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Remaining Structural Capacities of Steel Railway Bridges

Evaluation de la capacité restante de ponts de chemin de fer

Verbleibende Tragwerksfestigkeit von Eisenbahnbrücken aus Stahl

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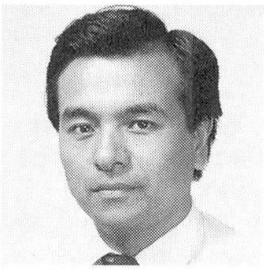

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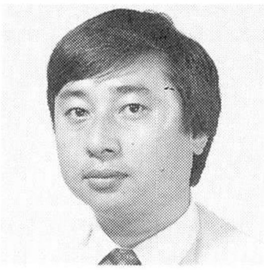


SUMMARY

The paper describes mainly the theoretical structure of the method of evaluating remaining structural strength and remaining life of steel railway bridges, as decided by committees and the fixing of reference values. This paper also describes the outlines and an embodiment of a computer-assisted system to facilitate its introduction to actual jobs.

RÉSUMÉ

Ce rapport décrit principalement la structure de la méthode d'évaluation de la capacité restante des structures de ponts de chemin de fer, ainsi que de leur longévité. Il résulte du travail d'un comité, qui a fixé des valeurs de référence. Ce rapport traite aussi de la création d'un système d'assistance par ordinateur, afin de faciliter l'introduction de cette méthode.

ZUSAMMENFASSUNG

Diese Abhandlung beschreibt hauptsächlich den theoretischen Aufbau eines Verfahrens zur Beurteilung der verbleibenden Tragwerksfestigkeit von Eisenbahnbrücken aus Stahl, das von verantwortlichen Ausschüssen auf der Grundlage von Bezugswerten festgelegt wurde. Die Abhandlung gibt ausserdem eine Übersicht über ein computerunterstütztes System zur Erleichterung seiner Einführung in die Praxis.

1. INTRODUCTION

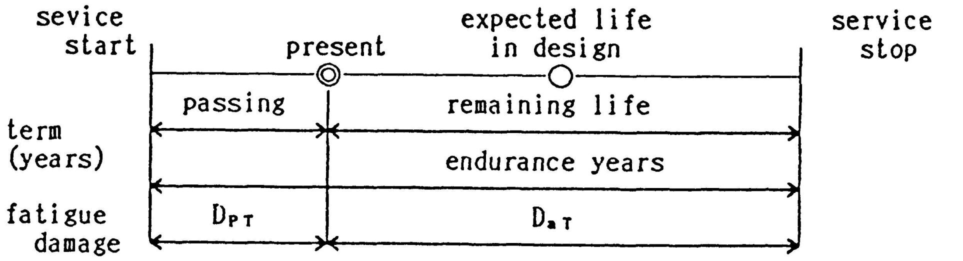
Maintenance and management of steel railway bridges in Japan is faced with two problems. One is a fatigue problem as exemplified in Tokaido Shinkansen. The other is that the average age of steel railways is higher than 60 years-the design age. Both problems are based on fatigue. Evaluating remaining life is necessary. This remaining life evaluation was not generalized sufficiently. Recently, however, remaining life evaluation procedures and standards also have been developed. In addition, development of systems to process such evaluation has been made. This report is an outline of a fatigue damage evaluation system developed by Railway Technical Institute and BMC Corp.

2. DEFINITION OF SERVICE LIFE

Remaining life evaluation is made in relation to the following two points.
(1)"Structural life" when a main member reaches the end of its service life as a result of repetition of nominal stress.
(2)"The time of occurrence of fatigue crack" when members suffer fatigue damage due to local stress.
There are several definitions of "service life" which determines a period of time when a steel railway bridge can survive. According to one theory, service life expires when a bridge has suffered a fatal damage, economically and physically to such an extent that justifies the judgment that its structural strength and functions have been lost. Under this theory, service life means a physical service life considering the economic aspects of a bridge. Remaining service life is estimated by this method.
The "time of occurrence of fatigue crack" due to local stress is when fatigue damage has impaired the function of a particular member.

