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DETERMINATION OF THE WATER WAY FOR BRIDGE AT KUDALASANGAM - ADAVIHAL ACROSS MALAPRBHA RIVER IN KARNATAKA USING GIS APPLICATION

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ABSTRACT:

Floods are a recurrent phenomenon, which cause huge loss of lives and damage to livelihood systems, property, infrastructure and public utilities. This can be attributed to many reasons including a steep increase in population, rapid urbanization growing developmental. India is highly vulnerable to floods. The frequency of major flood is more than once in five years. Floods have been a recurrent phenomena on which brings settlements, misery to human lives and losses to infrastructure and public utilities.

The Roads and Barrages are one of the main communication systems of Human civilization which requires proper planning design and executions. In recent year 2019, Malaprbha River has experienced heavy flood which causes submergence of Hostorical place Kudalasangam Temple surroundings area with Crop land and Roads due to construction of Bridge at Kudalasangam - Adavihal across Malaprbha river near Adavihal.

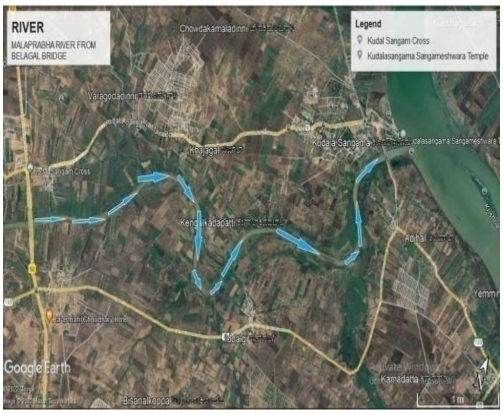
An attempt is made is this study to ascertain the flood prone area surrounding the Bridge and probable causes of flood in Malaprbha River using Arc GIS and related software to find the adequacy of the bridge structure to safely pass the flood water.

Key words: *Key words: Arc GIS, Flood, Inundation, Water way*

1.0 Introduction:

The Malaprabha River originates from the Western Ghats at an altitude of 792 m MSL at Kanakumbi in Khanapur taluk of Belgaum District. It runs for a distance of 304 km before joining the Krishna River at an altitude of 488 meters near Kudalasangam in Bagalakote district. Its basin is approximately triangular in shape, located in the extreme western part of the Krishna basin.

The Kudalsangam temple is the famous historical place which is located in the confluence of Malaprbha river with Krishna The Aykya Mantapa of Lord Basavewar



and Neelamma temple are located just at the confluence point. The villagers from right bank of Malaprabha river have to travel via NH-50 to visit Kudalasangam,
Fig.1. Malaprabha river line from Belagal bridge to Krishna river (Google earth image)

The bridge site is located immediately upstream of its Confluence with Krishna River and in the back waters of Narayanapura Dam. The present connectivity of Kudalsangam is from NH-50 (earlier NH-13). The place can be approached after crossing Malaprabha Bridge near Belagal on NH-50. This is quite a long route for pilgrims from districts located on the northern side of Krishna River. The length of this route to Kudalsangam from Thangadagi Bridge via Dhanur, Hungund, Belgal and Khaigal is about 36.00 Km.
In order to provide a shorter route to the pilgrims on the northern side of Krishna River, it is proposed to construct a new high level bridge across Malaprabha, immediately upstream of its confluence with Krishna River. The length of this route to Kudalsangam from Thangadagi Bridge via Adavihal village will be about 5 Km. After the confluence a major bridge across Krishna River near Thangadagi has been built. This is located about 5 Km downstream of the Adavihal bridge.

