Modern structures set more and more requirements for materials from which they are made. Therefore, more often composites are used, which stand out by better material properties than single constituents, from which composite is produced. One of the commonly used materials is composite made out of carbon fibre reinforced polymer. Such material is characterized by high strength and low mass, and for this reason, it has found many applications in aerospace and automotive industry, building industry and sports equipment.

This material is characterized by stiffness, strength, elasticity, etc., which are different in various directions. Moreover, for example, carbon fibre reinforced composite has high tensile strength in a direction along fibres. However, during tensioning in a direction opposite to placed fibres or during compression of the material, the results are not so impressive in terms of strength. Such phenomenon does not occur in common element of structures made out of metals, glass, and plastics. This multidirectionality of composites creates additional possibilities during the design of new structures because the layout of reinforcing fibres can be selected so that the structure bear loads in a safe way, and simultaneously was lightweight. In order to optimally utilized directional properties of composites, it is crucial to possess full information about the material.

Classically, properties of structural materials originate from the destructive test, in which specimen of appropriate geometry is tensioned, bend or compressed, until it breaks. In opposite to traditional materials such as metal alloys, glass or plastics, composite material properties strongly depend on direction. Therefore, destructive tests of fibre-reinforced composites usually do not provide full information about their behaviour. For this reason, other techniques are utilized for characterization of material properties, including techniques based on analysis of Lamb wave propagation in the material.

Lamb wave phenomenon can be imagined by analogy to waves spreading in water. The stone thrown into the water causes circularly spreading waves on its surface. If spreading waves on water surface meet on their way some solid, they reflect, creating an additional circular pattern on the water surface.

Elastic waves behave similarly, but they occur in solids and are traveling with much higher velocities. A specific example of such waves are Lamb waves which occur in thin structures and propagate in the whole material volume and not only on the surface. The special element attached to the structure, can similarly excite a wave as a stone thrown into the water. These waves propagate from the excitation place in all directions. However, their behaviour (wavelength, its velocity, etc.) is strictly connected with properties of the material in which they propagate. Thanks to that, it is possible to determine material parameters by analysis of Lamb wave behaviour in considered material, which is the subject of this project.

An additional advantage of such approach is non-destructive character and possibility of application for operating structure. Based on such techniques it is possible to create a system which continuously will be monitoring the health of structural element and in case of changes in its parameters, i.e. damage occurrence, send/display an appropriate message.

During the project implementation, the Lamb wave propagation patterns will be studied experimentally and numerically in order to find a correlation between them and material properties. It will involve the development of numerical tools and adaptation of modern optimization methods. This type of study has not been conducted so far for materials with a high degree of anisotropy. Once, the procedure is established, experiments will be conducted towards (a) model verification, (b) temperature effects, (c) monitoring of material property degradation and (d) feasibility of model-assisted SHM system.