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RESEARCH ARTICLE

Waste Management of Emergency Construction Work. Case Study: 40 Dwellings in Seville (Spain)

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Abstract: Eco-efficient rehabilitation of buildings and neighbourhoods should include strategies to reduce the potential environmental impact of buildings under consideration for demolishment. In this case, good construction and demolition (C&D) waste management can represent a doubly eco-efficient approach: advantage is taken of much of the building and the volume of waste is reduced during construction and demolition work.

Construction and demolition waste management in emergency situations is a subject yet to be studied in the construction sector. This kind of work, although not very common, involves major building damages and the need for punctual, partial or total demolitions. The amount of C&D waste can be a major problem to deal with, and its management during the critical first phases can determinate the progress of the rehabilitation.

Conditioned by a greater number of factors than normal construction works, the lack of time for the identification, quantification, and evaluation of C&D waste renders this type of extremely useful study.

In this work, from the case study of the emergency repair of a residential building of 40 dwellings in Seville (Spain) seriously affected by a soil displacement, Generated C&D waste are identified and the waste reduction techniques used are shown. These techniques contributed to achieve the planned objectives and to control in advance the cost.

Finally, the most important data, C&D waste quantification and the managing cost are presented in order to serve as reference for similar circumstances in the future because there areno clear references to be used.

Keywords: Construction, Demolition, Emergency, Management, Quantification, Waste.

1. INTRODUCTION

Within the eco-efficient rehabilitation of buildings and neighbourhoods, it is essential to include strategies for the reduction of the potential environmental impact of buildings that may be demolished. There is much debate, with specialists in the field studying the social, political and environmental factors at European level, and a strong interest in the option of rehabilitation from the population, who want to defend their neighbourhoods from demolition [1].

The demolition and new construction involve higher costs, material waste, emissions, use of trucks to transport materials and waste, and greater noise and disturbance. By contrast, rehabilitation regenerates neighbourhoods and prevents the abandonment of degraded neighbourhoods and therefore the unnecessary expansion of cities [2].

The causes that may lead to a demolition could include obsolescence, natural disasters and/or accidents, for which good management of construction and demolition waste can represent a doubly eco-efficient aspect: retention of leverage of much of the building, and the principle of hierarchy, prevention, reuse, recycling and controlled disposal of

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all potential waste.

The environmental problem posed by C&D waste is derived not only from its volume, but also from its treatment. The environmental impacts include: contamination of soil and water resources by uncontrolled landfills, deterioration of the landscape, and, above all, waste elimination without recycling or re-using the material [3].

The tendency in the field of construction is to consider C&D waste as inert waste to be deposited in landfills, and, in some cases, in uncontrolled dumps. Waste management requires a tendency change towards the prevention of the generation of waste and, failing this, towards waste recycling and re-use and/or energy recovery [4].

Waste minimization plays an important role in the improvement of environmental management. From this standpoint, economic instruments for minimizing construction waste can be employed to encourage waste-prevention efforts, to discourage the least desirable disposal practices, as well as to prevent the negative consequences of environmentally unfriendly treatment and disposal practices of construction waste materials [5]. In order to both minimize the amount of C&D waste entering landfills and to reduce the construction project cost, a good waste management plan is needed in order to properly treat waste, by preventing mixtures and deterioration [6, 7].

Many models have been established over the last decade to determine the project waste quantities [8, 9]. The present authors, together with others, have also developed a quantification model to estimate the type and quantity of waste generated by different construction projects, such as new buildings, demolition, renovations and alterations [10]. The classification code used is the same as that which Spanish quantity surveyors normally employ to obtain the legally required bill of quantities, thereby making the model both easy to understand and to implement [11].

In Spain, the Spanish Royal Decree 105/2008 (R.D.105/08) is a specific legislation at state level for C&D waste production and management [12]. The legislation objectives are summarized in a waste hierarchy, which runs from the most to the least efficient measure: prevention, reuse, recycling, energy recovery, and adequate waste disposal. In order to attain these new objectives, three key areas have been identified: a good waste quantity estimate, waste separation at origin, and differentiated management definitions for each waste type.

Although C&D waste generation has been widely studied in Europe, and The European Commision has set the main objectives for the future in recycling. The level of recycling and material recovery of C&D varies greatly across the European Union. In the particular case of a rehabilitation project under emergency conditions, no data is known and specific management problems arise. The contractors' main goals are speedy rehabilitation work and disposal of the waste into landfills. No special measures for separating different material types are taken due to their incompatibility with the work time-span established.

