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Structural Performance and Fatigue Behaviour of Orthotropic Steel Bridge

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Abstract— Orthotropic steel bridge is a type of steel bridge in which stiffeners are connected either longitudinally or transversely or in both directions. These bridges are widely used in long span bridges and urban viaducts because of their light dead weight and shorter construction time. In present study orthotropic steel bridge with U shaped hollow ribs are considered and intended as analysis investigations of minimum fatigue life and maximum stress developed in orthotropic steel bridge under truck load. Minimum fatigue life is calculated based on Soderberg method using ANSYS 16.1 software. Fatigue failure is a prominent problem for such bridges due to large number of welded connections. In order to improve the fatigue life of the orthotropic steel bridges; implemented an ultra light weight concrete having density 1250 Kg/m3 inside the ribs.
Keywords - *Fatigue, Fatigue life, Orthotropic, Ribs, Soderberg method, Stiffeners.*

1 Introduction

ORTHOTROPIC bridge is one whose deck typically comprises a structural steel deck plate stiffened either longitudinally or transversely, or in both directions. Decks with different stiffnesses in longitudinal and transverse directions are called orthotropic.Stiffners are secondary sections attached to stiffen the bridge against out of the plane deformations.In orthotropic steel bridges ribs are welded to the underside of the deck plate as longitudinal stiffeners. This allows the deck both to directly bear vehicular loads and to contribute to the bridge structure's overall load bearing behavior. The steel deck plate and ribs system may be idealized for analytical purposes as an orthogonal anisotropic plate; hence it is abbreviated as orthotropic.

Orthoropic steel bridges are widely used in long span bridges, movable bridges, urban viaducts and also bridges with restricted beam depth.The main advantages of orthptropic steel bridges are high strength to weight ratio,convenient to construct,cost effective and causes less seismic damages to bridge piers.

Orthotropic steel bridges are very prone to fatigue failure due to the presence of welded joints can be defined as the weakening of a material caused by repeatedly applied load. Fatigue failure is the formation and propagation of crack which is a significant problem affecting the service life of the steel bridges. Fatigue life is the number of loading cycles of a specified character that a specimen sustains before failure of a specified nature occurs.

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2 Methodology

The software used in the study is ANSYS 16.1.Modelled a bridge of 12000 mm length using Fe250 grade steel.Provided four U shaped ribs with a spacing of 635 mm.Top width, height and thickness of the ribs are 320 mm, 240mm and 12 mm respectively.Spacing between two cross girder is 3000 mm. Applied a truck load of 200 kN uniformly distributed over an area of 200 mm x500 mm at 500 mm away from the cross girder. Linear analysis for ultimate stress and minimum fatigue life is performed. Fatigue analysis in workbench is done by mean stress correction of Soderburg which is usually overly conservative.

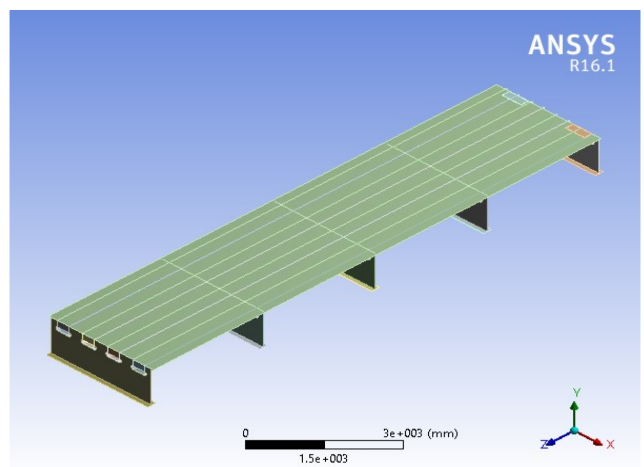

Fig. 1 Isometric View Of Orthotropic Steel Bridge Model

Inorder to increase the life of the orthotropic steel bridge ribs are filled with ultra light weight concrete and also performed linear analysis for ultimate stress and minimum fatigue life.Analysed and compared the results obtained.

