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Strain Measurements on Steel Road Bridges

Mesures des déformations sur des ponts-routes métalliques

Verformungsmessungen an stählernen Strassenbrücken

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SUMMARY
The paper presents strain measurements made on steel bridges subjected to heavy international road traffic. Stress histograms are prepared for the main girders and deck elements to facilitate assessment of fatigue resistance.

RESUME
L'article présente les mesures de déformations faites sur des ponts-routes métalliques soumis au trafic lourd international. Les histogrammes des contraintes ont été tracés pour les poutres principales et les éléments du tablier, pour faciliter l'estimation de la résistance à la fatigue.

ZUSAMMENFASSUNG
An stählernen Strassenbrücken, die dem internationalen Schwerverkehr dienen, wurden Verformungsmessungen durchgeführt, welche im Artikel diskutiert werden. Mit Hilfe der ermittelten Spannungshistogramme soll eine bessere Abschätzung der Lebensdauer dieser Bauelemente ermöglicht werden.

1. INTRODUCTION

Present development and increase of the road transport intensity especially international transport of the big loads makes the problem lying in the investigation of the exploitational stress effect for the bridge construction for the road building specialists in the numerous countries.
Road bridges are designed in such a way that they carry the loads caused by the standard vehicles.
Standard loads are bigger than the loads of the vehicles moving along the roads, especially for the possibility of transport of the over-standard load. Assuming of such loads during the design of the construction for the resistance and stability is motivated by the necessity of guarantee before the steel yield point and buckling will be reached also under the sporadical big overload. The standard loads however are not used in such a way as the designing directions require. The road bridges are subjected to the various forces [1,2] during the exploitation, starting from the constand loads of the constructions themselves, anchangeable in time, through the slowly changing load resulting from the influence of the temperature and material strain, to the quickly changing various loads resulting from the moving vehicles.
Considering such a great randomness of the road bridge loads transversely and along the span the values of the internal forces in their elements cannot be easily calculated by means of the theoretical methods.
For this reason the strain measurements in the chosen types the road bridges steel span have been made, and in this way information about the particular elements of the bridge construction effort were obtained.

2 INVESTIGATIONS DESCRIPTION AND ORGANIZATION

Program of the investigation comprised four types of simply supported bridges differing in the span and the construction of the main girders and in the type of the deck.
General characteristics of the tested bridges with the specification of the measuring points is given on the Fig.1.
The tested bridges are placed on the main international roads characterized by great traffic. One of the bridges, is placed within a town. Street car traffic is also held on this bridge.
The measurements have been done by means of the strain gauges glued to the main girders flange in the one-second and one fourth of the span length as well as on the deck elements.
Initial values were recorded durably by means of two six-channel loop oscillograph on the lightsensitiver paper.
Additionally, in order to observe the speed and the way in which the vehicles move /overtaking, passing, traffic jam/ [4] the video recording was introduced. During the measurements there existed possibility of inspecting the results on the oscilloscope.
Detailled scheme of the measuring set is shown on Fig. 2.
In order to shorten the time of the recording in one hand and as the result of the attempt to record the traffic structure closest to reality on the other, six half-hour periods during the whole day were chosen, that is 24,00'-0,30', 4,00'-4,30',..,20,00'-20,30'.
The results of the measurements obtained this way were related to the whole day. At the same time during the measurements the

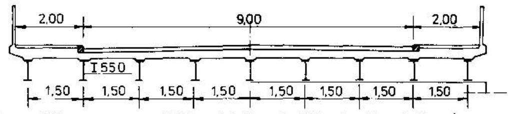
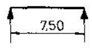
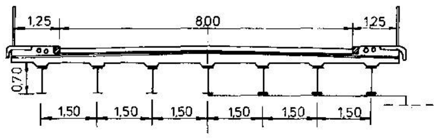
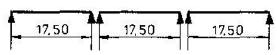
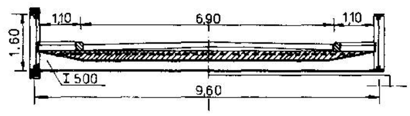
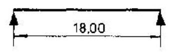
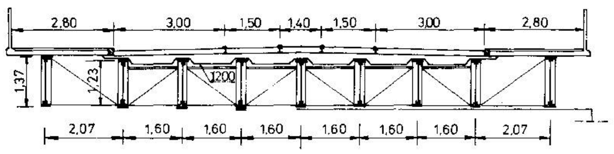
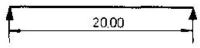
TYPE	CROSS - SECTIONS	STRUCTURAL SCHEME	NUMBER OF MEAS-URING POINTS: CROSS BEAM	MAIN GIRDER: BOTTOM FLANGE	MAIN GIRDER: TOP FLANGE
A	ROLLED BEAMS ; CONCRETE SLAB 		—	12	—
B	WELDED BEAMS ; CONCRETE SLAB 		—	12	—
C	RIVETED BEAMS, STEEL DECK PLATES ; CROSS BEAM IN SPACING 2,00 m 		4	4	4
D	RIVETED BEAMS; STEEL DECK PLATES; CROSS BEAM IN SPACING 1,47 m 		2	10	—

