

Summary Master's thesis 'Progressive Collapse Indicator' November 2009-Simon Bolle

Progressive collapse is a collapse where a local failure leads to a disproportionate collapse. Different terms like initial failure, propagation of failures and disproportionate damage are important aspects of such collapses. In current design practice, a method to measure a structures' progressive collapse sensitivity in its early design phase and taking into account all aspects of a structures collapse resistance does not exist. The objective of this research is to develop a tool that takes into account all aspects of a progressive collapse and can aid the engineer in assessing a design, in its early design stage, on progressive collapse.

At first, the initial failure is elaborated. Different events can cause the failure of elements. The probability an initiating event occurs at a certain element is different for each element. Mitigating measures can limit the chance of occurring for certain events. The initial events are applied on the model in 2 steps. First the location (or: element) of the event is chosen by a random selection method and a distribution of failure chances on the model. Second, the size of the damage is determined by applying a Gaussian curve over the model, both in x- and z-direction. This determines if adjacent elements, related to the removed element in step 1, are removed.

The model is calculated by FEA-software. Only linear and first order calculations are considered. These limitations lead to inaccuracies of the results compared with reality. A stability analysis has been performed to determine the buckling lengths of columns with more accuracy. Catenary action is one of the main modelling methods in designing against progressive collapse. This method is implemented into the tool. Iteratively, the forces and deformations are calculated which develop during the occurrence of catenary action.

The evaluator of the tool determines whether or not a progressive collapse can be assumed based on four failure criteria. The first criterion is the occurrence of a local mechanism. If this occurs a progressive collapse is counted. Local mechanisms are reduced by applying rotational and translational springs in structural systems with pinned connections. The second condition is a strength criterion. For all elements, unity checks are calculated. If a unity check exceeds 1, the element will be removed from the model and the model is reanalysed and evaluated. The third criterion is a deformation condition. If the displacement of an element exceeds a limit it is assumed the element has failed, but will not be removed from the model. Finally, a progressive collapse is based on the amount of total damage. If the damage is disproportionate, the collapse is called a progressive collapse. If none of the above happens, no progressive collapse occurred.

A progressive collapse indicator (PCI) is calculated. One design is analyzed a certain number of iterations, resulting in an amount of progressive collapses. Then, the PCI is the number of progressive collapses, divided by the number of iterations performed. It gives an indication about the sensitivity of a design to progressive collapse.

It is concluded that a tool is developed that includes all aspects of a progressive collapse, but that it can not be used in daily practice. Yet, the resulting propagating failure of elements sometimes leads to irregular results and thus needs refinement. Also, since input of a user's design is not possible, implementations are needed to achieve that.

Thesis committee: Prof.dr.ir. J.G.Rots, ir.J.L.Coenders, ir.K.C.Terwel, ir.J.W.Welleman.