Abstract - The estimated area exposed to flood disaster in Malaysia is estimated around 29,000 km² or 9% of the entire country, affecting approximately 15% of the total population. The purpose of this study is to develop a physical model under tidal influence for Selangor River and to assess the floodplain and water level for various flow conditions with and without tidal influence. The model was developed utilising a non distorted scale of 1:100. The test was carried out for various flow with (i) fixed low water, (ii) mean sea and (iii) high water, with and without tidal influence for all cases. The results showed that the water level increases as the flow increases and causes the flood. Flooding does not occur at downstream under all conditions tested.

Keywords – Floodplain, meandering, physical model, river channel, tidal effect.

I. BACKGROUND

Flooding is one of the disasters in this country. The estimated area exposed to flood disaster in Malaysia is estimated around 29,000 km² or 9% of the entire country which affecting 2.7 million people or approximately 15% of the total population of Malaysia (Hiew, 1996).

Flood can be categorized as:
• Flash flood (very high intensity rain at very short period)
• Monsoon flood (prolong rain during monsoon season)
• Coastal flood (Due to High Tide effect)

In facing the flood problem in tidal areas, construction of tidal control gates are commonly being used. In London, Thames Barrier which was built in 1982 is one of the approaches in controlling flood due to spring tide. Whilst in Malaysia, the construction of barrage in some of the rivers such as Sg. Muda, Sg. Kerian and Sg. Besut is to control the effect of high tide. However, it is crucial to have a clear understanding of the overall effect of this type of structure as a solution to flood problems in order to provide the best solution to the problems along the rivers.

Basically flood can occur at any reach of a river due to different factors.

In the upstream area it usually caused by the discharge which exceed bankfull flow and that discharge cannot be sustained by river cross section and river bed. Whereas flood occur in estuary area is caused by the tidal influences. However, at the middle stretch of the open channel the occurrence of flood is more complex to explain because of the combination of both factors.

Presently there are still lack of research on open channel hydraulics which is under the tidal influenced. One of the main reasons to the lack of research in this area is the limited data available such as water level and flow along the river bed. The difficulty to produce rating curve in the tidal influence area also influence the calibration process. Therefore, only one value is normally used in hydraulic analysis, such as highest spring tide which will result in very high water level and is inaccurate.

II. OBJECTIVE

The objective of the study can be describe as follows:
• To develop a physical model under tidal influence for meandering in river channel.
• To assess the floodplain and water level for various flow conditions and tidal influence

III. SCOPE OF THE STUDY

To construct physical model at National Hydraulic Research Institute of Malaysia. This includes choice of materials, physical model scale, evaluating and setting up the instruments.

Gathering the available data of Sungai Selangor for the simulation in the experiment. Running the physical experiment covering flow from low to high without tidal influence under low tide, mean sea level and high tide and flows with tidal effect. Fig. 1 shows the Flowchart of the study process.
IV. METHODOLOGY OF STUDY

The method of research identified are as follows:
• To develop a physical model which have the tides control instruments at the estuary.
• To assess the water level at floodplain which includes open channel and floodplain including tidal area.
• Carry out simulations under flooding and high tides conditions.

A. Data Collection and Analysis of Site Data

Site datas as per Table I are used in the modeling and the development of physical model.

<table>
<thead>
<tr>
<th>Types Of Data</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>River Channel</td>
<td>Cross section, river alignment and hydraulic structure</td>
</tr>
<tr>
<td>Flood Plain</td>
<td>Cross section, infrastructure information and topography</td>
</tr>
<tr>
<td>Hydrology</td>
<td>Flow from the upstream which is not effected by tides</td>
</tr>
<tr>
<td>Water level at the river mouth</td>
<td>Information on changes of water level at river mouth</td>
</tr>
</tbody>
</table>

B. Data Input

Cross sections data and information of structure along the river are available in Drainage & Irrigation Department of Malaysia. The cross section data is the main input to the hydrodynamic model.

