GEODESY MONITORING OF DEFLECTION OF A CRANE OF SUSPENSION ROOF OF A HALL – CONCEPTION, CONSTRUCTING SOLUTION AND TEST MEASUREMENTS OF MEASURING SYSTEM

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1. INTRODUCTION

Numerous catastrophes which occurred in 2006, especially referring to a series of unique in European building history collapse of construction of load carrying structures of roof slope of 3 exhibitory and public utility halls, force us to cogitate about purposefulness of introducing in Poland the system of early signaling and threat warning considering high gauge building objects which are susceptible to deformations under the carry weight of snow and/or ice.
Catastrophes, the most tragic in their results, which devoured together 146 victims, within just 2 months, concern vast exhibition – sport halls:

- **Ice rink in Bad Reichenhall (Upper Bavaria) on the 2nd January 2006, with 15 dead victims.**
- **Load carrying construction of a flat roof from light metal of Katowice International Fares in Chorzów hall on the 28th January 2006 (Bielgus, Rygulak, 2006). 65 people lost their life. It was the most tragic and the biggest catastrophe of a building object in the history of Poland.**
- **Collapsing of the roof of Basmann Market Hall in Moscow on the 23rd February 2006 with 66 victims of this tragedy.**

Instruments and additional devices used in dislocation measuring practice do not exhaust demand for new measuring technology, (Pachuta, Pachuta 1993; Ćmielewski, Kowalski 2005), that could considerably assist geodetic monitoring of building construction (Bryś, Przewłocki 1998; Jaśkowski, Jóźwik 2003).
In the study we present Telemetric Measuring System (TSP) elaborated by the authors. The system can be used for constant appointing the value of growth of an arrow of a crane deflection of suspension roof of vast exhibition – industry halls.

2. CONCEPTION AND BUILDING OF MEASUREMENT SYSTEM

Telemetric Measuring System consists of vertically hanged laser transmitter and measuring receiver and personal computer together with software for transforming a stream of data and appointing the situation of energetic middle of leaser beam for optional measuring cycle, (fig. 1, 2, 3).

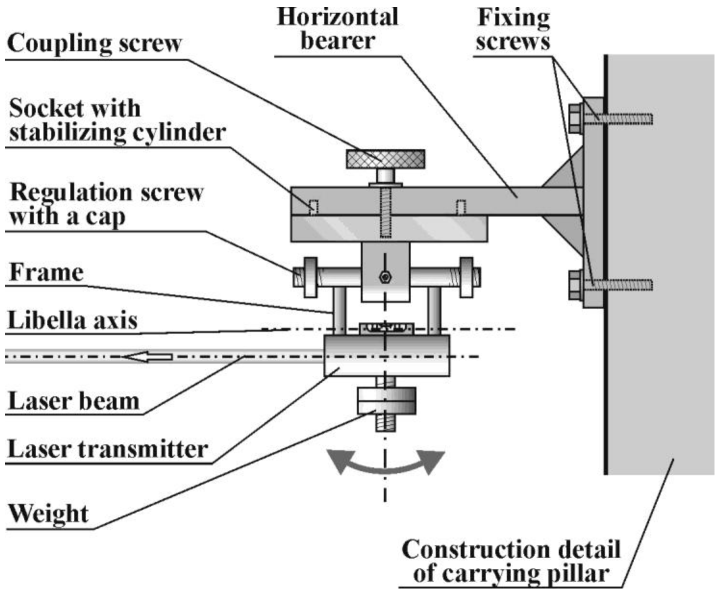

Fig. 1. Self-levelling horizontal laser transmitter.

