Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte
Band: 69 (1993)

Artikel: Floor response from vier of human body and construction
Autor: Pirner, Miroš / Fischer, Ondej
DOI: https://doi.org/10.5169/seals-52583

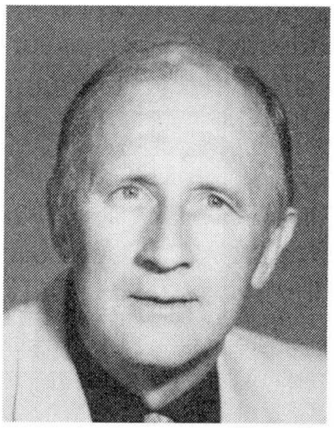
Floor Response from View of Human Body and Construction

Comportement des planchers du point de vue physiologique et constructif

Deckenverhalten in physiologischer und konstruktiver Hinsicht

Miroš PIRNER
Prof. Dr.
Czech Academy of Sciences
Prague, Czech Rep.

Ondřej FISCHER
Prof. Dr.
Czech Academy of Sciences
Prague, Czech Rep.



Miroš Pirner, born in 1928, civil engineer from the Techn. Univ. Prague 1952. Worked till 1970 as assistant professor, five years as research worker. In 1976–1990 head of the department of statics and dynamics at the Res. and Testing Inst. of Buildings. Since 1990 director of the Institute of Theoretical and Applied Mechanics.

Ondřej Fischer, born in 1929, got his civil engineering degree at the Techn. Univ. of Prague. Worked as a teaching assistant for 10 years, 3 years at practical design of civil engineering structures, since 1964 in the Czechoslovak Academy of Sciences. Concerned with scientific research in the field of dynamics of structures.

SUMMARY

The serviceability of structures with reference to their effect on the human organism is determined by the respective Codes. The authors have collected the results obtained by 15 years of measurements of response of the buildings of different systems, different materials and subjected to different dynamic loads. The authors present one method for the limitation of the vibrations of a textile factory building by means of a system of additional masses and rubber insulators.

RESUME

Des normes traitent de l'aptitude au service de constructions en fonction de l'effet que peuvent avoir les vibrations sur la sensibilité de l'organisme humain. Les auteurs exposent les résultats qu'ils ont recueillis au cours de 15 années de mesures sur les vibrations des bâtiments constitués de différents systèmes et matériaux et soumis à différentes actions dynamiques. Ils proposent une méthode de limitation des vibrations dans un ancien bâtiment servant d'atelier textile, en lui substituant un système de masses additionnelles posées sur des appuis élastiques en caoutchouc.

ZUSAMMENFASSUNG

Die Ausnutzbarkeit der Konstruktionen in Bezug auf die Empfindlichkeit des menschlichen Organismus für Schwingungen wird durch Normen vorgeschrieben. Die Autoren präsentieren ihre in 15 Jahren gesammelten Ergebnisse von Messungen der Schwingungen von Gebäuden verschiedener Systeme, Baustoffe und dynamischer Lasten. Es wird vorgeschlagen, die Schwingungen eines alten Fabrikgebäudes durch ein System von Zusatzmassen auf elastischen Gummilagern zu vermindern.

1 Introduction

The level of vibrations transferred to human body has proved to be a very important component of environment condition, influencing significantly the man's health, the quality of his production and the sense of comfort. Also the Czecholovak hygienic rules [2], [3] give admissible values of accelerations, differenciating living and working places, the type of the work and the time of exposure to the vibrations. In the same way as the importance of the environment requirements has grown during last years, it has also increased the number of contentions and the vibrations had often to be objectively appraised; we have therefore measured several tens of buildings and some of their results are summarized in Fig. 3.

