Steel Truss Bridge Using Mesh Insensitive Method

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***Abstract*:** Bridge is a complex structure made out of materials; they are a part of life. Now a day there is widely increased traffic demand, material ageing, cracking of bridge components, physical damages incurred by concrete, corrosion of reinforcement and maintenance of bridges periodically for their performances. Steel concrete highway bridges subjected to dynamic effect due to variable magnitude due to no. of vehicles crossing of deck pavement. Depending on the magnitude and intensity of dynamic actions, this adverse effect may affect the structural system response that could also lead to a reduction of the expected bridge service life. Fatigue failure is important subject to the researcher in domain of the mechanics fracture. Current studies discuss to calculate the fatigue in gusset plate connection in steel bridge used the mesh insensitive structural stress approach by using equivalent stress method.

***Index Terms* – Steel truss bridge, Fatigue analysis, Equivalent von-mises stress, Fatigue fracture, Mesh insensitive.**

I. INTRODUCTION

Nowadays, more and more large steel bridges are constructed worldwide due the steel is good in both tension as well as compression. Steel has high strength to weight ratio. Most of the time steel bridges fails due fatigue. Fatigue failure is the important parameter. In fact 80-90% of failures in steel bridges are related to fatigue fracture. It is important to study fatigue damage in these bridges. Fatigue occurs in connection such as welded, bolted and riveted. Due to the action of cyclic loading in the bridges such as dead load and different types of high weight vehicles passed on the bridges; in that case of fatigue occur at connection most of the time. Welded joints are usually prefabricated in factory to ensure high welding quality. The welded joints between the flange and gusset plate are subjected to varying tensile stresses and other adverse effects on fatigue resistance and thus susceptible to fatigue damages. In general, the adverse effects include stress concentration, weld defects and residual stresses at welded joints [1-4].the effect of stress concentration, weld defect and residual stresses on fatigue resistance of welded joints have been investigated [9]. the geometry of weld joints was optimized and a corner-fillet profile(CFP) at weld of cruciform joints was recommended to reduce stress concentration [5].different method for evaluating fatigue resistance of welded joints have been proposed with consideration of stress concentration and weld residual stress. Nominal stress method is recommended by several design specification for steel structures, such as Eurocode3 [10].the mesh-insensitive structural stress and S-N curve method for ship structure. [11].form the above study observed that fatigue is mostly occurred in critical zone such as welded connection in steel bridges. At present, fatigue analysis in welded joints carried out using equivalent stress approach using different mesh size.

1.1 Proposed Work

1.1.1 Methodology

Steel truss bridge is considered. The dimensions of bridge component are found by design according to IRC specification. Modeling and analysis of bridge and welded connection using different size of mesh such as 33 mm 36mm,39mm and 42mm using finite element software SAP2000 and ANSYS. Comparison and equivalent von-misses stress, maximum principle stress and factor of safety for fatigue. In second part of paper used viscous fluid damper reduced the axial forces and again compare the results for fatigue analysis.

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II ANALYSIS

2.2 Configuration of Bridge

Table -1: Loading and Other Data

One span length of bridge	80 m
No of panel	10
Height of bridge above substructure	13.25m
Width of bridge	10 m
No. of lane	2 lane + 1m side walk on each side
Height of Pier	20m
Thickness of slab	300 mm
Wearing coat	75 mm
Side walk	3.6 kN/ m^2
Railing	0.36 kN/m

- SIDL -

  P = $\left(13.3 + \frac{400}{L}\right)\left(\frac{17-w}{143}\right)$

  P - Live load in kN/m^2.

  L - Effective span of main girder

  W – Width of footway in m.

  SIDL – 2.0313 kN/m^2

- Live load – class 70R and class A tracked vehicle as per IRC.

