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IMPLEMENTATION WASTES IN CONSTRUCTION

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ABSTRACT

The history of investigation on waste mainly revolves around the recycling of the waste, reusing the waste materials, and the effect of waste on environment. No considerable studies have dealt with the identification of the causes of waste. In the present study, the development of waste has been categorized in three groups of 1. Waste due to designing, 2. Waste due to implementation, and 3. Waste due to utilization. This study focuses on the waste due to implementation. It provides a redefinition of construction waste. Overpopulation and the decrease of resources require a correct and wise use of them. In all countries, a huge amount of the national capital is devoted to construction that signifies the importance of investigations on waste to minimize it in the construction projects. The present study aims to introduce the causes of waste, and to present a checklist to control and minimize it.

Keywords: waste, implementation standards, resource losses.

1. INTRODUCTION

The present study investigates the various reasons and factors of causing waste in construction and building projects. Waste management can be taken into account in two different levels: first, through managing those factors that cause waste, and second, through managing the wasted materials by reusing or recycling them, and studying the effect of these materials on the environment. The factors of causing waste are divided into three categories: 1. Waste due to designing, 2. Waste due to implementation, and 3. Waste due to utilization. This study particularly deals with the wastes due to implementation that stand among the first level wastes. The wastes due to design and utilization have been undertaken in another study. Identifying the causes of waste can lead us to codify policies to prevent them. Nowadays, the optimized use of the resources, and the selection of the best option is the most important activity of the construction managers. The main concern of the building sites is to gain the optimized use of the resources and the capital, and to demolish their wastage.

All the examples of waste are related to Iran; consequently, some may exclusively concern the case of Iran, and on the other hand, there might be cases in other countries that might not be observed in the constructions taking place in this country. The overall aim of the study is to identify and enlist the causes of waste that can eventually result in their localization for Iran.

The significance of the study: In regards to scientific perspectives: The presented categorization of waste is novel and differs from the categorizations in the literature of the waste study; this adds to the significance of this study. The literature indicates that in the studies, the waste of building material has been regarded as “unwanted materials”, and waste has been an “unfixed” subject matter (Wikipedia, 2013). In this study, a different definition of waste is presented, and the objective is to prevent waste from happening.

In regards to the implementation managers and organizational needs: 10% to 15% of the input materials and resources in sites are wasted that directly affect the costs of the projects; moreover, the reduction or even the demolition of waste is a totally management concern that turns this study into an important one for the managers and the organizational needs.

The objectives of the study: the aim of this study is to identify, minimize, and possibly eliminate wastes from the construction cycle. In practice, IPMA invites every organization to create its specific ICB, called NCB7. Today, approximately, thirty European countries, and countries such as Egypt, India, and China are deploying NCB Standard. Since the costs of every construction project consist of 10% waste that can vary for every country due to different implementation methods, waste management is suggested to be considered in NCB Standard.

Spatial domain of the study: the study deals with the projects of residential and office sites of Iran.

The time span of the study: By the passage of time, new implementation techniques and machinery are introduced, and the construction materials change in type that can affect the amount of waste, the temporal domain of the study matters. The samples and observations of the study are related to 2000-10 decade.

The hypotheses of the study: Four hypotheses are raised for the study; 1. The causes and factors of waste can be identified and managed; 2. The reduction of waste is possible by training implementation equips; 3. Building owners, advisors, contractors, and building operators treat the problem of waste in a targeted, specialized, and flowcharted way; 4. The type of contracts (competitive bid, or agreement contracts) affect the amount of waste.

The Definition of Waste: Although various definitions are given for waste, there has been no exact comprehensive definition to the present day. Minimizing Construction and Demolition Waste indicates that waste refers to those solid inutile materials that result from the construction, repair, demolition, or scrape of the buildings and roads. The definition includes ruined places, and debris remained after cleaning up a site including concrete, bricks, asphalt, plaster, wood, soil, trees, and bushes (Minimizing Construction and Demolition Waste, 2004). Another definition introduces waste as those materials whose cause (its controller) means to eliminate it from the construction cycle (Ferguson, 1995). The other defines it as unwanted materials that are created in construction industries either directly or indirectly. The waste includes construction materials, such as insulations, nails, electric wires, or wastes caused during the preparation of sites such as dredging materials, uprooting trees or rubbles. Construction materials can maintain plumbic, asbestos, or poisonous materials (Kourmpanis, 2008). The majority of construction wastes result from the absence of need or the demolition of materials like bricks, concrete, and wood in the construction process (Skoyles and Skoyles, 1987). As the definitions imply, current definitions do not deal with the causes of waste; to fulfill this gap, the present study defines waste in the implementation as follows: disobedience from implementation standards results in the loss of resources; this process is called waste. Waste reduces the efficiency, and increases the costs.

