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STUDY OF METAL TIMBER JOIN BY ACOUSTIC EMISSION METHOD

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ABSTRACT

Real behaviour and general load carrying capacity of timber structures mostly depends on the load bearing capacity of joints. Among the effective types of modern structures are constructions with joints with connections on the basis of metal plates slotted into timber profiles. The paper deals with steel to timber joints with slotted plates. Non-traditional measuring method was using at measuring strength of structure metal-wood-metal too. One of them was acoustic emission method, which belongs to a group non-destructive testing method. This method, in contrast to other ones, records only active defects into followed structure. Therefore its application in this test can be great acquisition especially in areas of development connections. According to expectation a critical part was the connection metal-wood. Note that the acoustic emission method reflected defect rise in structure much sooner than followed by eye, or which it is possible immediately determine by other used methods. Time-frequency analysis plays a central role in signal analysis. It has been already recognized that a global Fourier transform of a long time signal is of little practical value to analyze the frequency spectrum of a signal.

Keywords: Ultrasonic testing, Acoustic emission method, Metal timber join, Time-frequency technique, Short time Fourier transformation, Timber, Steel, Connections

1. Introduction

Many times we have already been able to convince ourselves, that the use of experience and knowledge, resulting even from far past have brought surprisingly good results. One of such experience is knowledge that noise, resulting from the load applied to a structure with cracks (disturbances) is profoundly different from the noise of the same subject without cracks. This phenomenon has been known long time ago. As early as the Middle Ages this phenomenon was used for detection of cracks in ceramic vessels after their firing. The mentioned phenomenon makes it possible to detect cracks in metallic materials as well.

Generally known is its very old application in the railway transport. In development and application of methods used for detection of defects in construction components and materials this phenomenon has been however often neglected. It has happened for a long time mainly by

reason that the advanced measuring techniques and appropriate mathematical apparatus, needed for evaluation of measured signals were missing or not available.
Only methods of time-frequency analysis, in co-operation with classic spectral analysis make possible a complete analysis of measured signals with good possibilities of classification and identification of defects. The noise, arising from the shock to tested construction or component, is namely very interesting due to the fact that it contains a number of mutually independent and well recognisable symptoms, according to which it is possible to differentiate materials both with and without cracks.
These symptoms are included particularly in time-frequency spectres of measured noise signals. The composition of the spectrum of noise of each material is given by several characteristics with their own side components in time-frequency level. The spectrum of measured noise changes with time during the whole phenomenon. Symptoms of cracks are following:

- Changes of the size of amplitudes of particular characteristic frequencies,
- Movements of characteristic frequency components,
- Existence of new frequency components,
- Existence of wider modified spectrum than in the case of good product.

2. Experimental set up

It was implemented nearly destructive testing tensile strength of timber join with conjunction at both ends. Simple tensions strength tests were submitted metal-timber join (a type of conjunction is in Fig. 1), which contained metal at the ends of join. These joins had different constructions. Some joins were shaped by some piece; others were hold on by the help of pivots. Tested specimen was loaded by simple tension (Fig. 2). Common load was three cycles, when the third cycle was conducted to destruction.

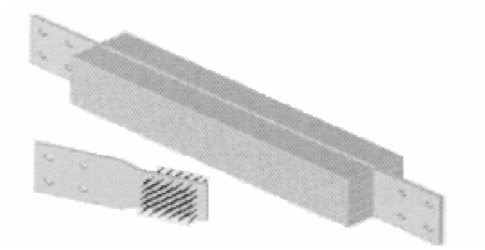

Fig. 1: Schematic representation of metal timber join.

