EVALUATION AND MANAGEMENT OF CONSTRUCTION MATERIAL AND TIME WASTE BY PARETO ANALYSIS METHOD

V.Rajeshkumar[1], P.Indhiradevi[2], D.Karthik[3]

[1]*Assistant Professor, Department of Civil Engineering, KPR Institute of Engineering and Technology, Coimbatore.*

[2]*Assistant Professor, Department of Civil Engineering, KPR Institute of Engineering and Technology, Coimbatore.*

[3]*Assistant Professor, Department of Civil Engineering, KPR Institute of Engineering and Technology, Coimbatore.*

Abstract - *A high level of waste is assumed to exist in construction. Material waste and time waste has been recognized as a major problem in the construction industry. Material waste not only affects the budget of that project but also the overall economy of the country. Time waste leads to increase in costs of the project. Studies from various sites have confirmed that waste represents a relatively large percentage of production costs. The objective of this study is to identify the major causes of the waste in construction industry by conducting questionnaire survey in various construction firms. From the literature factors causing material and time waste was identified and grouped into 5 categories. It includes Deign and documentation attributes, Operational attributes, Material Procurement, on site materials, Material Storage, Handling and Transportation, Site management and practices and Environmental and other conditions. The factors were ranked using Relative Importance Index (RII) to identify the major factor affecting material and time waste. Pareto analysis was used to determine the most critical success factor in material and time waste. Model has been developed based on the result from the pareto analysis to identify the importance percentage of material and time waste in construction industry.*

Key words: waste minimization, construction firms, pareto analysis

Introduction

Waste has been considered to be a major problem in the construction industry. High level of waste is assumed to exist in construction. Partial studies from various sites confirmed that waste represents a relatively large percentage of production costs. Waste in the construction industries is important not only from the perspective of efficiency, but has a major impact on the environment, both in terms of the resources it consumes and also the waste it produces. The construction industry is responsible for producing a whole variety of waste, the amount and type of waste depends on factors, such as the stage of Construction, type of construction work and practices on site. Thus, waste minimisation is an important area in construction industry.

Literature Review

According to **Lawrence Lesly Ekanayake** (2000**)** design changes while construction works are in progress is the most significant cause of waste generation at site. His study was based on a postal questionnaire study of the larger construction firms. He concluded that there is a

need for the design and construction teams to interact closely to avoid unnecessary waste related to design problems.

O.O. Akinkurolere and S.O. Franklin (2005) conducted the questionnaire survey on material wastage and management. He finally recommends that recycling and reusing of construction waste is a viable option in construction waste management and material wastage can be reduced by giving incentives to the workers for better handling of materials and by having trained personals to supervise the works.

Said Saker Al-Moghany (2006) aim was to identify the main waste causes in Gaza Strip construction industry in order to establish an initial framework for future studies to develop methods for prevention and elimination of waste causes inherent in the construction process. he finally conclude that Reworks that don't comply with drawings and specifications, rework due to workers' mistakes, conversion waste from cutting uneconomical shapes are the main waste causing factors.

According to **A.B. Wahab and A.F Lawal**(2011) last minute client requirements and cost of construction materials was ranked highest in questionnaire survey and he suggest to incorporate "waste management plan" as one of the documents dearly during tendering process.

L.Muhwezi and L. M. Cham1uriho (2012),conducted the structured questionnaire to identify the major attributes of construction wastes on building projects in Uganda, and used T-test statistical technique in comparing means and SPSS version 12.0 software was used to determine the major construction waste generation attributes.

Faisal Talib and **Zillur Rahman** (2010): identified some of the key factors that contribute to the success of total quality management. Pareto analysis was used to sort and arrange the Critical success factor according to the order of criticality. The results of this study will help in successful implementation of total quality management program in organizations.

S. AL Haadir and **K. Panuwatwanich** (2011): they identified the critical factors affecting the successful implementation of safety programs among construction companies in Saudi Arabia. Pareto principle was employed to develop seven most critical success factors, which represent the areas where companies should focus their attention and effort to achieve better safety levels through effective implementation programs.

Serdar Durdyev and **Syuhaida Ismail** (2012): Qualitative data collected using pilot interviews formed the basis for questionnaire surveys of project managers, contractors and subcontractors to improve the on-site productivity problems in the New Zealand construction industry. The quantitative data was analysed using the multi-attribute method and Pareto analysis.

