

Stress Distribution and Design of Deck Slab Bridges

Nagesh Balekundri¹, Abhijit Galatage²

¹P.G student, Department of Civil Engineering, Savitribai Phule Pune University, Maharashtra, India

²Professor, Department of Civil Engineering, Savitribai Phule Pune University, Maharashtra, India

Abstract - Bridge is a structure which is importance to facilitate a communication route for carrying road traffic or other moving loads. There are various types of bridges but the simplest type of bridge is single-span deck slab which is supported on its end. Various methods can be used for analyzing and designing the superstructure of bridge which is deck. In this project, the main focus on the methodology of design and analysis of deck Slab Bridge by limit state method as per IRC-112:2011 and compare with working stress method as per IRC-21:2000. The main objective of this thesis is to develop set of plans for 3.0m to 10.0m spans reinforced deck slab by using limit state method as per IRC-112:2011. In this present work modeling of deck slab bridges with different spans for 3m,4m,5m,6m,7m,8m,9m, and 10m.the width of bridge is taken as 12m and carriageway width 7.5m for all spans. The analytical tool used in this present study is STAAD PRO V8i. Analyses are done using STAAD PRO V8i live loads as per IRC-6:2016 standards. Beam element analogy is adopted for the analysis of the models. In this present study we study the effect of stresses on deck slab.

Key Words: Deck slab, LSM, WSM, IRC class, Effective Width Method, 70R Tracked Loading, IRC standard

1. INTRODUCTION

1.1 History of Bridges

Bridge is a structure that provided passageway over obstacles such as valleys, rough terrain of water by spanning those obstacles with natural materials. They was begun be used in ancient times when fist modern civilizations started rising in the Mesopotamia, from that point on knowledge , engineering and manufacture of new bridges spread beyond their borders which enabling slow but steady adoption of bridges all across the world. In the beginning bridges were very simple structure that were built from easily available resource such as wooden logs and stone. Because of that, small span very close distance and the structure integrity was not high because at that time mortar is not invented. Modern bridges are usually made with the combination of concrete, irons and cables, and can be built from very small sizes to incredible lengths that span entire mountains, rough landscapes, lakes and seas. Bridges may be classified by how the forces of tension, compression, bending, torsion and shear are distributed through their structure.

1.2 Types of Bridges

Following are the different types of bridges as shown in figures below.

- Beam bridges
- Truss bridges
- Arch bridges
- Cantilever bridges
- Suspension bridges
- Cable stays bridges

1.3 Importance of Bridges in India

- 1) Bridges are used in transportation systems such railway track, highway bridges.
- 2) Bridges are used to avoid the obstacles and providing passage over the obstacle.
- 3) Bridges are constructed to reduce the travelling time.
- 4) Bridges connect difficult terrains.
- 5) Bridges are used in militaries

1.5 Objective of the Study:

Following are the main objective of the present study:

1. To develop table based on different spans and different loading conditions using LSM as per IRC112-2011.
2. To find out the stress distribution in deck slab bridges to understand the behaviour.

1.6 Scope of the Work:

1. The standard table of deck Slab Bridge for span 3m to 10m is prepare by using LSM as per IRC112-2011.

2. Effect of different grade of concrete on stress distribution had been studies.

From this study we can conclude that percentage of steel reduction in limit state method as per IRC-112:2011 compare to working stress method as per IRC-21:2000. So, limit state method as per IRC-112:2011 is economical compare to working stress method as per IRC-21:2000. In this present study we study the effect of stresses on deck slab. From this study we can conclude that as span of the bridge increases the stresses also increase. In this present study also discussed the effect of grade of concrete on stress

distribution, as the grade of concrete increases the stress developed on deck reduces.

2. ANALYSIS OF BRIDGES

2.1 Introduction

STAAD Pro Is a finite element analysis. Design that includes a state of the user interface, and international design codes. It is capable of analysing any structure exposed to static loading, earthquake and moving loads. STAAD Pro is the premier FEM analysis and design tool for any type of project includes culverts, bridges, plants, towers etc.

2.2 Loads on Bridges

2.2.1 Dead load

Dead load is the self -weight of the super structure and any permanent loads fixed there on, it includes super imposed dead load and crash barrier.

