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Causes of Reinforced Concrete Materials Waste in Construction Projects

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A B S T R A C T

Reinforced concrete is one of the most widely used items in construction projects. Wastes of construction materials have been recognized as a significant problem for different stakeholders involved in construction projects. Material waste affects the efficiency and productivity of construction projects negatively, especially the reinforced concrete materials as it represents a large portion of most construction projects' costs. This paper aims to identify and analyze the main causes of the reinforced concrete materials waste (RCMW) in the Egyptian construction projects from the point of view of contractor and consultant site engineers. A literature review was conducted to gather a list of causes contributing to the RCMW. The resulting 23 causes were categorized into four groups; design, material management, labor, and site management. The resulting list of RCMW causes was subjected to a questionnaire survey for quantitative analysis and identification of the most important causes of RCMW from the point of view of contractors and consultants. The analysis of variance (ANOVA) and paired-samples t-test were used to study the effect of participants' experience on their scoring. The experience relative importance index (ERII) of these causes was calculated to assess their effects on RCMW. The overall results indicated that the most ten important causes of RCMW are: lack of on-site material control, lack of supervision, poor coordination, design change, over procurement (unused materials), rework due to worker's mistake, waiting for resources, selection of unsuitable material, material storage, incorrect materials (wrong procurement).

1. Introduction

Construction materials cost differs from project to another and according to this research, it is about 50 - 60 % of total construction project's cost, so making control on materials is the best way to reduce the overall project cost (Lenin et al. 2014). The concrete waste in housing projects ranges from 2.5% - 3.0% (Poon et al. 2004; Bossink and Brouwers 1996) and the average amount of concrete waste ranges from

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4.0% - 9.5% in construction projects (Tam et al. 2007). Arshad et al. (2017) define waste in the construction industry as "any incompetence that results in use of tools, material, labor, equipment, and the capital in larger amount than those measured as essential for the construction". Reinforced concrete waste at construction sites occurs because the excess fresh concrete mix, excess rebar, and concrete debris resulting from demolition. Improper design, poor planning and procurement, inefficient material handling, residues of raw materials, and unexpected changed in building design are considered as the main construction waste causes according to Cheng et al. (2015).

The origins of a large amount of waste related to changes in design, leftover material on site, wastes from packaging and non-reclaimable consumables, design/detailing errors, and poor weather (Faniran and Caban 1998). Also, construction material waste is related to design, site operation, material handling, procurement routes, and subcontractor's practices (Osmani et al. 2006). Although many previous researches have been conducted to identify the main causes of material wastes on sites, material wastes on construction sites are classified to substitution, overproduction, waiting time, transportation, movement, processing, inventories, production of defective products, and other factors according to a study developed by Universidad Federal do Rio Grande do Sul (UFRGS) (Sanmath 2013). Based on past studies, there was a difference in the average amount of concrete waste in the same type of project. This difference is due to many causes such as the experience of workers, reworks due to worker's mistakes, damaged materials on-site, and others. So, studying and analyzing these causes in detail is very crustal. Many researchers have discussed material waste in different ways. Mat and Kasim (2017) focused on the most influential factors which affect materials management in construction project activities. Mahamid (2020) recognized the relationship between rework and material waste in building construction projects in Saudi Arabia. But the objective of this paper is to identify the causes of reinforced concrete materials waste and analysis theses causes from the point of view of contractors, consultants and overall. The paper is structured as follows: At first, a brief overview of (RCMW) causes in construction projects is discussed. Then Analysis and discussions of the data collected are presented. Finally, a summary and conclusions of the paper are presented.

2. Causes of Reinforced Concrete Material Waste

Material waste plays an important role in any construction project, so several studies concentrated on this issue. Based on the literature reviews and interviews with experts in reinforced concrete works in construction projects, the most important researches on materials waste are presented in Table 1 and their research contribution in this field where (23) causes were identified as the main important and influencing causes on (RCMW). The main issues discussed in Table 1 are: identifying material waste causes in construction projects, discussing the current practices of waste reduction at construction site and identifying various causative factors of construction waste in construction activities. Then, the most important (23) factors are extracted with a brief explanation as shown in Table 2 and identified to demonstrate its importance. Based on Table 2, these causes are categorized into four groups; design, material management, labor, and site management.

