Report on Hydrological details of Mutha River Bridge

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Site Visit Report

	Bridge 1	Bridge 2	Bridge 3
Location	Mutha river, Warje	Nanded-Shivane link bridge	Near Khadakwasla
Type of Bridge	Major Bridge	Minor Bridge	Culvert
Foundation soil	Rock	Rock	
Type of Road	Two way	Two way (under construction)	Two way
	Asphalt	Concrete	Asphalt
Supporting structure	1. Mass concrete pier	Mass concrete pier	Abutments
	2. Hammer head		
No. of pier	8	4	0
No. of span	9	5	1
Surrounding Structure	Crematorium	Temple, Crematorium	Buildings
Length	108		
Skew Angle	30	20	
Meandering	Minor curvature		


WARJE
वारजे
TAPODHAM
तपोधाम
M NAGAR
रॅम नगर
SUN CITY
सन सिटी

Bridge I

Girders

Drainage provision

Abutment

Girders

Span view

Hand Rails

Approach Slab

Road Pavement

Span view

Dirt Wall

Transmission Lines

Bridge II: Minor Bridge


Under Sluice


Span view

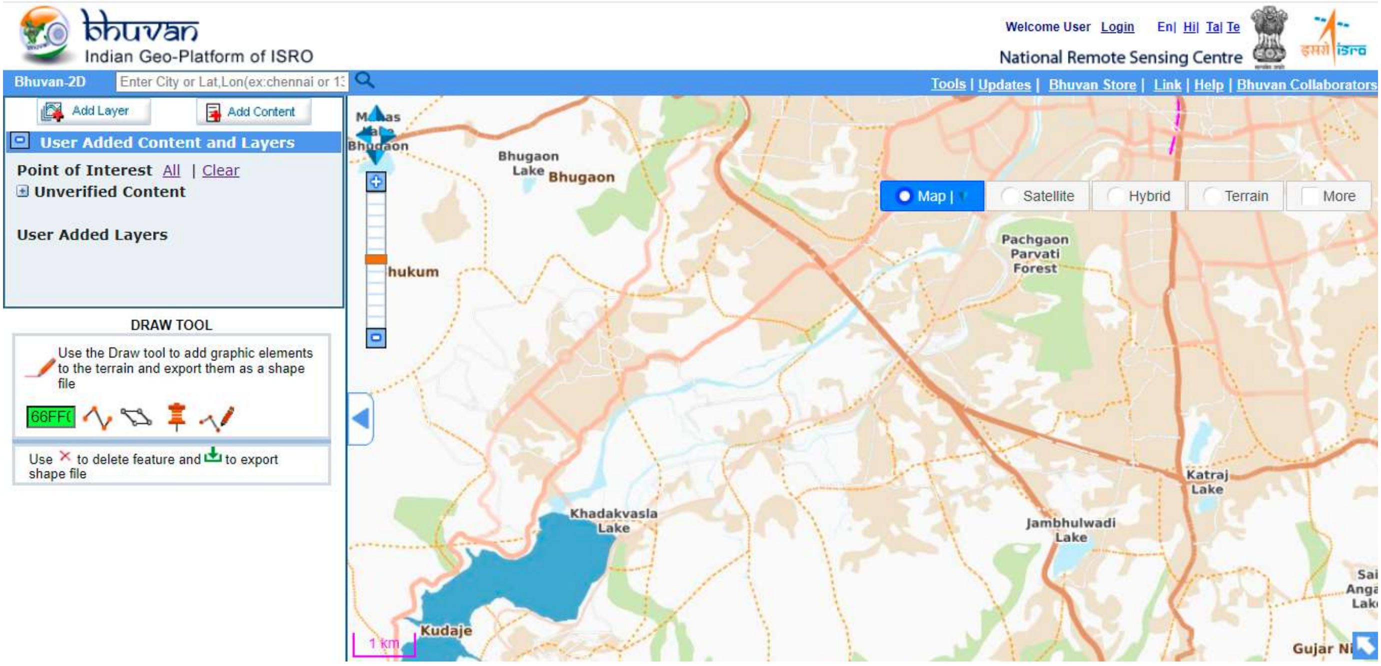
Bridge III: Minor Bridge

General information of river Mutha

Name of River / tributary	- Mutha
Origin of river	- Bhima Basin
Length [km]	- 10.4
Catchment area [km^2]	- 2036

Location

River has been dammed twice, first at the Panshet Dam (on the Ambi River), used as a source of drinking water for Pune city and irrigation. The water released here is dammed again at Khadakwasla and is an important source of drinking water for Pune. One more dam has been built later on the Mutha river at Temghar. Bridge is located downstream of Khadakwasla Dam.

