Experimental Investigations and Comparison of RCC Composite Column With Ansys

Dr. S.V. Admane[1], Mrs. T.D. Sayyad[2], Ms. Pinjarkar Sampada[3], Mr. Dahe A.N.[4]
[2]H.O.D, Dept of Civil Engineering
[3, 4]Lecturer, Dept of Civil Engineering
[1]Principal
[1, 2, 3, 4] BhivrabaiSawant Polytechnic, Wagholi, Pune, India.

Abstract*- An experimental investigation of the behavior of reinforced concrete columns and a theoretical procedure for analysis of slender reinforced and composite columns of varied shaped cross section subjected to biaxial bending and axial load are presented. In the proposed procedure, nonlinear stress–strain relations are assumed for concrete, reinforcing steel and structural steel materials. The proposed procedure was compared with test results of 3 I-shape,3 cicular-shape,3 square-shape reinforced concrete columns subjected to short-term axial load and biaxial bending, and also some experimental results available in the literature for composite columns compared with the theoretical results obtained by the proposed procedure& ANSYS , good degree of accuracy was obtained. The composite specimens, on three slender, had a square cross section. The effects of the axial compressive force, slenderness of the cross section, different material properties of concrete and steel, and load-deflection on the maximum load capacity of a composite column were examined. In later stage Experimental model is verified by finite element analysis tool ANSYS workbench, comparing stress-strain curve of experimental results.*

Keywords*-* Reinforced concrete column; Composite column; Biaxial loading;Ultimate strength; Stress–strain models,ANSYS

I. INTRODUCTION

1.1 Concrete: In this section, concrete is synthetic construction material made by mixing cement, fine aggregate (river sand), coarse aggregate (gravel or crushed stone) and water in proper proportion. This mixture hardens into a rocklike mass as result of chemical reaction between cement and water. Concrete will continue to new to harden and gain strength as long as it is kept moist and worm. This condition allows the chemical reaction to continue and the process is known as curing.

1.1.2 RCC PURPOSES AND TYPES OF REINFORCING STEEL: Reinforced concrete was designed on the principle that steel and concrete act together in resisting force. Concrete is strong in compression but weak in tension. The tensile strength is generally rated about 10 percent of the compression strength. For this reason, concrete works well for columns and posts that are compression members in a structure. But, when it is used for tension members, such as beams, girders, foundation walls, or floors, concrete must be reinforced to attain the necessary tension strength. Steel is the best material for reinforcing concrete because the properties of expansion for both steel and concrete are considered to be approximate] y the same; that is, under normal conditions, they will expand and contract at an almost equal rate.

1.2 Introduction to Composite Column

1.2.1 Composite column:-A steel-concrete composite column is a compression member, comprising either a concrete encased hot-rolled steel section or a concrete filled tubular section of hot-rolled steel and is generally used as a load-bearing member in a composite framed structure.

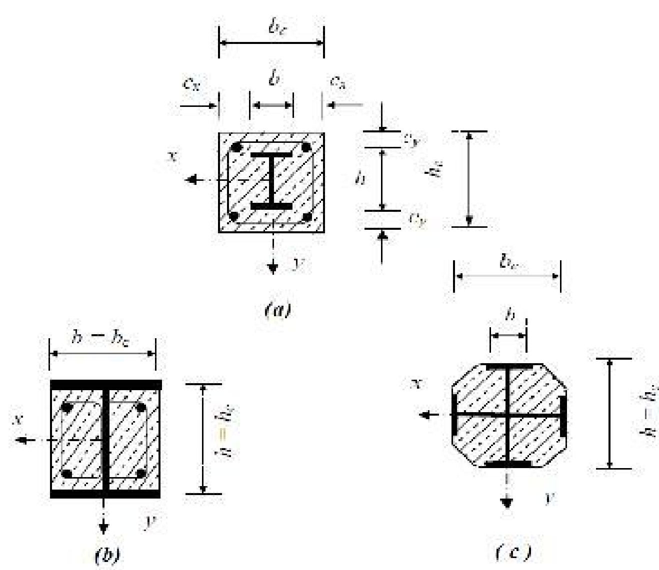


Fig 1:- Different types of reinforced column

1.2.2 Concrete encased composite column:-An encased composite column is a column composed of a steel shape core encased in concrete with additional longitudinal reinforcing steel and lateral ties. In order to qualify under the 2005 Specification as an encased composite column, the following criteria must be met:

a) The cross-sectional area of the steel core must comprise at least 1% of the total composite cross section.
b) The concrete encasement of the steel core must be reinforced with continuous longitudinal bars and lateral ties or spirals. The minimum lateral reinforcement must be at least 0.009 sq. in. per inch of tie spacing.