3. Questionnaire Survey

A questionnaire survey was conducted to quantify the RCMW causes. The questionnaire was divided into two parts: Part 1- the participant's personal information as position, experience…. etc.; and Part 2- the measurement of the importance of the RCMW causes by selecting one option out of the 1-5 scale. Each cause of RCWM was measured on a Likert scale using five options: 1= very low importance; 2= low importance; 3= moderate importance; 4= high importance and 5= very high importance. A questionnaire was distributed to contractor and consultant site engineers from different types of construction projects such as residential, non-residential, and civil projects.

According to a study conducted by (Baxter and Bartlett 2001), the following formula is used to compute the required sample size for this study.

$$N = \frac{K^2 * P(1-P)}{E^2} \quad (1)$$

Where N is the sample size needed, K value equals 1.645 with confidence level of 90%, P degree of variance is 0.5 with E the acceptable margin of error = 10%. By substituting all of these parameters in previous equation, the required sample size of this study is 68 as a minimum value.

Table 1. Reinforced Concrete Materials Waste (RCMW) Research Contribution

Researcher	Year	Research Contribution
Garas	2001	Discussed the origins of material waste in the Egyptian Construction Industry. The study demonstrated that the most important causes of material waste were “Changes to design” and "Late information"
Osmani et al.	2006	Discussed the assessment of UK contractors' and architects' towards waste minimization, by investigating the waste minimization strategies into current design processes, examining contractors' existing waste management practices and determining responsibilities, and barriers to, managing waste minimization.
Dania et al.	2007	Discussed the practice of material waste management in construction industry by firms in Nigeria. The research considered that the most important goals of any project is to deliver in the required quality, time and cost
Smallwood and Rwelamila	2008	Discussed the Quality Management System (QMS) which effectively integrates Quality Assurance (QA), Quality Control (QC) and Quality Improvement (QI). Users and clients seek assurance: that the construction process will not result in any fatalities, disease and injuries, destroying the environment, and that the buildings and structures don't have any defects, costly maintenance and will not compromise the environment.
Osmani et al.	2008	Discussed the six variables that contributed to construction waste during design stages. The findings of the survey clearly indicate that waste minimization is not a priority during the design process.
Olatunji	2008	Discussed the existence of some of the main predetermined causes of material wastage and the degree of contributions of material waste in construction projects.
Muhwezi et al.	2012	Identify the major attributes of construction wastes on building projects in Uganda and measures of minimizing their occurrences.
Oko and Emmanuel	2013	Identify the most important and wasteful building material during any construction operation.
Sanmath	2013	Describes the main causes of research studies carried out in Pune (Maharashtra) India at the one of the famous sites of Kumar Builder construction that investigated the occurrence of material waste which occurred at 3 building sites located in different location of the Pune.
Agyekum et al.	2013	Discussed the main sources and causes of materials waste on construction sites arising from storage and handling of high waste generating building materials.
Ahankoob et al.	2014	Discussed the current practices of waste reduction at construction sites with regard to material and introduced some measured that are performed to decrease the impact of material waste.
Asghar et al.	2014	Identify activities generating the wastes in transportation, storage and design and procurement of all building materials. The results revealed that storage and handling have been chosen as the most important causative factor of waste production in construction activity. Improper material storage was identified as the main factor in producing waste in storage and handling phase. The usage of low-quality material in design stage and also changes in material price were recognized as major and most influenced causes of waste production in these stages.
Mahamid and Elbadawi	2014	Aims at identifying the main causes of material waste in building construction projects from the contractors' viewpoint and seeks to rank the considered materials according to their level of importance from the contractors' viewpoint.
Nikmehr et al.	2015	The findings revealed that important causes of C&D waste generation on construction sites were all associated with lack of skills and experience of workers and lack of awareness of the concept of waste and values of construction materials.

