USE LASER TO MEASURE GIRDER DEFLECTION

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1.0. INTRODUCTION

In engineering practice, there are often required to carry out the measurement of beam, girder or plate deflection in a short time in a few chosen points. Traditional methods, based on the measurement by dial gauges, inductive or surveying methods, require the commitment of the team, need expensive and complicated equipment and are time consuming [2].
The paper presents a new, simple way to measure deflection of selected items using the device DKKZ-2010, which uses a laser light source.

2.0 A GENERAL DESCRIPTION OF THE PROTOTYPE INSTRUMENT DKKZ-2010

Described in this article DKKZ-2010 device is a prototype of automated instrument used for measuring the deflection of structural elements in many points in a short time. The prototype is based on the use of directing a laser beam in conjunction with laser rangefinder (Fig. 1).
The usefulness of the instrument DKKZ-2010 was examined in a model and the measurement of the foot-bridge - pedestrian connector between the two buildings. In the case of model tests results of the measurements of deflection device DKKZ-2010 compared with the results of measurements made by TOPCON's N22 leveller. Readings were made on the measuring staff about a millimetre scale.

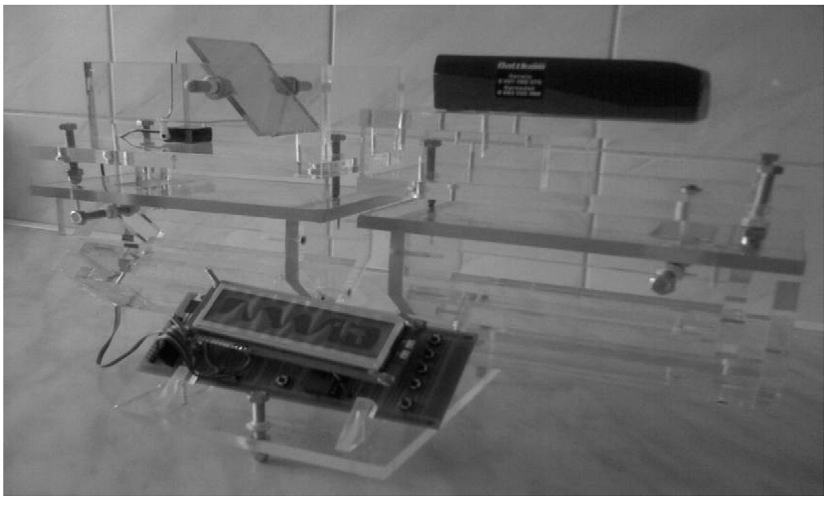

Fig. 1. General view of construction and the control system of prototype instrument DKKZ-2010 to measure the deflection.

The prototype uses laser rangefinder Leica DISTO D3, which accuracy is [3]:
- **0,1 mm for measure distance to 10 m,**
- **$(0,1 + 0,025 \cdot 10^{-6}D)$ mm for distance 10 – 30 m,**
- **$(0,1 + 0,1 \cdot 10^{-6}D)$ mm for measure distance above 30 m.**

To obtain the high accuracy distance measuring by rangefinder, it was decided that the maximum range of the instrument is measuring up to 30 m.

In order to determine the effect of changing direction of the laser beam on measurements, theoretical analysis course of the light rays was performed. The graph of the accuracy depending on the location of the measuring point over the device was drawn (Fig. 2) [1].