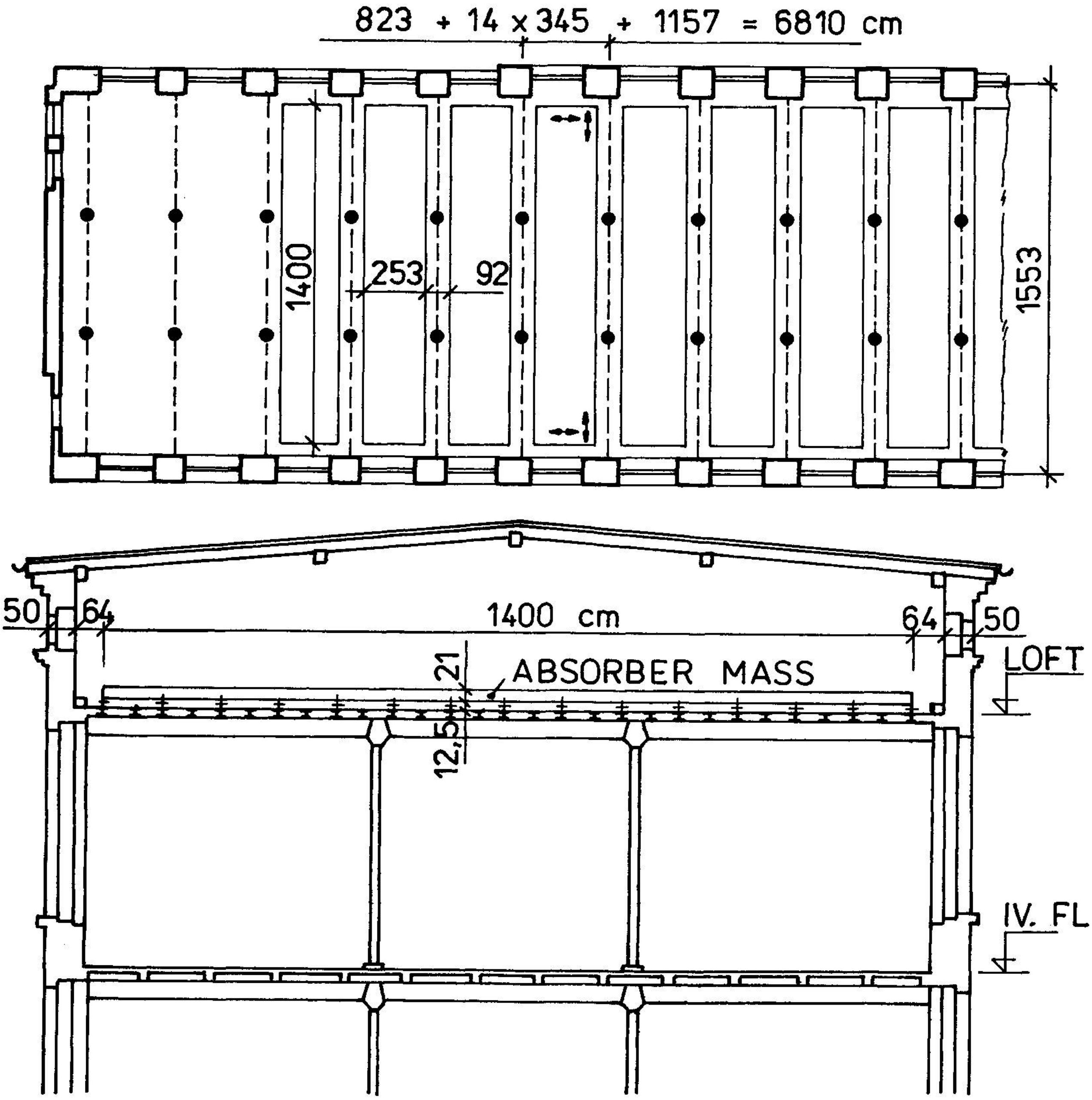


Fig. 1 Cross section and ground plan of the building

The methods of limitation of horizontal movements of tall buildings with very low natural frequencies (less than 1 cps) using big masses moved by hydraulic jacks are well known [1]. Here we present a more simple example of limitation of horizontal vibrations of one old textile factory building by means of the passive tuned mass damper, i.e. by a system of additional masses supported by rubber elements.

