Experimental Study on Bearing Capacity of Stainless Steel Lipped C Section Stub Columns

Fan Sheng Gang, Zheng Baofeng, Shu Ganping

Southeast University

Nanjing, China

OUTLINE

Part 1: Introduction

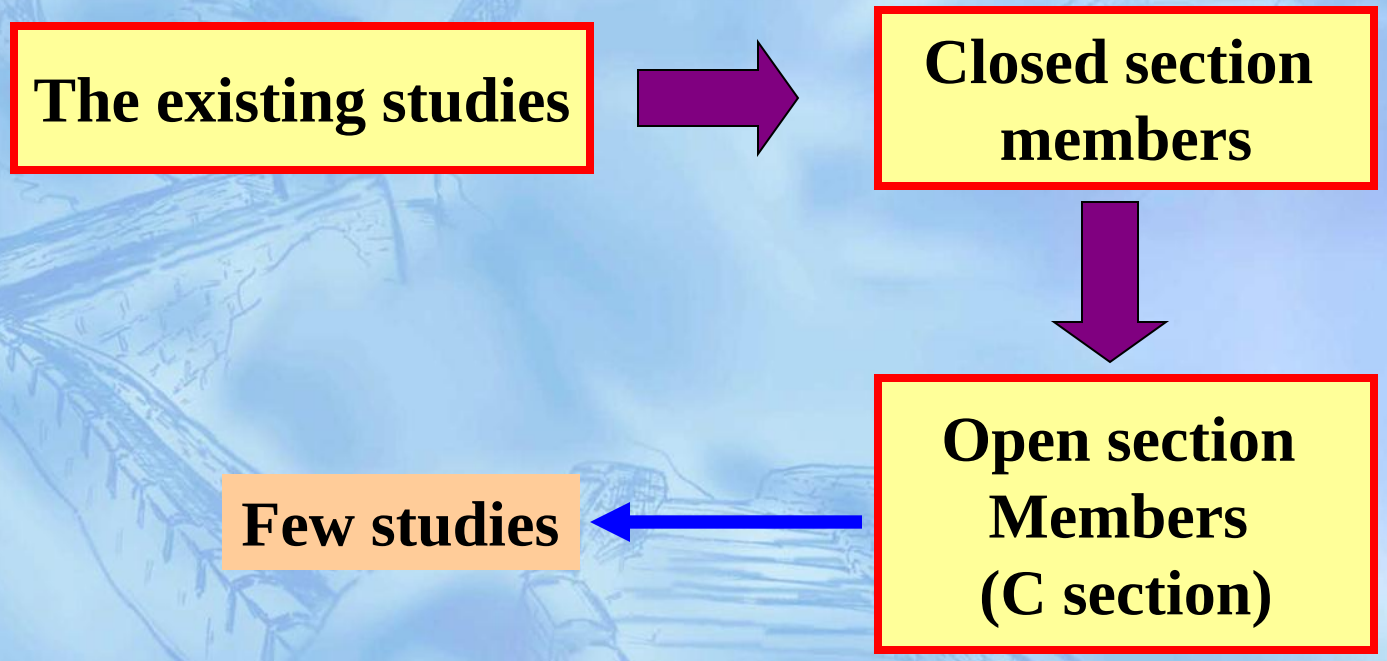
Part 2: Mechanical Property Tests

Part 3: Stub Column Tests

Part 4: Comparisons

Part 5: Conclusions

Part 1: Introduction



Part 1: Introduction

A series tests were performed on stainless steel material S304 for Lipped C section members.

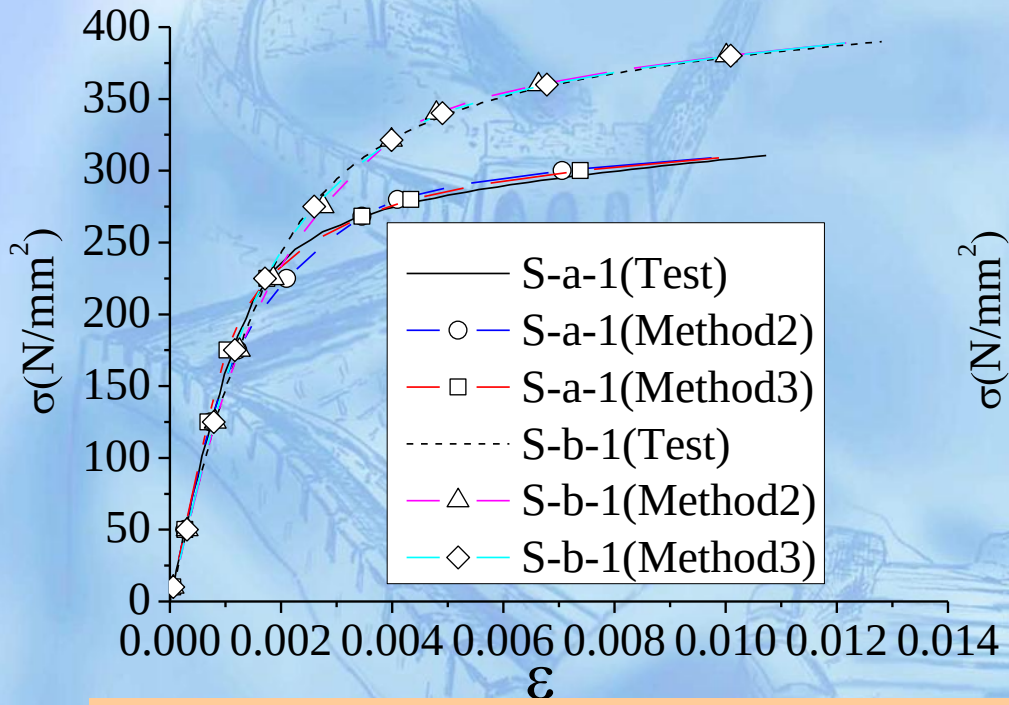
- **16 mechanical property tests**
- **10 axially loaded stub column tests**
- **28 eccentrically loaded stub column tests**

