THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

國家鋼結構工程技術研究中心香港分中心
Chinese National Engineering Research Centre
For Steel Construction (Hong Kong Branch)

CNERC

NEWSLETTER
DECEMBER 2020
ISSUE SEP - DEC 2020

FEATURE STORY

CIC Research Webinar on Advanced Steel Solutions and Co-engineering

CIC Research Webinar on Advanced Steel Solutions and Co-engineering" organized by the Construction Industry Council (CIC) was held at the CIC Headquarters on 19 October 2020 with over 600 engineers joined. Both Ir Prof. K. F. Chung, Director of CNERC, and Ir Jun Kan, Managing Director of the China Roads and Bridges Corporation, were invited to be the keynote speakers. This Webinar aims for prominent researchers to share their latest research achievements, and experienced practitioners to share their real-life applications of research outcomes. Through the Webinar, practitioners and researchers could exchange views on research needs and initiation, explore ways for more co-engineering which could facilitate adoption of research products in construction practice.

During the Webinar, Prof. Chung shared his research findings and the engineering applications of high strength S690 steels. While Ir Jun Kan, Managing Director of China Road & Bridge Corporation (CRBC) shared the technical challenges and innovation in the construction of the Cross Bay Link, Tseung Kwan O.

From left: Ir Dr. Richard Pang, Director of Industry Development of CIC, Ir Jun Kan, Managing Director of CRBC, Ir Prof. K. F. Chung, Dr. James Wong, Senior Manager – Construction Productivity of CIC, and Mr. Hailong Liu, Deputy General Manager of CRBC.

Announcement of Results - NSFC/RGC Joint Research Scheme 2020/21

Research Grants Council of Hong Kong
香港 研究資助局

On 30 October 2020, Prof. K. F. Chung, Director of CNERC and Dr. H. Y. Ban, Tsinghua University have been awarded funding for a joint project by Chinese National Natural Science Foundation of China and the Research Grants Council of Hong Kong under the NSFC/RGC Joint Research Scheme 2020/21. The project title is "Research on Structural Behaviour of Stainless-Clad Bi-Metallic Steel Welded Connections and Joints under Monotonic and Cyclic Actions". Prof. Chung will receive a funding of HK$1,158,000 from RGC while Dr. Ban will receive a funding of RMB1,000,000 from NSFC for the 48-month collaborative project.

CNERC Engineering Research Seminars

Starting from this September, CNERC will be organizing monthly engineering research seminar among its research personnel as a platform to share their latest research findings and ideas.

On 11 September 2020, the first monthly engineering research seminar was held, and the following topics were presented and discussed.

Presentation Title	Speaker
Microstructure change during welding of high strength steel S690-QT and S960-QT	Ms. Tingyu XIAO
Push-out tests for innovated shear connection system in prefabricated bridges	Dr. Xuanding WANG
Standard tensile tests on high strength S690 steel curved coupons	Dr. Yifei HU
Corrosion monitoring and mechanism design of expandable modular integrated construction	Mr. Hao JIANG
Internal space of eMiC for fire-proof and water-proof insulation	Mr. Eric YUEN

The second CNERC monthly engineering research seminar was held on 9 October 2020 with the following presentations.

Presentation Title	Speaker
Research on robotic welding of CNERC	Ir Victor WU
Development of constitutive model with ductile fracture for S960 high strength steel	Dr. Cheng CHEN
Preliminary results of the push-out test for innovated shear connection system in prefabricated bridges	Dr. Xuanding WANG
Numerical analysis on residual stresses in T-joints between S690 CFCHS	Dr. Yifei HU
Characterization of macrostructure and microstructure of heat affected zones in high strength steel	Ms. Tingyu XIAO
Design calculation of truss-out bamboo scaffold	Ms. Wei FENG

The third CNERC monthly engineering research seminar was held on 6 November 2020 with the following presentations.

Presentation Title	Speaker
Atmospheric Corrosivity on Infrastructures in Hong Kong	Mr. Hao JIANG
Development of Constitutive Model with Ductile Fracture for S960 High Strength Steel	Dr. Cheng CHEN
Microstructure Chang during Single Pass and Multi-pass Welding	Ms. Tingyu XIAO
Push-out Test for Innovative Shear Connection System in Prefabricated Bridges	Dr. Xuanding WANG

Webinar presentation organized by Tianjin University

Prof. K. F. Chung and Dr. Y. F. Hu were invited by Prof. Zong Liang of the School of Civil Engineering and Architecture of Tianjin University to present their research work on 5 November 2020. Prof. Chung reported the latest research findings and engineering applications of high strength S690 steels in construction, in particular, structural adequacy and ductility of both the high strength S690 steels and their welded sections. Dr. Hu presented a systematic experimental investigation into structural behaviour of T-joints between S690 circular hollow sections subjected to various loading conditions, and suitability of current design methods in the Structural Eurocode EN1993-1-8 was demonstrated with a comparison between the test and the design results.

The Forum was hosted by Professor Zong Liang while Professor Han Qinghua, Dean of School of Civil Engineering and Architecture of Tianjin University, delivered a welcome speech. The presentations lasted for about 2 hours, and they were attended by a total of 174 participants including academics, research students and undergraduates from Tianjin University and other universities.

Webinar on MiC Technology

CNERC and Hong Kong Constructional Metal Structures Association jointly organized a series of webinar on Modular Integrated Construction (MiC). Starting from November 2020, a series of four webinars on MiC will be held monthly to provide the latest information on research findings and engineering applications in MiC technology.

The first MiC webinar was held on 26 November 2020, and we were privileged to have Prof. Tarek Zayed, Professor of the Department of Building and Real Estate at The Hong Kong Polytechnic University to share his research findings and the engineering applications of BIM-Based Optimal MiC Installation Schedule. Over 250 engineers had attended the webinar, and the participants actively participated in the Q&A session.

