MODERN EXAMPLES

OF

ROAD AND RAILWAY BRIDGES.

WROUGHT-IRON ARCHED BRIDGES AND VIADUCTS.

THE theory of the equilibrium of arches, until of late years, commanded but little attention from practical men, partly owing to the fact that, since it was derived from observations of their own failures and successes, it came rather too late to be of much service to them, but chiefly owing to the form in which it was presented by mathematicians, who, by giving a fictitious importance to insignificant matters, effectually obscured the broad truth, that the whole question was essentially a comparatively simple problem of weight and leverage. Although the condition of a brick or stone arch, under any given load, is easily ascertained, a considerable amount of intricate calculation is required to get an equally definite result if iron—a material of great mobility, both from changes of strain and temperature—be employed. But, fortunately, in this country, it seems to be the general opinion of engineers that it is inconsistent to insist upon mathematical accuracy in the proportions of structures where some 300 to 400 per cent. is considered necessary, and is allowed, for contingencies; and that a correct appreciation of general principles, the only sure basis for the formation of a sound judgment, is of greater value than many long formulæ. The necessity of this familiarity with general principles, as a guard against the undue influence of precedent, is especially obvious on the introduction of a new material, since there is an inherent tendency to mould it into the forms used for the preceding one. Thus, the imitation of stone arches is apparent in the short-framed voussoirs of the Sunderland and other early cast-iron bridges, in the rusticated and painted casings of Wiebeking's timber bridges, and in numerous other instances; whilst countersunk rivets in face work, and other similar contrivances, show the analogous influence of cast iron on wrought.

Some time elapsed between the general adoption of wrought iron for girder work and its introduction into arches; and, at first sight, cast iron, the material best able to resist crushing, seems the most suitable for a structure where, apparently, the compressive strains are the only ones. That this advantage is merely apparent, the following brief review of the work done by a wrought-iron arch will, we think, be sufficient to prove, since it is universally admitted that cast iron is very inferior to wrought in structures where it is liable to sudden changes, both in the amount and direction of strain.

Let W denote the total load distributed, and r the ratio of span to rise, then the maximum *natural* thrust (T) of an arch, under any circumstances, will be $\frac{W\,r}{8}$, and the maximum strain can never be less than $T\sqrt[2]{1+\frac{16}{r^2}}$. There are three disturbing forces; deflection, change of temperature, and change in position of the load, tending to increase this strain on the arch. The problem is, to neutralise the two first by proper adjustments, and to reduce to a minimum the inevitable transverse strain thrown on the bridge by the latter, either by providing adequate depth, or by taking advantage of the principle of continuity in the "girder" part which will have to resist it. It will be convenient to ascertain, first, the nature and amount of these forces in a segmental arched rib with immovable abutments (practically a single-arch bridge), and then by what modification of form we shall be enabled to comply best with the conditions of the problem set before us.

Deflection, though it rather lessens the total amount of compression on an arched rib, throws it in unequal