ISSN No. 2456-0472
The Engineering Journal of Application & Scopes, Volume 3, Issue 1, May 2018

PLANNING AND DESIGNING OF BRIDGE OVER SOLANI RIVER

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Abstract: As the need of this bridge is to overcome the traffic, we feel that there is urgent need for the construction of a new bridge over Solani River. The construction has to be economic and aesthetic as well. As we have observed the increase in traffic volume over the years and our analysis of the traffic volume study there is an urgent requirement of double lane bridge. Hence we are designing a plate girder bridge which is suitable for short and medium span.

Designing of the bridge is to be done keeping in mind the traffic volume, river bed condition, flow of river and other factors related to bridge construction.

Bridge is structure which provides passage over a road, railway or other service is carried over an obstacle such as a river, valley and other road or railway line, either with no intermediate support or with only a limited number of supports at convenient locations. Strength, safety and economy are the three key features that cannot be neglected before the finalization of types of bridges. While deciding the types of bridge, spans and other parameters are to be studied carefully to meet out the need of suitability to site conditions. The scope of this project is to confine to the design aspect related to variable parameters. Depth of web, thickness of web, width of flange and span of bridges are the variable parameters considered during the design of Plate Girder Bridge. The use of steel often helps the designer to select proportions that are aesthetically pleasing. Structural steels have high strength, ductility and strength to weight ratio. Thus it has become the obvious choice for long span bridges as steel is more efficient and economic. Among the various types of bridges plate girder bridges, truss bridges and box amount girder bridges are more commonly used. As the cost of steel is rising we have to reduce the quantity of steel used without affecting the strength of section. In this thesis a plate girder bridge is designed as per the Limit state method using theIRC-6, IRC-8, IRC-21, IRC-24, IS 800:2007, IS-875(II), IS-1893Part-I and analysed by Bentley STAAD.PRO vi8.Design calculations are carried out for simply supported single span. Seismic and wind effect is also taken in to account at design stage. To clarify the design procedure and the current state of practice, a comprehensive literature search and survey were conducted. Recommendations pertaining to best practices for planning, design, and construction activities, as well as applications and limitations are also provided. Based on the design results, conclusions are arrived at to know the behaviour of plate girder bridges when designed using Indian code.

Keywords: Steel bridges, design comparison, Welded Plate Girder, Indian Road Congress

I. INTRODUCTION

In 1840 Proby Thomas Cautley, English engineer reported on the proposed Ganges canal, for the irrigation of the country between the rivers Ganges. Hindan and Yamuna – then called the Jumna, which was his most important work. Digging of the canal began in April 1842.

The dam was faced with many complications – among them was the problem of the mountainous streams that threatened the canal. Near Roorkee, the land fell away sharply and Cautley had to build an aqueduct to carry the canal for half a kilometre. As a result, at Roorkee the canal is 25 metres higher than the original river.

When the canal formally opened on 8 April 1854, its main channel was 348 miles (560 km) long, its branches 306 miles (492 km) long and the various tributaries over 3,000 miles (4,800 km) long, Over 767,000 acres (3,100 km^2) in 5,000 villages were irrigated.

77.48^oE, 29.45^0N & 78.03^0E, 22.55^0N and an average elevation of 268 m above mean sea level. Average rainfall of the area is 1,170 mm and the temperature varies approximately from 1^oC in winter till 45^oC in summer. Texture of soil influences the infiltration, surface runoff, evapotranspiration, inter flow, and aquifer recharge.

Study indicates that the type of soiling the catchment area is low an average proportion of 50-55% of sand, 35-42 % Silt and 8-15% Clay.

Solani River is a seasonal tribute of the Ganges River. Besides Solani River, a few other seasonal stream are also present name as Ratmau and Pathri Rao, originating from Shivalik hills (lower Himalayan mountains range).

The Solani River, a discontinuous stream was crossed on a radiant curve water passage ornamented with lions and with methodology dikes more than 2 miles in length.

