

POSSIBLE USES OF THE RCD PRODUCTION IN PROJECTS OF BUILDING RENOVATION

¹Blandón González, Begoña; ¹Barrios Padura, Ángela; ¹Molina Huelva, Marta; ¹Gómez de Terreros Guardiola, Pedro; ¹Fernández Ans, Pablo; ¹García Madrona, Isabel;

¹Romero Odero, Jose Antonio

¹Escuela Técnica Superior de Arquitectura, Universidad de Sevilla

Avda. Reina Mercedes 2. Sevilla 41012.

**e-mail: bblandon@us.es, abarrios@us.es, martamolina@us.es, pgomez@us.es,
pabloans@rehabilitaenergia.com, isagarmad@alum.us.es,
jose.romero.1994@gmail.com**

ABSTRACT

Ofentimes, the incorporation of ordinances and application of regulations of technical, social, or urban nature imply an appropriate study and analysis of the building, the population affected, their habits and any of the consequences caused by the resolution of new demands.

The research developed by the team REPROGRAMA in the University of Seville, CONTRATO I+D, related to the field of action of the Consejería de Fomento y Vivienda of the Agencia de Obra Pública de la Junta de Andalucía, considers the needs of intervention in the Andalusian housing stock built between the 1940s-80s, in order to improve an active aging process, taking into account a gender perspective, comfort requirements, energy savings, and environmental sustainability.

Considering the rehabilitation of the housing stock as one of the greatest challenges of today for cities and always considering the three pillars of sustainability, this research is to reflect upon the existing reality and to propose protocols of intervention, which would satisfy the social needs and meet the demands of the current regulations, improving the quality of life for the users and the protection of the environment.

In this presentation we explain an important part of the research we've done, the management of the RCD generated in the construction of energetic rehabilitation from one particular case of great singularity—the neighborhood of Nuestra Señora del Carmen in the district of Los Remedios of Seville. In this case, the planned constructions will create a great amount of waste, which should be taken into consideration since it could be one of the facets that questions the viability of the intervention.

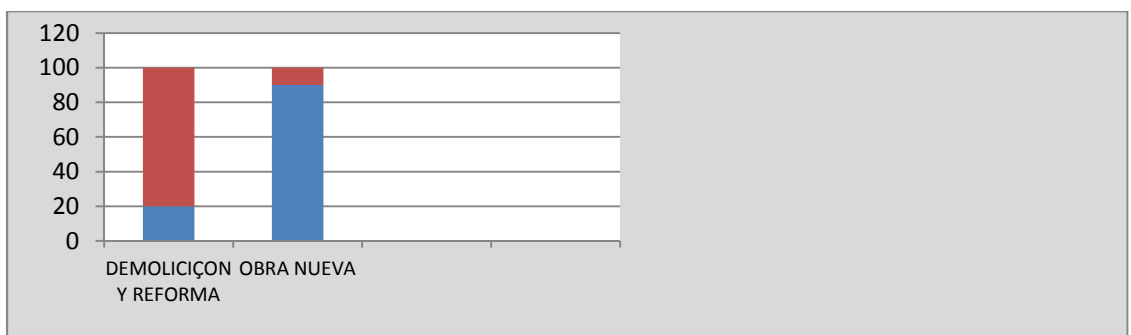
We will show our proposal of the RCD management, including quantification, assessment, minimization, selection and treatment in situ, and the possibilities of use of the original building. We will offer the results obtained in relation to reusing and recycling the wastes to reincorporate them to the building, extending its lifespan as a “secondary material”, as part of the natural process in reformation projects and rehabilitation of buildings, in accordance with the Directive 2008/98/CE or the Plan Nacional Integrado de Residuos (National Integrated Plan of Wastes) 2008-2015.

Keywords: rehabilitation, RCD, waste, recycling, reuse

1.- Introduction

From the consolidation of the first landfills considered legal (2000) in the metropolitan area of Seville, the volume of RCD that was generated was able to be measured and the studies corresponding to the characteristics of the debris deposited began; this way we could learn the possibilities of use they had at that time.

In this respect and to address the same geographical location, the current situation of crisis in the construction sector is manifested by a significant reduction in the volume of RCD generated by new development. Thus, a high percentage of the RCD now deposited come from rehabilitations and reforms in existing buildings, therefore exhibiting variations in their characterization different from the already studied because of the origin and source of the material. The incorporation of ordinances and regulations implementing technical, social or urban nature, and the current low demand regarding the implementation of new construction have led to an increase in the number of jobs considered as a “minor construction” in the park already built and it reverses the graph of percentages presented today.



