UNIVERSITY OF WEST BOHEMIA

Applied and Computational Mechanics 1 (2007) 307 - 312

Applied and Computational Mechanics

Uncertainty and reserves in determination of dynamic machine loads acting on supporting structures

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Received 5 September 2007; received in revised form 5 October 2007

Abstract

The reliability of dynamic loads for supporting structures. Machinery producers reserves´ and estimates of the loads determination. Reliability probabilistic indexing. Materials and loads characteristics and uncertainty of their determination. Structure dynamic loads according to ČSN EN 1991-3 Action on structures – Part 3 Action induced by cranes and machinery. On the example of machine for concrete paver production, the design characteristics are analysed and then verified with experiment.

Keywords: dynamic loads probability, structural resistance and safety, characteristic and design values

1. Introduction

The Czech Standard [3] establishes principles and requirements for safety, serviceability and durability of structures, describes the basis for their design and verification and gives guidelines for greater aspects of structural reliability. ČSN EN 1991-3 Action On Structures – Part 3 Action induced by cranes and machinery defined principles for the machine foundation design [4]. A complete survey of static and dynamic forces for various design situations should be obtained from the machine manufacturer together with all other machine data such as outline drawings, weights of static and moving parts, speeds, balancing etc.

2. Managing the reliability of a structure

2.1. Loads acquirement for foundation design according to [4]

The following data should be obtained from the machine manufacturer

- loading diagram of the machine showing the location, magnitude and direction od all loads including dynamic loads
- speed of machine
- critical speeds of the machine
- outline dimensions of the foundation
- mass moment of inertia of the machine components
- details of iserts and embedments
- layout of piping, duction etc, and their supportig detail
- temperatures in various zones during operation
- allowable displacements at the machine bearing points during normal operation

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2.2. The foundation design principles

The foundation shall be designed and executed in such a way that it will, during its intended life with appropriate degrees of reliability, and economically sustain all actions likely to occur during execution and use. The structure remains fit for use for which it is required.

The choice of reliability level for a particular structure should take into account all relevant factors.

The foundation design is provided in two limit states

- Ultimate limit-state – the safety of the structure
- Serviceability limit-state – structure functioning under normal use, comfort of people

2.3. The investigated structures

The supporting structure for concrete paver producing machine is usually designed as elastic supporting rigid concrete block as shown in [1] or [2]. Elastic support elements are made of BALAR – elastic mats or from cork mats. This elastic layer is between rigid block and production hall plate foundation. In one case, the rigid block is founded on the bore piles and between plate foundation and rigid block there is a free joint. The dynamic loads are caused by machines CPM50 and HESS1500-2. Excitation frequency is from 33 Hz to 50 Hz and excitation forces act in vertical direction.

