A SIMULATOR OF MUTUAL DISPLACEMENTS IN HYDROTECHNICAL STRUCTURES

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1. INTRODUCTION

Safety requirements for hydrotechnical structures impose a duty of monitoring displacements of the structures' elements as well as their mutual displacements onto users of weirs and dams in an assumed external frame of reference (The Official Journal of 1997, No 21, Item. 111, The Official Journal of 13 March 1995, No 25, Item. 133). To examine mutual displacements of structural elements separated with a expansion joint a flat gap gauge is used among others (CBSiPH, 1975). The gap gauge has been designed in the Central Research and Water Construction Design Office "HYDROPROJEKT" in Warsaw and is used for measuring mutual displacements of elements of weirs and dams. See the below presented designed and produced prototype of a displacement simulator.

2. THE GAP GAUGE PRINCIPLE OF OPERATION

The gap gauge is composed of three duly situated bolts (CBSiPH, 1975). These bolts are fixed in concrete, with use of a mould, on both sides of a expansion joint (fig.1). The construction idea consists in making an equilateral triangle of the bolts, of a side length of 254 mm (10 inches), while one of the sides should be parallel of the expansion joint.

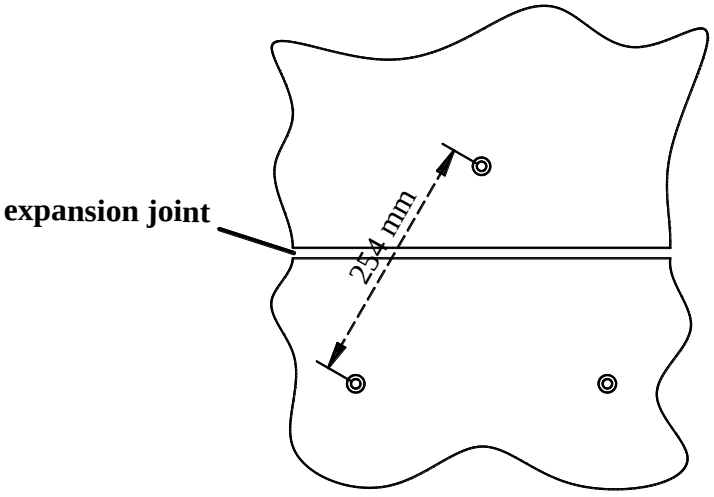

Fig. 1. Scheme of location of the gap gauge bolts towards the expansion joint.

The length of the triangle sides is measured. In case of a change in mutual position of the elements, the lengths of two sides will change (fig.2).

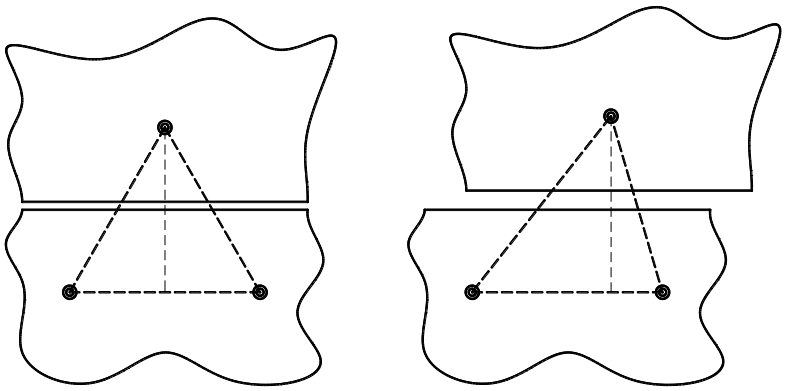

Fig. 2. Scheme of position of the gap gauge bolts before and after displacement of the examined elements.

With the knowledge of the triangle sides lengths of the initial and periodical measurement *w, p,* and *q* are respectively calculated (fig. 3) according to the formulae (1-4):

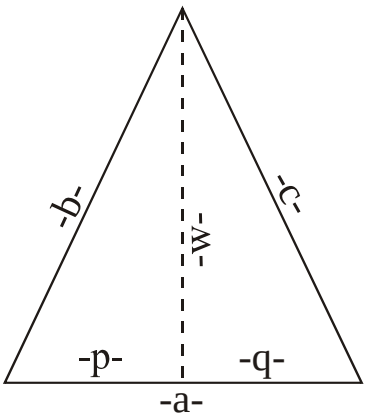

Fig. 3. Marking scheme.

$$p = \frac{a}{2} + \frac{b^2 - c^2}{2a} \qquad (1)$$

$$q = \frac{a}{2} - \frac{b^2 - c^2}{2a} \qquad (2)$$

$$w = \sqrt{b^2 - p^2} \qquad (3)$$

control :

