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## TRANSACTIONS.

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## MASONRY ARCHES FOR RAILWAY PURPOSES.

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In dealing with the arch, the writer feels that it will be necessary to proceed carefully; as many Engineers have the impression that for any possible view of the subject some authority may be cited, and that all of them are still more or less at variance with the practical results obtained in construction. The writer of the present paper has no desire to propound any new theory of the arch, or to advocate any one in particular; but will rather make it his aim to conpare the theories which have obtained the greatest currency with the of ject of ascertaining the conditions of construction and loading to which they are applieable, and also to indicate directions in which further investigation is still required to meet the ease of railway arches earrying heavy rolling londs.

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As it often happens, the discussion on this subject is largely due to misunderstandings which have arisen, owing to the different points of view taken by different authors, and the differing conditions which they have in their minds and do not sufficiently explain. The physical and mechanical properties which the materials are assumed to possess, the method of design and construction, and the purpose of the arch as regards the duty it has to fulfil, are seldom given with the charness that such fundamental considerations should have. In most cases it is only by reading and re-reading, examining the conditions as expressed mathematicall, and noting carefully some obscure hint occurring in the course of the investigation, or even by reference to the examples cited, that the assumed conditions can be inferred. The investigation in different countries has also been cappied on without sufficient reference to what has been ascertained elsewhere.

The older theories of the arch need not be reviewed here. The modern study of the subject dates from the introduction of railways, and origin ated with Méry and Moseley, who were the first to investigate the properties of the curve of pressure. (1) The various theories on the subject have now resolved themselves into two leading ones, which under more or less modified forms have obtained by far the greatest currency. The first of these may be briefly stated as follows: the curve of pressure must remain within the middle third of the arch ring, in order that the stability of the structure be as wed. The second is based upon the principle of least resistance, and anintains that the thrust developed at the key will not exceed the least amount capable of maintaining equili-brium. The first of the se has great currency amongst English authors. und heing endorsed by Rankine, is often referred to as an axiom. On the Continent the second is largely adopted as an improvement on older theories, and prominent among its exponents are Dapuit and Scheffler. Since Graphical Statics has developed so widely from the foundations laid by Culmann and Lévy, (2) it has been almost universally adopted us the best method for the investigation of the stability of the arch. It must be noted, however, that so far as the arch is concerned it is only a method, and does not afford a solution apart from more general prin-We have also the help of a large amount of observation and ciples. experiment, but these must be distinguised from each other. In observing structures during and after their erection all the conditions are present, but the difficulties of observation admonish corresponding care in the inforences drawn. In making experiments with models, these difficulties can be largely removed, but the material employed being usually different, the difference in physical properties must be allowed for.

A complete theory of the arch must apply to the fiuished structure fulfilling the purposes of its construction; but before proceeding to examine the theories referred to, we may first mention the conditions which accord with the ordinary principles of statics and for which no special theory is required; and we must also examine carefully the physical and mechanical properties of the material with which we have to deal, as explained in works on the subject. The design, method of construction, and purpose of the arch with respect to the loading it has to carry, furnish further conditions which must be taken up in connecto carry, lurnish furner, thenselves.