Carmen Llinares-Millán • Igor Fernández-Plazaola
Francisco Hidalgo-Delgado • María Montserrat Martínez-Valenzuela
Francisco Javier Medina-Ramón • Inmaculada Oliver-Faubel
Isabel Rodríguez-Abad • Andrea Salandin
Rafael Sánchez-Grandia • Isabel Tort-Ausina *Editors*

Construction and Building Research

Springer

Construction and Building Research

Carmen Llinares-Millán • Igor Fernández-Plazaola • Francisco Hidalgo-Delgado • María Montserrat Martínez-Valenzuela • Francisco Javier Medina-Ramón • Inmaculada Oliver-Faubel • Isabel Rodríguez-Abad • Andrea Salandin • Rafael Sánchez-Grandia • Isabel Tort-Ausina
Editors

Construction and Building Research

Springer

Editors
Carmen Llinares-Millán
Universitat Politècnica de València
Valencia
Spain

Igor Fernández-Plazaola
Universitat Politècnica de València
Valencia
Spain

Francisco Hidalgo-Delgado
Universitat Politècnica de València
Valencia
Spain

María Montserrat Martínez-Valenzuela
Universitat Politècnica de València
Valencia
Spain

Francisco Javier Medina-Ramón
Universitat Politècnica de València
Valencia
Spain

Inmaculada Oliver-Faubel
Universitat Politècnica de València
Valencia
Spain

Isabel Rodríguez-Abad
Universitat Politècnica de València
Valencia
Spain

Andrea Salandin
Universitat Politècnica de València
Valencia
Spain

Rafael Sánchez-Grandia
Universitat Politècnica de València
Valencia
Spain

Isabel Tort-Ausina
Universitat Politècnica de València
Valencia
Spain

ISBN 978-94-007-7789-7 ISBN 978-94-007-7790-3 (eBook)
DOI 10.1007/978-94-007-7790-3
Springer Dordrecht Heidelberg New York London

Library of Congress Control Number: 2013955015

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Foreword

The 2nd International Conference on Construction and Building Research, held at the Polytechnic University of Valencia's Advanced School of Construction Engineering in November 2012, was set up under the auspices of the Conference of Directors of Building Surveying and Construction Engineering Schools as a tool for exchanging innovative scientific information and technology transfer.

Numerous areas of knowledge converge in the construction industry, necessitating the combination of numerous scientific and technological variables and a multidisciplinary approach to research in the field, and so a very broad perspective is required to establish ongoing relationships between contributions from different areas.

It is tremendously difficult to find any master formula for bringing different studies together and it can only be done in a context of collaboration and multidisciplinary enrichment.

Therefore, in order to publish and disseminate the results, the Organising and Editorial Committee for the 2nd International Conference on Construction and Building Research felt it was extremely important to select some of the studies presented that examine issues in materials and building systems; construction technology; energy and sustainability; construction management; heritage, refurbishment and conservation.

The appeal of this publication lies in the fact that it groups together, from an interdisciplinary perspective, various studies that generate knowledge, promote technological development and are committed to innovation which is fundamental for the industry's future.

I hope that this publication will prove highly useful for construction professionals, researchers, innovators and in short, for people interested in deeper exploration of issues in the complex world of building and construction.

Francisco Javier Medina Ramón
Director
Escuela Técnica Superior de Ingeniería de Edificación
Universitat Politècnica de València

Contents

Part I
Building Construction Management

Carmen Llinares-Millán

Abstract The construction industry is currently undergoing a process of change to adapt to the new market situation. In this scenario of change, management processes must be improved to boost competitiveness. This present chapter examines studies on these processes from a variety of perspectives.

From a strategic approach, the chapter identifies success factors for architectural practices and differences between project management systems.

From a process-centred approach, it looks at management models able to improve quality, reduce production times and minimise costs with examples of their application to building processes, ceramic coatings construction and C&D waste.