The typical data input for foundation design is in fig.1. *(Compare with 2.1.)*

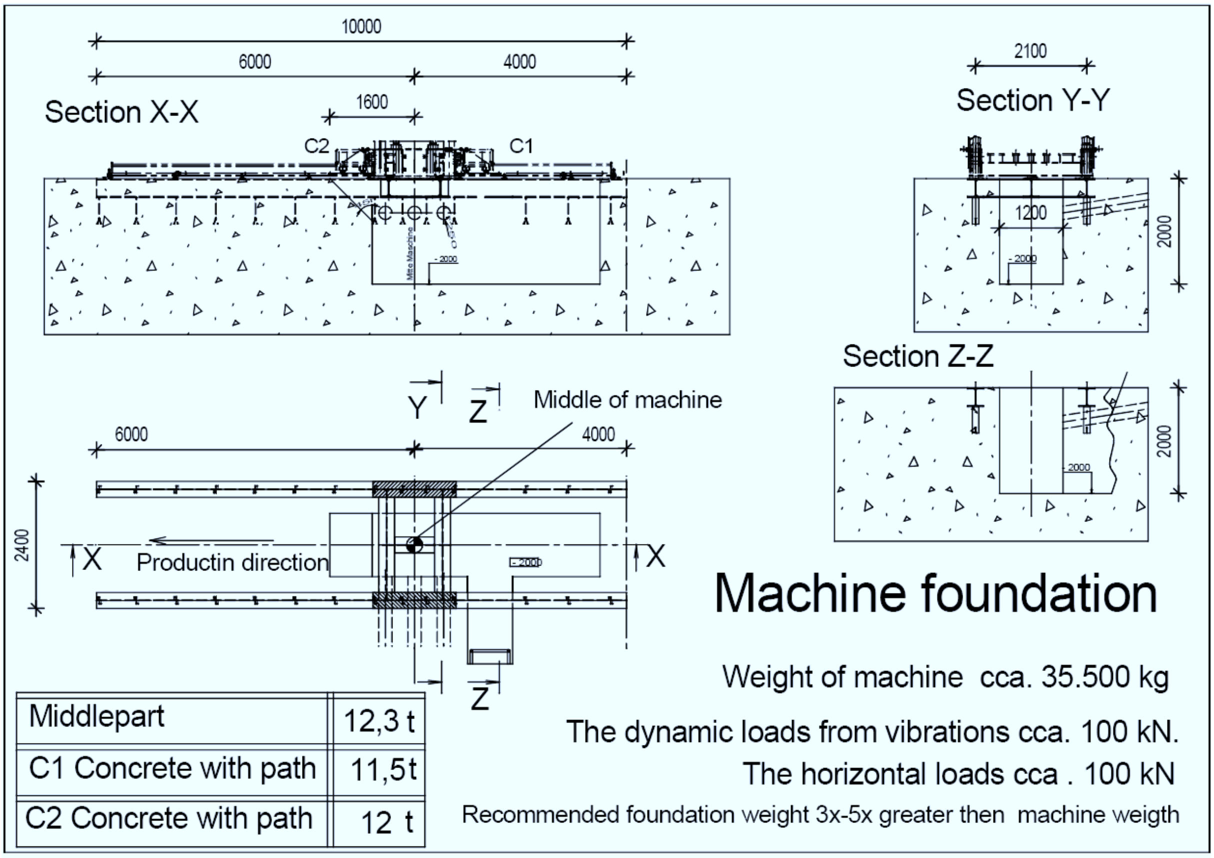

Fig. 1. Typical input data.

3. The reliability of dynamic loads for supporting structures

The structure resistance is defined by characteristic and design value of material properties, structure dimensions and its stiffness [5].

Relationship between structure resistance (R) and machine actions (E) is shown in fig.2.

