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AN ANALYTICAL APPROACH FOR ASSESSING THE CONSTRUCTION AND DEMOLITION WASTE IN CONSTRUCTION INDUSTRY BY USING STANDARD PRACTICES

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ABSTRACT

C&D waste is a remarkable waste stream, the wide measure of waste expand from the consequence of expanding construction, maintenance, retrofitting and demolition activities in India. It is evaluated that in India the construction firm produces around 18 million tons of waste every year. This makes huge difficulties regarding space for disposal, unapproved dumping, blending with biodegradable waste, and so on. Presently the construction and demolition (C&D) waste accumulation framework in India is overseen in a decentralized way by each sub-contracted organization. This absence of inclusive approach for C&D waste management causes confusing and in some cases singular state of mind in regards to the different measures for C&D waste. Therefore active waste management should be enforced. Construction stakeholders have wide range of best applications in C&D waste administration that can be implemented, so they should be assessed for their effectiveness. This research study aims to assistance the construction stakeholders in making a decision on C&D waste management. This paper brings out a survey accompanied among by the construction managers and agents in directive to calculate the effectiveness of 24 standard practice measures in respects to C&D waste administration, recognizing the most suitable types of construction projects to implement these applications and also the benefits and drawbacks of their implementation in a construction project. Results of this study show that among the highly effective best applications are: the usage of industrialized frameworks and the contract of suppliers managing the waste. In addition, small containers are providing in the work spaces is also another high valued application, although only 44% of respondents frequently appliance this measure in their works.

Key words: Construction & Demolition waste; Standard practice; Waste management; Construction stakeholders; Survey.

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1. INTRODUCTION

In India from past decades wide-ranging construction events are occurred and it produced a major quantity of construction and destruction waste (CDW). According to the Technology Information, Forecasting & Assessment Council (TIFAC), the total volume of waste generated in 2015 was around 18 million tons mentioned in TIFAC. While the activity has now arrived in a decay phase, due to the economic downward and the change in the productivity cycle, complications are caused by such waste, or slightly, by its organization requisite to be addressed and deliberated in depth.

When huge construction started wisely in both the government and private sectors are started constructing innumerable projects like government buildings, ventures, infrastructure, and profit-making buildings. Construction and destruction waste management (CDWM), a critical element towards sustainable development as metropolitan, includes separation, storing, collection, and rearrangement, carry age, treating, and discarding of destruction waste to decrease its adverse influence on environment. Unmanaged CDW becomes an aspect for promulgation of innumerable infirmities.

Construction waste generation has been recognised as a foremost issue due to its direct influences on the environment as well as the efficiency of the construction industry. A study accompanied by Ameh and Daniel (2013) found that payable to the material wastage on an average 21–30% of budget overruns ensued in building projects. Similarly, a least priority is allocated to the construction waste management and frequently limited resources and motivations are made accessible to assist waste management (WM) practices.

As a consequence of waste generation, contractors have to bear loss of profit due to the contribution of additional overhead budgets and postponements; loss of productivity due to the additional time participation for vacuuming; and substantial waste discarding costs. Similarly the commitment for waste production is often handed to subcontractors who have to evaluate the quantity of budget and time attendant with waste production through bid the tender. However, Guthrie et al (1995) stressed that it is likewise a burden to the client; since the client in the end needs to endure the cost related with WM. Manowong (2012) found that clients realize that construction WM as minor priority than profit growth and regarded WM as an activity which contributes strongly to project expenditures. Since profit growth is the main objective of industries, they are hesitant to implement environmentally friendly practice measures in the direction of WM except they are gainful.

Mincks and Johnston (1995) argued that a wrong statement subsists among construction consultants that time consumed in managing construction waste is a loss of productivity and pointy out that WM consider as a profitable venture in the construction firm. Construction and destructive waste production not only has cost implications for treatment processes but also consumes valuable land due to dumping deeds. Moreover, the industry can't keep on practicing if the ecological assets on which it depends are drained. In this way, the significance of WM desires to be agreeing in directive to encourage stakeholders to

accomplish aims associated to WM. Regardless; the quantity of waste production differs from country to country liable on the financial and social individualities of a country, explanations used to-classify waste and filling the data in record methods. Likewise, the powerful usage of WM designs is influenced by the similarity of WM designs with the real circumstance.

