



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 6, June 2022

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 8.118

9940 572 462

6381 907 438

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# Deterioration Assessment of Steel Tubular Column with Different Orientation

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**ABSTRACT:** Steel tubular columns have been used in civil structures due to their high strength, ductility, and fire resistance. However, there are issues causing steel tubular columns locally corroded, this makes difficulty in accepting this type of member in practice. This paper focused on the deterioration assessment of steel tubular columns under local corrosion. To develop the critical data needed for understanding the behaviour of such columns, a group of specimens were modelled and analysed. The local corruptions in the steel tubes of the specimens were represented by the artificial notches. The main objective is to calculate the loss of strength of the steel tube corroded at different alignment. Modelling and analysis were done using ANSYSworkbench software.

**KEYWORDS:** Local corrosion, artificial notch, ANSYS software, hollow square steel tube.

## I. INTRODUCTION

Hollow structural members are extensively used as compression member in civil engineering structures. Tubular form of steel sections is strong and efficient. They have a wide application in the present trends of construction practices. Because of their ductile properties they possess good structural and earthquake resisting properties. Members after construction would be affected by environmental factors and causes corrosion as years pass. Steel corrosion exists anywhere steel is present in structures. Corrosion leads to decrease of strength and load carrying capacity of steels and components.

Pitting corrosion is a kind of localized corrosion and harmful to structures such as steel-structured buildings, marine structures etc.

## II. LITERATURE REVIEW

Jing Zhang et.al.<sup>[1]</sup> investigated the collapse mechanics and ultimate strength of a stiffened plate with pitting damage experimentally on specimens with circular shaped holes representing the pits in the plate and their ultimate strength was studied. The ultimate strength reduction is related with the degree of pitting and volume loss. Ultimate strength reduced by 30.5% with increase in degree of pit. Ultimate strength is reduced by 5% when corrosion volume loss increased by 3 times. Local corrosion is more likely to occur compared with uniform corrosion.

Lanhui Guo et. al.<sup>[2]</sup> studied the axial compressive behaviour of square CFST stub columns with local corrosion simulated by artificial notch through the combination of experiments and finite element analysis. Compression strength and stiffness of specimen with horizontal, vertical and sloping notch was studied. Compression strength decreases with increase in notch length by 2.17%. With increase in notch orientation decrease in compressive strength by 7.48%. Compression strength and stiffness of specimens with horizontal notch and sloping notch was found to degrade seriously while the vertical notch had little effect on the compression strength of specimens.

Haijia Huang et.al.<sup>[3]</sup> they focused on the circular CFST stub columns with local groove corrosion on steel tubes. These columns are tested under axial compressions. Experimental and analytical method was carried out. Parameters include varying depth, width length and orientation. The peak resistance and ductility were significantly reduced due to presence of vertical and slanted artificial notch and is less remarkable in case of horizontal notch. For horizontal notch case, the failure modes of these specimens were found to be dominated by the global flexural buckling similar to the case without notch.



**III. OBJECTIVE**

1. Performing the axial load study of corrosion damage scenario for tubular steel column considering local groove corrosion
  - o Local groove corrosion in the form of artificial notches is made and studied with the effect of groove corrosion in horizontal, vertical and inclined direction.
2. Due to those damages found out, how much amount of strength is lost from the member and change in the behaviour of column is analysed.

**IV. METHODOLOGY**

- Collecting various literature reviews on corrosion study and methods to strengthen the corroded section.
- Validation of circular hollow section with a notch using ANSYS.
- Modelling and analysis of steel tube with varying parameter using the ANSYS workbench 2021 R2.
- Comparing the results of various models and their structural behaviour is investigated.
- Concluding from the results.

**V. FINITE ELEMENT MODELLING**

Modelling of the SHSs section was done using ANSYS WORKBENCH 2021 R2. The steel section was simulated using the 8-noded 3D solid element SOLID 185. The steel square hollow section (SHSs) of 150 x 150 mm section with thickness 5mm and 450mm height. Support condition considered was pin-pin end condition. Twelve typical models are chosen with notch, including one model without notch, eleven models with notch.

The material properties of steel are shown in Table 1. Table 2 shows the details of the model cases used for the analysis. Fig.1 shows FE models modelled using ANSYS workbench.

