



**INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH  
TECHNOLOGY**

**THE EFFECT OF PROJECT LIFE CYCLE'S STAGES ON 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 basic problem which had faced the Sudanese construction projects the crucial factors which belong to their project stages.

The main objectives of this study are to identify the stages affecting the performance of Sudanese construction projects, and to determine their factors. The literature review has been done to gather the information about the stages and their factors which 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. The stages average indexes were examined which was clear these stages have to improve to rise the project performance. The regression analysis and correlation were done in order to find out the relation and the effect between the performance and the project's stages. This study has some conclusions such as the instrument for measuring the factors affecting the performance is reliable and valid, as well as the stages have a positive effect on performance.

**KEYWORDS:** Crucial Factors, Sudanese Construction Industry, stages, 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 which are: 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]. In this study, the above mentioned stages which were considered as the project life cycle in Sudan are examined sperately to measure its effect on the final performance.

**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 most important type in this study was the macro factors which included formulation of project policies, framework of project organization, key personnel, management control, and management of information[6]. Furthermore, there are another important characteristics of construction projects were defined but aren't limited to:

1. Complexity of project
2. Size of project.
3. Level of technological advancement
4. Type of client.
5. Project funding
6. Availability of information at project inception and points at which any remaining information will be required/be available.
7. Ownership of building
8. Type of specification
9. Information management
10. Project impacts
11. Allocation of risk and liability.
12. 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 factors which affect construction projects are summarized according to literature review and the experience of author which summarized in table 1.

*Table 1. The effect factors of stages*

stage	factors
Bid preparation	Qualification of contractor
	Tender studying
	Execution plan
	Safety plan
	Subcontractor plan
	Quality manual
Project characteristics	Complexity
	Organizational
	Policies
	key personnel
	management control
	Level of technological advancement
	project funding
	Availability of information
	Type of specification
	Project impacts
	Allocation of risk and liability
Risk budget	
Project management	Responsibility assignment matrix(RAM)
	Organizational Commitment
	WBS
	requirements and documented
	The jobsite layout plan
	Engineering program
	Durations
	resource requirements
	Network diagrams
	Budget estimation tools
	Communication with all parties
	lock-in materials price and its price escalation
	materials waste
	storing method
	continuity in material supply
	Control of flow of materials
good information system	
development of	

stage	factors
	personnel
	Optimal quantity (EOQ)
	Tracking the deviations
	the correct or prevent actions
	Apply & appropriate documentation
	communication means
	Weekly meeting
	Priority for risk meeting
	Risk plans
	Change control
	The requirements conformance
	Leads and Lags
	Performance Reviews
	Variance Analysis
	Schedule Compression
	Constructability Review

## 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 as well as 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[28]. In this study, the questionnaire survey was used to obtain information about 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 2.

*Table 2. 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 3, 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 3. 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 4. 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 4. Factors analysis of project management**

scales	Factor number	Eigen-value	% 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 management	9	14.417	40.046
		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 5. The critical factors had values less than the scale average (3) such as the following: Subcontractor plan with mean (2.77) in Bid preparation stage, Availability of information with mean (2.76) in project characteristics, and Organizational Commitment with mean (2.72) in project management stage. 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 5. Results of the project life cycle's stages*

stages	Factors	Factor Mean	General mean
Bid preparation	Qualification of contractor	3.19	3.25
	Tender studying	3.85	
	Execution plan	3.72	
	Safety plan	3.04	
	Subcontractor plan	2.77	
	Quality manual	3.00	
Project Characteristics	Complexity	3.76	3.17
	Organizational	3.40	
	Policies	3.27	
	key personnel	3.71	
	management control	3.19	
	Level of technological advancement	3.27	
	project funding	3.67	
	Availability of information	2.76	
	Type of specification	2.91	
	Project impacts	2.76	
	Allocation of risk and liability	2.97	
	Risk budget		
Project management	Responsibility assignment matrix(RAM)	2.63	3.21
	Organizational Commitment	2.72	
	WBS	2.95	
	requirements and documented	3.51	
	Constructability Review	3.65	
	The jobsite layout plan	3.54	
	materials waste	3.32	
	storing method	3.27	
	Engineering program	3.63	
	Durations	3.74	
	resource requirements	3.63	
	Network diagrams	3.17	
	Budget estimation tools	3.17	
	Communication with all parties	3.63	
	lock-in materials price and its price escalation	3.78	
	continuity in material supply	3.55	
	Control of flow of materials	3.40	
	good information system	3.27	
	development of personnel	2.32	
	Optimal quantity (EOQ)	3.25	
	Tracking the deviations	3.48	
	the correct or prevent actions	3.42	
	Apply & appropriate documentation	3.46	
	communication means	3.41	
Weekly meeting	3.87		
Priority for risk meeting	3.28		
Risk plans	2.76		

satges	Factors	Factor Mean	General mean
	Change control	3.23	
	The requirements conformance	3.28	
	quality control tools	2.27	
	Leads and Lags	2.42	
	Performance Reviews	2.70	
	Variance Analysis	2.53	
	Schedule Compression	2.78	
Project performance	$(3.25+3.17+3.21/3)*100/5 = 64.2\%$		

**The effect of stages’s factors on the projects’ performance**

By using Pearson correlation and linear regression technique which were done by SPSS program in order to examine the correlations between the stages and the final projects performance as well as the predicted equations seperately which were displayed in the following table 6.

*Table 6. Results of the simple linear regression*

Model	Unstandardized Coefficients		Standardized Coefficients	R <sup>2</sup>
	B	Std. Error	Beta	
constant	22.349	4.062	0.846	0.715
Bid	12.873	1.212		
constant	17.165	4.169	0.865	0.749
characteristics	14.851	1.283		
constant	10.191	4.850	0.861	0.741
Project management	16.832	1.482		

The three equations which can be measured seperately the performance (Y) according to the project stage's average X as following:

Bid preparation satge (X1):  
 $Y=22.349+12.873X1.....(1)$

Project characteristics (X2):  
 $Y=17.165+14.851X2.....(2)$

Project management (X3):  
 $Y=10.191+16.832X3.....(3)$

It is clear from the table 6, the correlations between the final performance and (bid preparation, project characteristics, and project management) are 0.846, 0.865, and 0.861 respectively which indicates that the correlations were strong. In addition, R<sup>2</sup> of the bid preparation was (0.715) which indicates there was a positive effect on the performance as well as there were another factors didn’t belong to the bid preparation’s factors which may affect the performance.

In project characteristics, the R<sup>2</sup> was (0.749) which indicates there was a positive effect on the performance as well as some factors may affect the performance didn’t belong to the characteristics’s factors.

Further, R<sup>2</sup> of the project management was (0.741) which indicates there was also a positive effect on the performance as well as there were also another factors didn’t belong to the project management’s factors which may affect the performance.

With regards to factors which didn’t belong to the that stages' factors, these stages can formulate and contain those factors. Nonetheless, there may another factors which don’t belong to these stages.



## CONCLUSIONS

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

1. The instrument for measuring the 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 project's stages have a positive effect on their construction project's performance.
3. Every stage has crucial factors which affect the performance. So they have to improve those factors separately.

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APPENDIX

Appendix - 1: Questionnaire about the 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 all the information and specifications needed to complete the					

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