Jorge Mascarenhas

LISBON, EARTHQUAKE OF 1755

The principles adopted
(Les techniques mise en oeuvre)

Abstract

Since ancient times the city of Lisbon had been hit by numerous earthquakes. In 1755 it was hit by a strong earthquake, between VII and X on Mercalli Scale, Which was followed by a great fire leaving the lower part of the city in ruins.

It was decided for commercial reasons to build a new city on top of the ruins, without ever forgetting the possibility of another hecatomb.

For built the new city on top of the ruins of the old one, all necessary precautions being taken, from the urban plan to the details of construction as well as the architectonic plan for the buildings in case further earthquakes should occur.

Thus, the new urban plan had a perfectly clear network, with wide streets allowing inhabitants to escape via the two large squares located at the tops, and also making it difficult for fires to spread. The rubble of the ruins enabled the level of the land to be raised so as to prevent flooding from the river in the event of an earthquake. In order to prevent the land from being infiltrated by inhabitants debris, which would make the land less stable in the event of a disaster, a sewage disposal system was build.

The architectonic details were simplified, especially the facades, which had no decorative features or accessories that could in any way endanger passer-by or encourage the spread of fire between floor or buildings. To increase the stability of the facades in the event of a disaster, there were a perfect alignment of the facades openings. The height of the buildings was limited for the first time by the width of the streets, and also related to the depth of the buildings, which ere not to be more than four floors in height. The roofs of each building were limited by walls to control possible focuses of fire.

For the first time an anti-seismic wooden structure, (called the "cage"), was to be used in a systematic way. The "cage" was carefully tried out and perfected by military engineers before being applied. It had elaborate connections so that its elasticity would absorb the vibrations also allowing the walls to be lightened.

Arches, vaults and thick stone walls prevent the foundations and ground floor from being crushed or from collapsing in the event of an earthquake, as well as preventing the spread of fire from the shop level.

It is interesting to note at this point that, unlike other parts of the world that have been destroyed by earthquakes, where architectonic and constructive details tended to develop slowly, and almost always on an individual basis, here every precaution was taken in case of further earthquakes, in a conscious, systematic and scientific way, starting with the care taking over the urban plan, revealing all the knowledge available at the time, which was not as rudimentary as is often supposed. Suffice it to say that the famous Torre de Belém, to give just one example, built two centuries earlier, right on the bed of Tagus River, withstood both the tremors and the fury of the water at the time of the earthquake.

Front-An old street before and during the earthquake

I.-Introduction.

In the year 1755, the lower part of the city of Lisbon was hit by a huge earthquake and destroyed immediately by a fire which lasted several days, (fig.1).

Fig.1-Panoramic views of the city and during the earthquake

The city that was destroyed was a mesh of numerous streets and alleyways, as it had grown in a piecemeal fashion according to the residents needs or the whims of builders, on the unstable lands of an old creek, (fig.2). Which were unsafe and unhygienic. The streets were obstructed by buildings, making it difficult to reach the safety of the squares in the event of a tremor or a fire, (fig.3).

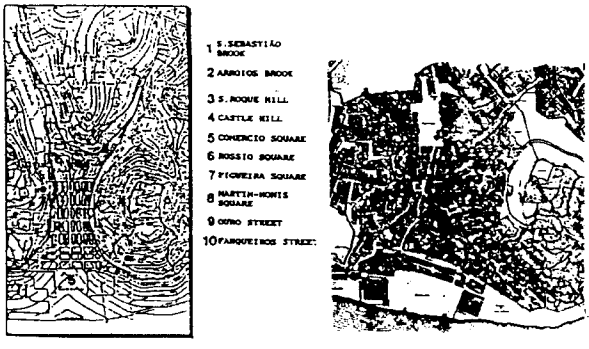

Fig.2-The creek and the old city.

Fig.3-A street before the earthquake

Following the destruction of the city by the earthquake, which registered ten on the Mercalli Scale, and by the terrible fire which followed, it was decided that the best solution was to level the city completely and build a new city with a regular plan on top of the rubble.

The area comprised in the new plan was 0.24 squares kilometers, or 300 meters by 800 meters of a densely built up urban land with five-storey buildings covering 50% or more of the area, (see fig.4 and fig.5, on next page). A strictly controlled regularly planned urban area of this size and density is unique in eighteenth century Europe, with the possible exception of St. Petersburg.

The reconstruction necessarily followed strict functional and economic principles, given the scarcity of specialized labor and materials and the difficult economic situation in the country. There was an urgent need to rehouse many families as well as to protect against future earthquakes.

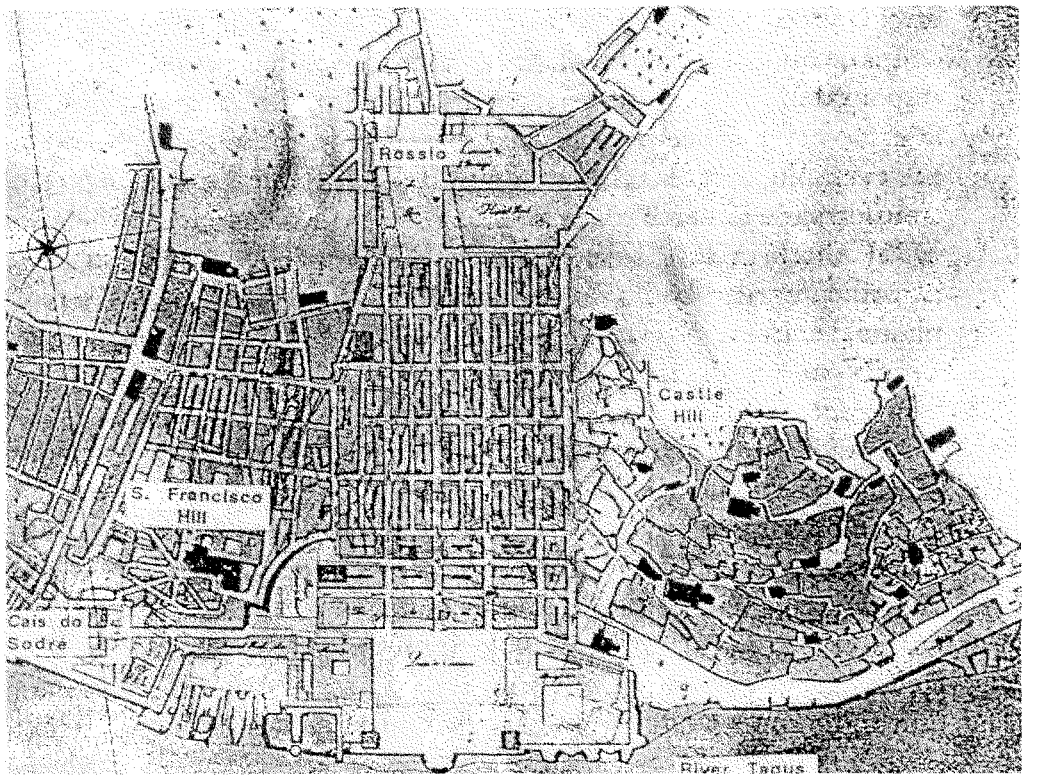

Fig.4-After the earthquake. Proposed plan of the reconstruction.

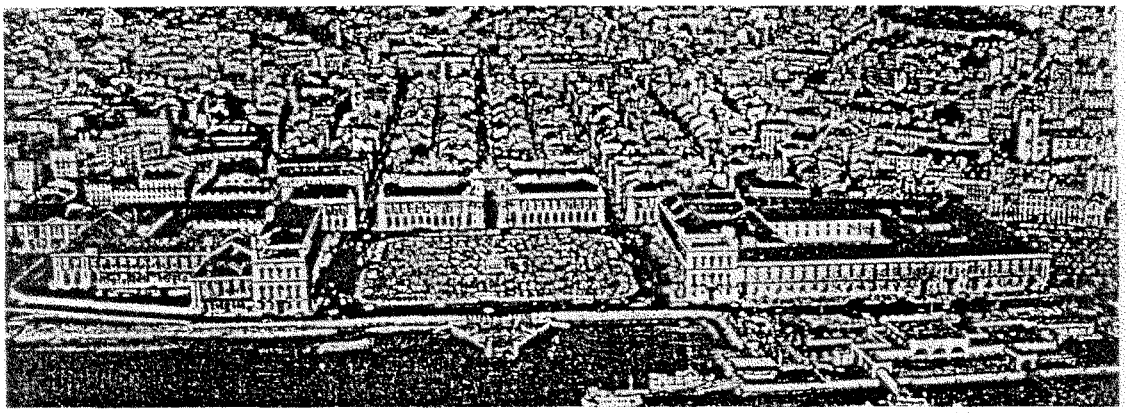

Fig.5-Aerial view of the down area rebuilt by the Marquis of Pombal.

At an urban architectonic level, a city built on highly original and efficient urbanistic principles appeared, in which safety and hygiene had been carefully considered.

In order to rationalize the building resources available, a pre-fabrication system was chosen to make this possible the dimensions of buildings were modular. Making the reconstruction an early example of dimensional coordination. Several other precaution against fire or earthquake were incorporated in the design.

To make it possible to construct high buildings on unstable land an ingenious wooden structure to resist earthquakes, called the gaiola (cage), was created.

Unfortunately only a part of the initial project was implemented, and work that had been expected to take five years dragged on for many more. As time passed, fears lessened leading to safety precautions for earthquakes and fires being altered or even ignored.

Thus, not all the buildings were built according to the safety regulations, which will be described, although they were simple to apply as they were well adapted to the scarce resources available and to traditional building techniques.

II.-The Reconstruction and the principles adopted.

The Marquis of Pombal, Minister of King D. José I, Handled the devastation competently and kept in good spirits during the crisis. His energies were directly channeled into overcoming the devastation created by the disaster.

Fig.6-The Marquis of Pombal and his collaborators study the reconstruction plans.

To execute the reconstruction, Pombal relied on the expertise of certain professionals including Manuel da Maia, (fig.7), the Kingdom's official engineer. He was an expert in fortifications and it was he who planned and executed the reconstruction of the city.

The reconstruction of the city proved to be peak of the notable career of this military engineer, who was then in his eighties. By looking at his rational proposals, we can see a "practical" man, a man of "good sense" and a professional who was always conscious of problems concerning safety and hygiene as much at the urban level as at the architectural level. He created the very specific "Pombaline style" characterized by its austerity and rationality.

Manuel da Maia prepared three alternative proposals for the reconstruction of the city. The process of reconstruction is shown of following scheme, (fig.9).

In the third part of the dissertation. The plan prepared by Eugénio dos Santos, (Inspector of the Royal Construction Works and an architect of the Senate) was chosen, (fig.8). This was to build over the razed ruins of the old town.

The project satisfied economic interests and also took account of the need for safe and comfortable conditions for tenants.

Fig.7-The engineer Manuel da Maia

Fig.8-The architect Eugénio dos Santos

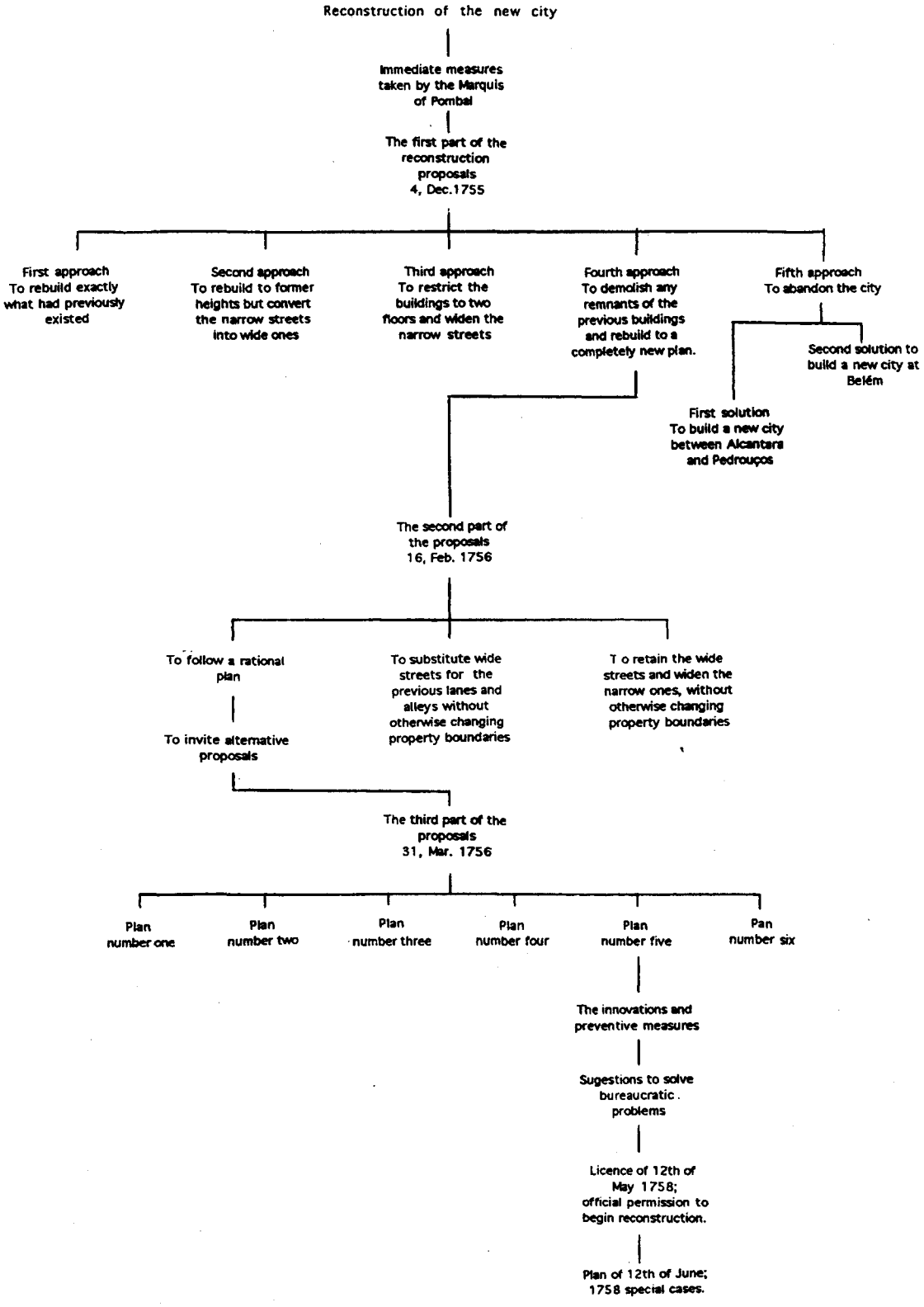

Fig.9-The process of reconstruction

The approved plan for reconstruction

In the Rossio Square and Comércio Square were linked by three main streets, Augusta, Ouro and Prata, part of a complex of eight streets, (three main and five secondary ones), perfectly parallel and rectilinear, oriented in the north-south directions. Nine streets cross orthogonally in the east-west direction, (fig.10). Transitional areas were created whose boundaries followed the foot of the Madalena and S. Francisco slopes.

