

Systematic modelling of wind turbine dynamics and earthquake loads on wind turbines

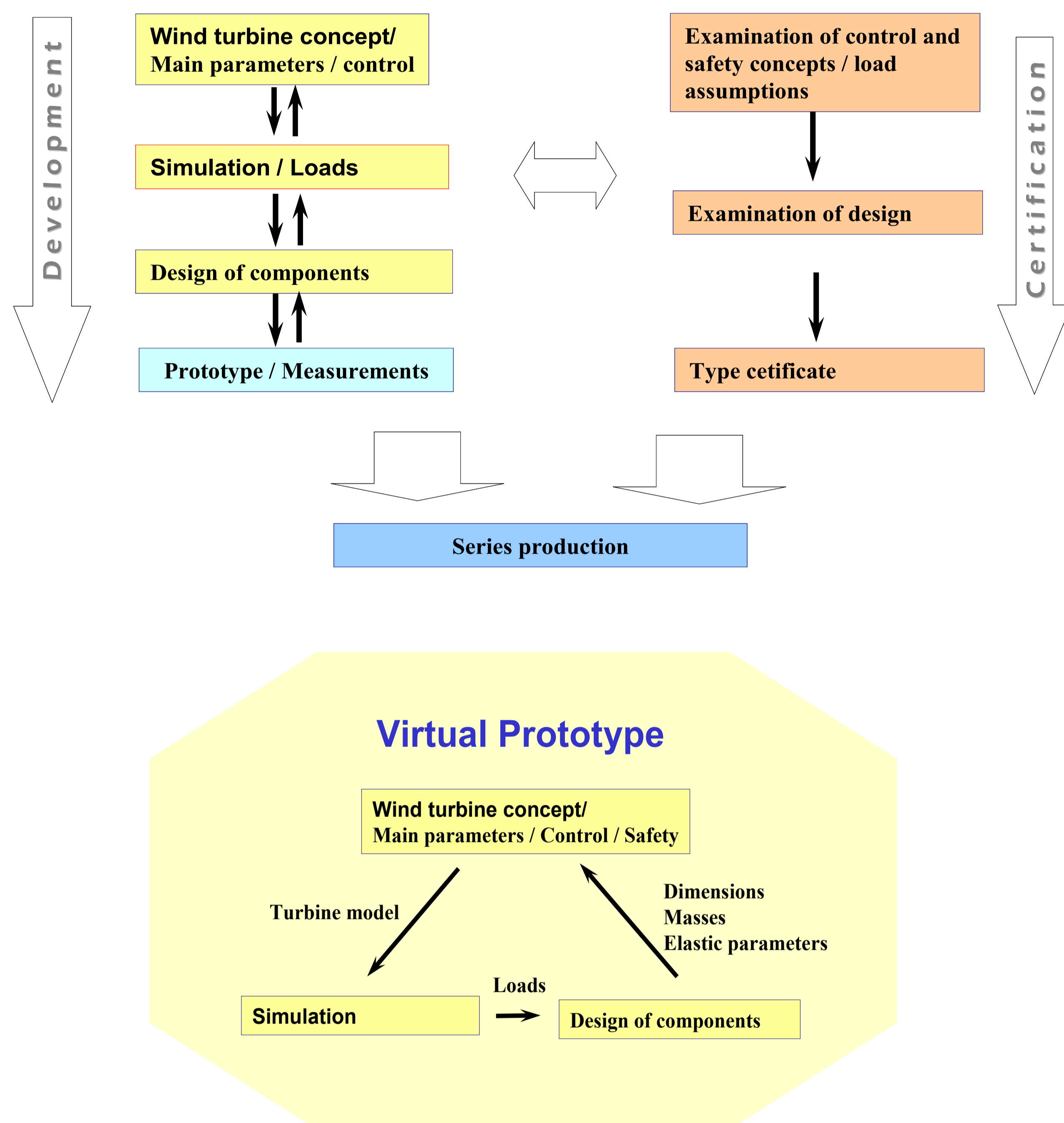
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Abstract: We present results on an ongoing project to develop a new computer simulation code for wind turbine dynamics and structural loads. This fully independent, self-contained program constitutes a multi-body system with a strictly modular structure. All flexible components of the turbine are modelled by a variable number of free modes which can be adjusted by the user to his needs. Special emphasis has been laid on the interaction of foundation and ground. A ground response model has been implemented. This offers users the possibility to get useful information like the bearing pressure distribution directly from the simulation.

