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OPTIMIZATION MODEL FOR FAMILY HOUSE PLOT ELEMENTS – THE ISTRIA CASE

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Preliminary notes

At today's level of spatial planning the criteria for the plot elements optimization are set including the ambient features' application, the plot structure, formulas average and unity parameters. The optimal model refers to the best utilization of a family house plot from the aspect of the house inhabitants. Research indicates that numerical expressions of quantities and the surfaces of particular structural elements necessary to complete a family house plot are unequal. According to the optimization criteria, average surfaces for structural elements are determined within limited, minimal and maximal plot surfaces.

Keywords: *family house plot, optimization model, plot elements*

Model optimalizacije elemenata parcele obiteljske kuće – primjer Istre

Prethodno priopćenje

Na današnjem stupnju prostornog razvoja, postavljeni su kriteriji optimalizacije elemenata parcele koji uključuju primjenu ambijentalnih značajki, strukturu parcele, formule prosjeka i jedinstvo parametara. Optimalno je najbolje iskorištena površina na parceli obiteljske kuće za život njenih ukućana. Istraživanja ukazuju da brojčani iskazi količina i površina pojedinih strukturnih elemenata, potrebnih za kompletiranje parcele obiteljske kuće, nisu jednaki. Prema kriterijima optimalizacije, utvrđene su srednje površine svih strukturnih elemenata unutar limitirane, minimalne i maksimalne površine parcele.

Ključne riječi: *elementi parcele, model optimalizacije, parcela obiteljske kuće*

1 Introduction

Relevant literature focuses on ambient features or individual parcel element characteristics for houses dimensions (size measurement) and ancillary buildings, garden, parking, etc. According to the method of construction plots represent different types of buildings such as the so-called open, closed and semi-buildings [1]. Various types of houses (detached, semi-detached, terraced, atrium) were processed, and their measurements include dimensions (length, width and height), surface area and ratios between build surface area plot [2], as well as the dimensions and family house plot surface areas [3]. Types of houses were especially examined from the aspect of the positional ground plan concerning the daily and nightly living space of types: I, L, U, C [4], as well as the corresponding measurements, surface and coefficients of the family house plot [5]. Relevant papers highlight the dimensions and surface areas of atrium houses [6], as well as traditional atrium houses in Beijing. This paper explains the influence of feng-shui models on the design of traditional Beijing courtyard houses from a historical and cultural point of view [7]. Approximate dimensions of family houses can be analysed based on their geometric layout which can vary from a simple form, and a cube size form, to a complex divided form [8]. Survey research on sizes and methods of building and arrangement of family house plots within and outside of towns in Istria was conducted [9]. Family houses can be regulated, either by a modular network when the grid is of smaller dimensions or through modular fields when the dimensions correspond to the construction requirements [10]. There are also illustrations of numerical expressions concerning usage density and sums of build area on family house plots [11].

The new folk architecture of today is the architecture of outbuildings and ancillary buildings (additional construction), complementing the main building [12].

In the structure of a traditional Mediterranean style house, representing a part of the cultural heritage of a certain region, a structural connection between the house and the garden can be noticed, from the aspect extending residential functions into the open space of a family house plot [13].

The optimal number of parking spaces provides an adequate parking service level for the users with a minimum of waiting time or searching for an available parking space [14].

The creation of family house plots, in the field of architecture and urbanism, from the spatial planning point of view was based on two elements: the family house plot and the house itself [15 ÷ 18], etc.

Research on family house plots and houses in Istria points to the following characteristics:

- Minimum and maximum surface measurements of one and the same characteristics and elements, regulated by town spatial planning documentation, differ significantly i.e. there are multiple discrepancies between the two;
- Terminology relating to the position of the house on a house plot is inconsistent in spatial planning documentation;
- The opinions of the surveyed persons support measurements for newly planned houses resulting in a higher quality of living and performance of certain activities within the house area [9].

From the theoretical point of view, element measurements were according to the "built and non-built" plot surface areas.