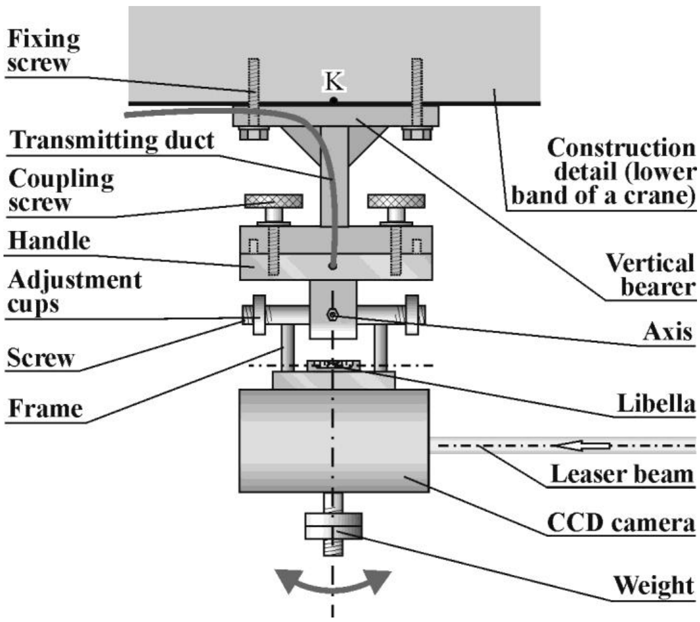

Fig. 2. Measuring transmitter with photo detection CCD camera.

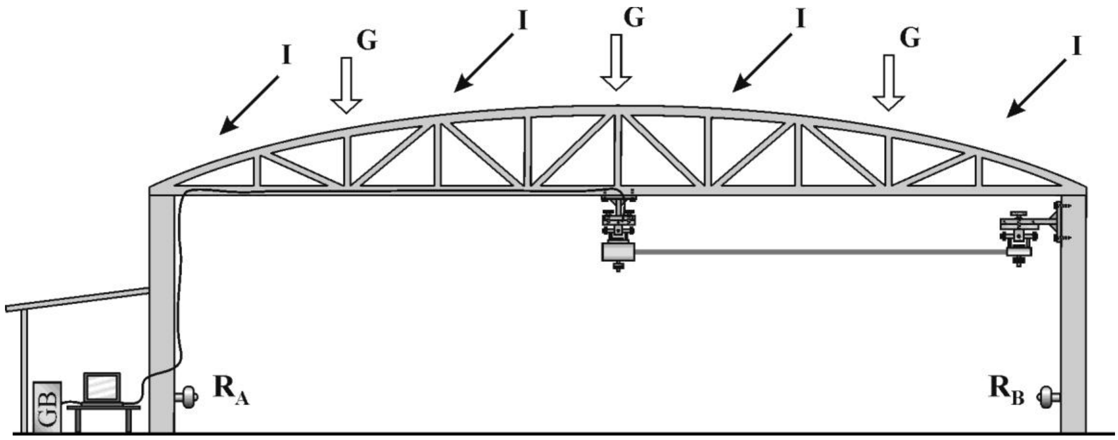

Fig. 3. A scheme of positioning the details of laser of measuring and controlling system in a hall in question.

Markings:
G - snow and/or ice load
I - insolation causing thermal quasi-deshaping of bearer construction

Because of a possibility of occurrence of vertical dislocation between carrying pillars and lower belt of bearer, which are due to additional load, the most useful situation of laser transmitter would be lower bearer belt of the load-bearing structure of the roofing.
Drawing 4 shows geometry of deflection of the lower belt of bearer and vertical movements of the CCD camera and laser transmitter in the period Δt_{0-i}.