For the particular case of Spain, the supplement and Development of a waste management model for every construction venture which should include the demonstration up of:

- A waste management report (WMR), is developed during the designing phase of the construction project.
- A waste management plan (WMP), is developed through the forecasting stage of the building work.

These documents should necessarily contain an explanation of the Standard practice (SP) measures of reuse, final disposal of the waste and the explanations regarding storage, treatment or any additional managing operation of the C&D waste to be carried out on the working site.

Besides, specific works on SPs in C&D waste management have also been of curiosity to many authors. Regarding these Standard practices, the research study by Osmanie et al. (2008) exposed architectures assumed that waste is mostly formed through site operations and infrequently produced during the design phases. Though, about 33% of building waste basically rises from design results, as this study stated.

Tam (2008) has done research the capability of the performance of current WMP waste management plan system in Hong Kong. In this study, the foremost aids gained in waste decline and waste separation is the proposed methods for in-site reuse of materials. In the conclusion, the usage of prefabricated modules is measured as the foremost measure to inspire waste reduction.

Other researchers have concentrated their analysis on reason's influencing C&D waste management on site, e.g. Yuan et al. (2011) and Wang et al. (2010). Both studies have recognized innumerable critical achievement factors for the C&D waste management; i.e. the limited sum of zones in which results – if acceptable – will confirm successful competitive performance.

Although research on C&D waste management in Asia has been extensively conducted, little attention has been paid to SPs of C&D waste management in other geographic areas. 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 (Lu W, 2010). In this sense, although the fact that the SPs analysis are set in a Spanish perspective, there is lack of inclusive research to discover solutions for construction waste production in India. This research study aims to determine (best application) Standard practice measures to eradicate and/or reduce waste generation in construction projects in India. Results of this research study afford worthwhile inputs for Conclusion making practices around construction WM.

2. OBJECTIVES

- Identify the most normally utilized 24 Standard practice measures in respect to C&D waste administration.

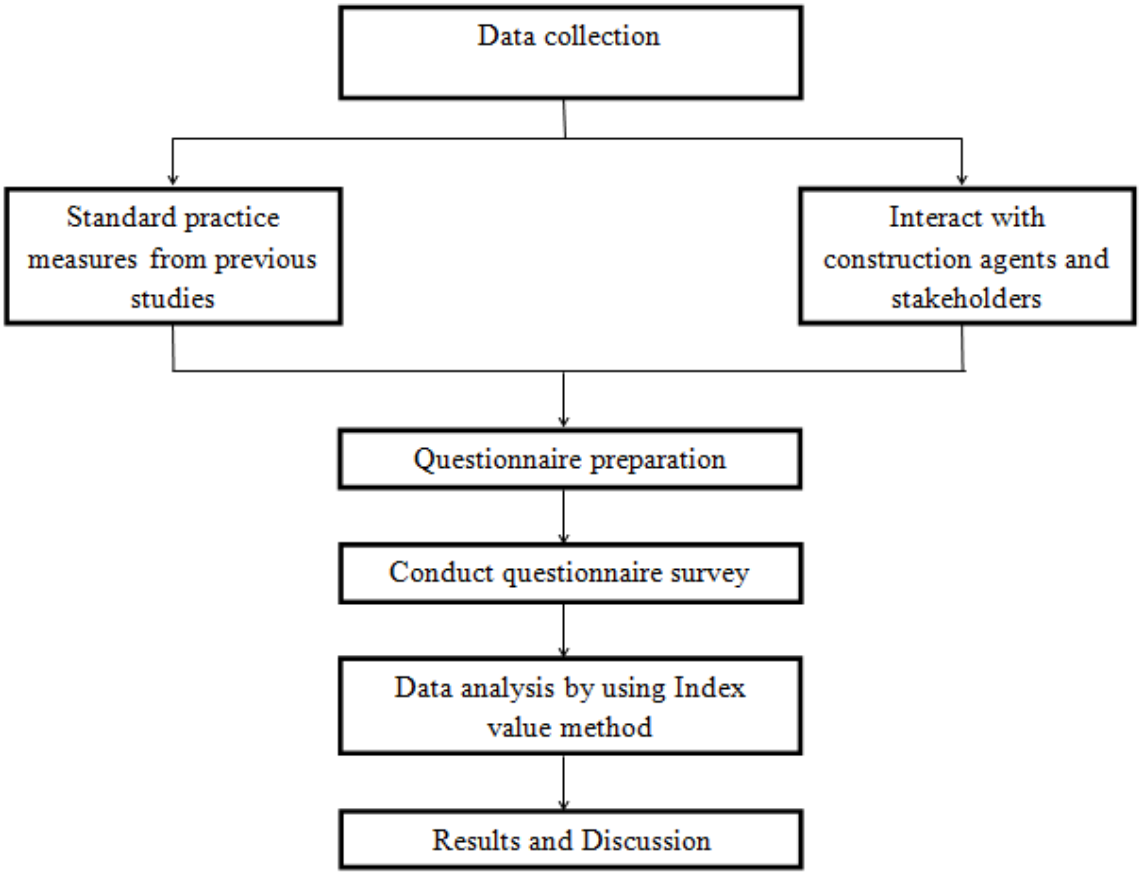
- Analyse the suitable construction project type on which SPs be implemented by using index value method.
- Perform a questionnaire survey to the agents & stakeholders.