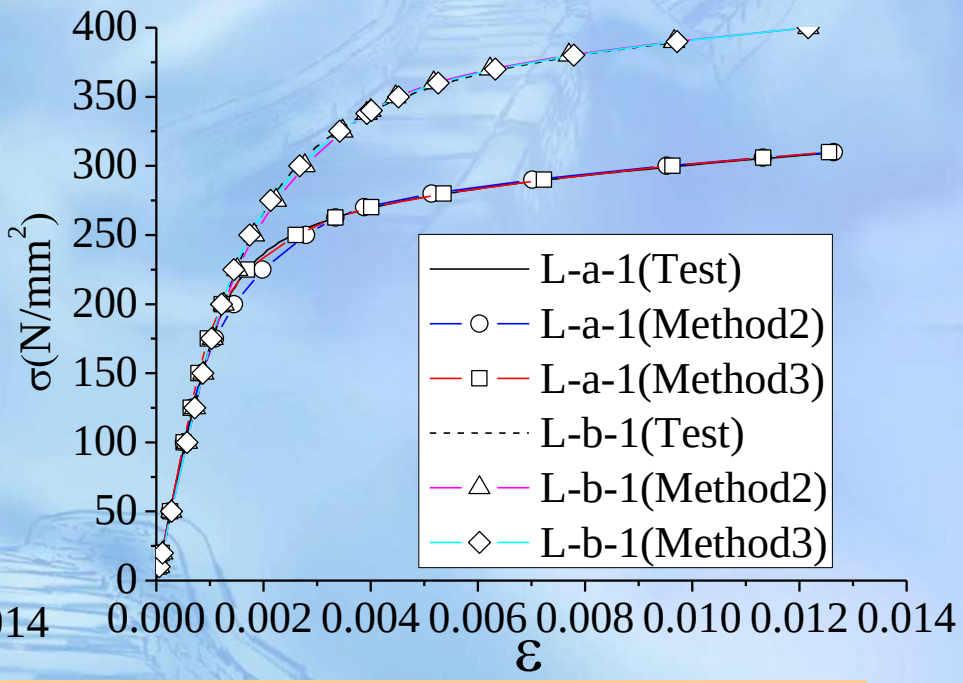
Part 2: Mechanical Property Tests

Flat specimen tests (both longitudinal and transverse) → **To investigate anisotropy of the material**

Corner specimen tests → **To reveal the influence of cold working on material properties**

Flat Specimen Tests



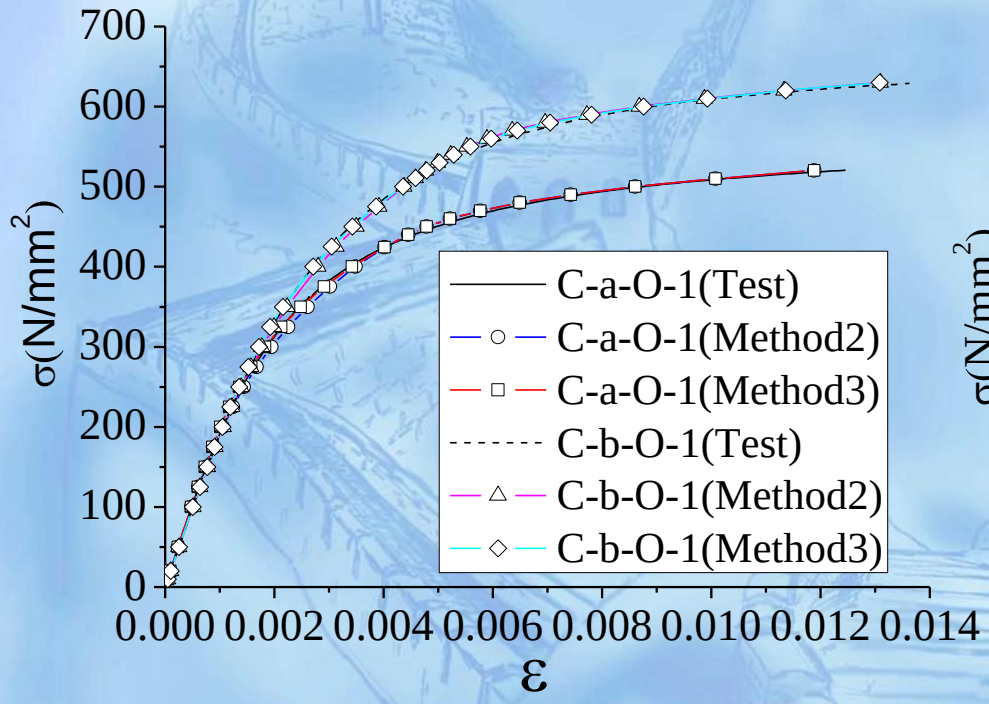


Test: to fit the curve according to test data;

