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Research Paper

Project Performance Evaluation Based On Time-Cost-Desigh Capacity and Plant Utilization

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ABSTRACT:- *This study was carried out to evaluate the performance of Beninese construction projects. To achieve this, data related to construction project budget achievement, schedule achievement, design capacity, and plant utilization for projects such as schools, medical centers and supermarkets was analyzed. After analysis, poor performance was assigned to all investigated projects because the success index value of each project is less than the success index value of successful project. However, in order to well manage the cost and schedule performance, Microsoft project was used to track down the work progress of each construction project. The result shows that all the projects were finished behind deadline and the overwork day's increases when the size of project increases so the larger and more complex a project is，the more lower the project performance will be. Therefore, corrective actions and serious improvements to management are recommended for new development construction projects.*

Keywords:- *Construction project, Projects performance, Success Index, Cost Management, Schedule Management, Planning Management.*

I. INTRODUCTION

Construction is one of the largest segments of many economies, and contributes greatly to the gross domestic product of most nations. It is the phase of civil engineering in which the ideas of the planner and the detailed plans of the designer are turned into physical reality. The quality of this work depends on the coordination of the efforts of all parties involved in the project. The ability to complete the project within the cost budget, by the scheduled completion date, and with zero lost-time accidents, zero disputes, zero rework and overall satisfaction is the goal of the construction teams [1]. However, statistics indicate that construction projects in a high percentage of developing countries are completed with highly unsatisfactory performance. Statistics from the World Bank (World Bank Report 2011), a partner in many development projects, show a high rate of unsatisfactory construction project performance in the case of Africa.

In the West African nation of Benin, the government and international organizations involved in development have spent a lot of capital in the construction field, but the projects, once finished, seldom reflect the amount of money which has been spent. Benin already spends around $712 million per year on infrastructure, equivalent to about 16.5 percent of its GDP. Looking ahead, if Benin could improve its infrastructure to the level of the middle-income countries of the subcontinent, growth performance could be enhanced by as much as 3.2 percentage points per capita. Therefore the country faces a major challenge related to the effective performance and quality management of its development construction projects.

Quality management has been defined as follows: "All activities of the overall management function that determine the quality policy, objectives and responsibilities, and implement them by means such as quality planning, quality control, quality assurance, and quality improvement within the quality system" ISO 8402 (1995). This means that all participants -- executive officer, project manager, project engineer and contractors -- must play an effective role throughout the lifespan of the project. Researchers have proposed a number of approaches to this problem. One is to improve work plan reliability, or conversely reduced variability, through production shielding using the last planner system [2]. The integrated production scheduler IPS is an Internet-enabled system for collaborative scheduling that implements the last planner concept and identifies key

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constraints in the work plan [3]. Meng [4] has reported that Poor performance can be effectively reduced by improving some aspects of the relationship and through the adoption of supply chain collaboration, and also mentioned that a long-term collaboration is more favorable for performance improvement than a short-term collaboration

Many developing countries, especially African countries, face the problem of unsatisfactory performance of construction development projects. Efforts to address the problem may benefit from research that has been done around the world concerning the successful performance and management of construction projects. Takim et al. [5] found that performance measurement can be used to judge project performance, both in terms of the financial and non-financial aspects, and to compare and contrast the performance with that of others, in order to improve programme efficiency and effectiveness in the project organizations. According to Steven et al. [6], measurements are needed to track, forecast, and ultimately control those variables that are important to the success of a project, and this has been agreed upon by many researchers and practitioners such as Sinclair & Zairi [7]; Mbugua et al. [8]; Love et al. [9]; and Chan [10].

