

Analytical study of the causes of material waste in implementing the construction envelopes in Egypt

Enass Salama ¹, Nesreen Khalil.²

A b s t r a c t

The construction industry consumes a large portion of the raw materials and generates an enormous amount of solid waste annually especially in installing the building envelope.

Despite the positive impact of the building envelope on achieving the economic development goals of the countries, it has been proven that the waste generated from the construction and installation processes has a significant negative impact on the economy and the environment, which led to a waste of 10% of the cost of project materials according to global statistics in 2010.

This paper aims to (1) identify the causes and impacts of wasted materials, (2) present the results of the field study conducted by the authors to investigate the causes of material waste in the implementation of building envelopes in Egypt, (3) identify the most important, sub-factors and causes of material waste in the implementation of building envelopes in Egypt. (4) Based on experts' opinions, recommendations are made to avoid wasting materials in implementing building envelopes in Egypt.

Keywords: building envelope — waste - material – control – causes - activities.

1. Introduction

The economic development of a country depends to a large extent on the construction of buildings, thus the sustainability goals and the performance of the construction industry are challenged by the huge amount of solid waste which causes a huge loss to the economy and environment. (1)

Moreover, the high cost of executing construction projects has made it important for contractors to take action to reduce construction waste. (2)

The Egyptian government is exerting great efforts in implementing many mega construction projects towards implementing the goals of the Strategic Development Strategy for Egypt 2030 and to keep up with sustainability in buildings by installing the building envelope with the state of the art materials and methods.

¹ Teacher assistant at Modern Academy for Engineering and Technology (Maadi)

² Associate. Professor, Architectural Dept, faculty of Engineering Matariya, Helwan University

But a lot of waste occurs in the installation building envelopes, where project managers and construction staff typically fail to control waste in construction projects and to identify the root causes of waste generation due to the lack of appropriate tools to measure it (3). So construction waste is numerous and bulky where poor management is a norm. (4)

The authors aims to identify the causes and impacts of wasted materials in building envelope installation in Egypt to support the Egyptian SDS 2030 and reduce wasteful material in installing building envelopes.

2. Research Objectives and Methodology

To achieve the mentioned aim, the research methodology consists of reviewing the literature on material waste and its impacts, then a questionnaire was designed to :

1. Determine factors that control materials in implementing building envelopes.
- 2- Understand the impacts of Waste on the construction industry.
- 3- Analytically study the results to find out the main and sub-causes of materials' waste in implementing building envelopes in Egypt.
- 4 – Acquire the respondents' comments suggesting wasting material in implementing building envelopes in Egypt.
- 5- Determine the results of research and recommendations for construction companies, especially the envelope installation companies, based on experts' opinions to control wasteful material in the implementation of building envelopes in Egypt and provide ideas for future research.

3. Literature review

3.1 Construction waste

The term "waste" has been defined in several ways. Waste is any incompetence that results in the use of materials, tools, equipment, and labor, as necessary for construction. On the other hand, waste consists of excessive work and material losses that produces additional cost to the project but does not add value to the product (5).

In construction materials, waste can be defined as the difference between the total amount of material brought to the site and the actual amount used (6). Construction site waste can be categorized into physical type (loss of material and damage) and non-physical types (cost and time overrun) (4).

In the past few years, material waste in construction has been considered a major topic of research worldwide (7).

This paper focuses only on material wastages especially in implementing building envelopes without discussing other aspects such as cost and time overrun.

3.2 Factors controlling material in implementing building envelope

There are several Factors that affect material usage in implementing building envelope in its several steps: (8) (9)

- **Building envelope design**

During project processes one of the main factors generating wasteful materials is the employer's requests of several last-minute changes to the project envelope design which generate wasted material while installing building envelope.

Another cause of this problem is the lack of communication between the misunderstanding of the client's requirements and the various project parties so that any changes in the design of the project envelope consumes time and money.

To avoid this cause of waste, a lot of consideration must be taken to reduce wasteful material, during the envelope design step.

- **Handling and storing envelope material**

Incorrect techniques of handling materials along with failure to follow the protection methods required to protect the materials from weather conditions have resulted in improper storage of materials, hence causing wastage of materials.