Fig.1. General characteristics of the tested bridges and measuring points distribution

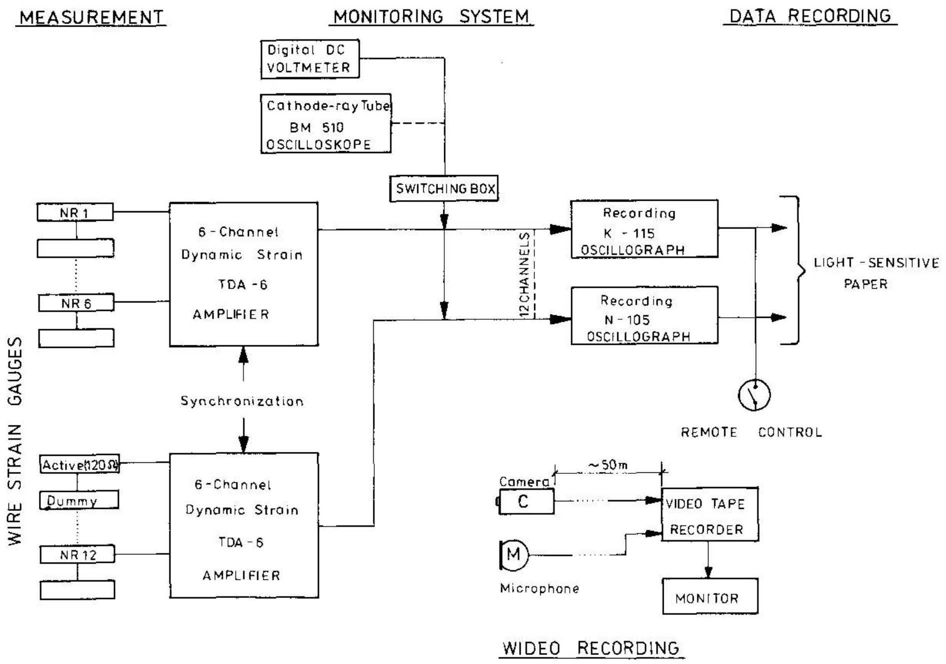


Fig.2. Data acquisition system

record of the traffic size and its structure.

3 THE MEASUREMENTS RESULTS ANALYSIS

In order to make analysis the obtained results were composed to the load traffic measurement from the all- Polish full-year investigations an the adequate routes and places. The analysis took into consideration the day of the week and month in which the measurements were made Good conformity of the author's own results with the all-Polish traffic measurements was obtained. As the result of the traffic structure on the tested bridges record it can be stated that the relation of the number of trucks and passenger cars was included in the limits from 20/80 /for the city bridge/ to 29/71 /for the route leading in the direction of the border/. To illustrate the variety of the road bridge loads [1,3] in the table on Fig.3 the main types of the trucks which can be met on the Polish road most often were drawn up.