3. CALCULATING REMAINING LIFE

The Fig.1 illustrates an idea about formulation.



D_{aT} : (annual cumulative fatigue damage anticipated thereafter)×Tr
D_{PT} : up to a given time and cumulative fatigue damage

Fig.1 Life vs. passing years of a steel railway bridge

This analysis needs following data.
(1) History of live load
(2) Relation of live load with active stress
(3) Fatigue strength of joints in the precise target position.
These will generally require large data and practically made the work

troublesome. Therefore, the following items were taken into consideration for generalization.

(1) Regarding live load, axle load distributions were investigated for all railroad line territories and statistically processed to obtain a central value.

(2) For the relation of live load with a stress, an actual stress ratio (measured stress divided by design stress) was examined and rearranged. Fig.2 shows stress ratios (α) used for railway bridges at present.

(3) A fatigue test was conducted for long-life areas by service stress to determine evaluation strength.

This is a specimen. Live load was determined from the result of long-term (from about three months to one year here) measurement of real bridges.

The remaining life evaluation formula is as Fig.3.

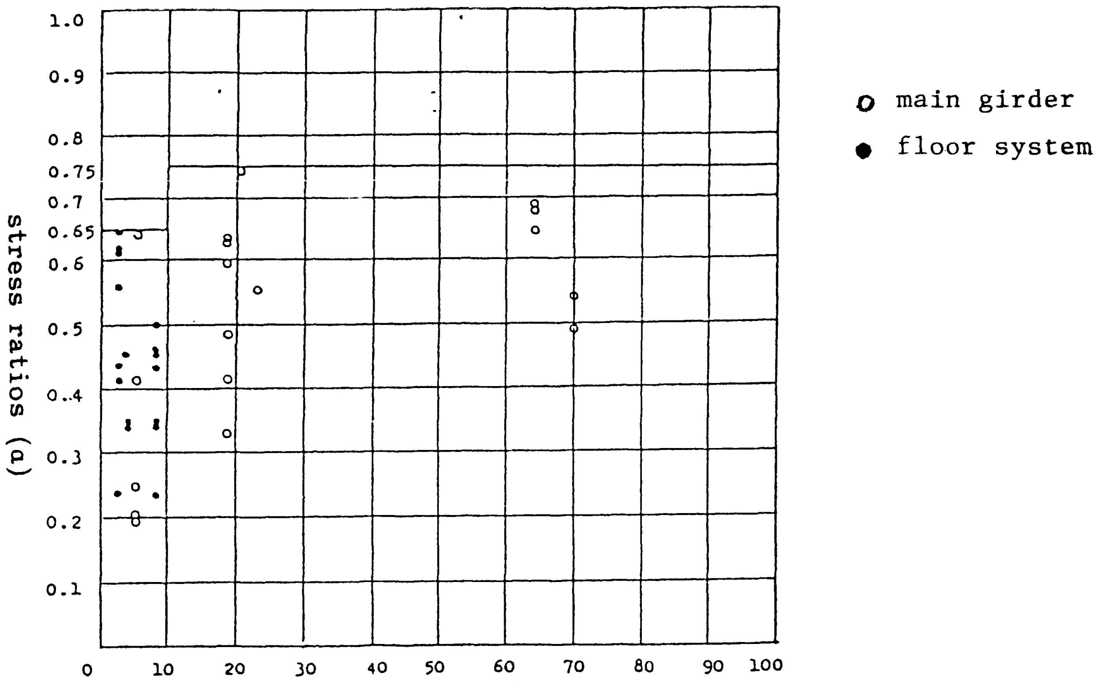


Fig.2 Research result of stress ratio

$$Tr = N_0(1-D_{PT})/\sum_{i=1}^{ka}\{n_{aeq(i)}\left(\frac{\Delta\sigma_{amax(i)}\,\alpha}{\Delta\sigma_{f0}}\right)^m\}$$

$\Delta\sigma_{amax(i)}$: maximum stress range exerted by trains operated in future.

