Building Envelope Rehabilitation Costs: Determination and Variability

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Abstract: In recent decades, there has been a great deal of investment in Portugal in the construction of new buildings to the detriment of the rehabilitation of existing ones. As a result, the historic centres of towns and cities are deteriorating, while their suburbs are spreading. One of the main problems affecting the rehabilitation of residential buildings is that it is extremely difficult to accurately estimate the costs involved. Although there are established methods (and technical documents available) to aid the costing of new buildings, there is a lack of official information about the costs of rehabilitation work, particularly as regards the external envelope of buildings. This article demonstrates how to determine rehabilitation costs (with particular emphasis on the envelope of residential buildings) by gathering information from specialized companies, assessing price variability and consulting databases of rehabilitation costs from other countries. It also presents some examples of costing for particular rehabilitation jobs.

Key words: Rehabilitation, building envelope, costs.

1. Introduction

In recent decades, there has been a great deal of investment in the construction of new buildings to the detriment of the rehabilitation of existing ones. However, various studies undertaken have shown that even the most recent buildings frequently show significant signs of external envelope deterioration, particularly damage to renders and dispersed cracking. There is also often marked deterioration of glazed parts, which may need to be replaced (in which case, the opportunity is often taken to improve thermal insulation conditions).

This paper argues that political decision-makers should be encouraged to redirect funds away from new construction projects towards the rehabilitation of existing residential buildings. One of the main arguments for this has to do with the appearance of our towns and cities. Buildings in the historical centres are often in an advanced stage of physical decay, which contributes to the depopulation of those areas.

Meanwhile the suburbs continue to grow, generating the need for new investment in infrastructures.

The rehabilitation of residential buildings should be approached as an integrated process, involving diagnosis, the intervention decision, estimation of costs, the preparation of a plan of intervention, the monitoring of the work, and subsequent maintenance. The decision to intervene in a building will depend, essentially, upon the financial resources available. When the developer understands what is necessary, he can decide whether to opt for total or only partial rehabilitation. For this reason, it is very important to know the costs involved in rehabilitating the outer envelope of buildings and their variability, particularly given the fact that the outer vertical envelope represents around half of total costs. Indeed, when roof parts are added, then the percentage is never less than 65%.

2. Determining Building Costs and Providing Estimates

Cost determination is an attempt to translate the expenses involved in carrying out a particular project to a certain standard so as to provide as accurate a notion

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as possible of the real cost of the work. Underlying all civil construction costs are value yields (labour, materials, equipments, etc), which influence the quantities of the means of production contributing to the production of any unit amount. The cost represents the sum of all work (labour, materials, equipment, taxes, administration, etc) necessary to carry out a particular job or service and corresponds to the amount paid for it.

As for the estimate, this will reflect all the expenses that the company envisages that it will have in a particular job, plus the anticipated profit margin. Expenses or costs may vary in accordance with different components and are divided into direct costs, construction site costs, indirect costs and profit.

Gathering information about costs in the domain of rehabilitation is difficult and laborious. Not only are there constraints that need to be taken into account that are not present in new buildings, but also the process requires human and material resources to enable the information to be collected and processed in a credible way.

3. Determining Rehabilitation Costs: Specific Issues

Knowledge and effective cost management are basic requirements for the economy of rehabilitation operations. Efficient methods do exist of determining costs and carrying out economic-financial assessments. However, these are only effective when there is complete and accurate understanding of the costs involved, since these provide the base information underlying such methods and analyses [1].

With new buildings, there are documents to support the costing process, and information is available about expenses and value yields. In rehabilitation work, however, which often involves less familiar tasks, it is exceptionally difficult to establish reliable yield values and consequently unit costs. Given all the parameters involved, determining such costs is usually extremely difficult, especially as there is no official information

available about prices practised. Thus it is useful to analyse the factors contributing to price variations.

Factors affecting rehabilitation costs are diverse and difficult to quantify. They include:

- Conditions affecting circulation, access and the setting up of the construction site;
- The size of the building, number of floors and housing units to be renovated, and the average area involved;
- The presence of the occupants during the works;
- Manpower availability;
- The cost of topographical surveys, assessments of the prior state of the building and other preliminary studies; the undertaking itself; the re-housing of occupants during the course of the work; technical administration, inspection and management of the work, and miscellaneous external costs (compensation for damage to neighbouring buildings or streets, insurance, etc).

