



## Welcome to the newsletter of SSRC International Liaison!

The Structural Stability Research Council, SSRC, is the world's preeminent organization dedicated to advancing stability research for application to structures. SSRC has members in more than twenty countries, coming from all continents. In an effort to improve communication among researchers from different parts of the world, SSRC has created the International Liaison Committee. The objective of this committee is to gather reports from different parts of the world to stay apprised of current developments in structural stability research and practical applications.

Upon discussion, the International Liaison Committee decided that one of the alternatives to accomplish the objective is to create the present newsletter, which will be issued biannually. In the near future, other activities will be added to this effort with a single goal: to integrate the structural stability research community by informing about the different advancements on this matter and by presenting real world structural stability problems.

SSRC would like to thank the contributors to this first issue of the newsletter. Six reports from four different continents that combine research with practical applications are presented in this issue.

In this newsletter:

- [Experimental test research on wide flange beam-to-HSS column connections,](#)
- [Behavior of beam-to-column cold-formed section connections subjected to bending moments,](#)
- [STROBE - Stronger steels in the built environment,](#)
- [Structural stability during the construction of a steel box girder bridge,](#)
- [Overall-slenderness based direct design for strength and stability of innovate hollow sections - HOLLOSSTAB,](#)
- [Experimental calibration of built-up compression members.](#)

If you are interested in collaborating with the International Liaison Committee or would like to submit a report to be published in this newsletter, please send an e-mail to [tasanchez@adstren.com](mailto:tasanchez@adstren.com).

# Experimental test research on wide flange beam-to-HSS column connections

## Researchers:

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SPONSORED BY NIPPON STEEL (NSMP) AND THE MEXICAN INSTITUTE OF STEEL CONSTRUCTION (IMCA)

This research study aims to evaluate the seismic response of wide flange beam-to-rectangular HSS column connections through experimental tests and numerical analysis. The main goal of these tests and analysis is evaluating if these connections may qualify for seismic applications as special or intermediate steel moment frames. The test specimens have a T-shaped configuration (Figure 1), with a W24x68 steel ASTM A992 beam that connects to the midspan of an HSS16x16x5/8 steel ASTM A500 Gr. B column. These specimens represent a sub-assembly of an exterior connection in a steel moment frame subjected to earthquake forces simulated through the cyclic loading protocol from the AISC seismic provisions (ANSI/AISC 341-16). In total, eight steel connections are being evaluated (Figure 2), with different configurations (welded and bolted), diaphragms (internal, external and through). Some of these connections are typical in the Mexican standard practices that had not been tested, and others are adaptations of typical connections in other countries with potential application in the Mexican standard practices. These tests and analysis will allow characterizing the behavior of each connection in terms of its failure mode (e.g. yielding, buckling, fractures), stability, strength, stiffness and ductility, thus concluding if they qualify for applications as special or intermediate steel moment frames in seismic zones.

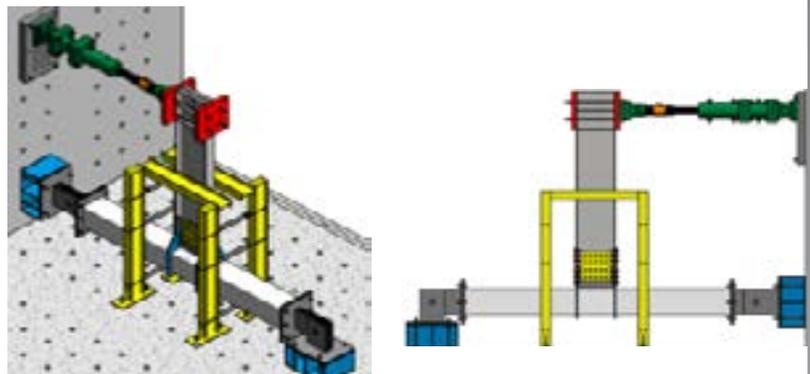


Figure 1. Test setup



Figure 2. Specimens with wide flange beam-to-HSS column connections

# Behavior of beam-to-column cold-formed section connections subjected to bending moments

Researchers:

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Mohamed M. El-Saadawy, Housing and Building National Research Center (HBRC), EGYPT

