

Comparison of Load Classification System Across the World for Interoperability Between Different Countries

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Abstract: This paper presents a comparison of various load classification system across the world. The bridges and vehicle are given load class based on load classification system, which is based on standard hypothetical vehicle class. Indian load classification considers 11 hypothetical vehicles for classification of bridge and vehicle. These hypothetical vehicles are classified as 3, 5R, 9R, 12R, 18R, 24R, 30R, 40R, 50R, 60R and 70R with both tracked and wheeled configurations, as given in IRC -06 – 2017. The NATO STANAG 21 load classification system consider 16 standard load classes of hypothetical vehicles which are classified as 4, 8, 12, 16, 20, 24, 30, 40, 50, 60, 70, 80, 90, 100, 120, 150 in both tracked and wheeled configurations. The Indian and NATO systems uses different vehicle load classes and wheel configurations, leading to difficulty in drawing comparisons regarding performance of various bridges produced by different countries to carry a vehicle being produced by different countries. Therefore, there is need to establish a comparison between standard vehicle load class of these two systems for interoperability between different countries. In this article a comparison has been made between Indian and STANAG load classification system.

Keywords - Load classification system, Indian Road Congress, NATO STANAG 2021, Vehicle classification system, Bridge classification

I. INTRODUCTION

The load classification system is designed to prevent a particular vehicle from crossing a particular bridge, if the vehicle would induce stresses exceeding the safe values in that bridge. The basis of the system is that each vehicle and bridge carry a load class number. If the vehicle class number is less than or equal to the bridge class number, the vehicle may cross over that bridge. If it is higher, the vehicle must not cross and must be diverted. Under exceptional operational conditions this prohibition may be lifted on the specific orders of the competent authority in the operation zone, who will have to balance the effect of overloading the bridge against the tactical importance of the crossing. Different types of load classification systems are being used around the globe, most prominent being Indian load classification system and NATO STANAG 2021 load classification system. Since these two systems follows different hypothetical vehicles for classification of bridge and vehicle, there exist difficulty in drawing comparisons regarding performance of various bridges produced by different countries to carry a vehicle being produced by different countries. Therefore, it is not possible to correlate

the class number computed by Indian system to that of the internationally accepted NATO system, causing interoperability issues, which being requirement of the present day between various countries due to globalization.

A comparison of load class would enable comparing the capability of bridge equipment and vehicles being produced by different countries.

II. INDIAN LOAD CLASSIFICATION SYSTEM

This classification is given by Indian Roads Congress. As per IRC 6-2017, the design live loads shall consist of standard wheeled or tracked vehicles or trains of vehicles. These hypothetical vehicle loadings are categorized in to five types.

- (a) IRC Class 70R loading
- (b) IRC Class AA loading
- (c) IRC Class A loading
- (d) IRC Class B loading
- (e) IRC Special Vehicle (SV) loading as per IRC

This further present 11 hypothetical vehicles for classification, for limiting loads in each bridge class and form the basis of classification of bridges. These hypothetical vehicles are classified as 3, 5R, 9R, 12R, 18R, 24R, 30R, 40R, 50R, 60R and 70R with both tracked and wheeled configuration. A bridge is given a load class number equal to that of the highest standard load class which it can safely withstand.

III. NATO LOAD CLASSIFICATION SYSTEM

Load classification system outlined in North Atlantic Treaty Organization (NATO) Standardization Agreement (STANAG) 2021, categorizes military vehicle loading and the capacity of bridges, ferries, and rafts. This agreement standardized a method of computing the load classification of bridges, ferries and rafts and vehicles for NATO countries. Under this agreement, every bridge can be assigned with a specific load capacity classifying number a load class and every vehicle are assigned to a specific category from total of 16 hypothetical load classes. If the vehicle load class is lower or equal to the bridge load class, that vehicle can safely pass over that bridge, else vehicle will be diverted. This methodology is independent of various national codes, such as EC standards from the European

Union or DIN standards from Germany, and allows closer interoperability between NATO countries.