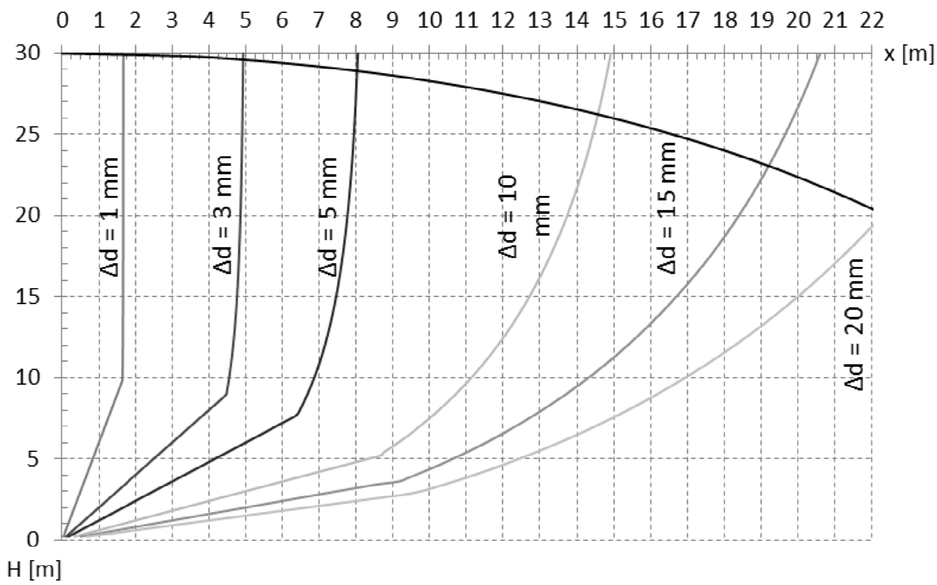

Fig. 2. Accuracy nomograph of deflection measurement as function of the position of the measuring point over the device DKKZ-2010 [1].

3.0 . MODEL TESTS OF FLAT BAR DEFLECTION

3.1. Diffraction study of steel flat bar

In model measurements was used a flat steel (the black - brown colour) with dimensions 5 x 45 x 1130 mm. Supporting points are spaced about 110 cm. On flat bar marked 5 measure points. Measurements were conducted at three different heights above the base of the instrument: 84 cm, 116 cm i 147 cm (Fig. 3).

Fig. 3. View position for measurements in terms of model.

Fig. 4. View of load flat bar with measuring staff for deflection control by leveller.

It was made full cycle of loading and unloading involving additional weight load of steel flat bar weighing 6.63 kg and subsequently weighing 9.34 kg, then the mass reduction of 6.63 kg and removing the load. The mass was applied in the middle of the flat bar (Fig. 4). Examples of results of flat steel deflection measurements using the DKKZ-2010 and control measurements by leveller are shown in Fig. 5 and 6.

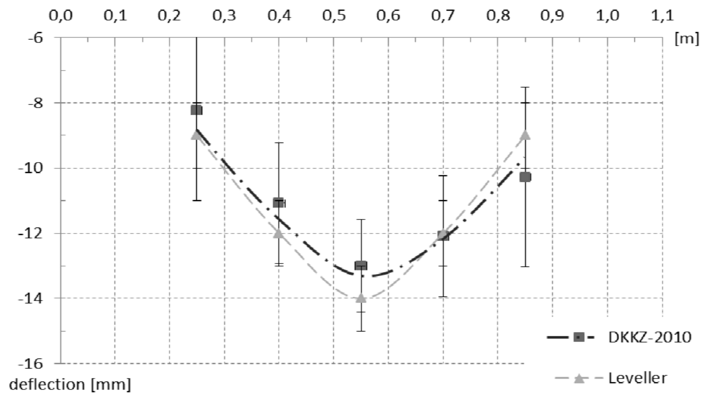

Fig. 5. Flat steel deflection for H = 147 cm and load 6,63 kg.

