

Analysis on Railway Sleepers using ABAQUS

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Received: 06 July 2021

Accepted: 28 November 2021

Keywords:

Pre-stressed concrete sleeper, fatigue life, static loading, dynamic loading.

ABSTRACT

The Railway sleeper play important role in the complex railway system when subjected to repeated stresses due to the movement of locomotive. Also the increased speed and different axle loads from the train causes stress variation in the Sleeper. So it is necessary to assess the fatigue life of the sleeper. The Pre-stressed concrete sleepers being the common application is considered for study using Finite element software to assess its fatigue life. The Sleepers are subjected to static and dynamic loads. The axle load in the locomotive WAM-4 in Indian railway is chosen for the fatigue analysis. The analysis showed stress range after application of load cycles was reduced leading to fatigue failure. So, the cycle which caused this low stress range is taken as fatigue life of sleeper.

1. INTRODUCTION

Many structures are subjected to cyclic loadings. Railway sleepers are main component of the railway track system which is subjected to one such loading. Sleepers also resist the lateral and longitudinal moment of the rail. Sleepers laid years ago showed fracture and failure leading to deterioration. The effect of repeated loading causes fatigue failure in the system. Sleepers are transverse beam resting on ballast carrying the wheel load from the train through rail. The main function of sleeper is to support the rail, maintaining the track gauge and to transfer the load from rails to ballast. Pre-stressed concrete sleepers are widely used nowadays in Indian railways

Pre-stressed sleepers are developed with longer life with lower maintenance cost. The pre stressed sleepers has more advantage than wooden and concrete sleeper that used in the earlier railway system. Pre-stressed concrete sleeper are expected to withstand high magnitude of dynamic loading and harsh environmental factor. The most used pre -stressed railway sleeper is PCS-12 mono-block concrete sleeper which has been taken into account for analysis of static and dynamic behaviour of the sleeper.

2. OBJECTIVE

This paper aims to study the fatigue failure of the pre stressed concrete sleeper (PCS-12) subjected dynamic loading due to the wheel movement occurring from the locomotive engine and other components also to determine the stresses that acting on the rail seat position. The change in the time period and amplitude of loading due to the movement of train causes variation of stresses in the sleepers. When subjected to static and dynamic responses the pre stressed concrete sleepers undergo deformation due to flexure and bending. The local stress concentration in the concrete sleeper forms cracks or crushing of the sleeper. Finally fatigue life due to the repetition of stress in the sleeper is analyzed.

3. METHODOLOGY

The properties for the pre stressed concrete sleeper were collected and Finite element model of the PCS-12 concrete sleepers were made using ABAQUS software. The pre stressing tendon were placed in the sleepers and arranged in position and length. The rails were placed on the sleepers and the interaction between the sleeper and rails were made. The static and dynamic loading is applied on the sleeper through the rails for repeated number of cycles in accordance with time period and amplitude of loading based on the speed and distance of the rail wheel. The stress curve for the sleeper for repeated number of load cycle from the train is plotted and the fatigue life of the sleeper is assessed by determining the failure due to maximum stresses that occurred due to static and dynamic loading.

4. MODELLING

4.1 Material Properties

Table 1. Parameters used for Finite element analysis

Definition	Values
Young's modulus of PCS Sleeper	$37 \times 10^3 \text{ N/mm}^2$
Young's modulus of RAIL	$2 \times 10^5 \text{ N/mm}^2$
Poisson ratio of PCS Sleeper	0.2
Poisson ratio of PCS Rail	0.3
Density of steel E_c	7850 kg/m^3
Density of PCS Sleeper	2600 kg/m^3

4.2 Modelling of Rail system

PCS Sleeper: The PCS-12 railway Sleeper is modeled according to the dimension and specification and the

prestressing tendon are placed from the bottom of the prestressed sleeper at a distance if 50mm form the bottom of the sleeper.

Table 2. Specification of PCS-12

Definition	Values
Top Width	154mm
Bottom Width	270mm
Depth of sleeper	235mm
Length of sleeper	2750mm
No. of. Tendons	18
Pre-stressing Force	31 ton

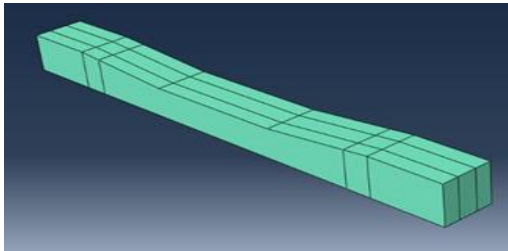


Figure 1. Sleeper

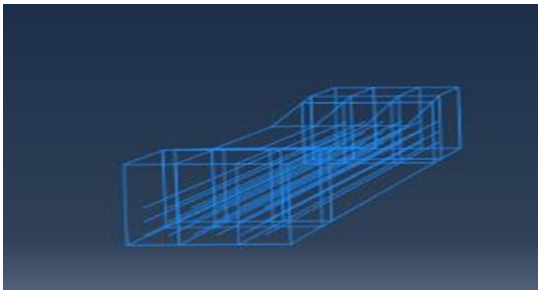


Figure 2. Placement of tendons

Rail: The rail section which is mostly used in Indian railway system for broad gauge is Flat Footed rail which is modeled and placed on the railway sleeper