3. METHODOLOGY

Based on various researches survey studies to identify several accomplishment factors in C&D waste, the research survey methodology presented here is used to identify the efficiency of the Standard practice measures. In the sense, the index value is used to measure the major significance of each SP analysed. Therefore, the steps used for identification of effective SPs for C&D waste management are:

- Identifying a complete set of a selection of SP's.
- Investigate on each Standard practices (SP) importance by conducting questionnaire survey.
- Based on the questionnaire survey data calculate each index value; and analyse the obtained data.

Flow Chart of Methodology



3.1. Selected Standard practices for C&D waste management

From the investigation of stakeholders at construction site and previous literatures covering C&D waste management this study identified a total of 24 SPs for successful C&D waste management; 9 of them regarding the design phase of the construction process Table (1) and 15 during the construction stage Table (2).

3.2. Standard practices of questionnaire survey

For the scientific research surveys are very helpful research tools to get the data of prime sources using well planned questionnaire achieving reliable specific information. The questionnaire methodology suggests a descriptive analysis data, which can be statistically preserved to improve the consistency of the survey analysis.

In general questionnaire surveys are well accepted research methods. In this study, a questionnaire through online has been reflected as the most suitable modality for the following reasons:

- Effectiveness: E mails are the most effective tools are used between the stakeholders and agents involved in the construction process.
- Confidentially: Due to the topic addressed, it has been necessary to ensure, the anonymity of the people questioned.
- Questionnaire length: This questionnaire survey affords better flexibility concerning other modalities, i.e. the respondent has time to improve and review their replies, as well as to look up before answering any questions. On the other hand, the survey passed out to persons with whom it is hard to continue a lengthy telephone discussion or assemble a personal interview, as they are not available.

Special care desires to be paid on the questionnaire drawing up, preliminary the aim of the questionnaire survey into applicable questions. The huge mainstream of the questions asked in this survey are closed reviews, as they more effective and ability the additional data analysis.

The survey accompanied to collect opinions of these SPs reveals in two parts. The first part was considered to collect the information of about respondents, such as their experience, type of enterprise and training in C&D waste topic. Determining these kinds of variables allows obtaining groups for comparisons so as to interpret the different answers collected. In the second part, invite the respondents to evaluate the 24 SPs measures selected, in terms of their effectiveness and feasibility. For these questions, the grading scale used has been the well-established. The level of importance was measured on a 5-scale, where 5 denoted very good, 4 quite good, 3 moderate, 2 slightly, 1 poor.

Table 1 Selection of Standard practice measures (Design stage)

No.	Stage	Standard practice
D1	Design	Plan to utilize the reusable waste materials in the same construction site.
D2	Design	Detect the activities in construction that can allow reusable materials from the construction.
D3	Design	Provide a free space in construction site for the correct Construction & Demolition waste management.
D4	Design	Use prefabricated or modular systems that generate limited waste.
D5	Design	To decrease the quantity of raw materials usage by optimizing the design sections and as significance the Construction & Demolition waste generation.
D6	Design	Use the constructive systems which favour the separation of their elements at the peak level of their useful life.
D7	Design	Use the raw materials which have high content of recycled material.
D8	Design	Plan to follow the 4R's Principle (i.e. reduction, reuse, recycling and recovery) at suitable stages of each activity.
D9	Design	Plan to utilize the artificial raw materials than the naturally available materials.

