Prediction of fatigue life in a steel bridge

Autor(en): **Marek, P.**

Objekttyp: **Article**

Zeitschrift: **IABSE reports = Rapports AIPC = IVBH Berichte**

Band (Jahr): **37 (1982)**

PDF erstellt am: **16.07.2024**

Persistenter Link: https://doi.org/10.5169/seals-28949

Prediction of Fatigue Life in a Steel Bridge

Prédiction de la durée de vie dans un pont métallique

Voraussage der Lebensdauer einer Stahlbrücke

P. MAREK
Assoc. Prof.
Czech Technical University
Praha, CSSR

SUMMARY
The paper presents the fatigue life investigation of a temporary, high strength steel bridge for tram traffic. The loading as well as response history was considered and a fatigue criterion, based on the stress-range concept, was applied. In agreement with the safe service life estimate supported by a simple fracture mechanics study, fatigue cracks were observed in the bottom flange after about three and a half years of use. The bridge was removed.

RESUME
L'article présente l'examen de la durée de vie d'un pont temporaire en acier à haute résistance soumis au trafic de trams. Les charges aussi bien que leurs évolutions ont été considérées et un critère de fatigue, basé sur le concept amplitude de contraintes, a été appliqué. Des fissures ont été observées dans l'aile inférieure après environ trois ans et demi de service, et ceci en accord avec l'estimation de la durée de service fiable et avec une étude simple de mécanique de la rupture. Le pont a été enlevé.

ZUSAMMENFASSUNG
Dieser Artikel beschreibt eine Lebensdauerberechnung einer provisorischen Brücke aus hochfestem Stahl, welche von Strassenbahnen befahren wird. Die Lasten sowie das Tragverhalten und ein Ermüdungskonzept, welches die Spannungsdifferenz berücksichtigt, wurden in Betracht gezogen. In Übereinstimmung mit einer Lebensdauerabschätzung, welche sich auf bruchmechanische Überlegungen abstützt, wurde nach einer Betriebsdauer von 3 1/2 Jahren ein Ermüdungsriss im unteren Flansch gefunden. Die Brücke wurde für den Verkehr gesperrt.

1. INTRODUCTION

In order to solve a local public transportation problems a temporary four-span tramway steel bridge was built over Vltava river in Prague. Simple supported plate girders - see Fig.1 - made of high strength steel were exposed to heavy traffic. While the theoretical data (design according the current specifications) and experimental results (loading test of a completed bidge) proved the required safety with respect to the strength criterion, the prediction of fatigue life had to be prepared considering the actual loading and response history.

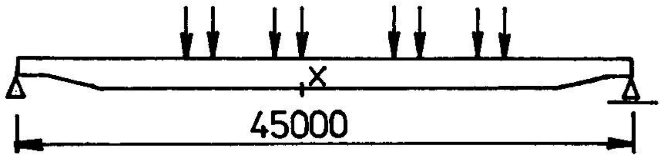


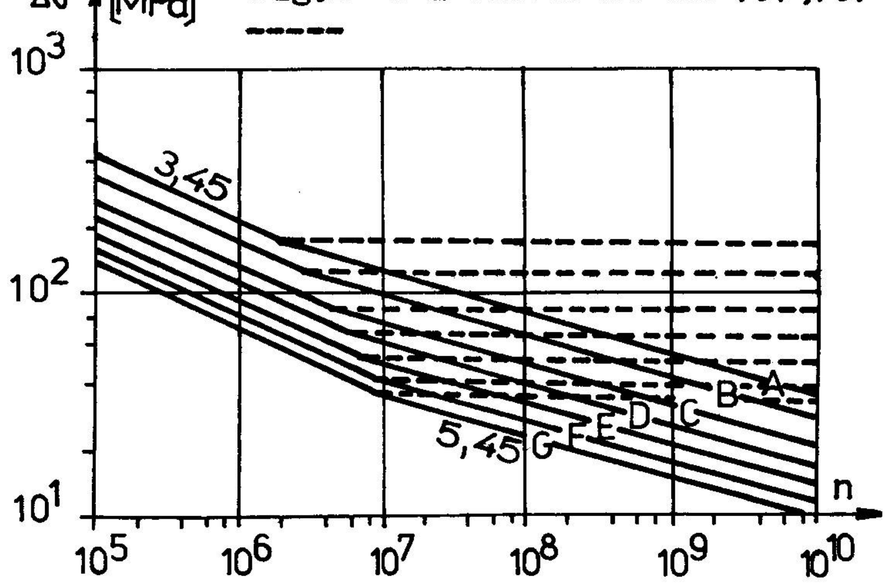
Fig.1 Scheme of the 1824 mm high plate girder (X - the location investigated with respect to fatigue)

