The Hat Trusses

The Structural System of the Twin Towers

This photograph shows the top of the hat truss of one of the towers during its construction. credit: the Skyscraper Museum

The fourth primary structural subsystem in each tower was the hat truss -- a lattice of large diagonal I-beams that connected the perimeter walls to the core structure between the 107th floor and roof. This structure was also known as the "outrigger truss system."

The hat truss structure strengthened the core structure, unified the core and perimeter structures, and helped to support the large antenna mounted atop the North Tower. The hat truss, which contained both horizontal and sloping I-beams, connected core columns to each other, and connected the core to the perimeter walls. Most the beams connected core columns to each other, while a set of sixteen horizontal and sloping beams spanned the distance the core and perimeter walls. Eight of these, the outrigger trusses, connected the corners of the core to the perimeter walls, while another eight connected the centers of the core's periphery to the perimeter walls.

The hat trusses are central to the "probable collapse sequence" described by NIST's Final Report on the Twin Towers. It blames the hat truss for transferring "column instability" between the core structures and the perimeter walls. In other words, it asserts that reinforcing structures caused the Towers to self-destruct. Its section entitled "Results of Global Analysis" describes the "structural deterioration" of the North Tower as follows:

6.14.2 Results of Global Analysis of WTC 1

After the aircraft impact, gravity loads that were previously carried by severed columns were redistributed to other columns. The north wall lost about 7 percent of its loads after impact. Most of the load was transferred by the **hat truss**, and the rest was redistributed to the adjacent exterior walls by spandrels. Due to the impact damage and the tilting of the building to the north after impact, the south wall also lost gravity load, and about 7 percent was transferred by the **hat truss**. As a result, the east and west walls and the core gained the redistributed loads through the **hat truss**.

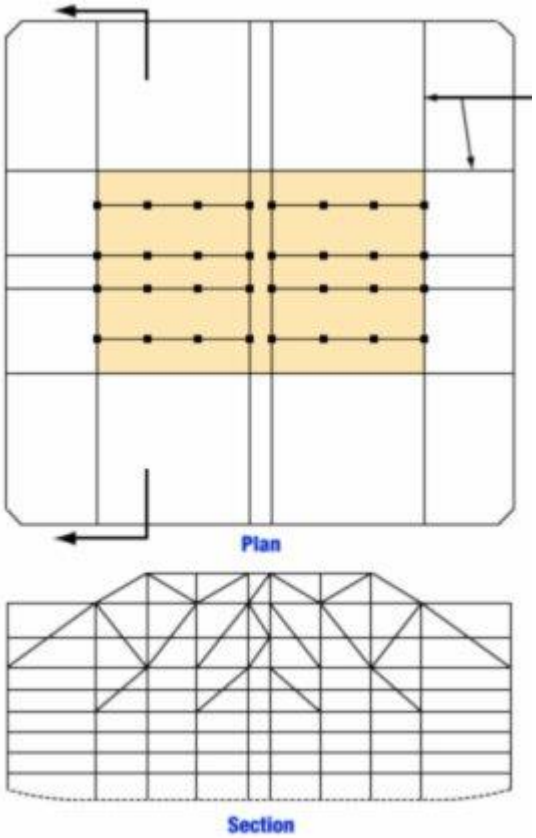


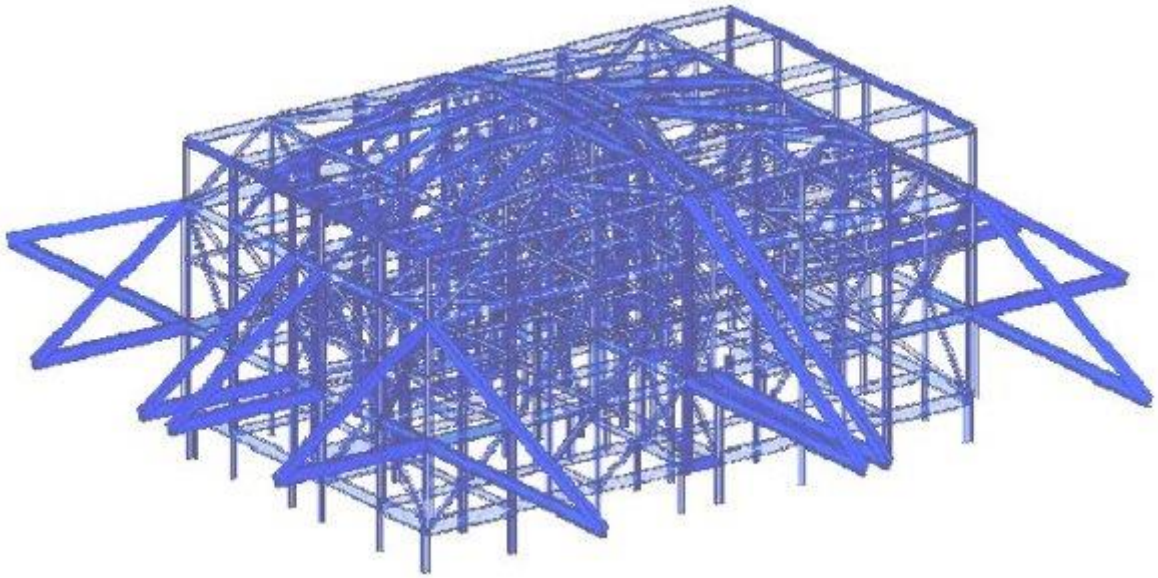
Figure 2-10 Outrigger truss system at tower roof.

This schematic from Chapter 2 of the FEMA Report provides some detail on the geometry of the hat truss.

Structural steel expands when heated. In the early stages of the fire, structural temperatures in the core rose, and the resulting thermal expansion of the core was greater than the thermal expansion of the (cooler) exterior walls. About 20 min. after the aircraft impact, the difference in the thermal expansion between the core and exterior walls, which was resisted by the **hat truss**, caused the core column loads to increase. As the fires continued to heat the core areas without insulation, the columns were thermally weakened and shortened and began to transfer their loads to the exterior walls through the **hat truss** until the south wall started to bow inward. At about 100 min, approximately 20 percent of the core loads were transferred by the **hat truss** to the exterior walls due to thermal weakening of the core; the north and south walls each gained about 10 percent more loads, and the east and west walls each gained about 25 percent higher loads. Since the **hat truss** outriggers to the east and west walls were stiffer than the outriggers to the north and south walls, they transferred more loads to the east and west exterior walls.

The inward bowing of the south wall caused failure of exterior column splices and spandrels, and these columns became unstable. The instability spread horizontally across the entire south face. The south wall, now unable to bear its gravity loads, redistributed these loads to the thermally weakened core through the **hat truss** and to the east and west walls through the spandrels. The building section above the impact zone began tilting to the south as the columns on the east and west walls rapidly became unable to carry the increased loads. This further increased the gravity loads on the core columns. Once the upper building section began to move downwards, the weakened structure in the impact and fire zone was not able to absorb the tremendous energy of the falling building section and global collapse ensued.
[1]

[emphasis added]



This illustration from Page 11 of NIST's Final Report of the National Construction Safety Team on the Collapses of the World Trade Center Towers (DRAFT) shows the hat truss.

References

1. Final Report of the National Construction Safety Team on the Collapses of the World Trade Center Towers, *nist.gov*, , page 144-5 (PDF pages 194-5)