Rehabilitation works are qualitatively different from new constructions. For example, they involve the repair of defects and improvements. They may also include small jobs that belong to the domain of periodic maintenance. The work may be done using traditional techniques and materials, or sometimes with sophisticated technology and materials, both of which will obviously affect the cost. There is also the need for preliminary work, such as demolition or prior consolidation (which is of course unnecessary for new buildings). These all bring additional expenses which often lead to surcharges.

Repair, reconstruction, the replacement of parts, and improvements may also make use of techniques and materials that are in current use for new works. However, this does not mean that rehabilitation costs are similar to the costs of a new building. On the contrary, rehabilitation jobs often involve more difficult working conditions, which negatively affect the returns [1].

In rehabilitation interventions, each case is specific, and it is not always possible to obtain all the

information necessary for costing through initial diagnoses and assessments. Consequently, it is not easy to standardize costs or rates of return. That is to say, there are multiple contextual factors that need to be taken into account in order to obtain specific information about the costs of particular jobs or tasks involved in rehabilitation work. Yet such information is of interest not only for the building contractors (for the preparation of estimates and control of the project) but also for the developers (who need to anticipate costs of undertakings and keep control of their company's budget).

Information about rehabilitation costs should be presented as systematically as possible, indicating all the main elements. These are:

- Working conditions (particularly access and the need for auxiliary equipment);
- Detailed description of tasks to be carried out (degree of complexity, quantity, locale, difficulty of execution, etc);
- Degree of complexity of the operation in which the task is included.

There exists some information grouped in the form of various global indexes that can help determine costs:

- Cost structures per type of rehabilitation (taking into account initial and final quality indexes);
- Rehabilitation costs/m² of gross construction area, relative to building parts or to the whole building (rehabilitation types);
- Costs of rehabilitation/household (by type), etc., particularly useful for the entities involved to decide whether or not to go ahead with rehabilitation operations, and to what extent [2].

In the light of the above, rigorous costing requires a complete diagnosis of the building by qualified experts, and the preparation of detailed specifications of the various jobs to be carried out.

4. Divulging Rehabilitation Costs

Few methods of structuring rehabilitation costs are known, and those that have been divulged in the

foreign literature have many limitations or are difficult to adapt to other countries [3]. In general, estimation methods are based upon a description of the building and classification of the state of degradation. They may be divided into a preliminary phase, where the decision is taken to demolish or rehabilitate, following in-depth studies, a physical examination and overall cost assessment; and a second phase, which corresponds to the rehabilitation proper. A series of comparable buildings (Standard Buildings) may also be studied, on the understanding that the costs will be approximately the same.

As yet in Portugal there have been no publications providing typical rehabilitation costs. In this country, the usual procedure is to produce an estimate based on a prediction of the various tasks necessary and their total cost, empirically defined on the basis of knowledge acquired from previous works.

Comparisons with other countries are useful, particularly when rehabilitation is more common than new construction work. In those situations, the publication of rehabilitation costs is considered to be of major importance for market transparency and for the maintenance of competition in the sector. In France, there is a public organization, the Rehabilitation Cost Observatory (OCTR), whose mission is to inform the public of the basic costs of rehabilitation work, using figures obtained from the records of processes to support property owners and tenants [4]. In Spain, companies can obtain precise information on line about standard costs of rehabilitation work [5], while in the United Kingdom, there is a document available entitled "Rebuilding Costs Guide" [6]. Interested parties may also do an on-line estimate of costs in order to have an idea of the resources that will be required for rehabilitation work.