There are 16 standard classes of hypothetical vehicles which are classified as 4, 8, 12, 16, 20, 24, 30, 40, 50, 60, 70, 80, 90, 100, 120, 150 in both tracked and wheeled configurations. The classification numbers were originally developed from studies of the hypothetical vehicles having characteristics about the same as those actual military vehicles of NATO nations.

According to NATO agreement, the means of classifying a vehicle is closely associated with the procedure for rating a bridge. The load effect produced by a above series of hypothetical vehicles are used to define a set of load class numbers. Standard classification curves were developed using above hypothetical vehicle load for classifying vehicles. Each standard load class has a bending moment (BM) and a shear force (SF) curve, produced by plotting bending moment and shear force induced by these vehicles on the sample-span lengths. A vehicle is classified by comparing the curves of maximum BM and shear which a particular vehicle imposes on spans up to 91.5 m with the classification curves for the standard load classes. The load class so assigned to a vehicle does not represent the actual weight of a vehicle. It represents a combination of factors that include gross weight, axle spacing, weight distribution to the axles and speed.

IV. DIFFERENCE IN LOAD CLASSIFICATION SYSTEMS

After formation of NATO in 1970, came out the standard agreement in the form of STANAG 2021. The basis of the system in both the cases for load classification however remains unaltered, NATO standard agreement STANAG 2021 only converts it into a metric system and adds or changes a few clause/parameters for standardisation. In India standard, vehicle classes are classified from Load Class 3 to 70 with tracked and wheeled configurations. As per NATO STANAG 2021 load classes have been established from Load class 4 to 150 with tracked and wheeled configurations. Further, the axle configuration, tyre load and width of vehicle of same class No are totally different in two systems. This difference in load class system leads to different effect of vehicle on bridge spans, even if the class No are identical. Therefore, there is requirement to compare the load classification system of India and NATO countries to facilitate interoperability and to ensure that any bridging system in the world can be used for negotiating any vehicle coming from any worldwide source.

V. GENERAL DESCRIPTION OF THE SYSTEM

In Indian load classification system, the load effect produced by a series of hypothetical vehicles are used to define a set of load class numbers, which form the link between the carrying capacity of the bridge and the effect produced on it by real vehicles. Each of these load class is defined by a UBM (i.e. unit bending moment = BM/span) classification curve, a shear force classification curve, maximum single-axle and tyre loads, and minimum overall ground contact width. The UBM and shear force curves are produced by calculating the maximum values of UBM and

shear imposed on spans up to 79.30 m by a range of successively heavier hypothetical vehicles at 30.48 m spacing. The load classification curves so produced show a series of successfully higher standard load classes denoted by successively higher numbers. In calculating UBM and shear, no allowance is made for impact effects of vehicle.

An unclassified vehicle is classified by comparing the curves of maximum UBM and shear force which a particular vehicle imposes on sample spans up to 79.30 m with the classification curves for the standard vehicle load classes. The vehicle class number is obtained by interpolation and is assigned the nearest whole number. A bridge is classified by giving it a number equal to that of the highest standard load class whose effects (UBM, shear, axle load, etc.) it can safely withstand for an unlimited number of uses. Thus, vehicles are classified by giving them a number, which is independent of any particular bridge that they may cross. Similarly, bridges are classified or designed for a standard load class and not for any specific vehicle.

VI. ANALYTICAL VEHICLE CLASSIFICATION PROCEDURE

Standard vehicles are normally classified using analytical method to classify standard vehicles. To classify a vehicle using the analytical method, the following dimensional and weight-distribution data are needed:

- (a) Gross vehicular Weight (empty and loaded)
- (b) Load on each axle (empty and loaded)
- (c) Load on each wheel (empty and loaded).
- (d) Tire size and pressure per axle.
- (e) Number of tires per axle.
- (f) Spacing between the axles.
- (g) Width (outside-to-outside) of the tires or tracks and width (inside-to-inside) of the tires or tracks.
- (h) Length of the track that is in contact with the ground.

To classify a vehicle steps given as below need to be adopted, which is same for Indian and NATO system. The difference is firstly, that the NATO system uses maximum bending moment curve and Indian system uses UBM curve. Secondly, the Indian standard hypothetical vehicle configuration is different from NATO system even though the load class number is same.