Continue of Table 1.

Eze et al.	2017	Assessment of the perception of tradesmen and construction operatives on material waste generation in construction industry, and also have a view to encourage to better performance in construction projects in Nigeria.
Mat and Kasim	2017	Focuses on material management, specifically in identifying the most influential factors which affect material management in the construction project activities. Consequently, this study sorted the most important influential factors and categorized them based on their specific group. About 47 factors were identified; they are classified into 8 groups: (1) management; (2) planning and handling on site; (3) site condition; (4) transportation; (5) supplier and manufacturer default; (6) materials; (7) governmental interferences; and (8) contractual.
Arshad et al.	2017	Reducing quantity of wastes and making a substantial contribution towards sustainable development and cost control.
Saad and Chafi	2019	Indicated that the top five critical waste factors are activity start delays, unused employee creativity, rework, long approval process, and waiting due to work not completed by others.

Table 2. Reinforced Concrete Materials Waste (RCMW) Causes

Cause	Explanation	Category
Design change	Changing in the design or construction of a project after the contract is awarded and signed	**Design**
Lack of drawing information	Skipping some of the details in the drawings by architects and engineers	**Design**
Construction error	Executing the activities on the site in a wrong way that doesn't meet the requirements of the customer	**Material Management**
Selection of unsuitable materials	Using unsuitable materials in construction stage which causes building defects and the end product doesn't achieve the specifications required	**Material Management**
Lack of on-site material control	Making efficient storing, purchase and consumption of materials	**Material Management**
Unnecessary movement of workers	Using of inadequate equipment, ineffective work methods, or poor arrangement of the working place and as a result of this waste time and effort	**Labor**
Uncompleted design	The action that happens because designers do not have the necessary experience, supervision, quality systems or time to produce the complete drawings required on time and this will lead to change orders	**Design**
Rework due to worker's mistake	The mistakes that happen during the construction stage, so it is crucial to train workers how to handle material to achieve the 3Rs (Reduction, Reuse and Recycled)	**Labor**
Waiting for resources	Stopping time on site due to lack of materials, manpower and equipment required for the work.	**Material Management**
Material theft	The process of materials robbery and deterioration	**Material Management**
Change in material prices	Fluctuating of raw material prices during the project construction phase	**Material Management**
Weather conditions	The atmospheric conditions that represented in temperature, wind, clouds and rain and which affect site work	**Site Management**
Unskilled workers	The workers who haven't special experience or training, which cause work difficulty, delay and low quality.	**Labor**

Continue of Table 2.

Material handling	The movement of material or products within an organization from one place to another place. The use of proper equipment for material handling and advance planning to minimize multiple handling will result in direct cost and time savings.	**Material Management**
Poor coordination	The process of managing resources in an organized manner so that a higher degree of operational efficiency can be achieved for a given project	**Site Management**
Material storage	The provision of adequate space, control and protection for materials, components and equipment that are to be kept on a construction site during construction processes. It is also necessary to plan and reserve storage areas for materials to avoid multiple materials movement.	**Material Management**
Leftover materials on-site	Something that remains unused or unconsumed after the finishing of the site work. Material control needed to avoid any potential material surplus occurring at the construction stage	**Material Management**
Design errors	Lack of instruction in the drawing and specifications and they are unavoidable in any construction projects	**Design**
Site Layout (Working conditions)	Identifying, sizing, and placing temporary facilities (TFs) within the boundaries of construction site.	**Site Management**
Over procurement or unused materials	Purchasing materials in larger quantities than required, which leads to wasting the materials on site and exposing them to damage and theft	**Material Management**
Lack of supervision	The lack of attention paid to workers during working on site which causing waste on labor, equipment and materials	**Labor**
Incorrect materials or wrong procurement	Miscommunication between engineers and specifications which leads to purchasing incorrect or wrong materials and leads to waste	**Material Management**
Damage during transportation	The process of stacking materials incorrectly which leads to waste. During the internal materials movement on site, excessive handling and using improper equipment is considered as the main reason of material damage during transportation on site	**Material Management**