Ehab H.A.H. Aly, Housing and Building National Research Center (HBRC), EGYPT

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Cold-formed sections are often used in the construction of mid-rise buildings due to their high strength-to-weight ratios and fast erection. In these buildings, the connections between joists and studs are mainly simple connections. However, the application of these sections can be extended to moderate span portal frames where the connections between members are subjected to bending moments. The strength and stability of such frames depend to large extent on the behavior of the connections between their members. Over the last twenty years, several researchers have undertaken tests on cold-formed section connections subjected to bending moments. The majority of them classify the connections as semi-rigid due to the effect of bolt-hole elongation, but some suggest that as the maximum capacity of the section is reached the connection can be considered rigid.

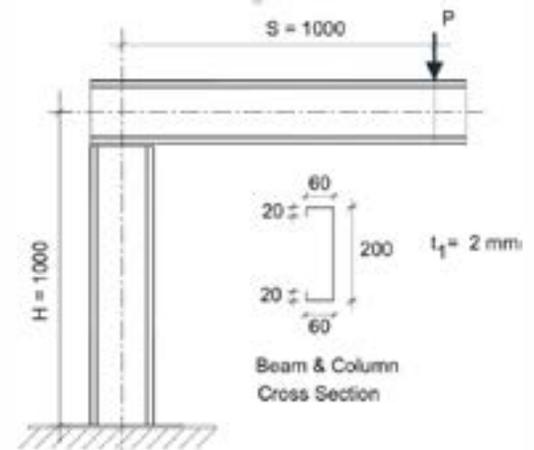


Figure 1: Case of study

In this research, experimental investigations are carried out to study the structural response the connection between a beam and column fabricated from cold-formed sections as shown in Fig. 1. Lipped channel sections with dimensions of 200 mm for the web, 60 mm for the flanges and 20 mm for the lip are studied. Figure 2 shows the schematic diagram and a photograph of the test setup. Two types of cold-formed section connections subjected to bending moments are studied as shown in the finite element models of the test specimens given in Fig. 3. In the first type, the beam is connected to the column via a bracket plate in the form of a tapered gusset plate attached to the web of the beam and column sections. In the second type, the flanges of the connected beams and columns are joined together by an additional rectangular plate on the tension and compression side. Moreover, the experimental set-up is simulated numerically using a non-linear finite element model. The cold-formed sections are modeled using shell elements while the connecting fasteners are modeled using beam elements.

