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Brandteknisk projektopgave

Titel: Optimalt design af stål parkeringspladser til fuld brandspredning

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The design optimization of steel structures is usually carried out by choosing a profile that minimizes the amount of steel, under the boundaries of carrying mechanical loads and being compliant with maximum allowed displacements. The fire verifications are typically performed at a later design stage by applying the amount of insulation needed to keep the profile below its critical temperature during fire. This strategy keeps the steel costs to a minimum, but often results in relatively high costs for insulating the structure, which may nullify the scope of the original design optimization. A typical example is the use of I-profiles, which possess the highest elastic and plastic resistance modulus at 20°C, but the lowest in fire, due to the rapid heating caused by the high surface-to-volume ration. This thesis investigated possible beneficial effects of the consideration of fire verification in the early design stage on a steel car park.

Car parks represent at present critical structures from the point of view of fire design, as indicated by several recent and past cases of major car park fires (the most recent and resounding being the car park fire in Liverpool, in 2008, where 1400 car were involved in the fire). Despite such events, steel car parks are often designed by assuming a local fire of 3-4 cars. This assumption allows sparing (and often completely avoiding) the fire insulation of the elements, thus making the steel car parks competitive in price with a concrete structure. If a larger design fire, involving more cars, are used the general fire safety level of the car park will be higher. This seems desirable, but it will add the necessity of fire insulation and thereby increase the price of the car park.

For this reason, car parks are one of the structures that could mostly benefit from an early inclusion of fire consideration into the design procedure, which could allow it to keep being competitive on the price while also ensuring a higher fire safety level. In the work with this thesis the formulas and methods for designing steel profiles in both bending and axial loading was used to make an Excel sheet program that graphically show the potential optimization or saving options for an initially designed profile.

A case study of a typical steel car park was initially designed using the current methods of a local fire with 3 cars thereby totally avoiding fire insulation. The design was then added the fire insulation needed to withstand the temperatures of a larger design fire following the parametric fire curve. This increased the price of the total price (including decking, facades, etc.) of the car park by 29% and 87% for the steel structure alone. The optimization program was then used for an optimization of the profiles and it was found that the price increase from the initial car park could be reduced to a 5% increase in the total price of the car park by and 16% for the steel structure alone.

It has been concluded that considering the choice of profile type at an early stage may show that a saving option is possible but that this option could be very hard to find without the help of the developed Excel sheet program. Quantifying this by the use of the case study showed that a saving potential can be found that ensures the structure can be designed using a much larger design fire resulting in a building with a higher fire safety level at a minimal price increase.