Model tests on structural damping on bridges

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Model Tests on Structural Damping in Bridges

Essais sur modèles de l'affaiblissement structural des vibrations dans les ponts

Modellversuche über die strukturelle Dämpfung in Brücken

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1. Introductory

The vibration damping coefficient of structures is many times greater than that of small specimens, when the same material was used. Furthermore, the damping data vary in wide limits, depending strongly on tested object's structural characteristic / see Table 1 /. Material damping represents only a part of the global damping. The remaining part, in most cases a greater one, may be treated as a result of non - material damping factors.

Table 1

Type of bridge	Log. decrement of damping min	max	max/min
reinforced concrete	0,182	0,490	2,69
prestressed concrete	0,099	0,310	3,14
steel	0,061	0,161	2,64

This phenomenon, known as structural damping effect, encloses the total influence of spatial material distribution in the structure, mutual connections of members as well as the technical state of structure.

When the possibility of structural form modifications is nearly unlimited, some examples only can be given. These are, statical scheme including, the shape and size of bridge cross-sections, type and number of connections, the surface-structure conjointment as well as the type of bearings.

In contrast to the material damping, where some hypothesis, the numerical data too, are known, the structural damping is till now not very well recognized. Unfortunately none of mentioned above structural influences can be excluded from the global damping values, when existing bridges are dynamically tested. This interesting problem, which could be useful for pre-evaluation of the bridge dynamical properties, seems to be suitably solved, when testing the adequately constructionally adjusted big models.

Such tests have been undertaken by the author in Silesian Technical University.

2. Tests description.

The influence of some structural variations in tested models was investigated,namely:bearing type,number and stiffness of the floor beams as well as the skew angle.The participation of both material and structural dampings in the global damping was analysed.The effect of succesively increasing initial dynamic displacement was enclosed with test programme too.

Thirty-five steel beams in single- and double-beam systems were tested,when steel of normal structural standard was used.

The basic model element was a single welded I-beam of 3,0 m span /Fig. 1/.Two main beams joined transversaly with a number of floor beams, formed a simple double-beam bridge gridwork.The number of floor beams increased from two to five /Fig. 2/.In one of the tested series the floor beam/main girder stiffness ratio was succesively decreased from 3,0 to 0,03 /Fig. 3/.The skew angle varied every 15^{o} in limits from 45^{o} to 90^{o}, /Fig. 4/.

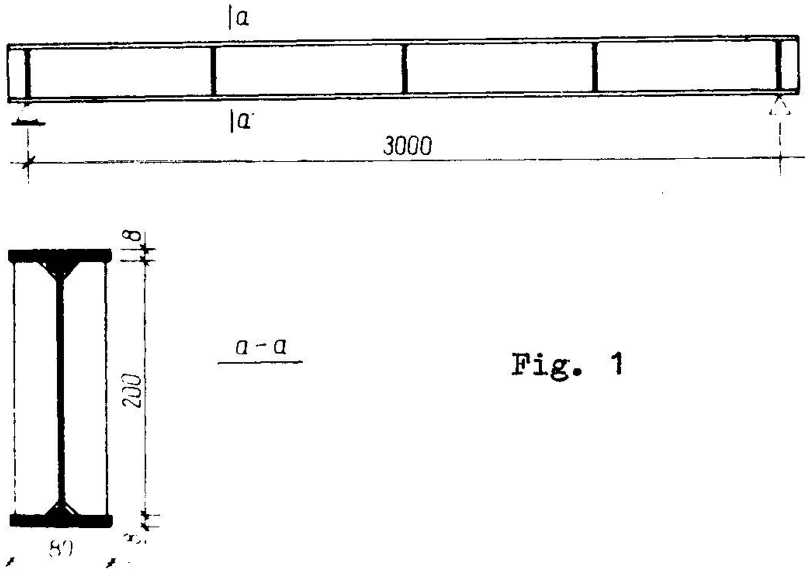


Fig. 1

Six types of bearings were used.A,B,C, D,E,F - types respectively:steel plate bearing with and without bituminous pad, steel tangential bearing, steel roller bearing,two- and five-layered steel-rubber bearings. Identical denotations are used at Fig. 5 .

The single - beam models were used only for bearing effect test. Double-beam models uniformly supported with tangential and roller bearings,served for the testing of remaining , enclosed by programme , structural effects.

