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NON LINEAR ANALYSIS OF BEAM COLUMN JOINT WITH GEOPOLYMER

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ABSTRACT:

The ancient Romans used concrete and poured it into moulds to construct a sophisticated network of aqueducts, culverts, and tunnels. Pre-cast technology is now used in a range of architectural and structural applications, from individual components to full building systems. When an earthquake strikes a reinforced concrete structure, the beam-column junctions are critical zones. Due to the huge stresses and moments generated by significant ground shaking, concrete in the joint location cracks diagonally and crushes. Thus, for the design of beam-column junctions, extremely ductile materials are necessary. There are three types of beam-column joints: interior, exterior, and corner. The purpose of this research is to analyses RCC buildings for dead loads, live loads, and earthquake loads in order to identify critical joints and to analyses critical joints in ANSYS for axial forces, shear forces, and bending moments, as well as the impact of utilizing a geopolymer layer.

Keywords: Beam Column Joint, Geo-polymer, Non Linear Analysis, ANSYS, Staad Pro

I. INTRODUCTION

General:

The beam-column joints are the crucial zones when a reinforced concrete building experiences an earthquake. The large forces and moments produced during severe ground shaking leads to diagonal cracking and crushing of concrete in the joint region. Thus, highly ductile materials are required for the design of beam-column joints. Beam-column joints can be classified into interior, exterior and corner joints. The longitudinal bars of a beam need to be anchored into the column to ensure a proper grip, especially in the case of exterior beam-column joints. The capacity of the beam in an exterior joint is governed by the moment created by shear capacity of beam rather than its flexural capacity.

Geopolymer concrete is earning attention nowadays for its low CO_2 emissions and as a sustainable alternative to ordinary portland cement. The term "geopolymers" was first coined by Joseph Davidovits in 1978 to classify a Three-Dimensional (3D) polymeric network of alumino-silicate binders. An alkaline activator solution is used in the geopolymerisation reaction which acts as a catalytic liquid system. GPC can be cured under ambient conditions thus reducing the usage of water compared to conventional curing methods. Heat cured specimens gained strength immediately but more compressive strength was obtained for specimens which were cured in ambient conditions. A combination of Sodium Silicate (Na_2SiO3) and Sodium Hydroxide (NaOH) solutions are commonly used in the production of Geopolymer Concrete (GPC). The compressive strength of GPC specimens increased with the increase in concentration of NaOH so GGBS and fly-ash are the most commonly used source materials in the production of GPC. The usage of GGBS and dolomite together as binders is a comparatively new method in the production of GPC. Ground Granulated Blast Furnace Slag (GGBS) is a by-product released from the blast furnaces of the iron industry. It is evident from the experimental studies that inclusion of GGBS enhances concrete workability, durability, density, compressive strength and reduces the setting time. Dolomite is a by-product from rock crushing industry and contains higher CaO content which can significantly improve the strength of concrete . However, it has never been used in the production of GPC. Hence, it is expected that inclusion of dolomite for preparing geopolymer concrete can yield some better results and reduce its disposal problem as well.

The present study aims to evaluate the behaviour and performance of steel fibre reinforced dolomite-GGBS geopolymer concrete beam-column joints under mono tonic loading using finite element methods. Beam-column joints are modelled by using the Finite Element Method [FEM]-ANSYS to evaluate the response of joints under monotonic loading. Non-linear analysis has been carried out to study the behaviour of the beam-column joint models under gradually increasing monotonic load applied at the bottom of the free end of the beam. The crack/crush patterns, deflections and stresses at various points were evaluated for steel fiber reinforced GPC. lution ratio of Na_2SiO, to NaOH solutions, mixing time, curing time and curing temperature.

1.1 OBJECTIVES

The objectives of this study are specifically given as following.

1. To perform analysis of RCC building for Dead load, live load and Earthquake load to identify Critical joint.
2. To Perform analysis of critical joint for axial forces, shear forces and Bending moment in ANSYS and its effect using Geopolymer layer
3. Comparative analysis of beam column connection using Geopolymer with RCC beam column connection for bending stresses, shear stresses, principal stresses and Deflection
4. To investigate the important aspects of GFRP bars in geopolymer concrete, the flexural and shear behaviour of geopolymer concrete beams longitudinally and transversely reinforced with GFRP bars and stirrups, respectively, and the compression behaviour of geopolymer concrete columns internally reinforced with GFRP bars and ties.

II. LITERATURE REVIEW

A Survey of work done in the research area and need for more research

2.1 June, M. (2017).

Beam and column where intersects is called as joint or junction. The different types of joints are classified as corner joint, exterior joint, interior joint etc. on beam column joint applying quasi-static loading on cantilever end of the beam and study of various parameters as to be find out on corner and exterior beam column joint. The focus of our project is T-shaped concrete frame connection. There was minimum damage on the concrete column and joint panel zone. For a specimen with strong beams-weak columns, there was local buckling fracture on steel tube above and below the joint panel zone. It was found that both axial forces and beam to column linear stiffness ratio had impacts on joint capacity and ductility behavior of the specimens. However, addressed beam-column joints of substandard RC frames with weak columns, poor anchorage of longitudinal beam bars and insufficient transverse reinforcement. The behavior of exterior beam column joint is different than the corner beam column joint.

