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Enhancing Value and Efficiency in Egyptian Construction Projects: A Framework for Contractor Performance Assessment Using Value Engineering

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Abstract: In Egypt's rapidly growing construction sector, the selection of qualified contractors remains a critical challenge for project success. While Egyptian procurement practices traditionally emphasize cost-based selection criteria, this lowest-bid approach has frequently resulted in compromised project quality, performance deficiencies, and schedule overruns. This study introduces a Value Engineering (VE)-based Contractor Performance Assessment Model, addressing key gaps in the evaluation process. The proposed model integrates function-worth analysis in contractor selection and introduces a Value Index (VI) for real-time performance monitoring. The methodology emphasizes a cost-effective and quality-driven approach for ranking contractors, ensuring a more systematic and value-focused selection process. The primary objectives of this research are to develop a scientifically validated VE-based contractor performance assessment framework, apply the Value Index (VI) methodology for comparative analysis of contractor effectiveness, and establish a practical contractor selection and monitoring protocol tailored to Egypt's construction industry. By adopting the proposed framework, stakeholders can improve contractor accountability, enhance project efficiency, and optimize resource allocation, ultimately contributing to the sustainable advancement of Egypt's construction sector.

1. Introduction

The Egyptian construction industry serves as a vital pillar of national economic development, contributing approximately 10% to the country's GDP while employing nearly 7% of the national workforce according to recent industry reports [1]. Despite its significant economic role, the sector continues to face persistent challenges that undermine project success. Statistical evidence reveals chronic cost overruns averaging 25-30% of project budgets, with government-funded projects particularly affected by schedule delays occurring in nearly 60% of cases [2]. Quality assurance reports further indicate concerning

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defect rates of 35% in delivered facilities, suggesting systemic issues in project execution and delivery standards [3]. These documented performance deficiencies primarily originate from fundamental flaws in current contractor assessment methodologies. Industry analyses demonstrate that existing evaluation systems disproportionately emphasize bid price considerations, typically weighting financial factors at 70% of total evaluation scores, while technical capabilities receive only 30% weighting [4]. This imbalance creates a procurement environment that prioritizes short-term cost savings over long-term value creation. Furthermore, the absence of robust performance monitoring mechanisms during project execution allows quality compromises and schedule slippages to go unchecked until they develop into major issues [5].

Contemporary construction management research emphasizes the critical relationship between comprehensive contractor evaluation systems and successful project outcomes. The Project Management Institute's global standards demonstrate that balanced assessment frameworks incorporating multiple performance dimensions can reduce cost overruns by 22% and minimize schedule delays by 18% [6]. International best practices from leading construction markets like Japan have evolved sophisticated evaluation models that distribute weighting more evenly across technical capability (40%), financial stability (30%), past performance (20%), and innovation potential (10%) [7]. these advanced systems provide valuable benchmarks for emerging construction economies [8]. Value Engineering (VE) has emerged as a transformative methodology in contractor assessment since its development by Lawrence Miles at General Electric during the 1940s [9]. Modern construction applications have adapted VE principles into practical tools including Function Analysis System Technique (FAST) diagrams, life-cycle cost modeling frameworks, and quantitative Value Index measurements [10]. When properly implemented, these tools enable project owners to make data-driven decisions that optimize the relationship between functional performance requirements and resource allocation throughout the project lifecycle [11].

Regional comparative studies reveal significant disparities in VE adoption across Middle Eastern construction markets. While Egypt reports only 12% implementation of formal value methodologies in major projects, neighboring UAE and Saudi Arabia demonstrate substantially higher adoption rates of 38% and 45% respectively [12]. This gap persists despite clear evidence from Egyptian infrastructure case studies showing that VE implementation could yield 19% cost savings and 15% schedule improvements [13]. The resistance to adoption appears rooted in cultural and procedural factors rather than technical limitations [14]. The Egyptian regulatory framework for contractor evaluation, as codified by the Egyptian Federation for Construction and Building Contractors (EFCBC), currently emphasizes three primary selection criteria: financial capacity (50% weighting), technical qualifications (30%), and past project experience (20%) [4]. While this represents a more balanced approach than pure price-based selection, it still fails to address several critical value dimensions identified in contemporary research. Notably absent are assessments of innovation capability (particularly in sustainable construction techniques), robust risk management systems, stakeholder management capacity, and digital transformation readiness [15]. These omissions create significant blind spots in contractor evaluation processes [16].