Improper storage of building envelope materials in the project leads to defects and cracks that need to be replaced especially aluminum sheets.

Adequate storage of materials is important to prevent any waste in envelope materials and equipment by providing proper monitoring and management of the storage process.

- **Weather conditions**

Many project activities must be stopped if there is rain or strong winds during any stage of the project execution. However, some contractors work in bad weather, which causes waste of envelope materials.

So this variability in weather conditions is also one of the major external factors that generate waste in the envelope materials in projects and may also cause unwanted delays.

Time is an important factor in any project, but sometimes weather conditions force rescheduling of project plans and activities which will lead to additional costs to the estimated budget and delay in the project schedule. Waste due to weather conditions can be prevented with proper management, planning, and timely decision-making criteria.

- **Planning and management**

Proper management is undertaken during building envelope installation, and can greatly affect the waste rate. Poorly planned installation of the building envelope can result in multiple types and amounts of waste in materials.

The management team and site supervisors should be carefully selected to inspect the various processes of envelope installation and to ensure the proper flow of work.

Also, the appointment of a supervisor to ensure that no wastes are generated and that good planning and management will reduce waste in materials by knowing all building envelope installation activities, is advisable. Hence, proper planning and management is a major key if taken care of to eliminate any sources of wasted materials.

- **Workers**

Mistakes from workers caused by workers' behavior, improper training, overload, unaccepted skills, and poor management by senior engineers or supervisors result in wastage of materials during the installation of building envelope.

To ensure the quality of work generated by workers and to organize work on-site, the superintendent and engineers must be available during all building envelope installations to organize work on-site and ensure the quality of work produced by the workers. Also to enhance the result of the building envelope and reduce the material waste, workers must take responsibility for their work, have an acceptable work culture, and be motivated financially and morally.

- **De-coupling envelope installation from other site works**

De-coupling means removing specific activities from the parade of trades in the building process. When activities are based on predecessor activities specified with a finish-to-start relationship, subsequent activities cannot be performed before the previous activities are completed.

Problems and wasted materials can be reduced by de-coupling the façade installation from other construction work, while minimizing variability and waste at the same time (for example, internal transportation and waiting time), resulting in a continuous flow work of installation.

This results in flexibility and fast progress and continuous pace of the work thus allows for expediting the project schedule. Avoiding de-coupling when dealing with envelope materials stored on each floor also significantly reduces the possibility of damaging the envelope material and reduces damage in the envelope installation work, thus avoiding re-working of envelope components.

3.3 Impacts of Waste on the construction industry

The impact of waste on the construction industry can be summarized as follows:

- **Economic Impact**

There are different activities in the construction projects where multiple types of waste are produced. These wastes generate additional costs in the projects. The building envelope material is one of these types which is responsible for the excess unnecessary costs of the projects.

If this waste in the envelope material is reduced or properly managed, it can save a big amount of money and increase the construction companies' profits. The total percentage of materials in construction ends up in landfills at a huge rate that can reach about 9 percent where it's resolved and generate chemical compounds that affect the environment.

In Hong Kong, for example, the Department of Environmental Protection reported that about 2,900 tons of wastes were received from construction projects at landfills in 2007 and it was suggested that proper management can reduce this wastes. (9).

- **Impacts of waste on the environment**

This problem is considered vital in many developing countries including Egypt, where the waste contains chemical decomposition that can affect the

environment in terms of pollution. But few landfills in these developing countries may accomplish the environmental conditions according to the standards and few sites can be considered acceptable for the future use.

These problems are related to the chemical composition that is generated due to the garbage flowing from the construction site (10).

4. Analytical study:

A survey questionnaire was developed by the researcher. The questionnaire is set in the form of multiple-choice questions, which consist of several answers so that the participant can easily choose the most appropriate option (details of the questionnaire can be seen in Appendix A). These types of questions save participants' time.

The questionnaire was created with the help of the website www.google.com and the link was sent to people working in the construction industry, manufacturing, and installation of building envelope materials companies. Most of those who participated in the survey have enough experience in construction which enables them to properly answer the survey questions through Instant messengers and email programs.

