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# **The structural system of Lisbon's old "Pombalinos" and "Gaioleiros" buildings**

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# 1. INTRODUCTION

This dissertation addresses the topic of “Pombalinos” and “Gaioleiros” buildings and strives to complement the information already gathered and published by other authors.

Hence, the purpose of this master’s dissertation is to characterise the construction and structural features of “Pombalinos” and “Gaioleiros” buildings in Lisbon’s building stock, using the information specially gathered for the purpose from existing buildings and from written documents and drawings of the respective original designs.

The idea, therefore, is to provide additional information from a construction and structural perspective to support the planning of works and the implementation of architectural and structural rehabilitation of “Pombalinos” and “Gaioleiros” buildings and complement existing research with case studies.

The study is divided into 6 chapters, in accordance with the following plan:

1. Introduction	
• Considerations, objectives, basis and organisation of the study	
2. Historical Framework	
• Describes the evolution of the city of Lisbon contextualising the construction period under study	
3. Pombaline Buildings	
• A study of the architectural, construction, and structural aspects that characterise this type of building	
4. "Gaioleiro" Buildings	
• A study of the architectural, construction, and structural aspects that characterise this type of building	
5. Case Studies	
• Presentation of 5 case studies from the period under study	
6. Conclusions and Future Developments	
• Reflection on the aims achieved and suggestions for future studies	

## 2. HISTORICAL FRAMEWORK

A powerful earthquake hit Lisbon on the morning of 1 November 1755, “Dia de Todos os Santos”. The Portuguese refer to the disaster as the 1755 Earthquake and the international community calls it the Lisbon Earthquake. The tremor was felt all over Europe and is considered to be one of the most powerful quakes in history. The lower part of the city was almost totally destroyed and what survived ended up being demolished.

This is where Sebastião José Carvalho e Melo (“Marquês de Pombal”), the then Secretary of State for Foreign Affairs and War, takes over. He imposed emergency measures to quell disorder and to commence the reconstruction of the city.

The same year, Manuel da Maia, engineer-in-chief of the realm, began studying the reconstruction of the city and considered erecting the city in Belém. However, the political decision was to reconstruct the city in the original place.

The idea was to rebuild the city according to a well-defined general plan.

In addition to Manuel da Maia, two other architects were involved in the drawing up of the reconstruction plan, Eugénio dos Santos and Carlos Mardel, engineers that were vital to the success of the project. This district became known as “Baixa Pombalina”.

At the end of the 19<sup>th</sup> century Lisbon underwent an urban revolution, comparable to the reconstruction of “Baixa Pombalina” after the 1755 earthquake, and the city swelled in size. Industry and trade boomed, resulting in a significant increase in the population and the consequent expansion of the city towards the north. The city grew along two main axes: Avenida da Liberdade (opened in 1886) and Avenida Rainha D. Amélia (the present-day Avenida Almirante Reis).

This urban growth was planned by engineer Frederico Ressano Garcia and the area in question became known as “Avenidas Novas”.

It was at this time that the term “Gaioleiro” appeared, initially referring to the constructors and later to what they built. Over the years the term “Gaioleiro” came to mean constructions between the “Pombalino” period and the advent of reinforced concrete, a period spanning between the 1870s and the 1930s.

### 3. “POMBALINOS” BUILDINGS

“Pombalinos” buildings are characterised by their low cost, sturdiness, uniformity and simplicity, as they arose as a response to the needs of urban reconstruction following the 1755 quake.

The person who established the criteria the new city needed to meet was Manuel da Maia. The height of the buildings and the width of the main streets were regulated and the buildings began to be grouped in blocks, with a continuous façade and little variation, making it hard to ascertain where each building began and ended. These typically rectangular blocks were designed to form an orthogonal grid of streets in the Baixa district (Lisbon’s downtown) and to ensure better structural stability. However, it should be pointed out that certain rules were overlooked due to issues of profitability.

In order to ensure the streets were safer and unobstructed, any form of construction beyond the plane of the façade was prohibited, reason for which features such as rings to tether horses, shutters and flower boxes ceased to exist.

The specificity of the “Pombalinos” constructions begins with the solutions adopted for the foundations. The foundation system is generally composed of timber piles of around 1 meter in length and 15 centimetres in diameter (Mascarenhas, 2005). However, the significant heterogeneity of the subsoil led to the use of larger piles, up to 10 meters in length in some areas, as was the case of the side wings of the Praça do Comércio (Santos, 1994).

