RESEARCH ARTICLE OPEN ACCESS

Fatigue Reliability-A case study of bridge to find the stress due to Moving loads

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ABSTRACT:
The bridge when designed only for flexure may be subjected to premature failure as the concept of fatigue is not accounted which is an important parameter to be analyzed for estimating life of structure. Considering "Real vehicles" for analysis purpose makes more sense. "Moving load analysis" conducted to determine the design bending moment will yield more realistic and reliable data. Hence fatigue analysis is carried out by considering real vehicles obtained from traffic survey and its implicit factor was found

KEY WORDS: cyclic loading, C Program, fatigue, Indian road congress, implicit factor, load cycles, moving load analysis, Mat Lab 2000

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I. INTRODUCTION:

The word „fatigue‟ originated from the Latin expression „fatigue‟ which means „to tire‟. The phenomenon of fatigue refers to the behavior of structures under the action of repeated application of loads. It is a progressive, internal and permanent structural change in the material. At the beginning of the loading the propagation of the micro cracks is rather slow and as loading continues the micro-cracks will proceed, propagate and lead to macro-cracks, which may grow further. The macro-cracks determine the remaining fatigue life caused by stress until failure occurs.

Different Approaches to Fatigue Analysis

According to the definition of the fatigue life, the approaches for fatigue analysis can be classified into

- The crack propagation method or Fracture Mechanics approach.
- The strain-life method and
- The stress-life method or S-N curve approach

Cycle Counting

It is necessary to reduce the complex history into a number of events which can be compared which can be compared to the available constant amplitude test data. This process of reducing a complex load history into a number of constant amplitude events involves what is termed as cycle counting.

Counting methods have initially been developed for the study of fatigue damage generated in aeronautical structures. Since different results have been obtained from different methods, errors could be taken in the calculations for some of them. Level crossing counting, peak counting, simple range counting and rain flow counting are the methods which are using stress or deformation ranges. One of the preferred methods is the rain flow counting method.

Rain flow Counting ("falling rain" approach):

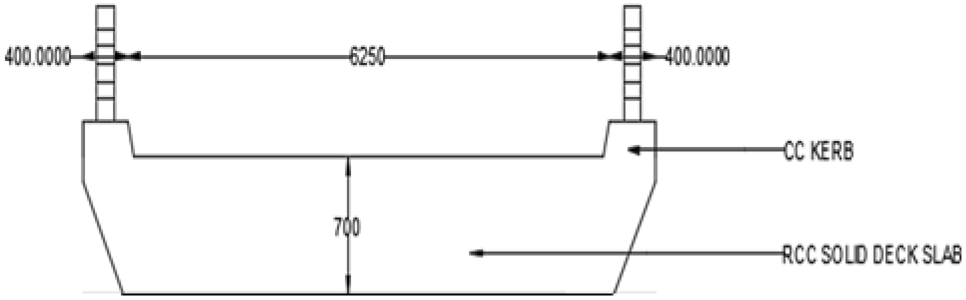
Rain-flow cycle counting method has initially been proposed by M. Matsuiski and T. Endo to count the cycles or the half cycles of strain-time signals. Counting is carried out on the basis of the stress-strain behavior of the material.

Objectives:

- The Major objectives of this study is to find the equivalent stress by considering the traffic growth
- To arrive at equivalent stress range on the basis of moving load analysis and traffic survey data

Data considered:
Bridge Data Reinforced Concrete Bridge Is Considered for the Purpose. It Is A 3 Span of 21m C/C Bridge.

Bridge Location	Hunsur, Mysuru- Madkeri Highway, (NH275)
Type of Bridge	Slab Culvert
Total Span	21m
Distance Between Piers	7m
Year of Construction	2007



Geometric properties of the cross-section are; Moment of inertia (Ixx) = 1.77 x 1010 mm4 Section modulus (Z) = 4.1 x 107 mm3

TRAFFIC DATA:
A definite knowledge of the volume and composition of traffic is essential for fatigue analysis. The information can be obtained by periodic traffic census and sample surveys, which are required to be judiciously conducted at periodic trends on many roads

Traffic census details

Sl no.	VEHICLE TYPE	Year 2016	Year 2017	Year 2018
1	CAR	6536	7000	7125
2	TWO WHEELER	6456	6896	7256
3	LIGHT COMMERCIAL VEHICLE (LCV)	1782	1895	2105
4	BUS (BS)	1400	1542	1890
5	TWO AXLED TRUCK(2AT)	2015	2125	2234
6	MULTIAXLEDTRUCK (MAT)	367	425	520

