ENGLISH VERSION

Control of Finished Work – Final Quality Inspection in a Social Housing Project

Control de la obra terminada – inspección final de calidad en un proyecto de interés social

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Abstract

Social housing is often associated to buildings of low quality level; however it is important to have objective elements to verify this question so the control of the finished work constitutes a good quality measure. This study presents and evaluates the problems found in a typical social housing project funded under the Brazilian housing program Minha Casa, Minha Vida, built in São Leopoldo, a city on southern Brazil. The work was monitored during the last six months of its final phase of execution. The inspection reports of the completed work were analyzed and observations were proposed directly at the construction site. The first owner's inspection reached about 64% failure. In some cases, it took four attempts to finally obtain the owner's acceptance. Analyzing data collected we concluded that windows, doors and ceramic coverings were a major source of complaints, reaching more than 77% of the problems pointed out in the inspections. The failures detected in this project were caused by problems related to workmanship, lack of quality of materials and the components used, as well as insufficient quality checks of the services performed. We observed the need to improve quality controls although the building firm had a certification by PBQP-H (a Brazilian certify similar to the ISO 9000). The correct procedures were defined on quality documentation but they were not followed

Keywords: *Inspection, quality control, social housing, civil construction, Brazil*

Resumen

La vivienda social se asocia generalmente con una construcción de bajo nivel de calidad. Sin embargo, es importante contar con elementos objetivos para verificar esta afirmación. El control de la obra terminada es una medida de calidad. Este trabajo presenta el análisis de los problemas encontrados en un proyecto de interés social típico, financiado por el programa Minha Vida, Minha Casa y construido en São Leopoldo, Brasil. Se acompañó la obra por seis meses en su fase final de ejecución. Se consultaron los reportes de inspección de obra terminada y se realizaron observaciones directas en la obra. La primera inspección de entrega alcanzó una reprobación de los propietarios alrededor del 64%. En algunos casos se hicieron cuatro inspecciones hasta la aceptación de la unidad. A partir de los datos del estudio y del análisis realizado, las carpinterías y los revestimientos de cerámicos se revelaron como la mayor fuente de fallos, alcanzando más del 77% de los problemas señalados en las inspecciones. Se encontró que los fallos detectados se debieron a problemas con la mano de obra y falta de calidad en materiales y componentes utilizados, así como hubo supervisión insuficiente de los servicios. Se observó que hay necesidad de mejorar el control de calidad, aunque la constructora tenga un certificado PBQP-H (certificación brasileña similar a la ISO 9000). Los procedimientos adecuados se definieron en los documentos internos, pero no se siguieron

Palabras Clave: Inspección; control de la calidad; habitación social; construcción, Brasil

1. Introduction

Social housing is often associated to buildings of low quality level. Brazil is building a great amount of social housing through a governmental program called Minha Casa, Minha Vida (MCMV) (Brazil, 2009). Although there are many building companies certified by the Brazilian Program of Habitat Quality and Productivity (PBQP-H) (Brazil, 1998),[2] it is easy to verify on an informal basis the low quality of the units produced. Nevertheless, it is important to count on objective elements to verify this perception until being able to promote the improvement of the future projects. With this target, the study focused on the evaluation of the problems found in a typical social housing in São Leopoldo, the final inspection documents were reviewed, observations were proposed at the work site and researchers took contact with the professionals in charged.

In construction, it is very important to count on an efficient management program for the project execution to avoid losses or errors in the works. Actually, companies have developed project management and control systems to ensure the good quality of services and products (Giacomello et al., 2014; Souza, 2004).

According to ISO 9000 standard, in construction, quality management depends on an adequate planning, including the first decisions, objectives and necessary attitudes; knowledge of the products and services employed; and attitudes for improving during the implementation of the processes (ABNT, 2005).

According to the Project Management Institute, PMI (2012), quality control is the process of monitoring and registering the results of the project activities execution, with a view to evaluate the performance and to recommend the necessary changes. For McCabe (2014), the quality changes shall be done during all the production process, by monitoring all the stages of the activities that are in execution, in order to warrant that all the activities are developing as they were planned.

Limmer (1997) estates that three main issues shall be considered for quality in construction: the quality in the planning phase, the quality control in all the execution stages and the quality guarantee of the completed building.