2.2.2 Live load

Bridge design standards specify the design loads, which are meant to reflect the worst loading that can be caused on the bridge by traffic. In India the bridge designed on basic of IRC-6:2016.

There are 3 types of standard loadings for the bridges are designed that is,

- 1 IRC class AA
- 2 IRC class A Loadings
- 3 class B loading

2.2.3 Impacts loading:

Provisions for impact or dynamic action shall be made by an incremental of the live load by an impact allowance expressed as a fraction or a percentage of the applied live load.

2.3 Combination of Live Load:

S.No	Carriageway Width (CW)	Number of Lanes for Design Purposes	Load Combination (Refer Table 6A for diagrammatic representation)
1)	Less than 5.3 m	1	One lane of Class A considered to occupy 2.3 m. The remaining width of carriageway shall be loaded with 500 kg/m ²
2)	5.3 m and above but less than 9.6 m	2	One lane of Class 70R OR two lanes for Class A
3)	9.6 m and above but less than 13.1 m	3	One lane of Class 70R for every two lanes with one lanes of Class A on the remaining lane OR 3 lanes of Class A
4)	13.1 m and above but less than 16.6 m	4	One lane of Class 70R for every two lanes with one lane of Class A for the remaining lanes, if any. OR one lane of Class A for each lane.
5)	16.6 m and above but less than 20.1 m	5	
6)	20.1 m and above but less than 23.6 m	6	

Table-1: Live load combination

2.4 Modelling of Deck Slab Bridge

For Span 10 m: After the preparation of preliminary model in STAAD Pro.v8i. Make a beam cursor on the beams cursor bar at the left of the screen and select the "Repeat

Translation" option on the toolbar. A dialog box will appear as shown below.