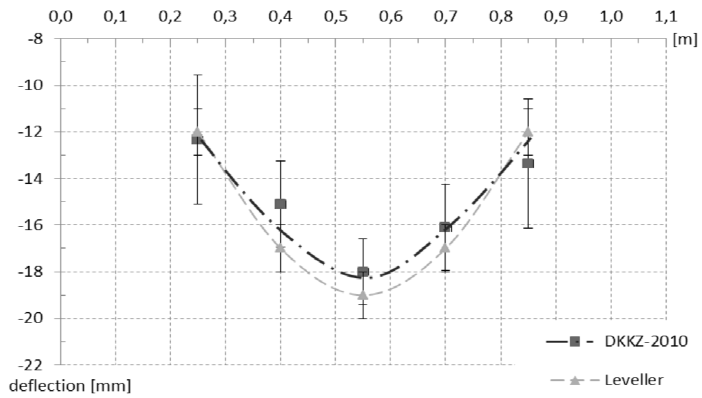

Fig. 6. Flat steel deflection for H = 147 cm and load 9,34 kg.

During the bending test was observed some random "distortions" of measurement results caused by incident angle of the laser beam on the oxidized surface of the flat. With the increase of the angle of laser beam on the element, speed measurements decreased from 2-3 measurements per second to about 1 measurement per 1-2 seconds. Specified angle of incidence angle is located between the incident beam and the normal to the surface of the measured steel flat.

3.2. Diffraction study of aluminium flat bar

In the measurement model also used a flat bar of aluminium alloy (with the silver surface) with dimensions 10x40x1526 mm. Supporting points of flat bar were spaced about 150 cm. On flat bar marked 5 measure points. The measurements were also measured at three heights from the base of the instrument in a series load - unload, as in the case of steel flat bar (point 3.1). Examples of results of flat aluminium deflection measurements using the DKKZ-2010 and control measurements by leveller are shown in Fig. 7 and 8.

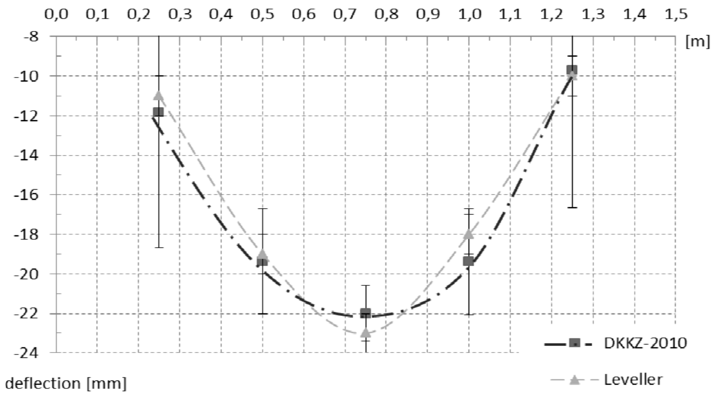

Fig. 7. Flat aluminium deflection for H = 147 cm and load 6,63 kg.

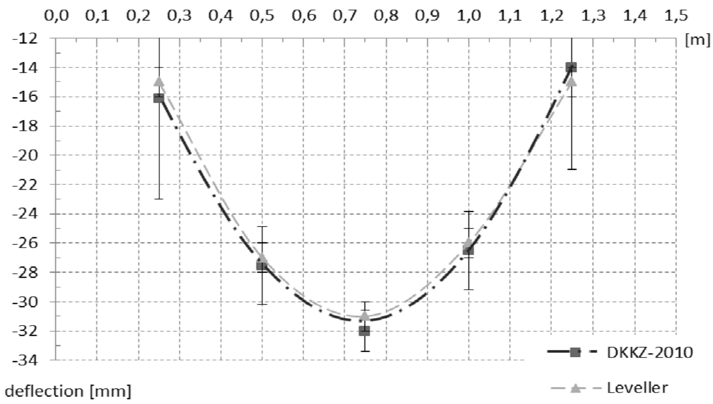

Fig. 8. Flat aluminium deflection for H = 147 cm and load 9,34 kg.

Comparing the flat deflection was found that the results of measurements obtained using the apparatus and the leveller overlapped to a greater extent than would result from a theoretical analysis of the accuracy (Fig. 2).

During the measurements it was observed that the measurements there was some "random glitches" of measurement results caused by the laser beam incident angle on the "silver" flat surface. As in the case of flat steel, an increase in measurement time with an increase in the angle of the laser beam on the element was observed.

