Assessment of Lot Shape in Business Park Design

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Abstract: Planning and developing a business park is a complex task, whichdemands integration across various fields of design and knowledge. The first choice to be made in the design process is relate to the zoning process and the definition of the lot layout and landscape. These first decisions will constrain all subsequent decisions concerning utilities, facilities and amenities. For this reason, the assessment of those issues is crucial for the perception of the overall quality of the business park design. The main goal of this work is to present a simple indicator which can assess the lot shape in order to optimize the building form and costs, the use of its open areas, the layout and the economic spacing of roads and the service routes. The indicator lot shape evaluatesthe performance of the lot design solutions according to the concept of compactness.

Key-Words: -Lot Layout, Lot Shape, Lot Shape Assessment, Business Park Design Assessment.

1 Introduction

Various fields of engineering and architecture knowledge are fundamental to the developing process of a business park. In a comprehensive manner, the main issues focus on planning public utilities, facilities and amenities offered by the park,also being relevant to the park design the area landscapeand the characteristics and layout of the lots available for the location of enterprises.

A multicriteria model for assessing the quality of business parks design, called AQPZE, was developed in Portugal by a group of researchers from the Polytechnic of Viana do Castelo and the University of Minho [1]. The model assessment focuses on twelve project components, as criteria,whobasically refers to the main public utilities, facilities, amenities and several other issues that should be considered in a business parks design, i.e.:

i) street network;
ii) water supply;
iii) sanitary sewerage;
iv) storm sewerage;
v) electricity supply;
vi) gas supply;
vii) telecommunications;
viii) street lighting;
ix) solid waste disposal;
x) facilities and amenities;
xi) zoning and lot layout;
xii) landscape.

The modeladoptsa multicriteriaanalysisbased on a hierarchical tree structure, where a set of lower level criteria contributes to the assessment of the next higher level criteria or dimension. The assessment of each bottom lower level criterion is achieved by using an indicator or a set of dependent indicators that reflect the performance of the adopted design solutions in that domain. The assessment modeldefines a global index, which reflects the quality of business park design as a whole, and also allows the acquisition of partial score board that evaluates the performance of each dimension or criterion. Thus, it may cumulatively assess the quality of the design within a specific project component or design solution.

Generally, the first choices to be made in the business park design are the zoning and lot layout within thelandscape proposal. These first decisions will identify the layout of the business park and constrain the option to be adopted for the definition of the utilities, the facilities and the amenities. Therefore, the assessment of these project componentsis crucial for the perception of the overall quality of the business park design.

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The next topics will focusin the identification of the main factors to evaluate the lot shape in order to optimize the buildings form and its cost as well as the use of the open areas. At the end, some discussion and conclusions are presented.

2 The Lot Layout and Coverage

The zoning and the lot layout of a business parks, and the offer of public facilities and amenities, are critical issues in the success of the promotion and operation of the park. The design approach to the zoning and the lot layout should, in a broad sense, encompass the general park design as well as the specific lot design.

While the specific lot design should address the landscape and the use of its open area, particularly on those available for service, storage and parking, the general park design should take into account the business park zoning, the provided lot size typologies and the lot layout and coverage.

This design approach is reflected on the assessment procedure adopted for the zoning and the lot layout. The Figure 1 shows the assessment processand the aggregationestablished by the relationship ofthe criteria.

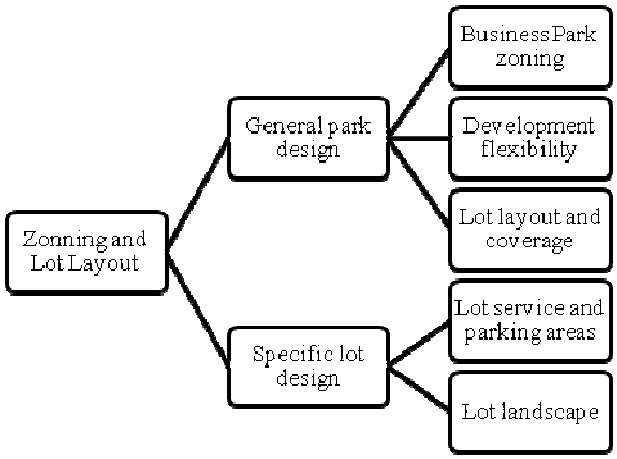

Fig. 1: Zoning and lot layout assessment criteria

As show in figure 2, the lot layout and coverage is assessed by using three indicators:

i) *street frontage*;
ii) *land use intensity;*
iii) *lot shape*.

