

from A36 steel plate and were 36 inches x 14–16 inches with plate thickness from 3/4 inch to 4 inches. Above floor 84, rolled or welded built-up I-shaped sections were used.

The floor system was supported by 29-inch-deep open-web joist trusses with A36 steel chord angles and steel rod diagonals. Composite 1-1/2-inch, 22-gauge metal floor deck ran parallel to double trusses that were spaced at 6 feet 8 inches. The floor deck was also supported by alternate intermediate support angles and transverse bridging trusses that were spaced at 3 feet 4 inches. The bridging truss also framed into some periphery columns. Figure 2-2 (in Chapter 2) shows the layout of a typical floor. Because 13-foot-wide and 20-foot-wide modular floor units were prefabricated for construction, the outside two trusses shared a common top chord seat connection with adjacent panels. All double trusses were attached to every other periphery column by a seat angle connection and a gusset plate that was welded to the spandrel and top chord. Therefore, all truss supports had two trusses attached to the seat connection. A single bolt was used for each truss sharing a seat connection. The bottom chord of each pair of trusses was attached to the spandrel with visco-elastic dampers that had a slip capacity of 5 kips. At the core, the trusses were connected to girders that were attached to the box or H-shaped core columns by beam seats welded to the column faces.

B.2 Mechanical Properties

Nearly all of the steel plate was produced in Japan to ASTM standards or their equivalent. None of the mill test reports were available that describe the mechanical properties and chemical composition of the steel used in the WTC structures. Approximately 100 potentially helpful steel pieces were identified at the four salvage yards that had contracts to obtain and process the WTC steel debris. These pieces have been removed and transported to the National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland, for storage and further study. No coupons were taken or tested to check material conformance with specification of any plate, rolled section, bolt, weld, reinforcing steel, or concrete. Visual examination of the debris did not identify any apparent deficiencies in the structural materials and connectors.

In lieu of actual WTC steel properties, typical stress-strain curves characteristic of 3 of the 12 steels used in the design and construction of the WTC complex are shown in Figure B-2 for three ASTM-designation steels with minimum specified yield strengths of 36 ksi (A36), 50 ksi (A441), and 100 ksi (A514). In general, as the yield strength of the steel increases, the yield-to-tensile-strength ratio (Y/T) also increases. For A36 steel, Y/T is approximately 0.6, whereas for A514 steel, Y/T is approximately 0.9. The yield plateau for five steels (yield points 36, 50, 65, 80, and 100 ksi) can be highly variable for structural steels, as is apparent from a comparison of the expanded initial portions of the five steels shown in Figure B-3. At the higher yield strength associated with quenched and tempered alloy steels, there may not be a distinct yield plateau; instead, the steels exhibit gradual yielding and nonlinear behavior with strain hardening.

High strain rates tend to increase the observed yield strength and tensile strength of steel, but may also reduce the ductility. There is a greater influence on the yield point than on the tensile strength. Figure B-4 compares the effect of a very high strain rate (100 in/in/sec) for a mild carbon steel with a more usual test speed of 850 micro in/in/sec. In this example, the yield point more than doubled, whereas the tensile strength was increased about 27 percent, and the Y/T ratio approached unity.

In fracture toughness tests where rapid load toughness is determined, the dynamic yield strength of certain steels can be estimated by the following equation taken from ASTM E1820 (ASTM 1999):

$$\sigma_{yd} = \sigma_{ys} + \frac{174,000}{(T + 460)\log_{10}(2 \times 10^7 t)} - 27.2 \text{ ksi} \quad (\text{B-1})$$