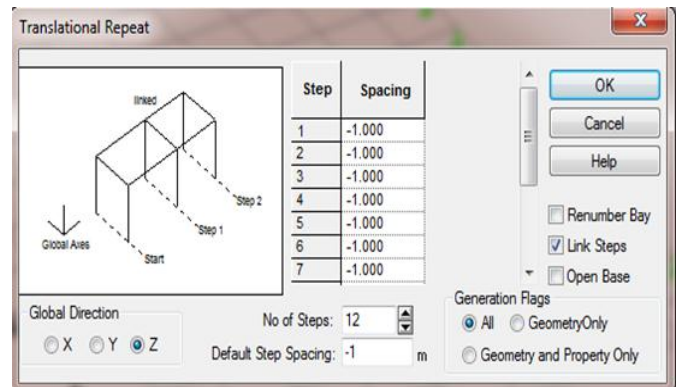


Fig-1: Dialog box showing Translation repeat in STAAD Pro.v8i

2.4.1 Live load

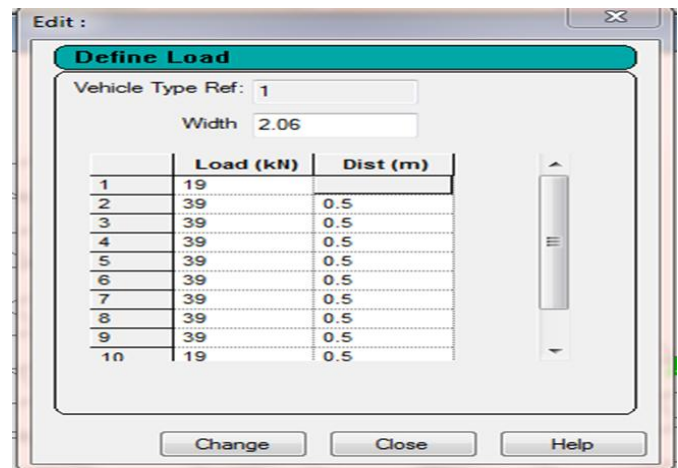


Fig-2: 70R tracked load defined

70R tracked load

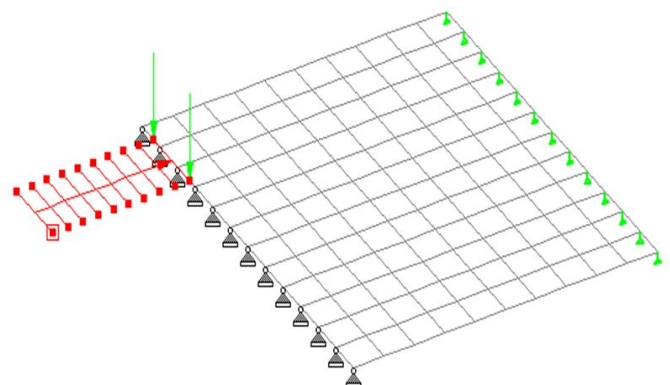


Fig-3: Analysis of 70R tracked vehicle for one-lane

2.5 Variation of Bending Moment v/s Span for Different Types of IRC Loadings

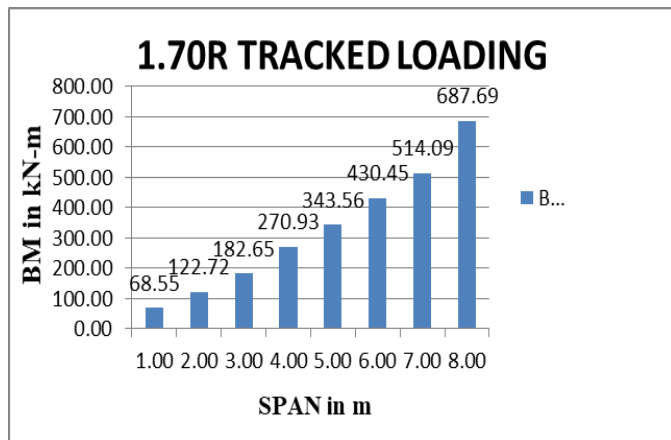


Fig-4: Variation of Bending Moment v/s Span for track loading

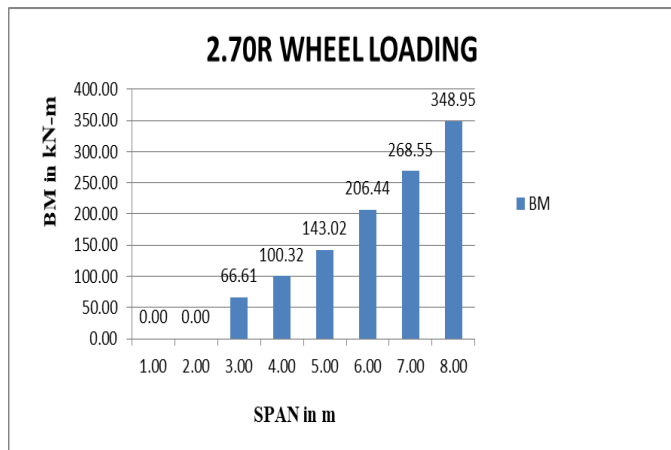


Fig-5: Variation of Bending Moment v/s Span for wheel loading

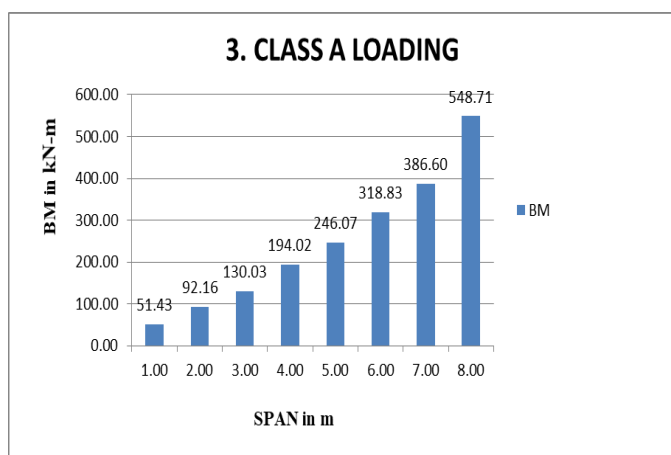


Fig-6: Variation of Bending Moment v/s Span for CLASS A loading

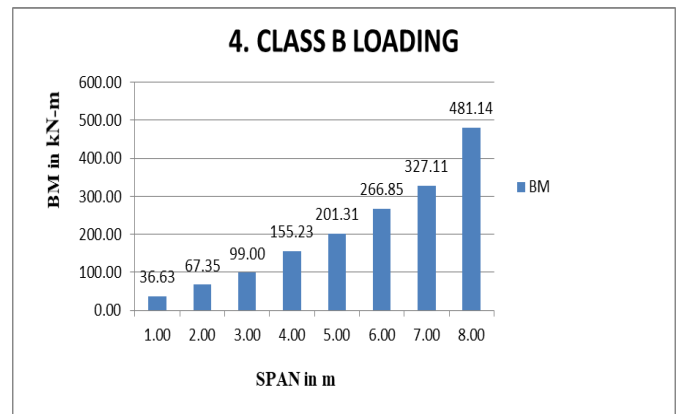


Fig-7: Variation of Bending Moment v/s Span for CLASS B loading

3. DESIGN OF BRIDGES

In past days the bridges are designed by using working stress method as per IRC-21:2000 .but now days according to government of India the bridge should be designed on the basic of limit state method. For the structural analysis purpose of bridge deck the Effective width method of IRC 112: 2011 is used and STAADPRO.V8i software used for the analysis purpose.

