Thermal Performance of Double Skin CFST Column

Rima Mary Kattookaran, Nisha Varghese

Abstract— Concrete-filled double-skin Tubular (CFDST) columns offer a number of benefits and are often used in tall buildings and other industrial structures. Concrete-filled double skin columns also have much bet- ter endurance characteristics than conventional reinforced concrete columns under fire conditions as the steel casting prevents spalling of the concrete, which remains better protected against fire.Another benefit is that the tubular form of the steel eliminates the need for formwork. The four different geometry such as circular,square and combination is taken.Numerical models were developed using ANSYS15 and investigated the behavior of concrete-filled hollow steel columns under post earthquake fire. For that CFDST columns were first subjected to axial loading, and then fire testing of the same specimens.The best specimen was found out by calculating the column having least percentage of load reduction capacity.

Index Terms—- CCDST,CFST,CSDST,SCDST,SSDST,Thermal analysis

1 INTRODUCTION

THIS document explains about Steel-concrete composite columns have been extensively used in buildings and other engineering structures. A concrete-filled steel tubular (CFST) column is formed by using concrete to in-fill a steel hollow section. In the last decades, a new type of steel concrete composite column, known as the concrete-filled double skin steel tubular column (CFDST), has been proposed. CFDST columns consist of two concentrically arranged steel hollow sections and concrete to fill the gap between the steel sections.When investi- gating the structural performance of CFDST columns, one of the most important aspects is seismic and thermal analysis as the columns are to be used in buildings. In recent years, especially in Asia, in order to reduce the selfweight of composite structures and reduce the adverse effects in case of earthquake, a new type of columns has been developed. CFDSHS and CFDTHS are the two types among the them.The later This new construction solution has higher strength and stiffness, and is called a concrete-filled double-tube hollow steel (CFDTHS) column. These columns have a high load-bearing capacity because the concrete core and inner tube are less affected by the high temperatures of a fire.Hence the column CFDTHS with different geometry is selected to findout which one will have least load reduction capacity.Thus this paper mainly deals with column having leastload reduction capacity which showing most better performance.

2 LITERATURE REVIEW

Literature survey done by referring and going through articles and journals published in the related area of the studies to get detail subject knowledge. Literature review refers to review of scholarly articles and journal papers. It helps us to evaluate and understand about previous findings in the topic of study.

2.1 Literature Survey

Aline L. Camargo; Joo Paulo C. Rodrigues; Ricardo H. Fakury; and Luis Laim(2019) were carried out study on Fire resistance of axially and rotationally restrained concrete filled double skin and double tube hollow steel column .The objective of this study based on thermal analysis with different types of concrete , loading level and stiffeness are considered.Ibaeza, L. Bisbyb, D. Rushb, M. L. Romeroc and A. Hospitalerc(2018)Analysis of concrete-filled steel tubular columns after fire Exposure. The objective of the study is a fiber beam model for the post fire response of CFST columns was produced. Cheng-Yong Wan, Xiao-Xiong Zha, Jean-Baptiste Mawul Dassekpo(2017) Analysis of axially loaded concrete filled circular hollow double steel tubular column exposed to fire.The objective of the study is to find the thermal performance a circular solid or hol- low concrete filled double steel tubular (CFDST) short and slender columns exposed to fire.

2.2 Objective

The objective of project is to findout thermal performance of CFST columns under thermal analysis with different geometry.Also used to found out most fire resisted column and least fire resisted column.

2.3 Scope

The title of the thesis is selected as thermal performance of double skin CFST column.The main scope is explained here. 3-D modelling using ANSYS 16.0 Workbench.It is also used to study the finite element modelling of double skin tubular columns.The parameter considered is the geometry are Circular ,square and combination of two.

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3 Validation

Validation is based on journal paper Fire resistance of axially and rotationally restrained concrete filled double skin and double tube hollow steel columns which was studied by Aline L. Camargo; Joo Paulo C. Rodrigues; Ricardo H. Fakury; and Luis Laim.

3.1 Finite Element Analysis

This thesis deals with the numerical study on behavior of double skin tubular columns postearthquake fire.Hence the finite element modelling was done using ANSYS Workbench 15.0 interface.SOLID 186 is the element assigned for modelling structural steel and solid 65 assigned for concrete.The properties are given in Table 1.