Practically, the building surface area has increased over time by up to 100 % when considering a plot surface

area. These element measurements point to the problem of unequal relationships between the "built and non-built" family house plot surface areas.

The lack of non-built family house plot surface area was replaced by using access roads and other public surfaces, creating a problem by leaving in these parts of the estates.

The rapid development of family houses and their inhabitants, in town centres and suburbs [19], calls for standards and new building and arrangement measures which provide a guarantee of quality and the living space preservation. Family house plot structural rules were determined [20, 21], and further elaborated for practical application.

For these reasons, this research is focused on the determination of equal surface ratios consisting of several elements on the same land used at the family home plot level. The aim of this paper is to determine the optimal, flexible and equal ratios of the construction surface and family house plot arrangement.

2 Methodology

In spatial planning the decision on the optimal solution is based on set criteria [22]. There are various methods in model processing. One of the methods is the model processed through diagrammatic and mathematic concepts [23] as well as the method of diagram for Plots per Gross Acre for plot surface measurement [3], as used in this model. Four criteria were used in this paper in order to optimise family house plot elements (Tab. 1).

Table 1 Methodological approach to optimization

Family house plot optimization criteria:
• Plot ambient features
• Family house plot structure
• Formula average
• Unity parameter

2.1 Plot ambient features

Ambient refers to the use of space, time and scope of the territory by the local authorities, and the stylistic features of the planning and architectural design of the house on the plot.

The specific purpose can be a plot for a family house, residential building, etc., or, more precisely, for a family house for residential purposes.

The territory for existing family houses is, at least, at the level of three local government organizational units which have passed spatial plans in the long-term period and have been issued decisions on the building and usage of family houses. The long-term period is a period longer than 20 years.

Ambient refers to the style characteristics of elements of appointment and the architectural design of a family house on a house plot. The style characteristics of the ground plan are documented in the cadastre records of the plot elements for the same method of land use.

In the process of applying the above mentioned optimization criteria, a random sample of western Istrian coastal area house plots was chosen which includes four local government units under the name "municipality". These are the former municipalities of: Buje, Poreč, Pula and Rovinj (1963 ÷ 1993) at the Republic of Croatia local government level (Fig. 1).

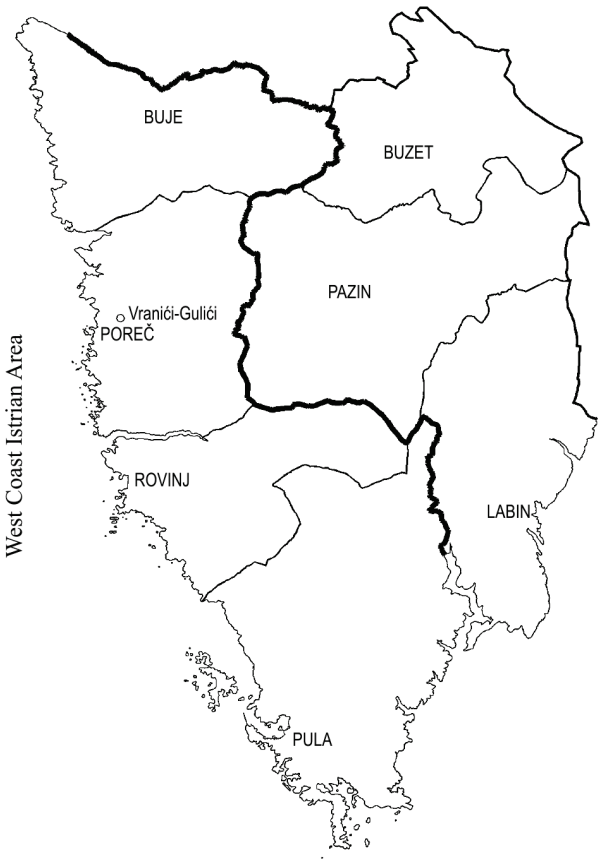

Figure 1 Municipalities of Istria

Figure 2 Town of Poreč, homeland surrounding of one part of estate Vranići-Gulići (URL)

Family house plots in Istria consist, traditionally, of two storey buildings (ground- and first floor) containing one or two apartments. There are a considerable number of family houses which also have additional constructions, such as garage, tool shed, storage for machines, wood, produce, etc. and a garden or courtyard around the house. Some gardens are arranged for rest, while others are not tended at all; they are with or without an access road to an open parking space. Streets join the

family houses together and the plot surface area construction is usually connected thereto. The properties of built and appointed plot surface areas are recorded in Plotting Plans.