Table 2 Selection of Standard practice measures (Construction stage)

No.	Stage	Standard practice
C1	Construction	Contract providers to manage their products Waste.
C2	Construction	Plan the size and count of containers needed for each activity.
C3	Construction	Provide register to note the quantities of Construction & Demolition waste and Control them.
C4	Construction	Carry out periodic inspections on the use of Construction & Demolition waste containers.
C5	Construction	Follow the project designs to stop Carrying out unexpected chases or holes.
C6	Construction	Separation of each waste category is performed on-site.
C7	Construction	Respect the directions of the manufacturer in the gathering of waste material.
C8	Construction	Distribute the small containers at the working sites.
C9	Construction	Decrease the surplus of ordered material to avoid Breakage of material at the worksite.
C10	Construction	Avoid buying the unnecessary packing materials.
C11	Construction	Use compact machines in the worksite for the Construction & Demolition waste.
C12	Construction	Coordination should be planned and review meetings about Construction & Demolition waste.
C13	Construction	Give command to the operators in the field of waste management.
C14	Construction	Project manager should interact with all the operators in the field of waste management.
C15	Construction	Using of building waste for filling purpose at construction site.

The full survey was accompanied from December 2017 to February 2018. The survey sample contained of an overall of 90 questionnaires circulated by electronic mail to the construction agents were randomly choose from the target people.

Throughout the survey period rate: E-mail & phone calling each construction agent preceding to the circulation of survey requesting for their accepting in participating and sending remainders every one week.

Later the replies were received the following criteria were used in instruction to select the valid replies:

- Unfinished surveys were erased from the study.
- Don’t know or unanswered results were erased from the study.

Considering the previous criteria, a total number of 63 useable responses have been reached, According to base research study 69% of response is measured acceptable; therefore the response rate for this survey is totally valid.

3.2.1. Types of construction projects

These are the types of construction projects where SP is implemented with greater feasibility and effectiveness

- Detached house, semidetached house and row houses
- Construct buildings in height <10 floors
- Construct buildings in height 10-30 floors
- Construct buildings in height 30-50 floors
- Construct buildings in height >50 floors

3.2.2. Advantages of SP implementation

- Major advantages in bids
- Raising staff awareness
- Cost variation after using recycled
- Saving raw materials
- Improvement of C&D waste management
- Reduce legal sanctions
- Improvement of the company image
- 4R's principle effectiveness
- How much advantage in budget

3.3. Data calculating and analysis

To calculate the relative effectiveness or significance of the SPs analysed, an index value for each SP has been calculated using Eq. (1). This equation is reference from Paola V and Mercedes del rio M (2013).

$$I_x = \frac{\sum_{y=1}^{5} N_{xy}\, V_y}{\sum_{y=1}^{5} N_{xy}} \ (x = 1,2, \dots .; y = 1,2,3,4,5)$$

Where:

- I_x is the index value of the SP measure effectiveness.
- V_y is the mean value chosen by the agents of each SP (S_1=1,…..S_5=5)
- N_{xy} is the sum of construction agents that selected the y_{th} value (V_y) for the x_{th} Standard practice.

Calculating index value for Design stage question of D1 is

$$I_x = \frac{(10 \times 5) + (01 \times 4) + (08 \times 3) + (03 \times 2) + (01 \times 1)}{22} = \frac{84}{22} = 3.818 \ \approx 4.0$$

Calculating index value for Construction stage question of C1 is

$$I_x = \frac{(16 \times 5) + (15 \times 4) + (06 \times 3) + (03 \times 2) + (01 \times 1)}{41} = \frac{165}{41} = 4.024 \ \approx 4.0$$

Eq, (1) is generally adopted to calculate their significance of index values for identifying the relative importance of factor/variables and it is used to calculate the index value of each SP analysed in this study.

By calculating the questionnaire survey results according to their index value score selected SPs were then ranked. This analysis has prompted to some part of the conclusion which, joined to the theoretical framework studied. Have given rise to the conclusion of this study.

Identifying all the SPs determined by the managers & agents in the waste management plans and reports is essential, and also, representing the feasibility and effectiveness of SPs

are important. In this regard, two categories of SPs have been distinguished: persons in the design stage of the structure and persons during the construction stage.