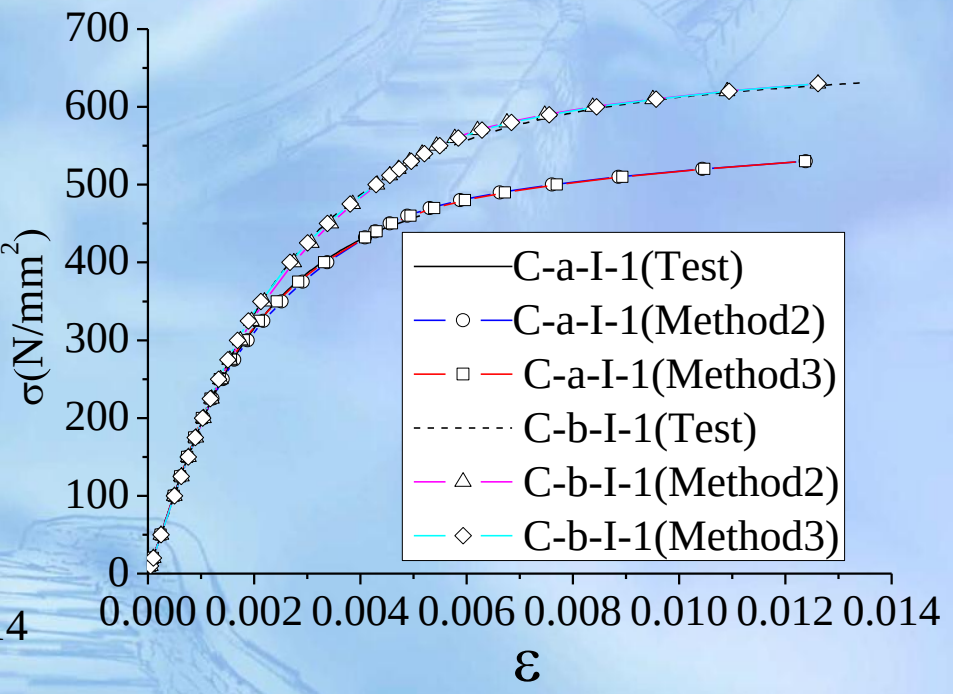
Method2: to draw the curve based on classic R-O equation;

It can be seen that the second method generates the lowest curve and the curve obtained through the third method fits the test results best.

Corner Specimen Tests



Intersection of Flange and Lip



Intersection of Flange and Web

Stress-strain curves of corner specimen tests

The second and third method are in good agreement with those fitted by test results.

Part 3: Stub Column Tests

Based on European Code (EC3) , the length of stub column specimens should be limited from triple the maximum section width to 20 times of the minimum gyration radius in order that section properties could be revealed but overall instability not happen.

Cold-formed stainless steel members of lipped C section are selected, section sizes including
C80×40×15×2.0,C120×40×15×2.0, C140×60×15×2.0, C160×60×15×2.0, C80×40×15×3.0,C100×40×15×3.0, C120×40×15×3.0,C140×60×15×3.0,C160×60×15×3.0

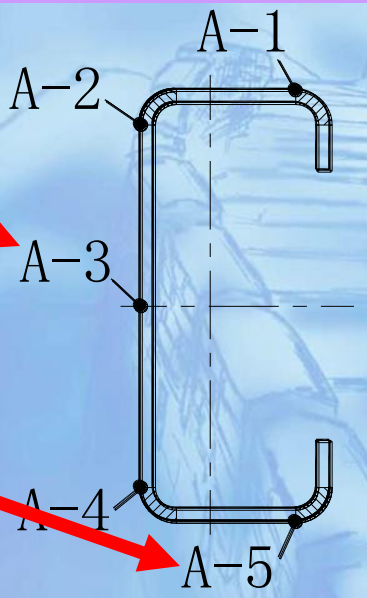
Imperfection Measurements

For later accurate analysis and calculation of axial and eccentric compressive bearing capacity of stub columns

