A Study of Relevant Features of over-Elevation as a Strategy for Urban Renewal

Maria Piqueras Blasco and Ivan Cabrera i Fausto

August 3, 2022

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M. Piqueras Blasco & I. Cabrera i Fausto
Universitat Politècnica de València, Spain

ABSTRACT: Urban contexts nowadays are frequently facing two important difficulties among many others. On the one hand, aging buildings are in a growing need of intervention. On the other hand, the continuous migratory tendencies towards cities often require new housing. The option of expanding the city vertically known as over-elevation is becoming a popular option to confront both issues. Far from a general increase of the number of storeys for any single building, this practice is much more surgical. It consists of the construction of light housing modules on the rooftop of existing buildings, but just when land regulations and constructive possibilities make it possible. In order to make this rather new methodology more attractive to all stakeholders, a better knowledge of this solution is a must. This research will analyse a set of relevant variables to be considered, such as architectural typology, materials, geometry or its constructive and structural typology. In this way, the objective will be to know the building and the relevant features to consider for over-elevation as a possible strategy for urban renewal.

1 INTRODUCTION

Cities are in constant evolution due to continuous economic, social and environmental changes. Nowadays, all of them have created an urban context defined mainly by two peculiarities. On the one hand, the evident lack of maintenance and updating of common spaces in many buildings located in historic city centers. On the other hand, the demographic dynamics towards cities generate the need for new housing in specific areas (Piqueras 2021).

Against this background, an over-elevation methodology is proposed as a possible response (Fig. 1). This practice consists of the construction of lightweight housing modules on the roofs of existing historic buildings when the regulations and construction possibilities make it possible. In exchange, the developer renovates, upgrades and updates the building to be elevated (Millán 2018).

Figure 1. Previous and final front elevation of a street hosting an over-elevation.

This practice offers multiple advantages, such as the optimization of the city's resources, as it does not require the extension of supply and transport networks or the construction of new facilities. In addition, it favors proper urban maintenance, and an update of current comfort standards in many buildings that probably do not meet these requirements. Similarly, over-elevation favors urban regeneration in central areas of cities, as these are potentially the most suitable buildings. This is mainly due to the existence of buildability, and the lack of rehabilitation in many of these properties (Piqueras & Fenollosa 2020).

While there are many benefits to this new strategy, there might be also disadvantages. If we refer to social terms, we find that the sudden introduction of new neighbors alien to the previous daily life of the building can sometimes be complex. Regarding building techniques, the technology employed is neither easy nor habitual, and therefore not always feasible (Piqueras & Fenollosa 2020).

This opportunity to build new dwellings on the basis of buildability is an appropriate phenomenon that might be encouraged. To make this practice an attractive solution for all stakeholders, a better understanding of this solution is necessary to enable standardization and normalization of the technology. For this reason, the main objective of this research is to establish a list of critical issues on existing buildings to develop the phenomenon of over-elevation.

Throughout this research, we start with the delimitation of the study area in the case of the city of Valencia. This research utilizes Colon and Russafa, a couple of popular neighborhoods of Valencia, Spain, as case studies and exportable examples. The variables of a set of selected buildings are analyzed, developing and understanding each of the parts that compose the existing building. On the one hand, the architectural analysis, and on the other hand, the constructive-structural analysis. These results are then questioned in order to elaborate a critical analysis of the important points to be considered in over-elevation.

Therefore, the set of research tools used will start with the distinction of the buildings proposed for the elevation, and then the data collection of the aspects to be analyzed. Bibliography on the typology of the selected buildings and their characteristics will also be used. Finally, specific bibliography on the phenomenon of over-elevation will play a relevant role.

2 STATE OF THE ART FOR THE CASE STUDY SELECTED

Colon and Russafa are popular neighborhoods of the city of Valencia, Spain, developed during the 19th and 20th century when the medieval walls of the historical center were demolished. The particularities of the buildings of this expansion area have been previously studied by other authors and institutions thoroughly, constituting an adequate case study. Consequently, the area of the study is the south east expansion area of the city of Valencia, which is defined by a specific urban context.