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[2] PBQP-H certification is a requirement for the building companies that enter in the projects of the Minha Casa, Minha Vida Program (PMCMV) and also for other funding lines from the Caixa Económica Federal and other banks in Brazil (Brazil, 1998, 2009). The PBQP-H certification is very similar to ISO 9000 (ABNT, 2005) but includes additional elements.

The quality at the planning stage (or project's quality) is based on the use of standards and procedures with the objective of assuring that the project is well done. In the quality control phase, the objective is to supervise the accomplishment of the standards established by the project and their corresponding specifications in the site, and to measure the deviations during the work development. Ultimately, quality guarantee covers the necessary actions and the standards and procedures application to assure that the constructed project satisfies the performance criteria established.

The work quality control includes the reception of materials and components, the control of the execution and the control of the finished work. In the completed work, it is necessary to verify the design requirements, the conditions according to the contracts or required by laws. The objective of the final evaluation is to fulfill the necessary elements so the owner may decide whether to accept or not the works (García Meseguer, 1991; Silva et al., 1995).

Forcada et al. (2013) say that for assuring the reduction of the defects it is necessary to put an emphasis in the quality control and in the supervision of the subcontracting operations, especially in areas where the problems are more common, and also during the final stages of construction.

For Nieto (1999), the evaluation of a social housing project is associated to the standards of every country. In Spain, the Building Technical Code (Código Técnico de la Edificación, CTE) requires that the acceptance control of finished work – of the entire building, parts or systems – shall verify the work done and that tests shall be done to facilities, according to that described by the project or applicable by laws (Spain, 2013).

Chile has a detailed regulation for the works control (MINVU, 2007; 2011); it exits some control charts by batches during all the construction periods and a final chart for the acceptance of each building unit (for example, a house). The regulation suggests the content and design of those charts. The Works Technical Inspection (Inspección Técnica de Obras, ITO) is a commission named to supervise the fulfillment of the contracts and to check the work quality.

In Brazil, according to the Conformity Assessment System of Companies, Services and Construction Works (SiAC), the building company shall establish a written procedure for the work inspection and also supervise the records before the work delivery to verify the conformity of the finished product with the owner's specifications and requirements (Brazil, 2012).

The final inspections shall verify the fulfillment of the project. In general, inspections are done by a professional from the company's quality sector or by an external regulatory body and are composed mainly by visual inspections, which depend on the experience and technical knowledge of these professionals. In some cases, the procedure is applied only for delivering the unit and may include the owner. Some authors suggest that the process improvement occurs by using some specific tools to reduce the subjective judgement of the inspection (Laofor and Peansupap, 2012; Tan and Tan, 2006).

2. Methodology and data collecting

This study focused on a project of social interest, built in São Leopoldo, a city located in southern Brazil, and is divided in two sections: data collection and data critical analysis. The available information was reviewed (all the final inspections) and the construction was visually observed at the site during the final six months of the project execution. Additionally, inspections were monitored and researchers took contact with professionals in charge.

The project conditions such as dimensions, number of units, specifications documents, technological characteristics, company's size and qualification, made the study case similar to many other projects of the MCMV program built in the region and in Brazil. So, the project studied can be considered as a representative case of the segment considered.

2.1 Company profile and project description

The building company was founded in 1980 and works in the metropolitan area of Porto Alegre, the capital of the state of Rio Grande do Sul, Brazil. Its developing areas are wide but focused mainly in social housing. During the last decades, it has developed many projects for the MCMV program. The company was certified by the Brazilian Program of Habitat Quality and Productivity, PBQP-H, in its highest level - A (Brazil, 2012).

The analyzed case is a residential project of social interest composed by blocks of flats, 5 floors each one, with 20 apartments by block, with a total amount of 180 dwellings of 60 m^2 each one, equal to 10.800 m^2 built and 158 car parking lots. The project was funded by the program Minha Casa, Minha Vida. The building system used is based on structural masonry of ceramic bricks and precast concrete beams. Figure 1 shows a drawing of the ground level of the building and Figure 2 shows the buildings' exterior view.