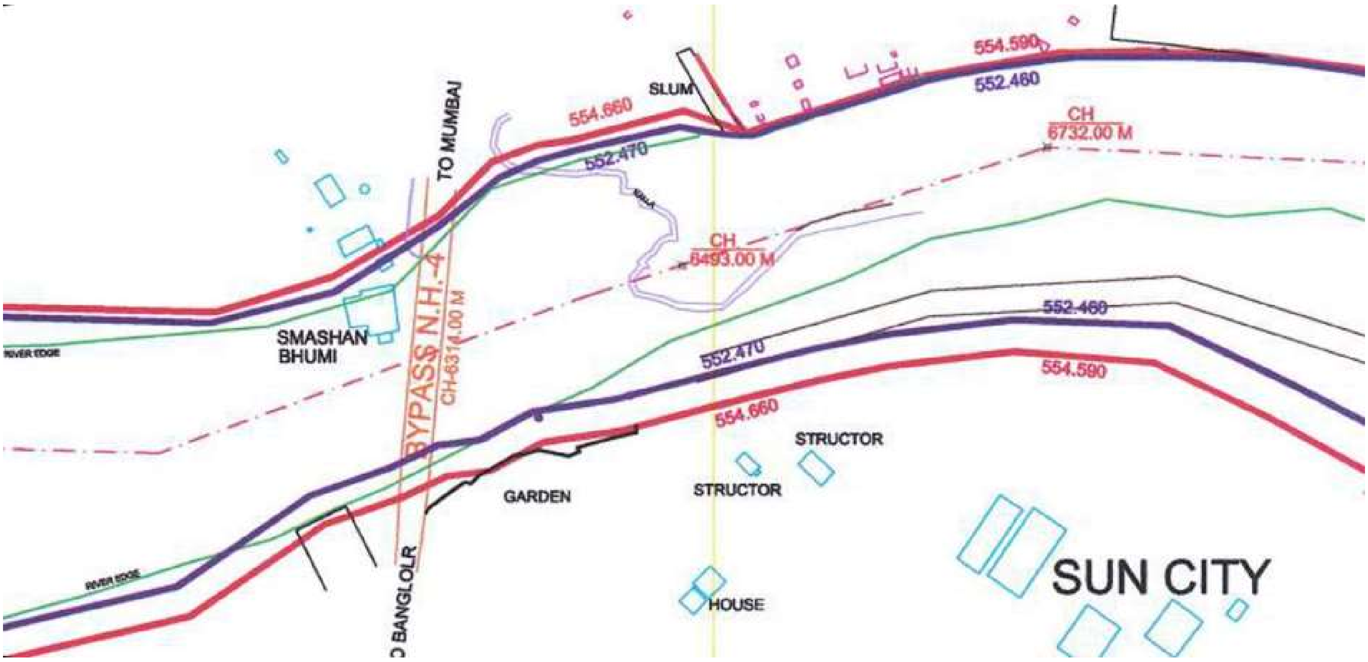


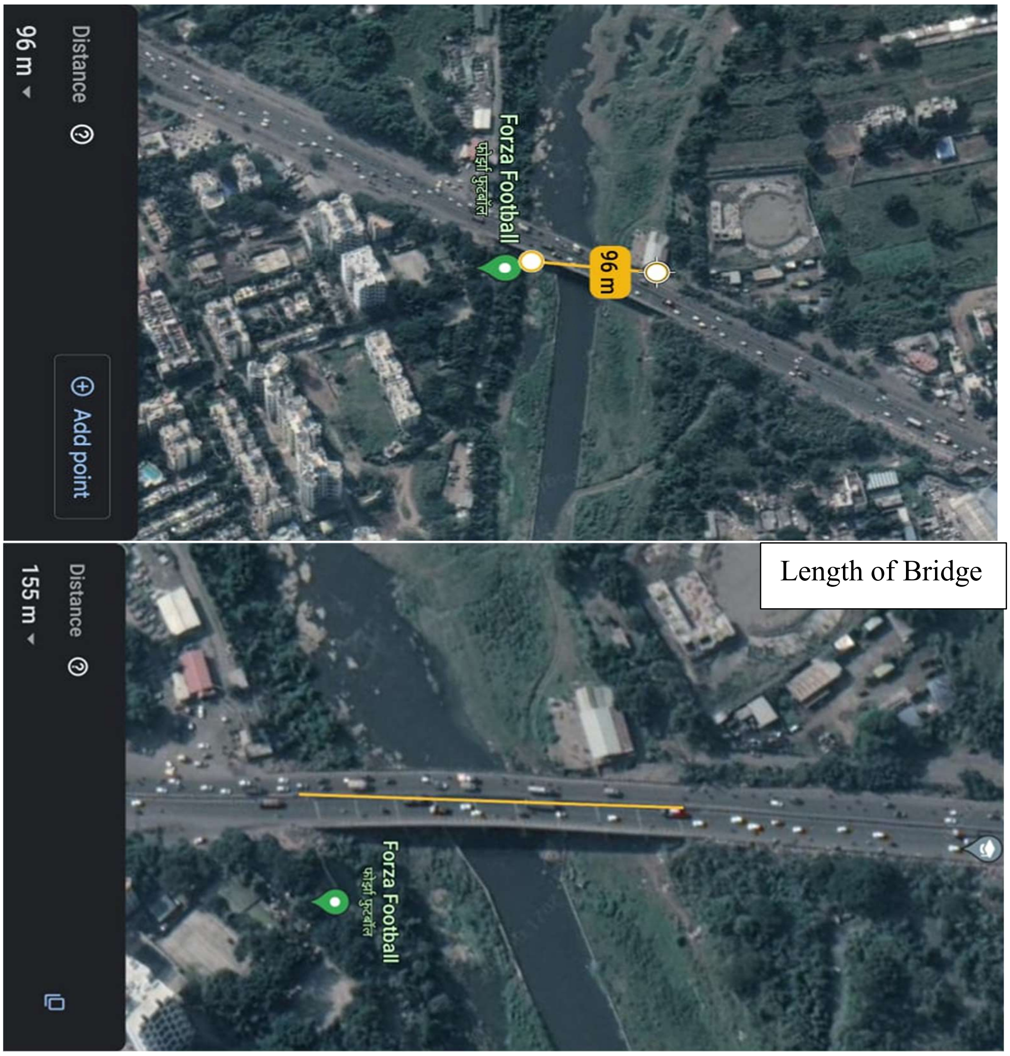
Information of bridge

- Location - Warje, Pune
- Coordinates - 18º28'28''N 73º48'33''E at bridge approach
- Catchment area - 76.569 sq. km. (7656.9 ha)
- Length of bridge -155 m
- Maximum hourly rainfall intensity – 7.67 cm/hr
- Distance of assumed bridge site from catchment area - 6.39 km
- From table 4.1 of IRC SP-13,

Coefficient of runoff for catchment characteristics(P) - 0.9 as river banks are defined by observation as steep, bare rock and also city pavements.

