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## The Sustainable Heritage of Vernacular Architecture: the Historic Center of Oporto

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### Abstract

Architecture is the result of different generative dynamics. Vernacular architecture is an example of building within inherent sustainable characteristics. By using a conceptual structure based on the architectural main components, it is possible to recognize the interrelations established in the past, and the ones crucial to respect in the present. The architectural values of the historic center of Oporto are analyzed, regarding the interactions of both its generative main topics and inherent sustainable values. In our historic centers we can see sustainability within architecture, as a whole, helping us to understand what components we must focus, why, when and where.

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**Keywords:** architecture dynamics; sustainability dynamics; built heritage; historic centre; conceptual matrix.

### 1. Introduction

Vernacular architecture is often an example of building within inherent sustainable characteristics: energy, materials and local resources<sup>1</sup>. It was sustainable without being aware of it, maybe because the main goal was not to define sustainability concepts, but to work with architectural ones. A sustainability conscience was intrinsically present, as an ideal to pursue good architecture. It was a natural language of place and time. The environmental ethics of building was a natural guideline for the concept of *dwelling* in a specific place. Afterwards, the notion of *machines for living* overwhelms this concept. The physical environment became a material, easy to manipulate and

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control. Architecture was global. When this global *way of living* failed due to environmental risks, sustainability arises again, though announced as a new concept to integrate in our architectural conscience. Therefore, several design measures attempt to establish a path for architecture, so to reach sustainability. It is widely accepted that an ecological building must consider local materials, wherever it is possible<sup>2</sup>. Moreover, “tomorrow’s sustainable architecture” should be adequate to its *use*, its *stability*, *durability* and *delight*<sup>3</sup>. In addition, “Green Vitruvius” alerts to the importance of solar passive design in order to improve the energy performance of the building<sup>2</sup>. Although it is crucial to validate both the environmental efficiency and performance of a building, this approach tends to reduce architectural values to quantifiable *data values*. Some attempt to elaborate a checklist for sustainable architecture, electing as main topics for the analysis the “environmental impact, social and cultural relevance, occupants, economic performance, the building”<sup>4</sup>. However strange may seem to consider *the building* as a detached topic. Also by measuring the range of *Input* (use of resources) and *Output* (environmental impact), we may even define the *Architectonic Ecosystem*<sup>1</sup>. Furthermore, with the *Sustainability Assessment Model* (SAM) we may evaluate a project by analyzing 22 performance indicators, divided in four groups of impact: resource consumption, environmental, social and economic<sup>1</sup>. Consequently, architecture is often qualified only by its level of sustainability. Nevertheless, sustainable architecture within these definitions is not, by default, good architecture. Good architecture can and should be able to absorb these notions. Some authors recognize it, by defining as main topics for grouping sustainable attitudes the *functional quality*, *architectural quality* and *use of resources*<sup>5</sup>. This approach, by assuming architectural values as guidelines, unfolds the vernacular *way of thinking* architecture, which define the character of our historic centers.

This paper aims to establish this sustainable inherent value, by exploring the potential of a conceptual model, further developed in previous studies<sup>6,7</sup>, due to its ability for managing complex and interdependent forces acting within a common field, which defines architectural dynamics.

## 2. Architectural dynamics

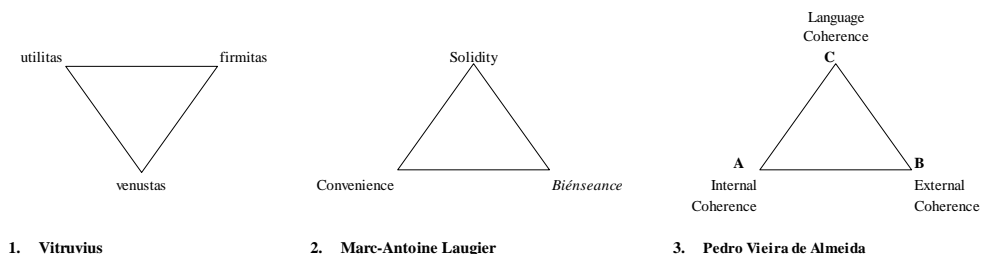


Fig. 1. Architectural conceptual models.

