Strategies to Reduce Defects in Floor and Wall Tiles; Application of Continuous Improvement Processes

P. Del Solar and M. Del Río

Abstract Continuous improvement is a key element in any business strategy, and it is even required in enterprises with a management system in agreement with the UNE EN ISO 9001: 2008 standard. However, due to the characteristics of the construction sector, it is especially complex to put it into practice. This paper describes the work underway to try to reduce defects in construction ceramic coatings applying continuous improvement tools. Once data on the construction defects found in seven housing building works have been collected, priorities were established for the implementation of the improved project, based on statistical tools for continuous improvement. The process of analysis is explained in this paper, as well as the reasons to deepen the study focusing on the shortcomings of this working chapter, so as to establish strategies to reduce failures in it.

Keywords Continuous improvement • Quality • Management • Construction failures • Construction defects

1 Introduction and Aims

This paper presents a research Project carried out on the Continuous Improvement process within the Quality Management Systems applied to construction companies.

Practically all Management models (ISO 9001, SixSigma, Total Quality Management TQM, Análisis de Modos de Fallo y Efectos) [1] defend Continuous Improvement as one of the most important processes in quality assurance. Industrial sectors in general, as can be seen in the existing literature, started to integrate improvement projects some years after Deming claimed the statistical techniques applied to quality, in Japan, in 1948. Today, the "Deming-Sheward circle" is widely known: Plan-Do-Check-Act.

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However, due to the singularities of the construction sector, and the continuous use of prototypes reproduction, implementing improvement processes and measuring the results is not easy, as it would have been in an assembly line.

Nevertheless, despite difficulties, the only way to improve is to know our mistakes before implementing actions to prevent repetition. To this end, we are working on the analysis of construction failures and designing a methodology to implement improvement plans and assessing their performance.

The aims of this paper, which gathers the progress of the on-going research work, are the following:

- Briefly explain the statistical quality tools applied in the study.
- Present the classification work of incidences detected in seven construction works.
- Establish priorities to enable setting strategies of the potential improvement projects.

2 Research Methodology

2.1 Background of Continuous Improvement

Today we have assumed *"continuous improvement and innovation as imperative to compete in the short-term and to survive in the long term in a globalized economy environment"* (our translation) [2]. Every author, management model or excellence model in management defends this premise. Although a long way has been followed—since the masters began to spread these ideas -we still have a long way to go in the construction sector. Our country, Spain, is particularly delayed when compared to United States or England, for example.

Juran [3] and Ishikawa [4, 5] have done a great job advocating and disseminating the benefits resulting from the implementation of the Continuous Improvement as an essential process to evolve from the "quality assurance" to the "Total quality" and "Quality Control" [2, 4].

In 1962, Ishikawa began to introduce Total Quality in Japan through the Quality Circles, affirming that, *"using total quality control with the participation of all the employees, including the President, any company can create better products (or services) at lower cost, as well as increasing sales, improving the utilities and turning the company into a top organization"* [4]. The concept of "total quality control" was devised by Armand V. Feigenbaum in the 1950s [4], but he argued that the TQC should be in the hands of specialists, as opposed to Ishikawa's approach, whose idea has reached our days.

In Spain however, within the construction companies, the quality assurance systems did not begin to be implemented until the 1990s, based on the ISO 9001 standard and today, Total Quality has not yet been integrated.

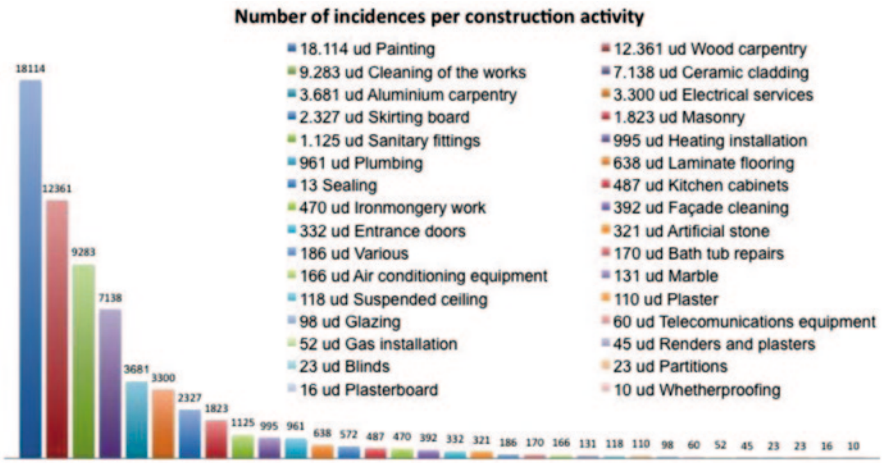


Fig. 1 Stratification historiogram of the number of defects per construction activity

