Comments on Ductility of Concrete Encased Composite Columns

Anca Gabriela POPA
Lecturer
Technical University of Cluj-Napoca, Romania
anca.popa@mecon.utcluj.ro

Anca Gabriela Popa, born 1964, received her civil engineering degree from the Polytechnic Institute of Cluj-Napoca, Romania. She worked in housing before becoming Reader at the Technical University of Cluj-Napoca. Her main area of research is related to structural mechanics.

Cristina Mihaela CAMPIAN
Professor
Technical University of Cluj-Napoca, Romania
cristina.campian@dst.utcluj.ro

Cristina CAMPIAN is a Professor at Technical University of Cluj-Napoca, Romania. She received her PhD degree from the National Institute of Applied Sciences Rennes, France. She is teaching steel and composite structures at the Civil Engineering Faculty in Cluj. Her main area of research is related to retrofitting of steel structures.

Summary

The paper describes experimental aspects for composite steel-concrete columns, with steel encased profile. Eurocode 4 provides a relative simple method to design composite columns, but it has some restrictions: related to cross – section, it applies only for bi – symmetrical form of the cross – section of the steel shape, and, for the concrete class, restricted to maximum C50/60. The main of this work is to analyse the behaviour of composite columns having the concrete of a higher class.

Keywords: composite steel-concrete columns, high strength concrete, experimental tests.

1. Experimental Program

At Technical University of Cluj – Napoca, Civil Engineering Faculty laboratories, tests were carried out on composite steel-concrete columns, focused on the increasing the concrete class, called in the following paper HSC (high strength concrete). Seismic resistance of columns was tested on full-scale specimens subjected to cyclic loading and a constant axial force (*Fig. 1 and 2*). The cross-sectional area of composite columns was 220 mm×170 mm and height varying from 2 m long, for 4 specimens, to 3 m long for the rest of them, resulting different slenderness.

Fig. 1: Specimen S2-3C when displacement is 120 mm

Fig. 2: Specimen S2-3C when displacement is 240 mm

https://doi.org/10.2749/222137813806521072

Similar experimental tests have been held in our department in year 2000, but the used concrete was a normal concrete (NC) C20/25. This was the start point for furthermore researches in order to be able to make a full comparison and parameters analysis. The testing procedure in both cases was the one recommended by ECCS for characterizing the behavior of steel elements assessing to seismic action (ECCS-TWG 1.3, 1986 – using a monotonic test to calibrate the cyclic tests).

Use of the composite members leads to larger openings, reducing the height levels and provides a better lateral stiffness. Under large-magnitude seismic events, concrete shells crack and lower the flexural stiffness of composite beam-columns. Nevertheless, the steel core acts as a back-up system in providing shear strength and the required ductility to prevent brittle failure modes.

The testing results on monotonic tests, obtained for the two types of columns (HSC and NC) are shown in *Fig.3*, as well as the history of the cyclic loading (*Fig. 4*).

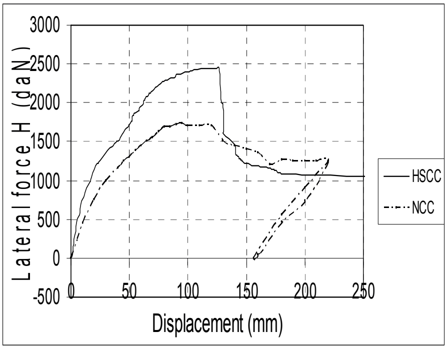

Fig. 3: Monotonic test comparison

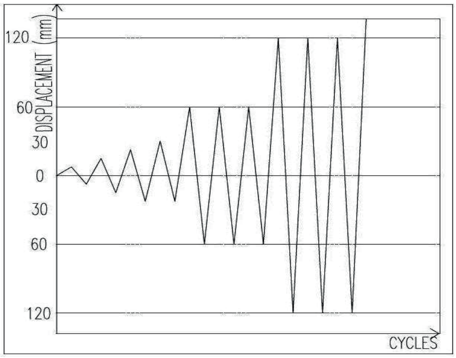

Fig. 4: The cyclic loading history

2. Conclusions

The following conclusions can be highlighted, within the limitation of the current research.

Failure modes were different, characterized by sudden and violent concessions due to cracking developments through aggregate in columns with HSC, while columns with NC shows a "slow" failure mode characterized by gradual decline of bearing capacity with the growth of the displacements. It is well known that high strength concrete is more susceptible to fragile failure than normal concrete, so it is, in a way, the presumed result. On the other hand, from the graphics and parameters analysis we can conclude that the columns with HSC have a higher energy absorption capacity, which can recommend this solution to the construction in seismic areas, even if the failure mode was brittle.

In structural terms, composite columns with concrete class C70/85 provide obvious better performances to structures, having significant increases to almost all analyzed parameters.

References

[1] EUROCODE 4: *Design of composite steel and concrete structures*. Part 1-1 ; General rules and rules for buildings ENV 1994-1-1.2004

[2] CAMPIAN C., CHIRA N., SAV V., "Strength and ductility of concrete encased composite Columns", Turkish Constructional Steelwork Association (TUCSA), Istanbul, *Proceedings of Steel Structures: Culture & Sustainability 2010*, pp. 485-493, ISBN 978-97592461-2-9.