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Comparative Study for the Design of single span bridge using AASHTO LRFD and Indian Standard Method

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ABSTRACT : *This report summarizes the comparative design of a single-span Bridge using AASHTO LRFD Bridge Design Specification, Indian standard T beam girder Bridge specification and Deck slab (excluding girders). The writers address the differences in design philosophy, calculation procedures, and the resulting design. Foundation design and related geotechnical considerations are not considered. The single span bridge is studied for 10m The significant differences were:- 1)Increased shear Force in IS Method; 2) Increased amount of Concrete in the deck Portion in IS Method; and 3)Large amount of Reinforcement was calculated in case of IS Method. For the design of more than 25m span above results were reversed.The design using LRFD Method is far safer than IS method (with/without Girder) because of special provision for parapet wall along the bridge. Design procedures under the LRFD Specification tend to be more calculation-intensive. However, the added complexity of the LRFD Specification is counterbalanced by the consistency of the design philosophy and its ability to consider a variety of bridges.*

Keywords -AASTHO, Bridges, Girder, Load and resistance factor design, IS Method, Spans.

I. INTRODUCTION

The ASSHTO-LRFD Specification uses the word ‘‘extreme’’ to describe two different items. Article 3.4.1 refers to ‘‘Extreme Events,’’ i.e., extreme loading events (AASHTO 1998). The Specification requires checking the deck for vehicular collision with railing system at extreme event limit state. This signifies that, at this level of loading, damage to structural component is allowed and the goal is to prevent the collapse of any structural component. It does not necessarily imply that the placement of the vehicle on the curb or sidewalk is an extreme loading event per Article 3.4.1 (AASHTO 1998).Thus it is engineers judgment to decide whether the placement of the load on the curb or sidewalk should be included in Extreme Event II (Article 3.4.1) or whether it should be included in the service and strength limit states (e.g., Service I, Service III, or Strength I). Inclusion in Extreme Event II is appropriate if the recurrence interval associated with the event ‘‘is thought to exceed the design life’’ [2] (Article C3.4.1; AASHTO 1998). Strength I is appropriate if the load event occurs more frequently; i.e., it has a recurrence interval less than the service life of the structure. The LRFD approach is reasonable for railings and sidewalks that are installed after the deck is in place and can distribute loads from the exterior to the interior girders. Although permitted, this approach may not be reasonable for the diaphragms and the deck itself. Before the deck concrete is set, the concrete is in the plastic state and it cannot distribute these loads to the interior girders. Therefore these loads were not distributed between the interior and exterior girders in the LRFD design of the example bridge. The maximum positive moment typically takes place at approximately the center of each bay. The maximum bending moment varies depending on overhang length and the value of distribution of dead load[1].The Indian Standard code prescribe that the Deck slab should be designed for the worst case of either one of the L.R.C. Class AA tracked vehicle, one lane of Class AA wheeled vehicle or two lanes Class A load train. It is necessary to compute Live Load Bending Moment for all three cases and take greatest of them. Class AA wheeled vehicle for span less than 4m and Class AA tracked vehicle for span exceeding 4m. If shear is desired to be computed; Class AA wheeled vehicle is to be considered for span up to 6m and tracked vehicle beyond 6m. for single lane bridge.[3]the paper summarizes the changes in design procedure by LRFD Method and compares the results with Design using Indian Standard (with and without girder) for one way bridge deck with span 10m. The comparisons are presented in the order they were encountered in the design: general design considerations, followed by design of longitudinal girder, shear design of the girder, deck design, and abutment design. Foundation design and related geotechnical considerations are not included in this paper.

II. GENERAL DESIGN CONSIDERATIONS

2.1The LRFD design philosophy (Fig 1) provides a common framework for the design of structures made of steel, concrete, and other materials. However, the flexibility of this approach also increases the complexity of the process. In general, load and resistance design code is based on structure under rare failure conditions. It is not as readily applied to other design considerations such as deflections, serviceability, fatigue, or creep, where behavior is often governed by service loads, i.e., day-to-day loads and deflections. Because of this difference, there are limit states established specifically for pre stressed girder design.
2.2T-beam bridge is by far most commonly adopted type in span of 10-25 m. This is particularly important when the design loading consist of concentrated wheel load, such as Class 70 R or Class AA wheeled vehicles, to be placed in most unfavorable position. The concept of cross beam can be introduced to get reduced deflection and increasing ultimate load capacity.
2**.**3Reinforced Concrete deck slab(Fig. 2)b is economical up to depth of about 8m.However construction is comparative simpler due to easier fabrication of formwork and reinforcement and easy placing of concrete. Deck slab should be designed for the worst case of either one of the L.R.C. Class AA tracked vehicle, one lane of Class AA wheeled vehicle or two lanes Class A load train. It is necessary to compute Live Load Bending Moment for all three cases and take greatest of them.

