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### THE CRITICAL FACTORS OF PROJECT LIFE CYCLE IN SUDANESE CONSTRUCTION PROJECTS

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#### ABSTRACT

The Sudanese construction sector is characterized by many small and large projects and high labor intensity, and accounted for 3.2% of the Sudanese country's GDP. The factors which affect the performance of Sudanese construction projects are the basic problem. The main objectives of this study are to identify the factors affecting the performance of Sudanese construction projects, and to determine the critical factors. The literature review has been done to gather the information about the causes and their factors that affect the performance of construction projects from the previous researches. The methodology which was conducted to gather the data was questionnaire which was examined to be reliable and valid according to statistical tests. The (52) factors were identified as factors affect construction projects. Thus, (17) factors of them were the critical factors which may lead to poor performance of Sudanese construction projects. This study has some conclusions such as the instrument for measuring the critical factors on the performance is reliable and valid, so the construction project performance is 64.2%.

**KEYWORDS:** Critical Factors, Sudanese Construction Industry, Critical Causes, Performance

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#### INTRODUCTION

The Sudanese construction sector is characterized by many small and large projects and high labour intensity. The Sudanese construction industry also has a number of factories and material suppliers that provide building materials and specialist fittings. The scope of Sudanese construction industry is very wide, includes residential construction, commercial building, irrigation, roads, tunnels, transportation, facility building, heavy engineering construction and industrial construction. The construction sector is an important to the Sudan economy; the construction sector accounted for 3.2% of the country's GDP in 2009 and grew by about 10% in 2010 in nominal terms, according to the Central Bank of Sudan [1]. The performance of the projects were affected by different factors which implicit in the stages of project life cycle. Thus, the impact of such factors may be taken into consideration to raise the project performance.

#### Stages of Project Life Cycle

The construction project passes through several stages of its project life cycle such as: Bid Preparation stage, Projects Characteristics study stage and Project Management stage (in this study) which consists of planning and execution stages so; the pre-

construction (planning) stage is the key to good project planning to anticipate potential problems before they become actual problems. And the execution stage begins with pre-construction meeting that essentially establishes the ground rules for working. Furthermore, the project management was discussed by author in other work [2], and to raise this study to concern as complete studying of project life cycle, the bid preparation, project characteristics, and project management were also adopted. In this study, the above mentioned stages were considered as the project life cycle in Sudan and have contributed in the performance of the construction projects.

#### BID PREPARATION STAGE

It is very important time to select the builder and award the contract. They are several methods for contractor to obtain bids some of them include but are not limited to advertising in a local publication, or by selecting a small group of reliable contractors from business associates (short list). After pre-qualification process in which to allow for limit number of contractor to submit their tenders, sometimes going to negotiation to select the better contractor [3]. The bid documents should include a provision requiring the contractor to furnish his or her past five-year safety record and workers'

compensation. More owners may insist the contractors to submit a quality control/quality assurance program with their bid to inform the owner of the programs they have in place to monitor the quality of construction [4]. The winner bidder should submit the bid documents such as Advertisement for bids, Information for bidders, Bid form, General notices, Notice of award, Notice to proceed, Bid bond, Performance bond, Payment bond, Contract form or agreement, General conditions or provisions, Supplemental and/or special conditions, Plans, Specifications, Execution plan, Safety plan, Subcontractor plan, and Quality manual [5].

### THE PROJECTS CHARACTERISTICS STAGE

In construction project, it's a time to study the characteristics of the projects which have certain critical characteristics that determine the appropriate actions to manage them successfully. Moreover, project characteristics have relations with other stages for helping these stages to raise their performance. There were some success factors which were divided to macro and micro factors. The macro factors included formulation of project policies, framework of project organization, key personnel, management control, and management of information. On the other hand, the micro factors included definition of project, efficient manner of project execution, and comprehension of project environment and selection of organisation realizing the project [6]. The characteristics of construction projects were defined such as:

1. Complexity of project
2. Size of project.
3. Effects of relevant political, legal and economic systems, including market conditions.
4. Importance for the project to be completed on time
5. Type of project.
6. Specific location, special weather and environmental concerns.
7. Level of technological advancement
8. Cost of the project
9. Quality of a project
10. Type of client.
11. Project funding
12. Availability of information at project inception and points at which any remaining information will be required/be available.

