavior at the core region of the joints were also studied. The size effect of the corresponding nominal shear strength of the RC beam-to-column joints was also explored. Their experiment results concluded that the failure modes of RC beam-to-column joints with different structural sizes were similar. There was a significant size effect, namely, the larger the structural size of the joint, the smaller the nominal shear strength at the core region of the joint. Increasing the structural size causes poor ductility capacity, fast degradation of stiffness and more dissipation energy. Moreover, cyclic loading makes the size effect on shear strength of RC joints stronger. The stirrups weaken the size effect on shear failure since the tested shear bearing capacity was mostly carried by the concrete part.

III. METHODOLOGY

Response spectrum analysis is a procedure for computing the statistical maximum response of a structure to a base excitation. Spectra which determine the base acceleration applied to each mode according to its period (the number of seconds required for a cycle of vibration). Response spectrum analysis produces a set of results for each earthquake load case which is really in the nature of an envelope. It is apparent from the calculation, that all results will be absolute values - they are all positive. Each value represents the maximum absolute value of displacement, moment, shear, etc. that is likely to occur during the event which corresponds to the input response spectrum.

The definition of the proposed numerical model was made by using finite elements available in the ANSYS code default library.

IV. CONCLUSION

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

- The result for Maximum Deformation for all models, the results conclude that the Deformation for precast model no 1 is less than the other precast patterns and RCC model, by around 5-10% for precast models and 30-40% for RCC model
- The result for Normal Stress for all models, the results conclude that the Normal Stress for precast model no 3 is less than the other precast patterns and RCC model, by around 15-20% for precast models and 40-50% for RCC model

- The result for Shear Stress for all models, the results conclude that the capacity of Shear Stress for RCC model is less than the other precast patterns, by around 30-35%
- The result for Maximum Principal Stress capacity for all models, the results conclude that the capacity of Maximum Principal Stress for RCC model is less than the other precast patterns, by around 40-45%
- The maximum deformation are reduced by 15-20 % in to Precast beam column connections as compared to RCC beam column connections.
- From the analytical study of the different shapes of beam column connection it is found that the precast connection is more effective as compared to RCC.
- The Normal Stresses, Shear Stresses, Equivalent stresses, Principal stresses are observed more at connecting elements of precast.
- The time history analysis result for Total Deformation mm for all models, the results conclude that the Total Deformation mm for RCC model is greater than the other precast patterns, by around 10-20%, and less for model no 3
- Above graph shows the time history analysis result for Shear Stress for all models, the results conclude that the Shear Stress for RCC model is greater than the other precast patterns, by around 25-30%, and less for model no 3
- The time history analysis result for Max. Principal Stress for all models, the results conclude that the Max. Principal Stress for RCC model is greater than the other precast patterns, by around 20-25%, and less for models no 3
- The time history analysis result for Normal Stress for all models, the results conclude that the Normal Stress for RCC model is greater than the other precast patterns, by around 10-15%, and less for models no 3
- The time history analysis result for Equivalent Stress for all models, the results conclude that the Equivalent Stress for RCC model is greater than the other precast patterns, by around 10-15%, and less for models no 3

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