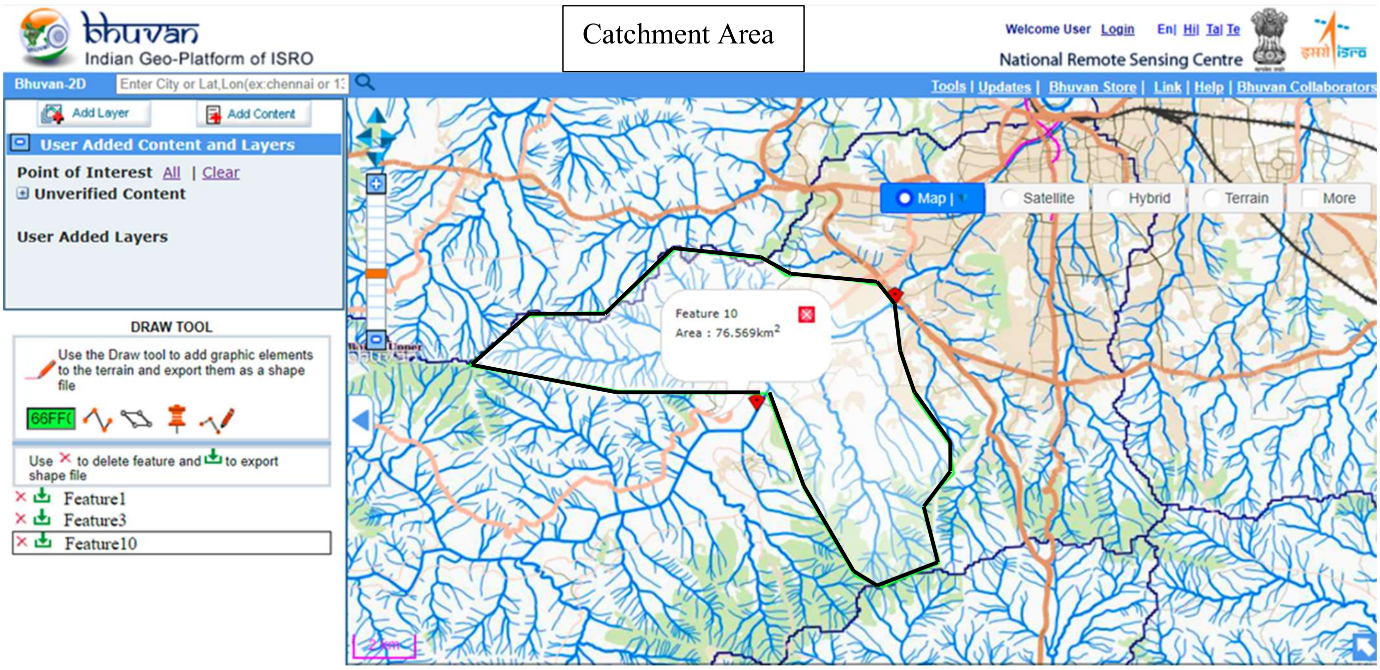
- Width of river - 96 m
- Discharge – 1479.9 m^3/s
- Soil profile - Rocky strata
- HFL in 25 years - 552.47 m
- HFL in 100 years - 554.66
- Afflux - 1.22 m
- Scour Depth – 5.29 m below HFL
- Velocity – 3.1 m/s