As in other similar neighborhoods across the world, over the years, laws have been promoting an increase in heights, so that some buildings have not been able to exhaust all of their buildability (Piqueras 2021). Thus, occasionally there is a discontinuity of heights between adjacent buildings, which is the opposite idea to the projected planning for the urban expansion which ambitioned a uniform urban landscape. Likewise, most of the buildings are in a poor state of conservation and maintenance for the 19th century urban expansion, in addition to not having elevators, either for economic reasons or simply because there was no need for them at the time. If to all this, we add that these buildings have an architectural value as urban heritage of the city, we find a clearly defined context: protected residential buildings, with vacant volumetry, and lack of maintenance and updating. Therefore, this window of opportunity opens up. It should be taken into account that the buildings in the expansion area have very similar characteristics compared to other areas in Valencia. This results in a standardization of their particularities, and therefore makes the study feasible for the whole area described.

Figure 2 shows the buildings that allow an over-elevation by the regulations, and that are also catalogued with some degree of protection in the study area. Therefore, a total of 66 samples will be evaluated. These are located in the widening of the city of Valencia, catalogued in the "Plan Especial de Protección del Ensanche de Valencia" (Special Plan for the Protection of the expansion area of Valencia) in the aforementioned neighborhoods of Colon and Russafa.

Figure 2. Buildings with a protection degree with the possibility of volumetric expansion according to special land regulations for the neighborhoods of Colon and Russafa in Valencia, Spain.

3 IDENTIFICATION OF BUILT ASPECTS

For the elaboration of this research, an identification of the different building aspects that influence the behavior of the structure is carried out. For this purpose, it is necessary to distinguish between two parts: the existing building and the extension. The existing building acts as a starting point, since it marks the circumstances to which the new construction will have to conform. On the other hand, the extension houses the new dwellings, which must be adapted to the conditions set by the base building, in addition to complying with the requirements and standards in force. This study focuses on the base building, which will set the typological and constructive-structural conditions for the development of the future technology.

3.1 *Architectural typology*

Local ordinances assign a predominant residential use to this expansion area. For this reason, the constructions that can be seen are very similar: blocks of apartments between party walls with courtyards that, according to the regulations, should reach 25% of the block. In addition, the plot had to have a minimum length of 8 m of facade and a minimum surface of 100 m^2. The maximum height of the buildings depended on the importance of the street, going from 12 m in secondary streets to 20 m in streets of the first order in the first plans. All these regulations were drafted in the different expansion plans that were approved over the years, the first of which was approved in 1844 (Taberner 1987).

Once the zone of action has been established, different parameters are identified. First, a distinction is made between 4 categories corresponding to the general layout of the buildings (Fig. 3). These categories take into account the layout of stairways, courtyards and dwellings. It is curious to verify that in all categories, two dwellings per floor separated by stairways (S) and occasionally courtyards can be found. As points in common we find that in types 1, 3 and 4, the stairway is located in the 2nd bay, while in type 2 it is in the 1st bay. However, the most disparate element between them are the potential courtyards, which are determined by the dimensions of each of the plots.

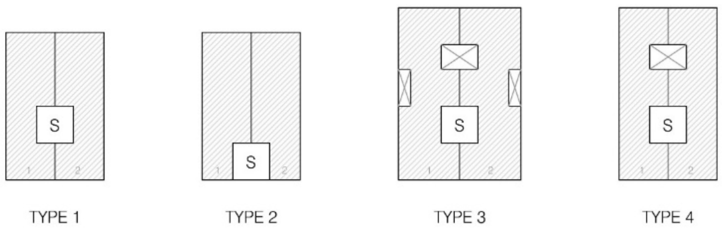

Figure 3. Classification of the general layouts of different types of residential buildings in the neighborhoods of Colon and Russafa in Valencia, Spain.