Vehicle Specifications considered for the Study

Vehicle type	**BUS (BS)**	**2AT**	**MAT**
vehicle name	Tata LP 1512 TC	LPT 1613	LPT 2521
Wheel base	5.895 m	4.225 m	4.165 m & 1.43 m
Total length of vehicle	10.025 m	7.38 m	9.26 m
Width of vehicle	2.434 m	2.115 m	2.44 m
Kerb Weight	40.13kN	44 kN	60.36kN
Gross vehicle weight	145.63kN	158.76kN	245kN
Front axle load-FAW	14.85 kN	16.3 kN	14.5 kN
Rear axle load-RAW	25.28 kN	27.7 kN	45.87 kN
Max permissible-FAW	46 kN	58.8 kN	58.8 kN
Max permissible-RAW	99.63 kN	99.96 kN	186.2 kN

As per IRC: SP: 72 – 2007, Buses ,Multi axle truck and two axle truck has to be considered for the study

INFLUENCE LINES

Influence lines are important in the design of structures that resist large live loads.

If a structure is subjected to a live or moving load, the variation in shear and moment is best described using influence lines. Constructing an influence line is completely different from constructing a shear or moment diagram

Assumption Followed in the Study Carried out:

1. Fast moving vehicles of 50Kmph vehicle speed with Clear spacing between vehicles2m is taken as scenario 1.
2. Slow moving vehicles of 25Kmph vehicle speed with Clear spacing betweenvehicles 1.5m is taken as scenario 2.
3. Single moving vehicles are taken as scenario 3.

Different vehicle combinations considered for the study

1. LMAT + ULMAT	6. L2AT + ULBS	11. LMAT + LBS
2. LMAT + UL2AT	7. LBS + ULMAT	12. L2AT + LBS
3. LMAT + ULBS	8. LBS + UL2AT	13. ULMAT + UL2AT
4. L2AT + ULMAT	9. LBS +ULBS	14. ULMAT + ULBS
5. L2AT + UL2AT	10. LMAT + L2AT	15. UL2AT + ULBS

Single vehicle Cas

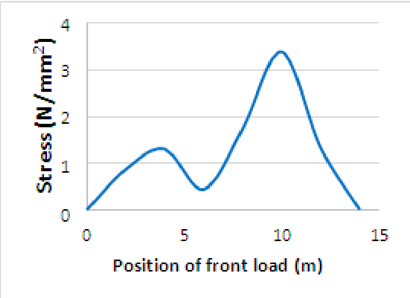
1.ULBS	**3.UL2AT**	**5.ULMAT**
2.LBS	**4.L2AT**	**6.LMAT**

II. RESULTS AND DISCUSSION

Moving load analysis is thus done for three types of vehicle movements (single moving vehicle,).
Graphs shown from 3.0 to 3.5 provide the details of analysis results obtained. Similarly, it has done for Fast moving vehicles and Slow moving vehicles