1.3 Problem Statement

Reinforced and concrete-encased composite columns of varied
cross section subjected to biaxial bending and axial load are commonly used in structures, such as buildings and bridges. A composite column is a combination of concrete, structural steel and reinforcing steel to provide an adequate load carrying capacity to the member.

1.4 Aim
To Study the composite column & comparison of experimental results with validation by ANSYS.

1.5 Objectives :

i) To develop analytical model for steel section and RCC composite column structures.
ii) To carry out parametric study on the performance of columns.
iii) To demonstrate the use of analytical model for design of different configurations of composite columns.
iv) To develop experimental setup for testing of composite column structures.
v) To carry out experimental analysis of composite column structures.
vi) To compare & validate experimental results and analytical results with ANSYS.

II. EXPERIMENTAL PROGRAM

The present project work is experimental oriented and requires preliminary investigations in a systematic way. The detailed testing on the each material of column is carried out.

2.1 Materials

2.1.1.Cement:-Cement used for casting the specimen was Ordinary Pozzolana cement of 53 grade. The cement was used in standard bags and transferred to latter to air tight steel drums to avoid deterioration of the quality. The specific gravity of cement was determined and found to be 3.15

2.1.2. Water:-The water used for mixing and curing the concrete is the potable water from the tap.

2.1.3 Fine Aggregate:-The fine aggregate used for the entire specimen was river sand. The specific gravity of fine aggregate used for concrete was determined and found to be 2.6

2.1.4. Coarse Aggregate:-The coarse aggregate used in the mixes were hand broken granite stone from quarries around Erode. 20mm size of aggregate was stored in separate dust proof containers. The specific gravity of coarse aggregate was determined and found to be 2.6

III. EXPERIMENTAL WORK

3.1 Tests on Cement:-

The cement used in this experimental work was Ordinary Portland Cement ofBirla Super Cement 53 grade ISO 9001:2008 manufactured confirming to IS 12269–1987[25].

Objective: a)To determine the fineness of cement by dry sieving as per IS: 4031 (Part 1) – 1996.

b)To develop ability to perform fineness test on cement for that, 1.To develop ability as proper sieving on cement as per procedure. 2.To develop ability of proper weighing of residue.
Material: -

• Cement Sample.

Table 1: Observation of Fineness of Cement

Sr. No.	Observation	Weight(gms)
1.	Mass of cement taken on IS sieve (gms) (W1)	100
2.	Mass of residue after sieving (gms) (W2)	95

Result :-Residue of cement is 5%.

Conclusion:-The fineness of the given sample of cement is **5%** (within) the limit specified by I. S.

Specification for Fineness of Cement:-As per IS: 12269 the residue of cement sample on the 90µm IS sieve after sieving, it's should not exceed 10% by total weight of given sample.

3.1.2 To Determine The Standard Consistency And Initial Setting Or Final

Setting Time Of Cement:-

Object:-

To determine (a) standard consistency and (b) initial and final setting times of a given cement sample by Vicat apparatus.

Apparatus:-Vicat apparatus with Vicat plunger, Vicat needles and Vicatmould, gauging trowel, measuring jar (100 to 200 ml capacity), weighing balance (accuracy 0.05 per cent of w), stop watch, non-porous plate etc.

Material:-Cement and Water (Potable water).

Observation and Calculation:-

a)For Standard Consistency
Mass of cement taken for one mould = 500 gm.
Type of cement = Ordinary Portland Cement (53grade).

Observation Table:-We made three trials to achieve our result of the normalconsistency using fresh cement in each trial.

Table 2: Observation of Consistency

Trial No.	Amount of Cement In gms.	Amount of water in mm^3	Percentage of water adding	Depth of penetration in 'mm'
1.	500	150	30%	16
2.	500	155	31%	9
3.	500	160	32%	5

Results:-The standard consistency of cement sample is found to be **31%**.

Conclusion:- The percentage of water required to prepare a cement paste of standard consistency is Pn = **31%**.

IV. MODELLING AND ANALYSIS.

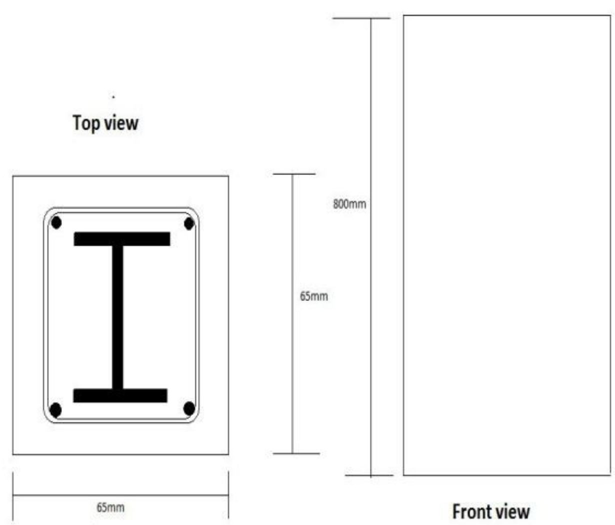
4.1 Tests on Steel RCC composite column structure:

For testing the column 12 columns are casted which are as follows:

3 no of RCC reinforced column with I-section.
3 no of RCC reinforced column with Square-section.
3 no of RCC reinforced column with Circular-section.