Validations with measured data have been carried out. As an application we present results on earthquake loads on a wind turbine, where we can fulfill the requirements concerning of the relevant wind energy and building standards concerning both the quality of the mechanical model and the form of the synthetic ground acceleration.

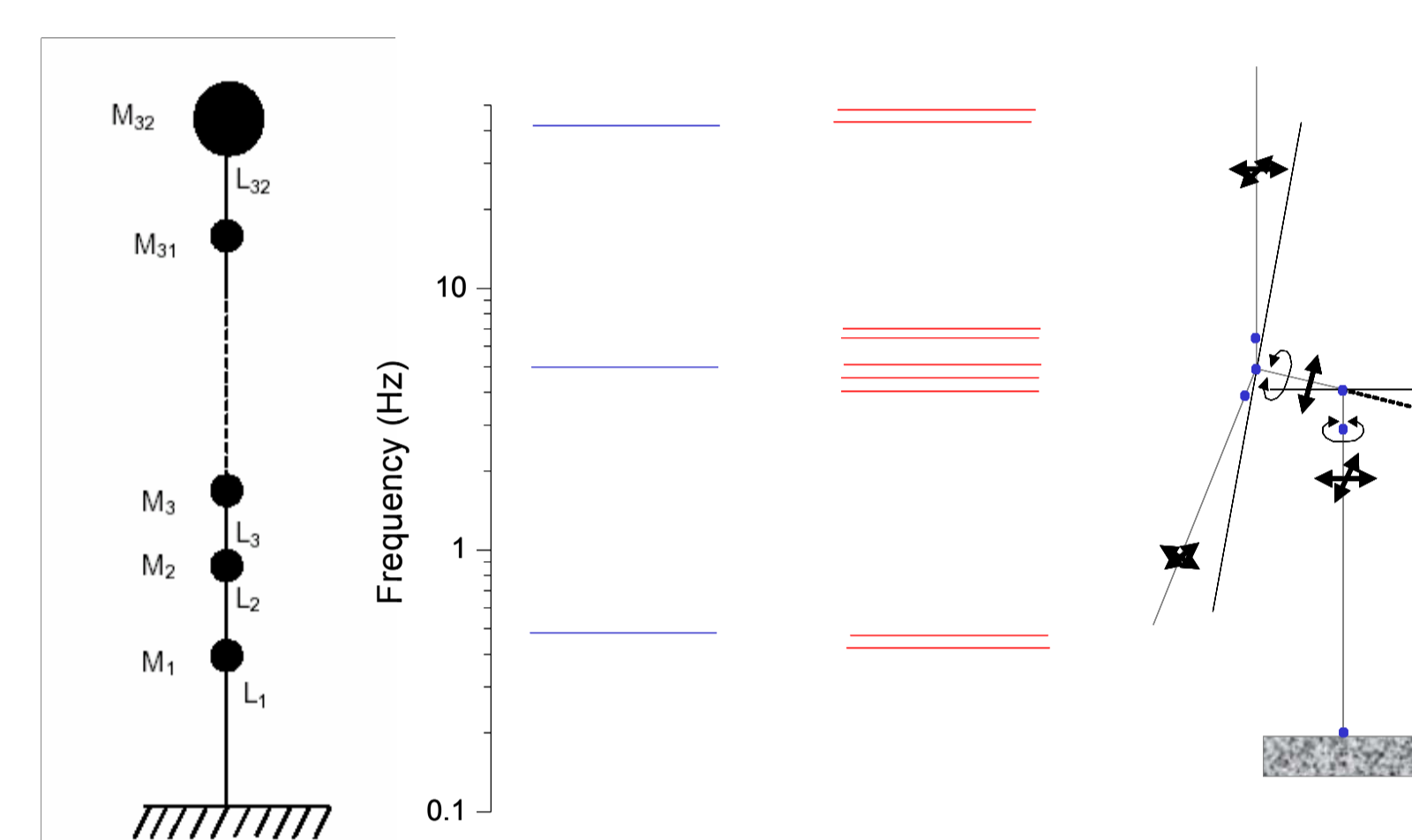
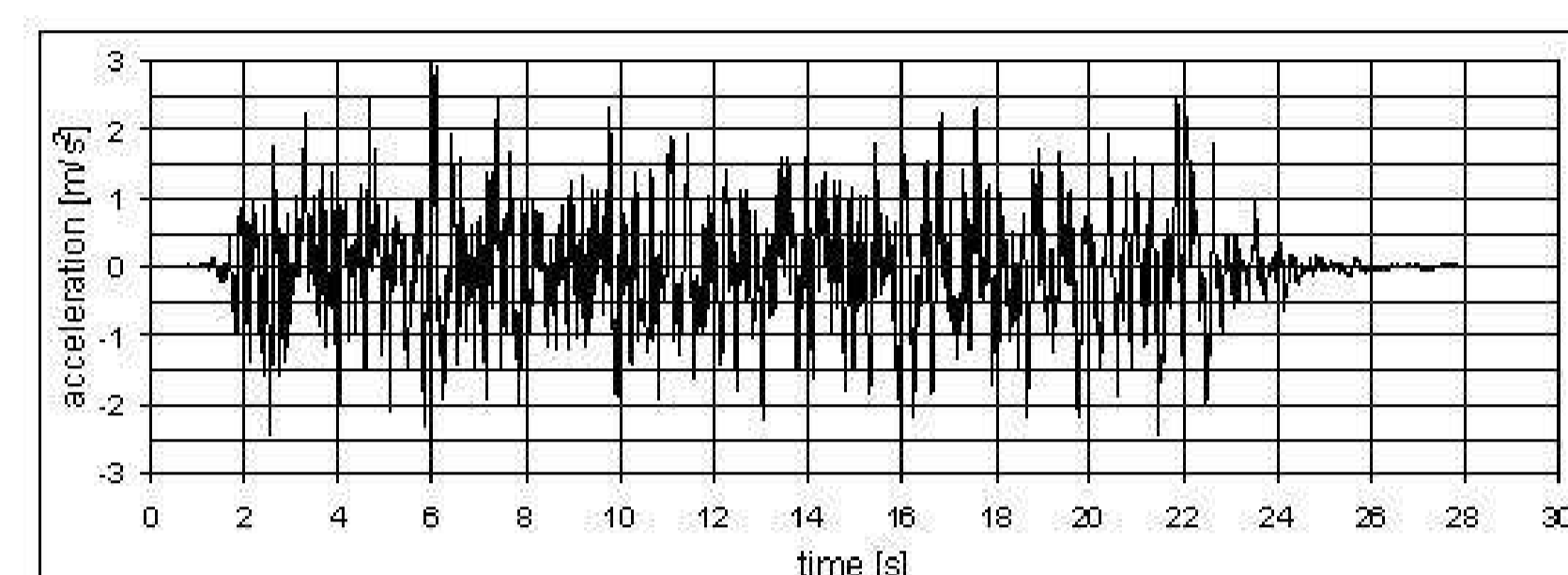
Further efforts will be made to extend the code to offshore wind turbines with general foundation structure and wave loads with the final aim to provide a full-fledged commercially available design code for on- and offshore wind turbines.