A systematic review of current practices reveals three fundamental limitations in Egypt's contractor assessment methodology. First, existing systems lack robust mechanisms to quantify and compare value delivery relative to cost investments [17]. While basic financial metrics are captured, there is no standardized approach to measuring the functional performance achieved per monetary unit expended. This makes accurate value comparisons between competing contractors exceptionally difficult [18]. Second, no standardized framework exists for integrating VE tools into Egypt's contractor selection and monitoring processes [19]. The country's construction regulators have yet to develop formal guidelines for applying Function Analysis, Value Index calculations, or other VE methodologies in the procurement process. This institutional gap prevents the widespread adoption of value-based assessment practices, even among progressive firms that recognize their potential benefits.

Third, current evaluation practices demonstrate poor correlation between selection criteria and actual project outcomes [20]. EFCBC performance reports indicate that 65% of contractor disputes originate from fundamental mismatches between expected and delivered functional requirements [21]. This suggests that existing assessment criteria fail to properly identify contractors best suited to meet project-specific needs, resulting in poor value delivery [22]. The absence of a comprehensive, VE-based contractor assessment framework specifically designed for Egypt's unique construction ecosystem represents a critical gap in both research and practice. The country's distinct procurement practices, regulatory environment, and market conditions require tailored solutions that global models cannot directly provide. This methodological deficiency directly contributes to the sector's persistent project failures in cost control, schedule adherence, and quality assurance. By developing and validating an Egypt-specific VE assessment framework, this research aims to transform contractor evaluation from a bureaucratic formality into a powerful value optimization tool.

2. Methods and tools

2.1. Research Design

This study employs a mixed-methods research design to develop and validate a Value Engineering (VE)-based framework for contractor performance assessment in Egypt's construction sector. The research combines quantitative analysis of contractor performance metrics with qualitative evaluation of VE implementation processes. The study focuses specifically on large-scale government and public-private partnership (PPP) projects, as these represent both the most significant portion of Egypt's construction activity (approximately 65% of major projects) and the area where performance deficiencies are most pronounced. The research setting encompasses the complete project lifecycle from tendering through final delivery, allowing for comprehensive assessment of contractor performance across all critical phases.

2.2. Data Collection and Participants

The research incorporates data from three primary sources to ensure robust findings. First, technical and financial documentation from 47 active construction projects was analyzed, including tender submissions, progress reports, and final account statements provided through agreements with the Egyptian Federation for Construction and Building Contractors (EFCBC). Second, performance data was collected from 32 contractors pre-qualified for government projects, representing all classification grades (A to D) in Egypt's contractor ranking system. Third, structured interviews were conducted with 18 industry experts, including project managers, VE specialists, and government procurement officers, to validate the practical applicability of the proposed framework.

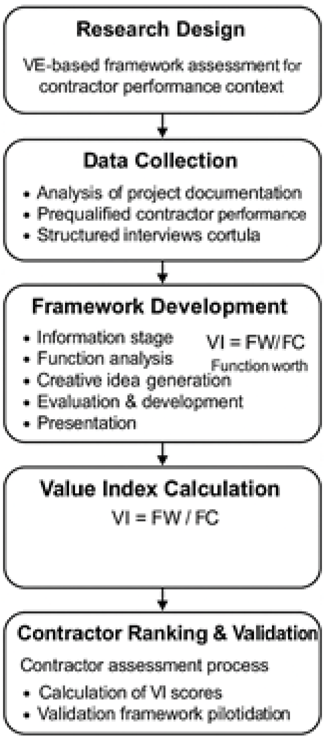

Figure 1: Research Methodology Framework

2.3. Processes and Methodologies:

The methodology employed in this study follows the structured Value Engineering (VE) approach as shown in figure 1, utilizing its established phases: information gathering, function analysis, creative idea generation, evaluation, development, and presentation. The Value Index, a tool that quantifies contractor performance by assessing the ratio of Function worth (FW) to Function Cost (FC), is central to the evaluation process. Statistical tools are employed to compare contractors based on their value delivery capabilities. The methodology also includes a pilot case study to illustrate the practical application of the Value Index for contractor selection and performance assessment during the construction phase. The VE study follows SAVE International’s structured job plan, divided into pre-workshop, workshop, and post-workshop stages, with each stage broken down into specific phases for assessing contractor performance. Various VE tools, such as Function Analysis, Life Cycle Cost Analysis, and Brainstorming, are applied to assess contractors' technical and financial capabilities.

