RHEOLOGICAL BEHAVIOR, IN NATURAL ENVIRONMENT CONDITIONS OF WOOD JOINTS OF A ROOF STRUCTURE

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REZUMAT. Lucrarea prezintă studiul principalelor îmbinări din componenţa unei structuri de acoperiş. S-au măsurat deformaţii ale îmbinărilor în funcţie de temperatura şi umiditatea relativă a aerului din mediul de testare, pentru fiecare îmbinare în parte. S-a realizat o comparaţie între deformaţiile îmbinărilor luate în studiu, pentru aceleaşi condiţii climatice, în funcţie de tipul îmbinării, de încărcare şi de poziţionarea în structura acoperişului. S-a realizat o comparaţie a deformaţiilor celor trei îmbinări, pentru fiecare anotimp în parte.

Cuvinte cheie: structură de acoperiş, îmbinări în lemn, deformaţii în timp, temperatură, umiditate relativă.

ABSTRACT. This paper presents a study of principal wood joints from different parts of a roof structure. There were measured deformations of joints related to temperature and relative humidity of air from the testing environment, for each joint separately. A comparison between joints deformations in study was made, for the same climatic conditions, related to joint type and loads and position in the roof structure. For each season, were compared deformations of the three studied joints.

Keywords: roof structure, wood joints, deformation in time, temperature, relative humidity.

1. INTRODUCTION

Wood constructions represent an important area in the world’s economy, because, nowadays, there is a tendency of using wood on a large scale. This tendency is justified by the technical, economical and technological advantages that it presents. The lack of fundamental research regarding wood joints in constructions and optimal joints from a rheological point of view imposes research that completes recent information and discovers the behavior of wood, so much used and not yet fully discovered.

2. IN TIME WOOD BEHAVIOUR

Wood constructions are exposed to different loads: both short and long term types of loads. Joints, like other elements, take this load, and are subject to different ways of deformations, terms of load time and other external factors. Joints are the main areas where energy may be dissipated by the possibility of using the plastic capacity of these parts of the structure (Madsen, 1992).

It has been practically demonstrated that wood deformation doesn’t occur just like an instantaneous change of form immediately after load is applied, but there is a continuous process of deformation under load, named *slow flow*. In certain conditions of temperature and humidity, under loads exercised over a long period of time, deformations increase until crack. (Öiger, 1994).

The slow deformation (creep) of wood is determined by important factors like: climatic conditions, relative humidity, temperature, moisture content of wood. The process of changing the moisture content will also increase the creep (Curtu, Roşca, 1993).

3. BEHAVIOUR OF WOOD JOINTS FROM A ROOF STRUCTURE

In order to determine deformations in time of the roof structure in Figure 1, there have been chosen, for the analysis, three types of representative joints, from different parts of the structure, with different levels of taking over loads.

Measurements were made using dial gauges and a temperature humidity logger. For measuring deformations of joints, a wood piece has been attached on one of the joint’s elements, in order to take and send deformations and displacements to the dial gauge, located under the wood piece.

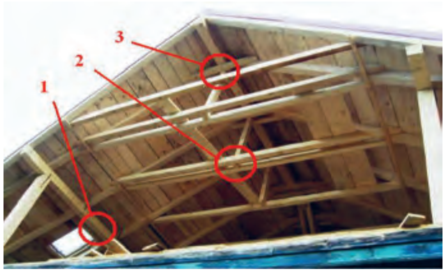


Fig. 1. Studied roof structure.

Measurements were made for 489 days. The measurement frequency of displacements was 7 days average, the one for temperature and relative humidity was 24 hours. Results of these parameters measure were presented in Figure 2 and 3.

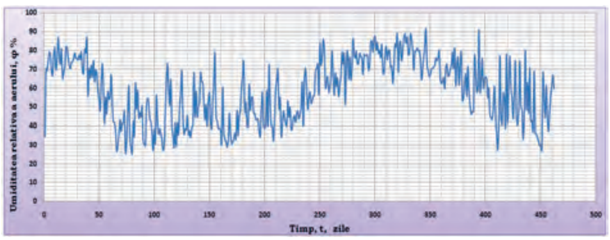


Fig. 2. Variation chart of temperature for 489 days.