Waste, the standards and Regulations: Canada and America have codified lows to control waste. In 1993, some standards and lows were regulation for the packing of instruction materials. In 1994, a national standard was defined consisting of policies and regulations to reduce, reuse, and recycle the waste (Canada's Green Plan, 2000). In 1996, regulations and guidelines were defined for the secure management of waste, including its reduction, reuse, recycle, transference, storage, and erosion (CWMR, 1991). According to the regulation 94/102 of America, a waste reduction program for construction and demolition projects consists of three main components: a. the verification of the waste, b. a schedule for its reduction, and, c. the implementation of the work according the schedule (Yeheyis, *et al.*, 2013).

Waste management

Based on the analysis of the scientific papers on waste management, they can be categorized in three main groups: 1. the classification of waste materials, 2. the strategy of managing waste materials (waste avoidance, reduction, and reuse), 3. The technology of waste expulsion; the categories indicate that there has been no enough consideration of the causes of waste in building sites (Shen, *et al*. 2004). The remarkable increase in warnings about the environmental effects of building wastes has resulted in the development of waste management as one of the subordinate issues of the management of construction projects (Teriö and Kähkönen, 2011; Berg-strtim, 1993).

Growing environmental consciousness, and additional costs due to waste have encouraged many construction companies to reassess their methods of design, implementation, and utilization (Gavilan and Bernold, 1994). Measuring the wastes due to construction plays a great role in the management of production systems, since it provides the information about the amount of waste materials that is an important index in the assessment of the system's operation, paving the way for its betterment (Formoso, *et al*. 2002). The omission of waste is one giant step to reduce, reuse and recycle (Agamuthu, 2005). There have been some investigations on the management of the wasted material, and their effect on human health (Caniato and Bettarello, 2013; Giusti, 2009); however, the majority of these studies have been devoted to the recycle of concrete demolition waste, environmental protection, and the recycle of resources (El Halim, *et al*. 2009; Rao, *et al*. 2007). Some models are suggested for the prediction of the waste rate for managers who prefer to reuse (Chandrakanthi, *et al*. 2002). A considerable amount of garbage production is related to building and construction industry (Bossink and Brouwers, 1996). Estimations vary, but an acceptable estimation is that 15 to 20 percent of municipal solid waste is caused by construction projects; consequently, municipals should focus on the reduction of waste in the construction (Kincaid, *et al*. 1995). WMMM (Waste Management Mapping Model) is an auxiliary model for the waste management design in the building sites that can be utilized as a contrastive means in the projects for waste management. This model facilitates the identification of acceptable or weak projects based on the waste control. The experiments have developed the plan model of waste management (Shen, *et al*., 2004).

In waste management, there are five Rs in the construction industry (CCA, 1992):

Less order of materials, the utilization of more durable materials	Reduce
Reuse of the construction materials in their original form	Reuse
The production of new materials by the construction waste	Recycle
The separation and recovery of reusable materials	Recycling and resource recovery
The management of the rest of the materials in a safe method	Residual materials

2. METHODS AND PROCEDURE

The common method to identify the causes of waste is field study and direct observations in the building sites. All construction sites make the population of the study. Giant installation projects, such as the construction of refinery and powerhouses are not considered in the population. To identify and control the causes of waste, a questionnaire was designed; besides different interviews were made with specialized agents of construction. Designing a questionnaire was aimed to identify the causes of waste, and the degree of significance of each cause. To do so, the process of construction was divided into 10 phases, with each phase including its subcategories. Based on the categorizations, the questionnaire was designed with 40 multi- optional, and 5 explanatory questions, based on the Likert Scale. The questionnaires were given to 60 contractor companies, advisor engineers, and maintenance companies. 41 questionnaires were answered and ready for the analysis.

3. THE CAUSES AND FACTORS OF WASTE

The causes of waste can be divided into three groups: 1. Causes and problems of design, 2. Causes and problems of utilization, and 3. Causes and problems of implementation that is the particular consideration of this study.

Wastes due to implementation

The causes and problems of implementation can be categorized in 21 groups as discussed below:

3.1. Wastes due to the nature of the material

The nature of some materials is highly liable to become wasted. For instance, clay blocks are increasingly popular in construction projects due to their light, quick, and easy nature; however, their fragility in transportation, and the electronic and mechanical piping through them, they leave a remarkable amount of waste. Figure-1 indicates the waste in clay blocks.

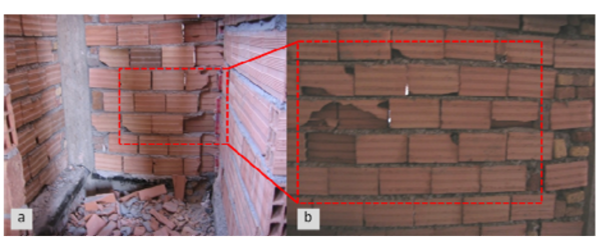

Figure-1. Shows waste in clay blocks.

