Measurements of transverse accelerations arising in bridges

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Measurement of Transverse Accelerations Arising in Bridges.

Messung der an Brücken auftretenden Querbeschleunigungen.

Mesures des accélérations transversales auxquelles peuvent être soumis les ponts.

M. Mauzin,
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Arising out of researches carried through in recent years on the French railways endeavours have been made to perfect a form of accelerometer in which the natural period of vibration is susceptible to measurement and in which the sensitivity is confined to a particular direction.

Generally speaking all existing forms of accelerometer are based on the same principle, namely the inertia of a mass, the displacement of which relatively to the structure is measured and is taken as proportional to the force represented by the mass of the structure multiplied by the acceleration which the latter undergoes. A simple calculation is enough to show that if the natural frequency of vibration of the apparatus is to be high (several thousands per second) the displacement on the mass must be extremely small (being of the order of $^1/_{10}{}^{th}$ to $^1/_{100}{}^{th}$ of a mm).

In these circumstances use has been made of the properties of piezo-electric quartz for the purpose of constructing an alternative form of apparatus. By means of a spring a certain mass is kept in contact with a piece of quartz, and variations in the pressure exerted on the latter, due to the mass being under acceleration, release in the quartz quantities of electricity, which are converted by means of a triode valve into a current which is recorded by means of an oscillograph. The natural period of vibration of such an apparatus is in excess of what can be recorded by the oscillograph employed (1000 per second).

Moreover, certain measurement arise in railway practice (for instance, the recording of very small longitudinal accelerations in a body subejcted to vertical accelerations of relatively high value) which make it necessary to devise some arrangement which will render the apparatus practically insensitive to accelerations perpendicular to a particular direction. This requirement has been met by special attention to the manner in which pressure is exerted on the quartz.

The idea arose of using this apparatus for measuring the transverse accelerations in bridges — a problem of evident importance, since in the course of time such vibrations may give rise to appreciable stresses. The apparatus here described was one which seemed eminently adapted to this purpose, as its high natural frequency of vibration and its sensitivity blased in one particular direction allow of measuring these transverse accelerations even though the vertical accelerations may be relatively much greater. A few examples of recards obtained in this way on railway bridges are given below.

Position of testing apparatus.

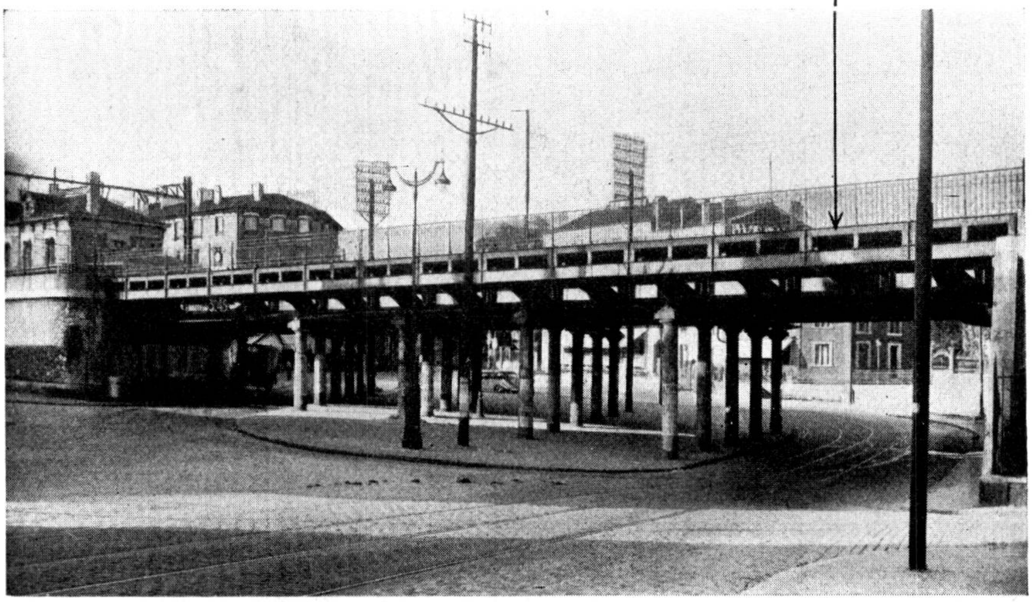

Fig. 1.

Skew deck-type bridge at Vitry-sur-Seine. Weight of bridge about 300 tons.