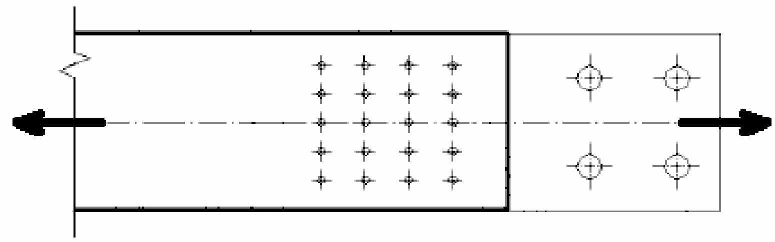

Fig. 2: The test specimen diagram with forces.

3. Acoustic Emision results

The first two cycles of loading are shown in Fig 3. Every point of this graph means hit detected by any sensor of all. More points at load increasing imply more acoustic emission activity. At the second loading cycle the acoustic emission activity increases as late as force is large than maximal force in the previous cycle.

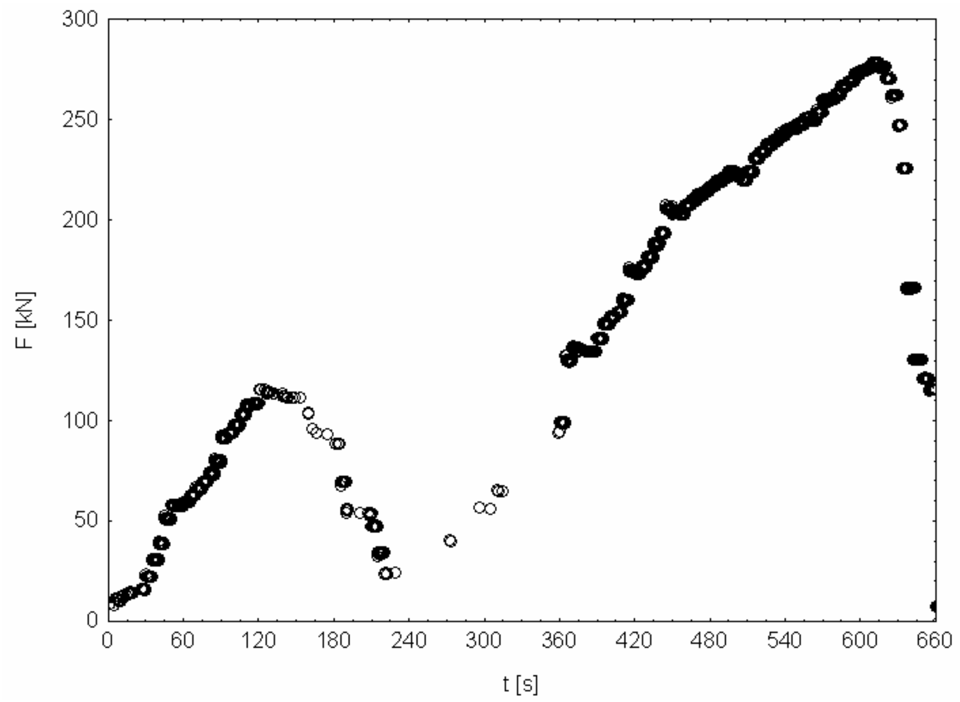

Fig. 3: Acoustic emission hits dependence on force and time.

