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Assessment of Lot Layout and Coverage in Business Park Design

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Abstract

The goal of this work is to present a simple tool which can assess the lot layout and coverage of a business park by using three indicators. The street frontage indicator evaluates the suitability of the spatial arrangement of the lot in order to ensure proper access to service vehicles, staff and visitors. The lot shape indicator evaluates the performance of the lot design solutions according to the concept of compactness. The land use intensity indicator intends to evaluate the quality of the site being developed regarding its building density. The assessment tool was applied to a business park located in Portugal, proved to be efficient and the results are discussed.

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Keywords: business park design assessment; lot layout assessment; street frontage; lot shape; industrial building density;

1. Introduction

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, which basically refer to the main public utilities, facilities, amenities and several other issues that should be considered in a business parks design: *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.*

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Generally, the first choices to be made in the business park design relate to zoning, the lot layout and landscape. These options will constrain all subsequent decisions regarding the utilities, facilities and amenities. Therefore, the assessment of these project components is crucial for the perception of the overall quality of the business park design.

Nomenclature

Rcfp	Frontage Length / Building Perimeter Ratio (-),
lf	sum of the building frontage lengths of all buildings (m),
lp	sum of the perimeters of all buildings (m),
Scf	Street Frontage Score (-),
Iclm	Mean Compactness Index of Lots (-),
A_i	area of the lot i (m^2),
Pi	perimeter of the lot i (m),
n	number of lots (-),
Sfl	Lot Shape Score (-),
Cos	Average Lot Floor Area Ratio (-),
Api	gross floor area of the building in the lot i (m^2),
Sios	Land Use Intensity Score (-).

2. The Lot Layout and Coverage

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 process and the aggregation established by the relationship of the criteria. As shown in Figure 2, the lot layout and coverage is assessed by using three indicators, which can be measured and evaluated*: i) street frontage; ii) lot shape; iii) land use intensity.*

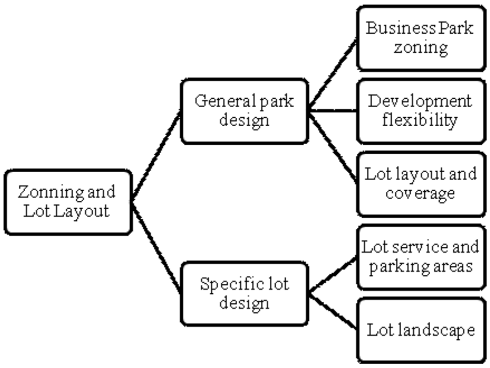

Fig. 1. Zoning and lot layout assessment criteria.

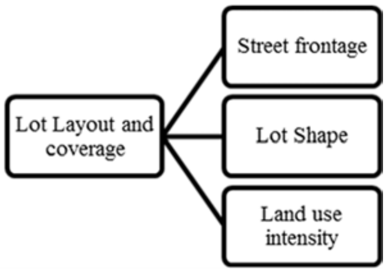

Fig. 2. Lot layout and coverage assessment indicators.

The first indicator - *street frontage* - is related to the dimension of the access of persons and goods within the lot. The second 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.

The last one is an indicator that measures the intensity of development, given its impact on the quality of the built environment [2, 3].

3. The Street Frontage

There is a correlation between the street frontage of an industrial building or warehouse and the ability to ensure a proper access to service vehicles, staff and visitors. A larger building frontage allows a better distribution of persons and vehicles flows and improves the operation of loading and unloading of goods [1,2].

3.1. The frontage measurement

The frontage measure adopted for the business park buildings is given by the *Frontage Length / Building Perimeter Ratio, Rcfp*, that is calculated through the Equation 1:

$$Rcfp = \frac{lf}{lp} \tag{1}$$

where lf is the sum of the building frontage lengths of all buildings, and lp the sum of the perimeters of all buildings.

For this purpose, it is considered as building frontage not only the frontage with the main street, but also the one with rear or side streets, if any. Alternatively, it is also considered as building frontage the rear and side elevations of the building that have a minimum of 17 meters setback from the lot boundary, allowing loading and unloading heavy vehicles inside the lot [2, 4].

3.2. Street frontage assessment

The *street frontage* indicator measures the performance of the lot and building design solutions according to the suitability of the spatial arrangement of the lot and its building footprint in order to ensure proper access to service vehicles, staff and visitors. This measurement is carried out by using a transformation function which gives the indicator score *Scf*, with a value ranging on a scale of 0 to 1, as follows:

$$\begin{aligned} Scf &= 0 && \text{if } Rcfp \le 0.125 \\ Scf &= 1/0.375\ Rcfp - 0.125/0.375 && \text{if } 0.125 < Rcfp < 0.500 \\ Scf &= 1 && \text{if } Rcfp \ge 0.500 \end{aligned} \tag{2}$$

4. The Lot Shape

It is established that rectangular or square lots with a high compactness are those that have the best potential for implantation of 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].

4.1. 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 $4 \pi A \leqslant P^2$. 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

[5]; the *Compactness Index of Gravelius*, $K_G = P / 2 \sqrt{\pi A}$, used in characterizing river basins [6]; or the *Area-Perimeter Measure*, $M_1 = 4 \pi A / P2$, used in the characterization of electoral districts [7].

The compactness measure adopted for the business park lots is given by de *Mean Compactness Index of Lots, Iclm*, that is calculated through the Equation 3:

$$Iclm = \frac{16\sum_{i=1}^{n}\frac{A_i}{P_i^2}}{n} \tag{3}$$

where *Ai* is the area of the lot *i*, *Pi* is the perimeter of the lot *i*, *n* is the number of lots, and *16Ai/Pi2* 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).