- Grade of concrete – M30 and f_y 345

2.2.1 Section Properties

Table 2: Section Properties

Sr.No.	Section Name	Section Size
1	Top chord	600 x 450 x 25 mm (box section)
2	Bottom chord	600 x 450 x 25 mm (box section)
3	Diagonal	600 x 450 x 25 mm (box section)
4	Bottom bracing	300 x 450x 25 mm (I- section)
5	Top bracing	300 x 450 x 25 mm (I- section)
6	Portal	150 x 150 x 10 mm (angle section)
7	Cross Beam	1300 x 320 mm thickness (Flange :20-25mm) and (web 10-15mm)
8	Stringer	Stringer (longitudinal 800 x 220) thickness(Flange: 16mm) and (web: 10mm)

2.2.2 Time History Analysis

Dynamic analysis is performed by linear direct integration time history analysis for different type of vehicle speed 100Kmph, 150Kmph and 200Kmph are considered as per future speed requirement. After the analysis axial forces calculated for the combined load of 1.2 (DL+LL).

Table-3: Maximum Axial Force on Truss Member

Sr.No.	Member	Axial Force
1	Diagonal	3074.972 kN (T)
2	Diagonal	2545.180 kN (C)
3	Horizontal	3284.36 kN (T)
4	Horizontal	3062.36 kN (T)

Therefore above combined axial forces are calculated. and after calculation that forces apply on the fatigue analysis in ANSYS Finite element software. For the fatigue calculation for the different types of mesh size are used 33mm, 36mm, 39mm and 42mm then equivalent von-misses stress and maximum principle stress and fatigue check for factor of safety are calculated.

2.3 Modeling

In modeling welded truss connection are considered for fatigue analysis. For that the weld thickness is 6 mm and the gusset plate thickness is 30 mm considered and Fatigue is calculated for the maximum axial forces at welded joint in truss bridge.

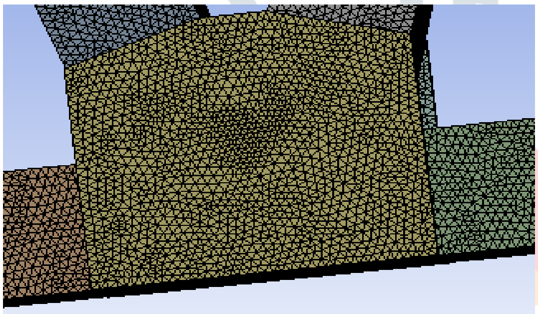

Fig -1: FEM modeling of 33mm mesh size.

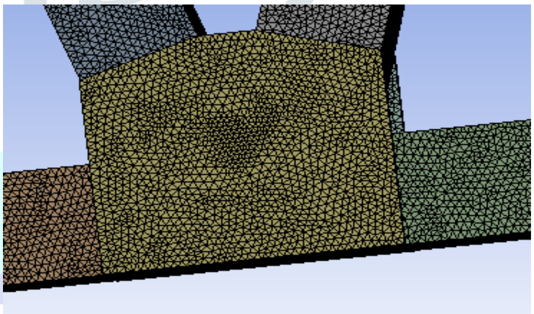

Fig -2: FEM modeling of 36mm mesh size.

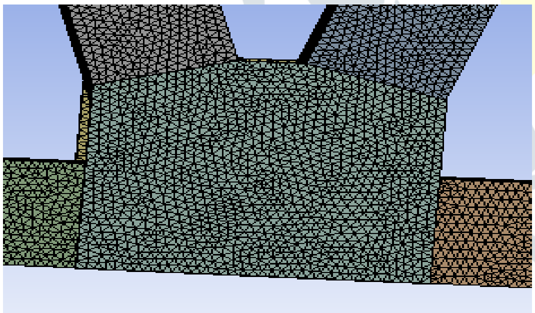

Fig -3: FEM modeling of 39 mm mesh size.

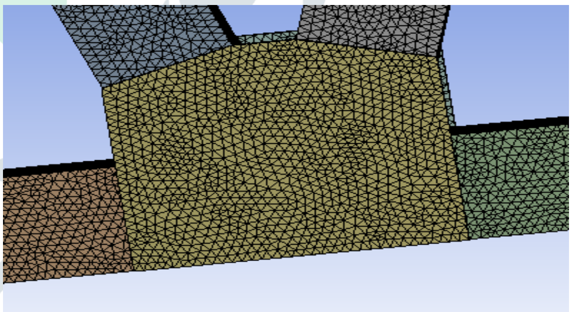

Fig -4: FEM modeling of 42mm mesh size.

