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Selection of Appropriate and Reliable Methods of Assessing Structure Bearing Capacity for Safe and Effective Operation of Highway Bridge System

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ABSTRACT

In order to select a suitable and effective bridge operating system and to ensure safety, the bearing capacity of structure components need to be estimated. This paper presents research results in terms of evaluating the bearing capacity of composite and non-composite steel bridges in the central Vietnam according to 22TCN 243-98 and AASHTO LRFR. The conditions and structural properties of several bridges were investigated. Analysis of the philosophy, sequence, content and conditions of the assessment was carried out. Based on the investigated database, evaluation of the bearing capacity was performed according to standards guide and requirements of each method. The analysis and comparison of received results clearly show that the LRFR approach is suitable and superior. Therefore, consideration should be given for it to be officially applied.

Keywords: *steel bridge, safety and reliability, structural assessment, load rating*

INTRODUCTION

Bridge systems on Vietnam's road network in general, especially on highways, play a critical role in the country's transportation infrastructure: they ensure the smooth flow of traffic, meet the demands of passenger and goods transport, and make a very important contribution to the social life.

Of Vietnam's entire road network of 224.480km (which includes national, provincial, district and urban roads), there are over 35,000 bridges, comprising a total length of 610,000m (Bala Sivakumar, 2005). The bridge system were constructed a long time ago, and, for many reasons, were designed and erected according to different standards and with different design philosophies and different management conditions. The quality of construction, maintenance and operation management, and the level of environmental impact were also different. So, throughout the entire road network, even in the regions, there is no uniformity in technical status or load capacity.

After service time or regular maintenance (approximately 20-40 years), most of the existing bridges were damaged and degraded and regular maintenance and repair work do not meet the growing demand of transport. Based on the recent testing result, there are many bridges with a low allowance load of 13T; 18T, 20T, etc (Statistics Conditions Highway Bridge on Road Management Zone IV, 2009). The lenient standards for overloaded vehicles on bridges resulted in an increase of damage, degradation and even posed risk of collapse. Moreover, the load limitation that was set was not based on a clear foundation, was usually inappropriate, unclear and therefore, had a deleterious influence on the operation of vehicular and transportation enterprises.

The exploitation regime, including the contents as publication of the bridge load, the bridge load restrictions, the licensing and issues management in circulation for overloaded vehicles, heavy vehicles, etc mainly established on the basis of the results of rated load capacity of the structure.

The current evaluation method is based on 22TCN 243-98: *The standard of testing highway bridges* (Ministry of Transportation, 1998). The contents of evaluating bearing capacity according to this standard are essentially based on the design philosophy and contents of 22TCN 18-79: *Design standard of bridges and culverts in limited states* (Ministry of Transportation, 1979), the standard used in the former Soviet Union. In the category of highway bridges, the standard 22TCN 18-79 was no longer in use and was replaced by the current design standard: 22TCN 272-05 (Ministry of Transportation, 2005). Therefore, the assessment according to 22TCN 243-98 has many disadvantages, not only limitations and shortcomings in terms of evaluating philosophy and contents, but also difficulties in practical application.

In most states of the United States the assessment of bridges is based on the Load and Resistance Factor Rating, known as AASHTO LRFR. Many studies (Tran, 2004; Tran and Trinh, 2010; NCHRP Report 575, 2007; Bala Sivakumar, 2005) have clearly shown the advantages of the LRFR method: the received results consensus on the reliability index in all evaluated load cases and is consistent with the AASHTO LRFD bridge design specifications. Thus, in case of using AASHTO LRFD standards in design, researching and applying AASHTO LRFR is a critical requirement in bridge testing and evaluating in Vietnam.

THE FUNDAMENTAL METHODS OF EVALUATING THE LOAD CAPACITY OF BRIDGES

General

The evaluation of the load capacity of bridges, also known as bridge-loading assessment or load rating, is conducted according to the regulations and guidelines of the standard. It is necessary to update the status of the structural system as well as the service characteristics to match the actual load conditions and the provisions of the standards used for evaluation. There is a belief that the evaluation of bridges should be based on the original designed standard. Evaluation of old bridges in Vietnam and other countries has shown that such understanding is superficial and inconsistent. In principle, a standard can be used in its entirety to assess any structure if the structural characteristics and load are determined in accordance with the philosophy of assessment, using the corresponding checking conditions.

