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The role of urban plans in promoting sustainable buildings

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ABSTRACT

This study aimed to identify if municipal plans, in use, establish rules that are favourable to sustainable buildings, specifically energy conservation techniques. A survey was conducted and 23 Municipal Master Plans and 17 Detailed Plans were analysed. It was concluded that the rules set by the plans do not aim energy conservation in buildings, but they allow the quantification of relevant indicators for this purpose.

Keywords: *Energy conservation, sustainable cities, urban planning*

Theme: Sustainable cities

INTRODUCTION

Urban planning aims to manage and organize the change carried out by men in the territory especially in the city, ensuring heritage and natural preservation while minimizing the impact on the environment. Urban planning is regulated by legislation and is materialized in spatial plans.

Portuguese legislation on land use and urban planning determines that territorial management is based on programmes and territorial plans. Programs set out the strategic framework for territorial development and can be of a national, regional or inter-municipal scope. Territorial plans establish options and concrete actions in urban planning and land use. Territorial plans can be municipal or inter-municipal.

There are three types of municipal plans: municipal master plan (MMP), urbanization plan (UP) and detailed plan (DP). According to the legislation the MMP establishes the strategy and the territorial model for the municipality. The UP develops and implements the MMP regarding land use, infrastructure location and collective facilities. DP also develops and implements the MMP but goes a step further and defines the layout and the volume of buildings [1].

It is found that, in accordance with the legislation, MMP and the DP are the most important plans in designing buildings and urban environment. MMP is mandatory and restrain other plans. DP has great influence in building design.

This article presents a survey to a set of MMP and DP to identify the rules used and their effectiveness in contributing to sustainable cities.

SURVEY ON RULES IN USE BY MUNICIPAL PLANS

A survey was conducted, in order to know whether existing plans promote sustainable building specifically energy conservation. The survey focused on the rules used in MMP to regulate the building and the building solutions found by DP.

Reviewed municipal master plans

Twenty three MMP from municipalities, across the country, were reviewed. Some of these municipalities are, according to the 2011 *Censos*, the most populous ones. Table 1 shows the selected municipalities, its population and the reviewed documents.

Table 1: Municipality, population and MMP

| Municipality: | Population: | Document: |
|---------------|-------------|------------------------------------|
| Alcobaça | 56596 | RCM nº177/1997 e Aviso nº6554/2012 |
| Almada | 173298 | RCM nº5/1997 e Aviso nº1922/2012 |
| Amadora | 175558 | RCM nº94/1994 e Dec. nº64/2004 |
| Barreiro | 79042 | RCM nº26/1994 |

| | | |
|----------------------|--------|------------------------------------|
| Braga | 181819 | Aviso nº11741/2015 |
| Bragança | 35319 | Aviso nº12248-A/2010 |
| Cascais | 205117 | RCM nº96/1997 |
| Coimbra | 143052 | Aviso nº7635/2014 |
| Gondomar | 168205 | RCM nº48/1995 |
| Guimarães | 158108 | Aviso nº6936/2015 |
| Lisboa | 545245 | Aviso nº11622/2012 |
| Loures | 205577 | Aviso nº 6808/2015 |
| Matosinhos | 174931 | Aviso nº3139/2014 |
| Moita | 66311 | RCM nº28/2010 e Aviso nº10488/2010 |
| Odivelas | 143755 | Aviso nº10014/2015 |
| Porto | 237559 | RCM nº19/2006 e Aviso nº4272/2012 |
| Santa Maria da Feira | 139393 | Aviso nº6260/2015 |
| Seixal | 157981 | Aviso nº2388/2015 |
| Setúbal | 120791 | RCM nº65/1994 e Aviso nº9397/2013 |
| Sintra | 377249 | RCM nº116/1999 e Aviso nº2088/2016 |
| Valongo | 93753 | Aviso nº1634/2015 |
| Vila Nova de Gaia | 302092 | Aviso nº14327/2009 |
| Vila Real | 52219 | Aviso nº7317/2011 |

Rules set by municipal master plans

The survey conducted on Table 1 MMP, showed that the main rules used to regulate building construction are intended to limit construction area and the number of floors. To limit construction area, MMP use plot ratio (or floor area ratio) and site coverage ratio. Plot ratio is the ratio of total gross floor area of a development to its site area [2,7]. Site coverage ratio is the ratio of the building footprint area to its site area [2,7]. When site coverage area is the lot area the rates are considered net, in general, used for urbanized area and city centers. But when site coverage area is the total area of the development including roads and public spaces rates are considered gross. Gross rates are specified in planning to regulate and control new developments and these where values searched for in MMP.

