Quantification of the impact of fire design on the interest of using "high yield strength" steels

Author : Florence Dechamps
Section : Faculty of Applied Sciences of University of Liege - Civil engineering
Academic year : 2021-2022
Supervisors : Jean-François Demonceau, Jean-Marc Franssen
Summary :
This work is a complement to the work on the interest of high yield strength steels in steel structures, which was carried out at ambient temperature. The main objective of this work is to study the economic interest of high yield strength steels ($f_y > 460MPa$) compared to the standard grade S355 under fire conditions.

Using high yield strength steels allows the element to have a reduction in cross-section for the same load, which is obviously of great interest. However, when fire conditions are introduced, the mechanical properties of the steel are degraded. The consideration of instabilities will be more unfavourable than at ambient temperature. This is due to the use of a specific buckling curve, an increased slenderness to account for the higher temperature and a stricter classification of the sections. This work therefore provides an indication of the extent to which these unfavourable conditions will influence the interest in using high yield strength steels in fire conditions.

In addition to this study of the economic interest of high yield strength steel grades, a study of the dimensioning design will be carried out and will determine which design, between the design at ambient or elevated temperature, will govern the choice of the optimal profile. Indeed, fire design is indissociable from ambient temperature design, as both are complementary.

This work will be based on the development of appropriate calculation methods incorporating fire resistance at 30 minutes exposure in the process of selecting the optimal profile. These codes will take into account different situations such as whether the element is protected by intumescent paint or not, and whether it is subjected to tension or compression.

This work has shown that despite the degradation of the mechanical properties of steel, the economic interest of high yield strength steels is clear. This interest will be higher for tensioned elements than for compressed elements. Despite the existence of a large zone of non-interest for protected elements, the use of high yield strength steels with passive protection remains interesting.

When investigating the dimensioning design between the ambient and elevated temperature designs, it was found that the fire design was more likely to determine the optimal profile when the elements were fire-susceptible and when their thermal degradation was greater than the applied load reduction due to the fire condition. Furthermore, protection reduces the element's thermal degradation and the design at ambient temperature is more likely to govern the design of the profile compared to the unprotected case.