

## Description of the experiment: Damage detection of timber structural joint by Coaxial Correlation Method in 6-D space

The timber stand was considered as the object of study (Fig. 1). This stand consists of a main beam with the length of 2 meters and additional beam with total length of 3 meters, which are connected at an angle of  $90^\circ$ . Additional beam has additional support in the middle of the beam and two suspended platforms for static loading. Both beams are made of C18 strength class with  $150 \times 50$  mm cross-section.

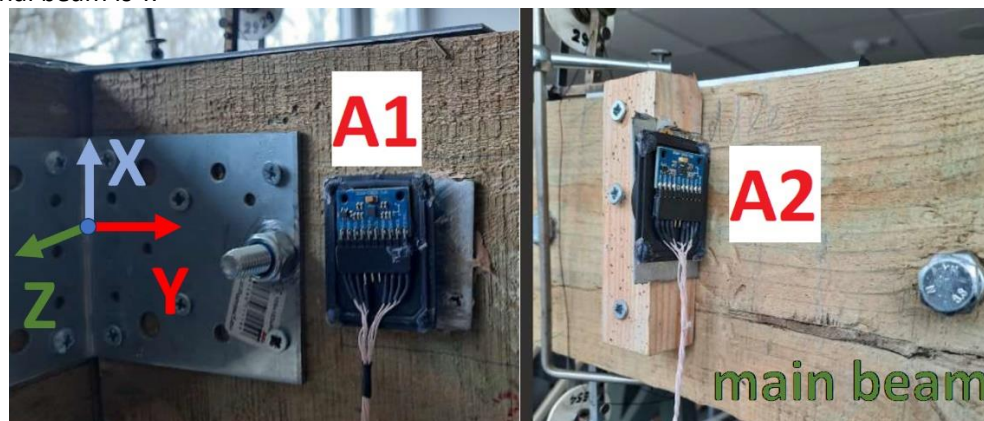
To join beams, steel screws of a diameter 4 mm, steel bolts with the strength class 8.8 and a diameter of 8 mm, angle profiles Arras Construction Furniture OU  $105 \times 105 \times 90 \times 3.0$  and perforated steel plates Arras Construction Furniture OU  $200 \times 50 \times 3.0$  were used.

The vibration load on the stand was generated by electrodynamic actuator placed at the end of the additional beam and is marked as “EA” on the Figure 1.



**Figure 1.** Stand of two timber beams connected at an angle of  $90^\circ$  and electrodynamic actuators “EA”.

Two 6D sensors were coaxially placed on the beams as it can be seen on Figure 2, on either side of the investigated joint. The first sensor (A1) was placed near the joint on the additional beam. The second sensor (A2) was located in the centre of the span of the main beam on its outer side. 6D sensors are implemented by MPU-9250, which contains a 3-axis gyroscope and a 3-axis accelerometer. The stand axes in accordance with the sensor's axes are shown on Figure 2, where vertical axis is X, the longitudinal axis of the main beam is Z, and the longitudinal axis of the additional beam is Y.

