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INVESTIGATION ON REINFORCED CONCRETE COLUMNS WITH HOLES

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Abstract - *The principle of the research is to investigate the behaviour and ultimate strength of the reinforced concrete columns with transverse openings with different shape size, location and shape. Transverse openings are often provided in reinforced concrete columns to allow access for services, such as pipes for plumbing, electrical wiring air conditioner pipes. The provision of such openings may result in the loss of strength, stiffness and ductility and, hence, significant structural damage may be sustained, if the provision of the openings is not considered adequately during the design or construction stages. Presence of openings in columns due to stress concentration develops cracks. Experimentally investigating the influence of transverse openings in columns to examine the strength reduction is carried out in present study. Ten columns were experimentally casted with and without openings. The finite element modelling and analysis is done in Ansys software.*

Key Words: **Shape, Geometry, Location, Size of opening, Ansys, Cast Specimens**

1.INTRODUCTION

In the construction of modern buildings, a network of pipes and ducts is necessary to accommodate essential services like water supply, sewage, air-conditioning, electricity, telephone, and computer network. Usually, these pipes and ducts are placed underneath the beam soffit and, for aesthetic reasons, are covered by a suspended ceiling, thus creating a dead space. Passing these ducts through transverse openings in the columns leads to a reduction in the dead space and results in a more compact design. The provision of such openings may result in the loss of strength, stiffness and ductility and, hence, significant structural damage may be sustained. Presence of openings in columns due to stress concentration develops cracks. if the provision of the openings is not considered adequately during the design or construction stages. For un-braced structures, loss of stiffness leads to redistribution of internal forces and moments.

1.1 Parameters That Influence The Column's Ultimate Strength

Boundary conditions: In all experimental tests found in the literature, restraining elements that were applied along the top and bottom edges were designed as hinged connections that prevented translation while allowing free rotation.

Slenderness and Aspect Ratio: In general, slender columns will have a lower ultimate strength provided that increasing the slenderness ratio from 9 to 27 will reduces the ultimate strength. A study also showed that the reduction in strength with increasing slenderness was more pronounced in columns made out of high strength concrete than in those made of normal strength concrete, subsequently showed that the failure mode is sensitive to both slenderness and end eccentricity.

When RC columns subjected to axial loads, reinforcements are mainly required to compromise the effect of creep and shrinkage in concrete and additionally due to accidental eccentricities in the applied load.

1.2 Objectives

To investigate the reduction in load carrying capacity of the reinforced concrete columns having openings with different size, geometry and location experimentally and analytically. To strengthen the reinforced concrete column having opening by providing steel casing around the openings.

2. ANSYS SOFTWARE

ANSYS is a finite element analysis (FEA) code widely used in the computer-aided engineering (CASE) field. ANSYS software allows engineers to construct computer models of structures, machine components or systems; apply operating loads and other design criteria; and study physical responses, such as stress levels, temperature distributions, pressure, etc. It permits an evaluation of a design without having to build and destroy multiple prototypes in testing.

A Solid65 element was used to model the concrete. This element has eight nodes with three degrees of freedom at each node translations in the nodal x, y, and z directions. Solid65 is used for the 3-D modelling of solids with or without reinforcing bars (rebar). A Link180 element was used to model steel reinforcement. This element is a 3D spar element and it has two nodes with three degrees of freedom translations in the nodal x, y, and z directions.

Table -1: Details of Casted Columns

Col.No.	Dimension (mm)	F_{ck} (N/mm²)	Reinforcement	Dimension of holes (mm)	Shape of hole
C0	150 x 150	30	4#12mm	Control specimen	Solid column
C1				20	circle
C2				30	circle
C3				40	circle
S4				20	square
S5				30	square
S6				40	square
CC7				20	Circle with casing
CC8				30	Circle with casing
CC9				40	Circle with casing

The above casted specimen were modelled in Ansys work bench and analysed. The analytical investigation carried out here is conducted on 10-RC columns; all columns are raised in vertical position with by vertical load on top surface. At a plane of support location, the degrees of freedom for all the nodes of the solid65 elements were held at zero. In nonlinear analysis, the load applied to a finite element model is divided into a series of load increments called load step. At the completion of each load increment, the stiffness matrix of the model is adjusted to reflect the nonlinear changes in the structural stiffness before proceeding to the next load increment. The ANSYS program uses Newton-Raphson equilibrium iterations for updating the model stiffness. For the nonlinear analysis, automatic stepping in ANSYS program predicts and controls load step size. The maximum and minimum load step sizes are required for the automatic time stepping. After comparing analytical and experimental result analytical studies have done in openings provided at different locations, multiple openings at different locations and vertical opening.