Waste classification in demolition is a more complicated process than that which takes place in new construction. Optimum waste handling and recycling depend on separating in situ and coordinating the selective demolition processes properly. For example, a selective demolition implies that waste separation is carried out, both before and during demolition, in order to prevent material mixing and contamination. However, the economic savings derived from selecting the debris during the demolition process are yet to be studied in depth [13].

As established previously, in current rehabilitation projects, specific barriers arise which limit the framework implementation. The present work establishes a simplified procedure in order to implement good C&D waste management, which is defined in an actual emergency project in Seville, Spain.

In Seville, during excavation work in the construction of an underground car park, the displacement of a diaphragm wall took place after retiring the access ramp to the bottom pit. The terrain decompression produced a settlement in the foundation of a block of 40 homes in the Barriada Renfe neighbourhood situated next to the excavation work (Fig. **1**). Due to the appearance of cracks and fissures, which revealed structural damage, and to the risk of collapse of a crane tower structure situated between the site and the affected building (Fig. **2**), the evacuation of the housing and care of people affected was necessary [14]. After taking immediate security measures to halt the progression of the damage and to verify the effectiveness, a commitment to repair the homes within a year of those affected was set.

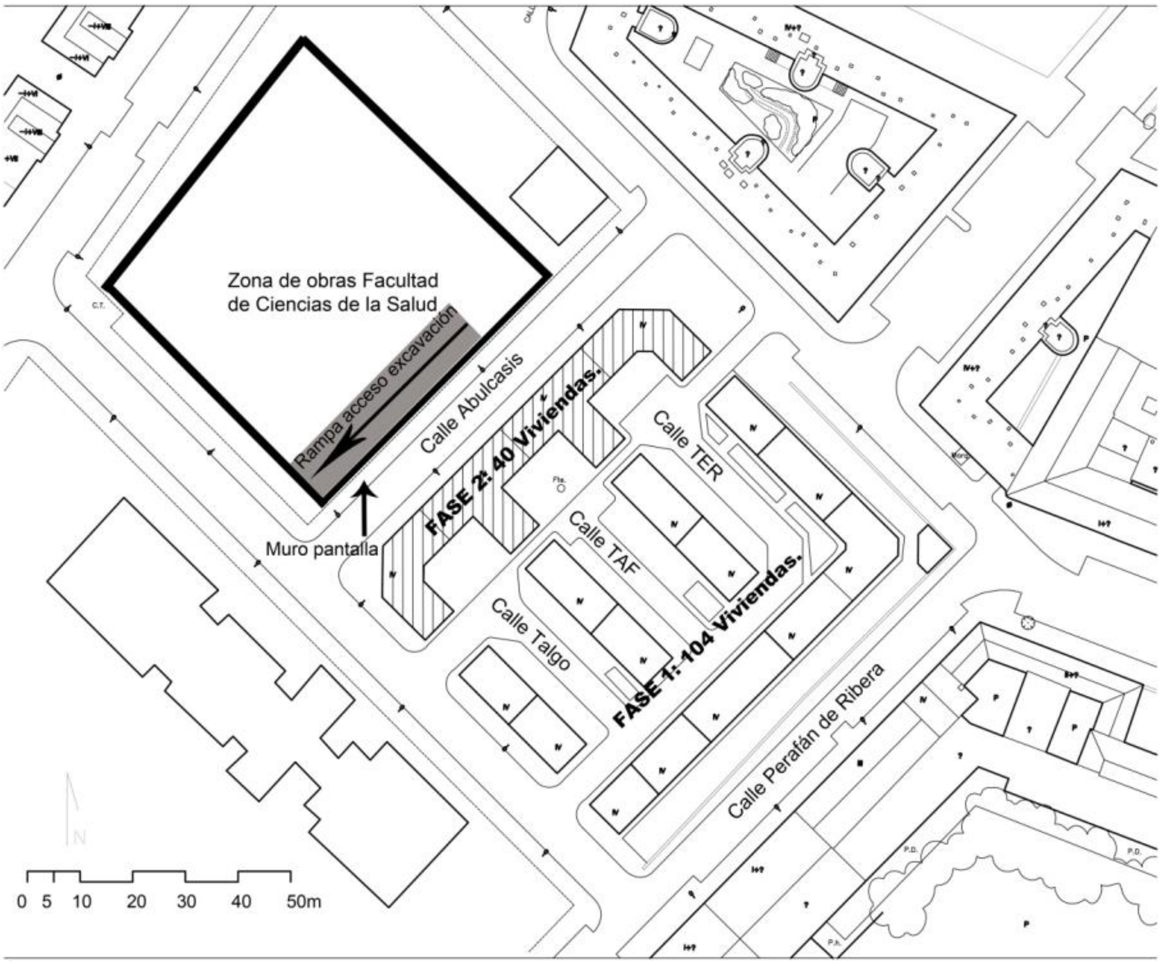


Fig. (1). Barriada Renfe environment. (Seville).

