Analysis of stress and deformation of the flood barrier

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Abstract: Increasing security protection of the population against floods has become in recent years a complex issue. It is a fact that the flood barrier should be light, easy to assemble, easy to store and also impermeable. In this article was compiled methodology for measuring and testing and analysis of flood defenses in hydrodynamic laboratory. Tests were conducted by impact with wood log on the flood barrier, which evaluated stress and strain flood barriers.

Keywords: Flood barrier, experimental measuring, numerical analysis, stress, deformation

1 Introduction

Analysis of stress and deformation of the flood barrier is Important for optimization design. Dimensioning, material properties, geometry flood barriers are very important for fast assembly, tightness and adequate mechanical properties for the protection of the population against floods. Impact with wood log into the flood barrier is one of the tests forming a methodology for testing the flood barriers [1, 2, 3].

2 Description of the solution

Experimental device parameters and settings was retained for comparison. Impactor (wood log) moves of speeds 0,2 - 2 m.s^{-1}. The whole process took away speed-camera and performed the record of measured values. Measurements were made in hydrodynamic laboratory at company JAP-Jacina (Fig.1). Measurements were performed using a system DEWETRON DEWE 5000 (Fig.2). Record the measurement data including the synchronized recording of speed camera was performed on this disk device. It was necessary to correct the force and acceleration from measured data of dynamometer and accelerometer. It was found that these forces cannot be ignored. Repeat several rounds open circuit and comparing records, we concluded that the records are identical and reproducible. Maximum deflection plates of flood barriers at the moment of impact, which was calculated as the difference signal "center" and the diameter of the signals of the two edge sensors. This calculation is based on the assumption that the extreme sensors measure the deformation of the rubber seal fins in the anchoring columns. The difference signal thus eliminated this distortion, and shows the actual deflection plates of flood barriers. From the mean values of acceleration of the impactor was calculated energy deformation by the Eq. (1).

$$E = m \int_0^{h\max} a(s)ds \quad ; \quad E_{cylinder} = \frac{1}{4}\pi d^2 \int_0^{h\max} p(z)dz \tag{1}$$

In the preceding formula represents: E - mechanical energy [J], m – mass [kg], acceleration [ms^{-2}], d – diameter of cylinder [mm], p(z) - pressure [kPa].

To determine amount of strain and the size of the stress between the wood log and plate of flood barrier were compiled numerical analysis using the finite element method in the program Ansys Workbench 14.5. Ansys uses implicit algorithm for calculations [3], where individual states of the analyzed compression are updated gradually in time t to time t+dt according to Eq. 2.

$$\delta u_{i+1} = u_{i+1}^{t+\Delta t} - u_i^{t+\Delta t}. \tag{2}$$

Where $u_i^{t+\Delta t}$ is vector of nodal displacements for ith iteration in the time $t + \Delta t$.

