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Experimental Modeling of Dam Break Flood Wave Depth Propagation on A Fixed Bed

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Abstract-Generally, countries are considered to be developed based on their advanced technological infrastructure. One of the necessary infrastructure requirements for any a developed country is the construction of dams to generate power and providing water for irrigation purposes. Despite their necessity, however they pose a great risk to both human lives and infrastructure present in their vicinity. If a dam collapsed in an area close to human population, it could cause great havoc and economical loss. To diminish these hazards, there is a need to study different modes of dam failures and their subsequent effects downstream of the dam collapse. Numerical models are being made to simulate breaching of dams and effects downstream which requires field or laboratory data. The purpose of this study is to collect data by observing the effects of a water wave moving on a non-erodible channel bed with downstream side gate open i.e. without presenting any obstruction to the flow. It is observed that with the passage of time, flood wave height as well as velocity reduced. It was also observed that the maximum height of water wave was attained during interval of 1 to 4 seconds, whereas time taken for the wave to completely dissipate is 43 seconds.

Keywords-Dams, Downstream Open, Flood Wave; Height, Model, Velocity

I. INTRODUCTION

Dams are defined as barriers that obstruct, restrict or stop the flow of water. Consequently, small dams play significant role in country's economic development because it helps in developing recreational activities, production of crops and electricity and may more [i]. Despite the benefits that dams provide to society they are also considered harmful due to the risk they pose to the infrastructure as well as the human population located in the vicinity of the dam. The damages occur due to waves that flood the downstream area. These waves are of great magnitude in both height and velocity and progress on the downstream side with great force causing destructions and flooding of the nearby areas. A flood is defined as a rising and overflowing of a body of water especially onto normally dry land [i]. Dam break may occur due to various reasons such as heavy rainfalls or structural damages etc. Thus, analysis of potential failure and its effect on the proximate regions needs to be carried out for all Dams [ii]. Analysis of dam break has been carried out vastly for different types of dams, most of the time the studies focused on time taken for breaching of dams and different forms of breaches that occurred [iii][iv][v][ii][vi]. While a few cases are experiments carried out on large scale models studying effects downstream of a dam [vii].

Effect of waves, generating from dam break, have been studied for the condition of non-erodible beds. [viii][ix], while most studies have focused on dam breaching and different modes and shapes of breaches, less focus has been given to the effect of the waves generated as a result of these dam breaks. These days numerical models and soft wares are being used for forecasting, however these models are also developed from real life dam break phenomena. Since it is difficult to obtain the data in real time (when the event is occurring) such as: discharge, water level, velocity etc., Physical models are prepared with pre-determined conditions in order to imitate the real time events and is controlled by standardized instruments and similitude analysis [x]. A study was carried out for developing a numerical model with the help of comparison of results of a scaled down model [xi]. In another case the numerical model accuracy was checked with the help of scenarios already carried out in the laboratory and whose results were recorded for different conditions. The results of these experimental tests were used for comparison purposes [xii]. Some studies presented comparison numerical model results to check the performance accuracy of these models and the underlying equations. [xiii].

Number of researchers have worked on experimental and numerical modeling of downstream wave propagation due to dam break some of these studies include [xiv, xv, xvi, xvii, xviii].

This paper focuses on simulating dam break conditions to collect data which may be required for numerical simulations in further studies. In this study, the depth variation of a wave generated on non-erodible bed is measured. In this case full dam break was simulated which make this study unique as compared to studies presented in literature.

II. Experimental Setup and Instruments

The experiments were carried out in the open channel located in hydraulic laboratory of Civil Engineering Department of University of Engineering & Technology Peshawar having dimensions of length of 4.52 m, height of 0.762 m, width of 0.3048 m and a slope of 0.002 as shown in Fig. 1 below. It is composed of a glass and steel body with one gate at the U/S and other on D/Sof the channel which are operated manually. Opening mechanism consisting of wheels being mounted in the vertical sides of the gates that move up and down within fixed side guides to reduce the frictional resistance during their movement shown in Fig. 2. At the U/S side of channel, there is a tank which can store water and is supplied to the channel during experiment. and is considered as the dam reservoir for the series of experiments.

Fig. 1. Open Flow Channel with reservoir.

Fig. 2. D/S gate opening/ closing wheel mechanism

A standard scale in SI Units was marked on channel and used to measure the height of the wave at different sections of the channel which were taken at 0.127m interval for uniformity and consistency as shown in Fig. 3. The experimental tests were carried out when the D/S gate was open so as to provide no obstacle to the propagating wave in case of dam break.

Fig. 3. Standard scale placed on the channel side

III. Experimental Procedure for Dam Break

The process consisted of filling the reservoir with water through an electric motor from underground water tank. The reservoir was filled to a height of 0.9144m, the schematic diagram of which can be seen in Fig. 4 below, and the steel gate was closed to imitate a reservoir and dam model. The gate was then opened manually by wheel opening/closing mechanism to simulate dam break and a strong flood wave propagated towards the downstream channel. The data in the form of water wave height was collected by means of a standard metric scale placed along the length of the channel at 0.127m intervals for each experiment. Similarly, the other two coordinates i.e. Y axis along the channel width and Z axis along flood wave height were also measured. The readings along Y axis were taken using point gage installed over the channel sides as shown in Fig. 5.