Once this first classification has been established, a summary table is provided with the data collected from the 66 samples mentioned above. The study area has very similar architectural characteristics. First of all, a distinction is made between 2 main groups according to the structural system, either by a system of load-bearing walls and brick masonry columns, or by a concrete grid system. Then, within each main group, a further subdivision is made. Seven subgroups are distinguished in the load-bearing wall system and just one subgroup in the concrete system. This second classification (Table 1), unlike the previous one (Fig. 3), catalogues the buildings depending on the set of all the parameters studied. In contrast, in Figure 3, a distinction is made by taking into account only their general distribution. Therefore, the table shows a series of parameters such as: the number of buildings, the average age of construction, the current heights, the possible heights of elevation allowed by the regulations, the architectural style, and the classification according to the schemes previously described.

Table 1. Classification of the data collected for the 66 samples.

System of load-bearing walls and brick masonry columns

Id	no. buildings	Average age	Storeys	no. floors over-elevation	Layout	Predominant style
A	1	1910	3	1	Type 1	Academic eclecticism
B	33	1913	4	1	Type 1	Academic eclecticism
C	2	1917	4	1	Type 2	Academic eclecticism
D	8	1919	4	1	Type 3	Academic eclecticism
E	1	1910	4	2	Type 3	Academic eclecticism
F	9	1929	5	1	Type 1	Academic eclecticism
G	8	1928	5	1	Type 3	Academic eclecticism

Concrete grid system

Id	no. buildings	Average age	Storeys	no. floors over-elevation	Layout	Predominant style
H	4	1918	4	1	Type 4	Academic eclecticism

Once these tables are considered, it can be deduced that the predominant option in the area of the study zone is the system of load-bearing walls and brick masonry columns. In addition, typology B stands out notably with a total of 33 buildings, which represents 50% of the total number of buildings. Analyzing the overall table, we find very similar values. It should be noted that most of the over elevations correspond to the extension of one floor, except for one building where the regulations allow us to build two floors. Thus, blocks from five to six storeys are obtained.

Another point to take into account is that the average age of a building is 100 years. It is worth mentioning that according to the current Spanish Building Technology Code the useful life of a residential building is 50 years. However, we frequently find out that most of the buildings which we are inhabiting in the historical districts of western cities have more than met his requirement (Piqueras & Fenollosa 2020). Therefore, we find that buildings still have the durability characteristics to increase this useful life. In fact, buildings can still be in operation even if they are over 50 or 100 years old. It is also worth mentioning that the energy, material and environmental costs of demolishing a building and erecting a new one are very high, and therefore the rehabilitation of existing buildings is a good sustainable, economic and architectural practice (Druot, Lacaton, & Vassal 2007).

If we refer to the architectural style, we must highlight the movement par excellence in Spain between 1910 and 1930: academic eclecticism. Although this feature will not affect the structural characteristics, it should be taken into account in the design of the project, so that the existing facades can coexist with the new ones. Finally, it should be noted that the predominant distribution scheme is type 1, followed by type 3. Both have the stairway located in the 2nd bay, but they are differentiated by the inclusion of courtyards in type 3. This is due to the increase in surface area, both in building depth and in facade, since in order to incorporate light and ventilation to the different rooms it was necessary to introduce openings with an essentially vertical component throughout the building.

3.2 *Construction-structural typology*

The expansion zone was determined by the Industrial Revolution, which transformed the social and economic models in the society of the time. This also had consequences on the model of the city, and it was throughout the nineteenth and early twentieth centuries where the most important physical urban transformations took place in the city of Valencia. All this change is reflected in the buildings, which were directly affected by the materials and construction techniques used. The different parts that make up the buildings are shown below. In this way, we will be able to know and identify the most critical points and those to which more attention should be paid for the development of technology.