4. RESULTS AND DISCUSSION

4.1. Arrangement of the questionnaire survey respondents

The Arrangement of the questionnaire survey respondents were agents from: 35% from design stage and 65% from building stage. After the total sum of valid replies nearly 76% had good experience in newly constructing buildings whereas 24% worked mainly in rehabilitation or demolition works. In addition, respondents were invited to assess their experience and training regarding C&D waste management on a 5-point scale, where 5 denoted very high efficiency and 1 denotes very poor efficiency. Results display an average value of 3.5, which is medium-high knowledge.

4.2. Standard practice measures assessment

In the results analysing, only replies from the agents who are working in design stage have been measured, as they working at this stage and who can carry out SPs through the stakeholders in the building stage, both agents from design stage and building stage ones - were requested to rate the on-site SPs from 1 to 5, in this sense, the assessment of the two types of stakeholders were to curiosity, because both of them have to regulate the Construction stage SPs in their necessary management documents - In the design stage the agents should determine SPs in the waste management report and implementation of SPs in the WMP waste management plan.

4.2.1. Standard practice assessment during the design stage

Significant if the agents in design stage commonly use SPs in their projects has been considered a main factor. Outcomes presented that stakeholders in the design stage normally used SPs as to forecast the utilization of reusable waste materials in the same working site, and to establish an area in the work site for the correct collection of the C&D waste produced (Table 3) However, less than half of the respondents use prefabricated elements in their projects (41%) and even less than 10% those who use products with a high content of recycled materials (9%), despite being a measure that significance minimizes the generation of C&D waste according to the previous literature review studies analysed from (Osmani et al., 2008; Lu and yuan, 2010).

Table 3 Index value calculation for each SP analysed in the design stage

No.	Standard practices during the design stage	%[a]	Assessment (Me)	I_x
D4	Use prefabricated or modular systems that generate limited waste.	41%	4.50	4.409
D1	Plan to utilize the reusable waste materials in the same construction site.	64%	4	3.818
D8	Plan to follow the 4R's Principle (i.e. reduction, reuse, recycling and recovery) at suitable stages of each activity.	18%	4	3.636
D3	Provide an area in work site for the correct Construction & Demolition waste management.	54%	4	3.545
D2	Detect the activities in construction that can allow reusable materials from the construction.	36%	3	3.181
D6	Use the raw materials which have high content of recycled material	9%	3	3.045
D7	Use the constructive systems which favour the separation	27%	3	3.000

	of their elements at the peak level of their useful life.			
D5	To decrease the quantity of raw materials usage by optimizing the design sections and as significance the Construction & Demolition waste generation.	31%	3	2.818
D9	Plan to utilise the artificial raw materials than the natural materials.	22%	3	2.750

Only design stage respondent's results.

[a] Percentage of respondents which usually implement SPs Respondents of the design stage can select more than one SP, and therefore, the sum of percentages can exceed 100%.

Ultimately SPs usually implemented by the agents in the design stage aim at the correct management of the C&D waste within the construction site, as opposed to the ones who aiming in the direction of a minimization of their generation.

In addition to defining the customary SP implemented by the agents in the design stage, agents estimated them regarding their effectiveness and viability. From the mean assessment chosen by the agents for each SP, the index value (I_x) has been reached using Eq. (1) (Table 3). In short, considering a space in the construction site for the C&D waste and the soil remains management, as well as the use of prefabricated system, can be highlighted with an I_x value and average exceeding 3.4 and 4 respectively. This means that these SPs tend to be medium-high effective measures.