Table 2: Plot ratio values adopted by MMP

| Municipality: | Plot ratio | | | | | | | | | |
|----------------------|------------|------|------|-----|------|-----|------|-----|-----|--|
| Alcobaça | 0.25 | 0.3 | 0.4 | 0.6 | | | | | | |
| Almada | 0.35 | 0.5 | 0.7 | | | | | | | |
| Amadora | 0.3 | 0.6 | 0.8 | | | | | | | |
| Barreiro | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | | | | |
| Braga | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 1.0 | 1.1 | 1.2 | 1.4 | |
| Bragança | 0.5 | 0.6 | 0.8 | | | | | | | |
| Cascais | 0.4 | 0.5 | 0.8 | 1.0 | | | | | | |
| Coimbra | 0.35 | 0.4 | 0.45 | 0.5 | 0.65 | 0.7 | 0.9 | 1.3 | 1.8 | |
| Gondomar | 0.6 | 0.8 | 1.1 | 1.4 | | | | | | |
| Guimarães | ----- | | | | | | | | | |
| Lisboa | 1.2 | 1.5 | 1.7 | | | | | | | |
| Loures | 0.35 | 0.5 | 0.6 | 0.7 | 0.8 | 1.0 | 1.25 | 1.5 | 2.0 | |
| Matosinhos | 1.0 | | | | | | | | | |
| Moita | 0.4 | 0.45 | 0.6 | 0.7 | | | | | | |
| Odivelas | 0.3 | 0.55 | 0.6 | 0.8 | 0.85 | | | | | |
| Porto | 0.6 | 0.67 | 0.8 | 1.0 | 1.4 | | | | | |
| Santa Maria da Feira | 0.7 | 0.8 | 0.9 | 1.0 | 1.1 | 1.2 | | | | |
| Seixal | 0.5 | 1.0 | | | | | | | | |

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|-------------------|-----|-----|-----|-----|-----|
| Setúbal | 0.5 | 0.7 | 1.0 | 1.5 | |
| Sintra | 0.2 | 0.3 | 0.4 | 0.5 | 0.7 |
| Valongo | 0.6 | 0.8 | 1.2 | 1.4 | |
| Vila Nova de Gaia | 0.4 | 0.8 | 1.2 | 1.8 | |

Table 2 presents plot ratio adopted values and Table 3 presents site coverage ratio and the maximum number of floors allowed. For 23 MMP surveyed only one doesn't use plot ratio, this makes for this sample, the most common ratio. Unlike site coverage ratio which is adopted only by 5 MMP.

Table 3: Site coverage ratio and maximum floor number.

| Municipality: | Site coverage | | | | | Floor number | | | |
|----------------------|---------------|-----|------|------|------|--------------|---|---|---|
| Alcobaça | ----- | | | | | 2 | 3 | 4 | 6 |
| Almada | 0.1 | 0.3 | 0.6 | 1.0 | | 2 | 4 | 6 | |
| Amadora | ----- | | | | | 3 | 5 | 8 | |
| Barreiro | 0.2 | 0.3 | 0.4 | | | ----- | | | |
| Braga | 0.7 | | | | | 2 | 3 | 4 | |
| Bragança | 0.25 | 0.3 | 0.4 | 0.6 | | 2 | 3 | 6 | |
| Cascais | 0.35 | | | | | 3 | 5 | 7 | |
| Coimbra | ----- | | | | | 2 | 3 | 5 | 7 |
| Gondomar | ----- | | | | | ----- | | | |
| Guimarães | 0.3 | 0.6 | 0.7 | 0.8 | 1.0 | 2 | 3 | | |
| Lisboa | ----- | | | | | ----- | | | |
| Loures | ----- | | | | | 2 | 4 | 6 | 8 |
| Matosinhos | ----- | | | | | ----- | | | |
| Moita | ----- | | | | | 2 | 3 | 5 | |
| Odivelas | 0.55 | 0.5 | 0.45 | 0.35 | 0.25 | 4 | 8 | | |
| Porto | ----- | | | | | ----- | | | |
| Santa Maria da Feira | ----- | | | | | 2 | 3 | 4 | 5 |
| Seixal | ----- | | | | | 2 | 3 | | |
| Setúbal | ----- | | | | | 3 | 4 | 5 | 8 |
| Sintra | ----- | | | | | 4 | 5 | | |
| Valongo | ----- | | | | | 4 | 9 | | |
| Vila Nova de Gaia | ----- | | | | | 4 | | | |

This survey shows that plot ratio adopted by MMP vary between 0.2 and 2.0 site coverage ratio between 0.1 and 1.0. It was also noticed that the municipalities with the higher plot ratio values do not used them for the entire territory since there are other predicted values. The maximum floor number is frequent and generally set by zones, the minimum was 2 floors and maximum was 9 floors. The following figures show the plot ratio values and the maximum number of floors systematized by frequency of use, or number of occurrences.

