CATHEDRAL CHURCH, BALLAGHADRUN, COUNTY MAYO, IRELAND.

(*With an Engraving, Plate* XXIX.)

This church, of which we present our readers with a view, is now being built from the designs and under the direction of Messrs. Weightman, Hadfield, and Goldie, architects, of Sheffield, as the cathedral church of the Right Rev. Dr. Durgan, R. C. Bishop of the Diocese of Achonry. It was commenced some three or four years ago, and after laying the basement course, the works were suspended for some time, until they were recently commenced under the direction of the above-named firm. The plan consists of a spacious nave and aisles, chancel, side chapels, western tower, and sacristy. The proportions of these various portions were already determined before Messrs. Weightman and Co. commenced operations, and they have been in consequence very much crippled in carrying out their design. The style selected, as combining economy with ecclesiastical character, is the Early English, with a somewhat later character of Geometrical design in the chancel. The internal columns are circular, banded, and supporting on their caps the shafts which carry the feet of the partial groining of the roof, which is formed of a combination of panelled wagon-head ceiling and groining. The total length of the church is 168 feet by 59 feet. The whole masons' work is being executed in blue limestone from quarries on the estate of Lord Dillon, the lord of the manor, who generously presented the site for the edifice. Messrs. Doolin, of Westland-row, Dublin, are the contractors.

REVIEWS

The Physical Conditions involved in the Construction of Artillery; with an investigation of the relative and absolute values of the materials principally employed, and of some hitherto unexplained causes of the Destruction of Cannon in Service. By Robert Mallet. London: Longman. 1856. 4to. pp. 283.

Though by the title of this work it would appear to treat solely of the strength and construction of cannons, the investigations into which the author enters relate to subjects of the highest importance to the civil engineer and student of the general theory of the strength of materials. The chemical and mechanical constitution of metallic bodies, their forms of fracture, their manufacture, and their economical properties, of which this volume treats, are subjects of very general interest, though professedly those topics are here discussed for the purpose of investigating the strength of artillery.

Mr. Mallet's principal object, however, is to advocate a system of his own for the construction of guns, and to this we shall first direct attention, commencing by stating the defects of the common system of construction which he endeavours to avoid, and then our own views as to the efficacy of his methods of avoiding them. Several of the subjects to be considered ought to be discussed in a memoir rather than in a review; but as our conclusions in several particulars materially differ from those of the author, we have thought it right to state our processes of investigation, so that those who are desirous of checking the accuracy of the results may have the opportunity of doing so. And if these remarks appear to be carried to undue length, our excuse is that they relate to one of the most instructive examples of the theory of the strength of materials which occurs in practice. We believe that any civil engineer who thoroughly mastered the mechanics of artillery, would find his conceptions on the subjects of his own profession so much enlarged, that he would think his time and labour had been well bestowed upon the study.

It is well known to those who have had to investigate the tension of vessels, that if a uniform cylindrical vessel of material of finite thickness be subject to uniform pressure on its inner surface only, the tension of the vessel will *not* be uniform. On the contrary, the tension will be greatest on the inner surface and decrease towards the exterior. A consequence of this is, as we shall consider more fully presently, that such a vessel may be subject to a rupturing tension inside, before its outside is strained at all.

The cause of this inequality of strains may be explained as follows. Suppose the thickness of the material of the cylinder made up of any number of concentric cylindrical shells. An expansion of the innermost shell by tension will cause it to press on the next shell. The consequent expansion of that will cause it to press on the next to it, and so on to the outermost shell. Now, if these shells were not closely fitting, it is clear that the first would be expanded somewhat, before it began to press the second; and that would be expanded somewhat, before it began to press the third. It is true, that we cannot suppose that any interval in reality exists between these hypothetical shells before they are expanded, but the *compressibility of their thickness* by their mutual normal pressure produces the like effect as the supposed intervals. It can easily be seen that if the material between the innermost and outermost shell were very soft, the first shell would have to be expanded very much before the outermost shell began to expand at all. Therefore, it might happen that the inner shell burst before even the outer shell came into use.

We proceed to investigate more precisely the tensions of the different parts of the cylinder,—after stating why we are not satisfied with the investigation, for the same purpose given in the Appendix to the work before us, and written by Mr. Hart, Fellow of Trinity College, Dublin. He has stated so fairly and clearly the objections to his method, that we cannot do better than quote his own words. He states that his conclusion depends "upon the following admissions—First, that the extending force bears a constant ratio k to the extension; secondly, that the compressing force bears a constant ratio k' to the compression; and, thirdly, that fracture only occurs when the extension has exceeded the limit m; but it still remains to be proved by experiment, whether the resistance to extension is diminished or increased by simultaneous compression in a transverse direction, and *vice versâ*. Judging from the fact that the extension of a piece of india-rubber produces a visible compression in the transverse direction, and *vice versâ*, it seems probable that the effect of either of these forces must diminish considerably the power to resist the other; and if this be so, the resistance of the tube will be lessened; it is also conceivable that a very great compression might of itself produce fracture, *i. e.* disintegration, without any extension; or might (before reaching the crushing limit) make the material more easily broken by a transverse tension."

Our objection to Mr. Hart's method may be shortly summed up in this—that he does not investigate the normal compression of the cylinder; that is, the effect of mutual pressure of the consecutive cylindrical shells above mentioned, by which the extension of one produces extension of the others. The theory which we shall adopt on this subject is an extension of the well-known "Hooke's law," on which the general equations of elasticity of Cauchy, and those given by Professor Stokes in the eighth volume of the *Cambridge Transactions*, and the investigations of many other mathematicians, are founded. An admirable investigation of these general equations is given by Mr. Maxwell in a memoir on the 'Equilibrium of Elastic Solids,' in the *Edinburgh Transactions*, vol. xx.

The relations between the co-efficients of normal and tangential elasticity just referred to, may, we think, be determined as follows. If a cube of elastic material be subject to external normal pressures or tensions, the displacement of each face of the cube depends not only on the elasticity in the direction of that displacement, but also on the *cubical* condensation or dilatation of the material. So that if the cube be subject to perpendicular forces only on its faces, the pressure on any face would be not merely proportional to the displacement in its own direction, but dependent also on the lateral displacements, for on the latter depends the cubical condensation or dilatation. When this is neglected, each tension is, according to Hooke's law, in a constant ratio (e) to the extension in its own direction. When the cubical extension is introduced, experiment leads to the conclusion that the consequent additional tension is approximately in a constant ratio to the cubical extension. This ratio (E) is the same for all directions of the strain when the material is equally elastic in all directions.

Let the dimensions of the cube be unity, and let c be the cubical compression; l, n, t, the tensions on three contiguous faces of the cube; λ, ν, τ, the displacement produced by them. Then, by the principles just laid down,

$$\left.\begin{aligned} l &= \mathrm{E}c + e\lambda \\ n &= \mathrm{E}c + e\nu \\ t &= \mathrm{E}c + e\tau \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1.)$$

These equations represent, in fact, the first terms of the expansion of the function which each pressure is of the two sorts of compressions.