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ANALYTICAL INVESTIGATION ON THE BEHAVIOUR OF CFRP JACKETTED/WRAPPED CIRCULAR HOLLOW STEEL SECTION SUBJECTED TO AXIAL COMPRESSION

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Abstract: *This paper presents a study of the axial strengthening of the cfrp jacketted circular hollow steel section when subjected to axial compression and paper provides numerical nonlinear simulations based on the finite element method using the software package ANSYS/Standard(15.0). Circular models are created with different wrapping schemes of different spacing and different strip width orderly 50mm,60mm,70mm and spacing of 30mm,20mm,10mm respectively.The total deformation, stress-strain behavior,strain energy are analysed and the results were compared.*

Keywords: Hot-rolled circular hollow section, ANSYS/Standard, FE models, Axial loading, Total Deformation, Stress strain behaviour, strain energy.

I. INTRODUCTION

Hollow structural members can be one solution to maximise strength-mass and stiffness-mass ratios, and to minimise the weight contribution on foundations which can finally reduce the structure's overall budget. Hollow structural members have already been used in many existing bridge pierss, panels, prefabricated assemblies. metallic and concrete filled tubular structures become structural unsatisfactory and ageing of those structures and its deteriorations are often reported Therefore, actions like implementation of new materials and strengthening techniques become essential to combat this problem. Even though the traditional strengthening techniques like section enlargement and external wrapping of steel plates are successful in practice, these techniques revealed serious difficulties. In contrast, rehabilitation methods using fibre reinforced polymer (FRP) composites do not exhibit any of those drawbacks. The application of fibre materials for the external strengthening of reinforced concrete (RC) structures has been widely carried out and reported in the past few decades.

The advantages of FRP over steel plates are the low weight of the bonded material, easy applicability and the capacity to cover areas with limited access. High stiffness fibres, such as carbon fibres, can effectively enhance the structural properties of steel structures; additionally,

composites could also enhance the fatigue life of steel structures. However, there has been limited research in this area. There are uncertainties concerning the long term behaviour of these applications and the bonding between the composite materials and steel, and this is the focus of this study.

In recent years, there have been many investigations emerged in strengthening of steel structures with FRP composites, especially in the area of thin-walled steel structures. From the past research, it was observed that there have been investigations done with the use of CFRP as a strengthening
material for metallic members and also external wrapping of FRP significantly enhanced the strength and stiffness of the steel tubular members, besides investigation on strengthening of CFST members using fibre are not widespread. Hadi et al compared the behavior of FRP confined hollow RC columns subjected to concentric loading. They found they enhance the RC columns performance, by delaying rupture of the concrete and reinforcement.
Yua and Hub examined the behaviour and modeling of FRP-confined concrete-filled steel tubular columns subjected to cyclic axial compression Their research concludes that the axial strain of the column is normally larger than the plastic strain of the concrete but smaller than the plastic strain of the steel tube

The objectof the paper is to evaluate analytictaly investigate the behaviour of CFRP jacketed hollow steel sections when subjected to axial compression and the analytically observation also includes failure modes, stress strain behaviour and enhancement in load carrying capacity

2. SECTIONS DETAILS

Table 2: List of specimen details

Profile name	Strip width(mm)	Strip spacing (mm)	Section diameter (mm) (R)	Depth (mm) (L)
CC	0	0	100	700
CHSF(L1)	700	0		
CHSF(L2)	700	0		
CHS(L1)-50-30	50	30		
CHS(L2)-50-30	50	30		
CHS(L1)-60-40	60	20		
CHS(L2)-60-40	60	20		
CHS(L1)-40-60	70	10		
CHS(L2)40-60	70	10		

3. NUMERICAL ANALYSIS

The finite element program ANSYS is a computational tool for modelling structures with material and nonlinear behaviour. ANSYS version 15.0 was used to simulate the model and find maximum deflection and specific energy capacity of CFRP wrapped specimen.

3.1. Element profile:

All cicular hollow steel sections were modelled by using shell elements. CC represents the controlled column1.CHS represents the circular hollow section.L1 and L2 represents the single and double layer.,50-30,60-20,70-10 represents the strip width and spacing between the strips respectively.F represents the full wrapping of the sectios.

