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**Project Management Strategies for Concrete Application: Optimization
of Project
Timeline, Quality, and Cost**

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Abstract

Efficient project management is critical in concrete pavement projects, where balancing project timeline, quality, and cost directly impacts overall project success. This research investigates effective project management strategies, specifically focusing on the optimization of timelines, quality control measures, and cost management practices, through a detailed case study on Cement Bound Granular Material (CBGM) applications in pavement construction. The study employs a descriptive-analytical approach, utilizing both quantitative and qualitative data gathered from industry-standard practices, technical guidelines, and field case studies. Findings demonstrate how strategic management practices significantly enhance project efficiency by optimizing scheduling, improving material and construction quality, and effectively controlling costs. The results also highlight practical insights into the trade-offs involved when optimizing one dimension over another. Recommendations are provided to guide project managers in adopting integrated project management approaches to achieve optimal balance and improved performance outcomes in concrete pavement projects.

Key words :

(Concrete, Pavement, Management, Projects, Timeline, Cost Management, Quality Control, RC, CBGM)

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List of Terminology

Abbreviation	Full Term
CBGM	Cement Bound Granular Material
CPM	Critical Path Method
PERT	Program Evaluation and Review Technique
BIM	Building Information Modeling
PMI	Project Management Institute
SPSS	Statistical Package for the Social Sciences
IoT	Internet of Things
KPI	Key Performance Indicator
ANOVA	Analysis of Variance
IRI	International Roughness Index
CPD	Continuous Professional Development
WBS	Work Breakdown Structure
FMEA	Failure Mode and Effect Analysis
HMA	Hot Mix Asphalt
QA/QC	Quality Assurance / Quality Control
EPC	Engineering, Procurement, and Construction
RAM	Reliability, Availability, and Maintainability
BOQ	Bill of Quantities
NPV	Net Present Value
BCR	Benefit-Cost Ratio
DBB	Design-Bid-Build
SCM	Supply Chain Management
RCP	Reinforced Concrete Pavement

List of Abbreviations

Term	Definition
Cement Bound Granular Material (CBGM)	A type of hydraulic-bound material used in pavement construction, offering high strength and durability.
Critical Path Method (CPM)	A project scheduling technique used to determine the longest sequence of dependent tasks to optimize project timelines.
Quality Control (QC)	A systematic process ensuring that construction materials and practices comply with project specifications.
Cost Management	The practice of estimating, budgeting, and controlling project expenses to avoid cost overruns.
Lean Construction	A methodology focused on reducing waste, increasing efficiency, and improving value in construction projects.
Pavement Rehabilitation	A set of techniques used to restore the structural integrity and functional performance of deteriorated pavements.
Project Timeline Optimization	The use of scheduling tools and techniques to minimize project delays and improve delivery time.
Value Engineering (VE)	A systematic approach to improving project efficiency by reducing costs without compromising quality.
Sustainability in Pavement Construction	Practices aimed at minimizing environmental impact by using recycled materials, reducing emissions, and optimizing energy efficiency.
Work Breakdown Structure (WBS)	A hierarchical decomposition of the total project work into smaller, manageable sections.
Engineering, Procurement, and Construction (EPC)	A project delivery method where a single entity is responsible for engineering, purchasing materials, and construction.
Public-Private Partnership (PPP)	A funding model where government and private sector entities collaborate to finance and operate infrastructure projects.
Supply Chain Management (SCM)	The coordination of materials, resources, and logistics throughout a project's lifecycle to ensure efficiency.
Reinforced Concrete Pavement (RCP)	A type of concrete pavement reinforced with steel mesh or bars to enhance its strength.

CHAPTER 1: General Framework of the Study

Introduction:

Concrete is one of the most widely used construction materials globally, recognized for its durability, versatility, and cost-effectiveness (Neville, 2011). In recent years, concrete pavement construction has experienced significant advancements driven by the increasing demand for efficient and sustainable infrastructure solutions. Project management is essential in concrete pavement projects as it directly influences key project components, including project timelines, quality assurance, and cost optimization (Kerzner, 2017). These components are interconnected; imbalance can result in project delays, increased costs, and compromised quality.

This research emphasizes Cement Bound Granular Material (CBGM), a hydraulically bound material extensively employed in pavement construction due to its high strength, durability, and environmental benefits (Britpave, 2005). According to Britpave (2005), CBGM offers advantages such as rapid strength gain, reduced pavement thickness, and improved overall sustainability, making it a preferred choice for modern infrastructure projects.

However, effectively managing CBGM pavement projects presents challenges, including optimizing timelines without compromising quality, controlling cost overruns, and ensuring compliance with technical standards and specifications. Addressing these challenges requires integrated project management strategies that comprehensively optimize timelines, quality, and costs (PMI, 2021).

This study aims to answer the primary research question: How can project management strategies be effectively applied to optimize the timeline, quality, and cost of CBGM pavement projects? Supporting this main question are several sub-questions:

- What specific project management techniques can optimize the timeline of CBGM pavement construction?
- How can quality control measures be improved to ensure CBGM pavements meet or exceed performance expectations?
- What cost management practices are most effective in controlling expenses in CBGM pavement projects?

The primary objectives of this research include investigating current project management practices in CBGM applications, identifying critical factors impacting timeline, quality, and cost, and proposing integrated management recommendations to optimize these critical dimensions.

The scope of the study focuses on CBGM pavement projects, with data collection and analysis centered around practical examples, industry standards, and expert input. The outcomes are expected to provide actionable insights and guidance for project managers, engineers, and decision-makers involved in concrete pavement construction.

literature review :

The literature review for this research addresses critical areas relevant to the project management strategies in concrete pavement construction, focusing particularly on CBGM. It explores current literature on concrete pavement project management methodologies, CBGM-specific properties, and optimization techniques applied to construction timelines, quality control, and cost management.

According to Neville (2011), concrete's long-term performance depends significantly on the effectiveness of project management, which involves proper scheduling, resource allocation, and adherence to established quality standards. Kerzner (2017) further emphasizes the interdependency of project timelines, quality assurance, and cost control, indicating that an integrated approach to these dimensions is essential for achieving successful project outcomes. Technical standards, notably BS EN 14227, clearly define the specifications and applications of hydraulically bound materials like CBGM, stressing the necessity of stringent quality control and rigorous adherence to established guidelines to ensure reliable pavement performance (Britpave, 2005).

Previous studies and practical case examples have demonstrated that efficient project management practices can substantially enhance concrete pavement construction outcomes, reducing overall project timelines, improving quality consistency, and controlling budget expenditures effectively (PMI, 2021).

Research Problems:

Despite the numerous benefits associated with CBGM pavement construction, there are several challenges in project management that impact the successful implementation of these projects. According to Britpave (2005), hydraulically bound materials like CBGM require careful management practices to avoid project inefficiencies. The following are critical issues frequently encountered in managing CBGM pavement projects:

1. Delays and scheduling inefficiencies significantly impacting overall project timelines (Kerzner, 2017).
2. Variability in quality control measures affecting pavement performance and longevity (Neville, 2011).
3. Cost overruns due to inadequate budgeting, resource allocation, and financial control mechanisms (PMI, 2021).
4. Compliance challenges with technical specifications and industry standards, leading to rework and added project costs (Britpave, 2005).

Effectively addressing these problems requires integrated and comprehensive project management strategies, emphasizing a balanced approach to optimizing timelines, quality, and costs.

This study aims to answer the primary research question: How can project management strategies be effectively applied to optimize the timeline, quality, and cost of CBGM pavement projects? Supporting this main question are several sub-questions:

- What specific project management techniques can optimize the timeline of CBGM pavement construction?
- How can quality control measures be improved to ensure CBGM pavements meet or exceed performance expectations?
- What cost management practices are most effective in controlling expenses in CBGM pavement projects?

The primary objectives of this research include investigating current project management practices in CBGM applications, identifying critical factors

impacting timeline, quality, and cost, and proposing integrated management recommendations to optimize these critical dimensions.

The scope of the study focuses on CBGM pavement projects, with data collection and analysis primarily centered around practical examples, industry standards, and expert input. The outcomes are expected to provide actionable insights and guidance for project managers, engineers, and decision-makers involved in concrete pavement construction.

Research Hypotheses:

Based on the identified problems and insights from preliminary questionnaire data, this research proposes the following hypotheses, reflecting expected statistical relationships:

H1: There is a statistically significant relationship between the application of effective project management techniques and improvements in project timeline efficiency in CBGM pavement construction.

H2: There is a statistically significant relationship between enhanced quality control measures and the overall performance and durability of CBGM pavement.

H3: The implementation of robust cost management strategies significantly correlates with reduced cost overruns in CBGM pavement projects.

H4: Adherence to technical standards and specifications shows a significant positive relationship with project quality and reduced incidence of rework.

These hypotheses will be tested statistically using appropriate analytical methods to confirm or refute the stated relationships within the study context.

Research Objectives:

To address the research problems effectively, the study seeks to answer the following research questions formulated as objectives:

- What project management techniques are most effective in optimizing the timeline of CBGM pavement construction?
- How can quality control measures be improved to consistently achieve high-performance outcomes in CBGM pavement?
- What cost management practices effectively minimize cost overruns and enhance financial control in CBGM pavement projects?

Research Importance:

The significance of this research stems from its direct response to practical challenges highlighted in previous studies and preliminary questionnaire findings. Unlike previous studies that separately addressed timeline, quality, or cost issues in pavement projects, this research uniquely integrates all three dimensions, providing a comprehensive framework for optimized project management. Furthermore, the outcomes of this study aim to offer actionable insights and practical recommendations, enabling project managers, engineers, and stakeholders to effectively balance project timelines, enhance quality control, and manage costs, ultimately contributing to more sustainable and economically viable CBGM pavement projects.

Research Methodology:

This study employs a descriptive-analytical approach, systematically integrating both qualitative and quantitative methodologies. A structured questionnaire will be utilized to gather primary data from industry professionals, project managers, and technical experts engaged in CBGM pavement projects. Data collected through this questionnaire will be statistically analyzed using methods such as correlation and regression analysis to verify the relationships proposed in the research hypotheses. Additionally, qualitative data from technical guidelines, industry standards, and relevant field case studies will complement quantitative findings to provide comprehensive insights into effective project management strategies.

CHAPTER 2: The Theoretical Framework and Previous Studies

The Theoretical Framework:

A review of prior studies is essential to position this research within the existing body of knowledge. The following categories summarize relevant research:

- **Studies on CBGM Applications in Pavement Construction:** Research has demonstrated the advantages of CBGM in reducing pavement thickness and improving sustainability (Britpave, 2005).
- **Project Management Strategies in Construction:** Multiple studies have analyzed how scheduling techniques, resource allocation, and risk management influence construction timelines and costs (Kerzner, 2017; PMI, 2021).
- **Quality Control in Concrete Pavements:** Prior studies emphasize the importance of rigorous testing, material selection, and adherence to specifications to ensure long-term performance (Neville, 2011).
- **Cost Optimization in Infrastructure Projects:** Several economic analyses highlight effective cost control measures that help prevent budget overruns in large-scale projects (Brigham & Ehrhardt, 2019).

This chapter synthesizes these theories and prior studies to build a comprehensive understanding of project management strategies for CBGM pavement projects. The following chapter will present the practical application of these concepts in real-world case studies.

Previous Studies:

1. The study of (Al Fuhaid, 2022) - Application of Mechanistic Empirical Pavement Design Guide Software in Saudi Arabia

- **Relevance:** Explores structural pavement design techniques related to pavement distresses such as rutting, cracking, and the International Roughness Index (IRI), focusing on various regions in Saudi Arabia.
- **Summary:** This study utilized the Mechanistic-Empirical Pavement Design Guide (MEPDG) software to calibrate and predict pavement design life based on material properties, roadbed characteristics, climate, and traffic loads across four Saudi regions: Central (Riyadh), Eastern (Al-Ahsa), Western (Jeddah), and Northern (Arar). The findings provide a foundational pavement design that can be adjusted according to specific project requirements to achieve the desired design life.
- **Potential Use for the Study:**
 - Incorporate MEPDG software insights to optimize concrete pavement designs in terms of durability and performance.
 - Apply region-specific data on material properties and climatic conditions to enhance the accuracy of project planning and execution.

2. The study of (Martins, 2022) - Rubblization of Shaybah Airport Runway Pavement—A Sustainable Circular Economy Solution

- **Relevance:** Presents a practical, cost-effective, and sustainable method for repairing deteriorated airfield concrete pavements in Saudi Arabia.
- **Summary:** This paper discusses the successful implementation of rubblization technology to rehabilitate the Shaybah Airport runway. By converting existing worn-out concrete pavement into a high-

quality aggregate base, the project achieved significant cost savings, reduced environmental impact, and expedited construction timelines. This approach aligns with circular economy principles by repurposing materials and minimizing waste.

- **Potential Use for the Study:**
 - Explore rubblization as a sustainable technique for concrete pavement rehabilitation in project management strategies.
 - Assess the benefits of adopting circular economy principles in construction projects to optimize costs and timelines.