1-Rossio square
2-Comércio Square
3-Ouro Street
4-Augusta Street
5-Prata Street
6-Madalena Street
7-S. Francisco Hill

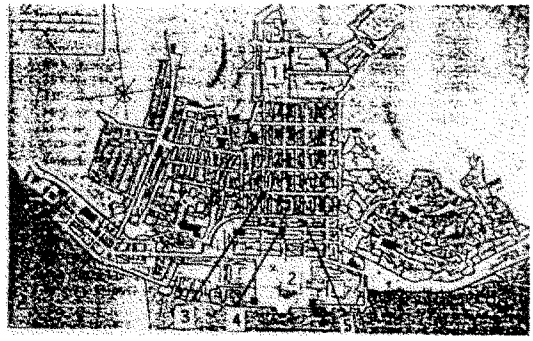

Fig.10-The approved plan

Even though there were serious limitations in terms of manpower and materials available, fire and earthquake safety considerations were not ignored at either an architectonic or an urban level.

II.1.-At the urban level

Before

A confusing muddle of streets and alleys which made it difficult to escape to the squares, (fig.11).

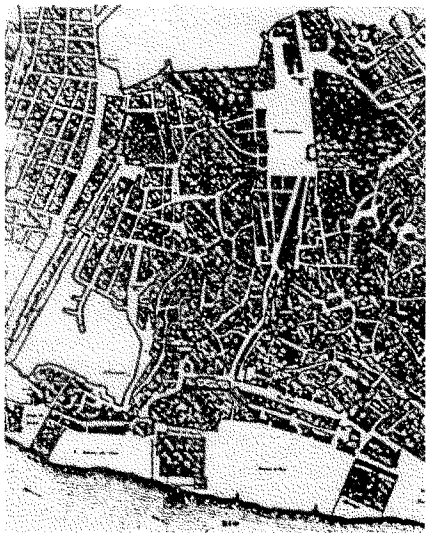

Fig.11-Lisbon before the earthquake

After

A clear, well-defined street plan, (fig.12).

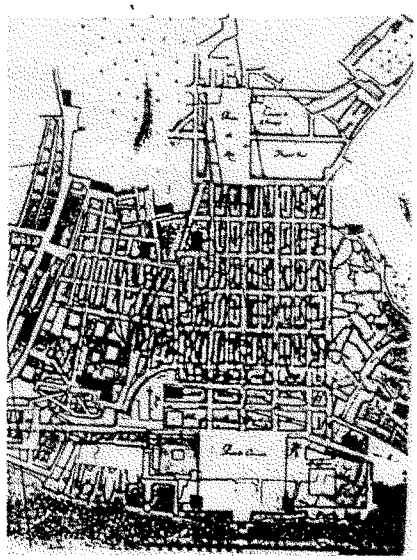

Fig.12-Lisbon after the earthquake

Fairly low-lying land subject to constant flooding by high tides, (fig.13).

Fig.13-Before the earthquake

Leveling out of the old city using the rubble from the ruins to raise the level of the land and even reclaim more land from the river, (fig.14).

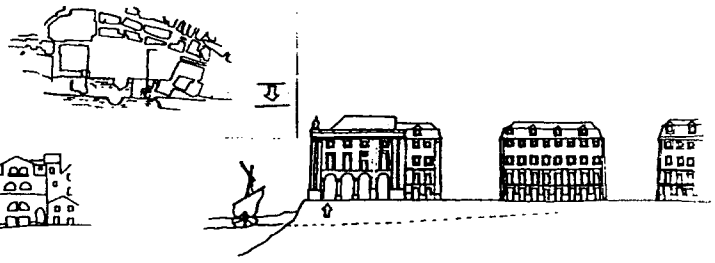

Fig.14-After the earthquake

Unstable land with constant infiltration leading to saturation with liquid waste, (fig.15).

Fig.15-Before and during the earthquake

Drainage of land with a sewage system which drained water from both the Pombaline area itself and the nearby hillsides, (fig.16).

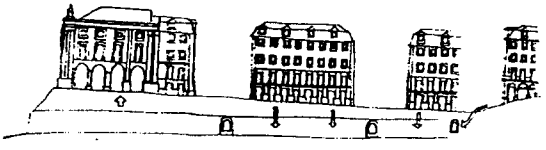

Fig.16-After the earthquake

Neighboring hillsides unstable, (fig.17).

Fig.17-Before the earthquake

Hillsides stabilized by buildings, (fig.18).

Fig.18-A Pombaline block

Blocks with no precise shape or orientation, (fig.19).

Larger blocks following the lines of the quake and the flow of alluvium with the exception of Comércio Street, due to the importance of the previous Ferros Street, (fig.20).

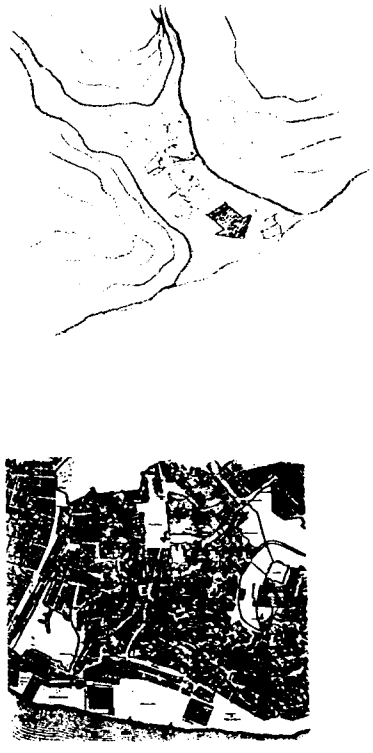

Fig.19-Before the earthquake

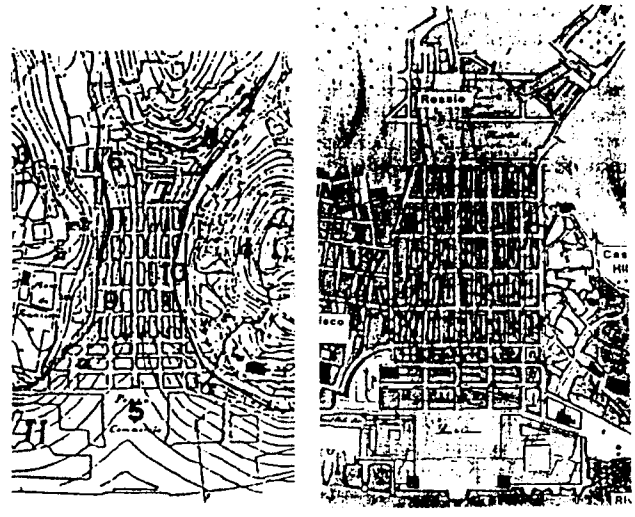

Fig.20-After the earthquake

Numerous palaces and churches in the center of the old area, creating large foci fire that were hard to control, (fig.21).

Fig.21-A church in the old town

A reduction in the number and scale of the palaces and churches. The more monumental of the public buildings clearly separated from the rentable buildings and concentrated in the Praça do Comércio, (fig.22).

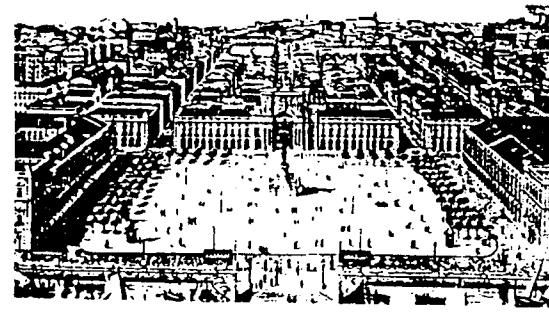

Fig.22-The Comércio Square

Buildings were not in line, (fig.23)

Fig.23-An old street

Facades were in a straight line, (fig.24).

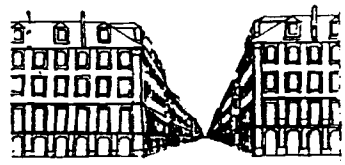

Fig.24-A new street

"Funnelling" of streets, (fig.25).

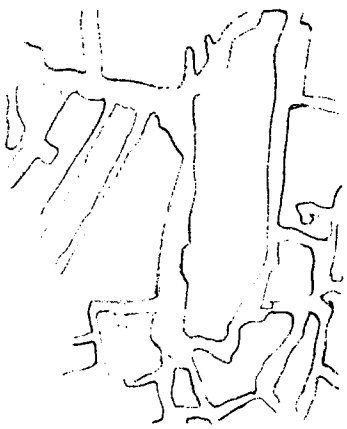

Fig.25-An old street

Widening the connections with the new town, (fig.26).

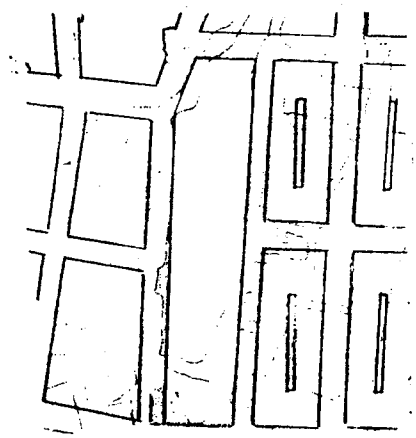

Fig.26-A new street

Vehicles, horses and pedestrians circulate in same area, (fig.27).

Fig.27-An old street

Creation of separate areas for vehicle and pedestrian circulation, (fig.28).

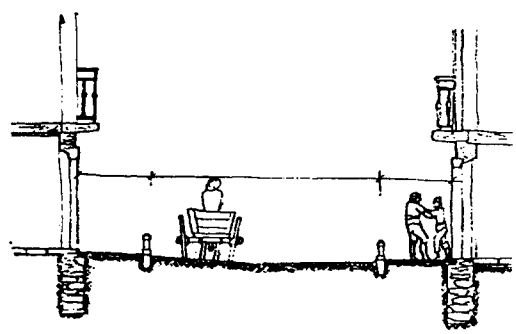

Fig.28-A new street, section

Buildings too high in relation to of streets, (fig.29).

Fig.29-An old street

Inconsistent depth and height of buildings, (fig.31).

Fig.31-Old buildings

Unsatisfactory ways of fighting fires, (fig.33).

Fig.33-An old street during a fire

Height of buildings equal to the width of the streets, (fig.30).

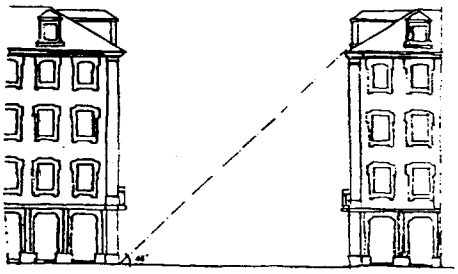

Fig.30-A new street, section

A good and consistent relationship between the height of the facades and the depth of the buildings, (fig.32).

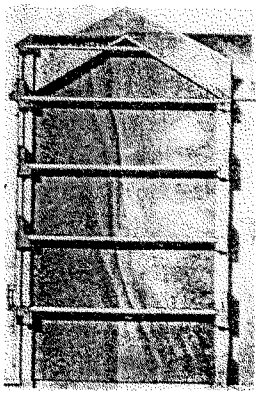

Fig.32-A new building, section

Fountains equipped with leather, buckets, (fig.34).

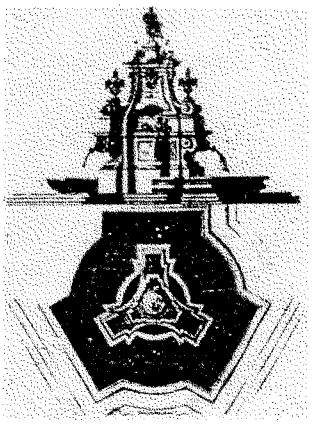

Fig.34-A new fountain

Extensions upper levels or over streets tunnels, (fig.35).

Extensions of any kind were prohibited, (fig.36).

Fig.35-Additional constructions or tunnels

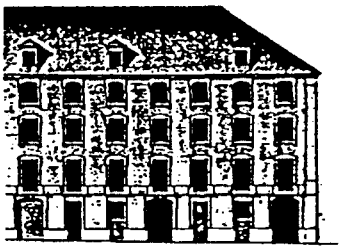

Fig.36-No additional constructions or tunnels

II.2.-At the architectural level

The origins of the Pombaline rentable buildings are not well known; it is certain, however that this major development of rentable buildings in Portugal, anticipated the time when a major French architectural theoretician, J.L. Durand was making a clear distinction between public and rentable buildings, giving a special impetus to the architecture of rentable buildings over most of Europe and stating that the ideal building to live in should be solid, healthy and comfortable. The more symmetrical and the simpler it was, the more economical it would be.

