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The Investigation of Body Hole on Fatigue Rate of Steel Beams through Limited Elements Method

[1]Sina Hooshyar, [2]Mahdi Koohdaragh, [3*]Farid Hosseini Mansoub

[1]Islamic Azad University, Ajabshir Branch, Ajabshir, Iran
[2]Young Researchers Club, Tabriz branch, Islamic Azad University, Tabriz, Iran
[3]Islamic Azad University, Maragheh Branch, Maragheh, Iran

ABSTRACT

The identification of material fatigue and its control has been started for a century. Structure parts will be broken under frequent and oscillating stresses. These kinds of failures occur frequently therefore they are called fatigue failure. In this paper, we are going to investigate the fatigue of loading capacity of steel beams affected by alternative loads which lead to body holes. Then a square sample with holes on it was modeled in Ansys 5.4 system and the effects of load kind and its coefficients were investigated.
KEY WORDS: Fatigue, Alternative Load, Hole, Coefficient Load.

INTRODUCTION

Steel structures under changing forces and high changing velocity such as bridges, porter beams, tanks, tubes with high changing pressure, structures installed on machineries of turbine, generator or compressor and other similar structures should be checked for their fatigues. In the case that a point of structure stress is changed alternatively, it can be said that the structure is under dynamic forces and will fatigue. The fatigue structure is of low strength.

Most of dynamic quality detecting experiments are carried out under statistic loading and leads to a stress-strain graph with slow loading. It should be performed in a way that the needed time for thorough bending spread is supplied. These kinds conditions are acceptable for most of structures. When parts loading have changed by time or are non-statistic the conditions will be changed completely. For instance, if a --- beam is under pressure and strain in a short period of time, some stresses will be caused which are called oscillating or alternative stresses. These stresses lead to failure. Most of analyses clarify that a high amount of practical stresses are less than material hidden strength and even less than yielding strength. A significant attribution of these failures is their frequent occurrence therefore they are named fatigue failure. After parts failure under statistic load, they will be changed mainly after passing yielding strength stage. Theses parts will be replaced before their real failure. In fact, most of the statistic failures will be determined but fatigue failures are sudden and dangerous. Planning against statistic failures is easier. But fatigue is a complicated and narrowly identified. A person of tinge knowledge of fatigue should increase the assurance coefficients to 2 or 3 times in order to prevent any possible fatigue but he can not challenge in planning fields. On the basis of regulation, experimental formula and limited element software economic and assured enough plans can be carried out [1-4].

Fatigue strength is a function of internal and external material groove effects (bubble, hole or crack) and loading qualitative (alternative or changing) and is not material special attribution. Groove effects are total defects caused by groove, scotch, crack, bubble, gases, harmful material, atomic defects, defective steel joints, defective welding, cutting and hollowing which cause steel weakness [5-6].

This paper investigates the fatigue of steel beams' loading capacity on which there are some holes caused by demanded performance. Then a square sample with holes on it was modeled in Ansys 5.4 system and the effects of load kind and its coefficients were investigated.

Fatigue Experiment

Samples will be put under replicated or changing loads and sweep oscillation or stress digits will be written till failure in order to clarify material strength against fatigue loads. Moore machinery is a winch beam experimental tool. The sample is carefully put under pure bending and in an axial position by this machinery in order to prevent any scotch (Fig.1). there are other machineries for fatigue experiments which are utilized in sweep or oscillation axial, spiral or compound stresses [7-8].

***Corresponding Author:** Farid Hosseini Mansoub, Islamic Azad University, Maragheh Branch, Maragheh, Iran.
Email: farid_hm59@yahoo.com

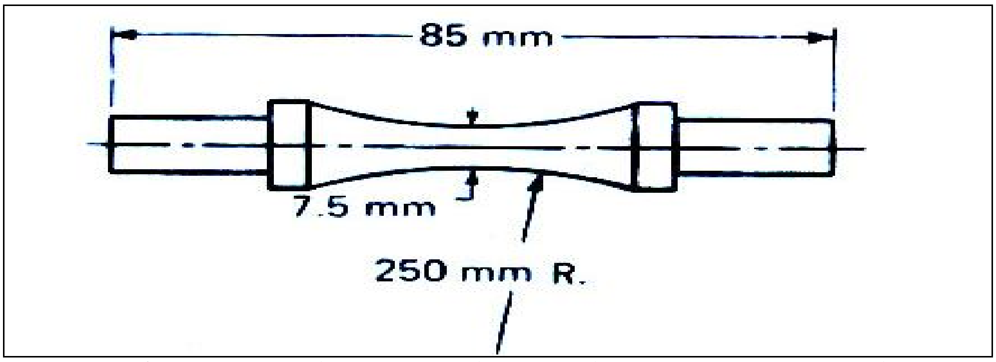

Fig.1. Geometric size of experiment sample in Moore machinery. Bending torque is monotonous in the entire curve. If the sample break in middle part, the failure part is the highest stress amount and it will confirm experiment accuracy. Failure of other parts will make doubts over the existence of gap or crack in material.

