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Analytical Study on Fatigue Behaviour of Steel Truss Girder Joints

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Abstract

Truss girders represent a very rational construction form and facilitate construction, making with minimum material expenditure and a very high degree of efficiency. They are especially suitable for large-span structures and for greater load transfer in building construction as well as bridge construction. The performance of girders depends largely on the effectiveness of joints. In this work, modeling of each composite joint was carried out by using finite element method and software ANSYS-2014 to evaluate and compare the ultimate strength and fatigue behaviour of different joints. Overall investigation may provide reference for design and construction of composite joints in composite truss bridges.

Keywords: *Composite K joint, Concrete filled, fatigue behavior, Finite element analysis.*

1. Introduction

The concrete and steell composite structures have been extensively applied in bridge constructions due to the benefits of combining two different constructional materials. The structural performance of composite truss bridges depends largely on the effectiveness of joints. Thus joints in composite truss bridges should possess high strength and stiffness as well as fatigue performance in order to withstand complicated forces is transmitted through it.

Now a day, the use of composite trusses, mainly adopting tubular members has been increasing in bridge design due to their merits over traditional materials. Aesthetical qualities, light weight, high-strength to weight ratio, developments in cutting and welding technologies and high efficiency in construction are the advantages of tubular members for civil engineers to prefer this material. In ccomposite trusses, steel and concrete act together, hence reducing deflections and increasing strength and life. Jun He et al investigated the mechanical behaviour of composite trusses under different load conditions and results showed that joint parts which connect steel truss and concrete slabs are the most important components in structure system [5].

Composite sections have higher stiffness than the corresponding steel sections and thus bending stress as well as deflection are lesser. In a plate–truss composite steel girder bridge, the economic benefit is realized through the stiffness and lightness of the steel girder structure, since less material is used [11].

In order to avoid stress concentration, it is necessary that tubular joints are reinforced by many stiffeners. The strength of the joint can improve if the deformation of the chord wall is restricted by concrete [10].

The concept of strengthening truss girder joints results increased life span of structures and, as a result, could contribute significantly to the economy of the nation

2. Scope

The scope includes a comparison of ultimate strength and fatigue behaviour of concrete filled and additionally reinforced tubular K joints of truss girder. The results from finite element analysis using ANSYS will provide references for the design and construction of joints in steel truss girder.

3. Objectives

1. To determine the ultimate failure load of concrete filled and additionally reinforced tubular K joints of truss girder using Finite Element software.
2. To understand the fatigue behaviour of joints in truss girder joints having good ultimate strength in static analysis results.
3. To compare the ultimate strength and fatigue behaviour of concrete filled and additionally reinforced tubular K joints of truss girder.

4. Validation

An FE model of composite truss K joint was validated using FE results from journal [5]. The Results of validation are shown in Table 1.

Table 1: Results of Validation

Joint Designation	Von misses stress (MPa)		Error (%)
	Obtained from FEA in paper	Obtained from ANSYS	
K- joint with Headed studs	250	231.018	7.6

5. Present Study

5.1 Tubular K joints

The specimens are tubular K-joints and their size shown in Fig.1 The size of a chord member of steel pipe is D = 318.5 mm in diameter and T = 6.9 mm in thickness, and that of the diagonal members of steel pipe is d = 216.5 mm and t = 5.8 mm. Each stud is having a diameter of 3mm and length 60mm. Six specimens were modelled as given in Table: 2.

Table: 2 Details of specimens.

Sl No:	Specimens	Composition
1	K1	Circular hollow tube
2	K2	Filled concrete in a chord member
3	K3	Filled concrete both in a chord and diagonal members
4	A1	Filled concrete and reinforced by dowels both in chord and diagonal members
5	A2	Filled with concrete both in chord and diagonal members, and reinforced by a dowel in a chord member
6	A3	Composed of filling concrete both in chord and diagonal members and had a gusset

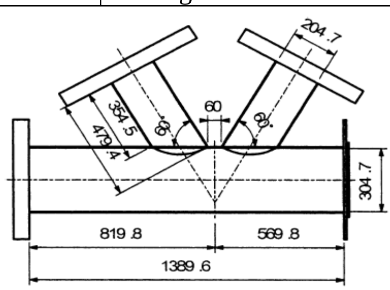

Fig. 1 Size of specimen.