5. Study of the Variability in Rehabilitation Costs

In a recent Doctorate study [7], an analysis was conducted of a series of interventions in recent

buildings in order to create a primary database of the real costs of interventions in residential buildings located in Oporto, in northern Portugal, with special attention given to the outer envelope. The respective records (of works by the same designer) were analysed, consisting of execution plans (including both written documents and drawings), bids entered by different companies in response to the calls-for-tender launched by the condominium administrators, and assessment reports of the bids tendered. The study also described the constitution of each building in the sample, the construction systems used for the envelope and the main problems detected. Finally, the total value of the rehabilitation work was indicated. The analysis of the interventions and the 33 bids tendered by the various contractors yielded a diverse group of average prices for rehabilitation work. This provided a cluster of average unit costs and enabled the creation of a computer programme called “ESTIMA – Estimate of the costs of rehabilitation work on residential buildings”, consisting of three inter-related modules (the first involved records of works already inserted, resulting from previous studies), complemented by a study of the variability in rehabilitation costs of relatively recent buildings [8–11].

6. Data Collection and Processing

In 2008, the list of works in the computer programme ESTIMA was extended and a selection was made of the most common kinds of work carried out on the external envelope of residential buildings [9]. Particular emphasis was given to the façades (vertical envelope), as this is the part that usually costs the most in works of this type.

In a first phase, the list was distributed to companies so that the costs of each work in a predefined unit could be supplied. However, there were problems in the filling out of this list. Therefore, in a second phase, it was decided to request estimates of rehabilitation works already concluded in order to compare the prices and try to understand the reasons for the variations.

Over time, this list has been updated and complemented by further studies carried out within the ambit of a Master’s dissertation, various published articles and by direct observation of work in progress, in which factors such as working conditions, time required, manpower, etc are also taken into account, in addition to the cost of the work itself. At present, the list consists of 7 sub-categories of costs with a total of 121 items [10]: General costs (5 items); Opaque parts (30 items); Glazed parts (25 items); Roof (23 items); Singular points (14 items); Balconies and terraces (14 items); Rainwater drainage (10 items).

Around 300 Portuguese companies were consulted and 20 different contractors participated in total. Approximately 6% of the works took place in the south of the country; 11% in the north and 28% in the central zone. Information was not available about the location of the remaining 56%.

It should also be pointed out that, though some responses were received, it was in fact very difficult to obtain information on this matter, which demonstrates the atmosphere of distrust or lack of interest that exists in the sector.

After the data from the estimates had been processed, it was found that the greatest discrepancy and highest prices were in the category of General Costs. For example, in the case of costs of “assembling, maintaining and dismantling the construction site”, the amounts varied between €15.98/un and €1,896.46/un within the same company. When companies present such divergent prices for items measured as a global value, they are taking probably advantage of extensive clauses to increase their profit margins.

Other examples where marked discrepancies were found were:

- In the opaque parts, the “treatment of façades covered with ceramic tiles” were costed at between €42.27/m² and €12.83/m² by different companies;
- As regards glazed parts, the “replacement of lacquered aluminium window frames” varied between

€141.37 and €750.00 per m², among different companies;

- In the category “roof”, the “preparation of screed mortars” varied between €6.51/m² and €48.63/m² in jobs performed by the same company.

Although there may be differences as regards the materials and details of the job, and even in the difficulty of executing this type of work, nothing justifies such enormous price differences. While we might expect discrepancies between different companies, it is startling to find price discrepancies for the same job in estimates provided by the same company. This matter clearly warrants further attention.

As regards the opaque parts of the façade, one case involved only the application of ceramic tile, while another contemplated not only the provision and application of the tiles, but also the application of thermal insulation and mouldings to parts of the roof. It was found that this second job, despite being much more extensive, had a lower average price (€31.79 /m²) than the first one (€32.80/m²), which is neither predictable nor logical.

In the subchapter “Balconies and terraces”, another case is described that involves the repair/replacement and painting of metal railings, and yet another where the railings are only replaced and painted. This time, the difference between them was a mere €0.19, when

we might have expected the repair job to have been more costly.

To complement this study, we also compared the prices quoted by these companies with reference costs for rehabilitation jobs given on a Spanish internet page. The comparison is presented in Table 1.

As we can see, works in Spain are generally more expensive than the average in Portugal, a fact that can be explained by that country’s higher economic level and average wage. However, there is a great difference in the quantification of costs related to “Repairs of tiled roofs, including cleaning and repair of structural elements, replacement of worn-out parts, painting and protective treatment [m²]. In Portugal, this costs €120.00 and in Spain €28.06. The same occurs with the job “Painting the wooden surfaces of window frames [m²]” where the prices in Portugal is €160.04 and in Spain €30.01 [10].