However, poor quality was identified by Koskela [11] as one of the major factors causing low productivity. Ralph et al.'s [12] study indicates that productivity can be measured and analyzed at the project level based upon field data from construction operations. Pheng and Chuang [13] defined project success as the completion of a project within acceptable time, cost and quality, and as achieving the client's satisfaction. Wang and Huang [14] studied how the engineers evaluate a project's success and to what extent the key project stakeholders' performance correlates with project success. Ugwu and Haupt [15] proved that resource availability is an important factor for consultants because it affects the process performance of construction projects. Lam et al. [16] stated that the allocation of risk among the contracting parties in a construction contract is an important decision leading to the success of the project. Ahadzie et al.'s [17] study shows that regression models can be a reliable tool for predicting the performance of project managers in mass house building projects. Yeung et al. [18] in their study developed a performance index which can be used by construction senior executives and project managers to measure, monitor, and upgrade the current performance of their relationship-based projects. Shrestha et al. [19] found that the construction speed and project delivery speed per lane kilometer of design-build projects were significantly faster than those of design-bid-build projects. Georgy et al.'s [20] study indicates that engineering design activity is a key determinant of a project's successful implementation, and that many of the project deviations emanate from the detailed design phase, where most of engineering design activities take place. All of this research proves that the performance of construction projects depends on the work service quality of project participants.

Construction projects in Benin have yielded unsatisfactory performance results for many years and continue to do so today; most projects are completed with delays and budget overruns, and sometimes with rework and disputes. Construction costs in Benin are higher than those of Nigeria, Kenya and some other developing countries; therefore, construction projects need to be more efficient, and a serious method of management must be implemented at every stage. These problems of performance involve both projects financed by the government and those financed by foreign donors. As a result, many civil society activists and international organizations have begun to complain about construction project performance management in Benin. This paper focuses on an analysis of construction project performance in Benin which evaluates construction planning efficiency for some projects done in the past. To meet this requirement, success index (SI) of Griffith et al.'s [21] were used to evaluate the performance for projects such as schools, medical centers and supermarkets, based on data collected in a statistical investigation. The success index (SI) involved evaluating the performance of each category of project in terms of budget achievement, schedule achievement, design capacity and plant utilization. In total the idea of this study is to analyze and identify the reasons why most of African construction projects fail through the success of the project planning and execution phases. The survey has been done by interviewing some civil engineers, including construction engineers and construction managers recognized as experts in this field by Beninese government ministries. The data collected pertain to construction projects in Cotonou, Porto-Novo, Abomey and Parakou, and statistical analysis has been done to determine the performance of construction projects in Benin.

II. RESEARCH METHODS

Statistical investigation focused on construction projects located in Cotonou, Porto-Novo, Abomey and Parakou. A summary of research done in the past, and a global analysis of project reports prepared by the government's department of construction projects (African Development Bank Reports 2004), were compiled in order to create a large list of factors affecting construction performance in Benin. However our study focused only on one main factor, planning which was identified as exerting a significant influence on a project performance. The survey, which analyzed major Beninese development projects, was related to the construction of schools, medical centers and supermarkets. Since the Beninese government put in place a decentralized system, a standard model has been adopted for development construction projects such as schools, medical centers, and supermarkets, and standard dimensions have been designed for those projects. Therefore in the case of a school, three classroom modules with a director's office and a warehouse could occupy an area of 288 square meters for construction, while a minimum area of 900 square meters has been projected for medical centers. In the case of supermarkets, an area of 1500 square meters for construction was obtained. In total sixty (60) projects were chosen; of these, twenty (20) were school projects, twenty (20) were medical center projects and twenty (20) were super market projects.

