Car Park Design and Fossil Free Vehicles

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Danish car fire in an open shed roof

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Abstract

The lecture assesses the design fire load for cars and car park structures based on investigations of fire loads of modern cars. Actual fire scenarios have shown to be much more severe and involve a larger number of cars than many design fire recommendations prescribe.

Based on knowledge about fire load and fire performance of parked cars, consequences are presented for fire safety design car park structures and especially for application of a fire protection of the steel in steel car park buildings.

The fire load of an empty average car was about 6.7 GJ in 1985, 7.5 GJ in 1995, increasing to 8.5 GJ in 2007 and 10.5 GJ in 2018. The value relates to the weight share of combustible material, which in 2018 was increased to about 35%. To this, you have to add petrol and other goods left in the car, that we can assess as the fire load 1.5 GJ corresponding to 40 liter petrol leaving us with an average fire load of a modern petrol based car as 12 GJ. If it instead is electric, available data for Litium-ion batteries seems to increase this with up to 4 GJ. The fire load of an average electric car may therefore be considered about 14 GJ at present ([1], [3] and [4]).

The floor area per car in a car park varies from 18 to 22 m^2, where the smallest areas are usually found in car park buildings in central parts of the cities, where the buildings are usually filled with cars.

Based on these data, we must recommend assessing a design fire load on a car park structure to be 330 MJ/m^2 enclosing surface for petrol cars and about 400 MJ/m^2 for a future fire load of electric cars.

This means that common steel profiles like HE200A and IP400E should have a fire protection similar to that of at least 40 mm if the fire load is 400 MJ/m^2 and the opening factor is 0.02 $m^{½}$. This magnitude of the opening factor corresponds to the conditions of a filled car park building, where ventilation must take place between and above the ceilings of the cars.

Finally, we consider a design practice applied for several car parks constructed with unprotected steel.

A study of the recommendations [2] and calculations made as a basis for actual building projects indicates how the presumptions made leads to a design with no fire protection.

First, it is presumed that only 3-4 cars can burn at a time. This is obviously not in accordance with actual fires, where all cars in a car park has burned no matter if it is in a building or in the open. For example, 1400 cars burned because one car was ignited in a car park building in Liverpool 1/1 2018. The presumption of only a few cars burning is applied in the steel structure design by postulating that only one bay of a continuous beam can be affected and the neighbor bays can contribute carrying the load.

Second, the fire-load is assessed as for old cars, and as explained this is about half of the relevant fire load today.

Third, the ultimate strength of steel is applied instead of the yield strength without taking consequences of the corresponding ultimate strain into account.

Each of the three presumptions gives a doubling of the load-bearing capacity of beams and columns and in total the load-bearing capacity has been increased with a factor 8 compared to what we may consider to be safe.

References

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