1. Research project objectives

The project aims to evaluate the methods of tomographic imaging based on the ultrasonic waves propagation in structural elements. The tests will be performed on wooden beams and masonry columns.The influence of cross-sectional geometry and the occurrence of moisture on the waves transition phenomenon in a given element will be examined. The waves propagation velocity and the path of its transition in the examined cross-section will be evaluated. The obtained results will be used to perform the cross-sectional transmission tomography images. The research will enable the assessment of ultrasonic tomography algorithms and its usability for imaging of wooden and masonry elements. Additionally, three-dimensional models will be created to reflect areas with different ultrasonic waves propagation velocity values.

In the planned studies, the thesis suggested that both moisture and cross-sectional geometry influence the transmission of ultrasonic waves in masonry and wooden elements.

2. Research to be carried out in the project

The project involves testing on masonry and wooden elements. The implementation of the basic objectives will be carried out with the use of numerical FEM simulations and experimental research. The studies will be divided into two stages. In the first stage, the masonry columns and wooden beams cross-section geometry influence on the ultrasonic waves propagation in selected cross-sections of the tested elements will be investigated. In the second stage, the impact of moisture on the waves propagation velocity in the studied objects will be assessed. The results of experimental simulations will enable to carry out a detailed analysis of the given structural element's material and wavespropagation velocity dependence. The results obtained for two different materials will be compared. The impact of material heterogeneity and the combination of two materials (brick and mortar) on the obtained results will be investigated.

On the basis of the created experimental models known material parameters, computer models enabling further numerical analyzes will be prepared. The ultrasonic waves propagation, both in terms of path and velocity, determined from numerical simulations, will be compared to the actual state. The aim of the received data juxtaposition is the most possibly accurate numerical models validation that will contribute to further research of cases for which the experimental research will not be performed. The results obtained from both laboratory and numerical tests will allow the tomographic images creation of the examined cross-sections of wooden beams and masonry columns. The 3D images will be developed to accurately visualize the geometry of the entire structure of the studied elements.

3. Reasons for choosing the research topics

Structural wooden and masonry elements are still one of the most frequently used material solutions in engineering. They are constantly appreciated in traditional construction, in service and public utility buildings, or sacred objects. Reliability and strength of structural elements, both masonry and wooden, affect the stability of entire structures, which is why it is so important to monitor the technical condition of these elements. The damages considered as most dangerous are the ones not visible from the outside and inducing internal degradation of the material. It is possible to distinguish here both the influence of geometric changes in the cross-section and the moisture present in the element. Therefore, it is important from the point of view of the structure's safety to know the construction elements internal structures, which is enabled by our ultrasound tomography.

The project is multifaceted, using knowledge in the field of masonry and wooden constructions mechanics, and materials science. The proposed research is of a basic nature, hence it allows to know the processes of tomographic images creation for the proposed structural elements. The results of the conducted research will provide important information on the possibility of ultrasonic waves usage for tomographic imaging in construction, for the homogeneity of materials testing, as well as for the detection of moisture.