Dr. T. M. Chan, host of the webinar (left), and Prof. Tarek Zayed, speaker of the webinar (right).

CNERC Research Seminar 2020

On 2 December 2020, CNERC organized the CNERC Research Seminar 2020 as a platform for academics and researchers in different Departments at PolyU to share and discuss their research findings and achievements.

The Seminar was hosted by Prof. K.F. Chung, and the event was held on-line through ZOOM meeting. There were about 60 participants attending online as well as at the venue at Room Z414.

Programme:

Time	Presentation Title	Speaker
2:00 p.m. – 2:25 p.m.	Determination of a full range constitutive model for high strength S690 steels with damage evolution	Dr. H. C. HO, Research Assistant Professor (CEE)
2:25 p.m. – 2:50 p.m.	Managing risks in modular integrated construction projects: The role of building information modelling	Dr. Amos DARKO, Research Assistant Professor (BRE)
2:50 p.m. – 3:15 p.m.	Real-time forecasting of thermal field induced by a fire in tunnels using deep learning algorithms	Dr. Xiqiang WU, Research Assistant Professor (BSE)
3:15 p.m. – 3:30 p.m.	***Break***	
3:30 p.m. – 3:55 p.m.	Static behavior of innovative composite shear connectors used in the prefabricated bridge girder	Dr. Xuanding WANG, Postdoctoral Fellow (CEE)
3:55 p.m. – 4:20 p.m.	A simplified approach for the collapse assessment of steel framed-structures	Dr. Jingzhou ZHANG, Postdoctoral Fellow (BRE)
4:20 p.m. – 4:45 p.m.	Effect of welding residual stress on behaviour of high strength steel tubular T-joints	Dr. Yifei HU, Postdoctoral Fellow (CEE)
4:45 p.m. – 5:10 p.m.	Development of constitutive model with ductile fracture for S960 UHSS	Dr. Cheng CHEN, Postdoctoral Fellow (CEE)

RESEARCH

Starting from the previous issue, the CNERC Newsletter will incorporate research articles from our researchers in sharing the latest findings in their research work. Should there be any question or comment in these research work, you may send an email to: cnerc.steel@polyu.edu.hk or contact the researchers directly. The researchers' contact information is available right at the end of each article.

A total of 4 research articles are provided as follows:

1. Residual stresses in S690 Cold-Formed Circular Hollow Sections due to Transverse Bending and Longitudinal Welding

2. Cyclic tension-release behaviour of SMA plate and applications in novel self-centring beam-to-column connections

3. Compressive behaviour of high strength square and rectangular concrete-filled steel tubular stub columns

4. Research work on mechanical behaviour of High Strength Steel S690

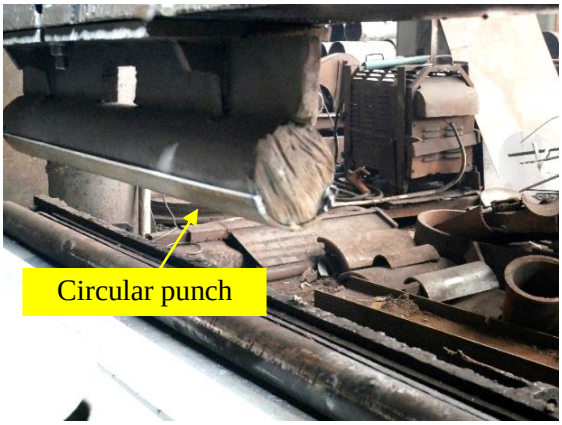
CNERC RESEARCH

Residual stresses in S690 Cold-Formed Circular Hollow Sections due to Transverse Bending and Longitudinal Welding

An experimental and numerical investigation into residual stresses of S690 cold-formed circular hollow sections (CFCHS) due to transverse bending and longitudinal welding has been conducted. It is generally expected that adverse effects of residual stresses on both cross-section and member resistances in the S690 CFCHS are proportionally less pronounced, when compared with those in S355 CFCHS owing to increased yield strengths of the steels. Hence, there is a need to determine the distribution of residual stresses in the S690 CFCHS through a rational experimental and numerical investigation in order to provide accurate data for subsequent structural assessment on these sections.

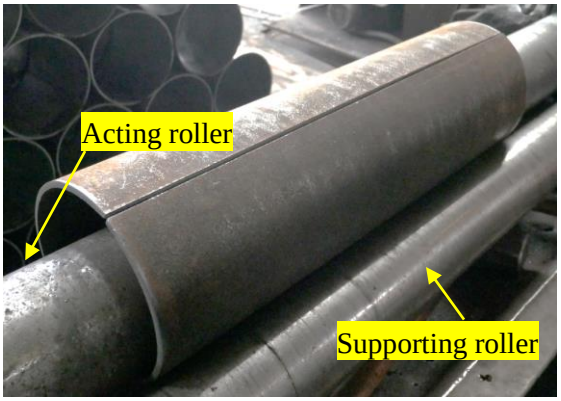
Highlights:

- An investigation into thermal and mechanical responses in S690 cold-formed circular hollow sections (CFCHS) is carried out.
- Surface temperature history and residual stresses in these sections have been successfully measured.
- Three coordinated finite element models are established to simulate both the transverse bending and the longitudinal welding.
- All of these three models have been carefully calibrated with measured data.
- Both measured and predicted residual stresses of these CFCHS are smaller than those reported in the literature.
- A multi-linear model is proposed to describe these residual stresses for assessments of S690 CFCHS.

