Current requirements in buildings regulations and codes – ASCE 7-05

The North America code "ASCE STANDARD 7-05 – Minimum design loads for buildings and other structures" clear recognizes that modern structures face a significant risk of showing progressive collapse, which is a main failure mechanism in approximately 15 -20% percent of building collapses.

ASCE 7-05 states that, except for specially designed protective systems, it is usually impractical for a structure to be designed to resist general collapse caused by gross misuse of a large part of the system or severe abnormal loads acting directly on a large portion of it. However, precautions can be taken in the design of structures to limit the effects of local collapse, and to prevent or minimize progressive collapse. Progressive collapse is defined as the spread of an initial local failure from element to element resulting, eventually, in the collapse of an entire structure or a disproportionately large part of it.

The concept of notional removal of one element is referred, but it is also noted that it is prudent to analyze if an abnormal event will cause the failure of only one element.

The risk of progressive collapse in modern structures is increase by some of the following aspects:

1. Lack of general awareness among engineers of the importance of robustness;

2. The use of non-load bearing interior walls and partitions;

3. Reduction of continuity, ties between elements and joint rigidity, in order to increase construction speed and reduce costs;

4. Unreinforced or lightly reinforced load-bearing walls in multistory structures may also have inadequate continuity, ties and joint rigidity;

5. In roof trusses and arches there may not present sufficient strength to carry the extra loads or sufficient diaphragm action to maintain lateral stability of the adjacent members if one collapses;

6. Reduction of safety factors in modern codes, in comparison with older structures;

7. Use of higher-strength materials and, consequently, more slender sections, results in structures more flexible and sensitive to load variations and, in addition, normally more susceptible to construction errors.

In order to guarantee minimum robustness of structures, ASCE 7-05 defines two main alternatives:

- Direct Design
- Indirect Design

Direct design includes the definition of alternate load paths and specific local resistance method while, indirect design uses provisions of minimum levels of strength, continuity and ductility that result in acceptable robustness. Details that are appropriate for resistance to moderate wind loads and seismic loads often provide sufficient ductility.

The most important methods to increase robustness are:

Ties: An integrated system of ties among the principal elements of the structural system should be defined. These ties may be designed specifically as components of secondary load-carrying systems, which often must sustain very large deformations during catastrophic events. At a simple level, continuity can be achieved by requiring development of a minimum tie force, say 20 kN/m, between structural elements.

Load-Bearing Interior Partitions: The interior walls must be capable of carrying enough load to achieve the change of span direction in the floor slabs.

Redundant Structural Systems: The use of redundant structural systems provides an alternate load path that allows framing to survive removal of key support elements.

Ductile Detailing: The use of low-ductility detailing must be avoid, in particular, in elements that might be subject to dynamic loads or very large distortions during localized failures.

Compartmentalization: The use of compartmentalized construction in combination with special moment resisting frames should be considered.

Generally, extraordinary events with a probability of occurrence in the range 10^{-6} to 10^{-4} or greater should be identified, and measures should be taken to ensure that the performance of key load-bearing structural systems and components is sufficient to withstand such events.

ASCE 7-05 recognized that the design approach to these events, based on limitation of spread of damage rather than damage prevention, is entirely different from the traditional approach to designing to withstand dead, live, snow and wind loads, but is similar to the philosophy adopted in modern earthquake-resistant design.

Member failures may be controlled by protective measures that ensure that no essential load-bearing member is made ineffective as a result of an accident, although this approach may be more difficult to implement. Where member failure would inevitably result in a disproportionate collapse, the member should be designed for a higher degree of reliability.