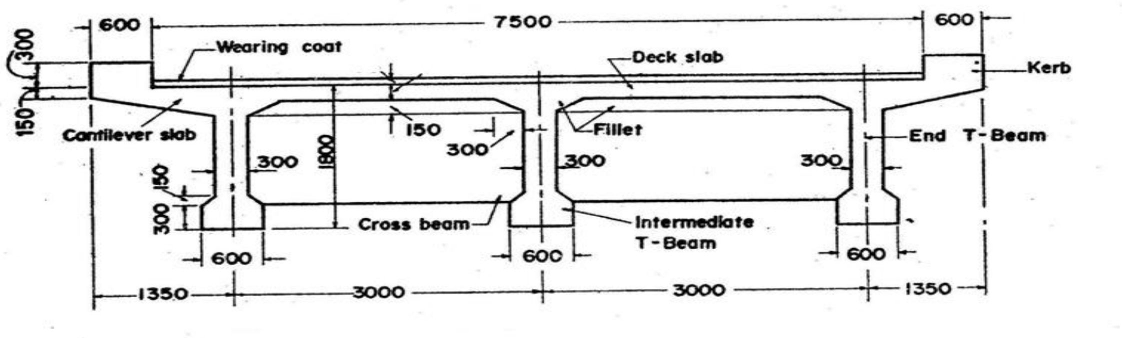

Fig.1: Basic design philosophy consideration for LRFD Method.

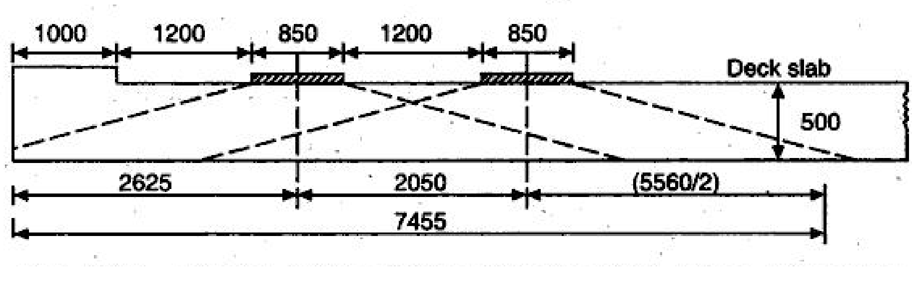

Fig. 2: Vehicular load consideration for IS Class AA Tracked vehicle.

III. DEAD LOAD, DL SHEAR FORCE COMPARISON

	Dead Load(Deck)	Dead Load(Wearing Coat)	Dead Load(Girder)	Total DL
LRFD Method	5.24(KN/m^2)	2.39(KN/m^2)		7.39(KN/m^2)
IS Method (without Girder)	21(KN/m^2)	1.76(KN/m^2)		22.36(KN/m^2)
IS Method(With Girder)	5.5(KN/m^2)	1.76(KN/m^2)	61.35(KN/m^2)	68.61(KN/m^2)

IV. PERMANENT DEAD LOADS

LRFD Specification Article 4.6.2.2.1 states that ‘‘where bridges meet the conditions specified herein, permanent loads *of* and on the deck *may* be distributed uniformly among the beams and/or stringers’’ [2](AASHTO 1998 emphasis added) The LRFD approach is reasonable for railings and sidewalks that are installed after the deck is in place and can distribute loads from the exterior to the interior girders. These loads were not distributed between the interiorand exterior girders in the LRFD design of the example bridge. A comparison on the dead loads for the LRFD design, Indian Standard Design with and without Girder is shown in Table 1. These results indicate that, compared with the Standard Specification design, the Indian Standard design(Without girder), which is suggested for span less than 8m, increases the non-composite dead Load by 66%. This result is incorporated with span less than 10m. For Longer span we found LRFD method is far better than the Indian Standard method. Also Results when compared with Indian Standard Design (with Girder) it is found that Permanent dead Load in case of LRFD is 88.22% less than that of Indian Standard Design (with girder).