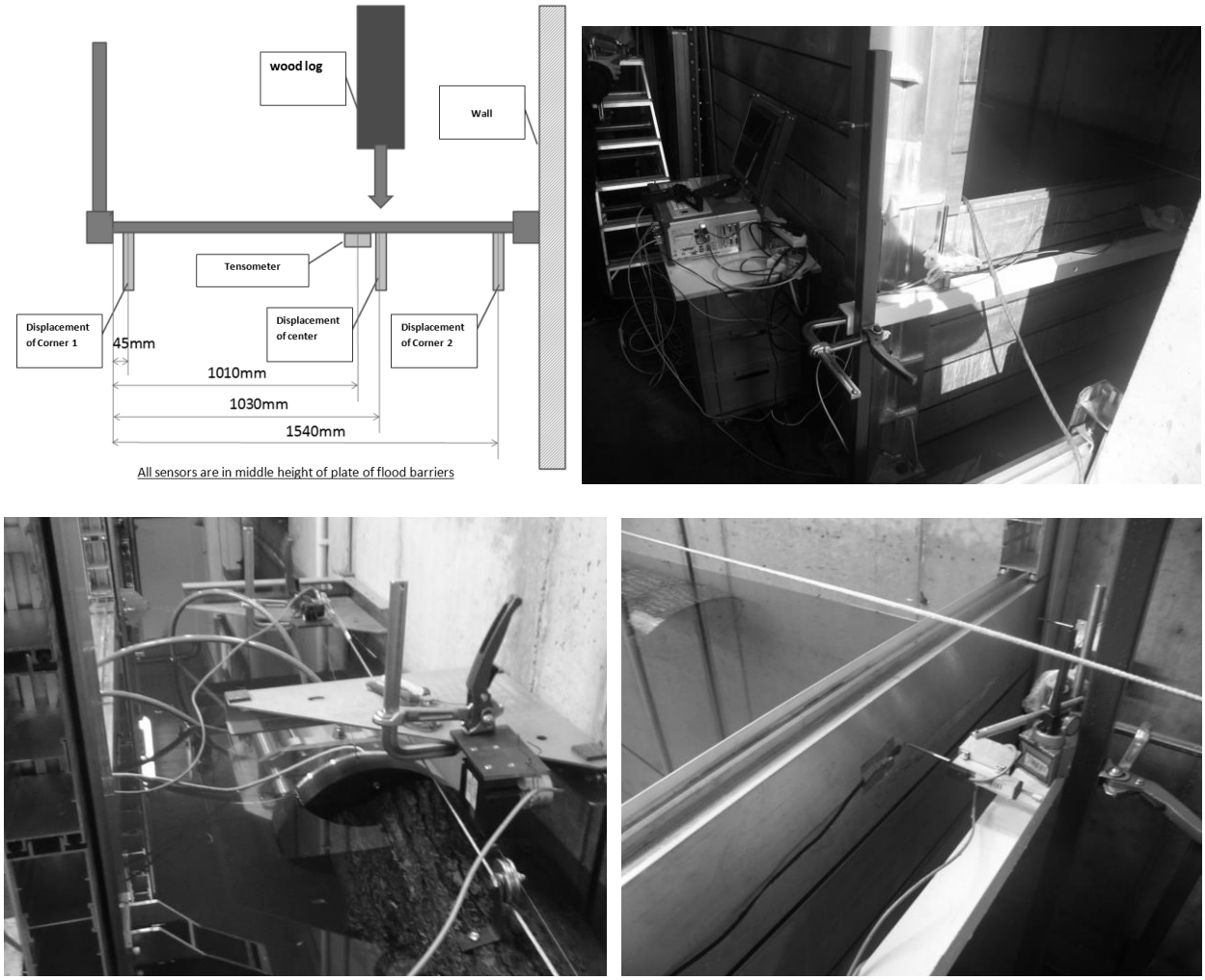

Fig. 1: Experimental device and measurement on the flood barrier in hydrodynamic laboratory

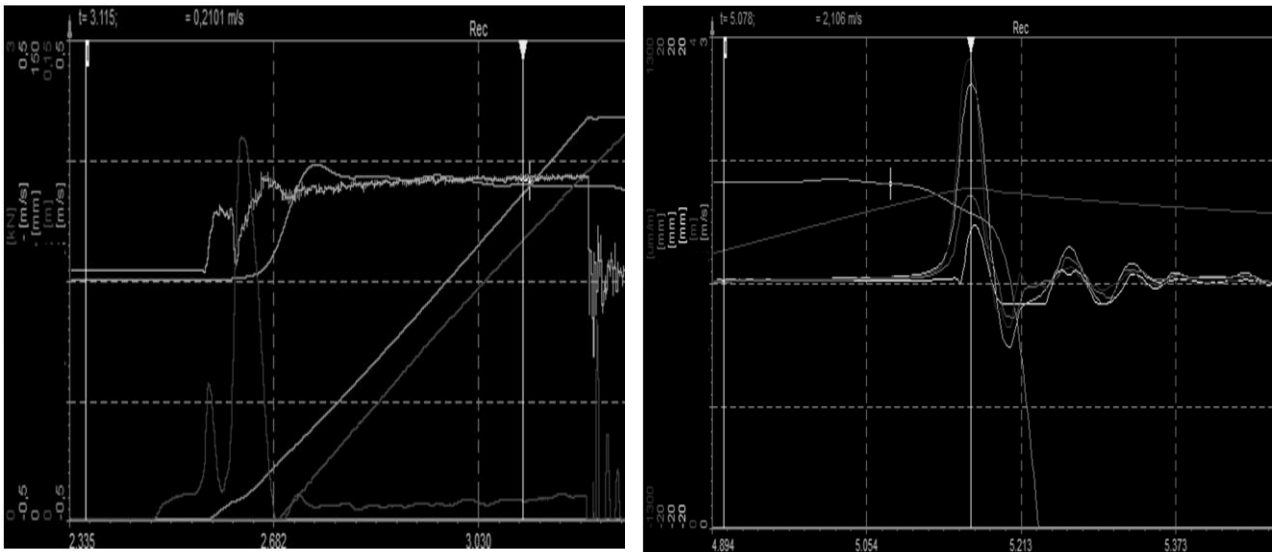

Fig. 2: Experimental data from system DEWETRON DEWE 5000

3 Results and summary

8 measurements were performed for speed of 0,1 - 2 m / s. From the measurements was evaluated the results:

- Velocity of wood log in the impact of flood barrier.
- Maximum deflection plates of flood barrier at the moment of impact. It was calculated as the difference signal "center" and the diameter of the signals of the two corners sensors (see Fig.1).