3. The study of (Al-Qaili, 2021) - Enhancing MEPDG Distress Models Prediction for Saudi Arabia by Local Calibration

- **Relevance:** Focuses on improving the accuracy of distress models used in the Mechanistic-Empirical Pavement Design Guide (MEPDG) to predict pavement performance in Saudi Arabia.
- **Summary:** The study emphasizes the necessity of local calibration to increase the precision of distress models within the MEPDG framework. By tailoring these models to the specific conditions of Saudi Arabia, the research aims to enhance the reliability of pavement performance predictions, leading to more effective design and maintenance strategies.
- **Potential Use for the Study:**
 - Implement localized calibration techniques to improve the accuracy of pavement performance predictions in project management.
 - Utilize enhanced distress models to inform decision-making processes related to maintenance scheduling and resource allocation.

4. The study of (Al-Harbi, 2022) - Optimization of Pavement Maintenance Scheduling in Saudi Arabia

- **Relevance:** Focuses on optimizing pavement maintenance schedules, aligning with interests in timeline optimization.
- **Summary:** Researchers utilized decision-support models and life cycle cost analysis to determine the most cost-effective pavement maintenance schedules while maintaining quality standards.
- **Potential Use for the Study:**
 - Compare optimization techniques used for pavement scheduling with concrete project scheduling.
 - Assess how maintenance scheduling principles could be adapted to concrete applications.

5. The study of (Al-Dhaheri, 2020) - Cost Optimization in Pavement Construction Using Local Materials in Saudi Arabia

- **Relevance:** Directly relates to cost reduction strategies in infrastructure projects.
- **Summary:** This study evaluates the cost-benefit analysis of using locally available materials versus imported materials in road construction, highlighting how local material selection affects both quality and cost-efficiency.

- **Potential Use for the Study:**

- Adapt similar cost-benefit models to assess concrete material selection.
- Analyze the balance between quality and cost in construction material choices.

6. The study of (Alotaibi, 2021) - Quality Control of Rigid Pavement in Saudi Arabian Highways

- **Relevance:** Involves quality management strategies for concrete pavements.
- **Summary:** The research examines common defects in rigid pavements, proposing best practices for mix design, curing techniques, and project management strategies to improve pavement durability.
- **Potential Use for the Study:**
 - Implement similar quality control methodologies in concrete applications.
 - Examine how quality management in Saudi pavement projects can be applied to broader construction practices.

7. The study of (Al-Fadhil, 2019) - Time-Cost Tradeoff Analysis in Highway Construction Projects in Saudi Arabia

- **Relevance:** Focuses on the time-cost tradeoff, similar to schedule crashing methodology.
- **Summary:** The study uses project management tools like the critical path method (CPM) and Monte Carlo simulations to analyze the impact of schedule acceleration on project costs and quality.
- **Potential Use for the Study:**
 - Compare results with findings in schedule crashing for concrete projects.
 - Adapt project management frameworks from highway construction to the case study.

Chapter 3: Methodology

3.1 Introduction:

This chapter outlines the comprehensive methodological approach adopted in this research to investigate effective project management strategies for optimizing timeline, quality, and cost within Cement Bound Granular Material (CBGM) pavement construction projects. It clearly presents the chosen research approach, description of the targeted community, detailed criteria for sample selection, tools and techniques for data collection and analysis, and the methods applied to verify the reliability and validity of the research instrument. Furthermore, this chapter elaborates on the statistical procedures employed to interpret collected data, particularly highlighting descriptive statistics, correlation analyses, reliability tests, and hypothesis testing outcomes.

3.2 Research Methodology:

This research employs a descriptive-analytical approach, merging qualitative insights from technical guidelines, industry reports, and real-world case studies with quantitative data derived from structured questionnaires. The rationale behind adopting this methodology is its capacity to generate comprehensive insights by statistically validating theoretical assumptions and analyzing practical implications. Quantitative data from questionnaires were analyzed using the Statistical Package for the Social Sciences (SPSS) to confirm hypothesized relationships among key project variables, while qualitative data provided context and practical depth to the findings.

3.3 Research Community:

The targeted research community includes professionals directly involved in the construction sector, specifically those experienced with CBGM pavement projects. This group comprises project managers, civil and structural engineers, technical supervisors, quality control specialists, and cost control experts operating within private sectors.

For the purposes of this study, the research sample was limited to construction professionals working within [Saudi Arabia, Jeddah, Jeddah Islamic Port], where CBGM pavement applications are actively utilized. The study was conducted within a specific timeframe from 2024 to 2025, which may influence the generalizability of the findings to other periods or evolving industry practices.

Additionally, due to logistical and resource constraints, data collection was restricted to professionals accessible through direct outreach, industry networks, and professional associations. While efforts were made to obtain a representative sample, the findings may not fully capture the perspectives of professionals working in different geographic regions or project scales.

3.4 Research Sample According to Demography:

A purposive sampling technique was employed to select 33 professionals actively involved in CBGM pavement projects. The sample size and composition were chosen carefully to reflect the demographics of industry professionals actively engaged in relevant projects. The demographic distribution of the sample is summarized below and detailed in Tables 3.1 and illustrated in Figure 3.1:

Table 3.1.1: Gender Frequency.

		Gender			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	27	81.8	81.8	81.8
	Female	6	18.2	18.2	100.0
	Total	33	100.0	100.0	

Table:3.1.2: Age Frequency.

Age		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	30 or less	12	36.4	36.4	36.4
	31 to 35	11	33.3	33.3	69.7
	36 to 45	6	18.2	18.2	87.9
	46 or above	4	12.1	12.1	100.0
	Total	33	100.0	100.0	

Table:3.1.3: Education Frequency.

Education		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Bachelor's degree	26	78.8	78.8	78.8
	Master degree	4	12.1	12.1	90.9
	Doctorate degree	3	9.1	9.1	100.0
	Total	33	100.0	100.0	

Table:3.1.4: Years of experience Frequency.

Years of experience		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5 or less	15	45.5	45.5	45.5
	6 to 10	7	21.2	21.2	66.7
	11 to 15	7	21.2	21.2	87.9
	above 15	4	12.1	12.1	100.0
	Total	33	100.0	100.0	

Table:3.1.5: Job Frequency.

		Job role			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Contractor	22	66.7	66.7	66.7
	Consultant	4	12.1	12.1	78.8
	Designer	2	6.1	6.1	84.8
	Client	5	15.2	15.2	100.0
	Total	33	100.0	100.0	

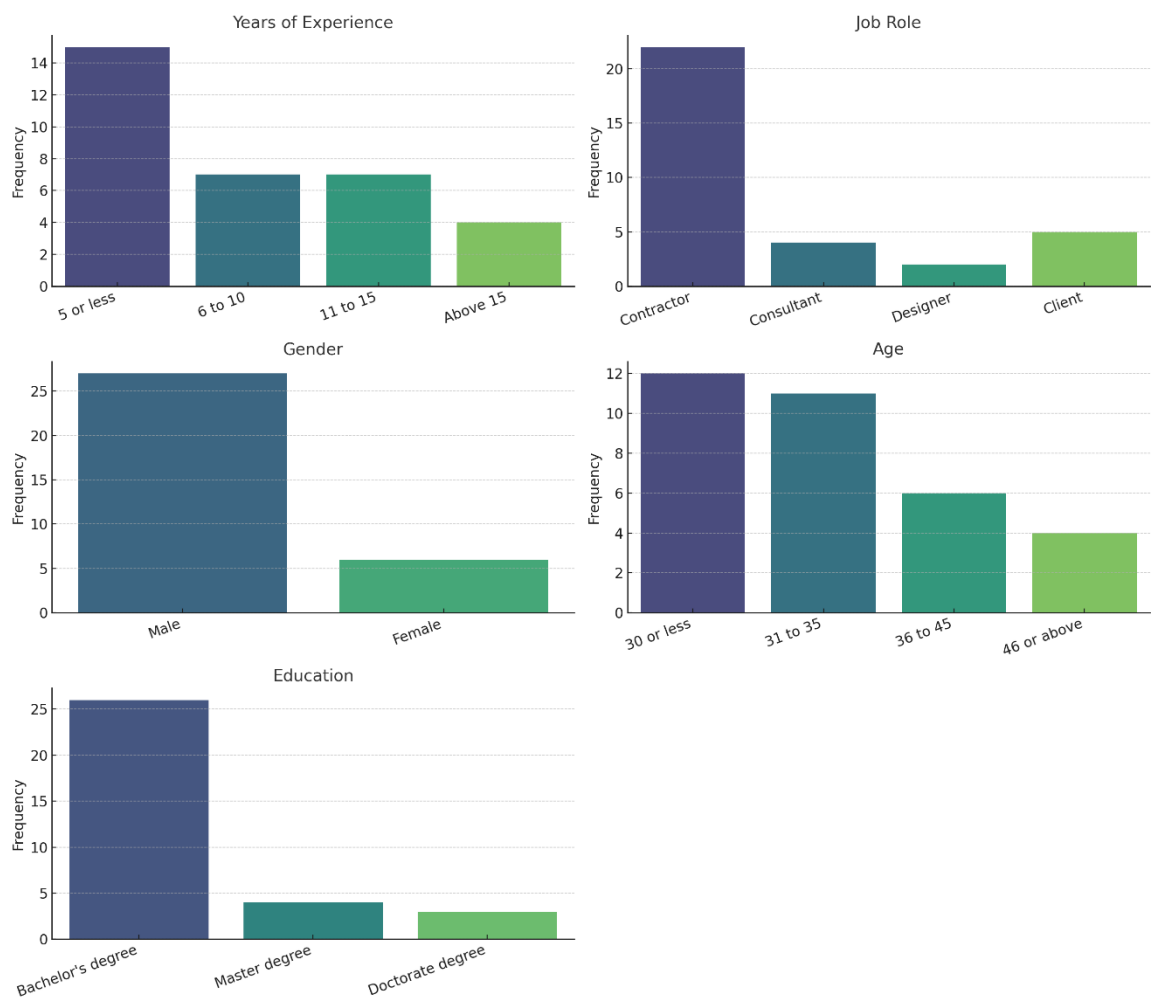


Figure 3.1: The demographic distribution of the sample.

Gender distribution indicates 81.8% male respondents and 18.2% female respondents.

Age demographics reveal that 36.4% of respondents were aged 30 years or below, 33.3% were between 31 and 35 years, 18.2% were between 36 and 45 years, and 12.1% were aged 46 years or above.

Educational qualification showed that 78.8% held a bachelor's degree, 12.1% a master's degree, and 9.1% held a doctorate degree.

Professional experience varied with 45.5% having 5 years or fewer, 21.2% between 6 to 10 years, 21.2% between 11 to 15 years, and 12.1% had more than 15 years of experience.

Detailed demographic statistics are summarized in Table 3.1 and Figure 3.1.

3.5 Research Tool (SPSS):

SPSS software version was utilized extensively to analyze questionnaire data due to its robust analytical capabilities, user-friendly interface, and accuracy in managing complex datasets. SPSS enabled the execution of various statistical analyses such as descriptive statistics, reliability tests, Pearson correlation analysis, and One-Way ANOVA tests. These statistical methods were pivotal in verifying the research hypotheses, assessing internal consistency, exploring demographic impacts on responses, and identifying significant relationships among variables.

3.5 Validation of Research Questionnaires:

To enhance the robustness and credibility of the research findings, careful validation of the questionnaire was conducted through multiple rigorous processes:

3.5.1 Expert Validation:

The content validity of the questionnaire was established through an expert panel consisting of experienced engineers, academics, and practitioners in concrete pavement construction. Feedback from these experts was meticulously reviewed, and necessary adjustments were made to ensure clarity, relevance, and accuracy of the questionnaire items.

3.5.2 Internal Consistency (Reliability Analysis):

Internal consistency of the questionnaire items was assessed using Cronbach's Alpha coefficient through SPSS. The reliability results demonstrated acceptable to good internal consistency, with Cronbach's Alpha values reported as follows:

Timeline Efficiency: Cronbach's Alpha = 0.771

Cost Management: Cronbach's Alpha = 0.680

Quality Control: Cronbach's Alpha = 0.855

These results indicate that the questionnaire effectively measures the intended constructs. (Refer to detailed reliability analysis results will attached in appendices).

3.5.3 Pearson's Correlation Analysis:

Pearson correlation analysis was performed to determine the strength and significance of relationships among project timeline efficiency, quality control measures, cost management practices, and overall project outcomes. Findings revealed significant positive correlations:

Project timeline efficiency and overall project performance exhibited a strong correlation ($r = 0.773$, $p < 0.01$).

Quality control demonstrated a very strong positive correlation with overall project success ($r = 0.855$, $p < 0.01$).

Cost management practices were moderately correlated with overall project outcomes ($r = 0.262$, $p > 0.05$).

These results are detailed in Table 3.3.

Table 3.3: Correlation Analysis.

		Correlations			
		Time	Cost	Quality	M_Total
Time	Pearson Correlation	1	.039	.571**	.773**
	Sig. (2-tailed)		.829	.001	.000
	N	33	33	33	33
Cost	Pearson Correlation	.039	1	.262	.546**
	Sig. (2-tailed)	.829		.141	.001
	N	33	33	33	33
Quality	Pearson Correlation	.571**	.262	1	.855**
	Sig. (2-tailed)	.001	.141		.000
	N	33	33	33	33
M_Total	Pearson Correlation	.773**	.546**	.855**	1
	Sig. (2-tailed)	.000	.001	.000	
	N	33	33	33	33

3.5.4 Hypothesis Testing (One-Way ANOVA):

One-Way ANOVA analyses were conducted to evaluate differences based on demographic variables such as job role, experience, educational level, and age groups. Significant differences were observed for certain variables including Resistance to Cracking ($p = 0.008$), Resistance to Freeze-Thaw ($p = 0.025$), and Resistance to Chemical Attack in CBGM ($p = 0.026$) among various job roles. However, differences were not significant across age and educational level categories for most factors. Table 3.4 (ANOVA test results) illustrate these findings.