Graphic 1 “Comparison according to the origin of the RCD deposited in the landfill Las Jarillas”. Souce: the author.

At present, the quantity and quality of the RCD deposited in the landfill and the ability to benefit from these is suggesting a new study about changing the attitude and efforts of the experts in implementing constructive solutions to achieve a more sustainable construction.



Fig. 1 “Disposition of deposit at outside”. Souce: the author.

The work done by the team REPROGRAMA from the University of Sevilla, CONTRACT I+D concerning the competence of the Ministry of Public Works and Housing from 2012 Public Works Agency of the Government of Andalusia, provides intervention needs for the built parks of Andalusia from the 40s, on the basis of

¹ Único vertedero de inertes (año 2000). San José de la Rinconada. Sevilla.

promoting active aging and from the gender perspective, with comfort, energy-saving and environmental sustainability requirements. From a social standpoint, accessibility and security in the urbanization of neighborhoods and in the interior of the building are resolved in only few cases. In addition, the rigid types of housing are often not able to respond to the aging of the population, or host the great diversity of family structures that currently exist. On the other hand, in the years of urban development which we are dealing with, in Spain it was hardly taken into account environmental sustainability paradigm in which we find ourselves today. That is why the materials, building systems and facilities used at that time do not meet current regulatory requirements for energy efficiency. Thus we arrive at the current situation in Europe, where we find cities with huge residential bags that do not respond to social needs and, in some cases, are becoming areas of social exclusion. This problem developed in a context of economic crisis like the present one, leads us to believe in rehabilitation as the main form of intervention.

2.- Objectives

In any of the considered interventions, enforcement of the planned work towards meeting the requirements generated a large amount of waste whose final destination must be seen assessing the feasibility of the intervention. Whereas the rehabilitation of a grand built residential park is one of the major challenges today for cities and taking in every present moment the three pillars of sustainability, this research sets the general objective to reflect on the existing reality and proposes protocols of intervention that meet the needs and current regulatory requirements, improving the quality of life of users.

Therefore, in this paper we will show the analysis of the management of RCD in the proposed rehabilitation of some residential blocks in the Barrio de los Remedios de Sevilla (Spain): The Neighborhood of Nuestra Señora del Carmen. This site is identified as the most unique and complete for the progress of our research, as it constitutes an important architectural heritage of the twentieth century which currently has some degree of vulnerability, thus requiring prompt intervention to ensure its preservation and improvement. With this intervention arises urban regeneration of a settlement as peculiar as this one, giving a simultaneous response to social, environmental and economic aspects.

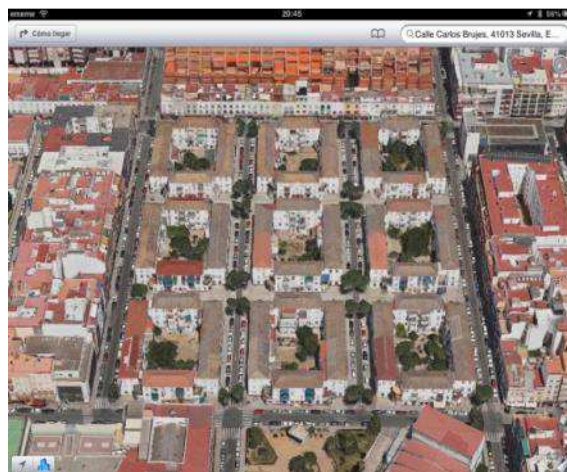


Fig 2 “Neighborhood of Nuestra Señora del Carmen, Sevilla”. Souce: I+D REPROGRAMA.

This study gives us the opportunity to apply our knowledge of the RCD generated in the metropolitan area of Seville, its prospects of immediate use and viability of the solution adopted. This research aims to contribute actively to the improvement and

environmental protection, including the minimization of waste generated and providing control and management strategies, planning the possibilities of using the RCD as part of the process in reform projects and rehabilitation of buildings, in accordance with Directive 2008/98 / EC or the National Integrated Waste Plan 2008-2015.

3.- Origin of RCD considered for study

In the study of RCD generated in the metropolitan area of Seville during the first decade of 2000, the RCD were quantified distinguishing, among others, those considered of stony nature (concrete, ceramic, land, etc) and whose volume amounted to 77% of total inert.