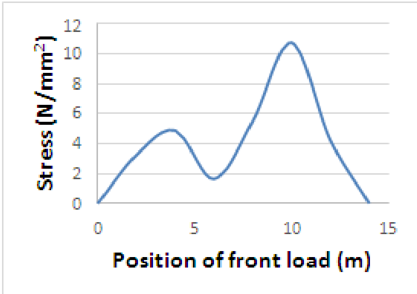
Single Vehicles cases

Case 1:- ULBS



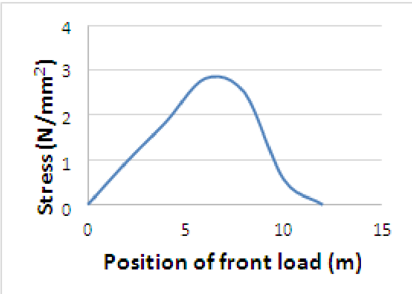
Graph 3.0: Stress variation for ULBS

Case 2 :- LBS



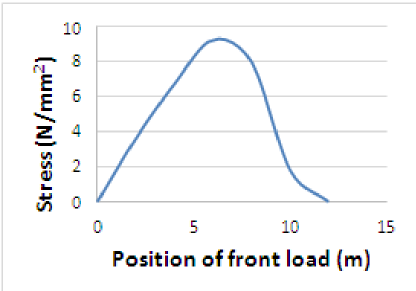
Graph 3.1: Stress variation for LBS

Case 3 :- UL2AT



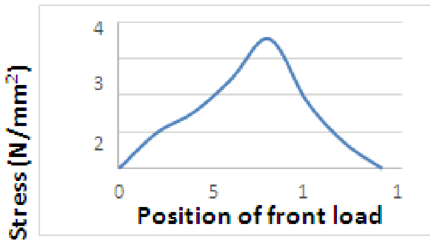
Graph 3.2: Stress variation for UL2AT

Case 4 :- L2AT



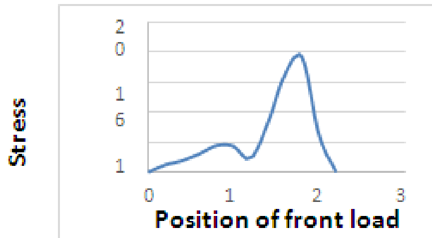
Graph 3.3: Stress variation for L2A

Case 5 :- ULMAT



Graph 3.4: Stress variation for ULMAT

Case 6 :- LMAT



Graph 3.5: Stress variation for LMA

Equivalent Effect of Moving Loads:
The results of moving load analysis shown in graphs 3.0 to 3.5 along with the concepts of Miner's cumulative damage model and rain flow counting is considered for further analysis

The results of moving load analysis are shown in graphs. The result of moving load analysis for each case is used to find Sr max and corresponding number of cycles.

Equivalent effect of moving loads for scenario 1

Vehicle combinations (Scenario 1)		**Srmax (Mpa)**	**n (Cycles)**
Case 1	LBS+ULBS	2.36	1.027
Case 2	LBS+L2AT	2.672	1.508
Case 3	LBS+UL2AT	2.616	1.023
Case 4	LBS+LMAT	3.787	1.121
Case 5	LBS+ULMAT	2.88	1.036
Case 6	ULBS+L2AT	2.33	1.007
Case 7	ULBS+UL2AT	1.177	1.351
Case 8	ULBS+LMAT	3.785	1.001
Case 9	ULBS+ULMAT	1.413	1.074
Case 10	L2AT+LMAT	3.787	1.081
Case 11	L2AT+ULMAT	2.45	1.025
Case 12	UL2AT+LMAT	2.885	1
Case 13	UL2AT+ULMAT	2.89	1.126
Case 14	L2AT+UL2AT	2.594	1.004
Case 15	LMAT+ULMAT	3.787	1.02

Equivalent effect of moving loads for scenario 2

Vehicle combinations (Scenario 2)		**Srmax (Mpa)**	**n (Cycles)**
Case 1	LBS+ULBS	2.515	1.023
Case 2	LBS+L2AT	2.594	1.516
Case 3	LBS+UL2AT	2.589	1.016
Case 4	LBS+LMAT	3.787	1.134
Case 5	LBS+ULMAT	2.649	1.028
Case 6	ULBS+L2AT	2.594	1.008
Case 7	ULBS+UL2AT	1.177	1.349
Case 8	ULBS+LMAT	3.787	1.002
Case 9	ULBS+ULMAT	1.413	1.119
Case 10	L2AT+LMAT	3.787	1.053
Case 11	L2AT+ULMAT	2.594	1.017
Case 12	UL2AT+LMAT	3.787	1
Case 13	UL2AT+ULMAT	1.413	1.088
Case 14	L2AT+UL2AT	2.594	1.002
Case 15	LMAT+ULMAT	3.787	1.008

Equivalent effect of moving loads for scenario 3

Single Vehicle (Scenario 3)		**Srmax (Mpa)**	**n (Cycles)**
Case 1	LBS	2.515	1.018
Case 2	ULBS	1.111	1.041
Case 3	L2AT	2.594	1
Case 4	ULAT	1.177	1
Case 5	LMAT	2.787	1.001
Case 6	ULMAT	1.413	1

Equivalent stress range for all the traffic data obtained

Sl no	Vehicle Combination	Equivalent stress range (Mpa)-2016 Traffic	Equivalent stress range (Mpa)-2017 traffic	Equivalent stress range (Mpa)-2018 traffic
1	Scenario 1	4.75	5.23	5.36
2	Scneriao-2	4.25	4.65	4.85
3	Scenario 3	3.25	3.9	3.95

III. SUMMARY AND CONCLUSIONS

While designing fatigue sensitive structures like bridges, the designer must ensure that the structure is adequate against fatigue failure also. Fatigue being a complex phenomenon requires to be addressed in a rational way. Typically, fatigue is affected by every repetitive load which acts on the structure. Hence, a load data collection and subsequent statistical analysis has been carried out as reported here

The developed stress are useful for evaluating/analyzing the reliability of the existing bridges for actual load effects with regard to fatigue

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