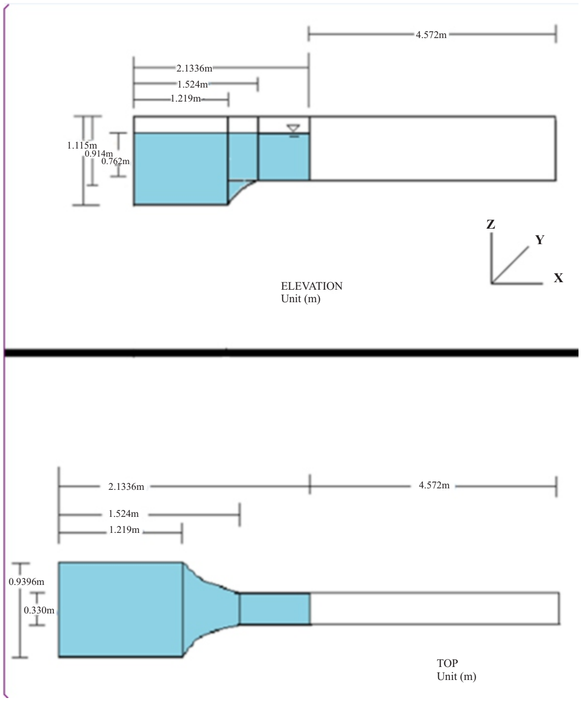

Fig. 4. Schematic diagram of channel and water tank showing different dimensions along X and Y axes.

The ruler was provided and used at 35different sections to measure the height. At every section, the water wave height was measured by mimicking the same controlled version of dam break to guarantee consistency and diminish mistakes in the data gathering.

The sections were marked at an equal interval of 0.127 m intervals along the length (X) of the channel and at an equal interval of 0.1524m along the width (Y) of the channel. Fig. 5 defines the directions of axes.

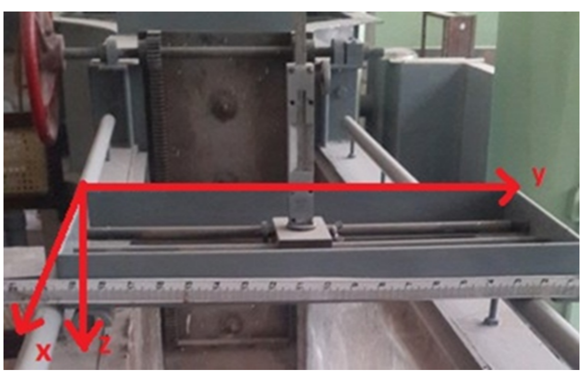

Fig. 5. Different axes indication with respect to the channel

The measurements were recorded continuously as long as the wave propagation continued which was a period of 43 seconds. The data taken at each cross section was then plotted in graphical form to observe height variation with respect to distance. Summary of data obtained is shown in Table I below.

TABLE I
DETAILS OF HEIGHT VARIATION OF FLOOD WAVE

For D/s Gate Open						
X(m)	1.01	1.27	1.65	2.79	3.55	4.44
Max. H (m)	0.38	0.35	0.317	0.247	0.267	0.254
T(sec)	1.00	2	3	3	4	5

IV. RESULTS AND DISCUSSION

Number of experiments were carried out to find the height variation with time. The maximum height obtained at different selected points and corresponding time intervals is shown in Table 1above. The maximum height attained by the water wave occurred within1 to 4 seconds of the dam break initiation. The same variation is shown graphically in Fig. 6. It shows that the experimental readings are in accordance with the general trends observed i.e. height decreases as the wave travels further downstream. Although the results in this study shows almost the same pattern as is present in literature but the experimental analysis in this study was carried out for entirely different condition. In literature most of the research is based on partial dam break while here in this study we use full dam break and that is the contrition in this study. Secondly, although the pattern of wave height diminishing as it moves downstream is same as previous studies but the height of generated wave is much higher as compared to the partial dam break presented in previous studies.

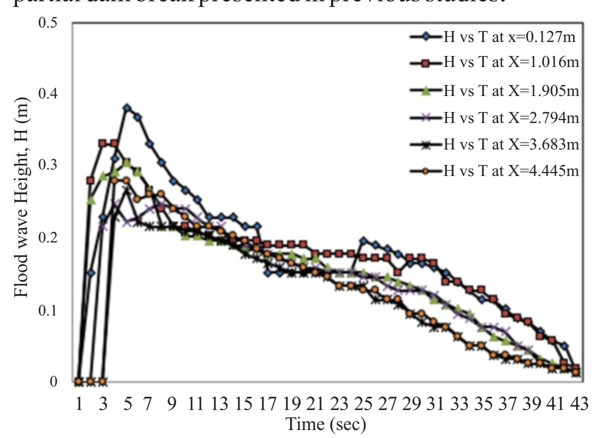

Fig. 6. Flood wave depth variation with time at different selected sections.

V. CONCLUSIONS

This study is carried out to study the height variation of wave generated due to dam break with time. The figures above show that the results obtained in this study adhere to the generally observed phenomena that the height of the flood wave reduces as the wave propagated away from the dam even if there was full dam breaching. So, it can easily be concluded that partial or full dam break will not change the pattern of wave height generated downstream of the dam with time however the magnitude of wave height will be greater for full breaching as compared to the partial breaching. The results also showed that the maximum height was 0.381m that occur at the very first section after the dam after 1 seconds verifying that the maximum height occur just after the dam break point and very rapidly. So, from this study it can be concluded that the areas near to the dam break are more flood prone areas and will be affected immediately after the dam break.

The findings of this study will benefit the society in the sense that the people can be warned not to construct their houses near to the dam site due to its vulnerability in case of dam break. Secondly, the flood warning authorities can inform the people living further downstream of the dam to evacuate the area within specified time. Similarly, the extent of flood affected areas can be defined in advance for dam break condition.

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