

Improving Approaches to Processing of the Results of Experimental Evaluation of the Materials Fatigue Characteristics on the Basis of "Laddering Approach"

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The problems of analyzing the results of experimental evaluation of endurance limit and its distribution characteristics according to the "laddering approach" are considered. The interpretation of processing the results of fatigue tests obtained by the "laddering approach", which provides unique estimate of the values of these quantities and is based on the use of the full amount of experimental data, is suggested.

Keywords: "LADDERING APPROACH", THE RESULTS OF FATIGUE TESTS, ENDURANCE LIMIT.

Introduction

One of well-known and widespread method of evaluating the average value and distribution parameters of the endurance limit during the fatigue tests of the construction materials is the "laddering approach" suggested by Weibull [1].

There is no need to describe in detail the essence of this method, since it is well known. We only note that the average value of the endurance limit and its standard deviation are estimated using dependencies, respectively,

$$\sigma_{-1}^{cp} = \sigma_0 + d \cdot \left(\frac{\sum i \cdot n_i}{N} \pm 0,5 \right) \quad (1)$$

$$S_{\sigma_{-1}} = 1,62 \cdot d \cdot \left(\frac{\sum i^2 \cdot n_i \cdot N - (\sum i \cdot n_i)^2}{N^2} + 0,029 \right) \quad (2)$$

where σ_0 - the lowest stress level; d - the interval between the stress levels, the number of intact (broken) samples on the i^{th} stress level; $N = \sum n_i$ - the total number of intact (broken) samples.

Without setting the problem of a detailed analysis of the approach, we mention only some of the nuances and ambiguities faced by researchers when using it.

Results and Discussion

According to the Weibull works [1, 2], the evaluation of the material characteristics is conducted on a smaller number of samples (broken or intact). Moreover, in the first case, in the dependencies (1, 2) in front of numerical coefficients we use "plus" sign, and in the second "minus" sign. Thus, the evaluation is made, as if on an incomplete amount of the samples used in the studies. And for even total number of samples it is very likely that in the end, when there is the same number of intact and broken samples, what represents a particular problem because, as it will be shown below, using the dependencies (1, 2) produces different results.

In the work [2], during the evaluation of the endurance limit of steel 30Jl there were tested 28 samples, of which the amount of broken and intact ones was the same - 14. The results of the studies [2] are shown in Figure. In this case, broken and intact samples are "equal." If we evaluate the distribution parameters of the endurance limit on the intact samples, the average value of the endurance limit and its standard deviation will be

equal, respectively $\sigma_{-1}^{cp} = 153,143$ MPa, and $S_{\sigma_{-1}} = 9,456$ MPa, and if the same parameters are evaluated on the broken samples, then: $\sigma_{-1}^{cp} = 158,714$ MPa, and $S_{\sigma_{-1}} = 6,431$ MPa.

Thus, there is evident ambiguity in evaluation the characteristics mentioned above and the necessity to develop the "laddering approach". The solution of this problem exists. It is enough to present as a set of random values of the material endurance

limit the data presented in **Figure 1** and received by the principles of the "laddering approach", and by statistical processing to find the distribution law of the endurance limit and by defining the parameters of the latter to evaluate σ_{-1}^{cp} and $S_{\sigma_{-1}}$.

As the analysis showed that the presented in Figure 1 data are best described by a normal distribution with parameters: $\sigma_{-1}^{cp} = 158,596$ MPa and $S_{\sigma_{-1}} = 5,256$ MPa.

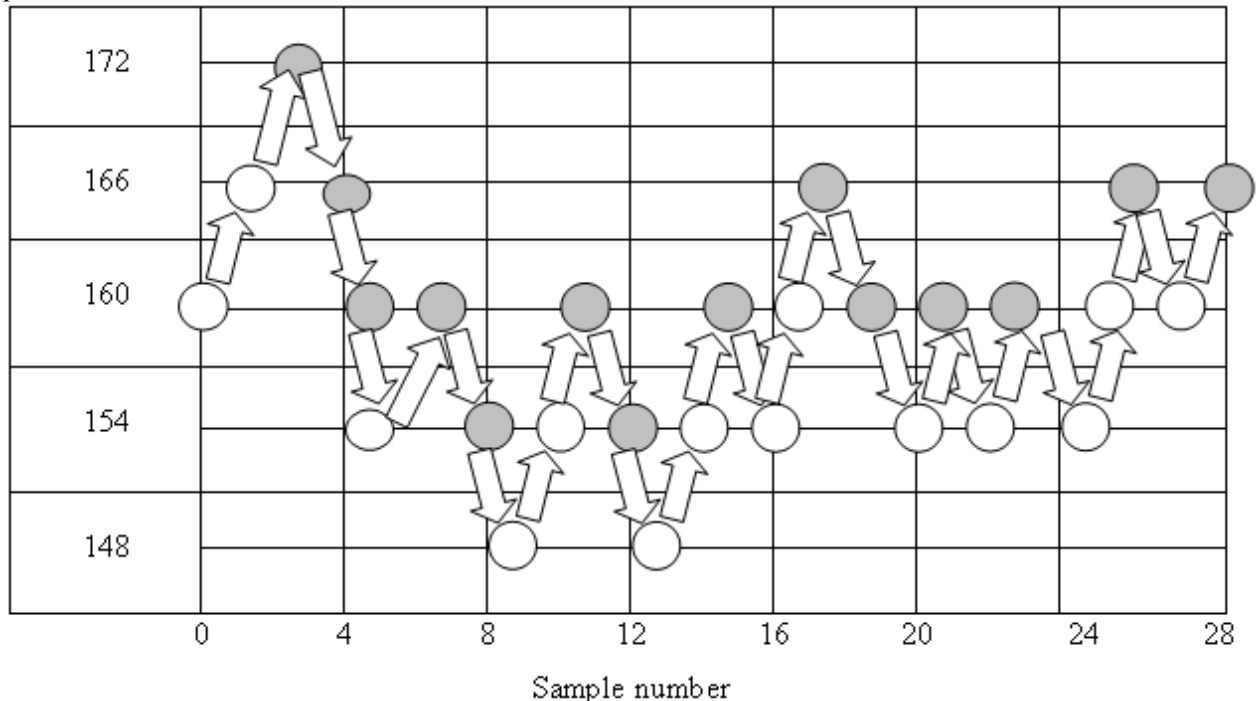


Figure 1. The scheme for the test of steel 30J1 samples by means of the "laddering approach"

○ - the sample remains intact; ● - the sample is broken

Conclusions

The suggested interpretation of results processing of fatigue tests obtained by the "laddering approach" provides unambiguous evaluation of σ_{-1}^{cp} and $S_{\sigma_{-1}}$, and is based on the use of the full amount of experimental data.

References

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Совершенствование подходов к обработке результатов экспериментальной оценки усталостных характеристик материалов на основе развития «метода лестницы»

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Рассмотрены проблемы анализа результатов экспериментальной оценки предела выносливости и характеристик его рассеивания по «методу лестницы». Предложена интерпретация обработки результатов усталостных испытаний полученных «методом лестницы», которая дает однозначную оценку значений упомянутых величин и базируется на использовании полного объема экспериментальных данных.

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