Physical Model Studies of a Bridge across River Hindon: A Review
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Abstract:
The hydrological model is prepared to predict the most possible effects on the channel. Effect such as change in river bed, morphology topology. There are two types of models physical model and mathematical model. These models are used to know the highest flood level, to get idea about the flood prone areas. This study is carried to fix the safe deck level, afflux, waterway and scouring effect after construction of RRTS bridge. It is observed by studying various researches that physical model gives compatible results with actual site conditions. By using actual site data which is converted into a suitable scale & physical model is prepared. If the model is prepared without changing actual site data it will give the correct readings.

Keywords: Morphology, safe deck level, flood level, waterway, scour, afflux etc.

1. INTRODUCTION
River Hindon, a tributary of river Yamuna, is entirely reined with a catchment area of 7038 sq.km. It flows between Ganga and Yamuna for 400km through Muzaffar Nagar, Ghaziabad and Noida before joining river Yamuna just outside Delhi. A river composed of main course and the tributaries which brings substantial contents in the form of dissolved particles and minute separate particles from both natural and anthropogenic sources. Flood constitutes one of the critical problems and the problem is gigantic and becomes more complicated with the passage of time[4]. The flood in 1998 sever flood is the highest record. The value of travel time of flood wave from base station to forecasting station according to historical method is 2 days[4]. The flood forecasting equation for Goalundo Transi station is \( Y = 1.283X - 8.351 \) in this paper. Unfortunately, river play major role in transportation and accommodation of industrial waste water and runoff from agricultural lands and most of times serves as a place for disposal of sewage[2]. In this paper Physical model study is carried out on Hindon river model covering a reach from 8km upstream to 2km downstream of bridge connecting Dilshad Garden to New bus adda in Ghaziabad. This study is carried out for construction of RRTS bridge for Northern Railway. In this regard National Capital Region Transport Corporation(NCRTC) has approached Central Water And Power Research Station(CWPRS), Pune for the conduct of Physical model studies to assess the hydraulic parameters of proposed bridge. NCRTC is a government of India enterprise body and this body is responsible for construction of railway bridges in northern areas for facilitating fast and rapid transport of railway corridors. The NOIDA, part of NCT has proposed to road bridges across river Yamuna, one connecting Ghaziabad-Noida-Faridabad passing through sectors 167A-168 and another one passing through sectors 149A-150 to improve the traffic movement from Noida, UP to Haryana[1]. The functional plan on transport for NCR-2032 recommended connecting Delhi with various nodal towns in NCR through 8 Region Rapid Transit System Corridors. It has 8 corridors out of which 3 corridors are passing through Delhi-Ghaziabad-Meerut RRTS. Regional Rapid Transit System (RRTS) being a high-speed, high capacity rail based commuter Transit System. It will drastically reduce the travel time between various nodes of NCR served by it. Such transport solution will support the goal of sustainable economic and social development of the region, with protection of environment. This paper discusses the details of the model studies for proposed bridge across river Hindon connecting Delhi-Ghaziabad-Meerut RRTS corridor which is being taken up for implementation by NCRTC.

Figure 1. Auto-Cad drawing of proposed RRTS bridge
2. LITERATURE STUDY

2.1 Studies for locating a road bridge on river Yamuna in Meandering reach at New Delhi – A case Study. (S.S.Kerimani, Jotsana Ambekar, S.P.Hedao, R.G.Patil)

In this paper the author state that, they have taken three different discharge conditions 7,022m³/s (which was recorded as maximum discharge in 1988 at Wazirabad Barrage), 9,910m³/s (design discharge considered for ISBT bridge and bridge proposed subsequently on Yamuna), 12,750m³/s (check flood for substructures, foundation and protection works suggested by central water commission) for the construction of a bridge across Yamuna. For model preparation and their methodology and also to study maximum water level, velocity and discharge intensity under existing condition with straight guide bund we have referred this paper.

2.2 Hydraulic modelling of river flow-data collection and problem solving (Ronny Verhoeven, Robert Banasiak, Jaroslaw Chormanski)

In this paper the study of discrepancy between theoretical solution of the Saint-Venant equations for flood routing calculations and the problems caused during practical implementation is often quite big. The equations used for steady and unsteady flow simulation, topographical and hydraulic collection of data, longitudinal profile and friction coefficient, etc. are referred from this paper.

2.3 Hydraulic model of river flow and storage effects in the Mackenzie Delta, Canada (Jenuifer Nafziger, Faye Hicks, Rohyn Andrishak, Philip Marsh)

This paper reports on the application of hydrodynamic model and development of the same model of river flows and off-channel storage effects on the Mackenzie Delta, Canada.

To estimate reduced or increased ice jamming, how water levels through the delta changes with respect to change in river flows, increasing sea-level, various river flow and storage effects, etc are studied from this paper.