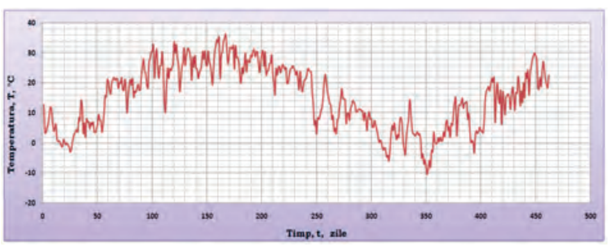


Fig. 3. Variation chart of temperature for 489 days.

It has been observed that relative humidity of air in the measurement environment had a variation between 25,5 % (in spring time) and 91,4 % (in winter time). The environmental temperature had a variation between –10,5 ^{o}C (in winter time) and +36,2 ^{o}C (in summer time). When temperature increases, the relative humidity decreases.

One of the devices was fixed on the middle point of the beam, to measure its deformation (Fig. 4). Deformations registered for 489 days were correlated with temperature and relative humidity variation, data being shown in Figure 5.

Total deformation of the first joint was 0,2367 mm. These deformations are higher with the increasing of relative humidity and the decreasing of temperature. They have strong fluctuations when climatic parameters vary. The lowest value of deformation was at higher temperature and lower humidity. The higher deformation was at lower temperature and higher humidity.

a. b. c.

Fig. 4. Device during measurement for the beam .

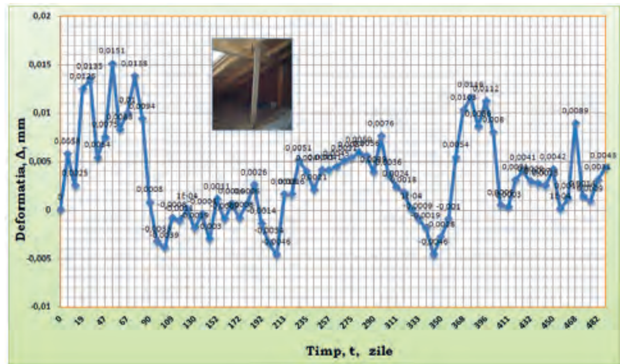
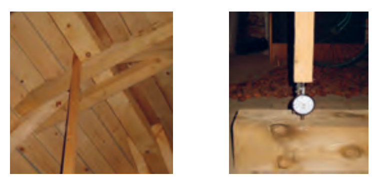


Fig. 5. Deformation of the beam for 489 days.

The second device was placed, in the same way, to the highest joint in the roof structure. It was attached on one of the joint's element, as shown in Figure 6. Deformations of the second joint, registered for 489 days, were presented in Figure 7, related to temperature and relative humidity of air fluctuations.



a. b.

Fig. 6. Device during measurement for the second joint

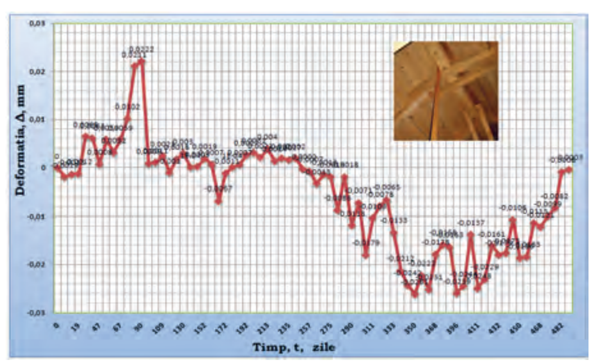


Fig. 7. Deformation of the second joint for 489 days.

It has been observed that the second joint taken into study had slower variation than the first one for the same measuring period of time and same climatic conditions. Total deformation of the second joint was 0,4134 mm. The higher deformation value was at the highest temperature and lower humidity. The lowest value of deformation was at the lowest humidity and higher temperature.

Figure 8 presents the third joint that was analyzed in the same way as the others, from the highest position in the roof structure.

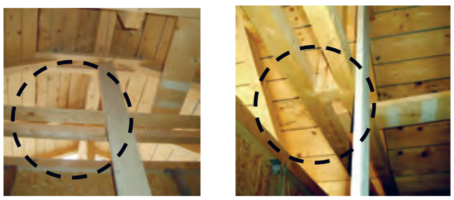


Fig. 8. Device during measurement for the third joint.