3.2.1 *Foundations*

The foundation has been the construction system that has varied the least during the 19th and early 20th centuries. For this reason, the foundation is made of strip footings under the load-bearing walls of the building. On some occasions, when cast iron columns are employed or under the masonry columns of inner frames, simple spread footings can also be found. Materially, they are executed with dry masonry, or with some natural cement. Their width is usually about 150 cm and usually responds to twice or three times the thickness of the load-bearing wall to be supported. Their depth usually reaches one or two meters (Bretones 1990). Occasionally, and when the firm ground is not at the upper levels, the walls themselves are built up with masonry or large stones (Soriano 2013).

3.2.2 *Vertical structure*

The vertical structural system of the buildings in the study area is based on the arrangement of parallel load-bearing walls, which act as front and rear facades. In addition, in the interior there are frame displayed parallelly to the facades (Fig. 4). Dimensionally, the load-bearing walls are made of solid brick and range from one and a half to two feet thick, although this depends on the height of the building. It is very common to find thicker walls on the first floor, depending on the height of the building (Bretones 1990).

As for the interior frames, they are halfway between a portico and a load-bearing wall, since they are frames built from solid brick columns with greater longitudinal dimension. Thus, if these are isolated, these are large columns in the direction of the portico. On the other hand, the extreme columns are buttresses connected to the party walls to give more lateral stability. On this occasion, it is worth mentioning the introduction in some cases of cast iron columns from 1920 onwards. It can be found as a replacement for the columns on the first floor of commercial premises, when the economic difference was really profitable compared to the increase in surface area (Bretones 1990).

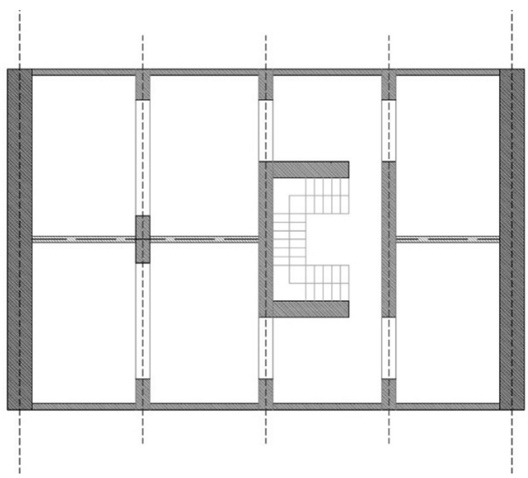

Figure 4. Diagram of type B building showing the structural system using load-bearing walls parallel to the façade.

Another element that contributes to the stability of the structure is the partitioning with bracing purposes. These are also made of solid brick and a thickness of half foot. These partitioning walls are displayed perpendicularly to the façade and other load-bearing walls and frames in order to connect them and to bind with other party walls and stairwells (Soriano 2013).

Although in the past party walls were shared between neighboring buildings, this concept changed much before the typologies which we are considering were built. Thus, each of these buildings has its own party walls made of half-foot-thick solid brick without an air chamber.

Finally, it must be mentioned that the stairwell is a rigid element bracing the whole structures as well, being made with masonry of solid brick with a thickness of one foot.

3.2.3 *Horizontal structure*

If we mentioned earlier that the foundation was the point that had varied the least in terms of construction techniques and materiality, the same cannot be said of the floor slabs. The evolution of materials is evident in the design of horizontal structural elements.

Thus, in the Colon and Russafa buildings it can be observed that most of the floor slabs are unidirectional, composed of a framework of timber and joists (Fig. 5). The joists are supported on the beams, and at the same time, the beams are supported on the interior frames. The beam filling is made with one or two brick threads. In addition, brick rubble and mortar were used as filler to facilitate the leveling and subsequent laying of the ceramic pavement (Bretones 1990).