2.2 Subramani, T., & Piruntha, M. (2018).

Fly Ash based geopolymer concrete is critical to study the fulfillment of a new material in various packages for its use in production of structures and additionally the eco pleasant concrete. For implement this recent material distribution of longitudinal and lateral metal, tie spacing, and the extent of axial load. Model created by ANSYS with 9-feet long columns. Loading will be increased gradually 10KN maximum deflection at 0.051mm at 50KN. The specimens have been subjected to an axial load underperforming FE analysis of RCC column by using ANSYS software. The result shows the appropriate way of using the scientific technique to geopolymer concrete columns subjected to mixed axial load and biaxial bending.

2.3 M. N. Kataoka

Due to the substantial rise in the usage of precast concrete structures in multistory buildings, this work provides a research on the behavior of beam-column connection with focus on the continuity given by the slab reinforcement. Two prototypes were evaluated, each one with a different detail of the continuous reinforcement distribution. In both connections, the steel area utilized on the concrete cover of the hollow core slab was the same, altering the quantity of bars that traveled through the column and the ones that were put next to the column. The testing findings demonstrated that the connection with bars close to the column exhibited stiffness enhancement and a superior cracking control. According to the categorization the two tested connections may be termed semi-rigid.

2.4 Chun-Chieh Yip(2019)

Software simulation enables design engineers to have a better picture of possible structural failure behaviour and determine the accuracy of a design before the actual structural component is fabricated. Finite element analysis is used to simulate the behaviour of the reinforced concrete beam under the flexural test. During the flexural test, results are recorded for both simulation and experimental tests. By comparing the results, beam displacement, crack patterns, and failure modes can be studied with better accuracy. The accuracy percentage for yield load and ultimate load between the two tests results were 94.12 % and 95.79 %, respectively, whereas the accuracy percentage for elastic gradient before the yielding stage was 81.08 %. The behaviour between simulation and laboratory models described is based on crack pattern and failure mode. The progression of von Mises (VM) stresses highlighted the critical areas of the reinforced concrete beam and correlation between the experimental specimen, in terms of flexural cracks, shear cracks, yielding of tension reinforcement, and the crushing of concrete due to compressive stress. This paper concludes that simulation can achieve a significant accuracy in terms of loads and failure behaviour compared to the experimental model.

2.5 R.A. Hawileh et.al(2009)

In this work, a detailed three-dimensional (3D) nonlinear finite element model is 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 precast joint is modeled using 3D solid elements and surface-to-surface contact elements between the

beam/column faces and interface grout in the vicinity of the connection. The model takes into account the pre-tension effect in the post-tensioning strand and the nonlinear material behavior of concrete. The model response is 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 order to predict this failure mode, stress and strain fields in the mild-steel bars at the beam–column interface were generated from the analyzed model. Such fields of stresses and strains are hard to measure in experimental testing. 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. Successful finite element modeling will provide a practical and economical tool to investigate the behavior of such connections.

2.6 B. Abdel wahed(2020)

This study aims to assess numerically the behavior of a wide range of reinforced concrete (RC) components under bending or combined effect of bending and axial compression. Reference case studies of RC beams with different reinforcement ratios and beam-column joints are modeled using LS-DYNA software. When larger time step is used in modeling with implicit solvers, convergence problems may appear at higher degrees of nonlinearities, as the solution is reached through multiple iterations to reach equilibrium at every time step. To avoid these divergence issues, explicit time integration procedure is another alternative and can be used effectively in simulating dynamic problems. With minimizing inertia effects, this procedure can also be used to solve static and quasi static problems. In this study, explicit time integration procedure is utilized and the acting loads were applied slowly to minimize the inertia effects. Consequently, longer run time for the simulation process is needed with explicit time integration. Selective Mass Scaling (SMS) can be used to control the required run time by increasing the model critical time step by adding artificial mass to a limited number of stiff elements like, the transverse reinforcements. With this procedure, similar results to the reference experimental findings are obtained in terms of load-displacement curves, crack patterns and strains in the reinforcements. Models verification with different added masses are shown using grid convergence index (GCI) method. The main objective of this work, is to assess the accuracy of explicit solvers in modeling RC elements under quasi static loading. So that, they may be used with confidence for modelling different RC elements.

VIII. CONCLUSION

- The goal of the comparison of FE analysis results with the experimental test results is ensure that the present finite-element model and analysis are capable of predicting the response of the beam-column joints.
- Comparison between the load-Stress results obtained from finite element analysis for control and Geo polymer specimens shows that the Stress has significantly increased for the Geo polymer specimen. The Stress of GFRP specimens of T shape and L shape- RG1, RG2 and RG3 are 63.15%, 17.04%, 13.04% Less than the Non retrofitted specimen.
- The different configurations of GFRP considered or the specimens were by attaching to the top, bottom and lateral sides of beams. The results show that the stress, Strains are reduced as compared to non Geo polymer specimen.
- As the stress decreased the load carrying capacity and strength increases by using GFRP as compared to non-Geo polymer specimen.
- Cracks are developed at the joint due to shear failure. It shows the cracking pattern in beam column joint.

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