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THE INFLUENCE ANALYSIS OF CHANGING TEMPERATURE CONDITIONS ON BUILDING CONNECTORS DEFORMATIONS OF THE BYDGOSZCZ UNIVERSITY OF SCIENCE AND TECHNOLOGY



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INTRODUCTION

The variability of external and internal air temperatures affects the temperature distribution in the building housing elements (exterior partitions and their joints) and, consequently, their thermal insulation and deformation.
The study aims to determine the influence of variable thermal insulation of building housing elements on their deformations. The paper presents the research results on the deformation of above-ground connectors of buildings of the Bydgoszcz University of Technology campus. During the investigation, the physical parameters of partitions and connectors of above-ground connectors were determined using numerical tools. To carry out the analyses, design materials were studied, a field inspection was carried out regarding the characteristics of the structure, and thermal imaging measurements of the connector structure were carried out. Since the thermal quality of building housing elements impacts displacements, the paper compares the results of physical parameters of housing elements of the tested above-ground connectors with the results of geodetic displacement measurements assumed on the connectors of the network of controlled points. Precise surveying technologies were used to measure displacements using Leica's TDRA6000 coordinate laser station. Field measurements and numerical analyses were carried out for various thermal states of the structure. Comparing the results of geodetic measurements with those obtained by numerical analysis will allow verification of the theoretical model.

RESEARCH AREA

The area of research is the floors of three above-ground fasteners located at the Bydgoszcz University of Science and Technology (Fig. 1), characterized by a different structure of insulating layers. The analysis will cover design materials, measurements of the characteristics of the floor layers, thermal imaging measurements, and 3D displacement of the control network installed on the floor.

Fig. 1. View of the connectors included in the study

RESEARCH METHOD

A significant influence on the deformation of the structure under the influence of temperature is its thermal insulation characteristics. It is essential when designing to choose such parameters of partitions so that the result of deformation does not cause destruction and deterioration of its technical condition.
Thermal imaging and geodetic displacement measurements were made in three measurement epochs differing in temperature conditions. Thermal imaging measurements were performed inside and outside the connectors using the FLIR SC660 thermal imaging camera from EC Test Systems (Fig. 2). The displacement of the network of controlled points was measured with the TDRA6000 laser station (Fig. 3). It consisted of recording the 3D coordinates of the controlled points of the network (Fig. 4) at each free station a-e. The calculations were carried out in two stages. In the first stage, the height differences between the network points were calculated, and then its strict alignment was carried out. The second stage involved the determination of horizontal displacements of the established network. At this stage, the calculation was made using the plane coordinates (X, Y) of the controlled points by carrying out several transformations.

Fig. 2. View of the thermal imaging camera during the measurement

Fig. 3. View of the TDRA6000 at one of the positions

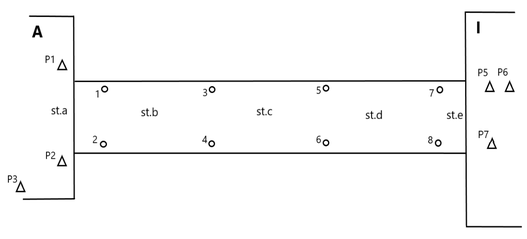

Fig. 4. A sample network sketch established on one of the connectors

RESULTS

The research was carried out on three connectors connecting the buildings of the Bydgoszcz University of Science and Technology. The location of the connectors is presented in Fig. 5.