The questionnaire was distributed to 300 experts in the top, medium and lower-level management working in construction site who deals regularly with reinforced concrete works. Only 220 responses were received, from which about 20 responses were excluded because of their random and non-respectable answers. So, the total number of participants taken into consideration in this study is 200 and they are distributed as 133 contractors' site engineers and 67 consultants' site engineers. The experience of the participants is categorized into four levels with five-year intervals as shown in Table 3.

Table 3. Distribution of Survey Participants

Participants' Organization/Position			Participants' Experience (E)			Total
			Years	**Level**	**No.**	
Contractor Site Engineer	**Valid**	133	E ≥ 15	4	46	146
			15 > E ≥ 10	3	9	
			10 > E ≥ 5	2	39	
			E < 5	1	39	
	Excluded	13				
Consultant Site Engineer	**Valid**	67	E ≥ 15	4	5	74
			15 > E ≥ 10	3	13	
			10 > E ≥ 5	2	29	
			E < 5	1	20	
	Excluded	7				
					200	220

4. Analysis of Variance (ANOVA) for RCMW Causes

The primary purpose of a two-way ANOVA (factorial analysis) is to understand if there is an interaction between the two independent variables on the dependent variable. Two-way ANOVA is employed to study the influence of participant organization/position and their experience on RCMW. The ANOVA output report is containing statistical elements as sums of squares (SS), degrees of freedom (df), and mean squares (MS), F statistic, and P-value. The F statistic is used in the hypothesis test and the P-value informs on the significance. A P-value is an evidence to reject the null hypothesis and suggests that the group means are significantly different. This statistical technique does not analyze the data directly but indicates the percentage contribution of each factor by determining the variance of the data (Johnson and Wichern 2007). The results obtained from the analysis of variance indicate that there was a significant interaction between the participant's organization/position and experience on the analysis of the RCMW causes. Firstly, the significance (P-value) of most RCMW causes was less than 0.05 as shown in Table 3. Secondly, Simple main effect analysis showed that the consultant site engineer with $15 > E \geq 10$ showed the most significant effect in design change as illustrated in Figure 1(a). Additionally, the contractor site engineer with $E < 5$ resulted in the most significant site layout causes as illustrated in Figure 1(b). So, the participant's organization/position and experience will be considered in calculating and analyzing the RCMW causes.

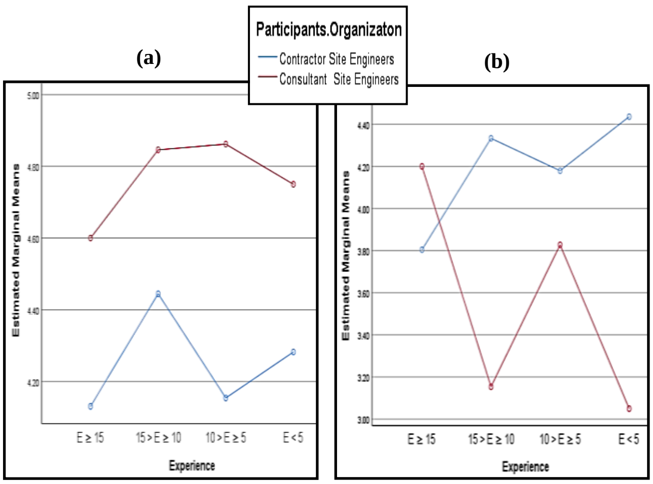

Fig. 1. Effect of Experience and Organization/ Position on RCMW Causes Marginal Means
(a) Design Change, (b) Site Layout