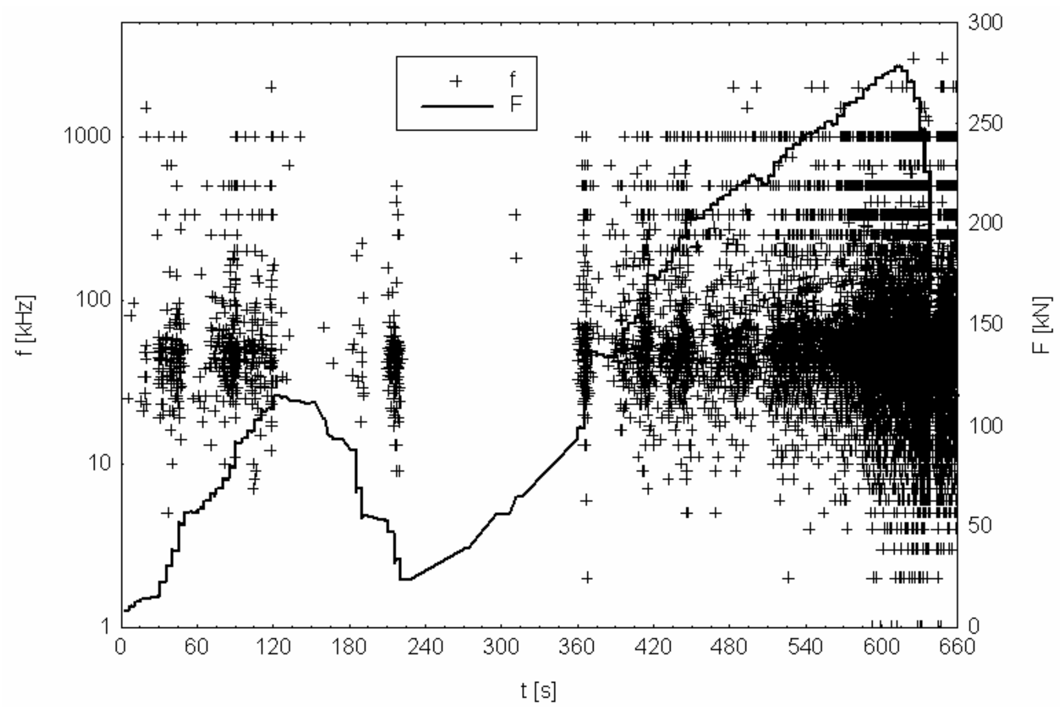

Fig. 4: Acoustic emission hits dependent on average frequency and time (dagger) and dependence force (solid curve) on time.

Average acoustic emission frequency (in next text is termed only average frequency) distribution of acoustic emission hits detected by one sensor is shown in Fig. 4. Hits with average frequency band around 50 kHz is contained in whole loading range. We suppose those sources are deformation connection between metal pin and timber. High average frequency can show bend these metal pins. Presence low average frequencies are registered up to the second cycle, when force is higher then maximal force in the first cycle.