The success index (SI) measurement proposed by Griffith et al. [21] was used to evaluate the performance of each project. The success index (SI) is related to four objective measurements of project execution: budget achievement, schedule achievement, design capacity, and plant utilization. Design capacity is defined as the nominal output rate of the facility that is used during engineering and design to size equipment and mechanical and electrical systems. While plant utilization is defined as the percentage of days in a year the plant produces. So the success index measure (SI) objective is to evaluate the performance of each construction project through the success of project planning and execution phases. In addition the success index (SI) presented in this study has been previously successfully used in three separate research investigations. In all three instances, the success index was used as the dependent variable for measuring the effect that independent variables (pre-project planning effort; project team alignment) had on project success and the result has been with best correlations in the range of 0.39-0.49, with a level of significance at 0.01. These results demonstrate the value of the success index in measuring the success of construction project and can be used on projects of different size and type. Good performance of construction projects, in terms of limiting costs and adherence to schedules, followed by good performance of project planning and execution phases is related to the success of the projects. Therefore the success index rating of all selected projects will be analyzed with the overwork delayed on each project and any differences in interpretation will be discussed. The success index investigation inspected twenty (20) projects within each of the three categories. The survey was done by interviewing construction engineers and managers using a structured questionnaire about the project's success, and the responses were then analyzed to determine the success index of the projects.

2.1 Project planning analysis through Success Index measure

In this first step, the success measurement of construction projects was evaluated by using Griffith et al.'s [21] method. Several success variables were identified as the main variables affecting the project planning and execution phase's performance of Benin's development construction projects. Some of these, such as project controls, were classified into subcategories (budget achievement; schedule achievement); and the project characteristics were also classified into subcategories (design capacity; plant utilization). Together, these were identified as the most important variables at play in the survey. It was completed by asking construction engineers and managers this question: "What are the main problems that hinder the success level of Benin development construction projects?" A list of eighty (80) responses was obtained from personnel associated with each of the ten (20) construction projects (schools; medical centers and public supermarkets). At least one interviewee discussed project control issues on 36 of the projects, whereas interviewees discussed operating characteristics on 24 of the projects. The responses percentages by project (schools; medical centers and public super markets) and by respondents (construction engineers; construction managers) in terms of project controls and project characteristics were different. The success index calculation of each type of project was made using the following equation:

$$(SI) = P[(P_B xB) + (P_S xS)] + O[(O_C xC) + (O_U xU)] \quad \textbf{(1)}$$

Where, P is the variable weight of project controls; P_B is the variable weight of budget achievement responses; P_S is the variable weight of schedule achievement responses; O_C is the variable weight of design capacity responses; and O_U is the variable weight of plant utilization responses. When the project was completed within the budget and behind the authorized schedule, the value for budget achievement value B was 3 and the value for schedule performance value S was 1. For the same project, if after 6 months of operation the facility was operating above the design capacity for which it was originally planned and the plant utilization was also above the amount originally planned, the design capacity value C and the plant utilization value U would both be 5. Table 1 shows the value of those variables.

Table 1 Reclassification of Success Variables (Gibson and Hamilton 1994)

Variable	Range	Value
Budget achievement (B)	Under authorization budget	5
	At authorization budget	3
	Over authorization budget	1
Schedule performance (S)	Under authorization budget	5

	At authorization budget	3
	Over authorization budget	1
Percent designed capacity attained (C)	Over 100% planned	5
	100% of planned	3
	Under 100% of planned	1
Plant utilization at 6 months (U)	Over 100% planned	5
	100% of planned	3
	Under 100% of planned	1

III. ANALYSIS AND DISCUSSIONS

The statistical analysis of data collected has been done. The success index (SI) performance of all construction projects: schools, medical centers, and public supermarkets were calculated. The success index (SI) performance of schools, medical centers and supermarkets from Table 2 is 2.79, 2.74 and 2.64 respectively. An index value of 1 indicates the complete failure of a project and a value of 5 the complete success of a project; therefore, poor performance has been assigned for all those projects because their success index value was less than 3.