The graphs Nos. 1 and 2 show the vertical and lateral accelerations as measured in a skew bridge having a weight of 300 tonnes with the decking carried above the girders. Graphs Nos. 3 and 4 refer to a skew bridge weighing 120 tonnes, again with the decking above the girders. Graphs Nos. 5 and 8

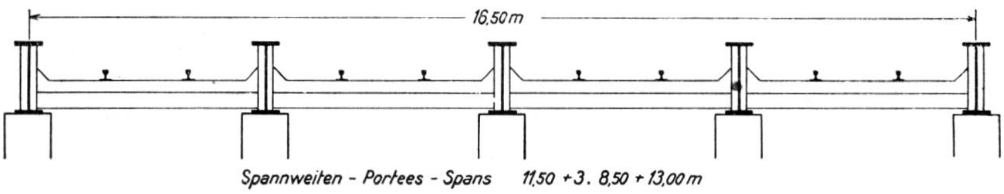

Fig. 2.

Cross section.

relate to a square bridge weighing 600 tonnes with the decking below the girders, the measurements having been made at the upper and lower booms respectively. The following are the values of the accelerations.

For the 300-tonne skew bridge (Figs. 1 and 2).

Vertical accelerations: graph 1 — at high frequencies g/2; at the natural period of the vibration of the bridge g/10.

Lateral accelerations: graph 2 — at high frequencies g/5; at the natural period of vibration of the bridge g/13.

For the 120-tonne skew bridge (Figs. 3 and 4).

Vertical accelerations: graph 3 — at high frequencies g/1.2; at the natural period of vibration of the bridge g/5.

Lateral accelerations: graph 4 — at high frequencies g/2; at the natural period of vibration of the bridge g/7.

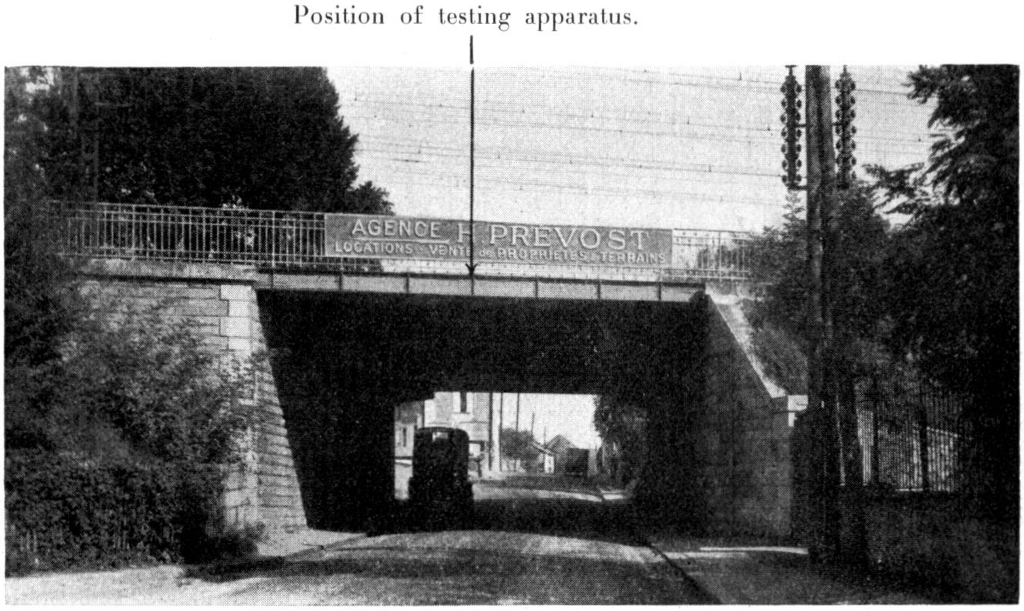

Fig. 3.

Skew deck-type bridge at Epinay-sur-Orge. Weight of bridge about 120 tons.

For the 600-tonne straight bridge (Figs. 5 and 6).

1) Measurements carried out on the upper portion of the girder. Vertical accelerations: graph 5 — at high frequencies g/0.8. No apparent natural period of vibration.

Lateral accelerations: graph 6 — at high frequencies g/1.25. No apparent natural period of vibration.

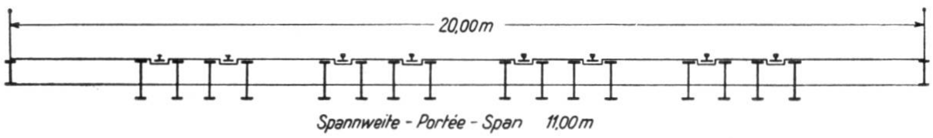

Fig. 4.

