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From Leonardo da Vinci to Fritz Leonhardt – The Role of Physical Measurement Models in Bridge Engineering

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ABSTRACT

Since ancient times, physical processes have been explored with models to understand the laws of nature. In the late 15th century Leonardo da Vinci researched the behaviour of bending of elastic beams of various spans using physical models. Later, in the 20th century, physical models were indispensable for civil engineers and architects to check the load-bearing capacity of unconventional and innovative structures. Even today, physical models are used in different engineering disciplines, for example, to test the behaviour of long-span bridges in wind tunnels. This paper attempts to give an overview of important testing facilities which achieved technological progress in the field of bridge engineering. The models built and the tests performed in these facilities will be used as examples and will answer the question of the critical role these models played in the planning and construction process. The authors are collecting information and are analysing these physical measurement models in the current research project, “Last Witnesses”, funded by the German Research Foundation (DFG) to replicate some of them as digital twins. The results will be available to the public in an openly accessible database.

Keywords: physical measurement model, bridge model, structural modelling, digital twin, database.

1 INTRODUCTION: HISTORICAL USE OF PHYSICAL MODELS

The use of physical models can be retraced back to ancient Greece or Rome, for example, to examine military equipment. There is also evidence that engineers in the Gothic period used models to build enormous cathedrals. From the Renaissance, there are known numerous sketches and writings on the use of models, among others, by Leonardo da Vinci (1452-1519) on flying machines, canals, and civil structures. Still, he never describes the construction of his models, so no built models by Leonardo da Vinci are known.

There are thus numerous individual examples of the use of physical models in various scientific disciplines, often as a demonstration that something works, to test a manufacturing method, as a teaching object for artisans or to convince potential customers. In the Age of Enlightenment, experiments on models were carried out more systematically and noticed by practising engineers. The trend towards more scientific approaches also led to the study of the theoretical principles of how the results of model experiments could be scaled up to actual construction, for instance, by Leonard Euler (1707-1783).