Initial imperfections of specimens were measured using milling machine

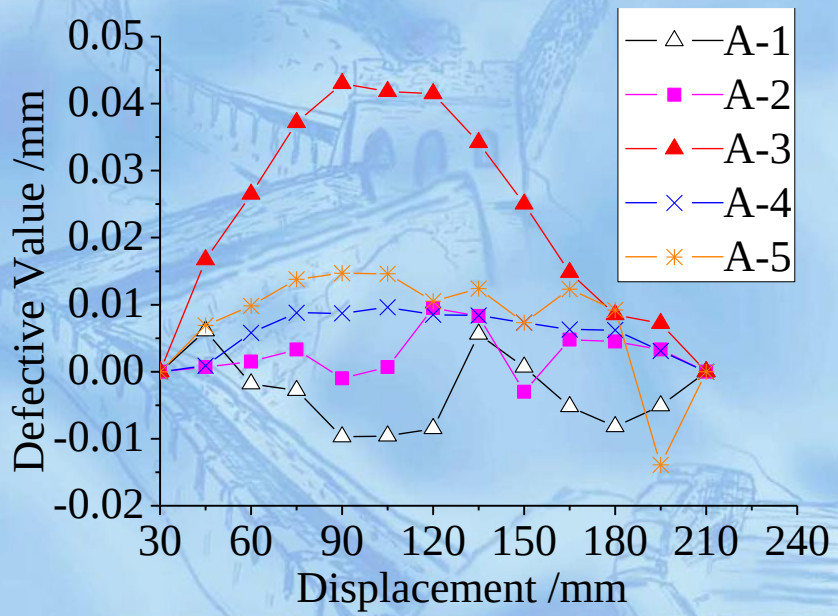
Three points on the web

One point on each flange

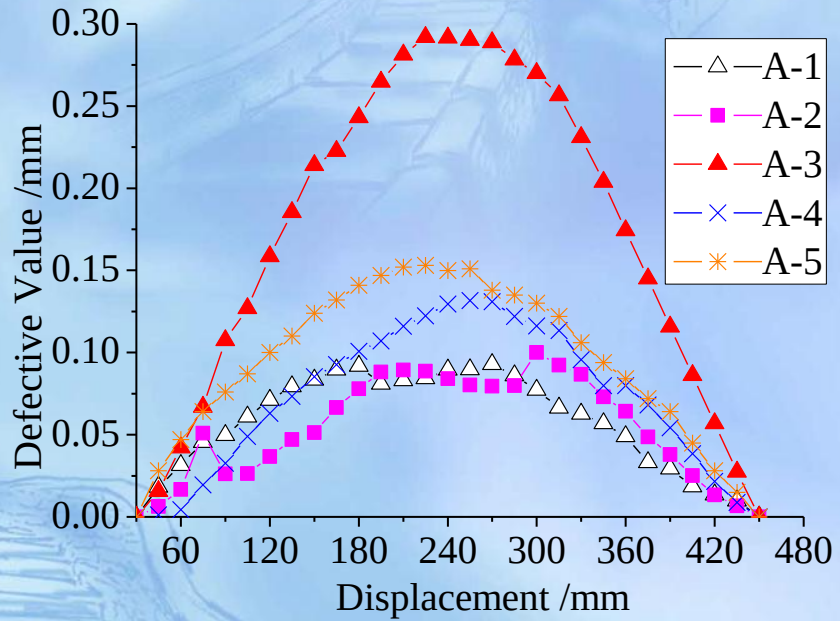


15 mm intervals were set between two measuring lines.

Imperfection Measurements



C80×40×15×2



C160×60×15×2

Imperfection curves of stub column specimens

Bearing Capacity Tests of Stub Columns

Failure Phenomena and Process

There are two buckling modes of stub columns .

Convex in the web near the middle cross section and concave in the flange

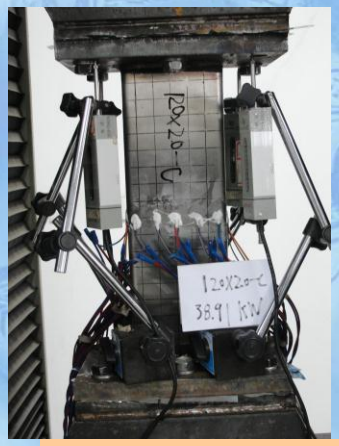
Mode 1

Concave in the web near the middle cross section and convex in the flange

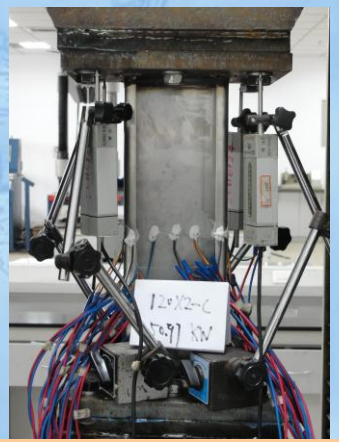
Mode 2

23 specimens developed the first buckling mode with the rest 15 in the second mode

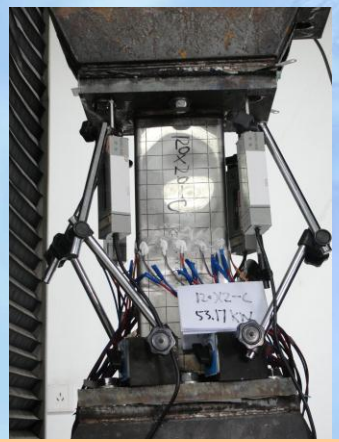
The failure process and phenomenon of test specimen (T-3-C) under various load levels are shown in following figures.



P=38.91KN

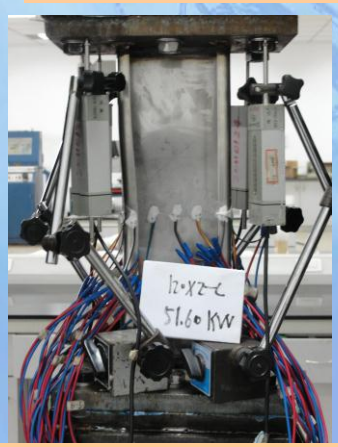


P=50.97KN

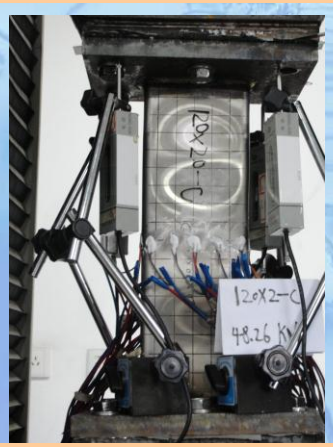


P=53.51KN

P=52.72KN



P=51.60KN



P=48.26KN

Failure (front)

Failure (back)