$$w = \sqrt{c^2 - q^2} \qquad (4)$$

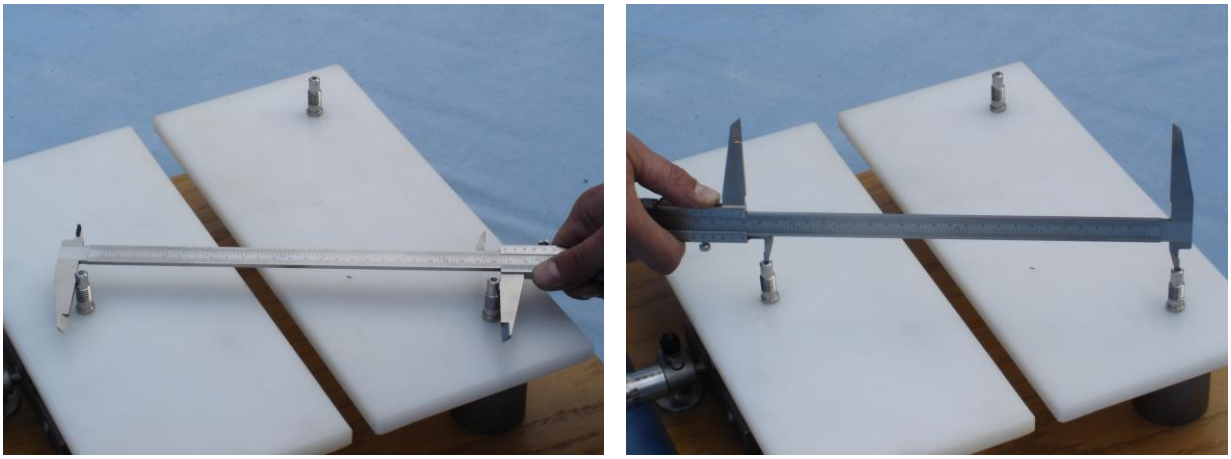

Fig. 4. Methods of measuring the triangle sides lengths a) towards the bolts, b) towards the bolt centres.

When the results differ, it means the examined elements have changed the position. The measurement of the triangle sides lengths is done with a slide caliper towards thetriangle forming bolts or towards the cavings in them (fig.4).

3. SIMULATOR OF FLAT DISPLACEMENTS

For didactic and testing purposes a device simulating mutual displacements of structure elements has been designed and constructed (Bioły G. 2005), presented in fig. 5.

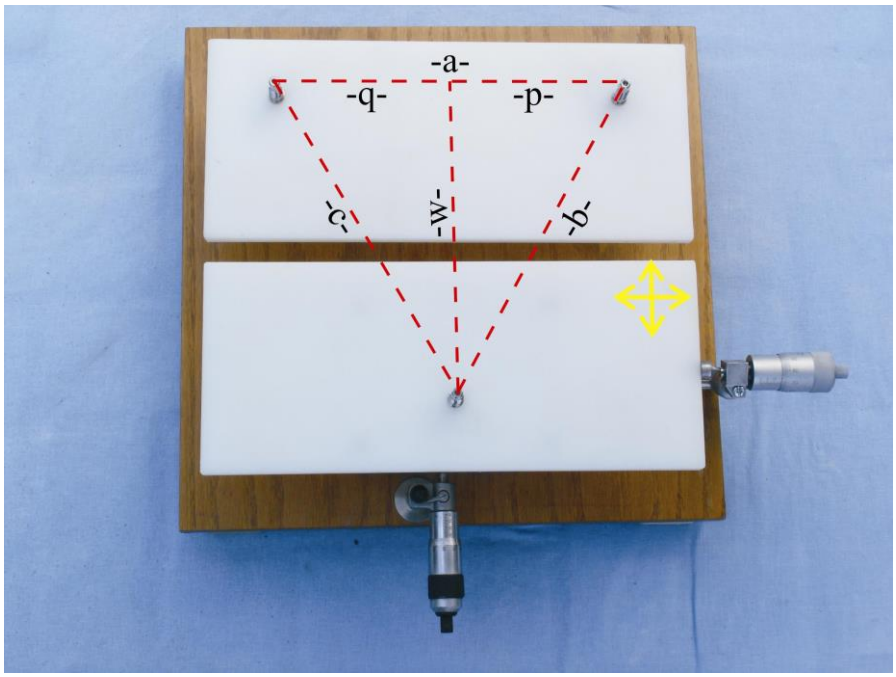

Fig. 5. Examle of realized displacement simulator.

Displacement simulator (fig.5) is composed of the following elements:

- **a base,**
- **a static element,**
- **a movable element,**
- **three bolts of the gap gauge,**
- **two micrometric screws.**

The operation principle of the simulator consists in moving the movable element with use of the micrometric screws in two mutually perpendicular directions, i.e. one parallel of the expansion joint and the other perpendicular of it. By measuring triangle sides lengths before and after mutual displacements of the simulator elements the *w, p, q* parameters are calculated. Knowing the real values of mutual displacements of elements read from the micrometric screws and calculated from the triangle sides lengths measurement (1-4) one can define the real accuracy of displacement measurements with a specific slide caliper. Within the framework of his degree thesis (Bioły G. 2005) a several hundred measurements were done of mutual displacements of the simulator elements. The measurements were executed in the following way: first the location of the movable element was changed with the use of micrometric screws, then the side lengths were measures with a slide caliper, the *p, q* and *w* values were calculated and compared with readings of the micrometric screws. For a slide caliper of a nominal accuracy of 0,02 mm, a real accuracy of measurement of displacements of 0,03 mm has been achieved.

4. CONCLUDING REMARKS

The above presented device makes it possible to:

- **undertake a simulation of mutual displacements of elements separated with a expansion joint in lab conditions, and**
- **define the real accuracy of measuring instruments used to measure changes in expansion joint width.**

The presented simulator has been a subject of a patent application to Polish Patent Office (Anigacz W., Bioły G. 2006). At the Fifth Stock-Exchange of Innovations in Opole (2007-03-12) it won the Main Prize in the category of Educational Innovations.

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