TABLE 1

PROPERTIES OF ULTRA LIGHT WEIGHT CONCRETE

Density	1250 Kg/m^3
Ultimate tensile strength	2.03 MPa
Compressive strength	48.03 MPa
Youngs modulus	10.79x10^3 MPa
Poissons ratio	.15

3 RESULTS

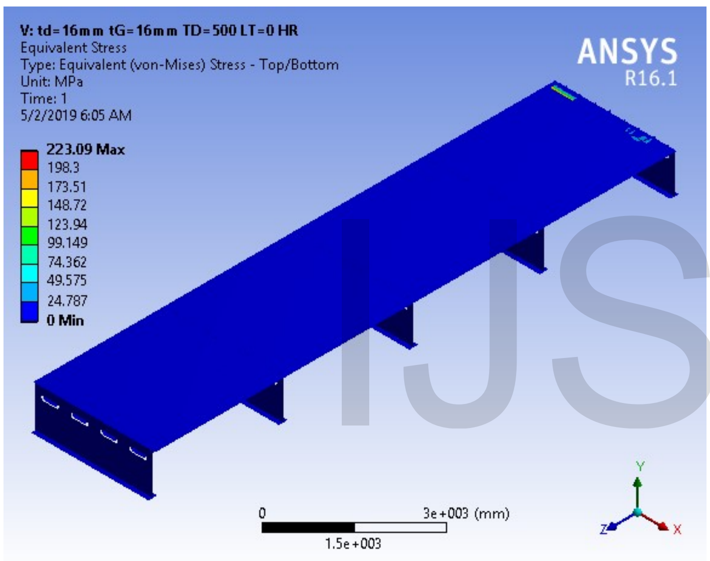

Fig.2 Isometric View Of Equalent Stress Developed At Ortgotropic Steel Bridge Before Strengthening When Load Is Applied 500 Mm Away From The Side And 0 Mm Away From The Edge

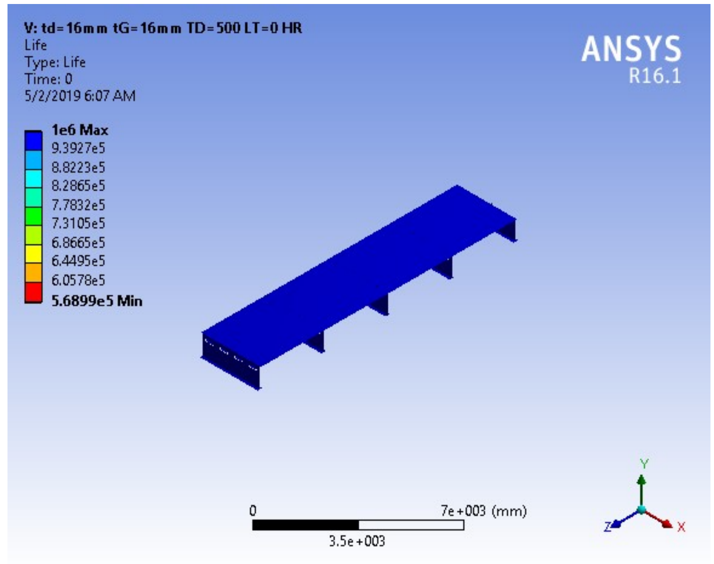

Fig.3 Isometric View Of Minimum Life Of Orthotropic Steel Bridge Before Strengthening When Load Is Applied 500 Mm Away From The Side In Tranverse Direction And 0 Mm Away From The Edge In Longitudinal Direction

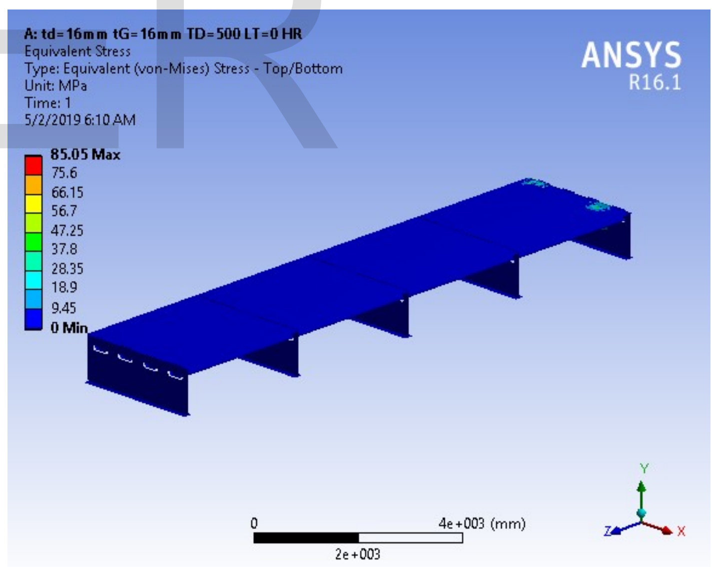

Fig. 4 Isometric View Of Equalent Stress Developed At Orthotropic Steel Bridge After Filling Ribs With Ultra Light Weight Concrete When Load Is Applied 500 mm Away From The Side And 0 mm Away From The Edge