II. DEFINITION

A bridge is a structural member which provides passage which provides passage over any obstacle without blocking the way. This passage is used for road, railway or a canal. Commonly there are six types of bridge:

- Beam bridge
- Truss bridge
- Arch bridge
- Suspension bridge
- Cable-stayed bridge
- Cantilever bridge

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Components of bridge
The main parts of bridge are:
a) Deck slab, girder, truss(parts of decking)
b) Bearing
c) Abutment and piers
d) Foundation for abutments and piers
e) River training works
f) Approaches to the bridge to connect the bridge proper to the roads on either side
g) Hand rails, parapet and guard stones

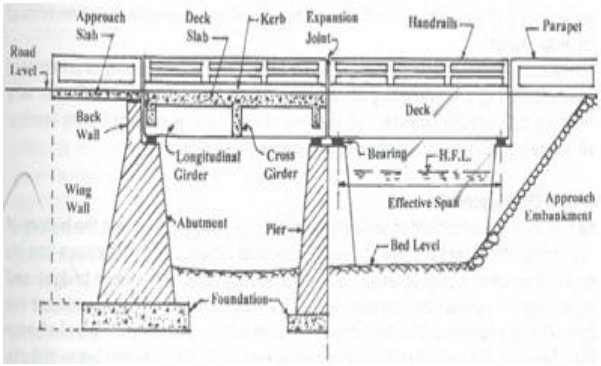

Fig 1: Components of a bridge [10]

Substructure: The component of a bridge which is below the bearing and above the foundation is substructure.
Superstructure: The component of a bridge which is above the level of bearings is superstructure.
Foundation: The portion below the bed level of a river bridge is called foundation.

III. CLASSIFICATION OF BRIDGE

1. According to form or type of superstructure :
- Slab bridge
- Beam bridge
- Truss bridge
- Arch bridge
- Cable stayed bridge
- Suspension bridge

2. According to material of construction of superstructure:
- Timber bridge
- Concrete bridge
- Stone bridge
- RCC bridge
- Steel bridge
- PCC bridge
- Composite bridge
- Aluminium bridge

3. According to inter span relationship:
- Simply supported bridge
- Cantilever bridge
- Continuous bridge

4. According to length of bridge:
- Culvert bridge (less than 6 m)
- Minor bridge (6 m to 60 m)
- Major bridge (60 m to 120 m)
- Long span bridge (more than 120 m)

5. According to anticipated type of service and duration of use:
- Temporary bridge
- Permanent bridge
- Military purpose bridge

IV. PLATE GIRDER BRIDGE

We are selecting plate Girder Bridge as these are suitable for short and medium span. These support railroads, highways, and other traffic.
Plate girders are I beam made up of structural steel plates. In some cases girders may also be of Z shaped. The depth of the girder should not be less than 1/15 of the span. Stresses on the flanges near the centre of the span are greater than near the end of the span hence the top and the bottom flange plate are reinforced in the middle portion of the span.
Spacing of piers between the abutments is dependent on the capacity of selected plate girder.
There is usually a choice available between:
a) Using two widely spaced longitudinal girders, with cross girder system supporting the deck.
b) Providing multiple longitudinal girders with small spacing.

Fig 2: Plate Girder Bridge

V. LITERATURE REVIEW

Cooke, et al. (1983) have studied the experimental behavior of four steel plate girder webs stiffenedeither transversely or transversely and longitudinally is considered.
Guarneri (1985) has presented extensive results of tests to collapse I-section plate girders with stiffeners at various angles of inclination, along with an analytical interpretation of the results, are presented.
Cynthia (1987) Plate girder design according to LRFD is very similar to the ASD method presented in the 8th Edition Manual of Steel Construction.
Takashi andTamakoshi (1988) The subjects of this research were non-composite and composite steel plate girder bridges,which were selected because they are the most common types of bridges in the country.

