extension rods arranged in pairs as shown. Both longitudinal and transverse bracing were
designed in view of the extraordinary circumstances of the location. Very high winds
sweep through the gorge and produce conditions requiring the most careful consideration
in connection with such an elevated structure, while its vibrations, caused by moving
trains, call for scarcely less attention.

A train of consolidation engines formed the moving load under which the viaduct
was designed.

The following is a recapitulation of the main data:

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of iron towers</td>
<td>20</td>
</tr>
<tr>
<td>Number of columns</td>
<td>110</td>
</tr>
<tr>
<td>Number of spans</td>
<td>41</td>
</tr>
<tr>
<td>Total length of iron-work</td>
<td>2053 ft</td>
</tr>
<tr>
<td>Length of each clear span</td>
<td>61 ft</td>
</tr>
<tr>
<td>Length of each tower span</td>
<td>38</td>
</tr>
<tr>
<td>Highest tower</td>
<td>297 ft</td>
</tr>
<tr>
<td>Average height of towers</td>
<td>170 ft</td>
</tr>
<tr>
<td>Width of top</td>
<td>10 ft</td>
</tr>
<tr>
<td>Width of base (widest part)</td>
<td>103 ft</td>
</tr>
<tr>
<td>Pounds of iron in viaduct</td>
<td>3,500,000</td>
</tr>
<tr>
<td>Pounds of steel in track and fastenings</td>
<td>100,000</td>
</tr>
</tbody>
</table>

Besides the railway track, the viaduct is provided with a sidewalk on each side.

PLATE IX.

RONDOUT BRIDGE.

One mile south of Kingston, N. Y., on the line of the New York, West Shore and
Buffalo Railroad, the railway pierces the rocky ridge just north of Rondout, then emerging
from the tunnel, it is carried over the creek by the viaduct and through spans shown on
this plate. The viaduct is adjacent to the tunnel, and the southern portion of it consists
of eleven lattice deck girders, alternately of 51- and 30-foot spans, with one exception of
20 feet and another of 60.

The northern portion consists of a series of three pin-connected spans, and the entire
superstructure is carried on the top of towers varying from 32 to 140 feet in height. As
shown on the plate, the two longer spans are over Rondout Creek, and at an elevation of
155 feet from base of rail to surface of water.

The separation of trusses in each through span is 29 feet, and the depth of the two
longer spans 45 feet; the length of panel is 18 feet.

The general design of the structure is such as to secure the greatest economy of
material, in combination with the requisite stability at such an elevation. As there are
two trusses only to each pin-connected span, and a double track to be carried, the con-
ditions to be fulfilled were such as are not ordinarily found.

The construction of the towers is admirably adapted to the requirements of stability
and economy. Phoenix columns are used in compression, and all details are so formed as
to act in the most direct and effective manner. The three through spans are so placed
on the towers that their weights are equally distributed on the four legs.

The viaduct is 531 feet long, while the whole structure has a length of 1244 feet.
The total weight of iron is about 2000 tons.

PLATE X.

METROPOLITAN ELEVATED RAILWAY.

This plate shows some features in the construction of the Metropolitan Elevated
Railway of New York City. The requirements of this work were certainly most
unique, and at its inception the difficulties of design were unusual in engineering
experience. The construction of an entire railway line on an elevated iron structure, to
be subject to the demands of steam traffic, would give rise to more than ordinary engi-
neering problems, but when these conditions are coupled with others, required by an
almost absolutely continuous use of the structure, the difficulties encountered are very
materially increased. Although the speed of the trains on the elevated railways of New
York are not high, yet the short intervals of time between them permit scarcely any
rest to the metal of the viaduct. Hence the fatigue of the iron becomes an important
consideration.

This incessant use also gives rise to very wearing demands on the connections of
the lateral and transverse systems of bracing, especially on the curved portions of the
line, some of which are reversed.

This plate shows a portion of the road where the design was such as to meet the
difficulties arising from a combination of greatly-increased height with a reversed curve.
The inherent stiffness of the Phoenix column in all directions, as well as its superior
capacity for resisting compression, render it peculiarly adapted to such extraordinary
conditions as these. The transverse and lateral bracing, as well as the longitudinal
bracing of the towers, were made sufficiently heavy to permanently meet the require-
ments of the circumstances. The whole amount of elevated railway built by this
company in New York City up to the present time is 30.3 miles of single track.

PLATE XI.

METROPOLITAN ELEVATED RAILWAY.

This plate shows the general character of the same structure as the preceding, but
on the tangent along Ninth Avenue.

The superstructure is composed of lattice girders of a heavy type, carrying the
railway lines, while a very firm system of transverse bracing is secured by the pairs of
latticed struts in combination with the curved knee-braces at the tops of the columns.
The latter, as shown, are of heavy Phoenix section. In short, this structure is built to
secure that unusual degree of strength and stiffness that is necessary to withstand the
extraordinary demands upon it.

The general methods employed in the erection of the structure were also somewhat
peculiar to its character. After the vertical columns were firmly anchored in place the
longitudinal girders were raised into position from the traveller resting on the portion
already constructed. The transverse and lateral bracing were then completed. The
structure was thus made to serve the purpose of its own false works.