SUMMARY OF LUU NGUYEN NAM HAI's THESIS

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Keywords: Progressive collapse, robustness,multi-storey building, loading sequence, alternative load path, key elements, catenary action.

The less of knowledge, in the codes and scientific documents on the behaviour of the building frames in the exceptional events, requires the more researches and developments! This thesis presents the researches on the global response of the steel and composite building frame further to an impact leading to the loss of a column. It aims to understand the two main objectives, as describes here under:

- The global behaviour of the steel and composite frame in an exceptional event loss of a column.
- The parameters influence the activation of catenary action within the frame when a column lost.

Regarding to the first objective, the activities are performed in order to answer the three details questions:

- How the internal forces distribute within the building frame?
- How does the alternative load path activate in the frame? Which structural members are included in the load path?
- If the frame fails as the progressive collapse, what is the key element of that process?

And the second objectives give the other three questions:

- Which conditions are needed to activate the catenary action?
- What and how many parameters influence such a phenomenon?
- When catenary action happened, the building frame will collapse on which mode?

Aims to these targets, the adopted strategies are applied as in this bellow briefly description. The researches based on the assumptions: the analyses are performed in 2D and the dynamic effect is neglected.

More specifically, the description of a change of the loads acting on the frame in the transition from a "normal" to an "abnormal" state is presented as the progressively removing of a column. The loading sequence is divided in order to highlight the investigation methods which will be used later on. There are 3 Load Phases are defined.

The definition of loads concerns the detection of additional loads that the frame has to support when the column loss occurs. The knowledge of the internal force distribution helps to understand how these additional loads to be supported are transferred to the foundation within the structure. The members activated in this way constitute the alternative load path. Through the identification of the alternative load path, it is finally possible to identify the critical zones; in particular, continuity between the structural elements involved in the alternative load path has to be ensured.

In order to investigate the extension of frame capacity by activating the catenary action, the bottom beams are extracted from the frame in the three following levels of extraction: frame level, substructure level and isolated membrane beam level.

At the frame level, the frame's response to an unusual loss of a column is simulated by the reduction of the whole building to the 2D frame and the definition of the abnormal load. From the investigation results done at this level, the full scale distribution of the internal forces is obtained. Along with the internal forces' flow within the frame, it can be pointed out that the directly affected part mainly represents the response of the frame, especially in Load Phase 3.

The second level, which is called the substructure/subsystem level, involves the extraction of the directly affected part to create a substructure model. The extraction includes two procedures: simplifying the part members and creating the equivalent boundary conditions. Once this appropriate substructure is developed, its behavior will represent the response of the frame to the exceptional event.

Especially in load Phase 3, after the directly affected part fully yields, catenary action is activated in the bottom beams. Since the other members of the part cannot support the load, this beam's behavior represents the behavior of the part, and likewise, of the frame. So, in load Phase 3, the investigation is done at the isolated equivalent beam's level.

However, in the formation of an alternative load path, the additional load acting on the directly affected part is fully transferred to the adjacent columns. Moreover, the arch effect is triggered by the deformation of the columns. The new analytical substructure is developed to investigate these previous effects.

In the third loading phase, the membrane phenomenon is triggered. This phenomenon has an advantage in that it extends the alternative load path and increases the frame's load capacity. There are three important parameters influencing this phenomenon, as it is influenced by the surrounding members. Each parameter's analytical calculation is developed in the thesis and also the reciprocal relation between them is presented.

All of the analytical developments are validated by comparing to the FEM numerical investigation in OSSAD 2D and FINELG. It is proved the appropriate accuracy of these method's results.

As conclusion, identifying the two alternative load paths and determining their initial conditions were the first achievements of this thesis. Determining the possibility of activating the alternative load path was made possible by comparing the 2 specific critical values.

Two analytical models are developed in order to calculate how the forces act on each member within the alternative load path. Their loading states were used to measure the frame’s ability to maintain the alternative load path after the accidental event. In turn, this ability determined the robustness of the frame, as the second achievement.

The third achievement is: together with Jean–Francois Demonceau, the results of the investigation allowed the author to predict the full global behavior of the frame in an exceptional event.

The last achievement of this thesis was to calculate the three parameters to provide to Demonceau with the means to develop the full frame’s robustness assessment method.