3.3 materials Geometry:

All CHS models were created as surface body elements and they are extruded to the length of 700mm.The CHS were made as thin shell element.The strip wrapping was also drawn thin shell element and then extrude to the required spacing.This procedure is continued for entire length of the section

3.4. material modeling

The thickness of the CHS section was assigned and the layered CFRP was also assigned for the selected strips in the section.The strips were given as single or double layer as per the need and their overall thickness also given for each layer.

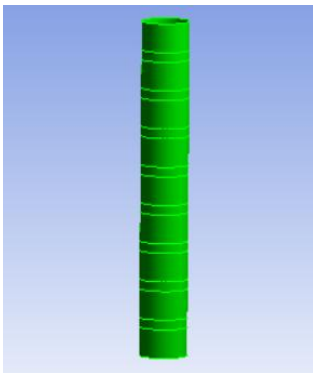


Fig.1.Section geometry

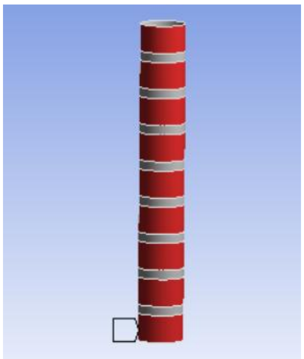


Fig.2. CFRP wrapped specimen

*3.5. Finite element mesh***:**

The influence of the finite element size on the behavior of circular hollow steel section was first studied. Meshing is used for accurate presentation of complex geometry, easy representation of the total solution, and capture of local effects. According to results requirement meshing can be increase (or) decrease and apply the mesh size as (5X5) were generated automatically by the ANSYSprogram and used in all simulations .

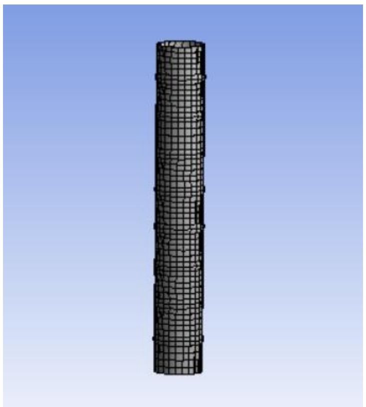


Fig. 3 Meshing of CHS sections

*3.4. loading, and Boundary conditions***:**

A load of 200KN was given along Z +ve direction and along –ve Z direction simply supported condition was assigned for all specimens.

Fig. 4 Load application

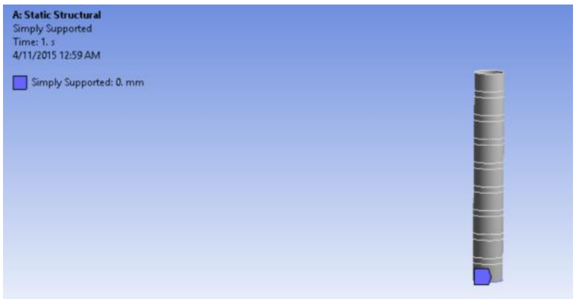


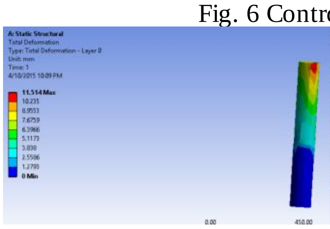
Fig. 5 Applying support condition

4. ANALYTICAL RESULTS

4.1 Load-carrying capacity

The total deformation for all the specimens were shown in the table and figures. The total deformation of controlled column is 34.712mm. the deformation of fully single layered CFRP wrapped specimens is 11.514mm.17.538mm for 50 mm strip with 30mm spacing, 15.875mm for 60mm strip with 20mm spacing and 21.566 for 70 mm strip with 10mm spacing.This results shows that single layer full wraped specimens is subjected much less deformation than other strip wrapped specimens,But while considering the cost factor full wrapping of specimens is much expensive than that of the stip wrapped specimens.The 70 mm strip with 10mm spacing is not much effective than that of striped specimens as its deformation is more than 50% of the fully wrapped specimens.while the 60 mm strip and 50 strip doesn't have much variation in deformation between them,but on the cost basis 50mm strip can be adopted as it utilizes less CFRP when compared with the later.
The total deformation for all the double layered CFRP wrapped specimens is much minimum when compared with controlled column and single wrapped specimens.For fully double wrapped specimens the deformation is 4.449mm whereas 7.063mm for 50mm strip with 30mm spacing,6.272mm for 60mm strip with 20mm spacing and 7.9036 for 70mm strip with 10mm spacing.Although 70mm strips shows better performance than single wraping scheme,economically its not preferable.

