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ELABORATION OF DESIGNS OF HIGH-LOADED LAMINATED RUBBER-METAL VIBROISOLATORS APPLIED FOR BUILDINGS VIBROPROTECTION

Types of designs of multilayer rubber-metal vibration isolators intended for vibroinsulation of buildings are investigated. The design obtained by results of static and dynamic tests and applicable for use in building construction is offered.

Keywords: vibroinsulation of buildings, vibroisolators, static and dynamic tests.

Introduction

Development of multilayer rubber-metal vibration isolators intended for vibroinsulation of building is an urgent problem because of increase in spread of shallow subway network and city railways in Moscow and other Russian cities, as well as because of lack of inexpensive rubber-metal vibroisolators. For example, there are 30 vibroisolated facilities only in Moscow.

Vibroisolators designed to be operated under heavy load, with low natural frequency (less than 12 Hz) are applied for vibroinsulation of buildings. Import vibroisolators offered are rather expensive. At the present time, domestic vibroisolators rated at 15 tons are developed.

The aim of the study is development of domestic multilayer rubber-metal vibration isolators to be applied in the system of vibroprotection of multistoried building of little and middle number of storeys (up to 12—15 storeys). The study secured the financial backing of Scientific and Technical Centre “Building Protection” within the limits of collaboration of Co Ltd “Promtechnauka-Plan” (D. Sc. in Engineering V. I. Yurovsky, Ph. D. in Engineering N. P. Gomonova). Vibroisolators can find use in the systems of technological equipment vibroprotection.

It is generally known that the first building of modern design protected from vibration (with natural frequency of oscillations of 7 Hz) with the use of rubber-metal vibroisolators was built in 1966. 7-storeyed (Albany Court, London), located under underground railway station, has initiated construction of vibroprotected multistoried buildings in the world building practice.

Relatively low vibroisolated buildings (5—8 storey) were constructed in 1960s and 70s, later, vibroisolation was applied for protection of large structures. In so doing spring-damper systems, joining sheets made of different elastomers as well as multilayer rubber vibroisolators were used. At the present time, three types of building vibroinsulation are used in building practice of the leading countries.

1. Classical vibroinsulation with the use of multilayer rubber-metal vibration high-loaded isolators made of natural or synthetic rubbers.

2. Spring-damper systems of vibroinsulation.

3. Vibroinsulation with the use of solid sheet vibroisolators made of foamed polyurethane and other similar synthetic materials.

Stability of elastic properties of the rubber or elastomer is the most important factors when choosing material for elastic elements. Compounds on natural rubber have the best properties in this respect, since they practically aren’t subjected to aging and provide longevity of vibroisolators, comparable with longevity of other building structures (of steel, concrete, etc.).

Otherwise, the problem of substitution of vibroisolators increasing their rigidity under rubber ageing arises. This is the problem of “delayed” assembly and disassembly of vibroisolators. This problem is not so trivial as it may seems, particularly at irregular shape of buildings. Changeable element is removed, the new one strains to the load exceeding calculated vertical load on the vibroisolator. This leads to emergencies and long stops of construction-and-assembling operations during “delayed” assembly. Application of natural rubbers resolves the problem.

Efficiency is another important parameter of vibroisolation depending on frequency of vibroisolation and properties of damping. Efficiency determines ability of vibroisolation to dampen system vibrations in different modes of vibrations. Low-frequency systems with relatively low damping are the most efficient in which required parameters of vibroisolation are achieved using metal springs together with hydraulic dampers as elastoviscous elements.

Economic indexes are important parameters of vibroisolation. Rubber-metal vibroisolation made of natural rubber has the best parameters, gaskets made of sheet polyurethane stacked under foundation plate have the worst ones.

Hence, multilayer rubber-metal vibroisolators made of natural rubber are chosen as operating elements of vibroprotection systems based on technical and economic factors.

Vibroisolators were developed in the form of right-angled samples 235x235x60 mm made of medium-rigidity natural rubber (≈50 units by Shore). Metal plates of 2 mm in thickness were placed in parallel inside of isolators. Rigidity of isolators was regulated by the number of plates. The more plates are in isolators the more rigid isolator is and the closer correlation “load-movement” is to linear one”.

Selection of properties of vibroisolators was performed subject to the spectrum of dynamic effects under traffic in the underground. Components with frequencies in the range of 18—50 Hz prevail in dynamic load. In this connection natural vibrations of the vibroisolator under load should constitute 8—12 Hz. The availability of linear sequence of the diagram “load-movement” is the important condition for maintenance of properties in the range of load under which vibroisolators should be operated.

Parameters of vibroisolator design were changed to obtain movement of the vibroisolator under load of 30 tons ≈ 300 kN approximately, on 2—3 mm, which provides natural frequency of vibroisolatorof the order of 9—11 Hz.

The following types of vibroisolators were developed, produced and tested: 1) type 1 has 2 reinforcing plates; 2) type 2 has 3 reinforcing plates; 3) type 3 has 4 reinforcing plates; 4) type 4 has 5 reinforcing plates.