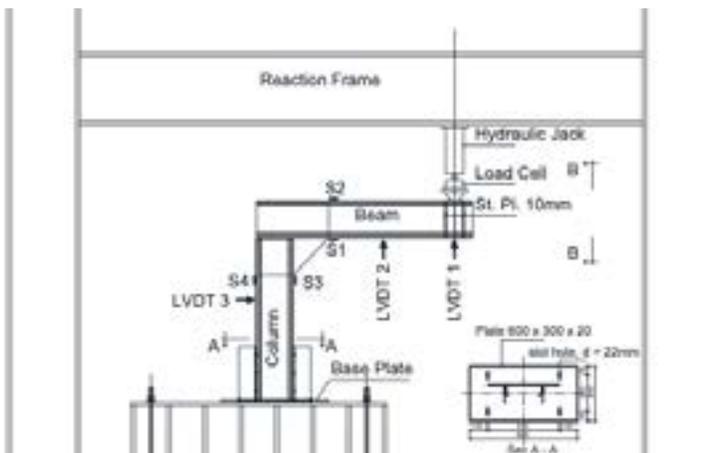


Figure 2: Schematic diagram and photo for the test setup

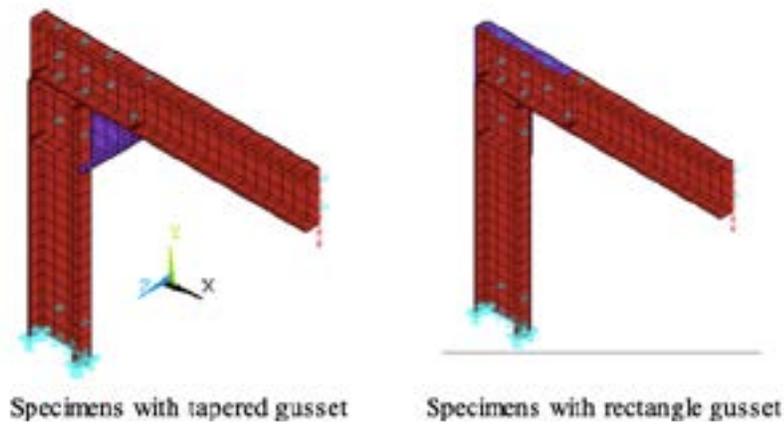


Figure 3: Finite element models

## STROBE - Stronger steels in the built environment

### Research Institutions:

RWTH - RWTH Aachen University, GERMANY

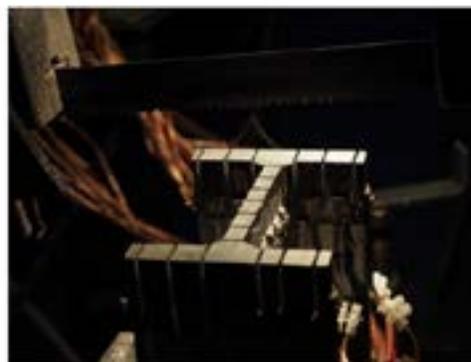
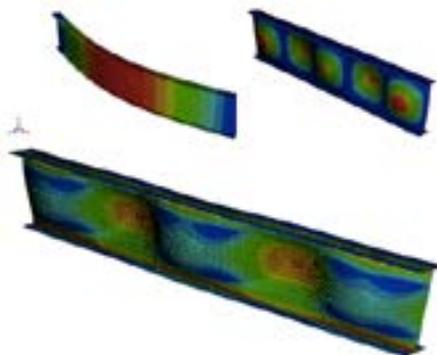
SCI - The Steel Construction Institute LBG, UNITED KINGDOM

UC - Universidade de Coimbra, PORTUGAL

FUNDED BY THE RESEARCH FUND FOR COAL AND STEEL OF THE EUROPEAN COMMISSION

This project will study the structural response of HSS from S460 to S700, considering both hot rolled and fabricated I shaped sections (homogeneous and hybrid). Focus is on basic issues allowing for usage of HSS with lower ductility values, exploiting plastic capacity, leading to more slender and highly utilized profiles. The scientific work builds strongly on the successfully completed RFCS projects RUOSTE and HILONG. The related issue of dynamic response will also be tackled. The benefits will be quantified by design comparisons and life cycle assessments. The project focuses on building structures, both single and multi-storey. However, the results will have generic applicability to a far wider range of structures. Specialist topics related to fatigue and seismic loading are outside the scope of this project. The key technical themes covered within STROBE are:

- Ductility and toughness requirements for HSS material,
- Design of hybrid plate girders,
- Plastic design of HSS (homogeneous and hybrid) beams and frames,
- Stability of HSS columns (homogeneous and hybrid), beams and beam-columns,
- Dynamic response of HSS (homogeneous and hybrid) floor systems
- Weight, carbon and cost savings made possible with HSS systems.



# Structural stability during the construction of a steel box girder bridge

Researchers:

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Andrés Robalino, ADSTREN Cía. Ltda., ECUADOR

The Villorita Bridge is a box girder bridge located in Quito, Ecuador, that is composed by two reinforced concrete decks over four steel girders. The bridge has two spans of 52.25 [m] and 92.75 [m], respectively (Figure 1), and was constructed using the incremental launching method. Due to the site conditions, a set of two girders was launched at the time. Because the launching level was approximately 4 [m] higher than the final level of the bridge, after launching, the steel girders had to be descended using strand jacks located at each support (Abutment A, Pier B, and Pier C), as shown in Figure 2. Temporary structures were designed and constructed at each of these three positions to mount the strand jacks for the lowering operation. Due to site constraints at the abutment and piers, the result was three steel structures with slender geometries, where the structural stability of the system was scrutinized in detail. In addition to checking that the structure had an appropriate resistance for the expected vertical loading condition, asymmetric load distribution and accidental lateral loads were also considered during design. Similarly, eigenvalue buckling analyses were performed in Mastan (<http://www.mastan2.com/>) to determine the critical load and study the frame behavior at different stages. The temporary structure at Pier B, for example, had a total height of 11.70 [m] and was placed over a small area of 1.69 [m<sup>2</sup>] (Figure 3). This structure was constructed with 13000 [kg] of structural steel and was designed to support a nominal load of 6000 [kN]. The construction of these temporary structures is an example of the applications of refined stability studies during the erection of steel girder bridges. The entire construction process of the Villorita Bridge is documented in the following video: <https://www.youtube.com/watch?v=DoqYv-C6MKw>