Two solid and impressive rentable buildings, the Almada Building and Ludovice House, that had withstood the earthquake, could be the immediate inspiration for the Pombaline buildings, some of their details being simplified for the sake of standardization and economy[4] (fig.37 and fig.38).

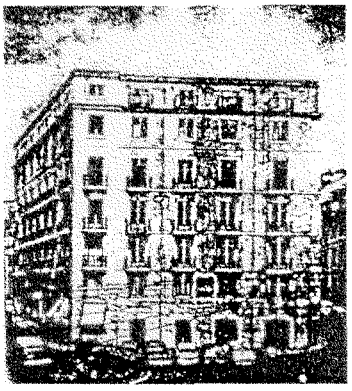

Fig.37-The Almada building

Fig.38-Ludovice house

Number 110, St. Julião Street was chosen to illustrate the architectonic and constructive techniques that very employed, (fig.39).

To illustrate the gaiola, (cage), was chosen the number 85, Ouro Street, (fig.74)

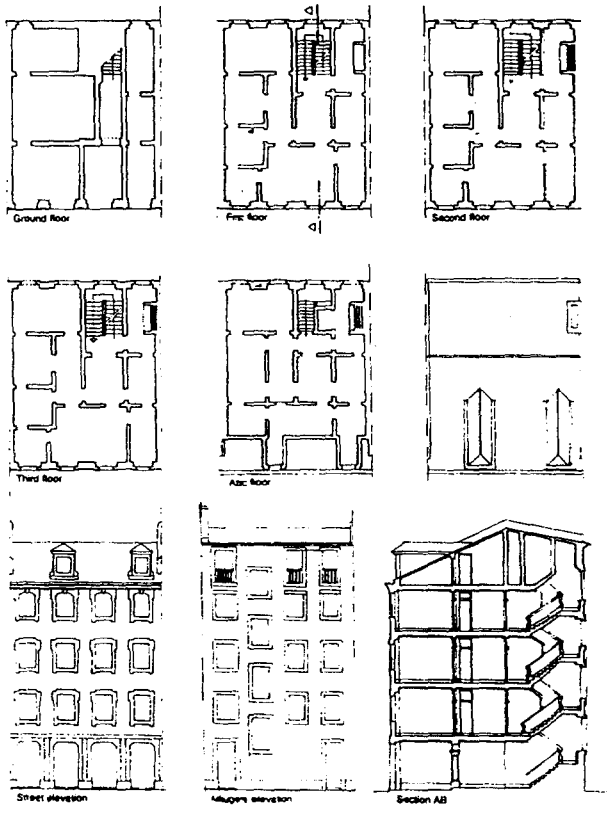

Fig.39-Number 110, St. Julião Street

All buildings strictly the same height, to prevent the spread of fire,(fig.40).

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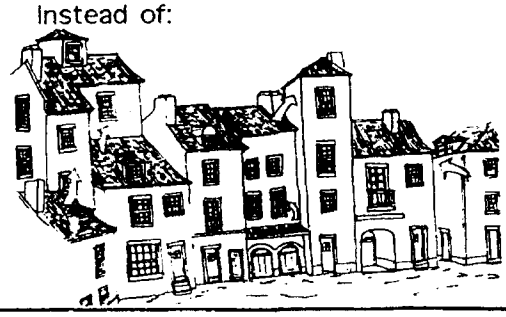
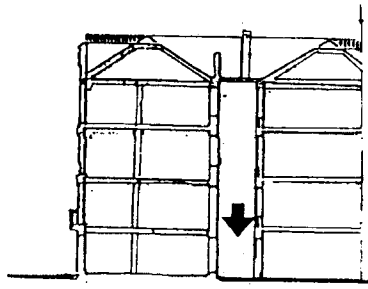
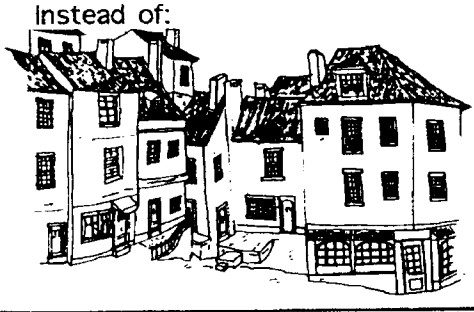


Blocks with courtyards which allow for the rescue of residents in the event of a disaster, (fig.41).



Blocks in a simple, well defined shape, which contributed to greater structural stability, (fig.42).

Instead of:



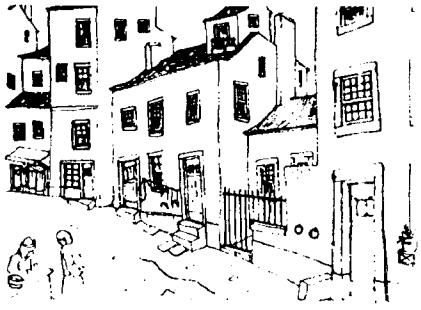
The party walls of the buildings were solid, thick and with no openings, so as to prevent the spread of fire from one building to another, (fig.43).

Fig.44-A block

Solid quoins in dressed stone, (fig.45).

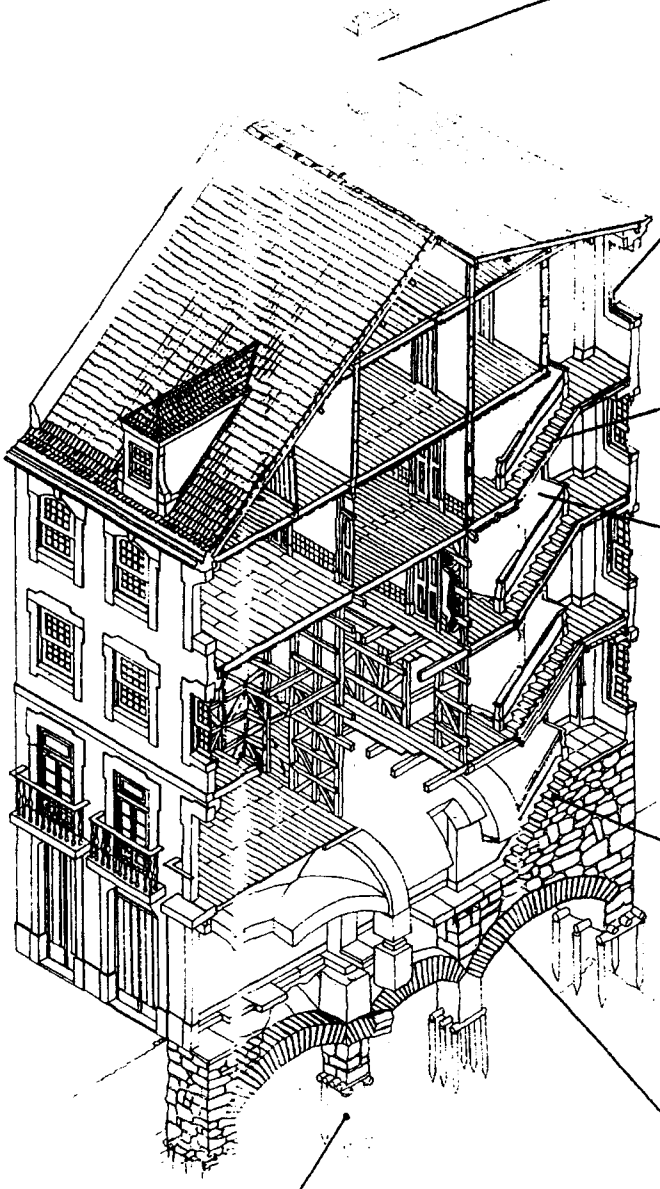
Beyond the line of the façades, the construction of benches in stone, steps and flower beds was prohibited so as not to obstruct the way, (fig.46).

Instead of:



Windows built away from the corners, (fig.47).

Instead of:

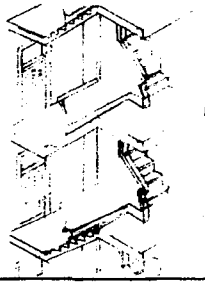


Chimneys always placed on the courtyard side to prevent them from falling into the street in the event of an earthquake.

In the earlier buildings the stairs had windows on the landings which looked out onto the common internal courtyard, facilitating rescue in the event of disaster.

The flights of stairs are generally straight, separated by level landings.

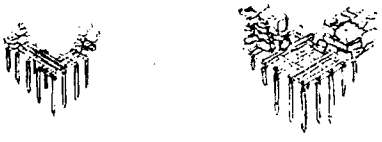
To prevent rapid spreading of smoke or fire, the stairway climbs alongside a wall and has no *bomba*, (open well), (fig.48).



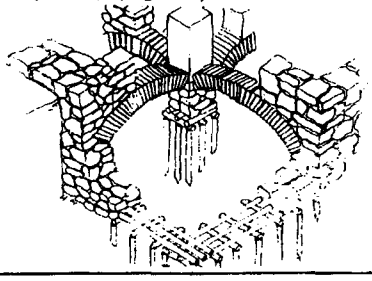
The steps of the stairs up to the first floor were stone.

To reduce the risk of fire spread at ground floor level, in many buildings the "cage"was only built from the first floor up .

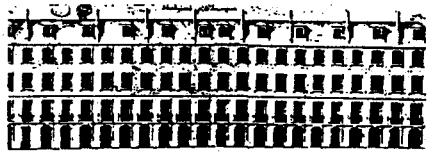
An ingenious system of foundations made with timber piles gave the buildings greater stability on alluvial land, (fig.49).



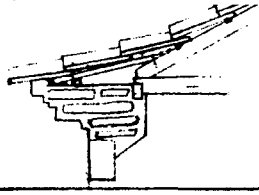
A system of foundation arches which increases the solidity of the foundations in the event of an earthquake, (fig.50).



The parapets which were at the top of party walls were eight palms higher than the roofs, (fig.51).

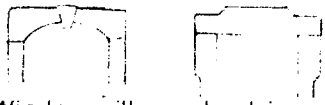


Eaves with the lowest three courses of tiles fitted up to prevent their slipping off into the street, (fig.52).



Stonework with a simple but careful design.

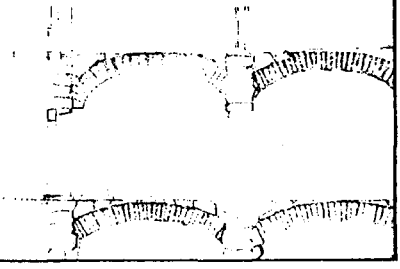
Arched or thickened lintels to withstand the bending stress imposed, (fig.53).

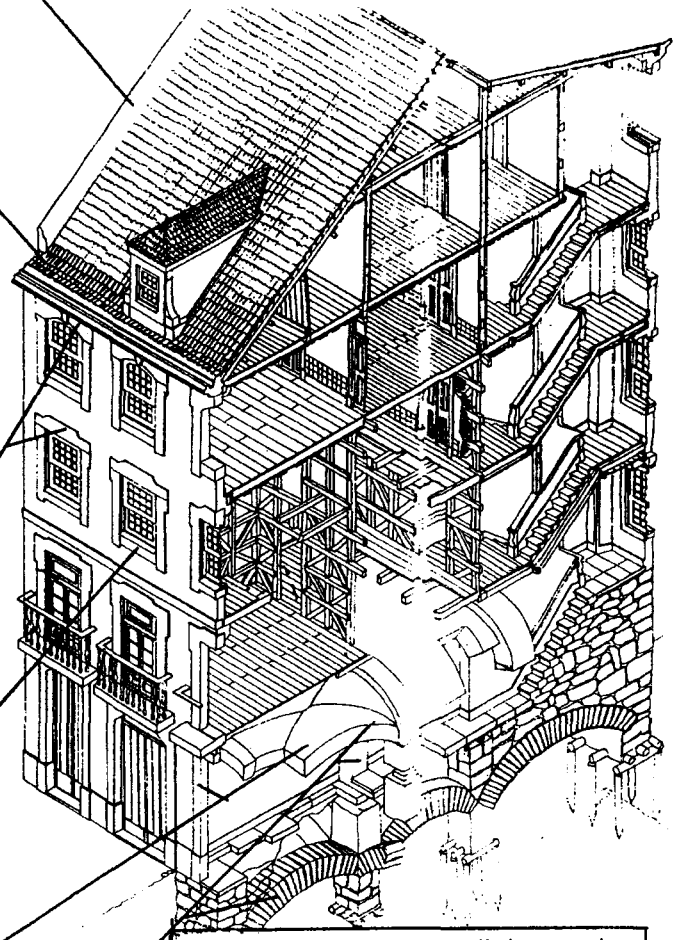


Window sills wedged in so that they are not crushed by the load from the jamb stones, (fig.54).

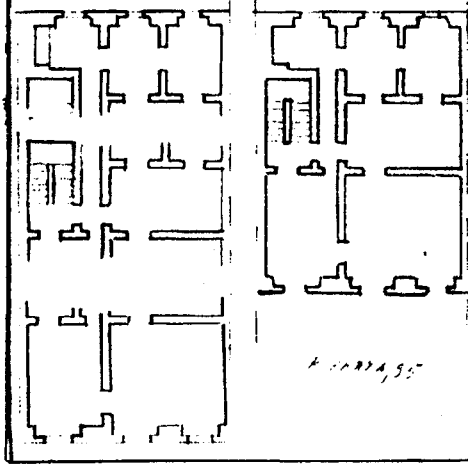
The ground level was constructed as a solid set of thick walls and stone vaults which would prevent the spread of any fires in the shops or stables to the upper levels.