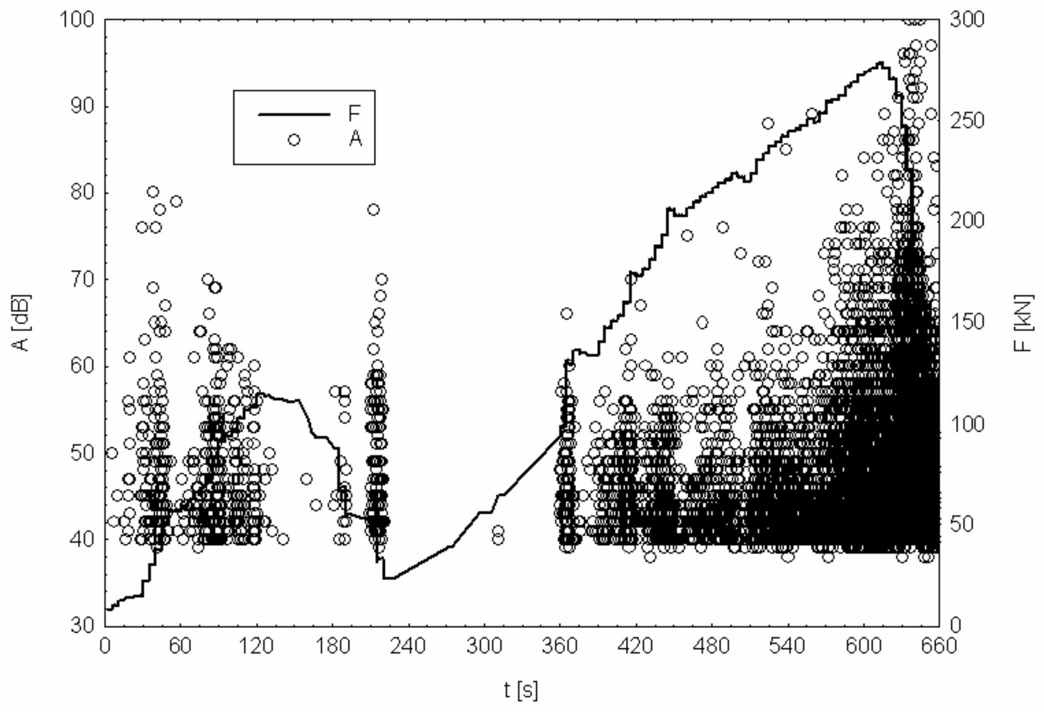

Fig. 5: Acoustic emission hits dependent on amplitude and time (circle) and dependence force (solid curve) on time.

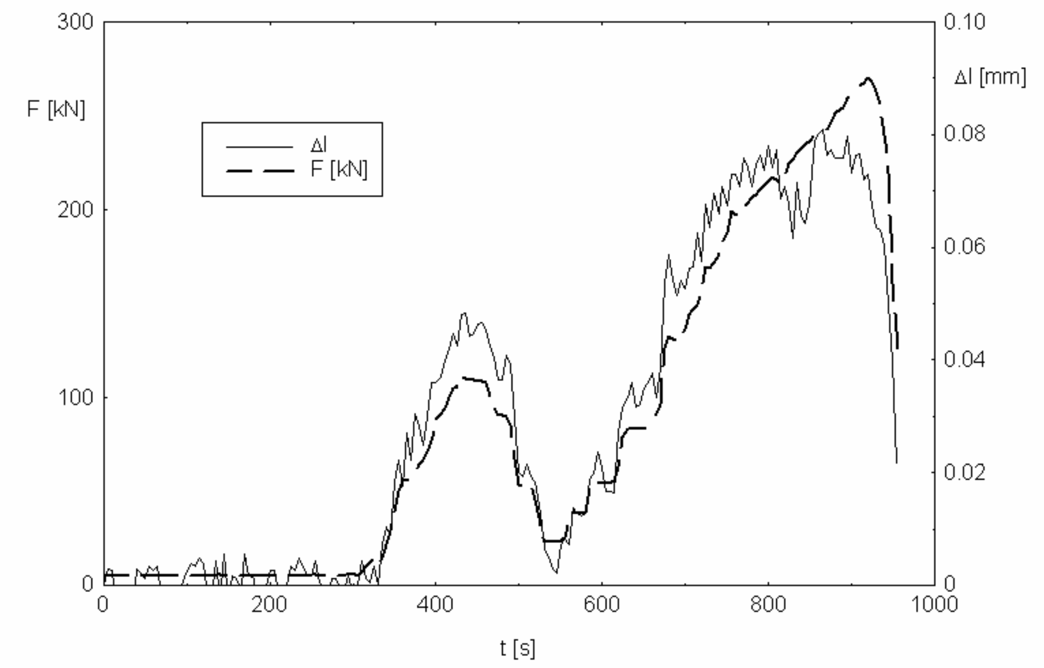

Fig. 6: Characteristics of strain (solid) and force (dashed) on time.

Distribution of acoustic emission hits in dependence on acoustic emission amplitude (in next text is termed only amplitude) is shown in Fig. 5. Maximal value of amplitude is in the end of second cycle.
Strain of specimen is agreed with on force (Fig. 6). That does not detect any “small” defect into structure. In the other hand acoustic emission activity is only in generating or creasing defect into structure.