Finally, the chapter presents a person-centred approach, with examples of studies focusing on the worker, job promotion systems, experiences in architects' careers and the qualities a project coach should have. Users are also analysed in order to integrate their needs in the design process.

Stop Designing Architecture, Design Your Practice!

J. Lago-Novás

Abstract Contemporary practice has proven that design quality is not sufficient for success. Throughout architecture's history, there has existed the naive perception that best designs came from artists whose practice remained untouched by the imperatives of business. Most architects are entrepreneurs and designers who face business responsibilities without the right training. Architects must learn how to analyze business ideas, identify opportunities and consider marketing strategies at different stages of the design process.

But architects have all been taught similarly; this is design based, with very little or non-existent business education. When architects start their practice, they start straight away designing architecture without being aware that what they are starting is a business and therefore their first design should be their own practice. Getting management skills will help them not only to manage their businesses by understanding all stakeholders, but will help architects to learn how to earn opportunities to design.

The results shown in this article, proves through a ranking system, that a successful practice is well balanced among design excellence and business management awareness.

Keywords Management • Practice • Success • Architecture • Business

1 Introduction

Most architects start their practices by winning a competition or a commission straight away and without a business plan. This situation makes that 80 % of these practices close during the first 12 months. There is no other industry where the owner of the business starts it without having a business plan, without designing the business [1]. But there are various examples of successful practices that have proven that designing the practice as well as designing architecture is a successful business model without compromising any of both sides of the balance.

J. Lago-Novás (✉)
IE School of Architecture and Design, Eugenio Salazar 58,
28002, Madrid, Spain
e-mail: jlago@dscgroup.es

C. Llinares-Millán et al. (eds.), *Construction and Building Research*,
DOI 10.1007/978-94-007-7790-3_1,

There are measurable indicators of success that help to identify successful examples so that we can then analyse what these practices have in common so that we can define a design business model which is successful both for designing architecture and for designing the management processes of the practice.

1.1 Definition of success

In order to understand the analysis and classification of the data and ultimately understand the obtained conclusions, it is absolutely necessary to define what **success** in architectural practice means in this article: those practices that are able to generate and identify opportunities consistently to design architecture.

Without clients there is **no architecture**, and without excellent architectural design there is no possibility to attract the appropriate **clients**. Therefore, both are two faces of the same coin, both with the same importance; it's a true balance between talent and management.

1.2 Existing environment

The environment where architects operate has changed and we need to answer the challenges of this new environment in order to be successful. Change brings opportunities, and the practices that adapt best, will be the ones with more chances to be successful.

In the current economic environment, where the destruction of architecture companies are double of the ones in any other industry [2], is important to underline that there are architecture practices than not only are not going bankrupt, but they are even growing. They are growing thanks to the design of business and organizational models that have allowed them to grow in a sustainable way and be flexible enough to adapt to the changing and difficult scenario. Most of these practices are Anglo-Saxon, in particular, practices from the US, where design management processes where implemented years ago due to the fact that most of these practices started at the same time as the industrial revolution, and therefore they adopted those industrial production processes into the management processes of the architectural practice.

The lack of management education in the architecture schools makes it very difficult for architects to understand that success in architectural practice is a perfect balance between talent and professionalism, and sometimes one or other part of the balance is misunderstood and underestimated depending whom you speak with. These underestimations even make people to think that architects with lots of commissions compromise their architectonic quality or that architecture *artists* will inevitably go bankrupt due to their lack of business management awareness.

This lack of alignment between architectural quality and business management [3] makes that architectural practices with an amazing talent have to close due to

economic circumstances; and practices with great amount of commissions, due to the lack of talent, create uninteresting architecture objects.

2 Indicators of Success

There are various indicators that determine the success of an architectural practice. It's important to remember that these indicators are according to the definition of success mentioned at the beginning of this work. Therefore these indicators value: public recognition, recognition within the architecture sector, financial results [4] and operational results, all at the same level and with the same weight.