V. VEHICULAR LIVE LOAD

For the AASHTO-LRFD Method of Deck analysis Minimum distance from the wheel to the adjacent parapet should be 1ft.Dynamic load allowance 33%.Load factor(Strength I) is 1.75 and multiple presence factor(Single lane) is to be taken as 1.20[4] . Live load effect for the LRFD(approximate method) may be determined by modeling deck slab on girders which has to be spaced by using specification from table SA4.1-1 from LRFD Code of bridge design. (Fig3)

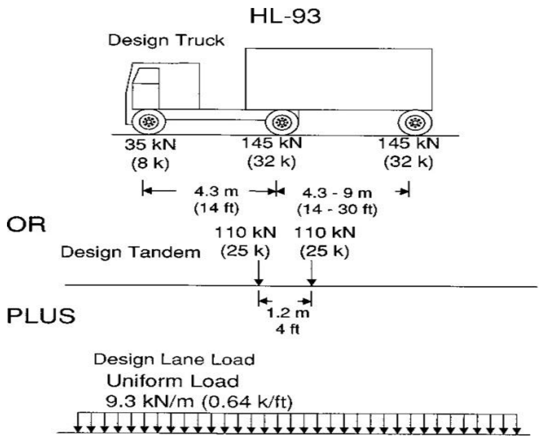

Fig. 3: Vehicular load consideration for LRFD Method.

For the Indian Standard Live load calculation Deck slab should be designed for the worst case of either one of the L.R.C. Class AA tracked vehicle, one lane of Class AA wheeled vehicle or two lanes Class A load train. It is necessary to compute Live Load Bending Moment for all three cases and take greatest of them. Class AA wheeled vehicle for span less than 4m and Class AA tracked vehicle for span exceeding 4m. If shear is desired to be computed; Class AA wheeled vehicle is to be considered for span up to 6m and tracked vehicle beyond 6m. for single lane bridge. (Fig 2)

VI. LOAD FACTOR

In the AASHTO LRFD design philosophy, the applied loads are factored by statistically calibrated load factors. In addition to these factors, one must be aware of two additional sets of factors which may further modify the applied loads. *STable 3.4.1-1,STable 3.4.1-2*The first set of additional factors applies to all force effects and is represented by the Greek letter η (eta) in the Specifications. These factors are related to the ductility, redundancy, and operational importance of the structure. A single, combined eta is required for every structure. These factors and their application are discussed in detail in Design Step 1.1. In this design example, all eta factors are taken equal to one. *S1.3.2.1* The other set of factors mentioned in the first paragraph above applies only to the live load force effects and are dependent upon the number of loaded lanes. These factors are termed multiple presence factors by the Specifications. These factors for this bridge are shown as follows: *STable 3.6.1.1.2-1* loads factor can now be factored by the appropriate load factors and combined to determine the governing limit states in the pier cap, column, footing and piles

1. There is no provision of Load Factor in Indian Standard code.

VII. SLAB DESIGN

For bridge design[7] (span 10m, carriage width 7.5m, wearing Course 80mm width of bearing 400mm, kerb 600mm, grade of concrete M-20, grade of steel Fe-415). The LRFD-based design requires #5 at 145 mm spacing as Transverse reinforcement, #6 bars at 140mm spacing in top layer and #6 at 210 mm spacing also #5 at 210 mm spacing for bottom distribution reinforcement (all bars are of 16 mm diameter). Using Indian standard (with girder) Method reinforcement required was 16mm diameter bars at 190 mm spacing as main reinforcement, 8mm diameter bars at 170 mm spacing.16mm diameter bars at 200 mm spacing for design bending moment in longer span, also for T Beam 8 number of 32mm diameter bars provided in 2 rows, 3 bars of 36mm are bent at support to take up the shear stress at support and 8mm diameter 2 legged stirrup with spacing of 250mm. (Fig5,6)The Large difference in both designs are found because in IS Method it has been distinguish the design method for bridge span less than 8m also it was observed that the bridge design for span 10m was safe in case if designed without considering Girders.