5.2 Finite Element Material Models

5.2.1. Concrete

Concrete having modulus of elasticity (E) = 319000 N/mm^2 and Poisson's ratio (ν) = 0.2 was taken.

5.2.2. Reinforcement

Steel bars having modulus of elasticity (E) = 210000 N/mm^2 and Poisson's ratio (ν) = 0.3 was taken.

5.3 FE Model

Finite Element modelling has been done in ANSYS 14. SOLID65 element is used for the three-dimensional modelling of concrete and steel

5.4 Boundary Condition

For each of the two ends of diagonal members were fixed. Axial loading is applied to find out the ultimate load.

6. Result and Discussion

6.1 Ultimate Load

Static analysis has been carried out on specimens in ANSYS 14 to find out the ultimate load carrying capacity.

Table 3: Ultimate strength of specimens

Sl No:	Specimens	Ultimate load (kN)
1	K1	570
2	K2	1200
3	K3	1500
4	A1	3400
5	A2	2939
6	A3	3650

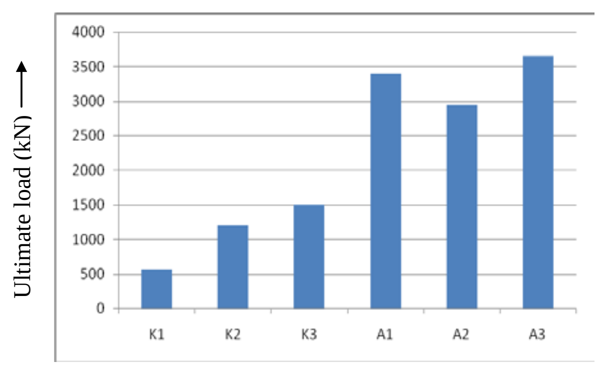

Fig.2 Ultimate load of different specimens

The ultimate load of specimen A1, A2 and A3 are 5.96, 5.16 and 6.4 times the ultimate of hollow specimen K1.

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6.2 Von Misses Stress Diagram of specimens

The von misses stress of specimens under ultimate load is given below.

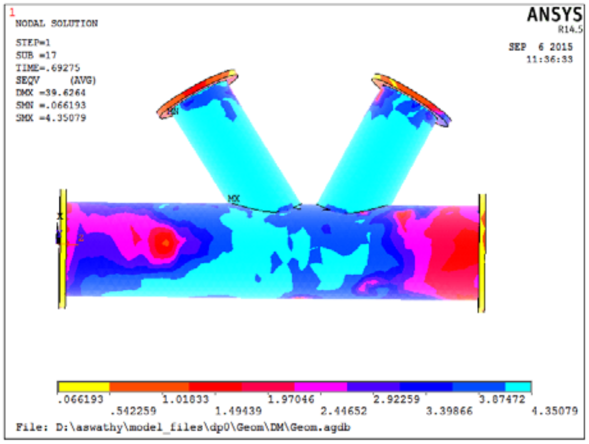

Fig.3.Von misses stress diagram of K1.

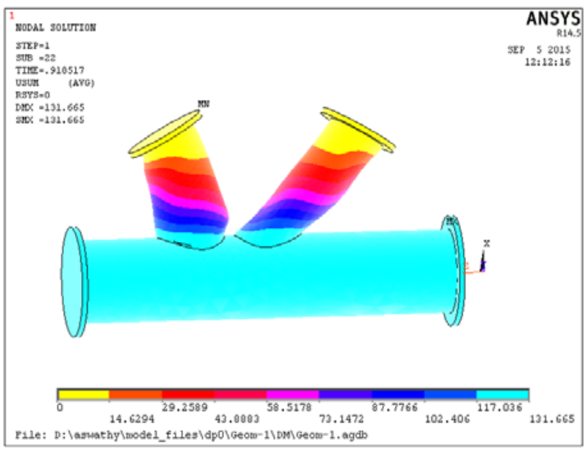

Fig.4.Von misses stress diagram of K2.