One such Plotting Plan is the Cadastral Plan containing the cadastral culture of the land or the conditions for ways of using the land (house, family house, garage, shed, garden, yard, path, etc.), Fig. 2.

2.2 Family house plot structure

The mentioned ambient features in the family house plot structure can objectively be presented, through cadastral records in terms of the land cadastral cultures and associated elements. House, family house = element of the main construction; garage, shed = element of ancillary construction; garden or yard = remaining arrangement element and path, parking space, etc. = vehicle access arrangement element (Fig. 3).

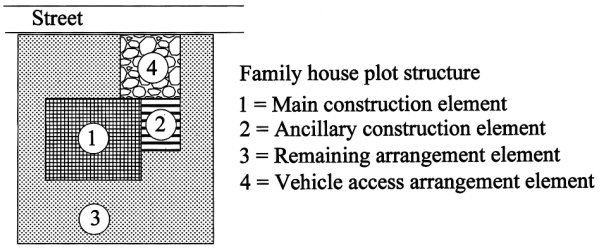

Figure 3 Family house plot [24]

2.3 Average formula

Family house plot structure in terms of the elements can be presented as follows:

$$A_2 = A_{\text{os}} + A_{\text{do}} + A_{\text{r}} + A_{\text{p}}. \tag{1}$$

Markings in the formula are meant for surface areas (m^2) and are of the same significance as in Fig. 3.

2.3.1 Element quantities and surface areas

Generally

$$A_{j_x} = \sum A_x,\ \text{m}^2, \tag{2}$$

where:
j_x − quantity of family house plot elements for x; x is a label for elements: os − main construction, do − ancillary construction), r − remaining arrangement), and p − vehicle access arrangement;
$\sum A_x$ − sum of surface areas from quantities of parcel elements x.

2.3.2 Element average surface areas

Element average surface area for a family house plot is calculated as:

$$A_{sx} = \frac{\sum_{i=1}^{j_x} A_{xi}}{j_x},\ \text{m}^2, \tag{3}$$

where:
A_{sx} − plot element average surface area, i − number of elements; $i = 1,2,\ldots,j_x$;
$\sum_{i=1}^{j_x} A_{xi}$ − sum of family house plot elements;
j_x − the same as in Eq. (2).

Individually

$$A_{\text{sos}} = \frac{\sum_{i=1}^{j_{\text{os}}} A_{\text{os},i}}{j_{\text{os}}};\ A_{\text{sdo}} = \frac{\sum_{i=1}^{j_{\text{do}}} A_{\text{do},i}}{j_{\text{do}}};$$
$$A_{\text{sr}} = \frac{\sum_{i=1}^{j_{\text{r}}} A_{\text{r},i}}{j_{\text{r}}};\ A_{\text{sp}} = \frac{\sum_{i=1}^{j_{\text{p}}} A_{\text{p},i}}{j_{\text{p}}}; \tag{4}$$

where:
A_{sos}, A_{sdo}, A_{sr}, A_{sp} − plot element average surface area; os, do, r, p − the same as in Eq. (2); i − the same as in Eq. (3).

Substitution of Eq. (1):

$$A_2 = A_{2\text{s}};\ A_{\text{sos}} = A_{\text{a}};\ A_{\text{sdo}} = A_{\text{b}};\ A_{\text{sr}} = A_{\text{c}};\ A_{\text{sp}} = A_{\text{d}}$$

$$A_{2\text{s}} = A_{\text{a}} + A_{\text{b}} + A_{\text{c}} + A_{\text{d}}, \tag{5}$$

where:
$A_{2\text{s}}$ − average plot surface area, (m^2).