When massive concrete test stand was used,any undesired distorsion of results was practically out of the question.

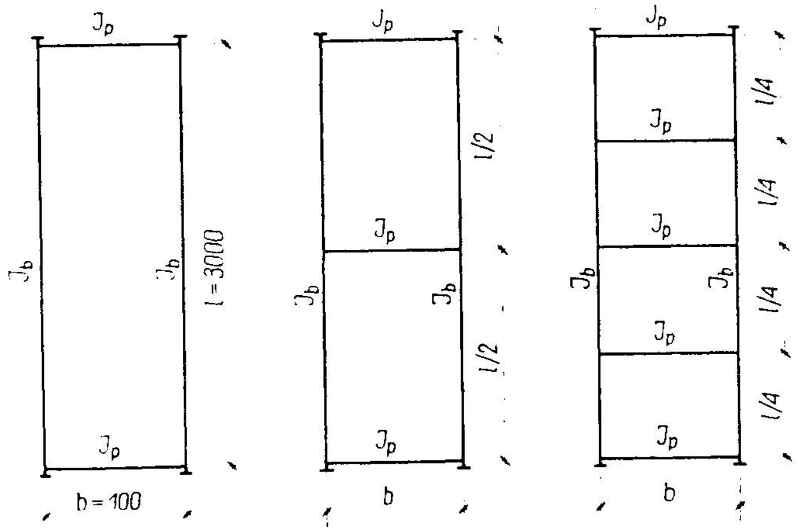
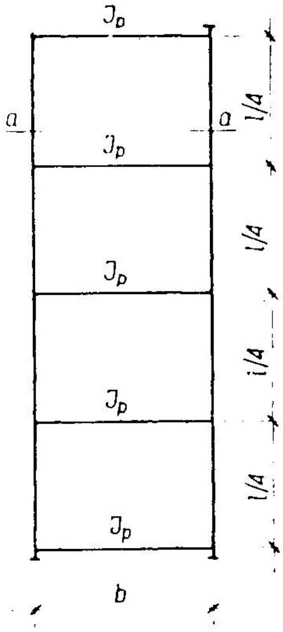


Fig. 2

The vibration source was a single dynamic impulse,caused by the rapid release of initially deflected / y_o= 1-5 mm / and with dial indicators controlled test beam.Vibrograms of the free damped



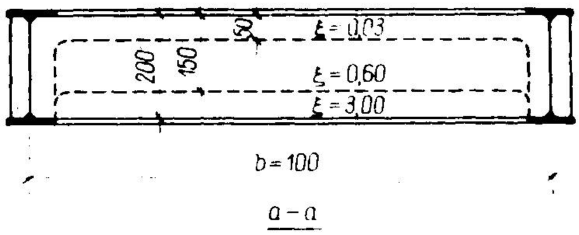


Fig. 3

$$\xi = \frac{I_p \cdot l}{I_b \cdot b}$$

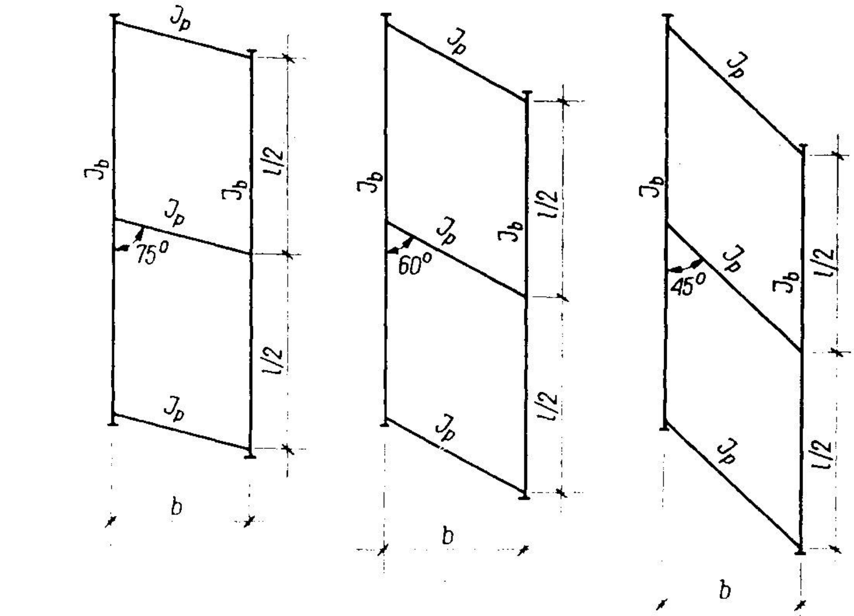


Fig. 4

vibrations were recorded with Hottinger s set.