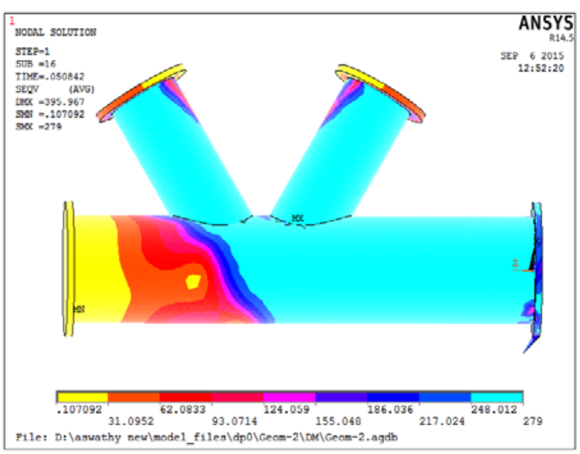

Fig.5.Von misses stress diagram of K3.

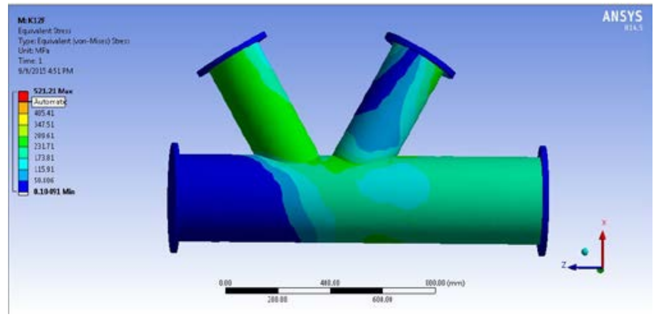

Fig.6.Von misses stress diagram of A1.

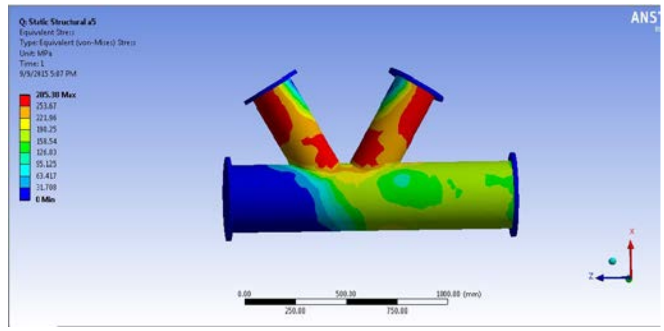

Fig.7.Von misses stress diagram of A2.

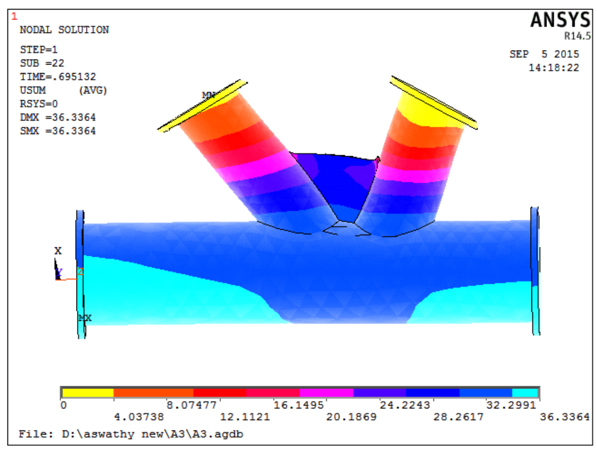

Fig.8. Von misses stress diagram of A3.