A set of vaults, thick walls and arched foundations, a solid base for the building in the event of an earthquake or the excavation of neighbouring land, (fig.55).



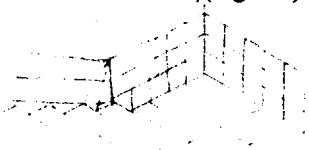


Three rooms parallel to the façade, the middle one being far from the façades, thus safer in the event of an earthquake, (fig.56).



The lath on the walls meant it was possible to add a layer of plaster without affecting the elasticity of the "cage" panels, (fig.57).

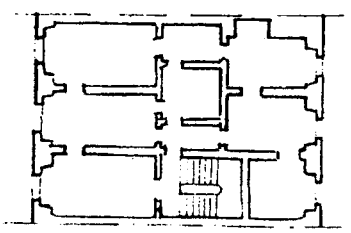
The austerity of the decoration also contributed towards safety, the only decorative feature being the three courses of tiles of the dado, inherently non-combustible,(fig.58).

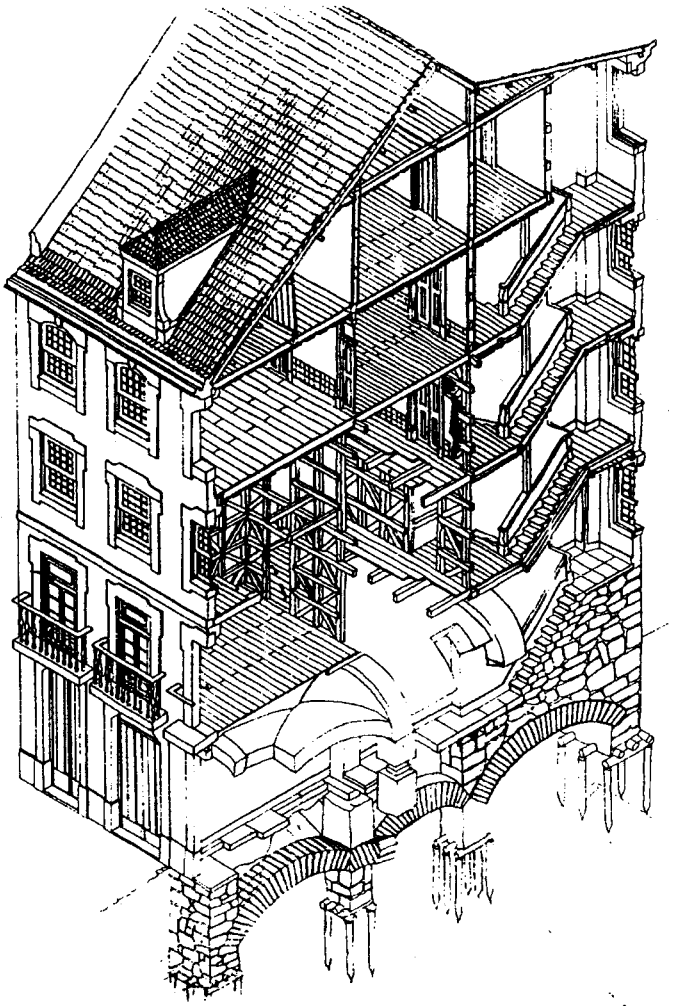


Wooden shelves and shutters were also prohibited as they could encourage the spread of fire from one building to another, (fig.59).

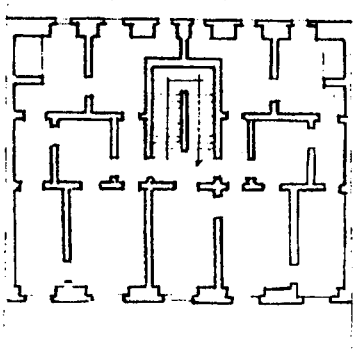
Ground level without corridors arcades, or small spaces, (fig.60).

Interior walls perpendicular to each other, (fig.62).





In many cases the stairs,, positioned on the central axis of the building, reinforced its symmetry, confering greater solidity on the structure, reducing the eccentricity of the loading, (fig.61)



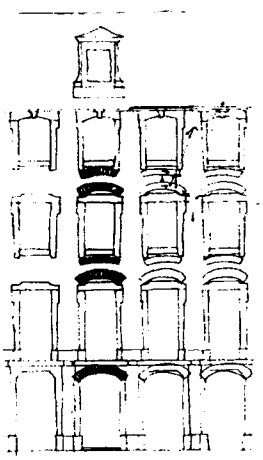
All decorative elements (urns, statues, flowerpots, etc), above the eaves were forbidden, (fig.63).

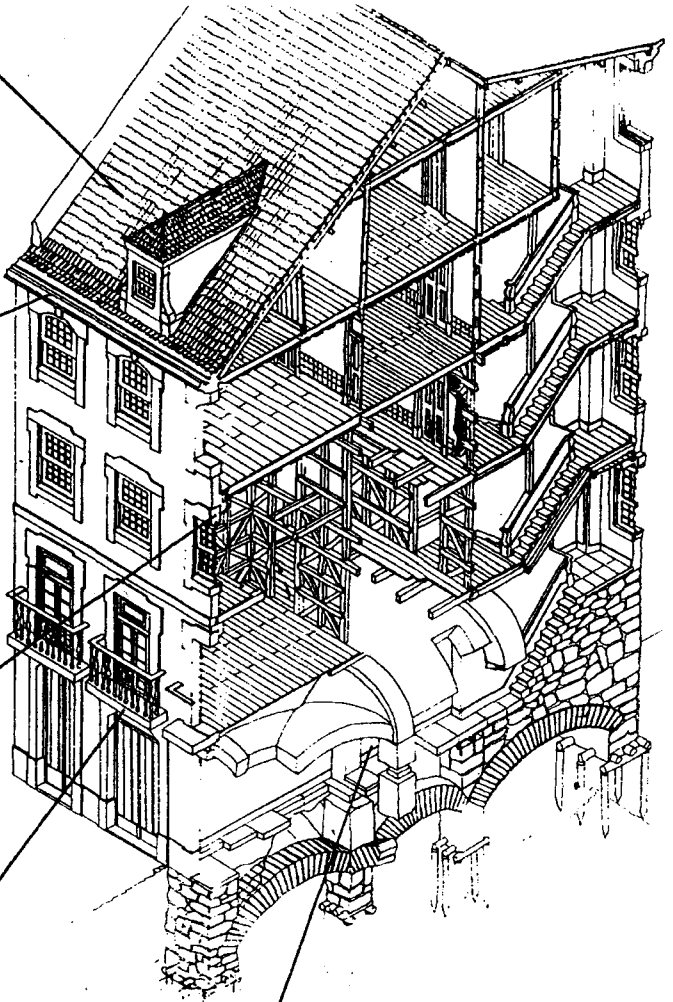
The height of the buildings is the same as those, in the Comércio Square, with three residentialfloors for homes and one for commercial accomodation No extension was allowed, (fig.64).

On the façade, the stonework was fixed to the "cage" by means of iron clamps so as not to fall onto of pedestrians in the event of a tremor, (fig.65).

Balconies consisting of a stone console in order to prevent the spread of fire from the warehouse or shop doors to the French windows on the first floor.

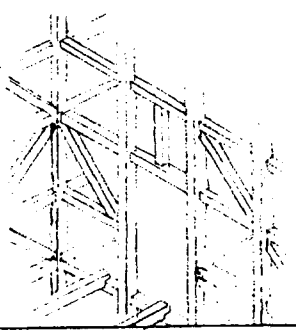
Perfect alignment of the façade openings, (fig.66).





The entrance halls to the flts were completely isolated from the shops by solid masonry walls, (fig.67)

The *gaiola* (cage), a wooden structure, with elastic connections, enabled the building to withstand small tremors well, (fig.68).

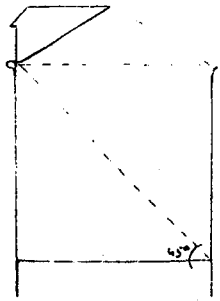


The ceilings were simple with wood clearly seen, without plastering or decoration which could easily come off and injure the residents, (fig.69).

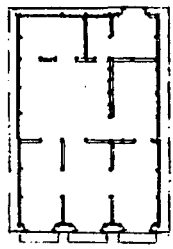
The buildings are not too elongated (façade).

The structure of the *gaiola* was proportioned and the height was never more than three times the width on plan.

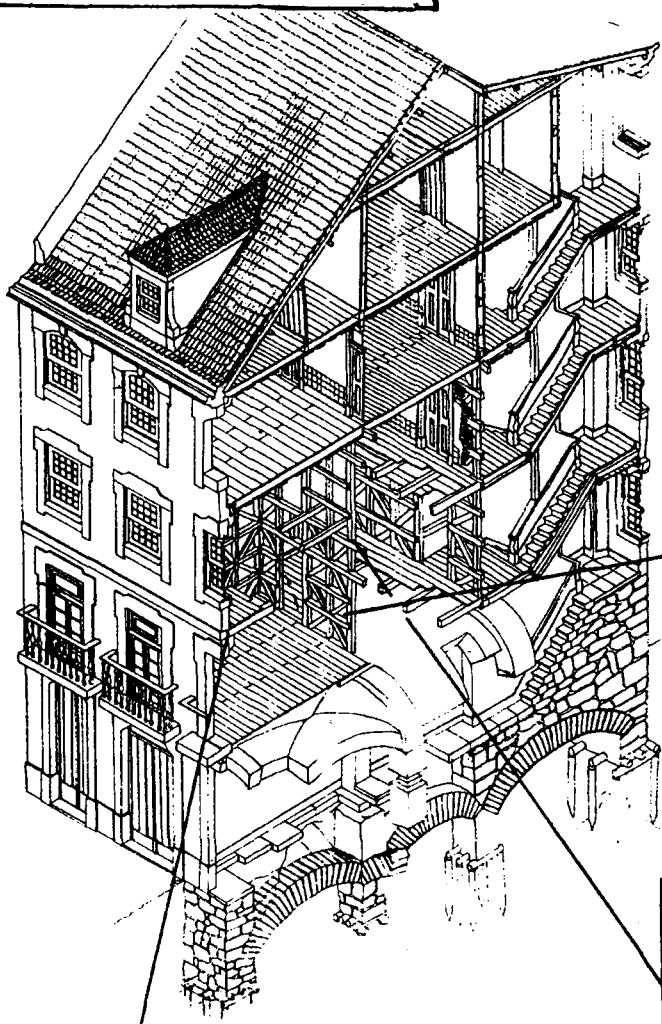
For the smallest size of flat we have, (fig.70):



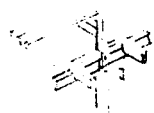
A uniform distribution on the plan of the principal structural elements (supports), (fig.71).



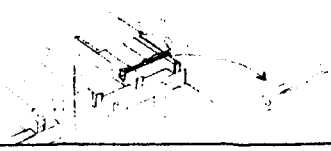
A simple structure (a St. Andrew´s Cross), making it easy to predict how it would behave during an earthquake, (fig72).



Perfect continuity in the height of the structural elements, (fig.73).



Floor beams fixed to perimeter walls by means of metal straps, (fig.74).



Ductile resistance of the different elements to the force of an earthquake.

A symmetrical structure so as to reduce the effects of torsion.

The gaiola

During the 1755 earthquake, the lower part of Lisbon, sitting on soft, alluvial land, suffered great structural damage, due to the increase in the size of the waves with the predominance of a certain frequencies.

The traditional buildings were made up of masonry work, which generally consisted of irregular stonework held together by weak mortar, that didn't withstand the effects of seismic actions.

During the period of reconstruction, a wooden structure, gaiola (cage) was adopted for the buildings. These constituted additional resistance and a guarantee of flexibility to enable the structural solution to behave in a more adequate manner in its response to earthquakes.

The cage was quite ingenious the simplicity of its construction and practically, and besides offering greater safety for both people and property, was greatly to benefit the financial interests of the proprietors by allowing the buildings to rise above the three floors initially stipulated on very unstable land.

The structure of the cage is basically made up of a series of panels with horizontal, vertical and diagonal members which formed a series of Saint Andrew's crosses. This design feature of the structure derived from empirical knowledge of the fact that it is difficult to deform a triangle.

The structure of the stairwell was generally reinforced by horizontal elements so that there would be multiple support points for the structure of the stair landings.

From the first floor up, all the walls in the building benefited from the cage structure however, the street and the internal courtyard facade walls and a simplified structure; the diagonal bracing disappeared leaving a few vertical and horizontal elements where the wrought iron clamps were fixed which held the masonry around the facade spaces in place.

The connections between the various oak or pine struts in the structure were elastic, which meant that, in the event of an earthquake the whole structure could adapt to movements of the land, keeping upright and still supporting the wooden floors, even though the plasterwork would be reduced to powder or small pieces.

For economic reasons or due to the long period of reconstruction there are variations from one building to another.

An usual example of a cage is illustrated on following pages.