Cross section (diagramatic).

2) Measurements carried out on the lower portion of the girder.

Vertical accelerations: graph 7.

At high frequencies g/0.66.

At the natural period of the vibration of the bridge g/2.6.

Lateral accelerations: graph 8.

At high frequencies g/1.6.

At the natural period of vibration of the bridge g/7.

It will be seen that according to these graphs the greatest lateral accelerations were those obtained in the 600-tonne straight bridge (g/1.25 at the upper portion of the girder and g/1.6 at the lower portion).

In the other bridges the acceleration did not exceed g/2 laterally.

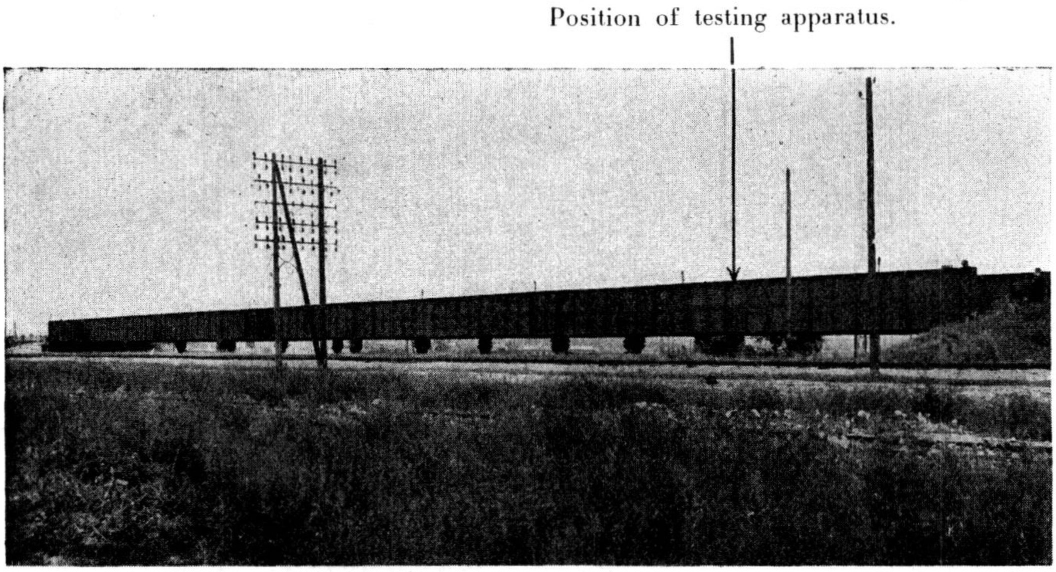

Fig. 5.

Straight through-type bridge at Maisons-Alfort.

Weight of bridge about 600 tons.

In addition, measurements of the acceleration have recently been effected on masonry bridges carrying railways; the values obtained were slightly lower than those recorded from the steel bridges.

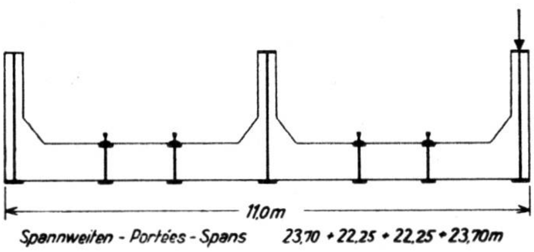

Fig. 6.

Cross section.

It should be noted that these figures are given only as examples, the object of the present note not being to study the acceleration to which bridge are in fact exposed and the consequent stresses arising in them under traffic, but merely to indicate the possibilities of use of this new apparatus.