The following is a typical example: we still used 22TCN 243-98 to assess not only the load-bearing capacity for the bridge designed by 22TCN 18-79, but also for old bridges designed by other standards.

In this study, we have used 22TCN 243-98: the standard of testing highway bridge and assessment guidelines based on AASHTO LRFR method to assess some composite steel bridges in the central Vietnam (Road Management Zones IV&V).

Evaluation According to Testing Process of Highway Bridge 22TCN 243-98

Checking contents according to 22TCN 243-98, which is similar to 22TCN 18-79, are based on the design philosophy of the limit states. The condition that prevents the limit states from being applied is "Action must be smaller than Capacity". The general format of the checking equation is

$$\sum \beta_i n_i \left(1+\mu\right) S_i^{tc} \le mkR^{tc}\omega \qquad (1)$$

Where :

β_i	= combination factor
n_i	= load factors
$1+\mu$	= impact factor (only with live load)
S_i^{tc}	= nominal load effect
m	= factor of working condition
k	= factor of homogeneity of the material
R^{tc}	= nominal resistance of material
ω	= geometrical characteristics of the bearing section

In this paper, only checking contents of all parts of the main girder in composite steel bridge are considered. Particularly, with the load used to check, one has to ensure safety of the basis of such effects as: normal stress, shear stress and converted stress. Factored and standard internal forces are determined according to formulas of 22TCN 18-79 (Ministry of Transportation, 1979). Note that this understanding was not presented with any specific explanation. Therefore, in the case that the standard 22TCN 18-79 is no longer to be used in bridge design, the evaluation based on equation (1) becomes very difficult.

a. Normal stress checking:

$$\sigma = \frac{M_{tt}}{I_{tt}}.y \le R \qquad (2)$$

where: M_{tt} : Maximum factored bending moment
Itt: Moment of inertia of the section (without reduction section)
y: Distance from neutral axis to the considered point
R: Flexure strength

b. Shear stress checking:

$$\tau = \frac{Q_{tt}.S_{ng}}{I_{ng}.b}.y \le R_c \qquad (3)$$

where: Q_{tt}: Factored shear force
Sng: static moment of the net area from the neutral axis to the edge of the section
Ing: Net inertia moment of the section
b: width of section at neutral axis
Rc: Shear strength

c. Equivalent stress checking

$$\sigma_{td} = \sqrt{0,8\sigma^2 + 2,4\tau^2} \qquad (4)$$

where: σ: normal stress at checkpoint
τ : shear stress at checkpoint

d. Check the fatigue strength:

$$\sigma = \frac{M'}{I_{tt}}.y \le \gamma R \qquad (5)$$

where: M': moment at the point to check fatigue
γ : reduction coefficient for strength when considering fatigue.

The other checking contents are carried out following the guidance in the references by Ministry of Transportation (1979, 1998)

Evaluation According to Resistance and Load Factors Method (AASHTO LRFR)

Overview of AASHTO LRFR method

In 1989 AASHTO released a manual process for testing the load capacity of concrete bridges and steel bridges, prepared for the first version of the LRFR process. By using the method of reliability indicated in the instructions, the engineers realised that the calculation results were more convergent. However, at that time the United States still used the design method of load factor (LFD) and allowed stress (ASD), so the usage of LRFD is not a good selection for many US states.

In 1994, AASHTO published the inspection manual for bridges to replace the current survey and maintenance handbook. The new manual included new guidelines for load rating by allowing stress (ASR), but mainly focused on load rating by a load factor. Additionally, the bridge subcommittee of AASHTO has officially used the AASHTO LRFD standard for bridge design since 1994. Since that time, many US states have used all or parts of LRFD as a bridge design standard. Before the time of applying LRFD nationwide (2007), AASHTO recognised the need for developing further methods for LRFR and updated them to the inspection manual. For the process and research results, AASHTO issued a Guide Manual for condition Evaluation Load and Resistance Factor Rating (LRFR) of Highway bridges in 2003 (Manual 2003) (AASHTO, 2003).