Barriada Renfe is located north of the historic centre of Seville, developed on four levels with a 3,504m^2 total floor area, and was built in the 50s in two phases each with a different foundation system. The first phase was built on 420, 630-mm-diameter and 20-metre-deep piles, while the second, consisting of 4 blocks, for economic reasons, was performed using a shallow foundation [15]. The structure of both phases is made of brick masonry, and the second phase was damaged while the first experienced no damage.

The pathology affects the whole building although the magnitude of the damage changes depending on the proximity to the highest point of settlement. The soil decompression process caused by the displacement of the diaphragm wall, produced a differential settlement in the foundation of the affected building thereby provoking a distortion of up to 18 mm within the first month of the accident.

Due to the necessity of ascertaining the development of the damage from the initial stages, points on the building façades, inclinometers in Abulcasis street, and monitoring points in the diaphragm wall were monitored. A reconnaissance campaign was also conducted to determine the soil composition through a geophysical electrical survey to ascertain the state of compaction.

The information obtained in the tests determined that the land had poor bearing characteristics; heterogeneities in its layers and hollows were detected with evidence of underground water streams [16]. Since it was a terrain of alluvial materials with minor consistency, the land had little resistance above a depth of 20 metres. It was also observed that the underground water level had large variations in the area closest to the diaphragm wall.

Fig. (2). Condition of the work on the day of the accident.

The brick masonry presented longitudinal and transversal arches of various sizes depending on the position in the building (Fig. **3**). In addition to the reconnaissance and monitoring of the building, a damage characterization according the Burland scale [17] was carried out. The classification ranged from serious to moderate damage (3-4 damage levels).

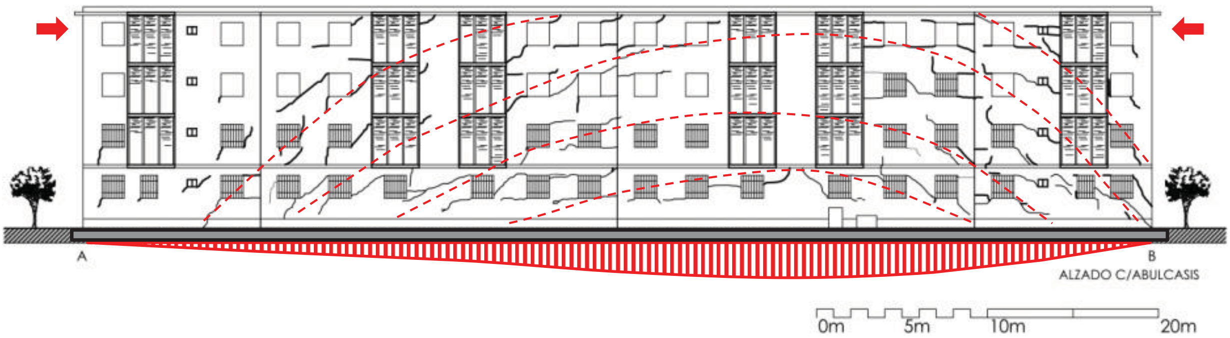


Fig. (3). Arches of displacement in brickwork.

Emergency work is that which is carried out to mitigate catastrophic events or situations that involve a serious risk [18]. Such work is characterized by the immediacy with which it is performed and, due to its catastrophic nature, characterized by the absence of previous projects or studies that would define the solutions to be adopted in detail. Project documentation, whose character is of justification towards the competent authority, is provided retrospectively. In many cases, at the start of the work there is no available information to aid in the choice of the most appropriate solution or to quantify materials.

Applicable solutions must provide a balanced response, by combining aspects such as economics and deadlines. The restoration of buildings under emergency conditions is a complex task that cannot be approached from a particular perspective; a comprehensive response must be given.