3.1 Details of Deck Slab Bridge IRC Standard for 3m to 10m Span

STANDARD IRC TABLE FOR SPAN 3m to 10m
Table 6.1 Typical Reinforcements for R.C. Deck Slabs (Right Span).






Effective Span	Slab Thickness		Bottom Reinforcement		Top Reinforcement		Side	
	Centre	Edge	Location	Along X	Along Y	Along X	Along Y	Along Y
m	D1	D2	Name	A	B	C	D	E
	mm	mm	Shape					
3.0	450	300		16φ150	8φ150	10φ250	10φ250	10φ
4.0	500	350		16φ140	10φ150	10φ250	10φ250	10φ
5.0	550	400		20φ150	10φ125	10φ225	10φ225	10φ
6.0	600	450		20φ125	12φ150	10φ220	10φ220	10φ
7.0	650	500		20φ110	12φ150	10φ200	10φ200	10φ
8.0	750	600		20φ100	12φ140	10φ140	10φ140	10φ
9.0	820	670		25φ130	12φ130	10φ130	10φ130	10φ
10.0	900	750		25φ125	12φ115	10φ125	10φ125	10φ

Fig-7: Details of deck slab as per IRC (tracked loading)

The theoretical analysis results and STAAD pro vi8 results are compared, the STAAD pro results are almost close to the

analysis results, from that we can say that the STAAD pro analysis is very effective and gives quick results.

The design of deck slab is done for span 3m 4 m 5m 6m 7m 8m 9m and 10m as per different IRC loading condition.