This calculation is based on the assumption that the extreme sensors measure the deformation of the rubber seal in the plate of flood barrier. The difference signal thus eliminates results distortion, and shows the actual deflection plates of flood barrier.

- Maximum value of relative elongation ε plates of flood barrier at the moment of impact.

The dependence of the measured signals at speeds aren't see clear (Fig. 3). It may be due to loss of water in a test channel due to the considerable volume of water which overflowing at impact. The water was continuously added in hydrodynamic laboratory, but the level of water between tests gradually declined. This will also reduce the impact place of wood log in plates of flood barrier. Time visual record of the impact of wood log on the plates of flood barrier is seen on the Figure 4. Figure 5 show results of deformation and stress in plates of flood barrier. Results on the Fig.5 were calculated by using FEM simulation of impact of wood log on the flood barrier according a schema on the Figure 1, above left. All results are in the table 1.

Tab. 1: Results of measurement of displacement and elongation of plate of flood barrier

Measurement	Velocity [m/s]	Center [mm]	Wall [mm]	Corner n.2 [mm]	Displacement [mm]	Elongation [um/m]
1	0,8	6,0	2,5	2,5	3,5	614
2	1,1	8,3	3,3	3,3	5,0	818
3	1,0	7,7	3,1	3,1	4,6	780
4	1,4	10,1	3,9	3,9	6,2	944
5	1,5	12,1	5,4	3,5	7,7	888
6	1,9	13,5	5,3	3,3	9,2	846
7	1,95	15,9	7,3	4,3	10,1	1138
8	2,01	17,5	7,0	5,3	11,4	1331

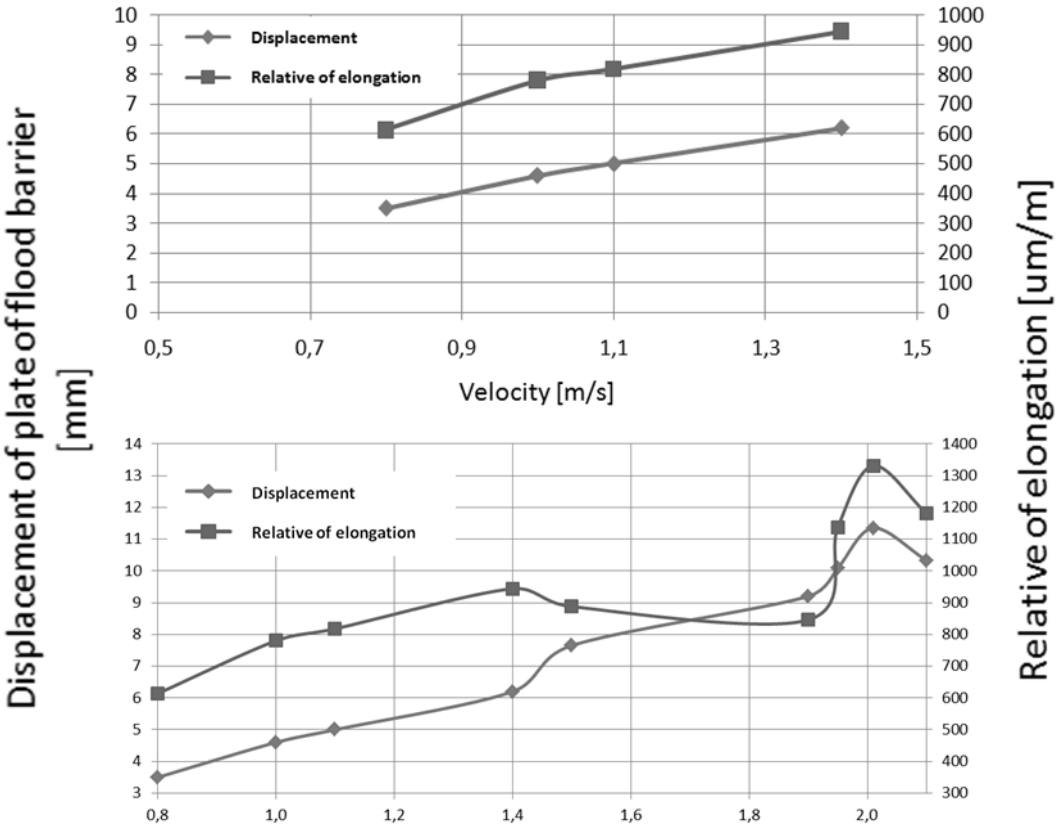

Fig. 3: Experimental device and measurement on the flood barrier in hydrodynamic laboratory