In Spain, the appearance of RD 105/08, where the production and management of construction and demolition waste is regulated, established the need to incorporate the management of construction and demolition waste into the architectural project by estimating the amount of waste to be generated, setting preventive measures, and defining reuse operations. In emergency work, the absence of a prepared architectural project does not justify the omission of waste management and hence this management must be based on technical experience. Furthermore, this situation creates problems in the treatment of waste and with waste management centre authorities due to the lack of waste quantification

On the other hand, in the case of the presence of hazardous waste during the work where no protection measures and treatment have been defined, there may be situations of delay in the progress of emergency work and the danger of further catastrophe and/or damage is maintained.

For this case study, and for a better understanding in general, we propose that each of these factors be considered, and that the technical solutions adopted for the emergency repair and management techniques used for the minimization of construction waste be analysed so that, overall, a joint vision can be achieved on how the work was carried out and this can serve as a benchmark for similar situations in the future.

2. METHODOLOGY

In this article, in the case of rehabilitation of buildings in an emergency, a number of strategies are proposed in order to follow the principle of hierarchy in the treatment of C&D waste, which is outlined in the Royal Decree 105/2008: prevention, reuse, recycling, and proper disposal. This methodology is used as a guideline during site work due to lack of specific waste management for emergency situations as described herein.

On the first level of the hierarchy, prevention appears. There are numerous studies that define strategies to reduce waste generated in the work through good organization in which all contractors and workers participate [4]. In rehabilitation, this prevention passes through the stage of good location and storage of materials to be used, while minimizing breakage, losses and cuts, and the use of material purchased in bulk reduces packaging waste [8]. Within the level of prevention, it can be decided to partially demolish the building and to clean up the affected areas.

Reuse is on the second level. In the case of rehabilitation, many elements of the building can be disassembled, cleaned and made ready for relocation thereby providing guarantees for proper functioning and long life. As in the previous level, good management and cleanliness are necessary for the prevention of any kind of deterioration in dismantled materials, either by water or impact during the work. Materials that can be reused include doors, windows, equipment, and furniture [19].

Recycling is on the third level. This strategy is more difficult to carry out in rehabilitation work since many tasks are performed simultaneously, thereby generating a variety of waste that needs preventive on-site separation. Royal Decree 105/2008 includes such cases where there is insufficient space for waste to be separated and therefore mixed residues have to be submitted to treatment plants.

Finally, in the lowest level of the hierarchy, there is the controlled disposal of waste: mandatory where the case study is carried out, in Seville, Spain (Royal Decree 105/2008). Special strategies for the management of sludge and slurry in the foundation underpinning are proposed, and constructive solutions with low environmental impact in brick masonry are also proposed. In the case study, all these strategies are for the particular case of a work of rehabilitation in emergency conditions, in which the damages are caused by accidental soil displacement. Because of the structural risk, the rehabilitation took place in a short period after the accident, without time to design a proper C&D waste study and facing these problems with creative solutions and management.

3. RESULTS

First of all, and to define the legal aspect of the repair, this work was performed under the authority of a decree of the city council to repair damaged homes within a maximum period of one year from the accident. It was also required that the building be returned to its previous state, with no quality improvement or geometric modification in the building.

The absence of a planned project and of construction and demolition waste quantification precludes the usual procedure for management authorization through the granting of a planning [4] license. It is therefore necessary that the decree for the implementation of the emergency work authorization expressly mention that the constructors for the shipment of waste become the authorized centre, thereby obviating the planning license that C&D waste management usually needs [12].

Technical solutions should be immediately available on the market to avoid delays in their application that could, in turn, result in exceeding the time-limit of one year for the completion of reparation work. C&D waste management cost must be calculated and under strict control in order to avoid it overrun.

3.1. Foundation Underpinning

Bearing in mind that the time factor is crucial in emergency works, underpinning using micropiles was chosen [16] from among the various options available since it offered the fastest solution to apply and the one that had the fewest unknowns [20].

During the development of the work, there were a series of mishaps that compromised the planning and lead to the constructors reneging on their commitments to the homeowners. The unknown presence of large pieces of granite in the foundation generated the need to seek alternatives to drilling the foundation, since from the time taken in the first perforations, it was calculated that making just one micropile could require a whole day (1). These circumstances were compounded within the building, since the reduced clearance area necessitated the use of small machinery (and the distance to the drilling made the use of the above solution unfeasible). After analysing other possibilities, it was decided to use a drill rig that is fed the energy required for percussion by an air compressor by supplying it inside the sheath while rotating. This solution enabled the micropiling to be carried out through drilling, thereby significantly improving the performance of the work. No increases were found in the cracks of the building, nor other symptoms that would indicate that the structure was being affected. Externally, the building was already fully underpinned, which promoted the overall stability and prevented the increase of seats or movements.

