УДК 725.1

THE MAIN REASONS OF THE WTC TOWERS COLLAPSE: HYPOTHESIS AND APPROVAL

(based on materials of A.S. Usmani, Y.C.Chung and J.L.Torero, School of Engineering and Electronics, University of Edinburgh, Edinburgh, UK «HOW DID THE WTC TOWERS COLLAPSE: A NEW THEORY»

Cheprasova V.E.
Scientific advisor a candidate of cultorology, associate professor Vonog V.V.
Siberian Federal University

The topicality of this research is explained by the fact that there is hypothesis proved by English investigators A.S. Usmani, Y.C.Chung and J.L.Torero, according to which the structural damage of the WTC Towers was caused to major degree by fire than by the terrorist attack. This report presents the results of the investigation into the collapse of the Twin-Towers of the World Trade Center, New York. The most important issue, namely `what structural mechanisms led to the state which triggered the collapse'. Let's study this case in more detail.

The collapse discovered mechanism is a simple stability failure directly related to the effect of heating. Additionally, the mechanism is not dependent upon failure of structural connections.

For engineers it is necessary to learn the effect of fire on the construction in order to use this knowledge in revision of existing buildings and in design of new ones and as a result to increase the reliability and safety of the constructions.

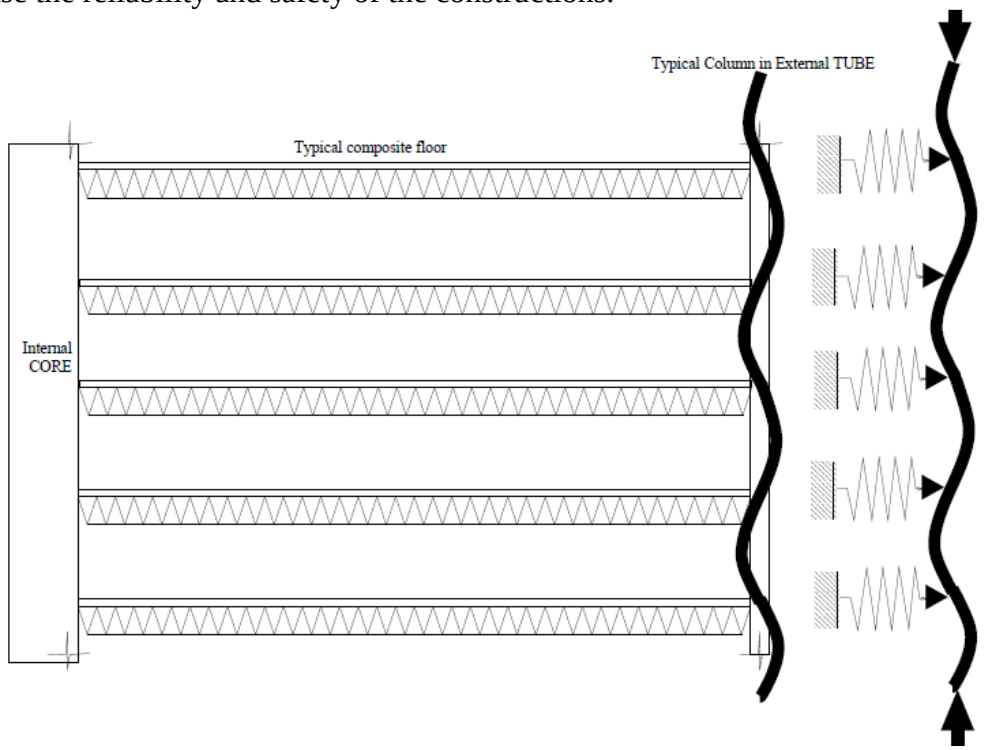

Figure 1 - Classical buckling of columns in a multi-storey frame with sufficient lateral restraint

Figure 1 shows a frame with external and internal columns connected by a long-span composite truss floor system (the internal columns are part of the building core and the external columns represent the closely spaced tubular columns). Figure 1 also shows the classical buckling collapse mechanism of the external columns under overloads.

For this mechanism, it is necessary that the composite floor system has sufficient axial stiffness to be able to provide a minimum restraint to the column. It allows us to represent the whole system as a column laterally supported by translational springs.

Now consider that for some reason the spring stiffnesses are reduced. This could occur if there was fire on one or more floors connecting the external and internal columns. Obviously that if the fire burnt for long period of time, it would eventually soften the steel trusses supporting the floors. Once the steel stiffness (modulus) reduces sufficiently, the axial stiffness demand for lateral support to the columns will no longer be available.

Initially the floor system may expand resulting in the pushing out of the external columns.

Eventually the increasing membrane compressions will lead to buckling the floor and further increase in deflections.

The significant change in the geometric shape of the floor system will lead to further reduction in axial capacity, leading to a rapid loss of lateral restraint to the column. If the fire has affected several floors, this loss of restraint will allow a much smaller load to buckle the external columns in a different buckling mode.

A computational and analytical investigation has been carried out to test the hypothesis outlined above and determine possible collapse mechanisms for the World Trade Center Towers when subjected to a large fire.

We obtained the following results of our research:

1 Composite truss floor system was too slender to continue to supply the column lateral support demand.

2 The maximum temperature of the columns themselves has been limited to 400 C (often not reached as failure occurred before this temperature is attained).

3 At such temperatures the columns are expected to retain over 90% of their axial stiffness, which would be sufficient to continue supporting the loads. However the loss of lateral support from one or more of the composite truss floors will clearly reduce the gravity load capacity (Euler buckling load is reduced to 25% for the loss of just one floor).

To sum up I’d like to make the following conclusions:

1 This analysis presented a collapse mechanism that is rather unique for the type of structure that the WTC Twin-Towers represented.

2 This analysis also shows that the collapse is initiated principally by a stability mechanism as a result of geometry changes in the structure caused by thermal expansion effects.

3 It can therefore be concluded that these buildings could have collapsed as a result of a major fire event. This is of course assuming that any of the active fire suppression systems would either fail or be unable to control the development of the fire. This is a normal assumption when designing fire protection for buildings.