The latest version of the ISO 9001: 2008 standard stresses the importance of the continuous improvement process and defends the principles of Total Quality: i. e. focus on the customer, address responsibility, company involvement at all levels, etc.

Our research project aims to establish a methodology, which will enable the implementation of improvement projects in a simple way in construction companies.

2.2 *Improvement Project Applied to Diminishing Construction Defects*

As Ishikawa states: *"The seven tools of quality control, when used skilfully, allow to solve 95 % of the problems of the different jobs. Intermediate and advanced statistical tools are only needed in 5 % of cases."* [5]. These seven tools are:

- Pareto chart
- Cause and effect diagram (or Ishikawa diagram or herringbone).
- Stratification
- Verification or check sheet
- Histogram
- Scatter diagram
- Control graphs and charts.

In the first phase of our study, we have worked with the "Check sheet", taking data from five housing construction works, and collecting a total of 65.528 incidences. These incidences have been classified in different categories regarding the "Stratification" tool. [6]. All these data was obtained thanks to the collaboration of ARPADA construction company, whom we want to express our gratitude (Fig. 1).

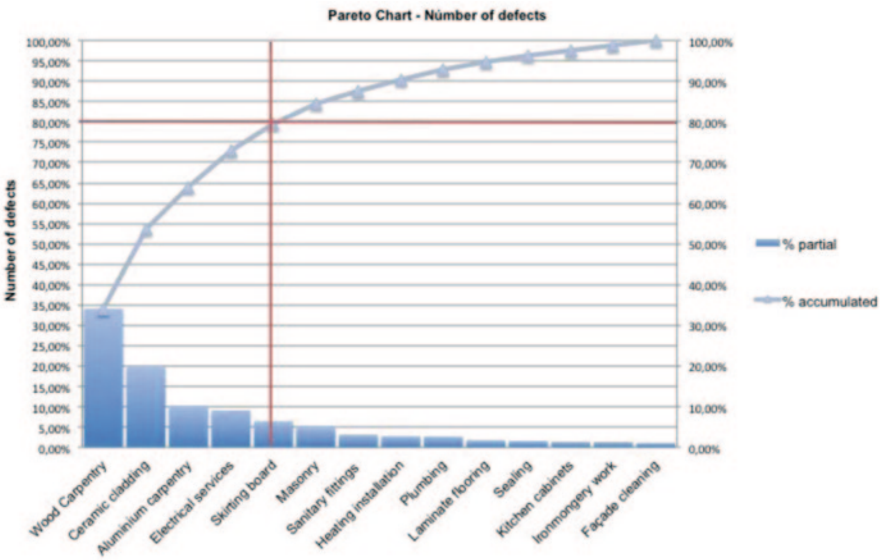


Fig. 2 Pareto Chart—Improvement projects prioritizing

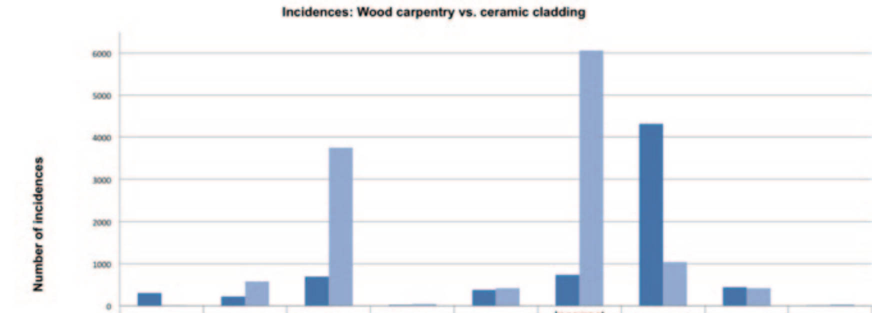
Due to the low impact on repair cost of the construction activities with more incidences: painting and cleaning works, we decided to separate data and focus on trades with the greatest impact and representing more than 1 % of the total. With this data a "Pareto chart" is represented providing information to *"determine the frequency or the relative importance of various problems or causes"* and helps to *"concentrate on vital issues sorting them in terms of importance"* (our translation) [7; Fig 2].