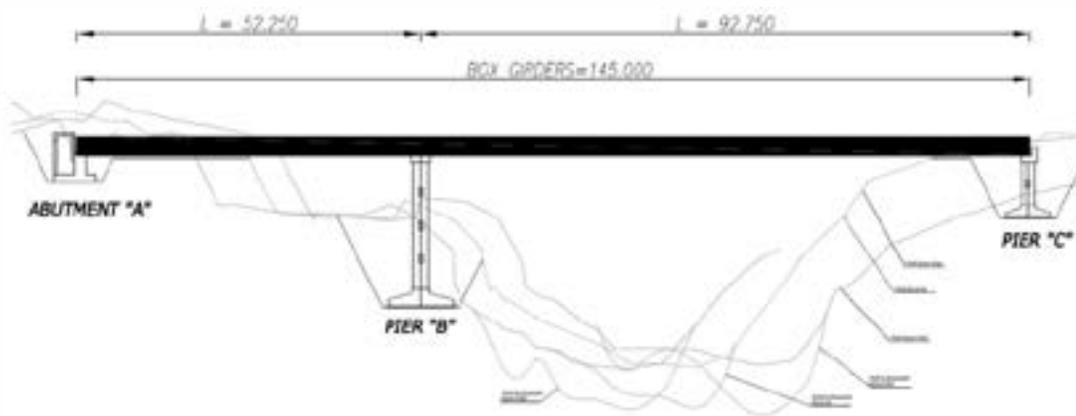


Figure 1: Bridge elevation

Figure 2. Bridge hanging from strand jacks during lowering operations



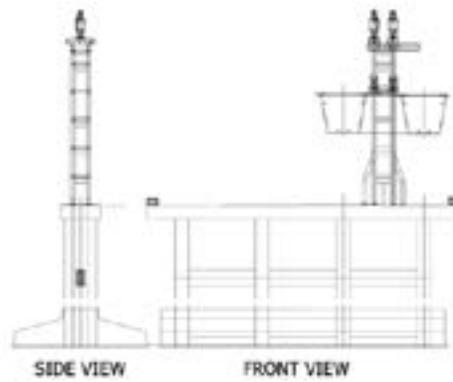


Figure 3: Temporary structure at Pier B

Overall-slenderness based direct design for strength and stability of innovative hollow sections - HOLLOSSTAB

Research Institutions:

University of the Bundeswehr Munich, GERMANY

Imperial College of Science Technology and Medicine, UNITED KINGDOM

Instituto Superior Técnico

Convention Européenne de la Construction Métallique, BELGIUM

Centre Technique Industriel de la Construction Métallique, FRANCE

Université Laval, CANADA

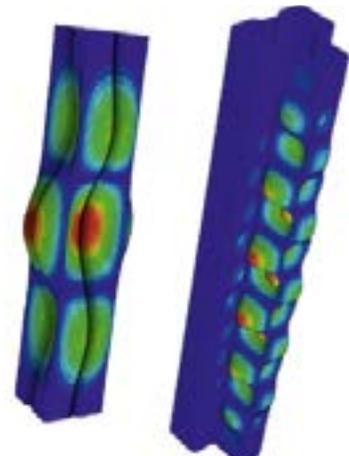
Conducciones Y Derivados S.L.U.