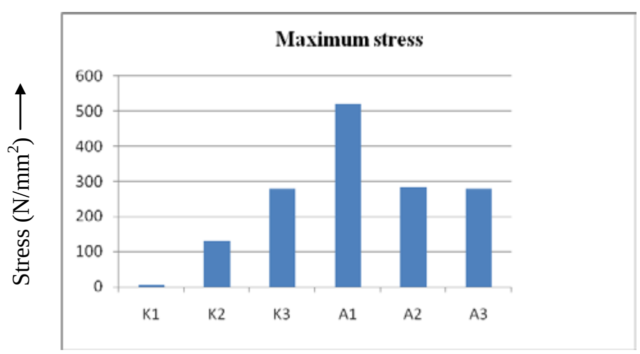

Fig.9 Maximum stresses of different specimens.

By comparing the analysis results in Fig. 2 and Fig. 9, the ultimate load and von misses stresses of A1, A2 and A3 are higher than other specimens. Hence we go for fatigue analysis of these specimens.

6.3 Fatigue Analysis

Specimen A1, A2 and A3 applied a load of 2000 kN at end of chord member. The minimum life was obtained at the intersection of the chord and diagonal members.

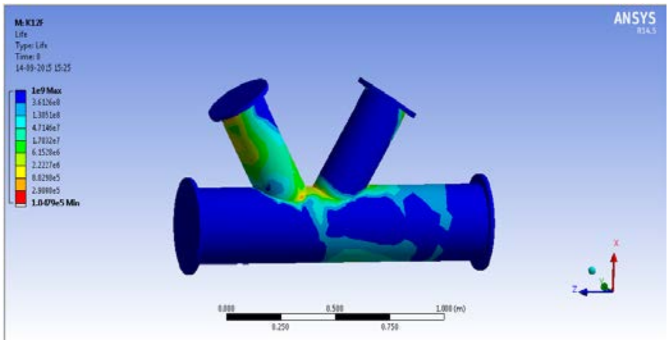

Fig.10. Life of specimen A1 at 2000 kN.

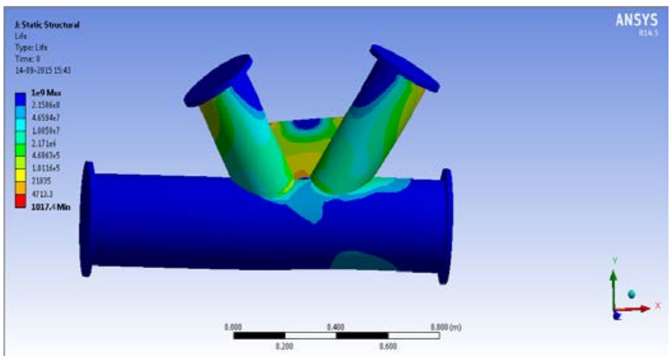

Fig.11. Life of specimen A2 at 2000 kN.

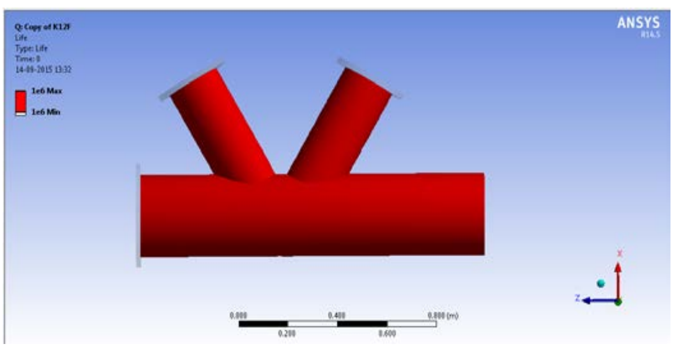

Fig.12. Life of specimen A3 at 2000 kN.

Specimen A3 is having infinite life at 2000kN.Hence specimen A3 again loaded with 3400kN to find out its life.