- (a) Step 1. Compute the maximum moment produced by the vehicle on each of five or six sample spans of different lengths between 10 and 300 feet.
- (b) Step 2. Plot the moment and span length of a wheeled vehicle or tracked vehicle. Assign a class number by interpolating between the standard bending moment curve classification curves at the point where the class number is the largest.
- (c) Step 3. Compute and plot the shear points on the standard shear classification curves and assign a new class number, if the class is higher because of the shear that a vehicle induces in the selected different spans.
- (d) Step 4. Use standard width correction table to compute the hypothetical width by linear

interpolation between standard hypothetical vehicles.

- (e) Step 5. Compare the width of vehicle actual and the width hypothetical vehicle. Then increase or decrease the class number by the percentage in the table. Increase the classification if the vehicle's outside-to-outside track or tire width is narrower than the corresponding hypothetical vehicle. Decrease the classification if the vehicle's outside-to-outside width is wider than the corresponding hypothetical vehicle. The maximum axle or tyre load of the vehicle may exceed that given in the hypothetical vehicle chart. If it does, increase the class to that of the hypothetical vehicle of the same maximum axle or tyre load, interpolating between the values in the chart, if necessary. Round the final classification up to the nearest whole number.

VII. HYPOTHETICAL VEHICLE LOAD CLASS COMPARISON OF INDIAN AND NATO STANAG SYSTEM

For the purpose of comparing the load class of hypothetical vehicle being used by Indian and NATO systems, above mentioned rationale was adopted. Since, 12 m to 46 m long bridge span are being widely used on ground, therefore six bridge spans i.e. 15, 18, 24, 30, 36 and 46 m were considered as sample span for the study. The calculation and analysis were carried out manually as well as using application program in Microsoft excel. Further, the results were ascertained analytically using students' version of STAAD pro SW.

The hypothetical vehicle load class as given in Indian and NATO system were applied on the six selected spans. The max shear force (S.F) and maximum bending moment (B.M) for all hypothetical load classes were calculated. For calculation of max shear force, the tracked vehicles were positioned such that the end of track just entered the end of span and wheeled vehicles were positioned on the spans such that the rear axle of vehicle just entered the span. For calculation of maximum bending moment, the tracked vehicles were positioned at the centre of the span and wheeled vehicles were positioned on the spans such that the centre line of span was halfway between centre of gravity (CG) of load and the axle with heavier load.

Firstly, max S.F were calculated for different vehicle load classes of these systems and thereafter S.F were compared for each class of load. The load classes of STANAG system which had the same S.F value or below as that of S.F produced by Indian vehicle classes were placed together under same category of class. By doing so, the load class which had produced the same/ less value of S.F (by different load classes of different load class system) were placed under one category of load class. Secondly, the B.M produced by vehicles were compared for each class of load of these classification systems. The load classes of STANAG 2021 system which had the same B.M value or below as that of B.M produced by Indian vehicle classes, were placed together under same category of vehicle load cl. Hence, the table obtained above by comparing S.F was

rearranged and comparison table based on B.M were produced. Therefore, in the final comparison table, the load classes of STANAG system which had the same S.F & B.M values or below as that of S.F & B.M produced by Indian vehicle classes, were placed together under same category of class. By doing so we obtained the equivalent class of NATO standard vehicle to that of Indian standard vehicles. The analysis was carried out for both wheeled and tracked vehicles. Further, the BM and SF as obtained for NATO system were plotted on classification curve of Indian system and results were ascertained. One such set of charts (B.M and S.F) is presented as Chart 1 and Chart 2 which represent the UBM classification curve and Shear Force classification curve of tracked vehicle respectively.

The comparison table obtain above was further ascertained by modelling the above span bridges in STAAD Pro SW and applying the above vehicle loads on the bridge model. For analytical analysis purpose, the bailey bridge was modelled and above load class were applied. First the Indian load class were applied on the model and analysis was carried out. Thereafter equivalent NATO load classes were applied on the same model and analysis was carried out to check the adequacy of a bridge span to carry both Indian and NATO standard vehicles.