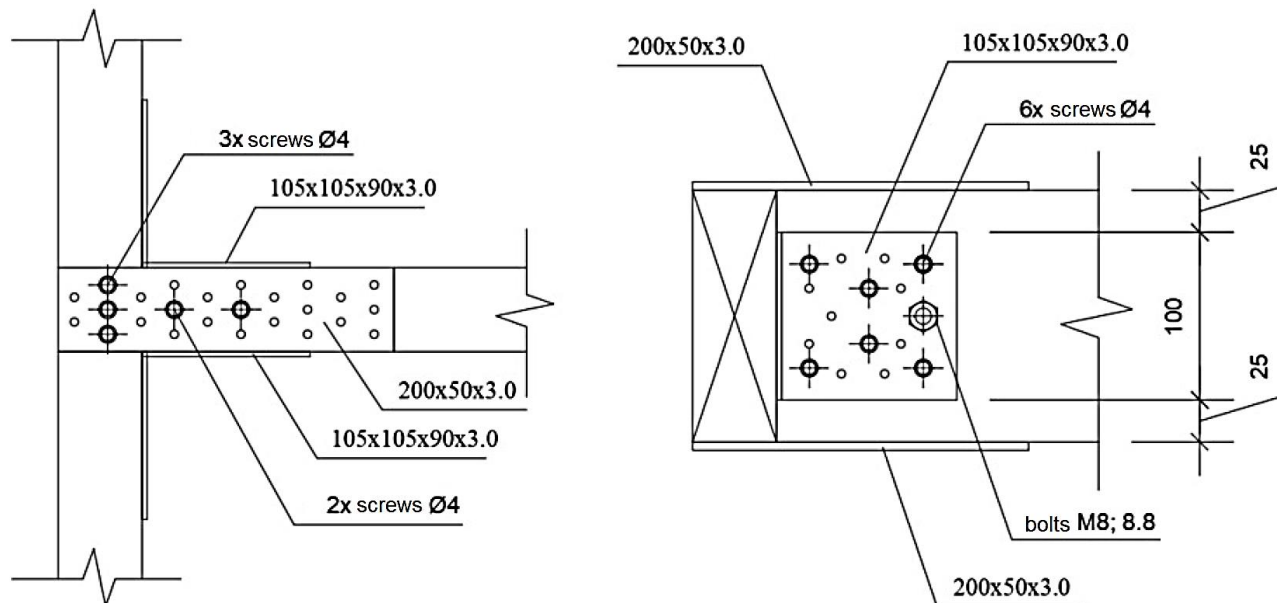


**Figure 2.** Placement of the accelerometers and the axes of the system.

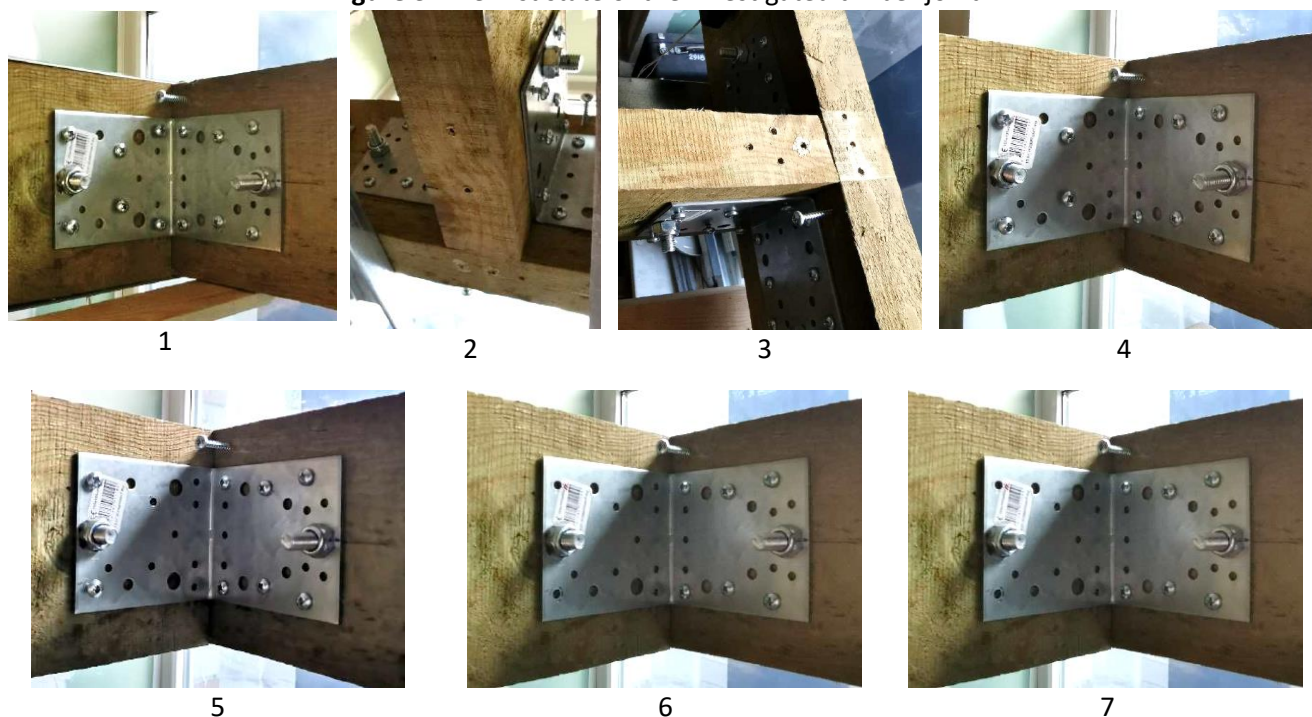
Seven structural joint states were studied. Five initial states of the joint correspond to a moment joint (the joint capable to absorb a bending moment). The sixth state of the joint was realised by removing connecting metal plates and screws, keeping only the bolt, and corresponds to hinged joint, which is not able to absorb any bending

moment. The seventh state of the joint was realised by removing the bolt also. All states of the joint are summarised on Figure 4.