This paper presents a brief review of the investigation and of the obtained results.

2. FATIGUE STRENGTH CRITERION

In czechoslovak specifications /1/ the fatigue criterion is based on the stress range concept(since 1976-/3/). Recently the bi-linear S-n curves were proposed for steel bridges /5/ - see Fig.2. The investigation of the fatigue life in the case of the tramway bridge was based on the actuel stress spectrum related to the location X (see Fig.1), on the application of Palmgren-Miner rule and S-n curves shown in Fig. 2. The main attantion was focused on the end zones of cover plates (lower flange of the girder), on the end zones of vertical stiffeners and on the errection joints. (Yield strength 500 MPa - steel grade ČSN 15222) The results were compared with results according ISO and SIA specs.

Fig.2 S-n curves in ČSN /3/,/5/



3. STRESS HISTORY

According to the traffic rules just one train was allowed to move on the bridge at one time - the mass of the train was about 16,5 t (empty) resp. 30,5 t (full loaded).The speed was limited to 20 km/h.

The investigation of loading and respose history was conducted in following parts :

a - full scale loading test of the bridge allowed the comparison of the stress ranges in selected locations obtained from theoretical analysis and from actual measurements,

b - the dynamic test (train mouving 20 km/h) allowed to estimate the dynamic response,

c - the 24 hours stress recording(using strain gages in selected locations) allowed to estimate a "typical" working day stress-range spectrum - see Fig.3 and Fig.4,

d - considering tramway time schedule,traffic forecast,etc. the one year stress range spectrum was estimated - see Fig.5

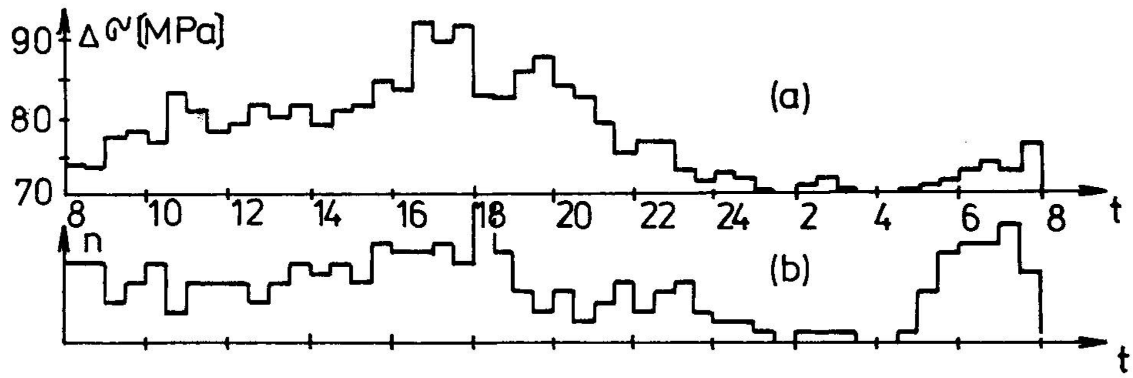


Fig.3 Results of 24 hour stress range recording in location X :
----- (a)- average stress range (half hour intervals)
(b)- number of cycles in half hour intervals