General view of a vibroisolator are shown in Fig. 1.

Fig. 1. General view of a vibroisolator

Tests were performed on servohydraulic machine Schenk (Germany), allowing to conduct both static and dynamic tests. The results of isolators double load tests (60 kN) of types 1, 2, of types 3, 4 (up to 800 kN) are shown in Fig. 2—5. All the isolators retain their stability and did not have external damage.

Each sample was tested twice, tests revealed stability of vibroisolators properties.

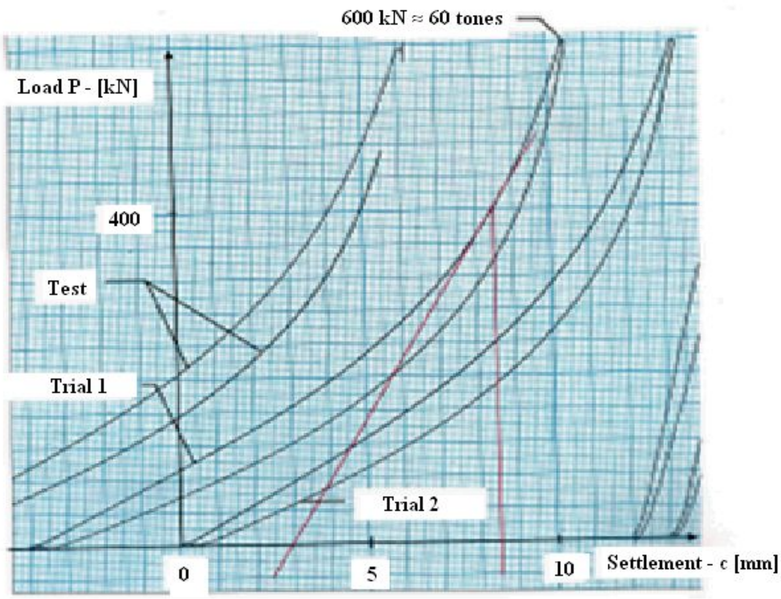

Fig. 2. Results of vibroisolator tests. Type 1

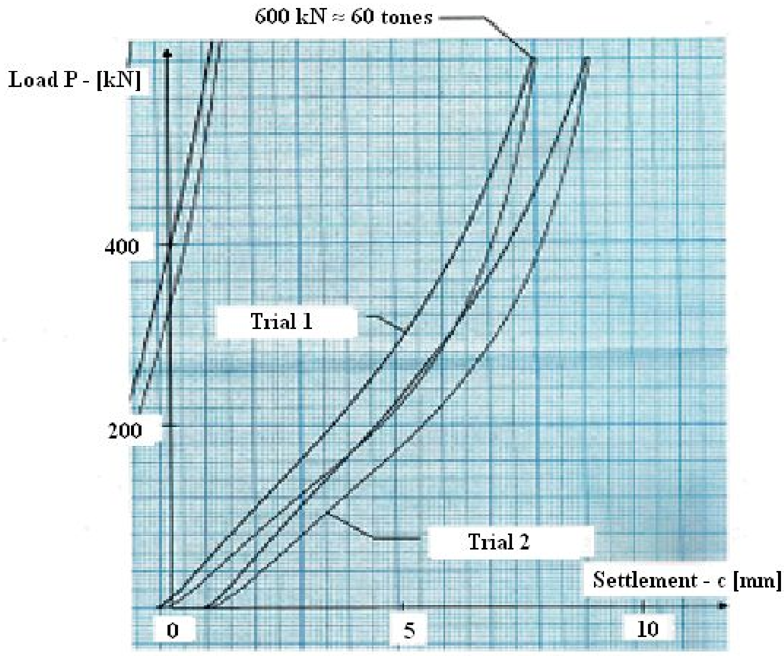

Fig. 3. Results of vibroisolator tests. Type 2

The results of tests showed that isolators of types 3 and 4 linear sequence of diagram “load-deformation” with had the best properties. These isolators were chosen for dynamic tests.