Diagram 1
g = 32 mm

Diagram 2
g = 64 mm

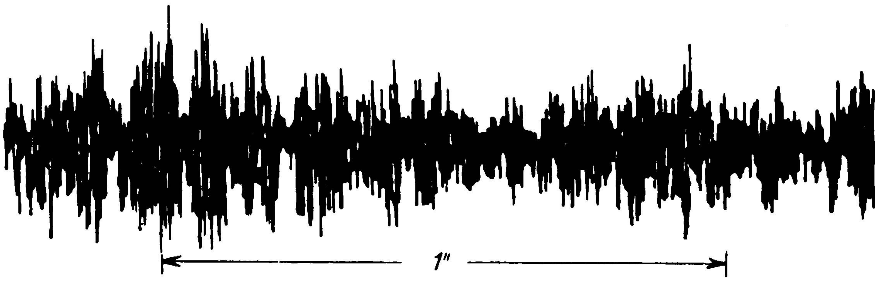

Diagram 3
g = 32 mm

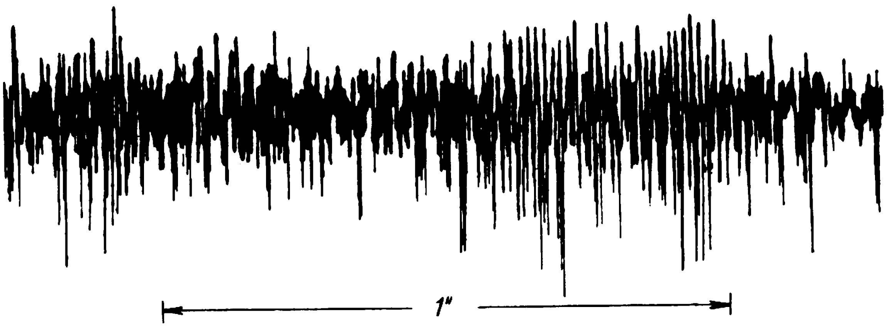

Diagram 4
g = 64 mm

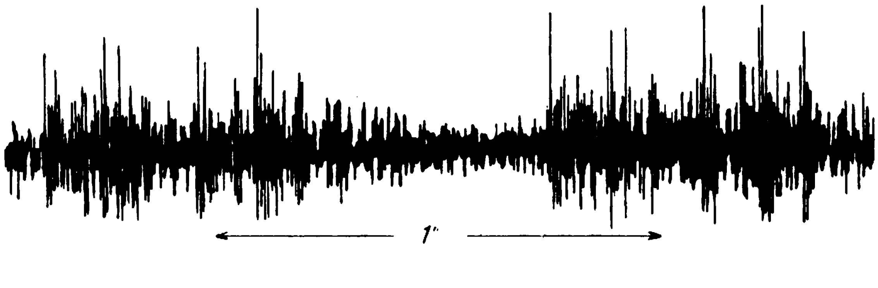

Diagram 5
g = 16 mm

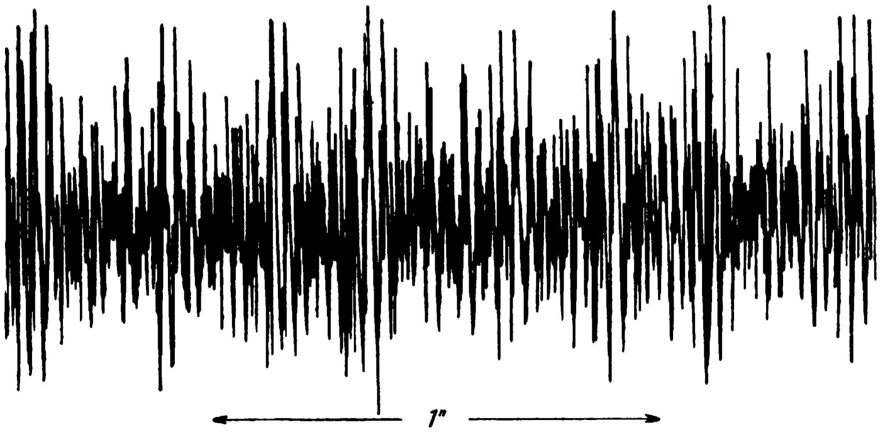

Diagram 6
g = 32 mm

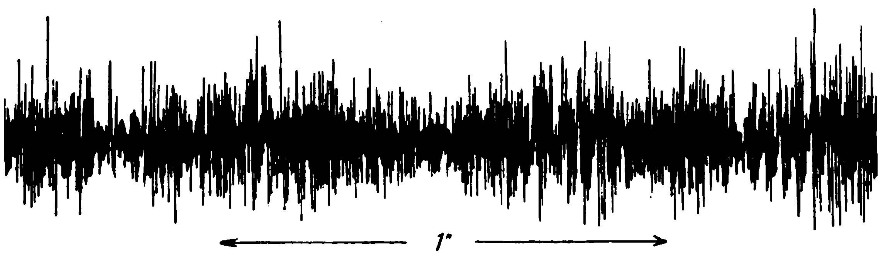

Diagram 7
g = 16 mm

Diagram 8
g = 32 mm

These records were obtained from the passage of different trains.