The completion of the foundation underpinning using micropiles in the case study led to the definition of the following waste:

- cement waste from grouting
- reinforced steel from injection tubes
- sludge without bentonite from the soil drilling
- concrete and stone mixed waste from foundation drilling

The most significant waste created was the sludge from drilling: the need to make a perforation 27 metres below the surface for each of the 232 micropiles of 140 mm in diameter, made a total of 385.71m^3 of perforated soil and required a 5,044.50 m^3 consumption of water (90% of the total consumed on site).

The alluvial soil characteristics contributed towards complicating the work due to the drilling mud (composed of water and soil) that became concentrated on work surfaces, and therefore hampered activities and conditioned the risk prevention measures for workers (Fig. **4**).

Fig. (4). Drilling sludge inside homes.

In order to deal with this waste, a provisional central slurry management site was established to decant the sludge for separative treatment. Two tanks were placed outside the building into which the sludge was poured alternately and, after extracted the water, the residue was subsequently transferred to landfill (Fig. **5**). After the completion of the work, these tanks were dismantled and the area was filled.


Digging
System installed
Slurry pump and hose
Tanks
Emptying tanks
Functioning system

Fig. (5). Installation of separative treatment process.

3.2. Repair of The Brickwork

The condition of the brickwork varied depending on its position within the arch of displacement and the magnitude of the settlement. This diversity in damages made it necessary to set up a methodology for the definition of which solutions to apply, and a relationship of each area of damaged brickwork was established with the degrees of the Burland scale and linked to the facility to repair, ranging from the least severe Grade 1 (Category 2 in Burland Scale), through Grade 2 (Category 3) up to Grade 3 (Category 4-5).

For Grade 3 damage, reconstruction of fractures was defined with new bricks that would replace broken bricks. This would involve the partial demolition of the masonry for further construction with new materials compatible with the existing materials (Fig. **6**). Grade 2 cracks were repaired through surface removal, and the application of fibreglass mesh and restitution of the surface coating. Finally, Grade 1 cracks were resolved by simply repairing the surface coating by means of plaster and paint.

Identification

Bricks used

Reparation in process

Reparation finished

Fig. (6). Masonry repair.

Within this activity, waste generated included:

- Clay and mortar mixed waste
- Packaging materials, plastics and paper
- Waste derived from plaster cladding and suspended ceilings
- Metals from carpentry and locks

It should be borne in mind that the entire ground floor had to be demolished for the underpinning. The waste management system incorporated the provisional collection of waste on site and its transfer to the waste management centre in large skips Fig. (**7**) that were properly protected under mesh in order to be transported on urban roads and highways.

Fig. (7). Skips for waste removal.

During the demolition in this phase, it was necessary to perform an in-situ monitoring of materials to be demolished in order to determine the possible presence of hazardous wastes, such as asbestos, cement drainpipes and lead pipes. 1Despite the age of the building, no such material was detected on site, possibly due to earlier interior renovations carried out by the owners to update the materials.

3.3. Repairing the Roof of The Building

Elements such as roof, interior joinery, and coatings were damaged to several different degrees owing to the movement of the building. The flat roof was affected and lost structural sealing joints, and hence repair was needed. The options available ranged from reparation of the existing roof and application of a waterproof paint to demolition and the construction of a new roof of the same characteristics. Reparation was chosen since the damage was specific and could ensure waterproofing in a short time and this option minimized waste.

Open fractures showed two different patterns: in the protruding sections of the building an effect of traction is produced; on the roof, compression in certain areas lifted tiles (Fig. **8**).