5. Experience Relative Importance Index (ERII)

To provide the experience relative importance index (ERII) expressed as a percentage for each RCMW cause, an importance index was calculated taking the consideration of the experts' experience. Questionnaire participants were selected based on their working experience with reinforced concrete work. According to the participants' experience years, the Experience Weight (EW_i) was assigned to reflect the experience level for the participant (i). Then, the Experience Mean (EM_j) for cause (j) was calculated based on the participants' responses and their EW_i. Finally, the $ERII_j$ for each RCMW cause (j) was illustrated mathematically according to the following equations (2), (3) and (4):

$$EW_i = \frac{E_i}{E_{Max}} \quad (2)$$

$$EM_j = \frac{\sum_{i=1}^{I_j} EW_i R_{ij}}{I_j} \quad (3)$$

$$ERII_j\% = \frac{EM_j}{\sum_{j=1}^{J} EM_j} \times 100 \quad (4)$$

Where: EW_i = experience weight for i^{th} participant; E_i = experience level for i^{th} participant (1-4); E_{Max} = the maximum experience level (4); EM_j = experience mean for j^{th} cause; R_{ij} = response of participant i for j^{th} cause (1-5); I_j = total number of participants respond for j^{th} cause; $ERII_j$ = experience relative importance index for j^{th} cause; and J = total number of RCMW causes (23). The results of Equations 2 and 3 are provided in Table 4 and the ranking of RCMW causes is illustrated in figure 2.

6. A Paired Samples T-Test

A trimmed mean (TM) is a method of averaging which depends on removing a small designated percentage of largest and smallest values before calculating the mean. The use of a 5% trimmed mean helps to reduce the influence of outliers or data points on the 5% tails that may unfairly affect the traditional mean in order to smooth the results and paint a more realistic picture (Kenton 2020). The traditional mean, 5% TM and EM for RCMW causes are presented in Table 4.

A t-test is used as a hypothesis testing tool that allows testing an assumption applicable to a population. Essentially, a t-test allows us to compare the mean values of the two data sets. Mathematically, a sample from each of the two sets is taken and established the problem statement by assuming a null hypothesis that the two means are equal. Based on the applicable formulas, certain values are calculated and compared against the standard values, and then the assumed null hypothesis is accepted or rejected accordingly. A paired samples t-test was assigned to determine if there is any significant difference between the experience and 5% trimmed means. The hypothesis assumptions were formulated as follows:

H_0 (Null hypothesis): $\mu_{TM} = \mu_{EM}$;

H_1 (Alternative hypothesis): $\mu_{TM} \neq \mu_{EM}$

Where: μ_{TM} = mean of 5% trimmed mean and μ_{EM} = mean of experience mean for each RCMW cause.