4. ANALYSIS RESULT

4.1 Comparison of area of steel provided for LSM and WSM

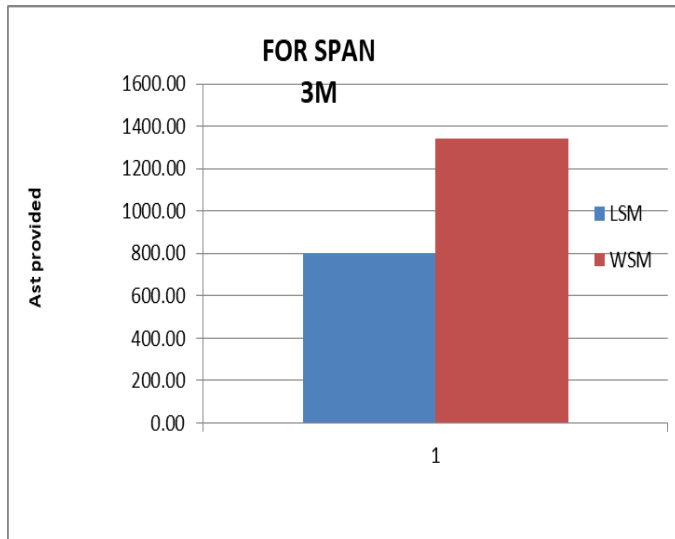


Fig-8: comparison of area of steel provided FOR LSM and WSM for 3m span

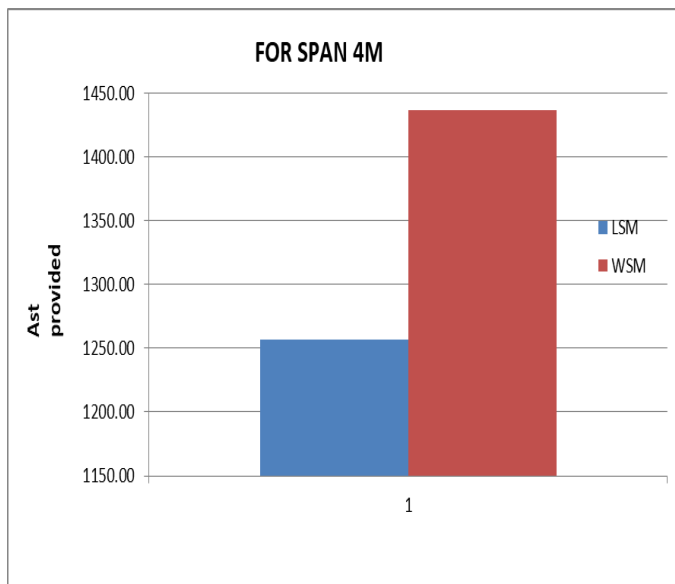


Fig-9: comparison of area of steel provided FOR LSM and WSM for 4m span

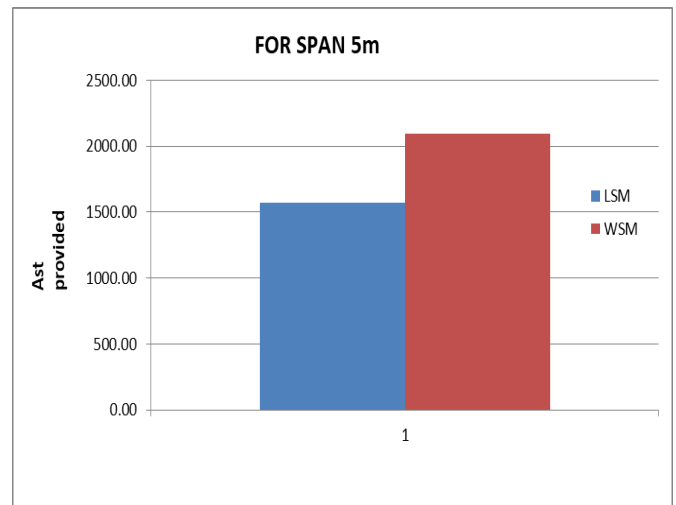


Fig-10: comparison of area of steel provided FOR LSM and WSM for 5m span

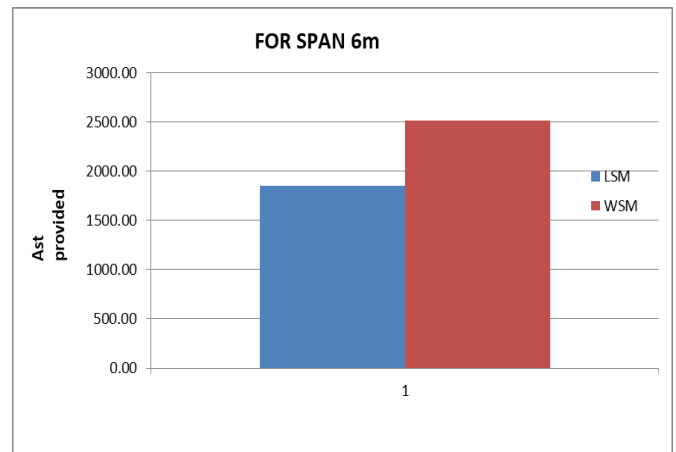


Fig-10: comparison of area of steel provided FOR LSM and WSM for 6 m span

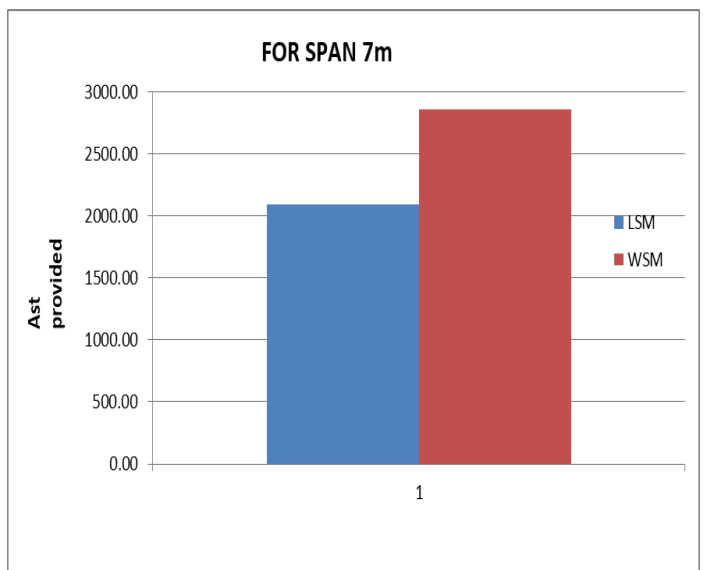


