Bone is a tissue which has capacity for continuous remodeling under the influence of dynamic mechanical load effect. This process is called functional adaptation. Bone which is not exposured to mechanical loads for a long time starts to attenuate. The hypothesis on this subject was presented by Julius Wolff who reached a conclusion that orientation of trabecular structure in this bone is compliant with the direction of principal stresses. The process of bone remodeling plays particularly important role in the context of implants and prostheses placed in it. Bones undergo continuous remodeling over one's lifetime, responding to current external conditions. They have ability to adapt density, shape and internal structure to existing stress conditions. Through mechanical processes, resulting in stimulating activity of appropriate bone cells - osteoclasts, osteoblasts and osteocytes, the bone remodels its structure. Possibility of foreseeing the consequences of implant placement on the process of bone remodeling presents extremely high importance for implant designers, as well as physicians performing the procedure, as performing studies on a living bones is practically very difficult, and in most cases even impossible. If an implant is placed incorrectly or its shape is not optimally selected, there is a possibility of bone tissue atrophy in the implantation region. This can lead to implant loosening, and consequently to its removal. Changes which are made to constructions of prostheses and implants are inspired by the results of numeric analyses, thanks to which it is possible to estimate long-term tissue reactions to their presence. Therefore, it is important to develop bone tissue remodeling model under the effect of loads.

The project is related to developing a model of bone tissue behavior under the influence of active loads. The suggested model is anisotropic and takes note of antagonistic osteoclast and osteoblast cells' activity, as well as the mechanism of bone adaptation associated with turnover of material property base without changes in density, which presents its uniqueness. Its concept is based on the assumption that any tissue condition with given density can be regarded as a composite of two conditions presenting compact bone and cancellous bone with minimal density. In each of these conditions, the tensors of elastic constants are known and every condition is characterized by different anisotropy. As a result of mixing these conditions, it is possible to obtain properties of a bone with any density, included between known conditions. Input data of the model will be derived from tomography measurements of femur bone. The model will include both heterogeneousness of density in the bone's head, as well as orientations of orthotropic properties.

Model will be applied to ABAQUS software based on finite elements method and then used to forecast changes in density of the femur bone. In order to perform realistic simulation, it is planned to construct a complete model of the human lower limb, along with a model of the muscular system. The model will consist of all extremity bones and main muscles, providing its stability. Additional advantage of this approach includes possibility to provide dynamic stress simulating typical stress conditions related to diverse limp placement or its motion. For this purpose the OpenSim software will be used, which allows to build, exchange, and analyze musuloskeletal models and dynamic simulations of movement.

After the initial verification of bone model, it will be further applied for calculations using the limp model. At this stage, the effect of heterogeneity of physical properties (including density or orientation of orthotropic properties in the bone's head) on obtained results will be tested. The task is to obtain results coherent with Wolff's hypothesis of principal stress trajectories, clinical observations and experimental data. The results of the model will be used to predict changes in bone properties and will be compared to experimental data for the femur head.