Fig. 6 Control column



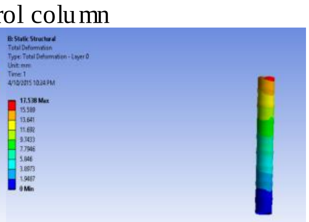


Fig. 7Full wraping-1 Fig.8 50-30-1

Fig. 9 60-20-1 Fig. 10 70-10-1

Fig. 11 Full wraping

Fig. 12 50-30-2

Fig. 13 60-20-2

Fig. 14 70-10-2

Comparing 50-30 and 60-20 both shows very less deformation and their difference in deformation is less than 1mm.considering the economic point of view 50-20 can be adopted.

Table.2.Displacement results

Profile name	**Load (KN)**	**Displacement (mm)**	**Buckling mode**
cc	200	34.712	Outward and inward buckling
CHSF(L1)	200	11.514	Outward and inward buckling
CHSF(L2)	200	4.449	Outward and inward buckling
CHS(L1)-50-30	200	17.538	Outward buckling at unwrapped location
CHS(L2)-50-30	200	7.063	Outward buckling at unwrapped location
CHS(L1)-60-20	200	15.875	Outward buckling at unwrapped location
CHS(L2)-60-20	200	6.272	Outward buckling at unwrapped location
CHS(L1)-70-10	200	21.566	Outward buckling at unwrapped location
CHS(L2)-70-10	200	7.903	Outward buckling at unwrapped location

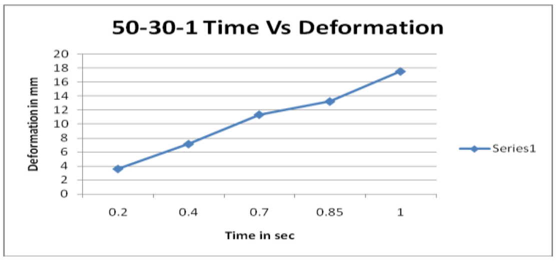


Chart. 1 CHS(L1)-50-30

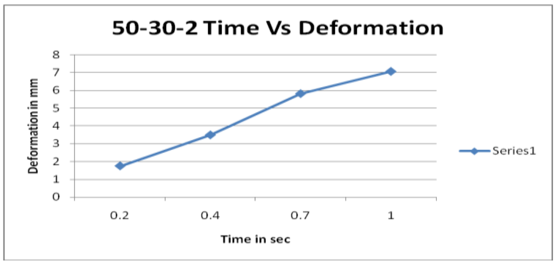


Chart. 2 CHS(L2)-50-30

Strain Energy of the member is defined as the internal work done in defoming the body by the action of externally applied forces. This energy in elastic bodies is known as elastic strain energy .

Table.3.Strain energy results

Profile name	**Minimum (mj)**	**Maximum (mj)**
cc	19907	48061
CHSF(L1)	237.15	18481
CHSF(L2)	122.61	8732.2
CHS(L1)-50-30	59.644	5146
CHS(L2)-50-30	23.304	2560.1
CHS(L1)-60-20	71.194	6517.9
CHS(L2)-60-20	23.9877	3283.4
CHS(L1)-70-10	85.436	7855
CHS(L2)-70-10	42.747	3329.5

CONCLUSION

The above validated results shows that the double layered 50-30 and 60-20 shows minimum deflection when compared with all other specimens.But as per economical point of view 50-30 is suggested as the best wrapping scheme. The strain

energy obtained for the specimen CHS(L2)-50-30 Seems to be minimum when compared with all the other specimens which means the energy utilised for deformation of the specimen is
Minimum.

FUTURE SCOPE OF WORK

Hence, different innovations can be done by changing the spacing and width of the CFRP strips. It is recommended that further experimental and numerical research is needed to find the suitable and economical wrapping schemes for strengthening of CHS members under compression.

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