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1. Field visit report

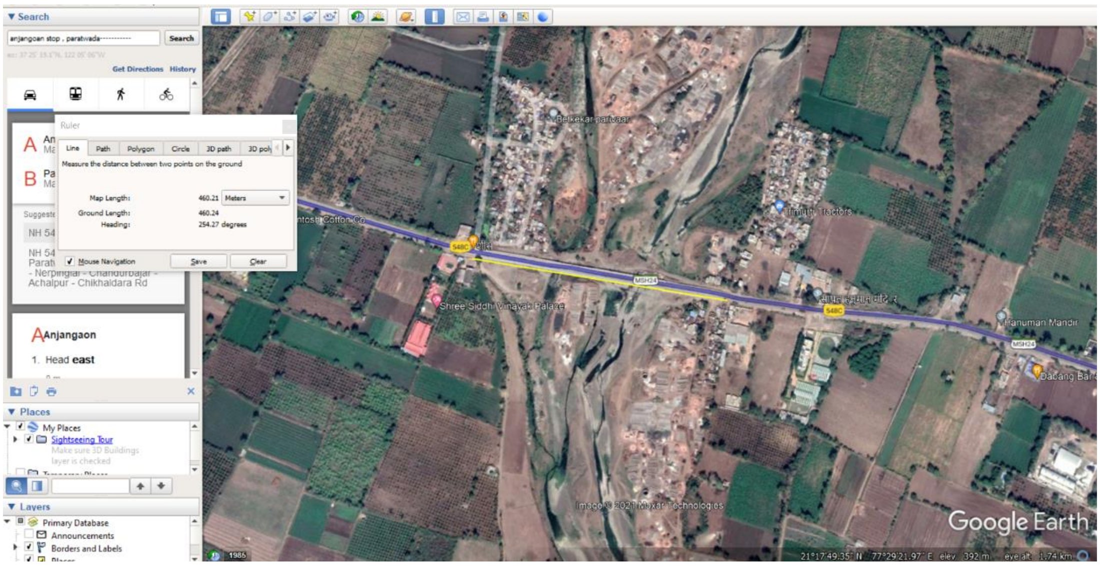
Visit Location : Anjangaon Road

River : Sapan

Date of Visit: 17/07/2021

Purpose of Visit: To Study about bridge and its component .

(Map of proposed bridge)



Following points where observed in the field visit :

Type of bridge : Major bridge

Foundation soil : Silty

Type of road : Two way , CC

Surrounding area : Wadgaon Village

Number of piers :12

It is Seasonal river and has minor meandering in this part.



Silty soil

Piers

Conclusions:

I learn about various factor affect planning , designing , and execution of bridge work