Table 2 Success Index of Beninese Development Construction Projects

	Variable	**Sum of responses by project**	**Weights**
Medical centers	Project controls	12	12/20 = 0.6
	Operating characteristics	8	8/20 = 0.4
	Total	20	1
	Success variable	Sum of responses by respondent	Weights
	Project controls		
	Budget achievement	37	37/65 = 0.57
	Schedule achievement	28	28/65 = 0.43
	Total	65	1
	Operating characteristics		
	Plant utilization	5	5/15 = 0.33
	Design capacity	10	10/15 = 0.67
	Total	15	1
	Success Index = 2.74		
Schools	variable	Sum of responses by project	Weights
	Project controls	12	12/20 = 0.6
	Operating characteristics	8	8/20 = 0.4
	Total	20	1
	Success variable	Sum of responses by respondent	Weights
	Project controls		
	Budget achievement	40	40/60 = 0.66
	Schedule achievement	20	20/60 = 0.34
	Total	60	1
	Operating characteristics		
	Plant utilization	7	7/20 = 0.35
	Design capacity	13	13/20 = 0.65
	Total	20	1
	Success Index = 2.79		
Public supermarkets	variable	Sum of responses by project	Weights
	Project controls Operating characteristics	12 8	12/20 = 0.6 8/20 = 0.4
	Total	10	1

	Success variable	Sum of responses by respondent	Weights
	Project controls		
	Budget achievement	42	42/60 = 0.7
	Schedule achievement	18	18/60 = 0.3
	Total	60	1
	Operating characteristics		
	Plant utilization	6	6/20 = 0.3
	Design capacity	14	14/20 = 0.7
	Total	20	1
	Success Index = 2.64		

The statistical analysis proves that all the projects fail in terms of budget achievement, schedule achievement, design capacity and plant utilization. The successful performance of any project is synonymous with planning effort, project manager goal commitment, scope and work definition, control systems, project manager technical capabilities, project team motivation, project schedule plan, project risk assessment, change management plan, risk mitigation plan, and cost control. As analysis from contractors, consultants and engineers involved in these projects execution, the projects low performance related to many aspects such as pre-project planning problems, design related problems, execution approach problems, change order problems, and work supervising problems. From Fig. 1 the success index of supermarket projects is lower than both school and medical center projects while the success index value of school construction projects is close to 3, value of good performance. The mean value of success index and standard deviation of each project are shown in Table 3. As shown in this table, the success index of each construction project is different to each other with standard deviation value of 0.058.

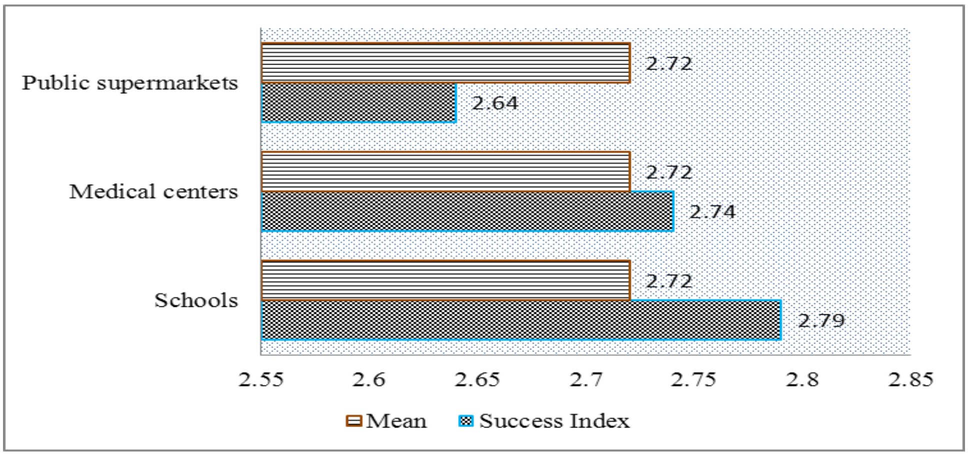

Figure1 Success index of Beninese construction projects

Table 3 Success Index Values for Beninese Construction Projects

Projects	**SI**	**Mean**	**S.D**
Schools	2.79	2.72	0.058
Medical centers	2.74	2.72	0.058
Public supermarkets	2.64	2.72	0.058