Axially compressed

Eccentrically compressed

Failure phenomena of compressed stainless steel stub columns

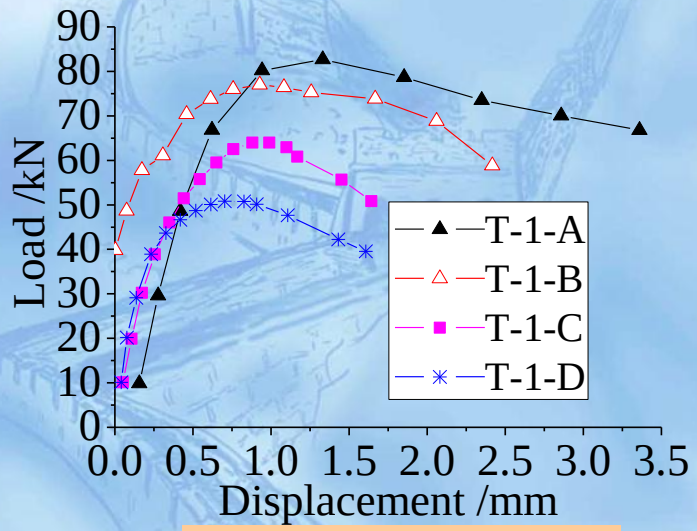
For specimens with the same cross section dimensions and height, eccentrically loaded columns developed more buckling waves than axially loaded ones.

Test Results

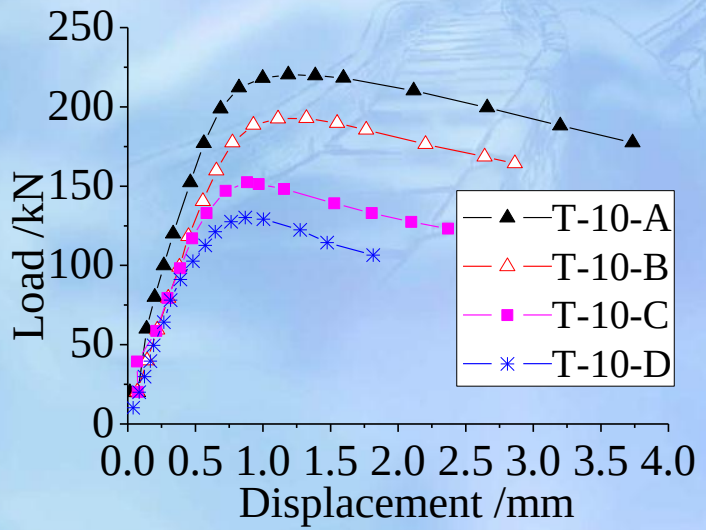
The test values of failure loads and the buckling modes of stainless steel stub columns are shown in following table.

Specimen code	Buckling mode	Test strength /kN	Specimen code	Buckling mode	Test strength /kN
T-1-A	Mode 2	82.70	T-6-A	Mode 2	182.55
T-1-B	Mode 1	76.98	T-6-B	Mode 1	151.68
T-1-C	Mode 1	63.99	T-6-C	Mode 1	113.71
T-1-D	Mode 1	50.80	T-6-D	Mode 1	107.65
T-2-A	Mode 2	75.60	T-7-A	Mode 2	190.72
T-2-B	Mode 1	79.17	T-7-B	Mode 2	175.01
T-2-C	Mode 1	61.12	T-7-C	Mode 2	130.45
T-3-A	Mode 2	76.55	T-8-A	Mode 2	188.33
T-3-B	Mode 1	69.76	T-8-B	Mode 2	173.52
T-3-C	Mode 1	53.35	T-8-C	Mode 1	127.17
T-3-D	Mode 2	46.48	T-8-D	Mode 2	115.9
T-4-A	Mode 1	89.78	T-9-A	Mode 1	223.95
T-4-B	Mode 2	78.42	T-9-B	Mode 1	196.35
T-4-C	Mode 2	58.42	T-9-C	Mode 1	154.25
T-4-D	Mode 1	54.06	T-9-D	Mode 1	130.28
T-5-A	Mode 1	86.77	T-10-A	Mode 1	220.29
T-5-B	Mode 1	77.23	T-10-B	Mode 2	192.84
T-5-C	Mode 1	61.91	T-10-C	Mode 2	152.50
T-5-D	Mode 1	51.41	T-10-D	Mode 1	130.23

Test Results



C80×40×15×2



C160x60x15x3

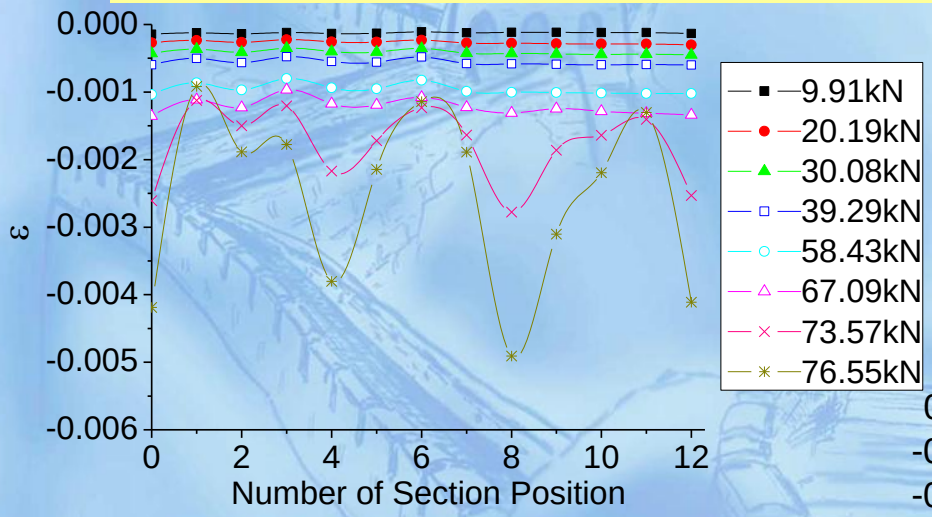
Load-displacement curves of stub column specimens

At the initial stage, the displacement appears linear growth with load.