C. Physical Modelling

Physical model which was developed covering the tidal influences area. The non distorted scale of 1:100 was used in the physical model after considering the practicality of the size in term of space available, construction cost and time required for the construction. Gravity is the predominant factor influencing fluid motion in free surface flow. Therefore in compliance with the Froude Law, \( F = \frac{V}{\sqrt{gL}} \), the corresponding model conditions are as summarized in Table II.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Dimensions</th>
<th>Scale Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>L</td>
<td>1:x = 1:100</td>
</tr>
<tr>
<td>Time</td>
<td>T</td>
<td>1:x^2 = 1:10</td>
</tr>
<tr>
<td>Velocity</td>
<td>LT^-1</td>
<td>1:x^3 = 1:100000</td>
</tr>
<tr>
<td>Discharge</td>
<td>LT^-1</td>
<td>1:x = 1:100</td>
</tr>
<tr>
<td>Pressure</td>
<td>ML^-1T^-2</td>
<td>1:x = 1:100</td>
</tr>
<tr>
<td>Force</td>
<td>MLT^-2</td>
<td>1:x^2 = 1:10^8</td>
</tr>
<tr>
<td>Energy</td>
<td>ML^2T^-2</td>
<td>1:x^4 = 1:10^8</td>
</tr>
<tr>
<td>Power</td>
<td>ML^3T^-1</td>
<td>1:x^5 = 1:10^7</td>
</tr>
</tbody>
</table>

The overall size of physical model is 10m x 40m and with a scale of 1:100. Fig. 2, 3 and 4 shows schematic diagram and cross section of the model.
TABLE III

MEASUREMENTS AND THEIR RESPECTIVE INSTRUMENTS

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge</td>
<td>V-notch placed at the outlet of the model system</td>
</tr>
<tr>
<td>Water Level</td>
<td>1) Movable point gauges, 2) Adhesive ruler scales, 3) Automatic water level</td>
</tr>
<tr>
<td>Velocity</td>
<td>Small and miniature current meter</td>
</tr>
<tr>
<td>Tidal</td>
<td>Tidal gate controller</td>
</tr>
</tbody>
</table>

E. Discharge Measurements

A $90^\circ$ V-notch sharp overflow weir with a calibrated discharge coefficient, $C_d$, of 0.6 was placed perpendicular to the flow at the outlet of the model system. The head-discharge relationship is derived from (1) (flow through V-notch).

$$Q = \frac{8}{15} C_d \sqrt{2gh} \tan \left( \frac{\theta}{2} \right) h^2$$  \hspace{1cm} (1)

where, $h$ is the flow depth over the weir and $\theta$ is the notch angle.

F. Simulation

Simulation process was carried out and the result of each experiment was recorded. The experiments were done under different scenarios, at different flow rates and tides conditions where the readings were recorded at eight (8) stations in the physical model as shown in the layout plan in Fig. 2 for the static condition. Cases of simulations carried out are shown in Table IV.

TABLE IV

TEST CASES

<table>
<thead>
<tr>
<th>No</th>
<th>Test Case</th>
<th>Tide Conditions</th>
<th>Flow (l/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Case 1</td>
<td>Flow only (without tidal effect downstream)</td>
<td>1, 2, 3</td>
</tr>
<tr>
<td>2</td>
<td>Case 2a</td>
<td>Low tide</td>
<td>1, 2, 3, 4, 5, 6, 7, 8</td>
</tr>
<tr>
<td>3</td>
<td>Case 2b</td>
<td>Mean Sea</td>
<td>1, 2, 3, 4, 5, 6, 7, 8</td>
</tr>
<tr>
<td>4</td>
<td>Case 2c</td>
<td>High tide</td>
<td>1, 2, 3, 4, 5, 6, 7, 8</td>
</tr>
</tbody>
</table>

V. RESULTS

The experiment were carried out for various scenarios as describe above. The data of water level and velocity for each experiment were recorded at eight (8) identified stations with eight different values of flows with the exception for case 1. At each location three (3) readings were taken for velocity i.e at the middle and two sides of the channel and one (1) reading for water level i.e at the middle of the channel. Flow and velocity were taken for three (3) different water levels (fixed) at the downstream i.e low water, mean sea and high water. For the tidal effect one (1) reading for water level and velocity were taken. These levels are based on the tide data taken at the refered locations. Outcome of the analysis obtain from physical modeling were analyse.

