central portion of the bridge, combining it with the rigidity of the side trusses in giving stiffness to the roadway.

The cables, as they hung freely between the towers, before they were loaded with the roadway, formed a pure catenary curve, the properties of which are well known to the mathematician; but when the roadway was added, which in any suspension bridge is much, or many times greater, than the weight of the cables themselves, their primitive character was changed; and under the influence of an equally distributive load, they assumed the form of a parabolic curve.

The difference between these two curves in deducing the strength of the bridge is inconceivable, but in calculating the length of the suspenders it cannot be disregarded. The parabola gives the readiest means of finding them, and the lines it furnishes approximate more nearly to the curve of equilibrium. A foreshortened view of the bridge, as seen from either bank, brings out the harmony of these lines in a very agreeable manner.

The Strength of the Cables.—To find the length of the arc formed by each cable, considered as a parabolic curve, if \( S = \text{half the arc, } y = \text{half the span, and } x = \text{the deflection, then accurately} \)

\[
S = \frac{y^2}{4} = \frac{m^2 + \log y + \sqrt{4m^2 + y^2}}{2m}
\]

the symbol \( \log \) being the hyperbolic logarithm.

By the equation to the parabola,

\[
y^2 = 4mx \quad \text{and} \quad x^2 = 4m
\]

the parameter. The vertical deflection of the cables at medium temperature is 91 ft., consequently the swayed cables will have an inclined deflection of 92.22 ft., and the length of the arc must be measured by this deflection. Substituting the values of \( x \) and \( y \) in the foregoing formula, \( \therefore x = 92.22 \), and \( y = 634.17 \), then \( S \), half the arc, becomes 643.00, and the whole arc is 1286.00 exactly . . . . . (1).

Similarly, if the deflection be taken at 90 ft. vertical, the swayed deflection becomes 91.24 ft., and the length of the arc will be 1285.62 ft. exactly.

For a deflection of 92.22 the arc measures 1286.00
For a deflection of 91.24 the arc measures 1285.62

The increment of difference 0.98 gives increment of arc 0.38, and \( \text{vice versd} \) . . . . . . (2).

The greatest tension upon the cables being at the points of suspension,

Let \( y = \text{half the span} = 634.17 \text{ ft.} \)
\( x = \text{vertical deflection} = 91.00 \text{ ft.} \)
\( P = \text{total weight of cables, roadway, and load equally distributed.} \)
\( T = \text{greatest tension in cables resulting from this load.} \)

Then,

\[
T = \frac{P}{4m} \sqrt{\frac{y^2}{4}} + 4m^2.
\]

By substitution,

\[
T = \frac{P}{4m} \sqrt{634.17^2 + 4 \times 91^2} = P \times 1.81 . . . (3).
\]

The factor, 1.81, multiplied into the load, \( P \), equally distributed, expresses the strain upon the cables at each point of suspension. In other words, every ton spread equally over the platform produces a strain of 1.81 tons in the line of the cables.

The Strength of the Stays.—If \( \theta \) be the angle of inclination of the stays, or the angle, \( \phi \), at which they intersect the horizontal plane, then their effect in sustaining a given load varies, as \( \sin \phi \), the smaller the angle the less their effect in giving vertical support; but to compensate for this difference the strength of the stays increases in the inverse ratio. Three sizes of rope are used, the longest being nearly thrice the strength of the shortest. The angles vary from 16° to 67½°. As they are applied, every one of the forty-eight stays is found, by the resolution of forces, to possess a lifting power varying from nine to fourteen tons ultimate, or two or three tons effective strength. The aggregate strain upon all the stays may be shown by a representative triangle of forces as deduced from the plans.—The sum of all the breaking strains being represented by the diagonal \( = 1344 \) tons net, the sum of the horizontal thrusts against the abutments will be represented by the base \( = 1148.07 \) tons, and the aggregate lifting power of all the ropes by the vertical side \( = 628.54 \) tons. The same proportions will hold good for all other stays less than the breaking strain. If the vertical side = 1, then the diagonal \( = 2.14 \), and the base = 1.83, let the vertical side represent the entire weight, \( P \), to be supported, then the strain upon the diagonal will be 2.14 \( P \) . . . . . (4).

The bridge is supported by cables and stays. Taking these separately, the cables have to support:

1. Their own weight. By \( \frac{1286 \times 54 \times 14}{6 \times 2000} = \frac{81.00}{\text{tons}} \).
2. The weight of 634 ft. of the central portion of the bridge, including all the suspenders, the cable bands, tension bolts, and washers over the whole length of the bridge . . . . . 79.60 tons.
3. The weight of the under floor gussets, attached to the central portion of the bridge, including a quarter of a ton strain on each gusset, to keep it taut . . . . . 5.00 tons.
4. The weight of the bridle and horizontal stays between the cables, including the strains upon the former . . . . . 2.00 tons.

Total weight resting on the cables, net tons . . . . . 167.60

The strain upon the cables produced by this weight is,

By (3) \( 167.60 \times 1.81 = 303.35 \) tons . . . . . (5).