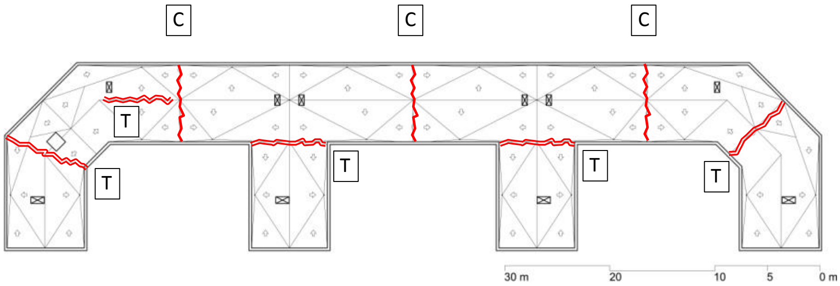


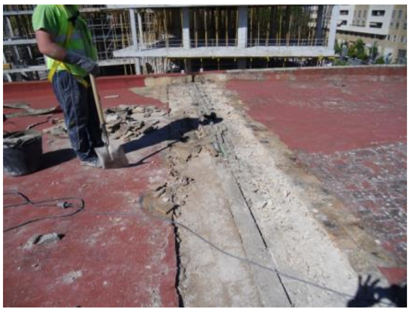
Fig. (8). Location of fractures on the roof. (C: compression; T: traction.)

Demolition

Inspection

New slope

Flooring



Joint demolition

Removing lead elements

Fig. (9). Roof repair. Part I.

The process for the reparation of the roof was as follows (Fig. **9**):

1. Demolition of affected joints, stockpiling lighting material.
2. Inspection of the structure.
3. New slope with stockpiled lighting material.

4. Waterproofing of joints (in compression fractures).
5. Flooring.
6. Waterproofing the entire surface with chlorinated rubber paint and fibreglass veil.

Joint waterproofing — Flooring — Roof cleaning — After cleaning — Fibre veil — Roof finished

Fig. (10). Roof repair. Part II.

The amount of waste was minimized during this phase. The materials included:

- Mixed ceramic and cement waste from roof flooring
- Lead remains from roof joints
- Paint containers and leftover glass fibres

Despite the small amount of lead, waste containers, and waste paint, a separative management was performed thereof using special containers that were collected by a specialized company.

3.4. Indoor Repairs

A particular methodology was applied for the repair of indoor damage depending on the extension of the damage, such as that on wall coverings, floors, carpentry, and installations.

The level of repair required and the damage to each home varied depending on the location within the building. The closer the dwelling was to the point of the greatest soil settlement, the more significant the damage was. As extreme examples, houses located on the ground floor were completely rebuilt (given the need to install underpinning), those on higher storeys and at the extreme ends of the building only suffered relatively light damage.

The magnitude of the need to repair damage and installations ranged from total reconstruction on the ground floor to some minor repairs on upper floors. The difference between the need to find, select and fix all the tiles of an entire flat and a simple replacement of a couple of pieces of tiles using reserve material stockpiled for years by the owners, illustrates the complexity of the management issue presented.

The indoor repair of damaged homes, due to its relation with the materials where the owners leave their personal touch, is perhaps the most delicate repair. At this point it is understood this is the one that awakens owner's sensibilities and where the decisions to be taken by the technicians should show more sensitivity to the owners. It was therefore decided to involve the owners in this process.

The need for success in the objectives of the work, with regard to the planning and the acquired social commitments in particular, led to the importance that was given to this phase of the work. The following process was therefore applied:

- Inspection of the housing and needs recognition, regarding both material and facilities. Collection of samples.
- Location of similar materials, mainly tiling, floors and carpentry on the market.
- Interview with the owners of each home to agree on the materials and/or their availability.
- Execution of the repair work.
- Viewing by owners of the housing for their approval.
- Repair of items that owners find unsatisfactory.
- Certification of completion of works and of living conditions. Justification for the planning authority.
- Keys returned to owners.

This methodology was very effective: interviews with the owners were very fruitful and valuable information could be obtained to proceed with the repairs. For example, in houses recently refurbished, the housing material supplier was known and could be contacted to perform the repair. In other cases, such as in older homes with a lower level of damage, several owners reported that they had small stockpiles of materials, which enabled repairs to be carried out with minimal inconvenience (Fig. **11**).

Fig. (11). Image of the previous state and subsequent repair of the interior.

The waste generated during this phase also corresponds to the phase of brickwork repair indicated previously, since both the brickwork repair and indoor repair phases were performed at the same time.

Note that, linked to these interior repairs, the need to repair only the damage and the possibility of access to the remaining material stockpiled by the owners greatly reduced the amount of waste. This waste was dealt with as mixed waste and transferred to a waste management centre.

3.5. Urbanization

Concerning the external urbanization of the building, the municipal water supply and sewage pipes required an inspection using a remote robot around the site. Soil decompression affected the direction and slope of the pipes and hence necessitated their repair. These sections were repaired directly by the service suppliers, who managed their own construction waste.