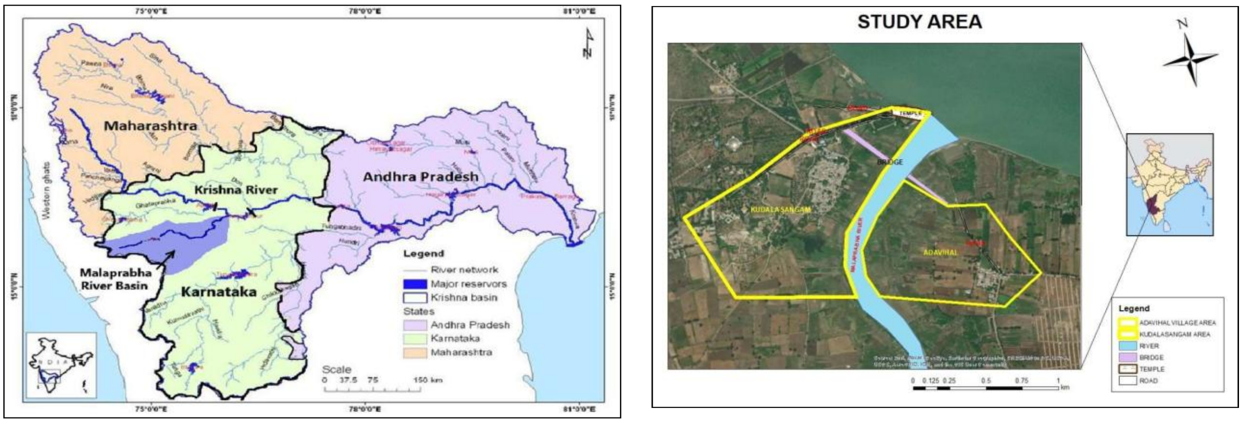


Fig.2 Location of Malaprabha Riverin Krishna Basin

The major bridges located on the upstream in the stretch of natural water way are, near Belagal on NH-50 , near Kamatagi on Hunagund- Bagalkote road, near Battadakal on SH-14, Near Cholachagudda on NH-367, near Holealur on Gadag-Bagalkote road.

2.0 Objectives

To ascertain the causes of flood at the study area, to assess the causes of silt accumulate and estimate the quantity of silt in between bridge piers To create area inundation map of Adavihal - Kudalasangam catchment at the time of flood 2019

3.0 Methodology

3.1 Bridge Details

The nearby village Adavihal at RL 498.00 m on the right bank and Kudalsangam at RL 499.00 m on the left bank is above the back water level of Narayanpur dam. Thus the backwater level of Narayanpur dam at the proposed bridge site is estimated to be 497.230 m with a free board of 0.5 m head loss through the bridge is 0.22m and top of pier will be at 496.450 m. With the depth of girder will be 2.0 m and slab thickness will be 0.30 the FRL of bridge will be 498.750 m. Hence it is proposed to keep FRL of bridge at RL. 499.000m this will also help to match the level on left bank side road level leading to Kudalsangam. Approaches are proposed with Embankment on either side with aside slope of 2:1 and with crash barrier, where the length of embankment is 3m.

Table 1 General features of existing bridge (DPR of bridge)

Latitude	16° 10' 46" N		
Longitude	74° 40' 16" E	Approaches on either side of bridge	a)Towards Kudala sangam 102.79 m
Length of bridge	735 m		b)Towards Adavihal 662.21m
Maximum water level (HFL)	492.252 m	Maximum height of embankment	8.60 m
Low water level	490.607m	Horizontal clearance	51.00 m
Vent way	702 m	Slope of embankment	2:1
Vertical clearance	7.00 m	Type of superstructure	Roof truss with RCC Deck slab
No. of piers	13	Type of bearings	POT cum PTFE bearings under each girder
Waterway	735 m	Type of substructure	Twin circular pier with capping beam
Soffit Level	499.252 m	Dia of pier	1.50m
Low water level	490.607m	Type of foundation	Pile foundation with bored cast in ¸situ piles
Horizontal clearance	51.00 m	Dia of pile	1.20 m
Water way	735 m	Type of pile	Bearing Pile
Soffit level	499.252 m	Reference codes	IRC: 5 – 1999, IRC:6-2010, IRC: 78-2000, IRC:86, IRC: 106, IRC:86, IRC: 106, IRC:112 - 2011, IS:456:2000, SP-16 DESIGN AIDSTO IS:456

3.2 Data collected from bridge site

Table 2 Daily inflows and out flow (Cusecs) details at bridge site

July 2015

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Water level	514.7	514.7	514.7	514.8	514.9	514.9	514.8	514.8	514.7	514.7	514.6	514.5	514.4	514.1	514.4
Inflow	2710	0	0	10175	10175	0	0	0	0	0	0	0	0	0	0
Out flow	2710	0	0	0	0	100	6110	5691	475	475	675	675	675	675	675

Date	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Water level	514.30	514.20	514.12	513.95	513.82	513.75	513.70	513.75	514.00	513.75	513.80	513.75	514.20	514.45	514.80	514.90
Inflow	0	0	0	0	0	12171	8919	15590	10675	10675	15055	28196	28976	34264	45366	20850
Out flow	675	5675	5675	15675	15675	15675	15675	10675	10675	10675	10675	10675	10675	10675	10675	10675

Aug 2017

Date	1	2	3	4	5	6	7	8	9	10	11	12**	13	14	15
Water level	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60
Inflow	35521	20849	21001	21003	21003	21003	11836	6003	3086	1003	1003	6003	6003	5403	5403
Out flow	18448	20849	21003	21003	21003	21003	11836	6003	3086	1003	1003	6003	6003	5403	5403