2.3.3 Parameter

Parameter is a constant or mean of average element surface areas of the same land use and it can, generally, be presented as:

$$w_p = \frac{\sum w_{p,n}}{n}, \tag{6}$$

where:
w_p − parameter; p − refers to average surface areas of individual elements (a, b, c, d).
$\sum w_{p,n}$ − sum of average element surface areas of the same land use and for the observed number of local government organizational units n, $n \geq 3$.

Plot parameters have the following markings: w_{a} − main construction parameter; w_{b} − ancillary construction parameter; w_{c} − remaining arrangement parameter; w_{d} − vehicle access arrangement parameter.

2.3.4 Parameter share

$$\overline{w}_p = w_p \cdot \frac{A_{2s}}{A_{2op}} \cdot 100,\ \%, \tag{7}$$

where:
$\overline{w}_p$ − parameter share of surface area in percentage, %;
A_{2op} − optimal family house plot surface area.

2.3.5 Optimal family house plot surface area

$$A_{2op} = \left(w_a + w_b + w_c + w_d\right) \cdot A_{2s}, \tag{8}$$

where:
the markings are the same as in formula (6) and (7).

2.3.6 Limited family house average plot surface areas

$$A_{2min} \le A_{2op} \le A_{2max}, \tag{9}$$

where:
A_{2min} − minimal average plot surface area is the sum of the average element surface areas, which constitute the smallest family house plot surface area for a particular local government organizational unit;
A_{2op} − the same as in Eq. (8);
A_{2max} − maximal average family house plot surface area is the sum of the average surface areas, constituting the largest family house plot surface for a particular local government organizational unit.

2.4 Unity parameter

Unity combines average surface elements and ratios parameters belonging to the plot of the house. Unity is a diagram of the mathematical codes (that are) included in the model in order to optimize the elements of the plot. Equal and optimal family house plot elements have the following flexibly limited minimal and maximal surface areas: main construction (A_a), ancillary construction (A_b), remaining arrangement (A_c), and vehicle access arrangement (A_d). Equally, the optimal family house plot surface area (A_{2op}) is flexibly limited for selection of arbitrary plot (A_2).

The expression flexible means that a plot construction surface area may vary, and can thus be within the limited minimal and maximal plot surface area, constituting the parameter share of the main construction ($\overline{w}_a$ %) and/or ancillary construction ($\overline{w}_b$ %). On the other hand, the remaining arrangement surface areas are either equal to or greater than the surface areas of the parameter share of the remaining arrangement ($\overline{w}_c$ %) and/or vehicle access arrangement ($\overline{w}_d$ %). Larger remaining arrangement surface areas can be exchanged for smaller construction surface areas. Parameters are fixed values and their sum represents the optimal family house plot surface area. Parameter share is a numerical representation for limited measuring of the optimal element surface area (Fig. 4).