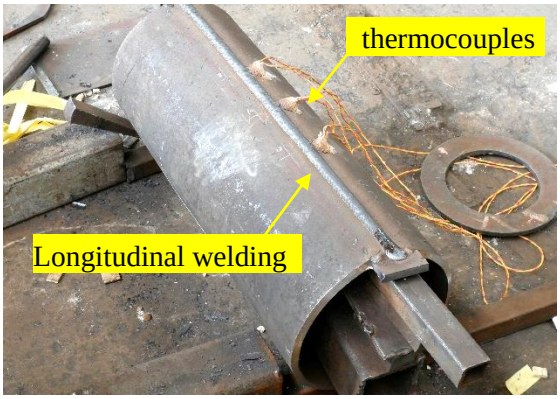


a) Press-braking for edge bending

b) Edge bending completed



c) Transverse bending with a three-roller bending process



d) Longitudinal welding after transverse bending

Figure 1 Fabrication processes of CFCHS

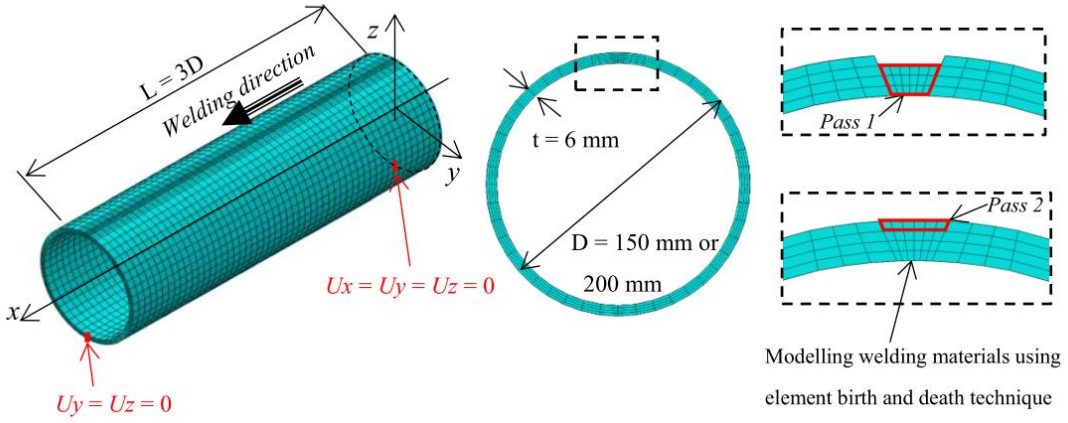
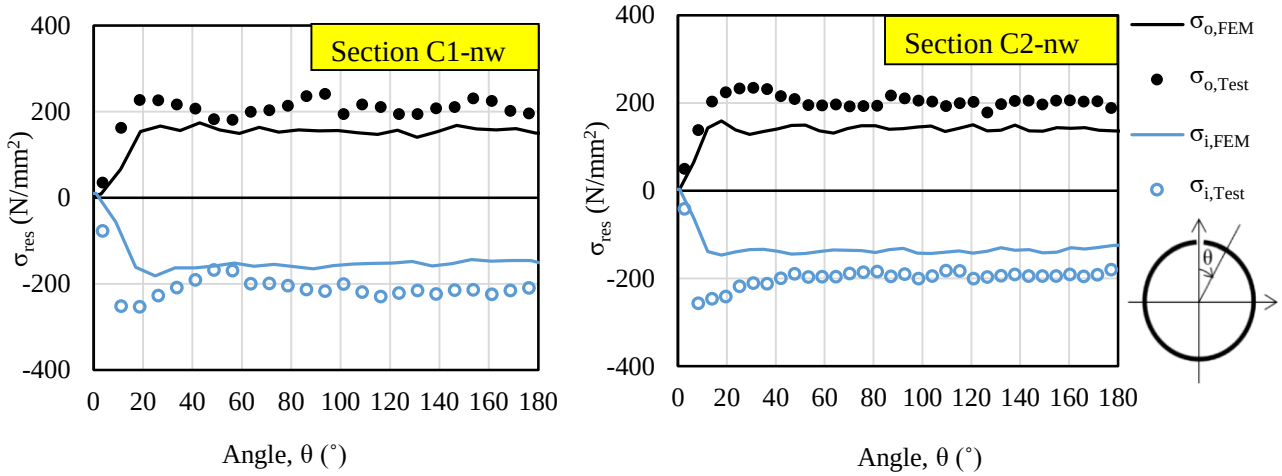
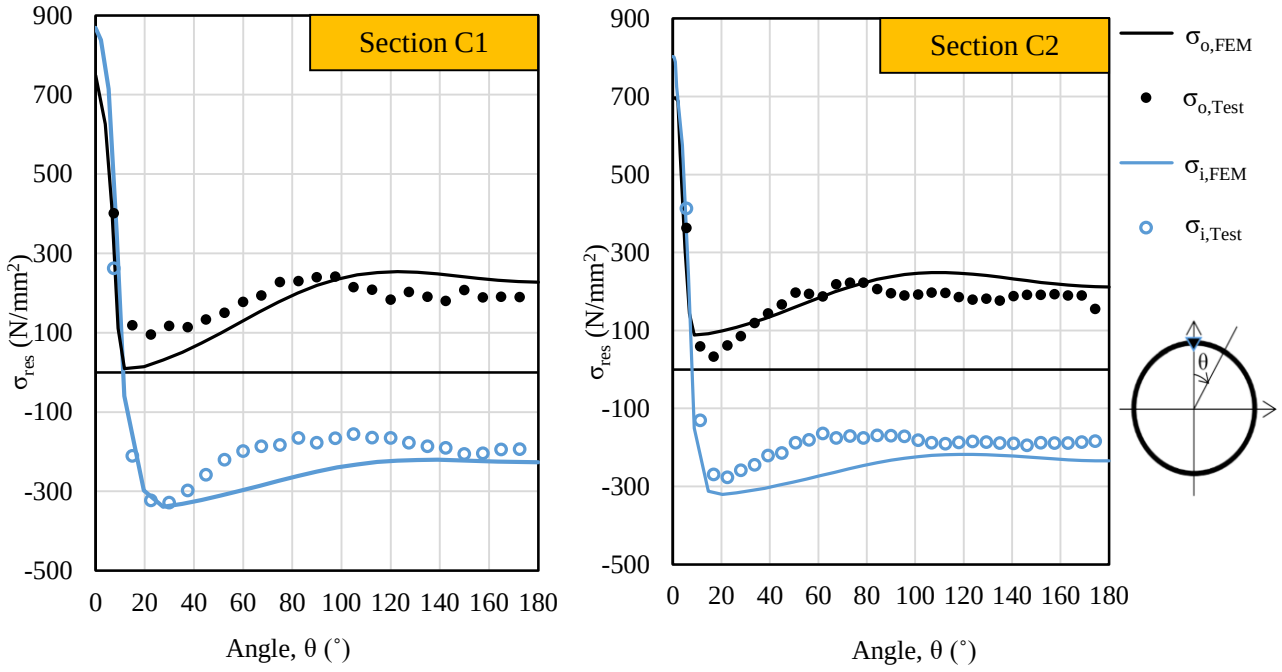