Date	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Water level	519.60	519.60	519.60	519.60	519.45	519.27	519.22	519.22	519.22	519.22	519.25	519.30	519.35	519.40	519.45	519.48
Inflow	6003	3003	3003	3003	0	0	0	513	513	513	6871	17886	20792	20803	27885	35224
Out flow	6003	3003	3003	3003	29499	35000	7291	513	513	513	1003	8106	11023	11023	18105	29356

Sept 2017

Date	1	2	3	4	5	6	7	8	9	10	11	12**	13	14	15
Water level	519.59	519.59	519.59	519.59	519.59	519.59	519.59	519.59	519.59	519.59	519.59	519.59	519.59	519.59	519.59
Inflow	56879	53333	32730	19023	19023	13106	6023	6023	11023	11023	11023	11023	12023	10523	25314
Out flow	34773	53333	32730	19023	19023	13106	6023	6023	6023	11023	11023	11023	12023	10523	25314

Date	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Water level	519.59	519.59	519.59	519.59	519.59	519.59	519.57	519.51	519.59	519.58	519.58	519.58	519.60	519.60	519.60
Inflow	45000	33413	36746	25080	25080	47669	99822	121316	88497	52535	41250	23217	13580	16804	431413
Out flow	45000	33413	36746	25080	25080	47669	106824	133572	84435	54560	41250	18333	13580	16804	43413

Oct 2017

Date	1	2	3	4	5	6	7	8	9	10	11	12**	13	14	15
Water level	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60
Inflow	54089	36582	27788	267.384	217871	18080	14080	17955	44246	25080	35080	24038	45080	30080	23830
Out flow	54089	36582	27788	35080	21871	18080	14080	17955	44246	25080	35080	24038	45080	30080	23830

Date	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Water level	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60
Inflow	78363	90125	66351	29246	13080	13925	15080	14037	13080	13080	9412	5080	5080	5080	5080	5080
Out flow	78363	90125	66351	29246	13080	13925	15080	14037	13080	13080	9412	5080	5080	5080	5080	5080

Aug 2018

Date	1	2	3	4	5	6	7	8	9	10	11	12**	13	14	15
Water level	519.520	519.6	519.60	519.6	519.600	519.6	519.6	519.6	519.600	519.600	519.600	519.600	519.600	519.600	519.580
Inflow	17162	23806	12900	17567	27482	24857	28608	45900	30900	30900	30900	30900	35900	54920	95136
Out flow	3400	6733	12900	17566	27482	24857	28608	45900	30900	30900	30900	30900	35900	54920	100020

Date	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Water level (m)	519.5	519.4	519.4	519.4	519.5	519.4	519.4	519.3	519.30	519.3	519.6	519.6	519.6	519.58	519.6	519.5
Inflow (m^3/s)	103393	127216	139703	126814	128438	154095	163160	145566	128770	124914	123550	126029	91000	64095	111741	136100
Out flow (m^3/s)	119563	142865	143615	128770	122569	159963	163160	163160	128770	93630	105656	136099	90900	64095	115803	136100

Sept 2018

Date	1	2	3	4	5	6	7	8	9	10	11	12**	13	14	15
Water level	519.50	519.600	519.600	519.600	519.600	519.600	519.600	519.600	519.600	519.600	519.600	519.600	519.600	519.590	519.580
Inflow	87805	55762	28399	40900	28817	30900	23400	20900	18900	18900	18400	10108	900	0	0
Out flow	87805	34707	28399	40900	28817	30900	23400	20899	18900	18900	18400	10108	900	2336	2336

Date	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Water level	519.530	519.460	519.390	519.320	519.250	519.180	519.110	519.040	518.970	518.900	518.830	518.760	518.760	518.760	518.710
Inflow	0	0	0	0	0	0	0	0	0	0	0	0	12624	12624	3573
Out flow	2336	13942	13692	13680	13692	13508	13171	13171	13171	13171	12624	12624	12624	12624	12624

July 2019

Date	1	2	3	4	5	6	7	8	9	10	11	12**	13	14	15
Water level	507.920	507.910	508.910	509.150	509.920	510.480	511.150	511.850	512.700	513.800	514.900	515.850	516.700	517.300	517.850
Inflow	0	0	16876	40092	40732	32190	41623	47302	69810	94597	104290	106582	109337	114035	111560
Out flow	416	405	98	98	98	98	98	98	6850	4921	98	128	5628	28253	33128

Date	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Water level	518.15	518.35	518.50	518.80	518.82	518.93	519.00	519.08	519.12	519.18	519.24	519.34	519.35	519.27	519.20	518.90
Inflow	82808	57083	46239	42883	26299	19155	13311	15174	7662	11413	11679	22595	29159	76305	102752	56447
Out flow	33128	33128	22836	20128	10962	962	128	128	128	128	128	3045	27203	91942	117336	176297