Construction Waste

Waste in construction is not only focused on the quantity of waste of materials on-site, but also related to several activities such as overproduction, waiting time, material handling, processing, inventories and movement of workers. It is generated during the construction process because of factors such as site preparation, material use, material damage, material non-use, excess procurement and human error.

Construction Wastes are in the form of building debris, rubble, earth, concrete, steel, timber, and mixed site clearance materials, arising from various construction activities including land excavation or formation, civil and building construction, site clearance, demolition activities, road work and building renovation. While some of these wastes are recyclable and reusable, most of them are usually dumped in landfill. Wastes are often the mixtures of inert and organic materials. The inert waste are normally used in public filling areas and site

formation works and the remaining wastes are often mixed and contaminated, not suitable for reuse or recycle but disposed of at landfills.

Types of Waste

Material Waste: Building material waste can be defined as the difference between the values of materials delivered and accepted on site and those properly used as specified and accurately measured in the work, after deducting the cost saving of substituted materials transferred elsewhere, in which unnecessary cost and time is defined as materials wastage.

Time Waste: The duration of construction tasks consists of process time, inspection time, move time, and wait time. Only process time is considered to be value adding activity. The reminders are non-value adding activities. the value adding activity as the activity that converts material and/or information towards that which is required by the customer; non value adding activity are the activity that takes time, resources or space but does not add value.

Causes of Waste Generation

Many factors contribute to construction waste generation at construction site. In this research waste has been grouped into five factors it includes (1) Design and documentation (2) Material procurement, on site materials and material storage handling and transportation (3) Operational attributes (4) Site management and practices (5) Environmental and other conditions. Causes are shown in table 1.

Research Methodology

128 questionnaires of Material and Time Waste were sent by mail and also approached different construction firm which includes client, contractor and consultant. The respondents were asked to rate each factors based on five point scale 1-very low 2-low 3-moderate 4-high 5-very high. Respondent were requested to indicate their responses based on their past experience in construction project. Each factor was ranked using Relative Importance Index.

Pareto Analysis

The responses were analysed using pareto analysis. Pareto analysis is a statistical method in decision making that is used for the selection of a limited number of tasks. It uses pareto principle 80/20 rule, which states that focus on tasks which causes 80% of problems. It is used to identify a specific number of tasks that cause significant number of problems. From the responses the analysis were carried out independently for each questions and found the most critical success factor which contribute to material and time waste.

The importance percentage of main factor, group factor and sub-factors are calculated. The cumulative percentage of all sub-factors are determined and arranged in descending order. Paeto chart was made for cumulative percentage in Y-axis and number of factors in X-axis. A line is drawn at 80%on Y-axis which is parallel to X-axis then drops the line down to X-axis, which gives the important causes on the left and less important causes on the right. Pareto chart for material and time waste is shown in Fig 1 and 2.