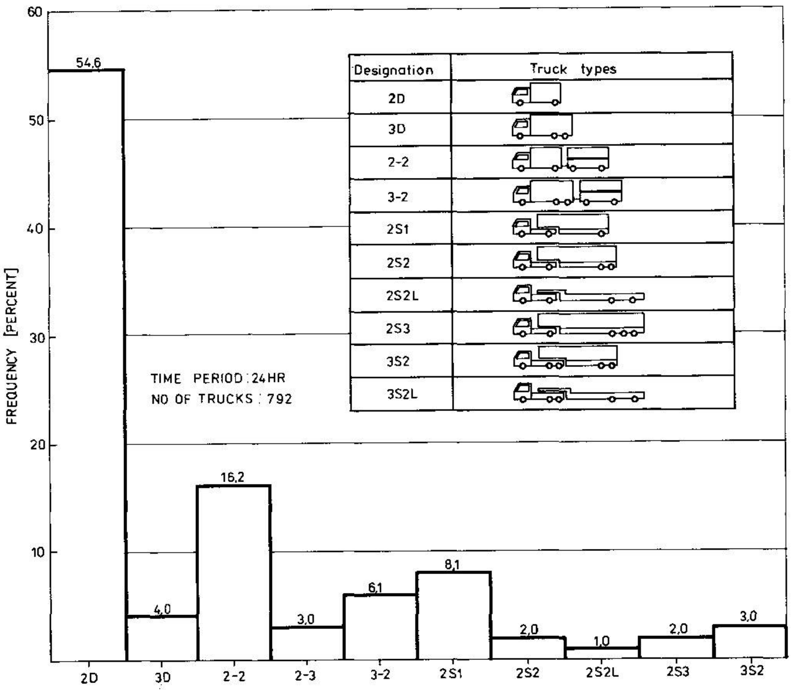


Fig.3. Frequency distribution of vehicles types from observations with the set of vehicle the most common on the Polish roads

The vehicles of the each type differ from one the other in the complete lenght, axial load and their base. The exemplary representative distribution of the particular type of the trucks frequency at appearance that was noted during the investigations of the bridge A is shown on Fig.3. Great similarity in the frequency of different types of the trucks appearance was noticed for different routes. Presented distribution shows that the great deal of the trucks taking part in the traffic are biaxial vehicles.
The Fig.4 shows exemplary oscillograms recorded under the passage of four most common types of the vehicles for the span average length l_t=17,50 m /Bridge B /, the short one l_t=7,50m/Bridge A/ and for the cross-beams in the spacing b=2,00 m /Bridge C/ and b=1,47 m /Bridge D/.
The oscillograms were obtained from the strain measurements for

the most loaded girders and cross-beams for the centre of their span.

