DYNAMIC RESPONSE OF RC FRAME AFTER COLUMN FAILURE

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There are two general approaches for decreasing the potential of progressive collapse for new and existing structures: *Direct Design* and *Indirect Design* (ASCE 7-05, 2005).

Direct Design approaches provide for detailed consideration of resistance to progressive collapse for structures during the design procedure. These approaches include *the Alternate Path (AP) method*, which requires that the structure be capable of bridging over a deficient structural member, with the resultant extent of damage being localized, and *the Specific Local Resistance (SLR) method*, which requires that the structure, or parts of the structure, provide sufficient strength to resist an accidental actions (UFC 4-023-03, 2005).

AP method is based on a simulated static redistribution of loads after failure of a key structural member (Kaewkulchai and Williamson, 2003).

This method consists of three allowable analysis procedures (UFC 4-023-03, 2005):

• *Linear Static*. The geometric formulation is based on small deformations and the material properties are treated as linear elastic, with the exception of discrete hinges that may be inserted. The full load is applied at one time to the structure, from which a vertical load-bearing element has been removed.

• *Nonlinear Static*. Both the material properties and geometric parameters are treated as nonlinear. A load history from zero to the full factored load is applied to the structure with a removed vertical load-bearing element.

• *Nonlinear Dynamic.* The material properties and geometric parameters are treated as nonlinear. A dynamic analysis is performed by instantaneously removing a vertical load-bearing element from the fully loaded structure and analyzing the resulting motion.

For Nonlinear Dynamic analyses of all construction types, apply the following design load combinations (Eq. 1) to the entire structure (UFC 4-023-03, 2005):

$$(0.9 \text{ or } 1.2)\ D + (0.5\ L \text{ or } 0.2\ S) + 0.2\ W \qquad (1)$$

where D – dead or permanent load (kN/m^2)

L – live or variable load (kN/m^2)

S – snow load (kN/m^2)

W – wind load (kN/m^2)

For a Nonlinear Dynamic analysis, double the loads from the failed element to account for impact and apply them instantaneously to the part of the structure directly below the failed element, before the analysis continues. Apply the loads from the area supported by the failed element to an area equal to or smaller than the area from which they originated (UFC 4-023-03, 2005).

Results of comparative calculations show that dynamic effect in multi-storey frames is more appreciable for increase of floors number (Almazov and Khoy, 2010). Dynamic factor K_{dv} equals two for linear static analysis. It's less than two for nonlinear static analysis but it increases with the number of floors because of plasticity of beams fulfils insufficiently at upper floors. In this case the insufficient plasticity of frame determines using Equation (2):

$$K_{dv} = \frac{K_{pl}}{K_{pl} - 0{,}5} + \frac{\sum_{i=1}^{n}\left(f_{pl,1} - f_{pl,i}\right)}{n f_{pl,1}} \qquad (2)$$

where $f_{pl,i}$ – plastic deflection of beam prior to failure of the 1st floor beam;

i – floor number;

n – number of floors.

Dynamic factor K_{dv} may be assumed on the basis of nonlinear analysis according to the proposed calculation procedure (Nemchynov et al., 2012).

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