SAFETY ENGINEERING OF ANTHROPOGENIC OBJECTS

INFLUENCE OF MEASURING DEVIATIONS OF THE COMPONENTS OF LAYERED WALLS ON THEIR DURABILITY

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Abstract

The subject of the article is the impact of measurement deviations of three-layer walls on the durability of these walls in buildings erected according to the OWT-67 / N system. This problem mainly concerns the external facade texture layer, which, apart from its own weight load, is exposed to the destructive influence of external factors, which include wind suction load and temperature load. The measurement deviation regarding the texture layer is the varied thickness of the board. Other diverse components that affect the fusion of the texture layer with the insulation layer and the construction layer are: diameter of rods hangers, coating thickness of rods hangers and diameter of rods anchoring hangers. Based on these measurements, a polynomial model was created based on an experimental plan that evaluated the durability of the layered wall.

Key words: texture layer, hanger, lagging, anchor rod, cross structure of the building.

INTRODUCTION

During field tests on a group of six large-panel buildings, open casts were made to check compliance of measurements with the design documentation and guidelines of the General Construction Research and Design Center, ITB instructions, and industry standards.

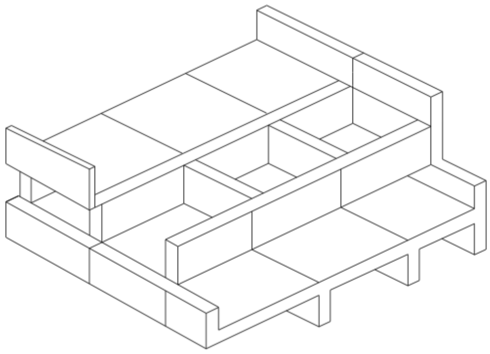

Figure 1. *Cross-system according to which the buildings were built in the OWT-67 system of panel building*.

The purpose and subject of the study were three-layer walls in the OWT-67 / N system. The corrosion level of the rods fixing the layers, i.e. the so-called "Hangers". The correct shape of hangers in layered panels was checked, as well as their location and amount in one of the panels.

1. Selection of the experimental plan necessary to conduct the study.

A group of six buildings constructed in the OWT-67 / N system was subjected to the experimental study. Three open casts were made in each building in order to assess the condition of "hangers" and anchor rods hangers in the texture layer. The various dimensions of layered wall components were subjected to statistical analysis. The plan was selected from the group of statistical plans determined by **PS / DS**, or rather **PS / DS-P**, i.e. poly selective due to multifactorial analysis. This is the Hartley Ha4 plan, which requires n = 17 measurements of the output value (response) Z. A rotational plan was adopted - α rotational equals 2,000, in which the first 16 systems constitute the nucleus of the plan, systems from 17 to 24 form star points, while systems 25 and 26 are the center of the plan. The excess of plan layouts in relation to the unknown functions of the test object occurs due to the criterion of informativeness. The selected Hartley Ha4 plan is characterised, and based on:

1. *Factors occurring on the conducted research.*

In the study, the following, according to the author of the study, the most important factors were taken into account:

- ✓ $\mathbf{X_1}$ – thickness of the texture layer of panels in the OWT system
- ✓ $\mathbf{X_2}$ – diameters of rods hangers
- ✓ $\mathbf{X_3}$ – coating thickness of hangers
- ✓ $\mathbf{X_4}$ – diameter of anchor rods hangers

Required states in OWT-67: 50 mm, in **OWT-67/N:** 60 mm

– α = – 2	**– 1**	**0**	**+ 1**	**+ α = + 2**
46,00	49,00	52,00	55,00	58,00

Table 1. *Summary of measuring deviations of the texture layer thickness*.

Note: The thickness of the texture layer was taken into account as for the OWT-67 system, because in the research the scope did not exceed the limit of the thickness of the texture layer required for the OWT-67 / N system. Therefore, it was not possible to estimate the measuring deviation ranges for the 60 mm thick texture layer.

Required state in OWT-67: 12 mm

– α = – 2	**– 1**	**0**	**+ 1**	**+ α = + 2**
10,00	11,00	12,00	13,00	14,00

Table 2. *Summary of measuring deviations of hanger rod diameter.*

Required state in OWT: 15 mm

– α = – 2	**– 1**	**0**	**+ 1**	**+ α = + 2**
10,00	12,50	15,00	17,50	20,00

Table 3. *Summary of measuring deviations of hangers cover thickness*.

Required state in OWT: 8 mm

– α = – 2	**– 1**	**0**	**+ 1**	**+ α = + 2**
6,00	7,00	8,00	9,00	10,00

Table 4. *Summary of measuring deviations of the rod anchoring hangers.*

As you can easily see, the measurement deviations fluctuated in both directions of the required thickness or diameter of the element, i.e. there were both minimally too small and maximum too large measurement deviations.