13. Nature and status of local construction industry, including available capacities of potential project participants, scarcity of work in particular fields, competitiveness.
14. Availability of materials and equipment that is required for the works.
15. Ownership of building
16. Type of specification
17. Flexibility of scope of works when contractor is hired.
18. Importance for project to be completed within budget.
19. Performance of available contractors and consultants on previous (similar) projects in the area in terms of meeting cost, quality and time targets; safety records and client satisfaction levels: as compared with the procurement modalities used.
20. Technical approval authorities
21. Density of a project.
22. Project impacts
23. Allocation of risk and liability.
24. Risk budget. [7].

### PROJECT MANAGEMENT STAGE

In general, the owner may engage a construction manager to provide professional construction management services and to provide advice to the owner including cost, schedule, safety, the construction process and other considerations and to ensure the requirements of the construction contract [3, 4]. It is important, the key elements of the recruitment and selection contractor may include clarity of nature vacancy to be filled, job description, personnel selection criteria, interview preparation, Responsibility Assignment Matrix (RAM), financial standing, technical ability, management capability, quality, safety, senior management and experience, tenure with firm, division of responsibilities, and Current projects/backlog [8, 9]. Moreover, the turnover which is represented as the degree of individuals to quit the membership of a social system, it may detract from the ability of companies and sites. The cost of turnover to organizations can be high [10,11]. There are also several factors affecting turnover such as Job Satisfaction and Organizational commitment. While the review of scope of work sets the parameters and constructability review for the construction project and identifies the work to be done, the scope describes the building layout, site of work, site work, number of rooms, number of floors, types of materials, dimensions, special equipment, storage requirements, WBS, and so on [12].

Consequently, Contract Review is to ensure that the company understands customers' needs and has the capacity and capability to meet those needs [13]. The researcher noticed the most problems in Sudanese construction project associated with a project contract that should not specify the scope, requirements, detailed specifications, and this may lead to disputes between the contract parties.

In general, the site layout planning is often done manually by marking up a site drawing to show different overlapping laydown areas [14]. The jobsite layout plan includes the following: jobsite space allocation, jobsite access, material handling, worker transportation, temporary facilities, jobsite security, and signage and barricades [3]. Moreover, Material handling plan often causes many cases of ineffective construction project, much more time, money, and materials goes to waste. Logistic planning is also used from a material flow perspective depending on critical activities that constrain the material handling, storing method, providing internal and external transport plans, placements suggestion, and production sequences [15, 16]. For efficient work performance, the process of sequencing which have identified all the activities that need to be performed on construction project can be done by engineering program [12]. Therefore, Schedule development is the process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule [17]. Scheduling helps manager and it seems to him like a compass and can be presented as Network diagrams.

In this stage, the budget estimation is important for forecasting and predicting cost and expenditures of a project and to produce a budget [18]. Some tools and techniques for forecasting the budget should be known such as expert judgment, analogous estimating, parametric estimating, bottom-up estimating, three-Point estimates, reserve analysis, and cost of quality (COQ),etc [19].

The hidden Buy- out stage is the transitional time between the preconstruction and the construction stages of a project. During buyout, a purchase orders and subcontracts are issued. This time may help to lock-in materials price and price escalation of it, and being able to communicate well with all parties. In addition, the goal of buyout is to assemble the best team possible to deliver a project [20, 3, 21].

