

A NEW FORM OF GIRDER.

EXPERIMENTS AT THE ROLLING MILLS WITH JACKSON'S CAST-IRON GIRDER.

Some interesting experiments were conducted the other day at the Pacific Rolling Mills, with a new form of cast-iron girder, the invention of P. H. Jackson, late Chief of the Bureau of Iron Construction, Department of Buildings, in New York. The experiment was really one on a mode of using cast-iron when subject to transverse strain, by which its whole cross section is compressively employed without taxing its comparatively feeble resistance. Before describing the girder, it may be well to bring forward for consideration some points on girders generally.

Cast iron possesses the enormous compressive resistance of 93,000 lbs. to the square inch, while its tensile strength is but from 14,000 to 15,000 lbs. The ratio computed by Mr. Hodgkinson is about $6\frac{1}{2}$ to 1.

The object attained in this construction is a perfect girder. When employed the bottom or tie rod is tension, and the arch is in compression in every part with no tensile strain whatever; the latter an object not before attained. The antagonistic force of compression to resist the tensile strain of the tie rod is exerted at the bottom or intrados of the arch, and this force is increased in the ratio of the increment of the load on the arch. The remaining part of the arch above the bottom is naturally compression due to the load. A summary of the peculiarity of this arch is as follows:

It is in effect a device for employing cast iron compressively, neutralizing the tensile strain due to transverse strain. The tensile strain on the tie rods is reciprocally utilized in compressive resistance at the intrados of the arch, thus destroying tensile strain in every part of its cross section. Another advantage in construction of a metallic girder made in sections of its lengths is, that should the tensile strain at the intrados of the arch, exceed that of compression by the action of the tie rods, the deflection of the arch is limited to the length of a bay only. For instance, in a girder 150 ft. in length, made in 10 bays, each 15 ft. long, the deflection that would injure the strength of the material of the arch is limited to the length of a bay of 15 ft., instead, as in other constructions, its weakness, by deflection, would extend over its whole length.

The neutral axis of this girder exists between the tie rod and the bottom or intrados of the arch, or midway between the antagonistic forces. With the segmental arch in one piece and the tie rod to resist the neutral axis, is near the bottom of the arch, and travels upward as the load is increased; as the neutral axis will exist wherever the two opposite forces cease to exist, being indifferent to either force. The economy in the use of this neglected material, cast iron, for long spans when subject to cross strain, is in the employment by which its tensile strength is not called into play; also another grave objection is by an unequal distribution of the metal, causing weakness in the casting when forming from the molten to the solid state, and from that condition until cold. The heavy parts in contraction, control the thin or weaker parts, or if the formation of the mold is such that the ends of a long casting set deep in it and offer a resistance to the contraction of the metal when forming from a liquid to a solid state, both of these adherent weaknesses continue and increase until cold. The weaknesses are entirely due to separation or taxing its comparatively feeble tensile strength, and not in the least injuring it in its compressive resistance, as cast iron is never in a contracted state other than cold; and as long as cast iron is used compressively, it makes no difference how many pieces it may be in of its length, providing its abutting parts squarely or equally meet and are kept in line. Take, for instance, the area of the abutting parts of the 25 ft. girder shown in the engraving or the cross section of the bottom flange in the center of a bay, which is 16 inches wide by $1\frac{1}{2}$ inches thick, which equals 18 inches.

Eighteen inches multiplied by 93,000 lbs. to the inch equals 1,674,000 lbs., or 746 tons; taking it at one-fourth when employed, we have the resistance of 186 tons as a safe employed load. The area of the tie rods to resist this compression at 8 tons working strain per inch, providing the arch has suitable rise, would be $23\frac{1}{2}$ inches, or more than 3 of 3 inches diameter rods. Tie rods are cheap—merely bars of wrought iron with threads and nuts. When a railroad train enters on a bridge borne by these girders, the opposite end to the train is prevented from raising by the abutting parts on the bottom of the arch compressively exerted. There is no part of the arch in which tensile strength is employed.