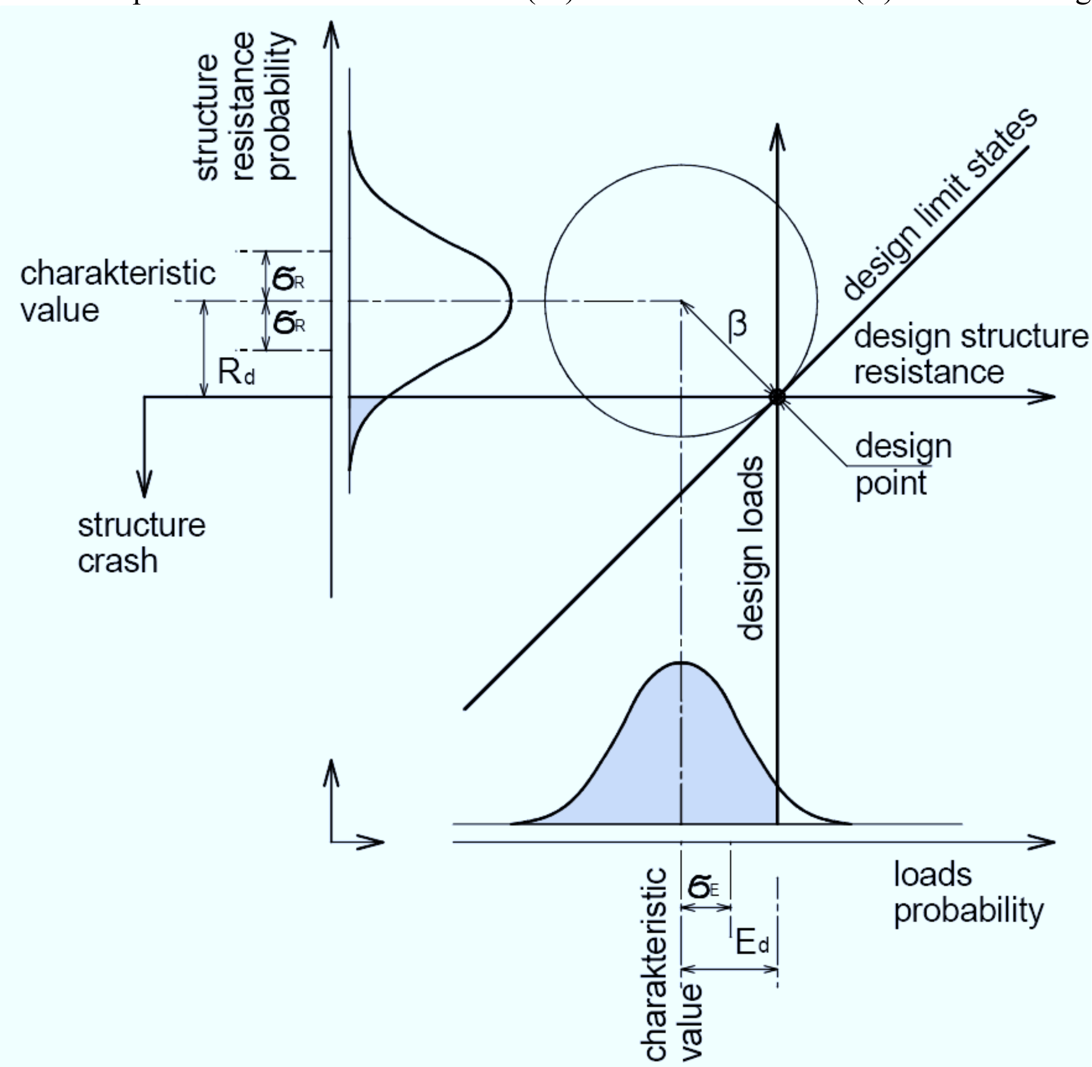

Fig. 2. Design reliability.

In the design principles as shown in fig.2, we design structures on the design loads. These loads are factored characteristic values, which can be defined as

$$E_d = E_k \cdot \gamma_E \quad . \tag{1}$$

Characteristic value is a principal one with fixed probability of being exceeded during a reference period. On the other side of equation there is design structure resistance. This is the structure characteristic with fixed probability of the real structure resistance being greater and safer. Typical data input for foundation (fig.2) gives no space for enough reliability level of the supporting structure. With the input data inaccuracy, the structure robustness increases. Design results are uneconomical and with low reliability in dynamic processes in addition - fig.3.