The vernacular *way of thinking* architecture unveils key strategies in order to materialize *dwelling*, emphasizing the notion of *shelter*. Since the seminal Vitruvius’ triumvirate, several authors established conceptual models looking for structuring these strategies (Figure 1). Vitruvius (1st century BC) stated that “In all construction should be taken into account its solidity (*firmitas*), its utility (*utilitas*) and its beauty (*venustas*)”. Marc-Antoine Laugier (18th century) also established several reflections about architecture: “one must build with solidity, for convenience and according to *bienséance*”. Pedro Vieira de Almeida (20th-21th century) defines three main poles that interact in the design process. Pole A, *Internal Coherence*, comprises the program formulation, the function. Pole B, *External Coherence*, gathers the determinants of the site and landscape. Pole C, *Language Coherence*, comprises the expressive means that compose the language of architecture, mainly its formal and spatial structures. In its conceptual triad, Pole B, the conception of “site and landscape” might tend to be interpreted as a single reference to local materials and solar passive design. Nevertheless, it relates more to the romantic principle of the humanized landscape, defending that architecture is mainly poetry, arising the notion of an immaterial essence.<sup>8</sup> It must be contextualised that, at the time of this conceptualization, the *firmitas* vertex was not an issue, all materials and constructive systems were available everywhere and the environmental comfort can easily be produced. On the other hand, it was upraised a fourth vertex, the *site and landscape in its poetic sense*, reflecting the immaterial variables of

a place: meaning, identity, history, defining a spatial character, its *genius loci*. The *genius loci* is a Roman concept, according to an ancient belief that each “independent being has its genius, its guardian spirit, which gives life to people and places, and determines its character and essence”.<sup>9</sup> Norberg-Schulz re-fetched this concept to architecture in the 80’s, curiously after the environmental failing of global architecture.

As sustainability, *genius loci* was, in the past, transversal to all *architectural poles*. By using local materials and resources to create a *shelter*, adequate to its use, its environmental surroundings and its occupants, they were able to accomplish singular *genius loci* for specific human settlements. Otherwise, we wouldn’t have nowadays i.e., the *character* and *essence* of our historic centres. However, along with the loss of a sustainable conscience, the *genius loci* was somehow forgotten and it might be the missing pole in our architectural ethics. Therefore, this ancient concept should always be present, as the fourth conceptual vertex of our architectural conscience, along with *firmitas*, *utilitas* and *venustas*. We are *building* some kind of *shelter*, for some kind of *use* (specific or not), to cause *delight* (collective and individually), but in a *specific place*. Agreeing with the *Gestalt* theory that argues that one cannot have knowledge of the “whole” by the sum of its parts, it should be explored how these complex and interdependent forces might act on a common field, in the definition of the built heritage of our historic centres.

### 3. Architecture quadrature

Within these tripartite schemes, we can acknowledge that different poles have become predominant at different times in architecture. However, this linear structure does not enable quantification, showing when the spirit of the age emphasizes one or more factors, highlights some kind of addiction between some poles, or reduces drastically one of them. It is crucial the managing of four fields – *firmitas*, *utilitas*, *venustas*, *genius loci* -, a quadrature.

In this case, it was reinterpreted a conceptual matrix of psychology’s study of group dynamics, as an operative reference due to the mechanics of its construction, the flexibility to assume several configurations, and by denoting dynamic variations in the group. “The word *dynamic* implies complex and interdependent forces acting within a common field or frame”<sup>10</sup>. Two variables, interacting as two opposite concepts, define a common frame.

In Architecture, the two main conceptual guidelines are the notions of *objective* and *subjective*, *rational* and *irrational*, synthesized in *material* and *immaterial* (Figure 2.a). Architecture balances between these irrational sensitivities and the rational activities as Quaroni reconized: “...by changing the scale in the design process, also varies the relation between *rational* and *irrational* moments, being these last more frequent at small and medium scales, almost disappearing in larger scales.” He also considered that both *utilitas* and *firmitas* belong to the rational sphere of knowledge, whereas *venustas*, as the mode to manipulate *utilitas* and *firmitas* in order to obtain architecture, both belong on the one hand to the rational sphere and on the other, to the irrational.

