ARBITRARY GENERATION OF VERY LONG, AND TSUNAMI-LIKE WAVES USING AN OPTIMZED PUMP-DRIVEN METHOD

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INTRODUCTION

The last decade has seen a large number of tsunami, as a result of subsea earthquakes and landslides, and an increasing number of floods exacerbated by climate change. These geohazards have resulted in frequent flooding of coastal hinterland and riverine floodplains, with the flow motion often described as a very long, or tsunami-like wave. These inundations, the resulting potential for loss of life and valuable assets, have been subject to intense research, both experimental and numerical. A recent push in experimentation involving long waves has led to novel methods, to generate and accurately control long waves in laboratories. Work of Goseberg et al. (2012, 2013), Rossetto et al. (2012), and others details some of the advancements made. Many of the methods used to generate long waves still suffer from shortcomings, either from still being inaccurate or difficult to adjust, or more importantly, were only demonstrated in smaller flumes with complex geometry and limited width. However, accurate and arbitrary generation of long waves is important, as wave transformation near-shore necessitates to generate time histories of surface elevation characteristic to specific coastal settings.

This work hence showcases a recent implementation of a pump-driven long wave generation, with novel control strategies, an optimized inlet geometry, and an extra-wide and uniquely long propagation flume with the overall aim to provide the latest insight into experimental long wave generation.

SYSTEM DESIGN AND REALIZATION

The current system design is based off the work of Goseberg (2011) and Goseberg et al. (2013) that used high-capacity pumps with PID-control to generate arbitrary waves, however, the propagation section was a race-track type flume with complex reflection regimes; the pumps were propeller pumps, and the zero-rotation state of these pumps while generating resulted in oversteering of the employed control strategy.

Therefore, the novel system design depicted in Figure 2 consists of four new high-capacity pumps with rotating lobes (rotary-lobe pumps of 500 l/s maximum discharge, Netzsch GmbH, Germany) connected to a recently constructed 80 m long, and 4 m wide propagation section. As rotary lobe pumps allow for a zero discharge while at zero rate of rotation, the overall system response to control action is much improved, allowing to generate arbitrary waves more accurately, but more importantly, with much less adjustment effort as compared to the development system reported in the past. In addition, the inlet and outlet areas have been optimized by employing analytical and numerical modelling, and these optimized diffusors are presented as well.

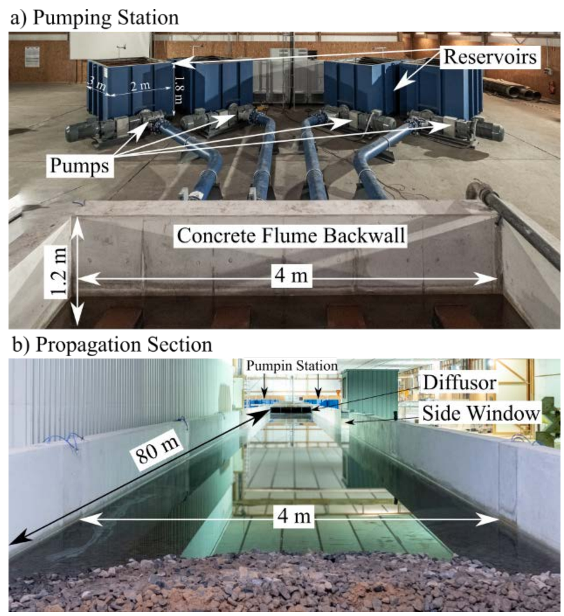

Figure 1. a) Pumping station including four rotary lobe pumps, reservoirs and pipes. b) Concrete flume, view directed towards the pumping station.

PERFORMANCE INDICATORS AND RESULTS

The novel pump-driven generation of long waves and tsunami-like waves is then demonstrated for a set of benchmark waves. Current capabilities and limitations of the implemented method and the facility, particularly with respect to the limit given by the reservoir volume (36 m³ in total), are shown. To that end, the optimization strategy and improvements made along the way are also presented, capitalizing on past knowledge of diffusor design in air ducts. Control design techniques are used for the wave generation. This approach guarantees the stability of the closed loop system and is not employed in depth by coastal engineering groups.

CONCLUSIONS AND FUTURE WORK

This work presents an improved pump-driven long wave generation, building on previous work, but characterized by a number of specific improvements serving the overall purpose to generate accurate, arbitrary long waves that fully resemble prototype observation near-shore as well as during overland flow. Future work will encompass specific research, e.g. 3D effects of tsunami inundation.

REFERENCES

Due to space limitations, references are omitted in this work, but will be provided in detail at a later stage.