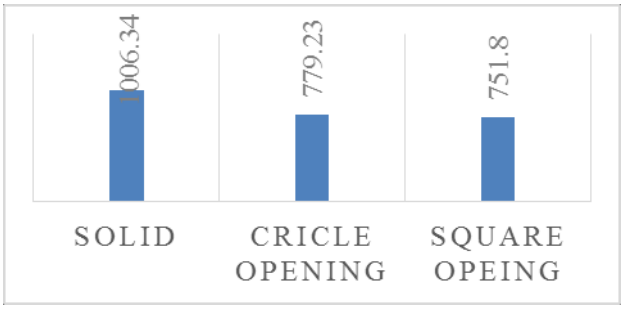

Chart -1: Stiffness of the Column

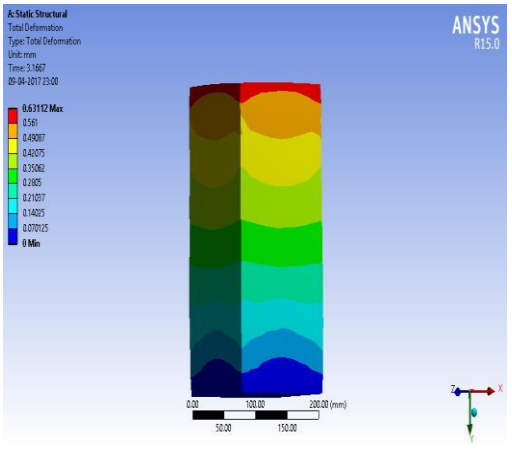

Fig -1: Deflection diagram of solid column

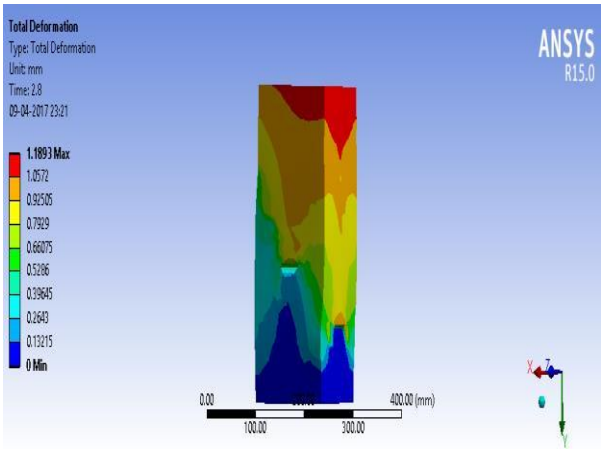

Fig -1: Deflection diagram of column having 40mm circular opening.

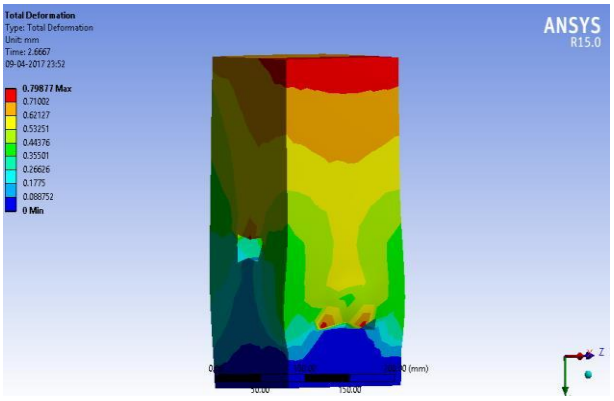

Fig -1: Deflection diagram of column having 40mm square opening.

3. CONCLUSIONS

Solid concrete column showed an ultimate strength of 28.4 N/mm^2. Analytical result also confirmed with the same with minor variation. Column with circular opening of 40mm diameter exhibits a reduction in load carrying capacity of 10.1%, compared with solid column. Column with square opening of 40mm size exhibits a reduction in load carrying capacity of 15%, compared with solid column. Openings in column reduce the stiffness. As the size of the opening increases stiffness reduces. Regarding the shape of opening circle has more stiffness than square.

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