Therefore, *firmitas* (I) is materiality, objective, rational and quantifiable. Although with a recognizable component of materiality, both *venustas* (II) and *utilitas* (III), may depend on subjective criteria, and unquantifiable or intangible notions. *Genius loci* is clearly immaterial “squared”. It is the character and essence of places and sites, with their social and cultural specificities. (Figure 2.b). Within this conceptual model, we are able to recognize architecture as a dynamic process, where its generative components act within a common field. Moreover, it is noticeable that the growth of one pole implicates the reduction of others (Figure 2.c). Quaroni had already warned for the errors in architecture, arising from the reduction of the Vitruvian components.<sup>11</sup>

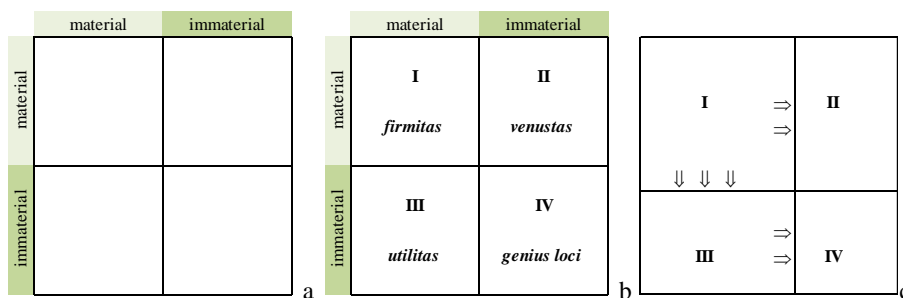


Fig. 2. (a) Architecture conceptual guidelines; (b) Architecture quadrature; (c) Architecture dynamics.

#### 4. Sustainability and retrofitting strategies

Nowadays, Europe's approach to the heritage retrofitting of historic centres is associated with sustainability criteria, seeking to incorporate European regulations on building's habitability and energy efficiency. Sustainability tends to be acknowledged as a new vertex or pole in the architecture dynamics. The "Green Vitruvius" argues that, in addition to the original *Vitruvian triumvirate*, another fourth ideal is missing, *restituitas* or *renovation*<sup>2</sup>. However, as sustainability, this is not a missing architectural concept. It is more a procedure, an attitude to improve in architecture. It is the enhancement of the *firmitas*, the *utilitas* and the *venustas* of an existing building, either in a single or combined way, by treasuring its *genius loci*.

In the Merriam-Webster dictionary, *sustainable* is a 'method of harvesting or using a resource so that the resource is not depleted or permanently damaged.' Which is the same notion of retrofitting our built heritage. In a previous study<sup>7</sup>, it was interpreted the role of sustainability within this architectural quadrature (Figure 3).

The *material* column defines attitudes, measurable or definable by quantitative values - the *material* essence. On the other hand, the *immaterial* column defines conscience, unmeasurable but definable by qualitative values - the immaterial essence. *Respect* leads us to our sustainable conscience. Social relevance, cultural identity, local coherent design and social ethics are themes belonging to our *immaterial* guideline, some of them present in two quadrants. *Reduce* and *Reuse*, enclose the notions of environmental impact, resource consumption and economic performance. All of them measurable and quantifiable, belonging to our *material* guideline (Figure 3.a). *Reduce* and *Reuse* both, may define sustainable attitudes. Some of them may belong to one or more quadrants, while others might change their position, or have different relative weights, regarding distinct specificities. These complex and interdependent forces, acting in a common field define sustainability dynamics and, by default, sustainable architecture (Figure 3.b).

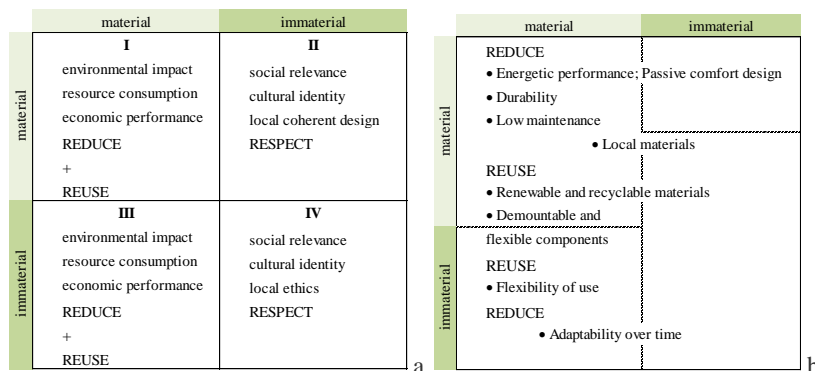


Fig. 3. (a) Sustainability in architecture; (b) Sustainability dynamics.