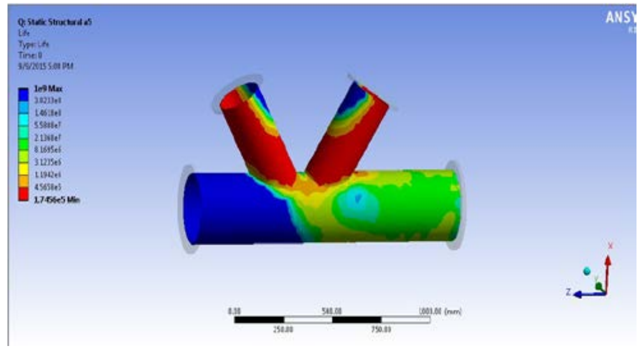

Fig.13. Life of specimen A3 at 3400 kN.

Table 4: Comparison of results.

Specimen	Ultimate Load (kN)	Minimum Life (Cycles)
A1	3400	104879
A2	2939	1017.4
A3	3650	174500

Now it is clear from Table:4 that, joints A3 (Composed of filling concrete both in chord and diagonal members and had a gusset) and A1(Filled concrete and reinforced with dowels in both chord and diagonal members) possesses high strength and long life in comparison with other specimens.

7. Conclusions

- Ultimate loads of specimens are increased as their reinforcements are increased and the lowest ultimate load is obtained for hollow specimen.
- The specimen filled concrete with dowels, and the specimen filled concrete with a gusset have the highest ultimate load.
- Comparison of ultimate load of six specimens was done and three specimens with maximum ultimate load were chosen for fatigue analysis.The maximum life is obtained for the specimen filled concrete with dowels in chord and diagonal.

References

[1] Wenjin Huang , Luigi Fenu, Baochun Chen, Bruno Briseghella, “Experimental study on K-joints of concrete-filled steel tubular truss structures”, Journal of Constructional Steel Research, February 2015,Vol.107,PP 182–193.

[2] ZHENG Shang-mln, WAN Shul, “Finite element analysis of shear lag effect on composite girder with steel truss webs”, Journal on High way and transportation research and development,2014, Vol. 8,Pp 89-93.

[3] Lanying Zhu, Zhijun Wang, Mengli Song, "Experimental study of steel truss girder with Z-shaped clips", Conf. on Advances In Civil, Structural and Environmental Engineering- ACSEE, 2014,PP-89-93.
[4] Joanna Jankowska ,Sandberg, JarosławKołodziej, "Experimental study of steel truss lateral–torsional buckling", Journal of Engineering Structures, September 2013, Vol.46, PP 165–172.
[5] YuqingLiu, HaohuiXin , Jun He , DongyanXue, Biao Ma , "Experimental and analytical study on fatigue behavior of composite truss joints", Journal of Constructional Steel Research, January 2013,Vol.83,PP 21–36.
[6] DongyanXue, Yuqing Liu, Jun He, Biao Ma, "Experimental study and numerical analysis of a composite truss joint", Journal of Constructional Steel Research , January 2011,Vol.67 ,PP 957–964.
[7] Fidelis RutendoMashiri, Xiao-Ling Zhao, "Square hollow section (SHS) T-joints with concrete-filled chords subjected to in-plane fatigue loading in the brace", Journal of Thin-Walled Structures, October 2009,PP-150-158.
[8] Scott Walbridgea, Alain Nussbaumer, "Probabilistic fatigue analysis of shop and field treated tubular truss bridges", Journal of Constructional Steel Research, June 2008, PP156–166.
[9] Yong-Bo Shao, "Analysis of stress intensity factor (SIF) for cracked tubular K-joints subjected to balanced axial load", Journal of Engineering Failure Analysis, march 2006, Vol.13, PP44–64.\
[10] Yoshinaga Sakai ,Tetsuya Hosaka b, Akira Isoe ,Atsushi Ichikawa, Kaoru Mitsuki, "Experiments on Concrete Filled And Reinforced Tubular K-Joints Of Truss Girder", Journal of Constructional Steel Research, May 2004,Vol.60 ,PP 683–699.
[11]R.H. Wang, Q.S. Li , Q.Z. Luo, J. Tang, H.B. Xiao, Y.Q. Huang, "Nonlinear analysis of plate–truss composite steel girders", Journal of Engineering Structures ,April 2003, Vol.25, PP 1377–1385.

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