The virtual wind turbine



Earthquake loads on wind turbines

- Generate 3-D realistic synthetic accelerograms
- Specified in standards e.g. Eurocode 8 ...
- Include accelerograms in SI-WEC as ground acceleration



With SI-WEC

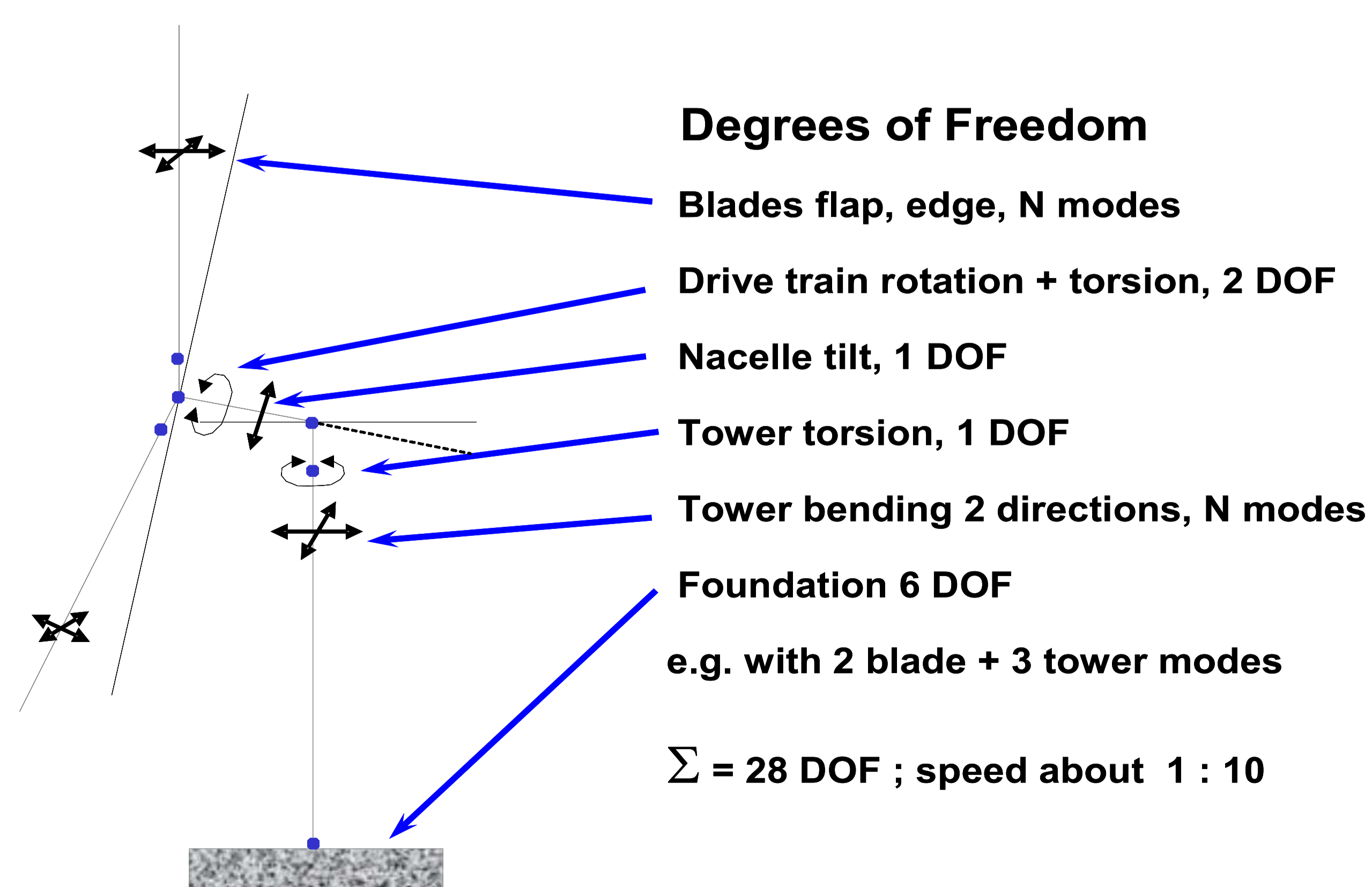
- Synthetic accelerograms according to various standards
- Requirements of standards for analysis of tower/foundation loads can be fulfilled (85 % of system mass, at least 3 tower modes)
- Accurate results for modes of the system
- Accurate results for tower/foundation dynamics and loads
- Detailed picture of machine and blade loads obtained