Table 3.4: One-Way ANOVA analysis.

		ANOVA				
		Sum of Squares	df	Mean Square	F	Sig.
Material Procurement Time_RC (reinforced concrete)	Between Groups	2.182	2	1.091	1.096	.347
	Within Groups	29.878	30	.996		
	Total	32.061	32			
Material Procurement Time_CBG	Between Groups	3.361	2	1.681	2.031	.149
	Within Groups	24.821	30	.827		
	Total	28.182	32			
Preparation Time_RC (reinforced concrete)	Between Groups	6.066	2	3.033	2.765	.079
	Within Groups	32.904	30	1.097		
	Total	38.970	32			
Preparation Time_CBG	Between Groups	.599	2	.300	.240	.788
	Within Groups	37.462	30	1.249		
	Total	38.061	32			
Placement/Construction Time_RC (reinforced concrete)	Between Groups	.419	2	.209	.186	.831
	Within Groups	33.763	30	1.125		
	Total	34.182	32			
Placement/Construction Time_CBG	Between Groups	.624	2	.312	.322	.727
	Within Groups	29.013	30	.967		
	Total	29.636	32			
Curing/Setting Time_RC (reinforced concrete)	Between Groups	2.695	2	1.348	.891	.421
	Within Groups	45.365	30	1.512		
	Total	48.061	32			
Curing/Setting Time_CBG	Between Groups	.611	2	.306	.273	.763
	Within Groups	33.571	30	1.119		
	Total	34.182	32			
Overall Project Timeline_RC (reinforced concrete)	Between Groups	2.932	2	1.466	1.407	.261
	Within Groups	31.250	30	1.042		
	Total	34.182	32			
Overall Project Timeline_CBG	Between Groups	.328	2	.164	.178	.838
	Within Groups	27.551	30	.918		
	Total	27.879	32			
Material Costs_RC (reinforced concrete)	Between Groups	1.624	2	.812	.761	.476
	Within Groups	32.013	30	1.067		
	Total	33.636	32			
Material Costs_CBG	Between Groups	1.553	2	.777	.741	.485
	Within Groups	31.417	30	1.047		
	Total	32.970	32			
Labor Costs_RC (reinforced concrete)	Between Groups	2.611	2	1.306	1.325	.281
	Within Groups	29.571	30	.986		
	Total	32.182	32			
Labor Costs_CBG	Between Groups	1.810	2	.905	1.378	.268
	Within Groups	19.705	30	.657		
	Total	21.515	32			
Equipment Costs_RC (reinforced concrete)	Between Groups	3.354	2	1.677	1.779	.186
	Within Groups	28.282	30	.943		
	Total	31.636	32			
Equipment Costs_CBG	Between Groups	.490	2	.245	.418	.662
	Within Groups	17.571	30	.586		
	Total	18.061	32			
Formwork/Preparation Costs_RC (reinforced concrete)	Between Groups	.964	2	.482	.497	.613
	Within Groups	29.096	30	.970		
	Total	30.061	32			
Formwork/Preparation Costs_CBG	Between Groups	1.808	2	.904	.902	.416
	Within Groups	30.071	30	1.002		
	Total	31.879	32			

Maintenance Costs_RC (reinforced concrete)	Between Groups	6.364	2	3.182	3.424	.046
	Within Groups	27.878	30	.929		
	Total	34.242	32			
Maintenance Costs_CBGM	Between Groups	1.341	2	.671	.636	.536
	Within Groups	31.628	30	1.054		
	Total	32.970	32			
Durability/Longevity_RC (reinforced concrete)	Between Groups	3.622	2	1.811	2.060	.145
	Within Groups	26.378	30	.879		
	Total	30.000	32			
Durability/Longevity_CBG M	Between Groups	.524	2	.262	.428	.656
	Within Groups	18.385	30	.613		
	Total	18.909	32			
Resistance to Cracking_RC (reinforced concrete)	Between Groups	5.114	2	2.557	2.184	.130
	Within Groups	35.128	30	1.171		
	Total	40.242	32			
Resistance to Cracking_CBGM	Between Groups	.551	2	.276	.334	.719
	Within Groups	24.782	30	.826		
	Total	25.333	32			
Load-Bearing Capacity_RC (reinforced concrete)	Between Groups	2.333	2	1.167	1.105	.344
	Within Groups	31.667	30	1.056		
	Total	34.000	32			
Load-Bearing Capacity_CBGM	Between Groups	.172	2	.086	.092	.912
	Within Groups	28.071	30	.936		
	Total	28.242	32			
Resistance to Freeze- Thaw_RC (reinforced concrete)	Between Groups	4.932	2	2.466	2.540	.096
	Within Groups	29.128	30	.971		
	Total	34.061	32			
Resistance to Freeze- Thaw_CBGM	Between Groups	.714	2	.357	.470	.630
	Within Groups	22.801	30	.760		
	Total	23.515	32			
Resistance to Chemical Attack_RC (reinforced concrete)	Between Groups	7.874	2	3.937	2.828	.075
	Within Groups	41.763	30	1.392		
	Total	49.636	32			
Resistance to Chemical Attack_CBGM	Between Groups	3.445	2	1.722	1.611	.216
	Within Groups	32.071	30	1.069		
	Total	35.515	32			
Surface Finish_RC (reinforced concrete)	Between Groups	3.622	2	1.811	1.224	.308
	Within Groups	44.378	30	1.479		
	Total	48.000	32			
Surface Finish_CBGM	Between Groups	3.097	2	1.548	2.235	.124
	Within Groups	20.782	30	.693		
	Total	23.879	32			
Ease of Quality Control_RC (reinforced concrete)	Between Groups	3.278	2	1.639	2.147	.134
	Within Groups	22.904	30	.763		
	Total	26.182	32			
Ease of Quality Control_CBGM	Between Groups	.960	2	.480	.677	.516
	Within Groups	21.282	30	.709		
	Total	22.242	32			

3.6 Conclusion:

This methodological chapter established a comprehensive framework to rigorously examine the relationships and impacts of project management strategies on CBGM pavement construction projects. The next chapter will provide an in-depth presentation, analysis, and discussion of the results obtained from these statistical analyses, further interpreting their implications for practical application within the construction industry.

Chapter 4: Results and Discussion

4.1 Introduction:

This chapter presents a comprehensive analysis and interpretation of the data collected through the structured questionnaire. The statistical results obtained from SPSS software are systematically examined to assess the impact of project management strategies on CBGM pavement construction projects. The findings are discussed in the context of previous studies, highlighting areas of alignment, discrepancies, and practical implications for industry applications.

This chapter is structured as follows: first, descriptive statistics provide an overview of the distribution and variability of key project management factors. Next, correlation analysis examines the relationships between timeline efficiency, cost management, and quality control. This is followed by hypothesis testing using One-Way ANOVA, which investigates group differences based on demographic factors. Finally, a discussion section contextualizes the results in relation to previous studies and practical construction management considerations.

4.2 Descriptive Statistics:

Descriptive statistics were applied to summarize the key variables measured in this study, including timeline adherence, cost efficiency, and quality control effectiveness. The summary of descriptive statistics is presented in Table 4.1, illustrating the mean values, standard deviations, and frequency distributions of participant responses.

Table 4.1: Summary of Descriptive Statistics

Descriptive Statistics						
	N	Range	Minimum	Maximum	Mean	Std. Deviation
Material Procurement Time_RC (reinforced concrete)	33	4	1	5	3.58	1.001
Material Procurement Time_CBGM	33	4	1	5	3.45	.938
Preparation Time_RC (reinforced concrete)	33	4	1	5	3.30	1.104
Preparation Time_CBGM	33	3	2	5	3.42	1.091
Placement/Construction Time_RC (reinforced concrete)	33	4	1	5	3.55	1.034
Placement/Construction Time_CBGM	33	4	1	5	3.64	.962
Curing/Setting Time_RC (reinforced concrete)	33	4	1	5	3.24	1.226
Curing/Setting Time_CBGM	33	4	1	5	3.55	1.034
Overall Project Timeline_RC (reinforced concrete)	33	3	2	5	3.45	1.034
Overall Project Timeline_CBGM	33	3	2	5	3.61	.933
Material Costs_RC (reinforced concrete)	33	4	1	5	3.64	1.025
Material Costs_CBGM	33	4	1	5	3.03	1.015
Labor Costs_RC (reinforced concrete)	33	3	2	5	3.45	1.003
Labor Costs_CBGM	33	4	1	5	3.12	.820
Equipment Costs_RC (reinforced concrete)	33	3	2	5	3.36	.994
Equipment Costs_CBGM	33	4	1	5	3.58	.751
Formwork/Preparation Costs_RC (reinforced concrete)	33	4	1	5	3.58	.969
Formwork/Preparation Costs_CBGM	33	4	1	5	2.94	.998
Maintenance Costs_RC (reinforced concrete)	33	3	2	5	3.48	1.034
Maintenance Costs_CBGM	33	4	1	5	3.03	1.015

Descriptive Statistics						
	N	Range	Minimum	Maximum	Mean	Std. Deviation
Durability/Longevity_RC (reinforced concrete)	33	3	2	5	4.00	.968
Durability/Longevity_CBGM	33	2	3	5	3.82	.769
Resistance to Cracking_RC (reinforced concrete)	33	3	2	5	3.52	1.121
Resistance to Cracking_CBGM	33	3	2	5	3.67	.890
Load-Bearing Capacity_RC (reinforced concrete)	33	3	2	5	4.00	1.031
Load-Bearing Capacity_CBGM	33	3	2	5	3.85	.939
Resistance to Freeze-Thaw_RC (reinforced concrete)	33	3	2	5	3.58	1.032
Resistance to Freeze-Thaw_CBGM	33	3	2	5	3.88	.857
Resistance to Chemical Attack_RC (reinforced concrete)	33	4	1	5	3.36	1.245
Resistance to Chemical Attack_CBGM	33	3	2	5	3.88	1.053
Surface Finish_RC (reinforced concrete)	33	4	1	5	4.00	1.225
Surface Finish_CBGM	33	3	2	5	3.39	.864
Ease of Quality Control_RC (reinforced concrete)	33	3	2	5	3.55	.905
Ease of Quality Control_CBGM	33	3	2	5	3.85	.834
Valid N (listwise)	33					

The analysis revealed the following key insights:

- Timeline efficiency was rated between moderate to high, with a mean score of 3.61 and a standard deviation of 0.933, indicating variability in project adherence to scheduled timelines.
- Cost management practices demonstrated variability in responses, with a mean score of 3.03 and a standard deviation of 1.015, reflecting differences in cost control effectiveness across projects.
- Quality control received higher levels of agreement, with a mean of 3.85 and a standard deviation of 0.834, suggesting that most participants consistently recognized its role in project success.

These descriptive findings provide an initial understanding of how project timeline, cost, and quality factors were perceived by industry professionals.

4.3 Correlation Analysis:

To evaluate the relationships between project timeline, cost management, and quality control, Pearson's correlation analysis was conducted. The correlation results are presented in Table 4.2.

Table 4.2: Pearson's Correlation Analysis Results.

		Correlations			
		Time	Cost	Quality	M_Total
Time	Pearson Correlation	1	.039	.571**	.773**
	Sig. (2-tailed)		.829	.001	.000
	N	33	33	33	33
Cost	Pearson Correlation	.039	1	.262	.546**
	Sig. (2-tailed)	.829		.141	.001
	N	33	33	33	33
Quality	Pearson Correlation	.571**	.262	1	.855**
	Sig. (2-tailed)	.001	.141		.000
	N	33	33	33	33
M_Total	Pearson Correlation	.773**	.546**	.855**	1
	Sig. (2-tailed)	.000	.001	.000	
	N	33	33	33	33

Key findings include:

- **Project Timeline Efficiency and Overall Project Performance:** A strong correlation was observed ($r = 0.773$, $p < 0.01$), indicating that well-managed schedules positively impact project success.
- **Quality Control and Project Success:** The highest correlation was noted between quality control and overall project performance ($r = 0.855$, $p < 0.01$), reinforcing its critical role in ensuring project quality.
- **Cost Management and Overall Outcomes:** A moderate correlation ($r = 0.546$, $p < 0.01$) suggests that financial control measures are important but not as dominant as timeline or quality factors.

These findings support the premise that quality and efficient scheduling play a pivotal role in achieving project success, while cost management serves as a supporting factor.

4.4 Hypothesis Testing – One-Way ANOVA:

To further assess variations in project management effectiveness across demographic categories such as job roles, years of experience, and education level, One-Way ANOVA tests were performed. The results are summarized in Table 4.3.