Figure 2 Finite element model of CFCHS for coupled thermomechanical analysis

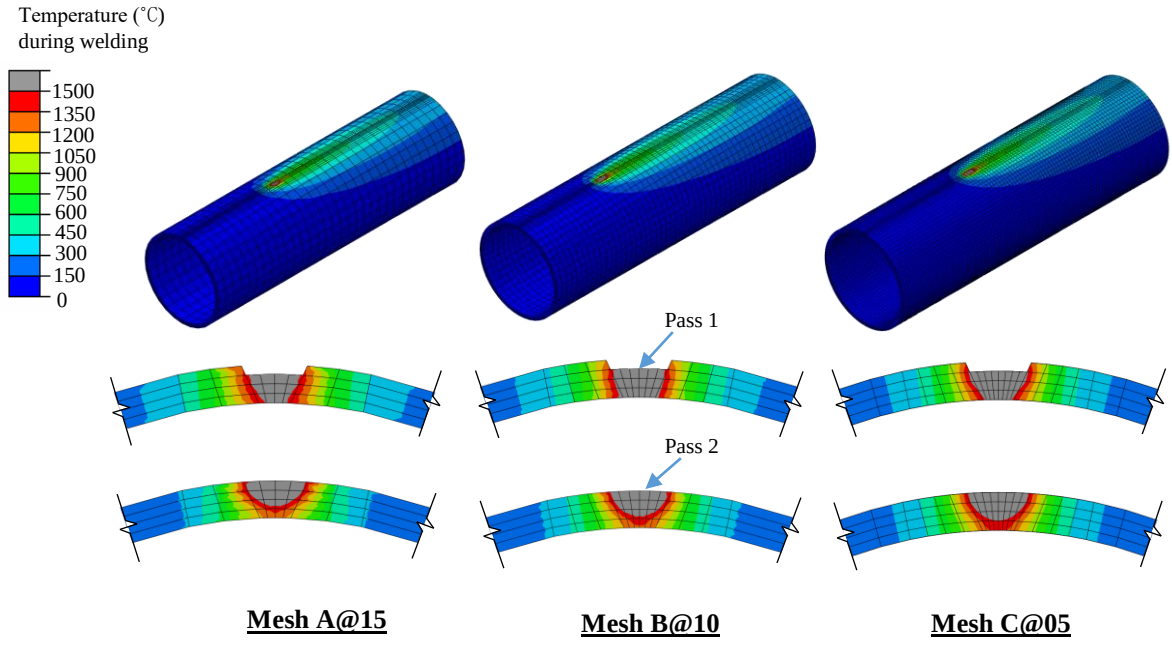


a) Transverse bending



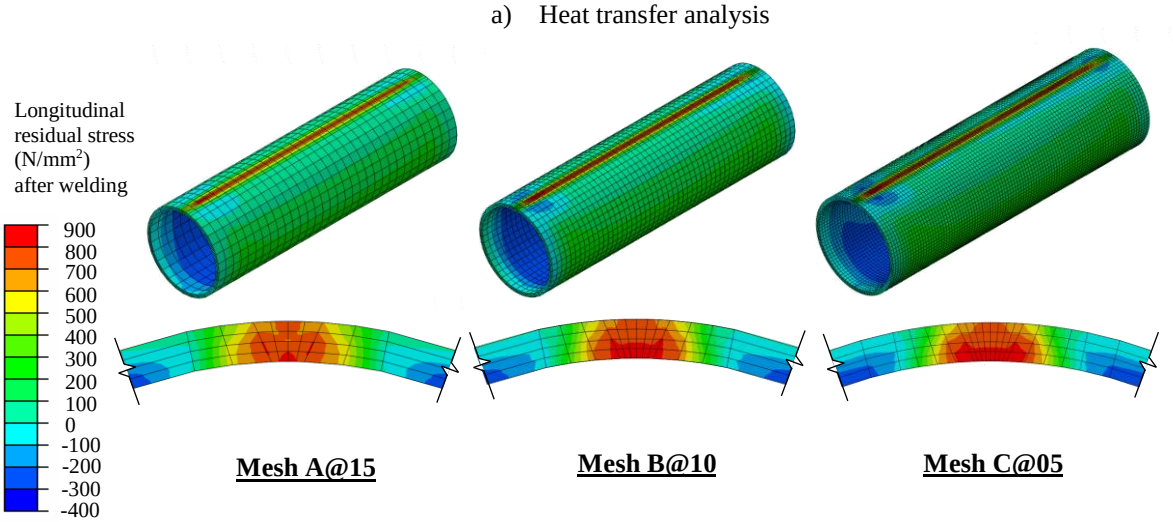
b) Transverse bending and longitudinal welding