On the other hand, the ground floor can be distinguished from the other floors by the materials used in the flooring. A stone masonry raft foundation is built on the main foundation platform. The ground floor ceiling features masonry arches and vaults (brickwork in the case of the vaults and stone in the case of the arches), which support the 1<sup>st</sup> floor flooring.

Structurally, “Pombalinos” buildings are based on a three-dimensional grid, commonly known as “Gaiola Pombalina”, the vertical planes (longitudinal and transverse) of which consist of a wall system and the horizontal planes of the flooring and respective structure. The vertical structure of “Pombalinos” buildings consists of stone masonry outer walls (the wall of the lightwell is considered to be an outer wall) and timber-framed interior walls with mixed masonry infilling. Horizontally, the three-dimensional

structure of “Pombalinos” buildings consists of flooring where the beamwork runs perpendicular to the façades (Figures 1 and 2).

The structural walls, perpendicular to the façade walls, do not normally support vertical loads transmitted by the flooring and only serve to brace the building in the direction perpendicular to the façades, enhancing the building’s three-dimensional behaviour, which in turn improves its dynamic behaviour.

With regard to roofs, “Pombalinos” buildings feature two types: triangular and mansard, the latter being more common in more important streets and squares. Another characteristic of mansard roofs is that they render the attic habitable.