After 70 days from fixing the device, the joint had displaces so that the wood element attached to the joint had no more contact with the dial gauge. It was necessary to reposition the measuring device. Deformations of the joint during measurements are shown in Figure 9. Total deformation of this joint was 0,1954 mm, which demonstrates that there has been shrinkage of the elements. This shrinkage determined the displacement of the wood element from the dial gauge.

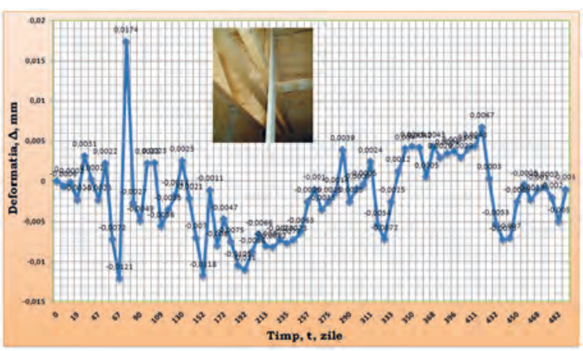


Fig. 9. Deformation of the third joint for 489 days.

It has been observed that the higher deformation value was at the highest humidity and lower temperature. The lowest value of deformation was at lower level of both humidity and temperature.

4. ANALYSIS OF THE INFLUENCE FACTORS ON JOINT BEHAVIOR IN TIME

The comparative analysis of the three joints was showed that the joint from the top of the roof structure had the lowest values of displacements during the 489 days of study, but also had the highest differences in value. The registered data are shown in the graph in figure 10.

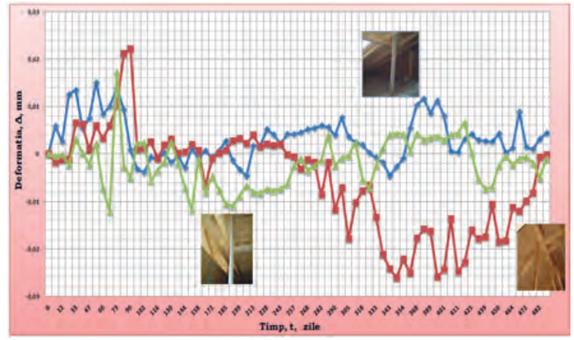


Fig. 10. Deformation of all studied joints for 489 days.

Figures 11-14 show seasonal deformation for one year for each joint. Thus, for the beam considered in the study (Fig. 11.), the highest values of displacements and the largest fluctuation occurred in winter-spring when the air temperature and relative humidity were extreme values, but also because of snow loads. Summer-fall recorded movements were relatively constant and close to values lower than winter-spring.

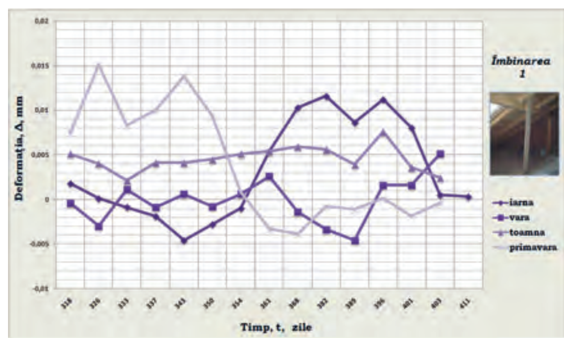


Fig. 11. Deformation of the beam on seasons, for one year.

For the connection of Figure 12 there were also extreme values of displacements in the winter-spring period, much higher than those of the beam studied. Over the summer the displacements are small.

Third joint taken in the study behaved differently from the other two, small variations occurring between seasons.

For each season, there have compared the three joints deformations studied. It was observed that during spring, the three joints behaved similarly, the values are close. During summer, the third joint's movement was lower compared with the first two. For autumn-winter periods, the joint at the top of the structure analysis showed significant differences of displacement, compared with the other two analyzed.

5. CONCLUSION

It has been observed that the second joint had the slowest deformations in time. Cyclic variation of relative humidity determines cyclic variation of deformations. Joint deformations decrease with the increasing of temperature values. Higher temperatures, determine lower relative humidity values, which take to deformations of joints. For the first two joints, deformations were higher than for the third one.

