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EXPERIENCES WITH AN SEA SOFTWARE TOOL FOR RESPONSE AND SENSITIVITY CALCULATION

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1. INTRODUCTION

The term "statistical energy analysis" (SEA) was originally established in the early sixties to describe a specific approach to problems of noise and vibration transfer. Nowadays when "SEA" is mentioned, also a special calculation method that uses the SEA approach is meant. This method predicts the response of a structure to random vibration excitation. The structure is divided into subsystems that correlate to resonant mode groupings, for example longitudinal, transverse, torsional or bending waves in a plate or a beam which is part of the structure. Taking the injected power, the power exchanged between the subsystems and the power loss due to damping of the subsystems, quantities of vibrational energy stored in the subsystems are calculated using a power balance. In order to perform such a calculation, one needs to know the damping loss factors (DLF) of the subsystems and the coupling loss factors (CLF), which describe the power exchange between the subsystems. These quantities may either be deducted by measurements or be estimated from material and geometric parameters by calculation.

The calculation method SEA is underlying some assumptions that do not hold for most arrangements of subsystems. Disregarding that fact SEA results are frequently reported to be in good correlation with experimental estimations of the response. In most cases DLFs and CLFs come from measurements carried out on separated parts of the structure or in situ. This is impossible, if one wants to predict the performance of a hypothetical or non-existent structure. Very small (non-confidential) literature can be found about the reliability of SEA calculations with CLFs estimated by calculation. This was the reason to start a survey in which some structures known from the literature were modelled using only that information which would be available without any measurements on the structure.

2. SOFTWARE

SEATS, an SEA software tool written by the author, was used in all calculations. The main features of this PC-running software are the calculation of CLFs from structure parameters as well as the estimation of response and also its sensitivity to all the loss factors. A structure to be calculated may be broken into beams, plates and rooms, which may carry longitudinal, bending and torsional or transverse waves, if applicable. The CLFs may be calculated for different types of beam-plate connections, for generic beam-beam and plate-(beam)-plate connections, each including n members with any desired connecting angle and joint stiffness, and for plate-room and room-plate-room connections.

3. RESULTS

The survey has covered up to date 6 different structures. In this paper the results from the modelling of two of these will be presented as examples. The first one is a relatively simple structure (three wood-fibre boards of different size and thickness, see Fig. 1) [1] modelled with 9 subsystems. First the structure was modelled using material parameters from tables as if there were no measured data available (Fig. 1), then a second model was built up with measured frequency-dependent material and damping data from [1]. In Fig. 1 the results from these two models are compared with the measured energy level difference from [1]. Although its input data is small and not very precise, the first model gives a good estimation of energy level difference; the result from the second model is not much better.

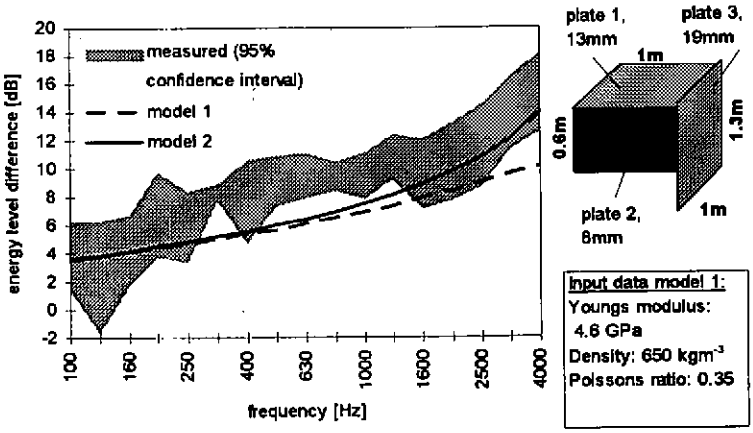

Fig. 1 Structure 1 (3 wood-fibre boards): measured and calculated energy level difference from plate 1 to plate 3 when plate 1 is exited

It seems if one should be able to compute the behaviour of such a simple structure with good success. But what if the structure is more complicated and has more subsystems? This is illustrated in the second example, in which a part (four storeys) of a building-block constructed building made of heavy concrete is considered [2]. Again the structure was modelled using data (see Fig. 2) available from tables. In the model 86 plates (including those from neighbour parts of the building) and 4 rooms were used; therefore a total of 262 subsystems was included. The results for the energy level difference with this large model are about 5 dB less than those measured [2] (Fig. 2). The second, improved model considers measured [2] rotational stiffness on the plate joints for CLF calculation. Its results agree remarkably good with the measured energy level difference.

