What do you see when you throw a stone in the water? A wave appears on its surface. Usually, when we talk about waves, we associate them with those on the water. However, it turns out that there are many types of waves in nature. There are sound, light, electromagnetic waves... Some we hear, others we see or we just feel their action. Some need special conditions to spread, others don't. Among the whole range of waves, elastic waves can be distinguished and they are the subject of research in this project.

Elastic waves propagate, i.e. spread in an elastic medium. As examples of elastic bodies can be given aircraft sheathings or steel structures used in buildings. When a fragment of the medium is suddenly deflected from the equilibrium position, the surrounding particles vibrate, and due to the elastic properties, the vibrations are are further transmitted. During the movement, the waves propagate in all possible directions. They are reflected from edges of elements, or various defects occurring inside the material. The reflected waves interfere, and after some time disappear, due to damping, leaving the structure in its original position.

Observation and analysis of the elastic wave propagation can provide information on the state of the system in which the wave propagates. This is one of the non-destructive measurement techniques used in monitoring the condition of structures. As a non-destructive technique, it does not interfere with the tested structure. Therefore it can be exploited during typical usage of the system (e.g. during an airplane flight or in a building object under operation). Unfortunately, the precise mathematical description of the elastic wave is quite complicated and is limited to simple cases of a plate (an element with two dimensions much larger than the third one) or a band (an element with one significant dimension). It has already been mentioned that the propagating wave reflects from the edge, and therefore also the way the element is supported matters. Theoretical considerations are also limited in this case. The aim of the project is to observe and understand better the nature of the phenomenon of elastic wave propagation in a system with complex geometry.

Another difficulty associated with the propagation of the elastic wave, apart from the mathematical description itself, is its measurement. The elastic wave cannot be seen with the naked eye. Its amplitude, i.e. the largest deflections are too small. In addition, it travels at a very high speed, depending on the type and the temperature of material in which it propagates. For example, a transverse wave in steel propagates at a speed of over 3000 m / s, i.e. a trip from Zakopane to Gdansk with wave's velocity would take less than 4 minutes. It is not surprising then that the measurement of the elastic wave causes many difficulties. Currently, two methods are used: contact (using PZT transducers glued to the structure) and laser Doppler vibrometry. The first method allows you to measure the wave at selected points to which the transducers are glued, while the second one allows you to measure the wave at all points where the laser light shines. Laser vibrometry is currently the most accurate method for measuring speed and displacement. Both methods will be used in the presented task.

Observation of the wave and recording of its propagation will be made on samples similar or even the same as fragments of real engineering structures. These will be isolated frame nodes, made of IPE 300 (beams) and HEB 160 (columns). The elements will be joined by welding. This is relatively simple node construction. However, it gives great research possibilities. On such samples it is possible to observe the wave on sections of material of varying thickness, in elements with different boundary conditions, or with some curvature.

Another issue that requires attention is the effect of stress caused by various types of loads applied to the system, on the way the wave propagates. Is the relationship between load and wave speed or amplitude observable? If excessive loads are applied to the structure, the material may become yielded, i.e. permanent changes in its structure may occur. To determine both strains fields (based on deformations) and displacements of node elements as a result of the applied load, and especially regions where yielding has occurred, the Digital Image Corelation (DIC) method will be used. What happens to a wave when it encounters such an area? How big do the deformed areas have to be, to be detectable on the basis of wave measurements? These and the other problems related to the phenomenon of elastic wave propagation in body with complex geometry will be examined in scope of the presented project.