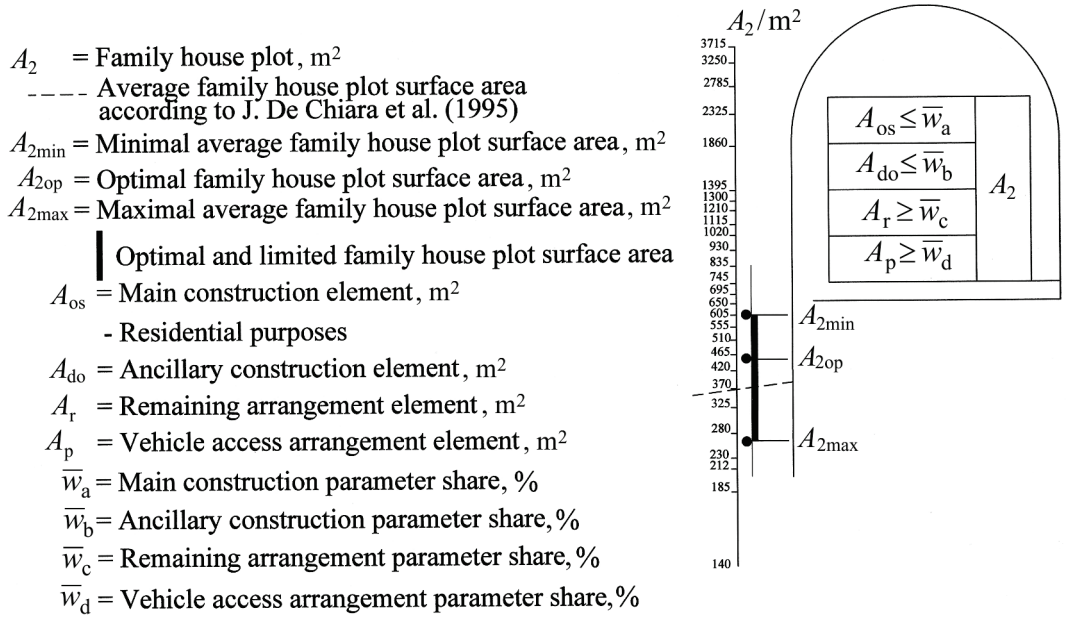

Figure 4 Diagram of markings and values for measuring family house plot element [24]

3 Family house plot numerical measures - the case of Istria

3.1 Quantity

In Eq. (2) the numerical representation of quantities and surfaces of main and ancillary constructions and rest arrangement and traffic access were calculated in m².

Municipalities differed in element quantities as well as family house surface areas – also in residential purposes, both individually and as a group. Buje had 6626 family house plots and various quantities of ancillary construction elements (182), remaining arrangement elements (5370) and vehicle access arrangement elements (139). Poreč had 7341 family house plots with various quantities of ancillary construction elements (515),

remaining arrangement elements (8226) and vehicle access arrangement elements (946). Pula had the highest number of family house plots (13 528) and various quantities of ancillary construction elements (3615), remaining arrangement elements (83 335) and vehicle access arrangement elements (1708), and the last, Rovinj had 4156 family house plots and also various quantities of ancillary construction elements (1107), remaining arrangement elements (4394) and vehicle access arrangement elements (410).

Table 2 Calculation of family house plot elements of the West Coast Istrian Area [24]

Municipalities	Quantities and surface areas of family house plot elements – residential purposes (in the) – application of Eqs. (2), (3) and (6)							
	j_{os}	$\sum A_{os}$ / m^2	j_{do}	$\sum A_{do}$ / m^2	j_r	$\sum A_r$ / m^2	j_p	$\sum A_p$ / m^2
Buje	6626	1696295	182	13009	5370	1506344	139	46402
Poreč	7341	912947	515	16005	8226	2355689	946	343789
Pula	13528	1559936	3615	194414	83335	3766925	1708	1394961
Rovinj	4156	467350	1107	34566	4394	1220204	410	123720

The surface areas of plot construction and arrangement are also added to the number of the above mentioned elements (Tab. 2). On the municipalities of Poreč, Pula and Rovinj level, there were more remaining arrangement elements than family houses, suggesting the fact that certain parcels contained more corresponding elements and cadastral plot. In general, the elements of ancillary construction and vehicle access arrangement had a considerably lower number of elements than the main construction elements' number. The above mentioned numerical data indicated a lack or, in some cases, an excess of quantities and surface areas of elements needed to complete the family house plots. The reasons for this numerical diversity of elements lay in the traditional manner of plot creation as well as in lack of coordination concerning the vocational rule terminology for cadastral land surveys and methods of spatial planning (Fig. 5).

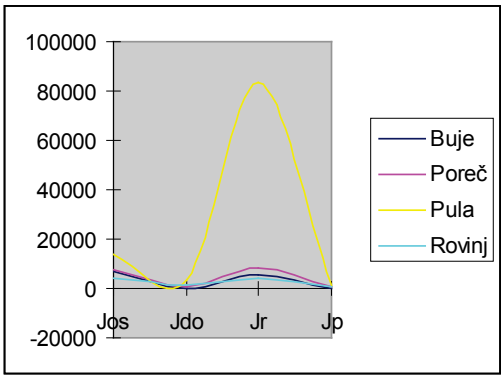

Figure 5 Diagram quantity for family house plot elements

3.2 Elements

The average surface areas of elements, family house plot and optimal surface areas were calculated for four municipalities: Buje, Poreč, Pula and Rovinj.