2. Report on Hydrological details of Purna bridge (Tributary of Tapi river)

2.1 General information of main River Purna Tributary of Tapi

Name of River / tributary - Purna

Bank - Left

Elevation of source above m.s.l. [m] - 900

Length [km] - 274

Catchment area [km2] - 18929

2.2 Location

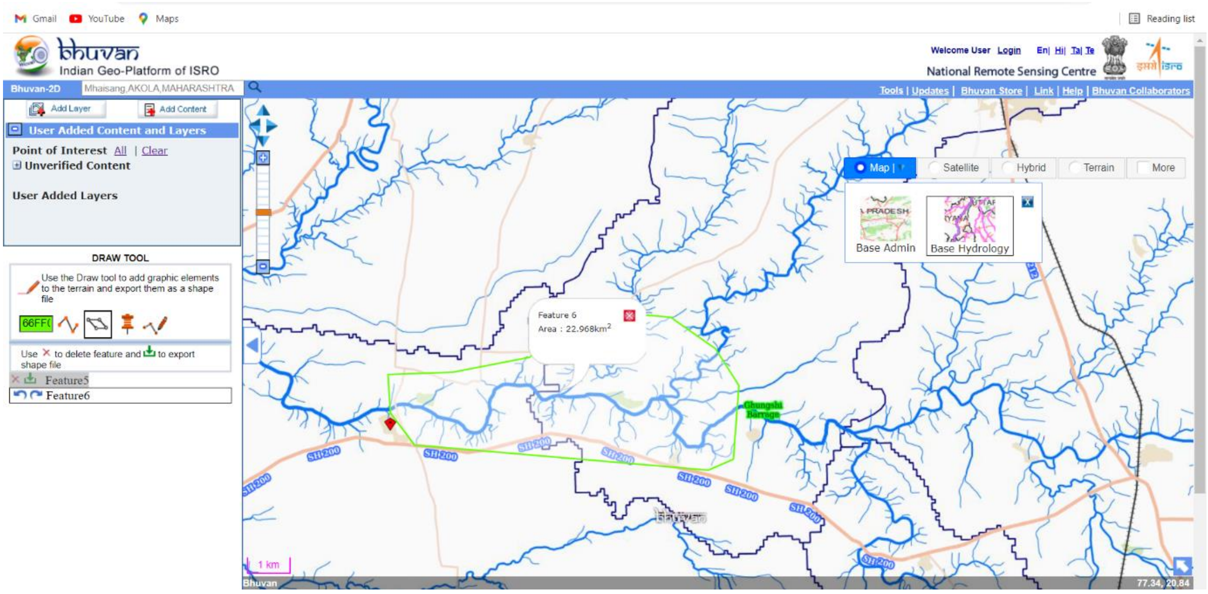
The Purna River is a river of Western India.It runs parallel to the Tapti River.The river rises in the eastern Satpura Range of southern Madhya Pradesh state, and flows westward, draining Maharashtra's Vidarbha region before flowing into the Tapti River at Changdev in Jalgaon, Maharashtra. The westshed lies mostly in eastern Vidharbha region of Maharashtra state and is nearly 7500 km.The Purna River starts in Amaravti district of Maharashtra and flows across Akola, Buldhana and Jalgaon district. The river finally flows into the Gulf of Khambhat near the city of Navsari in Southern Gujarat.

2.3 Information of bridge

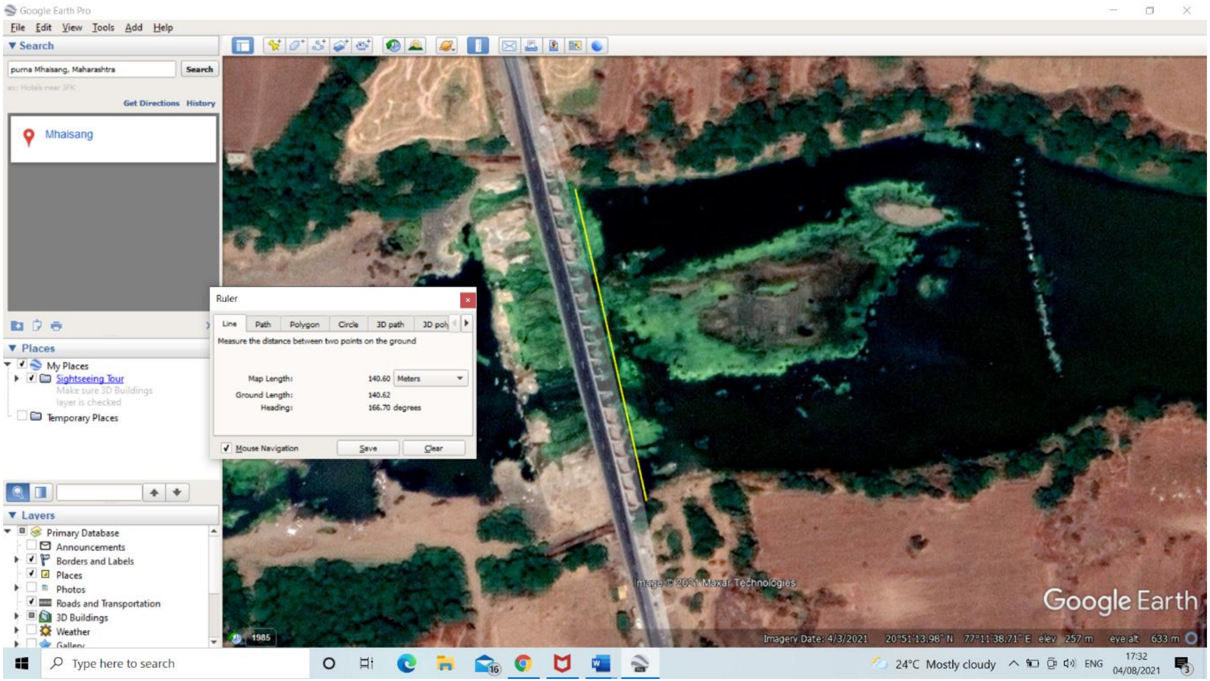
- Location -Near Mhaisang
- Catchment area -22.968 sq km (2296.8 ha)
- Length of bridge -160 m
- Maximum hourly rainfall intensity -12 cm/hr
- Distance of asummed bridge site from catchment area -7.705 km
- Coefficient of runoff for catchment characteristics(P) -0.6 as river banks are defined by observation as clayey soil.
- Width of river -140 m