Table 4. Analysis of RCMW Causes

Category		Causes	Two Way ANOVA Results					Mean	5% TM	EM	ERII
			SS (Sum of Score)	df (Degree of Freedom)	MS (Mean Squares)	F (Static)	P-value				
Design	**1**	Design Change	0.346	3	0.115	0.275	**0.843**	4.41	4.47	**3.02**	**4.61%**
	2	Lack of Drawing Information	4.169	3	1.390	1.576	**0.196**	4.13	4.24	**2.85**	**4.35%**
	3	Design Errors	16.084	1	16.084	22.152	**0.000**	3.68	3.70	**2.56**	**3.90%**
	4	Uncompleted Design	12.532	1	12.532	10.450	**0.001**	3.78	3.86	**2.55**	**3.89%**
Material management	**5**	Construction errors	4.981	3	1.660	2.242	**0.084**	3.78	3.84	**2.67**	**4.07%**
	6	Selection of Unsuitable Materials	6.135	3	2.045	2.689	**0.047**	4.19	4.27	**2.91**	**4.44%**
	7	Lack of on-Site Material Control	2.922	3	0.974	3.530	**0.016**	4.57	4.61	**3.10**	**4.73%**
	8	Waiting for Resources	0.935	3	0.312	0.539	**0.656**	4.40	4.46	**2.96**	**4.51%**
	9	Material Theft	5.572	1	5.572	7.075	**0.008**	4.18	4.25	**2.82**	**4.30%**
	10	Change in Material Prices	4.188	3	1.396	1.069	**0.363**	3.94	4.04	**2.64**	**4.02%**
	11	Material storage	6.463	3	2.154	2.664	**0.049**	4.30	4.31	**2.89**	**4.41%**
	12	Material Handling	2.848	3	0.949	1.532	**0.207**	4.23	4.38	**2.87**	**4.38%**
	13	Leftover Materials on Site	17.048	1	17.048	15.044	**0.000**	3.92	4.02	**2.63**	**4.01%**
	14	Over procurement Materials	7.508	3	2.503	4.843	**0.003**	4.38	4.44	**3.01**	**4.59%**
	15	Incorrect Materials or Wrong procurement	3.387	1	3.387	5.940	**0.016**	4.22	4.24	**2.88**	**4.39%**
	16	Damage During Transportation	1.405	3	0.468	0.888	**0.448**	4.28	4.31	**2.87**	**4.38%**
Labor	**17**	Unskilled workers	9.195	3	3.065	4.297	**0.006**	4.15	4.22	**2.83**	**4.32%**
	18	Rework Due to Worker's Mistake	8.515	3	2.838	5.587	**0.001**	4.34	4.39	**2.99**	**4.56%**
	19	Lack of Supervision	1.141	3	0.380	1.037	**0.377**	4.52	4.58	**3.09**	**4.71%**
	20	Unnecessary Movement of Workers	4.260	3	1.420	2.878	**0.037**	4.30	4.33	**2.86**	**4.36%**
Site manage - ment	**21**	Weather Conditions	7.986	3	2.662	3.210	**0.024**	4.16	4.23	**2.81**	**4.29%**
	22	Poor Coordination	3.030	3	1.010	2.460	**0.064**	4.53	4.58	**3.09**	**4.71%**
	23	Site Layout	13.044	3	4.348	4.530	**0.004**	3.92	3.97	**2.67**	**4.07%**
											100%

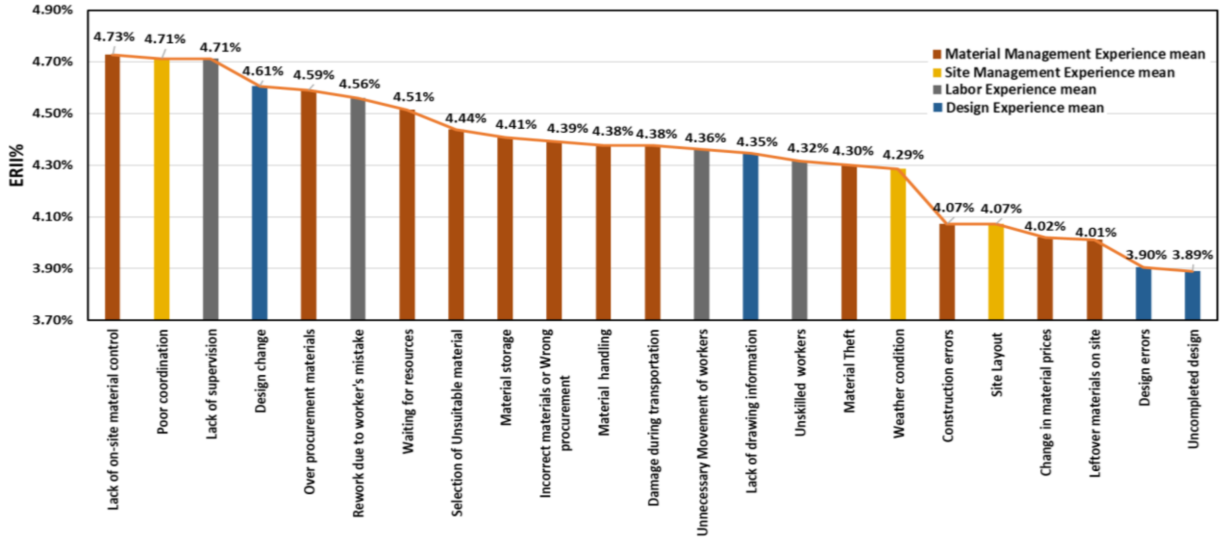

Fig. 2. Ranking of RCMW causes according to Experience Relative Importance Index (ERII)