Fig-10: comparison of area of steel provided FOR LSM and WSM for 7 m span

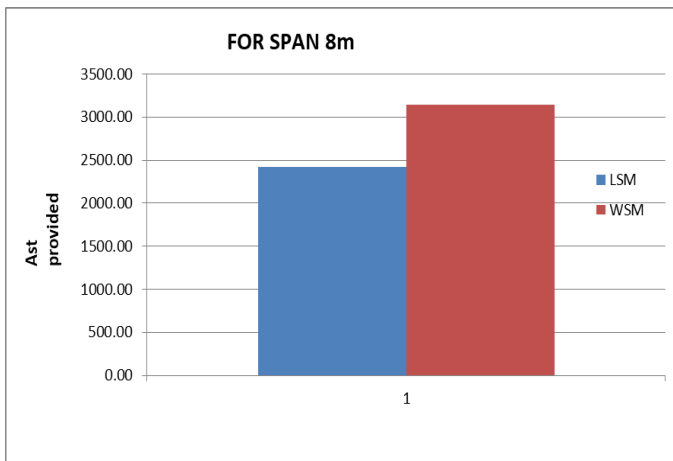


Fig-11: comparison of area of steel provided FOR LSM and WSM for 8 m span

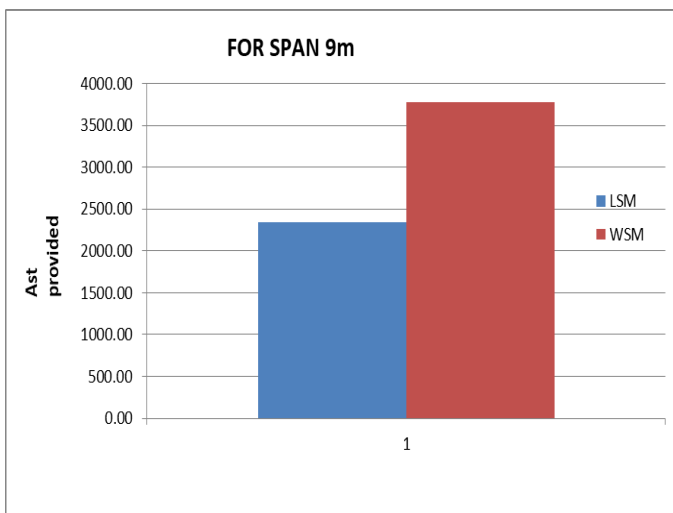


Fig-12: comparison of area of steel provided FOR LSM and WSM for 9 m span

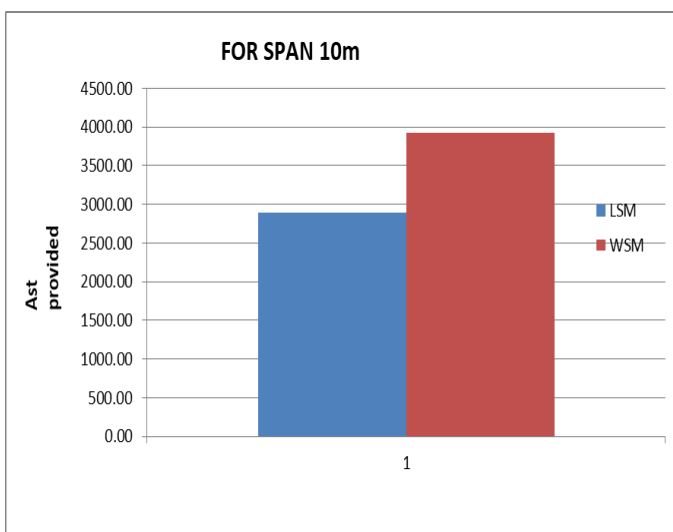


Fig-13: comparison of area of steel provided FOR LSM and WSM for 10 m span

4.2 Comparison of IRC Table for WSM BM and LSM

The variation of bending moment of IRC table and LSM v/s span shown. From Fig.14. We see that the bending moment is increased as increase in span of the bridge.

