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Iron and steel feel the heat

It has been suggested that fire alone could not have brought down the Twin Towers on September 11th, 2001, says S.Ananthanarayanan.

These persons say that the fire of the aviation fuel of the plane that crashed into the towers was not hot enough to melt the steel of which the towers were built. They suggest that there must have been a bomb that went off, to bring the towers crashing straight down like that.

How hot was it?

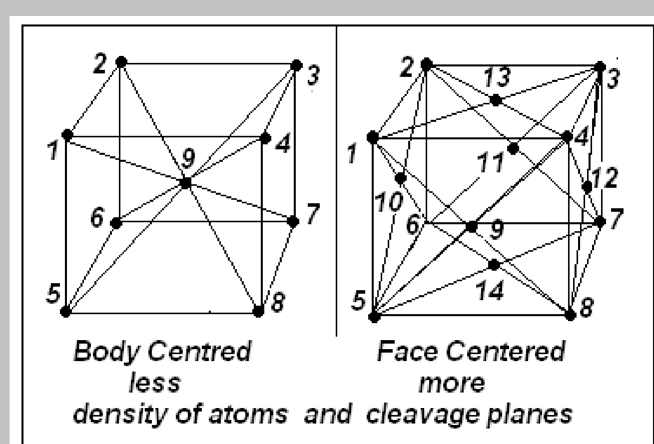
The temperature of burning aviation fuel is 825 ºC, while the melting point of steel is 1525 ºC. Then how could the towers have crashed? They would have just got terribly hot, but they would not have fallen, the skeptics say.

The answer has been straightforward – that steel does not need to melt to lose its strength – it gets down to 50% of its strength by 650 ºC. 100,000 litres of jet fuel and other combustibles, like curtains, wood and paper, burning with plenty of air, would have taken the temperature above that temperature all through the building. Differences in temperature of hundreds of degrees between parts of the framework would have strained the weakened steel members and snapped the connections of beams to vertical columns. And one truss that failed would load the next and so on. And the lowest parts would have borne the greatest loads. There was no need for any bomb.

Steel – crystals and temperature

Iron and steel consist of billions of crystals fused together as the molten metal condensed. But the atomic structure of iron, or steel which is iron with some carbon, mostly, changes its behaviour somewhat abruptly as the temperature changes. It is not far different from the way that water behaves as the temperature falls below 4 ºC. We all know that when water cools to this temperature it stops contracting and begins to expand.

In the case of solid (that is, frozen) steel, as the temperature rises above a little over 700 ºC, the crystal structure changes from body centred cubic (bcc) to face centered cubic (fcc). The latter crystalline form allows more planes for crystals to slide over and steel at higher temperatures bends and twists more easily than at lower temperatures. A common example of face centered cubic crystal is the sugar cube, which is not know for its strength!



In the case of steel, the crystal structure undergoes another change at a still higher temperature, when it reverts to the body centered cubic form. These changes are all 'phase changes', just like when water changes from liquid to ice, and there are large energy transfers involved. Just like boiling water stays at 100 ºC till it has changed all to vapour, steel also needs to pause at these temperatures of phase change, to absorb or to give up the extra heat associated with the changes.

Carbon, etc. in steel

The presence of other metals in steel results in changes in the structure of atoms joining into crystals and leads to greater strength or changes in the temperature of phase change. Thus, for special purposes, like in aircraft engines, where the temperatures are constantly higher than temperatures where steel remains effective, alloys that contain very little iron and more of special materials, like titanium, are used.

But for all this, the fact remains that steel loses strength at higher temperatures and it is not necessary that the melting point be reached before steel structures can collapse. At the same time, civil engineers are aware of this quality of steel and they usually 'over-engineer' the steel part of structures to have enough strength even in the course of a fire. By this token the Twin Towers should not have crashed and the controversy continues.