4. Time-frequency analysis of hit

Short Time Fourier Transformation $STFT(\tau,\omega)$ is defined

$$STFT(\tau,\omega) = \int s(t+\tau)g(t)e^{-j\omega t}dt\,, \qquad (1)$$

where $s(t)$ is analysed signal, $g(t)$ is weighted windowed function, ω is oscillation frequency, τ, t is time. Discrete amplitude of STFT named spectrogram can computed by

$$A_{STFT}(n,f) = \sum_m \left(g_M(m) \left| \sum_k w_N(k)s(n+k+m)\exp(-j2\pi fk) \right| \right), \qquad (2)$$

where w_N is usual windowed function. The Short Time Fourier Transform can compute by series Fourier Transformation (Fig. 7).

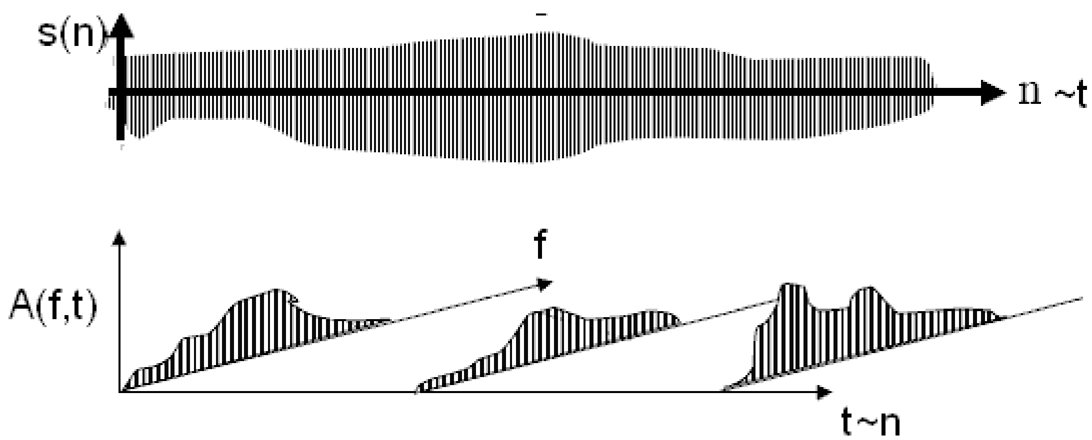

Fig. 7: Algorithm STFT is set up FT.

Some of all hits were recorded by 1 MHz sampled frequency. Two in different time and loaded cycle are shown in Fig. 8 and 9. There are four graphs in a figure. If we look at it from side left upper graph shows amplitude (voltage) depended on time, right upper shows frequency spectrum computed by Welch algorithm, down ones show time frequency behaviour computed by Short Time Fourier Transformation (left with amplitude, right with logarithm amplitude). Note black colour in these graphs mean higher amplitude then grey.
Basically frequency band contained in both graphs is around 50 kHz. At 600 s (Fig. 9) in comparison at 90 s (Fig. 8) there is interesting frequency 320 kHz which is contained in whole followed time and has relatively small amplitude.

