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Box Type Minor Bridge on Small Rivers in Alluvial Region

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Abstract

Since time immemorial, humankind has been using various techniques to cross the rivers, streams or any depression without closing or obstructing the original flow through a structure called bridge. With the span of time and advancements in civil engineering, several types of bridges have come into existence like wooden, steel, masonry arches, RCC and pre stressed concrete bridges. Indian Roads Congress categorizes three types of the bridges on the basis of length i.e. culverts up to 6.0 m, minor bridges above 6.0 m to maximum 60.0 m length and major bridges above 60.0 m. In present scenario, minor bridges over small rivers has become necessary for development and prosperity of nation as most of the roads have to cross small rivers at several places to connect remotest corner of the country.

Bridges, though a manmade structure, over a period become an important part of environment because in most of the cases water flowing below is used for drinking, irrigation and underground recharging. The alluvial region of India spread from Punjab to West Bengal has a peculiar nature because soil is almost soft in nature consisting of mainly sand, clay and silt which is fertile for vegetation. Water retention and its movement condition are high throughout the year. Several type of water bodies which exists in this type of region are pond, small drain, small and medium rivers which drains into the big rivers like Ganga, Yamuna, Ghaghara, Gomati and Sai etc.

Since long time, road system on the earthen track and pucca has been introduced for traffic like chart, chariot and motorized vehicle. There were little number of bridges over major rivers i.e. bridge alone to cross over the river Ganga except in few places like Allahabad, Kanpur and Varanasi and over the Ghaghra Algine bridge, Maghighat, Bhatni. Some bridges were constructed over small and medium rivers in medevial period by local rulers and businesspersons, which have now become obsolete. It is found that most of the bridges are of masonry arches wooden and trusses having insufficient water and carriageway.

After independence, the road network system has been improved to meet out socio economic needs of people. The new bridges have been constructed with standard road width and sufficient waterway. Study has been conducted for existing new constructed bridge system over small river and alluvial region of Uttar Pradesh to set guidance for future course of action in replacing and providing new bridges to optimize the needs of the people.

Bridge system being provided over small & minor rivers for the road network for new and replacement of older bridge at different site is varying from place to place. For this purpose, study has been conducted for sustainable option of minor bridges over small rivers discharge up to 300 m^3/s. It is found that the box type minor bridges are best option on small & minor rivers.

Introduction and brief Topographical features

The field study of the bridge system of river Reth has been conducted and mentioned in paper-1 et-al Varma Rakesh and Srivastava Rajendra Kumar Published in International Conference held in Ram Swaroop Memorial University Review of existing bridge system in small rivers in alluvial region of Uttar Pradesh in 2019. In this paper authors pointed out the type of bridge system provided over river Reth having about 75 km stretch in district Barabanki U.P. falling under critical alluvial region. Considering study of this system it is found that 10 numbers of the bridges are provided as under. The maximum discharge of the river from 106 m^3/s.

Table 1: Bridge location and Type

Sr. No.	Chainage(in Km.)	Type of Bridges	Connecting Villages
1	2.85	Well foundation	Barkernagar, Parimathpur
2	6.1	Well foundation	Gyannagar, Diyantnagar
3	13.64	Well foundation	Sarifabad, Attyarpur
4	22.2	Well foundation	Bergadha, Saheria
5	35.45	Well foundation	Munaira
6	42.5	Well foundation	Wadinagar, Saheliya(Darapur),
7	48.0	Well foundation	Lucknow-Barabanki road (Old)
8	56.870	Well foundation	Dunpurwa Banki road, Chillhata, Punaurapur
9	63.050	Well foundation	Kaithisaraiyya, Dewa road
10	71.950	Open foundation	Garhi, Chhindvahi

It is observed that most of the bridges in the river are having bridge system over well foundation which is seems to be uneconomical and time taking affair in construction. This type of the system requires heavy machines etc. A comparative study has done and found the box type minor bridges are economical and easy in construction.