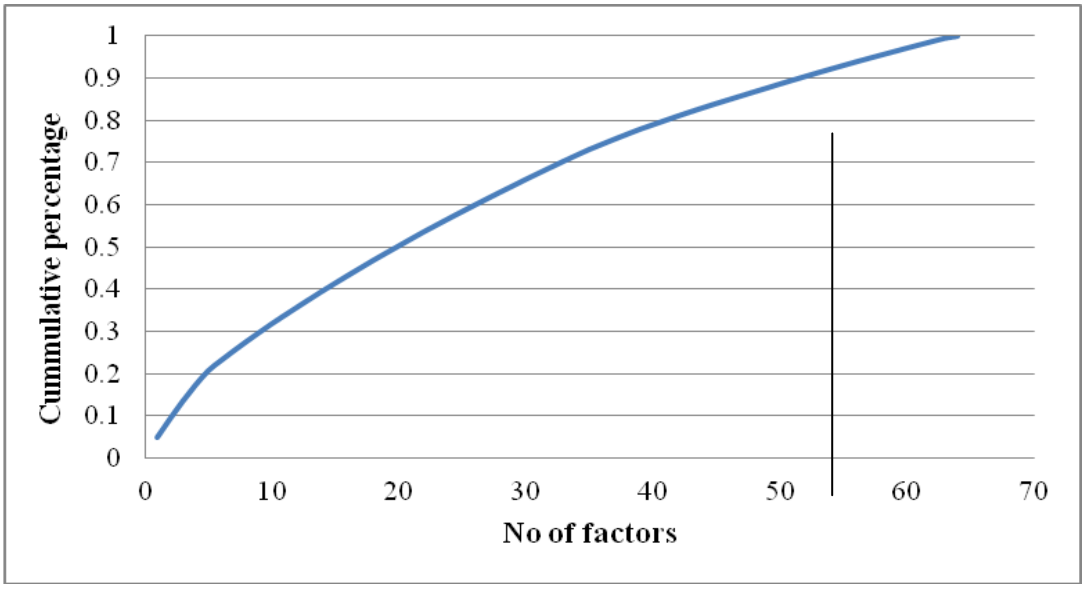


Fig 1- Pareto Chart for Material Waste

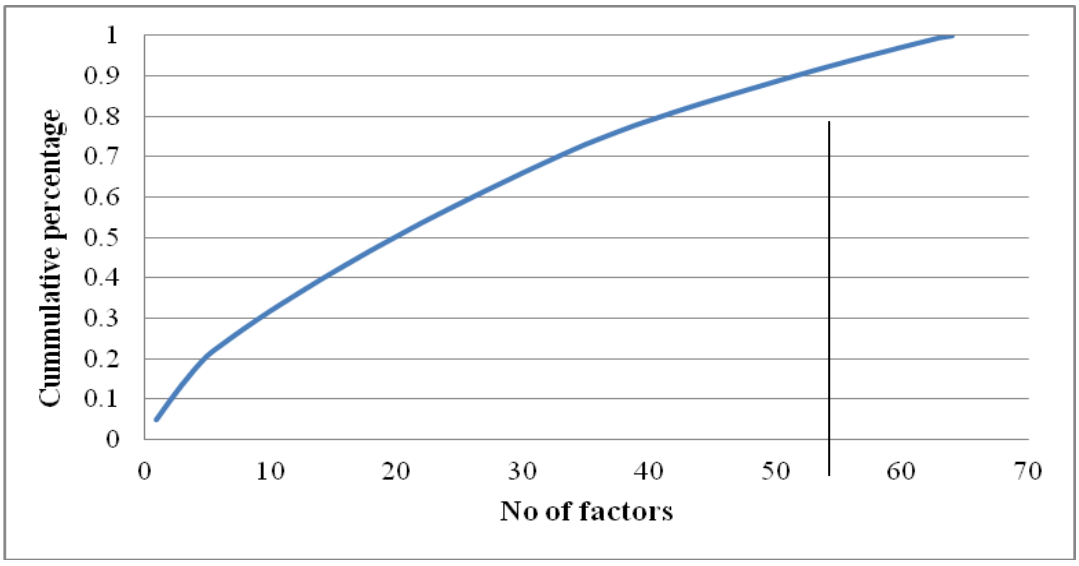
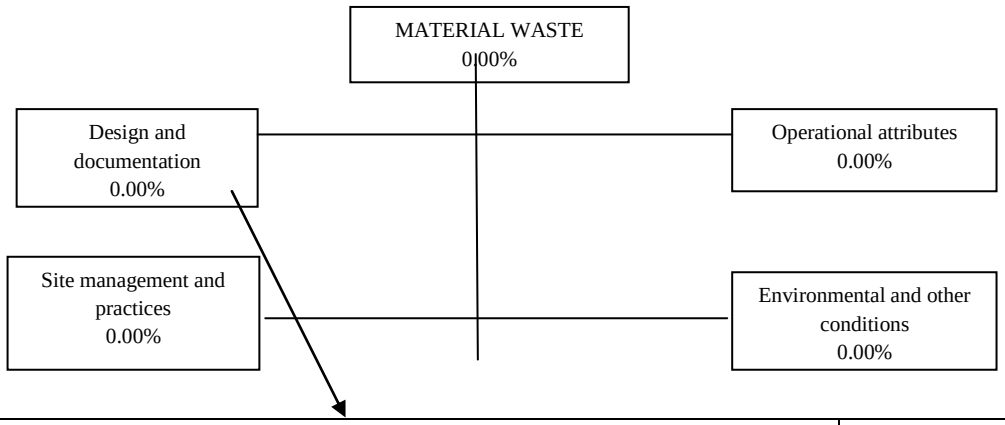