Figure 3 Measured and predicted surface residual stresses of CFCHS



Predicted temperature during welding

a) Heat transfer analysis



Predicted residual stresses after welding

b) Thermomechanical analysis

Figure 4 Temperature and residual stress distributions in the vicinity of welding seam of Section C1

Researchers: Dr. Y. F. HU (Email: yi-fei.hu@polyu.edu.hk), and
Prof. K. F. CHUNG (Email: kwok-fai.chung@polyu.edu.hk)

Cyclic tension-release behaviour of SMA plate and applications in novel self-centring beam-to-column connections

A novel SMA-plate-based connection may be realised by employing the SMA plate in the connection. Fig. 1 shows the dimension of the SMA plate specimen and the test rig, and the specimen was examined by cyclic tension-release loading scenarios. As shown in Fig. 2, the stress-strain response shows typical flag-shape hysteretic loops, and good energy dissipation capacity in a wide deformation range was characterised. Compared with the specimen in the virgin state (Phase 1), the behaviour of the specimen in the post-training stage (Phase 3) was varied. In particular, the training cycles may enhance the post-yielding behaviour of the SMA plate, whereas the energy dissipation capacity may be compromised. Based on the test results of the SMA plates, finite element (FE) analysis was carried out, and the FE predictions are shown in Fig. 2. As can be seen, the FE model can well capture the mechanical property of the SMA plate under the cyclic tension-release loading scenarios.

Then, it was proposed that SMA plates may be installed in novel beam-to-column connection, and the notion of the connection is shown in Fig. 3. The corresponding FE model of a prototype connection was developed and analysed, as shown in Fig. 4. Thus, it is expected that the proposed connection may achieve moderate energy dissipation and excellent self-centring capability concurrently. According to the analysis results, it was observed that the inelastic deformation was mainly concentrated in the SMA plate and the SMA washer. The test programme of the connection is currently underway.

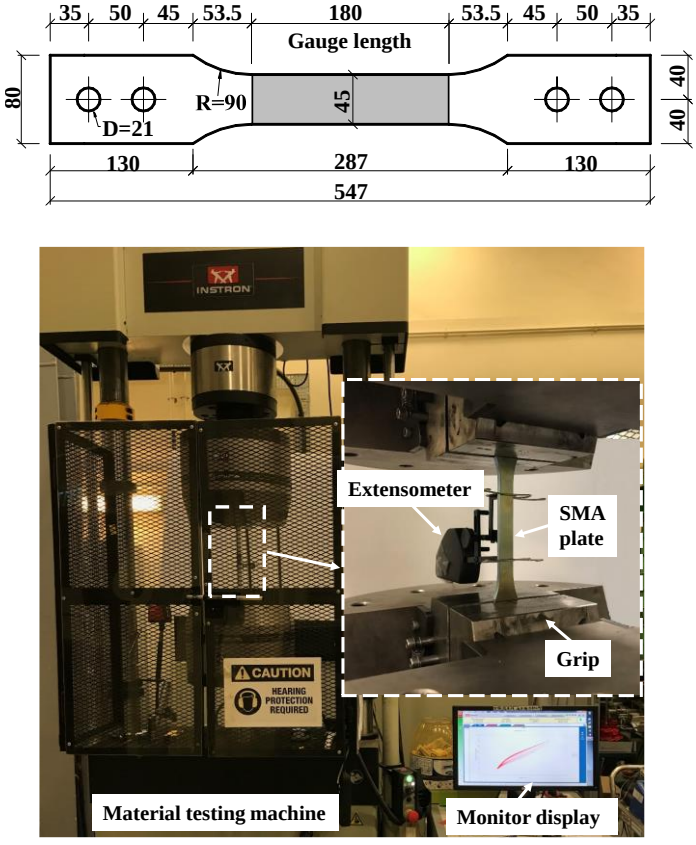
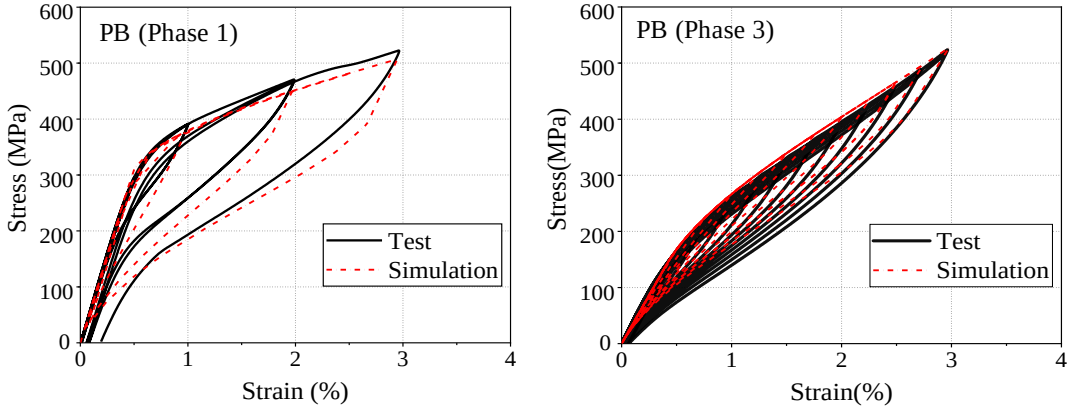