Comparative Study

For the comparative study, the bridge on well foundation design data of 3×14.5 m is given below-

Design Data

1. Design discharge (Q) = 300.0 m^3/sec
2. Highest flood level (H.F.L.) = 104.1 m
3. Lowest Water level (L.W.L.) = 100.00 m
4. Span arrangement = 3 × 14.5 m c/c of bearing
5. Length of bridge = (14.5 + 0.55) × 3 = 45.15 m
6. Road way = 7.5 m
7. Wearing coat = 0.075 m
8. Material used Concrete M-20 in plugs M-40 in kerbs and crash barrier M-30 in rest and steel Fe-500
9. Designed Loading = 2 Lane class A or single lane 70R
10. Formation Level = 108.209 m
11. Outer dia of well = 6.0 m
12. Inner dia of well = 3.8 m
13. Silt factor = 1
14. Submerged unit weight of soil (γ_{sub}) = 10 kN/m^3
15. (S.B.C.) at bottom of well foundation = 620 kN/m^2
16. Soil properties below well cap,
(a) Cohesive force (C)= 0,
(b) Internal angle of friction(Ø) = 30°

17. Clear water way = 3 × 14.5 −2.0 × 2.0 − 2.0 ×1.2 = 37.1 m
18. Lacy's water way = 4.8 = 83.15 m
19. Restriction = 100 –
(37.1/83.15)*100 = 53.38%

20. Design discharge = 300.0 m^3/sec

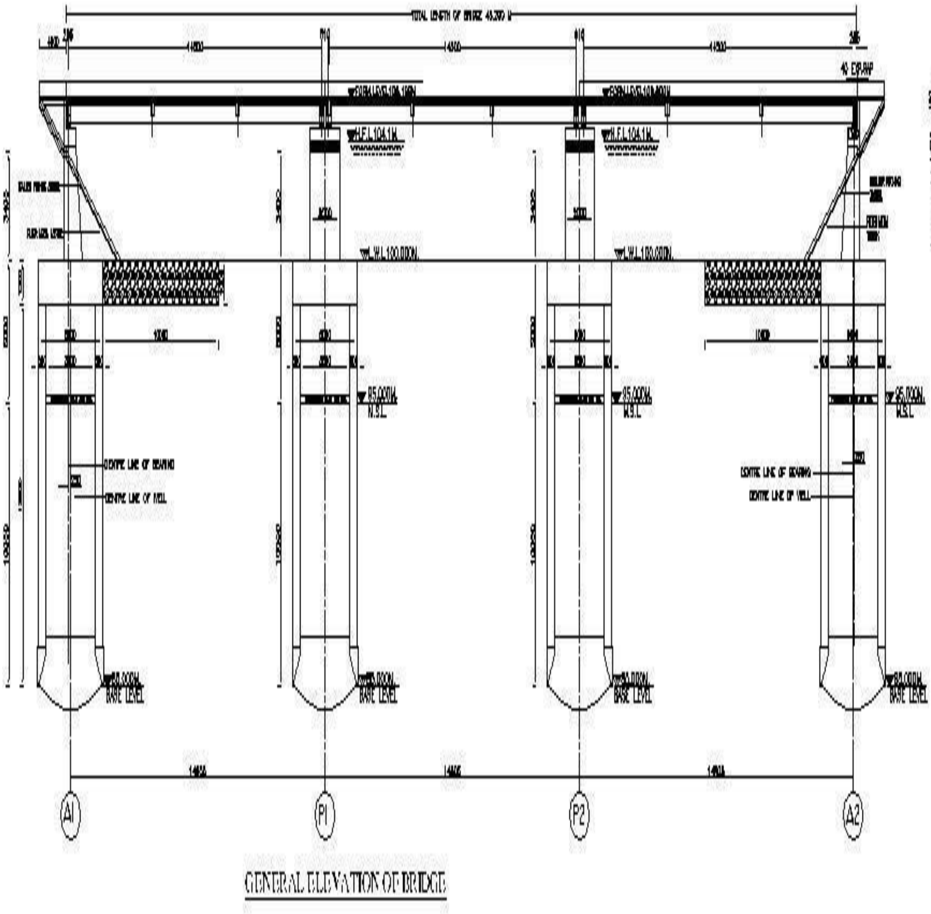
21. Discharge / meter =300/37.1= 8.09 m^3/sec/m