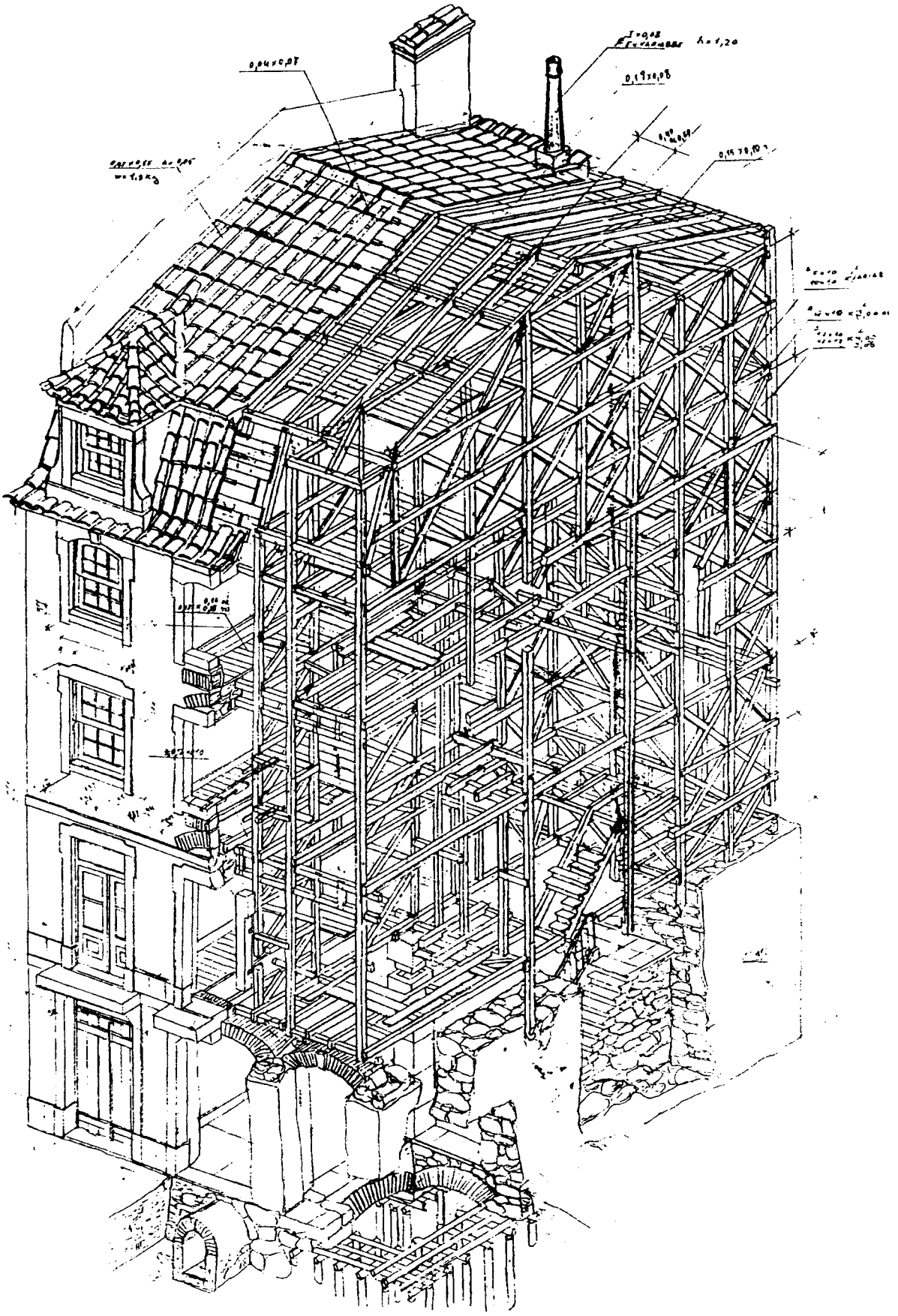


Fig.74-Constructive perspective

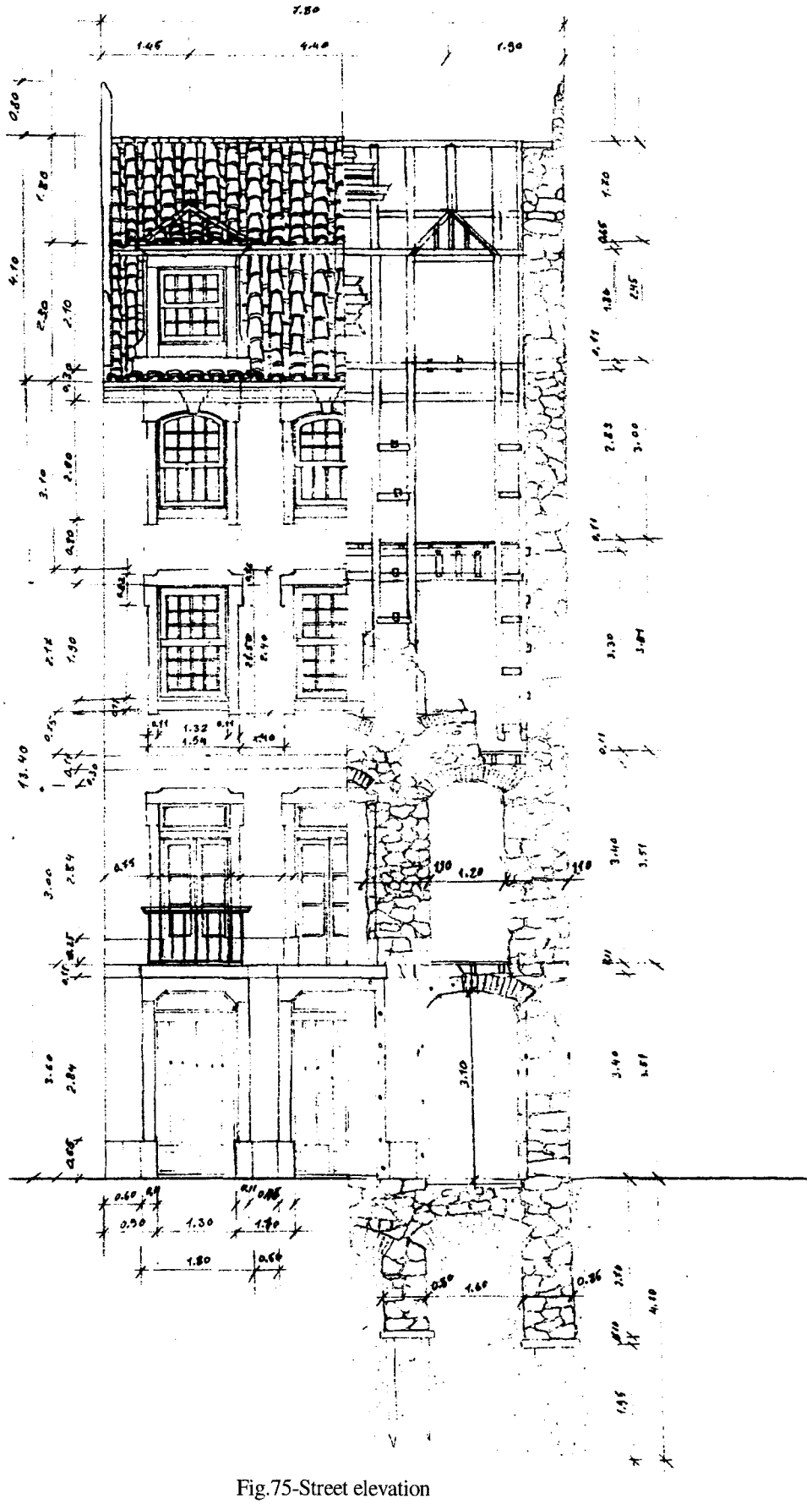


Fig.75-Street elevation

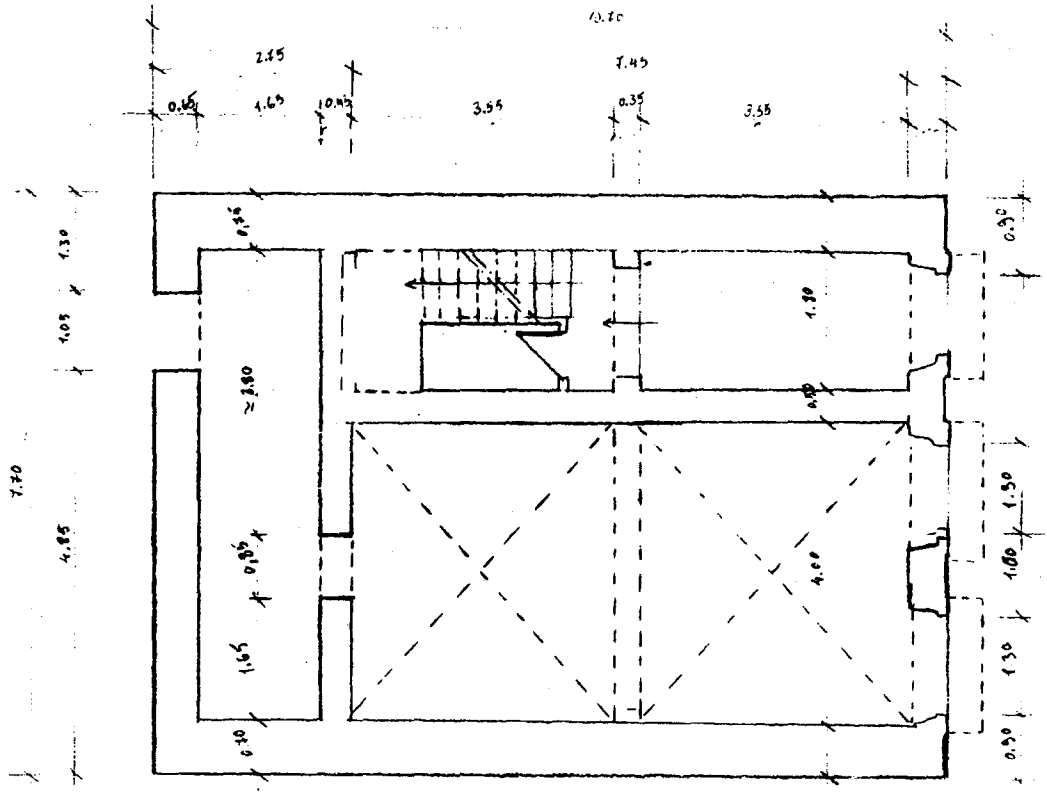


Fig.76-Ground floor

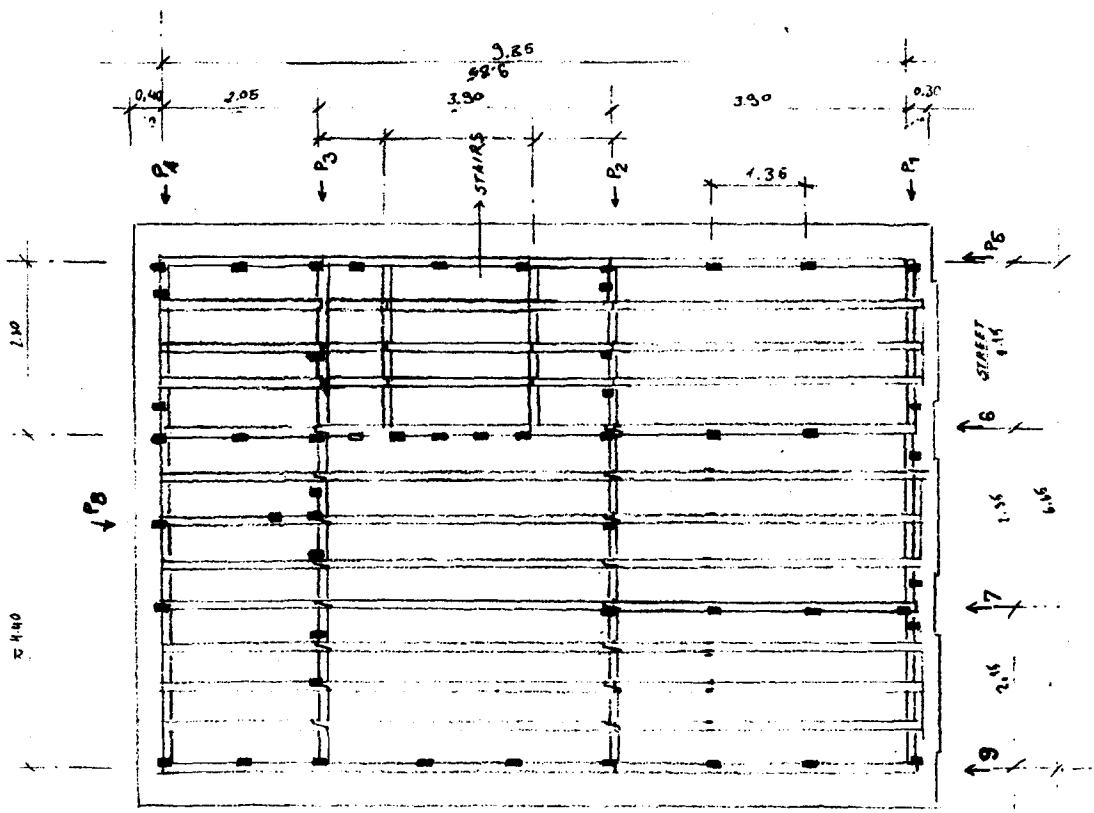


Fig.77-Structure of the pavements

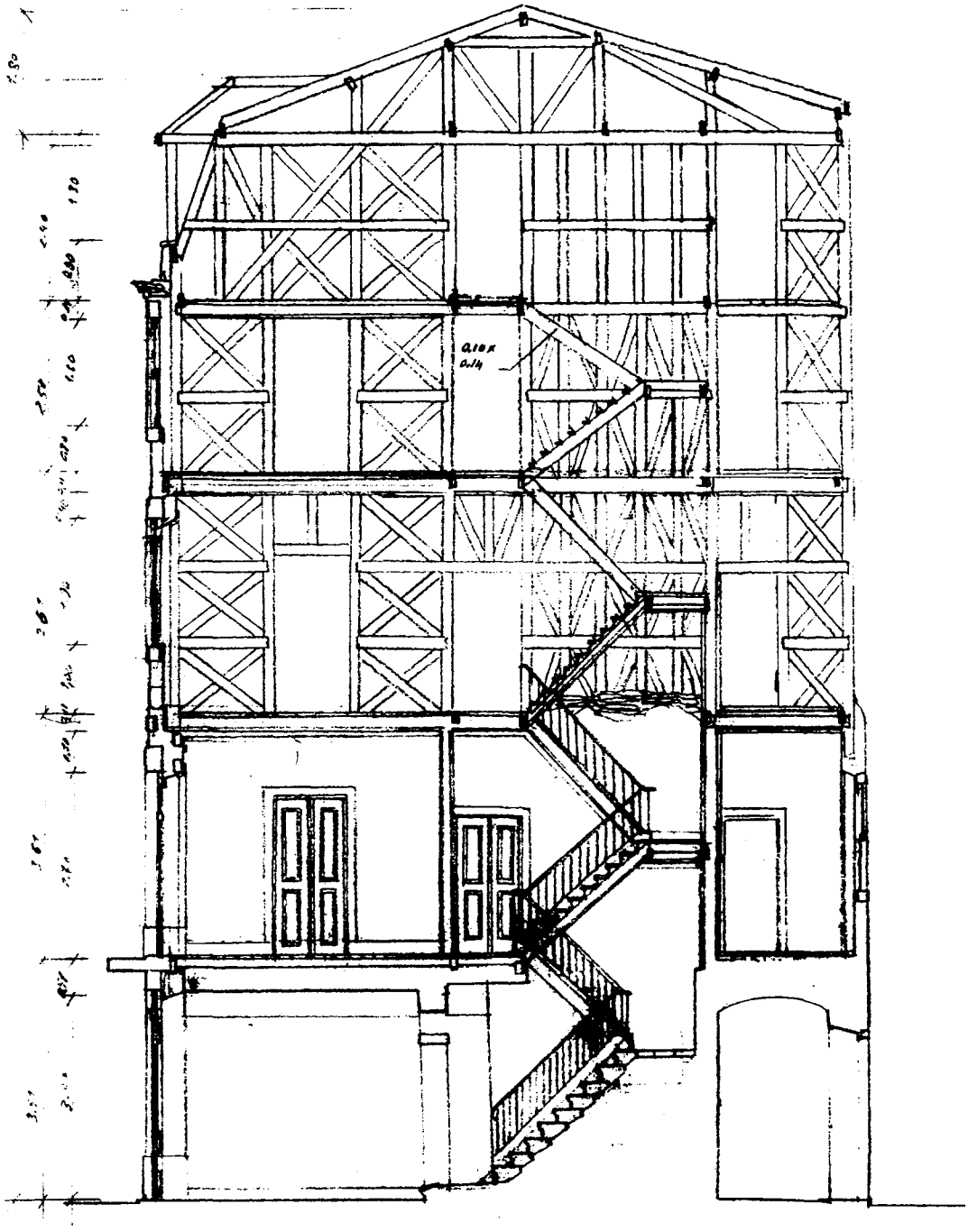


Fig.78-Constructive section

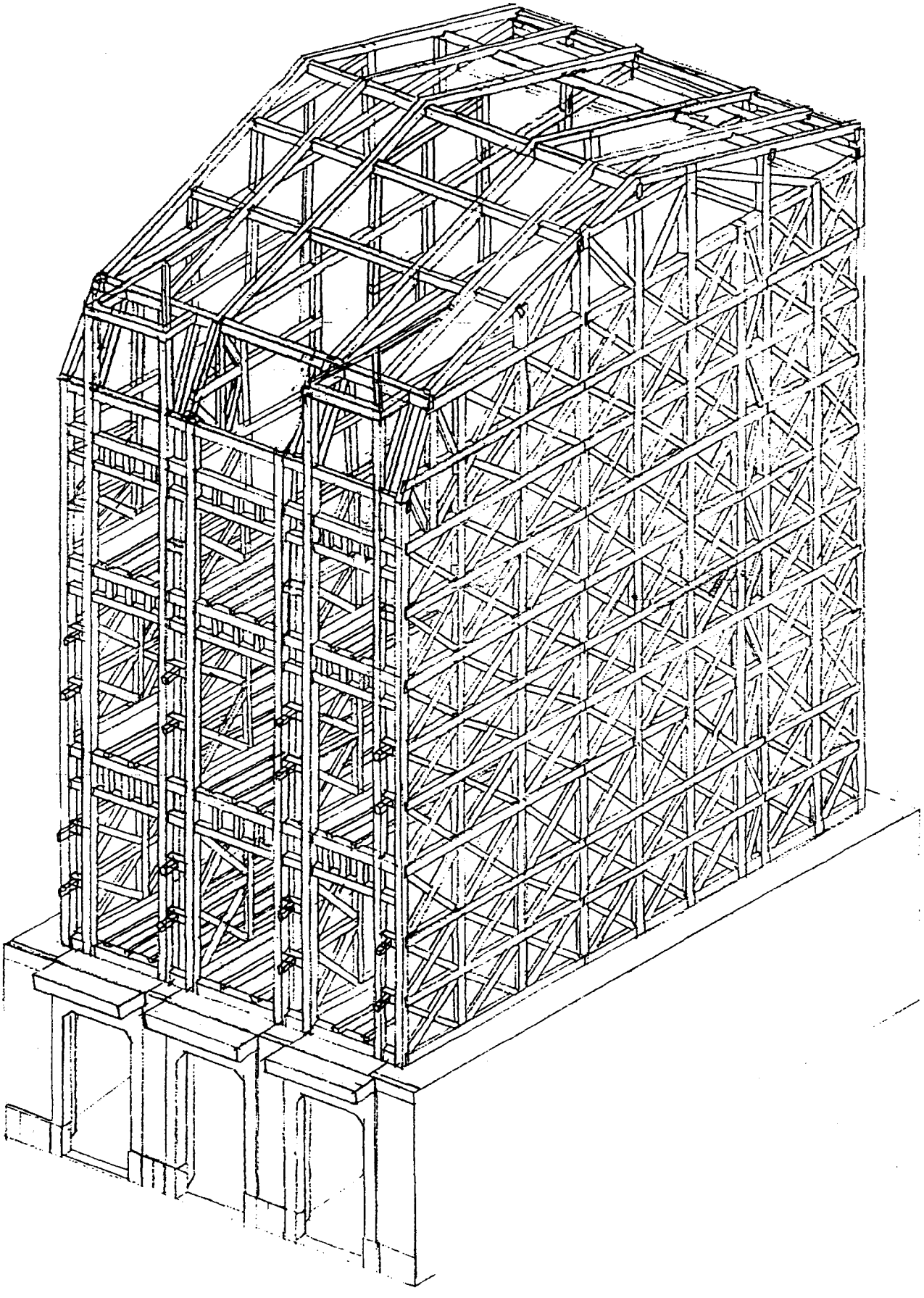


Fig.79-The cage

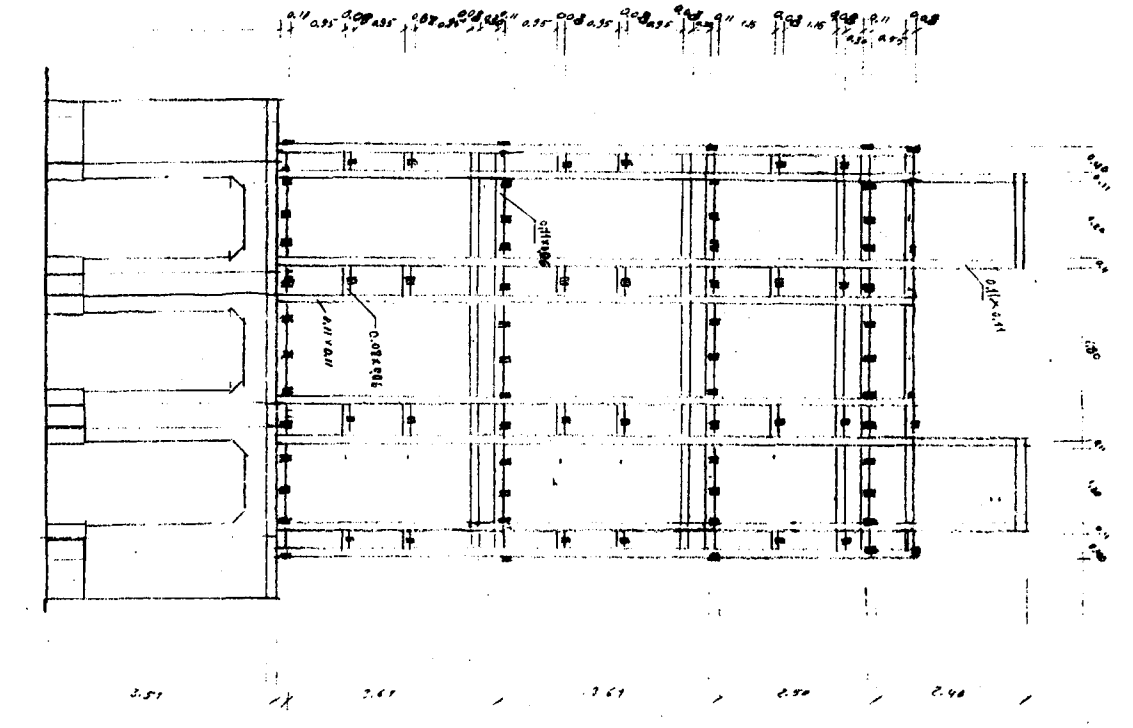


Fig.80-Portico 1

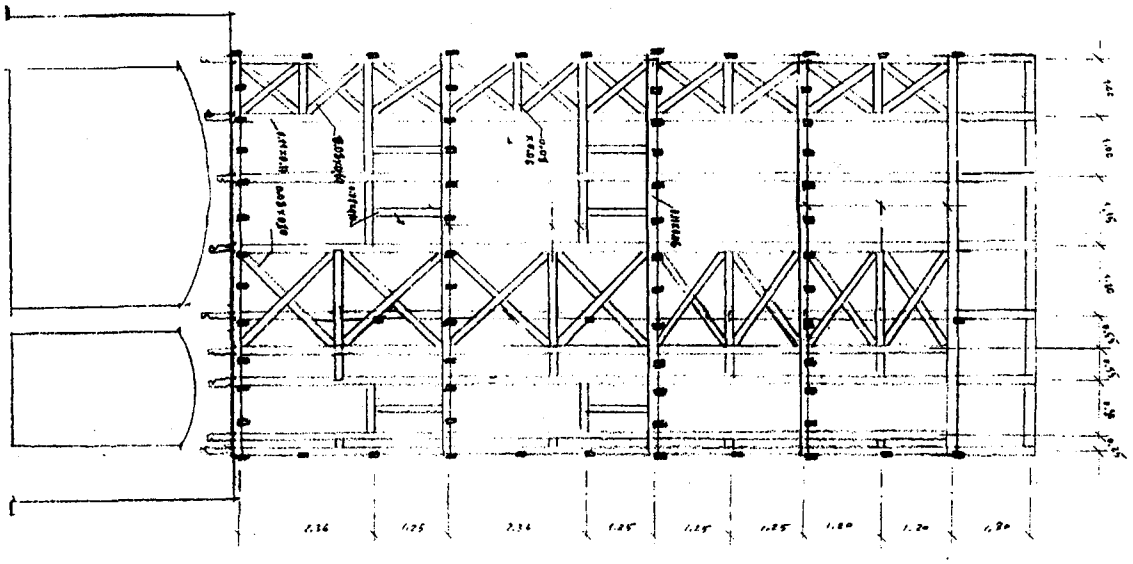


Fig.81-Portico 2

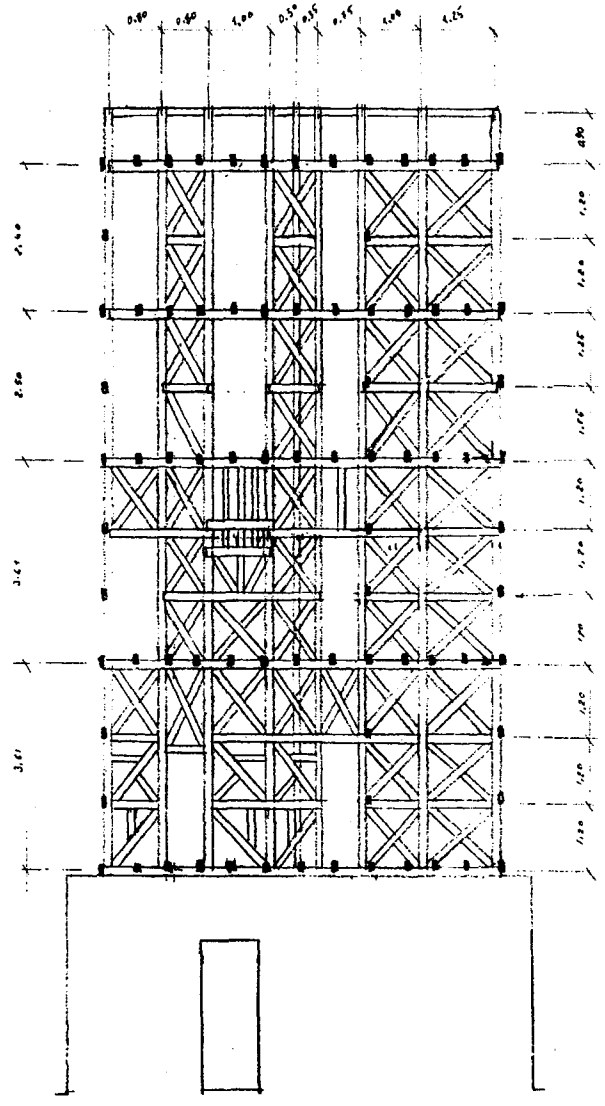


Fig.82-Portico 3

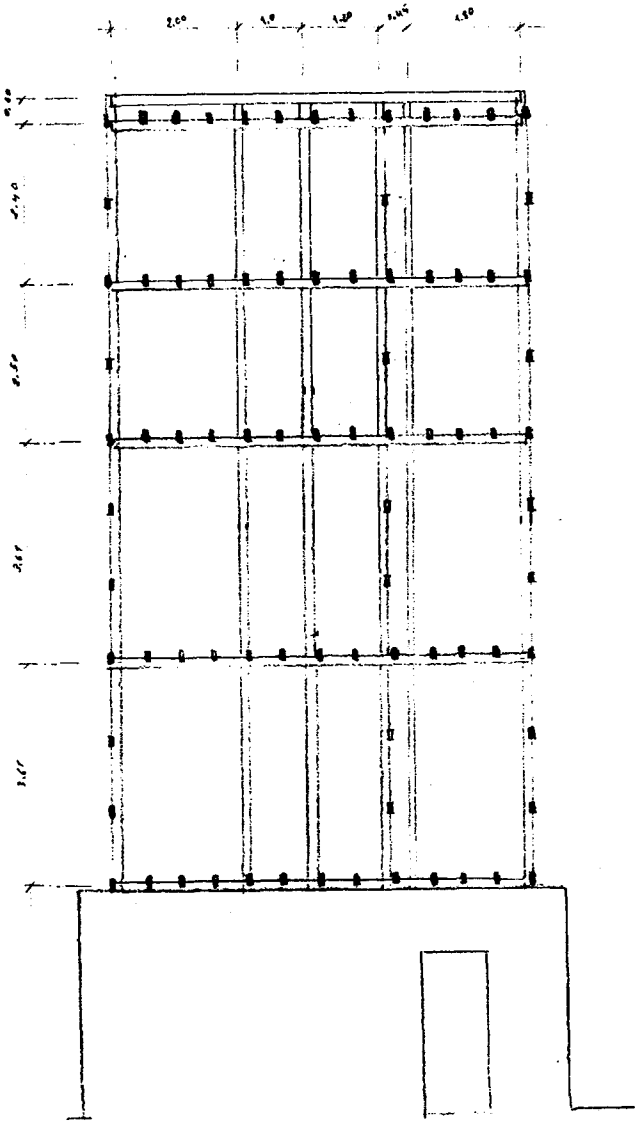


Fig.83-Portico 4

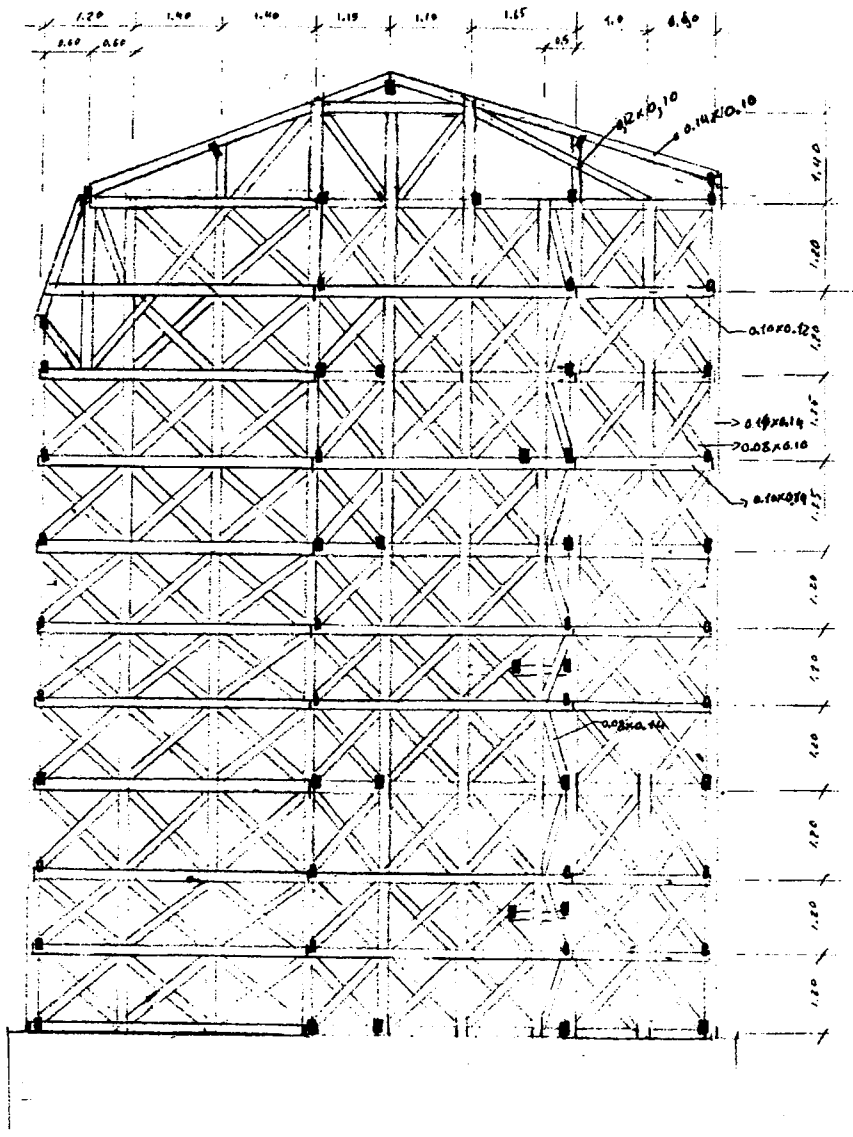


Fig.84-Portico 5

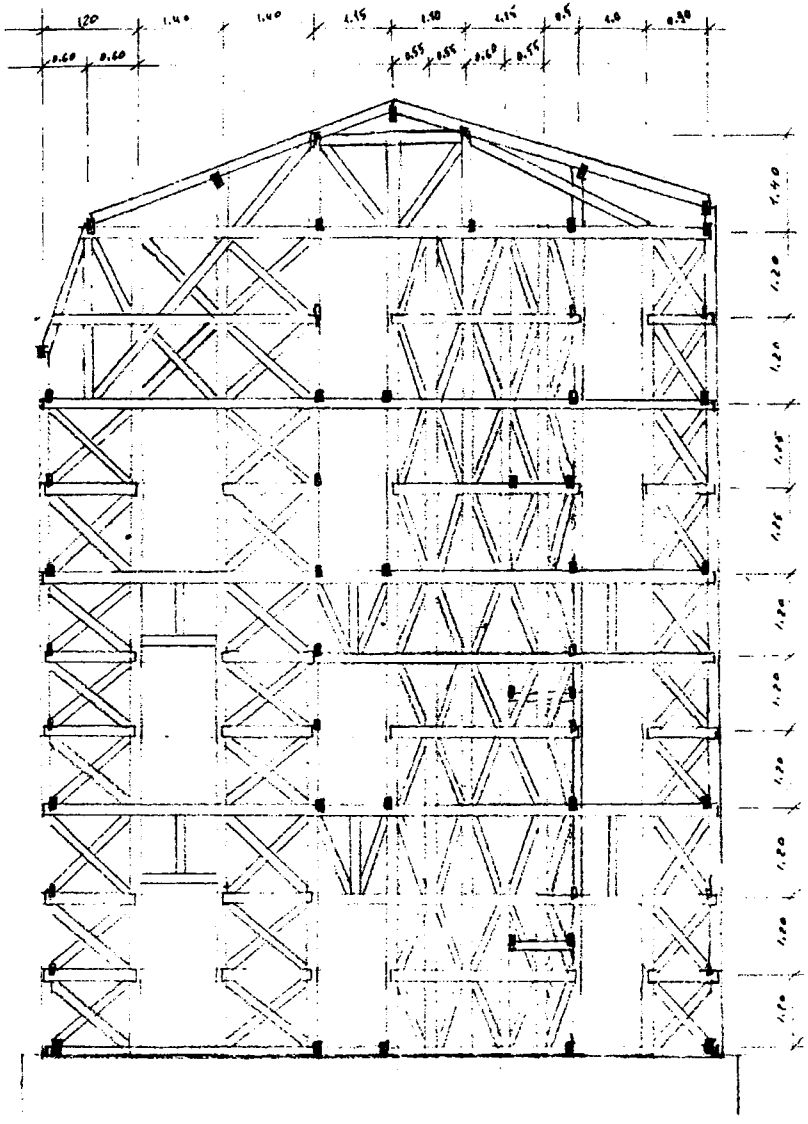


Fig.85-Portico 6

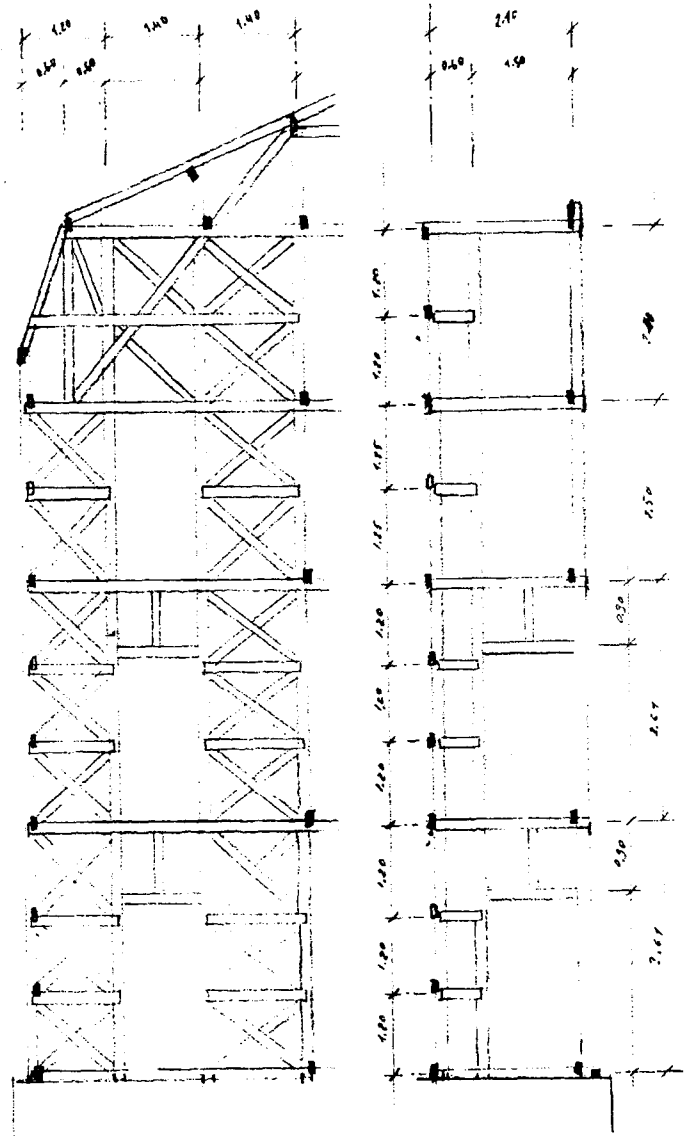


Fig.86-Portico 7 and 8

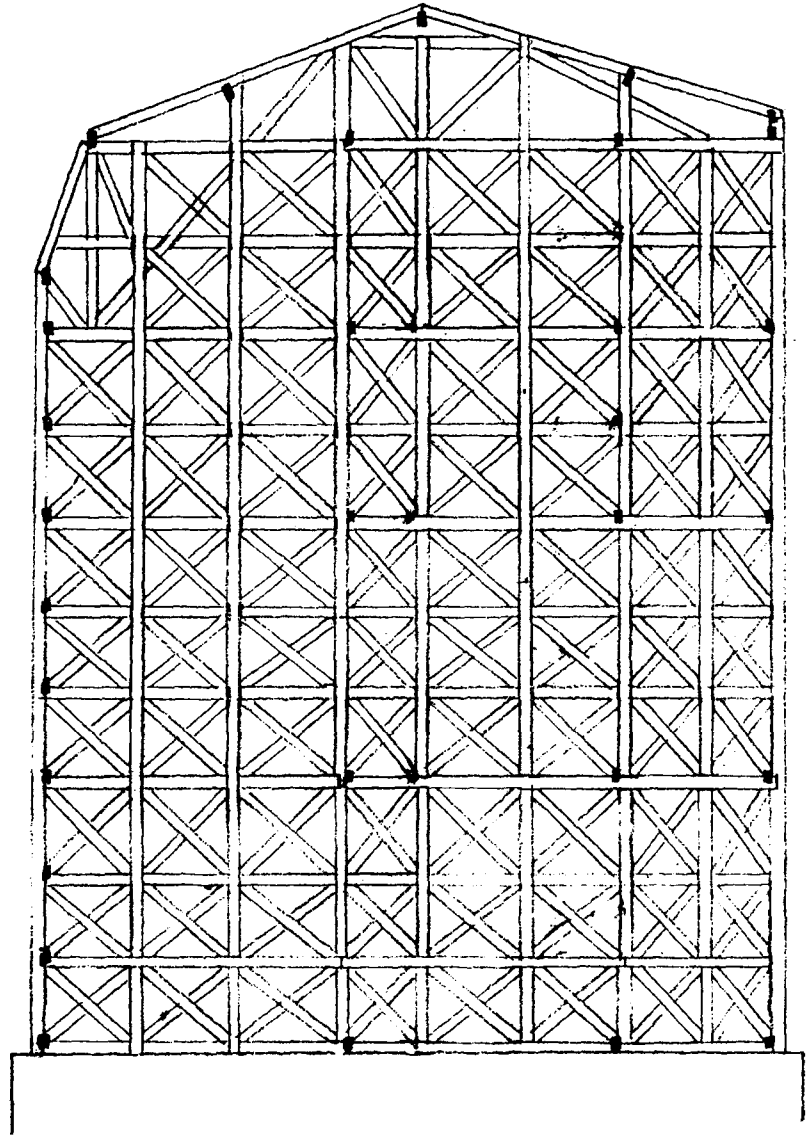


Fig.87-Portico 9

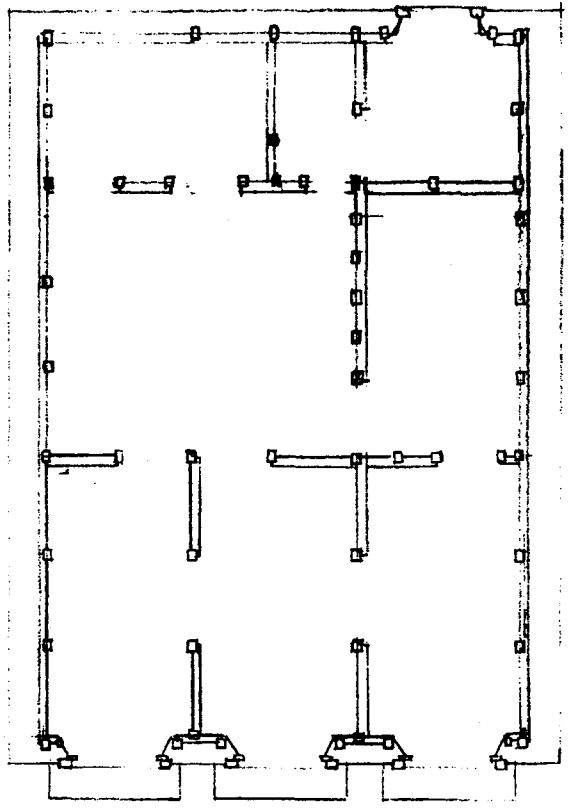


Fig.88-Plans of first, second and third floor

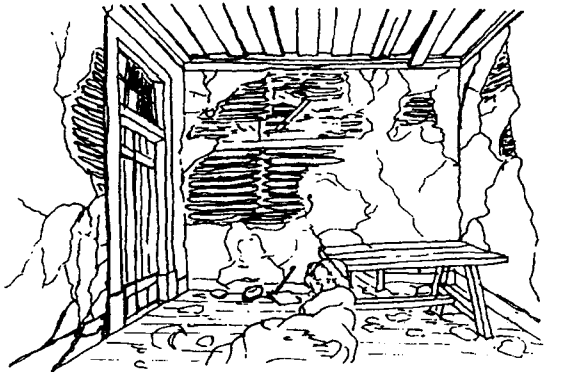


Fig.89-The cage of a room during and after the earthquake

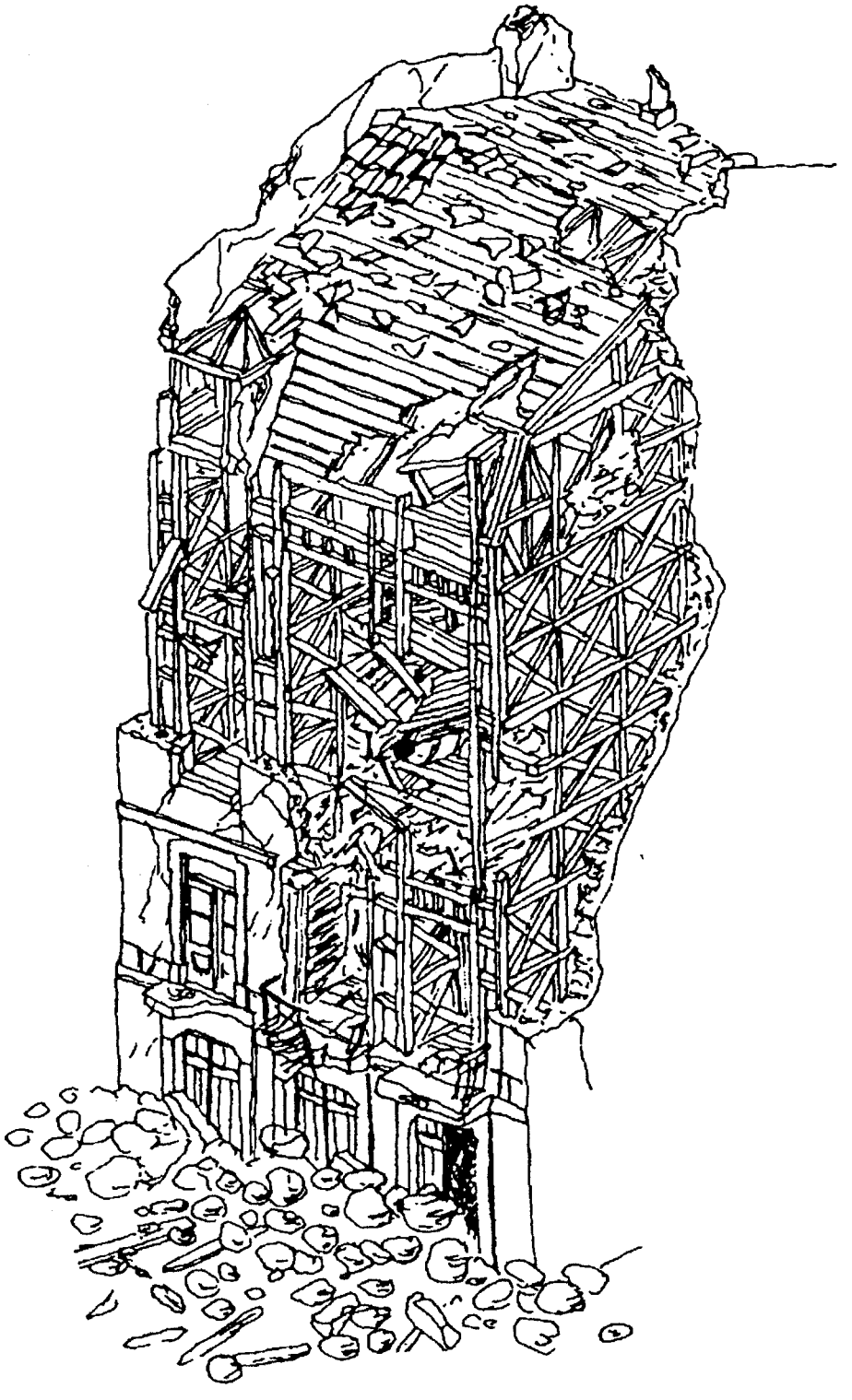


Fig.90-The cage after the earthquake

III.-Alterations introduced