Fig. 1. Specimen design and test arrangement



(a) (b)

Fig. 2. Strain-stress response of the SMA plate specimen: (a) the SMA plate in the virgin state (b) the trained SMA plate

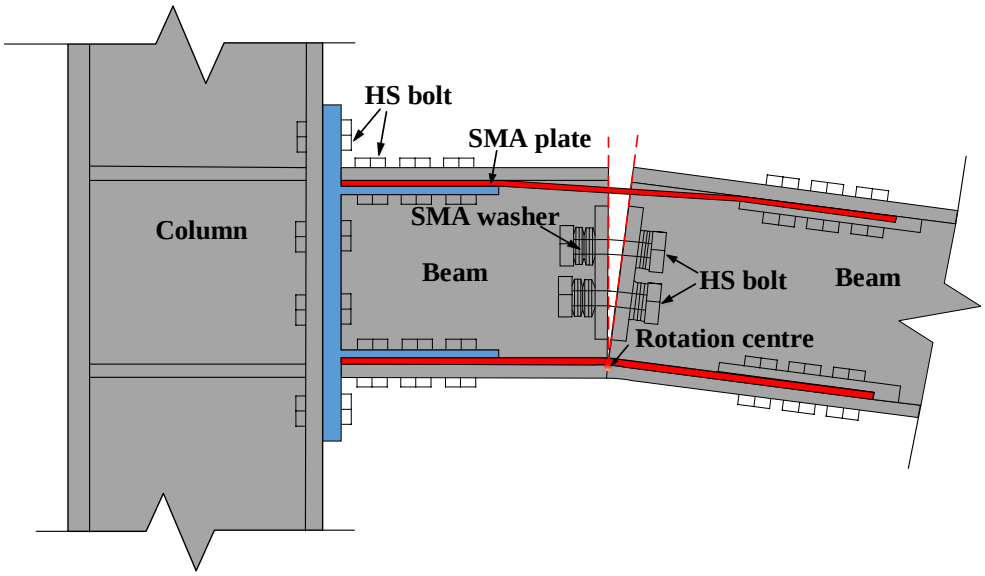
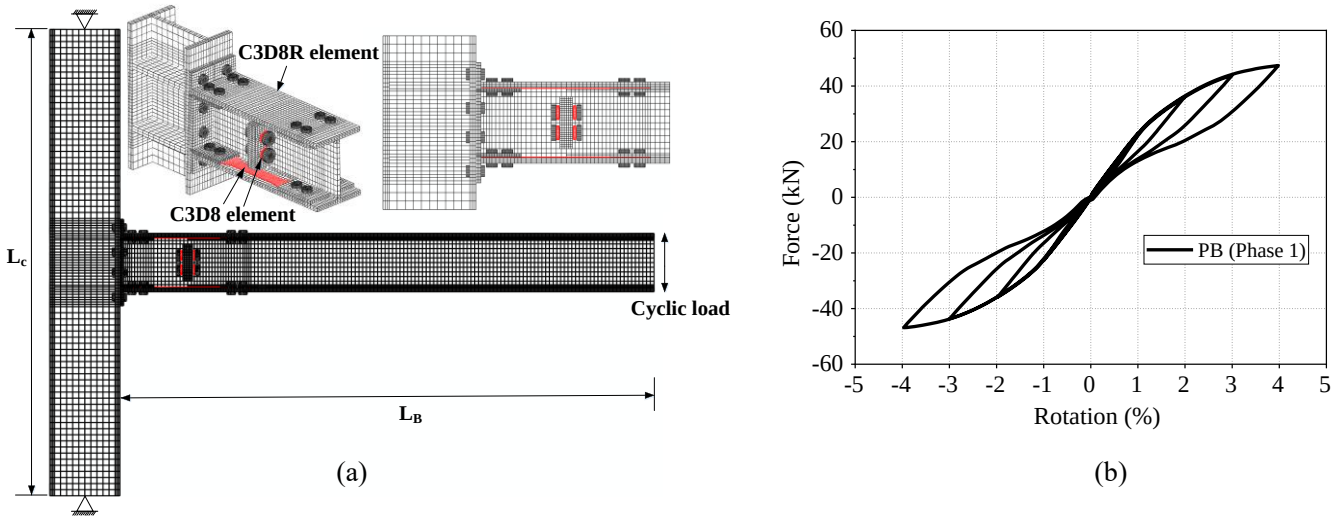


Fig. 3. The notion and deformation pattern of the novel beam-column connection



(a) (b)

Fig. 4. Numerical simulation of the connection: (a) FE model of the connection (b) hysteresis curve of beam-column connection

Researchers: Dr. Ke KE and Prof. Michael YAM (Email: michael.yam@polyu.edu.hk)

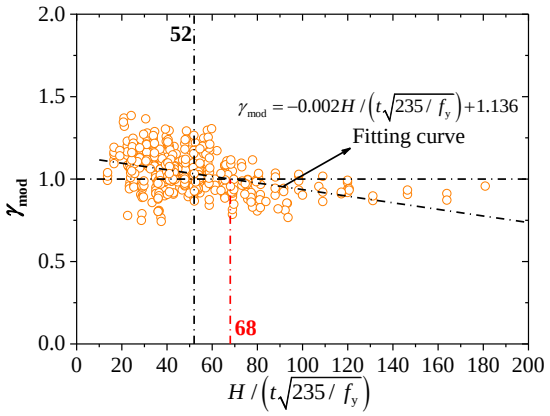
Compressive behaviour of high strength square and rectangular concrete-filled steel tubular stub columns

Concrete-filled steel tubular (CFST) members have been widely adopted in construction industry due to their aesthetic appearance and excellent structural performances. CFST sections optimise the uses of steel and concrete over conventional reinforced concrete (RC) members or steel members. The outer steel tube provides confinement to concrete core increasing the compressive strength of concrete, while in turn the concrete core delays the local buckling of steel tube fully exerting the material strengths. In addition to potential strength enhancements, the application of CFST members also accelerates the construction process with the steel tubes acting as permanent formworks.