3.2 Methodology

Modeling of concrete filled double skin column tubes. In this process case study building is properly modeled in the software proper load cases should be assigned. Validation process

TABLE 1
PROPERTIES OF MATERIAL

Properties	Steel	Concrete
Yield Strength	393MPa	-
Tensile Strength	438MPa	-
Youngs Modulus	210GPa	25GPa
Poissons Ratio	0.3	0.15
Compressive strength	-	28.5MPa

is an important process which ensures correct- ness of the end product, this process helps to check product quality obtained from the software.

Validation should be done using same software in which project study is being planned.Analysis of this CFST column by proper modeling helps to understand how the deformation ,failure at each time Result and discussion is a key step in the project. After conducting analysis, results obtained are carefully studied and reasons for such outputs have to be discussed in detail to understand the obtained output.

Conclusions have to be drawn from the obtained result. This should consist of a brief account of the entire project including procedure adopted and result. Future scope proposition refers to listing out of all the areas that were omitted in the current project. All the criterias that were not accounted in the scope of this study could be listed as future scope. Further studies could be done by future researchers based on this future scope.

3.3 Results

The validation results of thermal as well as structural are shown .The thermal results shown in figure 1.

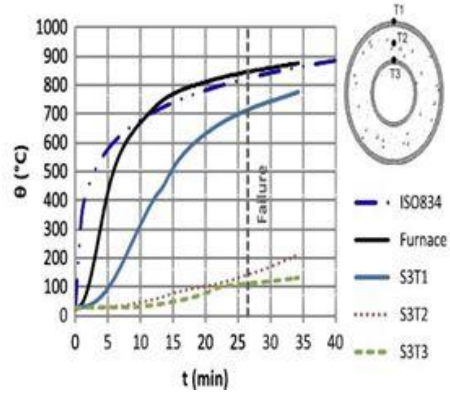

Figure 1. Shows thermal results from journal that is referred. Here graph having temperature at 30minutes that is critical temperature.

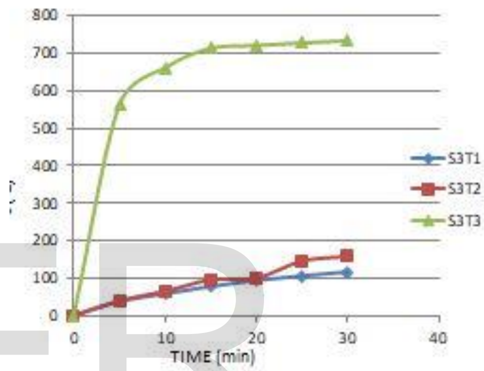

Figure 2. Shows thermal results from analysis.Here graph having temperature at 30minutes that is critical temperature.

4 Parametric Studies

4.1 General

A total of 12 column models were considered. The specimens are cantilever supported over a height of 3000mm with axial load at the top. The columns had a same steel and concrete cross-sectional area.The specifications of these specimens were given in Table 3. The cross sectional view of CCDST,SCDST,CSDST,SSDST are shown in figure 3.

TABLE 2
DEFORMATION RESULTS

Sl.No	Validated	Deformation
1	Journal	45
2	FEM	43.29
3	Percentage error	3.9

The above results are obtained at 30minutes of failure and it's a static result.The deformation is in mm.

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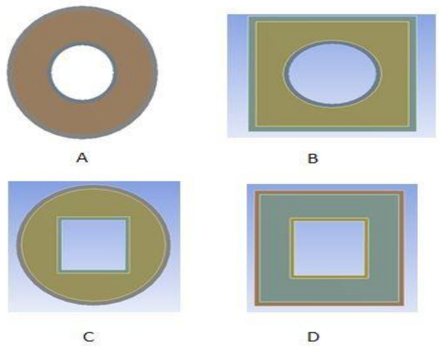

Figure 3. Show the crosssectional shape of 3m column A).CCDST,B).SCDST,C).CSDST,D).SSDST.

