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Resistance of Composite Steel-Concrete Columns with Solid Steel Profile

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Abstract: Composite steel-concrete columns with solid steel profiles are characterized as high-resistance columns. Design of these columns is limited in practice due to absence of simplified design method according to EN 1994-1-1 [1]. Reasons are residual stresses in steel profile caused by fabrication process and limitation strains in concrete. Recommendations have been determined for simplified design method according to EN 1994-1-1 for composite columns with cross-section type of high strength concrete filled steel tube with solid steel profile. These recommendations have not been verified yet in application of columns with cross-section type of solid steel profile covered by reinforced concrete.

Introduction

Composite steel-concrete columns with solid steel profile are often used to increase the resistance of columns in combination with small dimensions of cross-section. Higher bending resistance is possible to reach by combination with steel tube. Solid steel profile allows to reach more slender columns. These columns include two types of cross-section. Concrete filled steel tubes with solid steel profiles and solid steel profiles covered by reinforced concrete (Fig. 1). Standard [1] does not contain the design-rules according to simplified design method because of residual stresses in solid steel profile and strain limitations in concrete with centrally situated solid steel profile.

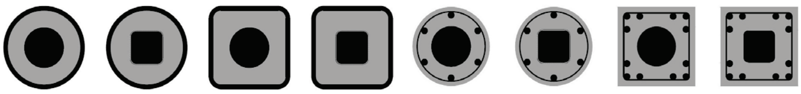

Fig. 1: Types of cross-sections of composite steel-concrete columns with solid steel profile

Design of composite steel-concrete columns according to EN 1994-1-1

Simplified design method is based on cross-section interaction curve assuming full plastic behavior of materials and neglecting the strain gradient in cross-section. Influences of real strain gradient and strain limitations in concrete are covered by reduction factor of plastic bending capacity α_M. This reduction factor α_M depends on grade steel ($\alpha_M=0,9$ for steel grade up to S355 or $\alpha_M=0,8$ up to S460). Strain limitations in concrete cause wide elastic areas in steel parts of cross-section. This effect is especially obvious in cross-section with central solid steel profile (Fig. 2). It leads to significant deviation against material full plastic assumption. Residual stresses arising during fabrication process due to uneven temperature distribution in cross-section by cooling process. Residual stresses in solid steel profile cause reduction of flexural stiffness. These effects had been investigated on columns with section of concrete filled steel tube with solid steel profile [4]. Results and conclusions show that:

- Dimension of solid steel profile has influence on ratio of steel and concrete. Different concrete-steel ratio influences differences between full-plastic resistance and reduced resistance by α_M. It follows that reduction factor α_M must be variable value depending on dimension and steel grade.
- Equivalent imperfection is close to value L/400. This equivalent imperfection must be corrected by factors of steel grade, dimension of solid steel profile and related slenderness of column.

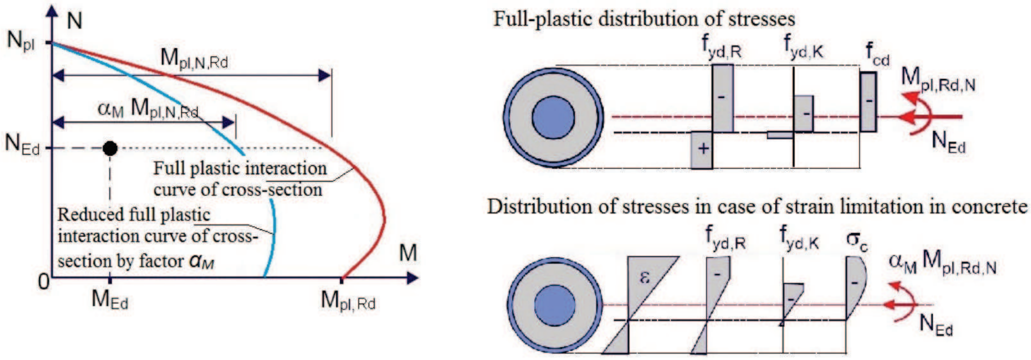

Fig. 2: Full-plastic distribution of stresses and influence of strain limitation in concrete [3]

Experimental research of composite steel-concrete columns with solid steel profile covered by reinforced concrete

It has not been verified yet if mentioned recommendations are applicable for design of composite steel-concrete columns with solid steel profile covered by reinforced concrete. Actual experimental research (Fig. 3) should lead to determine reduction factor α_M, equivalent imperfection and buckling curve for composite columns with investigated cross-sections. For short-term laboratory tests a fully encased in reinforced concrete cross-section with a circular steel profile was chosen. A total of 6 columns in two series were tested.

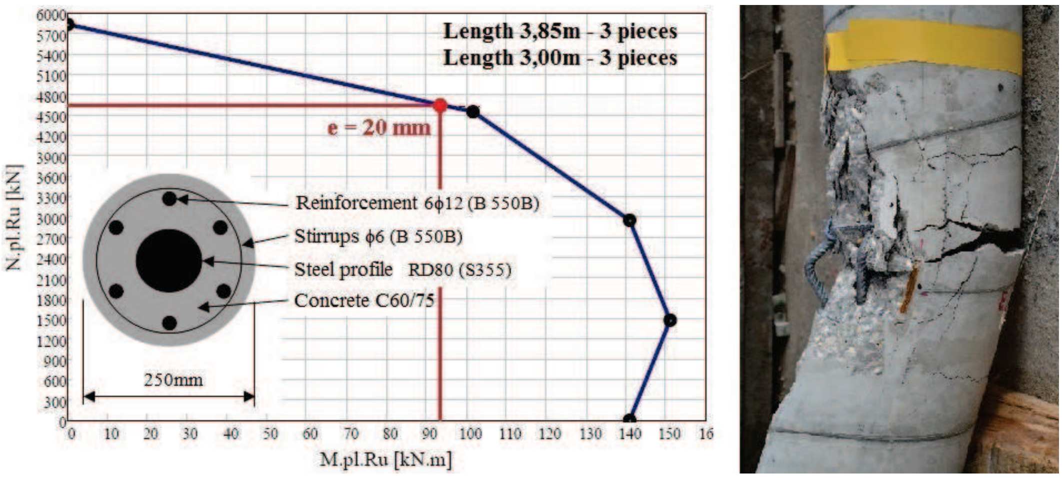

Fig. 3: Interaction diagram and failure of tested composite column

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