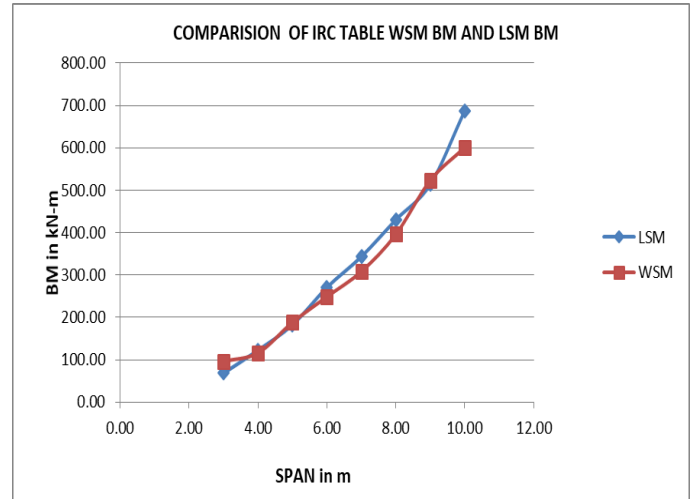


Fig-14: comparison of IRC TABLE For WSM BM and LSM BM

4.3 Comparison of Effective Depth

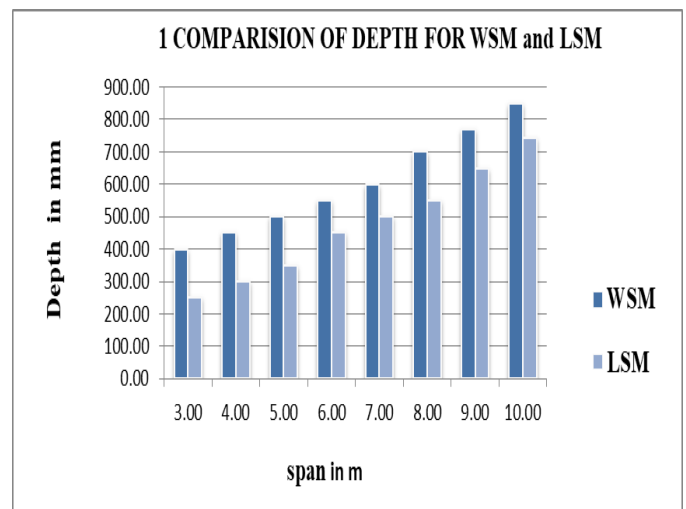


Fig-15: comparison of effective depth

4.4 Comparison of Percentage Steel Reduction for Ast

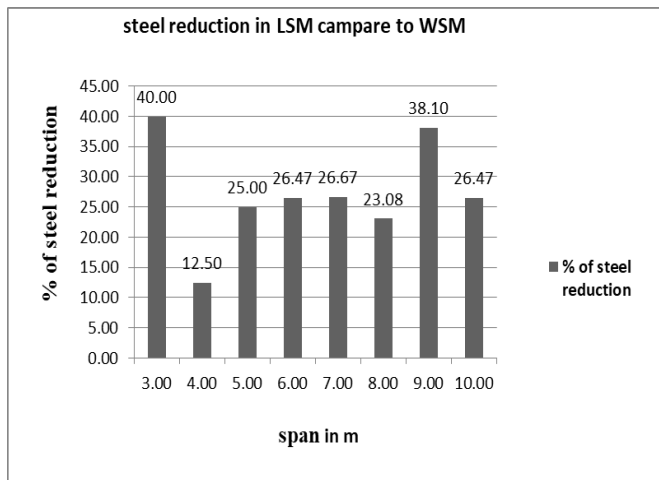


Fig-15: comparison of percentage steel reduction for Ast

4.5 Comparison of Steel Required for Deferent Grade of Concrete

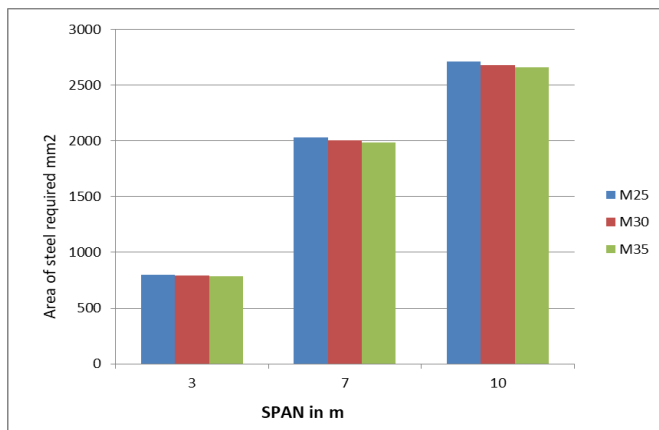


Fig-16: comparison of steel required for deferent grade of concrete

5. CONCLUSIONS

From the present study conclusion can be drawn as follows:

- Maximum BM is obtained at the centre of span maximum SF is obtained at the support.
- Class AA 70R tracked vehicle gives maximum live load and shear force for the all the spans, it is due to the maximum uniform dead load with less contact length.
- We conclude that percentage of steel reduction for different spans such as for 3m span 40% reduction in steel. For spans 4m 5m 6m 7m 8m 9m and 10m reduction in steel 12.5%, 25%, 26.47%, 26.67%, 23.08%, 38.1%, 26.47% respectively.
- We conclude that the limit state method is considerably economical design compare to working stress method.

- The conclusion obtained from my research work is that the effective Width Method specified in IRC is time consuming method, as for each class loading we have to calculate area and for longer vehicle with number of axles, it is more lengthy job. So it is better to go any alternative method which will provide similar results and with less effort. The FEM are suitable and gives quick results.
