Review

John Lyness recommends this comprehensive book to all those interested in the development of structural forms, those developing physical models, and those structural analysts making physical model comparisons with CAD output.

Physical models: Their historical and current use in civil and building engineering design

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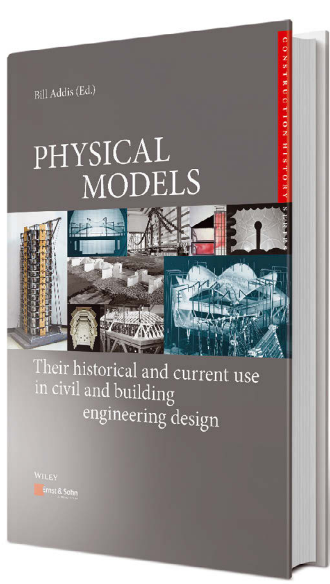

THIS BOOK PROVIDES an extensive historical review of the engineering use of physical models of structures of all types, over the last two millennia. The book comprises five chronologically ordered sections, with each containing up to 10 articles written by a relevant expert in each structural or physical model area.

Each article narrative is substantiated by a reference list and complemented by figures and photographs of physical models. Very usefully, wherever possible, model scales are given throughout and although the detailed coverage of similitude derivations is not given in each article, they can be accessed using the reference lists.

On a first reading of the book, it becomes apparent that, by the 20th century, physical modelling expertise had become highly developed in a number of laboratories, design consultancies and material development institutions. This enabled the use of new materials for the design of structures such as reinforced concrete (RC) shell roofs, highway bridges, cooling towers, dams and arenas.

Section A presents reviews and critiques of physical models of structures from classical times up until the end of the 19th century. The coverage describes models used for masonry structures and catenary (chain) models that were used for bridges and ecclesiastical buildings. Towards the end of this period, roof and bridge spans increased substantially in parallel with the development of new structural theories and materials.

The inversion of tensile catenary and hanging-net models allowed the development of new 'compressive' structural forms. The limits of the applications of inverted tensile form models in design are wisely pointed out.

Together, Sections B and C cover the physical modelling of structures from the 1890s to the 1980s. This period includes the recoveries from WWI and WWII which stimulated the development of new structural materials and structural forms.

The use of RC, prestressed concrete and steel fabrication rapidly expanded in response to the modernisation of transport infrastructure, water resources infrastructure and the construction of large buildings. Principal among the structural developments were the use of RC plates, RC shells for arch dams and large roof spans in the forms of folded plates or shells.

This was also a time for experimentation and for refinements to physical model construction. Within these sections, model materials such as plaster of Paris, micro concrete, rubber, gels, soap films and Perspex are described, in addition to another dozen model materials in other book sections. The use of dimensional analyses and physical similitude also evolved together with more representative model loading systems and improved model instrumentation.

During the 20th century, the limits of model instrumentation, the equivalent model loading systems and the limits of model material behaviour were quantified and allowed quantitative accuracy assessments of model results. Also, the appropriate use of physical models for form finding, elastic behaviour and collapse behaviour verification was rationalised so that the choices of physical model scales, types and model boundaries could be optimised for each of the design stages.

From the book, the peak use of physical models in structural design appears to have been identified as post-WWII. However, the case is made for the continued relevance of physical models. Small-scale models can now be efficiently produced using 3D printing technology or 3D reductive sculpting processes.

Since the 1960s, instrumentation and data-processing technologies have become more inexpensive for recording experimental measurements. This has been particularly advantageous when recording and analysing time–history results for the physical models used in structural dynamics.

In Sections D and E, the use of models in some contemporary areas of application is described – wind loading, earthquake loading, geotechnical centrifuge models, acoustic design, photoelasticity and photogrammetry techniques, 3D printing for small-scale model creation and the development of 'shaking tables' for earthquake modelling.

Section E looks to the future and describes in more detail the use of models to determine air flow dynamics and gusting around structures, a review of the principal global earthquake modelling institutions, geotechnical centrifuge modelling case studies, and the physical models used in connection with the assessments of the acoustic and ventilation performance of structures.

In summary, this comprehensive book provides very thorough historical and engineering reviews of the use of physical models and describes the advances in structural forms and materials that necessitated the development of these models to resolve design problems and verify the structural behaviour of the design – with public safety always a concern.

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