2. Shaping the function of the test object based on input factors and validation of measurement methods

The regression analysis graph (Fig. 2) shows that there are more factors significant in the study than insignificant.
Research object function:

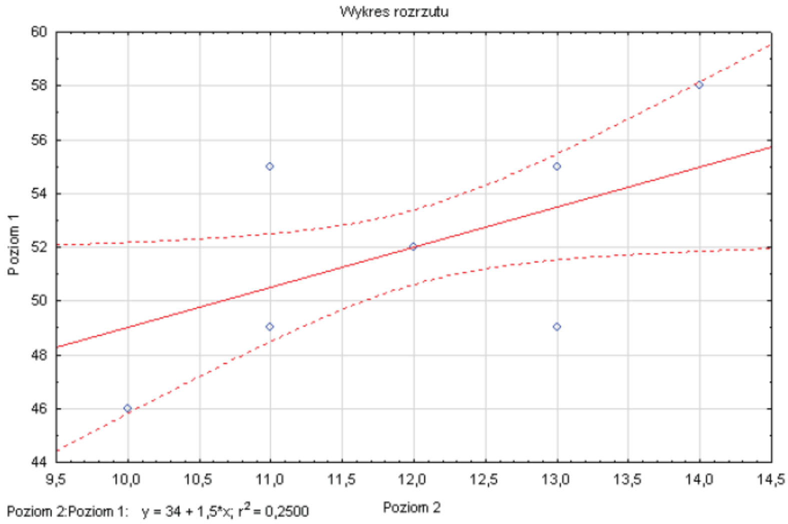

Figure 2. *A graph regression analysis*.

The linearity graph of the regression analysis (Fig. 3) shows the share of selected components in the experimental plan and at the same time it can be concluded from the graph that the selected factors are important in terms of durability of the three-layer wall. The influence of other factors, so-called uncontrolled.

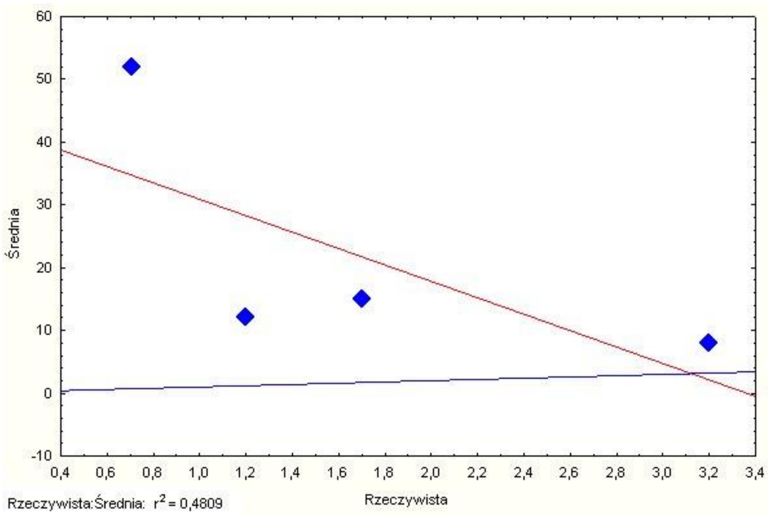

Figure 3. *A graph linearity regression analysis with the auxiliary line y = x.*

3. Creating a calculation model according to the selected experiment plan

Determining the number of unknown factors:

$$N_a = \frac{(i+1)\cdot(i+2)}{2} = \frac{(4+1)\cdot(4+2)}{2} = \frac{30}{2} = 15$$

where:

i – number of input quantities
The selected function of the four variables of the test object takes the form:

$$\mathbf{Z_w = F_w(X_1, X_2, X_3, X_4)} \qquad (1)$$

The object function in the form of a second-degree polynomial for four factors takes the form:

$$\mathbf{Z = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_{11}x_1^2 + a_{22}x_2^2 + a_{33}x_3^2 + a_{44}x_4^2 + a_{12}x_1x_2 + a_{13}x_1x_3 + a_{14}x_1x_4 + a_{23}x_2x_3 + a_{24}x_2x_4 + a_{34}x_3x_4} \qquad (2)$$

Model form generated from a computer program after rejecting irrelevant components:

$$Z = 8{,}00 + 10{,}369\,\mathbf{x_2} + 7{,}557\,\mathbf{x_1^2} + 16{,}77\,\mathbf{x_2^2} + 8{,}056\,\mathbf{x_3^2} + 16{,}936\,\mathbf{x_4^2} + 11{,}388\,\mathbf{x_1x_2} + 11{,}113\,\mathbf{x_1x_3} + 8{,}80\,\mathbf{x_2x_3}$$