Fig 2- Pareto Chart for Time Waste

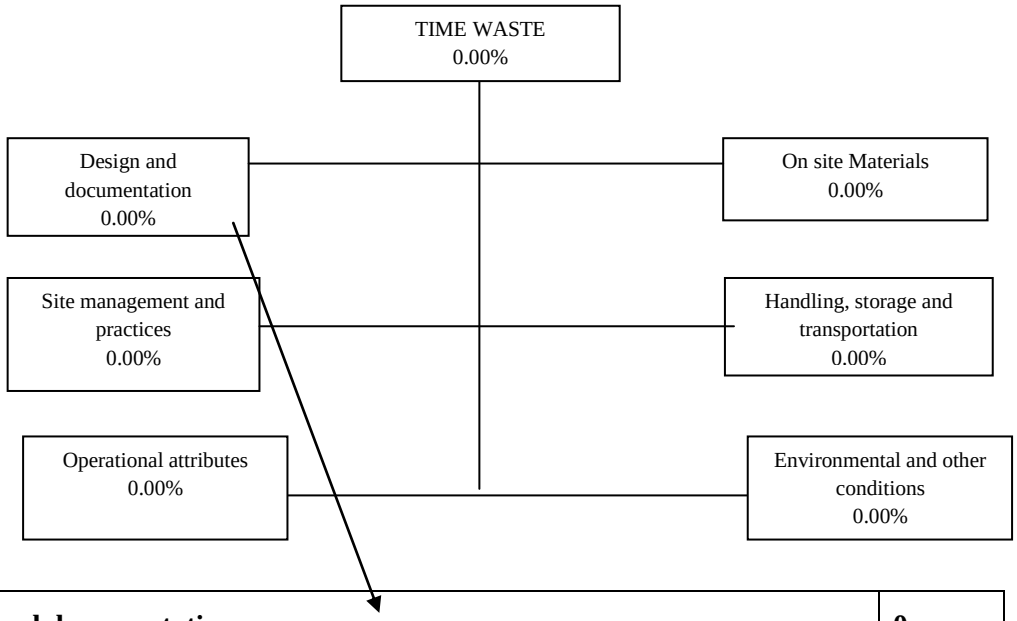
Model Development

From the chart 41 factors of material waste and 45 factors of time has been identified as most critical factors, a model has been developed using Excel, which will be used to identify the importance percentage of waste in construction project and will help in reducing the waste in future project. In this study material waste model has four main critical factors and six main critical factors in time waste. By pressing any one of the main factors a new page will appear which contains sub-factors, the user completes the column (X) by a percentage ranging from 0 to 100 based on the working condition then the user presses the finished tab to return to main page. This is repeated for all main factors. condition then the user presses the finished tab to return to main page. This is repeated for all main factors. The final result represents the percentage of material and time waste in that particular site. Material waste model is shown in Figure 3 and Time wate model in Fig 4.. Table 1 shows the critical factors of material waste and Table 2 shows the critical factor of material waste.



Design and documentation				**0**
No	**Critical sub-factors**	**Percentage value**	**X**	**Answer**
1	Design changes and revisions during construction work	0.0188		0.000
2	Selection of low quality materials	0.0201		0.000
3	Rework due to workers mistakes	0.0191		0.000

Fig 3: Model of Material Waste



Design and documentation				**0**
No	**Critical sub-factors**	**Percentage value**	**X**	**Answer**
1	Design changes and revisions during	0.0188		0.000
2	Selection of low quality materials	0.0201		0.000
3	Rework due to workers mistakes	0.0191		0.000