The 2003 Manual focused on the LRFR method but also gave instructions for the loaded factor rating (LFR) and allowed the states to choose either. The manual includes many examples using LRFR methods. In addition, a few highlights are custom load factor for live load considered overweight live loads and new chapters on the evaluation of fatigue and non-destructive testing. The manual uses the philosophy of resistance and load factors that has been researched, analysed and evaluated as "including the content required to provide a more powerful, more flexible control strategy for bridges" (NHCRP, 2001; Bala Sivakumar, 2005).

Overview of load rating

Bridge design and load capacity assessment are somewhat similar in methodology and philosophy; however, they also contain some basic differences. In designing, the engineer works with an assumed loading that is wider than the load that the bridge has to be subjected to in the specific assessment conditions. On the other hand, when evaluating the bearing factor of a structure, the engineer has to work with the current real resistance (depending on status) of the bridge. Basically, the bridge evaluation relates to the determination of safety loading capacity. The owner conducts three kinds of load types for assessment: design loads, legal live loads and special loads.

Bridges are designed to handle a variety of vehicles, and they reflect the philosophy and design standards at the time the bridge was built. As standards of design and inspection are developed, the knowledge and experience of resistance, operations, and real loading of the bridge are continually updated. *Therefore despite whichever standard used in designing, for safety reasons, all bridges under consideration should be evaluated and tested with a view to current traffic conditions and, if possible, the latest standards.*

Testing and evaluating the bearing capacity of bridges for live loads is needed, especially for trucks exceeding the normal live loads. According to the Bureau of Transportation Statistics of America, due to the increasing demands of the use of trucks in industry, the load rating demand also increases. If oversized vehicles frequently use the bridge, the life of bridge will be shortened, or irreparable damage will result if no reasonable solution can be provided.

The capability of a bridge to carry loads is determined through the Load Rating process. The primary result of this process is the calculation a Rating Factor (RF) at controlling locations for each loading situation considered. A Rating Factor is simply the ratio of the available load capacity to the load produced by the vehicle that was considered. The Rating Factor is always associated with a particular live load, and is a useful tool for management of load restrictions.

The Rating factor should be greater than or equal to one (RF ≥ 1), which shows that the structure is safe to bear the load in question.

Evaluation flowchart of bridge based on AASHTO LRFR

The LRFR flowchart (Appendix A6A) illustrates the process of evaluating the bridge based on the LRFR approach (AASHTO, 2011). Strength limit state is the crucial factor for deciding the allowance loading of the bridge, whether the bridge should cease operations or needs to be repaired. Sometime, serviceability and fatigue limit states can apply to some bridges.

- When checking with live load HL-93, bridges with RF ≥ 1 are considered to satisfy load conditions with all live load of AASHTO (Type 3S2, Type 3-3) and each State.
- Bridges with RF <1 (for HL-93) will be evaluated with legal live loads of AASHTO or each State. If no satisfaction, bridges should be tested and limited load measures applied, or repairing and strengthening solutions implemented.

LRFR Equation and Factors

The Load and Resistance Factor Rating (LRFR) of a bridge accounts for both the physical condition of the bridge and the loadings. The Load and Resistance Factors recognise uncertainties in making judgments on the basis of strength, analysis and loading. The basic rating equation (MBE-2 6A.4.2.1-1) is shown as:

$$RF = \frac{C - \gamma_{DC}.DC - \gamma_{DW}.DW \pm \gamma_P.P}{\gamma_L.LL.(1+IM)} \qquad (6)$$

In the LRFR Rating Factor equation:

RF = Rating Factor

C = Capacity, nominal resistance of component in each limit state :
- In strength limit state : $C = \phi_c.\phi_s.\phi.R_n$ (with $\phi_c.\phi_s \geq 0,85$)
- In service limit state : $C = f_r$.