- Soil profile -The soils are deep, calcareous, clayey and very greyish brown in colour.
- Elevation – 254 , 256 , 257 m
- Discharge – 463.03 m^3/s
- Cross-section – 240 m^2
- Velocity – 1.93 m/s
- Linear waterway – 103 m
- Skew angle – 28.95 degree
- Afflux – 505 mm
- HFL – 257.505 m
- Scour depth – 3.6 m
- Vertical clearance – 1.2 m

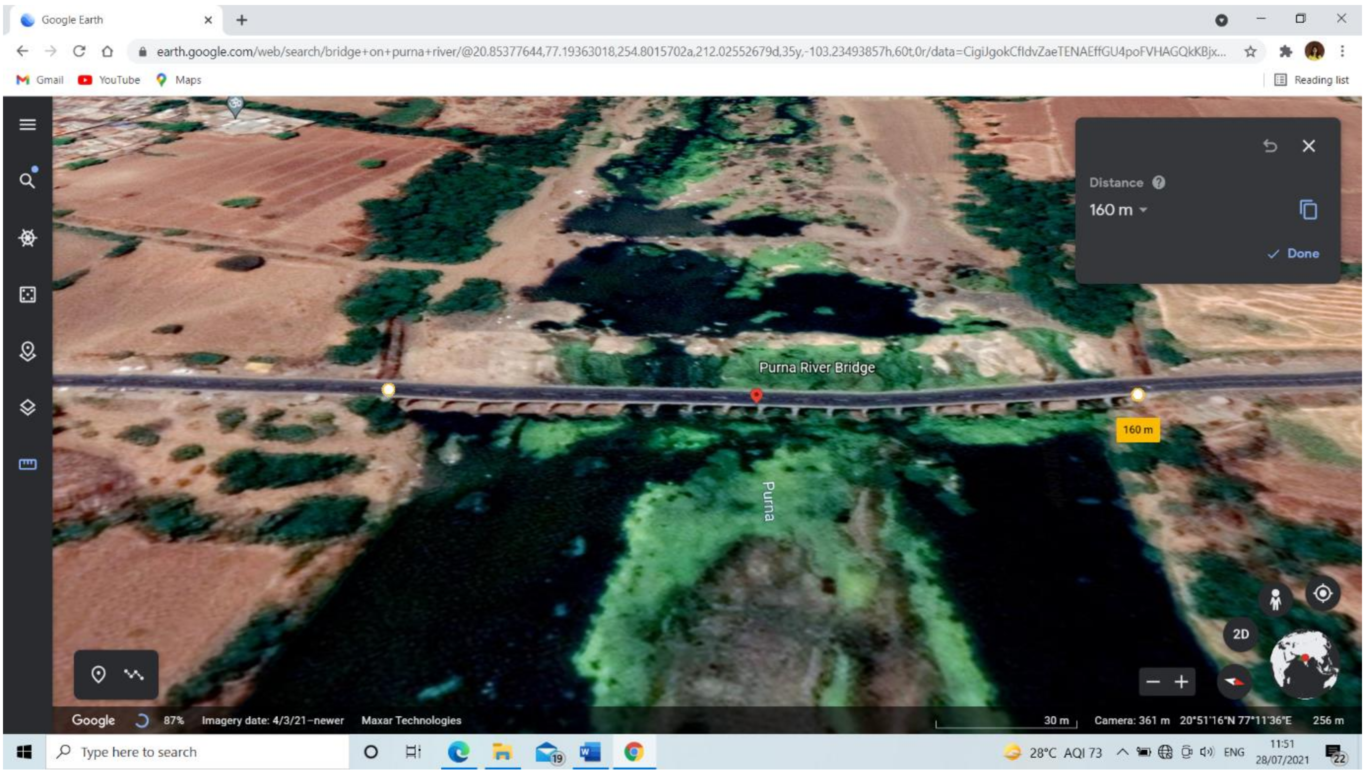
Catchment area -



Width of bridge-



Length of bridge-



2.4 Discharge calculations

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 m3 /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.

Unit Hydrograph Method

The Unit Hydrograph, frequently termed as the unit graph, is defined as the hydrograph of storm run-off at a given point in a river, resulting from an isolated rainfall of unit duration occurring uniformly over the catchment and producing a unit run-off. The unit run-off adopted is 1 cm depth over a catchment area.

The term "Unit-Rainfall Duration" is the duration of rainfall excess resulting in the unit hydrograph. Usually, unit hydrographs are derived for specified unit durations, say, 6 hours, 12 hours etc. , and derived unit hydrographs for durations