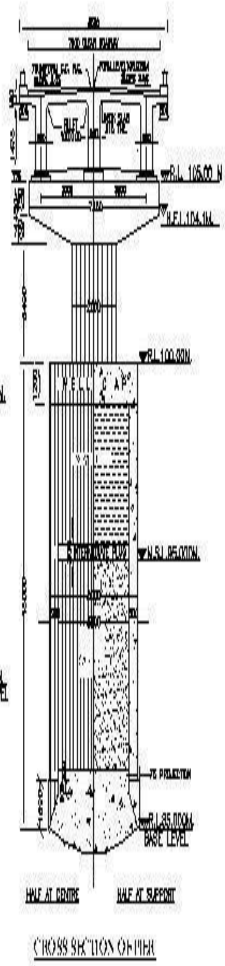
22. Mean scour depth (dsm)= 1.34 $(dsm^2/ksf)^{1/3}$

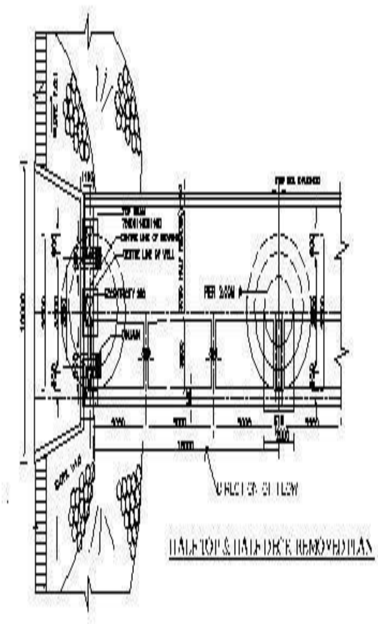
23. Scour depth below H.F.L.
(a) For pier = 2 × 5.4 = 10.8 m
(b) For abutment = 1.27 × 5.4 = 6.86 m

24. Depth of the foundation = 10.8 + = 12.6 m but we provide 15.0 m including cutting edge

25. Depth of well required below L.W.L./Top of well cap = 105.534 − 0.7−4.834−85.0 = 15.0 m>12.6 m
26. Mean scour level of pier well = 104.1 − 2 ×5.4 = 93.3 m say 95 m, Mean scour level of abutment well 104.1 − 1.27 × 5.4 = 97.242 m which lie with in abutment well cap mean scour level kept same as pier well.


A1
P1
P2
A2
GENERAL ELEVATION OF BRIDGE


HALF AT CENTRE
HALF AT SUPPORT
CROSS SECTION OF PIER


HALF TOP & HALF DECK REMOVED PLAN

For compression a box type minor bridges for the same waterway and discharge a box type minor bridge 5×8m is considered the data of such type of bridges is given as under:-