The indicators are divided in three families according to the following description and named with R and a number that you can then trace in Table 1:

- **A: R&D:** These indicators examine the design quality, innovation and the admiration inside and outside of the architecture industry. The indicators are:
  - Most admired to work in. (R1).
  - Most admired inside the sector. (R2).
  - Most admired outside the sector.(R3).
  - Most innovative. (R4).

These results come from a poll that was made among 200 people over the web, during January and February 2012. 100 were architecture professionals and 100 were "outsiders".

- **B: Marketing and Communication:** These are selected according to the implementation and success of their communication [5] and design strategies within their business and design plans translated into measureable figures. The indicators are:
  - Number of search results in Google. (R5).
  - Number of visits into their corporate web page. (R6).
  - Ranking at the Google PageRank. (R7).
  - Number of followers in facebook. (R8).
  - Number of followers in LinkedIn. (R9).
  - Number of followers in Twitter. (R10).
  - Number of videos in YouTube. (R11).
  - Number of prints on and off-line. (R12).
  - Number of awards. (R13).
- **C: Finance and HR.:** These describe financial, operational and human resources aspects. The indicators are:
  - Number of built projects. (R14).
  - Number of employees. (R15)
  - Number of non-architects employees (diversity). (R16).
  - Number of countries where they work. (R17).

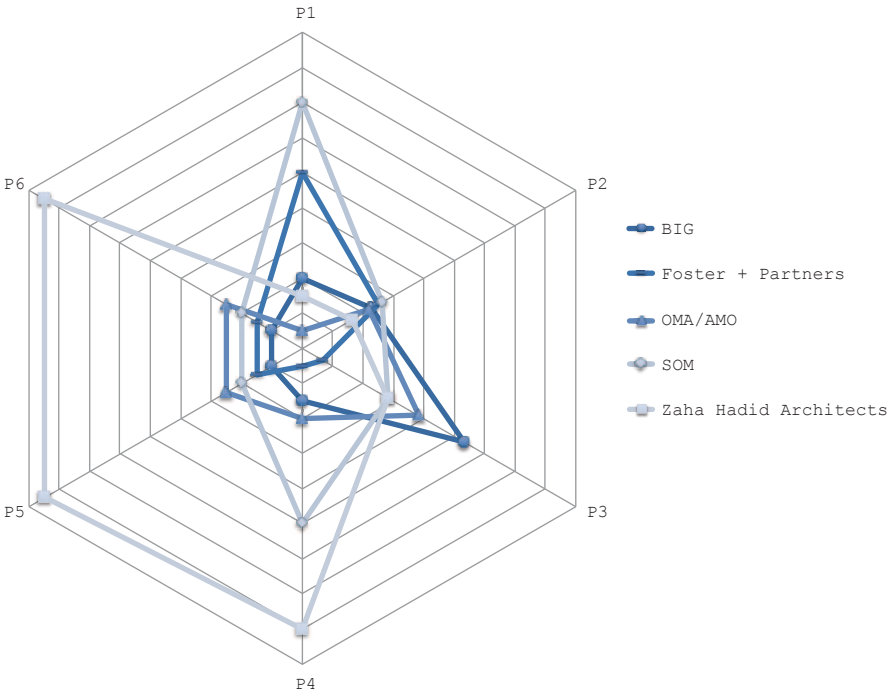

Fig. 1 Profiles according to indicators R1–R19

- Turnover. (R18).
- Profitability per employee: turnover/ number of employees. (R19).

Figure 1 shows the profile of five architecture practices according to the indicators mentioned above and divided according to: P1. Creativity. P2. Client focused. P3. Professionalism. P4. Collaborative. P5. Economically efficient. P6. Global

In Table 1 you can see the individual and global rankings of twenty top international practices according to the indicators of success described previously. R1 to R19 show each individual ranking from 1 to 20 among the offices that are shown in the first column. i. e. Aedas is ranked number 2 in R5, which is "Number of search results in Google". The last column "Ranking" represents the final ranking as an average of all other 19 rankings.