ROLLED STEEL BEAMS							
DIMENSION AND PROPERTIES AS PER ISI SPECFICATION IS: 2062-1999							
Designation	Depth of Section	Width of Flange	Thickness of Web	Weight / Mtr	Sectional Area	Moduli of Section	
	h	B	t	w	a	Zxx	Zyy
	(mm)	(mm)	(mm)	(Kg)	(cm2)	(cm2)	(cm2)
ISMB 100	100	60	4.5	11.5	14.6	51.5	10.9
ISMB 125	125	70	5.0	13.2	16.6	71.2	11.7
ISMB 150	150	75	5.0	15.0	19.0	95.7	13.1
ISMB 175	175	85	5.8	19.5	24.6	145.4	18.9
ISMB 200	200	100	5.7	25.9	32.3	223.5	30.0
ISMB 250	250	125	6.9	37.3	47.6	410.5	53.5
ISMB 300	300	140	7.7	46.0	58.6	599.0	69.5
ISMB 350	350	140	8.1	52.9	66.7	778.9	76.8
ISMB 400	400	140	8.9	61.5	78.5	1022.9	88.9
ISMB 450	450	150	9.4	72.4	92.3	1350.7	111.2
ISMB 500	500	180	10.2	86.9	110.7	1808.7	152.2
ISMB 600	600	210	12.0	123.0	156.2	3060.4	252.5

These above mentioned columns are tested for compression under UTM. 1) Compression Test:



In this model ISMB 75 is used with casting later it is validated with ANSYS model5

4.1.2 Analytical Method-:

For the ultimate strength analysis, the biaxial eccentric ultimate load Nu can be determined by

$$N_u = \sum_k^r \overline{A}_{ck}\sigma_{ck} - \frac{A_{st}}{m}\sum_i^m \sigma_{st} - \sum_j^n A_{ij}\sigma_{ij}.$$

Slenderness effect

The slenderness effect of reinforced or composite column is considered by using the Moment Magnification Method (ACI 318-99 [7]) as follows: The moment magnification factor d is expressed as

$$\delta = \frac{C_m}{1 - 1.33N_u/N_{cr}} \geqslant 1.0,$$

in which Cm is the end effect factor (Cm =1:0 for the pinended column), taken as follows:

$$C_m = 0.6 + 0.4\frac{M_{u1}}{M_{u2}} \geqslant 0.4, \quad M_{u1} \leqslant M_{u2}$$

with Mu1 and Mu2 are the end moments of the column. Ncr is the elastic buckling load of column:

$$N_{cr} = \frac{\pi^2 EI}{(kL)^2},$$

wherekL is the effective length and E

I is the effective flexural rigidity of the column section. The effective flexural rigidity of the section plays an important role on the computation of the ultimate strength capacity of slender reinforced and composite columns and may be determined as follows: For reinforced concrete columns (ACI 318-99 [7]):

where Ec and Es are the modulus of elasticity of the concrete and the steel materials, respectively; Ig is the moment of inertia of gross concrete section of the column; Is is the moment of inertia of reinforcement about centroidal axis of member cross section; bd is the sustained load factor (bd ¼ 0 for short-term axial load). For composite columns