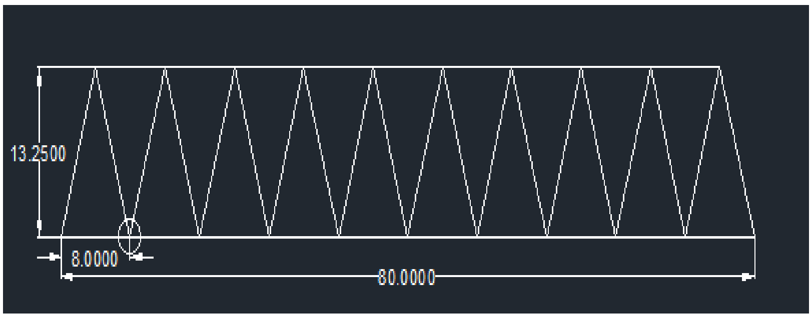

Fig -5: Location of truss joint considered for fatigue analysis.

III. RESULTS AND DISCUSSION

3.1 Results Comparison between equivalent stress with Different mesh size

From the results of equivalent von-misses stress is compared by using different mesh size. Below table show the when mesh size increased then the stress are reduces.

Table-4: Equivalent Von-misses stress and mesh size

Sr.No.	Equivalent Von-Misses stress	Mesh Size
1	59.964 MPa	33 mm
2	57.679 MPa	36 mm
3	47.421 MPa	39 mm
4	43.26 MPa	42 mm

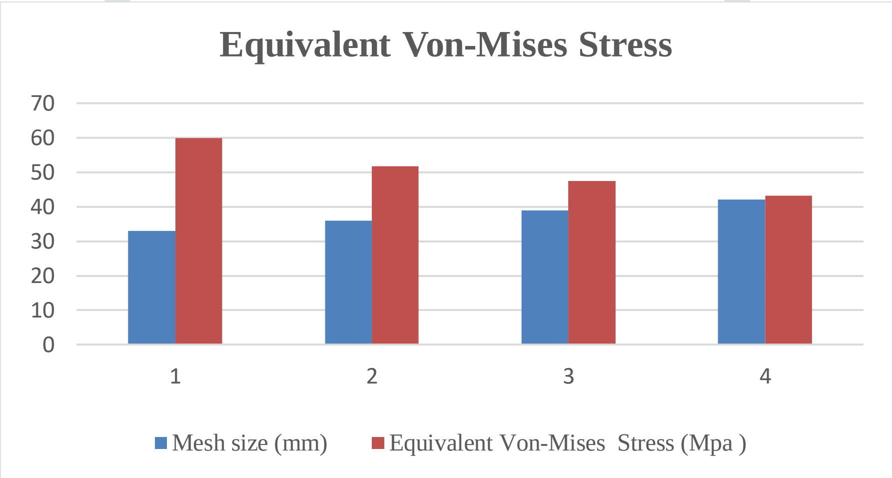

Chart -1 Mesh Size Impact on Equivalent von-mises stress

3.2 Result Comparison of maximum principle stress with different mesh size

From the results of maximum principle stress is compared by using different mesh size. Below table show the when mesh size increased then the principle stress is reduces.

Table-5: Maximum Principle stress and mesh size

Sr.No.	Maximum Principle stress	Mesh Size
1	39.043 MPa	33 mm
2	29.834 MPa	36 mm
3	29.088 MPa	39 mm
4	28.56 MPa	42 mm