3. Test results.

Logarithmic damping decrement,obtained from the vibrograms analysis,was intended for comparison of the damping properties of each separate tested model.

These empiric data represent doubtless the global damping too.The subtracting of the mean value of the material damping decrement for used steel standard /0,008 - proved by other authors/ enables evaluating of structural part of summarized effect corresponding with the characteristic of the tested model.

Results are given graphically in Fig. 5 and Fig. 6 .

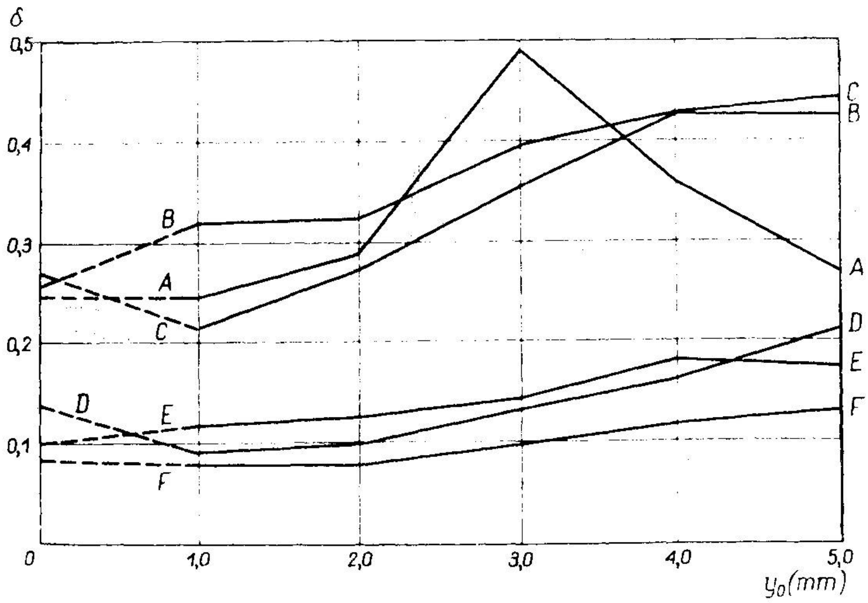


Fig. 5

Denotations-see text

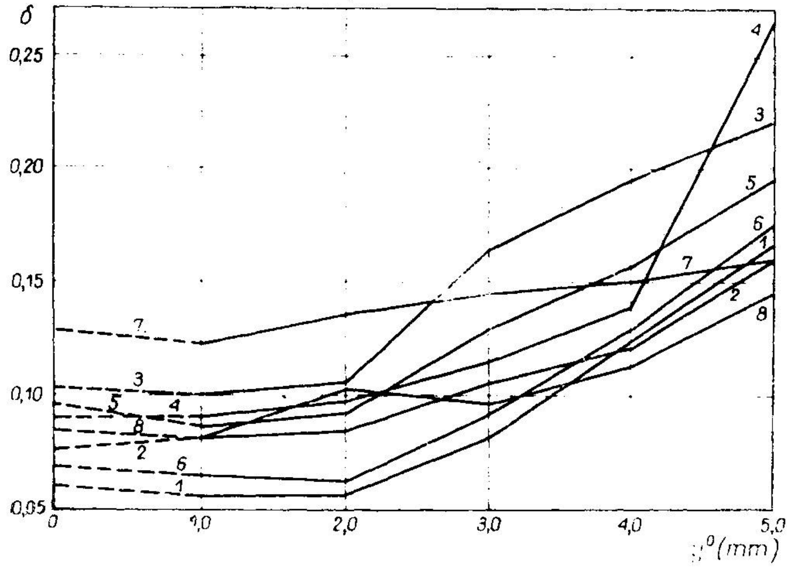


Fig. 6
Denotations:
δ – log. decrement
y_0 – inital deflection
ξ – see Fig. 3
n – number of floor beams
α – angle of skewing

1,2,3 – n=5
α=90°
ξ=resp. 3,0;0,6;0,03

4,5 – n=resp. 3;2;
α=90°
ξ=3,0

6,7,8 – n=3
α=resp. 75°; 60°; 45°
ξ= const.

