

NXGEN-CFSS – Towards the Next Generation of Cold-Formed Steel Structures: Advanced High Strength Steels

Summary

This exploratory research proposal aims to investigate the advantages of using advanced high-strength steels (AHSS) in the cold-formed steel (CFS) building sector, following the recent success of AHSS in the automobile sector.

Motivation, main goals and challenges

It is well known that the construction industry is responsible for a large portion of our society's environmental impacts. Indeed, reducing these impacts and making this industry more sustainable is currently one of today's major societal challenges. The replacement of the current conventional mild or high-strength steels (HSS) with AHSS will certainly contribute to mitigating those impacts (e.g. lower greenhouse gas emissions) since higher strength-to-weight ratios can be achieved, combined with lower life-cycle costs. The accomplishment of this goal will certainly lead to the next generation of CFS structures: advanced high-strength cold-formed steel (AHSCFS) structures.

Despite the success of AHSS in the automobile industry, these steel grades cannot be readily applied in the construction industry, since none of the current worldwide structural design codes covers them. Indeed, the analysis of the state-of-the-art involving AHSS in civil engineering reveals that applications are very scarce and recent. Moreover, with respect to conventional and HSS, AHSS exhibits specific features that render the development of efficient design rules rather challenging: (i) the constitutive relations are significantly more complex, (ii) the members become considerably more susceptible to complex coupled buckling phenomena, and (iii) all ultimate limit states must be revised (much higher yield and ultimate strengths, while Young's modulus is similar) since it may not be possible to simply adjust the current design rules prescribed for CFS members (Eurocode 3-1-3) through new partial safety factors. These issues must be addressed before AHSCFS members can be efficiently designed and become economically attractive. This project is motivated by the lack of knowledge

concerning the structural behaviour of AHSCFS members and the absence of design rules.

Strategy and methodology

This proposal investigates the advantages of using AHSS in the building/structural sector, focusing on uniformly compressed members (columns). To achieve this objective, the project comprises a well-balanced research plan comprising experimental investigations and advanced numerical simulations. The experimental programme comprises the (i) characterisation of the (i) constitutive relations of several types of AHSS (Fig. 1), e.g. using the two-stage Ramberg-Osgood model, and the characterisation of the variability of all parameters, (i₂) material imperfections (geometrical and residual stresses) of commonly used CFS cross-sections (e.g. unlippped and lippped channels), and (ii) performance of full-scale tests (Fig. 2) for all buckling limit states, including the coupled phenomena. The numerical investigations encompass an in-depth study of the structural behaviour of CFS columns prone to all buckling phenomena, including coupled local-distortional-global buckling mode interaction (a major issue for AHSS). The competitiveness of AHSS in the structural steel industry is assessed by comparing the strength-to-production cost ratios of representative grades of AHSS, HSS and conventional steels. The accuracy of the current design rules prescribed by Eurocode 3-1-3 is evaluated based on the ultimate failure loads, obtained experimentally and numerically.

Expected results

The project will provide (i) a database of experimental results of several types of AHSS (material and structural), (ii) an in-depth understanding of the structural response of AHSCFS columns, including relevant coupled buckling phenomena, (iii) strength-to-production costs of representative grades of AHSS, HSS and conventional steel, (iv) innovative cross-sections better suited for AHSS, and (v) the characterisation of the uncertainty of the resistance models provided in the Eurocode 3-1-3 for AHSCFS columns. Finally, the acquired knowledge will be transferred to the CFS industry.



Figure 1. Material characterisation tests of high-strength steels (with video extensometer).



Figure 2. High-strength cold-formed steel profiles (C-sections).

Project Reference

2023.13431.PEX

(<https://doi.org/10.54499/2023.13431.PEX>)

Leading Institution

IST-ID – Associação do Instituto Superior Técnico para a Investigação e o Desenvolvimento (Portugal)

Partners

NOVA.ID.FCT – Universidade Nova de Lisboa Associação para a Inovação e Desenvolvimento da FCT (Portugal), COFAC – Cooperativa de Formação e Animação Cultural (Portugal)

CERIS Principal Investigator

André Martins

(andrerdmartins@tecnico.ulisboa.pt)

CERIS Research Team

Rodrigo Gonçalves, Nuno Peres, Dinar Camotim, Pedro Borges Dinis, António Duarte

Funding

FCT – Fundação para a Ciência e a Tecnologia

Period

2025-2026

Total

49 977.23€

CERIS

49 977.23€