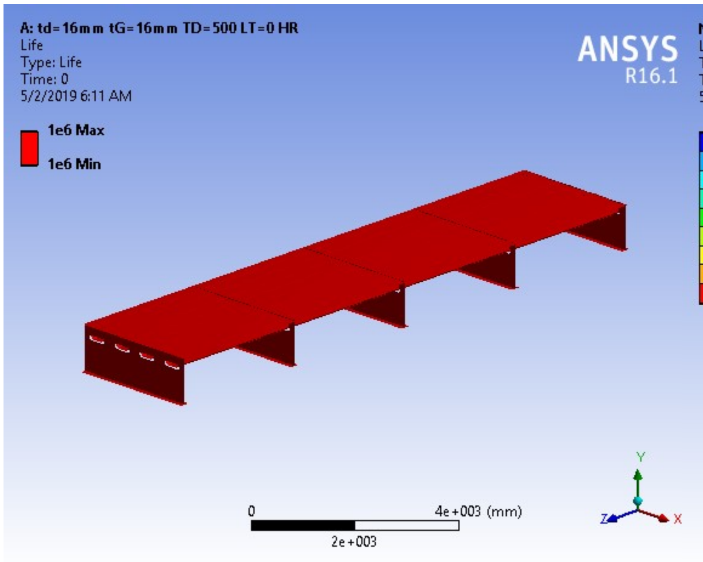

Fig. 4 Isometric view of minimum life developed at orthotropic steel bridge after filling ribs with ultra light weight concrete when load is applied 500 mm away from the side and 0 mm away from the edge

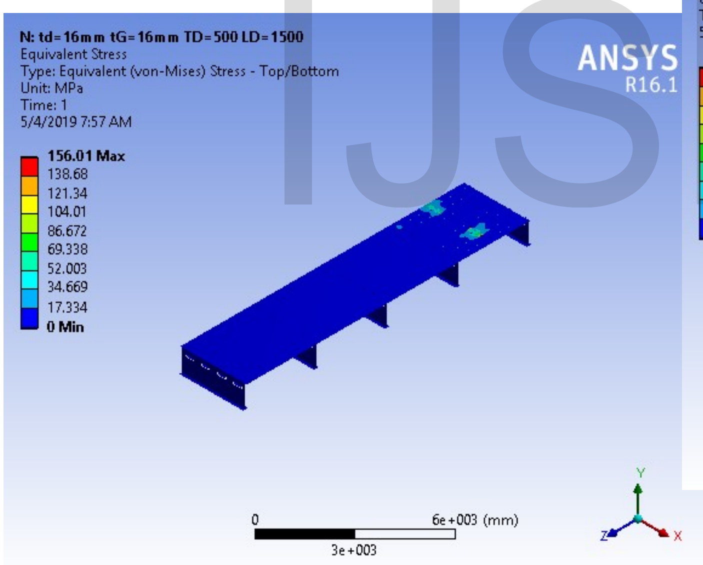

Fig.2 Isometric view of Equalent Stress Developed At Ortgotropic Steel bridge before strengthening when load is applied 500 mm away from the side and 1500 mm away from the edge