5 ANALYSIS

5.1 Static Structural Analysis

TABLE 3
SPECIFICATION OF SPECIMENS

Sl.No	SPECIMENS	OUTER STEEL TUBE SIZE(mm)	INNER STEEL TUBE SIZE(mm)
1	CCDST	219.1	101.6
2	SCDST	194*194	101.6
3	CSDST	219.1	113.5*113.5
4	SSDST	194*194	90.01*90.01

The thickness of steel tubes were maintained as 8mm and 6mm in outer and inner respectively.DST-Double Skin Tube, CC-Circular Circular,SC-Square Circular,CS-Circular Square,SS-Square Square.

The analysis is used to find out capacity of each columns during its initial time when col- umn subjected to only load.The temperature at that time is normal atmospheric or without any temperature.This is done to know what will be the initial capacity and deformation of column.The meshing and load given are as usual.The results obtained are represented as graph.

5.2 Transient Thermal Analysis

To know the temperature results as well as the structural results with different time inter- val the specimen subjected to transient thermal and static structural analysis.Hence the analysis is known as coupled field analysis. The analysis is carried by combination of two results.The first one is the force obtained and the another one is the temperature .
That is analysis are done twice to get results.Thus the static structural and transient thermal analysis done to obtain the final results.The re- sults obtained are from specimen which not undergone temperature analysis hence static results only to obtain initial capacity of the column specimen.From the validation results it was found that the column get fail at its critical time about 30 minutes due to the prop- erty loss of materials(steel and concrete).As there is no difference in material property the failure of column also take place at 30 minutes due to the thermal effect.Hence there need not want to calculate the results at each time interval. The columns were first sub- jected to axial load to the columns top plate in displacement control by gradual applied loading.The results of transient thermal analysis shown in figure.

6 RESULTS OF FEM ANALYSIS

6.1 Static results

The results at 0 minutes and 30 minutes of failure is shown in figure 4.The lateral deformation along its height of 3m is shown here.Also the load deflection curve is shown in figure5.

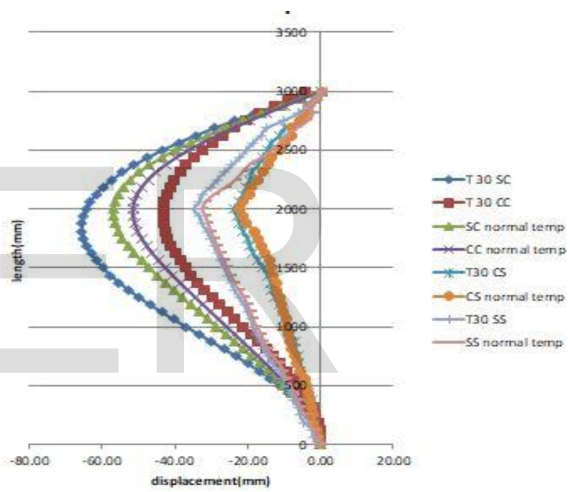

Figure 4. Show the lateral deformation of colums at 0 minutes and 30 minutes respectively.

The figure 4 shows the two results at 0 minutes as well as at 30 minutes after applying the temperature.

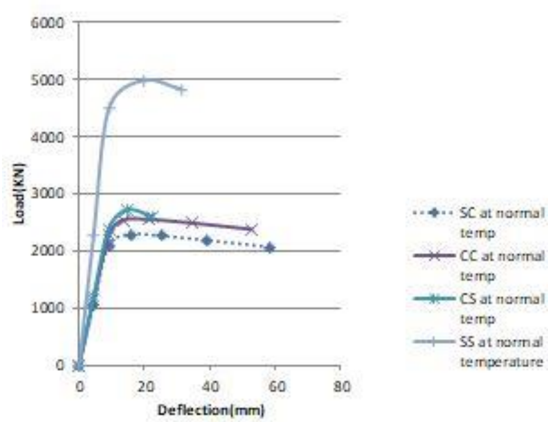

Figure 5. Show the lateral deformation of colums at 0 minutes and 30 minutes respectively.

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From the figure 5 the maximum capacity is for the SSDST without temperature.Initial load carrying capacity without considering temperature is better for the square square double skin tube and minimum capacity for the SCDST.The deflection is better for CCDST.The load capacity differs as the geometry changed.As this is the results for the tube under normal atmospheric temperature the objective is to find thermal performance.Hence the transient thermal analysis is done.

