An Experience Of Hydraulic Physical Model Study In Malaysia.

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Abstract. Water Resources Section at School of Civil Engineering, Universiti Sains Malaysia have involved more than 20 projects in pump sump physical modeling, 4 projects in hydraulic spillway study and more than 20 projects related to hydraulic physical model. The total cost of overall projects involved is more than 1 million USD. Hydraulic physical modeling has proven to be important and efficient tool in conceptual as well as detailed hydraulic design. Pump sump model provide effective solution to complex hydraulic problems with unmatched reliability. Meanwhile spillway study is often necessary to determine the possible occurrences of hydraulic jumps, splashing over the site walls and undesired flow vortices. This research can be done accurately because the equipment is complete and sophisticated. Problems related to hydraulic physical model can be solved wisely and accurately with aid of accurate design, data collection and data analyses.

1. Introduction

Resources Section of School Civil Engineering in University Science Malaysia had involve many project expertise in physical hydraulic modelling since 1999 until 2015 such as pump sump modelling, and spillway modelling, officially there has over 24 project was awarded. All these physical hydraulic model was developed in Integrated Research Space (Ruang Penyelidikan Bersepadu). Figure 1 show signage of Integrated Research Space (Ruang Penyelidikan Bersepadu). Meanwhile Figure 2 show building of Integrated Research Space (Ruang Penyelidikan Bersepadu). The physical hydraulic modelling activities need a large space for fabrication and specialized apparatus and it compatible with RPS.

![Figure1. Signage of Integrated Research Space (Ruang Penyelidikan Bersepadu) Equipment facilities](image)
2. Equipment facilities

Valeport Velocity Meter (VVM) shown in Figure 3. Used of this tools to measured velocities. For this study VVM used to get mean velocity only. VVM probe measure the velocity by the center of each node. The point of measurement near water intake are very detail compared to entrance part.

The flow measurement shown in Figure 4, is used to flow measure in the tank. Flow was pull through pump model into sectional side circulating pumps send to two calibrated ultrasonic flow meter and control valve to the intake structure modelled. The flow reading before and after was noted and be monitor to avoid fluctuation during sampling process.
The swirl meter or vortimeter show in Figure 5, is tools to calculate the swirl angle or angle of flow with due to the pump axis. While a swirl angle is a flow parameter to determine either the amount of swirl existing in the intake is acceptable for operation. The swirl angle measured in the pump sump model will be compared to the standard which is ± 5° [1].

![Figure 5. Swirl meter.](image)

The dye is in Figure 6 shows dosed into water surface, intake floor, intake wall intake entrance and under the bell mouth so that visualization of the flow distribution can be made. Vortices attached to fixed boundaries below the surface are difficult to detect and may require a careful search with the dye tracer technique [2].

![Figure 6. Dye tracer technique for observation approach.](image)

Miniature Current Meter shows in Figure 7. These system is highly sensitive to LOW velocities 5.0 cm/s up to 150 cm/s. The probe is accurate reading (± 2.5% comprised of an acoustic sensor with a high reading above 0.5 m/s, ± precision instrument that can be relied upon to give accurate reading ± 2% of true velocity.
A flow meter shown in Figure 8 is a tool used to measure linear and nonlinear, mass or volumetric flow rate of a liquid.

3. Physical Hydraulic Model

A physical model is to predict physical phenomenon behavior. The model can be trusted as a reliable if the design contains correct principles, although sophisticated measurement methods only to increase the accuracy of wrong interpretation [3]. The physical hydraulic model is indispensable because it has the ability to do something again in exactly the same way for many complicated flow situations and very useful when dealing with expensive and complex hydraulic works [4]. The main purpose of physical hydraulic is to optimize the design, maximize the operation with safety consideration aspects. Visualization from hydraulic physical model gives true information for researcher to make right and better decisions in designing [5]. The physical hydraulic represented in a scale and still reliable method to evaluate the designs of hydraulics structures where the hydraulic flow cannot immediately be computed mathematically in turbulent [6]. A scale model enable modification and remedial tasks to be quickly and urgently investigated. Combination between stimulation model and scaled down physical models with certain ratio are used to validate hydraulic structures design.
3.1. Pump Sum Model
Generally water pumps is very important in operational irrigation drainage, agricultural, storage plant and industry plant. However the pump always breakdown thus the rational to design of pump-sump was developed. The main problem for pump are surface and subsurface vortex. There was no initial method to predict these problem especially pre-rotation, uncontinuous distribution of flow and cavitation. Free surface vortices may pull air from surface into the pump and cause impeller unbalance loading and repeated vibration. All this disturbing will decrease pump capacity and capability [7]. Meanwhile subsurface vortex formation occur by little in submergence, but more in sump configuration, allocation pump in the sump, upstream situation, and channel with velocity, Subsurface vortices can be monitor using model test. Subsurface vortices which may produce coming from floor, site or back walls get into the pump and cause vibration and cavitation. The computational fluid dynamics (CFD) can be apply to predict the flow characteristics in physical model of pump sump [8].The pump sump modelling for flood mitigation before design improvement show in Figure 9a, while Figure 9b shows improvement had been taken by redesign and problem had been solve.

![Figure 9](image)

Figure 9. (a)Pump sump modelling for flood mitigation purpose before modification and (b) Pump sump modelling for flood mitigation purpose after modification and redesign

3.2. Spillway Dam
Dam is important public structure with multifunction such as water storage, flood control and power electricity supply [9]. Dam was construct with many part, among the other spillway is the most important structure in term of safety. Spillway is a structure control release flow from dam or bypass flow during high water level in dam. Design guideline use for spillway dam is refer to USBR [10]. The gravitational forces are dominant (most important) in free water surface work so the Froude Number must be made equal to the prototype [11]. Model similitude for this study 1:20, length 1:20, velocity 1:4.47 and flow 1:1788. The construction of physical model of spillway done base on down scale 1:20 from large scale. Perspex and pvc as material to construct because has ability to scale proportionally. Physical Model of spillway consist of inlet portion from the reservoir, the labyrinth weir, the chute, the spillway approach channel the stilling basin and a portion of downstream channel.

4. Conclusion
Both stimulation model and physical modelling are interrelated on each other advantages, thus, are recommended to be used together compare to separately. Combination stimulation model and physical hydraulic model, is the best solution of hydraulic designing. Experience being involve in to physical hydraulic project will increase the understanding precision of hydraulic phenomena and many problem can be solve realistically and economically.
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