Conducted with a representative sample of 72 respondents to investigate their perception and application of waste in construction (especially wasted materials) towards minimizing construction waste in the Egyptian construction industry. Only 55 of the 72 respondents answered the survey questionnaire, which represents a response rate of (76.3%).

- Section A questions are organized to investigate general information about respondents. It is shown that respondents with more than 20 years of experience interact with the questionnaire by a rate of 37.5% and who have 6-10 years and 11-20 years of experience interact by 25% each which means that good results will be obtained from the questionnaire, based on vast experiences as shown in Figure 1.

Moreover, most of the respondents have experience with mega construction projects, especially public and residential works as illustrated in Chart 2. This will enhance the research results.

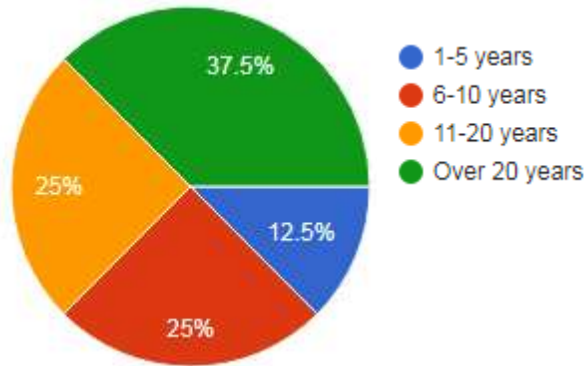


Chart (1)

Years of responded experience

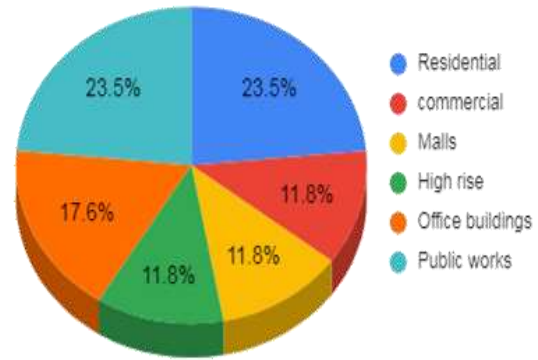


Chart (2) Type of projects does the respondents worked in

- Section B questions are structured to investigate the main and subsidiary causes of material waste in implementing building envelopes in Egypt. Chart (3) illustrates the impact of sub-factors of planning and management on material waste in building envelope implementation.

- About (70%) of the respondents believe that inefficiency or lack of site supervisors can affect the waste envelope material which is too high. Others (50%) stated that the management team can also impact a medium percentage and should be taken into account by the project manager.

- Chart (4) shows the effect of sub-factors for handling and storing materials on material waste in implementing building envelopes.

About (60%) of the respondents believe that storage problems could affect the waste envelope material being high. Others (50%) state that improper handling could also cause a moderate percentage that could be considered with proper supervision, increased workers' skills, and awareness.