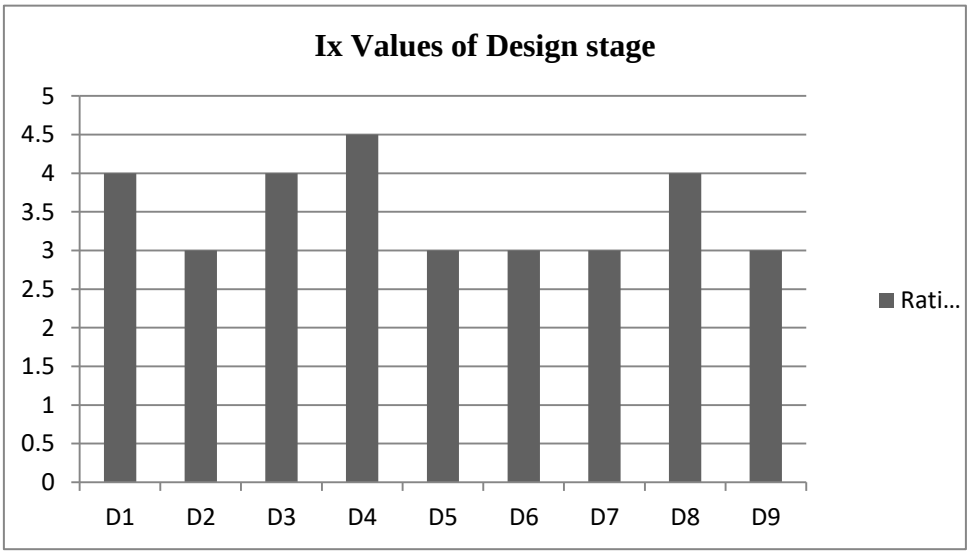


Figure 1 Index values of the Design stage SP measures

Furthermore, using construction products with a high content of recycled materials is considered an average or acceptable measure (I_x>3) and only 9% of the surveyed agents usually implement it (Table 3). This fact is possibly due to the lack of legislation setting out recommendations and technical specifications covering the valorisation of C&D waste to be used as alternate raw materials for new construction products.

4.2.2. Standard practice assessment during the construction stage

Regarding SPs second category – during the construction stage – Table 4 displays the results of the common construction stage SPs according to the surveyed stakeholders, which refers mainly to recruiting suppliers to manage waste products (63%) and to plan the number of containers and size needed for each activity (56%).

From the results, it is essential to mention that only 51% of respondents claim to have carried out periodic checks on the use of C&D waste containers or controlling and registering the quantities of waste leaving the work site. Moreover, results on Table 4 display that around 44% of construction agents do not practice source separation.

Table 4 Index value calculation for each construction stage Standard practice analysed.

No.	Construction stage Standard practice	%[a]	Assessment (Me)	I_x
C1	Contract providers to manage their products Waste.	63%	4	4.024
C6	Separation of each waste category is performed on-site.	44%	4	3.780
C9	Distribute the small containers at the working sites.	36%	4	3.487
C4	Carry out periodic inspections on the use of Construction & Demolition waste containers.	51%	3.50	3.439
C12	Avoid buying the unnecessary packing materials.	29%	3	3.392
C2	Plan the size and count of containers needed for each activity.	56%	3	3.208
C15	Using of building waste for filling purpose at construction site.	34%	3	3.242
C3	Provide register to note the quantities of Construction & Demolition waste and Control them.	51%	3	3.174
C11	Coordination should be planned and review meetings about Construction & Demolition waste.	29%	3	3.146
C8	Project managers should enhance the site engineers of about managing waste at site.	36%	3	3.086
C7	Respect the directions of the manufacturer in the gathering of waste material.	39%	3	3.044
C13	Use compact machines in the worksite for the Construction & Demolition waste.	17%	3	3.142
C5	Follow the project designs to stop Carrying out unexpected chases or holes.	46%	3	3.242
C10	Decrease the surplus of ordered material to avoid Breakage of material at the worksite.	31%	3	2.735
C14	Give command to the operators in the field of waste management.	29%	3	2.975

[a] Only construction stage respondent's results.

Agent's percentage of respondents which usually implement SP. Construction stage respondents can choice more than one SP, and therefore, the summation of percentages can exceed 100%.

Table 4 displays the assessment done by the surveyed agents and the index value acquired for each SP valued using EQ. (1).

In contrast with the significant factors specified in Begum et al. (2009) study, Respondents highlighted – with $I_x>4.0$ – the contracting of suppliers to manage their products waste. This means that it tends to be high effective measures. In addition, SP such as: Separation of each waste category is performed on-site, distribute the small containers at the working sites, Carry out periodic inspections and planning the size and count of containers required, are valued as medium-high effective measures ($I_x\geq3.0$).

In particular, distribute the small containers at working sites is a well valued measure; yet only 36% of respondents implemented this measure in their works consistently (Table 4). Moreover, between the results, the stakeholders & agents positively valued - $I_x>3.0$ – periodic

controls of waste containers and of the generated C&D waste quantities, although only 51% of those surveyed usually perform these checks (Table 4).