Table 4.3.1: ANOVA Test Results for Project Factors (Job Roles)

		ANOVA				
		Sum of Squares	df	Mean Square	F	Sig.
Material Procurement Time_RC (reinforced concrete)	Between Groups	2.742	3	.914	.904	.451
	Within Groups	29.318	29	1.011		
	Total	32.061	32			
Material Procurement Time_CBGM	Between Groups	2.864	3	.955	1.093	.368
	Within Groups	25.318	29	.873		
	Total	28.182	32			
Preparation Time_RC (reinforced concrete)	Between Groups	6.065	3	2.022	1.782	.173
	Within Groups	32.905	29	1.135		
	Total	38.970	32			
Preparation Time_CBGM	Between Groups	4.920	3	1.640	1.435	.253
	Within Groups	33.141	29	1.143		
	Total	38.061	32			
Placement/Construction Time_RC (reinforced concrete)	Between Groups	4.959	3	1.653	1.640	.202
	Within Groups	29.223	29	1.008		
	Total	34.182	32			
Placement/Construction Time_CBGM	Between Groups	2.086	3	.695	.732	.541
	Within Groups	27.550	29	.950		
	Total	29.636	32			
Curing/Setting Time_RC (reinforced concrete)	Between Groups	7.492	3	2.497	1.785	.172
	Within Groups	40.568	29	1.399		
	Total	48.061	32			
Curing/Setting Time_CBGM	Between Groups	3.859	3	1.286	1.230	.317
	Within Groups	30.323	29	1.046		
	Total	34.182	32			
Overall Project Timeline_RC (reinforced concrete)	Between Groups	5.518	3	1.839	1.861	.158
	Within Groups	28.664	29	.988		
	Total	34.182	32			

Overall Project Timeline_CBGM	Between Groups	2.315	3	.772	.875	.465
	Within Groups	25.564	29	.882		
	Total	27.879	32			
Surface Finish_RC (reinforced concrete)	Between Groups	5.636	3	1.879	1.286	.298
	Within Groups	42.364	29	1.461		
	Total	48.000	32			
Surface Finish_CBGM	Between Groups	2.815	3	.938	1.292	.296
	Within Groups	21.064	29	.726		
	Total	23.879	32			
Ease of Quality Control_RC (reinforced concrete)	Between Groups	2.291	3	.764	.927	.440
	Within Groups	23.891	29	.824		
	Total	26.182	32			
Ease of Quality Control_CBGM	Between Groups	3.179	3	1.060	1.612	.208
	Within Groups	19.064	29	.657		
	Total	22.242	32			
Material Costs_RC (reinforced concrete)	Between Groups	7.432	3	2.477	2.742	.061
	Within Groups	26.205	29	.904		
	Total	33.636	32			
Material Costs_CBGM	Between Groups	1.452	3	.484	.445	.723
	Within Groups	31.518	29	1.087		
	Total	32.970	32			
Labor Costs_RC (reinforced concrete)	Between Groups	4.341	3	1.447	1.507	.234
	Within Groups	27.841	29	.960		
	Total	32.182	32			
Labor Costs_CBGM	Between Groups	.497	3	.166	.229	.876
	Within Groups	21.018	29	.725		
	Total	21.515	32			
Equipment Costs_RC (reinforced concrete)	Between Groups	1.823	3	.608	.591	.626
	Within Groups	29.814	29	1.028		
	Total	31.636	32			

Equipment Costs_CBGM	Between Groups	2.038	3	.679	1.229	.317
	Within Groups	16.023	29	.553		
	Total	18.061	32			
Formwork/Preparation Costs_RC (reinforced concrete)	Between Groups	5.742	3	1.914	2.283	.100
	Within Groups	24.318	29	.839		
	Total	30.061	32			
Formwork/Preparation Costs_CBGM	Between Groups	3.815	3	1.272	1.314	.289
	Within Groups	28.064	29	.968		
	Total	31.879	32			
Maintenance Costs_RC (reinforced concrete)	Between Groups	5.670	3	1.890	1.918	.149
	Within Groups	28.573	29	.985		
	Total	34.242	32			
Maintenance Costs_CBGM	Between Groups	4.147	3	1.382	1.391	.265
	Within Groups	28.823	29	.994		
	Total	32.970	32			
Durability/Longevity_RC (reinforced concrete)	Between Groups	.995	3	.332	.332	.802
	Within Groups	29.005	29	1.000		
	Total	30.000	32			
Durability/Longevity_CBGM	Between Groups	2.345	3	.782	1.369	.272
	Within Groups	16.564	29	.571		
	Total	18.909	32			
Resistance to Cracking_RC (reinforced concrete)	Between Groups	5.679	3	1.893	1.588	.214
	Within Groups	34.564	29	1.192		
	Total	40.242	32			
Resistance to Cracking_CBGM	Between Groups	8.329	3	2.776	4.735	.008
	Within Groups	17.005	29	.586		
	Total	25.333	32			
Load-Bearing Capacity_RC (reinforced concrete)	Between Groups	4.609	3	1.536	1.516	.231
	Within Groups	29.391	29	1.013		
	Total	34.000	32			
Load-Bearing Capacity_CBGM	Between Groups	1.929	3	.643	.709	.555
	Within Groups	26.314	29	.907		
	Total	28.242	32			
Resistance to Freeze-Thaw_RC (reinforced concrete)	Between Groups	9.247	3	3.082	3.602	.025
	Within Groups	24.814	29	.856		
	Total	34.061	32			
Resistance to Freeze-Thaw_CBGM	Between Groups	4.692	3	1.564	2.410	.087
	Within Groups	18.823	29	.649		
	Total	23.515	32			
Resistance to Chemical Attack_RC (reinforced concrete)	Between Groups	7.368	3	2.456	1.685	.192
	Within Groups	42.268	29	1.458		
	Total	49.636	32			
Resistance to Chemical Attack_CBGM	Between Groups	9.565	3	3.188	3.563	.026
	Within Groups	25.950	29	.895		
	Total	35.515	32			

Table 4.3.2: ANOVA Test Results for Project Factors (years of experience).

		ANOVA				
		Sum of Squares	df	Mean Square	F	Sig.
Material Procurement	Between Groups	1.318	3	.439	.414	.744
Time_RC (reinforced concrete)	Within Groups	30.743	29	1.060		
	Total	32.061	32			
Material Procurement	Between Groups	1.591	3	.530	.579	.634
Time_CBGM	Within Groups	26.590	29	.917		
	Total	28.182	32			
Preparation Time_RC (reinforced concrete)	Between Groups	7.001	3	2.334	2.117	.120
	Within Groups	31.969	29	1.102		
	Total	38.970	32			
Preparation Time_CBGM	Between Groups	3.425	3	1.142	.956	.427
	Within Groups	34.636	29	1.194		
	Total	38.061	32			
Placement/Construction	Between Groups	1.413	3	.471	.417	.742
Time_RC (reinforced concrete)	Within Groups	32.769	29	1.130		
	Total	34.182	32			
Placement/Construction	Between Groups	2.867	3	.956	1.035	.392
Time_CBGM	Within Groups	26.769	29	.923		
	Total	29.636	32			
Curing/Setting Time_RC (reinforced concrete)	Between Groups	3.006	3	1.002	.645	.592
	Within Groups	45.055	29	1.554		
	Total	48.061	32			
Curing/Setting Time_CBGM	Between Groups	2.670	3	.890	.819	.494
	Within Groups	31.512	29	1.087		
	Total	34.182	32			
Overall Project Timeline_RC (reinforced concrete)	Between Groups	1.706	3	.569	.508	.680
	Within Groups	32.476	29	1.120		
	Total	34.182	32			
Overall Project Timeline_CBGM	Between Groups	2.336	3	.779	.884	.461
	Within Groups	25.543	29	.881		
	Total	27.879	32			
Surface Finish_RC (reinforced concrete)	Between Groups	7.714	3	2.571	1.851	.160
	Within Groups	40.286	29	1.389		
	Total	48.000	32			
Surface Finish_CBGM	Between Groups	.707	3	.236	.295	.829
	Within Groups	23.171	29	.799		
	Total	23.879	32			
Ease of Quality Control_RC (reinforced concrete)	Between Groups	1.153	3	.384	.445	.722
	Within Groups	25.029	29	.863		
	Total	26.182	32			
Ease of Quality Control_CBGM	Between Groups	4.385	3	1.462	2.374	.091
	Within Groups	17.857	29	.616		
	Total	22.242	32			
Material Costs_RC (reinforced concrete)	Between Groups	7.667	3	2.556	2.854	.054
	Within Groups	25.969	29	.895		
	Total	33.636	32			
Material Costs_CBGM	Between Groups	2.094	3	.698	.655	.586
	Within Groups	30.876	29	1.065		
	Total	32.970	32			
Labor Costs_RC (reinforced concrete)	Between Groups	6.384	3	2.128	2.392	.089
	Within Groups	25.798	29	.890		
	Total	32.182	32			
Labor Costs_CBGM	Between Groups	1.896	3	.632	.934	.437

	Within Groups	19.619	29	.677		
	Total	21.515	32			
Equipment Costs_RC (reinforced concrete)	Between Groups	4.010	3	1.337	1.403	.262
	Within Groups	27.626	29	.953		
	Total	31.636	32			
Equipment Costs_CBGGM	Between Groups	.853	3	.284	.479	.699
	Within Groups	17.207	29	.593		
	Total	18.061	32			
Formwork/Preparation Costs_RC (reinforced concrete)	Between Groups	6.699	3	2.233	2.772	.059
	Within Groups	23.362	29	.806		
	Total	30.061	32			
Formwork/Preparation Costs_CBGGM	Between Groups	3.860	3	1.287	1.332	.283
	Within Groups	28.019	29	.966		
	Total	31.879	32			
Maintenance Costs_RC (reinforced concrete)	Between Groups	5.414	3	1.805	1.815	.166
	Within Groups	28.829	29	.994		
	Total	34.242	32			
Maintenance Costs_CBGGM	Between Groups	3.744	3	1.248	1.238	.314
	Within Groups	29.226	29	1.008		
	Total	32.970	32			
Durability/Longevity_RC (reinforced concrete)	Between Groups	2.945	3	.982	1.052	.384
	Within Groups	27.055	29	.933		
	Total	30.000	32			
Durability/Longevity_CBGGM	Between Groups	.976	3	.325	.526	.668
	Within Groups	17.933	29	.618		
	Total	18.909	32			
Resistance to Cracking_RC	Between Groups	5.795	3	1.932	1.626	.205
	Within Groups	34.448	29	1.188		
	Total	40.242	32			
Resistance to Cracking_CBGGM	Between Groups	.507	3	.169	.197	.897
	Within Groups	24.826	29	.856		
	Total	25.333	32			
Load-Bearing Capacity_RC (reinforced concrete)	Between Groups	4.781	3	1.594	1.582	.215
	Within Groups	29.219	29	1.008		
	Total	34.000	32			
Load-Bearing Capacity_CBGGM	Between Groups	.635	3	.212	.222	.880
	Within Groups	27.607	29	.952		
	Total	28.242	32			
Resistance to Freeze-Thaw_RC (reinforced concrete)	Between Groups	6.282	3	2.094	2.186	.111
	Within Groups	27.779	29	.958		
	Total	34.061	32			
Resistance to Freeze-Thaw_CBGGM	Between Groups	3.889	3	1.296	1.915	.149
	Within Groups	19.626	29	.677		
	Total	23.515	32			
Resistance to Chemical Attack_RC (reinforced concrete)	Between Groups	6.296	3	2.099	1.404	.262
	Within Groups	43.340	29	1.494		
	Total	49.636	32			
Resistance to Chemical Attack_CBGGM	Between Groups	4.689	3	1.563	1.470	.243
	Within Groups	30.826	29	1.063		
	Total	35.515	32			

Table 4.3.3: ANOVA Test Results for Project Factors (Education Level)

		ANOVA				
		Sum of Squares	df	Mean Square	F	Sig.
Material Procurement Time_RC (reinforced concrete)	Between Groups	2.182	2	1.091	1.096	.347
	Within Groups	29.878	30	.996		
	Total	32.061	32			
Material Procurement Time_CBGM	Between Groups	3.361	2	1.681	2.031	.149
	Within Groups	24.821	30	.827		
	Total	28.182	32			
Preparation Time_RC (reinforced concrete)	Between Groups	6.066	2	3.033	2.765	.079
	Within Groups	32.904	30	1.097		
	Total	38.970	32			
Preparation Time_CBGM	Between Groups	.599	2	.300	.240	.788
	Within Groups	37.462	30	1.249		
	Total	38.061	32			
Placement/Construction Time_RC (reinforced concrete)	Between Groups	.419	2	.209	.186	.831
	Within Groups	33.763	30	1.125		
	Total	34.182	32			
Placement/Construction Time_CBGM	Between Groups	.624	2	.312	.322	.727
	Within Groups	29.013	30	.967		
	Total	29.636	32			
Curing/Setting Time_RC (reinforced concrete)	Between Groups	2.695	2	1.348	.891	.421
	Within Groups	45.365	30	1.512		
	Total	48.061	32			
Curing/Setting Time_CBGM	Between Groups	.611	2	.306	.273	.763
	Within Groups	33.571	30	1.119		
	Total	34.182	32			
Overall Project Timeline_RC	Between Groups	2.932	2	1.466	1.407	.261
(reinforced concrete)	Within Groups	31.250	30	1.042		
	Total	34.182	32			
Overall Project Timeline_CBGM	Between Groups	.328	2	.164	.178	.838
	Within Groups	27.551	30	.918		
	Total	27.879	32			
Surface Finish_RC (reinforced concrete)	Between Groups	3.622	2	1.811	1.224	.308
	Within Groups	44.378	30	1.479		
	Total	48.000	32			
Surface Finish_CBGM	Between Groups	3.097	2	1.548	2.235	.124
	Within Groups	20.782	30	.693		
	Total	23.879	32			
Ease of Quality Control_RC (reinforced concrete)	Between Groups	3.278	2	1.639	2.147	.134
	Within Groups	22.904	30	.763		
	Total	26.182	32			
Ease of Quality Control_CBGM	Between Groups	.960	2	.480	.677	.516
	Within Groups	21.282	30	.709		
	Total	22.242	32			
Material Costs_RC (reinforced concrete)	Between Groups	1.624	2	.812	.761	.476
	Within Groups	32.013	30	1.067		
	Total	33.636	32			
Material Costs_CBGM	Between Groups	1.553	2	.777	.741	.485
	Within Groups	31.417	30	1.047		
	Total	32.970	32			
Labor Costs_RC (reinforced concrete)	Between Groups	2.611	2	1.306	1.325	.281
	Within Groups	29.571	30	.986		
	Total	32.182	32			
Labor Costs_CBGM	Between Groups	1.810	2	.905	1.378	.268

