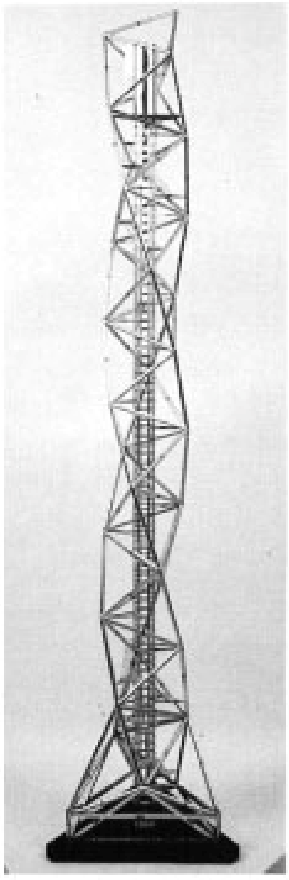
Structure of the Tower at Art Tower Mito



The building of the ATM tower is made up of 28 regular tetrahedra (pyramid-shaped polyhedra with four equal triangular faces), measuring 9.6m on each side, that are stacked upon each other. The edge lines of the stacked tetrahedra are automatically twisted. Steel pipes measuring 500mm in diameter and 21-60mm in thickness are arranged along the ridges, and six pipes are brought together at one point to create the integrated structure. Because a special joint is formed where the pipe materials converge, construction experiments were carried out beforehand to confirm that sufficient quality would be secured.

Buildings ordinarily feature a quadrangular structure composed of pillars and crossbeams, and some have braces inserted diagonally to produce triangles for additional strength. However, the ATM Tower is entirely composed of triangles, making its structure particularly efficient.

Though the interior elevator of the ATM tower is surrounded by pillars, the primary framework supporting the tower is the regular tetrahedral structure of the exterior. Supporting pillars known as rakers or raking shores have been installed along the lowest part of the regular tetrahedra, which serve to increase stability if lateral force is applied to the structure.

The stylobate (the platform upon which the tower is built) has a robust steel-framed ferroconcrete structure. Moreover, the basement is integrated with the surrounding parking area, serving as a weight that anchors the tower. The structure of the basement portion of the tower goes down to a depth of 6m from ground level, and is supported by the sufficiently solid bedrock layer that is distributed around the highland area of Mito City.

As for anti-earthquake measures, waveforms of large seismic movements from the past were used to assume maximum seismic movement, and time-history response analyses (computation methods simulating the shaking of the tower during an earthquake) were made to check the structural strength, deformation conditions, and so forth. During maximum-range seismic movements (intensity of approx. 6+ on the Japanese seismic intensity scale of 1 to 7; see Note 1), the ATM Tower is assumed to have sufficient structural strength, with the top of the tower being displaced around 90cm (the distance from its usual position to the maximum point of lateral displacement).

As for anti-typhoon measures, wind-tunnel experiments were conducted on a model of the tower to measure the force of wind that might hit the ATM Tower. Also, previous meteorological data from the construction site were used to set the assumed wind load, and both the structural strength and deformation conditions were checked again. During a maximum-range typhoon (10 minutes with an average wind speed of 37m/sec in the vicinity of the portion of the tower above ground, and a maximum instantaneous wind speed of approx. 54m/sec; the top of the tower was assumed to get a maximum instantaneous wind speed of 82m/sec; see Note 2), it is assumed that the top of the tower would undergo shaking of approximately 90cm. The structure of the tower thus makes it susceptible to greater wind-caused shaking than ordinary buildings experience, but its strength was judged to be sufficiently guaranteed.

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Note 1. Supplemental remarks

The concept of the seismic intensity scale was originally intended as a rough index of the degree of shaking experienced in an earthquake, and used to be decided upon subjectively by officers of Japan's Meteorological Agency, who would make their judgments based on their own sensations and the damage they viewed in surrounding structures. Currently, however, the figure is determined by a composite of the peak ground acceleration based on both horizontal and vertical movements, based on measurements of acceleration by seismic intensity-scale seismographs, with short- and long-period wave ranges eliminated from the calculation to a certain degree. As some people have pointed out, however, the seismic intensity figure does not directly describe how much damage has been sustained by buildings, as little damage will occur if there is large acceleration with an extremely short cycle, whereas a long cycle of one second (acceleration and speed) or more will have a great effect on buildings. When an earthquake of intensity 7 is registered, buildings will experience little damage because the peak ground acceleration is mostly in the short-period wave range. During the earthquake of March 11, 2011, for example, an intensity of 7 was recorded at Kurihara City in Miyagi Prefecture, but there was little damage to buildings, with no deaths or injuries. For that reason, the intensity of the maximum earthquake generally expected to occur at the ATM Tower site was set at around 6+, with a peak ground acceleration of approximately 300-500gal. (Incidentally, the intensity of the earthquake experienced at Mito on March 11 was 6-.)

Note 2. Supplemental remarks

As wind speed is variable—alternately blowing hard and then softly—considerations of structural design look at the average wind speed over a 10-minute period in times of strong gusts, as well as variations from that level. In the design of the ATM Tower, an average wind speed of 37m/sec was used (based on the probability of recurring once every 100 years) as the maximum level. The level of variation from that figure depends on the height of the building and the topography of the surrounding area above ground. In the case of ATM Tower, a variation rate in the maximum instantaneous wind speed was set at 54m/sec. The figures for wind speed announced by Japan's Meteorological Agency during typhoons are often the maximum instantaneous wind speed near ground level, so the designers of the ATM Tower took the maximum instantaneous wind speed to be 54m/sec in the area above ground.