$$EI = E_{ce}I_{ce} + E_sI_s + E_tI_t,$$

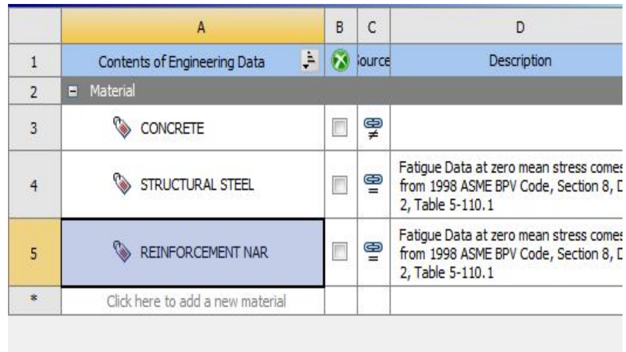
where

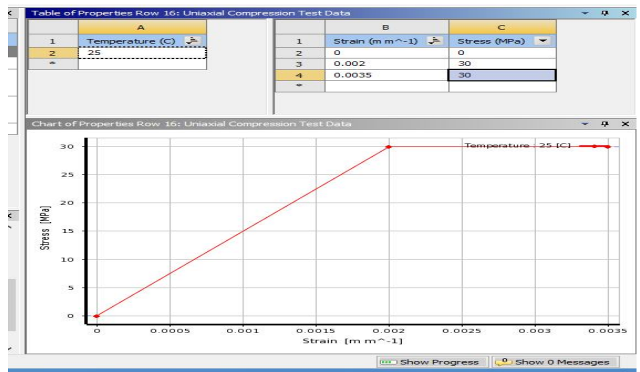
$$E_{ce} = 600f_c.$$

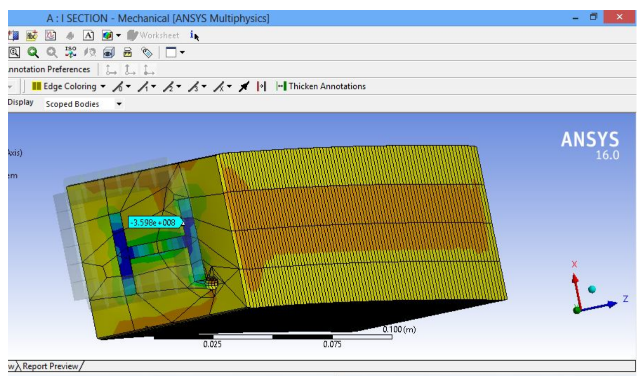
For biaxial bending, ACI 318-99 [7] recommends that the moment magnification factors shall be computed for each axis separately and multiplied by the corresponding moments as follows

$$M_{ux} = \delta_x N_u e_y, \quad M_{uy} = \delta_y N_u e_x.$$

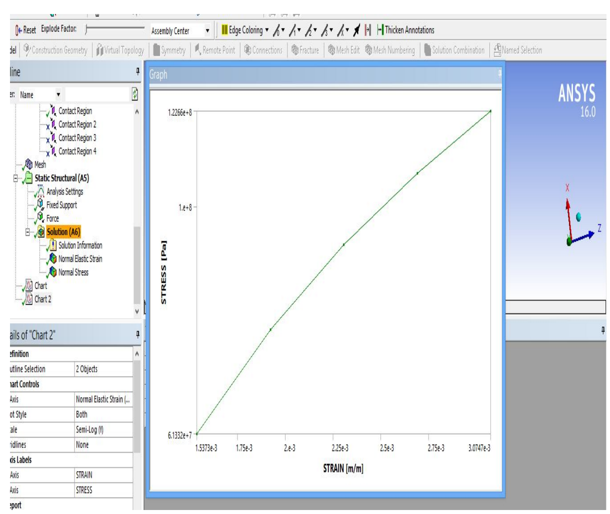
To reach the ultimate strength value Nu of a slender column, dx and dy are computed for each iteration until satisfying the equilibrium equations.







The following graph is generated by ANSYS showing stress-strain curve



V. RESULTS & DISCUSSIONS

5.1 COMPARISON BETWEEN NUMERICAL AND EXPERIMENTALRESULTS

Normal stress is calculated by

σ =Ultimate load/Cross sectional area
= (127.23 x 1000)/ (65x65) =38.055 N/mm^2

NORMAL STRESS		
EXPERIMENTAL	ANSYS	% ERROR
38.055	35.98	5.45

NORMAL STRAIN		
EXPERIMENTAL	ANSYS	% ERROR
0.0035	0.003	2.3

ULTIMATE LOAD		
EXPERIMENTAL	ANSYS	%ERROR
127.23	122.57	3.45

VI. CONCLUSIONS

a) Maximum load carring capacity is found in I-section @ 10-15% more than Circular section and Rectangular section of 800 mm length and 65 mm X 65 mm in cross section
b) In I-section specimen corner of column fails indicate shear failure due to axial load of UTM, therefore additional provisions should be made to avoid failure.
In later stage of study validation of specimen is carried out using FEA tool ANSYS.16, normal stress, strain and loading capacity of model is validated and error occurs @ 5% which is quite acceptable.From ANSYS models total deformation ,vonmises stress and normal stress and following results are obtained:
c) Total deformation and deformation in longitudinal direction is 15-20% less in I section as compared to Circular section and Rectangular section
d) normal stress found maximum in Circular section therefore it should be avoided for heavier loads but due to reduction in concrete it can be used as floating column

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