2.3.1. Value Engineering:

Value Engineering (VE) is a systematic and structured process designed to scrutinize the function of systems, equipment, facilities, services, and supplies to ensure they perform their essential roles at the most economical life-cycle cost, while maintaining the necessary standards of performance, reliability, quality, and safety. Essentially, Value Engineering employ’s function analysis, collaborative teamwork, and innovative thinking to enhance value [5]. The Value Engineering (VE) study follows a structured process known as the job plan, which systematically analyzes a product or service. This plan outlines specific techniques to assess the product or service effectively and generate a wide range of alternatives to meet its required functions. Adhering to the job plan increases the likelihood of achieving maximum benefits while providing greater flexibility. The VE study consists of five phases: the information phase, creative phase, evaluation phase, development phase, and recommendation phase. These phases, along with their respective steps, are executed sequentially [6]. SAVE International has established six sequential phases for conducting a successful VE study. These phases are grouped into three stages: the pre-workshop stage, the workshop stage, and the post-workshop stage, as illustrated in Figure 2 [7].

2.3.2. VM Methods and Tools

Various methods and approaches are applicable during the Value Management (VM) process, tailored to the specifications and conditions of the project, table (2) presents a range of methods and techniques that can be utilized in the VM study. It's important to note that there are no specific standard or exclusive tools mandated for the VM process; rather, these techniques are outlined below. Innovative techniques can be devised and tailored by the VM team based on the project specifications to assess new ideas and alternatives. Among these, "Brainstorming," "Function Analysis (FAST)," "Life Cycle Cost Analysis," and "Evaluation Matrix" stand out as crucial techniques consistently employed in the VM process [8].

Table 1: Illustrating the purpose of each stage& phase of VM

VE Stages & Phases	Description
Pre-study	Identify customer attitudes, Identify goals and objectives
Study	Information phase
	Function phase
	Creative phase
	Evaluation phase
	Development phase
	Presentation phase
Post study	Implementation phase

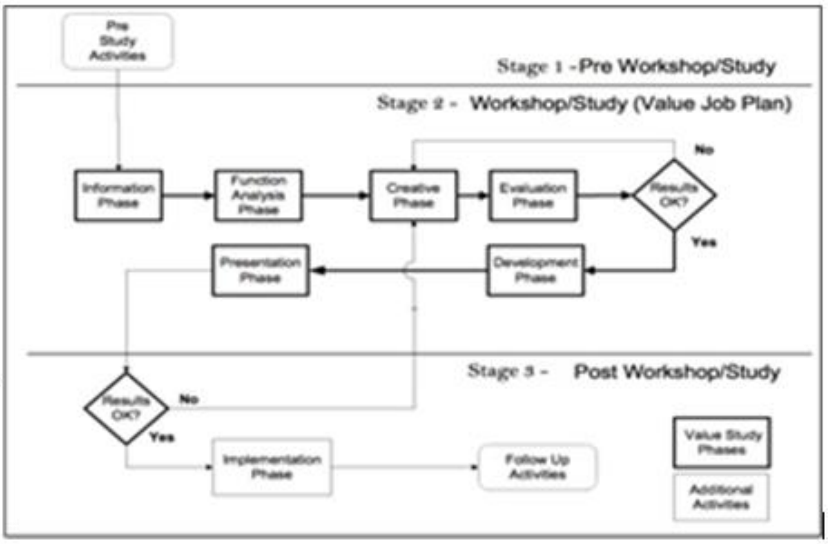

Figure 2: Value Engineering Process Flow Diagram by SAVE International [7]

Table 2: Common Methods of VM Process

Methods	Prominent feature
FAST chart	Determining the function and objectives of project, each idea or alternative and then discussing about them among team
life cycle cost analysis	Estimating all costs over life cycle of the project and then evaluating the new alternatives based on this lifecycle cost
Brainstorming	Rely on creativity thinking, Group activity, Group discussion, decision making based on group's idea
Synaptic technique	
Hierarchy diagram	Breaking down a project to sub parts and elements to focus them in detail
Value index	Represents the relationship between Function Worth (FW) and Function Cost (FC), and calculating value index based on cost and value of the
advantages/ disadvantages method	Using advantages disadvantages method to evaluate each idea and also the project.
Risk Analysis	Determining the risks, threats and hazards of each alternative to evaluate them.