With the tragic memories of the 1755 earthquake almost forgotten, it became common not to follow, or respect, the reconstruction plan (see fig. 91).

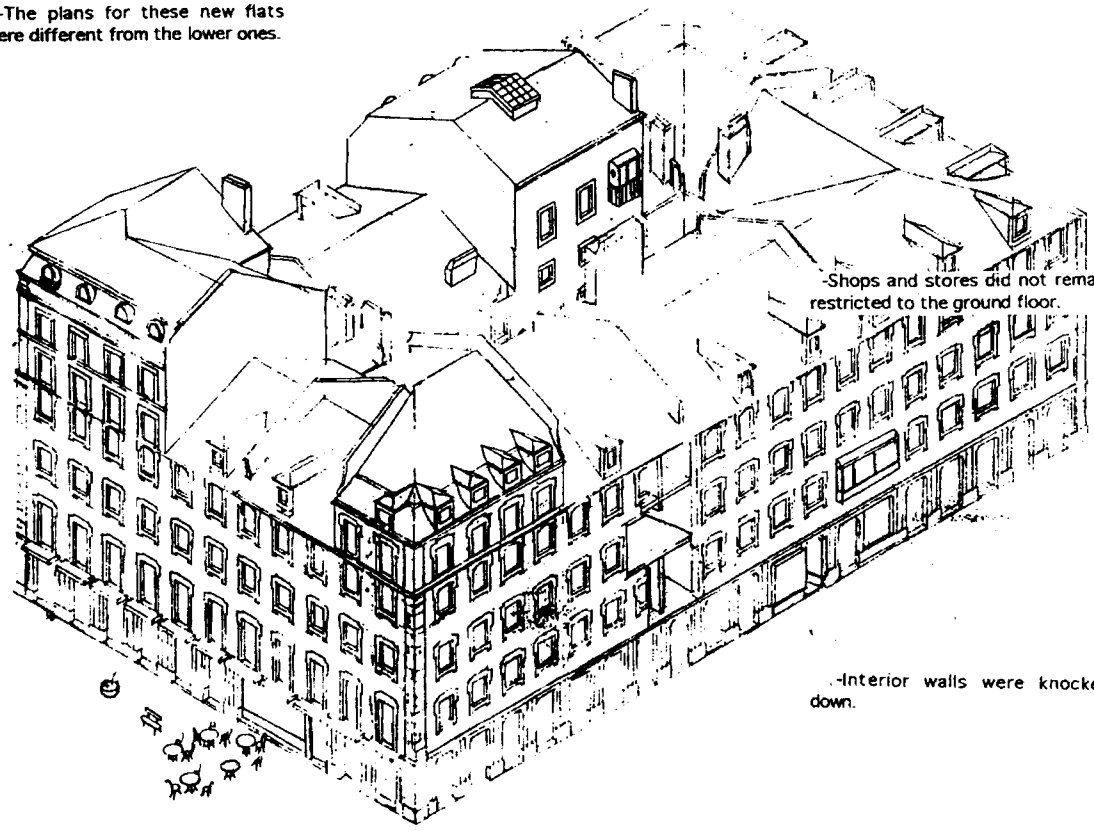
-More floors were added, the additions consisting typically of a poor imitation of the cage, made up of wooden posts which were small in diameter and without the bark removed, which created great structural discontinuity.

-The stairs were often widened and there are often skylights at the tops of the stairwells. Lifts were introduced.

-In the flats, toilets were installed in wooden compartments cantilevered out from the façades to the internal courtyards.

-The internal courtyards were encroached on an irregular fashion.

-The plans for these new flats were different from the lower ones.



-Shops and stores did not remain restricted to the ground floor.

-Interior walls were knocked down.

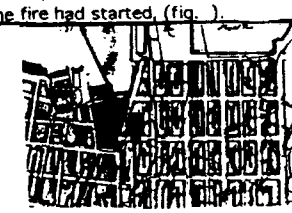
-The streets were cluttered up with cars, flowerpots, kiosks, benches and outdoor café terraces.

-Openings were formed in the separating walls between buildings.

-The height of the buildings became much greater than the width of the streets.

-With the constant expansion of the commercial sector, the openings at ground level were altered so as to allow for spacious shop windows.