3.2. Using low-quality materials

High- quality materials are so expensive; this creates the tendency for low- quality but cheaper materials that remarkably increase the amount of waste. In Figure-2 we can see the concrete wasted using unsuitable templates.

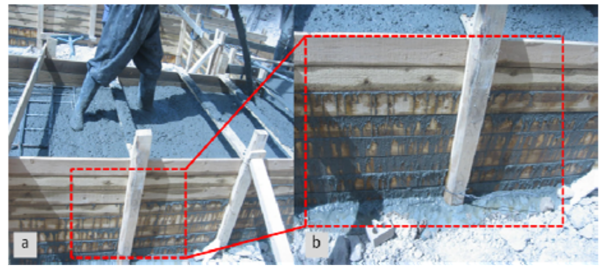

Figure-2. Concrete waste using unsuitable templates.

3.3. Incorrect transportation of push bricks

The discharge of push bricks, throwing them, moving them by hand etc remarkably increases the waste. In Figure-3 throwing the bricks from the floor to the working place have caused a lot of waste.

Figure-3. Manual transportation of bricks.

3.4. Improper packing of the materials

Proper packing is one of the ways of reducing the waste. Clay blocks, cement and plaster bags, tile and ceramic packs, and prefabricated concrete parts stand among those materials whose suitable packing would prevent waste largely. Figures 4 a and b, show the proper and improper packing of bricks, respectively.

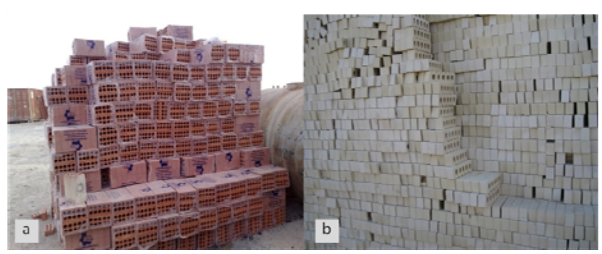

Figure-4. a. Suitable packing, and b. unsuitable packing of bricks.

ARPN Journal of Engineering and Applied Sciences

3.5. Improper depotting of materials

The correct depotting of materials, especially the sensitive materials to atmospheric conditions can prevent waste. Plaster and cement are two main materials whose depotting is very effective on their becoming waste. Bulk plaster and cement highly increases the vitality of proper depotting. Figure-5 indicates how improper depotting causes waste.

Figure-5. Unsuitable stock location of cement.

3.6. Lack of control, specialized equip, and knowledge over implementation issues

In fact, correct and permanent control by the specialized equip stand vital to waste control that can remarkably reduce the waste. A successful program for waste reduction requires education for contractors, architects, and construction engineers (Minimizing Construction and Demolition Waste, 2004). In Iran, construction equips usually are trained by practice, not education; furthermore, no mechanical techniques are acquired by them. Workshops that issue certificates for mechanical skills do not have education units and issue the certificates by the administration of exams only. The laws for employing people with mechanical skills certificate is not seriously followed.

3.7. Using no new and developed machinery

Deploying old machinery causes the waste of time, and the increase of costs. Naturally, new and modern machinery have much higher efficiency, whose purchase or rent is economical in long term.

3.8. Wrong estimations of materials

Mistakes in estimating the amount of the required materials not only increases the costs, but also increases the amount of waste. When the estimation is higher than the required amount, the left materials are not usually refundable and become waste. On the other hand, purchasing less than the required amount necessitates another purchase, to which the transportation costs must be added.

3.9. Unintended mistakes (carelessness of workers)

Unintentional mistakes are usually observed in all stages of construction. Figure-6 shows that careless use of the elevator has damaged the wall.

Figure-6. Careless use of lift.

3.10. Demolition due to no response of experimental results

When the experimental results of concrete, weld, etc. do not correspond, the experimented part must be demolished that causes waste. Figutre-7 shows how the concrete beam has been demolished since the experimental results did not correspond.

Figure-7. Destruction due to non-responsiveness of the results of the experiments.

3.11. Incorrect implementation methods

Another factor to prevent waste is the consciousness to correct implementation methods. Wrong methods and techniques can take place in every stage of

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the construction. In Figure-8 a and b, it is well shown that how incorrect methods have resulted in the damages to the mosque. The absorption of rain beneath the tiles has caused a lot of waste.

