Generalized Pareto Distribution for reliability of bridges exposed to fatigue

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ABSTRACT

The complexity of predicting the behavior of such structures as bridges is an important topic for the modern research. Due to the fact that many European bridges, as well as bridges all over the world, are coming to the end of their design life, the question of the extending their service duration is vital. Moreover, the study of such objects allows improving design rules for future structures and possibly some profit from an economic point of view.

To assess the reliability of existing bridges, in general, extreme effects on a structure are analyzed using the Extreme Value Theory (Coles et al. 2001) which allows forecasting return levels of actions within the period of interest. One of the most efficient approaches to be used is the Peaks Over Threshold (POT), which proved to work well for bridges. It has been successfully used to envision the forthcoming situation with an object (Zhou, 2013, Treacy, 2014), based on the long-term monitoring of traffic actions.

This theory is focused mainly on load effects of a relatively high amplitude. For instance, heavy (even overweighted) trucks are taken into account without paying attention to light cars. On the other hand, in particular cases of small bridges, effects caused by fatigue due to the cyclic traffic loading might be significant. Since the number of light duty vehicles in most cases is quite large, they may cause fatigue of certain elements of a bridge.

The interest of this study lays in fitting the generalized Pareto distribution (GPD), as a principal distribution of the POT approach, to the distribution of the number of fatigue cycles caused by different vehicles and axles of trucks. The extreme value analysis is applied to the high cycles fatigue behavior of bridges with reinforced concrete and steel deck slabs for different amplitudes of traffic loads. The proposed method is briefly presented in Figure 1. Research is carried out on the Anneau bridge in Switzerland and on the Millau viaduct, France. In the first case, predictions of a number of stress cycles are based on directly monitored signals from strain gauges. For the second object, WIM data are used to obtain load effects and count cycles with the following estimation of return levels; though, only local effects are studied due to the complexity of the object.

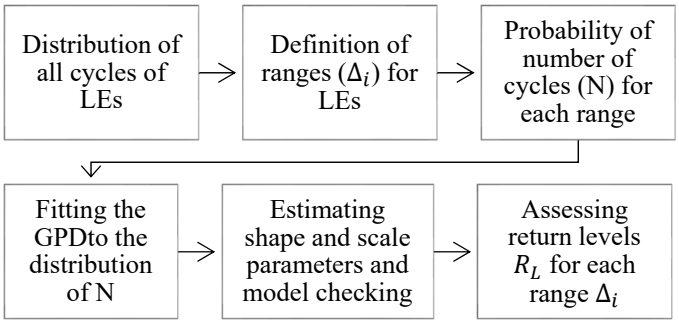

Figure 1. The algorithm of the proposed method

Obtained results show that estimating return levels of N (number of cycles) at given period is possible using GPD with its parameters. The proposed algorithm works in described cases, however, it does not show fatigue danger in perspective. Although, it might be applied to other structures with larger traffic volume.

REFERENCES

Coles, S., Bawa, J., Trenner, L. & Dorazio, P., 2001. *An introduction to statistical modeling of extreme values.* s.l.:Springer.

Treacy, M. A., 2014. *The use of monitored data in the verification of structural and fatigue safety of existing post-tensioned concrete highway bridges.* Lausanne: EPFL.

Zhou, X. Y., 2013. *PhD Thesis. Statistical analysis of traffic loads and their effects on bridges.* Paris: Université Paris-Est.