2 The behaviour of the building

The factory building under consideration is cca 100 years old, its groundplan and cross section are given on the Fig. 1. The building has 4 floors of reinforced concrete slabs (made later, in substitution of the original wooden ceilings), supported by two rows of cast iron columns. The outer walls are from bricks. On each floor there were 80 looms the operation of which excited the building in Y (longitudinal) direction, the frequency was 2.60 cps. The measured horizontal amplitude of the 4th (highest) floor was 0.3 mm, the natural frequency of the fundamental mode (Fig. 2) was 2.50 cps, the logarithmic decrement $\delta = 0.09$. The measured values of the displacement, velocity and acceleration are signed as point "12" in Fig. 3: the two boundaries depict the admissible limit values for brainworkers and for other workers after [2].

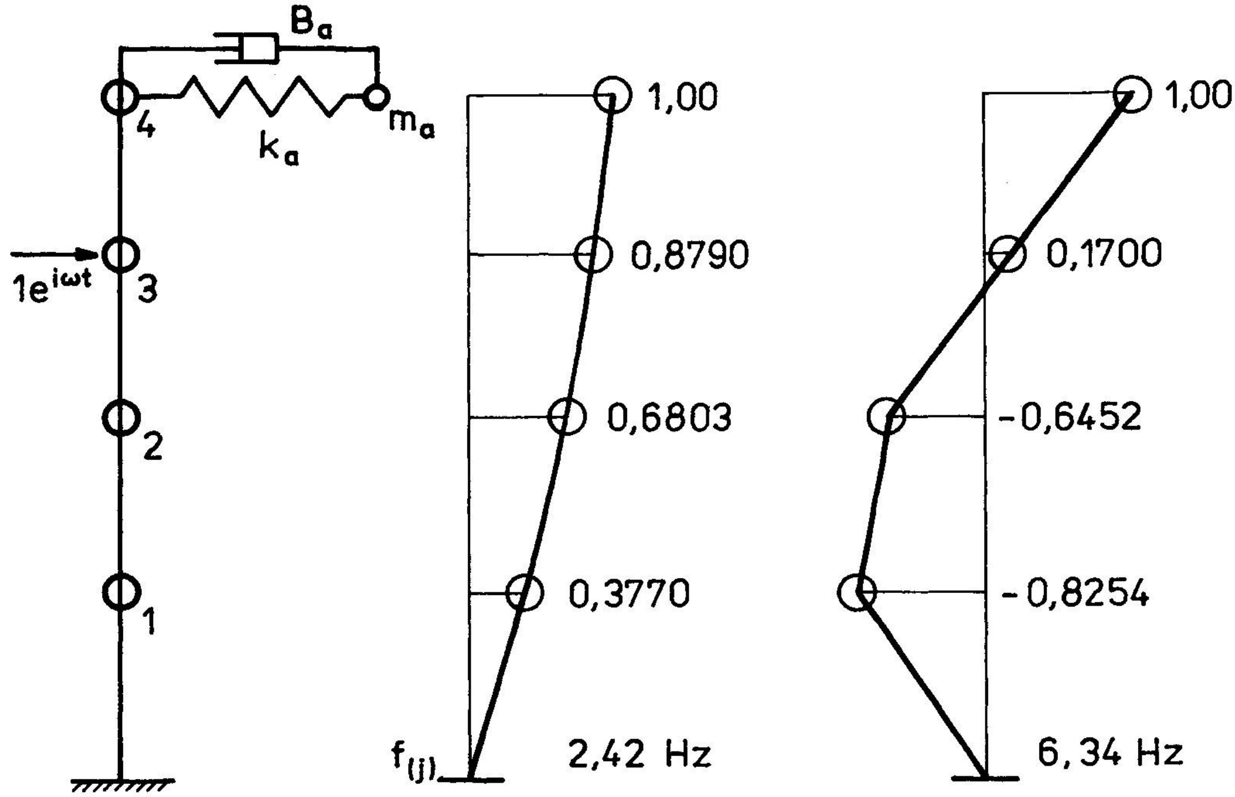


Fig. 2 Mechanical scheme of the structure and the calculated natural modes

The biggest measured value of the velocity of the response does not differ much from 5 mm/s, which is the limit (after [4]) for the appearence of the first damages of the structure. In spite of these large amplitudes and of the long duration of the vibrations the building was not cracked. Newertheless the walking on the 4th floor was difficult and that is why the possibilities of reducing the vibrations were seeked.