In execution stage, all managerial aspects should control the whole construction project. A Material management is a scientific technique, concerned with Planning, Organizing & Control of flow of materials, from their initial purchase to destination. It has also some benefits to sure right price, high turnover, low procurement and storage cost, continuity in supply, consistency in quality, good supplier relation, development of personnel, and good information system. [22]. The most aspects of the physical storage of goods can be categories as following: accommodation, labeling, location, preservation, handling methods and equipment, optimum quantity, health and safety, security, and records and information systems [23].

In general, safety on the job site is an important aspect of the overall safety in construction, due to most hazardous in the field. Furthermore, the safety responsibility on any construction project should be shared between all the parties involved in the project [24,12].

Every aspects of construction project performance must be monitored, tracked, and recorded to ensure that the project plays out according to planning stage, and has a reasonable chance of meeting the project goals for time, cost, and quality. Tracking the deviations will help to identify problem areas to choose the correct or prevent actions [23, 12].

The on-site management of a construction project involves great amounts of paperwork, even for relatively small projects, the documentation must be done to ensure communicate directions, questions, answers, approvals, general information and other material to appropriate members of the project team [3].

In order to ensure the best control, the good Communication which is critical to the success of construction project teams leading to more positive outcomes by using some communication means [25]. The most meetings bring people together weekly to share important information, allow debate, resolve problems, review progress and make on-the-spot collective decisions.

The point of view of the change must be controlled by change order which is contains a brief explanation of the nature of the change and whether it is initiated by the contractor or the owner and its relation with scope of project [4].

It is important, the process of quality control primarily deal with issues relating to the requirement conformance to the plans and specs by using quality tools to insure consistency in quality [12].

Also cost control is used to predict the final outcome of a project based on up-to-date status. Moreover, Cost control during various stages of a project deals with variances between budgeted, earned, and actual costs in each control category, and the cost control is based on the earned value concept [26.18].

Scheduling control is very important control technique which is to check that the project is being implemented as planned (monitoring) and acting to resolve problems (controlling) and comparing the actual schedule situation with the plan [17]. Thus, scheduling control must be monitored by using some tools and techniques such as Performance Reviews, Adjusting Leads and Lags, Variance Analysis and Schedule Compression.

A total of causes and their factors which affect construction projects are summarized according to literature review and the experience of author which summarized in Fig. 1.

Fig.1: Causes effect diagram showing factors affecting construction project performance.

**RESEARCH METHOD**

A research Strategy is to use both qualitative (Literature review) and quantitative (Questionnaire survey) methods. The qualitative method permits researchers to study selected issues in depth and detail, and produces a wealth of detailed information about a much smaller number of people and cases. The quantitative method gives a broad, generalizable set of findings presented succinctly and parsimoniously [27]. Thus, the research strategies adopted the literature review, and a questionnaire survey. The data used to test the research model were obtained from Literature review.

The greatest advantage of a questionnaire survey is its lower cost compared to other methods. A questionnaire survey can be used only when the objective of the study is clear and not complex [28]. In this study, the questionnaire survey was used to obtain information about critical factors and their effect on performance from a wide range of 100 Sudanese construction firms by their construction managers. The Likert scale approach (1-5) was used to scale responses in survey research ranging from "very disagree" to "high agree". A total of 70 usable responses were obtained. Detailed descriptive statistics which is relating to the respondents' characteristics are shown in Table I.