Simulation of Wind Energy Converters

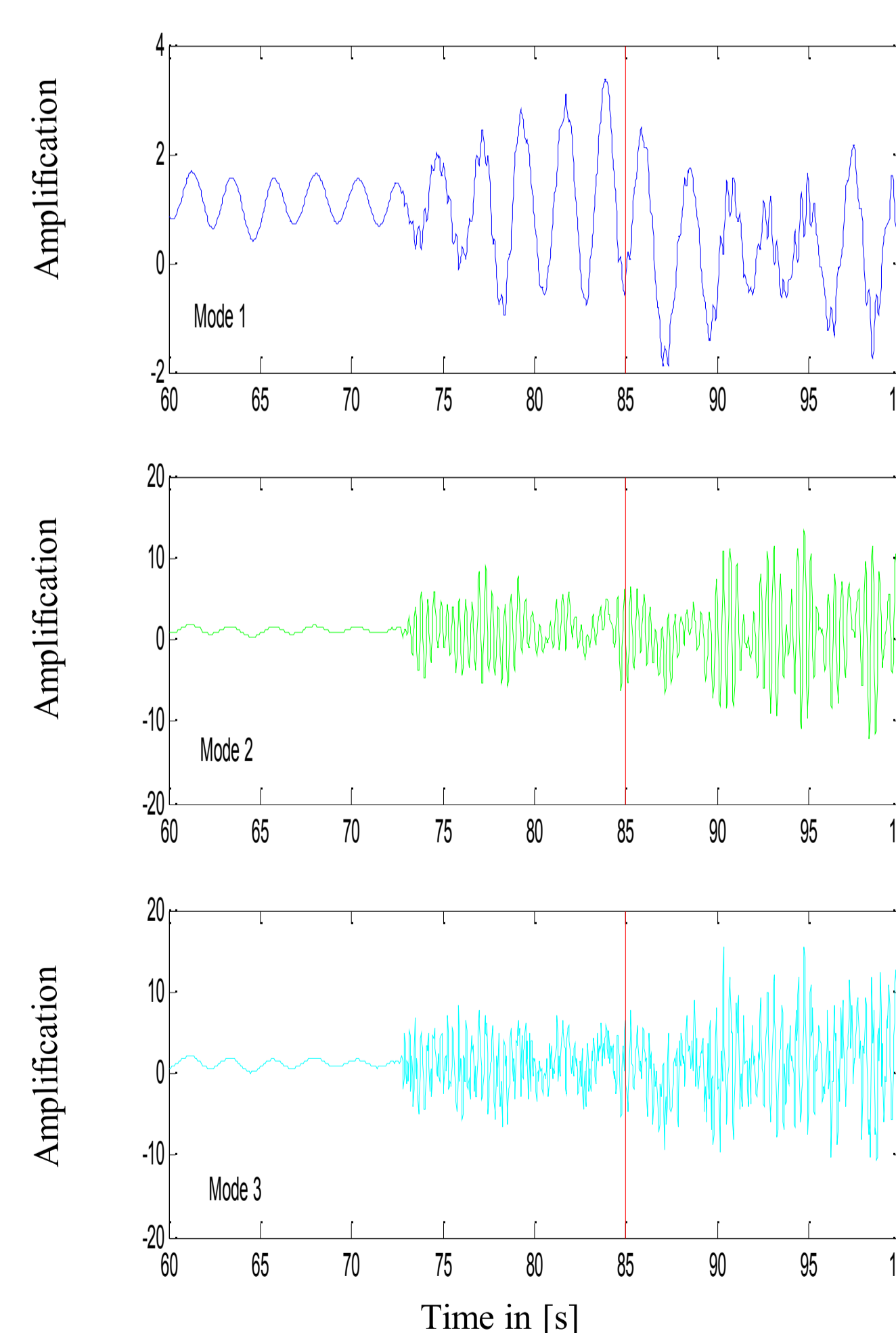
Aims for development (supported by TIFA-363):

