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THE COMPACTNESS INDICATORS OF SOLIDS

Keywords: *compactness indicator of solid, rectangular polygon, perimeter defect, area defect*

Indicators of Relative Compactness RC_{cube}, RC_{sphere} of solids introduced by Mahdavi and Gürtekin [3] (in default use to optimize the shape of a building) relative to the cube and sphere show the size which does not give a clear view of the degree of deviation of content for example expressed in terms of percentage points from the content of the perfect solid (cube and sphere). The comparison with the ideal solids (sphere, cube) and usually highly diverging from the practical, functional shapes of buildings, especially detached houses seems too idealized and as a result does not show the essence of things.

The authors of this paper aimed to propose an alternative solution to the problem so that the geometric description of the object, being the model of a building, could be directly translated into projections of a designed building and the elements important for the designer related to estimating the impact of changes made in this projection in the designing process on the costs of construction, demand for energy during usage, comfort of living and also the aesthetics. Alternative reference shapes were proposed (referring to the simplified models of buildings) and indicators based on them: RC_{cd} (solid content with respect to cuboid), RC_{sq} (solid content with respect to square base), *RDA* (relative defect of the area of the solid base), *RDP* (relative defect of perimeter solid base).

On the basis of so defined indicators, the authors make an analysis leading to the choice of a model indicator which describes the compactness of a solid block (the prism of any base).

The assumption was made concerning all solids having rectangular polygon in their base [2] inscribed in a rectangle with dimensions x=9 u, y=12 u, where u is any unit i.e. 1 u equals 1 m (fig. 1), with diversified heights: 1 h, 10 h, 100 h, where h=2,7 u. In the models analysis (fig. 3, 4), based on projections of actual buildings [4], likewise, height was assumed at h=2,7 u (as similar to the storey height of the building measured in meters).

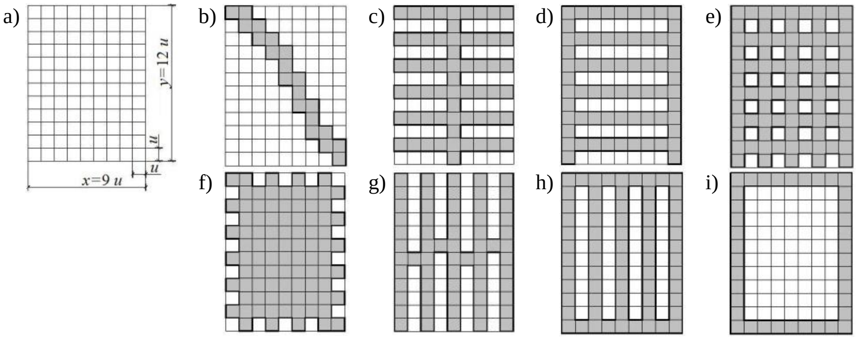

Fig. 1: Rectangular polygons representing different prismatic solid bases including a base having an extremely small (example b) or extremely large (example d) perimeter defects

For different cases of prismatic solid bases charts of indicators *RDA*, *RC*–1, RC_{cd}–1, RC_{sq}–1 and differences |RC_{cd}– *RC*|, |RC_{sq}–1–*RDA*| were made depending on the variant base B of the area A_b and corresponding to the height H of the value h (figure 2 shows the graphs for the solid of base in the range: from a full rectangle to the shape shown in Figure 1d, with H→1 h(=2,7 u)).

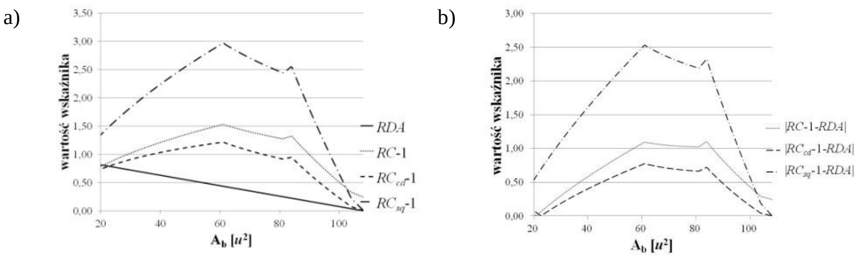

Fig. 2: Graphs of the analyzed indicators: a) *RDA*, *RC*–1, RC_{cd}–1, RC_{sq}–1; b) |*RC*– RC_{cd}|, |RC_{sq}–1–*RDA*| for solid bases in the range of: a full rectangle to the shape illustrated in Figure 1d, with H→1 h(=2,7 u)

The adoption of the modular rules (module measuring 1 u × 1 u) creating of solids and models gives sufficiently high possibility of modifying the solids and, thus, analysing different calculation cases. Each solid was made by the transformation of a rectangle solid base into a rectangular polygon by reducing the area by 1 u^2 (one module 1 u × 1 u) and then by subsequent reduction to obtain the shape shown in Figure 1.