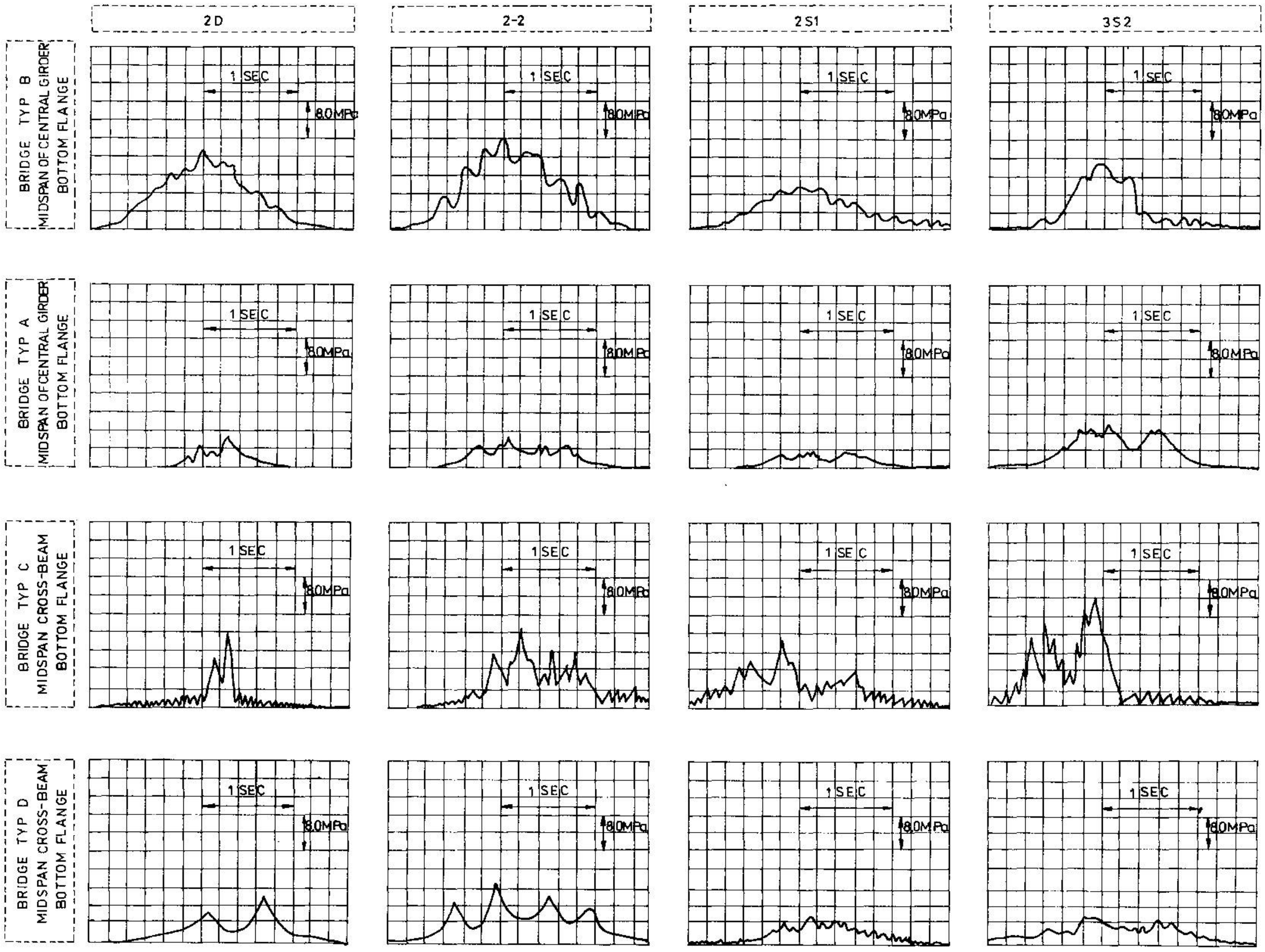


Fig.4 Exemplary oscillographic records under four types of trucks passing

From the oscillograms results that the shorter the main beams length, or the spacing between the cross-beams, the bigger is the number of the cycles of stresses to which those elements are subjected. The number of the cycles of stresses depends also on the type of the truck passing the bridge which is connected with the number and the axle base of the given vehicle. It can be noted that the cross-beams are subjected to the more numerous cycles of the stresses than the main girders. On the Fig. 5 shown oscillograms which were recorded for the botton flange of the cross-beam and the main beam of the bridge of the D type under the passage of the street car. The oscillograms show great influence of the track cooperation on the course of the stress. How remarkable is randomness of the stresses to which particular steel bridge construction elements are subjected can be noticed on Fig. 6. This figure shows the history of absolute scope of stresses which occured in the span centre,of the B type bridge central main girder in the order of their appearance. In order to evaluate the extend of the tested bridge's various elements of the construction exploitational effort, stress histograms [1] shown on Fig.7. were made for them.

Comparing the histograms No 1 and 2, made for type C bridge main girder in the midspans it can be noticed that despite full symmetry of the main girders and theoretical lack of cooperation of the deck elements with the main girders the histogram No 1 made for the top flange demonstrates higher level of the stress range than the histogram No 2 made for the botton flange. This is caused by the co-operation of the deck and flooring which is in such type of deck not taken into consideration in the calculations.

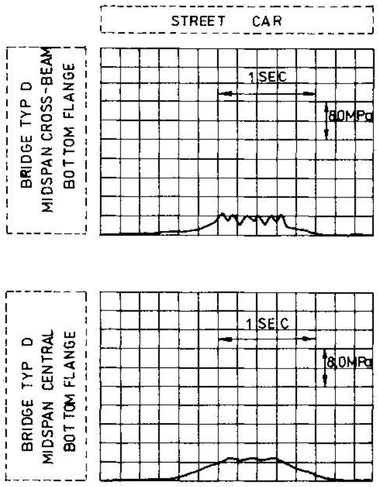


Fig.5 Oscillographic records under street car passing

In this case neutral axis moves toward botton thanks to which the top flange stresse become bigger. It can be noticed that the stress range distribution for the central beam No 3 and the terminal beam No 4 of the type B bridge differ essentialy. For the central beam frequency of higher stresses occurance is much bigger than for the terminal one. The histogram No 5 and 6 have been made for the cross-beams. Recorded negative values are the result of the cross-beams work as continuous structure which is not taken into consideration in the calculation for the cross-beam of this type.

Particular histograms present calculated stresses from the dead load and from the live specifications, for the corresponding places of the construction with the total number of events.

The maximum stress span equaled from 14,0MPa ± 2,0 MPa for the less efforted elements to 30,0 MPa ± 2,0 MPa for the most loaded central beam of the type B bridge.