As we mentioned before, the horizontal structure was one of the elements that had undergone the most changes over the centuries. Thus, from 1910 onwards, we began to see some elements made employing metal profiles (Bretones 1990).

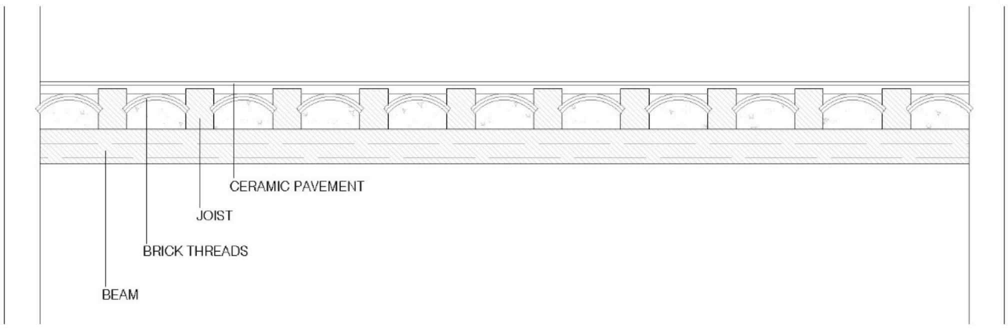

Figure 5. Cross-section of a typical slab with beam and joist framing.

3.2.4 *Roof*

Together with the floor slab, the roof has been another of the elements that has evolved the most. Thus, there are two main types of roofs. Initially, pitched roofs were the most common ones, but they gradually gave way to ventilated flat roofs.

In the case of the first one, it is a pitched gable roof leading rain water to the front and back façades. Constructively, it is composed of wooden elements, as well as the slab, arranged at an incline. In the case of Valencia, a special system is employed, consisting of joists spanning from the front and back bearing walls to interior timber beams acting as ridgecaps. Smaller rafters were placed on the joists in order to receive the ceramic pieces which composed the roof (Bretones 1990). Therefore, we find that the pitched roof will be one of the difficulties to be solved for the over-elevation.

If we refer to the flat roof, it should be noted that the type of solution of the time was the so called flat Catalan roof. It is composed by two differentiated layers defining and intermediate ventilated air chamber with a height ranging from 40 to 60 cm in order to improve the thermal comfort and to avoid condensation (Piqueras & Fenollosa 2020). Materially, the layer is composed of several layers of solid and very thin bricks placed on small, perforated and also thin brickworks built on the compression layer of the last slab that forms the roof.

This new solution began to be imposed from the second decade of the twentieth century. That is why, in most of our cases, the type of roof we find is the ventilated flat roof, so called Catalan roof. That fact makes it difficult to place elements that have to transmit loads to the structure on top of it. In addition, the definition of flat roof does not imply a perfect horizontality, since, in the same way, slopes are perceived to allow the evacuation of water.

By means of the Spanish code “Acciones en la edificación” (“Building loads”), external forces to be borne by the structure are determined in an approximate manner. Thus, the self-weight of the constructive elements of the Catalan roof is 2,5 kN/m^2, and the variable load according to the overload of use is 1 kN/m^2. These values will have to be taken into account when manufacturing the over-elevation whose final result should not differ meaningfully in order to avoid the need of structural reinforcement.

4 DISCUSSION

New homes obtained by means of over elevation must comply with a list of standards and technical issues, not only derived from the regulations, but also from the location where it is going to be placed. Hence, it is important to understand the existing building, since it marks some critical points that we must address both typologically and constructive-structural level.

If we refer to the typological requirements, we find those that respond to more general and formal criteria. According to the regulations, most of the extensions can only add one floor, a point that will be discussed later in the structural section. Likewise, only one or two dwellings may be built per floor due to the stair core, which is so predominant at the distributive level. In addition, the location of the courtyards must also be respected, as well as the conditioning systems that may be located on the roof.