other than these are converted into unit hydrographs of the above unit durations. The duration selected should not exceed the period during which the storm is assumed to be approximately uniform in intensity over various parts of the catchment. A 6 hours unit duration is suitable and convenient for studies relating to catchments larger than 250 sq.km . The unit hydrograph represents the integrated effects of all the basin constants, viz., drainage area, shape, stream pattern, channel capacities, stream and land slopes.

Discharge calculation

The design discharge for which the waterway of the bridge is to be provided, shall be based on maximum flood discharge of return period of 100 years. In case where the requisite information is not available, the design discharge shall be the maximum estimated discharge determined by rational method.

Discharge Calculation using Rational Formula,

Q = 0.028 PAIc

Where

Q =max. run-off in m3/s

A=area of catchment in hectares =2296.8 ha

Ic=critical intensity of rainfall in cm per hour = 12 cm/hr

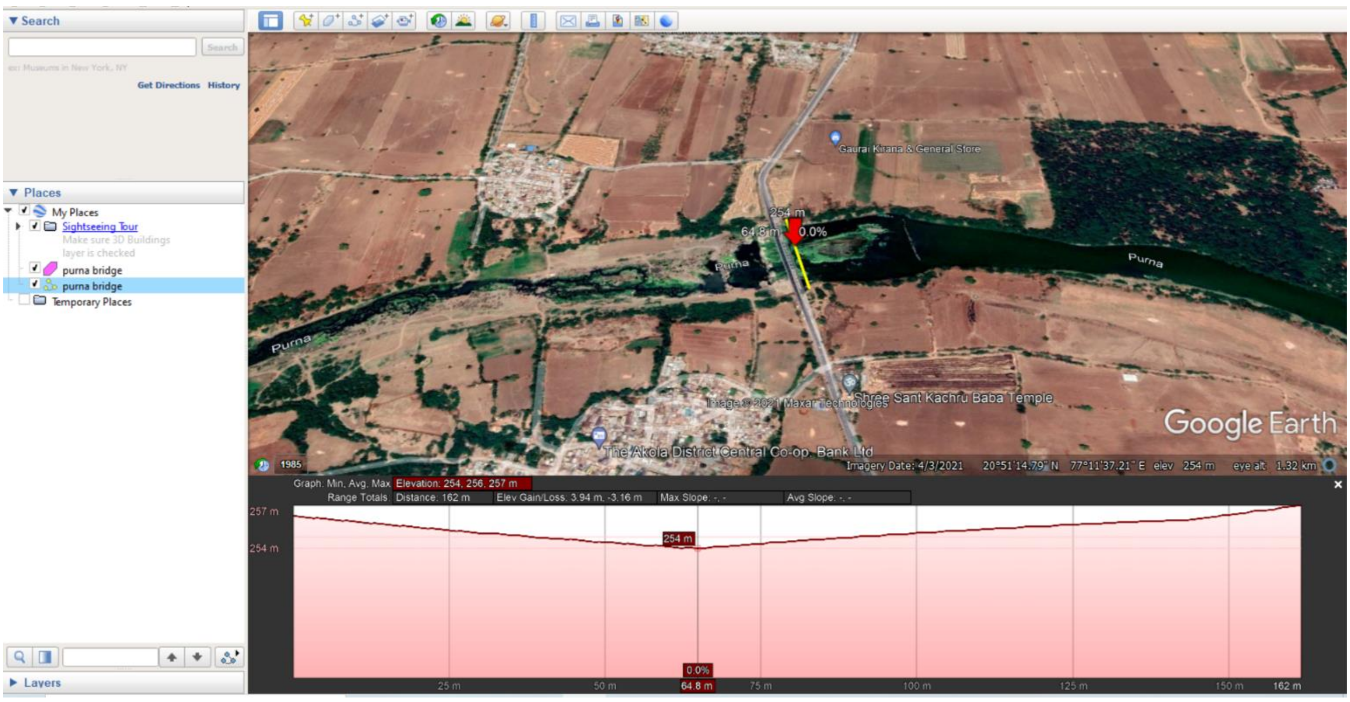
P=co-efficient of run-off for the catchment characteristics = 0.6