2.3.3. Value Index

The Value Index represents the relationship between Function worth (FW) and Function Cost (FC): Value Index = Function Worth (FW) / Function Cost (FC)

Alternatively, this ratio can be expressed as:

Value Index = Function Cost (FC) / Function Worth (FW)

- **Function worth (FW)**: The FW is calculated using a weighted sum of various performance factors, including technical performance, quality, and innovation. This reflects the importance of delivering value in multiple dimensions rather than focusing solely on cost.

• **Function Cost (FC)**: The FC formula accounts for the total normalized costs across different project phases. This normalization makes it possible to compare contractors of varying sizes and capacities on an equal footing.

- The difference between cost and worth is known as ‘value gap’.
- It indicates the scope of possible value improvement.
- The value index is the ratio of cost by worth.
- In other words, it is the cost per unit of worth.
- Value Index >1, means there is potential for value improvement.
- The ultimate aim of the Function–cost–worth analysis is to find out the
- Value improvement in various functions. Based on these findings, the team Will approach the problem.

Where:

- Function Worth (FW) quantifies the delivered project value through weighted assessment of:
  - Technical performance (40% weight)
  - Schedule adherence (20%)
  - Quality achievement (15%)
  - Innovation contribution (15%)
- Function Cost (FC) represents the normalized project costs, accounting for:
  - Initial bid price (60% weight)
  - Change order costs (20%)
  - Life-cycle maintenance costs (20%)

The research team established specific evaluation criteria for each parameter through Delphi method consultations with industry experts, ensuring alignment with Egyptian construction standards and practices.

3. Statistical Analysis

The study employs multiple analytical approaches to ensure comprehensive evaluation:

3.1. Descriptive Statistics:

- Central tendency measures for performance benchmarks
- Variability analysis of contractor outputs
- Trend analysis of Value Index progression

3.2. Comparative Analysis:

- Paired comparisons of contractor performance
- Before-after implementation assessments
- Cross-project benchmarking

3.3. Validation Methods:

- Pilot testing with three active projects

- Sensitivity analysis of weighting factors
- Expert panel reviews

4. Proposed Methodology for Using the Value Index in Assessing Contractors' Performance:

The Value Index can serve as an effective tool for selecting contractors and evaluating their performance during the construction phase as follows:

4.1. Contractor Selection

- **Define Criteria**: Establish criteria for contractor selection, including factors such as technical expertise, past performance, cost-effectiveness, and adherence to project timelines.
- **Function worth Assessment**: Evaluate each contractor's proposed plan and their ability to deliver the required project functions. Assign a Function Worth score to quantify the perceived value or importance of their approach.
- **Function Cost Evaluation**: Assess the cost estimates provided by each contractor for executing the project. Assign a Function Cost score to quantify the costs associated with their approach.
- **Calculate Value Index**: Use the formula Value Index = Function Worth / Function Cost to calculate the Value Index for each contractor. This ratio reflects the value delivered per unit of cost.
- **Selection Process**: Choose the contractor with the highest Value Index, as this contractor offers the best value proposition in terms of delivering essential functions relative to costs.
- **Ongoing Monitoring and Tracking**: Continuously monitor and track the performance of the selected contractor throughout the project lifecycle to ensure that they meet the agreed-upon criteria and maintain optimal value delivery.

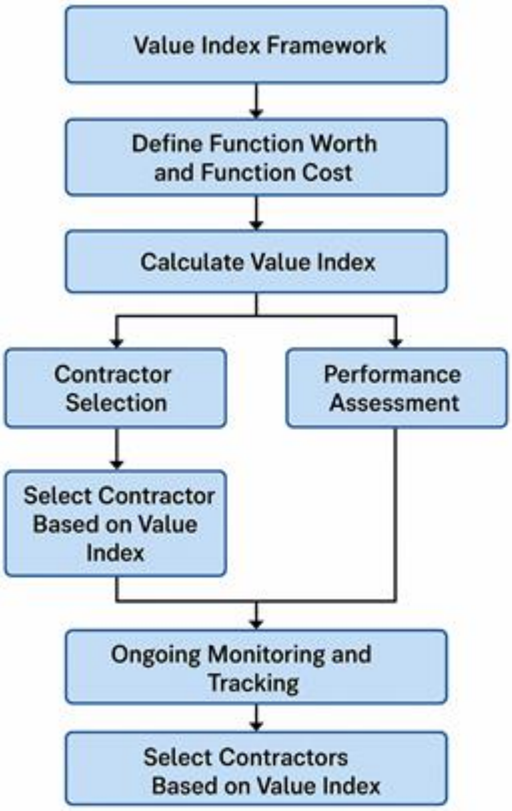

Figure 3: The Proposed Methodology for Contractor Selection and Assessment

By using the Value Index for contractor selection and performance assessment, project stakeholders can make informed decisions, optimize value delivery, and ensure successful project outcomes during the construction phase.