- We conclude that as the grade of concrete increases the area of steel required reduces, in this paper grade of concrete M25, M30 and M35 used for span 3m, 7m and 10m respectively.

REFERENCES

- [1] IRC: 5-1998 – “Standard specification and code of practice for road bridges” SECTION-I General features of design.
- [2] IRC: 6-2014- “Standard specification and code of practice for road bridges” SECTION-II Loads and Stresses.
- [3] IRC: 112-211 – “Code of practice for concrete road bridges”
- [4] IRC: 21-2000-- “Standard specification and code of practice for road bridges” SECTION-III cement concrete
- [5] IS: 456 - 2000, Indian Standard Plain and Reinforced Concrete-Code of Practice (Fourth Revision), Bureau of Indian Standards, New Delhi.
- [6] N. Krishnaraju “Design of bridges”, Fourth edition, Oxford & IBH Publishing Company Pvt. Ltd., New Delhi, India.
- [7] D.JOHNSON VICTORE “essentials of BRIDGE ENGINEERING”, sixth edition, Oxford & IBH Publishing Company Pvt. Ltd., New Delhi, India.
- [8] Sudip Jha and Cherukupally Rajesh” by Comparative study of RCC slab bridge by Working stress (IRC: 21-2000) and Limit state (IRC: 112-2011).
- [9] B.H.Solanki & Prof.M.D.Vakil “Comparative study for Flexure design using IRC 112:2011 & IRC 21:2000”, Published in International Journal of Scientific & Engineering Research, Volume 4, Issue 6, June 2013
- [10] Bhagwanth Singh Siddu” design and analysis of bridge structure using STAAD PRO
- [11] Nagashekhar and Shiv Kumar” effect of skew on the behaviour of RC girder bridges