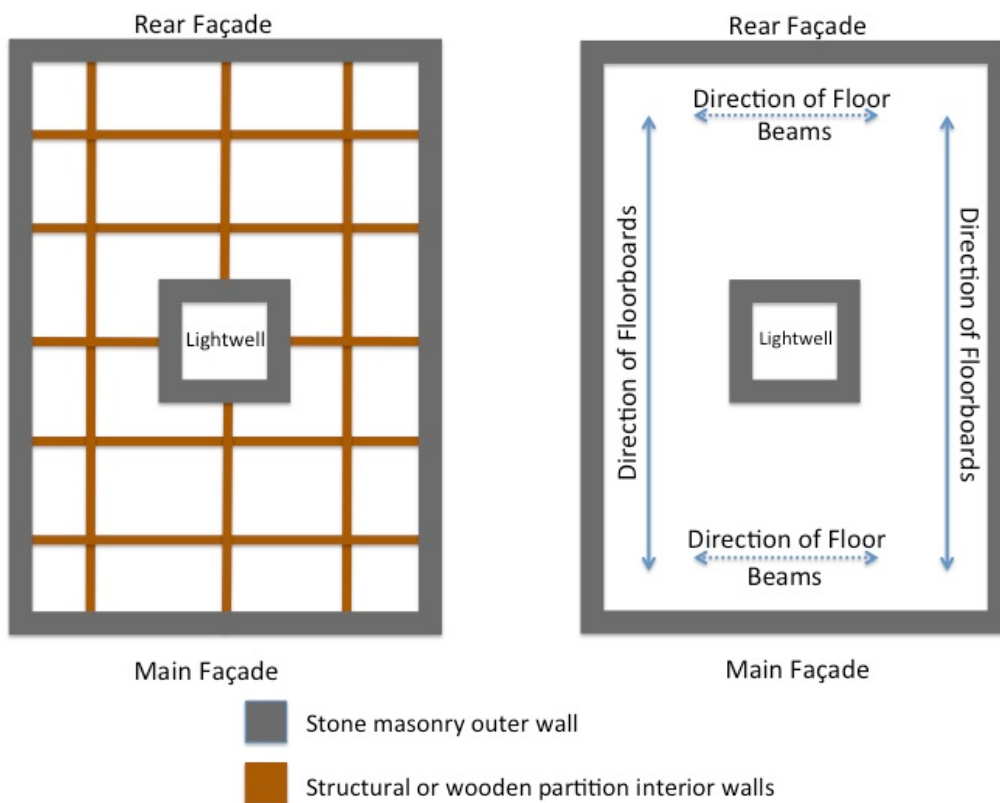


Figure 1 – Structural system of a “Pombalinos” building

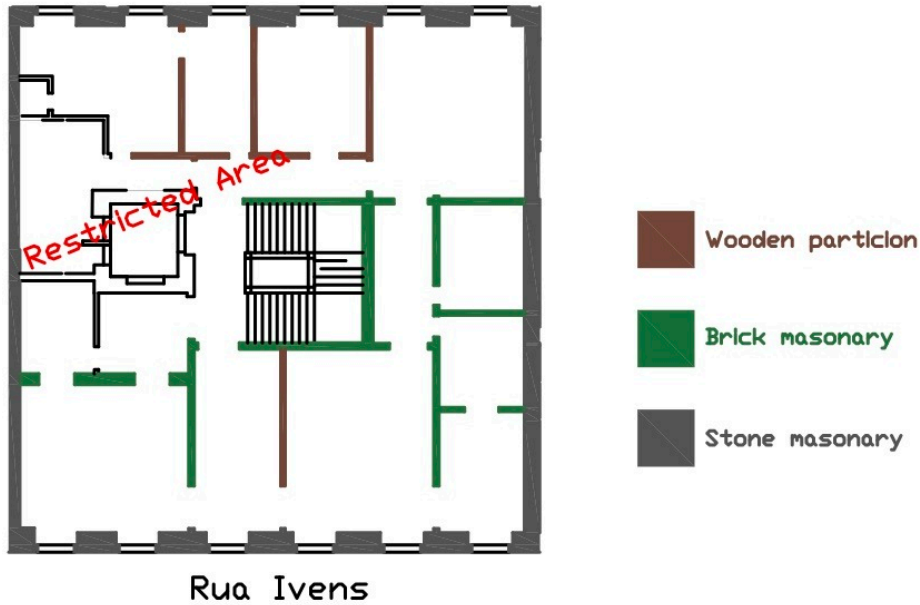


Figure 2 – Case Study – “Pombalinos” Building in Rua Ivens”, typology of the 2<sup>nd</sup> floor walls.

#### 4. “GAIOLEIROS” BUILDINGS

Construction at the end of the 19<sup>th</sup> century is characterised by a certain architectural freedom. This freedom can be seen in the varied window and ashlar designs, in the decoration of façades and in the introduction of new elements such as terraces and metal staircases at the rear of the buildings.

The buildings studied allowed a special focus on the structural system consisting of foundations, walls, floor beams and flooring.

The foundations of “Gaioleiros” buildings can be divided into two types: foundation footings and vaults or arches. In the first case, the walls are aligned with the foundations, but are thicker. Whenever the foundation soil only provided good load-bearing capacity at greater depths, walls, vaults or arches resting on stone masonry foundations were used.

On the upper floors, the wall system used in “Gaioleiros” buildings consists of an orthogonal grid composed of brick or stone masonry walls or wooden partition walls (Figures 3 to 5).

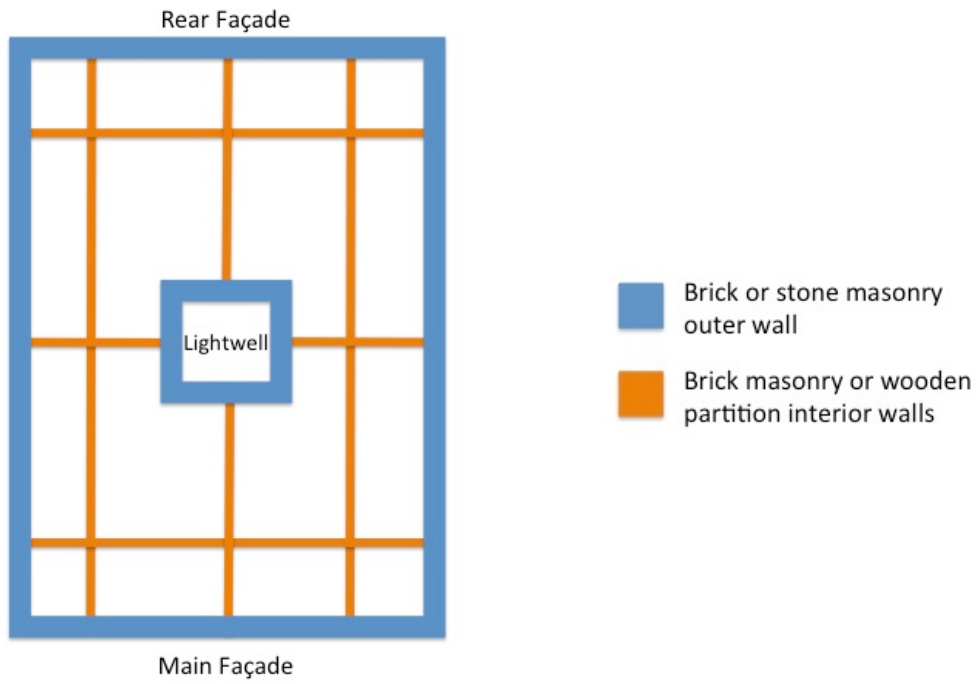


Figure 3 – Schematic diagram of walls in "Gaioleiros" buildings (Author)