To be able to analyze well the schedule performance of each project, Microsoft project was used to track down the work performance of each project. As shown in the tracking Gantt chart (Fig. 2), all the projects fail as planned and were finished behind schedule and deadline, so some extra works have been done in order to accomplish the projects. The overwork days on each construction project were very significant in the case of medical center and public supermarket projects than school projects. This result confirms the lower success index value of medical center and public supermarket projects in terms of budget achievement, schedule achievement, design capacity and plant utilization obtained from statistical analysis. Therefore more the project is complex more poor the success index will be. Fig. 3 shows the variation of overwork days on each construction project. As shown in this figure 75% of executed project has overwork day behind the average overwork day value (e = 27 days) of all executed projects. The construction projects observed in this investigation were completed over budget and were woefully delayed. The use of poor construction techniques, poor construction quality, ineffective design capacity and plant utilization, cost and schedule variance, were the leading causes of the low performance detected in those projects. The project planning management system fails to meet the requirements of successful project in terms of budget achievement, schedule achievement, design capacity, and plant utilization.

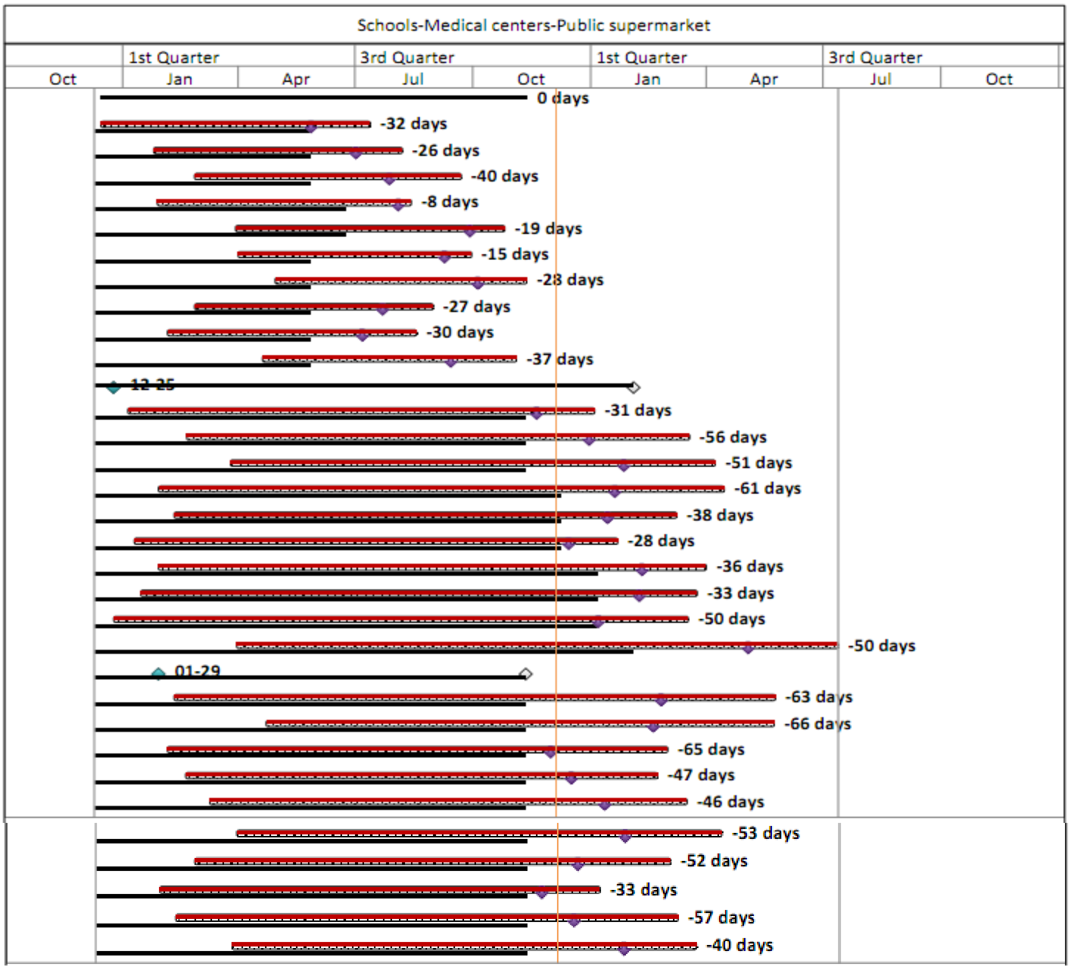

Figure 2 Tracking Gantt chart for work progress of each construction project

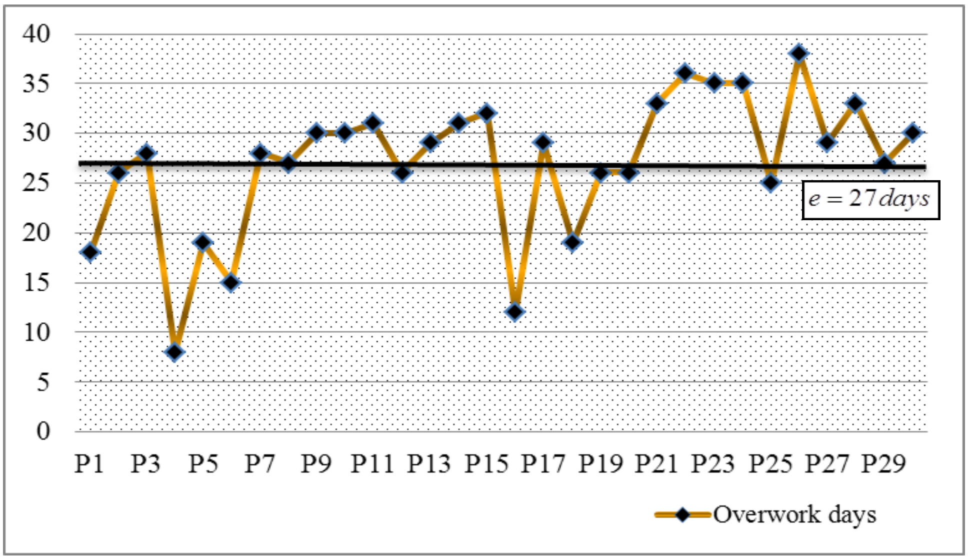

Figure 3 Overwork day's variation for each construction project