2.4 Hydraulic model studies for channelization of river Kosi for a reach model Chatra to Kosi barrage using Hockey stick shape spur(Sanjay A. Burele, Nayan Sharma, Z. Ahmad, I.D.Gupta)

This paper reports on the Channelization of stream to make it more suitable for navigation and to restrict the water to a certain width to reclaim lands for other various important purposes. Physical model studies are also conducted in this paper to investigate the various options for channelizing the stretch of river Kosi from Chatra to Kosi barrage, analysis of mathematical model results for various waterways are presented in this paper.

To study various model construction activity, design discharge, flow pattern studies, channelization studies (with construction), etc. this paper is referred.

3. MODEL STUDIES:

By study of above literature research paper we found model setup procedure. By referring paper[1]The model studies were carried out for the three different discharge conditions on model of river Yamuna. The existing mobile bed model of river hindon at New Delhi Ghaziabad constructed to a horizontal scale(Lr) of 1:125 and Vertical Scale (Dr) of 1:30, covering a river reach of 8km upstream and 2km downstream from Dilshad Garden to New Bus adda in Ghaziabad. The model reach including deep channels, shoals, spill portion and various existing bridge structure, etc[1].

The survey data is given by NCRTC to CWPRS to reproduce proper bed movement and roughness, the model bed is laid with sand having mean diameter(D50)of 0.34mm. The model discharge is measured using standing wave flume provided at the upstream inlet and is also verified at downstream of model. And it is done by using rectangular weir. Checking of flood for substructures, foundation and protection works suggested by the Central Water Commission. To achieve proper many options of guide bund geometries were studied on the model for proper distribution of flow over entire width of water way. Water levels observed on the model at various gauge locations with the prototype values. Hydraulic design of bridge would be done based on experiment results.

3.1 STUDY AREA

River Hindon, a tributary of river Yamuna, is entirely rain fed with a catchment area of 7083 km. It flows between Ganges and Yamuna for 400 km through Muzaffar Nagar, Ghaziabad and Noida before joining river Yamuna just outside Delhi. The width of a river 20 m to 160 m covering a river reach from 8 km upstream and 2 km downstream. That much reach was provided and of which 8 km and 2 km was used and the other area does not affect the study so the 8 km upstream and 2 km downstream was utilized for model studies keeping view on site limitations.

3.2 STUDIES UNDER EXISTING CONDITIONS

Studies were initially carried out for the existing conditions of river without reproducing the RRTS Viaduct Bridge. The alignment of the RRTS Bridge was identified and marked on the model for reference purposes as per the drawing figures 4 experiments were carried out for four river discharges. Independently after stabilizing the model bed by maintain the established tail water level immediately upstream of Hindon barrage, velocity, depth of flow with river discharges of Were measured at various locations, show the flow pattern near RRTS bridge at river discharges of respectively.

The flow conditions under existing conditions observed on the model indicate that the approach flow is concentrates on the left bank / left embankment/guide bund and is subjected to high velocity flow, The embankment guide bund toe near point A and portion of right guide bund under the bridges is under attack by the flow. Maximum water level, velocity and discharge intensity under existing condition with straight guide bund and elliptical guide bund at bridge axis shown in below Table No1.
Table 1. Maximum water level, velocity and discharge intensity under existing condition with straight guide bunds.

(S.S.Kerimani 2019)

<table>
<thead>
<tr>
<th>Discharge</th>
<th>Existing Condition</th>
<th>With Bridge in position with straight guide bunds</th>
<th>Afflux</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>At bridge axis</td>
<td>At bridge axis</td>
</tr>
<tr>
<td></td>
<td>WL (m)</td>
<td>Max. Vel. (m/s)</td>
<td>Max. discharge intensity</td>
</tr>
<tr>
<td>7022</td>
<td>198.40</td>
<td>2.44</td>
<td>13.60</td>
</tr>
<tr>
<td>9910</td>
<td>199.36</td>
<td>2.78</td>
<td>19.88</td>
</tr>
<tr>
<td>12750</td>
<td>200.38</td>
<td>2.56</td>
<td>17.22</td>
</tr>
</tbody>
</table>

Figure 2. Plan and sectional elevation of proposed bridge.

Photo 1. Flow pattern in the vicinity of proposed bridge site under existing condition (Q=7.022 m/s).
Photo 2. Flow pattern in the vicinity of proposed bridge site under existing condition (Q=12.75 m/s).

3.3. STUDIES WITH RRTS BRIDGE IN POSITION.

The RRTS Bridge was reproduced on the model as per the layout and supplied by the project authority. Shows the model setup with RRTS Viaduct Bridge in position. Experiments were carried out for four discharges. In each case after stabilizing the model bed by maintaining the established tail water level immediately upstream of Hindon Barrage. Water levels were observed in the model at various locations by using gauges located upstream and downstream of the RRTS bridge. Maximum velocities, discharge intensities without and with RRTS bridge along with the afflux at the bridge are analyzed.