-The original plan was not followed: the Assução Street does not link up with the Cruxifixo Street, which was exactly where the fire had started, (fig.).



-Doorways were formed and blocked in the internal walls, altering the geometry of the panels of the cage, in some cases, internal walls were even demolished completely.

-General maintenance work was often not carried out.

Fig.91-Alterations introduced

Bibliography

(1)-França, José-Augusto, "Lisboa Pombalina e o Iluminismo", 3rd edition, p.61, Bertrand Editora, Venda Nova.

(2)-França, José-Augusto, "Lisboa Pombalina e o Iluminismo", 3rd edition, p.78, Bertrand Editora, Venda Nova.

(3)-França, José-Augusto, "A reconstrução de Lisboa e a Arquitectura Pombalina", 3rd edition, p.68, Biblioteca Breve, Lisbon, 5.1989.

(4)-França, José-Augusto, "Lisboa Pombalina e o Iluminismo", 3rd edition, p.177, Bertrand Editora, Venda Nova.

(5)-The gaiola study based on:

-L.N.E.C., "1° Encontro sobre Conservação e Reabilitação de Edifícios de Habitação", Lisbon, 1985.

-Oliveira, C. Sousa, "Efeitos dos sismos sobre as construções", Engenharia e Arquitectura.

Collaboration of Eng. Carlos Rentein in
the study of the gaiola

List of illustrations

Front illustration by author.
1-Johan Cristian Leopold, 1755(?), Copy made by author from:, Col. Museu da Cidade, C.M.L., Lisbon.
