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REDUCED ORDER MODELLING OF VIBRATIONS IN WOODEN MULTI-STOREY BUILDINGS

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To construct wooden buildings of high performance regarding vibrations and structure-borne sound, it is desirable to have tools for predicting the effects of structural modifications prior to construction as testing prototypes and performing experiments is time-consuming and expensive. The long-term aim is therefore to develop prediction tools, making use of finite element (FE) models that are valid for general load-cases.

Accurately assessing the dynamic behaviour of multi-storey lightweight buildings, even at lower frequencies, requires FE models representing the geometry in considerable detail, resulting in the models being very large. The number of degrees of freedom (dofs) of such models easily exceeds the limits of computer capacity, at least for computations to be performed within reasonable lengths of time. The question arises then of how such FE models can be reduced in size while at the same time being able to represent the dynamic characteristics of the buildings in question with sufficient accuracy. A common way of creating reduced order models is by adopting a substructure approach, in which the FE model of the full geometry is divided into substructures, these being reduced in size by employing model order reduction of some sort and coupled to form a reduced global model. This project aims at establishing a framework for reducing FE models of wooden multi-storey buildings, employing substructure modelling, to create computationally efficient models.

Wooden multi-storey buildings are often constructed using prefabricated planar or volumistic elements, these offering a natural division of the buildings into substructures. The prefabricated elements are often separated by elastomer layers to reduce the vibration transmission in the buildings. The elastomer materials possess frequency-dependent properties while the substructures should contain only frequency-independent finite elements in order to be computationally efficient. The elastomers can, by this means, be excluded from the substructures and instead by regarded as coupling elements in the assemblage of substructures.

The computational efficiency of the substructures is affected by the choice of method for model order reduction. Moreover, the efficiency is affected, to a great extent, by the size of the interfaces connecting the substructures to each other. Large interfaces destroy the efficiency of the reduced models, why it can be necessary to employ interface reduction of some sort before the model order reduction is carried out. Different methods for interface reduction and model order reduction, respectively, were compared for wooden building structures in order to create reduced models as efficient as possible.

In a methodology commonly adopted for interface reduction, an additional node, referred to as a condensation node, is introduced to act as the interface to other substructures. The condensation node has both translational and rotational dofs and is coupled to the nodes of the interface surface. The coupling between a condensation node and the interface surface can be realised in different ways, a rigid body constraint for the interface surface being the most common option. Alternatively, the forces and moments acting on the condensation node can be distributed to the nodes of the interface surface by certain weight factors. For the interfaces between wood components and elastomer layers, it was found that distributed coupling is preferable for the interfaces of the wood components while rigid coupling is more accurate for the interfaces of the elastomers.

Many methods for model order reduction are available in the literature, describing different ways of establishing reduced systems by Ritz procedures [1]. Various methods involving eigenmodes of the full model have been proposed, component mode synthesis (CMS) by Craig & Bampton [2] being the most frequently employed method among structural engineers. Methods originating from control theory, based on purely mathematical considerations, have been increasing in popularity in recent years, Krylov methods [3] being the predominant ones. It was concluded in the comparative studies that CMS and Krylov methods offer comparable accuracy when employed in substructure modelling of such structures.

The conclusions drawn in the comparative studies will be used to establish the framework for creating the reduced models. The framework will be integrated with commerical FE software to offer a way of arriving at reduced models ready for analyses, starting from full FE models created in such software.

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