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# FATIGUE ANALYSIS OF TRUSS

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*Abstract:* **Three different modes of failure of steel structures are- member failure, joint failure and foundation failure. Any of the failure of the member results in total system failure. Hence, it is required to consider each of the failure under the different loading conditions. A roof truss is selected for the analysis subjected to wind loads and seismic loads with regular dead loads and live loads. A truss which is under function is taken for study. Analysis was carried out using STAAD Pro to check whether design is correct and also for finding out any other parameters. MAT LAB program is used for fatigue analysis; S-N diagrams are drawn for calculating number of cycles to predict life of the structure.**

***Keywords*: Truss, Bolt, Fatigue life, S-N curve, MAT LAB.**

## 1. INTRODUCTION

Steel truss is one of the well accepted roofing systems among a variety of roofing systems which is used in multi-storied buildings to support roofs, floors and internal loading. Trusses are used mainly because of their long span and light weight. Trusses in the form of bracings are used in industrial buildings to resist lateral loads and to provide stability. Steel structures are preferred over concrete structures since they require less time for completion of structure. As we focus on advantages of steel construction we have to look into disadvantages of it. Steel structures fail suddenly. In this project, the causes of failure have been noticed and the life of connections in steel structures is estimated.

During designing of steel structures against fatigue loading, engineer focuses only on steel members and joint design is left to fabricator. The assumption mainly is that there is no fatigue failure and joint design is not so important. In recent years there are many structural failures which are caused mainly due to fatigue. In the present study, analysis of steel truss is carried out. Roof truss is subjected to live load, dead load, wind load and its different combinations. The roof truss members and connections are designed in accordance with **IS: 800-2007.** The steel roof truss members detailing is done. The member properties are specified, supports are assigned to the steel columns. The purlins spacing is decided depending upon the type of the sheeting provided. The steel roof truss is connected to one another at a distance of 5m. There are 7 trusses connected to each other at ends. The dimensions of the building are 30m*25.76m. The width of the steel roof truss 25.76m and height of the truss is 0.75m which is supported by steel columns of height 7m from the ground level.

## 2. METHODOLOGY

After the analysis is carried out for the steel truss, the axial forces acting on each members is obtained. The members are either subjected to compression or tension depending upon the loading conditions. The truss members are designed using STAAD software only. All the members are checked whether they are satisfying the design conditions, if any member fails the member is redesigned depending upon the axial force acting on it. As per the analysis and design carried out there are 7 trusses connected to each other. In each truss there are totally 89 members. Total in 7 trusses there are 623 members. Each member is analyzed under static conditions and designed as per IS 800:2007. During analysis truss members are assigned by section properties. After the design is carried out by STAAD, we will get to know how many members will fail or pass. If a member fails, it is redesigned. If a member passes and a higher section is provided then the steel design will provide that member by a suitable economical section.

In the present study, all the top chord members and bottom chord members were assigned as ISA 150*150*10 LD, after design all the members were passed but many members were found uneconomical. In the design sheet (fig 5.1) below we can see the section properties of the members during the analysis and after the design. Hence, the design of the members is carried out by STAAD.

