required, without loss of time and with the greatest economy, and by methods based upon the most advanced engineering practice.

DETAILS.

The design of details has received from us especial attention. We have regarded it as one of the most important departments of bridge design, and have given it careful and continuous study in connection with the constantly varying and increasing demands of modern bridge practice. It has been our endeavor to give the greatest possible simplicity to details, and so dispose the material in them as to transfer stress in the most direct and simple manner, and by such a method to give to each main member precisely and only that kind of stress which it is intended to take.

All increments of chord stress are brought to bear directly and symmetrically upon the full chord section, thus completely avoiding all bending and cumulative stresses. This result we deem of great importance in constructive design, though it frequently fails in cases of member importance demands.

By the attainment of these ends we are enabled in tension members to concentrate the metal truly on the section lines of stress, and in compression members to dispose the sectional area as to enable it to act in the most advantageous manner possible, and thus to secure the most economical design.

Our forms of cross-section for compression members, chief among which is the well-known "Phoenix" section, have been developed on the basis of the latest and most comprehensive column tests, in combination with the results of many years of experience in American practice with open and closed columns.

Whenever "Phoenix" columns are used, effective preservative processes are employed, before the column is closed, on all surfaces that are not afterwards open to inspection and painting, the columns are then closed absolutely tight. Such columns have been examined after fourteen to twenty years' use, and found to be not in the slightest degree affected by oxidation, though in some cases the columns had occupied most exposed positions in respect to extreme hygrometric changes in the atmosphere, and, in fact, had at times been under water for several days.

In open columns built of plates and angles, or of channels and plates, we dispose the metal in the most judicious manner, in view of the duties which it has to perform. By the use of well-designed latticing the requisite stiffness is secured, with ample facilities for constant inspection and painting at proper intervals.

In all cases, whether of closed or open columns, we aim to form a member in which the metal is placed far from the neutral axis, and whose parts shall be so self-supporting as to cause the column to fail as a whole, thus avoiding a weakness quite common to many latticed or other columns. The "Phoenix" column is, however, the only form which entirely fulfills this condition.

Although much yet remains to be done in the empirical determination of the resistances and proportions of long columns with various end conditions, yet sufficient tests have already been made upon full-size "Phoenix" and upon latticed and other forms of columns on the Government machine at Watertown, Mass., and at Phoenixville and elsewhere, to obtain correct ideas of the relative merits of some of the principal forms of section.

The following formulae are expressive of those experimental results, which can be relied upon by engineers:

\[
P = \frac{42,000}{1 + \frac{1}{\beta}} \quad \text{Flat Ends.} \quad P = \frac{42,000}{1 + \frac{1}{\beta}} \quad \text{Pin Ends.}
\]

\[
P = \frac{39,000}{1 + \frac{1}{\beta}} \quad \text{Latticed, or Common Column.} \quad P = \frac{39,000}{1 + \frac{1}{\beta}} \quad \text{Latticed, or Common Column.}
\]

\[
P = \frac{39,000}{1 + \frac{1}{\beta}} \quad \text{Angle-Iron Struts.} \quad P = \frac{39,000}{1 + \frac{1}{\beta}} \quad \text{Angle-Iron Struts.}
\]

\[
P = \frac{39,000}{1 + \frac{1}{\beta}} \quad \text{Angle-Iron Struts.} \quad P = \frac{39,000}{1 + \frac{1}{\beta}} \quad \text{Angle-Iron Struts.}
\]

The great superiority of the "Phoenix" column in resisting capacity is well shown by a comparison of these formulae. They give results a little too low where the lengths become less than about 30 radii of gyration, with the exception of the last two, and a little too high when the lengths exceed 125 to 150 radii.

The formula for pin-end angle-struts is to be used only when the length exceeds 120 radii of gyration, as below that length the values of \( P \) for pin and flat ends are shown by experiment to be the same.—i.e., for the pins used in the tests.

EYE-BARS.

In order to bring the design of eye-bar heads to a state of perfection, we have made many hundred tests on full-sized bars, and secured such a contour of head that the full resistance of the body of the bar will always be developed if it be tested to failure.

We are now prepared to die-forge the eye-bar head under the steam hammer, or to form it by hydraulic pressure, as may be preferred.

RIVETED WORK.

In the design of riveted work we aim to produce results of the same general character as those obtained in the best pin-work. This is accomplished by placing the metal truly on the centre lines of stress, and causing the latter to intersect as nearly as possible at a single point at each joint.

The influence of the bearing pressure of the rivets against the intrados of the rivet hole on the tensile resistance of the bars and plates, as well as the shearing of the rivets and other methods of rupture of the joints, are carefully considered in all designs. Bending and other secondary stresses, so prevalent in nearly all riveted work, and constituting to some extent, at least, unavoidably inherent defects, are thus reduced to a minimum.