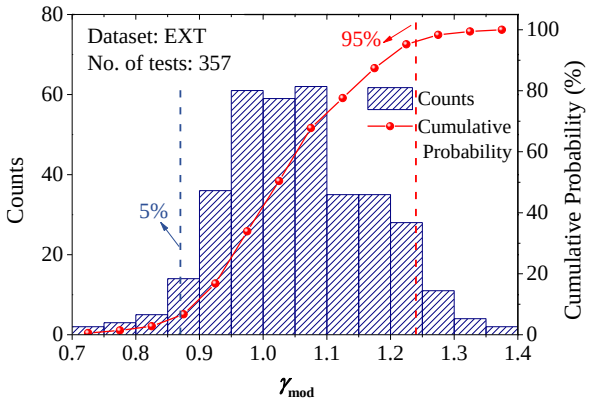
With the development of material manufacturing technologies and availability of various admixtures, high strength steel (with yield strength f_y greater than 460 MPa) and high strength concrete (with compressive cylinder strength f_c' higher than 50 MPa) are now commercially available at the market. As economical constructional materials, high strength steel and high strength concrete have become increasingly popular in construction and attracted the interest of many researchers. However, most of the current design codes around the world, such as ANSI/AISC 360-16 and EN 1994-1-1, do not cover the design of CFST members made from high strength materials. Related research and design rules high strength CFST sections are therefore imperative in order to promote the structural application of high strength materials.

In this project, design of square and rectangular CFST cross-sectional capacities in compression was systematically studied through data analysis and experimental investigation, which is summarised as follows:

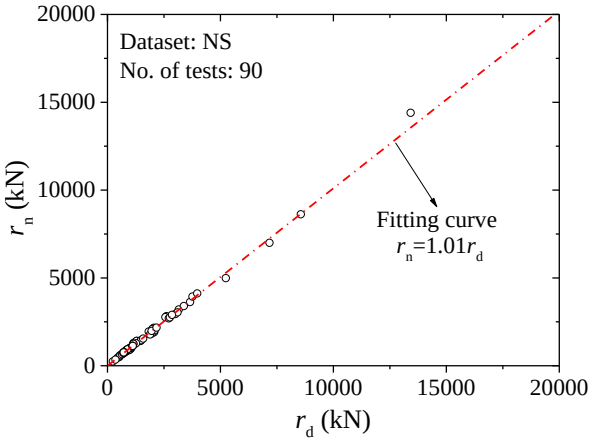
- a comprehensive experimental database consisting of 443 square and rectangular CFST stub column test results was developed;
- statistical evaluations were undertaken to evaluate the applicability of current design equation in EN 1994-1-1 to the design of high strength square and rectangular CFSTs;
- a new design equation was proposed and reliability analysis was performed to check the safety level of the proposed equation;
- an experimental investigation on 10 stub column tests was carried out to further verify the applicability of the proposed design recommendation.



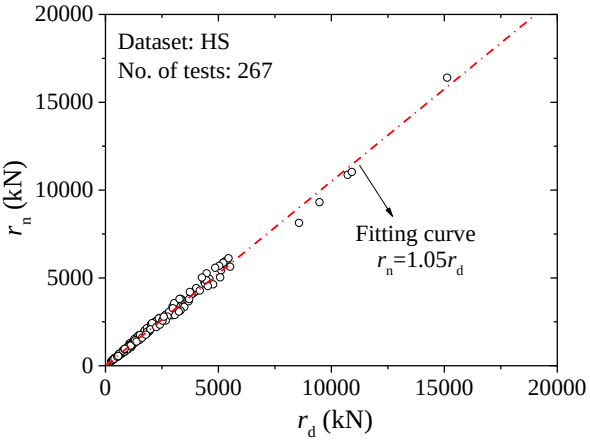
Model safety factor γ_{mod} versus cross-section slenderness $H/(t\sqrt{(235/f_y)})$ diagram.



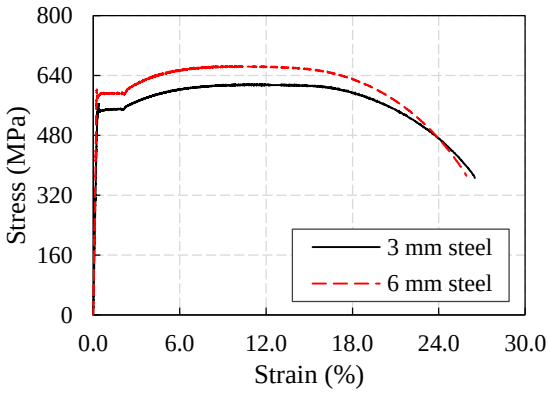
Distributions of model safety factor γ_{mod}.



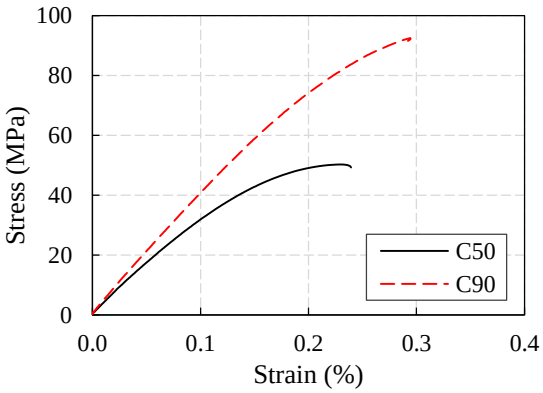
Nominal resistance r_n versus design resistance r_d diagram for normal strength specimens.