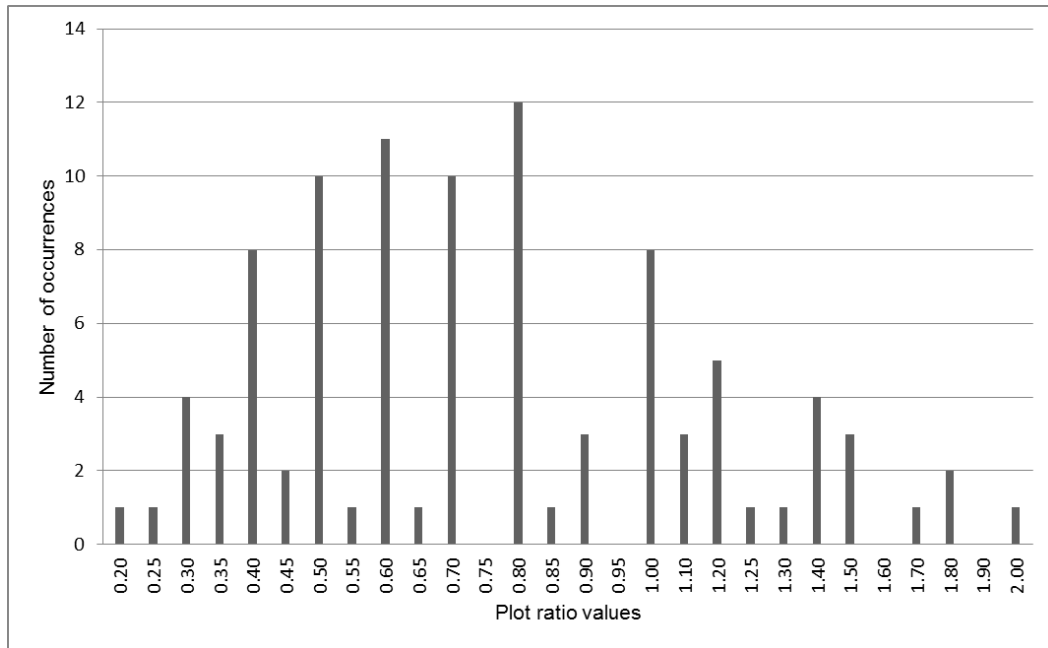


Figure 1: Distribution of the number of occurrences per plot ratio value

Figure 1 shows that the extreme values, low or high, as values below 0.3 or above 1.4 occur rarely.

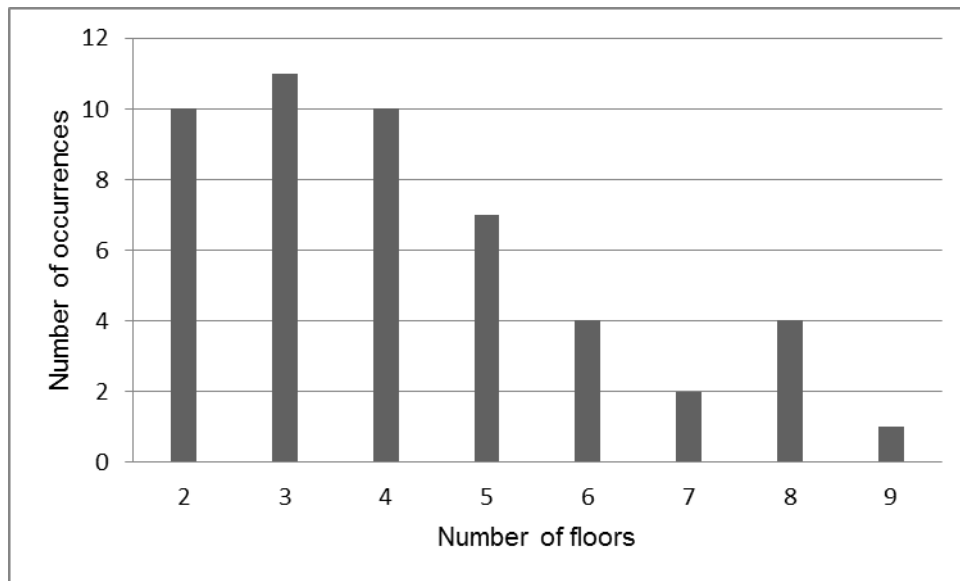


Figure 2: Distribution of the number of occurrences per number of floor

As for limiting the number of floors the lowest values: 2, 3 and 4 floors are the most frequent.