The minimum surface area of main construction element (A_a) was 115 m^2, while the maximum was 246 m^2. The minimum ancillary construction element (A_b) was 31 m^2, while the maximum was 71 m^2, which were significantly smaller than the main construction surface area. The minimum remaining arrangement element (A_c) was 45 m^2 of the municipality of Pula (Fig. 6), at the level of three municipalities while the maximum was 286 m^2 and, as such, it was the largest in comparison to other construction surface areas and plot arrangements. The minimum vehicle access arrangement element (A_d) was 8 m^2, while the maximum was 48 m^2 and, as such, was the smallest for the three municipalities.

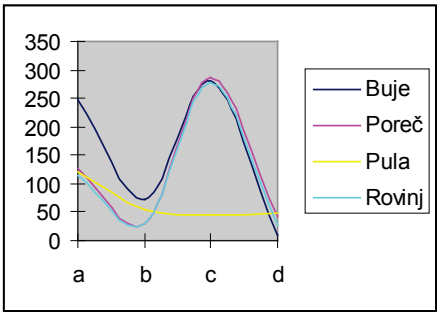

Figure 6 Diagram size for family house plot elements, in m^2

The maximum (A_{2max}) average family house plot surface area was limited to 606 m^2, while the minimum (A_{2min}) was limited to 269 m^2 (Tab. 3).

Table 3 Calculation of average family house plot element surface areas for West Coastal Istrian Area [24], in m^2

Municipalities	Average family house plot element surface areas in the application of Eqs. (4), (5) and (6)				A_{2s}
	A_a	A_b	A_c	A_d	
Buje	246	71	281	8	606
Poreč	126	31	286	41	484
Pula	122	54	45	48	269
Rovinj	115	31	278	27	451

3.3 Parameters

Parameters (w_p) and parameter shares ($\overline{w}_p$) for family house plots were calculated. With these parameters had the following surface areas: main construction (A_a) 152 m^2, ancillary construction (A_b) 47 m^2, remaining arrangement (A_c) 223 m^2 and vehicle access arrangement (A_d) 31 m^2. The optimal plot surface area (A_{2op}) for a family house was 453 m^2 (Tab. 4).

Table 4 Calculation of family house plot parameters for West Coastal Istrian Area [24]

Family house plot parameters in the application of Eqs. (6), (7) and (8)	
Parameter/A_{2s}	m^2
w_a	152
w_b	47
w_c	223
w_d	31
A_{2op}	453

The ratios of the parameters were chronologically: 34:10:49:7 (Fig. 8).

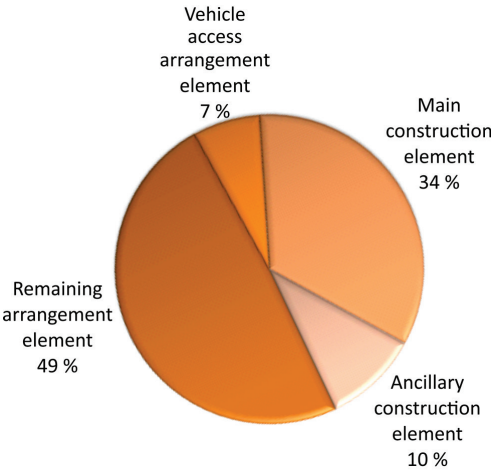

Figure 8 Parameter shares of surface of house elements, %

3.4 Equal and optimal family house plot elements

Equal and optimal family house plot elements have the following flexibly limited minimal and maximal surface areas: main construction, A_a = (115 ÷ 246) m^2; ancillary construction, A_b = (31 ÷ 71) m^2; remaining arrangement, A_c = (45 ÷ 286) m^2 and vehicle access arrangement, A_d = (8 ÷ 48) m^2 (Tab. 3). Equally, the optimal family house plot surface area ($A_{2op)}$ is flexibly limited for selection of arbitrary plot A_2 = (269 ÷ 606) m^2. For the purposes of comparison, an illustration of an optimization model and average family house plot surface area is given (De Chiara et al. 1995), which is somewhat smaller, 4000 ft^2/372 m^2, than the optimal, but is still within the limited average plot surface areas (Fig. 4).

