Zeitschrift: IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht

Band: 7 (1964)

Artikel: Discussion: fatigue life of structural members

Autor: Henderson, W.

DOI: https://doi.org/10.5169/seals-7959

IId 5

Discussion - Discussion - Diskussion

Fatigue Life of Structural Members[1])

Résistance à la fatigue des éléments de construction

Ermüdungserscheinungen von Konstruktionsteilen

W. HENDERSON
Scotland

Laboratory research is being directed at the problem of what will happen in material subjected to repeated cycles of fluctuating stress and it is to be expected that in due course we will have a reliable solution which will equate the numbers of varying ranges of stress cycles with the life of a member.

Particularly in relation to highway bridges this leaves the most imponderable problem for the designer still unanswered; how many cycles of stress at varying levels are to be assumed will occur in a given period and what service life is desirable in a member? There are considerable difficulties in providing a suitable answer.

Attempts are at present in hand in Great Britain to make "a priori" derivations from known data of the distribution and possible frequency of varying levels of loading from various types of vehicle and expressing these loading levels in terms of the basic design loading so as to provide a usable basis for calculating stress ranges associated with appropriate numbers of cycles. The available data consists of national statistics relating to the capacity of different classes of vehicle, regulations governing the weights of vehicles, hauliers statistics concerning the numbers of journeys of fully laden and empty vehicles and calculated maximum capacities of traffic lanes on carriageways.

It seems likely that the study will confirm the assumption that in general only members supporting comparatively short loaded lengths are likely to be subject to fatigue conditions. There are two reasons for this; the first being that static design loadings must reflect a possible congestion of heavy traffic unlikely to occur except on rare occasions, so that the upper limit of frequently repeated stress cycles will fall substantially below static design stresses. The second reason being that members supporting long loaded lengths generally have comparatively large dead load stresses. FISHER and VIEST

---

[1]) See "Preliminary Publication" — voir «Publication Préliminaire» — siehe «Vorbericht», IId, p. 497.

have pointed out that changes in minimum stress are of no great significance provided the stress range remains unchanged; nevertheless, increases in dead load stress do in general reduce the stress range, so that it is true to say that the greater the dead load stress the less is the probability of fatigue damage. The likelihood is that it will be found that only members such as battle deck units and short or moderate span fairly closely spaced stringers will be significantly affected by fatigue conditions. That is to say, members in which the maximum stress in caused by one wheel or one axle or possibly one vehicle, and where the minimum stress can be comparatively small.

To forecast the number of cycles and the various ranges of stress it is necessary to predict traffic growth and content over a period of possibly up to 200 years; it is necessary to estimate the proportion of goods vehicles which will be unladen, fully laden and, say, half laden; a guess must be made at the likely spacing at which vehicles will generally travel, and, particularly in the case of members where a small lateral displacement of the wheel load has a major effect on the range of stress, it will be essential to arrive at some estimate of the frequencies with which wheel loads are distributed over a fairly narrow lateral width of carriageway. The combination of all of these forecasts is bound to be a guess with a low probability of accuracy even within a very wide range. Experimental techniques of measuring stress ranges in existing bridges will provide a very little more valid basis than "a priori" methods, since these can relate only to present day and foreseeable future traffic distributions.

Moreover, whatever frequency and range of stress cycles is established for one road is unlikely to be true for another; indeed the spectrum for one part of the width of the bridge will be substantially different from those for other but structurally similar parts of the width. This circumstance cannot be compared with the apparently corresponding static design loading problem. In the latter case a maximum load is being stipulated which the bridge must assuredly sustain although perhaps but rarely in its life. So far as fatigue is concerned one is forced to the conclusion that the forecasting of stress ranges and numbers of cycles in elements of highway bridges over the length of time considered appropriate for the life of a bridge amounts almost to crystal gazing. At best one can conclude that major members are unlikely to be affected in this way and that the danger of fatigue damage is limited to certain elements.

In these circumstances, it is suggested, economic advantage may lie in the adoption of a deliberate policy of accepting that certain members of bridge structures should be considered to have a limited life very much shorter than the life of the whole structure, and to design these members or units so that they can readily and speedily be replaced. Battle decks and other members with high stress ranges would fall into the category which should be considered in this way; the approach is no more than is already adopted for carriageway

surfaces and timber decks and which should be, but is unfortunately not always adopted for those parts which are likely to be damaged by vehicles, as, for example, parapets.

Adoption of this policy would logically lead to a modified approach to the load factors desirable in the design of replaceable members. The consequences of damage whether due to fatigue or other causes could be assessed accordingly as they were immediately catastrophic or relatively insignificant, and the load factor adjusted appropriately. If such a policy were to be consciously and thoughtfully adopted, various other aspects of design would fall to be reconsidered; it is probable that the minimum acceptable thickness of metal could be substantially reduced, methods of fixing and fabrication might well be extensively altered and cheapened, and protective treatment reduced to a once for all process. It is impossible to anticipate the developments which might arise from the adoption of such a policy; it is conceivable, however, that very much lighter and cheaper battle deck construction would develop, and that consequent upon their increasing use, standardised, factory made products would become available. With the improvements of carriageway surfaces it is even possible that these could be applied to the deck in the factory, and would have a service life commensurate with the structural part of the deck.

Whether or not these developments materialise, it remains of real importance to approach the design of members susceptible to damage from fatigue, corrosion or other causes with a view to ready, cheap and quick replacement. In the past there have been many examples of the costliness of failing to do so, as for example where bridge bearings have had to be renewed, or the suspenders of a suspension bridge replaced as a result of corrosion.

Summary

Attention is drawn to the problem of predicting stress cycles in highway bridges and methods of doing so indicated. The units susceptible to fatigue damage are suggested. Design of these for a limited life is proposed and the possible consequences and advantages discussed.

Résumé

On attire l'attention sur le problème de la prévision des cycles d'efforts dans les ponts-routes, en indiquant les méthodes qui permettent d'y procéder ainsi que les éléments qui semblent susceptibles de se détériorer par la fatigue. On propose d'admettre une durée de vie limitée et de les calculer en fonction de cette durée; conséquences éventuelles et avantages sont discutés.

Zusammenfassung

Es wird auf das Problem der Vorhersage der Spannungszyklen bei Straßenbrücken aufmerksam gemacht und entsprechende Methoden werden angegeben. Ermüdungsgefährdete Konstruktionselemente werden erwähnt; der Autor schlägt vor, diese Elemente für eine beschränkte Lebensdauer zu entwerfen, wobei die daraus entstehenden Folgen und Vorteile besprochen werden.