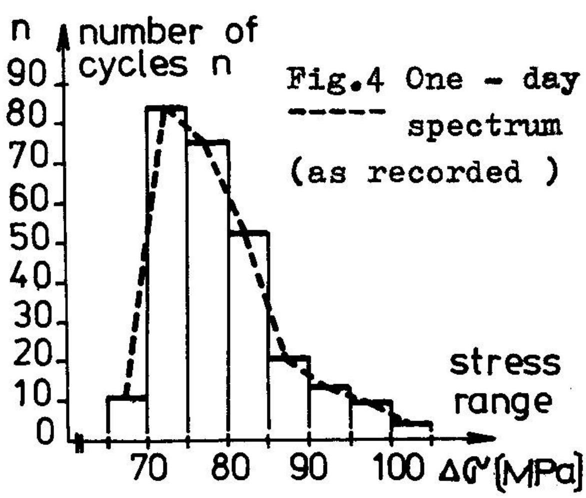


Fig.4 One - day
----- spectrum
(as recorded)

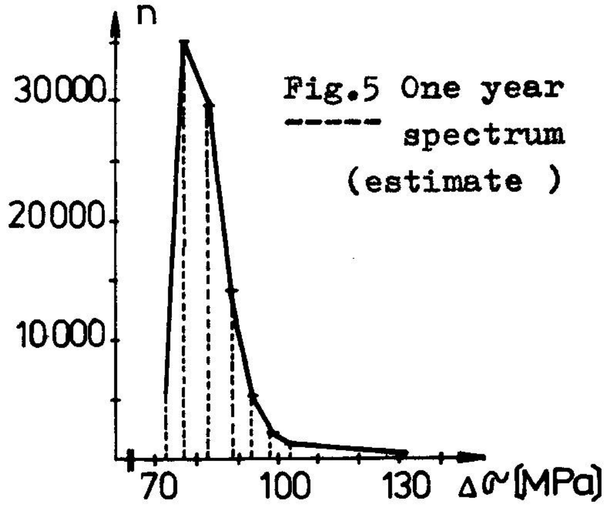


Fig.5 One year
----- spectrum
(estimate)

4. FATIGUE LIFE

Using one-year spectrum, Palmgren-Miner rule and S-n curves according to czechoslovak specifications /1/ the fatigue life was derived for individual notch categories - see Fig. 6(a). Considering the notch category "G" the four years limitation corresponds to the spectrum as shown on Fig.5.
Assuming the same stress range spectrum as above, a comparison was made using SIA /6/ and ISO /2/ specifications - see Fig. 6 (b),(c).

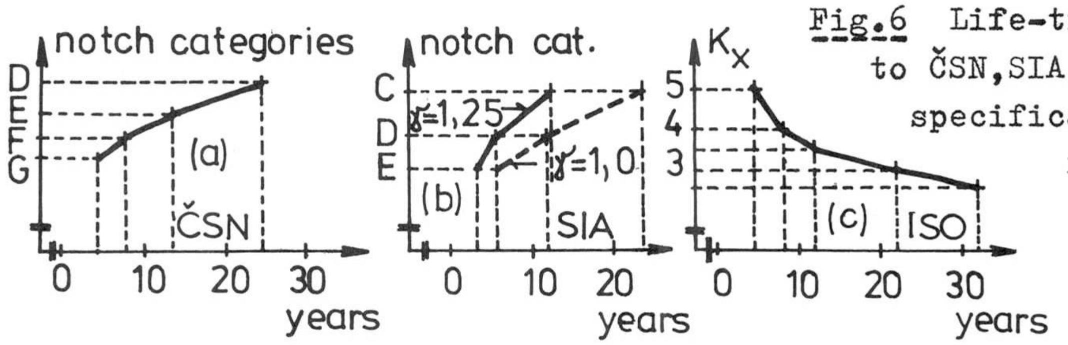


Fig.6 Life-time according to ČSN, SIA and ISO specifications ref./1/, /6/,/2/.

Due to rather low predicted fatigue life a periodic checking of the lower flange and some other locations was proposed after three years of service. Using a simplyfied fracture mechanics model /4/ an adequate interval for checking - six months - was suggested.