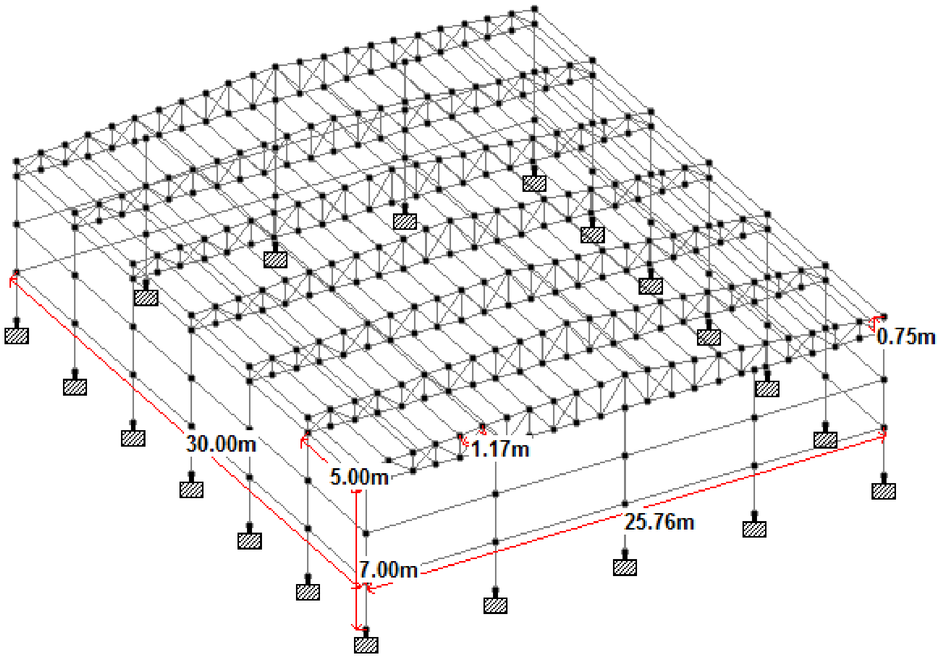



**Figure 1: Steel Roof Truss model created in STAAD Pro**

## 3. FATIGUE ANALYSIS

Fatigue failure is initiated by a small crack which is quite negligible as it is not detected very easily. These cracks usually develop due to discontinuity in the material. The fatigue failure is likely to deepen by presence of cracks, marks due to machining process. As the crack grows, the stress concentration increases. The stresses area is decrease due to the effect in magnitude of stress acting which ultimately leads to failure. Fatigue affected areas are brittle in nature. Design of structures for static failure is simple because of our comprehensive knowledge. Fatigue phenomenon is quite complex. The main reason of taking account of local stresses is to generate fatigue loads with greater accuracy which might play an important role in finding fatigue strength. MAT LAB is used for fatigue analysis of bolted connections. Program for finding out number of cycles for a bolt is written. The inputs are maximum stress, minimum stress, ultimate strength and fatigue strength for 1000 cycles. The output is fatigue strength and number of cycles after which the bolt might fail due to fatigue. Hence MAT LAB has made it easier and faster in obtaining results for various truss members. Theoretically, if we calculate a lot of time is taken but when we use a programming language like MAT LAB it becomes more convenient for the engineer to arrive at results at a faster rate.