At present, although with different origins, the advanced study of the RCD generated during the year 2013/14, has similar percentages which leads to the need to move in the direction of those countries with greater tradition in environmental strategies being considered building debris, which accesses the landfill with no apparent interest and therefore dumped without any treatment options.

The RCD considered for this study stems from the waste of construction generated in partial demolition and the implementation of new elements to be integrated as a solution to social needs and solving new requirements referred to in the neighborhood of Nuestra Señora del Carmen, in the district of Los Remedios after appropriate study and analysis of the building, the affected population and their habits. The origin of the resulting RCD, after the planned works, permits us to classify them into two groups according to the working phase in which they occur and their nature:

- RCD resulting from the demolition and partial / total removal of original construction solutions found: In this case, the origin of the waste from the elements and original building systems is mostly of ceramic nature; there are no remains from demolition of concrete (but there are of mortars) and the presence of land in the development of this work is different depending on the intervention proposed in the basements.
- RCD resulting from the implementation / replacement of elements according to the project. In this regard, project solutions incorporated in the implementation of the new units of work will be aimed towards minimizing the RCD generated in this study and the amount of waste resulting invaluable.

A significant proportion of waste material deteriorated is not included as a result of improper storage areas to reserve / protected areas for this.

In this section, packaging waste and unavoidable characteristics of the new reception and supply protections will be referred to the management of treatment and recycling in the corresponding plants.

Knowledge of constructive solutions and existing materials is essential as the starting point of this study as those of stony nature are presented as the largest percentage of the RCD generated.

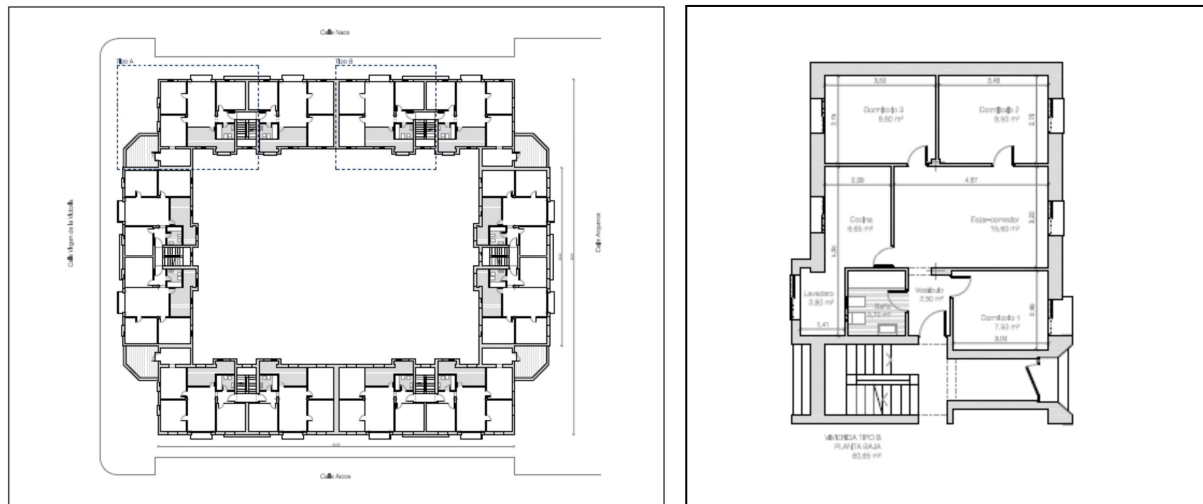


Fig. 3 “The block floor and housing type”. Souce: I+D REPROGRAMA.

As set out, the RCD are mixed with others that should be isolated in order to allow a greater percentage of utilization. The origin / composition of the expected waste is considered mixed, resulting in materials and products of different nature because of its location and arrangement during construction.

As shown in the corresponding table, the RCD to be generated during the dismantling and demolition in the block of Los Remedios are different in nature, but stress the significant volume of petros, are mixed with others, that can alter their technical characteristics and, in this respect are considered pollutants.

In general, the chances of actual use are conditioned primarily by economic and technical factors, which is the field work in which professionals demand an accurate study of the characteristics and quality of the obtained material.

4.- Selection and collection of RCD generated.