3.3. Diffraction study - the shape of the bottom surface of the foot-bridge

The study of foot-bridge was based on the measurement of distance between the laser light source (rangefinder) and a lower surface of the foot-bridge (Fig. 9). The lower surface of the foot-bridge was made of a slightly convex, transversely arranged panels. As a result of the measurement was obtained the shape of the foot-bridge surface and partly bridge deflection.
Device DKKZ-2010 was placed under construction in the middle of its length. It was made two series of measurements at an interval of 10 minutes. Foot-bridge was unload by utilitarian load (no pedestrians). The results of measurements of the shape of the bottom surface of the foot-bridge was shown in Fig. 10. Solid lines indicated the range of angles, where the accuracy is in the range from 1 to 5 mm. Because of the "wavy" shape of the bottom surface of the foot-bridge, measuring points (Fig. 10) don't form a horizontal line. The results shows the presence of surface irregularities.

As in the case of measuring the deflection of the flat, it was observed that with increasing the angle of incidence of the laser beam on element, rate of measurement drops. In the case of angles of incidence of the laser beam on the structure in excess of 30°, measurement time for a single point increased to 1s. For larger angles of incidence, measurement time increased to 2 - 3 seconds.

Fig. 9. View of measured foot-bridge.

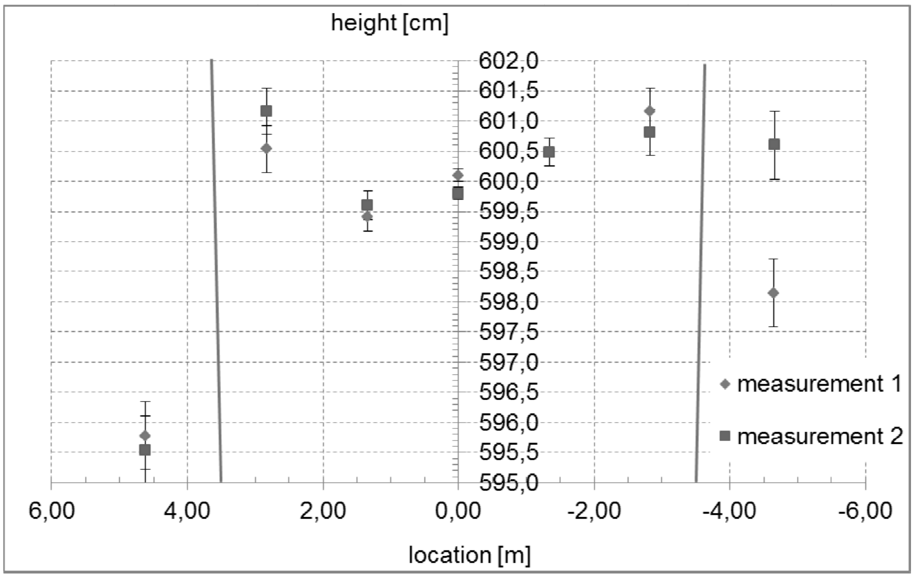

Fig. 10. The results of measurements of the shape - deflection the bottom surface of the foot-bridge (solid lines marks an accuracy range from 1 to 5 mm).

4.0. SUMMARY

On the basis of made analysis and measurement, it was found that the prototype of device DKKZ-2010 can be used for the determination of deflection or shape of selected elements in terms of model and real conditions (for structures, such as span of the bridge, girder of hall, ceiling beams). The usefulness of the instrument has proved to be the static loads. The prototype of instrument has the following advantages:
- low cost,
- easy operation,
- straightforward interpretation of the results obtained
- can be used in a variety of building conditions (in open field and in the halls)

The prototype of instrument needs further improvement to improve the accuracy and speed of measurement and its dimensions, as well as applications for measurement deflection caused by dynamic load and deflection at various levels.

REFERENCES

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