Structural effects of an impact on a reinforced concrete large structure

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The purpose of this talk consists in the research of new ways for calculating the induced vibrations in reinforced concrete structures submitted to commercial aircraft impact. The cutoff frequency for this type of loading is typically within the 40 to 100 Hz range, which would be referred to as the medium frequency range [HER05]. The determination of the shaking induced by an aircraft impact on an industrial structure requires dynamic studies. The response, especially during the transient stage, by using classical finite element method associated with explicit numerical schemes requires calculations with an important calculation time. Also this kind of calculation requires several load cases to be analyzed to consider a wide range of scenarios. By the way, the medium frequency has to be appropriately considered therefore the mesh has to be very refined and consequently, a refined time discretization.The linear behavior is not questioned outside the impact area, however, the non-linearity of the portion of the impacted structure can have a significant influence. A new multiscale computational strategy, the Variational Theory of Complex Rays [LAD01], is developed for the analysis of the vibration of structures in the medium frequency regime. Using two-scale shape functions that verify the dynamic equation and the constitutive relation within each substructure, the VTCR can be viewed as a mean of expressing the power balance at the different interfaces between substructures in variational form. The solution is searched as a combination of propagative and evanescent waves (as exposed for example in Figure 1).

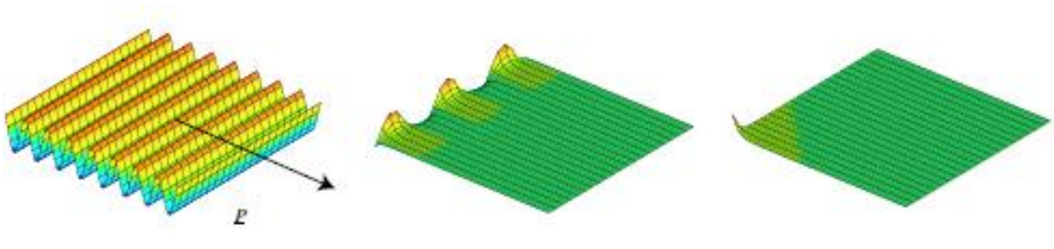

Figure 1. Shape functions considered in VTCR

Only the amplitude of these waves, which are slowly varying quantities of the solution, is discretized (following on the figure 2). This leads to a numerical model with few degrees of freedom in comparison with a Finite Element model.

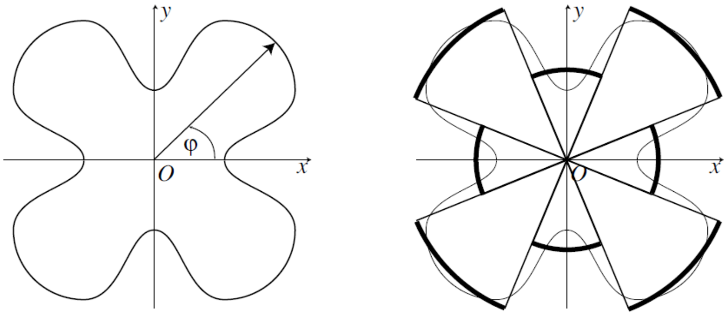

Figure 2. Discretized amplitude of the shape functions

The method summarized in figure 3 consists in an initial decomposition FFT (Fast Fourier Transform) of the signal loading. The VTCR ensures the transfer of the decomposed signal into the structure. The obtained signals are then processed by inverse FFT (IFFT) to reconstruct a time signal and a response spectrum [CHE05]. The aim is to develop a robust method to get mid-frequency spectra generated by an aircraft impact on a simplified structure [ROU15].

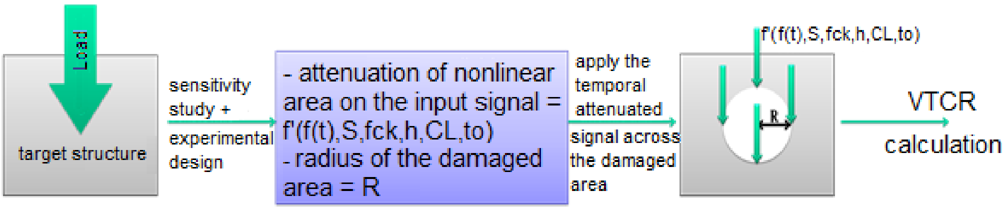

Figure 3. Global calculation strategy

Conclusions

This methodology provides three interests for the calculation of the induced vibration:

- Modeling a large FE Model is not necessary,
- The total frequency content is well considered without the need of a rich discretization,
- The calculation cost is less important as for FE calculation.

A set of examples will be provided in comparison with FE calculations regarding the behavior of a representative structure submitted to a time history loading. An attention is paid to the important gain of calculation time provided.

References

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