Given the volume of waste expected and the characteristics thereof, the possibilities of use are directed toward reuse and recycling into new works of conditioning and adaptation of outdoor spaces within the building.

Today, unlike the RCD that could be collected from the inert landfill from the Metropolitan Area of Seville and those already-performed parallel studies, the RCD generated during the work in the neighborhood of Nuestra Señora del Carmen will be recognized in the specific work and used directly in this project.

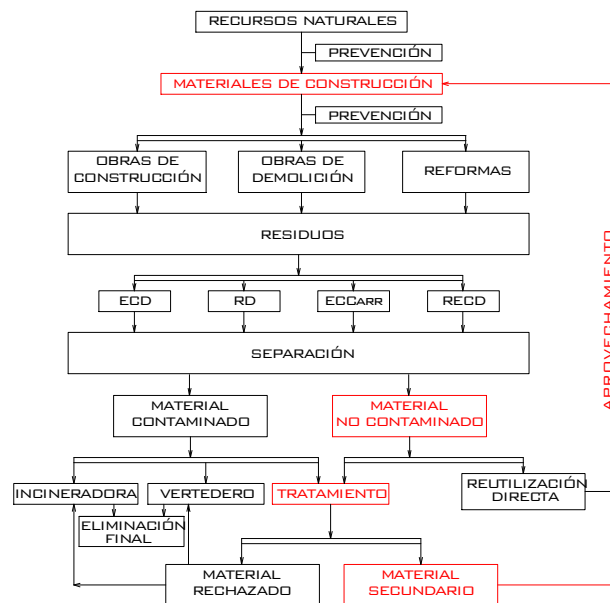
The collection of these will be organized selectively, having casks available, classified according to the various origins and possible final destinations of waste which would allow the organization, cleaning and subsequent management for the waste deposited in the most efficient way possible. To do this, the arrangement of the casks shall be provided on site (sufficiently protected) out of contact and access from the neighborhood to ensure the absence of organic residues from waste that would settle on the container for that purpose.

- Regarding the surplus land, the work provided contemplate design of the interior gardens around the block. However, maintaining the original dimension and the need for pavement favors the immediate reuse of the same and will not generate a significant amount of land to recycle.
- The remains of metals, woods, etc considered useless in this study were deposited in casks for this purpose.
- Also, the packaging and cardboard and plastic wrappers are organized in separate containers to allow for management and correct destination.

- Excessive percentage of gypsum which is adhered to ceramic materials in interior elements will be controlled from the beginning of the demolition, planning a previous working phase in which the coated pieces will be chipped off and withdrawn to recover the ceramic veneer. The remains may remain on the granular material obtained prior to recycling.
- On the existence of the insulating material from the debris that may impoverish the quality of the resulting product by the presence of fibers, etc deduced from studies, it is invaluable in the project, from the original construction solutions, to not be incorporated into the buildings of the era; it is a specific insulating material in the covering.
- Waste whose nature and value is important, suitable for immediate reuse more or less depending on the quantity, quality and care of dismantling and conservation (tile, brick tile, glazed tiles, etc).

In any case, the material will be placed in casks, free of remains that may be considered contaminant.

As a result after proper planning and management at this stage, we follow the line of work recommended by the European Union. Finally, subsequent treatment and utilization tasks will be simplified.



Graphic 2 “Research line in waste management according to EU”. Souce: PNRCD.

5.- Uses of the generated RCD

Given the volume of waste expected and its characteristics, the possibilities of use are directed toward reuse and recycling into the new jobs of conditioning and adaptation of outdoor spaces within the building.

The classification, separation and collection in situ, selectively, of the debris generated in the Barrio de Nuestra Señora del Carmen, helps us guarantee the origin and original quality of the material used. Control over the crushed material, cleanliness and reusability or treatment of subsequent recycling, will be conditioned by the results obtained in the characterization of the granular material, intended for its final destination.



Fig. 4 “RCD generated in refurbishment”. Souce: the author.

To do this, without any enforced rules, standardizing the type and number of tests to be performed on the granular material are taken as a reference, containing all the information about the characteristics required for the aggregates that are part of fillings, cobblestone, pavement and other coated on surfaces. Being aware of the nature of the selected material, the materials that form part of concrete gravel and others that require more demanding physical or mechanical properties are discarded. The team’s current research is focused on advancing their knowledge of this new granular material on which the characterization should be checked to be able to assess their properties and ability to benefit as the result. To do this, knowing the nature of the selected material, we take its resemblance to the RCD studied and the opportunity to extrapolate, as a first approach, the results of the granular material from the landfill. Logically, in a subsequent time, but prior to their application to the construction, the results should be checked in order to obtain enough technical features that confirm and define the properties of the chosen material and, in any case, the quality or properties of the manufactured product from the use of this waste.