At 95% confidence level, the t value was 69.650, the degree of freedom (df) was 22 and the significance was 0.000 < 0.05. Therefore, the null hypothesis was rejected and there was a significant difference between trimmed and experience means and the correlation between them was very high and nears to one as shown in Table 5.

Table 5. T-Test Results

Pairs	Mean	N	Std. Deviation	Correlation	t	df	Sig. (2-tailed) P-Value
Trimmed Mean (TM)	4.2496	23	0.24551				
Experience Mean (EM)	2.8509		0.16586				
TM-EM	1.3987		0.09631	0.964	69.650	22	0.000

7. Analysis of RCMW Causes by Project Organization/Position

In order to assess the RCMW causes by project organization/position, the consultants' and contractors' site engineers were separated and analyzed individually. To facilitate determining the degree of agreement between each project organization/position responses, the experience mean (EM) was calculated for total and each project organization/position. The RCMW causes, their ranking and the most important ten causes organized by a party are shown in Table 6. The ten most important RCMW causes in the overall results are indicated in boldface for better illustration.

The overall perception (consultant's site engineers and contractor's site engineers) is statically analyzed and the results show that the mean score of the causes contributing to RCMW generation in the Egyptian construction industry according to the total engineers' perception ranges between 2.55 and 3.10. "LACK of on-site material control" has the highest experience mean score of 3.10 while "uncompleted design" has the least experience mean score of 2.55. This implies that "Lack of on-site material control" is considered as the main important cause affecting material waste in the Egyptian construction industry while "uncompleted design" is considered as the least and according to the analysis of total respondents, it was also found that the most important ten factors are lack of on-site material control, lack of supervision, poor coordination, design change, over-procurement or unused materials, rework due to worker's mistakes, waiting for resources, selection of unsuitable materials, material storage and Incorrect materials or wrong procurement respectively.

From the **contractor site engineer's** analysis, it was found that lack of supervision is the most important factor while it was the second important factors in the total respondent's analysis, and lack of onsite material control is the second important factor on the contractor site engineers respondents while it was the second important factors in the total respondent's analysis, and lack of onsite material control is the second important factor on the contractor site engineers respondents while it was the first one on the total respondent's analysis. Also, from the analysis of consultant site engineers' respondents, it was found that design change is considered as the most important factor and ranking as the first one while it ranked as the fourth important factor in the total respondents' analysis. So, it was found that the results of the contractor's site engineers, consultant's site engineers, and total site engineers' opinions are very close and there is a slight difference in the final results.

According to the questionnaire analysis of **the consultant's site engineers**, the most important and effective causes affecting RCMW in the Egyptian construction industry are design change, lack of drawing information, and lack of on-site material control respectively. The results reveal that the experience mean score of the causative factors in the Egyptian construction industry ranges from 2.49 to 3.62. This proved that the most important and effective cause affecting RCMW based on the consultant's perception is "design change" while "leftover materials on-site" is considered the least one. Under the responsibility of **the contractor's site engineers**, the following causes are considered as the most important and effective causes affecting RCMW: lack of supervision, lack of on-site material control, and poor coordination. The results also show that the experience mean score of the causes contributing to RCMW according to contractors' perception ranges between 2.29 and 2.95. "Lack of supervision" has the highest experience mean score of 2.95 while "Uncompleted design" has the least experience mean score of 2.29. This implies that "lack of supervision" is considered as the main important cause that affecting material waste in the Egyptian construction industry according to contractors' perception while "uncompleted design" is considered as the least.