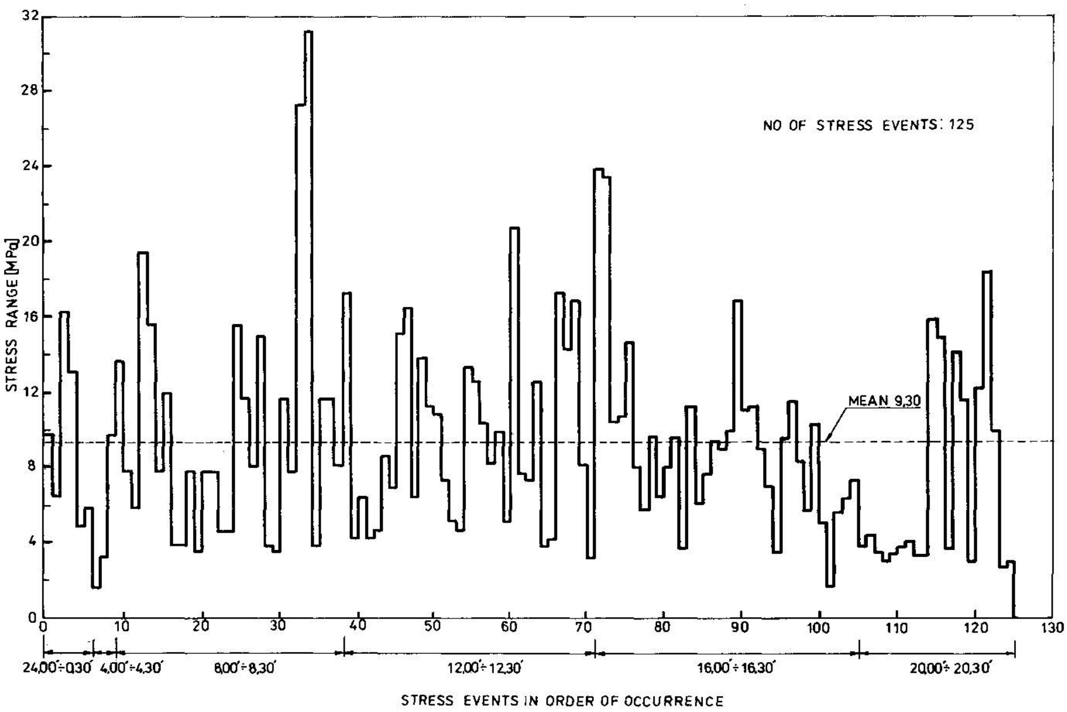


Fig.6. Sequence of stress range events

The relation of the measured stresses to the calculated ones from the live load together with the dynamic influence, that is the range to which stresses are used was included in the limits from 13,2% to 38,4% for the tested bridges whereas the relation between the measured and calculated stresses from the dead load oscillates in the interval from 12,1% for little loaded terminal beam to 104,5% for the cross-beam.