3 Conclusions

To be successful, practices have to be equally admired by their clients and within the sector. To manage to obtain this admiration, only practices that have designed their practices as well as their architecture manage to obtain both admirations. Like this,

Table 1 Individual and global rankings

	Estudio	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	Ranking
1	3DReid	20	20	20	12	18	19	18	18	13	13	18	18	12	17	14	13	20	9	9	20
2	ACXT	20	20	20	18	11	17	18	8	2	11	9	10	20	10	15	8	3	7	8	11
3	Aedas	20	20	20	15	2	11	1	6	3	6	3	17	15	15	1	1	2	3	16	7
4	Allies & Morrison	20	20	20	7	17	18	12	19	11	10	19	20	14	8	8	9	19	11	15	18
5	AS—Architecture Studio	20	20	20	9	19	9	12	20	20	20	20	15	18	20	11	14	7	11	11	19
6	BIG	4	8	11	4	6	6	1	3	8	1	7	3	11	13	7	18	18	9	2	5
7	Broadway Malyan	20	20	20	17	14	16	12	16	9	8	8	16	18	9	12	10	17	8	7	16
8	David Chipperfield Architects	1	6	20	6	12	13	1	4	12	20	15	7	7	5	5	16	9	11	10	8
9	Foster + Partners	10	1	1	10	4	5	1	13	4	2	6	1	1	2	6	3	4	1	3	1
10	Herzog & de Meuron	2	2	4	2	15	8	18	1	16	20	1	6	5	12	10	5	12	11	18	6
11	Jean Nouvel Ateliers	7	20	3	16	16	7	1	12	14	20	16	13	8	19	19	17	10	19	19	15
12	OMA/AMO	6	7	12	1	3	2	1	2	6	3	14	4	2	4	8	6	5	6	5	3
13	Populous Architects	20	20	20	19	20	20	1	15	10	5	17	18	15	7	3	15	6	5	1	12
14	Renzo Piano Building Workshop	8	4	20	13	10	4	1	14	20	9	10	14	6	18	20	12	14	20	20	13
15	RMJM	20	20	20	20	7	14	12	17	7	20	11	11	17	14	4	4	13	4	6	14
16	Rogers, Stirk & Harbour & Partners	11	5	10	8	13	10	12	9	15	12	13	12	9	3	17	11	15	11	14	9
17	Sauerbruch Hutton	20	20	20	11	9	12	12	11	20	20	12	8	10	11	13	20	16	18	13	17
18	Snohetta	5	20	20	5	8	15	1	10	17	7	5	9	12	16	16	18	10	17	12	10
19	SOM	9	3	13	14	5	3	1	5	1	20	2	2	4	1	2	2	1	2	4	2
20	Zaha Hadid Architects	3	9	2	3	1	1	1	7	5	4	4	5	3	6	18	7	8	16	17	4

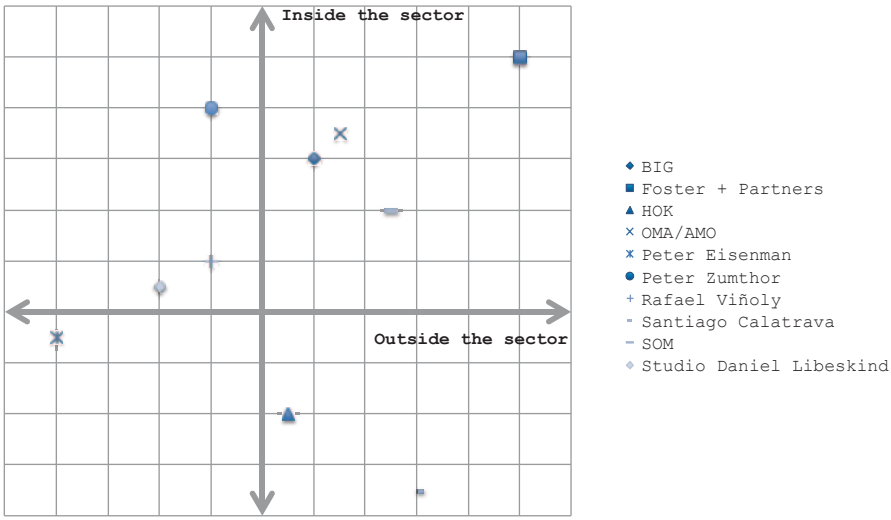

Fig. 2 Positioning-Admiration inside/outside sector

we can finally get, as you can see in Fig. 2, four different areas according to their profiles and how these practices consider as priority designing their practices as well as their architecture.