The first state of the joint is the joint which can absorb the largest bending moment and is realised with angle profiles Arras Construction Furniture OU 105x105x90x3.0 and perforated steel plates Arras Construction Furniture OU 200x50x3.0, steel bolts with the strength class 8.8 and a diameter of 8 mm and screws of a diameter 4 mm from both sides as it is shown on Figure 3.



**Figure 3.** The first state of the investigated timber joint.



**Figure 4.** Seven initial states of the investigated structural joint: 1 – joint detailed in Figure 3; 2 – joint where the bottom perforated steel plate Arras Construction Furniture OU 200x50x3.0 is removed; 3 – joint where the top perforated steel plate Arras Construction Furniture OU 200x50x3.0 is removed; 4 – joint with unscrewed 2 screws on both sides of the angle profiles Arras Construction Furniture OU 105x105x90x3.0; 5 – joint with unscrewed 2



more screws on both sides of the angle profiles; **6** – joint with unscrewed all screws and fixed only by bolt; **7** – joint with no connection between beams.

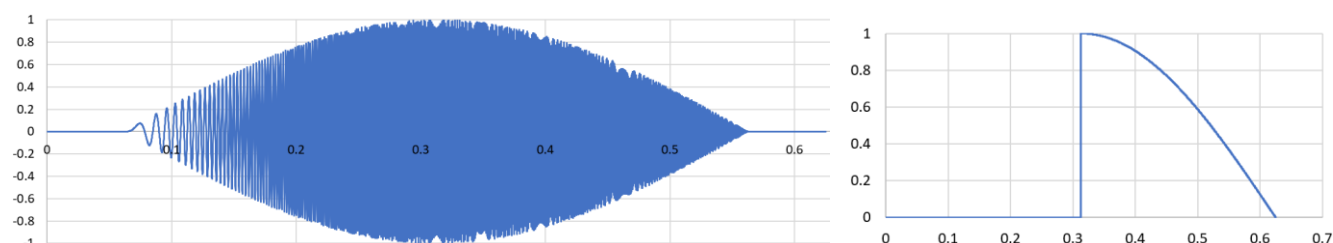
For each of the seven joint states, measurements were taken at five load levels, which were divided between two additional beam's loading platforms, and were equal to 0 kg, 60 kg, 120 kg, 180 kg and 240 kg. As an example, the state of the stand at load levels of 120 kg, 180 kg and 240 kg are shown in Figure 5.



**Figure 5.** Load level of 120 kg (left), 180 kg (middle) and 240 kg (right) of the timber beams stand.

The name of each measurement **.csv** file in the database has format **IMP\_XXX\_S.TXT**, where:

- IMP** indicates on the type of impact (“PULSE” – short impulse, or “SWP” – wave impact, sweep type signal with duration 0.5 s);



**Figure 6.** Types of impact: wave action (left) and short impulse (right).

- XXX** – indicates the load level on one platform (000 – 0 kg, 060 – 60 kg, 120 – 120 kg, etc.);
- S** is the number of one of seven joint states (which are described on Figures 3 and 4).

For example, the measurement designation PULSE\_120\_6.csv indicates that the measurement was carried out for the sixth state of the joint (where connection between two beams is realised by steel bolt M8), under impulse action with a total load level on the platforms of 120 kg.

Each **.csv** file has the following **structure**:

Columns														
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Time, s	Impact (pulse or sweep)	–	Measurements of the sensor (A1) on axes:						Measurements of the sensor (A2) on axes:					
			X	Y	Z	GX	GY	GZ	X	Y	Z	GX	GY	GZ

The structure's response was measured in three directions, namely, X, Y, and Z (see Figure 2), using two 3D accelerometers and around three axes, namely, GX, GY, and GZ, using two 3D gyroscopes, thus providing 6D space measurements.