R_n = Nominal member resistance (as inspected)

DC = Dead load effect due to structural components and attachments

DW = Dead load effects due to wearing surface and utilities

P = Permanent loads other than dead loads (secondary prestressing effects, etc.)
LL = Live load effect of the Rating Vehicle
IM = Dynamic load allowance
γ_{DC} = LRFD load factor for structural components and attachments
γ_{DW} = LRFD load factor for wearing surfaces and utilities
γ_P = LRFD load factor for permanent loads other than dead loads
γ_L = Evaluation live load factor for the Rating Vehicle
Where:

ϕ_c = Condition Factor
- Structures in good conditions: $\phi_c = 1$
- Structures in average conditions : $\phi_c = 0,95$
- Structures in bad conditions: $\phi_c = 0,85$

ϕ_s= factor considering redundancy of system. None or little redundant structure will have low value of ϕ_s so load capacity will decrease.
- Redundant structure : $\phi_s = 1$
- Non-redundant structure : $\phi_s = 0,85$
- Steel girder bridge with bolt joint, truss bridge: $\phi_s = 0,9$

ϕ = AASHTO LRFD Resistance Factor

- When considering live load HL93 for RF ≥ 1, bridge ensure service capacity without evaluation for other legal load (Type 3, Type 3S2 or Type 3-3).
- When considering live load HL93 for RF < 1, bridge will be estimated load capacity based on legal loads or allowance loads.
- In case of evaluation for legal loads :
+ 0,3≤ RF <1: Determine limited load for bridge and posting load.
+ RF < 0,3: Stop of service

Limitation of posting load in bridge

According to AASHTO LRFR, bridges with RF<1 have to be limited to the posting load to ensure traffic safety. The posting load of the bridge is calculated as follows:

- If RF ≥ 1,0: Posting load = W x RF (7)
- If 0,3 < RF < 1,0: Posting load = $\frac{W}{0,7}.(RF - 0,3)$ (8)

W: Weight of vehicle used in bridge evaluation
- If RF < 0,3: Bridge should be stop using.

Load factors of AASHTO LRFR

- For design live load (HL-93): Load factors specified in Table 1

Table 1: Load factors for live load HL-93

No.	Limit state	Design load checking (Inventory Level)	Design load checking (Operating Level)
1	Strength	1.75	1,35
2	Service	1,30	1.00

- For other live loads of AASHTO: Load factors specified in Tables 2 and 3.

Table 2: Load factors for legal loads of AASHTO (Strength limit state)

No.	Limit state	Traffic flow (vehicles/day)	Load factor
1	Strength	> 5000	1.80
2	Strength	1000	1.60
3	Strength	< 100	1.40

Table 3: Load factors for legal load of AASHTO (Service limit state)

No.	Structure	Limit state	Load factor
1	Steel	Service	1.30
2	Prestressed concrete	Service	1.00

- For other permanent loads: load factors specified in Table 4.

Table 4: Load factor for other legal loads

No.	Traffic flow (vehicles/day)	Vehicle weight	
		< 45T	> 67T
1	> 5000	1.80	1.30
2	1000	1.60	1.20
3	> 100	1.40	1.10

OVERVIEW OF CURRENT STATUS OF EXISTING BRIDGES IN CENTRAL VIETNAM AND AN EXAMPLE OF BRIDGE LOAD RATING

General information

In six provinces from Thanh Hoa to Thua Thien Hue, there are ten national highways managed by Road Management Zone IV with a total length of over 2,400 km,. In provinces from Quang Nam – Da Nang to Khanh Hoa (Central – Tay Nguyen), there are six national highways with 489 bridges that are managed by Road Management Zone V. There are two main types of bridge: precast simple reinforced concrete girder bridge (reinforced and prestressed), steel girder bridge (composite with a reinforced concrete slab) and several forms of temporary bridge.

From the statistics data, it can be seen that composite steel girder bridges make up a significant proportion of all bridges. All steel bridges in provinces from Thanh Hoa to Khanh Hoa are simple steel girder composite with reinforced concrete slab.

A survey of the current status of steel bridges in Road Management Zone V on National Highway 1A, Highway 19 was performed in June, 2010. Another survey covering steel bridges in Road Management Zone IV on National Highway 1A, Highway 49 and Highway 8 was conducted in late January and February, 2011.