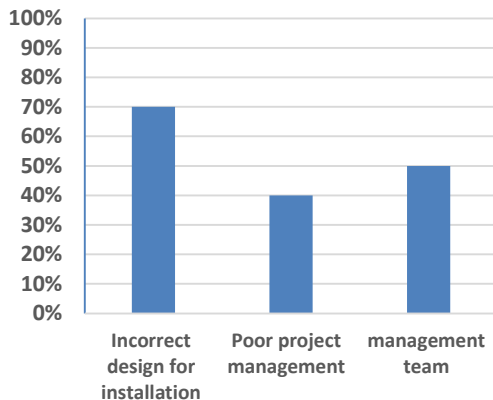


Chart (3) The sub factors impact of planning and management on wasteful material

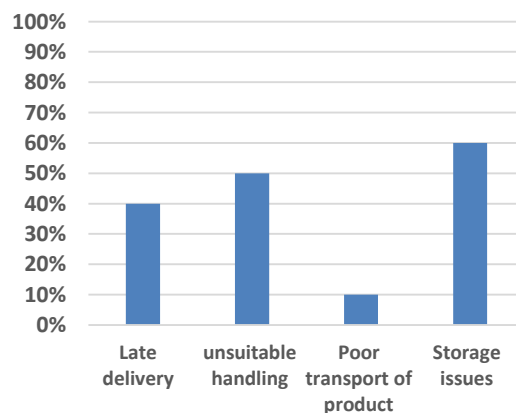
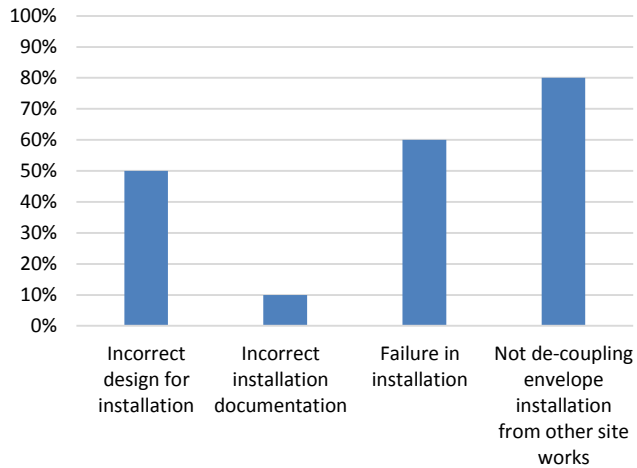


Chart (4) The sub factors impact of handling and storing on wasteful material

- Chart (5) shows the effect of the sub-factors of envelope installation on the waste of materials in the implementation of the building envelope.
- About (80%) of the participants believe that not de-coupling envelope installation from other site works in Egypt can affect the waste of

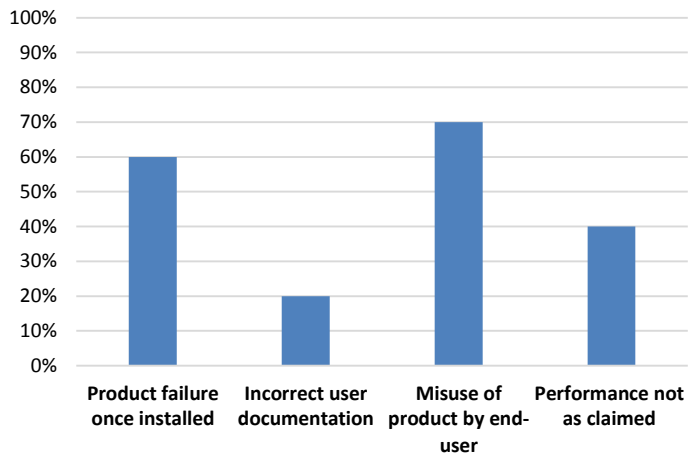


envelopes material and that is

one of the most common causes of waste that is very high and must be managed and planned to de-coupling envelope installation from other site works.

Another (60%) reported failure to install is moderate but effective in the presence of waste in the envelope material.

Chart (5) The sub factors impact of envelope installation on wasteful material



- Chart (6) shows the effect of sub-factors of operational failure on material waste in building envelope implementation.

About (70%) of the participants believe that the misuse of the product by the end user in Egypt could affect the wasted envelope material which is very high. Others (60%) stated that the product

Chart (6) The sub factors impact of operational failure on wasteful material

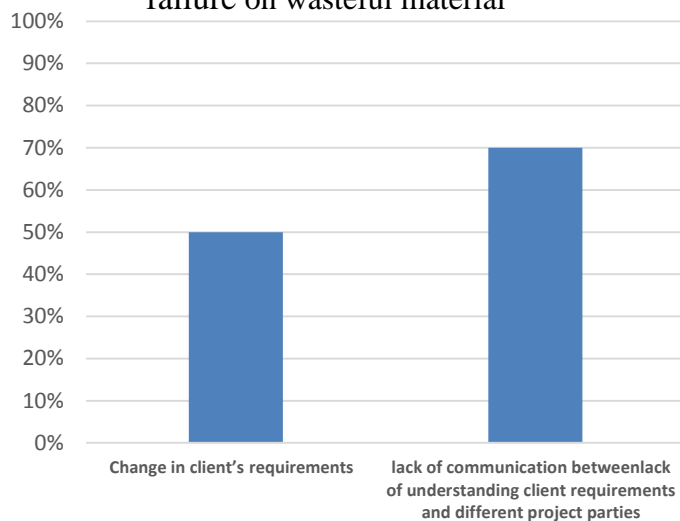


Chart (7) The sub factors impact of building envelope design on wasteful material

fails once installed, so this percentage should be taken into consideration.