- **Top right quadrant:** admired inside and outside the architecture industry: most successful practices.
- **Bottom right quadrant:** admired outside the sector, has the risk to become unconsciously in a corporate architecture office, compromising their architectural quality.
- **Top left quadrant:** Admired mostly inside the sector, is a kind of profile that tends to disappear due to the fact that their peers are not their clients, and without clients is not a feasible company.
- **Bottom left quadrant:** not considered either inside or outside the sector: mediocrity or lack of adaptation will make them disappear.

To be successful and survive in such demanding environment, architectural practices have to be creative, client focused, professionals, collaborative, economically efficient and global [6].

Identifying and giving response to these new opportunities that arise, practices that have designed their practices have better chances to be able to do so than those just considering design as a word remained for *artists*.

References

1. Cramer, J. P., & Simpson, S. (2002). *How firms succeed* (p. 8). Atlanta: Greenway Communications, LLC.
2. US Bureau of Labour Statistics. (2011). *www.bls.gov*.

3. Elias, H. (2010). *Marketing your practice*. London: RIBA Publishing.
4. Emmitt, S. (2007). *Design management for architects*. Oxford: Blackwell Publishing.
5. Rauterberg, H. (2012). *Talking Architecture*. Munich: Prestel.
6. Van Assen, M., Van Der Berg, G., & Pietersma, P. (2003). *Key management models*. Harlow: Prentice Hall.

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.

P. Del Solar (✉) · M. Del Río
Universidad Politécnica de Madrid, Madrid, Spain
e-mail: patricia.delsolar@upm.es

C. Llinares-Millán et al. (eds.), *Construction and Building Research*,
DOI 10.1007/978-94-007-7790-3_2,

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.

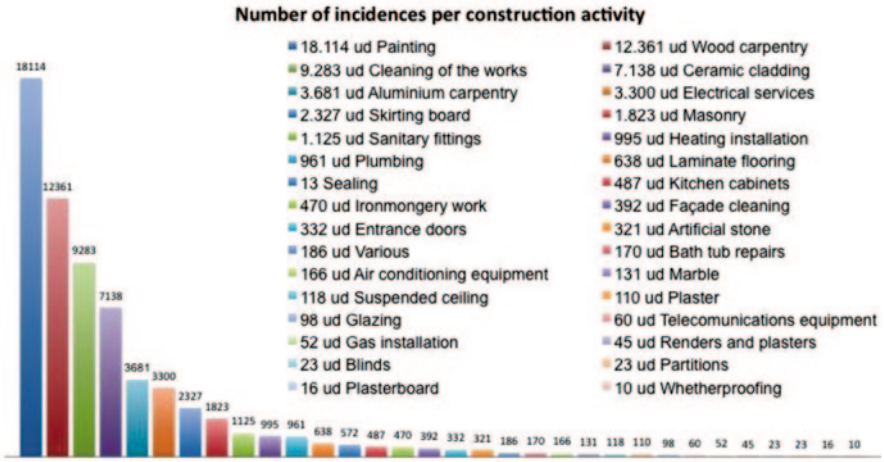

Fig. 1 Stratification historiogram of the number of defects per construction activity

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).