Today, when electing retrofit strategies, there is a predominant focus on quadrant I, *firmitas*, in order to *Reduce* its environmental impact, its resource consumption and its economic performance. The *venustas* quadrant (II) is always taken on account to *Respect*, but reducing its social relevance, cultural identity and local coherent design to the exterior elements, the street façade. The *utilitas* component (III), attentive on the *Reuse of these buildings*, works on its adaptability over time and flexibility of use, sometimes disregarding its original internal typologies or allotments. The use of renewable and recyclable materials, or demountable and flexible structures as the *sustainable* way to operate, might put to risk the *vernacular way* of thinking architecture, which made us achieve the sustainable character of these buildings - simple, minimal, operative, honest, coherent, durable over centuries, overwhelming on its *Genius loci*.

The following methodological approach to these concepts uses the buildings of the historic centre of Oporto as a case-study. These vernacular houses are analysed in its architectural components and potential retrofit strategies. There should be a balance between the most non-intrusive interventions on the *firmitas*, *venustas* and *utilitas* components, acknowledging the building as a whole, hierarchizing options, in order to mainly *Respect* the social relevance, cultural identity and local ethics of our historic centres – its *Genius loci*.

## 5. Methodological approach

### 5.1. The vernacular house in the historic centre of Oporto

“...the house that is one of the most typical expressions of Oporto, which has its own style and its legitimate tradition, which reflects the historical and socio-political conditions of the old town, the nature and life of its people(...).The house is always the product of a great multitude of interrelated elements, reflecting natural and historical conditions, technical, economic and social structure, professions, family concept, tastes, mentality and even certain feelings, especially feelings of group.”<sup>12</sup>

This zone, despite the variety of shapes, materials and colours bearing a closer range, is outstanding in its wholeness by uniform and aesthetic unit. It is a complex set, rich in diversity, but consistent<sup>12</sup>. This formal characterization was one of the most influential factors in the recognition by Unesco the Historic Centre of Oporto (HCO) as World Heritage in 1996: “The Committee decided to inscribe the nominated property on the basis of cultural criterion (iv) considering that the site is of outstanding universal value as the urban fabric and its many historic buildings bear remarkable testimony to the development over the past thousand years of a European city that looks outward to the west for its cultural and commercial links.”<sup>13</sup> The main research focused on these buildings in Oporto<sup>14,15,16,17</sup> have verified the existence of this homogeneity and systematization, morphological and typological, highlighting the spatial organization and the constructive system. Hence, traditional building materials and techniques should be preserved when selecting retrofit strategies. Given the specificity of these buildings morphology and its constructive system, there is both an architectural and sustainable heritage to preserve. As denoted in the last World Heritage Centre’s Report<sup>18</sup>, there is an “urgent need to implement a new urban culture (...), respecting the pre-existence of values and the character of the historic city but giving important advantages for the future”.

Although the buildings located in historic areas are exempt from energy regulations, studies were carried out<sup>19,20</sup> recommending to these buildings some energy retrofit strategies. In the opaque envelope (walls and roofs) it is proposed the internal adding of thermal insulation in order to approach the transmittance (U-value) defined in the energy regulations, or even to overcome them. These recommendations can however enhance the loss of internal heritage values, by following the principle of evaluating architecture mainly by its level of energy efficiency and external image. Portuguese cultural heritage preservation policies also lean towards interpreting it that way, by allowing alterations on its building’s interior. However, the HCO should not be acknowledged merely as a set of harmonic façades to preserve (Figure 4).



Fig. 4. Representative street façade.