$n_{aeq(i)}$: one year-equivalent number of cycles of maximum stress ranges exerted by passing trains.

$\Delta\sigma_{(i)}$, $n_{(i)}$: respectively stress range and its cycle, as obtaind by analizing the frequencies of variable stresses exercised by trains.

nn : level of stress range for frequency analysis of one passing train

Ny : number of trains passed in a year; if this is not a variable, $N=365\times n_{ad}$

n_{ad} : number of trains passed in a day.

Fig.3 Remaining life evaluation formula

4. BMC (Bridge Maintenance Consulting) SYSTEM

The results as mentioned above were programmed and rearranged into a fatigue diagnosis system capable of automatic processing. We call it FATIDAC system. This FATIDAC system is a part of the bridge maintenance and management system called BMC system. BMC system consists of :

(1) Bridge database
(2) Bridge diagnosis system
(3) Supporting system (expert system)

FATIDAC system forms a part of the bridge diagnosis system. The system has functions as a measuring instrument and executes measurement, evaluation analysis and outputting of a diagnosis report on the spot in a series of process. Data is registered on the database of the system and outputted in the form of a tabulation when necessary. This system is used for bridge diagnosis of decaying bridges abroad. BMC system performs also the following.

(1) Live load calculation
(2) Bearing capacity calculation
(3) Calculating vibration in relation to running performance
(4) Bridge stability calculation

5. EXAMPLE

Items for processing are as shown in the fig.4. The first example relates to prediction of occurrence of a local fatigue damage.

(1) Stress in the precise target position in measured. Concerning fatigue to be measured, a position to which a gage is fitted is shown in the standardized manual.
(2) Sampling is made several times, which is necessary for stress frequency analysis. (generally for statistical purpose)
(3) Live load history is inputted on the basis of the result.
(4) The cumulative fatigue damage ratio calculated.
(5) D value as a result of this calculation is judged in accordance with the category of judgment. A requires some measure and B will be confirmed on a priority basis by inspection in the future.(Fig.5)
(6) Finally an examination report is outputted. In this