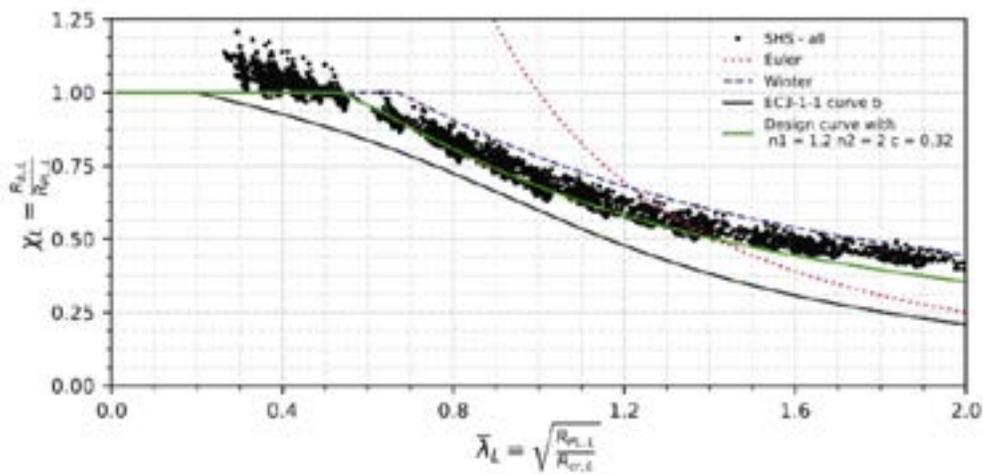
FUNDED BY THE RESEARCH FUND FOR COAL AND STEEL OF THE EUROPEAN COMMISSION

HOLLOSSTAB aims at developing new, direct design rules regarding strength and stability checks based on the “Overall Interaction Concept”. Addressing both usual steel grades as well as tomorrow’s high strength steels, this project will allow for more economic, innovative, “thin-walled” hollow section members. Simpler and faster design procedures will be developed, and both numerical tools and the latest statistical production data will be made available to structural engineers. These goals will be tackled by means of extensive numerical, analytical and experimental programs, with the close collaboration of key European industrial stakeholders from different EU countries.



Sample of the examined cross-sections





## Experimental calibration of built-up compression members

Researcher:

Ghada El-Mahdy, British University in Egypt (BUE), EGYPT

There is a large diversity in the requirements for designing built-up compression members between international design codes. Most codes, including the North American standards and specifications specify the use of an equivalent or modified slenderness ratio, whereas the EuroCode specifies the use of a continuous (smeared) shear stiffness of the column. Also, in the USA built-up battened compression members are not covered by either the AISC building specification or the AASHTO or AREMA bridge specifications. In general, all North American standards and specifications agree on the need of using an equivalent slenderness ratio or modified slenderness ratio, but differ in the factor used to multiply the local slenderness ratio. Theoretically it is difficult to estimate the exact value of this factor, and using direct experimental methods does not capture the exact value of this factor either due to the inevitable errors in the load readings and the problem of which column curve to use. Hence, a different approach is needed to determine the value of this factor. In this research, an experimental method to determine the exact value of the equivalent slenderness ratio of a built-up compression member by comparing it to the slenderness ratio of a solid column is given using the boundary conditions shown in Fig. 1. The number of interconnectors and the length of the column can be varied until a pivotal column is found from which the equivalent slenderness ratio about the axis passing through the open web is equal to the integral slenderness ratio about the axis passing through the solid web as shown in the finite element analysis in Fig. 2 and Fig. 3. This eliminates the uncertainties in measuring the load and in choosing a column curve. It is proposed that this method be used to calibrate all types of built-up compression members, whatever the type of interconnector used is or its connection to the main members. The aim of this research is to unify the requirements of international codes by directly determining the missing factor in the equivalent slenderness ratio equation.