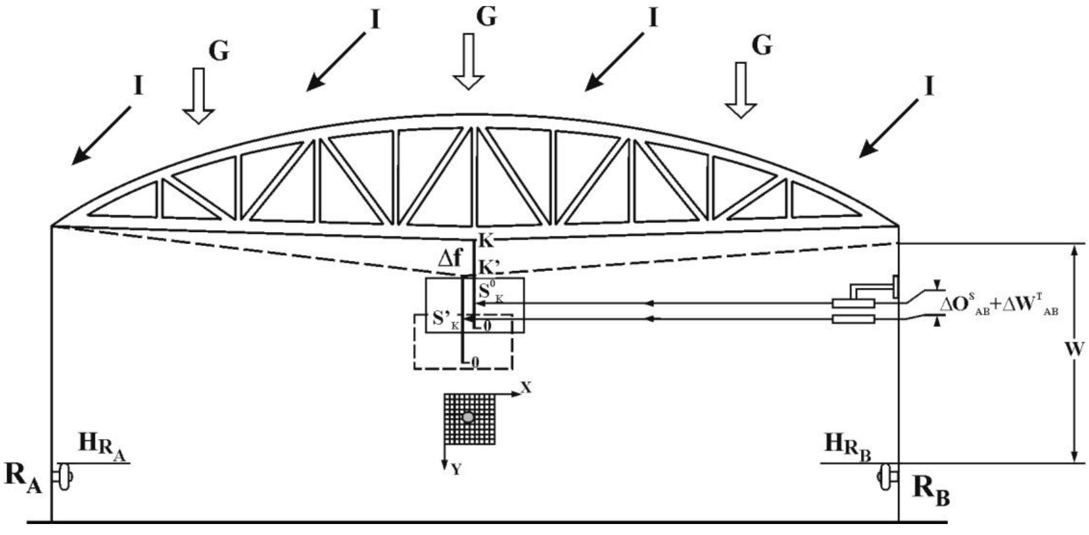

Fig. 4. Geometry of increment of deflection of the bearer and the CCD camera and laser transmitter.

For geometrical dependencies shown above, the increment of deflection arrow of the bearer is appointed by the equation:

$$\Delta f = K - K' = S_K{}^{/} - S_K{}^{O} + \frac{1}{2}(\Delta O_{AB}{}^{S} + \Delta W_{AB}{}^{T}) \quad \textbf{(1)}$$

where:

S_K^O **- coordinates of energetic middle of laser beam for O époque**
$S_K^/$ **- coordinates of energetic middle of laser beam for I measuring époque**
$\Delta O_{AB}{}^S, \Delta W_{AB}{}^T$ **- differences of height as an effect of settlement of carrier support and influence of thermal dilation**
$W^T = W \cdot (T^/ - T_o) \cdot \alpha$ **- increase of pillar length caused by temperature growth**
W **- height of the pillar**
$T_O, T^/$ **- pillar temperature in ^oC**
α **- coordinate of lineal dilation of steal or concrete**

In case of exceeding permissible values of deflection arrow or/and bearer relocation, computer communicates or/and alarm signals acoustic and light, should be automatically activated.

3. EXPERIMENTAL RESEARCH

Based on conception assumptions a prototype measuring system, presented in the pictures 5 and 6, was elaborated and constructed.
Research works were run in basement of Geodesy and Geoinformatic Institute of Nature University in Wrocław. Laser transmitter was situated on a wall stabilizer and the measuring receiver coupled with the simulator of vertical shifts, was attached to vertical research arm.

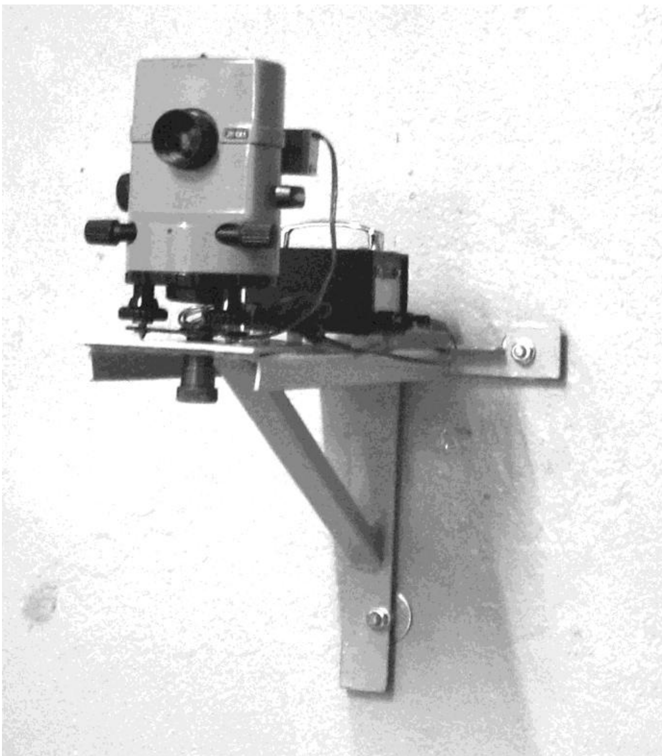

Fig. 5. A view from the front of laser transmitter situated on a wall stabilizer (self-leveling leveler 2N-10KL with laser spectacle unit).