Service Status and Load Advisory

According to the survey data in Road Management Zone V, the allowance load sign for all steel bridges is 25T. From Thanh Hoa to Thua Thien Hue, the National Highway 1A, 17/27 steel bridges have allowance load signing of 30T, and 5/27 bridges are rated at 25T. 3/27 steel bridges have no allowance load signing. However, in many cases, the weight of vehicles crossing bridges far exceeds the allowance load signs. The main reason is the rapid increase in traffic volume and types of vehicles, many of them being heavy trucks which exceed the load capacity of bridges and roads. Overloaded and oversized vehicles are the main means for transporting materials to economic zones, seaports, hydroelectric plants or for transporting timber from Laos via Lao Bao international border gate by No.7, No.8, No.9 and along National Highway No.1 (Statistics Conditions Highway Bridge on Road Management Zone, 2009; The Bridge Design Profiles, 2013).

To establish effective, affordable and safe regime of service, it is necessary to use evaluation results of the load capacity for structural parts.

An Examples of Bridge Load Rating

In the framework of the Project High Education $N^0$2 conducted at the University of Transport (Ha Noi), the research team conducted field surveys of steel composite girder bridges in provinces from Thanh Hoa to Khanh Hoa (Road Management Zones IV and V). Based on examined and updated current status, the team conducted an assessment of bridges according to the standard 22 TCN 243-98 and AASHTO LRFR manual. Herein are the main results of the bridge load rating of the Cua bridge, km 560 +445 1A in Ha Tinh and Cat Bridge, km 1065 +081 1A in Quang Ngai.

Result load rating for Cua bridge

Cua bridge, at km 560 +445 on NH.1A in Ha Tinh province, was built in 1978 with a design load of H30 - XB80. The structure consists of three simple steel girder spans (12m long each) with RC slab. Currently, Cua bridge is exploited with an allowance load of 30T as shown in Figure 1.

-Cross section, main girder structure and bracing system of Cua bridge

The width of the bridge is K = 8 + 2 x 1.25 m, B = 11.5 m. Cross-section includes 9 girders of I550x250, girder spacing is 1.2 m. In-place RC slab is M250 and 18 cm thick. Bracing system is type of truss with angle steel bars of L80 x 80 x 8 jointed by weld [Figure 2].

Figure 1: Images of Cua bridge surveyed in January 2011

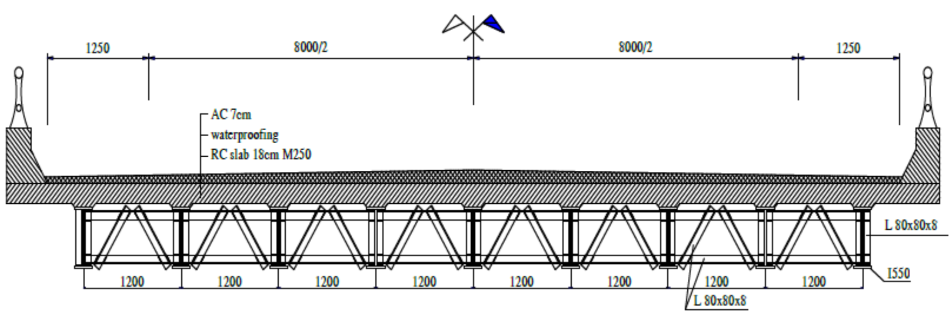

Figure 2: Cross-section of Cua bridge

Estimation load capacity of Cua bridge according to 22TCN 243-98

- Girder type: 9 girder of I550x250, flange thickness of 20mm, web thickness of 14 mm. In calculation, Ro=1900kG/cm2 và Ru = 2000kG/cm2. Deck slab thickness of 18 cm, concrete of M250. Evaluation results are shown in Table 5.

Table 5: Evaluation results according to 22TCN 243-98

- Normal stress at bottom edge of steel girder at middle span	***1615.81***	(kG/cm^2)
- Most critical shear stress	***187.20***	(kG/cm^2)

Normal stress at bottom edge of steel girder at middle span in control load combination of XB80 and dead load is 1615,812kG/cm2< Ru =2000 kG/cm2. Thus, Cua bridge can safely service a load of H-30 and XB-80 with quite large reserve for trucks. However, allowance load signal of 30T means that all vehicles over 30T weight with all configurations are prohibited from crossing the bridge.