Q = 0.028 *0.6*2296.8 *12

=463.03 m^3/s

2.5 Velocity calculations

Cross- section -



Q=AV

A=cross section area

=base * height / 2

=160 * 3 / 2

= 240 m^2

V=463.03 /240

=1.93 m/s

2.6 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:

W= C (Q)^1/2

W = regime width in meters (equal to effective linear waterway under regime condition)

Q = the maximum design discharge in m3/sec;

C = a constant usually taken as 4.8 for regime channels but it may vary from 4.5 to 6.3 according to local conditions.

W= 4.8 (463.03)^1/2

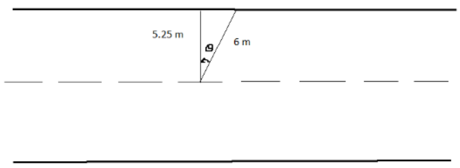
=103 m

2.7 Skew Angle

Skew angle is the angle between the axis of support and a line normal to the longitudinal axis of a bridge.

As it is two lane road bridge width shall provide for 7.5m carriageway plus a minimum of 1.5m footpath on either side wherever required as per provisions of IRC-5

Width of road =10.5 m



Skew angle = 28.95 degree

2.8 Afflux

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.

h = (V^2/17.88 + 0.015) x ((A/a)2 - 1)

where : h = afflux (in meters)

v = average velocity of the water in the river prior to constriction (in m/sec) =1.93 m/sec

A = unobstructed sectional area of the river at proposed site (in sq. m) =103 m

a = constricted area of the river at proposed site (in sq. m) =57 m

h=(1.93^2/17.88 + 0.015) x ((100/60)^2 - 1)

= 0.505 m

= 505 mm

2.9 Determination of HFL

Highest flood level is the level of highest flood recorded/observed or calculated from the design discharge, whichever is higher.

HFL = Max elevation +afflux

= 257 + 0.505

= 257.505 m

Height of bridge can be taken (257.505 -258) m from msl.

2.10 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

2.11 Vertical clearance

For openings of high level bridges, which have a flat soffit or soffit with a very flat curve, the minimum clearance shall be in accordance with the following table. The minimum clearance shall be measured from the lowest point of the deck structure inclusive of main girder in the central half of the clear opening unless otherwise specified.