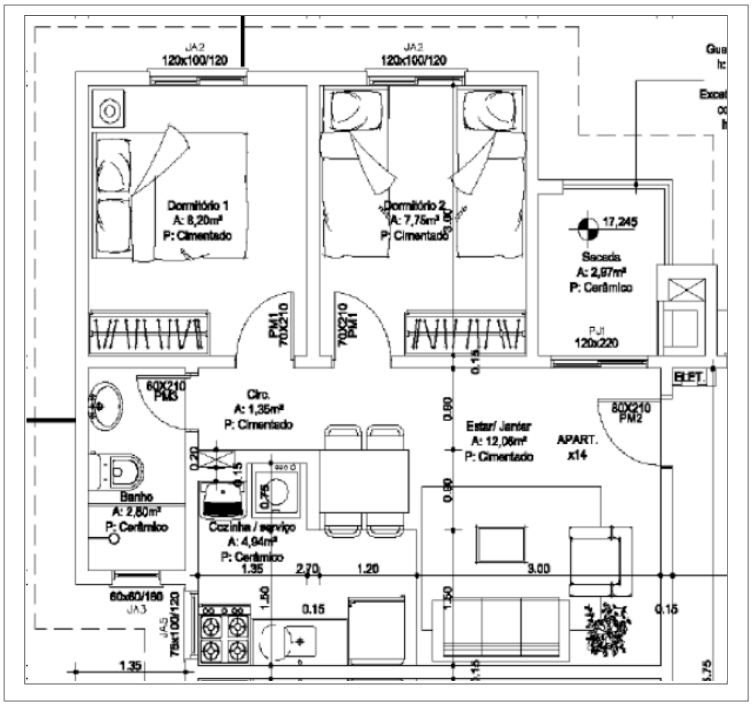

Figure 1. *Plan of one Apartment. Source: authors*

Figure 2. *View of a finished block of flats. Source: authors*

2.2 Documents related to quality

The company has a Quality Guide based on the SiAC (Brazil, 2012). The company's quality policies consider that compliance with time limits and reduction of costs, since the planning until the work delivery, are very important, and that the products and services supplied shall be of high quality.

The quality management system of that company is divided in: general requirements, documents' requirements, control of documents and records control. Documents are monitored, measured and analyzed periodically to reach the objectives established and implement the necessary actions for the continuous improvement of the management system. At the work site, the following documents were reviewed:

- *Work Instructions (IT): defines the procedures to execute a determined activity;*
- *Specification of materials in the work site (EMO): defines the procedures for reception, storage and preservation of the materials in the site.*

The company's documents also describe the procedures that shall be adopted in the inspections before the work delivery. People responsible for the quality area shall accompany the owners and write in the inspection report all the observations and the existing problems, if detected. After the inspections, the document is send to the company's commercial area, which in turn shall continue with the necessary procedures (formal delivery of the unit, to correct the problems found and do a new inspection).

3. Presentation and analysis of the results

Besides checking all the inspection's documents (to which we had free access), many inspection were physically followed in the site to better understand the process. In this case, the inspections were done by the project's quality agent (a civil engineer) or by an apprentice (a civil engineer student) accompanied by the owners, generally in visits of 40 minutes long.

3.1 Resume of the data collected

In the first stage, a general analysis of the failures described was done, according to the information written in the final inspection reports of each apartment (Table 1). The number of apartments not accepted was very high. In the first inspection 115 units were rejected (64% of the 180 units), distributed among all the blocks of flats (between 10 to 17 units rejected by block). In the second inspection, 23 units were rejected (20% of the 115 units rejected in the first inspection). In the third inspection, three units were yet reproved, and only in the fourth inspection all the units were accepted.

Failure reasons were then analyzed. Table 1 shows the amount of failures of the services declared by the owners. The number mentioned in the table corresponds to the number of units not approved with the mentioned problem and not to the number of apparitions of the complaint. For example, in the first inspection 114 units were not approved due to problems with wooden doors (entrance doors or interior doors), but the inspection report does not inform if the owner mentioned more than one door with problems. Nevertheless, accompanied inspections showed that it was a common issue to found more than one door with problem in a same unit.