4.2. Lot shape assessment

The *lot shape* indicator 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:

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

5. The land use intensity

There is ample evidence to suggest that the land use is a central issue in the field of urban planning and design. The land use intensity in urban areas, and particularly the intensity of building development, is measured with several physical indicators related to how much built area there is on the site. Most of them measure building bulk, and are related to the floor area or the building volume [8].

5.1. Land use intensity measurement

The *Floor Area Ratio (FAR)* is the principal bulk regulation controlling the size of buildings. *FAR* is the ratio of total building floor area to the site area. Other common building density ratios, used in various context, are the *Building Volume Ratio (BVR)*, that is the ratio of total building volume to the site area, and the *Building Coverage Ratio (BCR)*, that is the ratio of total building coverage to the site area. The latter is often associated to the maximum height of the building, so allowing the control of its bulk.

The land use intensity measure adopted for the business park is given by de *Average Lot Floor Area Ratio, Cos*, that is calculated through the Equation 5:

$$Cos = \frac{\sum_{i=1}^{n} Ap_i}{\sum_{i=1}^{n} A_i} \tag{5}$$

where *Api* is the gross floor area of the building in the lot *i*, *Ai* is the area of the lot *i*, and *n* is the number of lots. The *Average Floor Area Ratio*, *Cos*, is equal or greater than 0, and increases with the building bulk.

5.2. Land use intensity assessment

The *land use intensity* indicator measures the performance of the lot and building design solutions according to the building intensity. This measurement is carried out by using a transformation function which gives the indicator score *Sios*, with a value ranging on a scale of 0 to 1, as follows:

$$\begin{aligned} Sios &= 1 && \text{if } Cos \le 0.400 \\ Sios &= -1/0.40\, Cos + 0.80/0.40 && \text{if } 0.400 < Cos < 0.800 \\ Sios &= 0 && \text{if } Cos \ge 0.800 \end{aligned} \tag{6}$$

6. Case study: Business Park of Lanheses

The assessment tool of the *lot layout and coverage* was applied to Lanheses Business Park, which is located in Viana do Castelo, in the north of Portugal. This is a new generation business park, whose phase 1 covers a total area of 150.074 m^2, including 56.805 m^2 to build 33 lots for industry, storage and facilities (Fig. 3). The areas of the lots ranges between 428 m^2 and 4020 m^2. The former are eighteen and are intended to be used for startup and/or small companies. The remaining lots are exclusively for traditional industrial facilities.

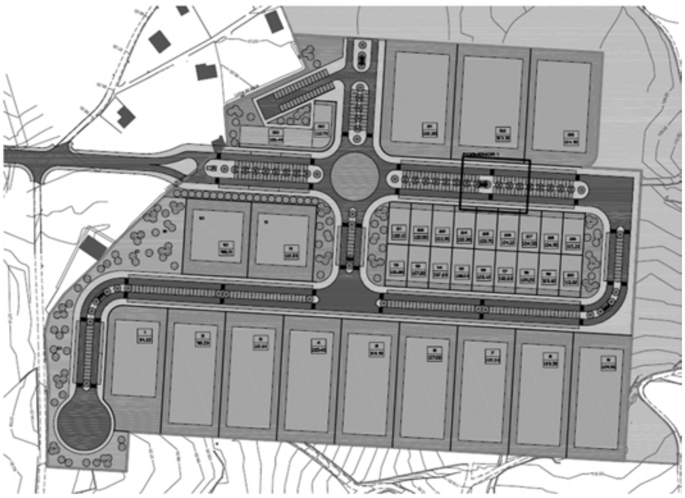

Fig. 3. Plan of Lanheses Business Park.

The Table 1 shows the evaluation and the combination of all the indicators, which led to a final score of 0.57 for the lot layout and coverage. For each indicator, its weight is indicated as well.

Table 1: Lot layout and coverage indicators evaluation, weighting and combination.

Criterion	Score	Indicator	Score	Weight
Lot layout and coverage	0.57	Street frontage	0.25	0.33
		Lot shape	1.00	0.33
		Land use intensity	0.45	0.33

7. Discussion and conclusions

The *lot layout and coverage* in Lanheses Business Park has a score of 0.57. This final score is a combination of the partial scores obtained from the *street frontage*, *lot shape* and *land use intensity* indicators, whose values are respectively 0.25, 1.00 and 0.45. So it can be said that the score reached for the first criterion was not suitable, nevertheless for the others was satisfactory. Indeed, the weakness of the *lot layout and coverage* in Lanheses Business Park is the *street frontage*, measured as the buildings frontage length relative to the buildings perimeter. This means that the average length of the buildings frontage is not enough to ensure in all cases the most suitable separation of the service areas from the personnel entrance or entrances provided for customers, management and staff. But it must be stressed that this score value is in part due to a large number of buildings intended for small startup companies, with just one frontage. However, this layout can be suitable for small firms, as the grouping of entrances eases the problem of supervision for small management staff, even if there is no provision for outside storage goods. On the other hand, the strength of the *lot layout and coverage* is the *lot shape*, assessed according to its compactness, since the related indicator has reached the maximum score. At last, the *land use intensity* score is penalized by the high floor area ratio verified on the eighteen lots to be used for startup and/or small companies, which have a floor area of 375 m^2 for a lot area of 428 m^2.

The assessment of the lot layout 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.

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