The calculation of sensitivity [3] enables easy access to those parameters which have a strong influence to the response and is for this reason sometimes more useful than response calculation, tough it seems to be not very common. One may guess that calculated values for sensitivity depends not so strongly on the precision of input data as response does. Unfortunately, some experiments with the two models of the building structure have shown that this is not true (Fig. 3).

Four more structures were modelled and calculated, three of them having also beam members. In only one case there was no satisfying agreement between the results calculated and those in the literature.

4. CONCLUSIONS

As a result of the survey that covered 6 structures, some general conclusions may be drawn:

- If an SEA software tool is available, which is capable of calculating coupling loss factors from geometric and material parameters, it is nearly always possible to build a model of a structure, which gives a quite good prediction of its response.
- This requires a detailed examination of the structure to find a practicable way to divide it into subsystems and to detect the right types of CLFs to be used (which type algorithm for calculation).
- The geometric and material parameters to be used should be of good precision to yield a good agreement between the true and the predicted response. In most cases such precision is only possible when using measurements.

The reliability of SEA-based calculation of response therefore depends on some prerequisites that are often not easy to meet in practice. Without any measurements at all only assessments are possible; anyway, the benefit is limited in such cases.

Although this fact may be not surprising for those who familiar with SEA techniques, it is emphasised here as an argument in future discussions about the reliability and usefulness of SEA calculation technique, especially in the early design stage.

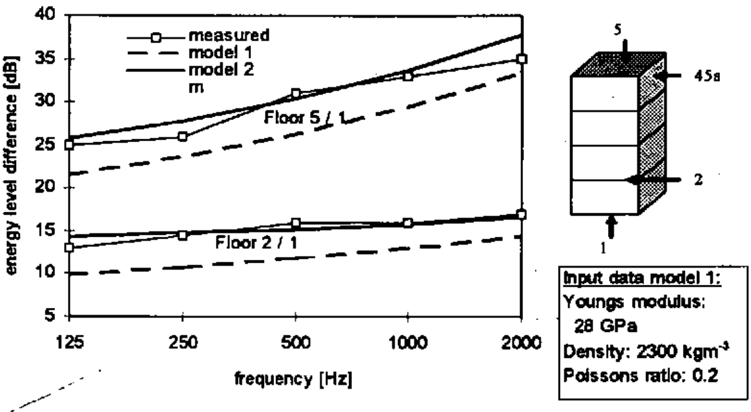

Fig. 2 Structure 2 (concrete building): measured and calculated energy level difference between floors when floor 1 is exited

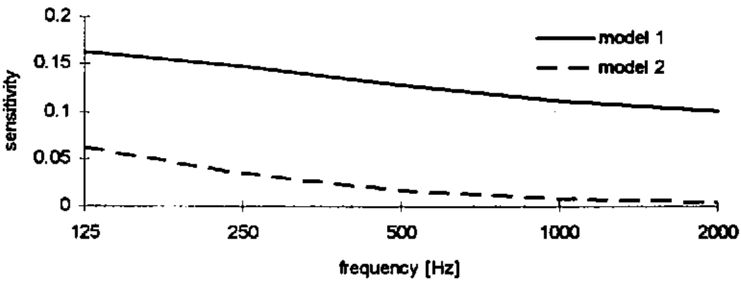

Fig. 3 Structure 2 (see Fig. 2) sensitivity example: Sensitivity of energy level on floor 5 to changes of the coupling loss factor from wall 45s bending waves to floor 5 bending waves

References

[1] M.-F. Petit, Anwendung der Statistischen Energieanalyse zur Be stimmung von Kopplungsverlustfaktoren einzelner Bauteile im eingebauten Zustand, (Dipl.-Ing. Thesis, TU Berlin 1990)

[2] W.Wöhle, B.Marx, ACUSTICA 73, 258 (1990)

[3] E. Sarradj, DAGA (1996, to be published)