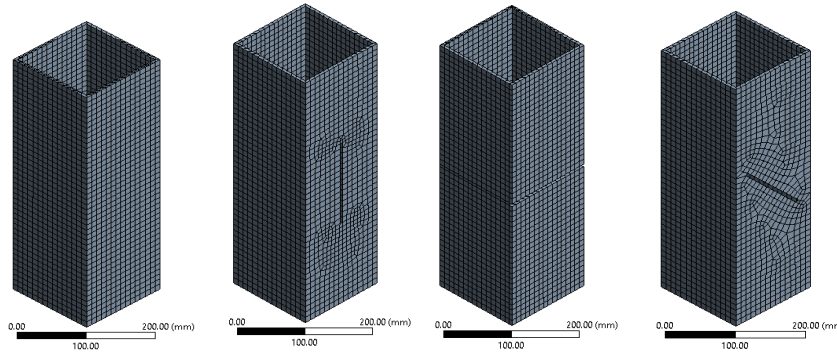
Table 1 Material Properties of Steel

Property	Value
Young’s modulus	200000 MPa
Yield strength	250 MPa
Ultimate strength	460 MPa
Poisson’s ratio	0.3

Table 2 Details of model

Models	Description
WN	Without notch
V-150-1.75-5	Vertical notch with depth varying, width varying and length varying
V-150-2.5-5	
V-150-3.75-5	
V-150-5-5	
V-150-5-7.5	
V-125-5-5	
V-225-5-5	
H-150-5-5	
H-150-5-7.5	
I-150-5-5	Inclined notch with width varying
I-150-5-7.5	

Corrosion assessment is studied by creating artificial notches on the hollow steel tube and a point load is applied. All the models are planned to be tested under hinged support condition there by preventing lateral displacement and allowing relative rotation. Models with vertical, horizontal and inclined notch is represented as V,H and I respectively. Models were considered for analysis by varying the notch depth, width and length.



a) b)c) d)

Fig 1 FE models a) steel tube without notch b) steel tube with vertical notch c) steel tube with horizontal notch and d) steel tube with inclined notch.

### VI. ANALYTICAL RESULTS

Analysis using ANSYS workbench software is carried out. Results in terms of ultimate load is used to compare all models. Table 4 shows the analysis results of the models. Figure 2 shows the deformed shape of the models with and without notch. Figure 3 show the load-deflection graph of the models.

Table 4 Analysis Results of models

SL. NO.	Model	Deflection (mm)	Load (kN)	Percentage decrease in load(%)
1	Without notch	3.08	884.51	1
2	V-150-1.75-5	2.75	870.41	1.59
3	V-150-2.5-5	2.75	867.05	1.97
4	V-150-3.75-5	5.41	799.75	9.58
5	V-150-5-5	1.36	800.06	9.55
6	V-150-5-7.5	7.21	766.11	13.39
7	V-125-5-5	5.16	813.16	8.07
8	V-225-5-5	3.27	779.66	11.85
9	H-150-5-5	3.18	529.49	40.14
10	H-150-5-7.5	2.20	521.33	41.06
11	I-150-5-5	2.84	599.00	32.28
12	I-150-5-7.5	2.84	595.14	32.72

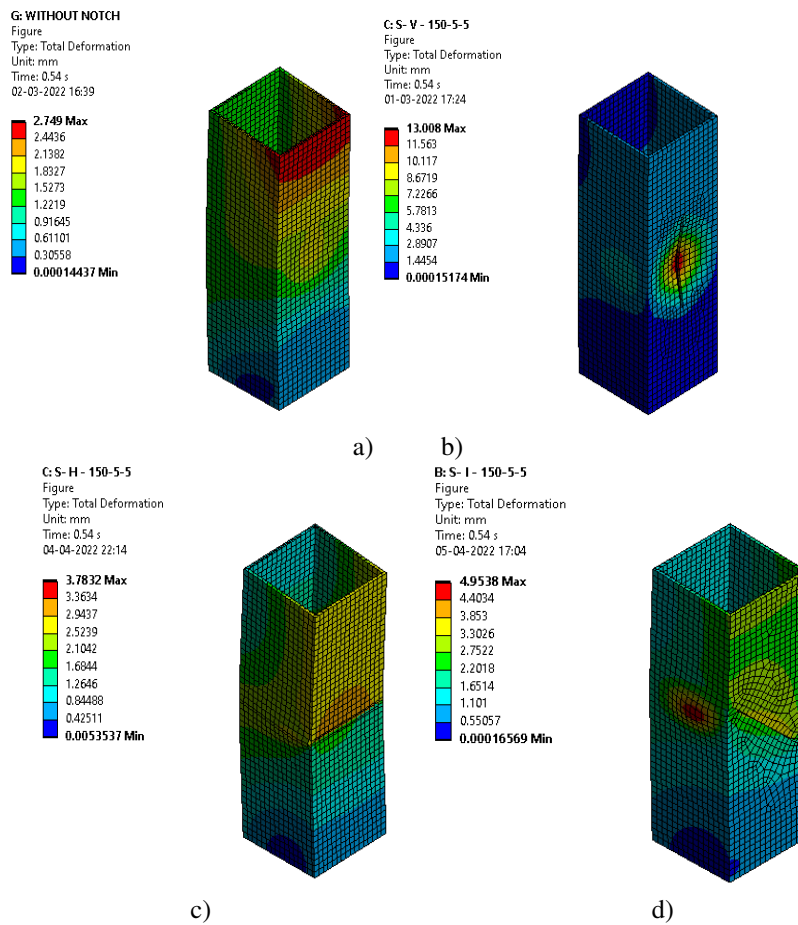


Fig 2 Deformed shape of the models (a) without notch, (b) vertical notch, (c) horizontal notch and (d) inclined notch