Discharge in Cumecs	Minimum Vertical Clearance in mm.
Upto 0.3	150
Above 0.3 & upto 3.0	450
Above 3.0 & upto 30.0	600
Above 30.0 & upto 300	900
Above 300 & upto 3000	1200
Above 3000	1500

Therefore , vertical clearance = 1.2 m

2.11 Scour Depth Calculations (without bed protection works)

The mean depth of scour 'dsm' shall be calculated below.

dsm = 1.34 x (Db^2 /Ksf) ^1/3

where d50 = m= 1 -effective grain size for bed [Refer grain size distribution curve in geotechnical report]

Db = the discharge in Cumecs per metre width

Ksf = 1.76 √m = 1.76 (m=1 assumed)

HFL =257.505 m

Clear waterway after making deductions for obstructions upto HFL(L) = 103 m (assumed)

Design discharge (after increasing the discharge by 30%) = 601.94 cumecs

Design discharge adopted for scour calculations (Q) = 601.94 cumecs

Discharge per metre width Db =(Q/L) = 6.02 m^2/sec

Normal scour depth dsm = 1.34 x (Db^2 /Ksf) 1/3 =3.6 m

Hence, dsm = 3.6 m

Maximum scour depth at Abutment locations = (1.27 x dsm) = 4.572 m

Maximum scour depth at Pier locations = (2 x dsm) = 7.2 m

Maximum scour level for Abutment locations = (HFL -1.27x dsm) = 252.933 m

Maximum scour level for Pier locations = (HFL - 2 x dsm) =250.305 m

2.12 Foundation

Foundation is that part of a bridge structure, which is in direct contact with and transmitting loads to the founding strata.

As per IRC 78, Clause 705,

For open foundation type in soil depth of foundation is should upto strata having safe bearing capacity but not less than 2 m below scour level or protected bed level.

minimum embedment of foundation soil is 2 m.

3. Failure of bridge

3.1 Due to scoring

Scouring of foundation is considered primary causes of failure as it occupies around 60% of total bridge failure together with other hydraulic causes. This bridge collapsed mainly due to scouring of soil below the foundation. Scouring of foundation can occur all over the year, it reaches peak when flood comes in water body over which a bridge is spanning. History of bridge failure indicates scouring of streambed around abutments and piers of bridge, led to maximum bridge failures. Scour at bridges is a very complex process. Scour and channel instability processes, including local scour at the piers and abutments, contraction scour, channel bed degradation, channel widening, and lateral migration, can occur simultaneously.

3.1.1 Case Study of Loon Mountain Bridge in Lincoln, N.H.

In August 2011 high water due to Tropical Storm Irene washed out an abutment of the Loon Mountain, New Hampshire Bridge. This bridge abutment was on the outer bank in a bend in the river, so swirling flow brought high velocity water into the outer river bank, causing quick erosion and loss of soil and rock under the concrete part of the abutment. The Bridge collapsed due to heavy scouring around the abutment after 11 inches of rain. The permanent solution includes multiple bank stabilization techniques coupled with the construction of a new bridge. The new three-lane bridge is 290-feet long with abutments which are secured via micropiles driven down to bedrock to protect against scour. The intersection at the entrance of the bridge was redesigned to improve traffic flow to the popular Loon Mountain Resort. Construction of the replacement bridge began in 2015 and the bridge was officially opened to vehicular traffic in the summer of 2016.

3.1.2 Case Study of Bridge at Jahu, Himachal Pradesh

The case study is over bridge failure, which is at Jahu, Himachal Pradesh. The Seer Khadd and Jabothi Khadd is located in the northern region of India. The bridge was located at distance of 460 km from New Delhi and 30 km from District Hamirpur .This is important link road which serves and connect three districts Mandi, Bilaspur and Hamirpur. This Point is considered as the center of Himachal Pradesh. This study is important because bridge collapsed two times due to same reason i.e. scouring of foundation. Local scour around the bridge abutment is one of the most critical causes of bridge failure.

First time (Arch failure)

On August 11, 2007 & August 12, 2007 due to heavy rain the concrete bridge got collapsed.

Second time

Due to heavy rain in the catchment of Seer Khadd on the night of 13th August, 2014 and in early morning of 14th August, 2014 bailey bridge over Seer Khadd at Jahu washed away at about 7:00 am. During second time of construction, the setup was totally changed.

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.