2A-Vieira da Silva, Augusto, "Dispersos", Biblioteca de Estudos Olisiponensis, Lisbon, 1960.
2B-João Nunes Tinoco, Edition of XIX c., copy from: França, José-Augusto, "Lisboa Pombalina e o Iluminismo", 3rd edition, p.26, Bertrand Editora, Venda Nova, 1987.
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6-Oil on cavan, Lupi, Miguel Ângelo; XIX c., Copy from: Serrão Veríssimo, O Marquês de Pombal, C.M. de Lisboa, Oiras e Pombal, Soc. Industrial Gráfica; Lisbon 1982.
7-Oil on Cavan, J.Machado, n.dat., Associação dos Arqueólogos Portugueses, Copy from fotograph publish in: França, José-Augusto, "Lisboa Pombalina e o Iluminismo", 3rd edition, p.233, Bertrand Editora, Venda Nova, 1987.
8-N. ass.; 1750, Associação dos Arqueólogos Portugueses, Copy from fotograph publish in: França, José-Augusto, "Lisboa Pombalina e o Iluminismo", 3rd edition, p.26, Bertrand Editora, Venda Nova, 1987.
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20A-Vieira da Silva, Augusto, "Dispersos", Biblioteca de Estudos Olisiponensis, Lisbon, 1960.
20B-E. Santos; Poppe, Plan number 6, copy from: França, José-Augusto, "A reconstrução de Lisboa e a Arquitectura Pombalina", 3rd edition, plate 7, Biblioteca Breve, vol.12, Lisbon, 5.1989.
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