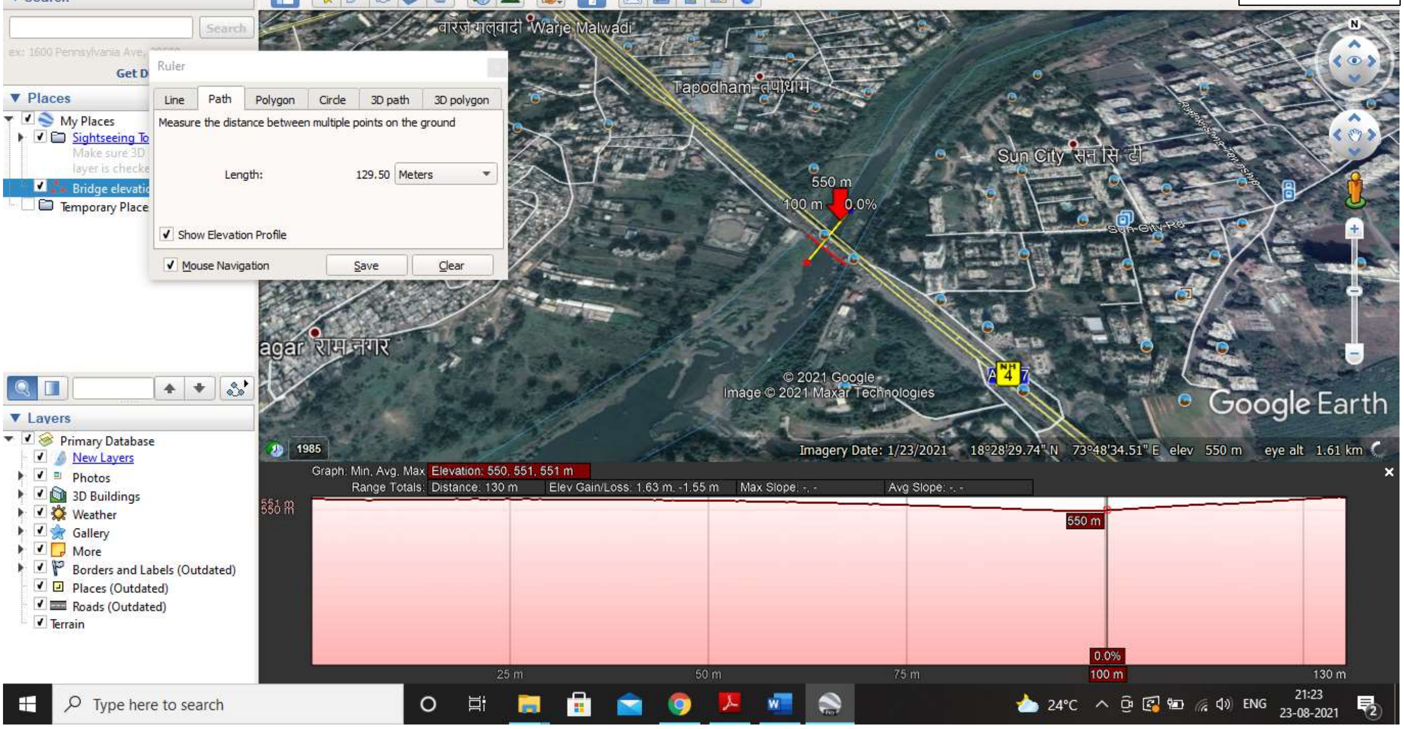
Length of Bridge

Catchment Area



Cross Section

Bed Slope



Discharge

Discharge has been calculated using:

- Empirical Formula
- Rational method
- Slope Area Method
- Synthetic Unit Hydrograph Method

Empirical Formula

Although records of rainfall exist to some extent, actual records of floods are seldom available in such sufficiency as to enable the engineer accurately to infer the worst flood conditions for which provision should be made in designing a bridge. Therefore, recourse has to be taken to theoretical computations. In this Article some of the most popular empirical formulae are mentioned.

Dickens Formula

$Q = CM^{3/4}$

Where ,

Q = the peak run-off in m^3 /s and M is the catchment area in sq. km

C = 1 1 - 14 where the annual rainfall is 60 - 120 cm

= 14-19 where the annual rainfall is more than 120 cm

= 22 in Western Ghats

Ryve's Formula : This formula was devised for erstwhile Madras Presidency.

$Q = CM^{2/3}$

Where

Q = run-off in m^3 /s and M is the catchment area in sq. km

C = 6.8 for areas within 25 km of the coast

= 8.5 for areas between 25 km and 160 km of the coast

= 1 0.0 for limited areas near the hills

Ingli's Formula : This empirical formula was devised for erstwhile Bombay Presidency

$Q = 125\, M/(M+10)^{1/2}$

Where

Q = maximum flood discharge in m^3 /s

M = the area of the catchment in sq. km

Rational Formula

A precipitation of Ic cm per hour over an area of A hectares, will give rise to a run-off Q = 0.028 A/c m3 /s

To account for losses due to absorption etc. introduce a co-efficient P.