Table 1. *Rejected items by inspection*

Problems	Cat*	Inspection		
		1st	2nd	3rd
Woodwork - exterior or interior doors	Car	114	22	4
Aluminum carpentry - windows	Car	53	12	1
Cleanness and presentation of the dwelling	Otr	44	8	0
Smooth plaster	Rev	41	6	0
Walls and floor ceramic coverings	Rev	37	8	0
Grout joint of the ceramic tiles	Rev	34	4	1
Aluminum carpentry – balcony door	Car	32	6	0
Water-based paints over plaster	Rev	25	2	1
Aluminum protection - balcony	Otr	22	2	0
Finishing of the installation *shafts*	Otr	19	4	1
Interior texturized paint – ceilings	Rev	16	0	0
Exterior texturized paint – balcony	Rev	13	1	0
Grid – balcony	Otr	6	4	0
Electric installation – circuit breaker mechanisms	Otr	6	0	0
Plastic rain gutter – balcony	Otr	4	2	1
PVC sheets- bathroom ceiling panels	Rev	2	0	0
Gypsum finish – ceiling in kitchen	Rev	2	1	0
Total of failures detected	-	470	82	9
Units inspected / rejected	-	180/115	115/23	23/3

Source: authors. *Category: Car: woodwork; Rev: finishing and paintings; Otr: others

In the first inspection it was observed that, from the 17 services that justified the rejection of the units, those with highest percentages of errors were doors (24%), windows (11%), plaster (9.3%) and ceramic coverings (8.7%). The lack of the apartment's cleanness was identified in 9.4% of the cases. In the second inspection, the list of services showed basically the same elements. The third inspection also showed the same problems, especially in interior doors.

In terms of the problems location, the services in balconies obtained 16.4% of the problems in the first inspection and 18.3% of the detected problems in the second, and the rest was distributed in different parts of the apartment.

Considering the characteristics of every work stage and the type of workmanship, the failures detected in the first inspection may be grouped in the following categories (see Table 1):

- *Woodworks (Car) - 199 problems (42.4%);*
- *Finishing and paintings (Rev) - 166 problems (35.3%);*
- *Cleanness and others (Otr) - 105 problems (22.3%).*

Based on the data collected, it is possible to conclude that the element that obtained the greater number of complaints was the woodwork, especially in wooden doors. The problems observed by the owners include different aspects. In the evaluation of doors, all the elements that form them were considered and had problems (swing door leaf, frame, flashings, locks, hardware and operation). More than a half of the reports complaints, concern the components and the rest was assigned to the execution (flashing fixing or operation; for example, the door does not remain close or was blocked).

Aluminum carpentry did also highlight among the elements rejected. In the balcony doors, the owners' complaints refer to the door operation. For the windows, the observations were for the operation, finishing of the interfaces between the carpentry and the walls or surface damages in the aluminum carpentry itself. The first two factors explain the 60% of these problems.

Elements related to the finishing (such as smooth plaster, ceramic tile coverings and paintings) represent the 35.3% of the failures mentioned in the first inspection. The ceramic coverings and their finishing was highlighted as the elements with the highest percentage of complaints. In the first and second inspection these works received 15% of rejection in both cases.

The review of the inspection reports that described the rejection reasons, points out that the most common complaints for coverings were the damage present in the smooth plaster and/or paintings, as can be appreciated in Figure 3. In the ceramic tiles, 35% of the complaints refer to the damages in the ceramic tiles (some of them broken) and the 50% are problems with the joints (appearance and variable joint widths). These problems were not adequately solved in all the units and, in consequence, they were mentioned again in the second inspection.

The interior cleanness, an issue that could be easily solved, was identified in 44 cases as a rejection reason or non-acceptance of the real properties. There was not supervision of the cleanness done in each unit. The cleanness checking occurred only at the moment when the inspections were done. Owners complained because carpentries were dyed with ink, the ceramic tiles were dirty and the toilet was obstructed, among other problems. In the second inspection, the problem was even larger because after repairing the damages no cleanness was done at all and residues as mortar and ink cans were found.

Figure 3. *Examples of problems in the interface between the wood flashings and plaster. Source: authors*

3.2 Probable causes of the problems detected

Initially, it can be said that the occurrence of failures in all the blocks of flats and in the different services indicates that there exists homogeneity in the construction quality level, leaving apart the explanations given by some contractors or in specific stages of the work execution.