4. PROVING STUDY

The RRTS authorities have submitted a technical report of model studies conducted for the road bridge about 8km upstream of the present bridge, the authorities have clearly indicated during the discussions that the observed gauge discharge data is not available. Hence, CWPRS was asked to adopt the water level Vs discharge variations given in the technical memorandum number 85RR(H2-02) titled “Hydraulic model study for road bridge over Hindon river at Ghaziabad by IRI, Roorkee. The data has been reproduced and observed water levels in the model for the given discharges at 700m and 2100m.
downstream of the said bridge is presented for comparison. It has been seen that by maintaining the water level at 2100 m downstream of the said bridge for given discharge, the water level observed on the model is consistently matching. Hence, the model is considered to be proved in such cases. While experiments were conducted for the proving studies, a gauge is established immediately upstream of Hindon Barrage. The readings of this gauge were established for maintaining the tail water levels later for conducting model studies without and with the proposed bridge.

<table>
<thead>
<tr>
<th>Discharges(Q)</th>
<th>Control gauge to be maintained for resoective(Q) at 2100m chainage D/s of Loni Bridge</th>
<th>Observed gauge reading at 700m D/s of Loni Bypass bridge (cm)</th>
<th>Observed gauge reading at Hindon Barrage U/s of divide wall (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>920 cumecc(1.58cusec in model)</td>
<td>204.65</td>
<td>33.6</td>
<td>38.7</td>
</tr>
<tr>
<td>1840 cumecc (3.165 cusec in model)</td>
<td>205.25</td>
<td>32</td>
<td>39</td>
</tr>
<tr>
<td>2760 cumecc (4.75 cusec in model)</td>
<td>205.75</td>
<td>28</td>
<td>37.4</td>
</tr>
<tr>
<td>3681.20 cumecc (5.33 cusec in model)</td>
<td>206.30</td>
<td>28</td>
<td>37.4</td>
</tr>
</tbody>
</table>

5. GENERAL METHODOLOGY

By study of above literature papers we found general methodology for Physical model studies as below:
I. Laying of model as per data available.
II. Use of discharge scale.
III. Alignment marking of model.
IV. Use of surveying methods and marking river boundaries.
V. Use of tin sheets for marking river profile.
VI. Conducting model studies by taking various discharges.

5.1. METHODOLOGY FOR MODEL SETUP

I. Survey: As per available topo or cross-section data of river Hindon at CWPRS, we analyzed the data. In this river plan, proposed bridge details and other existing structural details are studied and reproduced.

II. Scale: Considering the site condition and using help of Auto-Cad based on the horizontal and vertical scale other hydraulic scales are need to be derived using dimensional analysis and model analysis techniques.

MODEL SCALE:

Horizontal scale:- 1:125
Vertical scale :-1:30

As there is large variation in a horizontal and longitudinal basin so there is need of selecting different scale based on the variation

Discharge scale \( \propto Lr \times Dr \times \sqrt{Dr} \)

Velocity scale \( \propto Vr = \sqrt{Dr} \)

I. Bed Filling To remove the unwanted undulations over the ground with help of filling and cutting of land profile:
Excavation, laying concrete, murum, khaswa sand filling and river boundaries are marked.

The land profile is marked with the help of the Dumy level instrument and through the study the land filling and land cutting area is decided. The land is filled with a stones and gravels

II. Levelling:- levelling is a branch of surveying , the object of which is to establish or verify or measure geodetic height, and in construction to measure height differences of construction art facts, Instrument used like theodolite, levelling staff, River bed profile is marked by surface dressing to maintain given cross-section.

5.2.MODEL SETUP PREPARATION

I. Control gauge stations are marked as per actual site location.
II. Observation gauge stands are fixed near vicinity of proposed bridge.
III. Flow in the model is simulated with various discharge conditions.
IV. All discharges are then maintained at standing wave flume with its corresponding head marking marked on flume.
V. Various hydraulic observations are taken.
VI. Out comings are analyzed and studied in graphical and statistical way.
VII. Hydraulic design of bridge would be done based on experimental results.

6.CONCLUSION

Based on the model studies carried out for various river discharges at CWPRS, using post flood survey data various recommendations will be made for hydraulic design of bridge for suitable orientation of bridge required for free and smooth condition. The hydraulic model studies would be conducted to assess the rail bridge location, waterway and alignment. Water levels, afflux and velocity would be measured from the model for given discharges. Model will include given spill area along the stretch with details which affect the flow conditions in the river. Any other observations during the course of studies would
be reported and any other suggestions would be given if necessary.

7. REFERENCES