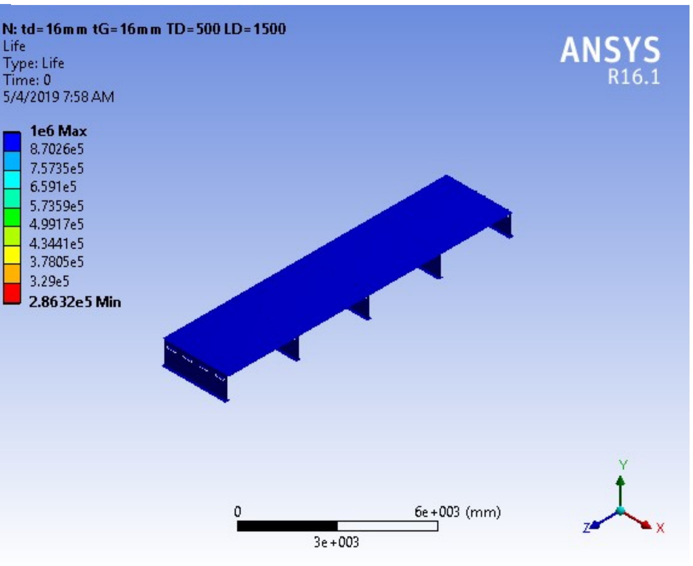

Fig.3 Isometric view of Minimum Life Of Orthotropic Steel Bridge before strengthening when load is applied 500 mm away from the side in tranverse direction and 1500 mm away from the edge in longitudinal direction

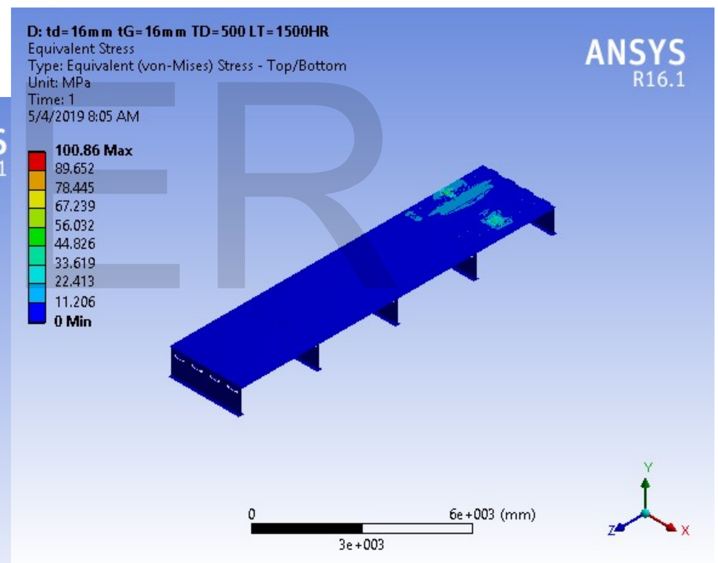

Fig. 4 Isometric view of equalent stress developed at orthotropic steel bridge after filling ribs with ultra light weight concrete when load is applied 500 mm away from the side and 1500 mm away from the edge

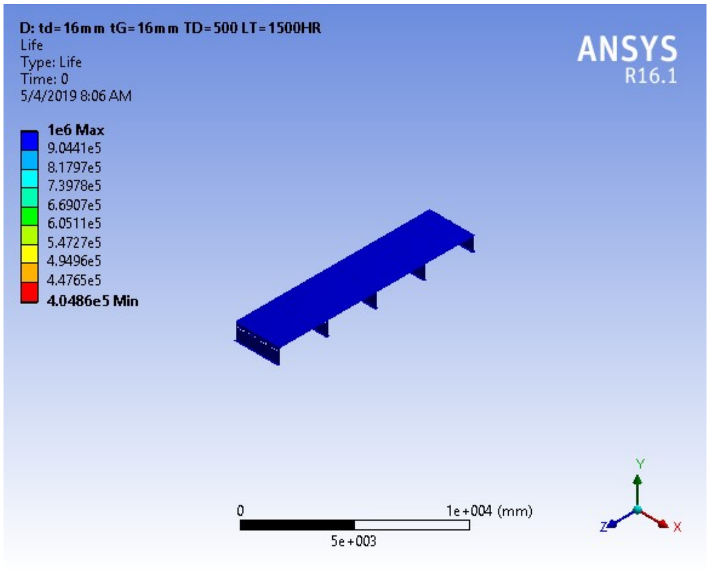

Fig. 4 Isometric view of minimum life developed at orthotropic steel bridge after filling ribs with ultra light weight concrete when load is applied 500 mm away from the side and 1500 mm away from the edge