When the solids were made, the following calculations were conducted:

- relative defect of the area of the solid base *RDA*(B),

- relative compactness of a solid with respect to cube with such a volume as the analysed solid, decreased by 1: *RC*(B,H)–1,
- relative compactness of a solid relative to cuboid with the height equal to the analysed solid decreased by 1: RC_{cd}(B,H)–1,
- relative compactness of a solid with respect to square base decreased by 1: RC_{sq}(B)–1,
- module differences: *RC*(B,H)–RC_{cd}(B,H), RC_{sq}(B)–1–*RDA*(B), *RC*(B,H)–1–*RDP*(B),
RC_{cd}(B,H)–1–*RDP*(B), RC_{sq}(B)–1–*RDP*(B).

Then two sets of models of buildings were prepared (in the form of a prismatic solid), whose base was a simplified projection of typical buildings [4]. The first (fig. 3) was used to analyse the defect of perimeter and area while the second (fig. 4) for analyzing the defect of area.

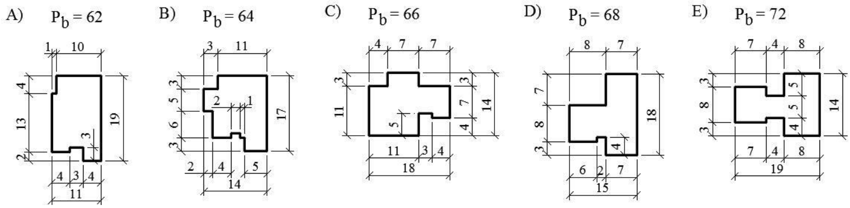

Fig. 3: Bases of building models (in the shape of prismatic solids) used for perimeter and area defect analysis (with A_b=188 u^2)

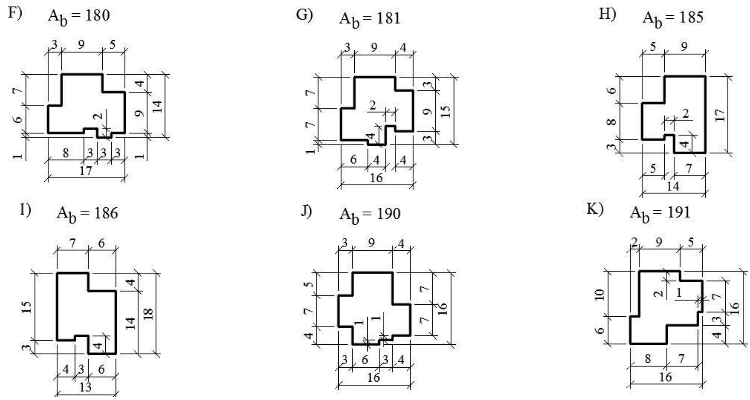

Fig. 4: Bases of building models (in the shape of prismatic solids) used for area defect analysis (with P_b=64 *u*)

For the given input data, calculations of indicator values and charts were made (fig. 5).

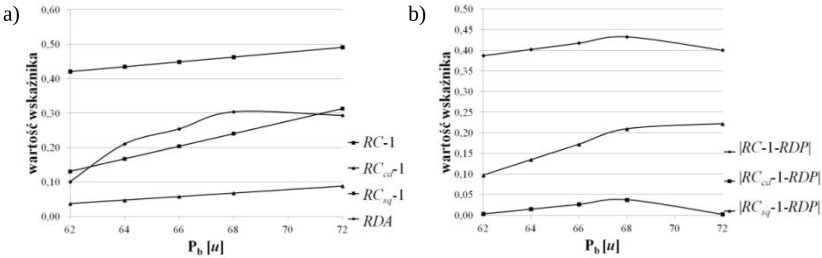

Fig. 5: Graphs of the analyzed indicators: a) *RDA*, *RC*–1, RC_{cd}–1, RC_{sq}–1; b) |*RC*–1–*RDP*|, |RC_{cd}–1–*RDP*|, |RC_{sq}–1–*RDP*| for models with bases shown in Figure 3, with H=2,7 *u*

The authors compared the indicators *RDA* (*RDP*) and RC_{sq}, which do not depend on the height of solids (model) and *RC*–1, RC_{cd}–1, which also depend on the height. As a result of the analysis, it was shown that the *RDA* indicator describes specifically the content of solids and the models of buildings.

It illustrates the percentage loss of rectangular polygon of the area of the solid base (model) in relation to the area of the rectangle described. This is especially evident when the area of a rectangular polygon differs from the area of the rectangle described on this polygon between 0% – 40%. On the other hand, the *RDP* indicator is to serve as information which indicates the usage of material needed for the execution of a side wall of a solid and, most of all, the value of heat loss through the building walls. Therefore *RDP* indicator was also compared to the *RC* and RC_{cd} indicators. The results of the research lead to the conclusion: *RDA* and *RDP* indicators appear to be the main determinants in assessing the optimum shape of the model (for prism solids) based on the rectangular polygon for a minimum total surface area for a given volume.

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