As we can see in the following table, the majority is of ceramic origin even though they are mixed/contaminated by other adhered materials, in a smaller percentage, which reduce or limit the original quality of the material.

STONE RCD BY ORIGIN OF THE MATERIAL	% OBTAINED
BRICK	52.9
MORTAR	25.49
GYP SUM	11.42
TILE	3.95
MARBLE/TERRAZZO	15.38

Table 1 “RCD provided stone”. Souce: the author.

While learning more about this new granular material obtained after crushing the rubble selected, we can see the resulting geometrical, physical, mechanical and chemical characteristics, this way predicting its properties and evaluating the possibilities of use and exploitation of the results obtained:

5.1.- Geometric characterization

We will obtain information about the shape, size and exterior aspect of the aggregate from the geometric characterization tests.

The results obtained on the material deposited in the landfill show their parallelism with Fuller's Curve allowing us to affirm that the grinding system chosen evenly distributes the variety of sizes obtained. The jump produced in the grains of sand reflects the different nature of the materials composing the mixture.

Regarding the shape coefficient and flakiness and elongation index, the results show data on the presence of lamellar or acicular aggregates that limit their use in construction. The shape of the crushed pieces and the results justify the composition. However, it can be appreciated as this ratio is reduced by the aggregate size. In any case, the aggregate size is conditioned with the connected device crushing machinery, being able, in any case, to make new dosages accordingly.

The MG selected in this study has a higher percentage in ceramic nature, reducing the percentage of fine sands and improving existing in grain size, the result of the mixture. Regarding the presence of peaks and no rounded edges, the intended use of selected material, requires a size whose geometry is presented in an appropriate estimated proportion.

5.2.- Physical and mechanical characterization

In the physical and mechanical tests of characterization, we will obtain information about the structure of the arid and behavior of the granular material against mechanical actions, which will be crucial for future application as an aggregate for construction.

The results obtained on the material deposited in the landfill show its density and behavior in the presence of water, getting an idea of its compactness. The void ratio is greater than desired in one of the intended uses but its density is suitable for any intended use.

The mechanical tests tell us about the loss of durability and resistance experienced by the material when subjected to certain actions. In this respect, the presence of soft particles and scratch resistance, resistance to fragmentation and its behavior against humidity are not negative for the required uses.

In this case, the properties of the selected ceramic material and its high percentage are transferred to the results without being suitable for concrete, but yes for coating building surfaces. Overall, the aggregates required in the construction should not soften or decompose water, and because of its ceramic nature, this value is innate to the selected material itself.

5.3.- Chemical characterization

From the chemical characterization tests, we will obtain results on their composition and behavior against atmospheric and chemical stress of the aggregate to which it is exposed during its life as a building material.

The results obtained on the material deposited in the landfill show a high clay content. This result is expected if one considers the poor baking of old bricks or potential contamination with clay soil, sand or gypsums that, although they are not actually clays, can decompose and crumble during the procedure that follows.

Moreover, a frost-resistant arid is required, being a quality which the studied material offers, as well as its resistance to chlorides, sulfates, etc., which shows its low aggression to the armor with which they may be in contact with.

Regarding the content of particles or substances, the excess concentration that can alter the properties of the materials limiting their future implementation do not reflect negative results for concrete coatings.

The MG selected in this study may, after a pre-cleaning process, reduce the clay content in its composition. Similarly, the selection process and after removing the coated gypsum give a positive result regarding the most appropriate percentage of

clay and light particles as aggregate for coating. Overall, we are trying to test the effect that is produced on the sample in an aggressive environment, one that these could be subjected to during the life of the material. The results are approximate, the real action is much slower and less aggressive.

After the study developed on each property, lack of habitability and comfort requirements are detected, thus the following are recommended: repairing the existing sockets and placement of new ground floor in contact with the steel and unifying criterion of urbanization (thus avoiding the deterioration that occurs in the front contact with the ground), flooring and paved courtyards. Including furniture and gardens (as a solution that limits the proximity to ground floor units) and the arrangement of planters in urbanization.