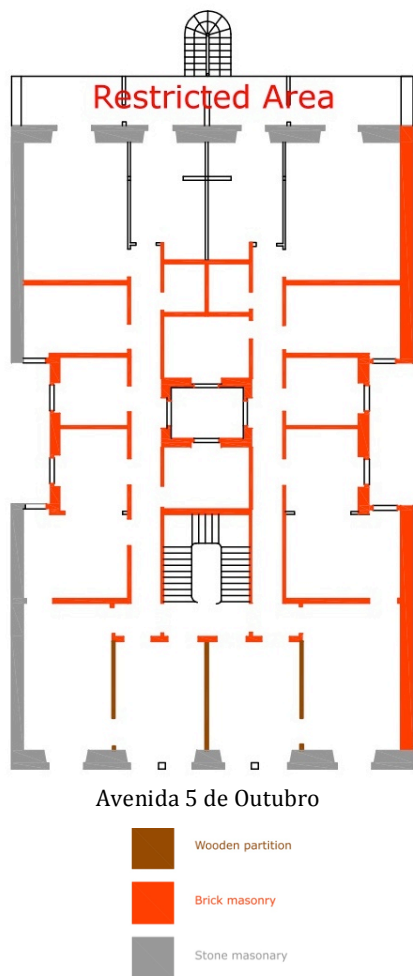


Figure 4 – Walls on the 1st and 2nd floors of the building located at N° 108 to 110 Av. 5 de Outubro

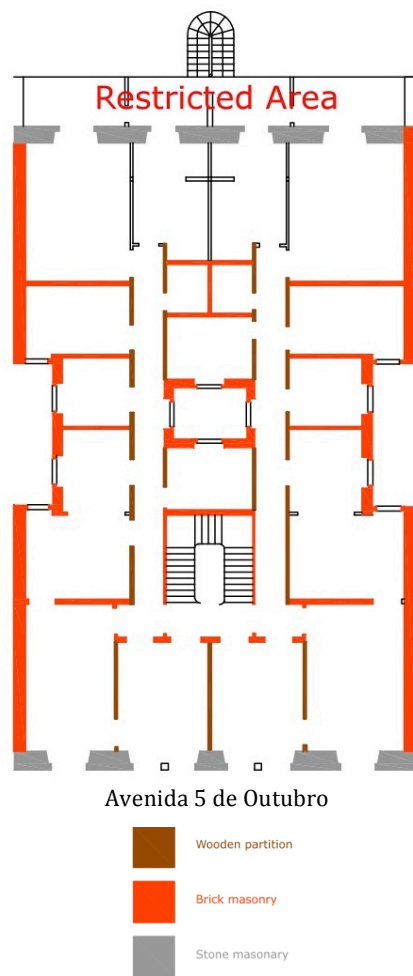


Figure 5 – Walls on the 3rd, 4th and 5th floors of the building located at N° 108 to 110 Av. 5 de Outubro

Generally speaking, stone masonry walls run parallel to the façade walls, whilst wooden partition walls remain perpendicular to the same. This fact is due to the building's horizontal bracing structure, consisting of floor beams running perpendicular to the façade, transferring the loads they bear to the outer walls, lightwell walls and interior brick masonry walls on which they rest. The direction of the floorboards is determined by that of the floor beams and, as consequence, floorboards normally run parallel to the façade (Figures 6 and 7).