The object of this device was to construct a perfect girder, the whole arch resisting compression, the tensile strain necessarily exerted by the ties, and using this essential resistance to render indifferent a most destructive force to cast iron, viz.: The tensile strain due to cross strain, showing an economy in this mutual antagonism, an equilibrium and forces negated.

The inventor has endeavored to make a continuous arch embodying the principle of the Voussoir arch. Mr. Jackson's is a sectional, continuous arch employed compressively over its entire cross section.

A Voussoir arch is composed of many blocks to make up its length, and without the use of cement or mortar between the blocks. With the exception of friction of the blocks as they slide downward, taking a more compressed position as the load upon them is increased or the abutments yield, there is no tensile strain whatever, upon them, and the calculation has only to be made as to the strength of the material in its compressive resistance. With a continuous segmental arch, made in one piece of its length, there is, at every point, a bending moment and a thrust force; therefore, a continuous arch brings into play both compression and extension as that of a straight girder, but with more of compression than extension. See page 9 of W. Airy's book on iron arches.

With an iron arch in one piece of its length, the wrought iron tie rods elongate in the ratio of 1-1000 of its length to every 10 tons tensile strain per square inch of cross section, and this elongation is considered the measure of the elastic force of the metal.

At this strain the elongation would be for a 25 ft. girder same as shown in the drawings, 3-10 of an inch. 25 ft. equals 300-1000 inches, equals 3-10 of an inch. At this elongation of the rods, be the material of the arch either of cast or wrought iron, the arch loaded will have so far straightened as to cause great tensile strain at the bottom, giving free play to the tensile strain caused by the load.

By this formation of cast iron into girders for long spans, using it compressively in the manner of employing cast iron columns, having a resistance of 60% in excess of wrought iron, (that is comparing the tensile strength of wrought iron at 25 tons to the inch, and the compressive resistance of cast iron at 41 tons, or the compressive resistance of wrought iron at 18 tons to that of cast iron) 41 tons is equal to 227%. It is so shaped that its defective strength for long spans may be made in as short sections as desired, and the tensile strain on the rods as increased is utilized to destroy the power of the load to rupture the arch. The prime cost of the 25 ft. girder was \$150. The girders in common use in this city to sustain 100 tons and 25 ft. long, supported only at the ends are sold at about \$350 each.

Fig. A, of the engraving, is an elevation of a girder experimented on. Length, 25 ft.; distance between supports, 23 ft. 2 inches; height, from bottom of tie to under side of arch, 2 ft. 3 inches. The cross section of arch (see Fig. B) was 16 inches wide by $1\frac{1}{2}$ inches thick at bottom, and the greatest height 10 inches. Two of $2\frac{1}{2}$ inches diameter wrought iron tie rods sustained the tensile strain. Figure C shows the knuckle joint, the round cast on the center piece, and the socket cast on end pieces, and with the strut cast on same piece, this latter resting on the bottom on the tie rods. Fig. D shows end of girder. At the top of the arch will be seen a space of $1\frac{1}{4}$ inches. Whatever may be the deflection, no parts of the arch, excepting the knuckle joint, touch, so that compression is only exerted on the line of the bottom flange. The cross section of arch (see Fig. B), is of the Hodgkinson form for straight girder and made to sustain a 16-inch brick wall; consequently, from its broad bearing for the wall, it is largely in excess in compressive resistance to the tensile capacity of the rods. The following is the cost of this girder in San Francisco where materials and labor are higher than in the Eastern cities and in Europe:

Weight of arch casting, 3,080 lbs., $3\frac{1}{2}$ c.....	\$100.10
Weight of tie rods and nuts, 902 lbs., $4\frac{1}{2}$ c.....	40.59
Fitting 4 bolts and lead.....	5.50
Drayage and painting.....	3.00

\$149.19

Had this been made to sustain 186 tons as a safe load, the breaking load, three times greater—the same casting to be used, but to have three of 3-inch diameter rods, it would have cost:

3,080 lbs. casting, as before.....	\$100.10
3 3 inch rods, 1848 lbs., $4\frac{1}{2}$ c.....	87.78
Other expenses.....	9.50

\$197.38

Difference..... \$48.19.