Aug 2019

Date	1	2	3	4	5	6	7	8	9	10	11	12**	13	14	15
Water level	518.550	518..41	518.310	518.150	517.880	517.650	517.260	517.100	517.080	517.300	517.700	518.240	518.480	518.550	518.420
Inflow	150409	205832	222113	222543	245252	279332	362875	367318	349526	571111	600049	603041	609081	588745	583701
Out flow	213453	230149	239520	249823	290116	316022	390072	390072	390072	530991	544784	540991	570000	570991	560991

Date	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Water level	518.27	518.27	518.50	519.15	519.20	519.40	519.50	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60
Inflow	489730	456407	386226	182240	150991	45064	20551	23711	17491	23991	10991	10991	10991	11991	15991	12825
Out flow	520991	456407	346261	182240	150991	5991	991	2658	12431	23931	10931	10901	10931	11991	15991	12825

Sept 2019

Date	1	2	3	4	5	6	7	8	9	10	11	12**	13	14	15
Water level m	519.600	519.600	519.600	519.600	519.350	518.75	518.34	518.43	518.10	517.90	518.78	519.20	519.20	519.17	519.59
Inflow M^3/s	6991	14491	26158	60283	109366	69920	106674	155850	171740	180343	223777	210119	206366	160489	113122
Out flow M^3/s	6991	14491	26158	60283	109366	174812	144313	174991	228407	213491	71741	131949	206366	165199	30657

Date	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Water level	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.60	519.58	519.59	519.60	519.60
Inflow	39350	62991	59491	34324	28075	40991	31824	28698	16826	22657	57741	123272	85785	39081	38991
Out flow	36491	62991	59491	34324	28075	40991	31824	28698	16826	22657	57741	128157	83991	35991	38991

Oct 2019

Date	1	2	3	4	5	6	7	8	9	10	11	12**	13	14	15
Water level	519.600	519.600	519.600	519.600	519.600	519.600	519.600	519.600	519.600	519.600	519.600	519.600	519.600	519.600	519.600
Inflow	20991	20991	27657	15991	19532	19532	32990	54491	23991	21823	30991	42324	55241	26408	30991
Out flow	20991	20991	27657	15991	19532	19532	32990	54491	23991	21823	30991	42324	55241	26408	30991

Date	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Water level	519.60	519.60	519.60	519.60	519.60	519.60	519.54	519.39	519.18	519.30	519.40	519.54	519.55	519.57	519.60	519.60
Inflow	30991	21824	15991	15991	25991	30991	156407	209406	203770	143629	107835	67901	61004	56930	31718	25298
Out flow	30991	21824	15991	15991	25991	30991	156407	240991	244464	122299	90298	40298	60420.137	51548	24797	25298

Table 3 Annual average rain fall (mm) over the bridge site

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2011	0	0	0	30	28	146	66.5	136	135	55.7	0	0	596
2012	0	0	0	48	0	17	7	40	19.4	2.1	21	0	154
2013	0	0	0	0	45	36	108	3.2	145	54.3	0	0	391
2014	0	0	21	10	83	20	31.6	187	135	30	0	4.2	522
2015	0	0	24	50	0	29	2	47	0	20.9	0	0	174
2016	0	0	0	90	4	118	86.4	46	179	8.2	0	0	531
2017	0	0	5	0	42	26	0	12	273	172	0	0	530
2018	0	0	0	0	14	66	76.2	37	12.3	4.2	0	0	210
2019	0	0	0	22	11	76	39.2	27	90.2	70.8	6	0	343
2020	0	0	0	5	8	33	39.2	72	95.8	87.8	0	0	341
2021	0	0	0	0	67	78	100	10	44.8	49.8	34	0	384
Total	0	0	5	23	27	59	50.6	56	103	50.6	6	0.4	

