ABSTRACT

The current basis of requirements regarding fire-protection in building codes in Germany and most other countries of the world is the ISO 834 temperature-time curve. It is supposed to cover all boundary conditions concerning fire load, ventilation and construction on the safe side. Because of this simplified design basis and the design of single components isolated of the overall structure, excessive requirements may partially result. These requirements can lead to a disadvantage of the steel construction compared to solid constructions. Consequently, steel structures usually have to be protected.

A fire safety design that considers the actual boundary conditions has to take into account the load-bearing and deformation behaviour of structural elements embedded in the entire structure. In this dissertation a method is presented that can be used to describe the thermal action of natural fires in multi-storey buildings considering a realistic fire spread. It is shown how the load carrying capacity of multi-storey steel-composite structures can be utilised considering the load redistribution of fire-exposed parts of the structure to non fire-exposed parts. As a result of a so-called risk-oriented fire safety design method, excessive requirements and costs of fire protection materials can be reduced.

On the basis of a defined design fire temperature-time curves of natural fires are determined by heat balance simulations and formulated in simplified equations as so-called real fire curves. The real fire curves are validated by comparison calculations as well as experimental data. In contrast to the ISO 834 temperature-time curve the thermal action of a fire in multi-storey residential and office buildings can be grasped realistically by the real fire curves. The real fire curves enable a simplified method to ascertain the thermal exposures of a natural fire to the structure without applying sophisticated heat balance models. In comparison to existing simplified methods for calculating the temperature-time-curve of a natural fire, the real fire curves offer a lot of advantages: They are based on an internationally accepted approach of the rate of heat release, they consider the actual ventilation conditions and the modification of the boundary conditions (breakage of glass, compartmentation failure, cell construction, fire fighting) as well.

By numeric simulations on the basis of a validated computer model it is shown, how steel and composite structural systems can be optimised to reduce the forces caused by the axial and flexural restraint in case of a fire. For different fire scenarios the load and deformation behaviour of a module-like building system is investigated. It is shown that unprotected steel members can be used if they are embedded in an overall structure and some rules of structural detailing are observed. Therefor a realistic development of the fire considering a successive fire spread has to be taken into account. For structural restoration and repair after a fire building systems with pinned steel connections and prefabricated floor slabs offer advantages. Due to the module-like assembly of the structure steel girders and floor slabs in the affected area can be removed without endangering the stability of the rest of the structure.