Estimation load capacity of Cua bridge according to AASHTO LRFR

In calculation, mechanical properties such as strength, elasticity modulus according to AASHTO standards are used. Girder is carbon steel, so minimum yield strength is 250 MPa. For deck slab thickness of 18 cm and concrete of M250, it is necessary to convert to standard compressive strength of cylinder sample 150x300 mm. From that, we obtain the equivalent strength is fc'= 16.21 Mpa. Evaluation results are shown in Table 6.

Table 6: Evaluation results according to AASHTO LRFR

Rating Factor by Moment	***RF***
* For inventory load level	
+ Interior girder	***1.451***
+ Exterior girder	***1.705***
* For operating load level	
+ Interior girder	***1.881***
+ Exterior girder	***2.210***
- Rating Factor by Shear	
* For inventory load level	
+ Interior girder	***2.741***
+ Exterior girder	***4.025***
* For operating load level	
+ Interior girder	***3.553***
+ Exterior girder	***5.217***

From the above results, minimum evaluation RF is 1.45 (larger than 1). Thus, evaluation result of Cua bridge with HL-93 load is passed, allowance load is unlimited.

Posting load, in the same configuration with HL-93, based on evaluation results according to AASHTO LRFR, is:

Posting load = W x RF = 32.5 x 1.451 = 47.168 (T).
(in which W = 325 kN ≈ 32.5 T is weight of HL-93)

This means that a truck with three axes (similar to the truck of HL-93, total weight of 47.168T) can be safely cross the bridge (based on load capacity of main girder). Allowance load signal of Cua bridge is 30T resulting in prohibiting all vehicles over 30T. As a result, the full use of the service capacity of the construction is obviously not made, while legal truck traffic is halted.

Result load rating for Cat bridge

Cat bridge locates at Km 1065+081 on NH.1A in Quang Ngai province. The structure consists of two simple steel girder spans (each 15.5m long) with RC slab. Currently, the Quang Ngai Road Construction & Management Company Limited has managed and utilised Cat bridge with an allowance load of 30T (Figure 3).

Figure 3: Images of Cat bridge surveyed on June 2011

Cross section, main girder structure and bracing system of Cat bridge

The width of the bridge is K = 8 + 2 x 1.0 m, B = 10.5 m. Cross-section includes 7 girders of I680 x 254. RC slab is M250 and 18 cm thick (Figure 4).

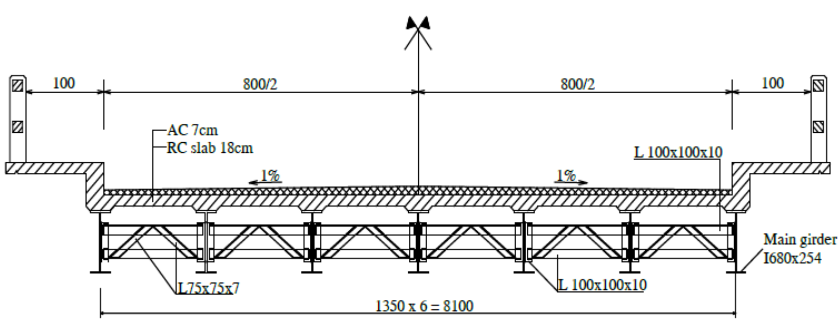

Figure 4: Cross-section of Cat bridge

Estimated load capacity of Cat bridge according to 22TCN 243-98

Evaluation results are shown in Table 7.

Table 7: Evaluation results according to 22TCN 243-98

Normal stress at bottom edge of steel girder at middle span	***2306.9***	(kG/cm^2)
Most disadvantages shear stress	***578.8***	(kG/cm^2)

Normal stress at bottom edge of steel girder at middle span in control load combination of XB80 and dead load is 2306.9 kG/cm^2> R_u =2000 kG/cm^2. Thus, Cat bridge cannot be safety utilised with a load of H-30 and XB-80.

Estimated load capacity of Cat bridge according to AASHTO LRFR

In calculation, mechanical properties such as strength, elasticity modulus according to AASHTO standards are used. Therefore, the girder is of carbon steel, so minimum yield strength is 250 Mpa. For deck slab thickness of 18 cm and concrete of M250, the equivalent strength is f'c = 16.21 Mpa. Load rating results are shown in Table 8.