Fig 4: Model of Material Waste

Table 1: Critical factors of Material Waste

Main Factors	Factors	Percentage at 80%	Percentage at 100%	Total percentage
Design and documentation	Design changes and revisions in drawing while construction is in progress.	0.015046	1.88	25.25%
	Selection of low quality materials.	0.016054	2.01	
	Errors in contract documents.	0.015248	1.91	
	Incomplete contract documents at commencement of project.	0.010479	1.31	
	Lack of information in the drawing.	0.014643	1.83	
	Lack of information about the types and sizes of materials on design documentation.	0.010412	1.30	
	Designer's inexperience in method and sequence of construction.	0.012292	1.54	
	Lack of attention paid to the standard size available on the market.	0.014173	1.77	
	Complexity of detailing in the drawings.	0.011822	1.48	
	Waiting for design documents and drawings.	0.014442	1.80	
	Contract duration is too short.	0.014375	1.80	
	Ambiguities, mistakes and inconsistencies in drawings.	0.013367	1.67	
	Poor coordination of all parties during design stage.	0.011621	1.45	
	Rework that do not comply with drawings and specification.	0.012494	1.56	
	Selecting lowest bidder subcontractor.	0.015517	1.94	
Operational	Lack of coordination between the main contractor and subcontractor.	0.019936	2.49	24.99%
	Lack of coordination between crews.	0.019231	2.40	
	Lack of workers or subcontractors or tradesman skills.	0.021547	2.69	
	Reworks due to workers mistake.	0.024165	3.02	
	Damage to work done caused by subsequent trade.	0.022957	2.87	
	Use of incorrect materials thus requiring replacement.	0.016815	2.10	
	Accidents due to negligence.	0.016815	2.10	
	Poor workmanship.	0.02195	2.74	
	Unfriendly attitude between project team workers.	0.017922	2.24	
	Delay in passing information to contractor.	0.017117	2.14	
Site management and practises	Changing instruction by supervisors.	0.015841	1.98	24.22%
	Lack of waste management plan.	0.01813	2.27	
	Lack of supervisions and delay in inspections.	0.017215	2.15	
	Lack of quality management system	0.016024	2.00	
	Poor communication and coordination between parties involved in the project.	0.01868	2.33	
	Poor site layout.	0.015017	1.88	

	Ineffective control of the projects progress by the contractor.	0.019229	2.40	
	Lack of technical professionals in contractor's organization.	0.020786	2.60	
	Poor management and distribution of labors, material and equipment.	0.019595	2.45	
	Inadequate information to project participants.	0.015292	1.91	
	Poor qualification of the contractor's technical staff assigned to projects.	0.018039	2.25	
Environmental and other conditions	Severe weather conditions.	0.047736	5.97	25.73%
	Effect of social and political conditions.	0.043909	5.49	
	Damage by other parties.	0.03404	4.25	
	Effect of subsurface conditions	0.03827	4.78	
	Subsurface site conditions materially differing from contract documents.	0.041895	5.24	

Table 2: Critical factors of Time Waste

Main Factors	**Factors**	**Critical factors**	**CF*100 / 0.8028**	**Total percentage**
Design and documentation	Design changes and revisions in drawing while construction is in progress.	0.012	1.53	**14.19%**
	Errors in contract documents.	0.013	1.64	
	Incomplete contract documents at commencement of project.	0.015	1.85	
	Designer's inexperience in method and sequence of construction.	0.013	1.64	
	Complexity of detailing in the drawings.	0.016	1.97	
	Waiting for design documents and drawings.	0.014	1.80	
	Rework that do not comply with drawings and specification.	0.017	2.06	
	Selecting lowest bidder subcontractor.	0.014	1.71	
material on site	Damage material on site.	0.020	2.49	**8.59%**
	Theft.	0.016	2.00	
	Lack of site material control.	0.018	2.23	
	Manufacturing defects.	0.015	1.87	
storage transportation and handling	Wrong handling of materials.	0.015	1.90	**5.34%**
	Materials not stored near the site.	0.014	1.76	
	Insufficient instruction about storage and stacking.	0.013	1.67	
operational	Rework due to workers.	0.020	2.54	**25.17%**
	Lack of coordination between crews.	0.016	1.98	
	Lack of workers or subcontractors or tradesman skills.	0.019	2.38	