This preventive cleaning of sewers in the site area was carried out in order to prevent the sedimentation of materials that could have been filtered from the site without knowledge. This was performed by a specialist in such activities through specialized pressurized water cleaning (Fig. **12**).

System in action Pressurized-water cleaning truck

Fig. (12). Cleaning the sewage pipes.

4. COST ANALYSIS OF WASTE MANAGEMENT

Management of C & D waste under emergency conditions must be performed in the same way than works unaffected by such circumstances. Reuse, minimization of consumption, and waste management are required by society and the law [21] in this type of work. In case of disasters, the repair is conditioned by the priority of eliminating serious risks but waste management remains as one of the principal objectives.

The main environmental difficulty in the case of emergency construction is waste quantification and its valuation, due to the lack of time for the analysis and technical planning. Tools available to anticipate costs in the management of construction and demolition waste [10, 11] are applicable but, given the absence of a previous project, it is difficult to assess the amount and cost of the waste generated and this must be based on the previous experience of technicians involved in this specific type of emergency work.

Lessons learned in this case study will provide data for technicians involved in future occurrences of this kind of works: In a 3,504m^2 emergency building repair, 1,425m^3 of mixed waste was managed, 5m^3 of hazardous waste, and 150 m of sewage pipes were cleaned; the cost associated with the activities of waste management amounted to 2% of the total cost of the repair, for which an average cost of 11.68 €/m^2 can be established in the waste management for the underpinning emergency work.

This data illustrates how waste management affects this type of work: as long as efficient management is maintained, this can represent a very small part of the overall cost. But difficulties associated to the lack of previous studies and unknown materials can be solved using a proper management.

CONCLUSION

Building interventions in emergency circumstances remain an area of little study and, since the population can be seriously affected by these interventions, it is necessary to expand knowledge in this area.

In this type of work, construction waste management is mandatory, although major constraints and uncertainties, such as minimum temporary margins or lack of previous studies, respectively, greatly complicate the quantification and valuation of waste generated.

The application of solutions for repairing damage requires the consideration and evaluation of the waste generated, in order to attain the solution that generates the least waste. Solutions, such as reconstruction of broken brick masonry, specific repairs of roofs, and the repair of finishings, generate less waste. The principle of hierarchy has been followed in the management of C&D waste, using basic strategies: prevention, reuse, and controlled removal for treatment, recycling and/or disposal. Concerning prevention, no elements that could be reused were demolished, and only damaged parts were replaced by similar materials to those used in the original project, and advantage was taken of any renewal material that had been stockpiled by the homeowners. Disassembled material that had lost its original features was reused, such as fences, tiles, floors, doors and windows. Finally, a selection of the on-site waste has been applied, whereby potentially hazardous material was separated from inert waste: this is the case for drilling slurry and packages of paints and concrete additives. All C&D waste was sent to treatment plants for final separation and recycling.

The actual Spanish legislation needs to include a more sustainable C&D waste management during emergency conditions. The present methodology can be tested in other types of accidents or natural catastrophes and a broader and more general methodology can be developed

The study of the costs that were generated in the work indicates that, under similar circumstances, the C&D waste cost of foundation underpinning and repair can be limited to 2% of the total cost of the execution of the construction and demolition work, with an impact on the built surface of 11.68 €/m^2. This figure should be kept in mind for similar emergency work in the future, especially where it is necessary to provide a costs estimation before any planning decisions can be made.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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Declared none.

REFERENCES

[1] A. Power, "Does demolition or refurbishment of old and inefficient homes help to increase our environmental, social and economic viability?", *Energy Policy,* vol. 36, no. 12, pp. 4487-4501, 2008. [http://dx.doi.org/10.1016/j.enpol.2008.09.022]

[2] A. Power, "Housing and sustainability: demolition or refurbishment?", *Urban Design and Planning,* vol. 163, pp. 205-216, 2010. [http://dx.doi.org/10.1680/udap.2010.163.4.205]

[3] P. Agamuthu, "Challenges in sustainable management of construction and demolition waste", *Waste Management and Research,* vol. 26, no. 6, pp. 491-492, 2008. [http://dx.doi.org/10.1177/0734242X08100096] [PMID: 19039063]

[4] M. Marrero, "Demolition waste management in spanish legislation", *The Open Construction and Building Technology Journal,* vol. 5, suppl. (Suppl 2-M7), pp. 162-173, 2011. [http://dx.doi.org/10.2174/1874836801105010162]