Table 8: Evaluation results according to AASHTO LRFR

- Rating Factor by Moment	***RF***
* For inventory load level	
+ Interior girder	***0.93***
+ Exterior girder	***0.86***
* For operating load level	
+ Interior girder	***1.21***
+ Exterior girder	***1.11***
- Rating Factor by Shear	
* For inventory load level	
+ Interior girder	***2.84***
+ Exterior girder	***3.68***
* For operating load level	
+ Interior girder	***33.1***
+ Exterior girder	***4.01***

From the above results, the minimum evaluation load factor is 0.86. Thus, evaluation result of Cat bridge with HL-93 load is unsatisfactory, and allowance load service load shall be limited.

Posting load, in the same configuration with HL-93, based on evaluation results according to *AASHTO LRFR, is :*

Posting load = Posting load = $\frac{W}{0,7}.(RF-0,3)$= 32.5 x (0.86-0.3)/0.7 = 26.0 (T).

(in which W = 325 kN ≈ 32.5 T is weight of HL-93)

When assessing bridges based on 22TCN 243-98, with pre-selected load (H-30 and XB-80), the result only is fail, service load shall be limited, but there is no reliable basis or related formula to select value of the limited load. With the method of AASHTO LRFR, when the evaluation factor RF <1 (and RF> 0.3), the limited load will be calculated by formula related to assessing weight (the weight of HL-93) and the found RF value.

Several bridges with the same structure and working condition as Cua and Cat bridges are also considered. For weak bridges, evaluation results according to two methods are generally suitable; however, evaluation based on AASHTO LRFR can recommend an appropriate allowance load signal.

CONCLUSION

Testing and evaluating load capacity of bridges becomes more important because of the longer life of bridges and higher flow of traffic including heavy trucks. In conjunction with the research material cited in this paper, the following conclusions may thus be deduced:

1. Vietnam has adopted bridge design standards of 22TCN 272-05 since 2005. This is a design method based on resistance and load factors using the AASHTO (LRFD) design philosophy. Otherwise, the testing process for highway 22TCN 243-98 is based on the design standard of 22TCN 18-79, which is a less complete, out-of-date and inadequate design philosophy. According to AASHTO regulations, whatever the design method used, all bridges must implement load rating in current traffic conditions following the latest standards to ensure safety. Evaluation method for the resistance and load factors AASHTO LRFR is a modern and up-to-date assessment method in the United States. It is applied to all bridges, regardless of design standards or construction time. So the application of evaluation methods AASHTO LRFR is reasonable and suitable with the application of design method AASHTO LRFD.

2. When assessing bridges based on 22TCN 243-98, with pre-selected load (H-30 and XB-80), the result is "pass or fail." If the result is "pass", the bridge may be automatically used with loads of H-30 and XB-80. Otherwise, the service

load shall be limited. It should be noticed that "pass" means the service load may be larger, but there is no reliable basis or related formula to select value of the limited or allowance load. This is a difficulty and also the main drawback of the evaluation method 22TCN 243-98. Moreover, due to specific restricted load conditions, using the load factors similar to that of design load is not reasonable.

3. With the method of AASHTO LRFR, when testing a structure with a design load of AASHTO LRFD HL-93 (also of 22TCN 272-05), with the evaluation factor RF ≥ 1, it can be concluded safe for operation with no requirement for load limit. On the contrary, if the evaluation factor RF <1 (and RF> 0.3), the load must be limited. An advantage of the AASHTO LRFR method is that from RF value, the limited load will be calculated by formula related to assessing weight (the weight of HL-93) and the found RF value.

   To facilitate the evaluation of load capacity, new standards for testing and evaluating should be promulgated that are consistent with current design specifications. The evaluation of bridges according to AASHTO LRFR is suitable with design philosophy of 22TCN 272-05 which ensures reliability with separate reliability coefficients.

4. Heavy trucks and overloaded vehicles are the main reason for overload and damage in parts of bridge structures. In Vietnam's current conditions, this situation has worsened, leading to rapidly damaged and degraded bridges. Therefore, it is necessary to study and implement solutions to limit and control overloaded vehicles. The limited load table must be clear, logical, consistent and easy to use by the configurations of vehicles.

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