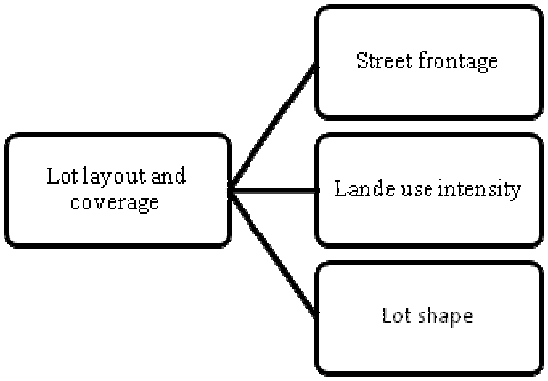

Fig.2: Lot layout and coverage assessment indicators

The first indicator - street frontage - is related to the dimension of the access of persons and goods to the lot. The second is an indicator that measures the density of development, given its impact on the quality of the built environment. The last one is an indicator of the lot compactness, knowing that its shape will determine, among others, the building form and costs, the use of its open areas, the layout and the economic spacing of roads and service routes [2] [3].

3 The lot shape

It is established that rectangular or square lots with a high compactness are those that have the best potential for implantationof buildings and use of the open areas, also enabling an optimized design of the exterior utilities, especially the road network. In addition, this typology of lots leads, as a rule, to the adoption of building forms also compact, which is reflected positively in the construction costs [1].

3.1 Compactness measurement

The compactness measure of a flat shape can be based on the isoperimetric theorem. This theorem is usually put in the form of the isoperimetric inequality, that states, for the perimeter P of a closed curve and the area A of the planar region that it encloses, that $4\pi A \leq P^2$. It should be noted that the equality holds if and only if the curve is a circle. Based on this inequality, various formulations of compactness measure were being adopted in various contexts, including, among others, the following: the *Coefficient of Compactness*, $CC = P^2 / 4\pi A$, used in image processing [4]; the *Compactness Index of Gravelius*, $K_G = P / 2\sqrt{\pi A}$, used in characterizing river basins [5]; or the *Area-Perimeter Measure*,M_1

= $4\pi A / P^2$, used in the characterization of electoral districts [6].

The compactness measure adopted for the business park lots is given by de *Mean Compactness Index of LotsIclm*, that is calculated through the Equation 1:

$$Iclm = \frac{16 \sum_{i=1}^{n} \frac{A_i}{P_i^2}}{n} \quad (1)$$

where:
A_i is the area of the lot *i*;
P_i is the perimeter of the lot *i*;
n is the number of lots;

$Icl = 16 \sum_{i=1}^{n} \frac{A_i}{P_i^2}$ is the compactness index of the lot *i*.

The *Compactness Index of the Lot Icl* ranges over the interval from 0 to 1.273, with a square lot taking the value of 1. The compactness index decreases with the increase of the ratio between the longer side versus the shorter side of a rectangular lot. For example, *Icl* takes values ranging from 0.889 to 0.750, if the longer side assumes the double or triple value of the shorter side of a lot with a rectangular shape, respectively. In the case of lots with a compact configuration, greater than the reference square, *Icl* takes values greater than unity, growing with de compactness of the shape. Eventually, the index has a value of 1.273 in the case of circular lots (not a normal solution).

3.2 Lot shape assessment

The indicator *lot shape* measures the performance of the lot design solutions according to the concept of compactness. This measurement is carried out by using a transformation function which gives the indicator score *Sfl*, with a value ranging on a scale of 0 to 1, as follows:

$$\begin{aligned} Sfl &= 0 && \text{if } Iclm \leq 0.700 \\ Sfl &= 1/0.15\ Iclm - 0.70/0.15 && \text{if } 0.700 < Iclm < 0.850 \\ Sfl &= 1 && \text{if } 0.850 \leq Iclm \leq 1.000 \\ Sfl &= -1/(4/\pi-1)\ Iclm + 4/\pi\ /(4/\pi-1) && \text{if } 1.000 < Iclm \leq 4/\pi \end{aligned} \quad (2)$$

For a better perception of the transformation function, the graphical representation is shown in the Figure 3.