Philbrick, et al. (1995) have studied the behaviour of two through plate girder railway bridges and investigated to determine a better approach to fatigue assessment.

Bhatti and Gahtan (1995) Optimum design of plate girders subjected to Highway Bridge loading is presented in this paper. The formulation is capable of handling composite or non-composite designs, shored or unshared construction, stiffened or unstiffened design, symmetric or unsymmetrical cross-section, simple or continuous spans, and prismatic or no prismatic girders.

Lee, et al.(1998) have investigated Nonlinear analyses on three-dimensional finite element models of transverselystiffened plate girder web panels (without longitudinal stiffeners) subjected to pure shear, including the effects of initial out-of-flatness.

Sause, et al. (2001) have studied about the High Performance Steels (HPS) are providing new opportunities to design cost-effective steel bridges by exploiting the high strength, corrosion resistance, fracture toughness, and weld ability of HPS.

Itani, et al. (2004) has presented the recent earthquakes exposed the vulnerabilities of Steel Plate Girder Bridge when subjected to ground shaking and the behaviour of Steel Plate Girder Bridge during recent earthquakes such as Petrolia, Northridge, and Kobe.

Yail, et al. (2013) this paper has addressed an extensive parametric study on the flexural behaviour ofvarious steel I-girder bridges subjected to selected MLC trucks, including the rating of the bridges, based on validated 3-dimensional FEA models. A total of 144 load models were used to evaluate the load effects of the selected MLC trucks on 6 different bridge superstructures.

Kavitha, et al., (2015) project deals with the Design of a grade separator in an intersection. The location is at four roads junction at SALEM town, which is facing major traffic problems due to the construction. We have done a traffic survey and designed all the structural parts for this grade separator. The deck beam is designed as a cantilever on a pier. The Pier is designed for the axial dead load and live load from the slab, girders, deck beam.

Abid (2015), In this paper a detailed parametric design optimization of the main girder of box type is performed for a 150Ton capacity and 32m long span crane, after its basic design using available design rules. Design optimization is performed using detailed 3D finite element analysis by changing the number, shape and location of horizontal stiffeners along the length of the girder and number and location of stiffeners along the vertical direction to control any possible buckling, with minimum possible weight and for safe stress and deflection.

Ehab and Ellobody (2017) The nonlinear behaviour and design of double track open timber floor plate girder railway deck steel bridges under combined buckling modes have been investigated and reported. Most of the aforementioned parameters were not incorporated in current design rules and has been highlighted in this research.

Gi-Ha Eom, et al. (2017) the optimum cross-sectional design of the I-girder/concrete plate system was achieved. Then, a single20 m TO girder/plate system and two 20 m TO girder bridges were constructed and tested to evaluate their performance. From the test, failure behavior, load carrying capacity, crack pattern, etc., are obtained. The results are discussed in detail in this research.

Literature critiques

The thorough extensive study of the literature predicts that Plate Girder Bridge designed in India is maximum with only Simply Supported span. It is reviewed that cost of Simply Supported Span Bridge may be high as compare to Continuous span. Some others deficiencies are as follows:-

- It was found that the studies were made only keeping depth of web constant.
- Suitability of span based on variation of other parameters were not checked.
- Excel programs are not used in literature, which avails easy calculations with varying values.
- It is not tried to make a design aids spread sheet to overcome the problems.
- There is lack of verification of analytical calculation results with software simulation results in a single research paper.
- Detailed calculation and software implementation with standard multiplication factor is not found in literature, hence is taken as aim of present research.

VI. TOPOGRAPHICAL SURVEY

A topographic map is a type of map characterized by large scale detail and quantitative representation of relief, usually using contour lines in modern mapping, but historically using a variety of methods. Traditional definition requires a topographic map to show both natural and man-made features. A topographical map typically published as map series, made of two or more map sheets that combine to form a whole map. A contour line is a combination of two line segments that connect but do not intersect; these represent elevation on a topographic map. The study or discipline of topography, while intersected in relief, is actually a much broader field of study which takes into account all natural and man-made features of terrain.