Q = 0.028 PAIc

Where

Q =max. run-off in m3/s

A=area of catchment in hectares

Ic=critical intensity of rainfall in cm per hour

P=co-efficient of run-off for the catchment characteristics

Table 4.1 Maximum Value of P in the Formula $Q = 0.028\ PAI_C$

Steep, bare rock and also city pavements		0.90
Rock, steep but wooded		0.80
Plateaus, lightly covered		0.70
Clayey soils, stiff and bare		0.60
-do-	lightly covered	0.50
Loam, lightly cultivated or covered		0.40
-do-	largely cultivated	0.30
Sandy soil, light growth		0.20
-do-	covered, heavy brush	0.10

Slope Area Method

Plot the probable scoured bed line. Measure the crosssectional area A in m2 and the wetted perimeter P in m. Then calculate the hydraulic mean depth, R by the formula.

R= A/P

Next, measure the bed slope S from the plotted longitudinal section ofthe stream. Velocity can then be easily calculated from one of the many formulae. To mention one, viz., the

Manning's formula:

V= 1/n *(R)^2/3 * (S)^1/2

Where

V = the velocity in m/s considered uniform throughout the cross section

R = the hydraulic mean depth

S = the energy slope which may be taken equal to the bed slope, measured over a reasonably long reach

n = the rugosity co-efficient

Q = A.V.

Thus, the discharge carrying capacity of a stream depends on its conveyance factor and slope.

Discharge Calculation using Rational Formula,

$\boxed{Q = 0.028\ PAI_C}$

where, A =area of catchment in hectares = 7656.9

I_C =critical intensity of rainfall in cm per hour = 7.67

P =co-efficient of run-off for the catchment characteristics = 0.9

Q =max. run-off in m^3/s

= 0.028×0.9×7656.9×7.67

$\boxed{Q = 1479.9\ m^3/s}$

Linear Waterway

For natural channels in alluvial beds and having undefined banks, the linear waterway shall be determined from the design discharge using some accepted rational formula at the discretion of the engineer responsible for the design. One such formula for regime conditions is:

$\boxed{W = C \times \sqrt{Q}}$

C – constant, usually taken 4.8

Q – Design discharge = 1479.9 m^3/s

$\boxed{W = 184.65\ m}$

Velocity Calculation

$\boxed{v = (1/n) \times R^{2/3} \times S^{0.5}}$

where,

n = Rugosity co-efficient= 0.035 for Natural streams (major rivers)

R = Hydraulic mean depth, equal to ratio of c/s area (A) to wetted perimeter (P)=10.71 m

S = Bed slope, measured over a reasonably long distance =1/2000

$\boxed{v = 3.1\ m/s}$

Vertical Clearance

Since, Design discharge, $300 m^3/s$ < **$1479.9\ m^3/s$** < $3000\ m^3/s$

$\boxed{\text{Vertical clearance} = 1.2\ m}$

Afflux Calculation

Afflux is the rise in the flood level of the channel, immediately on the upstream of a bridge, as a result of obstruction to natural flow caused by the construction of a bridge and its approaches.

$$\boxed{h= ((v^2 /17.88) + 0.015) ((A / A_1)^2 - 1)}$$

v- Average velocity of river prior to obstruction =3.1 m/s

A- Unobstructed sectional area of river =1125 m^2

A_1 - Obstructed sectional area of river = 628 m^2

$\boxed{h= 1.22\ m}$

Scour Depth Calculations (without bed protection works)

The mean depth of scour 'd_{sm}' shall be calculated below the HFL as per the provisions of, Clause No.703 of IRC 78-2000,

$$\boxed{d_{sm} = 1.34 \times (D_b{}^2 /k_{sf})^{1/3}}$$

where,

d_{50}=d_m=1, effective grain size for bed [Refer grain size distribution curve in geotechnical report]

D_b = the discharge in Cumecs per metre width

$k_{sf} = 1.76 \sqrt{d_m} = 1.76$ (d_m=1 assumed)

HFL=552.47 m

Clear waterway after making deduction for obstruction up to HFL (L)=184.65m

Design discharge (after increasing the discharge by 30%) =1923.94 cumecs

Design discharge adopted for scour calculations (Q)=1923.94 cumecs

Discharge per metre width D_b =(Q/L) =10.42 m^2/sec

Normal scour depth from HFL, $d_{sm} = 1.34 \text{ x } (D_b{}^2 /K_{sf})^{1/3} = 5.29$ m