- Start from scratch, use efficient algorithms from comp. mech. (✓)
- User-definable number of DOF (✓)
- Strictly modular design (✓)
- Fast new ODE solver, effective error control, variable DOF (✓)
- Detailed on-shore foundation model (✓)
- Improved aerodynamic model (in progress)
- Offshore modul (in progress)

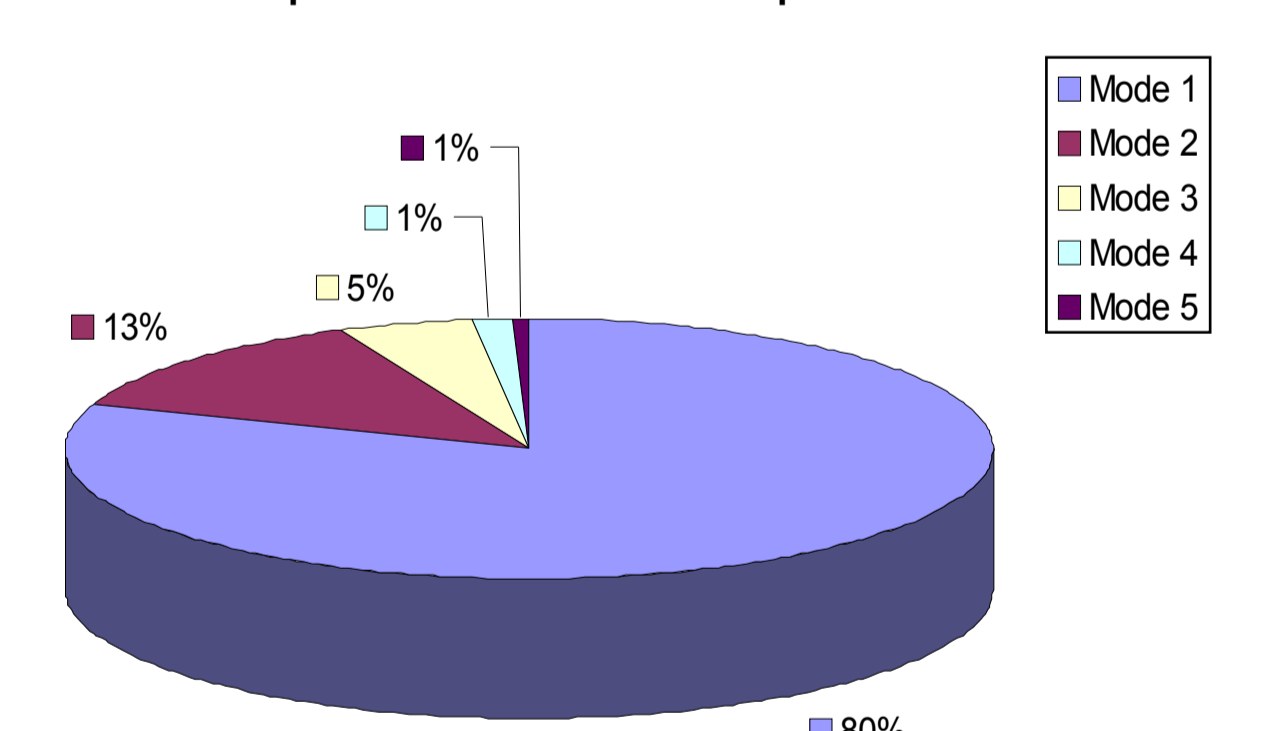
Final aim: Create a software (including pre- and postprocessing) for fast and accurate WEC simulation