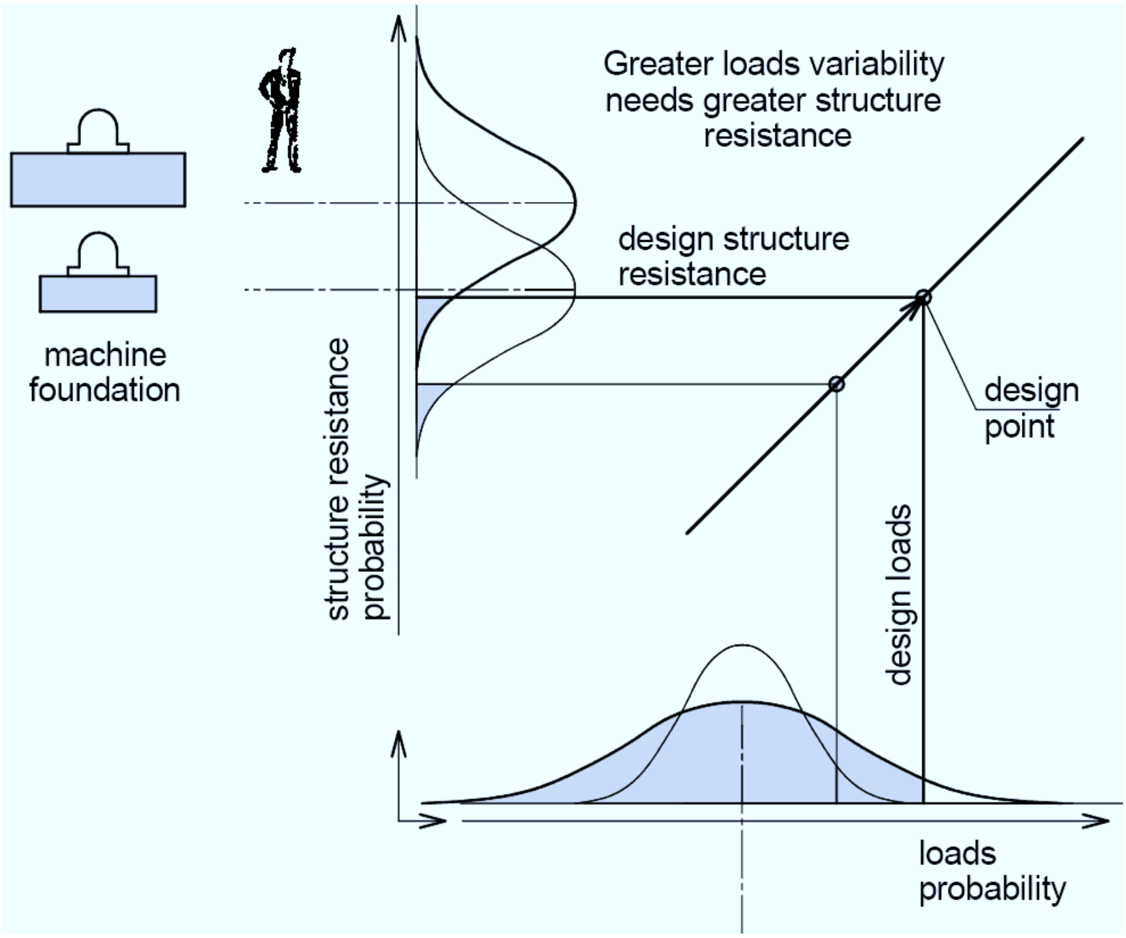

Fig. 3. Design reliability.

4. Measurement of supporting structure

The lowest dynamic transmission between the foundation and other hall structures was found in case of concrete block foundation with piles. At the same time this solution is the most expensive one. The worst resolution was in case of concrete block foundation in cork bed.

The real machine accelerations are shown in the fig. 4. Dominant excitation frequency is 33 Hz, by the production process, there are originated many horizontal and vertical impulses. These impulses are measured mostly at the oldest machine.

5. Conclusion

The machines are designed in detail. All supporting structure design needful forces are surely known but not for the civil engineers in contradiction with the European standards. This leads to uneconomical supporting structures with low level of reliability.

Acknowledgements

This research was supported as a part of GA projects No. 103/06/1521 for which the authors would like to thank the Grant Agency of the Czech Republic.