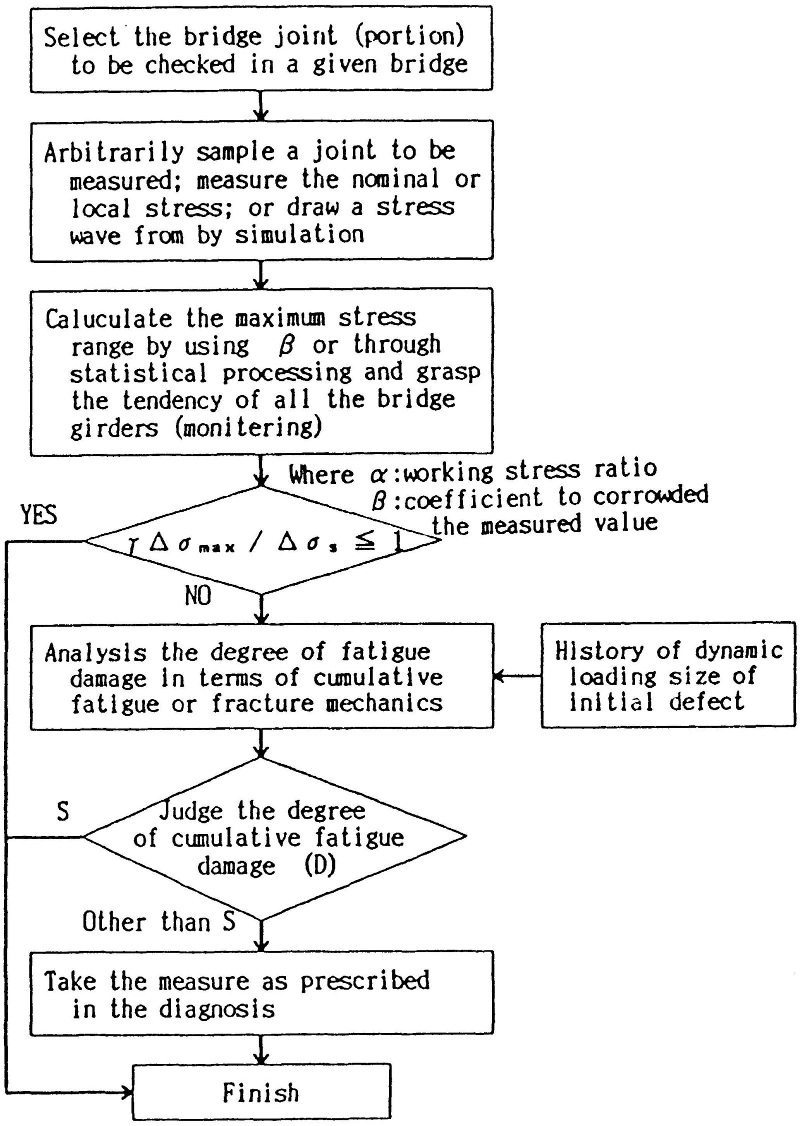


Fig.4 Flow chart of fatigue damage cheking

case, in accordance with the results of judgement early, a specific remedy is suggested. A suggests that a measure should be taken immediately in accordance with S-13 in the manual. B indicates that it should be inputted as a priority inspection item in the next general inspection. (Fig.6) This system is being employed widely for diagnosis of steel railway bridges by all Japanese Railway Companies, including Tokaido Shinkansen and private railway companies. Timely diagnosis ensures quantitative and objective bridge diagnosis.

累積疲労損傷度による健全度判定区分

累積疲労損傷度（D）		判定区分	検査への反映
D ≧ 1.0		A1	個別検査の実施
1.0 > D ≧ 0.8		A2	
0.8 > D ≧ 0.5		B	重点検査項目へ
0.5 > D ≧ 0.2	D ≧ 経年/設計想定寿命		
	D < 経年/設計想定寿命	C	検査の着目箇所へ
D < 0.2		S	通常通りの検査

注）1．Dの値は、個別に着目した箇所か、もしくは桁全体に適用する場合は、サンプリングした調査箇所）の平均値で判断してよい。
2．設計想定寿命：普通鉄道は６０年、新幹線は７０年を想定している。
（本四架橋は１００年）

Fig.5 Category of cummulative fatigue damage ratio

疲労損傷に対する診断書（累積疲労損傷度）

（1） 一　般　　　BMC Fatidac SySTEM

橋梁名	日本橋梁	桁番号	13	図面番号	WDG610−101
部材名	主桁	部位	上下フランジ	グループ名	BMC−1
適用する評価基準	JR保守標準（仮）			処理日	1992. 6. 4

（2） 各着目箇所に対する評価結果

解析内容		評価の基準値			累積疲労損傷度	累積疲労損傷度に対する判定区分
No	着目継手箇所	200万回強度 (MPa)	m	打切限界 (MPa)		
1	主桁下フランジガセット	65	3	21	2.72	A₁
2	主桁下フランジ	100	3	39	0.75	B
3	主桁上フランジガセット	65	3	21	0.61	B
4						
5						

（3） 判定結果と措置

解析No	判定区分	記事
1	A₁	「鋼構造物補修・補強・改造の手引き」のS−13を参考に対策を検討して下さい。
2	B	次回の「全般検査」では、重点検査項目として追加し、必ず確認して下さい。
3	B	次回の「全般検査」では、重点検査項目として追加し、必ず確認しこ下さい。

Fig.6 Example of examination report

REFERENCES

1. ABE,M. et al., Development of a System for Estimating the Remaining Life of a Steel Railway Bridge. The Second Japan-Korea Joint Seminar on Steel Bridges, Tokyo, Japan, July 1992.

2. HORIGUCHI,T. et al.,Development of Fatigue-Damage Rating System for Steel Bridges.
Proc. of the 4th Inst. Conf. on Fatigue and Fatigue Thresholds, July 1990 in Honolulu.