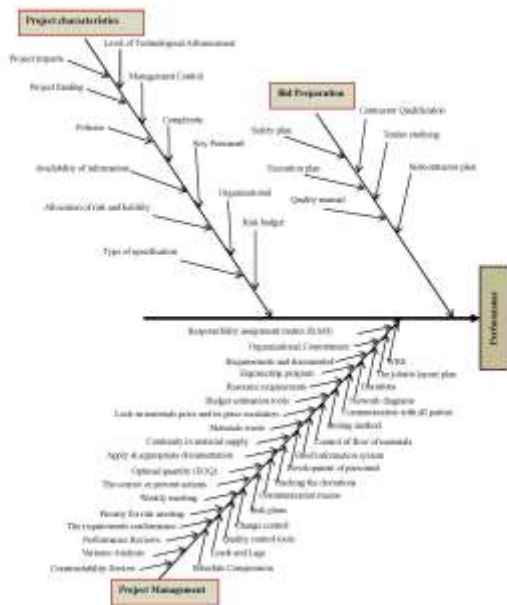


Table 1. The respondents' characteristics

	Description	frequency	Percentage
Experience (years)	Less than 5 years	18	26.7%
	5 to 10 years	21	30%
	11 to 15 years	15	21.4%
	15 years above	16	21.9%
Level of education	Graduate	28	40 %
	Post graduate	42	60%

**Data Analysis**

In this study, the measurement instrument should be reliable and valid. Thus, they should be evaluated for reliability and validity. The SPSS IBM 19 program was used in evaluation.

**Reliability**

Reliability refers to whether you get the same answer by using an instrument to measure something more than once [29]. The internal consistency method was used in evaluating the reliability of the survey instrument in this research. In Table 2, the Cronbach’s alpha are 0.70, 0.84 and 0.946 for bid preparation, project characteristics and project management respectively. Therefore, the instrument was judged to be reliable.

*Table 2. The reliability statistics*

Scale	Reliability Statistics	
	Cronbach's Alpha	No of Items
Bid preparation	0.740	6
Project Characteristic	0.848	12
Project Management	0.946	34

**Validity**

Validity is defined as the extent to which any instrument measures what it is intended to measure. In this study, only content validity and construct validity were conducted in order to evaluate the measurement instruments.

**1- Content Validity**

Content validity depends on the extent to which an empirical measurement reflects a specific domain of content. It cannot be evaluated numerically. To ensure the content validity, the survey was

established from the existing literature. Furthermore, pretesting was conducted by experts in the field of project management in construction. After the pretesting, these items were fitted the construction context of study.

**2- Construct Validity**

Construct validity measures the extent to which the items in a scale all measure the same construct and can be evaluated by the use of factor analysis which to find a way of condensing or summarizing the information [30, 31]. The factor analysis in this context was exploratory and the Principal component analysis method. Only the factors having latent (eigenvalues) greater than 1 are considered significant; those with eigenvalues less than 1 are considered insignificant and are disregarded [30]. In the case of these scales, two, three and nine factors emerged according to the rule that the Eigenvalues are greater than 1 as in Table 3. After the rotated (varimax) factor was done, there was no item to be deleted in bid preparation. On the other hand, the Item 6 in the project characteristics belonged to factors 1 or 2 as it loaded very significantly on both factors. Thus, its content was examined and decided that Item 6 (information management) should be deleted from this scale. In addition, the Item 17 from project management scale belonged to Factors 3 or 4 as it loaded very significantly on both factors. After its content was examined, it was decided that Item 17 (consistency in quality) should be deleted from this scale. In the final, the sum of questions has become 52 items, so the instrument was valid.

*Table 3. Factors analysis of project management*

scales	Factor number	Eigenvalue	% of variance
Bid preparation	2	3.572	51.028
		1.019	14.556
Project Characteristics	3	6.518	46.555
		1.501	10.721
		1.20	8.571
Project	9	14.417	40.046

scales	Factor number	Eigen-value	% of variance
management		3.257	9.046
		2.452	6.810
		2.392	6.644
		1.715	4.764
		1.387	3.853
		1.235	3.431
		1.113	3.091
		1.023	2.841

**ANALYSIS AND DISCUSSION**

The quantitative data generated from the questionnaire survey was analyzed using average index technique by SPSS program, and is displayed in Table 4. The critical causes had values less than the scale average (3) as the following: Scheduling control with mean (2.61), Team selection and employee turnover with mean (2.68), Safety in construction site with mean (2.76), and Quality control with mean (2.78). With respect to those causes, the respondents haven't applied them correctly which may lead to the poor performance of these causes. Furthermore, the general mean of the scales "Bid preparation, Project Characteristics and Project management" are (3.25), (3.17) and (3.21) respectively which are slightly greater than the mean average (3) which indicates that the respondents have little improvement for these stages, and the most firms didn't have a good preparation, proper planning and control execution very well, so the performance may almost be poor.