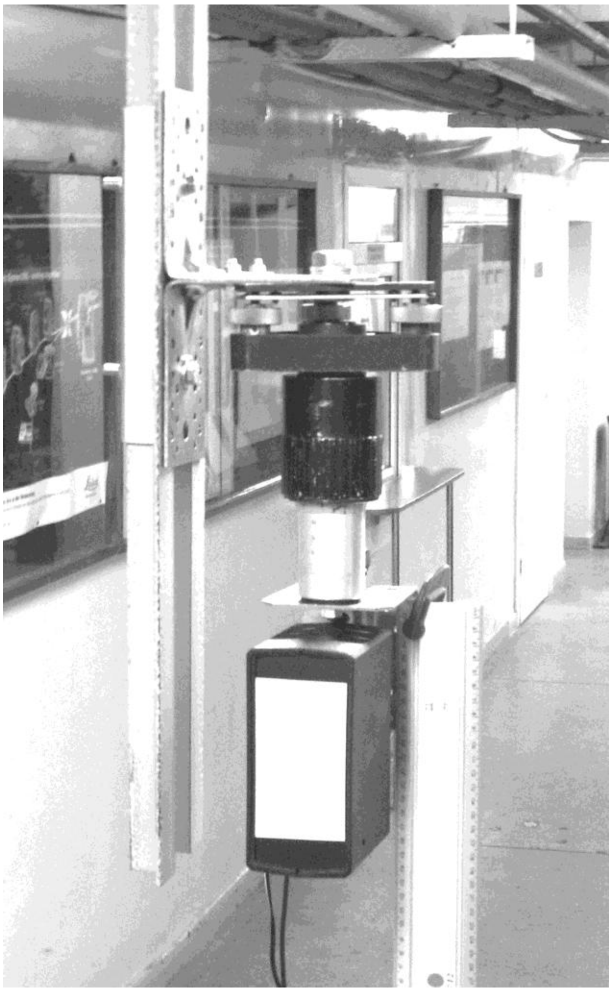

Fig. 6. A view from the front of the measuring receiver with shift simulator connected to an arm.

Testing experiment of measuring unit was run for two distances D (14 and 28 m) of laser transmitter from measuring receiver. During the experiment, simulated shifts of the receiver within the limit of 35 mm every 1 mm were made. Shifting the receiver and stability of placing the laser transmitter was controlled by the method of geometric liquidation with the use of leveler Ni005 and line scale. The results of numerous simulated shifts, registered with the measuring receiver connected by transmission cable with a computer allowed to define the middle error of a singular measurement of the situation of energetic middle of laser beam, which totals to 0,03 – 0,04 mm at the distance D=14 m, and for D=28 m within limit of 0,07 – 0.09 mm.

For experimental research of occurring for longer , intentional influence of effects of changes of optical density of the atmosphere to final value of noticed dislocations, additional series of test measurements for conditions current for laboratory corridor.

Table 1. Statement of average of readings from 10 measurements with registration every one second for data received from observation of stability of laser beam in 100 seconds for the distance of 28 m.

Lp.	Average reading [mm]	Standard deflection [mm]
1	22,50	0,06
2	22,45	0,04
3	22,64	0,06
4	22,59	0,06
5	22,61	0,05
6	22,58	0,07
7	22,67	0,04
8	22,64	0,08
9	22,71	0,05
10	22,58	0,05

4. SUMMARY AND FINAL CONCLUSIONS

A set of measuring system with use of laser technique and CCD converter connected to the computer presented in the study, carries out remote and automatic observation of deflection of carrier of rafter framing. Test measurements of simulated shifts of the prototype of photo-detection CCD receiver allowed initial definition of accuracy of the measurements of the situation of energetic middle of laser beam. From numerous measurements for the distance of 14 ma and vertical shifts within 35 mm, the maximal error equaled 0,04 mm and for 28 m it was 0,09 mm.

Fluctuation effect of the situation of energetic middle of laser beam registered by measuring receiver in 10 seconds was also researched. Quickly changing variations of beam situation consisted in the range of 22,45 to 22,71 mm. Dispersion of vertical situation of laser spot did not exceed 0,26 mm.

Registration and averaging of geometric middle of laser spot can be made with unrestricted time step.

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