Reviewed detail plans

For this study municipalities with high population density (number of inhabitants per km²), according to the INE [3], were selected.

Figure 3 shows the ten national municipalities with higher population density. Two were chosen, one from each metropolitan area, Amadora and Porto.

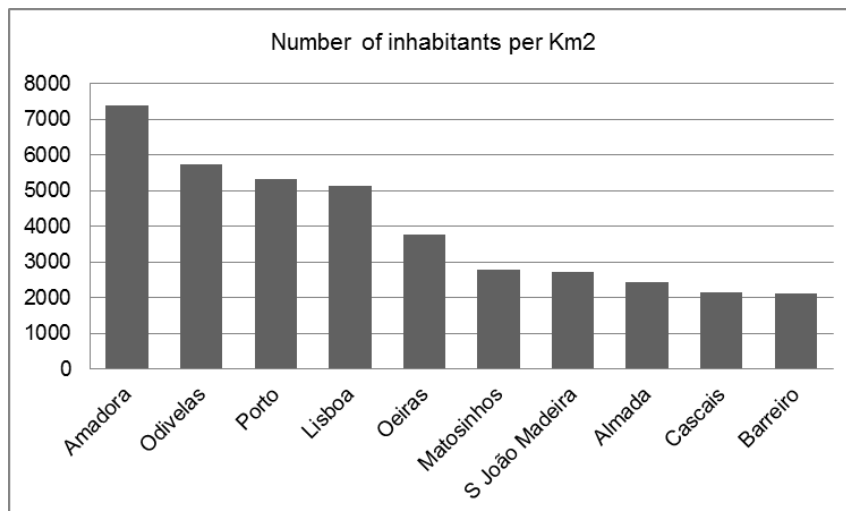


Figure 3: Ten municipalities with the highest population density. Source: PORDATA

Amadora municipality possess 17 detailed plans and Porto municipality 2, which are presented in Table 4.

Table 4: Detailed Plans of the Amadora and Porto Municipalities.

| Municipality: | Detail Plan for: | Year |
|---------------|--|------|
| Amadora | Rua Elias Garcia Zona Poente (street) | 1996 |
| | Ligação de Casal S. Brás /R. Comandante Ferreira do Amaral (street and intersection) | 1996 |
| | Rua Gonçalves Ramos/Rua Filipa de Lencastre (street) | 1996 |
| | Encosta Norte da Serra de Carnaxide (hillside) | 1998 |
| | Brandoa - Quarteirão 10 (quarter) | 1998 |
| | Brandoa - Quarteirão 17 (quarter) | 1998 |
| | Brandoa - Quarteirão 51 (quarter) | 1999 |
| | Brandoa - Quarteirão 2 (quarter) | 1999 |
| | Brandoa - Quarteirão 32 (quarter) | 1999 |
| | Brandoa - Quarteirão 21 (quarter) | 1999 |
| | Brandoa - Quarteirão 16 e 15 (quarter) | 1999 |
| | Brandoa - Quarteirão 52 (quarter) | 2001 |
| | Brandoa – Quarteirão 50 e 54 (quarter) | 2008 |
| | Brandoa - Quarteirão 1 (quarter) | 2008 |
| | Ribeira da Falagueira (riverside) | 2005 |
| | Parque Urbano do Neudel (park) | 2008 |
| | S. Brás (neighborhood) | 2009 |
| Porto | Antas (neighborhood) | 2014 |
| | Dallas (quarter) | 2015 |

The Ribeira Falagueira and Parque Urbano Neudel detail plan do not include urban areas, therefore those plans are outside this study scope.

Detail plan analyses

Detail plans blueprints were analysed to identify whether the buildings had south facing façades or south quadrant façades, if the spacing between buildings allow solar penetration in winter and also if green areas are offered.