There needs to do lots of experiments in order to clarify fatigue strength mainly because of statistical nature of fatigue. Fixed amount of bending load will be imposed in winch beam experiment. The number of sweeps should be counted. The first experiment carries out over a stress less than final stress and the next one will be done in a position a little less than the first one. The results will be shown on graphs of S-N axis (Fig.2). This graph can be drawn on semi-logarithmic or all-logarithmic papers. Horizontal graphs are drawn for iron metals and its alloy like steel after a number of stress and its replicates. The bending position will be shown exactly on logarithmic paper. The results will not be clarified in Cartesian coordinates [9].

The width of S-N graph is called S_f (fatigue strength). Fatigue strength always should be declared with the number of N rounds.

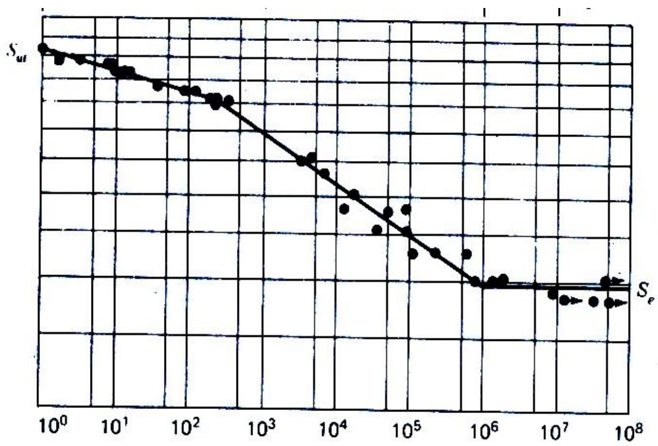

Fig.2. S-N graph for the results of thorough 2-way axial fatigue experiments, sample of steel with final strength ---, the maximum final strength---

Modeling

This part is going to have the modeling of samples in limited element system ANSYS 5.4. The samples will be modeled as following and in the next parts they will be analyzed:

1. 1st sample: beam I, lacks hole, section height 27cm, length 10m (s_1)
2. 2nd sample: beam I, with circular hole, section height 27cm, length 10m (s_2)
3. 3rd sample: beam I, with octagonal hole, section height 27cm, length 10m (s_3)
4. 4th sample: beam I, with --- hole, section height 27cm, length 10m (s_4)
5. 5th sample: beam I, with hexagonal hole, section height 27cm, length 10m (s_5)
6. 6th sample: beam I, with square hole, section height 27cm, length 10m (s_6)
7. 7th sample: beam I, with diamond hole, section height 27cm, length 10m (s_7)

In order to have exact calculation and result comparison, all the holes are selected with similar spaces. The characteristics of material for each sample will be introduced in the next stage and they will be analyzed through statistic analysis and the least amount of imposed load on samples that caused failures can be calculated on counters.

At last, in order to calculate the load and cycles needed for sample failures the fatigue analysis is utilized. All the samples are introduced in this kind of analysis and its fatigue .

The utilized material in this research is steel. The investigated samples were steel beams of structure. The characteristics of material for all the samples are: coefficient --- and density ---. The stress-strain curve of steel are considered as 3-lined for all the samples (Fig.3). the supporters are modeled as simple and gangly ones in all the samples.

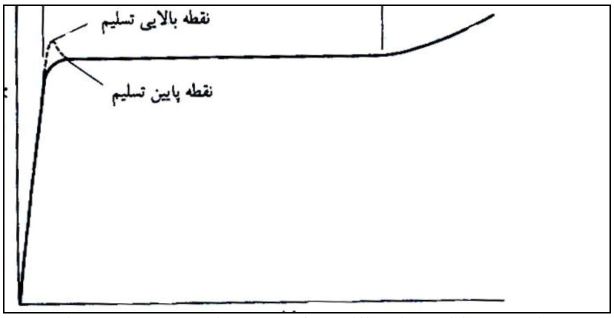

Fig.3. Stress-strain curve for utilized steel in samples

Fatigue Analysis and Results Investigation

In this part, it is going to investigate the loading with the number of various cycles and the amount of loads from big to small and the number of cycles causing failure will be modeled, analyzed and represented. These analyses are done separately for all the samples in various conditions of supporter and centralized and wide loadings.