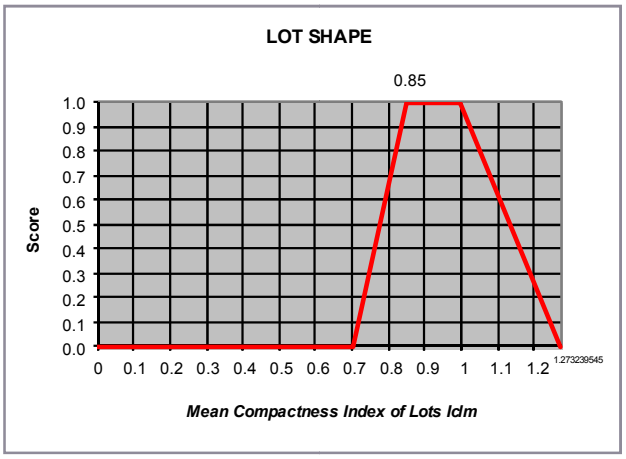

Fig.3: Lot shape assessment transformation function

This indicator assigns higher scores to the lots that are closer to shapes ranging from square to rectangular, the latter allowing the location of rectangular buildings having a length less or equal than twice the width. On the other hand, the indicator penalizes the buildings having elongated shapes, as well as those having shapes with compactness higher than the square, assigning a score equal to zero if Iclm $\leq$ 0.700.Also, the indicator assigns a score equal to zero to circular shapes.

The compactness values of 0.850 and 0.700 relate to lots with a rectangular shape, to locate rectangular buildings with a ratio between the length and width of 2 and 3, respectively. Taking into account the average buffer distance required from the buildings to the boundary of the lots, the corresponding relation between de sides of the lots will be 3.375 and 2.250, respectively.

4 Discussion and conclusions

The indicator assesses the lot shape according to its compactness measure throughout the *Mean Compactness Index of Lots*, *Iclm*. This index is achieved by calculating the mean value of the compactness of each lot.

The most common compactness formulations generally use the circular shape as a standard for comparison. The *Compactness Index of the Lot*, *Icl*, instead, takes as reference the square shape. In both cases, to the reference shape is commonly assigned the value of 1.

However, the score of the indicator *Lot Shape*, *Sfl*, reaches the maximum value of 1 for a set of compactness measures, ranging from 0.850 to 1. This assessment option intend to assign the higher

score to the lots that have shapes comprised between the square and the rectangular, provided that the latter enables the location of rectangular buildings having a length less or equal than twice the width.

The assessment of the lot layout, and consequently of the lot shape, should be a major concern in business park design. This will contribute to improve the design quality of the park and avoid major errors. Such assessment can also lead to significant functional and economic benefits.

References:

[1] Silva, J. *Quality Evaluation Model for Business and Industrial Parks (in Portuguese)*, PhD Thesis, University of Minho, Braga, Portugal, 2008.

[2] English Estates, Scottish Development Agency, Welsh Development Agency, Industrial Development Board of Northern Ireland, Development Board for Rural Wales, and the Highlands and Islands Development Board. *Industrial and Commercial Estates – Planning and site development*; Thomas Telford, London, 1986.

[3] Heredia, R. *Arquitectura e Urbanismo Industrial – Diseño y construcción de plantas, edificios y polígonos industriales*, Escuela Técnica Superior de IngenierosIndustriales de la Universidad Politécnica de Madrid, Madrid, Spain, 1981.

[4] Bassmann, H.; Kreyss, J. *Bildverarbeitung Ad Oculos***;** Springer, Heidelberg, 1998.

[5] Bendjoudi, H.; Hubert, P. *Le coefficient de compacité de Gravelius: analyse critique d'un indice de forme des bassins versants*. Hydrological Sciences – Journal des Sciences Hydrologiques, Volume 47, Issue 6, Association Internationale des Sciences Hydrologiques (AISH), Fontainebleau, 2002.

[6] Gillman, R. *Geometry and Gerrymandering*; Math Horizons, Volume 10, Issue 1, The Mathematical Association of America, Washington, 2002.