### 5.2. *Firmitas vs Venustas vs Genius loci*

“...in the seventeenth, eighteenth and nineteenth centuries seems to predominate the houses with two and three floors above the ground floor (...) and with two or three front windows (...). The façades are of a great simplicity of lines and a regular geometric design (...).”<sup>14</sup>

The constructive system, associated with the proportion of the allotment, establishes the morphological characteristics of the façade and the building. The structural characteristics of these buildings, namely the constitution of its envelope, it is one of the components that contribute most to the *homogeneity*, *unity* and *coherence* of these houses. Mostly erected between the 17th and the 19th century, the HCO buildings present a quite



narrow width and a large length. The external envelope is of **thick stone masonry**, with 2 or 3 windows per floor, according to the width of the allotment. These typologies create a harmonic street design, quite determinant in the UNESCO's classification. It is recognisable a strong correlation between the structural characteristics and the building's external image (Figure 5). In its interior, there is also an architectural heritage to preserve, such as original plaster work (Figure 6.a) and the internal **wooden** shutters (Figure 6.b). These wooden shutters are an example of a refined architectural design. The masonry walls are dimensioned to embrace them, when they are in the opened position. As a shading device, they reduce the solar heating gains in summer and reduce the heating losses in winter. The window's medium U-value is  $5.1 \text{ W/m}^2\text{K}$ , when the wooden shutters are opened all day, achieving  $3.4 \text{ W/m}^2\text{K}$ , when closed by night. By proposing the adding of internal insulation on the walls, we may threaten the maintenance of these wooden shutters and the original design. If not, the risk of thermal bridges is also increased.

Therefore, non-intrusive retrofit strategies should be favoured. The improvement of the air infiltration rate has a significant consequent decrease of the heating loads, the most noteworthy energy demand according to Oporto's climate<sup>21</sup>. In addition, we may restructure the original carpentry and substitute the single glazing window for a double one, respecting the original design. This is particularly opportune due to the most common bad state of conservation of the windows. The U-values of the building elements are quite distant from those referenced on energy regulations for new constructions, which are often used as a benchmark for retrofitting strategies, hence the propensity of adding thermal insulation. On the other hand, a non-intrusive approach to the regulation is to **establish the corresponding number of hours of daily heating use**, in order to stand below the heating loads limits, thereby defined. Previous studies<sup>22</sup> concluded that the heating demand can be placed below its corresponding limit, in comfortable conditions of heating use. The enhancement of ventilation and the substitution of single glazing for a double glazing proved to be operative strategies of intervention, either isolated or in conjunction.

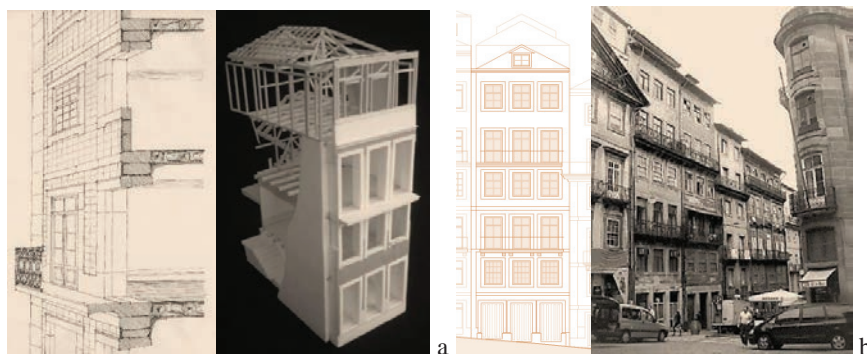


Fig. 5. (a) Structural and constructive characteristics; (b) External image.

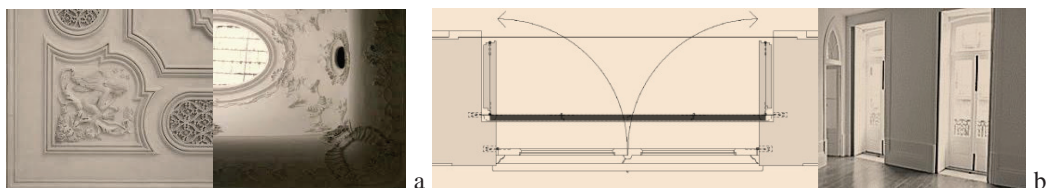


Fig. 6. (a) Plaster work; (b) Internal wooden shutters.