Fatigue Analysis in Sample Supporters with Imposing Centralized Load

The supporters of this part are modeled in the form of simple ones for all the samples in ANSYS 5.4 limited element system and the fatigue will be analyzed. Fig.4 shows the points of fatigue analyses for all the samples.

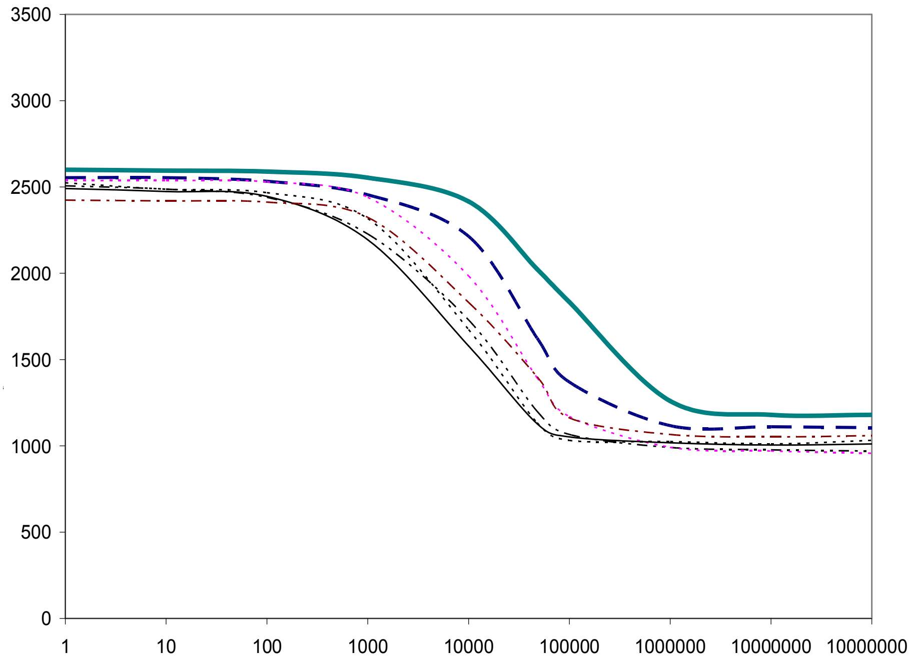

Fig.4. The graph of fatigue-strength-the number of cycles for all the samples

The graphs do not follow a constant order. Most of the graphs are partly in high and partly in low positions. Therefore, it can be said that samples do not have similar results in each limitation of load imposing cycles and most of the samples are in disordered shapes e.g. in comparing (s_5) and (s_6), s_5 is higher than s_6 in cycles of N=1 to N=100 and after N=100 s_6 is higher than s_5. It can be concluded that increasing the amount of load with extra cycles does not affects the failure of fatigue and the samples will not fail.

Fatigue Analysis in Simple Supporters with Wide Load Imposing

Wide loads are imposed on samples of simple supporters on the basis of various number of cycles and then they are compared and all the graphs will be drawn in one graph in order to have better comparison (Fig.5).

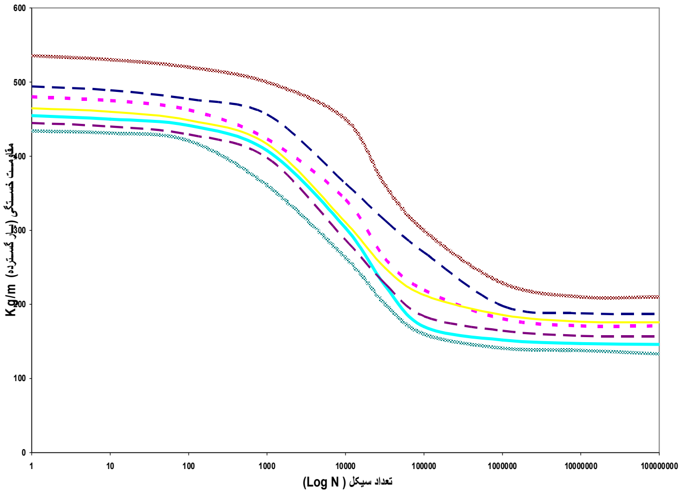

Fig.5. The graph of fatigue strength-cycle number

Fatigue Analysis in Tangly Supporters with Wide and Centralized Load Imposing

The supporters of this part are modeled in the form of tangly ones for all the samples in ANSYS 5.4 limited element system and the fatigue will be analyzed after imposing wide and centralized load. The results of fatigue analysis lead to a point with two components in 2-dimensional coordinate systems that the first component shows the number of cycle and the second one shows the corresponding fatigue strength (Fig.6, Fig.7).