Some months in advance, before beginning the execution of the work in study, the company had executed, in the neighboring land, another work with the same characteristics where almost the same contractors, engineers and employees worked, with similar problems, according to the description made by these professionals. So, the company had some kind of initial knowledge about the execution and the results.

The monitoring of the work during some few months and the contacts with contractors and engineers allowed correlating some explanations of the problems registered in the inspections. It was established that the main causes for the appearance of complaints in this project were:

- *Unskilled labor;*
- *Inadequate management of the materials;*
- *Lack of supervision.*

For the execution of the interior walls there were non-qualified personnel in the site; additionally the contractors' chiefs did not supervise adequately the masonry works, smooth plaster and ceramic tiles installations when they were under execution. The wall execution did not fulfill the project requirements, exhibiting different points with work voids of different sizes of those specified or with irregular edges. At the same time, company's employees responsible for the carpentry installation, when verifying that a window or door did not adjust to the window or door opening, they forced the adjustment so they can attain the target. As a result, there were operation problems in doors and windows, and damages in their interfaces with the coverings. Another consequence was the need of working once again the plasters and paintings. For costs reasons, the company ordered the workers who did the new plastering to do the new paintings. As they did not have the expertise in doing so, the re-painting resulted of low quality in these areas.

In the case of the wood carpentry, it was very common to detect inadequate storage problems. The material storage specification in the site (EMO) contains different items, among them three procedures are very important: reception, materials storage and preservation. The procedure for the materials reception determines that every material delivery in the work site shall be considered as a batch. The receptionist shall verify the materials and in case some exhibit non-conformity in quality, the entire batch shall be returned. In the project in study, the workers in charge not always did the controls stipulated in the EMO. Most part of the materials was stored according to those specified, but the same did not occur for the carpentry since it presented damages before it was installed in the work.

The general supervision of the different works execution was done by the person in charge of the work and by the chief of the main contractor, who checked the services done by their own workers. The supervision of the services related to carpentry and finishing was done by the quality agent (a civil engineer) or by an apprentice (a civil engineer student). Each one of them was responsible of verifying a determined type of service, but considering the work size the number of persons available for executing this activity was not enough. In the case of the company studied, the relationship was inadequate since there were 9 blocks of flats, with a total of 180 apartments. Different activities were executed in parallel operation, so some of them were not inspected, thus generating enchained failures, such as problems in the window/door openings derived in failures in windows and doors. Another factor that shall be considered is that only the quality agent had a special technical training to supervise the quality and this same worker had a double function to supervise and prepare the reports. The lack of a more efficient supervision during the services execution, along with the low qualification of the workmanship that executed certain services, gave rise to the appearance of the majority of the failures observed during the inspections.

4. Discusion and final considerations

As construction has a great variety of actors involved and the different services are developed over the production course, there are different factors that may affect the product quality.

In the studied project, based on the analysis of the data collected through the inspection reports, it was possible to detect that the services that showed more failures were wood carpentry and coverings. Some responses for these failures are: unskilled labor, inadequate storage of materials and lack of supervision.

To avoid failures in the services execution or to avoid work repetition, it is imperative to employ skilled labor according to the type of service required and do an efficient control of the services executed. The quality agent assigned to this function shall have more knowledge on this action field, having specific skills to distinguish the controls that shall be done. It is also important that the number of quality agents is proportional to the project size and that the supervision is not done by the contractors themselves.

An alternative to guarantee the quality and avoid problems is to store the knowledge produced during a project execution and to disseminate it for the personnel involved in the following projects in order to avoid failure repetitions (a continuous improvement process). For doing so, it is necessary to improve the communication between the engineering sector and the project sector.

Although the identified problems can be classified as simple or trivial matters, they occurred in a considerable amount, since 64% of the built units were rejected in the first inspection. The company had the recent experience in the construction of many projects of social housing and it was certified by PBQP-H. Nevertheless, the quality

observed in the work site is not adequate since it showed many points rejected, issue that do not correspond to the requirements of this certification. Moreover the quality policies are not fully observed, showing a preference for the cost reductions. The recent experience of the team in a very similar project is an aggravating factor. The company made a planning and scheduling for the works and documents also had a series of controls in relation to the services performed but they were not applied as it was planned.

5. Aknowledgments

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