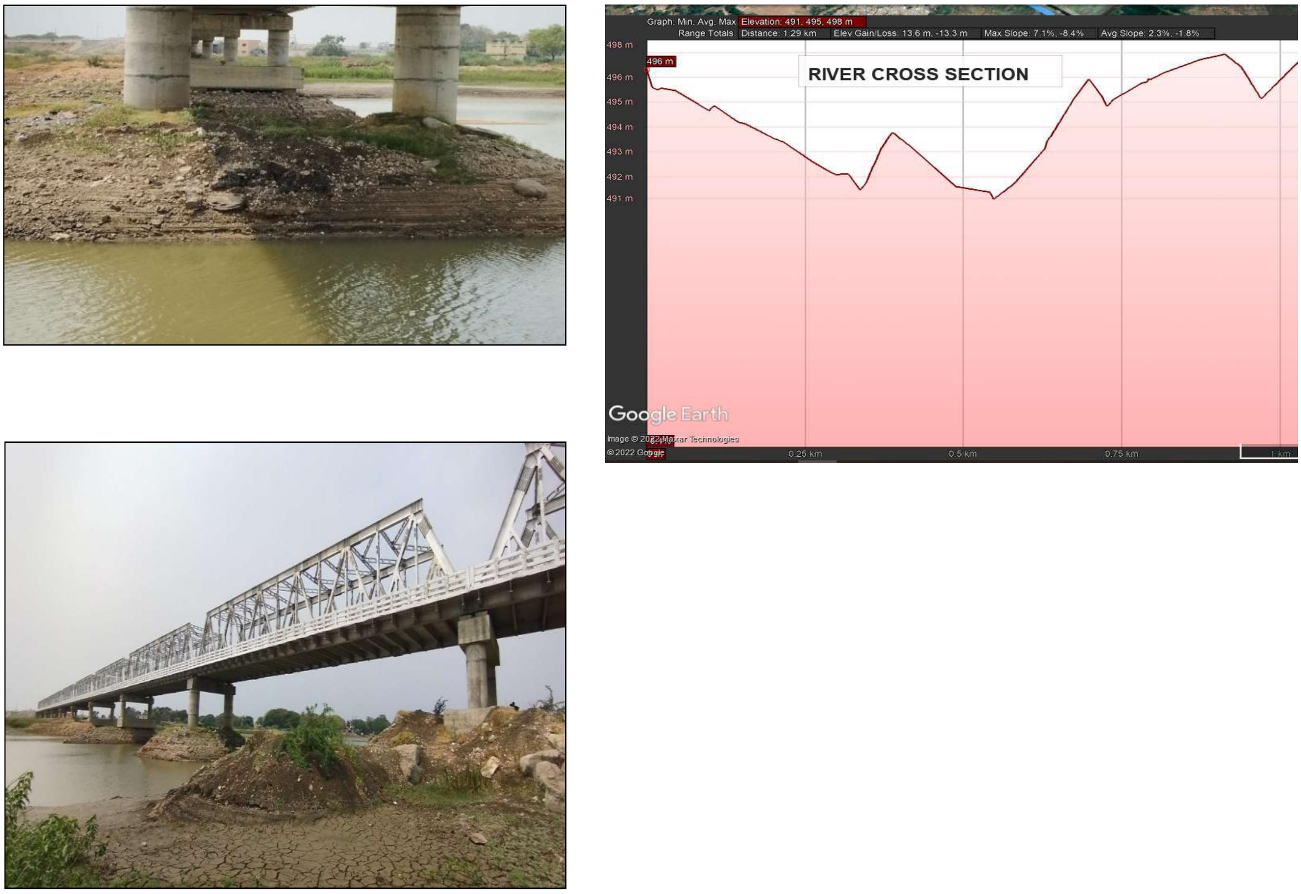


Fig.3 Kudalasangam-Adavihal Bridge

Waterway

Several States in the country, which have been constructing submersible structures for a longtime, have their own practices with regard to the permissible constriction, based on their experience and site conditions prevailing in the respective States. These practices may vary from State to State

For low level submersible structures like causeways, provide a vent area of about 40 per cent but not less than 30 per cent of the unobstructed area of the stream measured between the proposed road top level and the stream bed. In scanty rainfall areas where annual rainfall is less than 600 mm, the vent area can be reduced up to 20 per cent to 30 per cent of unobstructed area. However, the available area of flow under design HFL condition should always be at least 70 per cent of the unobstructed area of flow between the design HFL and the stream bed i.e. the obstruction under design HFL condition should not be more than 30 per cent**.** For submersible bridges, which would generally be provided with relatively higher road top level, the available area of flow under the structure should not be less than 70 per cent of the unobstructed area of the stream measured between the stream bed profile and the proposed road top level. (IRC: SP: 82-2008)