5. CRACKS OBSERVATION

After about three and half service years cracks were detected on several locations in the end zones of cover plates (lower flange) e.g. see Fig.7. A slow crack propagation was observed in some cases. After some complementary material tests (K_{IC}, crack propagation rate, /7/) and with respect to the coming winter season it was

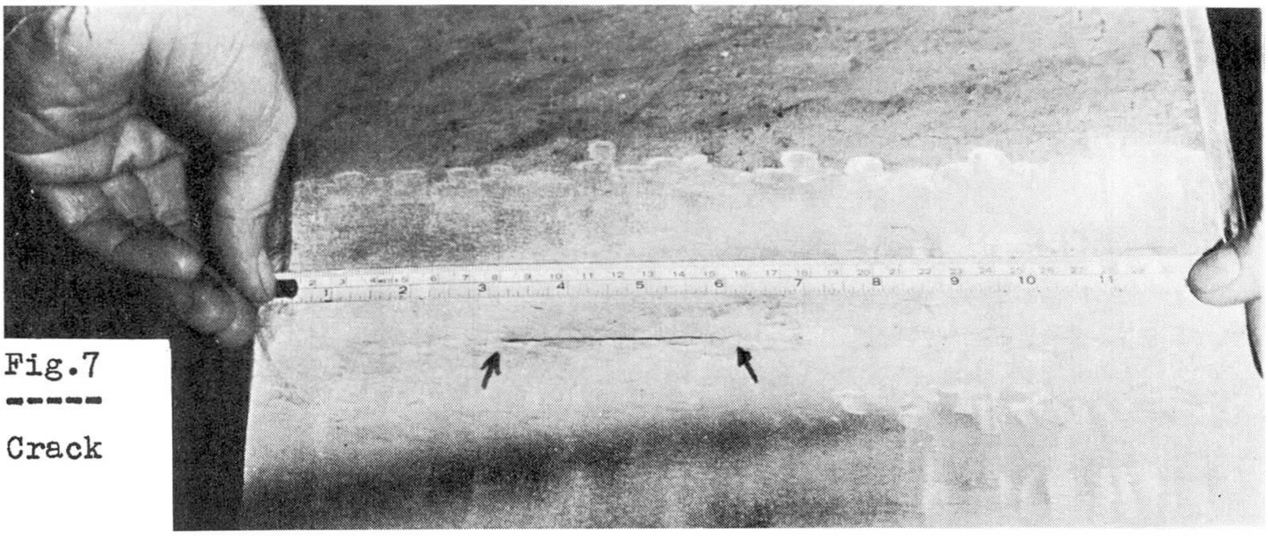


Fig.7 Crack

decided to interrupt the traffic on the tramway bridge and to replace it by different bridge system.
After a necessairy checking, the removed bridge girders may be used again as supporting parts of structural systems which are not subjected to fatigue loads (e.g. roof systems).

6. SUMMARY

The application of current specifications based on stress range concept and fracture mechanics study allowed to predict the fatigue life of a steel tramway bridge with sufficient accuracy. Attention was paid to the investigation of the actual loading and response history in order to estimate the stress range spectrum for important locations of the welded high strength plate girder.

REFERENCES

1. ČSN 73 1401 Design of Steel Structures (in Czech).Specifications. ÚNM Praha,1976,ČSSR
2. ISO - Tentative proposal for first draft of chapter on fatigue. 19.7.1979
3. MAREK P.: Fatigue Strength in revised Specifications ČSN 73 1401 (in Czech).Inženýrské stavby 1976/4,Alfa,Bratislava
4. MAREK P.,HÁŠA P.,and KOTTOVÁ J.: On the durability of steel bridge from the viewpoint of its fatigue strength (in Czech). Inženýrské stavby,1981/2,Alfa,Bratislava,ČSSR
5. MAREK P.,KROUSKÝ J.: Fatigue Strength of Steel Bridges (in Czech),Inženýrské stavby,1981/2,Alfa,Bratislava,ČSSR
6. SIA 161/1979, Stahlbauten,Schweizer Norm SN,Zürich
7. ZMRHAL V.: Experimental Investigation of a Bridge with respect to the Fatigue Life (in Czech). In: Proceedings of the Conference " Limit States Design of Metal Structures".ČSVTS (DT Plzeň),Karlovy Vary, April 1981,ČSSR

Leere Seite
Blank page
Page vide