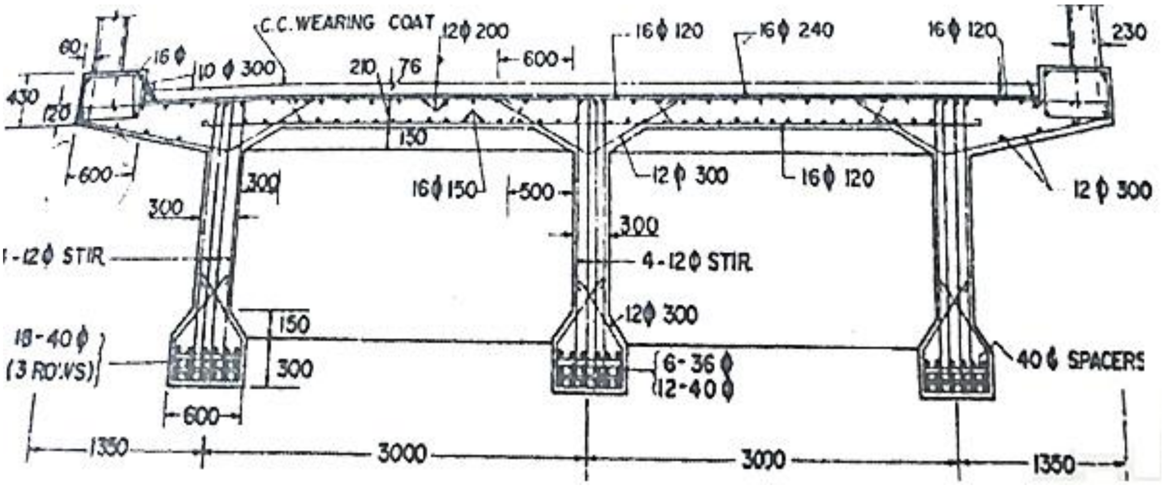

Fig 5 Deck Reinforcement at mid span of Girder (IS Method)

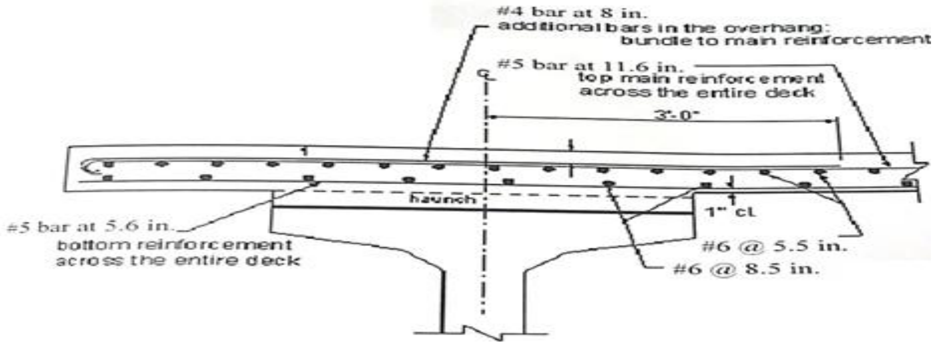

Fig 6 Cross section at mid span (LRFD Method)

VIII. CONCLUSION

Method	Reinforcement (Kg)		Concrete (Cum)		Wearing Course (mm)
	Deck	Girder	Deck	Girder	
Solid Deck Slab	5095.31	N/A	75	N/A	81.75
T - Girder	3220.02	3392.6	20.86	16.48	81.75
LRFD	3555.4	-	19.91	-	81.75

As It is clearly visible from above comparison that LRFD Design Specification has found to be most economical of the two methods, Results shows reverse nature in case of larger span but LRFD is more safer even for larger span. Indian Standard code suggest that the bridges more than 8m span should be designed with Girders and it was found that for bridge span of 10m is safe in all checks even without Girders so It is needed to be revise the Indian standard code with one standard Design for all span bridge. For Bridges with larger span Author suggest that incorporation of bridge design in India also because it has a higher safety factor, more safety norms. The resulting procedure is significantly more complicated. In general, more load cases are considered, and in specific design equations more parameters are included. As a result, many of the design calculations can no longer be readily performed by hand; for these calculations, computer methods are preferred. With the help of software tools, LRFD design of this type of bridge is not excessively tedious Here Author has carried out Comparison for only RCC bridges which may further be extended up to Steel bridges and pre stressed bridges.

REFERENCES

[1] Richard J. Nielsen, M.ASCE, and Edwin R. Schmeckpeper, M.ASCE, Single-Span Prestressed Girder Bridge: LRFD Design and Comparison, journal of bridge engineering / January / February 2002
[2](AASHTO). (1996). AASHTO standard specification for highway bridges, 16th Ed., Washington, D.C.
[3] Indian Standard: 456-2000PLAIN AND REINFORCED CONCRETE - CODE OF PRACTICE, Bureau of Indian Standards, New Delhi
[4](AASHTO). (1994a). Guide specification for distribution of loads for highway bridges, Washington, D.C.
[5](AASHTO). (1998). AASHTO LRFD bridge design specification, 2^{nd} Ed., Washington, D.C.
[6]Barker, R. M., and Puckett, J. A. (1997). Design of highway bridges based on AASHTO LRFD bridge design specifications, Wiley, NewYork.
[7]D.J. Victor,Essentials of Bridge Engineering (Oxford and IBH, J.P. House New Delhi, 2007).
[8]IRC: 5, 6, 21, 24, 40-1998 Standard specification and code for practice for road Bridges, Indian Road Congress, 1998.