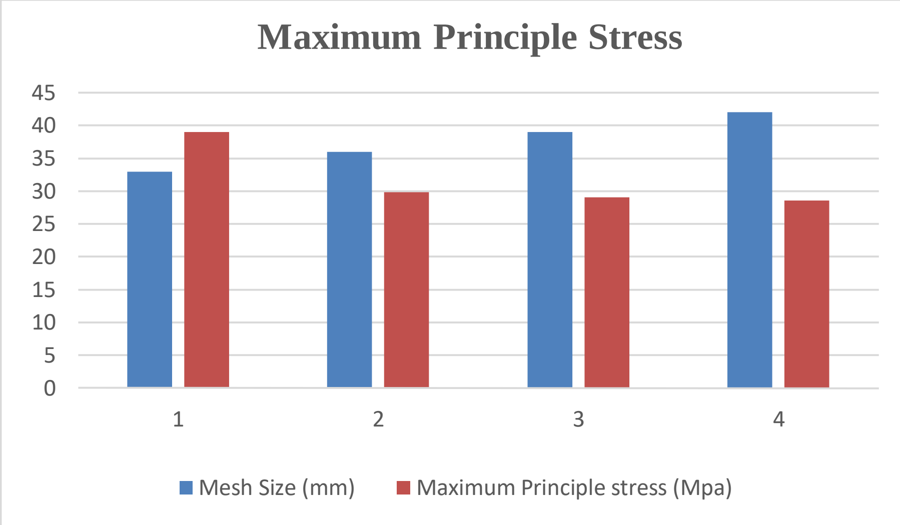

Chart-2 Mesh Size Impact on Maximum Principle Stress

3.3 Result comparison between fatigue (FOS) with different mesh size

From the results of fatigue check for FOS is compared by using different mesh size. Below table show the when mesh size increased then the factor of safety decreases.

Table-6: Fatigue (FOS) and mesh size

Sr.No.	Fatigue (FOS)	Mesh Size
1	1.4375	33 mm
2	1.668	36 mm
3	1.8178	39 mm
4	1.900	42 mm

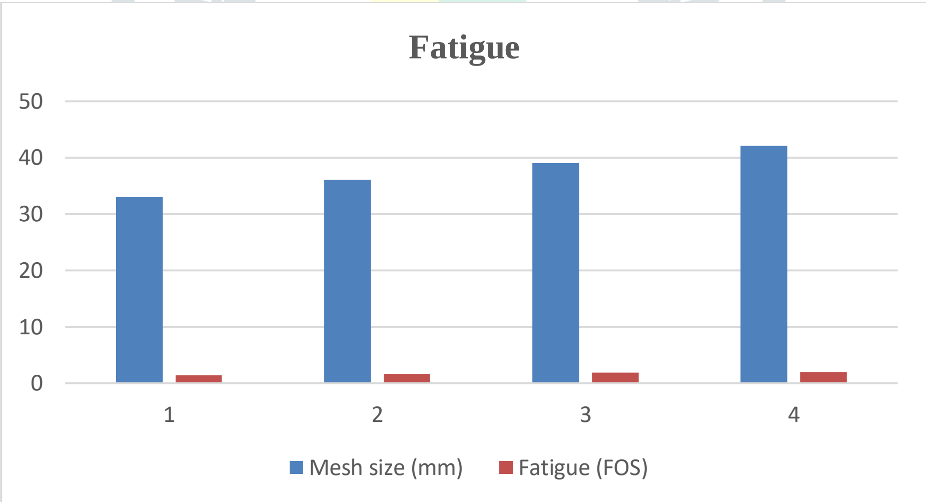

Chart -3 Mesh Size Impact on fatigue (FOS)

IV. CONCLUSIONS

By analyzing different mesh sizes and time history analysis these are the conclusions of this study

- The study of time history analysis it is concluded that speed of the vehicle increased then the more amount of axial forces is occurred at the truss joint.
- It is observed that when vehicle speed is directly proportional to the fatigue fracture of member.

- The study of result it is concluded that speed of the vehicle is also the one parameter of fatigue fracture occurred in steel bridges.

- According to different mesh size such as 33mm, 36mm, 39mm and 42 mm for calculation on equivalent Von-misses it is observed that when mesh size increases then stresses are decreased. Hence, it is concluded that equivalent stress is depend upon the mesh sensitive behavior.
- According to different mesh sizes for calculation on maximum principle stresses it is observed that when mesh size increases then maximum principle stresses decreased hence it is conclude that maximum principle stress is depend upon the mesh sensitive behavior.
- According to different mesh size to check the fatigue for factor of safety above result it is conclude that when mesh size changes than fatigue for FOS observed when mesh size increase than fatigue for FOS increased. Hence, it is conclude that fatigue for FOS does not depend upon the mesh sensitive behavior.

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