4. Conclusions.

When omitting the peculiar interpretation of the individual diagrams, some more general conclusions can be drawn.

The constructional form's effect on damping is evident and considerable.

In tested cases this effect reaches 70 – 90 % of the global damping.

The simple – formed bearings, low stiffness of the transversal beams as well as the angle of skew near to 90° result in relative increasing of the damping properties.

Remarkable is an evident increase of the damping accompanying the increase of initial beam deflection.

Considerable structural damping effects are to be expected especially in the short – span and primitive – supported bridges. In these cases the structural damping effect could be treated as the dominant one.

The damping effect of the rubber bearings doesn't exceed the one recorded for steel roller bearings.

Tests presented here concern hardly a limited number of possible form modifications in tested models. The too poor number of data does not give full enough

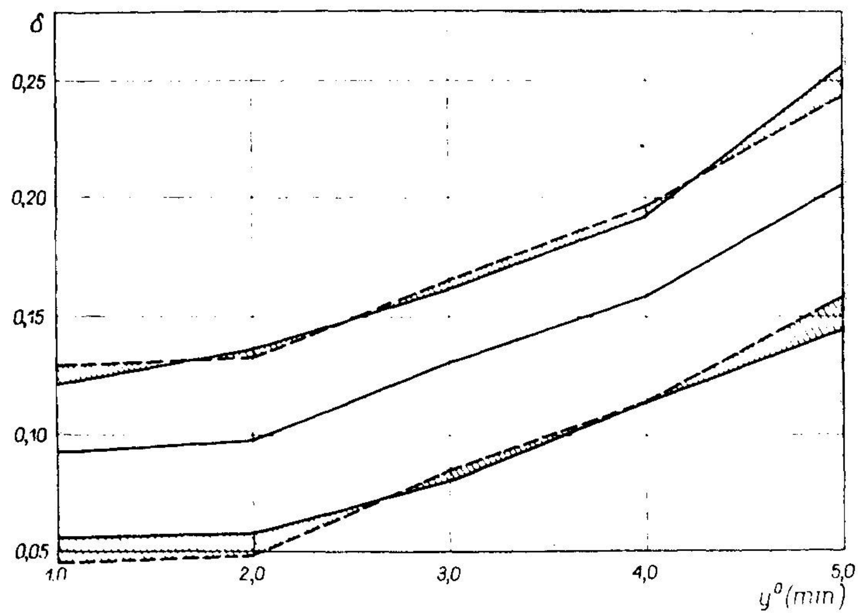


Fig. 7

representation of a tested phenomenon. The run of the envelope curves for all tested cases /Fig. 7/ indicates, however, some interesting regularities. They may give assumption, that in the mathematical analysis of free damped vibrations the global damping forces should be divided into material and structural parts. The material factor should represent of "specific damping" undependend of the structure's shape and sizes. These and the other constructional features should be described by the functional quantity enclosing in general the spatial material's distribution effect.

When analysing other forms of vibrations, additional damping forces should be still taken into account, especially these resulting from the vehicle / bridge co - action.

SUMMARY

Contribution of structural damping to the global one in the bridge systems has been analysed. The procedure results and interpretation have been given. The damping effect of bearings, stiffeners and skewing have been tested. In some cases the effect of structural damping in bridge structures can be the dominant one.

RESUME

On a étudié le part d'affaiblissement dans l'affaiblissement global de la construction des ponts. On décrit les essais, les résultats et leur interprétation. Les influences d'affaiblissement des appuis, des entretoises et du biai des ponts ont été comprises dans le programme d'essai. Dans quelques cas l'influence de l'affaiblissement structural peut s'avérer décisive.

ZUSAMMENFASSUNG

Es wurde der Dämpfungsanteil in der globalen Dämpfung der Brückenkonstruktionen untersucht. Der Testvorgang, die Ergebnisse und ihre Interpretation werden angegeben. Die Dämpfungseinflüsse der Lager, der Querträger sowie der Brückenschiefe wurden in das Versuchsprogramm einbezogen. In manchen Fällen kann sich der Einfluss der Dämpfung in der Brückenkonstruktion als massgebend erweisen.