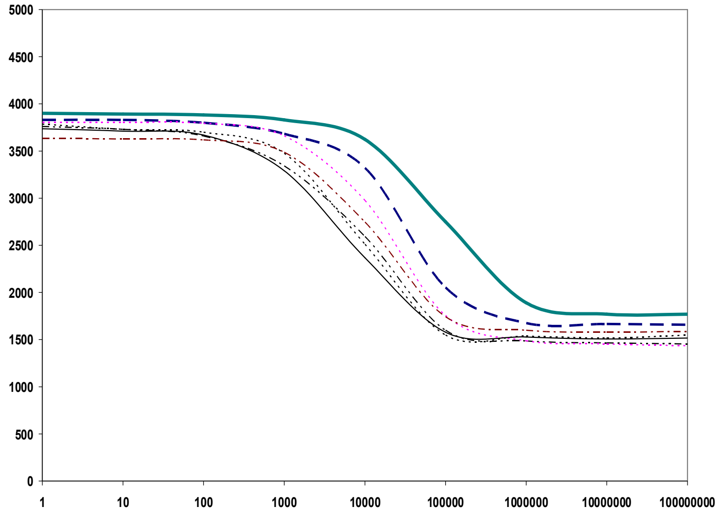

Fig.6. The graph of fatigue strength-number of cycles for centralized load

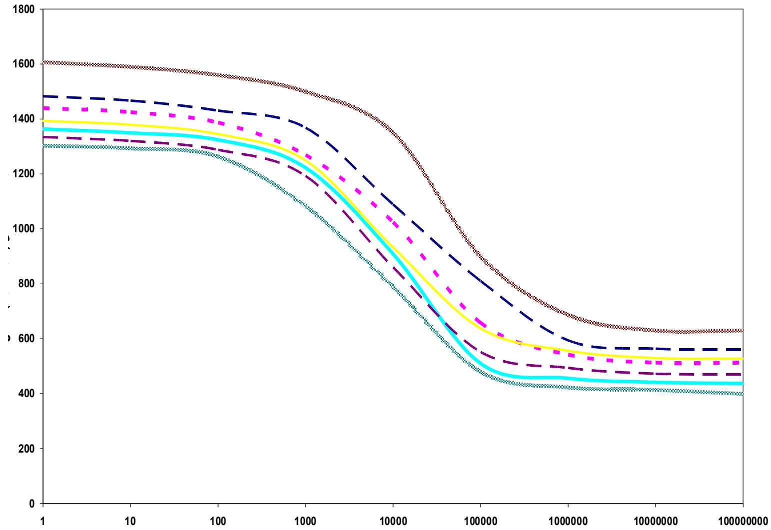

Fig.7. The graph of fatigue strength-number of cycles for wide load

As the figures represent the results of fatigue analysis under centralized and wide load imposing, the order of loading capacity of different kinds of beams with holes on them in both forms of simple and gangly supporters is:
Filled > circle > octagonal > --- > hexagonal > square > diamond

Conclusions

1. The investigations and results of fatigue analysis under centralized load in center of samples show that the loading capacity order of beams with hole on them in comparison to filled simple supporters is:
Filled > circle > octagonal > --- > hexagonal > square > diamond
2. Fatigue analyses show that the graph starts from maximum part and ends in one fifth of minimum part in all forms of loading.
3. Samples fatigue analyses of centralized load of simple supporter in the middle of beam mouth show that the fatigue strength of samples with hole on them is similar to the filled samples in cycle 1-100. A sudden fall in hole samples can be observed in cycle 100-10000. Then the fatigue strength of hole samples are nearer than filled ones in cycle 10000-1000000 and the treat of samples return to the first position in cycle more than 1000000.
4. The analyses of fatigue samples of wide load of centralized simple supporter on whole of beam mouth show that fatigue strength is not the same on the basis of various cycles e.g. the order of graphs whose the first one is based on N=1 show a disordered form in the next cycles and again the ordered ones. In normalized graph of fatigue strength-sample cycle number, the more near the normalized line to the unit, the more ideal the circular holes' samples will be.

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