Location of bridge

Coordinates: $29^{0}87^{'}93.93$”N $77^{0}90$’09.44”E
Elevation- 268meters (879ft)

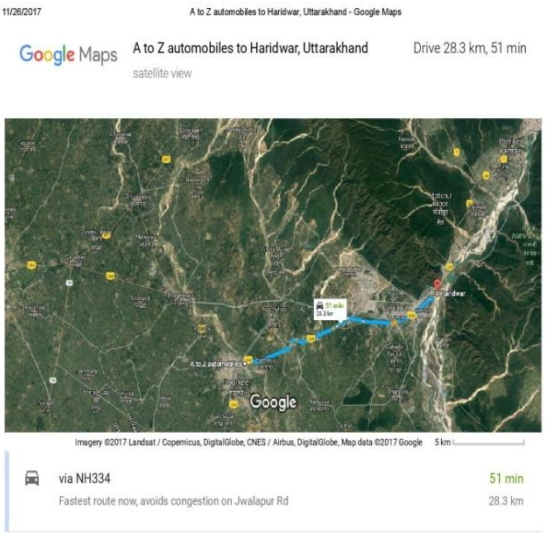

Fig 3: Satellite image of Solani River

Discharges in Solani River over 17 years:

Table 1: Discharge in Solani Riverover 17 years

S.NO	YEAR	DATE	DISCHARGE (m^3/year)
1.	2000	30.07.2000	13091
2.	2001	14.06.2001	7076
3.	2002	7.09.2002	6368
4.	2003	20.08.2003	5660
5.	2004	27.07.2004	7076
6.	2005	29.09.2005	4776
7.	2006	26.07.2006	1557
8.	2007	13.08.2007	6368
9.	2008	31.07.2008	16982
10.	2009	10.09.2009	14152
11.	2010	19.09.2010	8963
12.	2011	16.08.2011	12383
13.	2012	04.08.2012	3880
14.	2013	16.06.2013	19105
15.	2014	11.09.2014	5524
16.	2015	07.08.2015	9435
17.	2016	17.07.2016	5896
18.	2017	28.06.2017	10614

Note-Data is provided by NDGC ROORKEE
Average discharge taken for calculation is 8000cumecs

Regime cross-section
P=429.325 m
Hydraulics mean depth (R) =9.46 m
Cross sectional area, (A) =4114.36 m^2

Traffic study
Thetraffic in terms of cumulative number of standard exist (8160kg) to be carried by the pavement during the designed life.
Distribution of commercial traffic over the carriage way:
1) Single lane: design should be based on total number of commercial vehicle in both direction multiplied by two.
2) Two lane (single carriage way): 75% of the total number of commercial vehicle in both the directions.
3) Four lane (single carriageway): 40% of the total no. of commercial vehicle in both the directions.
4) Dual carriageway: 75% of the no. Of commercial vehicle in each direction.For dual 3 lane and dual 4 lane carriageway, the distribution factor will be 60% and 45% respectively.

Table 5: Traffic volume over existing Solani Bridge near Roorkee

Types of vehicle Direction ->	8-9 A.M		9-10 A.M		10-11 A.M	
	R-H	H-R	R-H	H-R	R-H	H-R
Car	372	350	304	229	236	250
Truck	50	43	54	26	63	38
Bus	92	88	67	52	53	62
HLV	45	24	32	09	37	27
Auto	17	04	08	20	15	10
2 wheeler	680	587	553	641	498	536

Note: Source- Self observed data (15/oct/2017)

- For car and auto
  Traffic intensity= 605 veh/hr
- For bus truck and tractor

Traffic intensity = 802.67 veh/hr

- For HLV and bullock cart

Traffic intensity = 58 veh/hr

- For 2-wheelers

Traffic intensity =582.5veh/hr

STAAD.PRO analysis:
STAAD or (STAAD.Pro) is a structural analysis and design computer program originally developed by Research Engineers International at YorbaLinda, CA in 1997. Design Bridge with new improved specifications are:

1) Bridge length = 225m
2) Span width = 10m
3) Length of each span = 45m
4) Number of span = 5m

Soil testing
Bridge construction is an expensive project,it is essential that all the necessary testsmay be conducted prior to the actual construction. These tests and investigations can reveal the bridge behavior under different dynamic loads. Computer aided design and testing are powerful tools that must be used to assist in the bridge design.