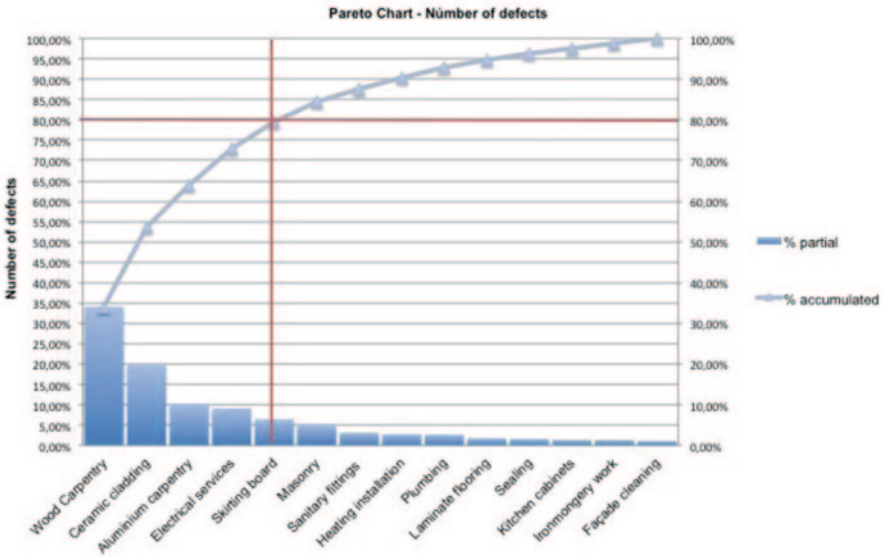

Fig. 2 Pareto Chart—Improvement projects prioritizing

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].

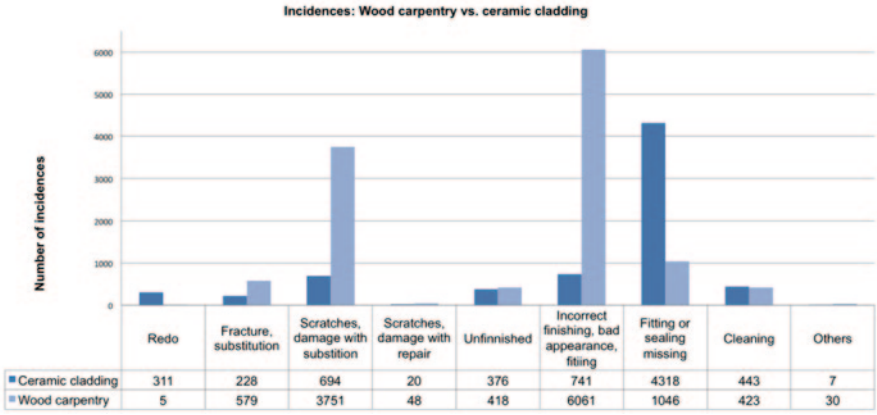

Fig. 3 Incidences in wooden carpentry and ceramic tile cladding

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.

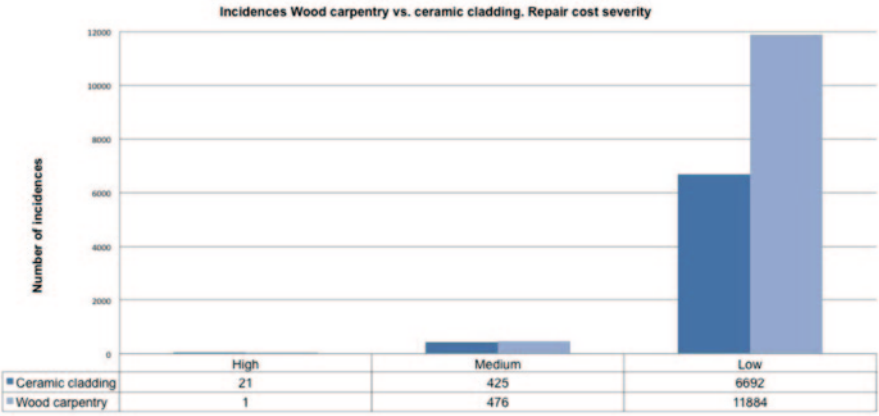

Fig. 4 Incidences in wood carpentry and ceramic coatings classified by repair cost severity

- 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.