Beam-180

Bolt diameter-20mm

Maximum stress-319.96N/mm²

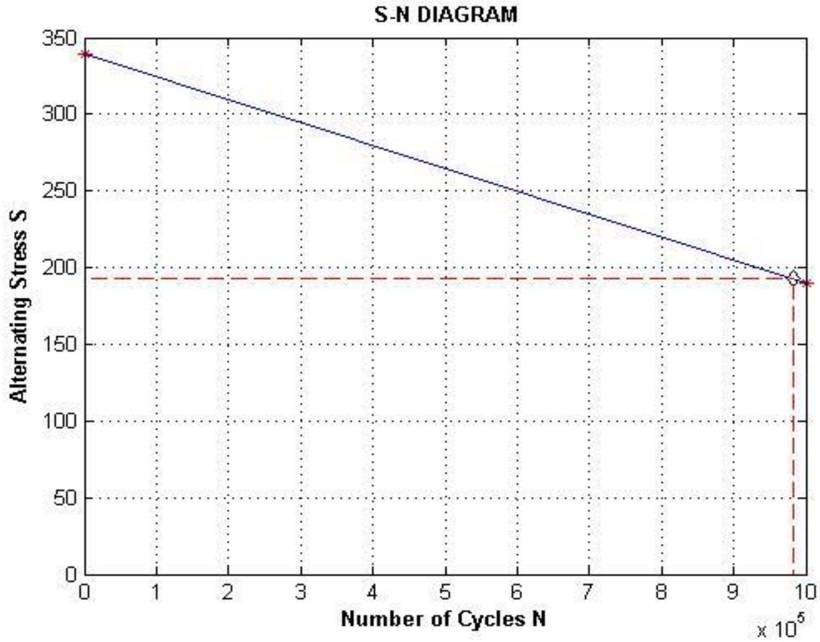
Minimum stress-184.73N/mm²

Ultimate strength-377.27N/mm²

Strength at 1000 cycle-339N/mm²

Strength at endurance limit-190.14N/mm²

Life of failure-$9.5*10^5$




S-N curve for bolt connection of beam 180

BEAM-248

Bolt diameter-20mm

Maximum stress-261.22N/mm²

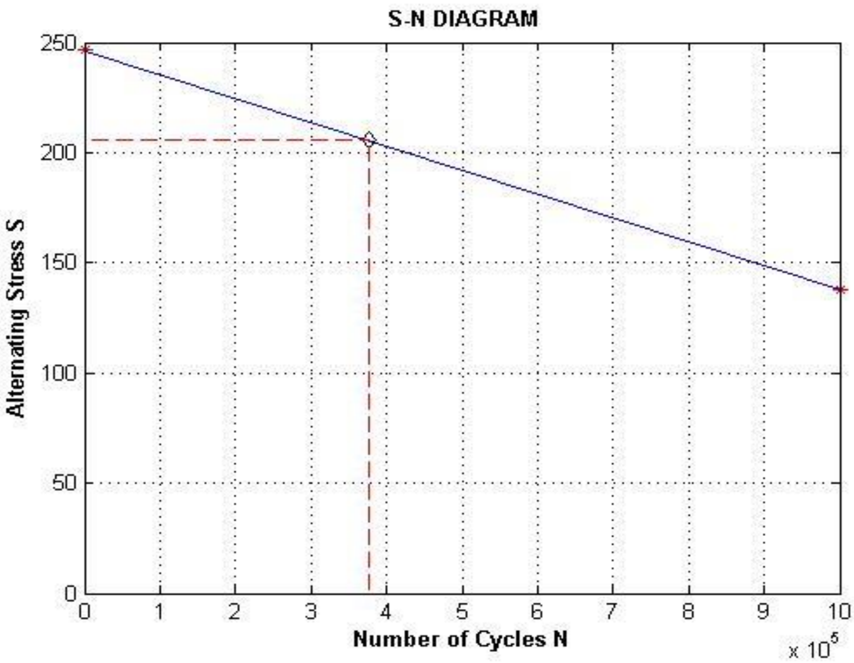
Minimum stress-184.73N/mm²

Ultimate strength-273.9N/mm²

Strength at 1000 cycle-246.46N/mm²

Strength at endurance limit-138N/mm²

Life of failure-3.75*$10^5$




S-N curve for bolt connection of beam 248

BEAM-207

Bolt diameter-20mm

Maximum stress-184.8N/mm²

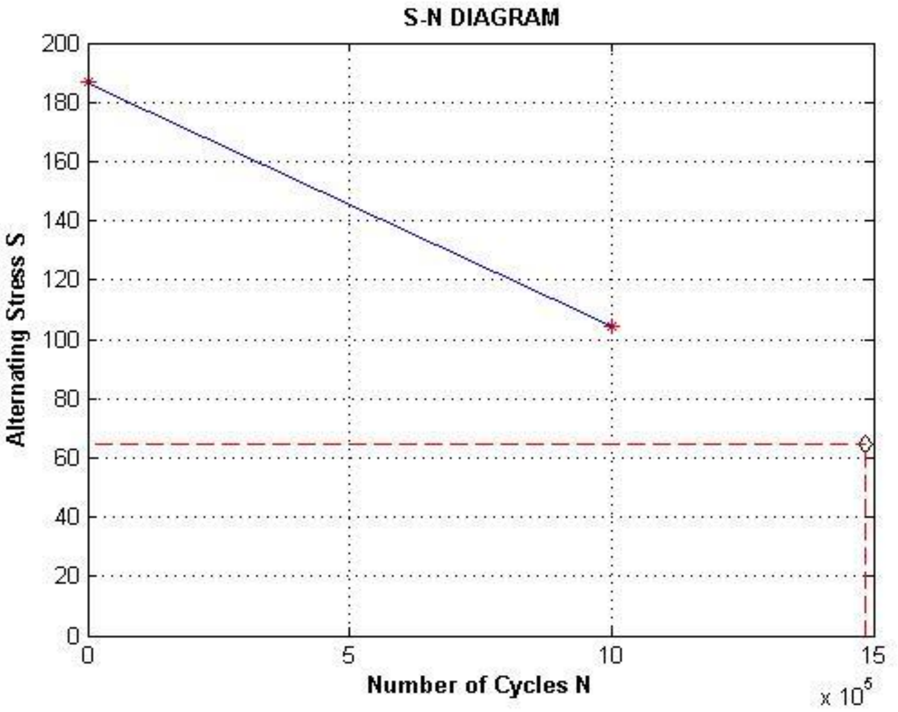
Minimum stress-163.8N/mm²

Ultimate strength-207N/mm²

Strength at 1000 cycle-186.57N/mm²

Strength at endurance limit-104.32N/mm²

Life of failure-$1.49*10^6$




S-N curve for bolt connection of beam 207

## 4. RESULTS AND DISCUSSION

The life of bolts for each connection in steel roof truss was determined by fatigue analysis. The analysis and design carried out by STAAD Pro gave an idea on the axial forces acting on the members and sections provided for the members were stable or not to resist the loads acting on them. The fatigue calculations were carried out. The S-N curve was drawn for each connection to determine the alternating stress and number of cycles. MAT LAB program simplified the calculation of fatigue. The life of joints found also depicted the safe service life of the structure. It highlighted areas of critical loads and failures which required more attention. Hence it is seen that all the connections have a minimum life $0.9*10^6$ to maximum life of $1.9*10^6$. Most of the connections had $1.5*10^6$. This shows that the structure has enough safe service periods.

## 5. CONCLUSION

During this analysis we figured out the life of failure of each bolted connection. S-N curve is drawn for each bolted connection. It is the curve plotted against stress and number of cycles. Number of cycles gives an idea about how long a structure is subjected to repeated stress. This also known as life of failure which indicates that the connection might fail after this period. When structure undergoes low cycle fatigue loading condition it has shorter life when compared to structure under high cycle of fatigue.

Fatigue failure analysis has determined that joint failure in steel structure is generally due to bolt failure. The calculated ratio of load transferred at different bolt location to total truss members, show that the load transfer of the bolt rows is affected by damage accumulation; as a result the load transfer is changed during fatigue life.

The results obtained during fatigue analysis by MAT LAB showed that the life of failure for each bolt is different due to the alternating stress. Hence, fatigue analysis has become an important analysis in today's construction for estimating life of a structure and to estimate the possible damages occurring in the structure during its service life.

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