

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

The 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° . Both beams are made of S355 strength class steel and have HEA 100 cross sections. The beams were joined by a SRS bolt with the strength class 8.8 and a diameter of 20 mm.

The vibration load on the stand was generated by two electrodynamic actuators, the first one was placed on the support of the main beam and is marked as “C” (close), and the second one – on the intermediate support of the additional beam with mark “F” (far).



Figure 1. Stand of two steel beams connected at an angle of 90° and electrodynamic actuators “C” and “F”.

Two 6D sensors were coaxially placed on the beams in the centre of the upper chord 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. 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 Z, the longitudinal axis of the main beam is X, and the longitudinal axis of the additional beam is Y.

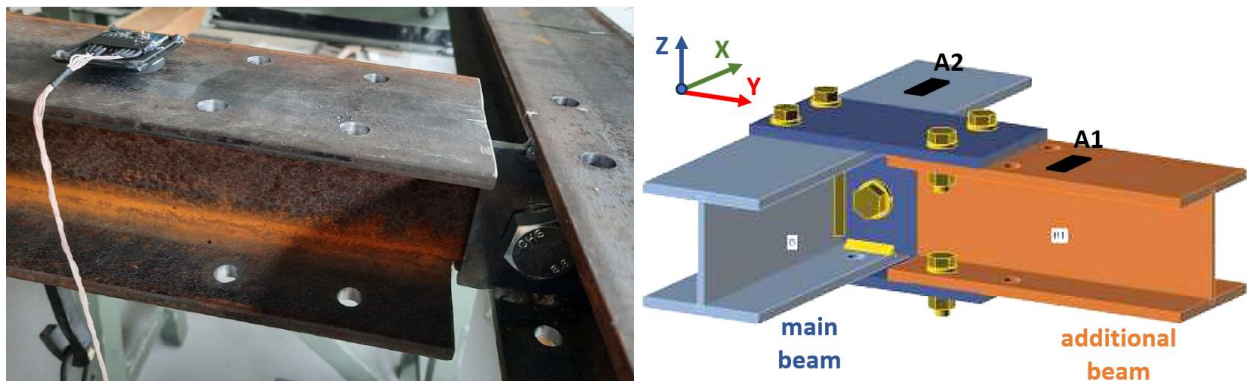


Figure 2. Placement of the accelerometers and the axes of the system.

Five structural joint states were studied. Four initial states of the joint (Figure 3) correspond to a moment joint (the joint capable to absorb a bending moment). The fifth state of the joint was realised by removing connecting metal plates and corresponds to hinged joint, which is not able to absorb any bending moment.

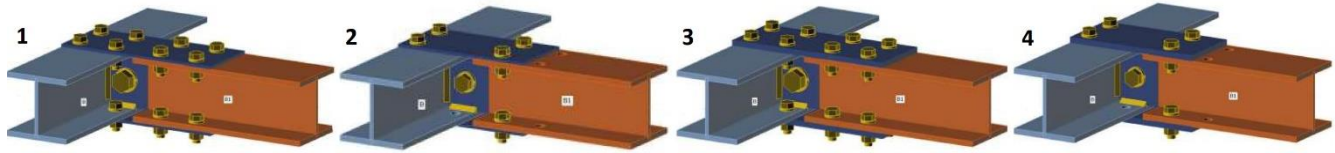


Figure 3. Four initial states of the investigated structural joint with corresponding value of bending moment (M), which can be absorbed: **1** – joint with 4 mm thick connecting metal plates screwed by 16 bolts ($M=9.9$ kNm); **2** – joint with 4 mm thick connecting metal plates and total number of bolts is 8 ($M=5.1$ kNm); **3** – joint with 8 mm thick connecting metal plates screwed by 16 bolts ($M=13.2$ kNm); **4** – joint with 8 mm thick connecting metal plates screwed by 8 bolts ($M=6.9$ kNm).

For each of the five joint states, measurements were taken at seven load levels for each of additional beam's two loading platforms: 0, 20, 40, 60, 80, 100 and 120 kg. As an example, the state of the stand at load levels of 60 and 120 kg are shown in Figure 4.



Figure 4. Load level of 60 kg (left) and 120 kg (right) of the steel beams stand.

The name of each measurement .csv file in the database has format **AB_XXX_K.TXT**, where:

- **A** is the label of the used electrodynamic actuator (“C” – closer actuator, placed on the support of the main beam, and “F” – farther actuator, placed on the intermediate support of additional beam);
- **B** indicates on the type of impact (“W” – wave impact, sweep type signal with duration 0.5 s, or P – short impulse);

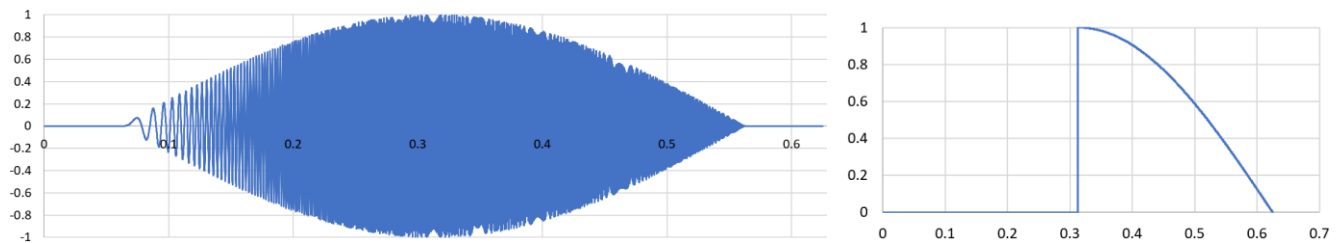


Figure 5. Types of impact: wave action (left) and short impulse (right).

- **XXX** – indicates the load level on one platform (000 – 0 kg, 020 – 20 kg, 040 – 40 kg, 100 – 100 kg, etc.);
- **K** is the number of one of five joint states (states from 1 to 4 is shown on Figure 3, state 5 is hinged joint without connecting metal plates, with only one bolt with diameter 20 mm between beams).

For example, the measurement designation CP_060_2.TXT indicates that the measurement was carried out for the second state of the joint, with a maximum moment load capacity of 5.1 kNm, under impulse action of the closer electrodynamic actuator with a load on each platform of 60 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	Used electrodynamic actuator (according to the name of the file)		Measurements of the sensor (A1) on axes:						Measurements of the sensor (A2) on axes:					
	F	C	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.