References

1. Project Management Institut. (2008). Guía de los Fundamentos para la Dirección de Proyectos (Guía del PMBOK®). Cuarta edición. USA.
2. Membrado Martínez, J. (2002). *Innovación y mejora continua según el modelo EFQM de excelencia*. Madrid: Ediciones Díaz de Santos.
3. Juran. (1994). *Gestión de la Calidad. Mejora de la calidad en los servicios*. Madrid: AENOR.
4. Ishikawa, K. (1985). *¿Qué es el control total de calidad? La modalidad japonesa*. NORMA S.A. Traducción al castellano 1988.
5. Ishikawa, K. (1989). *Introducción al control de calidad*. Ediciones Díaz de Santos. Traducción al castellano 1994.
6. Del Solar, P., Del Río, M., & Palomo, G. (2010). Sistemas de Gestión de la Calidad. Actividades del proceso de mejora continua: Estudio y Análisis de los defectos de construcción en edificación de viviendas. II Congreso Nacional de Investigación en Edificación. Escuela Universitaria de Arquitectura Técnica. Spain: Universidad Politécnica de Madrid.
7. Chang, R., & Niezwiecki, M. E. (1999). *Las herramientas para la mejora continua de la calidad*. (vols. 1 y 2). Ed. Gránica.

Success Strategies for On-Site Waste Management in Spanish Construction Sites

P. Villoria Sáez, M. del Río Merino and A. San-Antonio González

Abstract There is a wide range of measures that can be implemented in the building construction sites and not all of them are equally effective in reducing construction and demolition (C&D) waste generation or improving its management.

Therefore, this research carries out a survey conducted among the construction stakeholders in order to evaluate the use and effectiveness of 13 measures aiming to promote the minimization and correct management of C&D waste. In addition, this study identifies the most suitable types of building constructions to implement these measures and the advantages and drawbacks of their performance in a building construction project.

Results of this study show that among the highly effective measures are the contract of suppliers managing the waste, the distribution of small containers in the working areas and the periodic checks, although only 50 % of respondents usually implement this measure in their works.

Keywords Construction and demolition waste • Waste management • Success strategies • Construction agents • Building construction

1 Introduction

The large-scale construction activities occurred in certain countries of the European Union (EU) have produced a vast amount of construction and demolition (C&D) waste inappropriately managed, as only 50 % of it is actually recycled, not reaching the quantitative target established for 2020 [1–3]. In an attempt to correct the serious consequences, several countries are developing specific legal frames for C&D waste management, to encourage prevention, reuse and recycling.

For the particular case of Spain, the Royal Decree (RD) 105/2008 [4] proposes the inclusion and development of a Waste Management Plan (WMP) for each construction project. This document should necessarily include a description of the best practice measures of reuse, valorisation or final disposal of the waste and the

P. Villoria Sáez (✉) · M. del Río Merino · A. San-Antonio González
Technical University of Madrid, School of Building Engineering, Avda. Juan de Herrera 6, 28040, Madrid, Spain
e-mail: paola.villoria@upm.es

C. Llinares-Millán et al. (eds.), *Construction and Building Research*,
DOI 10.1007/978-94-007-7790-3_3,

descriptions regarding storage, handling or any other managing operation of the C&D waste to be carried out on the working site.

Although all these measures have been implemented by EU countries, according to de Guzmán Báez et al. study, professionals are still reluctant to implement best practices [5]. There is a wide range of practices that can be implemented, but not all of them are equally effective in reducing C&D waste generation or improving its management. Therefore, the agents involved in taking a decision on the C&D waste management might have difficulties in opting for the more effective ones. For this reason, assessing such practices would help agents in making more effective management decisions.