	Lack of coordination between the main contractor and subcontractor.	0.017	2.09	
	Accidents due to negligence.	0.015	1.92	
	Poor workmanship.	0.019	2.35	
	Waiting for materials or workers.	0.014	1.78	
	Equipment frequent breakdown.	0.015	1.85	
	Delay in arrival of equipment.	0.014	1.74	
	Poor technology of equipment.	0.018	2.22	
	Unskilled equipment operator.	0.019	2.30	
	Shortage of tools and equipment required.	0.016	2.02	
Site management and practices	Absence of detailed programs before the execution of the construction projects.	0.013	1.59	**20.81%**
	Lack of waste management plan.	0.014	1.70	
	Lack of supervisions and delay in inspections.	0.013	1.57	
	Lack of quality management system aimed at waste minimization strategy.	0.017	2.08	
	Poor communication and coordination between parties involved in the project.	0.013	1.56	
	Slow decision making by the site management.	0.017	2.15	
	Ineffective control of the projects progress by the contractor.	0.015	1.90	
	Lack of technical professionals in contractor's organization.	0.013	1.58	
	Delay in commencement of project.	0.013	1.59	
	Poor management and distribution of labours, material and equipment.	0.016	2.01	
	Inadequate information to project participants.	0.012	1.53	
	Poor qualification of the contractor's technical staff assigned to projects.	0.012	1.54	
Environmental and other conditions	Severe weather conditions.	0.039	4.90	**25.89%**
	Effect of social and political conditions.	0.039	4.84	
	Damage by other parties.	0.031	3.92	
	Difficulties in obtaining work permits.	0.030	3.79	
	Effect of subsurface conditions(type of soil, water table)	0.033	4.07	
	Subsurface site conditions materially differing from contract documents.	0.035	4.37	

Conclusion

The construction industry has been found to be major generation of waste. This study focused on material and time waste in construction project. From the analysis the major causes of material waste in construction are severe weather conditions, effect of social and political conditions, rework due to workers' mistakes, Lack of workers, Effect of subsurface conditions, inappropriate storage and time waste are severe weather conditions, Effect of subsurface conditions, rework due to workers' mistakes, Difficulties in obtaining work permits, equipment frequent breaking down. It has been observed from the survey that most of the company do not have waste minimization strategy so in future all industry should have minimization strategy to reduce the waste and to achieve sustainability. A model which is developed will be useful to identify the major factor leading to waste and their percentage, which helps the construction industry to minimize the waste.

Owners should give more importance to waste management at start of the project and should visit the site periodically and should see the record of waste management at construction site.

Contractor should prepare waste minimization plan, he should record the waste occurring at construction site to minimize them in future works.

References

1. Anis Adila bt Abdullah (2011) sustainable construction waste management in malaysia: a contractor's perspective- management and innovation for a sustainable built environment.
2. B.A.G.Bossink and H.J.H.Brouwers (1996) Construction waste: Quantification and Source Evaluation-journal of Construction Engineering and management
3. Building Research Station, (1981). "Waste of building materials." Building Research Establishment, Digest 247, Watford.
4. Caron Viljoen (November 2010) Quality factors Contributing to the Generation of Construction Waste-Construction Engineering and Management.
5. Faisal Talib and Zillur Rahman (2010) A study of total qualitymanagement and supply chain management practices
6. Ferguson, J., Kermode, N., Nash, C.L., Sketch, W.A.J. & Huxford, R.P. (1995). Managing and Minimizing Construction Waste – A Practical Guide. Institute of Civil Engineers London.
7. Gihan L.Garas, Ahmed R.Anis, Adel El Gammal (2008) Materials waste in the Egyptian construction industry-journal of Engineering Research
8. L.Muhwezi, L. M. Cham1uriho and N. M.Lema (2012) An investigation into Materials Wastes on Building Construction Projects in Kampala-Uganda-journal of Engineering Research.
9. Lawrence Lesly Ekanayake (August 2000) Construction Material Waste Source Evaluation-Strategies for a Sustainable Built Environment, Pretoria.
10. O.O. Akinkurolere and S.O. Franklin (2005) Investigation into Waste Management on Construction Sites in South Western Nigeria-American journal of Applied Science
11. Paola Villoria Sáez and Mercedes del Río Merino (2011) Managing construction and demolition (C&D) waste – a European perspective- International Conference on Petroleum and Sustainable Development.
12. Said Saker Al-Moghany(February 2006) Managing and Minimizing Construction Waste-Building and Environment.
13. Serdar Durdyev and Syuhaida Ismail (2012) Pareto analysis of on-site constraints and improvement techniques in construction industry.
14. Shreedhar A. Balaswamy,Poorva Chandrawat Harsh N. Gajaria(2008) Material Management In Construction Projects-Construction Management journal.
15. Skoyles, E.R., and Skoyles, J.R. (1987). Waste prevention on site. Mitchell Publishing Company Limited. London.
16. S. AL Haadir and K. Panuwatwanich (2011) Critical Success Factors for Safety Program Implementation among Construction Companies in Saudi Arabia.