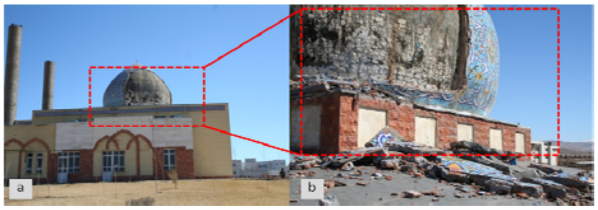

Figure-8. Detachment of a Mosque's dome tiles (a. front view, and b. side and top view).

3.12. Overtime work, and exhausted workers

Statistics indicate that 65% of bad events occur in the last hours of work, due to workers' fatigue. Overtime work reduces the efficiency and waste of materials. It is noteworthy that the investigations about this factor have provided accurate related results. This factor stands in line with such previous studies.

3.13. Compulsory wastes

The overlap of the reinforcements is always considered as waste. In concrete pillars, if we consider the length of the reinforcement of the pillars for more than one floor, two or three floors, for instance (by controlling the seismology of the reinforcement) the waste due to overlap can be prevented.

3.14. The lack of standard implementation methods

In many cases, there are no comprehensive standard methods for the implementation projects. The lack such methods can cause deviations in each phase of the project leading to waste. In line with the definition of the implementation standards, engineers, architects, and experiments should also be educated. Deviations and waste can only be controlled in a standard atmosphere. On the other hand, when researchers create new implementation methods, should define the related standards, and control the required instructions. To turn waste into a quantitative and contrastive entity to compare contractors and implementation methods, it would be effective to define the implementation standards.

Based on the questionnaire, other causes of waste are also identified that are listed below:

3.15 Broken instruments
3.16 Unbalanced climate conditions
3.17 Accidents
3.18 Extra combination of mortar and other combinatory materials due to lack of knowledge
3.19 Waste due to application process
3.20 Waste due to damage and peculation (The Dutch national environmental policy plan, 1993)
3.21 Lack of waste management plans

RESULTS

Based on the observations of construction sites, and the statistic analysis of the questionnaire, along with the interviews with implementers, the results are:

a) For some of the implementation methods, there are no implementation standards. Furthermore, there is a big difference between the theoretical studies and practical projects. This stands among the most important causes of waste.
b) The importance of waste has not gained the scientific attention of planners, implementers, and operators who deal with waste as a non-scientific and general issue (Osmani, *et al.*, 2006; Faniran and Caban, 1998 and Teo and Loosemore 2001). The reason lies in the low wages, consumable resources, uncompetitive nature of bids, and the considerable benefits of the private sector. In the recent years, the enhancement of costs has made the bids more competitive, and reduced the contractor benefits that have eventually highlighted the importance of waste.
c) According to the investigations, types of waste are different in design, implementation, and utilization. Waste due to implementation makes the largest portion of wastes in both quality and variety. Building owners and implementers mostly take this kind of waste into consideration.
d) Usually building owners and designers do not consider professional balance between time and resource allocation. In most cases, the priority of time over the resources (especially in the private sector) causes a lot of waste and increases the costs.
e) Lack of equips with required skills cause the most amounts of waste in construction projects. Old and out of date machinery stand the second.
f) In the observed two construction projects, the waste was higher in the one with competitive bid contract than the one with agreement contract (without the contractor benefit or the overhead).
g) In the two observed similar projects, the amount of waste was higher in the private project than the governmental one. The reason lies in the fact that the private sector takes the quick accomplishment of the project a priority, and usually suffers from the lack of the proper depotting of the materials.
h) In implementation, 10 to 15 percent of the resources become waste; the investigations indicate that waste can consist of the 10 to 15 percent of the materials that enter the sites (Skoyles and Skoyles, 1987).

RECOMMENDATIONS

Prior to designing and starting any projects, these issues should be taken into account:

a) For any type of implementation, its specified standards should be defined.
b) Priority should be with prefabricated parts; they remarkably reduce the waste.

c) After the implementation maps are prepared, the selection of qualified contractors and implementers can remarkably reduce the amount of waste.
d) The guidelines of the country's management and planning organization must be obeyed. This can reduce waste largely.
e) Contractors should be qualified in all aspects of implementation (buildings, roads, transportation, etc.)
f) To prevent wastes in the implementation, deploying qualified experts to consistently supervise the work, and secondary supervision (by the management and planning organization, for instance) can be effective.
g) To prevent economic corruption, it is necessary to create a database to report the costs of the project for the infrastructure per sq.m, since the costs of the projects differ from the tabular drawing in different implementation administrations.

The step-by-step recommendations below are for the contractors:

- Reduce cutting waste (stones)
- Keep proper contact with the suppliers to supply exactly the resources you require.
- Reuse the cutting wastes as much as possible.
- Select the most suitable place to depot the materials.
- Divide different wastes from each other.
- Develop a database for each cases of waste.
- Search for the most suitable materials to prevent energy loss.
- Develop methods for the verification of waste in various types of projects.

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