As can be seen, 80 % of the defects are concentrated in 5 construction activities:

- Wooden carpentry
- Ceramic tile cladding
- Aluminium carpentry
- Electrical installation
- Skirting board

2.3 Prioritizing to Establish Strategies

At this point we have to decide in which trade we are going to focus our efforts to try to implement action and control protocols in order to achieve a significant reduction in the defects produced. *"Often the first two or three types of defects comprise at least seventy or eighty per cent of the total." "Is clear that if we eliminate these specific defects, we will have eliminated most of the defects and the fraction of faulty units will decrease dramatically,"* (our translation) [5].



	Redo	Fracture, substitution	Scratches, damage with substition	Scratches, damage with repair	Unfinnished	Incorrect finishing, bad appearance, fitiing	Fitting or sealing missing	Cleaning	Others
Ceramic cladding	311	228	694	20	376	741	4318	443	7
Wood carpentry	5	579	3751	48	418	6061	1046	423	30

Fig. 3 Incidences in wooden carpentry and ceramic tile cladding

In this case, before focusing on specific defects, particular construction activities will be the center of interest. Our Pareto chart shows that the two construction activities with the greatest concentration of incidents are wooden carpentry and ceramic tile cladding.

Defects in these two groups were analyzed according to the other classification categories: action type for repair; repair cost seriousness; impact seriousness in the corporate image; and cause producing the incidence.

The following table compares the effects of these two trades according to the type of action (Fig. 3):

In this figure, a substantial difference can be seen in three groups:

- Scratches or damage requiring replacement or repair.
- Poor finishing, bad appearance or lack of fitting. The element, or piece is finished but in an incorrect way or it looks bad.
- Sealing of an element is faulty or poorly executed. It requires this operation for working successfully.

Analyzing the various groups, the following conclusions can be drawn:

- In the first group, although the number of incidents is far greater in wood carpentry trade, replacing a step or cabinet door is usually a fast and clean operation, but substituting a wall or a floor, fully or partially, has a substantial impact on the work and, it can generally influence other trades or construction activities. This means that the priority should be to work on defects in ceramic tiling.
- Something similar happens in the second group. Mainly, an aesthetic flaw does not technically require replacement or reprocessing as it falls within the permitted tolerances. It is however, a potential claim the property users might do, and occasionally, it might result in the need to redo the defective area. In this case, as well as in the previous case, the impact of cost and time in the ceramic tiling activity is greater than in that of wood carpentry.

	High	Medium	Low
Ceramic cladding	21	425	6692
Wood carpentry	1	476	11884

Fig. 4 Incidences in wood carpentry and ceramic coatings classified by repair cost severity

- The third group includes minor repairs, which can easily be fixed in both cases. Occurrences are more frequent in ceramic tiling.

In addition, the incidence between both construction activities classified in the other three categories are compared: seriousness due to cost of repair; impact seriousness on corporate image; and cause that produces the incidence.

The most important conclusion in these cases indicates that 96.14 % of the incidents of the woodwork belong to the group of low-cost repairs, confirming the conclusions drawn in the comparison previously commented (Fig. 4).

3 Future Research Lines

In accordance with the study so far—summed up in the previous sections—the research will be followed working on the improvement project of the defects found in the ceramic claddings. The steps to be fulfilled are:

- Study of the incidences in the ceramic cladding group.
- Defects stratification by types.
- Histogram and Pareto chart to establish action priorities within the defects of this activity.
- Proposal of Protocols and Verification/checking sheets to take into account in the construction phase by the workers and the subcontractors performing these jobs.
- Collect data in new construction works to determine the degree of improvement obtained.

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