$\boxed{\text{Hence, } d_{sm} \text{ is } 5.29\ m}$

Maximum scour depth at Abutment locations = $(1.27 \times d_{sm})$ =6.72m

Maximum scour depth at Pier locations = $(2 \times d_{sm})$ =10.58m

Maximum scour level for Abutment locations = $(HFL-1.27 \times d_{sm})$ = 545.75m

Maximum scour level for Pier locations = $(HFL - 2 \times d_{sm})$ =541.89 m

Foundation

As per IRC 78, Clause 705,

For open foundation type in rocks depth of foundation is taken as,

For hard rocks, with an ultimate crushing strength of 10 MPa or above arrived after considering the overall characteristics of the rock, such as, fissures, bedding plane, etc minimum embedment of foundation rock is 0.6 m.

Width of bridge

Width of bridge can be taken according to road width

As it is two lane road carriage way = 7.5 m

Considering footpath of 1.5 m on both side

Total width of bridge = 10.5 m

Case study 1: Failure of Tel Bridge

Location: Belgaon

The salient features of the bridge are as follows

Max Discharge: 11325 Cumec

Velocity: 319m/sec

Highest Flood Level: 171.04m RL

Maxm scour level: 146.32m RL

Foundation level: 137.20m RL

Causes of failure of Tel Bridge

i) Increased discharge than that for which the bridge was designed.

ii) Concentration of flow with high velocity towards Kesinga side (right side).

in) Erosion of the strata on which the wells were founded.

On 13/09/77 the Highest Flood Level rose as high as 171.63M RL & the discharge, calculated corresponding to the Highest Flood Level came out to be 15289 Cumec i e about 35% excess over the Design discharge of 11325 Cumec.

Reconstruction included of Garlanding piers by masonry structures.

Case study 2: Failure of Surlake Cut Bridge.

Location: Puri Konark marine drive, Orissa

Type of bridge: Box culvert

Max Discharge: 85 Cumec

Foundation type: Raft foundation

Failure:

1. Sudden discharge of 850 cmuecs.
2. Settlement of 325 mm D/S.
3. Displaced the sheet pile cut-off, resulting in heavy scour.

The bridge was designed for a discharge of 85 cumecs. Suddenly in the rainy season of 1997, because of a breach in the nearby River, Nuanai, discharge of about 850 Cumecs (i e 10 times the design discharge) passed through the box culvert. Because of such exceptionally high discharge, the velocity of water increased to a great extent and it displaced the sheet pile cut-off provided earlier and caused heavy local scour, forming deep gorge to the tune of about 5M in the Down stream end from Left Bank (Konark side) to the centre of the bridge and its depth gradually reduces towards the Up stream. The raft has been cracked & displaced in the central portion of the bridge. Near the joint of the suspended span there is a settlement of about 325mm on Down stream end. Thus the portion of the Box Structure of Left Bank (Konark side) has been tilted towards the Down stream end. As a deep gorge has been created in the Down stream end and the raft has settled to a great extent, it is quite risky to jack up the superstructure to restore the relative settlement of 325mm of the superstructure. A Baily Bridge type arrangement was made to restore the traffic on such an important route

Conclusion:

Fixing of the founding level in case of bridge depends on the discharge, waterway provided and type of strata of the river bed. For different types of soil the maximum scour level & founding level can be calculated depending on the silt factor, flow concentration & water way etc. But in case a sound hard inerodible rock is encountered at a level, higher than the Maximum Scour Level, then the scour line is considered to be the top of the rock level and founding level can be fixed by keeping the structure below the rock with some minimum grip length as per relevant code. But to take a decision, whether a rock is hard & inerodible, is a tricky one. In such cases, it is always preferable to take the help of an experienced geologist to find out the nature of rock and the rock profile (Dip & fault), along with field testing of the quality of rock (both Safe Bearing Capacity & erodibility) Then only the decision on foundation can be safe & suitable.