This extrapolation of results make the material selected suitable for use as aggregate for gravelling, to project on vertical surfaces and as an aggregate for the execution of terrazzo in situ for outdoor use. However, the results obtained with respect to their geometry confirm the existence of particles unsuitable for use as aggregates in the manufacture of concrete and sub-bases to condition the compactness of a soil in even the resistance, all according to rules taken as reference on the characteristics of the arid that it can join.

After narrowing its characterization, we will work on its projection as an application in construction (considering the RCD selected in Residential Blocks as a representation of the type of construction currently implemented).

6.- Conclusions

Knowing the properties of the RCD dumped in the metropolitan area of Seville, during the year 2012-13 and to consider the current possibility of using them, it was possible to extrapolate the results to the RCD under the rehabilitation of a few residential blocks in Seville as a unique and comprehensive model for future interventions. The material considered for this study stems from the rubble of construction generated from the partial demolition and implementation of new elements which will be integrated as a solution to social needs and to solving the new technical requirements taken into account after an appropriate study and analysis of the building, the affected population and their habits.

Of the volume of debris under construction, 93% are stones. This study raises the possibility of use and exploitation of 89%, allowing the incorporation to new construction, as a secondary material, and extending its useful life which otherwise would end up in the landfill. All of this is part of the management process defined in the project itself.

Specifically, the current existence and condition of the interior courtyards in the residential blocks expect an intervention which would allow the exploitation of the generated RCD.

In this way, the design of the courtyard is resolved by paving pedestrian areas with slabs of terrazzo executed in situ, with a graveled perimeter to provide privacy to the ground floor units, urbanization planters, baseboards in contact with the ground and exterior sidewalk on the bottom floor. Likewise, the implementation of new interior housing elements are expected to limit the generation of new debris because of prefabricated solutions to the existing.

For the considered applications, the relevant regulations do not establish limits nor recommendations regarding the results of the remaining trials not considered in this overview. The negative results of the Grit, Sand Equivalent, and Lumps of clay tests hinder the acceptance of the granular material studied as an application for paved and graveled constructions. They can be improved by adopting preliminary measures on the granular material regulating these parameters (pre-cleaning of the

material, more crushing, new dosages, addition of stone material from concrete or natural aggregate, etc.).

The knowledge of geometrical, physical, mechanical and chemical properties of granular material obtained after crushing of the selected stone RCD allow us to consider them suitable for the construction of certain uses, provided their economic and technical feasibility is demonstrated. Overall, the chances of actual use are conditioned mainly by those economic and technical factors, which is the field work that professionals demand an accurate study of the characteristics and quality of the material obtained, as it will have to compete with materials of traditional construction. Finally, considering this study as a standard/model for other similar cases and, so that the results and conclusions are extrapolated to other projects, an intervention model in which the sampling ensures adequate proportions of materials of different origin or nature should be developed, including granular material in similar proportions.

REFERENCIAS

[1] `Residuos procedentes de obras de Construcción/Demolición.

[2] “Caracterización del material granular obtenido del reciclado de RCD cerámico”. Tesis Doctoral Blandón Glez, B. Dpto. Construcciones Arquitectónicas. ETSA. Universidad de Sevilla. 2003.

[3] La barriada que nos ocupa forma parte del crecimiento durante el siglo XX de Triana, el arrabal histórico de Sevilla. Durante los años '50, se construyeron en este sector dos barriadas de promoción oficial que participaban de la idea de extender la ciudad mediante polígonos independientes y cerrados apoyados en vías de comunicación preexistentes. La traza del grupo residencial (Arquitecto L. Recasens Méndez Queipo de Llano) resulta innovadora en el conjunto del urbanismo sevillano, tanto por la distribución de zonas verdes, el trazado del viario y la preocupación por la orientación, inspirados en algunos de los principios recogidos en la Carta de Atenas.

La barriada se configuró como 636 viviendas de renta limitada, una isla residencial en la que no existían espacios comerciales, ni locales para uso social y comunitario. Los pisos se otorgaron en régimen de propiedad a pagar en cincuenta años. Hasta la finalización de dicho plazo, la gestión de las viviendas correspondió a la Organización Sindical del Hogar y Arquitectura hasta su desaparición, cuando sus competencias pasaron a la Dirección General de Arquitectura y Vivienda de la Consejería de Obras Públicas de la Junta de Andalucía.