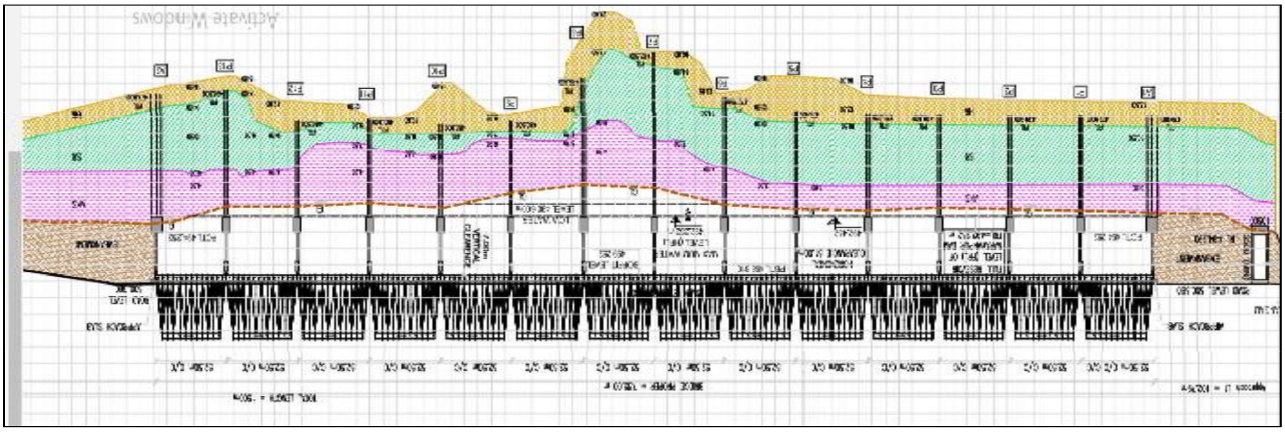


Fig.4 Longitudinal section of existing bridge at Kudalasangam-Adavihal

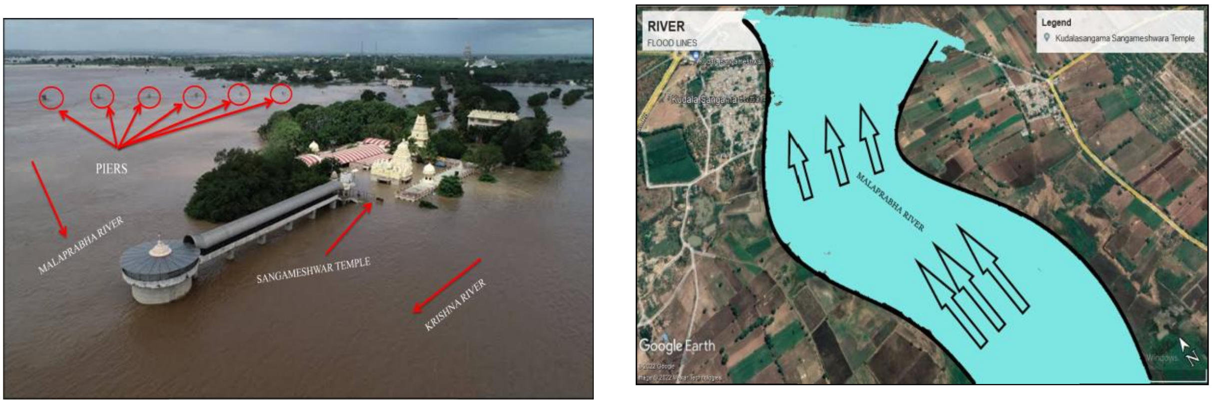


Fig. 5 Inundation area during 2019 flood

Fig. 5A- Photo of Waterspread Area near Advihal Bridge

4.0 Results and Discussions:

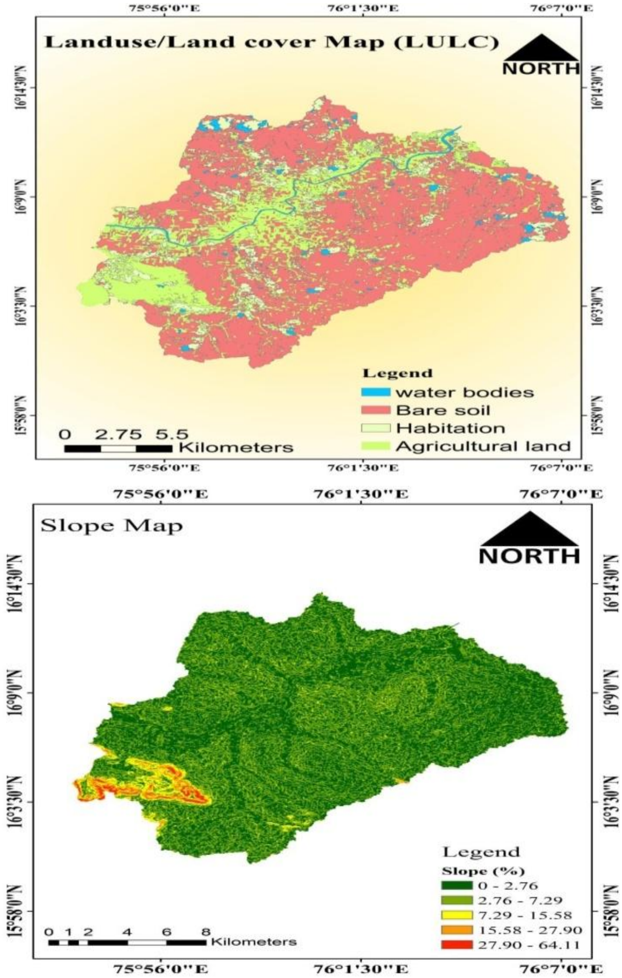