4 Conclusion

At the end of this paper the following possible conclusions have been drawn: Using Istria as a case study, the Optimization Model for family house plot elements was determined, but the same model may be applied for similar cases as well. The optimal model was determined by defining the criteria for optimizing family house plot elements. In the family house plot structure, four equal elements were set, differing by using the closed and open space surface areas. The closed space included the surface area consisting of two elements, of which one is the main and the other ancillary construction. Open space also included the surface area of two arrangement elements of which one is the remaining arrangement and the other vehicle access arrangement. Evaluation of the family house plot elements included the development of mathematical formulae, as the basis for the substitution of the structural surface areas numerical representation. By applying the formulae, calculation of surfaces based on quantities, elements and parameters were obtained resulting in a model for measuring a family house plot. This model forms a basis for equal, optimal and flexible construction and arrangement of a family house plot. The same was obtained by equally measuring element identities in the family house parcel structure. Selection of the arbitrary family house plot (A_2) within the minimum (A_{2min}) and maximum (A_{2max}) family house plot surface area represents a way of optimizing family house plot elements. The proof that an individual family house plot element is optimal and flexible is demonstrated when its calculation, using parameters, is found to be within the surface area of a specific plot (A_2) and minimal surface area of an average family house plot (A_{2min}).The plot construction practice to date in terms of the planning documentation is limited to its purpose, dimension (width, length and height), surface area or coefficients of construction and utilization as limiting factors. Optimal, flexible and equal plot construction allows the architects or certified planners greater liberty in their creativity for family houses as compared to previous practice. The optimization model for family house plot elements is applicable in urban planning and designing through approved projects, but it is inapplicable for demolition of the said houses if they are under the protection of a competent governmental authority.

Example

The owner possesses a family house plot of surface area A_2=500 m^2; A_{2min}= 269 m^2.
How to optimize family house plot elements.
Application of the model (Fig. 4):
Optimal surface area of the main construction element = 34 %·A_2/100 = 170 m^2;
Minimal surface area of the main construction element = 34 %·A_{2min}/100 = 91 m^2;
Main construction surface area range A_{os} = 91 ÷ 170 m^2.
Optimal surface area of the ancillary construction element = 10 %·A_2/100 = 50 m^2;
Minimal surface area of the ancillary construction element: A_{do} = 10 %·A_{2min}/100 = 30 m^2;
Ancillary construction surface area range A_{do} = 30 ÷ 50 m^2.
Optimal surface area of the remaining arrangement element = 49 %·A_2/100 = 245 m^2;
Maximal surface area of the remaining arrangement element = (49 %·A_2) /100 + addition for possible reduced divergence (170 ÷ 91) m^2 from non-constructed optimal surface area of the main construction element = (0 ÷ 79) m^2.
Surface range of remaining arrangement A_r = 245 ÷ 324 m^2.
Optimal surface area of vehicle access arrangement element = (7 %·A_2) /100 = 35 m^2;
Maximal surface area of vehicle access arrangement element = (7 %·A_2) /100 + addition for possible reduced divergence (50 ÷ 30) m^2 from non-constructed optimal surface area of the ancillary construction element A_p = 0 ÷ 20 m^2.
Vehicle access arrangement surface area range A_p = 35 ÷ 55 m^2.

Optimization of the elements of a family house plot

$A_2 = A_{os} + A_{do} + A_r + A_p =$
$= /(91 \div 170)+(30 \div 50)+(245 \div 324)+(35 \div 55)/ = 500$ m^2.

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