Mechanics of bar-and-plate structures with strong scale effects - mathematical modelling and experimental analysis

To design a structure optimally and safely, it is necessary to have the appropriate tools to predict the response of the structure to a specified load. However, it has been shown that when dealing with structures of nano- or micrometre dimensions, standard theories cannot correctly describe their behavior. Due to the fact that their external dimensions are close to the dimension of the internal structure of the material (e.g., grain size) they are made of, they exhibit different properties than their large-scale counterparts. These size dependent properties therefore require an appropriate theoretical description - so-called non-local theories are used and are being developed continuously. Within the framework of these theories, models of single structural elements (rods, beams, slabs) are being redefined to take into account the effect of the scale at which they are modeled. However, in order to describe a complex nano/microstructure, it is necessary to develop appropriate models that take into account both the scale effect and the cooperation of the individual elements. Therefore, this project will concern the mathematical modeling of complex structures such as trusses, frames and rod and plate systems, in which the scale effect will be taken into account. The models will utilize nonlocal theory based on non-integer order derivatives. Recent research results have shown that this approach is a promising way to capture scale effects.

Numerical simulations based on the developed computational algorithms and experimental tests will be performed to determine the influence of the size of the structure on its static and dynamic behavior. In addition, the agreement of the developed models with experimental measurements will be verified, and hence the suitability of the developed models to describe the behavior of nano/microstructures.

Proper understanding and modeling of the size effect are crucial for the analysis of nano- and microstructures. The expected results will expand the knowledge and contribute to a better understanding and prediction of the mechanical behavior of there structures. The scope of the project will include static and dynamic cases, and therefore the models developed will be useful for a wide range of mechanical problems. Moreover, in the future, the results obtained may constitute the base for the development of appropriate tools for the optimal design of structures in which scale effects occur (e.g., components in nano- and micro-devices).