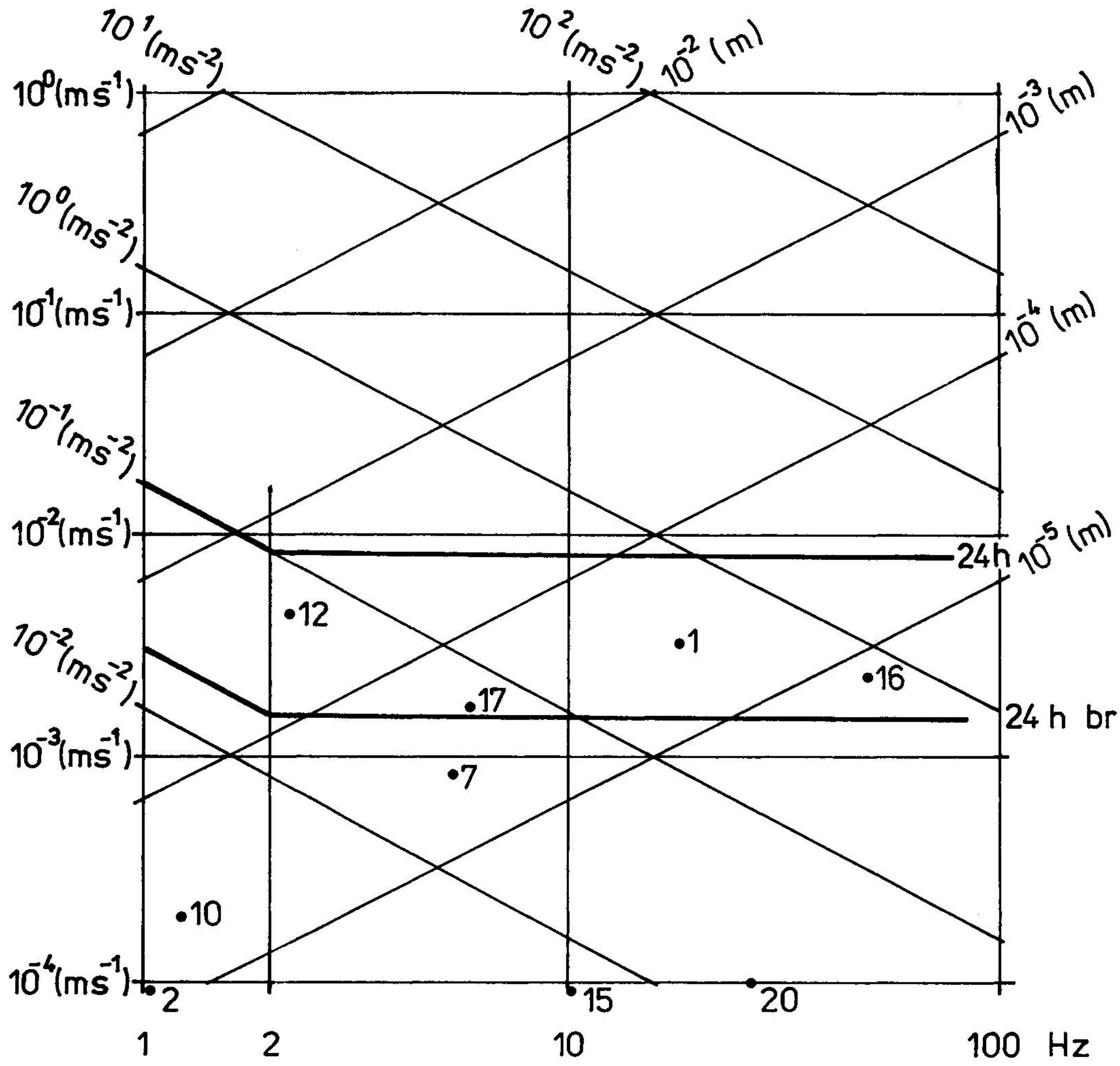
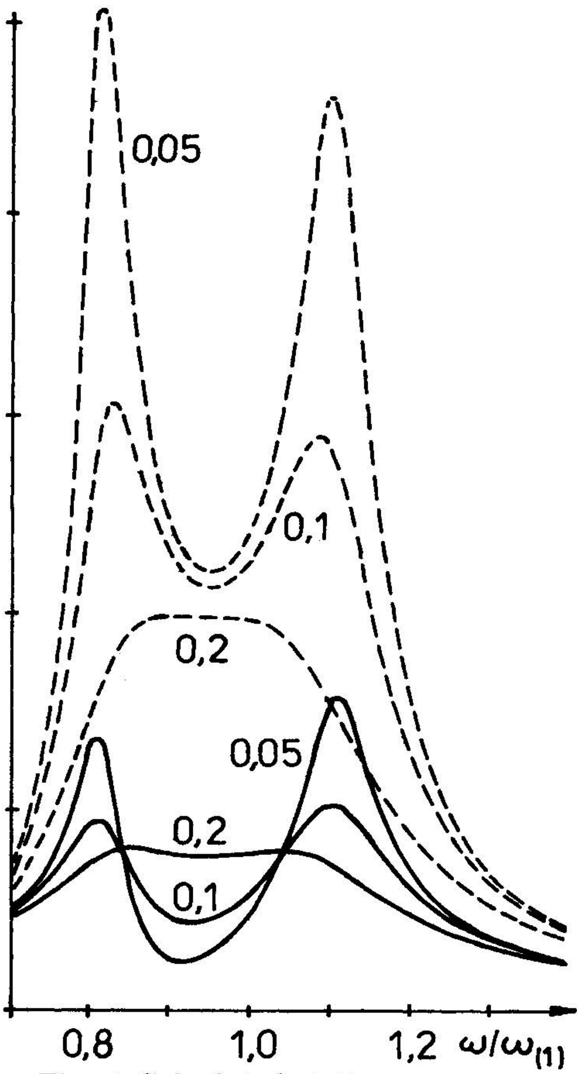