*Table 3. Result of the project life cycle stages*

Causes	Factors	Fact or Mean	Caus es mean	Scale Avera ge
Bid	Qualificatio n of	3.19	3.25	3

Causes	Factors	Fact or Mean	Caus es mean	Scale Avera ge	
preparation	contractor				
	Tender studying	3.85			
	Execution plan	3.72			
	Safety plan	3.04			
	Subcontract or plan	2.77			
	Quality manual	3.00			
	Complexity	3.76			
	Organizational	3.40			
Characterist ics studying	Policies	3.27			
	key personnel	3.71			
	managemt control	3.19			
	Level of technologic al advancement	3.27			
	project funding	3.67			
	Availability of information	2.76			
	Type of specification	2.91			
	Project impacts	2.76			
			3.17		3

Causes	Factors	Fact or Mean	Caus es mean	Scale Avera ge
	Allocation of risk and liability	2.97		
	Risk budget			
Team selection and employee turnover	Responsibility assignment matrix(RAM)	2.63	2.68	3
	Organizational Commitment	2.72		
Scope and contract review	WBS	2.95	3.37	3
	requirements and documented	3.51		
	Constructability Review	3.65		
Site layout planning	The jobsite layout plan	3.54	3.37	3
	materials waste	3.32		
	storing method	3.27		
Sequences and schedule development	Engineering program	3.63	3.54	3
	Durations	3.74		
	resource requirements	3.63		
	Network diagrams	3.17		
Budget	Budget estimation	3.17	3.17	3

Causes	Factors	Fact or Mean	Caus es mean	Scale Avera ge
Preparation	tools			
Buy- out	Communication with all parties	3.63	3.70	3
	lock-in materials price and its price escalation	3.78		
Material Handling management	continuity in material supply	3.55	3.35	3
	Control of flow of materials	3.40		
	good information system	3.27		
	development of personnel	2.32		
	Optimal quantity (EOQ)	3.25		
Monitoring and Control	Tracking the deviations	3.48	3.45	3
	the correct or prevent actions	3.42		
Documentation management and control	Apply & appropriate documentation	3.46	3.46	3
Effective Communication	communication means	3.41	3.52	3

Causes	Factors	Factor Mean	Causes mean	Scale Average
tion	Weekly meeting	3.87		
	Priority for risk meeting	3.28		
Safety in construction site	Risk plans	2.76	2.76	3
Scope & change control	Change control	3.23	3.23	3
Quality control	The requirements conformance	3.28	2.78	3
	quality control tools	2.27		
Scheduling control	Leads and Lags	2.42	2.61	3
	Performance Reviews	2.70		
	Variance Analysis	2.53		
	Schedule Compression	2.78		
Project management average	3.21			
Project performance	$(3.25+3.17+3.21/3)*100/5 = 64.2\%$			

**Critical Factors of Project life cycle**

From the last analysis, the critical factors that affect Sudanese construction project performance were listed according to the lower mean than the scale average (3) in Table 5.

*Table 5. critical factors of project life cycle*

No	Description	Mean	Scale average
1.	quality control tools	2.27	3
2.	development of personnel	2.32	3
3.	Risk budget	2.40	3
4.	Leads and Lags	2.42	3
5.	Variance Analysis	2.53	3
6.	Responsibility assignment matrix(RAM)	2.63	3
7.	Performance Reviews	2.70	3
8.	Organizational Commitment	2.72	3
9.	Subcontractor plan	2.76	3
10.	Availability of information	2.76	3
11.	Project impacts	2.76	
12.	Risk plans	2.76	
13.	Schedule Compression	2.78	
14.	Type of specification	2.91	
15.	WBS	2.95	
16.	Allocation of risk and liability	2.97	
17.	Quality manual	3.00	

**CONCLUSIONS**

A number of conclusions have been obtained from this research as following:

1. The instrument for measuring the critical factors of the performance is reliable and valid, and can be used by other researchers to test the effects of these factors on the performance.
2. The Sudanese projects performance is 64.2%. So, the improvement is required for the project stages. There were four critical causes and seventeenth critical factors which should be improved.