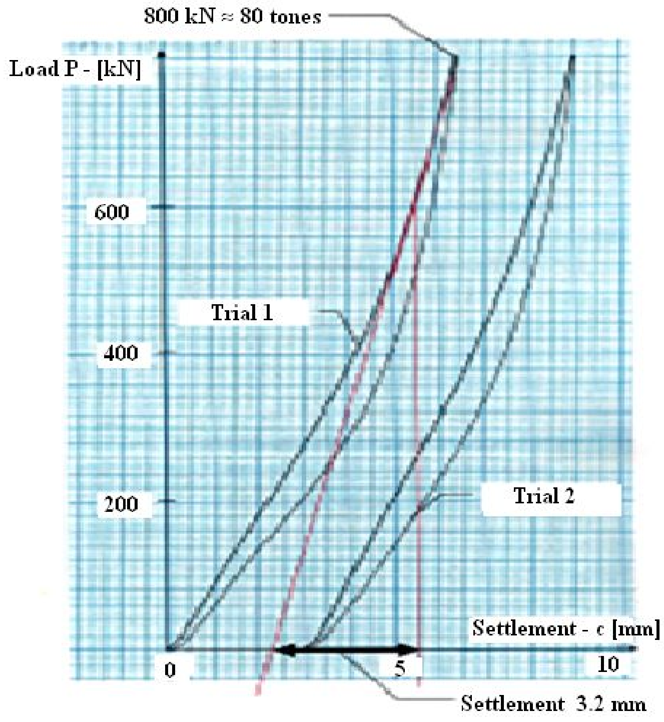

Fig. 4. Results of vibroisolator tests. Type 3

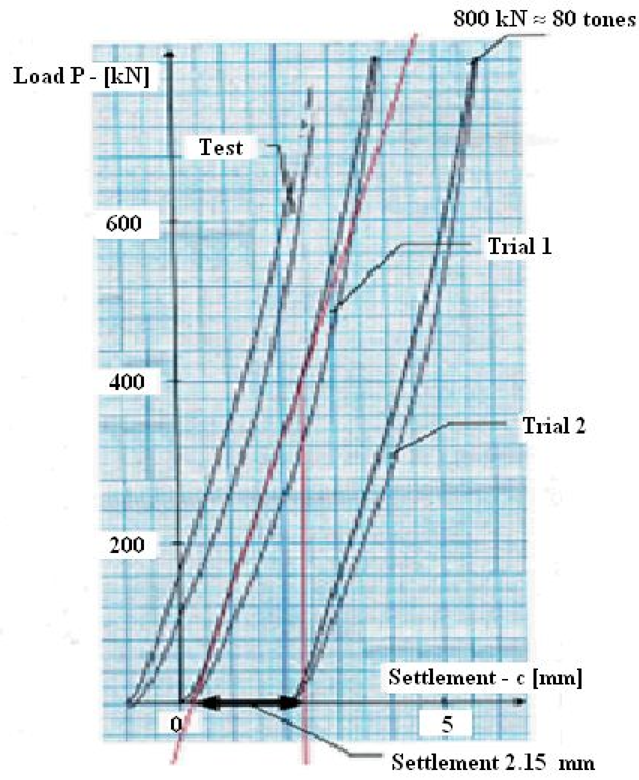

Fig. 5. Results of vibroisolator tests. Type 4

Natural frequency f under load was calculated as for conditional one-mass system of with elastic characteristic, determined by tangent modulus of elasticity using formula

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{c}},$$

where g is the gravitational acceleration; c is the movement under load (over tangent modulus).

Movement of vibroisolators under load was determined by tangent modulus (see auxiliary lines in Fig. 4, 5). Characteristic of vibroisolators were confirmed in the course of dynamic tests. The results of determination of vibroisolator natural frequencies using the resuls of dynamic and static tests are shown in the Table.

Table

The results of static and dynamic tests

Vibroisolator	Natural frequency, Hz	
	By results of static tests	By results of dynamic tests
Type 3	8.8	9.3
Type 4	10.8	10.9

Conclusion

It was determined by the results of static and dynamic tests that vibroisolators of type 3 (with 3 internal reinforcing plates) or type 4 (with 3 internal reinforcing plates) can be used as vibroisolators for systems of building vibroprotection under load of 300 kN = 30 tones. Based on static tests it was concluded that it is preferably to use vibroisolators with 4 plates (type 4). Good agreement of dynamic and static tests results confirm this fact. The drawing of the vibroisoolator is shown in Fig. 6.

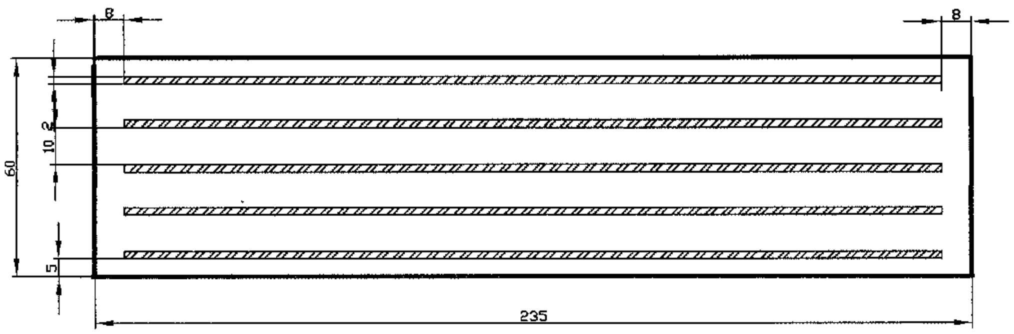

Fig. 6. Vibroisolator, type 4, selected for production. Section (sizes in mm)

Given vibroisolator can be applied in the building practice.

References

1. Recommendations on vibroprotection of bearing structures of industrial buildings. Moscow, 1988. 34 pp.