Fig. 3 Graphic representation of horizontal vibrations measured on some buildings. The solid line "24 h" shows the admissible limit for 24 hours of exposure, the line "24 h br" the same limit for brainworking personnel [2].

1 - Brick building, excited by tram
2 - Brick building, excited by road traffic
7 - Brick family house, excited by the operation of a saw mill (5 cps)
10 - Mining tower in normal operation
12 - Factory building described in this paper
15 - Concrete building, excited by street traffic
16 - Concrete building, excited by the operation of a piston compressor
17 - steel building, excited by the normal movement in the building

3 Remedy



After experiences with successful applications of pendulum absorbers on television towers and guyed masts [5] the authors designed a dynamic vibration absorber also for this case. The absorber should be installed on the loft of the building. It should consist of 14 horizontal slabs - steel basins 14.0 x 2.53 x 0.21 m filled with sand and covered by concrete shell. Each of these masses (14.30 t) was placed on 30 rubber bearings - cylinders of 100 mm dia and 65 mm heigt; the masses coud move horizontally while the rubber worked in shear. The system was modelled for the calculation as a shear-type building with 4 lumped masses; the 5th mass, that of the absorber, was attached to the 4th mass representing the ceiling of the highest floor and the roof (see Fig. 2). The attachment of the absorber has been modelled by a spring and damper according to the properties of the rubber elements, given by the producer. The system was calculated for harmonic excitation $F(t) = F_o \exp(i\omega t)$ acting on the mass m_3 (the floor of the workshop with the looms). From the shape of the resonance-curves (stationary amplitude of the response of the mass m_3 plotted against the frequency of the excitation ω - example see Fig. 4) the optimum type of the rubber bearing could be chosen. The construction of rubber supports of the absorber masses is shown on Fig. 5

Fig. 4 Calculated stationary response of the building with the absorber (solid line) and relative amplitude of the absorber mass (dashed line) for different damping β in the supports.

4 Conclusion

The author regret that the design of the described dynamic absorber could not be realised in spite of its simplicity and theoretical clearness. The meticulous apprehension of the management of the factory to invest a modest amount of money to a non typical device has caused the suspension of the project and the building was let to continue the vibration.

The arrangement and the construction of the absorber was mostly designed by Mr Zdeněk Patrman, whose helpful cooperation is gratefully acknowledged.