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APPENDIX

Appendix - 1: Questionnaire about the Critical Factors of Project life cycle in Sudanese Construction Projects

No	Factors	1	2	3	4	5
1	Our company is subject to prequalification for tender					
2	Our department studying the bid documents					
3	We submit the execution plan of work during bidding process					
4	We submit safety plan during bidding process					
5	We submit subcontractors management plan during bidding process					
6	We submit quality manual during bidding process					

No	Factors	1	2	3	4	5
1	We have skilled workers to implement complex projects					
2	Our company has strong administrative organization system for managing each activity					
3	Our company have clear policies and easy ways to perform tasks					
4	We have experience engineers studying the document content					
5	Each project has individual managing.					
6	The company keep pace with technological advances for the used machines					
7	The company studies the financial potential for clients before making the tender					
8	Bids contain					

No	Factors	1	2	3	4	5
	all the information and specifications needed to complete the job.					
9	All bid offer by consultant contain the complete specifications.					
10	We study the impact of the project on the environment and determine the appropriate solutions.					
11	Our engineers are qualified to determine risk may face the project during execution.					
12	We have a specific budget for the project risk management					

No.	Factors	1	2	3	4	5
2	Our company employees have absolute loyalty towards the company					
3	We use the work breakdown structure (WBS) in our projects as a tool for managing project.					
4	We identify and document all requirements of the client					
5	We review architectural designs, civil, mechanical, fire-fighting, etc.) and match them with bill of quantities and specifications before implementation (Constructability Review)					
6	We introduce site layout plan.					
7	We have a plan to reduce the materials wasted					
8	We use modern storage methods appropriate for each project					
9	We use project scheduling template such as(primavera, MS					

No.	Factors	1	2	3	4	5
1	We use a Responsibility assignment matrix in all projects (RAM)					

No.	Factors	1	2	3	4	5
	project, etc.)					
10	Our employees have a sufficient knowledge to determine the activities durations in the project					
11	All project resources required have been provided.					
12	We use critical path method(CPM)in the project control					
13	We estimate the costs of activities based on (WBS).					
14	The company has Communication plan between contract parties (client, consultant and contractor) prior implementation stage.					
15	We review the prices of materials and their escalation before the implementation stage					
16	We have a plan to supply the different sites of materials needed					
17	We have technical staff to control the material flow process according to site demand.					

No.	Factors	1	2	3	4	5
18	We have good storage plan.					
19	We have a job training program.					
20	Always keep to the Optimal quantity (EOQ)of storage of materials used in site					
21	The project managers track deviations that may occur during execution & take actions.					
22	We apply preventive or corrective actions when deviations will occur.					
23	We document all processes and activities during the project life cycle.					
24	For good communication, we use the modern media such as (camera site, the Internet, and multimedia)					
25	In the weekly meeting, we discuss the project progress.					
26	The weekly meetings priority is to discuss the risks.					

No.	Factors	1	2	3	4	5
27	We develop a risk management plan.					
28	WE use a specific forms with change order					
29	We conduct tests for each activity separately to make sure it conformed to the specifications					
30	We use the seven tools of quality control					
31	We use Leads and Lags to control and adjust schedule					
32	We use performance reviews to monitor and control schedule					
33	We use analysis of variance for adjusting schedule and cost.					
34	We use Schedule Compression when needed.					

\*Note: 1= Strongly disagree, 2= disagree, 3= Neutral, 4= agree, 5= strongly agree