Figure 1: End conditions of test specimens

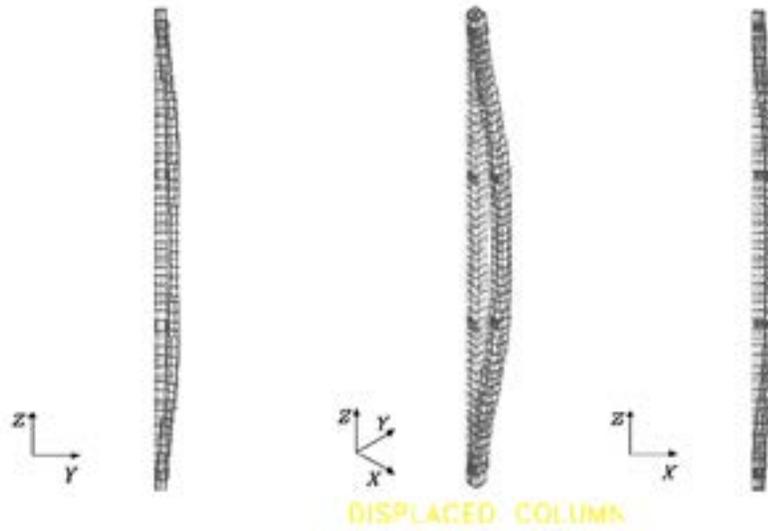


Figure 2: Displaced configuration of finite element model of specimen 120-63-2

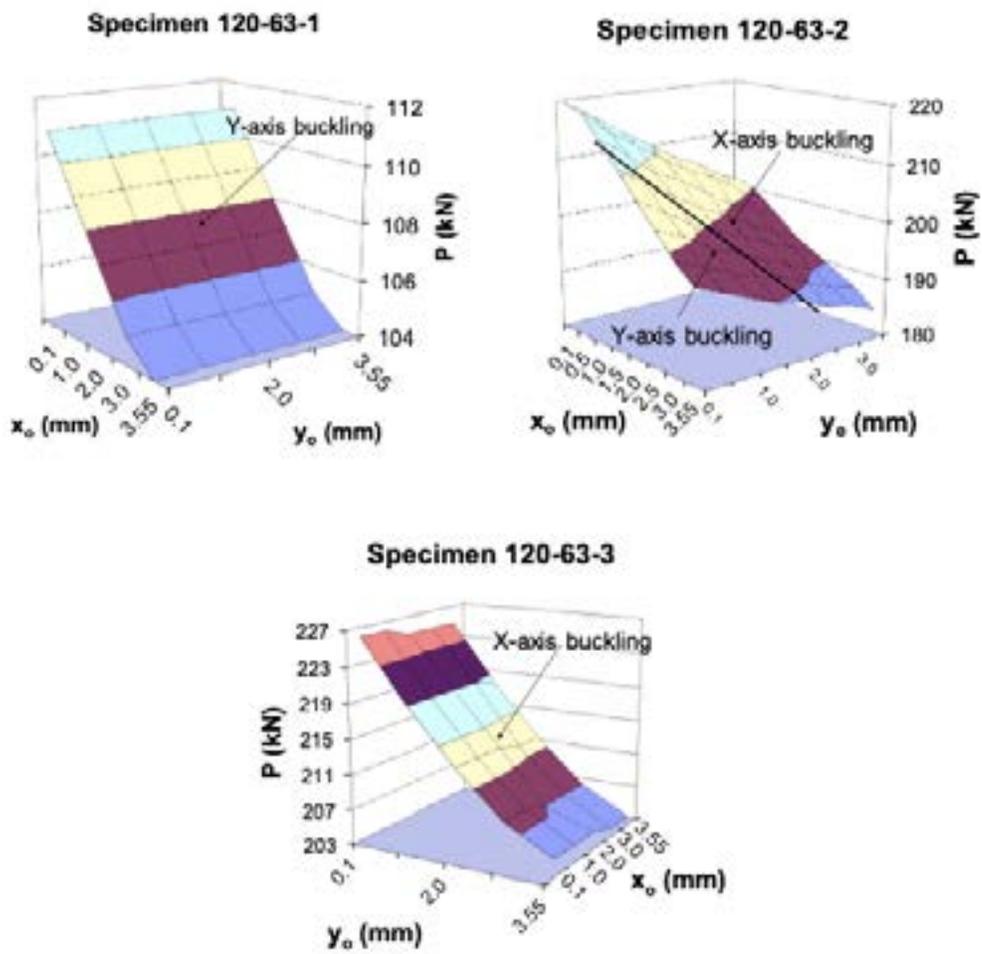


Figure 3: Finite element analysis imperfection surfaces