After the load reaches the ultimate value, the displacement increases rapidly, which put them in almost linear relationship again.

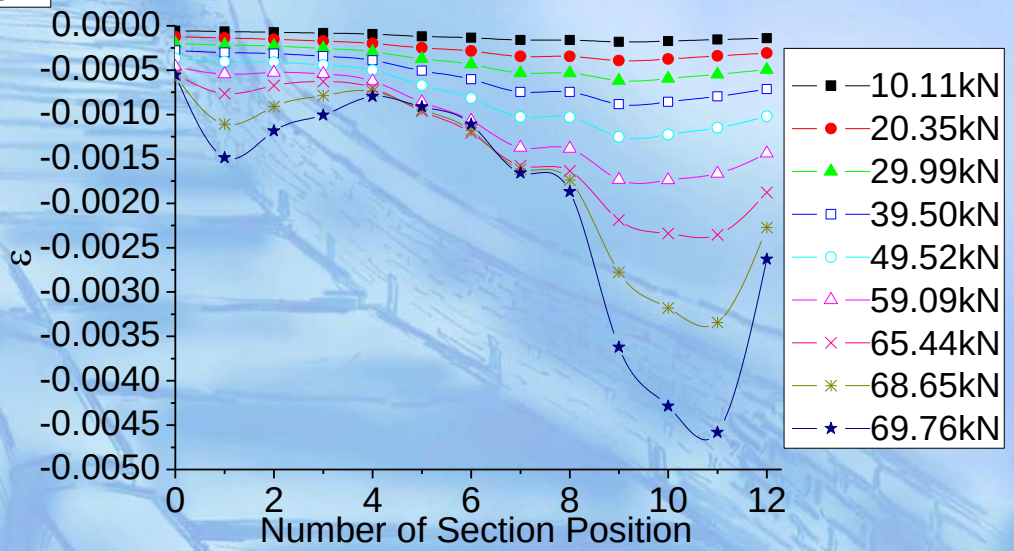
Test Results

The strain distributions across the middle cross section of the specimen(T-3-A~D) are shown in following figure

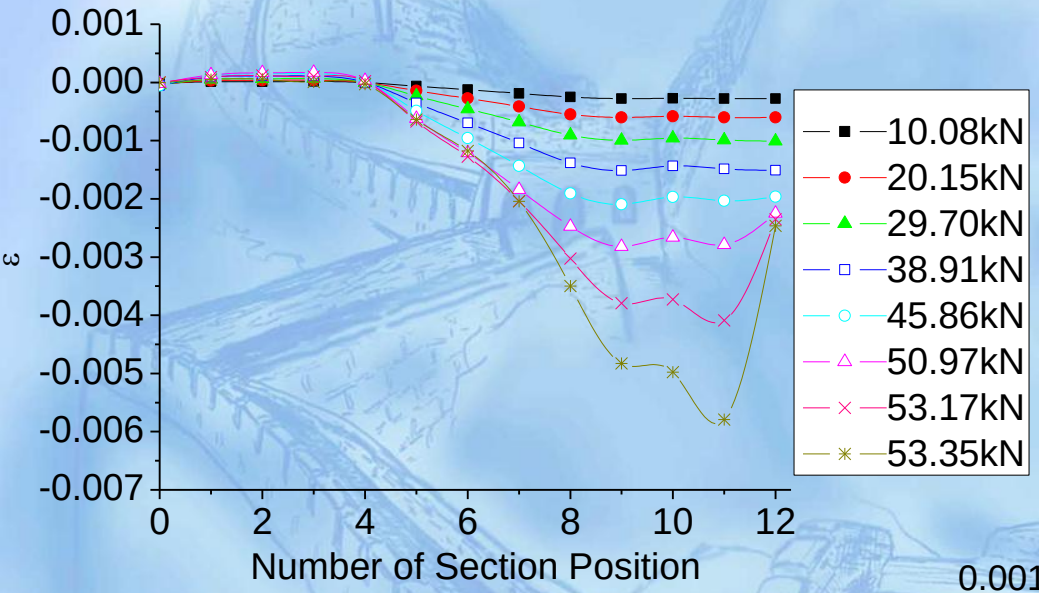


T-3-A (Eccentricity e=0)

T-3-B (Eccentricity e=14.51mm)