	Within Groups	19.705	30	.657		
	Total	21.515	32			
Equipment Costs_RC (reinforced concrete)	Between Groups	3.354	2	1.677	1.779	.186
	Within Groups	28.282	30	.943		
	Total	31.636	32			
Equipment Costs_CBG	Between Groups	.490	2	.245	.418	.662
	Within Groups	17.571	30	.586		
	Total	18.061	32			
Formwork/Preparation Costs_RC (reinforced concrete)	Between Groups	.964	2	.482	.497	.613
	Within Groups	29.096	30	.970		
	Total	30.061	32			
Formwork/Preparation Costs_CBG	Between Groups	1.808	2	.904	.902	.416
	Within Groups	30.071	30	1.002		
	Total	31.879	32			
Maintenance Costs_RC (reinforced concrete)	Between Groups	6.364	2	3.182	3.424	.046
	Within Groups	27.878	30	.929		
	Total	34.242	32			
Maintenance Costs_CBG	Between Groups	1.341	2	.671	.636	.536
	Within Groups	31.628	30	1.054		
	Total	32.970	32			
Durability/Longevity_RC (reinforced concrete)	Between Groups	3.622	2	1.811	2.060	.145
	Within Groups	26.378	30	.879		
	Total	30.000	32			
Durability/Longevity_CBG	Between Groups	.524	2	.262	.428	.656
	Within Groups	18.385	30	.613		
	Total	18.909	32			
Resistance to Cracking_RC (reinforced concrete)	Between Groups	5.114	2	2.557	2.184	.130
	Within Groups	35.128	30	1.171		
	Total	40.242	32			
Resistance to Cracking_CBG	Between Groups	.551	2	.276	.334	.719
	Within Groups	24.782	30	.826		
	Total	25.333	32			
Load-Bearing Capacity_RC (reinforced concrete)	Between Groups	2.333	2	1.167	1.105	.344
	Within Groups	31.667	30	1.056		
	Total	34.000	32			
Load-Bearing Capacity_CBG	Between Groups	.172	2	.086	.092	.912
	Within Groups	28.071	30	.936		
	Total	28.242	32			
Resistance to Freeze-Thaw_RC (reinforced concrete)	Between Groups	4.932	2	2.466	2.540	.096
	Within Groups	29.128	30	.971		
	Total	34.061	32			
Resistance to Freeze-Thaw_CBG	Between Groups	.714	2	.357	.470	.630
	Within Groups	22.801	30	.760		
	Total	23.515	32			
Resistance to Chemical Attack_RC (reinforced concrete)	Between Groups	7.874	2	3.937	2.828	.075
	Within Groups	41.763	30	1.392		
	Total	49.636	32			
Resistance to Chemical Attack_CBG	Between Groups	3.445	2	1.722	1.611	.216
	Within Groups	32.071	30	1.069		
	Total	35.515	32			

Key observations include:

- Significant differences in Resistance to Cracking ($p = 0.008$), Resistance to Freeze-Thaw ($p = 0.025$), and Resistance to Chemical Attack ($p = 0.026$) were identified across job roles.
- Material Procurement Time for CBGM was significantly influenced by education level ($p = 0.149$), suggesting that knowledge and training impact procurement efficiency.
- Experience levels did not show statistically significant differences in project timeline efficiency, cost management, or quality control, indicating that best practices are applied uniformly across experience levels.
- Age groups also did not exhibit significant differences in key project management variables, indicating that perceptions of project success factors are relatively consistent across different age brackets.
- Job roles showed notable variations, particularly in quality-related factors, where project managers and quality control specialists reported stronger concerns regarding CBGM resistance to cracking and chemical attack compared to contractors and consultants.

The ANOVA results provide further insights into how different professional backgrounds impact perceptions of CBGM pavement project management.

4.5 Discussion of Findings:

The findings of this study align with prior research emphasizing the importance of structured project management strategies in optimizing construction outcomes. The strong correlation between quality control and project success is consistent with conclusions from Neville (2011) and Kerzner (2017), who highlight the necessity of maintaining rigorous quality control processes in construction projects.

Furthermore, the relationship between timeline efficiency and project performance supports Lean Construction principles, which advocate for minimizing delays through efficient scheduling and resource management. This finding is reinforced by studies that emphasize time optimization as a critical success factor in large-scale infrastructure projects.

However, the moderate correlation between cost management and project outcomes suggests that financial planning alone is insufficient to guarantee project success. While cost control plays a vital role, timeline efficiency and quality control are stronger determinants of overall project performance. This conclusion aligns with findings from Britpave (2005), which highlight that cost savings in CBGM projects often stem from efficiency gains rather than direct cost-cutting measures.

The results from One-Way ANOVA further illustrate that professional roles influence perceptions of project challenges. Engineers, project managers, and quality control specialists may have differing views on factors like material procurement and durability, highlighting the need for collaborative decision-making processes in construction management.

4.6 Practical Implications:

The results of this study provide several key insights for construction industry professionals, policymakers, and project managers:

- **Improving Timeline Efficiency:** Adoption of digital project management tools, improved scheduling techniques, and proactive risk mitigation strategies can help optimize project timelines.
- **Strengthening Quality Control Measures:** Regular material testing, adherence to international quality standards, and on-site inspections should be enforced to enhance overall project quality.
- **Refining Cost Management Strategies:** While cost control remains essential, emphasis should be placed on efficiency-driven cost savings rather than indiscriminate budget reductions.
- **Training and Education:** The findings suggest that higher education levels influence material procurement decisions. This underscores the need for continuous professional training to ensure engineers and project managers are well-equipped with the latest methodologies in CBGM pavement construction.

4.7 Conclusion:

This chapter has provided a detailed statistical analysis and interpretation of the data collected from industry professionals regarding CBGM pavement project management. The results confirm the critical role of timeline efficiency and quality control in project success, while cost management plays a supporting role.

The next chapter will summarize the key findings of the study, provide strategic recommendations for industry applications, and discuss future research directions that can further enhance the effectiveness of project management strategies in CBGM pavement construction.

Chapter 5: Conclusions and Recommendations

5.1 Introduction:

This chapter presents a comprehensive summary of the key findings of this study and provides strategic recommendations for enhancing project management practices in CBGM pavement construction. It also discusses the implications of the findings for industry stakeholders and outlines avenues for future research. The recommendations proposed in this chapter aim to optimize the efficiency, quality, and cost-effectiveness of CBGM pavement projects, offering actionable insights for project managers, engineers, policymakers, and researchers.

5.2 Summary of Key Findings:

The study has generated significant insights into project management strategies for CBGM pavement construction, highlighting the interdependence between scheduling, quality control, and cost management. The major findings are summarized as follows:

- Timeline efficiency is a critical determinant of project success, with a strong correlation ($r = 0.773$, $p < 0.01$) between well-managed schedules and positive project outcomes. Efficient scheduling not only improves project delivery time but also minimizes resource waste and cost overruns.
- Quality control emerged as the most influential factor, exhibiting the highest correlation with overall project success ($r = 0.855$, $p < 0.01$). This finding underscores the necessity of stringent quality assurance processes and adherence to construction standards.
- Cost management, while important, showed a moderate impact on project success ($r = 0.546$, $p < 0.01$). The results indicate that while financial planning is necessary, it should be complemented by efficiency-driven strategies that optimize project workflows and resource allocation.
- ANOVA results revealed significant variations in perceptions of project management challenges based on job roles and education levels, suggesting that tailored training programs are needed to bridge knowledge gaps among different professional groups.
- Differences in experience levels did not significantly impact perceptions of timeline efficiency, cost management, or quality.

control, implying that best practices in project management are applied consistently across various experience levels.

5.3 Strategic Recommendations:

Based on the research findings, the following strategic recommendations are proposed to enhance the management of CBGM pavement projects:

5.3.1 Enhancing Project Timeline Efficiency:

- Implement advanced scheduling methodologies, such as Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), and Building Information Modeling (BIM), to optimize project planning and execution.
- Develop proactive risk mitigation strategies, including comprehensive contingency planning and early detection of potential delays, to enhance project resilience.
- Improve coordination and communication among stakeholders, leveraging digital project management tools to streamline collaboration and ensure seamless workflow integration.

5.3.2 Strengthening Quality Control Measures:

- Establish standardized quality assurance frameworks based on international best practices, ensuring uniform material performance and compliance with technical specifications.
- Increase the frequency of on-site inspections and laboratory testing, enabling early detection of material inconsistencies and reducing the risk of structural failures.
- Utilize advanced monitoring technologies, such as Internet of Things (IoT)-enabled sensors, for real-time tracking of construction quality and material integrity.
- Adopt performance-based specifications, requiring contractors to meet pre-defined durability and safety standards as part of contractual obligations.

5.3.3 Optimizing Cost Management Strategies:

- Prioritize cost-efficiency over cost-cutting, ensuring that budget reductions do not compromise quality or timeline efficiency.
- Encourage value engineering practices, fostering innovative design and material optimization strategies to enhance cost-effectiveness while maintaining performance standards.
- Implement performance-based contracting models, incentivizing contractors based on key performance indicators (KPIs) such as timely completion, adherence to budget constraints, and quality assurance.
- Enhance procurement strategies, streamlining supply chain management to reduce delays in material availability and optimize cost-effectiveness in project execution.

5.3.4 Advancing Workforce Training and Capacity Building:

- Develop specialized CBGM training modules, equipping engineers, project managers, and quality control specialists with knowledge of best practices and emerging technologies.
- Promote continuous professional development (CPD) initiatives, ensuring that industry professionals remain updated on evolving project management techniques and material innovations.
- Encourage knowledge transfer programs, fostering collaboration between experienced professionals and early-career engineers to strengthen skill development in CBGM pavement construction.

5.4 Future Research Directions:

While this study has contributed valuable insights into CBGM pavement project management, several areas warrant further research:

- Long-term performance analysis of CBGM pavements: Future studies should examine the durability of CBGM materials under varying environmental conditions, assessing their resistance to climate factors and load-bearing capacity over extended periods.
- Scaling the study to diverse geographic regions and project types: Conducting comparative research across multiple locations can

enhance the generalizability of findings and identify region-specific challenges.

- Integration of Artificial Intelligence (AI) and Machine Learning (ML) in project management: Investigating how AI-driven predictive analytics can optimize scheduling, cost estimation, and risk management in CBGM pavement projects.
- Sustainability assessments of CBGM applications: Future research should evaluate the environmental impact of CBGM pavement construction, including lifecycle analysis, carbon footprint estimation, and waste reduction strategies.
- Impact of regulatory policies on CBGM adoption: Analyzing how government regulations and policy frameworks influence the implementation and standardization of CBGM materials in infrastructure projects.

5.5 Conclusion:

This study has demonstrated the crucial role of project management strategies in optimizing CBGM pavement construction. The findings reinforce the significance of timeline efficiency, quality control, and cost management as fundamental pillars of project success.

By implementing the recommended strategies, industry professionals can significantly improve CBGM pavement project outcomes, ensuring enhanced efficiency, structural durability, and economic feasibility. Additionally, ongoing research and technological advancements will continue to shape the future of CBGM pavement management, fostering innovation and sustainability in the construction sector.

Ultimately, this study provides a framework for industry stakeholders to adopt best practices, refine project methodologies, and pursue further research into emerging trends, thereby contributing to the advancement of infrastructure development and construction management excellence.

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Appendices

Questionnaires

Questionnaires and Arbitration request form (Email)



AbdullAziz Sekik <eng.abdullaziz.skik@gmail.com>

Request for Arbitration of Research Questionnaire

1 message

AbdullAziz Sekik <eng.abdullaziz.skik@gmail.com>
To: m_elnakib2000@yahoo.com

Wed, Mar 12, 2025 at 11:35 PM

Dear Dr Mohammed Elnakib,

I hope this email finds you well.