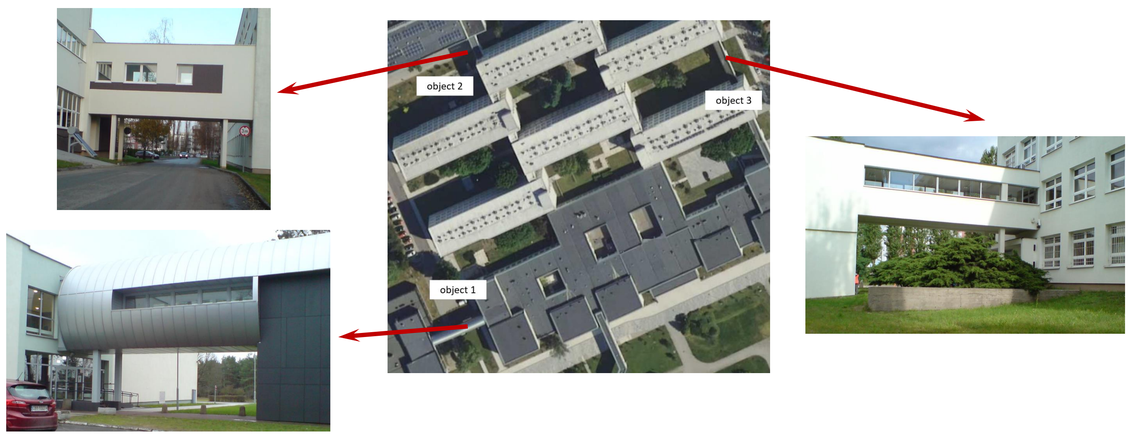

Fig.5.. Location of connectors on the university campus

Displacement measurements were made cyclically during different thermal conditions of the structure. The schedule for taking measures is shown in Fig. 6.

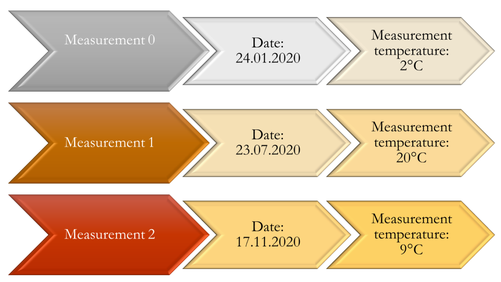

Fig.6. Geodetic measurements and thermal observations schedule

In each measurement series, thermal imaging measurements of the structure inside and outside the connector were performed simultaneously. Thermal imaging images showed the temperature distribution of the floors of the tested fasteners. An example of thermal imaging – temperature distribution – outside and inside connector No. 1 is shown in Fig. 7 and 8.

Fig. 7. Temperature distribution outside connector No. 1

Fig. 8. Temperature distribution inside connector No. 1

Fig. 9 and 10 present theoretical models and temperature distribution of the connection of the external wall with the floor on the ceiling above the passage in two variants: without floor insulation (photo 9) and with floor insulation (photo 10). The lack of insulation causes a significant decrease in temperature on the inner surface of the partition and, therefore, more considerable deformation of the floor and the risk of mold and mold fungi.

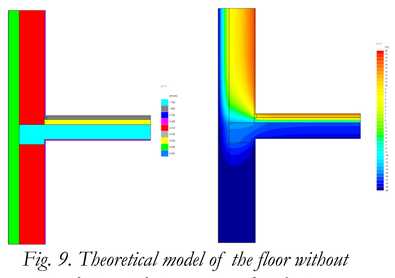

Fig. 9. Theoretical model of the floor without insulation with temperature distribution

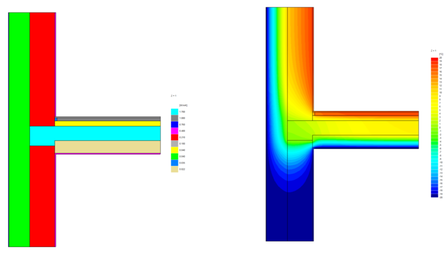

Fig. 10. Theoretical model of the floor with insulation along with temperature distribution

DISCUSSION AND CONCLUSIONS

Geodetic monitoring is used, among others, to determine displacements and deformations of engineering structures. It includes measurements, the subsequent analysis of which allows for specific conclusions regarding the dynamics of the occurrence of changes in the structure. These measurements also provide information about their geometric state and changes over time. The primary symptom of adverse phenomena occurring in construction objects is their displacements. They are monitored by performing a series of measurements of the network of measuring and control points established on the object. Modern measurement technologies enable the implementation of tasks that traditional methods have not allowed while ensuring precision. Thermal insulation of building enclosure elements can be considered about two criteria: thermal (heat transfer coefficient and linear heat transfer coefficient should be determined) and humidity (thanks to it, it is possible to assess the risk of mold and fungi and the risk of interlayer condensation). Measuring the thermal condition of a building can be based on measuring tools (measurement with a thermal imaging camera) and numerical tools, allowing to perform calculations to obtain optimal parameters of the tested objects. The study's main objective is to determine the influence of variable thermal insulation of building housing elements on their deformation by correlating the results of physical parameters of housing elements of the tested above-ground connectors with the results of geodetic displacement measurements. The main conclusion of the measures is that the fasteners have different insulation for floors – this is especially noticeable in winter at an outdoor temperature close to 0 ° C. This can lead to increasing the demand for thermal energy in the building, creating the risk of surface condensation and having an impact on reducing the technical condition of the building. The measurements and analyses lead to the verification of the developed model and allow for effective monitoring of building objects.