Fig. 6 LU/LC and Slope Maps

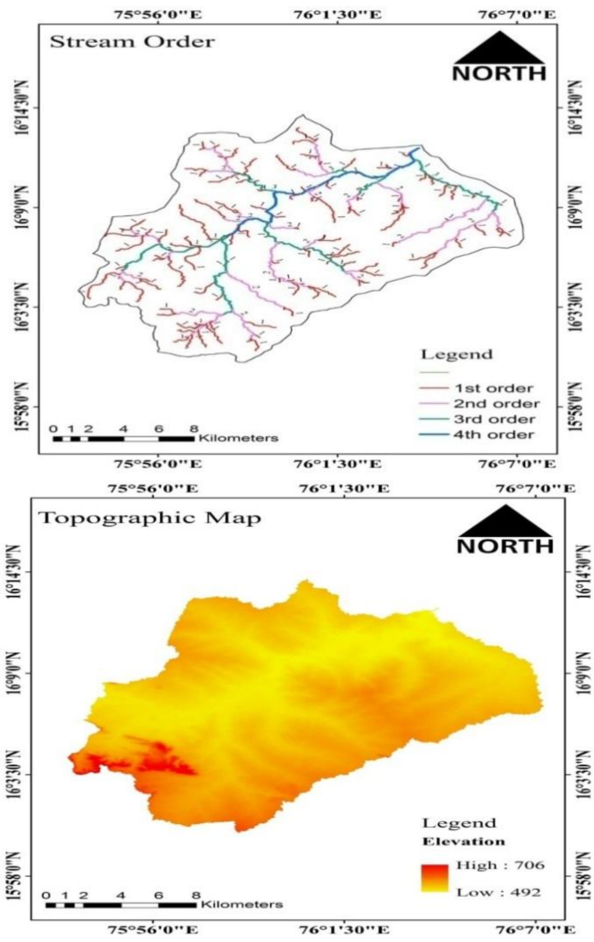


Fig. 7- Stream Order and Elevation Maps

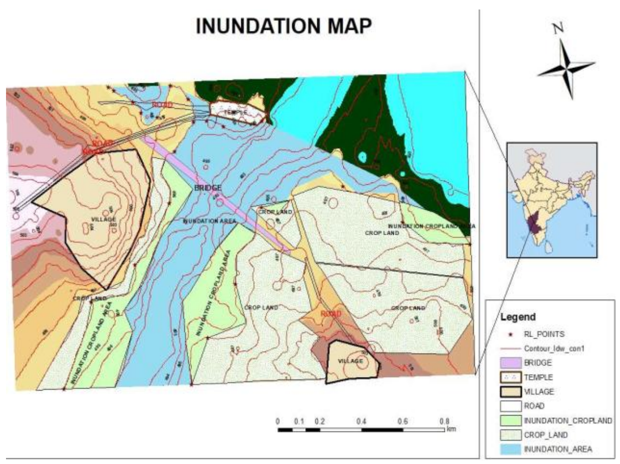


Fig. 8- Inundation Maps

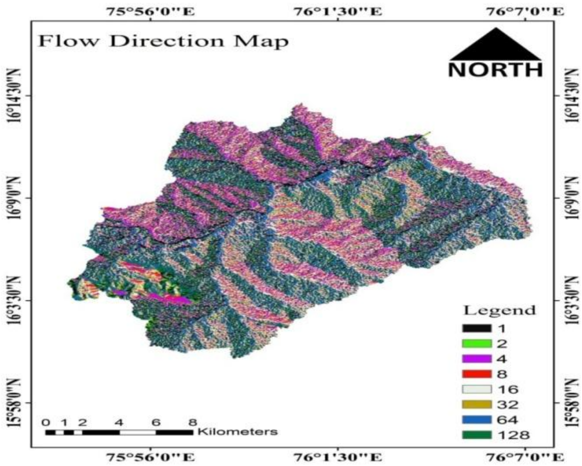


Fig. 9 Map of LULC, Slope, Stream order, Topography, Inundation, Flow direction during 2019 flood