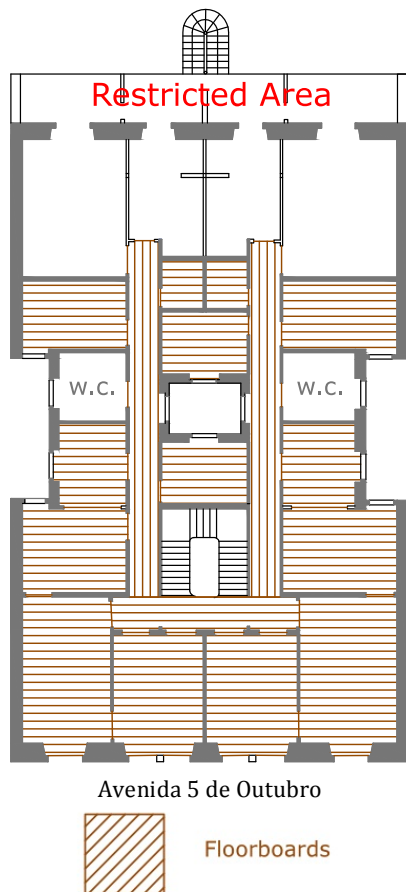


Figure 6 – Layout of floorboards, Nº 108 to 110 Av. 5 de Outubro

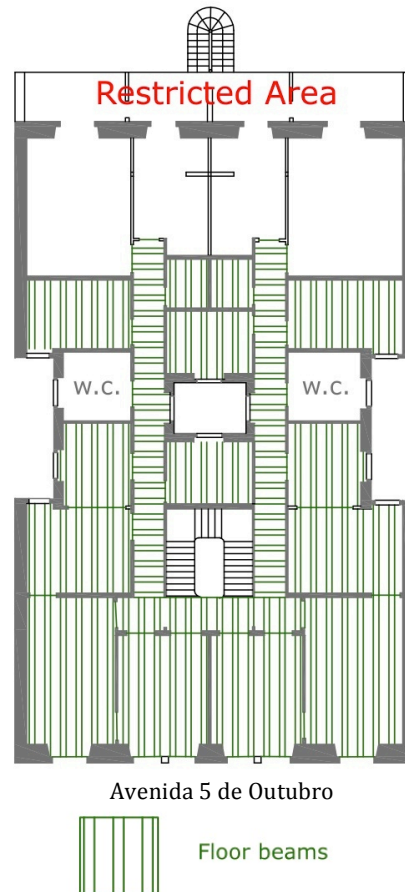


Figure 7 – Layout of floor beams, Nº 108 to 110 Av. 5 de Outubro

With regard to the roof, “Gaioleiros” buildings almost always feature varied forms of the sloping type. Varying sizes of the area covered by the roof, roof slopes, and the possibility to make the attic habitable led to a wide range of solutions.

To conclude, mention should be made of the existence of steel structural elements on the rear façade of “Gaioleiros” buildings, which have become a trademark of this type of construction. These features consist of “I” shaped cross-sections, or circular-shaped in the case of pillars, or “I”, “T” or “U” shaped in the case of beams. In the case of terraces, hollow infill blocks covered with screed rest on the steel beams.



## 5. CASE STUDIES

The descriptions of the construction system and the structural behaviour of “Pombalinos” and “Gaioleiros” buildings presented in this dissertation are supported by information contained in the limited bibliography available and surveys of buildings in Lisbon’s housing stock.

This study is based on information gathered from the following buildings:

1. “Pombalino” building at N<sup>o</sup> 27 to 33 Rua Ivens
2. “Pombalino” building at N<sup>o</sup> 12 to 14 Rua do Alecrim
3. “Gaioleiro” building at N<sup>o</sup> 20 Av. Praia Vitória
4. “Gaioleiro” building at N<sup>o</sup> 70 Av. Duque de Loulé
5. “Gaioleiro” building at N<sup>o</sup> 108 to 110 Av. 5 de Outubro

## 6. CONCLUSIONS AND FUTURE DEVELOPMENTS

The purpose of this work was to characterise the construction and structural features of “Pombalinos” and “Gaioleiros” buildings in Lisbon’s, so as to support the planning of construction work as well as the realization of projects of architectural rehabilitation of such buildings. This goal was achieved through the use of information collected exclusively for this study from existing buildings, from the written and drafted elements of the original projects as well as from the scarce existing bibliography.

The “Pombalinos” building is characterised by its stability, regularity and simplicity, having been developed as an answer to the needs of urban reconstruction experienced after the 1755 earthquake. Structurally, the “Pombalinos” buildings are based on a three-dimensional grid made of wood, usually known as “Gaiola Pombalina”. On the vertical plans (longitudinal and transversal) this mesh is comprised by a system of walls of mixed masonry with an internal wood structure (St Andrew’s cross) and horizontally by a wooden floorboard. Horizontally, the structure of the “Pombalino” building is formed by floorings with beams that are perpendicular to the façades. The foundations of the “Pombalinos” buildings were executed through a system of indirect foundations with timber piles, due to the bad conditions in the area where these buildings were built.

In the construction of the “Gaioleiros” buildings, the constructive system was simplified in order to spare time and money, maximizing the investment through the construction of buildings with a larger number of floors. At the time, the context of expansion of the city did not always have a concern with the sturdiness and the resistance of buildings.

Generally speaking, walls of brick masonry, walls of stone masonry and walls of wooden partitions, floor beams and wooden floorboards constitute the “Gaioleiro” building. All this structure of the “Gaioleiros” buildings is settled over foundation of small dimensions, very often by resorting to domes and arches of unloading.

Complementing the work of inspection, collection of data and characterization completed for this study, it would be interesting in future works to do a detailed analysis of the structure, through the use of structural analysis models that allow for the modeling of the non-linear behavior of the masonry. This current study and the aforementioned complement would lead to a complete structural characterization of Lisbon’s housing stock built prior to the development of reinforced concrete.

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