As for the constructive-structural requirements, those that meet much more delicate criteria are detailed. One of the clearest requirements that will condition the new dwellings is the metric one. The structure of the building has a clear geometry generated by the load-bearing walls, which will mark the rhythm of the support points of the extension to avoid punctual loads that produce bending moments possibly endangering the good performance of the existing secondary system composed by joists. this point will also condition the interior distribution.

Another noteworthy aspect is the lightness. It should be taken into account that, although the existing structure is in good condition, the building has not been designed to support one or two additional floors as heavy as the existing ones. However, the structure might have some remaining resistant capacity. For this reason, the new structure will have to meet lightness criteria so as not to affect the stability of the building. New loads to be considered in any over-elevation include the new housing module structure self-weight, and other dead loads such as partitioning (about 1 kN/m), enclosure (1 kN/m), and roof (1 kN/m^2). They also encompass live loads such as use (2 kN/m^2 for dwellings), and wind depending on its location.

We mentioned earlier that, according to the regulations, the construction of a single-storey building is mostly allowed instead of a two-storey building. This will also benefit the lightness of the extension. It is common for the vertical structure to be more oversized than the horizontal structure. Therefore, the new loads can be assumed, but without excessively penalizing the horizontal structure. This can be achieved by means of a good arrangement of the new elements, avoiding the loading of secondary elements. In this way, it is advisable to apply uniformly distributed loads on the primary elements or, even better, directly applied on the vertical elements such as load-bearing walls or buttresses.

Constructively, the roof will be another very significant issue, since it is the element that will be in contact with the extension. Therefore, it will mark the interaction between both. In the case of a flat roof, the upper layer would be eliminated, leaving the lower layer as the base slab of the dwellings, which means eliminating the waterproofing layer. On the other hand, if there is a gable roof, it would have to be completely removed and, therefore, this last floor would be affected, rendering the top floor unusable. In this case, it is necessary to reach an agreement with the owner. In the case of gable roofs, the last floor is not usually occupied by dwellings, but by storage rooms, so vacating them would not be a problem. The only thing that should be taken into account is to temporarily waterproof the floor so that, in case of rain, water does not seep into the dwellings below.

5 CONCLUSION

Many historic neighborhoods in multiple cities around the world have three common characteristics: protected residential buildings, legal possibility of hosting more floors and frequent lack of maintenance and updating. Therefore, there are different responses to this situation, and over-elevation is one of them when these three circumstances are combined with a strong demand for housing. This strategy provides a controlled and sustainable growth, based on the construction of housing on the roofs of buildings that have not yet exhausted their legal possibilities.

The construction of new housing starts from circumstances that condition its materialization and design, determined by the existing building and by the different current regulations. The following are the points to be considered for the development of an over-elevation.

- Lightweight is one of the main requirements for the design of the extension. Although the existing building structure can support more load, it cannot be increased indefinitely. Therefore, the new structure must meet minimum weight properties. This forces us to build the extension from lightweight structures.
- The buildings in specific study areas might present a frequent, clear and defined geometry that will condition the position of the new dwellings. Therefore, new structures will have to be guided by the parallel rhythm of the load-bearing walls, which at the same time will influence the interior distribution of the dwellings. Thus, this metric will be determined not only by the geometry of the structure, but also by the minimum requirements of the different living space regulations.
- The reception of the new dwellings is done through the roof. This means that the interaction of both structures is highly conditioned by the type of roof. In the case study chosen, most of them are flat, therefore, once the top layer has been removed, the correct support points must be found.
- The design of the extension should take into account the general image of the surroundings, so that it fits in with the architectural heritage of the city. The rhythm and geometry of the openings, the cornices, even the exterior materiality, must be in harmony with the rest of the façade.

The construction of the new houses presents specific particularities, motivated by the typological, structural and constructive context. The multiple conditioning factors, the meticulousness of the intervention, together with energy efficient and sustainable values, will be guaranteed by means of an industrialized and light construction methodology.

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