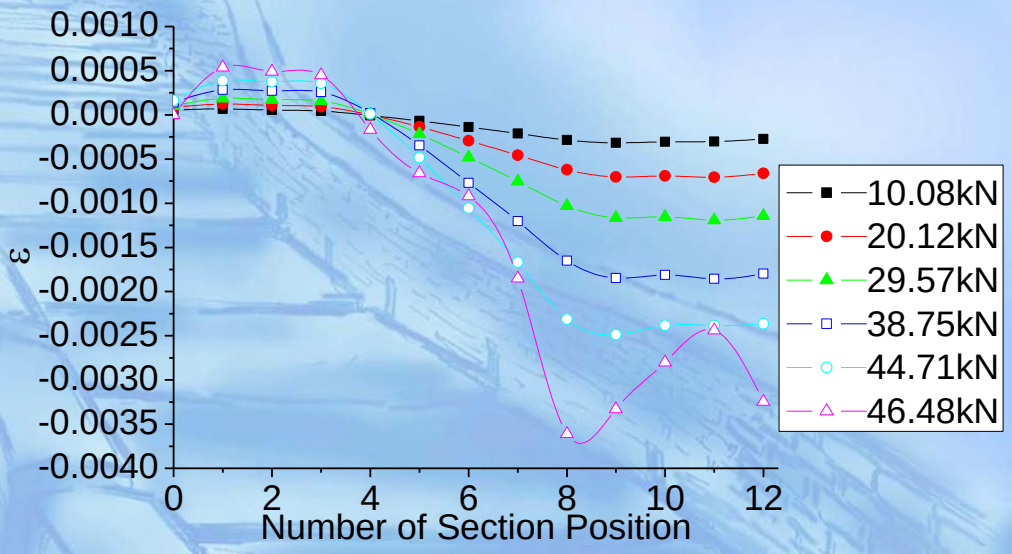


Test Results



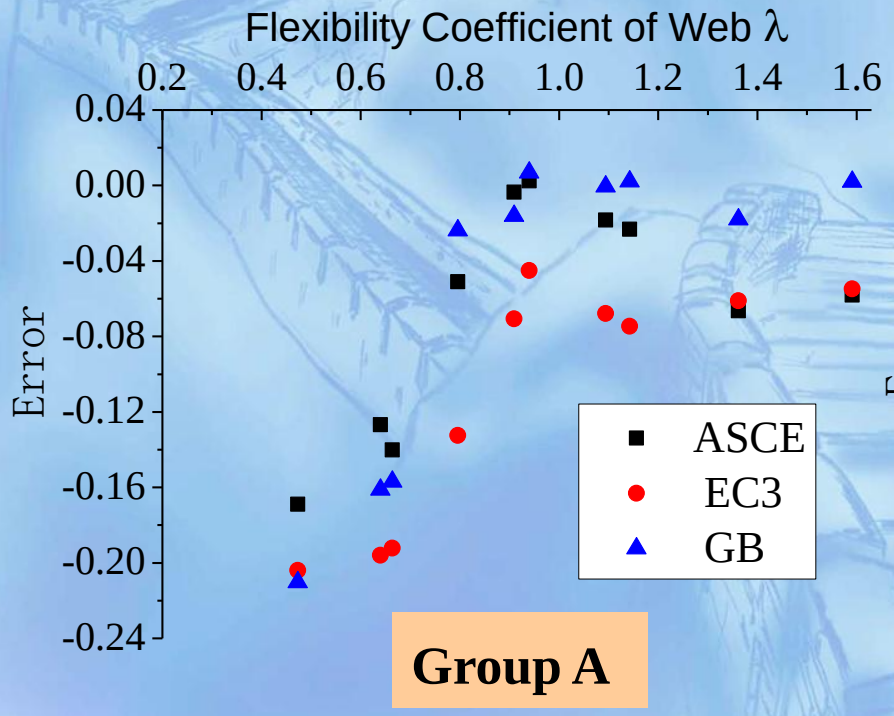
T-3-C (Eccentricity e=39.34mm)

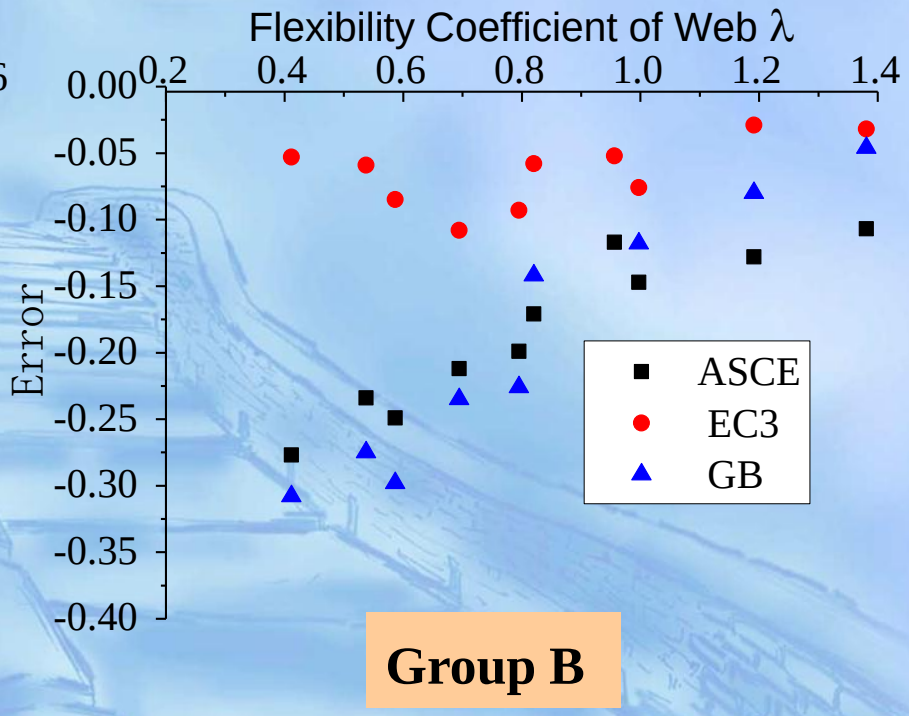
T-3-D (Eccentricity e=48.46mm)