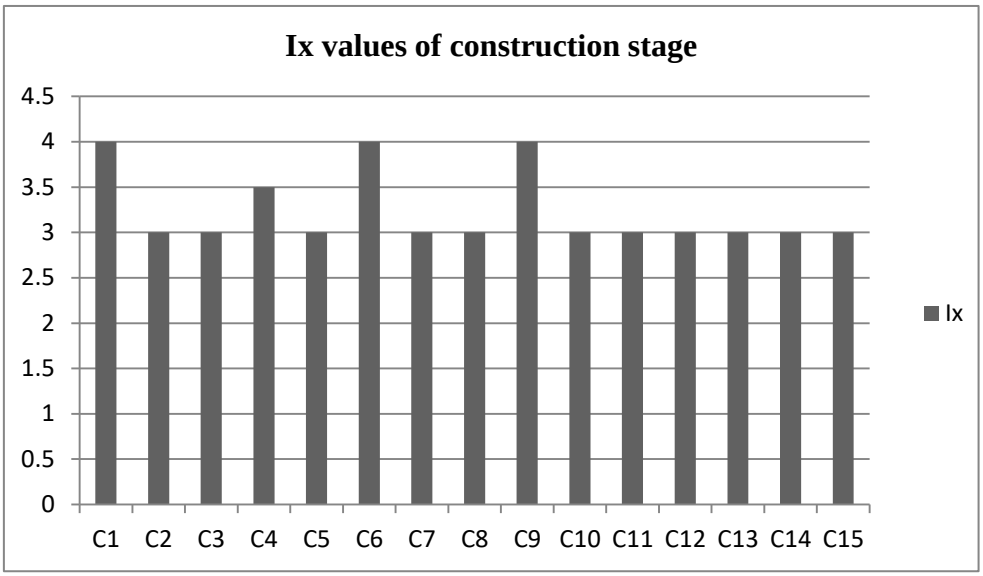


Figure 2 Index values of the Construction stage SP measures

4.3. Implementation of SP measures as regards the type of construction project

Nearly 76% of survey respondents, both in the design and construction stage, consider the type of construction project as highly determining factor when implementing SPs. In particular, respondents do more easily implement SP in construction works of detached houses and construct buildings in height > 50 homes, rather than other types of constructions, as exposed in Table 5.

Unique construction works are the main answers described by respondents in the "other" options. This is perhaps due to their greater economic margin, and because these projects are normally built in the city outskirts where space enough can be provided for a correct collection and segregation of C&D waste (Table 5).

Table 5 Types of construction projects where SP is implemented with greater feasibility and effectiveness

Types of construction works	Construction agents [a] (%)	Design agents [a] (%)
Detached house, semidetached house and row houses	39%	45%
Construct buildings in height <10 floors	15%	32%
Construct buildings in height 10-30 floors	44%	18%
Construct buildings in height 30-50 floors	29%	27%
Construct buildings in height >50 floors	44%	50%
Other	12%	0

Agent's respondents can choice more than one answer, and therefore, the summation of percentages can exceed 100%.

4.4. Advantages and drawbacks of implementing Standard practices

Fig. 3 signifies the value of the intermediate for every possible advantage of implementing SPs in the construction works. Values were recognized in a point scale by all the agents

surveyed (in the design and construction stages): 1 indicated that the established option does not improve the C&D waste management in the work site, and 5 meant that the SP highly improves it.

Surveyed stakeholders and agents pointed out that the chief advantages arising from the implementation of SPs in the companies are; improving the company image, it committed with the environment and improving the on-site C&D waste management, the saving of raw materials and raising staff awareness, for the above choices, the median reached a value ≥4.