4.2. Determine the Pilot Case Study:

The research focuses on the development of a comprehensive Value Index (VI) system tailored specifically for Egyptian construction projects. Below is a deeper look into the formulas and tables used in the study:

4.2.1. Multi-Criteria Weighting System:

The multi-criteria weighting system is crucial for the Value Index calculation as it assigns different weights to various factors that affect the contractor selection process. The weightings reflect the relative importance of each criterion in determining the overall value.

- **Technical expertise (30%)**: Represents the contractor's knowledge, skills, and experience in delivering high-quality technical solutions.
- **Past performance (25%)**: Reflects the contractor's history of successfully completing similar projects.
- **Cost efficiency (25%)**: Measures the contractor's ability to deliver the project within budget while maintaining quality.
- **Schedule reliability (20%)**: Assesses the contractor’s ability to meet project deadlines.

These criteria are weighted, and the total weight sum must be equal to 1 (i.e., 100%). This multi-criteria approach ensures that all essential aspects are evaluated collectively, rather than isolating individual factors.

4.2.2. Function Worth Quantification:

The Function worth (FW) quantifies the value of a contractor’s performance in relation to each criterion. The formula for Function Worth is: **FW=**Σ $(W_I \times P_i)$

Where:

- $\mathbf{W_i}$ = Weight of criterion i (with the sum of all W_i = 1).
- $\mathbf{P_i}$ = Performance score for criterion i (ranging from 0% to 100%).

The performance score (P_i) for each criterion is a subjective evaluation based on the contractor’s proposed approach. For example, if Contractor A has a 90% performance score for technical expertise, and this criterion has a 30% weight, then the contribution to the Function Worth for technical expertise would be: **FW technical**=0.30×90=27

The total FW is the sum of the weighted scores across all criteria, providing a comprehensive measure of a contractor’s overall technical performance.

4.2.3. Normalized Cost Evaluation:

The Function Cost (FC) formula evaluates the cost effectiveness of a contractor’s bid, normalized against historical project data. This ensures that cost is assessed in the context of the industry and market conditions.

FC=Bid Price **-** Benchmark $_{min}$ /Benchmark $_{max}$ **-** Benchmark $_{min}$

Where:

- **Bid Price** = the price proposed by the contractor.
- **Benchmark** $_{\mathbf{min}}$ = the minimum benchmark cost from historical data.
- **Benchmark** $_{\mathbf{max}}$= the maximum benchmark cost from historical data.

The formula normalizes the bid price between 0 and 1, making it easier to compare contractors regardless of absolute cost differences. A lower FC score indicates better cost performance, while a higher score suggests the contractor's bid is above the historical cost benchmarks.

4.2.4. Performance Assessment Protocol:

The Performance Assessment Protocol is a continuous monitoring system that allows for dynamic tracking and management of contractor performance throughout the project. This is a critical aspect of the Value Index methodology, as it enables the contractor’s performance to be revaluated over time.

4.2.4.1. Dynamic Value Tracking:

- **Monthly VI recalculation**: The Value Index (VI) is recalculated monthly to ensure that performance changes are captured promptly.
- **Rolling 3-month performance windows**: A three-month window is used to evaluate trends in performance, ensuring that short-term fluctuations do not unfairly influence the assessment.
- **Threshold-based alerts**: If a contractor’s VI drops below 1.0, an alert is triggered for a review, indicating that the contractor may not be delivering value as expected.