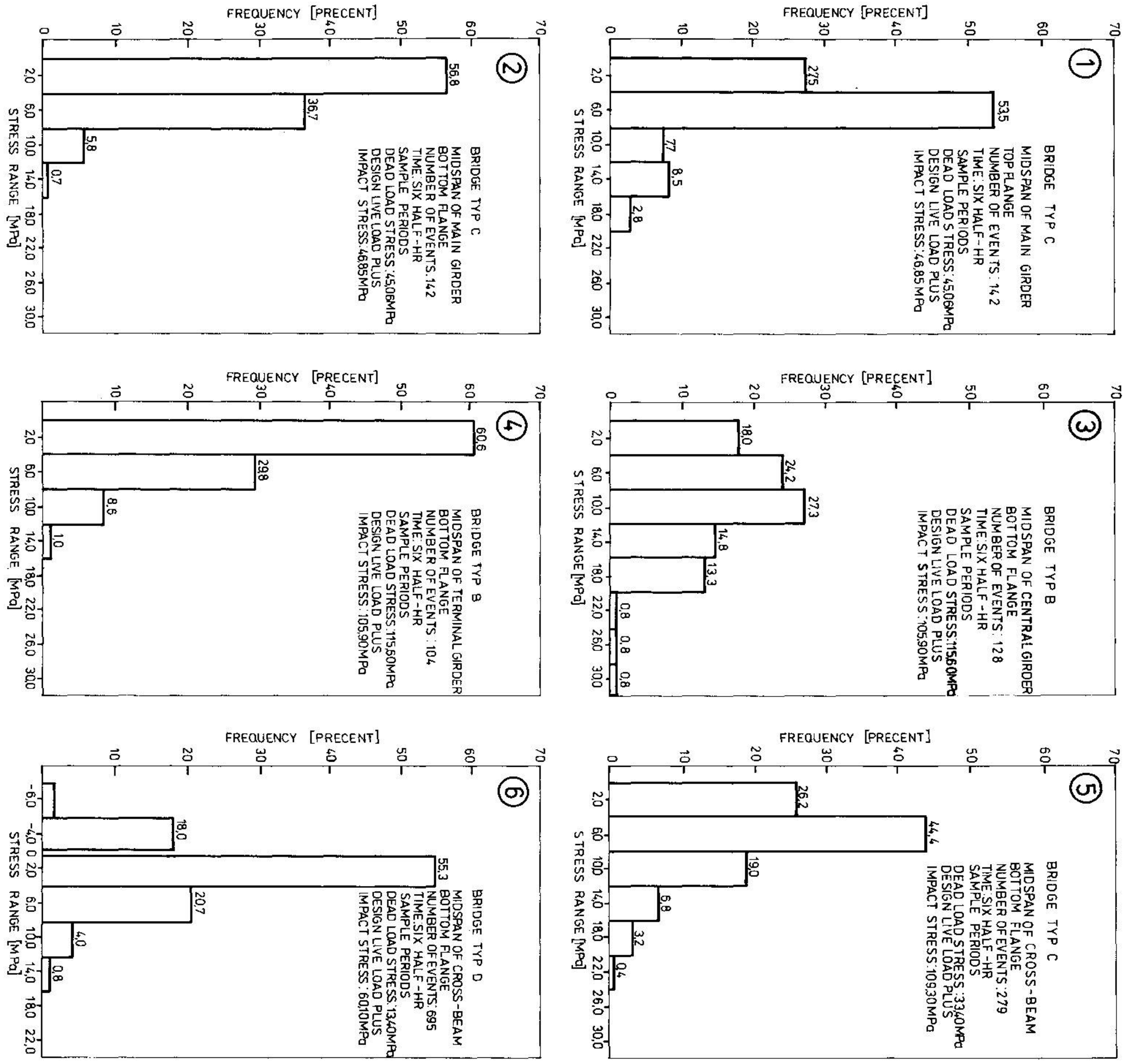


Fig.7 Exemplary frequency distributions of stress range from strain measurements

Having at the disposal a number of data about the stresses of the various types of bridges placed on the routes characterized by different intensity of traffic; considering expected increase and change of the traffic structure and applying one of the cumulative damage methods one can obtain exploitational resistance for the steel road bridges and the durability of the exploited bridges.

4. CONCLUSIONS

The above investigations allowed to observe the specific character of the stock of vehicles running on the Polish roads and their influence on the bridge construction.

Generaly, it can be noted that the construction elements stresses for all tested bridges are remarkably smaller than the stresses calculated under the normative loads The difference results not only from the fact that used vehicles are much lighter than the normative vehicles but also from he following facts:

- the cases that there is more than one vehicles on the bridge are isolated [2] , and all traffic lanes are fully loaded very seldom. During the investigations from 8 to 32 cases of trucks passing on the bridge were noted daily. Much more cases of trucks passing on the bridge /about 120/ and several jams were noted on the city bridge where the traffic intensity is bigger
- dynamic influence on the live loads is smaller than it is considered in calculations
- there is a remarkable influence of the deck elements, floor layers, railings co-operation with main girders
- in the case of deck elements we observe also the influence of continuous, which is not taken into consideration in the calculations

It can be noted that the phenomenon of fatigue for the deck elements and girders of small span should be taken into account much more than in the case of medium and big span girders.
In order to avoid the danger of possible fatigue crack in the newly designed bridges, or early preventing them in the exploited bridges the exploitational resistance of the steel road bridges should be evaluated which can be done on the basis of knowledge of the stress histograms.
Presented investigation should be treated as the diagnostic ones. For the closest future the investigations of wider range are planed which will include more types of bridges with various static schemes, with measurements system and perfection of the way of elaboration of the data.

REFERENCES

1 CUDNEY G.R.; Stress Histories of Highway Bridges. Journal of the Structural Division, ASCE, Vol. 94, No.ST12, December 1968, pp. 2725-2737

2 GALAMBOS CH.F., ARMSTRONG W.L.,: Acquisition of Loading History Data on Highway Bridges, Public Roads, Vol.35,No.8,June 1969 pp. 177-189

3 HEINS C.P., DERUCHER K.N.: Truck Characteristics and Stress Spectra for Steel Highway Bridges. Public Roads,Vol.41,No.3, December 1977,pp 132-139

4 HOBST E., KYŠKA R , SOKOLIK A.; Digitalizacia zaznamov merani priehybov cestnych mostov od prevadzkoveho zaztazenia s vyuzitim minipocitaca. Inženyrske Stavby,No.4,1980,pp.124-127