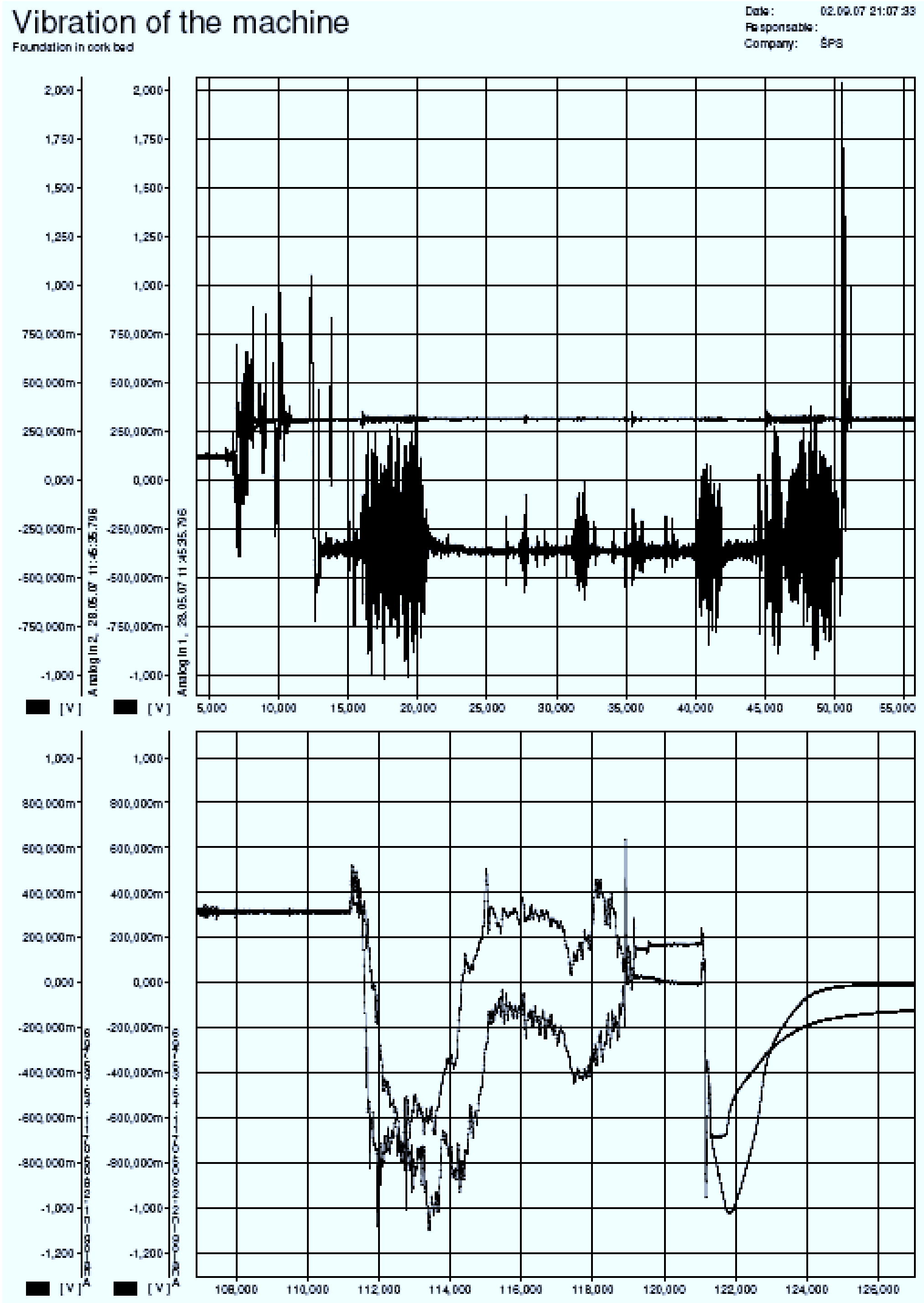

Fig. 4. Vibration of the machine.