To gauge the opinion of the companies as regards aspects that could influence rehabilitation work and their respective costs, a questionnaire was prepared. The following problems were identified by the companies as influencing significantly the execution of rehabilitation works:

- Difficult access to the locale and limited amount of space for the construction site;
- Lack of collaboration as regards additional safety measures and increased risk in demolition jobs;

Table 1 Comparison of jobs and prices.

Sub-Categories	Jobs	Average cost
Opaque zone	Application of external thermal insulation system with mechanical fixation to the wall rendered and painted.	€16.81/m ²
	Application of external thermal insulation system with mechanical fixation to walls covered with ceramic tile.	€7.80/m ²
Roof	Application of ceramic tiles to roof	€32.80/m ²
	Supply and application of ceramic tiles to roof including thermal insulation panels and mouldings with eaves, roof ridges, cornices and chimneys with zinc-plated flashings.	€31.79/m ²
Balconies and terraces	Repair/replacement/painting of metal railings	€80.34/m ²
	Replacement of railings on the balconies of façades in pickled and metalized iron painted and enamelled.	€70.15/m ²
Rainwater drainage	Installation of zinc drainpipes	€23.17/m ²
	Repair, replacement and painting of zinc drainpipes	€13.45/m ²

- The fact that few rehabilitation works were undertaken;
- Lack of detail in the preliminary analysis, which meant that unexpected anomalies were often encountered.

As regards aspects that affected the price with relation to new construction work, the following were mentioned by the companies:

- More manpower and transport required per unit of work, and the time-consuming nature of rehabilitation jobs compared to new constructions;
- Lack of technical knowledge (to enable the selection of the best solutions), specialized manpower and divulgation of rehabilitation techniques.

As to the execution of rehabilitation works, the following were mentioned as the main problems:

- Deficiencies in the plans (written documents and drawings) and in the job descriptions;
- Poor conditions for the setting-up and operation of the construction site, and presence of occupants at the site;
- Excessive bureaucracy, and delays in licensing different projects.

The suggestions presented by the companies for overcoming problems in the domain of rehabilitation were:

- “Simplification (of legislation) in licensing procedures for rehabilitation projects”;
- “The contracting of firms that specialise in rehabilitation projects, in order to ensure that the pre-existing situation is accurately described and full details are supplied”;
- “The need for legislation to limit as much as possible the licensing of new constructions in order to encourage the rehabilitation of old buildings, as a way of restraining the unbridled growth around the edges of towns and cities that is turning the centres into residential deserts”;
- “In half the time and with half the cost, contractors working on new buildings can produce double the

amount of work compared to rehabilitation jobs, which makes rehabilitation an unappealing option”.

7. Proposals for Cost Records

The most significant interventions can be identified through observation and direct intervention in rehabilitation works, and by means of a survey focusing on techniques used, the returns on the resources used and the main problems in execution. This has been the method used by the National Laboratory of Civil Engineering (LNEC) in Portugal to divulge information about the costs of works on new buildings, and it should also be applied to rehabilitation works.

Normally, observation records are stored in the form of spreadsheets that are standardised for each construction job. The recorded items may undergo various treatments, and by recording them in this way, we can obtain a list of the most significant jobs; the specific nature of each job and the respective unit of measurement; the quantification of the returns from resources (materials, equipment and manpower) involved in each job.

The records were obtained using the same process, despite the great difficulty in acquiring the collaboration of the people who have this knowledge.

The preparation of proposals for returns records or cost records of jobs was based upon a dialogue with the head of a construction team specialising in rehabilitation, who helped to identify the practical procedures and construction tasks typical of such work. This was then completed with the collection of information about materials and associated costs. Table 2 gives an example of the records created.

In order to carry out the works described in these records, it is necessary to consider some individual tools. These are not individually identified in the records, as their inherent cost is included in the percentage of charges.

The figures given for manpower were estimated using the formula $S_h = (V_m \times 12) / (40 \times 52)$, in which S_h

Table 2 Example of cost record for sub-task of applying insulation to a continuous façade with medium texture paint.