A. Test Cases

Total of 4 test case were carried out in the experiment and the discussion and analysis of the cases are as stated in Table V below.

TABLE V

TYPE OF ANALYSIS

<table>
<thead>
<tr>
<th>Analysis No</th>
<th>Test Case</th>
<th>Analysis Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Case 2a, 2b &amp; 2c</td>
<td>Graph of Water Level vs Distance</td>
</tr>
<tr>
<td>2</td>
<td>Case 2a, 2b &amp; 2c</td>
<td>Graph of Velocity vs Flow (8 stations)</td>
</tr>
<tr>
<td>3</td>
<td>Case 2a, 2b &amp; 2c</td>
<td>Graph of Water Level vs Flow (8 stations)</td>
</tr>
<tr>
<td>4</td>
<td>Case 2b</td>
<td>Illustrated Flood Prone</td>
</tr>
</tbody>
</table>

VI. ANALYSIS

The results of the above test cases were analysed and below are the discussions of the selected cases.

From the graph plotted, refer to Fig. 5(a) to Fig. 5(h), it shows that the water level increases as the flow increases for mean sea level condition.

http://dx.doi.org/10.15242/IIE.E0214013
Fig. 5 Plot of longitudinal section

Fig. 6(a) to Fig. 6(d) shows the extend of flooded area, for the original layout the experiment shows the water start to overflow the bank when flow is 2 l/s and flooded when flow is 3 l/s and worsen when the flow increases.

(a) Flow = 2 l/s

(b) Flow = 3 l/s

(c) Flow = 4 l/s

(d) Flow = 5 l/s

Fig. 6 Flood Plain - observed flooded area for mean sea level

Fig. 7 Plot of water level and velocity vs flow for mean sea level

VII. CONCLUSION

After performing a few experiment and study on the physical model at National Hydraulic Research Institute of Malaysia (NAHRIM) and analyzing all the data, several conclusions have been made from the study results.

The analysis shows that the water level in the channel increases as the flow increases. The water level were contain in the river channel during low flow but overflow the bank at 3 l/s. The records of water level in the channel is higher as the tide increases from low water to mean sea and highest at the high water.

At the riverouth it is observed that the water level is contained within the river bank and does not overflow into the flood plain at all time. This shows that the flood does not normally occur within the estuary areas.

The experiment shown that the objective of the study was successfully achieved however further improvement can be done such as to develop a distorted model.

RECOMMENDATIONS

It is recommended that further experiment shall be carried out to study the different cases such as introducing cut off at different river sections, introducing more than one cut off and creating bunds along certain stretches of river banks.

ACKNOWLEDGMENT

For the accomplishment of this project, I would like to extend the special and greatest gratitude to Prof. Dr. Norhan
Abd Rahman of Faculty of Civil Engineering, Universiti Teknologi Malaysia and Hj Abdul Jalil Hassan of Wallingford Software Sdn Bhd, for their enthusiastic effort and concern. With their invaluable advice, guidance and encouragement, I was able to complete this project.

I also gratefully acknowledge the support and understanding given by Director General of NAHRIM in allowing the usage of the facilities and space in NAHRIM Hydraulic and Instrumentation Laboratory and my colleagues in NAHRIM for their cooperation and hard working to ensure the success of the experiments and the data collections. Special thanks to Mr. Mohd Kamarul Huda, Mr. Arshad Othman, Mr. Irwan Mohd Nor, Mr. Ghazali Abdul Rahman, Mr. Sezali Baharudin, Mr. Fardzir Johari, Mr. Arif Mohd Nor, Mr. Hairy Ijun, Mr. Hasmizamzurin, Mohd Syafawi bin Mat Ail, Pn. Suriani Othman and Hafizun Othman and to everyone that not mentioned here who were ever willing to give their hand when ever I needed them.

REFERENCES


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