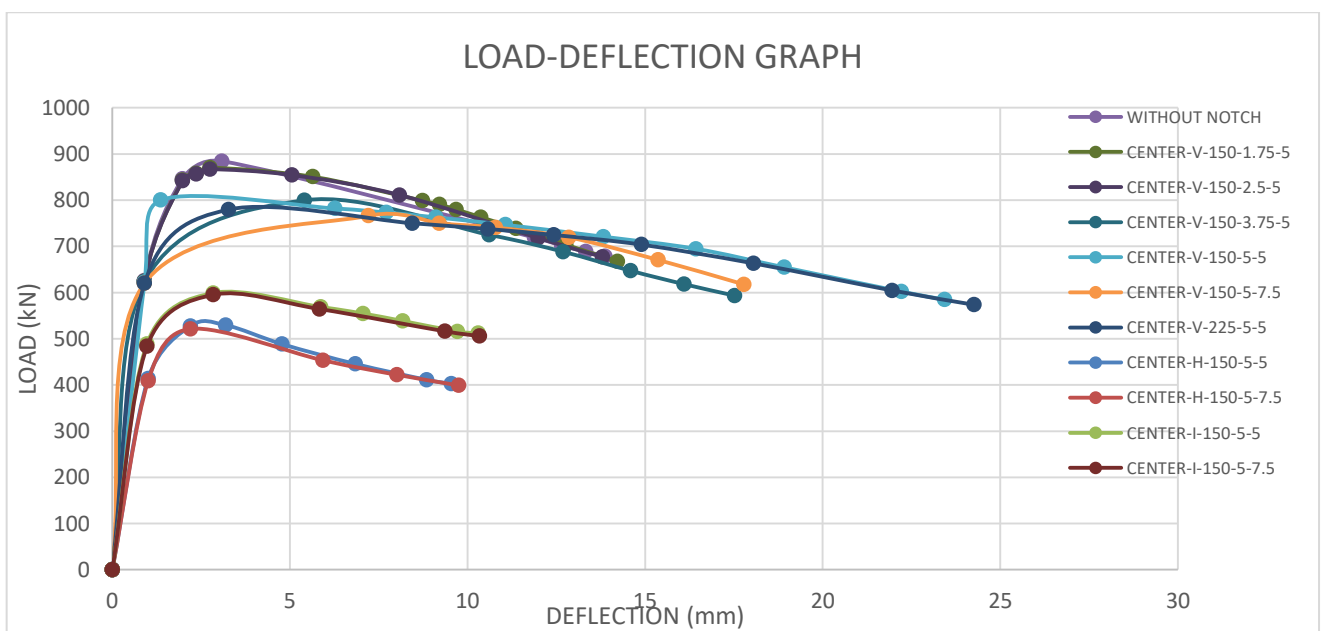


Fig 3 Graph showing load-deflection curve

From the analysis results it is observed that:

- For vertical notch at centre the stresses are concentrated at the notch centre. Here the effect of buckling and the stress due to notch is caused at the centre.
- The ultimate load carrying capacity was reduced upto 9.5% comparing the sections with notch depth varying and without notch.
- The ultimate load carrying capacity was reduced upto 13.39% comparing the section with notch width varying and without notch.
- The ultimate load carrying capacity was reduced upto 11.85% comparing the section with notch length varying and without notch.
- Load carrying capacity is reduced more when the width of the notch is increased.
- Ultimate load for horizontal notch was reduced to 41.06% and for steel tube with inclined notch the ultimate load is reduced upto 32.72%.
- From Fig 3 it is clear that the horizontal notch case shows the least load carrying capacity.

## VII. CONCLUSION

In this research focused on the behaviour of the square hollow tubular section locally corroded. Among the specimens the test parameters included the notch orientation, length, depth and width.

- When the notch length is increased the ultimate strength decreases and as the notch orientation was changed from 90° to 45° and 0° the percentage variation was showed to 11.85%, 32.28% and 40.14% respectively when compared to steel tube without notch.
- It is found that the ultimate strength of the SHS column is significantly reduced due to the presence of the horizontal and inclined artificial notch in the steel tube.
- Ultimate strength is comparatively less remarkable in case of steel tube with vertical notch.

It implies that in case of axial compressive strength the influence of notch mainly lies on the effective area of cross section of steel tube. The presence of notch cut off the load transferring path.

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**Impact Factor: 8.118**



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