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# EVALUATION OF AIR-BORNE AND STRUCTURE-BORNE SOUND TRANSMISSION IN BUILDINGS USING STATISTICAL ENERGY ANALYSIS; AN OVERVIEW

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## ABSTRACT
Sound transmission through buildings is becoming an important area of research, because of different materials of construction used and other aspects influencing the construction environment. Prediction techniques used for modeling such studies include Statistical Energy Analysis (SEA), Structural fuzzy concept, finite element techniques wherever feasible. Some important studies are highlighted in this paper and conclusions are drawn.

## 1 - INTRODUCTION
Statistical Energy Analysis is one of the approaches of solving complex problem associated with sound transmission through buildings. The study of transmission through building structures has become important in view of different types of building materials used in construction. Theoretical evaluation can be dealt with Statistical Energy Analysis (SEA) and of late with other techniques like Structural fuzzy and Finite element methods. Some important work on structural fuzzy aspects with SEA are outlined as follows:

## 2 - REVIEW OF LITERATURE
Lyon [1] studied the effects of a minor or a secondary substructure on the dynamics of a primary structure. Soize [2,3] presented a theoretical approach for the power flow techniques. He identified each term by using a global SEA equation for the fuzzy substructures. Modal analysis has been used to describe the coupled mechanical systems. Stationary response of the coupled system is constructed and explicit expressions for the unique invariant are given. The energy parameters of the acoustic cavity and the non term structure were introduced for evaluating the statistical mean values and dispersion values.
Whole et al [4] has investigated the coupling losses for a rectangular slab junction for incident, bending, longitudinal and transverse waves. Springs existing at the coupling points as well as potential losses were taken into consideration.
Guyader et al [5] has proposed a formulation for sound transmission by coupled structures with special attention to flanking transmission. His method treated each type of coupling specifically mechanical/mechanical and mechanical/acoustical coupling. The latter method was considered to be very weak because the hypothesis was admissible where air was the acoustic fluid medium.
Steel [6] has investigated structure borne sound transmission by Finite element technique. A finite element model was used as in a SEA model technique. It was seen that the semi-empirical relationships developed previously was in agreement with the numerical results of the finite element model.
Magrans [7] has evaluated the energy transmission paths from source to receiver. His study highlighted the possible transmission paths in a building.
Experimental investigations using SEA for the prediction of loss factors have been conducted and are outlined as follows:
Hopkins [8] has done laboratory measurements on free standing full size masonry wall elements connected at rigid junctions. These measurements were used for assessing the vibration reduction index ($K_{ij}$) of masonry wall elements.

Sean Smith [9] has conducted experiments using SEA to model different laboratory conditions. A significant difference of the order of 12 dB was found. This difference was for a double leaf plaster board light weight wall. It was concluded that the principle factor which affected the results of this Inter-Laboratory tests for the double wall was the lining material used in different laboratories.
Sean Smith [10] has predicted the sound transmission through a wall of perforated bricks using SEA. Special attention was given to the effect on sound transmission due to additional plaster board layers. SEA was identified as an approximate prediction technique where the wall was modelled as a single subsystem.
Schmitz. et al [11] has conducted experiments to determine the variance of sound transmission measurements in test facilities for heavy walls. An Inter laboratory test (ILT's) was performed in twelve different institutes. This ILT study included the measurement of sound reduction index, velocity levels and damping. The principle conclusions are that (a) Damping in terms of the elements loss factors. (b) Sound insulation could be converted with the measured damping to a reference loss factor. (c) Heavy elements could be mounted with an elastic connection to reduce laboratory influence.
Vermeir [12] has studied the influences of elastic layers (EL's) at junctions between walk and floor slabs on air borne and structure $-$ borne sound transmission in buildings. measurements were made on scale models with EL's at joints, the results were compared with the predictions of the statistical energy analysis model.
Gerretsen [13] provided an overview of prediction models in building acoustics where they have compared the SEA with CEN codes like EN12354 $-$ 1,2. For these models a reliable input data is required. Measurements to determine the junction characteristics such as vibration index, flanking loss are required. This study has to be extended to light weight and non monolithic type of constructions.

## 3 - CONCLUSION

It is observed that a reasonably good quantum of work has been done on theoretical modeling studies through Statistical Energy Analysis, Finite Element Methods and also combined techniques. Experimentally evaluated loss factors have been used in Statistical Energy Analysis (SEA) technique for determination of sound reduction index both for air and structure borne sound. Subsequently it can be stated that the following areas need attention:

- Different types of construction using light weight materials could be investigated for their accuracy and behaviour.
- Theoretical predictions involving Statistical Energy Analysis and Finite Element Techniques have so for been applied. Other hybrid techniques such as Structural Fuzzy or FEM could be developed to predict the sound transmission in buildings.
- Comparison of the results of various models (CEN model, SEA model and FEM model) by considering all wave types and multiple subsystems could be done.
- Improvement of the structure/model with linings need to the investigated both theoretically and experimentally.

## REFERENCES

1. **R.H.Lyon**, Statistical energy analysis and structural fuzzy, *Journal of Acoustical Society of America*, Vol. 97(5), pp. 2878-2881, 1995
2. **C.Soize**, Coupling between an undamped linear acoustic fluid and a damped nonlinear structure-Statistical energy analysis consideration, *Journal of Acoustical Society of America*, Vol. 98(1), pp. 373-385, 1995
3. **C.Soize**, Estimation of the fuzzy substructure model parameters using the mean power flow equation of the fuzzy structure, *Journal of Vibration and Acoustics*, Vol. 120, pp. 279-286, 1998
4. **W.Wohle and al.**, Coupling loss factors for statistical energy analysis of rectangular structural slab joints-part1&2, *Journal of Sound and Vibration*, Vol. 77(3), pp. 323-344, 1981
5. **J.L.Guyader and al.**, Energy transmission in finite coupled plates, *Journal of Sound and Vibration*, Vol. 81(1), pp. 81-92, 1982

6. **J.A.Steel and R.J.M.Craik**, Statistical energy analysis of structure borne sound transmission using finite element method, *Journal of Sound and Vibration*, Vol. 178(4), pp. 553-561, 1993

7. **F.X.Magrans**, Methods of measuring transmission paths, *Journal of Sound and Vibration*, Vol. 74(3), pp. 321-330, 1991

8. **C.P.Hopkins**, Measurement of the vibration reduction index, Kij on the free standing masonry wall construction, *Building Acoustics*, Vol. 6(3/4), pp. 235-257, 1999

9. **Sean Smith and al.**, An investigation into the reproducibility values of the European inter laboratory tests for light weight walls, *Building Acoustics*, Vol. 6(3/4), pp. 187-209, 1999

10. **Sean Smith and M.Fringuellino**, Sound transmission through hollow brick walls, *Building Acoustics*, Vol. 6(3/4), pp. 211-224, 1999

11. **Schmitz and al.**, Inter laboratory tests of sound insulation on heavy walls: part1&2, *Building Acoustics* , Vol. 6(3/4), pp. 159-186, 1999

12. **G.Vermeir and A.Osipov**, Sound transmission in buildings with elastic layers at joints, *Applied Acoustics*, Vol. 49(2), pp. 141-162, 1996

13. **E.Gerretsen and T.R.T.Nightingale**, Prediction models in building acoustics, *Building Acoustics*, Vol. 6(3/4), pp. 151-158, 1999