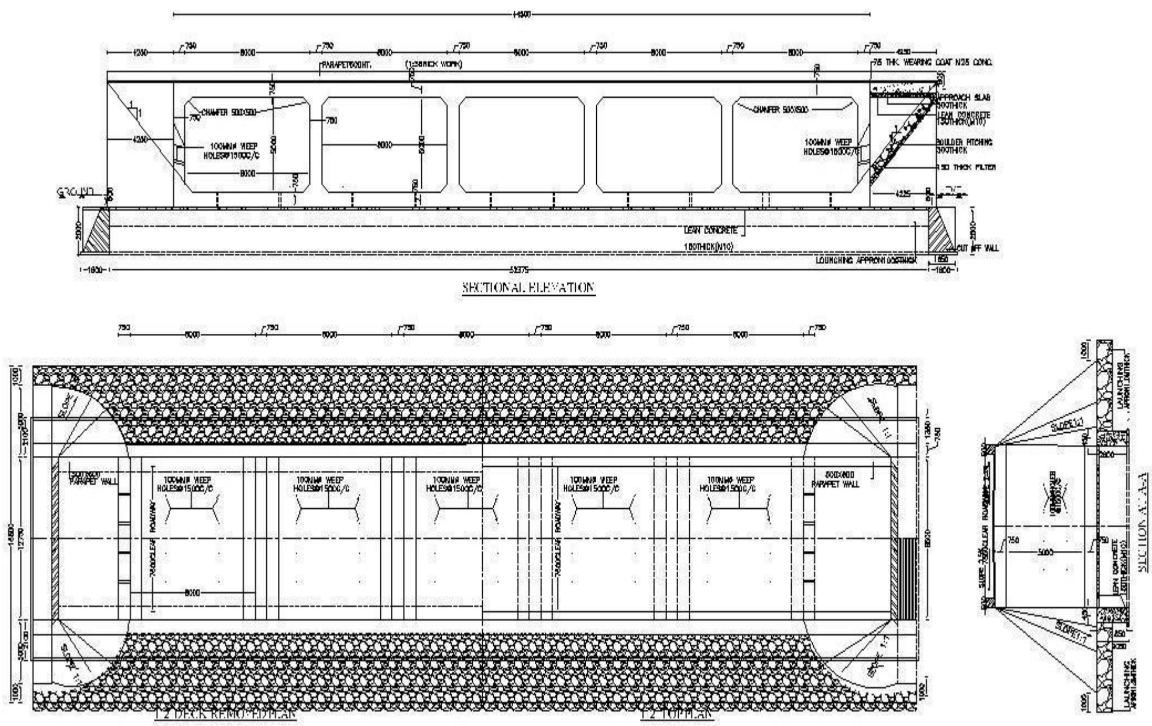
Data

Discharge = 300.0 m^3/s

Discharge per meter run= 274/40= 7.5 m^3/s
Mean scour depth (d_{sm})= 1.34 $(dsm^2/kgf)^{1/3}$ =5.15 m
Scour depth below H.F.L. for raft = 1.27 × 5.15 = 6.52 m
R.L. of bottom of cut off wall from H.F.L. =104.1-6.52=97.58
R.L. of bed of top of raft slab = 100
The depth of cut off wall below top of raft slab = 100-97.58=2.42 say 2.5
Clear Span (L) = 8.0 m

Road Way = 7.5.0 m
Parapet Width = 0.5 m
Barrel Length (B)= 8.5 m
Effective Length (Le) =L+D = 8.75 m
Clear height (H) = 5 m
Effective Height (He) = H+D = 5.75 m

Length of deck & raft slab (5Le+D) = 8.75×5+0.75
= 44.5 m
Wearing Coat = 7.5 cm
Thickness of members (D) = 0.75 m
Length of wing wall (H−D) = 4.25 m
Height of wing wall (H+2D) = 6.5m



Study and Discussion

As per information given above the bridge constructed on well foundation are uneconomical and not easy to construct. It require heavy equipments and skilled labours. On other hand box type minor bridge is more stable and economical. The top of waring coat in case of well foundation is 106.925 m while in box type minor bridge 105.825m i.e. 1.1 m additional height of bridge required which need extra cost approaches

Conclusion

The box type minor bridges are sustainable option in alluvial region for small and medium rivers.

1. Height of the bridge formation is lesser in case of box culvert that reduces the cost of approaches and the cost of land acquisition..

2. The box type minor bridges are constructed over raft foundation requiring less digging and dewatering.

3. The cost of construction is also reduced due to not using heavy and advance machine.

4. Time is also saved, as less digging is required during construction.

5. Structure is more stable in compression as compared to well foundation.

6. The floor of the foundation can also be used as a water retention device.

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