Table 3. Specification of Flat footed rail

Definition	Values
Type of gauge	Broad Gauge
Weight of Rail section	52 kg/m
Rail length	13.5m
Load on Rail	22 ton
Area of Section	6615 mm ²

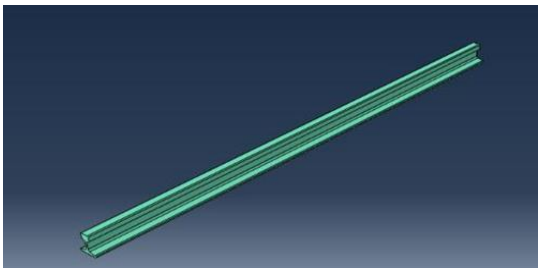


Figure 3. Rail section

Assemblage of elements: The pre stressed sleeper is arranged per meter length at spacing of 600mm and the rail is placed at a distance of 400mm form either side of the sleeper end. The rail is assembled over sleeper and given proper interactions.

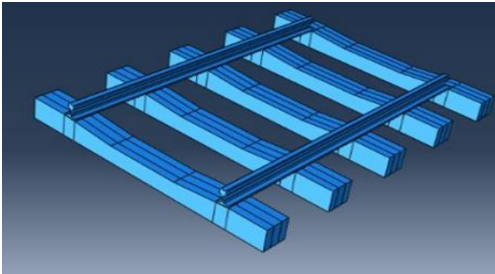


Figure 4. Assembly of Parts

5. LOADING

5.1 Fatigue Load Analysis

Generally the sleepers are subjected to in-situ vibration and tractive force caused by the movement of wheel over the rail. In addition to this the effect of repeated application of axle load should also be considered for long service period of sleepers.

Fatigue load occurs over sleepers when the wheel movement is for longer period; this fatigue load causes the initiation of cracks at the end of its fatigue life.

In the software fatigue cycles are given with amplitude for single cycle. Total of six sets of cycles are applied as fatigue load to the rail track system.

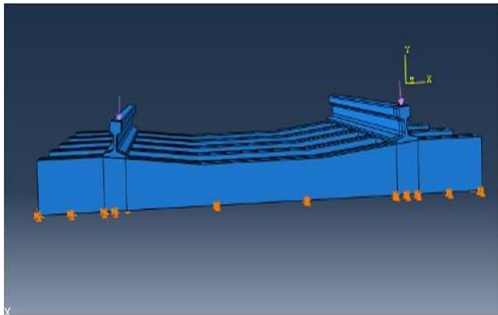


Figure 5. Loading on Static condition

The Fatigue life is based on S-N curve. Fatigue load also differs with amplitude and frequency of application of wheel load, in this study movement of one locomotive component is chosen and its amplitude and frequency is given input.

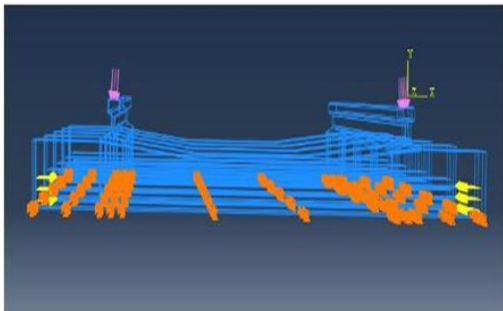


Figure 6. Loading on Fatigue condition

The cyclic loading were applied on sleeper in the time frequency 0s,0.13s,0.24s,0.81s,0.93s for a single cycle. The number of cycles is increased and corresponding stresses in the sleeper are computed in the software. The amplitude for initial cycle and final cycle are equal.

Increase in number of cycles causes decrease in the stress. This is due to development of cracks as the fatigue cycle increases.

6. Meshing

The created parts are assembled together and are individually meshed by giving its local seed and element type. The elements are meshed in order to get the well refinement of stress values in the sleeper.

In analyzing the results the finer meshes gave accurate results than the coarser one. The 3D stress element type is given for parts connected with concrete and a truss element type for tendons.

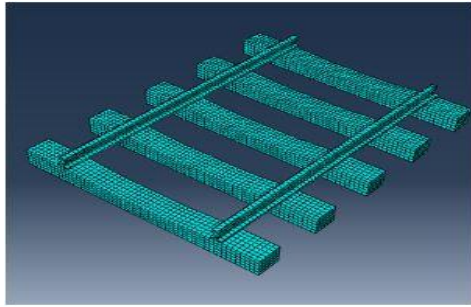


Figure 7. Meshing of Elements

7. Analysis and Results

The Prestressed concrete sleeper is subjected to different sets of cycles viz., 10^3 , 10^4 , 10^5 , 10^6 for the axle load from the train and the stress values are plotted against the number of cycles in order to plot the S-N curve which gives the fatigue life of sleeper.