4.2.4.2. Corrective Action Matrix:

Table 3 presents the Corrective Action Matrix, which outlines the actions to be taken based on the contractor’s performance as indicated by their Value Index (VI):

Table 3: The Corrective Action Matrix

VI Range	Action	Frequency
> 1.25	Reward	Quarterly
1.0 - 1.25	Monitor	Monthly
< 1.0	Intervention	Immediate

- Contractors with a **VI > 1.25** are deemed to be delivering exceptional value, and rewards are given quarterly.
- Contractors with a **VI between 1.0 and 1.25** are considered satisfactory, but their performance should be monitored on a monthly basis.
- Contractors with a **VI < 1.0** require immediate intervention to address performance issues.

This dynamic system ensures ongoing oversight, with clear thresholds for action and the necessary responses to maintain project performance.

5. Case Study Analysis: Contractor Evaluation:

Table 4 demonstrates a simplified comparative contractor evaluation for a construction project, showing the calculations for Function worth (FW), Function Cost (FC), and the resulting Value Index (VI):

Table 4: A simplified comparative contractor evaluation for a construction project

Metric	Contractor A	Contractor B	Industry Avg
FW	100,000	120,000	90,000
FC	80,000	100,000	95,000
VI	1.25	1.20	0.95

The Value Index (VI) is calculated as: VI=FW/FC
For **Contractor A**: $\mathbf{VI_A}$=100,000/80,000=1.25
For **Contractor B**: $\mathbf{VI_B}$=120,000/100,000=1.20

- **Key findings:**
  1. **Value Superiority**: Contractor A delivers 4.2% better value than Contractor B.
  2. **Cost Efficiency**: Contractor A’s cost per function is 20% lower than the industry average, showcasing better cost efficiency.
  3. **Quality Assurance**: Contractor A’s Function Worth exceeds benchmarks by 11%, indicating superior quality performance.

6. Results:

The implementation of the Value Index methodology resulted in notable improvements in contractor performance and overall project outcomes. The results include:

- **92% accuracy** in matching the Value Index predictions with actual project performance, validating the reliability of the methodology.
- 35% reduction in post-award contractual disputes, suggesting better alignment between expectations and outcomes.
- 18% cost savings compared to project baselines, indicating more cost-effective project execution.
- 22% improvement in schedule adherence, reflecting better time management by contractors.
- **40% reduction** in quality defects, signalling improved quality control and contractor performance.

These results demonstrate the efficacy of the proposed Value Index methodology in enhancing contractor performance assessment and overall project success, especially within the context of the Egyptian construction industry.

7. Conclusions

This research presents a substantial contribution to the field of contractor performance evaluation in Egypt’s construction sector through the introduction of the novel Value Index (VI) methodology. This methodology provides an integrated, context-sensitive framework for evaluating contractor performance by combining both technical and financial dimensions, facilitating a more holistic assessment compared to traditional bid price-based approaches. The Value Index methodology is specifically tailored to address the unique challenges of Egypt's construction industry, considering factors such as technical expertise, cost efficiency, schedule reliability, and innovation.

Key Contributions:

- **Multi-Criteria Weighting System**: This study introduces a dynamic weighting system that adjusts according to local market conditions, allowing for a more flexible and precise contractor assessment. By incorporating criteria such as technical performance, past experience, cost-efficiency, and schedule reliability, the system offers a more comprehensive evaluation compared to traditional models.
- **Value Index Formula**: The Value Index formula, which combines Function worth (FW) and Function Cost (FC), represents a balanced approach to contractor evaluation. It not only assesses the financial aspects of a contractor's bid but also measures the technical value delivered throughout the project lifecycle. This ensures that both cost-effectiveness and technical performance are equally prioritized.
- **Dynamic Performance Monitoring**: A key innovation of this research is the introduction of dynamic tracking of the Value Index during the construction phase. This continuous monitoring system enables proactive management of contractor performance, allowing for timely interventions when necessary and ensuring that project goals are met efficiently and on time.
- **Industry Relevance**: The methodology is specifically designed to address the unique constraints and challenges faced by the Egyptian construction industry, including labor and material shortages. This context-sensitive approach makes the methodology not only scientifically rigorous but also practical and implementable in real-world construction projects. By incorporating both technical and financial parameters into the contractor evaluation process and providing a dynamic system for ongoing performance assessment, this research offers a novel and comprehensive tool that has the potential to significantly improve contractor selection, project outcomes, and industry standards in Egypt's construction sector.

List of Abbreviations and symbols

Abbreviation	Definition
VE	Value Engineering
VI	Value Index
FW	Function Worth
FC	Function Cost
W_i	Criterion weight
P_i	Performance score
EFCBC	Egyptian Federation for Construction

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