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The Principles of Bridges

Though raised in Newcastle's coal-mining community, Charles Hutton (1737–1823) went on to make his mark as a teacher and mathematician. A fellow of the Royal Society (and recipient of the Copley medal), he carried out research into the convergence of series, ballistics, and the density of the earth. After flooding destroyed several bridges across the Tyne in November 1771, he began to study the design of bridges, and published this mathematical treatment in 1772. It demonstrates the ideal properties of arches and piers, with due consideration given to the force of water flowing against these structures. Hutton's practical observations also enhance a section that provides definitions of relevant terms. Not merely a solution to the demands of transport and trade, a well-designed bridge, in Hutton's eyes, stands as a structure of elegance and beauty.

The Principles of Bridges

Containing the Mathematical Demonstrations of the Properties of the Arches, the Thickness of the Piers, the Force of the Water against Them, &c.

CHARLES HUTTON

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MATHEMATICAL DEMONSTRATIONS

OF

The PROPERTIES of the ARCHES, the THICKNESS of the PIERS, the FORCE of the WATER againſt them, &c.

TOGETHER WITH

PRACTICAL OBSERVATIONS and DIRECTIONS drawn from the whole.

By CHA. HUTTON,
MATHEMATICIAN.

NEWCASTLE:

Printed by T. SAINT; and ſold by J. WILKIE in St. Paul's Church Yard, and H. TURPIN, in St. John's Street, London; and by KINCAID and CREECH, Edinburgh, 1772.

PREFACE.

A Large and elegant bridge, forming a way over a broad and rapid river, is juſtly eſteemed one of the nobleſt pieces of mechaniſm that man is capable of performing. And the uſefulneſs of an art which, at the ſame time that it connects diſtant ſhores by a way over the deep and rapid waters, alſo allows thoſe waters and their navigation to paſs ſmooth and uninterrupted, renders all probable attempts to advance the theory or practice of it, highly deſerving the encouragement of the publie.

This little book is offered as an attempt towards the perfection of the theory of this art, in which the properties, dimenſions, proportions, and other relations of the various parts of a bridge, are ſtrictly demonſtrated, and clearly illuſtrated by various examples. It is divided into five ſections: the 1ſt treats on the projects of bridges, containing a regular detail of the various circumſtances and conſiderations that are cognizable in ſuch projects: The 2d treats on arches, demonſtrating their various properties, with the relations between their intrados and extrados, and clearly diſtinguiſhes the moſt preferable curves to be uſed in a bridge; the firſt two or three propoſitions being inſtituted after the manner of two or three done by Mr. Emerſon in his Fluxions and Mechanics: The 3d ſection treats on the piers, demonſtrating their thickneſs neceſſary for ſupporting any kind of an arch, ſpringing at any height, and that both when part of the pier is ſuppoſed to be immerſed in water, and when otherwiſe: The 4th demonſtrates the force of the water againſt the end or face of the pier, conſidered as of different forms; with the beſt form for dividing the ſtream, &c. and to it is added a table ſhewing the ſeveral heights of the fall of the water under the arches, ariſing from its velocity and the obſtruction of the piers; as it was compoſed by Tho. Wright, Eſq; of Auckland, in the county of Durham, who informs me it is part of a work on which he has ſpent much time, and with which he intends to favour the public: And the 5th and laſt ſection contains a dictionary of the moſt material terms peculiar to the ſubject;

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in which many practical observations and directions are given, which could not be so regularly nor properly introduced into the former sections. The whole, it is presumed, containing full directions for constituting and adapting to one another, the several essential parts of a bridge, so as to make it the strongest, and the most convenient, both for the passage over and under it, that the situation and other circumstances will possibly admit: not indeed for the actual methods of disposing the stones, making of mortar, or the external ornaments, &c. those things I do not descend to, but leave to the discretion of the practical architect, as being no part of the plan of my undertaking; and for the same reason also I have given no views of bridges, but only prints of such parts or figures as are necessary in explaining the elementary parts of the subject.

As my profession is not that of an architect, very probably I should never have turned my thoughts to this subject, so as to address the public upon it, had it not been from the occasion of an accident in that part of the country in which I reside, viz. the fall of Newcastle and other bridges on the river Tyne on the 17th of november 1771, occasioned by a high flood which rose about 9 feet higher at Newcastle than the usual spring tides do.——And this occasion having furnished me with many opportunities of hearing and seeing very absurd things advanced on the subject in general, I thought the demonstrations of the relations of the essential parts of a bridge, would not be unacceptable to those architects and others who may be capable of perceiving the force of them, and whose ignorance may not have prejudiced them against things which they do not understand.

In the 4th section there is one thing forgotten to be remarked, viz. That in determining the best form of the end of the pier to be a right-lined triangle, the water was supposed to strike every part of it with the same velocity: had the variably increased velocity been used, the form of the ends would come out a little curved; but as the increase of the velocity in the best bridges is very small, the difference in them is quite imperceptable.

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