- Chart (7) shows the effect of the sub-factors of the building envelope design on the materials wasted in the implementation of the building envelope.

About (70%) of the respondents believe that the lack of communication between the lack of understanding of the customer’s requirements and the different parties in the project can impact the waste envelope material, which is a high percentage. The respondents suggest appropriate selection and planning of the best means of communication before starting the project.

- Chart (8) shows the effect of weather sub-factors on material waste in building envelope implementation.

About (80%) of the respondents believe that not making the right decision at the right time can have an impact on wasteful envelope material that is too high, while (70%) others stated that the weather and schedule is not taken into account in the project plans and it is also high so it is important to consider these two sub-factors in construction projects in Egypt to reduce the waste of envelope material..

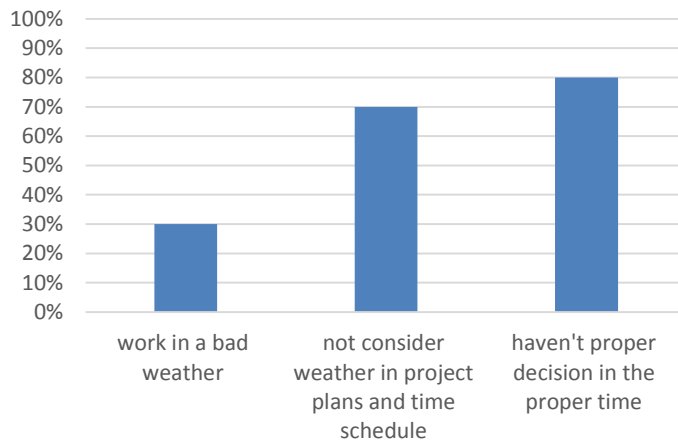


Chart (8) The sub factors impact of the weather on wasteful material

working attitude and improper training are also high so it is important to consider these two sub-factors in construction projects in Egypt to reduce the waste of envelope material..

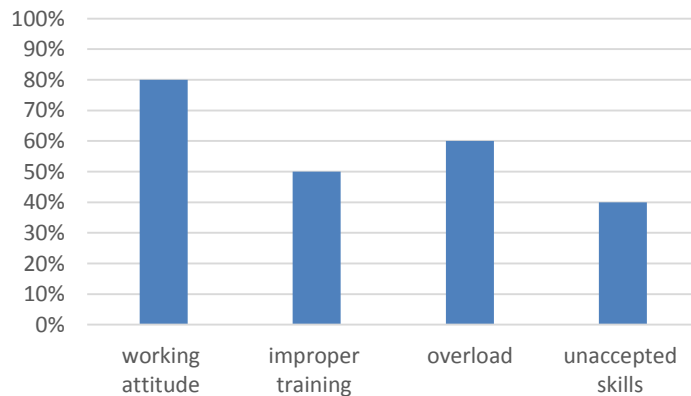


Chart (9) The sub factors impact of the workers on wasteful material

- Chart (9) shows the impact of workers in implementing the building envelope.

About (80%) of the respondents believe that the work attitude can affect the waste envelope material which is very high so it is important to clearly define the specific envelope installation tasks for the workers, the incentives and the penalties.