Task:	Application of fibreglass netting with two layers of glue for vertical coating with minimal overlaps of 10 cm, in which the second layer of glue has a sand or trowelled finish. Application of regulation primer and medium-texture paint between the two layers of glue. Finally, removal of rough surfaces on the façade using sandpaper (for mortar), after the second layer of glue has dried for 24 h.						
	Description	Quantity	Unit	Unit Cost	Unit	Partial Cost	Unit
Materials	Netting	1	m ²	0.68	€m ²	0.68	€m ²
	Glue	3.2	Kg/m ²	0.75	€Kg/m ²	2.40	€m ²
	Primer	0.6	Kg/m ²	0.52	€Kg/m ²	0.31	€m ²
	Paint	5	Kg/m ²	3.6	€Kg/m ²	18.00	€m ²
Manpower	Foreman	0.125	h/m ²	10.56	€h/m ²	1.32	€m ²
	Assistant	0.125	h/m ²	8.13	€h/m ²	1.02	€m ²
					Total	23.73	€m ²

is wage per hour and V_m the monthly income for 2009. The amounts involved were suggested by the business associations operating in the sector (150% for 2009). The percentage of indirect costs and construction site costs, plus the anticipated profit margin, were then added to the figures obtained.

8. Conclusions

As predicted, this study has confirmed that there is a great variability in the way prices are calculated for rehabilitation jobs. This is seen not only in the prices supplied by different companies for the same job, but also in the great divergence of prices proposed by the same company for similar jobs.

It should be pointed out that the cost of jobs (which are generally in line with what might be expected, as confirmed by the companies consulted) depends upon the conditions in which they are executed, such as the height, atmospheric conditions, materials required, the specific nature of the work, site accessibility, time required for the job (given that a job is never undertaken in isolation and that the manpower used may not be specialised), the existence of residents at the site, commercial strategy used, etc. Costs also depend upon the need for specialised manpower, the measurement unit used and the dimension of the job. However, nothing justifies the enormous difference in prices that was found during the course of this study.

These results therefore prove the urgent need that exists to standardise as much as possible the costs attributed to particular jobs by different companies. In this light of this, the best action would seem to be to prepare returns records which will facilitate the preparation of estimates for rehabilitation jobs.

The list of spreadsheets of different kinds of work should be constantly added to and updated, so that it becomes increasingly reliable as a basis for bids in calls for tender, as well as for the preliminary work involved in preparing estimates, budgets and reference values for rehabilitation works, whether these operate according to a price series system or, in special situations, with an overall price. Later, this should lead to the establishment of more secure average values, with the possibility of introducing “nuances” in accordance with the specific characteristics and conditions of each particular rehabilitation job.

The responses obtained from companies (as regards the main difficulties in determining rehabilitation costs, the aspects that differentiate these prices from those related to new constructions, and the main problems in carrying out rehabilitation work) have enabled us to acquire a deeper understanding of issues that of major interest. The importance of contracting and creating offices specialised in rehabilitation projects was highlighted by the companies consulted. This area of intervention also needs to be regulated by defining the skills required by the technicians that produce

assessment/inspection reports, in order to better qualify the companies that operate in the domain of planning, inspection and execution of rehabilitation works.

As this matter has now started to attract interest, with some collaboration from specialists in the field, there are intentions to study it further, in order to facilitate the rehabilitation of buildings and coordinate the various parties involved, thereby enabling them to gain the necessary efficiency.

Hence, let us finish with some suggestions for future developments:

- There is a need for an official document that establishes recommended prices for rehabilitation works;
- We should continue to prepare records of the costs of rehabilitation work, based upon the yields from manpower, materials and equipment obtained through direct observation or from databases collected from companies specialising in this type of work, with a view to publishing them;
- A Rehabilitation Cost Observatory should be set up to gather and divulge information relating to reference costs (such as the one that already exists in France);
- A more elaborate survey of work costs should be undertaken so that contractors do not feel the need only to undertake new construction jobs;
- The means of measuring rehabilitation works need to be improved, to avoid situations whereby the same cost calculation includes works charged at an overall rate when they are of completely different types and involve different working conditions.

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