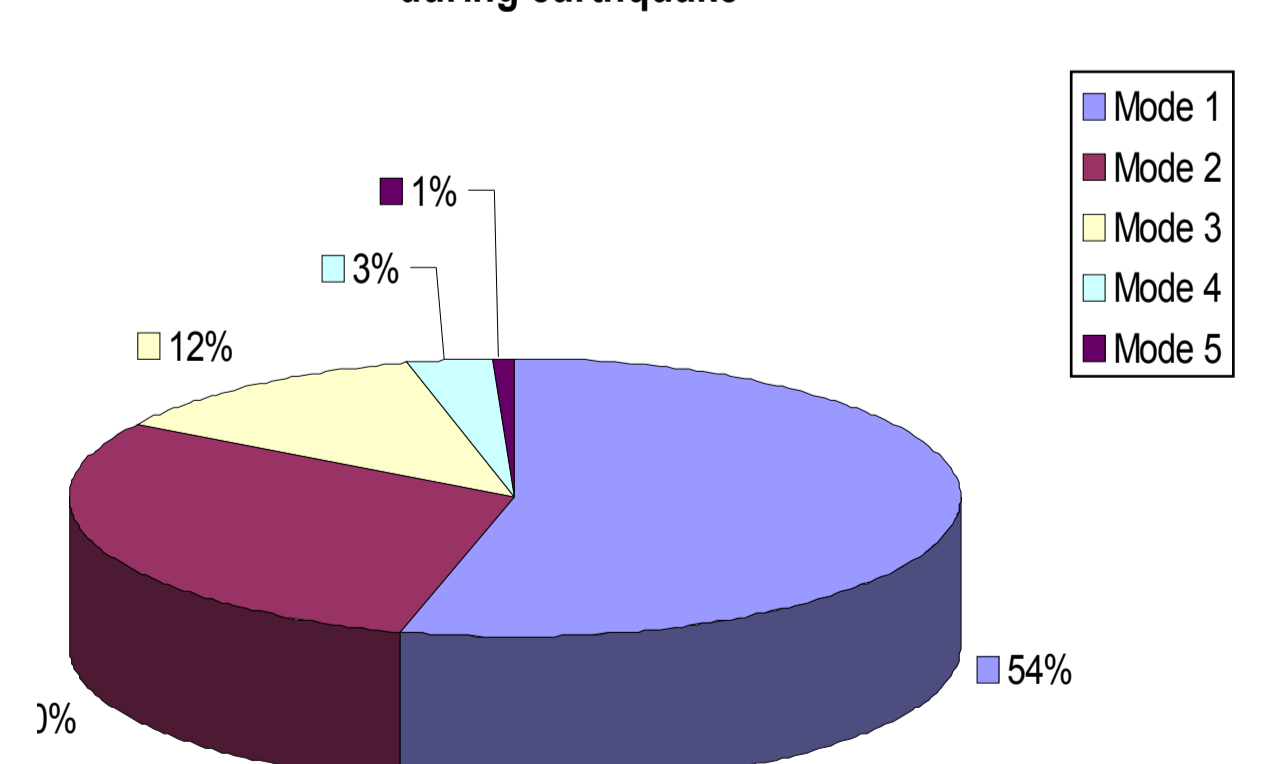
Amplification of thrust-wise tower modes



Modal Energy Distribution of Tower production at rated wind speed



Modal Energy Distribution of Tower during earthquake



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