4.2 Respondent's comments

Respondents provided the following comments and suggestions on ways to avoid wasting materials in the future in implementing building envelopes in Egypt based on their experience:

Table (1) Respondents observations and suggestions on the waste of materials (which have the highest percentage) in implementing building envelope in Egypt:

Causes of wasteful material	Explanation and suggested
Planning and management	
Site supervisors	- Proper chosen by Project managers
Poor project management	- Proper chosen special management to implement building envelope
Management team	- Proper chosen by Project managers
Handling and storing of materials	
unsuitable handling	-Proper supervision & increase worker skills and awareness
Storage issues	- Proper storage planning and supervision
Installation	
Failure in installation	- Follow company instructions - Exact supervisors in installation - Worker skills of the installation method
Not de-coupling envelope installation from other site works	- Manage and plan for de- coupling envelope installation from other site works as much as possible
Operational failure	

Product failure once installed	<ul style="list-style-type: none"> - Appropriate choice of materials - Due to manufacturing and this is possible with small rate - Storage and handling should be taken into consideration - Compliance with the company's instructions - Increase installation skills
Misuse of product by end-user	<ul style="list-style-type: none"> - Putting usage instructions for users in clear places - Control documents by independent body. - Better understanding of the system (assumed this is by the user; no detail was provided)
Building envelope design	
Lack of communication between lack of understanding client requirements and different project parties	<ul style="list-style-type: none"> - Proper Selection and planning of the best means of communication before starting the project. - Varieties in the means of communication between the project parties
Weather conditions	
haven't proper decision in the proper time	<ul style="list-style-type: none"> - Proper planning and management helps to have the proper decision in the proper time
Workers	
Working attitude	<ul style="list-style-type: none"> - Define the specifics envelope installation tasks to the workers clearly - Instruct them clearly and define the incentives and penalties.
Overload	Exact planning and management of envelope tasks separated than other tasks

5. Conclusion

The construction industry is being blamed for its negative impact on the environment even though it is considered one of the important industries that play a major role nationally and internationally with regard to achieving the sustainable development goals.

One of the important issues in construction projects is the generated wasteful material from the building envelope, which is one of the waste that is a big consumer for generating waste and non-renewable resources.

Due to the Egyptian SDS 2030 and in support of the large number of projects that are being implemented in Egypt at the present time, which are concerned with building envelopes and its technologies, this paper aims to identify the main and sub-causes and effects of wasted materials in building envelopes in Egypt to avoid them and reduce construction waste in the Egyptian construction industry.

The results of the survey questionnaire showed that the many factors that control materials generate sub-causes for wasted materials in different proportions, the highest of which must be taken into account through suggestions and comments of the respondents' experiences and choosing the best new methods to avoid them as Lean management after carefully identifying them and continuously noted them under appropriate supervision.

Lessons learned that improving understanding and managing expectations in all stages of building envelope implementation and life cycle (designer, installer, end user) can reduce waste of materials in implementing building envelopes.

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Appendix

Title : Wasteful material in building Envelope in Egypt

Section A: This section is structured to investigate general information about the Respondents
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- 1- Name:
- 2- Your current position in your company:
- 3- The years of experience in construction industry?
 - . 1-5 years
 - . 6-10 years
 - . 11-20 years
 - . Over 20 years
- 4- What type of projects does your company undertake? (please tick all that apply)
 - . Residential
 - . Commercial
 - . Malls
 - . High rise
 - . Office buildings
 - . Public works

Section B: Structured to investigate about the main and sub reasons for wasteful material in implementing building envelopes in Egypt.

Reasons for wasteful material in implementing building envelope in Egypt (please tick all that apply) in each factor of following points:

1- Planning and management:

- . Site supervisors
- . Poor project management
- . Management team

2- Handling and Storing of Materials

- . Late delivery
- . unsuitable handling
- . Poor transport of product
- . Storage issues

3- Installation

- . Incorrect design for installation
- . Incorrect installation documentation
- . Failure in installation
- . Not de-coupling envelope installation from other site works

4- Operational failure

- . Product failure once installed
- . Incorrect user documentation
- . Misuse of product by end-user
- . Performance not as claimed

5- Building envelope design

- . Change in client's requirements
- . Lack of communication between lack of understanding client requirements and different project parties

6- Weather Conditions

- . Work in a bad weather
- . Not consider weather in project plans and time schedule
- . Haven't proper decision in the proper time

7- Workers

- . Mistakes from workers caused by :
- . Working attitude
- . Improper training
- . Overload
- . Unaccepted skills

Thank you for your response.