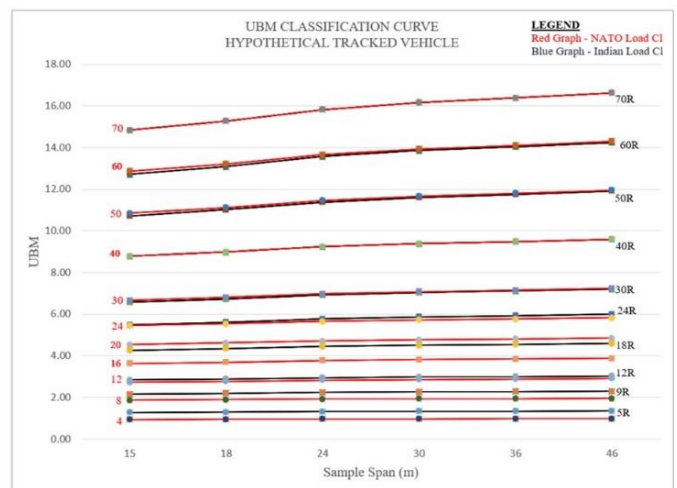


Chart I.

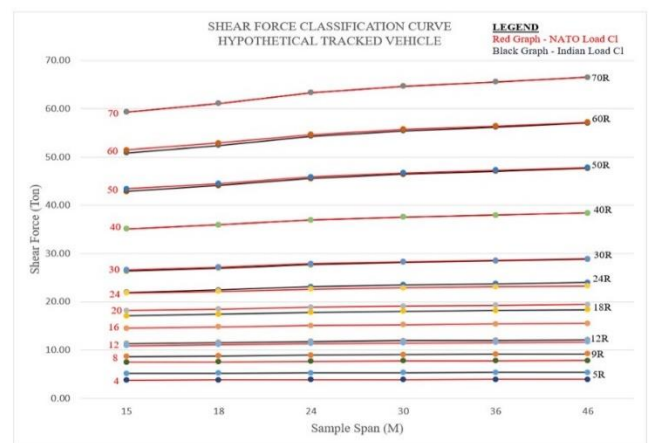


Chart II.

VIII. RESULT AND DISCUSSIONS

For tracked vehicle, result as presented in Table 1 were obtained, which shows comparison of various standard vehicle load classes of Indian and NATO STANAG 2021. It was observed that B.M and S.F induced on sample spans by standard vehicles of NATO system was almost equivalent to Indian standard vehicle classes. Slight variation was observed due to difference in contact area of track and the value of total load. However, the variation of BM and SF induced by same class vehicle of two systems on sample spans were in the range of only 1% to 2%.

For wheeled vehicle, result as given in Table 2 were obtained, which shows comparison of various standard vehicle load classes of Indian and NATO STANAG 2021. Since axle load, axle spacing, width of vehicle and wheel are very different in two systems, NATO standard vehicle induces greater BM and SF and same can be observed from load class No 12 onwards. It was observed that Indian load class were equivalent to the lower load class of NATO system from load class 12 onwards. The variation of BM and SF induced by same class vehicle of two systems on sample spans were in the range of 10% to 14%.

Table I.

Hypothetical Tracked Vehicle Load Class	
Indian System	Equivalent NATO System
5 R	4
9 R	8
12 R	12
18 R	16
24 R	20, 24
30 R	-
40 R	30, 40
50 R	-
60 R	50
70 R	60, 70

Table II.

Hypothetical Wheeled Vehicle Load Class	
Indian System	Equivalent NATO System
3	-
5 R	4
9 R	8
12 R	-
18 R	12, 16
24 R	-
30 R	20, 24
40 R	30
50 R	40
60 R	50
70 R	60, 70

IX. CONCLUSION

The equivalent load classification of NATO system as given in Table 1 and Table 2 will be able negotiate over an Indian bridge which was classified using Indian system and given class as per various standard load class of Indian system.

The analysis of above comparison using STAAD Pro SW ascertained that the stress induced, deflection and shear forces on bridge were well within allowable limits.

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