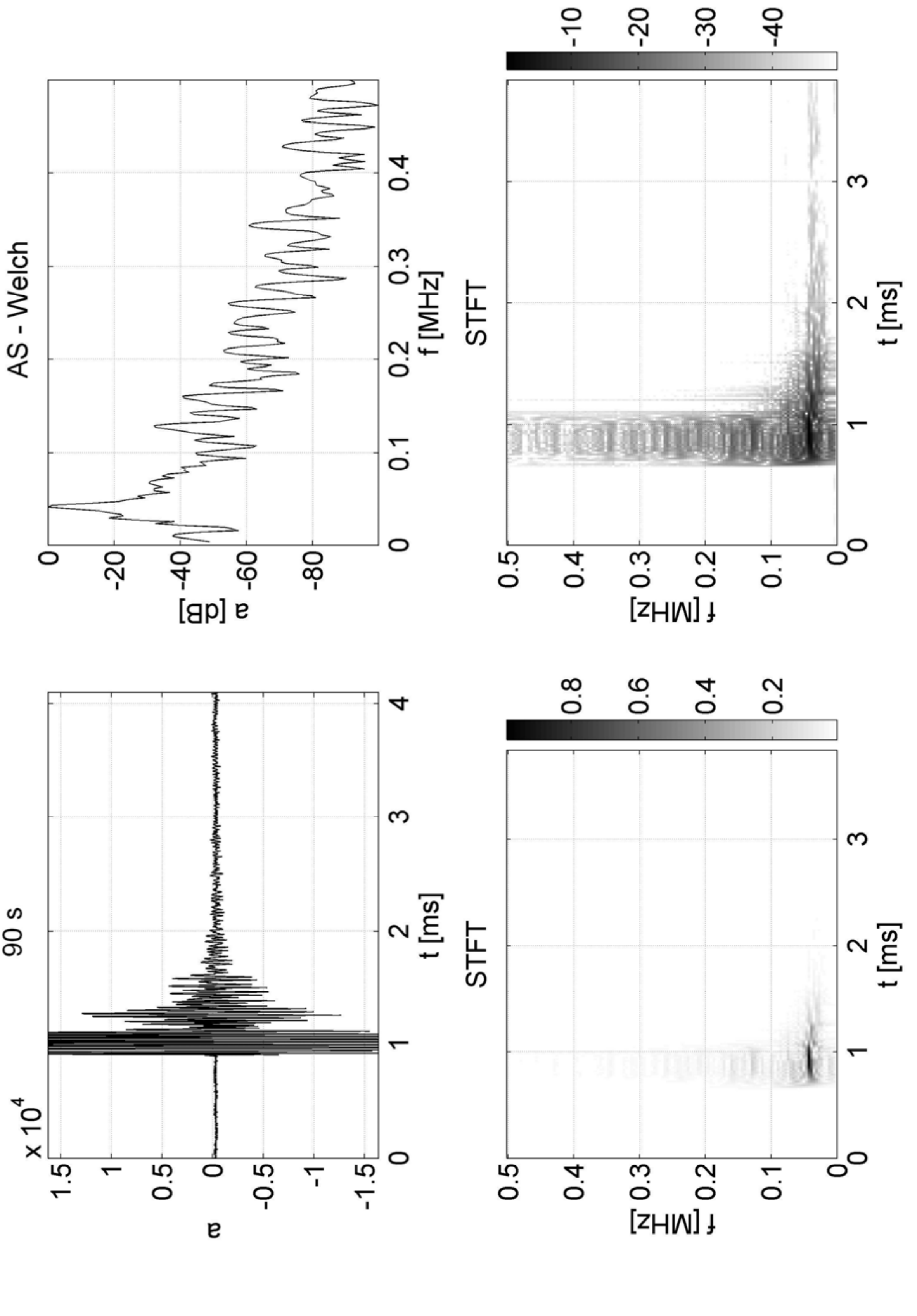

Fig. 8: Recorded hit in 90 s.