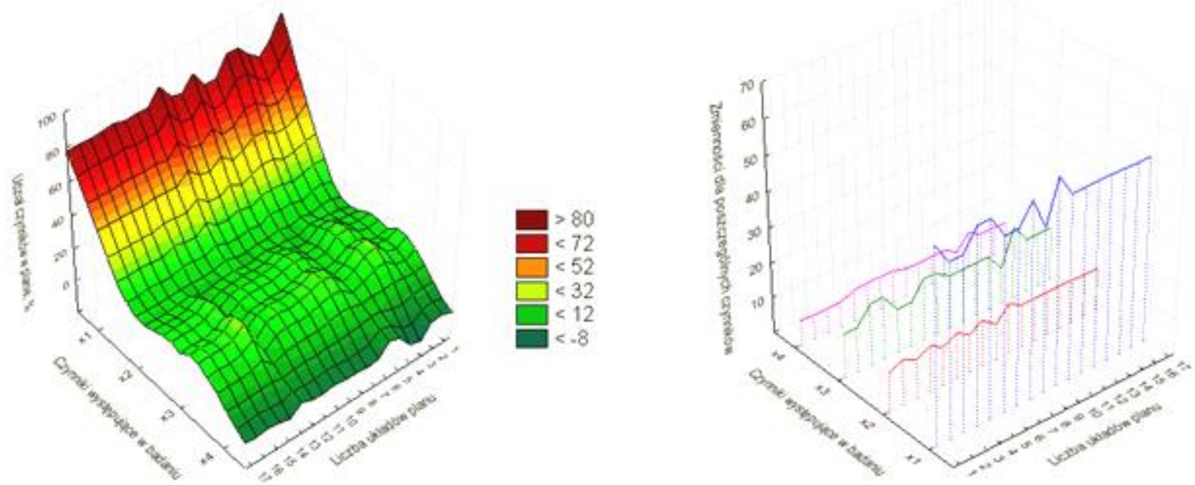

Figure 4. *The share of each constituent factors and their variability in the experimental plan.*

An attempt to optimise the model:

$$\frac{\partial \bar{y}}{\partial x_1} = \frac{\partial(8{,}00 + 10{,}369\,x_2 + 7{,}557\,x_1^2 + 16{,}77\,x_2^2 + 8{,}056\,x_3^2 + 16{,}936x_4^2 + 11{,}388x_1x_2 + 11{,}113x_1x_3 + 8{,}80x_2x_3)}{\partial x_1} = 26{,}28\,x_1 + 5{,}275$$

$$\frac{\partial \bar{y}}{\partial x_2} = \frac{\partial(8{,}00 + 10{,}369\,x_2 + 7{,}557\,x_1^2 + 16{,}77\,x_2^2 + 8{,}056\,x_3^2 + 16{,}936x_4^2 + 11{,}388x_1x_2 + 11{,}113x_1x_3 + 8{,}80x_2x_3)}{\partial x_2} = 28{,}57\,x_2 + 10{,}369$$

$$\frac{\partial \bar{y}}{\partial x_3} = \frac{\partial(8{,}00 + 10{,}369\,x_2 + 7{,}557\,x_1^2 + 16{,}77\,x_2^2 + 8{,}056\,x_3^2 + 16{,}936x_4^2 + 11{,}388x_1x_2 + 11{,}113x_1x_3 + 8{,}80x_2x_3)}{\partial x_3} = 23{,}94\,x_3 + 6{,}35$$

$$\frac{\partial \bar{y}}{\partial x_4} = \frac{\partial(8{,}00 + 10{,}369\,x_2 + 7{,}557\,x_1^2 + 16{,}77\,x_2^2 + 8{,}056\,x_3^2 + 16{,}936x_4^2 + 11{,}388x_1x_2 + 11{,}113x_1x_3 + 8{,}80x_2x_3)}{\partial x_4} = 12{,}143\,x_4 + 4{,}869$$

$$26{,}28\,x_{1,\text{optym.}} + 5{,}275 = 0 \Rightarrow x_{1,\text{optym.}} = -0{,}201$$

$$28{,}57\,x_{2,\text{optym.}} + 10{,}369 = 0 \Rightarrow x_{2,\text{optym.}} = -0{,}363$$

$$23{,}94\,x_{3,\text{optym.}} + 6{,}35 = 0 \Rightarrow x_{3,\text{optym.}} = -0{,}265$$

$$12{,}143\,x_{4,\text{optym.}} + 4{,}869 = 0 \Rightarrow x_{4,\text{optym.}} = -0{,}401$$

Note: The impact of insignificant factors was also taken into account in the attempt to optimise the model.

CONCLUSIONS

The article summarises the four most important factors affecting the durability of fastening the facade texture layer in a three-layer wall of a large panel building and at the same time on the safety of persons and external property in the event of detachment of the texture layer. The study concerned only the OWT-67 / N large-panel system. The analysis of measurement deviations in the conducted research, supported by the diagrams of the test object functions and the calculation model, showed that in the group of six tested large-panel buildings, the measurement deviations are included in such ranges that at the moment it does not significantly affect the durability of the façade layer fastening. An attempt to optimise the model indicates the extreme of the objective function for individual components in the conducted experimental study.

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