Moisture Content
a. Moisture Content of the soil where pier is to be constructed = 21.629%
b. Moisture Content of the soil where abutment is to be constructed = 12.170%

Specific Gravity
a. Specific Gravity of the soil where pier is to be constructed = 2.758
b. specific Gravity of the soil where abutments is to be constructed = 2.537

Liquid Limit Test
a. Liquid limit for piers corresponding to 25 blows as read from the flow curve = 24.6%
b. Liquid limit for piers corresponding to 25 blows as read from the flow curve = 26.2%

Proctor Compaction Test
a. The maximum dry density of the soil as obtained from graphwhere pier is to be constructed=1.592 gm/cm^3
The optimum moisture content of the soil as obtained from graph where pier is to be constructed = 19%
b. The maximum dry density of the soil as obtained from graph where pier is to be constructed=1.74 gm/cm^3
The optimum moisture content of the soil as obtained from graphwhere pier is to be constructed = 14%

V. REFERENCES

1. C. P Yadav, NDGC, (Gov. of India), Roorkee
2. http://www.iosrjournals.org/iosr-jmce/papers/vol14-issue6/Version-1/A1406010108.pdf
3. Cooke, N., Moss, P.J., Walpole, W. R., Langdon, D. W., and Harvey M. H. (1983), "Strength and Serviceability of

Steel Girder Webs". Journal of Structural Engineering pp 785-807.
4. Guarneri, G. (1985). ”Collapse of Plate Girders with Inclined Stiffeners.”
5.Gi-Ha Eom, et al. (2017) Design Optimization and Structural Performance Evaluation of Plate Girder Bridge Constructed Using a Turn-Over Process, Materials, 10, 283; doi:10.3390/ma10030283.
6. Kavitha.N, et al., (2015), Analysis and Design of Flyover, National Conference on Research Advances in Communication, Computation, Electrical Science and Structures, NCRACCESS.
7. M. Abid, (2015), Design Optimization of Box Type Girder of an Overhead Crane, IJST, Transactions of Mechanical Engineering, Vol. 39, No. M1, pp 101-112, Double Bridge.
8. M. Asghar Bhatti and A.S. Al-Gahtan, (1995) Optimum design of welded plate girders subjected to highway bridge loading, Transactions on the Built Environment vol 13, WIT Press, www.witpress.com, ISSN 1743-3509, pp225-232
9. Itani, A., Bruneau, M., Cardin, L., and Buckle, I. (2004). ”Seismic Behaviour of Steel Girder Bridge Superstructures.”
10. Victor Johnson D. “Essentials of Bridge Engineering, oxford and IBH publishers
11. T.R. Jagadeesh “Design of bridge structure”, 2nd edition PHI Learning Private Ltd.
12.https://www.google.co.in/imgres?imgurl=https://water.usgs.gov/edu/images/strea mflow2
13. http://www.engineeringcivil.com/the-ganges-canal.html
14. https://www.tripoto.com/places-to-visit/in-uttarakhand-india/solani-river
15. Gopal Ranjan, A.S.R Rao “Basic and Applied Soil Mechanics”, 2nd Edition, New Age International (P) Ltd.
16. “Soil Tests”. IS-2720:Part-3-1980,Part-6-1972 etc. <www.engineeringcivil.com><www.testsoil.com>
17. "3D Structural Analysis and Design Software - STAAD.Pro". *Bentley.com*. Retrieved 2016-07-27.