6.2 Thermal Results

The temperature results are shown in figure 6 also the values are tabulated in table 4.

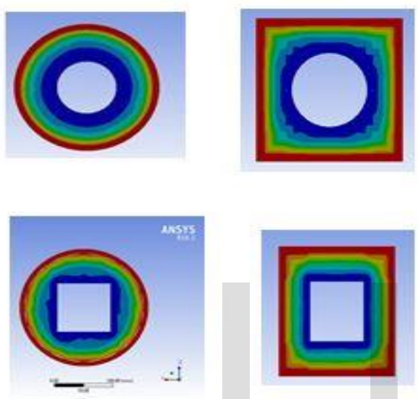

Figure 6. Show the temperature results at 30 minutes

TABLE 4
TEMPERATURE RESULTS

Specimen	Temperature result in degree celsious at 30min		
	Outer Steel (OI)	Middle Concrete (MI)	Inner Steel (II)
CCDST	820.08	200.8	116.75
SCDST	818.98	311.46	176.19
CSDST	842	555.34	376.07
SSDST	844.38	700.253	678.98

The results at outer ,inner and middle parts are shown

From the table 4. above the column get failed totally at 30 min and the temperature at each region will be different.The temperature at outside region will be higher as the temperature gets come first contact with the outside of specimen.Then the temperature to invards go on decreasing.
As the geometry changed the shape of concrete and steel changed which changes the cross section amount and this makes different temperature in different sections.

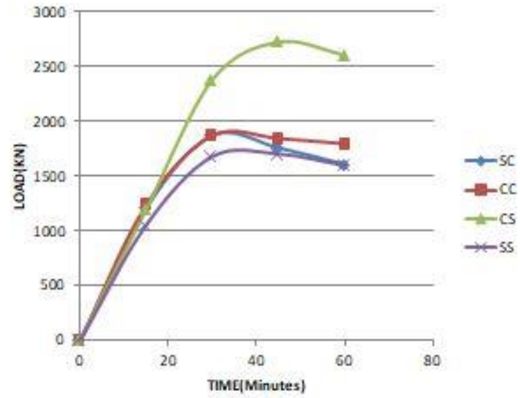

Figure 7. Shows load time curve at 30 minutes

7 COMPARISON OF RESULTS

7.1 Load capacity reduction percentage

The load capacity at initial and at 30 minutes of all columns are used to find out this results.These are tabulated and are given in table 5. From table 5 it is clear that the most effective column which is having less load reduction capacity.Hence the column is SCDST which is more effective for the thermal performance.If there is no effect of temperature the better performed column will be SSDST.

TABLE 5
LOAD REDUCTION CAPACITY IN PERCENTAGE

Specimen	Load(KN)	Load Capacity Reduction in Percentage (%)	Lateral Deformation(mm)
SCDST at T30	1873.7	18.25	66.47
SCDST at normal temp	2291.9	1	35.23
CCDST at T30	1871.5	26.46	43.623
CCDST at normal temp	2544.8	1	40.12
CSDST at T30	1771	35.13	23.855
CSDST at normal temp	2730	1	22.288
SSDST at T30	1701	65.9	34.824
SSDST at normal temp	4990	1	32.554

The results of load reduction capacity by comparing initial and final values are tabulated

Also the total deformation is little higher but it is only comparable hence as there is no such large deformation the good one is SCDST. As the project is mainly on the thermal performance from the test results the best suitable geometry is SCDST (Square Circular Double Skin Tube).Here load reduction capacity is 18.246 only compared to the SSDST having 65.91.Hence from the results SCDST can be adopted.

8 CONCLUSION

The aim of this thesis was to study the behavior of double skin tubular columns under fire with the help of ANSYS Workbench software. In this work parametric studies were done concentrating to different geometry of the column as circular,square and combination of both. The load reduction capacity percentage is less for SCDST.The temperature results are almost same for CCDST and SCDST.The load capacity reduction percentage is the only thing which shows the best column.The lateral deformation is maximum for SCDST and minimum for SSDST.Hence as the percentage of reduction is least for SCDST as 18% it is the best performed column.

9 Scope of Future Research

The following are for future study of the topic is that the column material can be changed and the same thermal performance can be found out.Another one is that experimental validation of the present study can be conducted.

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