Table 5: Facades solar orientation and green areas, by DP.

| Detail plan | South facing façades | South quadrant façades | Solar penetration | Green areas |
|---|----------------------|------------------------|-------------------|-------------|
| Rua Elias Garcia Zona Poente | NO | YES (< 50 %) | NO | YES |
| Ligação de Casal S. Brás – R. Comandante Ferreira do Amaral | YES (> 50 %) | | NO | YES |
| Rua Gonçalves Ramos–Rua Filipa de Lencastre | YES (> 50 %) | | YES | NO |
| Encosta Norte da Serra de Carnaxide | YES (< 50 %) | | NO | YES |
| Brandoa - Quarteirão 10 | NO | YES (< 50 %) | NO | NO |
| Brandoa - Quarteirão 17 | NO | NÃO | | NO |
| Brandoa - Quarteirão 51 | NO | NÃO | | NO |
| Brandoa - Quarteirão 2 | NO | NÃO | | NO |
| Brandoa - Quarteirão 32 | NO | YES (< 50 %) | NO | YES |

| | | | | |
|------------------------------|--------------|-------------|-----|-----|
| Brandoa - Quarteirão 21 | NO | NO | | NO |
| Brandoa - Quarteirão 16 e 15 | NO | NO | | NO |
| Brandoa - Quarteirão 52 | NO | YES (<50%) | NO | YES |
| Brandoa - Quarteirão 50 e 54 | YES (> 50 %) | | NO | YES |
| Brandoa - Quarteirão 1 | YES (< 50 %) | | NO | NO |
| S. Brás | NO | YES (>50%) | YES | YES |
| Antas | NO | YES (< 50%) | NO | YES |
| Dallas | NO | NO | NO | NO |

In 12 of the 17 DP analysed, it can be observed that buildings do not have a south facing façade. In 5 DP buildings were facing south, but only 2 DP ensure solar access for this buildings. Only half of the DP has green areas planned.

DISCUSSION

This paper presented a survey conducted to current Municipal Master Plans and Detail Plans. The plans were available through the Municipal electronic page or in *Diário da Republica*, which is the official legislation publisher. The presented sample, in spite of not being large, is believed to be representative and includes some of the most populous municipalities which are meaningful at national level.

In general, plans use rules concerning construction limitation both in area and in volume and neglect energy conservation in buildings. Detail Plans are meant to carry out Municipal Master Plans. Since MMP do not embrace energy conservation, DP create layouts that do not take it into account. The most common errors are:

- Buildings layout does not consider solar orientation.
- The relationship between buildings heights and free space prevents solar access.
- The lack of green areas in buildings surroundings.

ASPECTS TO BE CONSIDERED IN URBAN PLANNING TO IMPROVE ENERGY PERFORMANCE OF BUILDINGS

The territorial models proposed by municipal plans have great influence in buildings energy performance. Each municipality, zone and site has its own climatic characteristics. An analysis regarding sun exposure and microclimate conditions are essential to find the ideal options for each site. However it is possible to systematize some common aspects.

1 Provide a proper sun exposure:

- By turning a façade with openings to south, insuring solar gains during winter. The building layout shouldn't be constrained by the road network [4,6].
- By avoiding overshadowing. The road width and the space between buildings should take into account the buildings maximum height, allowing solar penetration during winter [4,6].

2 Improve microclimate conditions:

- By generating balance between green areas and construction. City vegetation has an essential role in regulating temperature and humidity, but also in pollutants absorption [5].
- By using trees to provide windbreak in winter and/or sunshades in summer [5].

These considerations are likely to be adopted by the Municipal Master Plans and implemented by the Detailed Plans thus creating conditions for more energy efficient buildings and therefore more sustainable cities.

CONCLUSIONS

Building regulations, codes or specific legislation establish the minimum performance level particularly regarding energy consumption. Today the minimum regulatory objectives are not enough, it is necessary to find the best solutions to have more sustainable cities. To achieve more sustainable cities regarding energy, technologies and innovative construction solutions must be combined with passive strategies and not replace them.

The Municipal Master Plan (MMP) and the Detailed Plan (DP) play a key role defining urban environment and building layout. This paper present a survey conducted on set a of plans from a several municipalities to examine whether the rules and the strategies used are promoting the energy efficiency of buildings. Several conclusions can be drawn:

- The rules used in MMP to control construction aim to quantify buildings area but do not specify qualitative aspects. The rules are regardless to sun access which is a negative factor for buildings energy efficiency.
- Construction quantification, usually, is determined by plot ratio indicator. In some cases plot ratio appears alone in others in conjunction with site coverage ratio and maximum floor number. The most common values in use are low, which is a positive factor because it prevents urban densification, which contribute to obstruct sun access.
- In general the layout of buildings planned in DP is not well chosen. But when buildings have a favorable orientation, solar access is not always guaranteed because of the lack of space in between.

These are the aspects that stand out from this study, based on the analyzed sample.

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