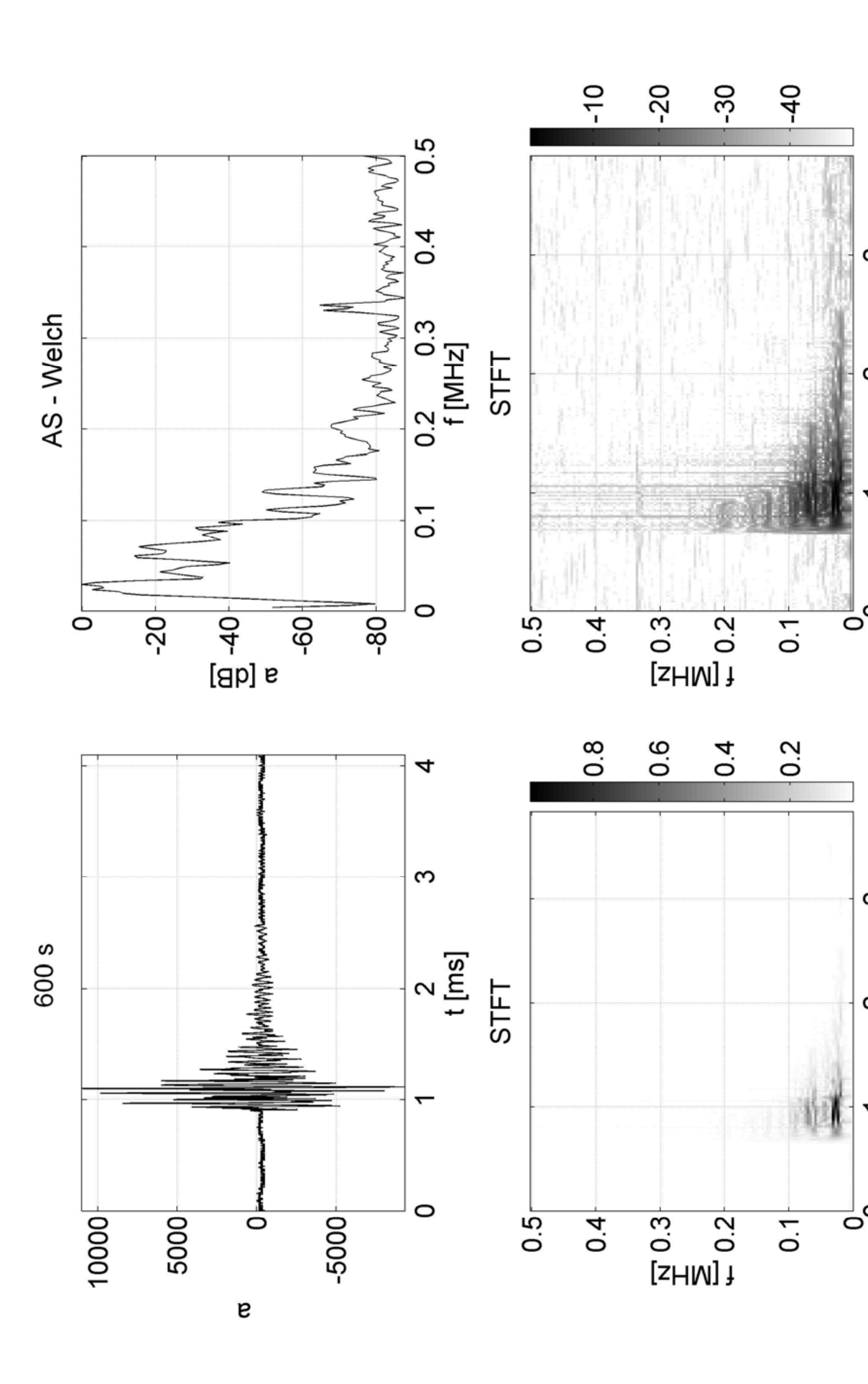

Fig. 9: Recorded hit in 600 s.

5. Methods of test join metal timber

One of the tested samples before loading is shown in Fig. 10. After experimental loading each of samples was followed visually. Defect on the surface of specimen are obvious (Fig. 11). Comparisons of some tested timber-steel join (system MKD, nail and pinned) are shown in Fig. 12. Extension was measured classical method (strain gauge) and by videoextenzometer.

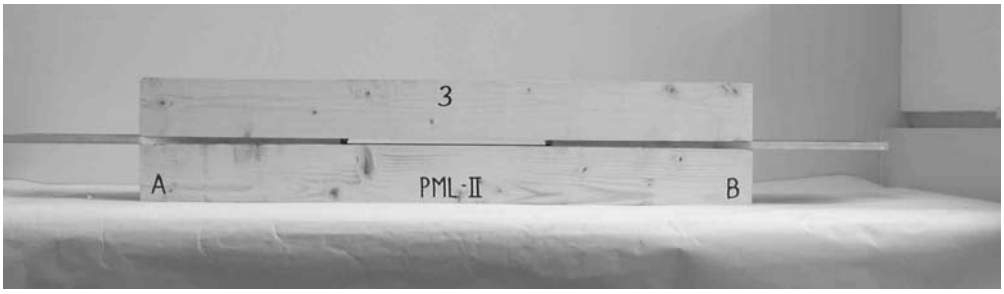

Fig. 10: The tested specimen.