Nominal resistance r_n versus design resistance r_d diagram for high strength specimens



Stress-strain curves of high strength steel.



Stress-strain curves of infill concrete.

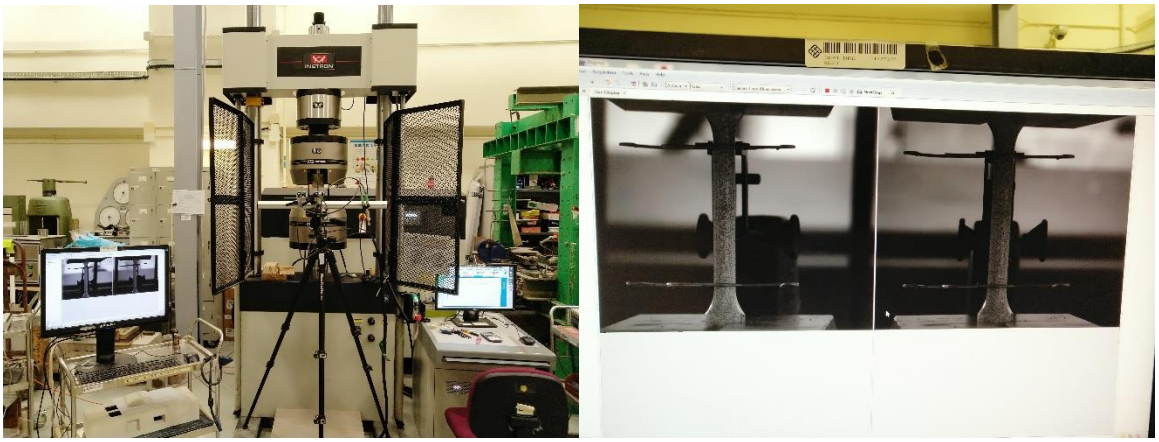
Researchers: Dr. Junbo CHEN (Email: jun-bo.chen@connect.polyu.hk),

Dr. Tak-Ming Chan (Email: tak-ming.chan@polyu.edu.hk) and

Prof. K. F. Chung (Email: kwok-fai.chung@polyu.edu.hk)

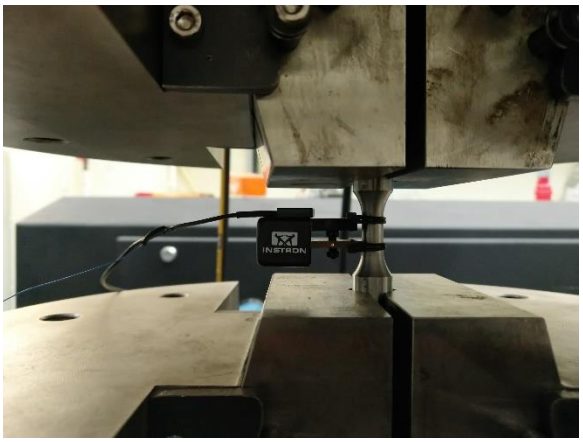
Research work on mechanical behaviour of High Strength Steel S690

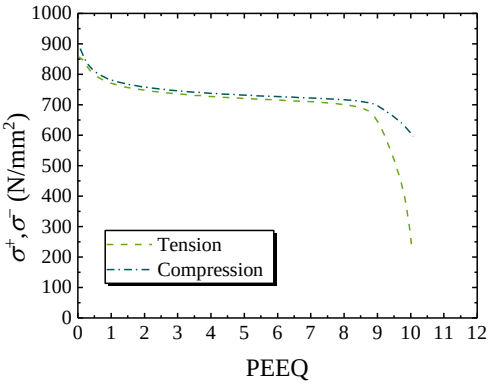
a. The mechanical behavior of Q690 under uniaxial loading was examined and the local deformation after necking was completely measured by Digital Image Correlation (DIC) system.
b. The benchmark test for fracture behaviour of Q690 which is from second Sandia fracture challenge was conducted. Its profile was measured by Zygo Laser Interferometric Non-Contact Profiler System from SKL and the corresponding field variables (e.g. displacement field, strain field) was recorded and analyzed by DIC.
c. Low cycle fatigue test of Q690 under strain control was conducted where Q690 shows a gradual degradation under cyclic plastic loading.



Monotonic test of Q690 with DIC

Benchmark test (from Sandia fracture challenge) for fracture behavior of Q690





Low cycle fatigue test of Q690

Researchers: Mr. Q. HE (Email: qun19.he@connect.polyu.hk), and

Prof. Michael YAM (Email: michael.yam@polyu.edu.hk)

UPCOMING EVENTS

CNERC and Hong Kong Constructional Metal Structures Association jointly organize a series of webinar on Modular Integrated Construction (MiC). Starting from November 2020, a series of four webinars on MiC will be held to provide the latest information on research findings and engineering applications in MiC technology. The presentation titles of the upcoming webinars are as follows:

Date	Presentation Title	Speaker
26 Nov 2020	BIM-Based Optimal MiC Installation Schedule	Prof. Tarek Zayed
7 Jan 2021	MiC: The Construction Industry's COVID-19 Pandemic Breakthrough	Dr. Amos Darko
14 Jan 2021	Application of steel tubular sections in MiC	Dr. T. M. Chan
21 Jan 2021	HKSTP, InnoCell – 1st Hybrid MiC Pilot Project in Hong Kong	Ms. Michelle Lui

For details of the CNERC's upcoming events, please check out our website at:
https://www.polyu.edu.hk/cnerc-steel/en/news-events/upcoming-events

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