8. Conclusion

The first objective of this research was to identify the main causes of RCMW in Egypt. A compiled list of 23 causes was obtained and subjected to further quantitative evaluation in a questionnaire survey to identify the most important causes of RCMW. The most ten important causes based on overall participants' results were: lack of on-site material control, lack of supervision, poor coordination, design change, over-procurement (unused materials), rework due to worker's mistake, waiting for resources, selection of unsuitable material, material storage, incorrect materials (wrong procurement). The results show near agreement between overall participants' and contractor site engineers results in the most three important causes, although there is disagreement in some cases such as design change. The consultant site engineers pinpoint their responsibility and give the design change the first rank. A correlation of the responses of project organization/position showed that there is a great matching opinion between the overall results and the contractor site engineers' results, while the consultant held an intermediate result.

9. Data Availability Statement

All Data and models that support the findings of this study are available from the corresponding author upon reasonable request.

Table 6. Ranking RCMW Causes by Project Organization/Position

Rank	Total Participants Result		Contractor Site Engineer		Consultant Site Engineer	
	Ranked Causes $_{Total}$	EM $_{Total}$	Ranked Causes $_{Contractor}$	EM $_{Contractor}$	Ranked Causes $_{Consultant}$	EM $_{Consultant}$
1	**Lack of on-site material control**	**3.10**	**Lack of supervision**	**2.95**	**Design change**	**3.62**
2	**Lack of supervision**	**3.09**	**Lack of on-site material control**	**2.90**	Lack of drawing information	3.54
3	**Poor coordination**	**3.09**	**Poor coordination**	**2.89**	**Lack of on-site material control**	**3.48**
4	**Design change**	**3.02**	Material handling	2.88	**Poor coordination**	**3.48**
5	**Over procurement or Unused materials**	**3.01**	**Over procurement or Unused materials**	**2.88**	**Lack of supervision**	**3.37**
6	**Rework due to worker's mistake**	**2.99**	**Rework due to worker's mistake**	**2.86**	Construction error	3.26
7	**Waiting for resources**	**2.96**	Unnecessary Movement of workers	2.86	**Over procurement or Unused materials**	**3.24**
8	**Selection of unsuitable material**	**2.91**	**Waiting resources**	**2.83**	**Selection of unsuitable material**	**3.23**
9	**Material storage**	**2.89**	**Incorrect materials or Wrong procurement**	**2.81**	**Rework due to worker's mistake**	**3.22**
10	**Incorrect materials or Wrong procurement**	**2.88**	**Material storage**	**2.79**	**Waiting resources**	**3.19**
11	Material handling	2.87	Weather conditions	2.78	Damage during transportation	3.11
12	Damage during transportation	2.87	Material Theft	2.76	**Material storage**	**3.07**
13	Unnecessary Movement of workers	2.86	**Selection of unsuitable material**	**2.74**	Design errors	3.03
14	Lack of drawing information	2.85	Damage during transportation	2.74	**Incorrect materials or Wrong procurement**	**3.03**
15	Unskilled workers	2.83	Unskilled workers	2.73	Uncompleted design	3.02
16	Material Theft	2.82	**Design change**	**2.72**	Unskilled workers	3.02
17	Weather conditions	2.81	Leftover materials on site	2.71	Material Theft	2.94
18	Construction error	2.67	Site Layout	2.71	Weather conditions	2.88
19	Site Layout	2.67	Change in material prices	2.56	Material handling	2.86
20	Change in material prices	2.64	Lack of drawing information	2.48	Unnecessary Movement of workers	2.86
21	Leftover materials on site	2.63	Construction error	2.35	Change in material prices	2.78
22	Design errors	2.56	Design errors	2.31	Site Layout	2.60
23	Uncompleted design	2.55	Uncompleted design	2.29	Leftover materials on site	2.49

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