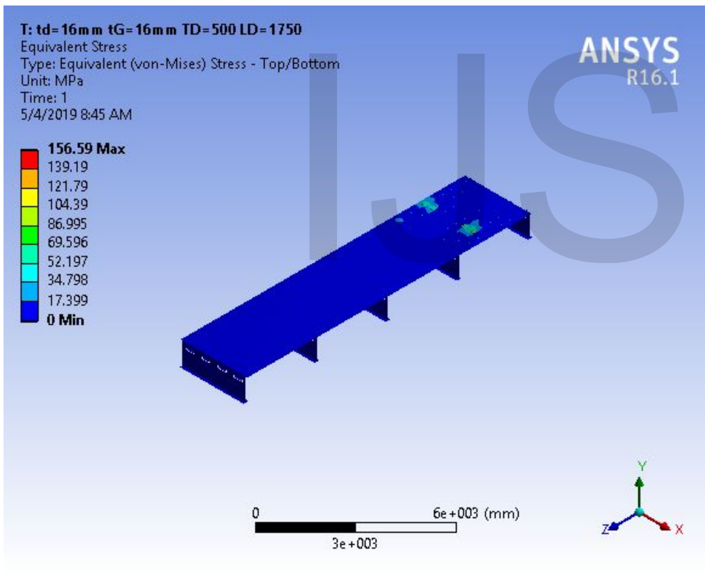

Fig.2 Isometric view of Equalent Stress Developed At Ortgotropic Steel bridge before strengthening when load is applied 500 mm away from the side and 1750 mm away from the edge

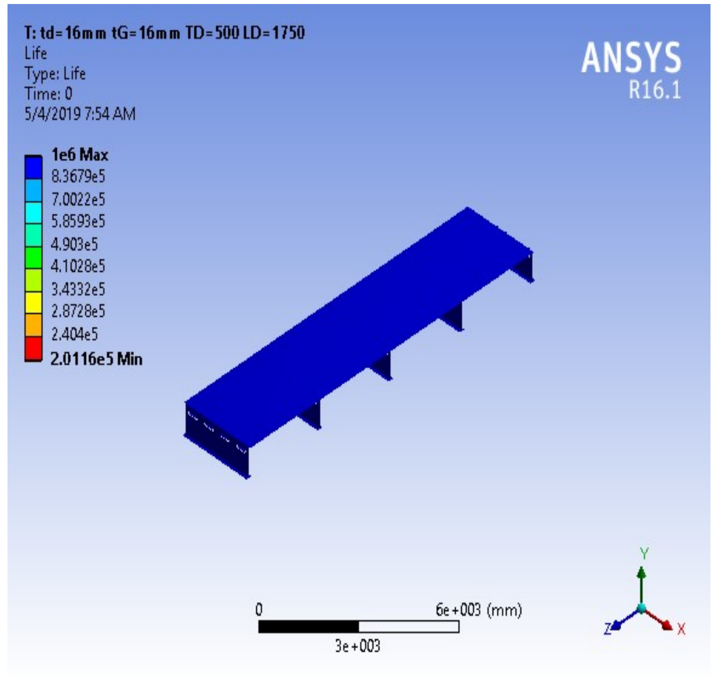

Fig.3 Isometric view of Minimum Life Of Orthotropic Steel Bridge before strengthening when load is applied 500 mm away from the side in tranverse direction and 1750 mm away from the edge in longitudinal direction

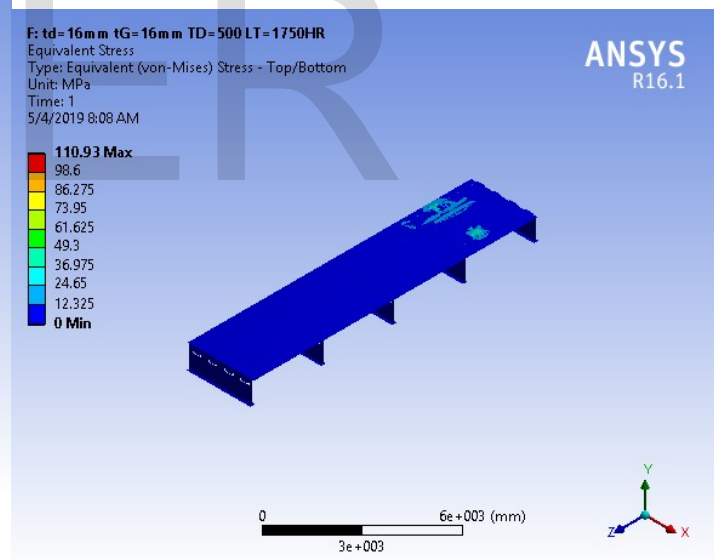

Fig. 4 Isometric view of equalent stress developed at orthotropic steel bridge after filling ribs with ultra light weight concrete when load is applied 500 mm away from the side and 1750 mm away from the edge