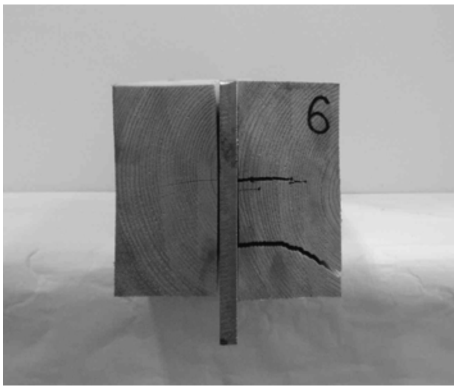

Fig. 11: The test specimen with crack after loading.

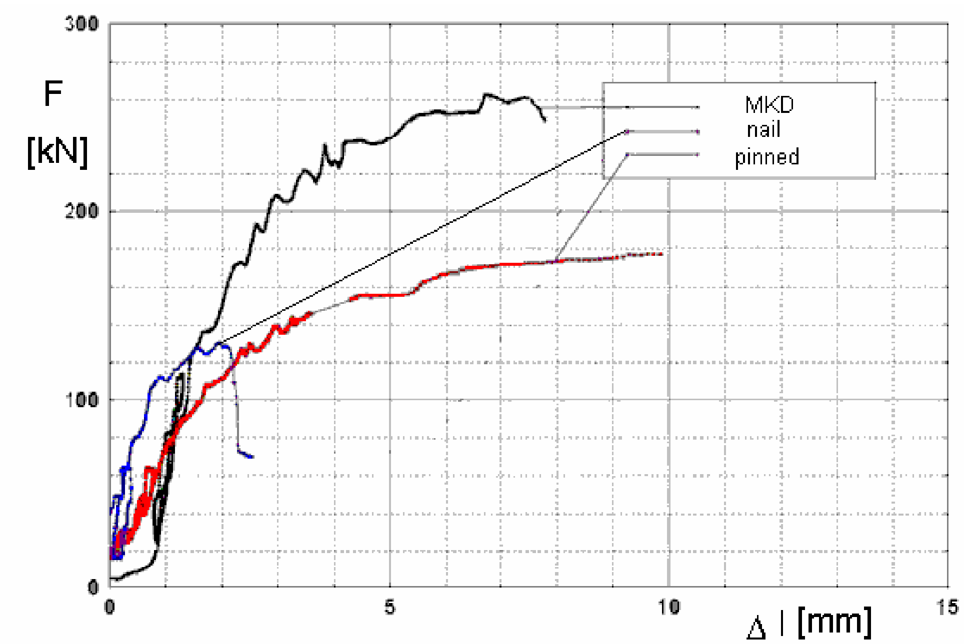

Fig. 12: Diagram of dependence loading and strain.

Deformation measurements by videoextenzometer offer global information about behavior steel-timber joint in whole observed areas. Evaluation of acquired values is determined displacement of particular point of timber element or their group with regard to point on fix equipment. Evaluation of acquired values is determined displacement of particular point of timber element or their group with regard to point on fix equipment.

6. Conclusions

Application acoustic emission method at non- and destructive testing can bring very interesting results in view of origins or process destruction suspense structure. How has already been stated in the introduction, this method records only active defects in structure. However these defects record essentially earlier than most of common methods, which record as well inactive defects.
Introduced charts and their descriptions illustrate possibilities classification so simple test, how detailed analysis acoustic emission signal parameters or signals would show possible determine "relative" signal sources at simple tension test and. In this case, whether originate defects was at deformation of wooden or metal parts.

Acknowledgements
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7. References

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