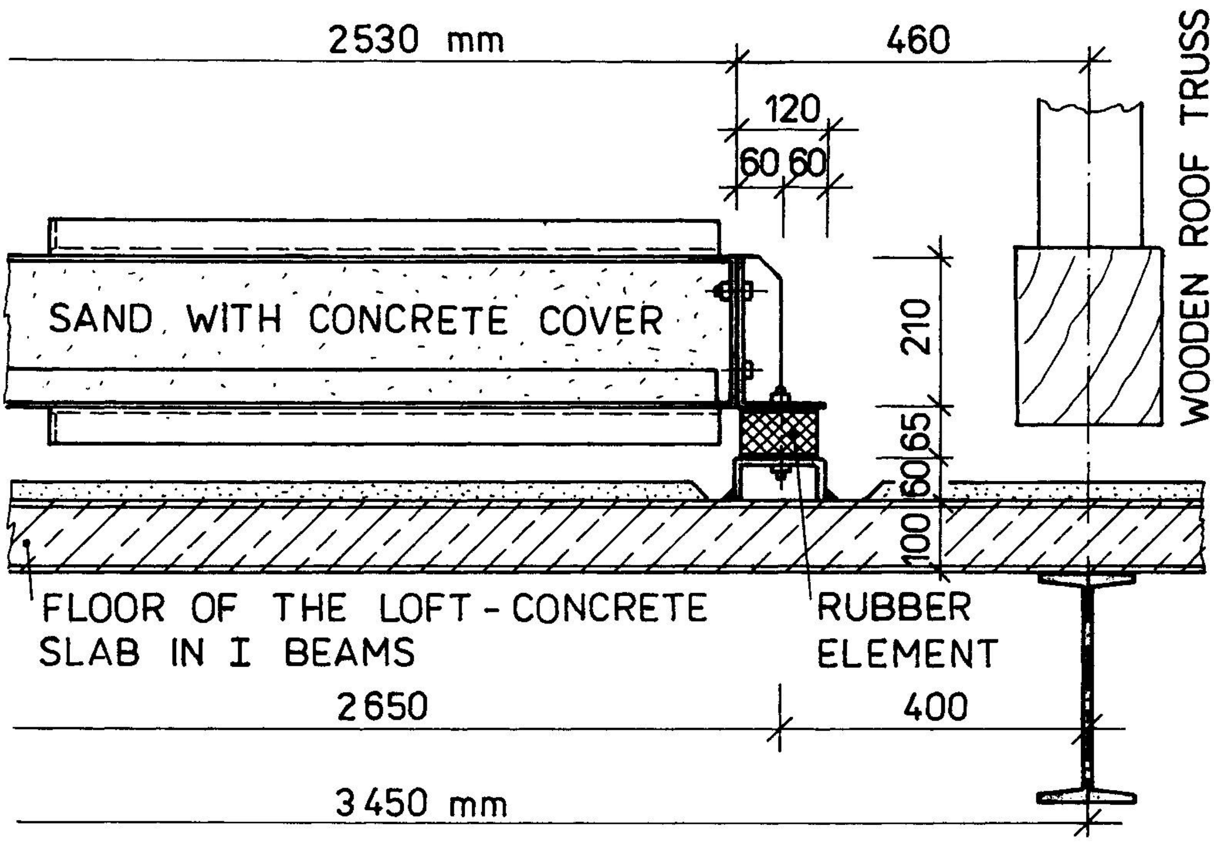


Fig. 5 Detail of one of the 30 rubber supports of one absorber mass

5 References

[1] Mc Namara R.: Tuned mass damper for buildings. Jour. struct. div., vol. 103, No St 9, p. 1785

[2] Hygienic codes of Ministry of Health CSR vol. 37, No 41 (in Czech)

[3] CSN 011405 Vibrations - permissible values and general requirements for measurement procedures in comunal environments. UNM Praha 1987 (in Czech)

[4] CSN 730036 Seismic loads of buildings. UNM Praha 1973 (in Czech)

[5] Koloušek V. et al.: Wind effects on civil engineering structures. Elsevier, Amsterdam 1983