Table 4 Susceptibility Ranges and Ratings

Parameters	Units	Rates	Susceptibility Ranges and Ratings	Susceptibility Class Ratings
LULC	Level	Water Bodies	Very high	5
		Agriculture	High	4
		Urban	Moderate	3
		Bare land	Low	2
		Forest	Very low	1
Slope	%	0-2.76	Very high	5
		2.76-7.29	High	4
		7.29-15.58	Moderate	3
		15.58-27.90	Low	2
		27.90-64.11	Very low	1
Topographic map	Scale	706	High	2
		492	Low	1
Stream order	Level	1st order	Low	1
		2nd order	Medium	2
		3rd order	High	3
		4th order	Very high	4
Flow Direction			East	1
			South East	2
			South	4
			South West	8
			West	16
			North West	32

			North West	64
			North East	128

The soil test results shows that the MDD of soil is 1.48 gm/cc OMC is 29.85% C and ϕ Values are 10.75Kg/cm^2 and 26' respectively,

Table 5 Perimeter and inundation area of Kudalsangam and Adavihal village

Sl .No	Perimeter (m)	Area (m^2)	Inundation
1	2,660	2,39,926	Village (Kudala sangam and Adavihal village)
2	34,582	5,549	Road (Kudala sangam village)
3	9,318	1,124	Road (Adavihal village)
4	10,297	10,42,626	Crop land
5	649	19,579	Kudala sangam temple
6	5,713	2,73,798	Inundation of crop land
7	7,045	8,24,999	Submerged area
Total	70,262	24,07,600	

4.1 Discharge in the river:

N = Rugosity co-efficient (Table-5.1; IRC: SP 13-2004)
Bed slope for Bed Material–Boulders, Gravel and sand (IRC 89-1997)

$$Q = A \times V \ldots\ldots\ldots\ldots\ldots.. (1)$$

Wetted perimeter: 1000 m
- Cross section area: 2750 m^2
- Bed slope: 1/100

$$Q = \frac{A*1.485 \times R^{2/3} \times S^{1/2}}{N} \ldots\ldots\ldots\ldots\ldots (2)$$

$$Q = 22,909.11 \ m^3/sec$$

Vent way calculation:
Lacey's equation:

$$Pw = 1.811C\sqrt{Q} \ldots\ldots\ldots\ldots\ldots (3)$$

$$= 1.811X3.5X\sqrt{22,909.11} \quad Pw = 959.38 \ m$$

$$Dsm = 1.34 \times [\mathbf{Db^2Kf}]^{1/3} \ldots\ldots\ldots\ldots (4)$$

Silt factor: $Kf = 1.76\sqrt{M}$
Db =Discharge/Length of bridge including approaches

Table 6 Comparison between existing and proposed parameters

Component	Length of bridge	Vent way (m)	Vertical clearance (m)	No. of piers	Water way (m)	Soffit Level (m)	Low water level (m)	Horizontal clearance (m)
Existing (m)	735	702	7	13	735	499	491	51
Proposed(m)	998	959	7	18	959	503	494	51

During heavy flood on 2019 the flood level raised up to 496m from existing HFL 492.252, which cause the flood inundating the surrounding areas of bridge abutments such as village, crop land, road, Kudalasangam temple.
The velocity of flow in Krishna River and Malaprabha River are 7.76 m/sec and 4.80

m/sec respectively during normal flow, where as the velocity flow increases to 9.68 m/sec, and 8.33 m/sec during flood

The soil samples were collected at random locations at approximately 10m interval, for a distance of 500m upstream and downstream sides of the bridge site. These soil samples were extracted from core cutter method and maximum dry density (mdd) test was conducted using procter method, specific gravity by pycnometer method and sieve analysis and also Unconfined compression strength test was carried out to find C and Φ. The testing of soil (angle of shearing resistance, (ϕ) in degrees = 26 and, cohesion intercept in kg/cm^2 or = 11.07 N/cm^2) which is accumulated from catchment below the bridge site shows that the silt is having less cohesion and easily flows and accumulated below the bridge causes flooding to the nearby area. The total quantity of silt accumulated at river bed is approximately 7,172.57 tones.

5.0 Conclusions

The Hydraulic design of the bridge is done based on HFL at 492.252 m with vent way 735 m but during heavy flood the HFL of the river Malaprabha flood is raised to 496m which causes flooding of the surrounding area, due to insufficient vent way. Velocity of flow in Krishna River is more compare to Malaprabha River hence the flow at conflict point is less which may results the accumulation of siltation below the bridge. The present provision of vent way is insufficient, likely to cause more backwater effect due to construction of Narayanapur Dam and flood in the Malaprabha river, Hence there is a need for increase of vent way of the bridge keeping the as HFL 496 m

The report is submitted to government of Karnataka to increase the water way under the bridge the same is under consideration

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