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Editorial

Engineering and Modeling of Water Flow via Computational Fluid Dynamics (CFD) and Modern Hydraulic Analysis Methods

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The manuscripts presented in this Special Issue will both present engineering analyses of problems of contemporary importance in fluid mechanics and hydrodynamics and describe historical water systems and the technologies used to design and operate them by ancient Old and New World water engineers. This approach will give readers the opportunity to understand the historic development of water engineering from ancient to modern times. While modern water engineering structures depend upon knowledge of known engineering technologies for their design and function, surviving water structures from centuries past leave gaps in our understanding of the water engineering technologies used for their construction and use. This knowledge gap regarding ancient engineering practices used to design and build complex water systems is addressed by several of the manuscripts focused on providing insights and answers regarding the historical development of water engineering.

To fill this gap in our understanding of ancient water technologies, Computational Fluid Dynamics (CFD) analysis of models of ancient canals and other hydraulic features are made to visualize water flow patterns, outlining the design intent of and usage of these systems by ancient water engineers. As CFD analysis of ancient water engineering technologies is conducted in terms of modern hydraulic terminology, it implies that a comparable knowledge base and understanding of water engineering principles existed in ancient times but was described in ancient technical nomenclature not preserved in the archaeological record. The introductory manuscript [1] gives nine examples of CFD use applied to examine prominent Middle Eastern, European, Asian and South American archaeological World Heritage Sites' water systems dating from 2500 BC to 1400 AD—this approach will identify the ancient water engineering technologies used in their design and operation. Further manuscripts [2,3] provide hydraulic engineering analysis results for 17th-century aqueducts and water storage hydraulic structures in Europe and North America to increase our knowledge of the hydraulic engineering knowledge bases used in later Old and New World sites' design and construction. One gap in the archaeological record concerns elaborate complex water engineering structures used for urban and agricultural use and their connection to and influence on the development and advancement of the social structure of a society. This gap is addressed via Complexity Theory [4] to determine the formal relationship between water technologies used by several ancient societies and the social structure evolution of these ancient societies, which existed in the 500–1450 AD time period. Complexity Theory increases our understanding of the effects of climate change in the form of extended drought and excessive rainfall periods on societal extinctions noted from archaeological investigations—this is now a topic of great importance given present-day extreme climate excursions equal to, or well beyond, those reported in earlier historical periods in terms of intensity. Descriptions of ancient water technologies given in [1–4] will close the gap in our knowledge of the water engineering structures of the ancient world identified through CFD use and Complexity Theory, determining the evolution, growth, and continuance or extinction of ancient societies based on their hydraulic engineering technologies when subject to extreme climate anomalies.

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Although this identification of ancient water engineering history comes with the downside of not knowing the mathematics and physics technologies available to past structures' water engineers when designing and operating complex water systems, the use of CFD analysis to frame in modern terms the hydraulic engineering technologies of several ancient societies gives a preliminary version of the water engineering knowledge base used in the design, construction and use of their water engineering structures. As an alternate source of water engineering knowledge beyond the equation-based technologies in current use, the observation and recording of water flow characteristics in natural settings by ancient water engineers could be the source of their water technology knowledge comparable to what modern age equations governing water flows duplicate and predict; this observation likely would serve as a knowledge base used by ancient water engineers in the design and construction of their water systems. This observation of ancient methods used to gain knowledge of hydraulic phenomena is comparable to the use of modern hydraulic test facilities to first observe hydraulic phenomena and then devise mathematical equivalencies to describe what has been observed.

Complex water system analysis problems and solutions based upon current mathematical and water physics knowledge are discussed in the remaining six manuscripts. In modern times, one important use of water engineering knowledge concerns societies' need for green energy production. This issue is related to major climate change effects attributed to carbon dioxide released into the atmosphere through organic fuel use, which is the source and cause of catastrophic flooding and drought effects now observed in extreme world weather patterns. Thus, a new emphasis on the importance of green energy production through the use of dams incorporating turbines connected to multiple electricity generators has become a major focus, and this subjects is the focus of the following six manuscripts. Modern green energy production research now places further emphasis on water control and distribution irrigation systems necessary to provide ample food supply for growing world populations. To examine current research on these areas of major concern, six manuscripts present advanced research on the engineering aspects of water energy dissipation regarding dam spillways [5], the structural integrity of hydropower discharge systems [6], the water supply pipeline sourcing of water-related power generating systems [7], and the use of CFD simulations of rotors at dam pipeline outlets as further sources of green energy electrical generation [8]. Additionally, water conservation measures related to the CFD modeling of Ringlet water reservoirs [9] together with CFD investigations of a Tyrollian lake's capacity to accommodate discharged spillway water used for off-season water supply for crops are the subjects of further investigations [10]. Of interest regarding the study of energy dissipation in water flowing in spillways of the 17^{th}-century French Lugdunum aqueduct system [2] is a similar 21st-century study of spillway water patterns and their erosional effects on downstream soil channels [5]—this issue indicates that water transfer effects in channel erosion and energy recovery still constitute major concerns that have remained present over centuries of research. In the same vein, many of the nine examples of ancient water system technologies discussed in [1] still have similar modern counterparts, particularly regarding technologies used for efficient food production increase—this has been a topic of major concern for ancient and modern societies throughout history.

This Special Issue addresses water engineering issues, many of which originate from antiquity, that still generate scholarly concern and interest millennia later insofar as they relate to the survival, continuity and development and progress of advanced societies (as reference [4] illustrates), as well as the need for stable food resources together and clean water resources for cities. This universal need, addressed in ancient and modern times for the development and advancement of cities, continues to be the subject of research studies in the present day. The manuscripts presented in this book provide research results relevant to efficient water use for societal development, a topic that has retained relevance from the earliest days of mankind's existence to the present day. Considering that the improvement and understanding of water technologies applied for urban and agricultural use remain

key issues, the totality and range of this Special Issue's manuscripts will advance research on both ancient and modern versions of water technologies.

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