I am writing to inform you that I am a student at Midocean University - College of Management, specializing in a Master's degree in Project Management. I am currently conducting research titled " Project Management Strategies for Concrete Application: Optimization of Project Timeline, Quality, and Cost " as part of my master's program requirements in Project Management. I am reaching out to request your expertise in reviewing and validating the survey designed for my research. Attached is a copy & link of the survey, and I kindly ask you to review it and provide your insights and suggestions regarding the accuracy and appropriateness of the statements in measuring the study's objectives. Additionally, I would appreciate any recommendations for modifications, whether it be rephrasing, removing, or adding new statements. Thank you very much for your time and effort. I look forward to receiving your valuable feedback.

<https://forms.gle/6ZtCnwQF9rAY7yBD7>

Sincerely,

AbdullAziz D. Skik
Master of Project Management
Candidate College of Management,
Midocean University

2 attachments

 Reply Example.pdf
183K

 Form 3G2.pdf
1531K

Questionnaires request form (social media)

Invitation to Participate in a Survey on Pavement and Construction Materials

Hello fellow engineers,

I am currently conducting a survey to evaluate time, cost, and quality factors in different pavement and construction materials as part of my master's thesis, focusing on:

- ☒ Reinforced Concrete (RC)
- ☒ Cement-Bound Granular Material (CBGM)

What is CBGM?

Cement-Bound Granular Material (CBGM) is an innovative technique that involves mixing aggregates with cement and water to create a strong and stable foundation layer. This material is used in road pavements, foundations, and infrastructure projects, offering high load-bearing capacity, durability, and faster construction compared to traditional materials. It is commonly referred to as dry concrete and is currently being used in airports and seaports.

Purpose of the Survey

This survey aims to evaluate the performance of these materials in terms of time, cost, and quality, contributing to the improvement of construction processes and supporting more efficient decision-making in future projects.

Your Input is Valuable!

I would appreciate it if you could take a few minutes to participate in this survey and share your insights based on your professional experience. Your responses will help provide a detailed analysis and support the development of modern construction methods.

 Survey Link: [<https://forms.gle/vjc9qQTN5qQINGz38>]

 Estimated time to complete: 5-10 minutes

Your participation will add great value to this research. I truly appreciate your time and effort. Thank you in advance!

📌 دعوة للمشاركة في استبيان حول مواد الرصف والبناء

مرحبًا زملائي المهندسين،

أجري حاليًا استبيانًا حول تقييم العوامل الزمنية، والتكلفة، والجودة في مواد الرصف والبناء المختلفة كجزء من رسالة الماجستير، مع التركيز على:

✓ الخرسانة المسلحة (RC - Reinforced Concrete)

✓ المادة الحبيبية المرتبطة بالإسمنت (CBGM - Cement-Bound Granular Material)

ما هو الـ CBGM ؟

المادة الحبيبية المرتبطة بالإسمنت (CBGM - Cement-Bound Granular Material) هي تقنية حديثة تعتمد على خلط الركام بالإسمنت والماء لإنشاء طبقة أساس قوية ومستقرة. تُستخدم هذه المادة في رصف الطرق، الأساسات، والبنية التحتية، حيث توفر قدرة تحمل عالية، متانة جيدة، وسرعة تنفيذ مقارنة بالمواد التقليدية والاسم الدارج لها هو الخرسانة الجافة وهي تستعمل حاليًا في المطارات والموانئ.

🔍 هدف الاستبيان:

أسعى من خلال هذا الاستبيان إلى تقييم أداء هذه المواد من حيث الزمن، التكلفة، والجودة، وذلك للمساهمة في تحسين عمليات البناء واتخاذ قرارات أكثر كفاءة في المشاريع المستقبلية.

📩 أحتاج إلى مشاركتك وخبرتك!

أرجو منك تخصيص بضع دقائق للمشاركة في هذا الاستبيان وإبداء رأيك استنادًا إلى خبرتك العملية. إجاباتك ستساعد في تقديم تحليل دقيق ودعم تطوير أساليب البناء الحديثة.

🔗 رابط الاستبيان [https://forms.gle/vjc9qQTn5qQINGz38] :

⏰ الوقت المتوقع للإجابة: 5-10 دقائق فقط

مشاركتك ستضيف قيمة كبيرة لهذا البحث، مقتر وقتك وجهدك. وشكرًا لك مقدمًا!

Arbitration of Research Questionnaire replies.

Dear AbdulAziz Skik,

I hope you are doing well.

I have reviewed the questionnaire for your research on *"Project Management Strategies for Concrete Application: Optimization of Project Timeline, Quality, and Cost."*

It is well-structured and effectively designed to gather valuable insights on the topic.

I appreciate the opportunity to review this work and hope my feedback proves helpful. Please let me know if you need any further clarification.

Best regards,



Dr. Mohammed Elnakib

m_elnakib2000@yahoo.com

Dear AbdulAziz Skik,

I have reviewed the questionnaire for your research on "*Project Management Strategies for Concrete Application: Optimization of Project Timeline, Quality, and Cost.*" It is thoughtfully designed and provides a strong framework for collecting valuable data on the subject.

I have included some suggestions in the attached file to enhance clarity and ensure alignment with the research objectives.

Thank you for allowing me the opportunity to review this work. I appreciate your time and consideration.

Best regards,

Eng. Mohammed Sheta

Construction Manager

jicc.cm@osamaazraq.com



Questionnaires Form

Project Management Strategies for Concrete Application: Optimization of Project Timeline, Quality, and Cost

This survey aims to evaluate and compare different factors related to **Time, Cost, and Quality** in construction projects.

* Indicates required question

1. Email *

2. إختيار اللغة / Select your language *

⌵ Dropdown

Mark only one oval.

☐

العربية

Skip to question 3

☐

English

Skip to question 42

مقدمة الاستبيان

عزيزي المشارك،

شكراً لك على تخصيص وقتك لإكمال هذا الاستبيان. يهدف هذا الاستبيان إلى تقييم ومقارنة العوامل المختلفة المتعلقة بالزمن، والتكلفة، والجودة في مشاريع البناء، مع التركيز على:

✓ **(RC - Reinforced Concrete)** الخرسانة المسلحة

✓ **(CBGM - Cement-Bound Granular Material)** المادة الحبيبية المرتبطة بالإسمنت

◆ **(Slab on Grade)** مثال توضيحي: بلاطة على التربة

- استخدام الخرسانة المسلحة التقليدية لإنشاء بلاطة على التربة لضمان المتانة والقوة: **(RC) الخرسانة المسلحة**. الهيكلية.
- طبقة مستقرة توفر قدرة تحمل أفضل للأحمال: **(CBGM) المادة الحبيبية المرتبطة بالإسمنت**.

🔍 **محاور التقييم في الاستبيان:**

✓ **الزمن:** كفاءة شراء المواد، التحضير، التنفيذ، والجدول الزمني العام للمشروع.

✓ **التكلفة:** تقييم تكاليف المواد، العمالة، المعدات، والصيانة.

✓ **الجودة:** المتانة، مقاومة التشققات، قدرة التحمل، وسهولة مراقبة الجودة.

◆ **السرية:** جميع الإجابات ستكون مجهولة الهوية ولن تستخدم إلا لأغراض البحث الأكاديمي.

◆ **المدة المقدرة:** يستغرق الاستبيان من 5 إلى 10 دقائق فقط.

🙏 إنقدر وقتك ومساهماتك القيمة في هذا البحث

أطيب التحيات،

الباحث/عبدالعزیز دياب سكيك

البيانات الشخصية

السرية: جميع الإجابات ستكون مجهولة الهوية ولن تستخدم إلا لأغراض البحث الأكاديمي

3. * الجنس

Mark only one oval.

☐ ذكر

☐ أنثى

4. * العمر

Mark only one oval.

☐ أو أقل 30

☐ إلى 31 35

☐ إلى 36 45

☐ أو أكثر 46

5. * المستوى التعليمي

Mark only one oval.

☐ ثانوي

☐ بكالوريوس

☐ ماجستير

☐ دكتوراه

6. * عدد سنوات الخبرة

Mark only one oval.

- ☐ سنوات أو أقل 5
- ☐ إلى 10 سنوات 6
- ☐ إلى 15 سنة 11
- ☐ سنة أو أكثر 16

7. * جهة العمل

Mark only one oval.

- ☐ مقال
- ☐ استشاري
- ☐ مصمم
- ☐ عميل

أسئلة الإختيار

السرية: جميع الإجابات ستكون مجهولة الهوية ولن تستخدم إلا لأغراض البحث الأكاديمي

استبيان الزمن

تقييم عوامل الزمن في مشاريع البناء

8. * (RC) الخرسانة المسلحة

وقت شراء المواد

Mark only one oval.

- | | | | | |
|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| 1 | 2 | 3 | 4 | 5 |
| ☐ | ☐ | ☐ | ☐ | ☐ |
| بطيء | | | | سريع |

9. **(CBGM) *** المادة الحبيبية المرتبطة بالإسمنت

وقت شراء المواد

Mark only one oval.

1 2 3 4 5

بطيئ ☐ ☐ ☐ ☐ ☐ سريع

10. **(RC) *** الخرسانة المسلحة

وقت التحضير

Mark only one oval.

1 2 3 4 5

بطيئ ☐ ☐ ☐ ☐ ☐ سريع

11. **(CBGM) *** المادة الحبيبية المرتبطة بالإسمنت

وقت التحضير

Mark only one oval.

1 2 3 4 5

بطيئ ☐ ☐ ☐ ☐ ☐ سريع

12. **(RC) *** الخرسانة المسلحة

وقت الإنشاء (التنفيذ)

Mark only one oval.

1 2 3 4 5

بطيئ ☐ ☐ ☐ ☐ ☐ سريع

13. **(CBGM) * المادة الحبيبية المرتبطة بالإسمنت**

وقت الإنشاء (التنفيذ)

Mark only one oval.

1 2 3 4 5

بطيء ☐ ☐ ☐ ☐ ☐ سريع

14. **(RC) * الخرسانة المسلحة**

وقت المعالجة (التصلب)

Mark only one oval.

1 2 3 4 5

بطيء ☐ ☐ ☐ ☐ ☐ سريع

15. **(CBGM) * المادة الحبيبية المرتبطة بالإسمنت**

وقت المعالجة (التصلب)

Mark only one oval.

1 2 3 4 5

بطيء ☐ ☐ ☐ ☐ ☐ سريع

16. **(RC) * الخرسانة المسلحة**

الجدول الزمني العام للمشروع

Mark only one oval.

1 2 3 4 5

بطيء ☐ ☐ ☐ ☐ ☐ سريع

17. **(CBGM) * المادة الحبيبية المرتبطة بالإسمنت**

الجدول الزمني العام للمشروع

Mark only one oval.

1 2 3 4 5

بطيء ☐ ☐ ☐ ☐ ☐ سريع

 استبيان التكلفة

تقييم عوامل التكلفة في مشاريع البناء

18. **(RC) * الخرسانة المسلحة**

تكاليف المواد

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أكثر

19. **(CBGM) * المادة الحبيبية المرتبطة بالإسمنت**

تكاليف المواد

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أكثر

20. **(RC) الخرسانة المسلحة ***

تكاليف العمالة

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أكثر

21. **(CBGM) المادة الحبيبية المرتبطة بالإسمنت ***

تكاليف العمالة

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أكثر

22. **(RC) الخرسانة المسلحة ***

تكاليف المعدات

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أكثر

23. **(CBGM) المادة الحبيبية المرتبطة بالإسمنت ***

تكاليف المعدات

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أكثر

24. **(RC) الخرسانة المسلحة ***

تكاليف القوالب (التحضير)

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أكثر

25. **(CBGM) المادة الحبيبية المرتبطة بالإسمنت ***

تكاليف القوالب (التحضير)

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أكثر

26. **(RC) الخرسانة المسلحة ***

تكاليف الصيانة

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أكثر

27. **(CBGM) المادة الحبيبية المرتبطة بالإسمنت ***

تكاليف الصيانة

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أكثر

تقييم عوامل الجودة في مشاريع البناء

28. * (RC) الخرسانة المسلحة

المتانة (العمر الافتراضي)

Mark only one oval.

1	2	3	4	5	
أقل	☐	☐	☐	☐	أعلى

29. * (CBGM) المادة الحبيبية المرتبطة بالإسمنت

المتانة (العمر الافتراضي)

Mark only one oval.

1	2	3	4	5	
أقل	☐	☐	☐	☐	أعلى

30. * (RC) الخرسانة المسلحة

مقاومة التشققات

Mark only one oval.

1	2	3	4	5	
أقل	☐	☐	☐	☐	أعلى

31. **(CBGM) * المادة الحبيبية المرتبطة بالإسمنت**

مقاومة التشققات

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أعلى

32. **(RC) * الخرسانة المسلحة**

قدرة تحمل الأحمال

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أعلى

33. **(CBGM) * المادة الحبيبية المرتبطة بالإسمنت**

قدرة تحمل الأحمال

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أعلى

34. **(RC) * الخرسانة المسلحة**

مقاومة دورات التمدد والتقلص

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أعلى

35. **(CBGM) * المادة الحبيبية المرتبطة بالإسمنت**

مقاومة دورات التمدد والتقلص

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أعلى

36. **(RC) * الخرسانة المسلحة**

مقاومة الهجمات الكيميائية

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أعلى

37. **(CBGM) * المادة الحبيبية المرتبطة بالإسمنت**

مقاومة الهجمات الكيميائية

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أعلى

38. **(RC) * الخرسانة المسلحة**

جودة التشطيب السطحي

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أعلى

39. **(CBGM) * المادة الحبيبية المرتبطة بالإسمنت**

جودة التشطيب السطحي

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أعلى

40. **(RC) * الخرسانة المسلحة**

سهولة مراقبة الجودة

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أعلى

41. **(CBGM) * المادة الحبيبية المرتبطة بالإسمنت**

سهولة مراقبة الجودة

Mark only one oval.