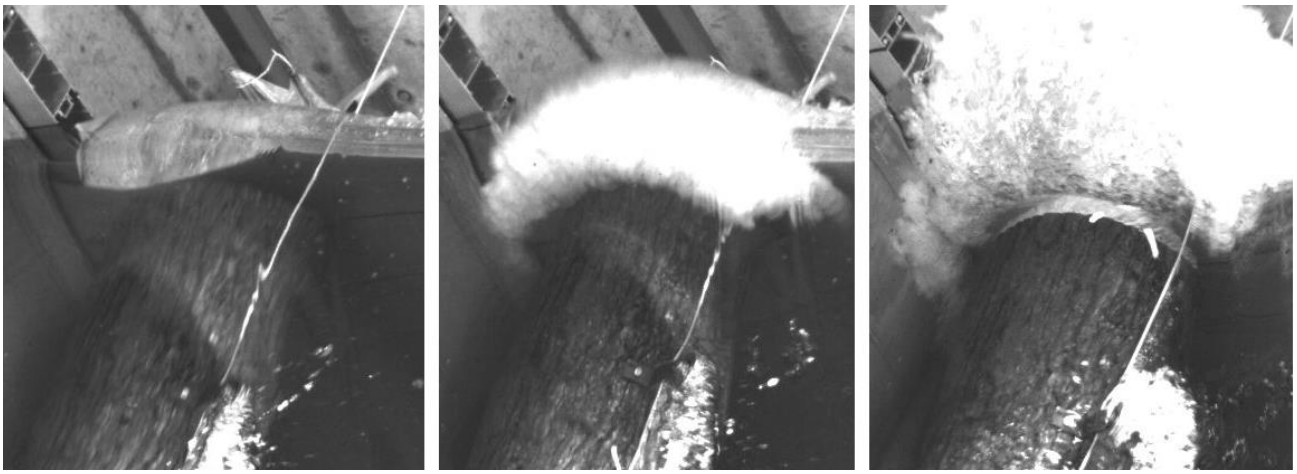

Fig. 4: Time response of detail impact of wood log on the plate of flood barrier

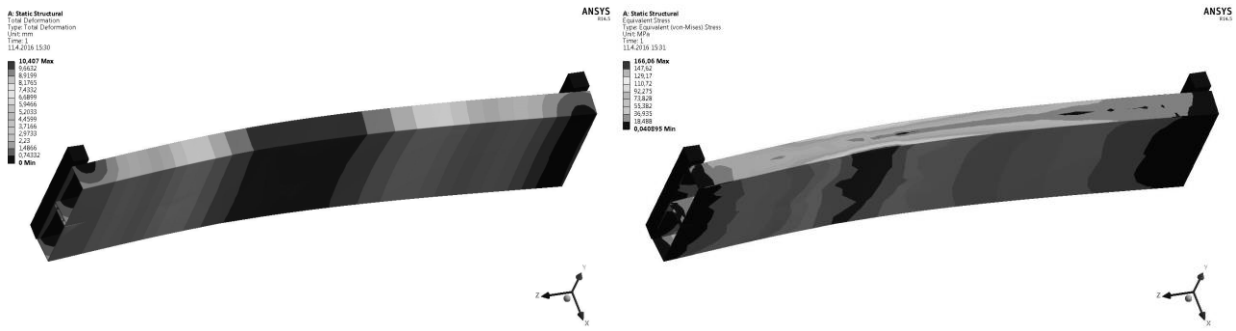

Fig. 5: FEM analysis: Deformation and stress of flood barrier

4 Conclusion

The tests and measurements of the current flood barrier suggest that are adequately dimensioned for impact of wood log. This has been demonstrated by measurement, FEM calculations and operations during the floods themselves. Of all the results show that all monitored signals are highly dependent on the speed of wood logs and place of impact in plate of flood barrier. In creating a methodology for conducting these tests will therefore need to strictly define the layout of the experiment, resp. correct placing sensors and clearly define how the impact load, thus the water level, a speed and angle of impact.

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