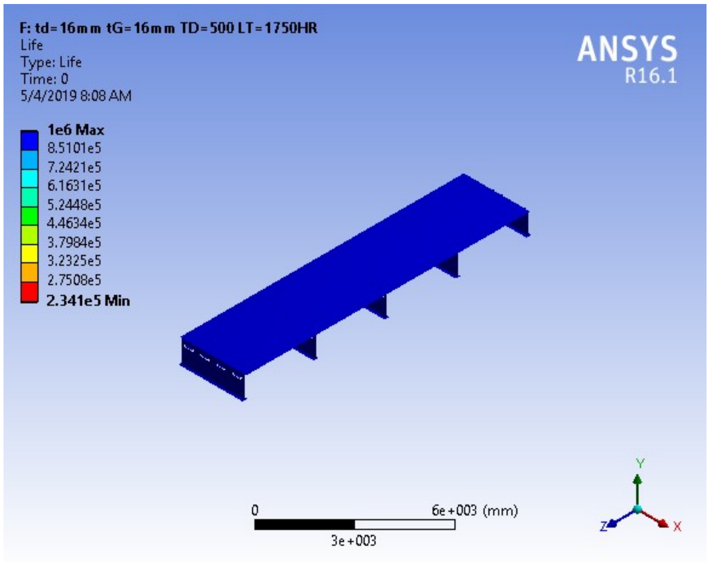

Fig. 4 Isometric view of minimum life developed at orthotropic steel bridge after filling ribs with ultra light weight concrete when load is applied 500 mm away from the side and 1750 mm away from the edge

TABLE 3
MAXIMUM STRESS AND MINIMUM LIFE COMPARISON

Position of load	Before Strengthening		After strengthening	
	Maximum Stress (N/mm^2)	Minimum life	Maximum Stress (N/mm^2)	Minimum life
500 mm away from side & 0 mm away from edge	223.09	$5.69x10^5$	85.05	$1x10^6$
500 mm away from side 1500 mm away from edge	156.01	$2.86x10^5$	100.86	$4.04x10^5$
500 mm away from side 1750 mm away from edge	156.59	$2.01x10^5$	110.93	$2.34x10^5$

4 DISCUSSIONS

The maximum stress developed in orthotropic steel bridge when load is applied 500 mm away from the side in transverse direction and 0 mm away from the edge in longitudinal direction is 223.09 N/mm^2 and minimum life is $5.69x10^5$.Maximum stress developed and minimum life after strengthening with ultra light weight concrete is 85.05 N/mm^2 and$1x10^6$.

The maximum stress developed when load is applied 500 mm away from the side in transverse direction and 1500 mm away from the edge in longitudinal direction is 156.01 N/mm^2 and minimum life is $2.86x10^5$.Maximum stress developed and minimum life after strengthening with ultra light weight concrete is 100.86 N/mm^2 and $4.04x10^5$.

The maximum stress developed when load is applied 500 mm away from the side in transverse direction and 1750 mm away from the edge in longitudinal direction is 156.59 N/mm^2 and minimum life is $2.01x10^5$.Maximum stress developed and minimum life after strengthening with ultra light weight concrete is 110.93 N/mm^2 and $2.34x10^5$.

5 CONCLUSIONS

The ribs are filled with ultra light weight concrete for strengthening .After strengthening iff the load is applied 500 mm away from the side in transverse direction and 0 mm away from longitudinal direction then there is 61.87% decease in stress development and 75.75 % increase in minimum life.If the load is applied 500 mm away from the side in transverse direction and 0 mm away from longitudinal direction then there is 35.35% decease in stress development and 41.25% increase in minimum life.The ribs filled with ultra light weight concrete for strengthening the orthotropic steel bridge .When the load is applied 500 mm away from the side in transverse direction and 1750 mm away from longitudinal direction then there is 29.15 % decease in stress development and 16.41% increase in minimum life.

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