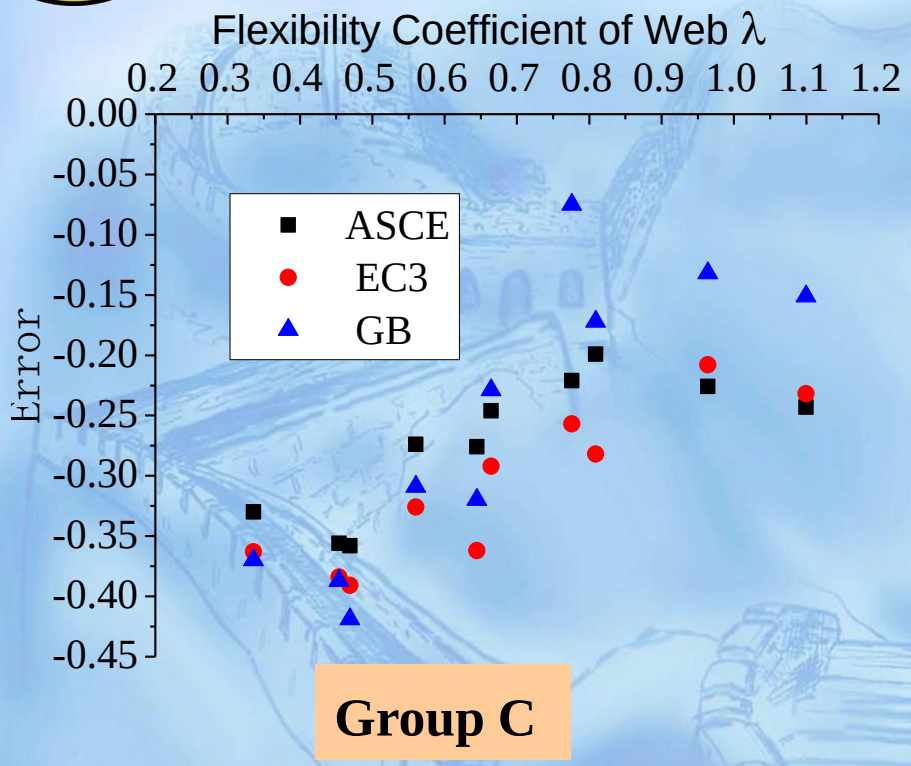
Part 4: Tests Comparisons of test strengths with design strengths of stub columns

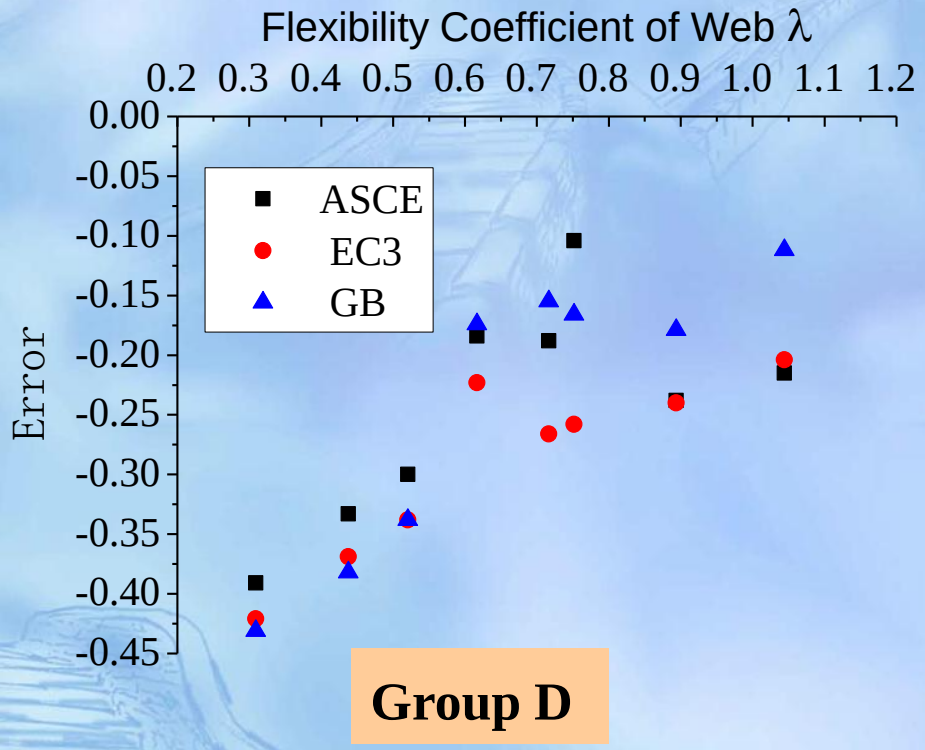
The following figure depicts the distributions of error in design strengths of stub columns in four groups according to the slenderness coefficient λ of the web.





Fourth International Structural Stainless Steel Experts Seminar---2012 London





The largest error occurs in the design strengths of European Code (EC3), then American Specification (ASCE), at last Chinese Code.

Part 5: Conclusions

- Stainless steel is anisotropic and the thickness has certain influence on the hardening index n.
- There are two buckling modes of stainless steel stub column specimens.
- With the increase of load, the load-displacement curves of stub columns appear firstly linear growth, then nonlinear behavior, and at last downward sloping lines.
- For bearing capacity of stainless steel stub columns, the values of codes are obviously less than test values.

Thank You Very Much!