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RECIPROCAL SYSTEMS AS THE GEOMETRIC TOOL FOR SHAPING TWISTED FORMS OF BUILDINGS

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The term *reciprocal system* means the set of structural elements connected with each over in this way that every element of the system is supported with the previous one and it supports the next one with itself. The external supports should be situated along the element spans and never at the points where elements are joined [1]. Reciprocal systems have been introduced into the architecture in the Middle Ages. Renewed interest in them is observed in recent years [2].

The article discusses the concept of shaping twisted forms of multi-storey buildings by use the reciprocal systems of beams as the structures of individual floor slabs. The basic analysis concerns the slabs in shape of regular polygons, based on systems composed of beams in a number equal to the number of sides of the slab. Due to the assumption that beams are supported at points located freely along the beam lengths, individual systems of beams can be rotated with respect to the other systems but the arrangement of the support points is still the same on all floors of the building (Fig. 1).

The systems built from beams connected at their ends (Fig. 2a) are the starting point for geometric analysis. The lengths of beams (e_1, e_2), being in such a case the dimensions of floor slabs, are variable and depend on the angles of rotation of beams relative to the supporting columns. Related systems may be constructed on the way of extension the beams in one (Fig. 2b) or both sides (Fig. 2c) beyond the connection points. In such cases, the dimensions of the individual floor slabs can be both the same or different, according to the lengths of the cantilevers (l_{11}, l_{12}, l_{21}, l_{22}). The system of every type may be adapted for any regular polygon. Variability of the method makes the possibility of shaping with its aid buildings with significantly different spatial forms.

The paper presents the geometric relationships describing the lengths and angles of rotation of beams as the function of rotation and dimensions of the floor slabs, established for different types of presented reciprocal systems. Alternative ways of shaping the geometric configuration of the structural system, effecting in the identical twisting the outer walls of the building, were identified. Moreover, the possibilities of shaping twisted forms based on the

configuration of beams and columns being multiplication of the basic square structure are shown. The paper was supplemented by a wide range of computer visualization of twisted forms of multi-storey buildings obtained by the tool of shaping described in the paper.

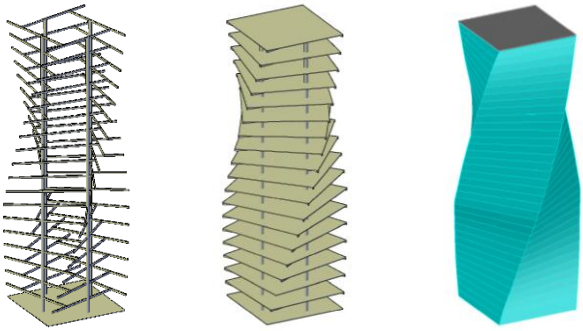

Fig. 1 Example of the formation of the twisted form of the building using a reciprocal system consisting of four beams.

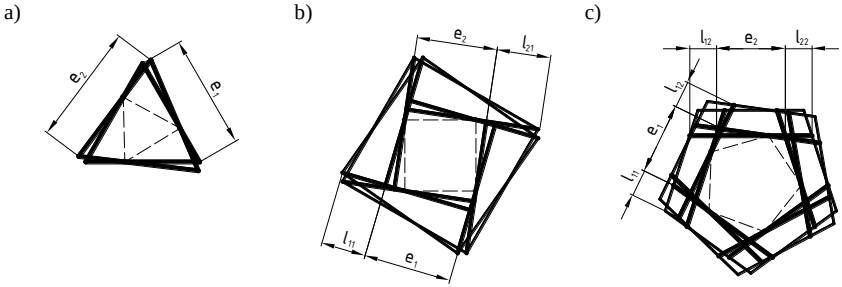

Fig. 2 Systems of beams supporting the next floor slabs of the buildings of twisted forms.

References:

[1] Parigi D., Kirkegaard P. H.: Design and Fabrication of Free-Form Reciprocal Structures, Nexus Network Journal, 2014, pp. 69-87.

[2] Popovic-Larsen, O.: Reciprocal Frame Architecture, Elsevier, Oxford 2008.