In the software different increment of fatigue cycles are changed every time to compute the relevant stress.

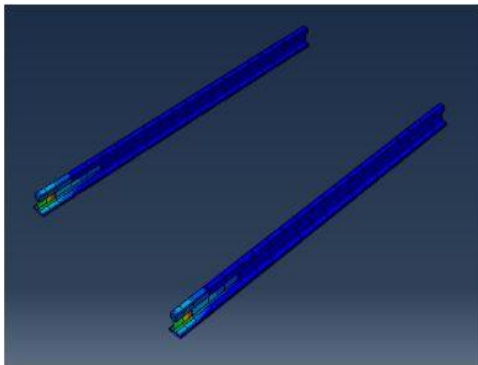


Figure 8. Stresses in rail

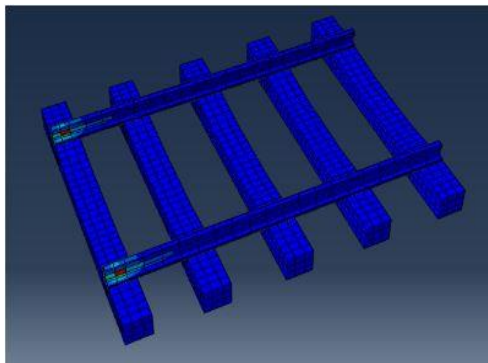


Figure 9. Stresses in sleeper along with rail

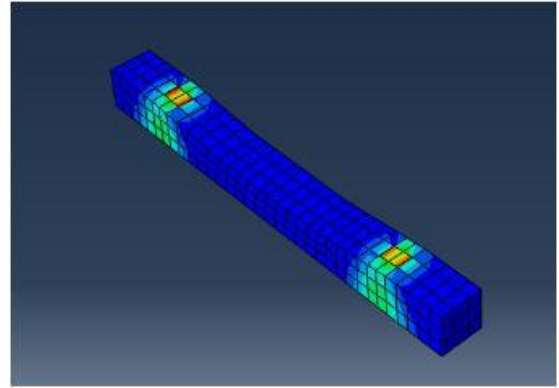


Figure 10. Stresses in Sleeper

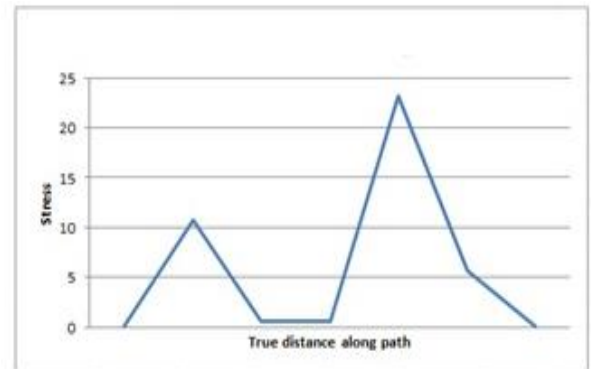


Figure 11. Stress along Sleeper

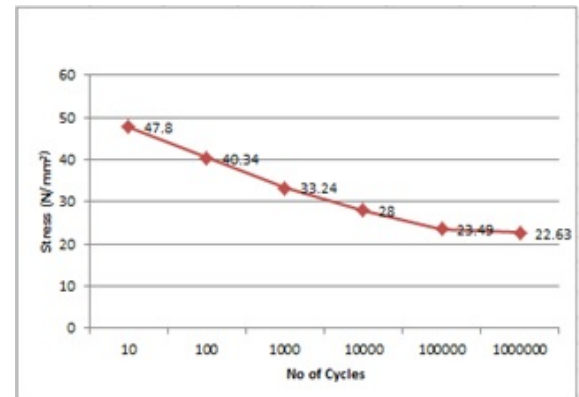


Figure 12. S-N Curve for sleeper

8. Conclusion

- ❖ The prestressed concrete sleeper which Subjected to repeated loading for a long period is experienced. The fatigue failure at particular cycle, in the sleeper is carried out in FEM software.
- ❖ The model made in the Finite element software (Abaqus) revealed a complexity in interaction between the sleeper and rail and shows that impact is higher under the rail and sleeper interface.
- ❖ The simulated model of the sleeper which is subjected to different cycles of static and dynamic loading and it is found that there is reduction in the stress range which occurs at 10^6 cycles of loading.
- ❖ Thus the further increase in stress in the sleeper causes fatigue failure of the sleeper and causes crack and deformation of the sleeper.

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