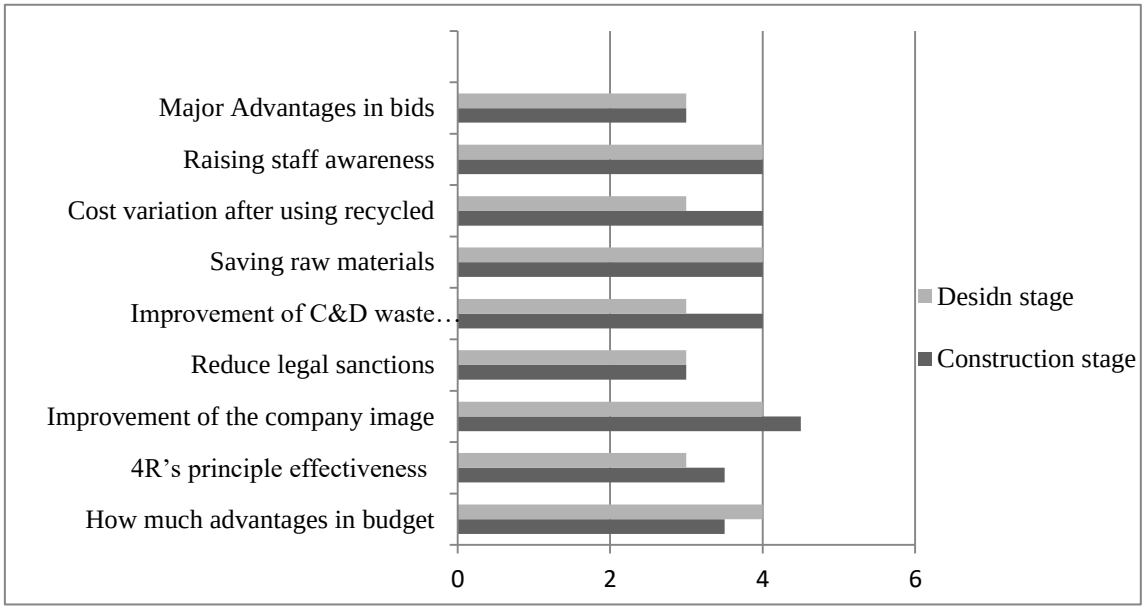


Figure 3 Advantages of SP implementation.

In addition, respondents determined that the submission of SPs contributes to certain extent (Value of the median ≤3.75), to decrease the economic cost to obtain greater advantages in bids, and reduce legal permissions. This result approves with the (informe entorno and Fundacion Entorno, 2009), which conditions that reducing legal permissions in the construction sector is not considered a main driving factor to adopt environmental policies.

Finally, comparing the result obtained in the design stage with those in the construction stage (Fig. 3), the final considers more positive the presentation of these SP, because probably the design agents are unaware of how these can improve the waste management in the working site, particularly reducing legal permissions.

On the other hand, when they were requested to deliver their opinion on the major drawbacks in implementing SPs, all the answers obtained can be classified into the following issues;

- Financial: the extra costs for a greater vigilance and regulator for its implementation due to lack of awareness of agents that get involved in the process. Ultimately, the need of a person just dedicated it.
- Time: more time devoted to sorting out waste, which conditions the work plan schedule.
- On site space: lack of space to locate the different types and varieties of waste containers.
- Increase of administration: extra paperwork i.e. filing control forms, and inspection reports.

The assessment accomplished in this paper suggests a detailed knowledge of the effectiveness and feasibility of each of SP studied. The methodology provided can be applied to obtain new assessments for other particular areas with other index values, representing their specific characteristics.

From the analysis implemented in this study the following conclusion can be presented:

- The drafting of principles should be highlighted resting down technical recommendations for the usage of new recycled materials in construction, as only 8% of the surveyed agents recognized the usage of recycled materials, despite it being a measure that suggestively minimizes the C&D waste.
- Through a sequence of analytical process, this research recognized the following 3 effective SPs during the design stage: (1) Use prefabricated or modular systems that generate limited waste, (2) Plan to utilize the reusable waste materials in the same construction site. (3) Provide an area in work site for the correct Construction & Demolition waste management.
- Moreover, 5 effective on site SPs have been recognized: (1) Contract providers to manage their products Waste, (2) Separation of each waste category is performed on-site, (3) Distribute the small containers at the working sites, (4) Carry out periodic inspections on the use of Construction & Demolition waste containers, and (5) Avoid buying the unnecessary packing materials. The distribution of small containers in the work areas is the third best valued measure (I_x=3.487), while only 36% of respondents applied this measure commonly in their works.
- Detached house constructions and construct buildings in height more than 50 floors, are the two kinds of dwellings where it is easier to implement SPs rather than other type of construction projects.
- The main advantages of implementing SPs are: improving both the company image and onsite Construction & Demolition waste management, while saving natural materials and Raising staff awareness about WM.

The SPs assessment advanced in this paper, emphasizing their effectiveness as well as their advantages and drawbacks, can help construction stakeholders and agents to make a conclusion between the widespread of possible C&D waste measures, ensuring a sustainable waste management procedure throughout the construction process and promoting nil waste generation buildings.

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