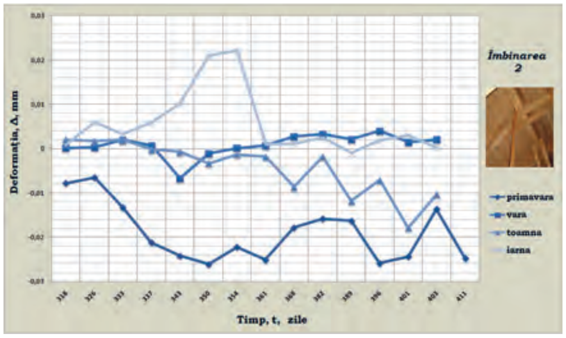


Fig. 12. Deformation of the second joint on seasons, for one year.

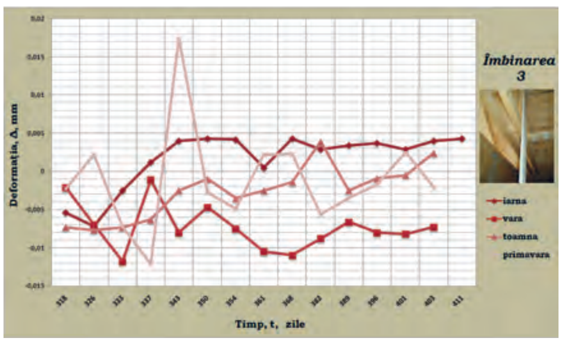


Fig. 13. Deformation of the third joint on seasons, for one year.

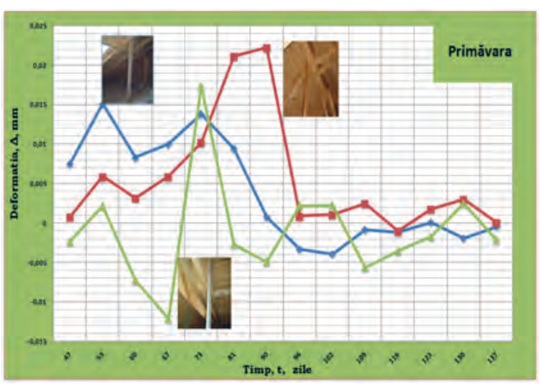


Fig. 14. Deformation for the three joints during spring.

The errors appeared are given by the deformations of the wood element attached to the joint in study, the size of these elements and deformations of the device's support. There are also very small differences between climatic conditions in the area of joint positioning into the roof structure.

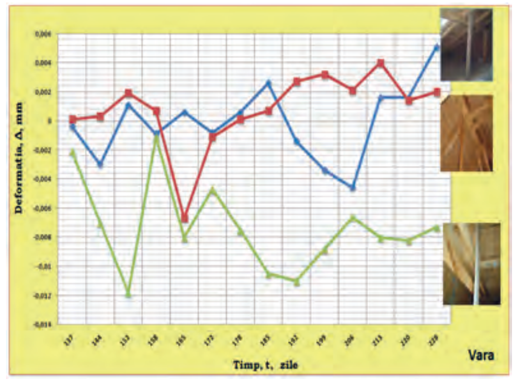


Fig. 15. Deformation for the three joints during summer.

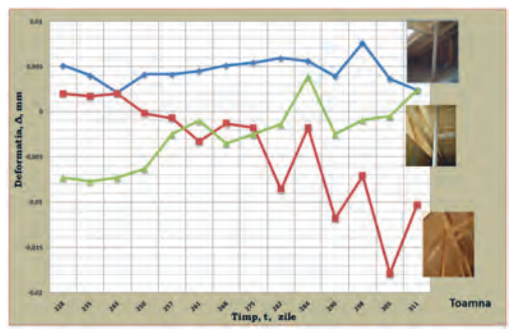


Fig. 16. Deformation for the three joints during autumn.

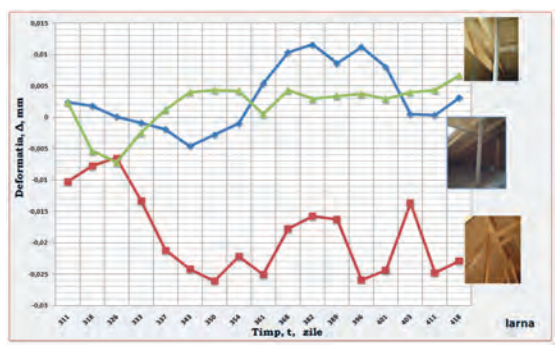


Fig. 17. Deformation for the three joints during winter.

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