Moreover, this situation has not only worried EU governments, but it has been of great interest for researchers in the field. According to [6] special attention to C&D waste management has been developed in recent years. Indeed, specific research within the construction sector has focused in optimizing waste management including quantifying methods of C&D waste generation, as Lu and Yuan claim [7]. Among these studies Solís-Guzmán et al. [8], Llatas [9] and Villoria Saez et al. [10] can be highlighted. Furthermore, specific works on best practices in C&D waste management have also been of interest to many authors [11–13]. Other researchers have focused their analysis on causes influencing C&D waste management on site [14, 15]. Both studies have identified several critical success factors for the C&D waste management; i.e. the limited number of areas in which results—if satisfactory—will ensure successful competitive performance.

Although research on C&D waste management in Asia has been widely conducted, little attention has been paid to best practices of C&D waste management in other geographic areas such as in the EU. The knowledge of C&D waste management developed in one geographical area is not easily adapted and applied to other areas without considering their contextual differences [16]. Therefore, the main goal of this paper has hence been to identify the most commonly used waste management strategies and to assess their efficiency and viability, determining advantages and drawbacks. To this end, a questionnaire has been performed to the stakeholders intervening in the construction process.

2 Methodology

The research methodology presented here is used to identify the effectiveness of C&D waste management strategies [17]. Therefore, the steps used for identification of the success measures are: identifying a full set of selected strategies; conducting a survey to investigate each strategy importance; calculating each index value based on the survey data; and analyze the data obtained.

From the body of literature covering C&D waste management [18, 19], a total of 13 strategies for successful on-site C&D waste management were identified:

1. Contract providers to manage waste products [12].
2. Planning the number and size of containers needed for each activity [20].

3. Register the quantities and characteristics of the waste that comes from the construction work and control it [21].
4. Carry out periodic checks on the use of containers of C&D waste [21, 22].
5. Follow the plans of the project to prevent carrying out unexpected chases or holes [16].
6. Perform an on-site segregation of each waste category [12, 20, 21].
7. Respect the instructions of the manufacturer in the collection of material [21, 23].
8. Give talks for operators in the field of waste management [12, 16].
9. Distribute small containers in the working areas to facilitate the segregation of the different types of waste [21].
10. Reduce excess of ordered material to avoid fracture of it [20, 21].
11. Buy materials avoiding unnecessary packaging [20].
12. Planning coordination and review meetings about C&D waste [22].
13. Use shredder machines or compactors in the worksite for the C&D waste [15].

Moreover, an online questionnaire has been conducted to collect opinions of these best practices. In this sense, respondents were invited to evaluate the previous 13 strategies selected, in terms of their effect and viability. The level of importance was measured on a 5-point scale, where 5 denoted very efficient and 1 insignificant.

The questionnaire was conducted from January to February 2012 and consisted of a total of 82 questionnaires distributed by e-mail to the construction agents in Spain, who were randomly selected from the target population of contractors. During the survey, the following strategies were taken to ensure a high response rate: e-mailing and phoning each construction agent prior to the distribution of the surveys asking for their acceptance in participating and sending reminders every two weeks. A total of 58 valid responses have been obtained, reflecting a response rate of 70.73 %.

Finally, to evaluate the relative effectiveness or importance of the measures analyzed, an index value for each strategy has been calculated using Eq. 1.

$$I_x = \frac{\sum_{y=1}^{5} N_{xy} V_y}{\sum_{y=1}^{5} N_{xy}} \quad (x = 1, 2, \ldots\ldots n;\ y = 1, 2, 3, 4, 5) \tag{1}$$

where:

I_x is the index value of the strategy effectiveness.
V_y is the mean value appointed by the agents of each strategy ($S_1 = 1, \ldots, S_5 = 5$).
N_{xy} is the number of agents that chose the y^{th} value (V_y) for the x^{th} strategy.

Equation 1 has been widely adopted to identify the relative importance of factors/variables by calculating their importance index values and it has been used to calculate the index value of each strategy in this paper [12, 15, 24]. The strategy measures selected were then ranked according to their index value score. This analysis has led to part of the conclusions which have given rise to the conclusions of this paper.