1 2 3 4 5

أقل ☐ ☐ ☐ ☐ ☐ أعلى

شكر وتقدير

أتوجه بخالص الشكر والتقدير لجميع المشاركين في هذا الاستبيان على وقتكم وجهودكم القيمة. إن مشاركتكم الفعالة وملاحظاتكم الهامة ساهمت بشكل كبير في إنجاح هذه الدراسة. أقدر تعاونكم ودعمكم، وأؤكد لكم أن إجاباتكم ستعامل بسرية تامة ولن تُستخدم إلا لأغراض البحث العلمي.

Introduction for the Questionnaire

Dear Participant,

Thank you for taking the time to complete this questionnaire. This survey aims to evaluate and compare different factors related to **Time, Cost, and Quality** in construction projects, focusing on **RC (Reinforced Concrete) & CBGM (Cement-Bound Granular Material)**.

To provide a clear understanding, let's consider an example of **Slab on Grade** construction using these three methods:

1 RC (Reinforced Concrete): Traditional slab-on-grade construction using reinforced concrete for strength and durability.

2 CBGM (Cement-Bound Granular Material): A stabilized material that serves as a structural layer, offering improved load-bearing capacity.

This questionnaire will assess the performance of these methods in terms of:

✓ **Timeline** – Efficiency in material procurement, preparation, construction, and overall project duration.

✓ **Cost** – Evaluation of material, labor, equipment, and maintenance costs.

✓ **Quality** – Durability, resistance, load-bearing capacity, and ease of quality control.

Each section consists of a **rating scale** for different aspects. Please provide your evaluation based on your **experience, knowledge, or project insights**. Your participation is highly valuable and will contribute to a better understanding of material performance in construction.

◆ **Confidentiality:** All responses will remain anonymous and used solely for research purposes.

◆ **Estimated Time:** 5–10 minutes to complete the questionnaire.

Appreciate your time and valuable input! 🙏 68

Best regards,

AbdullAziz D. Skik

Personal Information

All responses will remain anonymous and used solely for research purposes.

42. Gender *

Mark only one oval.

☐ Male

☐ Female

43. Age *

Mark only one oval.

☐ 30 or less

☐ 31 to 35

☐ 36 to 45

☐ 46 or above

44. Education *

Mark only one oval.

- ☐ Secondary school
- ☐ Bachelor's degree
- ☐ Master degree
- ☐ Doctorate degree

45. Years of experience *

Mark only one oval.

- ☐ 5 or less
- ☐ 6 to 10
- ☐ 11 to 15
- ☐ above 15

46. Job role *

Mark only one oval.

- ☐ Contractor
- ☐ Consultant
- ☐ Designer
- ☐ Client



Timeline Questionnaire

Time Factor Evaluation.

47. **Material Procurement Time ***

RC (reinforced concrete)

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

48. **Material Procurement Time ***

CBGM

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

49. **Preparation Time ***

RC (reinforced concrete)

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

50. **Preparation Time ***

CBGM

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

51. **Placement/Construction Time ***

RC (reinforced concrete)

Mark only one oval.

	1	2	3	4	5	
Less	☐	☐	☐	☐	☐	More

52. **Curing/Setting Time ***

RC (reinforced concrete)

Mark only one oval.

	1	2	3	4	5	
Less	☐	☐	☐	☐	☐	More

53. **Curing/Setting Time ***

CBGM

Mark only one oval.

	1	2	3	4	5	
Less	☐	☐	☐	☐	☐	More

54. **Overall Project Timeline ***

RC (reinforced concrete)

Mark only one oval.

	1	2	3	4	5	
Less	☐	☐	☐	☐	☐	More

55. **Overall Project Timeline ***

CBGM

Mark only one oval.

	1	2	3	4	5	
Less	☐	☐	☐	☐	☐	More



Cost Questionnaire

Cost Factor Evaluation

56. **Material Costs ***

RC (reinforced concrete)

Mark only one oval.

	1	2	3	4	5	
Less	☐	☐	☐	☐	☐	More

57. **Material Costs ***

CBGM

Mark only one oval.

	1	2	3	4	5	
Less	☐	☐	☐	☐	☐	More

58. **Labor Costs** *

RC (reinforced concrete)

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

59. **Labor Costs** *

CBGM

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

60. **Equipment Costs** *

RC (reinforced concrete)

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

61. **Equipment Costs** *

CBGM

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

62. **Formwork/Preparation Costs ***

RC (reinforced concrete)

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

63. **Formwork/Preparation Costs ***

CBGM

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

64. **Maintenance Costs ***

RC (reinforced concrete)

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

65. **Maintenance Costs ***

CBGM

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

Quality Questionnaire

Quality Aspect Evaluation

66. **Durability/Longevity** *

RC (reinforced concrete)

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

67. **Durability/Longevity** *

CBGM

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

68. **Resistance to Cracking** *

RC (reinforced concrete)

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

69. **Resistance to Cracking ***

CBGM

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

70. **Load-Bearing Capacity ***

RC (reinforced concrete)

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

71. **Load-Bearing Capacity ***

CBGM

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

72. **Resistance to Freeze-Thaw ***

RC (reinforced concrete)

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

73. **Resistance to Freeze-Thaw ***

CBGM

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

74. **Resistance to Chemical Attack ***

RC (reinforced concrete)

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

75. **Resistance to Chemical Attack ***

CBGM

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

76. **Surface Finish ***

RC (reinforced concrete)

Mark only one oval.

1 2 3 4 5

Less: ☐ ☐ ☐ ☐ ☐ More

77. **Surface Finish ***

CBGM

Mark only one oval.

	1	2	3	4	5	
Less	☐	☐	☐	☐	☐	More

78. **Ease of Quality Control ***

RC (reinforced concrete)

Mark only one oval.

	1	2	3	4	5	
Less	☐	☐	☐	☐	☐	More

79. **Ease of Quality Control ***

CBGM

Mark only one oval.

	1	2	3	4	5	
Less	☐	☐	☐	☐	☐	More

Acknowledgment

I would like to express my sincere gratitude and appreciation to all participants of this survey for your valuable time and efforts. Your active participation and insightful feedback have significantly contributed to the success of this study. I greatly value your cooperation and support, and I assure you that your responses will be treated with the utmost confidentiality and used solely for academic research purposes .

SPSS Outputs:

Frequencies

		Statistics				
		Gender	Age	Education	Years of experience	Job role
N	Valid	33	33	33	33	33
	Missing	0	0	0	0	0
Mean		1.18	2.06	1.30	2.00	1.70
Median		1.00	2.00	1.00	2.00	1.00
Std. Deviation		.392	1.029	.637	1.090	1.132
Range		1	3	2	3	3
Minimum		1	1	1	1	1
Maximum		2	4	3	4	4

		Gender			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	27	81.8	81.8	81.8
	Female	6	18.2	18.2	100.0
	Total	33	100.0	100.0	

		Age			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	30 or less	12	36.4	36.4	36.4
	31 to 35	11	33.3	33.3	69.7
	36 to 45	6	18.2	18.2	87.9
	46 or above	4	12.1	12.1	100.0
	Total	33	100.0	100.0	

Education

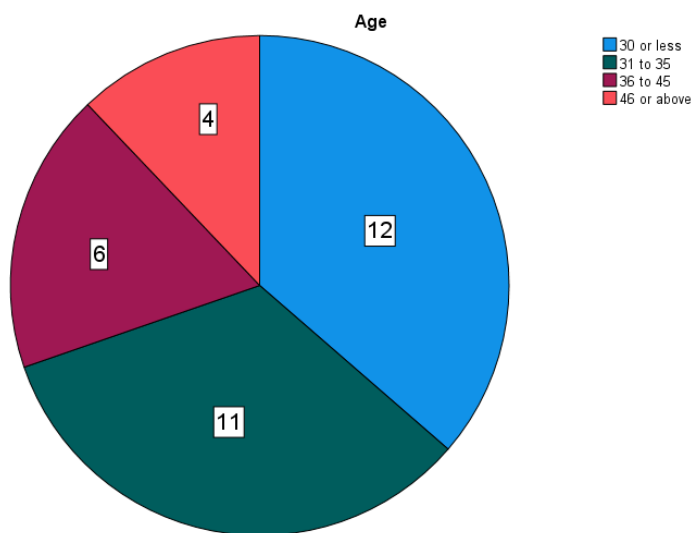
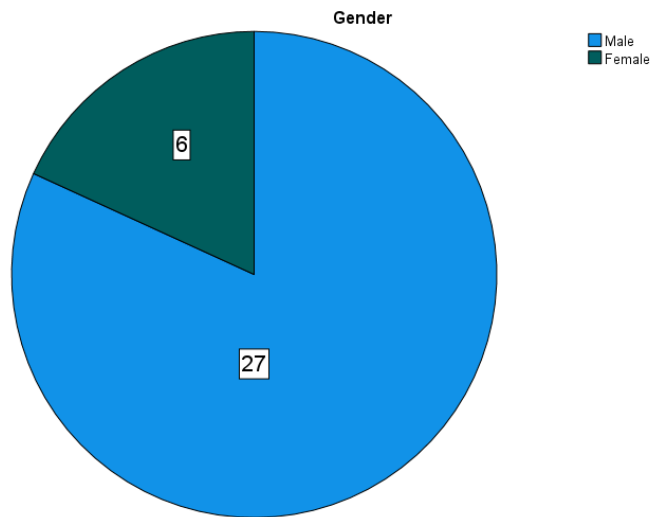
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Bachelor's degree	26	78.8	78.8	78.8
	Master degree	4	12.1	12.1	90.9
	Doctorate degree	3	9.1	9.1	100.0
	Total	33	100.0	100.0	

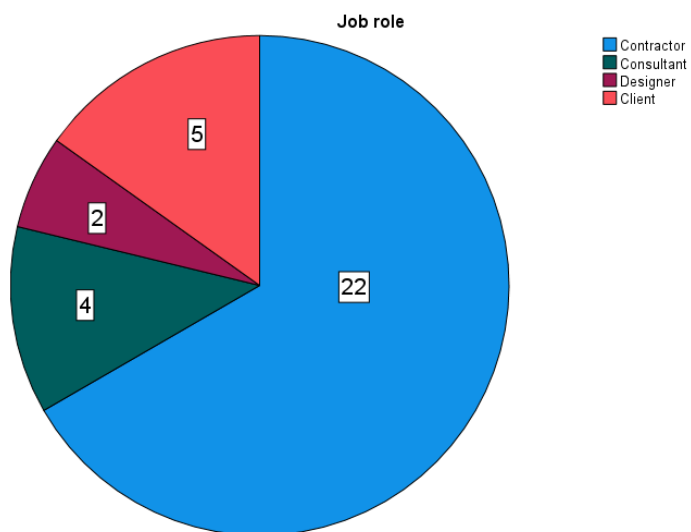
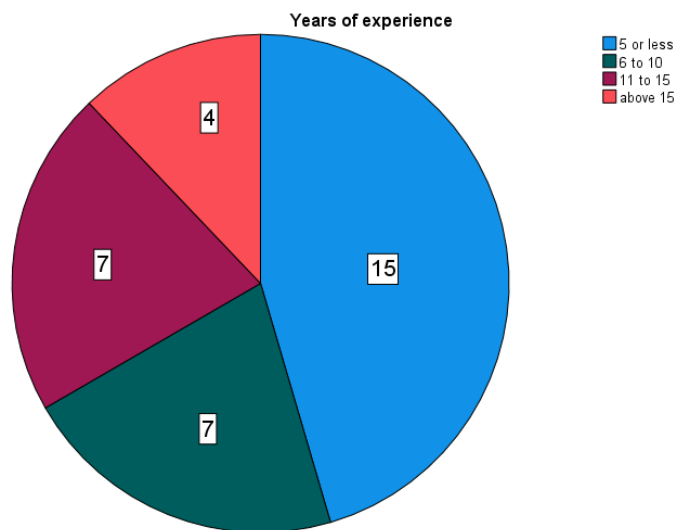
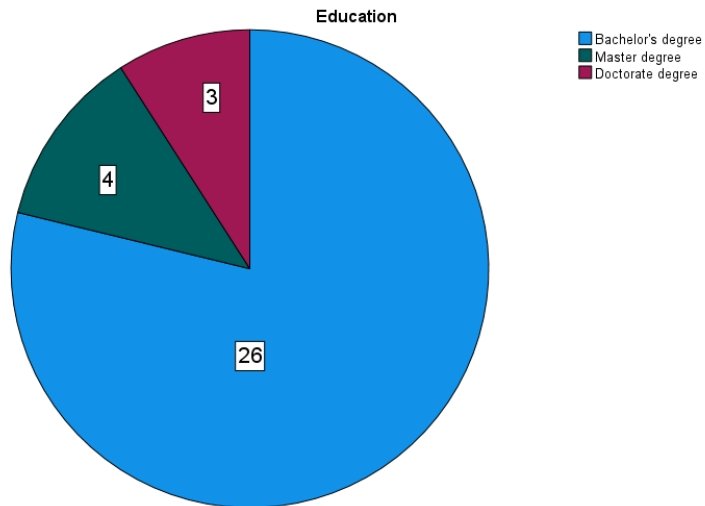
Years of experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5 or less	15	45.5	45.5	45.5
	6 to 10	7	21.2	21.2	66.7
	11 to 15	7	21.2	21.2	87.9
	above 15	4	12.1	12.1	100.0
	Total	33	100.0	100.0	