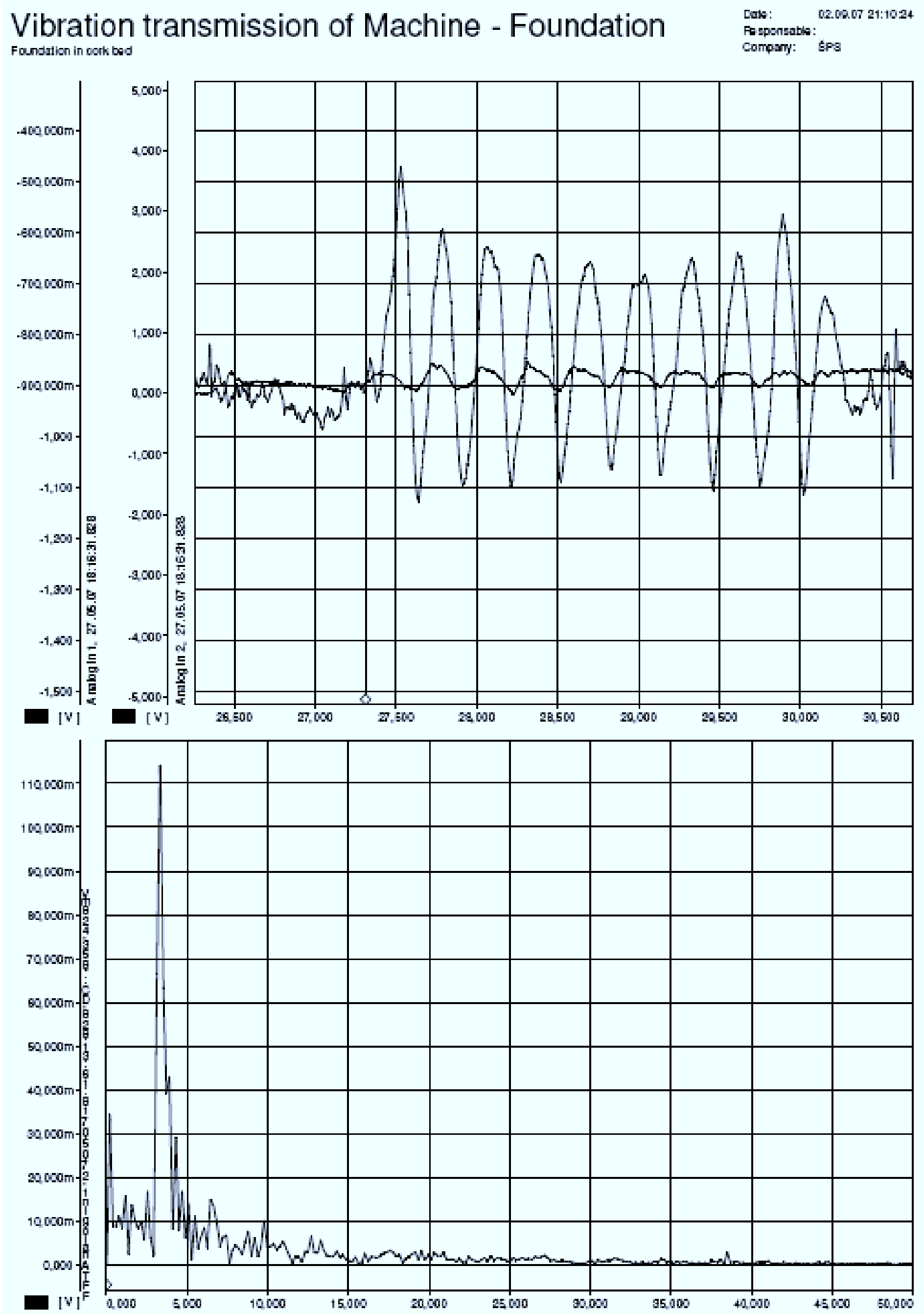

Fig. 5. Vibrations transmission between machine and foundation.

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