BUCKLING RESISTANCE OF A REINFORCED CONCRETE FRAMES IN FIRE CONDITIONS

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The subject of my PhD thesis is buckling resistance of a reinforced concrete (RC) frames in fire conditions. The columns are, besides the beams, the basic structural elements of the each frame. Therefore, the behavior of the columns has the significant impact on the behavior of the frames as a whole. The failure of the columns may occur due to material failure (stocky columns) or due to buckling (slender columns), which is mainly the geometric properties of the column. The deformability of the structure increases during the fire, adding to the exposure of RC frames to the buckling and stability phenomena. Because the concrete and steel are the plastic materials, the buckling resistance of the RC frames depends on plastic buckling of columns characterized by additional post-critical buckling resistance.

In the analysis of the buckling load frames, in addition to the aforementioned local plastic buckling of the column, the robustness of frame is also important. This is the ability of the frame that the local column failure does not result into the global collapse of the construction. The property is particularly important for fire safety of the frame, protecting human life and to reduce costs. To sum up, modern fire-safety design of the multi-storey RC frames requires a holistic approach, where the local and global stability of the frame have essential account.

The proposed model is a new numerical model for the non-linear geometric and material analysis of a reinforced concrete frames exposed to the mechanical and fire load. The model will define the buckling resistance and the behaviour of columns by post-critical buckling analysis. Additionally, the model will provide fair evaluation of prevalent parameters, which are applied for defining the criteria for explosive spalling of the concrete. Accordantly with the results, we will be able to predict the behaviour of RC frames at elevated temperatures.

Due to the complexity of the present phenomena, the model can be divided into three phases. In the first phase of the model, the time dependent change of temperatures in the fire compartment surrounding the RC frame will be determined. The heat transfer affecting the surface of the RC frame will be accounted for in boundary conditions of the next steep of fire analysis. The temperature distribution of the fire can be calculated by using the complex CFD methods or defined by standard ISO 834 fire curve, which is simpler way of determining the surrounding temperature.

In second phase, the coupled heat and mass transfer in the concrete exposed to fire will be observed due to heterogeneous structure of concrete, which consist of solid matrix, water and gaseous mixture of water vapour and dry air. Accordingly, the model include the determination of heat and moisture transfer in concrete during fire and the estimation of the special processes within the material exposed to the elevated temperatures, e.g. concrete spalling.

The third phase of the fire analysis will consists of the mechanical response of RC frames. Once the temperature and pore pressure variation in time and space has been obtained, the stress-strain state evolution in the RC frame during fire can be pursued. The contact between the concrete and reinforcement will be defined by a non-linear constitutive law. The material properties of the concrete and the steel will be temperature dependent. Further, the Reissner's kinematically exact planar beam theory will be used in the mechanical model. The governing equations consist of kinematic, constitutive, equilibrium and constraining equations will be written separately for the concrete and the reinforcement. Furthermore, we will assume the additive decomposition of geometric deformation into elastic, plastic, temperature and creep deformation of concrete and steel and transient deformation of concrete. We will look for the numerical solution of basic equations employing the strain-based finite element method. The numerical model will also consider the longitudinal delamination of the concrete-steel contact, weakening of the cross-section of the columns due to explosive spalling of the concrete and associated local buckling of the reinforcement.

Given the generality of the presented numerical model, the results of PhD thesis will enable a better understanding of holistic stability behaviour of the reinforced concrete frames in fire conditions. Finally, the findings of the research work will also bring technical benefits. With the presented numerical model, we will more accurately assess the fire safety reinforced concrete frames and after that, new requirements for the design of the RC structures will be set.