[5] R.A. Begum, C. Siwar, J.J. Pereira, and A.H. Jaafar, "Factors and values of willingness to pay for improved construction waste managementa perspective of Malaysian contractors", *Waste Management and Research,* vol. 27, no. 12, pp. 1902-1909, 2007. [http://dx.doi.org/10.1016/j.wasman.2006.08.013] [PMID: 17110094]

[6] M. del Río Merino, P. Izquierdo Gracia, and I.S. Weis Azevedo, "Sustainable construction: construction and demolition waste reconsidered", *Waste Management and Research,* vol. 28, no. 2, pp. 118-129, 2010. [http://dx.doi.org/10.1177/0734242X09103841] [PMID: 19723824]

[7] Y. Li, *Automation in Construction,* vol. 35, pp. 142-156, 2013. [http://dx.doi.org/10.1016/j.autcon.2013.05.002]

[8] J.C. Cheng, and L.Y. Ma, "A BIM-based system for demolition and renovation waste estimation and planning", *Waste Management,* vol. 33, no. 6, pp. 1539-1551, 2013. [http://dx.doi.org/10.1016/j.wasman.2013.01.001] [PMID: 23490358]

[9] Z. Wu, A.T. Yu, L. Shen, and G. Liu, "Quantifying construction and demolition waste: an analytical review", *Waste Management,* vol. 34, no. 9, pp. 1683-1692, 2014. [http://dx.doi.org/10.1016/j.wasman.2014.05.010] [PMID: 24970618]

[10] J. Solís-Guzmán, M. Marrero, M.V. Montes-Delgado, and A. Ramírez-de-Arellano, "A Spanish model for quantification and management of construction waste", *Waste Management,* vol. 29, no. 9, pp. 2542-2548, 2009. [http://dx.doi.org/10.1016/j.wasman.2009.05.009] [PMID: 19523801]

[11] M. Marrero, and A. Ramirez-De-Arellano, "The building cost system in Andalusia: application to construction and demolition waste management", *Construction Management and Economics,* vol. 28, pp. 495-507, 2010. [http://dx.doi.org/10.1080/01446191003735500]

[12] R. Decreto, *105/2008, de 1 de febrero, por el que se Regula la Producción y Gestión de los Residuos de Construcción y Demolición (Royal Decree 105/2008, February 1, which Regulates the Production and Management of Construction and Demolition Waste).,* Ministry of the Presidency: Madrid, 2008.

[13] M. del Río Merino, P. Izquierdo Gracia, and I.S. Weis Azevedo, "Sustainable construction: construction and demolition waste reconsidered", *Waste Management and Research,* vol. 28, no. 2, pp. 118-129, 2010. [http://dx.doi.org/10.1177/0734242X09103841] [PMID: 19723824]

[14] A. Ferreira-Sánchez, "Recalce en condiciones de emergencia: 40 viviendas cercanas al Río Guadalquivir, España", *Informes de la Construcción,* vol. 68, no. 541, 2016.

[15] Ministerio de Fomento, Archivo Central. Archivo histórico del Instituto Nacional de la Vivienda. Expediente Administrativo 104+40 Viviendas en Plaza de Armas. Sevilla. Proyecto (SE-1415-VP) y expediente (SE-1518-VP), 1956.

[16] A. Ferreira-Sanchez, *"Recalce en condiciones de emergencia: 40 viviendas cercanas al Río Guadalquivir, España"*, PhD Dissertation. Arquitectural Constructions II., University of Seville, Spain, 2016.

[17] J.B. Burland, "Behavior of Foundations and Structures, State of the art report", In: *9th International Conference on Soil Mechanics and Foundation Engineering*, Tokyo, 1977.

[18] Ley 30/2007 de 30 de octubre, de Contratos del Sector Público. Madrid. Ministerio de la Presidencia. 2007.

[19] *Code for Sustainable Homes.,* Department for Communities and Local Government: London, 2006.

[20] F. Da Casa, E. Echevarría, and F. Celis, "La intervención bajo rasante, la importancia de su conocimiento. La técnica de la inyección armada", *Informes de la Construcción,* vol. 59, no. 505, pp. 21-35, 2007.

[21] M. del Río Merino, "Legal aspects which implement good practice measures in the management of construction and demolition waste", *The Open Construction and Building Technology Journal,* vol. 5, suppl. 2-M2, pp. 124-13, 2010. [http://dx.doi.org/10.2174/1874836801105010124]