Job role

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Contractor	22	66.7	66.7	66.7
	Consultant	4	12.1	12.1	78.8
	Designer	2	6.1	6.1	84.8
	Client	5	15.2	15.2	100.0
	Total	33	100.0	100.0	





Reliability

Reliability

Scale: Time

Case Processing Summary

		N	%
Cases	Valid	33	100.0
	Excluded ^a	0	.0
	Total	33	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.771	10

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Material Procurement Time_RC (reinforced concrete)	31.21	29.610	.430	.753
Material Procurement Time_CBG	31.33	31.167	.310	.767
Preparation Time_RC (reinforced concrete)	31.48	27.758	.544	.737
Preparation Time_CBG	31.36	29.489	.390	.759
Placement/Construction Time_RC (reinforced concrete)	31.24	28.814	.488	.745
Placement/Construction Time_CBG	31.15	30.258	.389	.758
Curing/Setting Time_RC (reinforced concrete)	31.55	27.131	.522	.740
Curing/Setting Time_CBG	31.24	29.877	.385	.759
Overall Project Timeline_RC (reinforced concrete)	31.33	29.542	.417	.755
Overall Project Timeline_CBG	31.18	29.528	.483	.747

Reliability

Scale: Cost

Case Processing Summary

		N	%
Cases	Valid	33	100.0
	Excluded ^a	0	.0
	Total	33	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.680	10

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Material Costs_RC (reinforced concrete)	29.58	18.877	.469	.631
Material Costs_CBGM	30.18	19.091	.450	.635
Labor Costs_RC (reinforced concrete)	29.76	19.439	.414	.642
Labor Costs_CBGM	30.09	20.273	.429	.644
Equipment Costs_RC (reinforced concrete)	29.85	18.820	.499	.625
Equipment Costs_CBGM	29.64	23.114	.060	.697
Formwork/Preparation Costs_RC (reinforced concrete)	29.64	20.864	.261	.672
Formwork/Preparation Costs_CBGM	30.27	19.517	.408	.644
Maintenance Costs_RC (reinforced concrete)	29.73	21.142	.199	.684
Maintenance Costs_CBGM	30.18	21.091	.213	.681

Reliability

Scale: Quality

Case Processing Summary

		N	%
Cases	Valid	33	100.0
	Excluded ^a	0	.0
	Total	33	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.846	14

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Durability/Longevity_RC (reinforced concrete)	48.33	56.229	.482	.837
Durability/Longevity_CBG M	48.52	57.820	.492	.837
Resistance to Cracking_RC (reinforced concrete)	48.82	53.841	.551	.832
Resistance to Cracking_CBGM	48.67	56.104	.545	.833
Load-Bearing Capacity_RC (reinforced concrete)	48.33	53.542	.634	.827
Load-Bearing Capacity_CBGM	48.48	56.508	.480	.837
Resistance to Freeze-Thaw_RC (reinforced concrete)	48.76	53.627	.627	.827
Resistance to Freeze-Thaw_CBGM	48.45	55.568	.615	.830
Resistance to Chemical Attack_RC (reinforced concrete)	48.97	51.405	.628	.826
Resistance to Chemical Attack_CBGM	48.45	52.443	.696	.822
Surface Finish_RC (reinforced concrete)	48.33	56.729	.322	.850
Surface Finish_CBGM	48.94	58.371	.383	.842
Ease of Quality Control_RC (reinforced concrete)	48.79	60.672	.190	.853
Ease of Quality Control_CBGM	48.48	60.883	.199	.851

Correlations

Correlations

		Time	Cost	Quality	M_Total
Time	Pearson Correlation	1	.039	.571 ^{**}	.773 ^{**}
	Sig. (2-tailed)		.829	.001	.000
	N	33	33	33	33
Cost	Pearson Correlation	.039	1	.262	.546 ^{**}
	Sig. (2-tailed)	.829		.141	.001
	N	33	33	33	33
Quality	Pearson Correlation	.571 ^{**}	.262	1	.855 ^{**}
	Sig. (2-tailed)	.001	.141		.000
	N	33	33	33	33
M_Total	Pearson Correlation	.773 ^{**}	.546 ^{**}	.855 ^{**}	1
	Sig. (2-tailed)	.000	.001	.000	
	N	33	33	33	33

One Way Anova

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Material Procurement Time_RC (reinforced concrete)	Between Groups	1.318	3	.439	.414	.744
	Within Groups	30.743	29	1.060		
	Total	32.061	32			
Material Procurement Time_CBG M	Between Groups	1.591	3	.530	.579	.634
	Within Groups	26.590	29	.917		
	Total	28.182	32			
Preparation Time_RC (reinforced concrete)	Between Groups	7.001	3	2.334	2.117	.120
	Within Groups	31.969	29	1.102		
	Total	38.970	32			
Preparation Time_CBG M	Between Groups	3.425	3	1.142	.956	.427
	Within Groups	34.636	29	1.194		
	Total	38.061	32			
Placement/Construction Time_RC (reinforced concrete)	Between Groups	1.413	3	.471	.417	.742
	Within Groups	32.769	29	1.130		
	Total	34.182	32			
Placement/Construction	Between Groups	2.867	3	.956	1.035	.392

Time_CBG M	Within Groups	26.769	29	.923		
	Total	29.636	32			
Curing/Setti ng Time_RC (reinforced concrete)	Between Groups	3.006	3	1.002	.645	.592
	Within Groups	45.055	29	1.554		
	Total	48.061	32			
Curing/Setti ng Time_CBG M	Between Groups	2.670	3	.890	.819	.494
	Within Groups	31.512	29	1.087		
	Total	34.182	32			
Overall Project Timeline_R C (reinforced concrete)	Between Groups	1.706	3	.569	.508	.680
	Within Groups	32.476	29	1.120		
	Total	34.182	32			
Overall Project Timeline_C BGM	Between Groups	2.336	3	.779	.884	.461
	Within Groups	25.543	29	.881		
	Total	27.879	32			
Surface Finish_RC (reinforced concrete)	Between Groups	7.714	3	2.571	1.851	.160
	Within Groups	40.286	29	1.389		
	Total	48.000	32			
Surface Finish_CBG M	Between Groups	.707	3	.236	.295	.829
	Within Groups	23.171	29	.799		

	Total	23.879	32			
Ease of Quality Control_RC (reinforced concrete)	Between Groups	1.153	3	.384	.445	.722
	Within Groups	25.029	29	.863		
	Total	26.182	32			
Ease of Quality Control_CB GM	Between Groups	4.385	3	1.462	2.374	.091
	Within Groups	17.857	29	.616		
	Total	22.242	32			
Material Costs_RC (reinforced concrete)	Between Groups	7.667	3	2.556	2.854	.054
	Within Groups	25.969	29	.895		
	Total	33.636	32			
Material Costs_CBG M	Between Groups	2.094	3	.698	.655	.586
	Within Groups	30.876	29	1.065		
	Total	32.970	32			
Labor Costs_RC (reinforced concrete)	Between Groups	6.384	3	2.128	2.392	.089
	Within Groups	25.798	29	.890		
	Total	32.182	32			
Labor Costs_CBG M	Between Groups	1.896	3	.632	.934	.437
	Within Groups	19.619	29	.677		
	Total	21.515	32			

Equipment Costs_RC (reinforced concrete)	Between Groups	4.010	3	1.337	1.403	.262
	Within Groups	27.626	29	.953		
	Total	31.636	32			
Equipment Costs_CBG M	Between Groups	.853	3	.284	.479	.699
	Within Groups	17.207	29	.593		
	Total	18.061	32			
Formwork/P reparation Costs_RC (reinforced concrete)	Between Groups	6.699	3	2.233	2.772	.059
	Within Groups	23.362	29	.806		
	Total	30.061	32			
Formwork/P reparation Costs_CBG M	Between Groups	3.860	3	1.287	1.332	.283
	Within Groups	28.019	29	.966		
	Total	31.879	32			
Maintenance Costs_RC (reinforced concrete)	Between Groups	5.414	3	1.805	1.815	.166
	Within Groups	28.829	29	.994		
	Total	34.242	32			
Maintenance Costs_CBG M	Between Groups	3.744	3	1.248	1.238	.314
	Within Groups	29.226	29	1.008		
	Total	32.970	32			
Durability/Longevity_RC	Between Groups	2.945	3	.982	1.052	.384

(reinforced concrete)	Within Groups	27.055	29	.933		
	Total	30.000	32			
Durability/Longevity_CBGM	Between Groups	.976	3	.325	.526	.668
	Within Groups	17.933	29	.618		
	Total	18.909	32			
Resistance to Cracking_RC (reinforced concrete)	Between Groups	5.795	3	1.932	1.626	.205
	Within Groups	34.448	29	1.188		
	Total	40.242	32			
Resistance to Cracking_C BGM	Between Groups	.507	3	.169	.197	.897
	Within Groups	24.826	29	.856		
	Total	25.333	32			
Load-Bearing Capacity_RC (reinforced concrete)	Between Groups	4.781	3	1.594	1.582	.215
	Within Groups	29.219	29	1.008		
	Total	34.000	32			
Load-Bearing Capacity_C BGM	Between Groups	.635	3	.212	.222	.880
	Within Groups	27.607	29	.952		
	Total	28.242	32			
Resistance to Freeze-Thaw_RC	Between Groups	6.282	3	2.094	2.186	.111
	Within Groups	27.779	29	.958		

(reinforced concrete)	Total	34.061	32			
Resistance to Freeze-Thaw_CBG M	Between Groups	3.889	3	1.296	1.915	.149
	Within Groups	19.626	29	.677		
	Total	23.515	32			
Resistance to Chemical Attack_RC (reinforced concrete)	Between Groups	6.296	3	2.099	1.404	.262
	Within Groups	43.340	29	1.494		
	Total	49.636	32			
Resistance to Chemical Attack_CBG M	Between Groups	4.689	3	1.563	1.470	.243
	Within Groups	30.826	29	1.063		
	Total	35.515	32			

All praise and thanks be to Allah, whose guidance and blessings have enabled me to complete this research. Without His grace, this achievement would not have been possible. I am deeply grateful to my family, teachers, and colleagues for their unwavering support, encouragement, and wisdom throughout this journey. Their guidance and belief in me have been invaluable in shaping this work.

I also extend my appreciation to Midocean University for providing the resources and academic environment necessary for conducting this research. May this work contribute positively to the field and serve as a foundation for future advancements. May Allah bless us all with continued knowledge, wisdom, and success.

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المخلص

إدارة المشاريع الفعالة أمر بالغ الأهمية في مشاريع رصف الخرسانة، حيث يؤثر تحقيق التوازن بين الجدول الزمني للمشروع، الجودة، والتكلفة بشكل مباشر على نجاح المشروع ككل. يهدف هذا البحث إلى دراسة استراتيجيات إدارة المشاريع الفعالة، مع التركيز بشكل خاص على تحسين الجداول الزمنية، تدابير ضبط الجودة، وممارسات إدارة التكاليف، من خلال دراسة حالة تفصيلية لتطبيقات المادة الحبيبية المرتبطة بالإسمنت (CBGM) في إنشاء الأرصفة الخرسانية.

يعتمد البحث على المنهج الوصفي التحليلي، مستفيداً من البيانات الكمية والنوعية المستمدة من الممارسات الصناعية القياسية، الإرشادات التقنية، ودراسات الحالات الميدانية. توضح النتائج كيف يمكن للممارسات الإدارية الاستراتيجية أن تعزز كفاءة المشاريع بشكل كبير من خلال تحسين الجدولة الزمنية، تحسين جودة المواد والبناء، والسيطرة الفعالة على التكاليف. كما تسلط النتائج الضوء على التحديات والتوازنات العملية التي يجب مراعاتها عند تحسين أحد هذه الأبعاد على حساب الآخر.

ويختتم البحث بتقديم توصيات عملية لمساعدة مديري المشاريع في تبني نهج متكامل لإدارة المشاريع، يحقق التوازن الأمثل بين هذه العوامل، مما يساهم في تحسين الأداء والنتائج في مشاريع الرصف الخرساني.

الكلمات المفتاحية:

(الخرسانة، الرصف، الإدارة، المشاريع، الجدول الزمني، إدارة التكاليف، ضبط الجودة، الخرسانة المسلحة، CBGM)

استراتيجيات إدارة المشاريع لاختيار تطبيقات الخرسانة: لتحقيق التوازن بين الوقت والجودة
والتكلفة

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العام الدراسي:

2025