### 5.3. *Utilitas vs Venustas vs Genius loci*

"In Oporto this is the home to everyone and all classes; (...), imposed by its structure and also by a traditional ethics of vertical living - rooms to the front and to the back, the dining room and the kitchen on the top floor because of fire and smells, the attics for servants and storage and, in the middle, the staircase, lit by skylights; and, on the ground floor, to the street, the store."<sup>14</sup>

The first categorization of the construction system of bourgeois home in Oporto<sup>17</sup> has allowed a further definition of a constructive model, synthesized in a building of the nineteenth century<sup>23</sup>, as presented in Figure 7. This model synthesizes the typological archetype of these houses. The ground floor is usually commerce, sometimes with a private stair to the basement. In its origin, the upper floors defined one residence, around a central staircase. The *adaptability over time* and *flexibility of use* it is clear on the most common models of typological retrofits, which embrace a variety of areas for individual ownership, within the original allotment: one residence with  $n$  storeys; one residence per storey; one residence per storey and orientation. These dwelling units, i.e. in a typical house with three windows per floor, correspond approximately to 330 m<sup>2</sup> (with three floors); 110 m<sup>2</sup>; 50 m<sup>2</sup>. On the other hand, it is often proposed as a typological retrofit the joining of two allotments, in order to expand the dwelling surfaces possibilities. Although following the principle of respecting the original street façades, these proposals underestimate the heritage value of the constructive characteristics and morphology of these buildings.

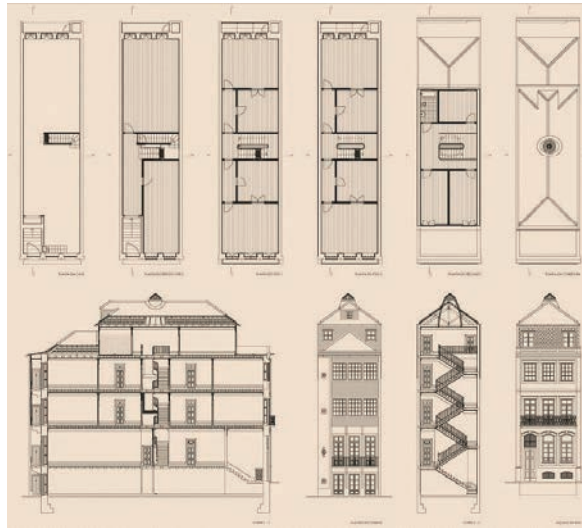


Fig. 7. Typological model of the vernacular house of Oporto

## 6. Conclusions

“...emerged in the primitive town 's specific historical and social conditions which governed its development, the narrow and high house acquired the status of cultural matter standards, and so persist in the local tradition , assimilating successive styles and techniques. (...) The housing type of Porto was fixed, it was *culturally* determined”.<sup>14</sup>

The conceptual methodology used in this reflective investigation led to the **recognition of the *Genius loci* concept** as the main generative component of the character of our historic centres. Considering the *architectural quadrature* hereby explored, our main focus when retrofitting its built heritage, must be to safeguard this immaterial component. Its inherent intangible values are the result of a converged dynamics of the notions of *firmitas*, *utilitas* and *venustas*. The constructive system, associated with the proportion of the allotment, establishes the morphological characteristics of the façade and the building. A *vertical ethics of living* launched the typological genesis of Oporto's housing. A local coherent design was achieved, with social relevance and cultural identity.

The sustainable concepts of *Reduce*, *Reuse* and *Respect* are the ones that should rule our architectural conscience, as it was instinctive in vernacular architecture. This attitude is crucial when retrofitting historic centres. It is essential to *reduce* not only the environmental impact, the resource consumption or the economic performance, but also the scope of the interventions. Non-intrusive retrofit strategies should be preferred and explored. There is a great potential on the *reuse* of the functional flexibility of the dwellings, as well as the local materials applied and

respective constructive details. Finally, it is vital to *respect* its generative architectural dynamics and values, which interacted all together within a common field, attesting its ability to establish the character of our built heritage (Figure 8).

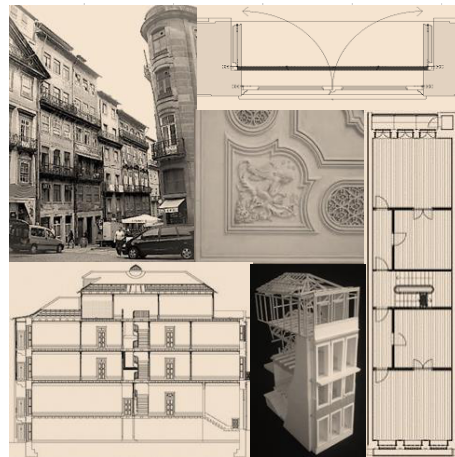


Fig. 8. Architecture quadrature of the historic centre of Oporto.

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