In order that building or civil engineering works shall be carried out efficiently, they shall be carefully and properly planned in the first instance. Decisions shall be made on construction methods, temporary works and contractor's equipment, labor, material and transport requirements, all set against time. Full consideration shall be given to alternative methods and the effect of each planned activity on the others. The works shall be broken down into a series of operations in the programming, from the temporary and preliminary operations throughout the completion of the permanent works. The programme should ideally be discussed and agreed by all concerned before work starts, to avoid confusion, delays and increased costs. Another very important pre-project assessment is risk management. Risk is an uncertain event, action, condition, or a situation and when it occurs, has a positive or a negative effect on at least one project objective, such as time, cost, scope, or quality. Fig. 4 shows project management in terms of risk analysis. As shown in this diagram the projects risk analysis were just focused on technical aspect (requirements, technology, complexity and interfaces, performances and reliability, and quality), external aspect (subcontractors and suppliers, regulatory, market, customer, and weather), organizational aspect (project dependencies, resources, funding, and prioritization), and project management aspect (estimating, planning, controlling and communication) but did not take into account risk mitigation and change management analysis. Risk mitigation builds risk response planning associated with threats to the project; to reduce the risk probability occurring and impacts while change management is some management plan related to the change on the project to control the scope of the project. So these two aspects of risk assessment are very critical for successful project in terms of project planning performance and need to be analyzed as part of risk management in order to avoid the project planning failure.

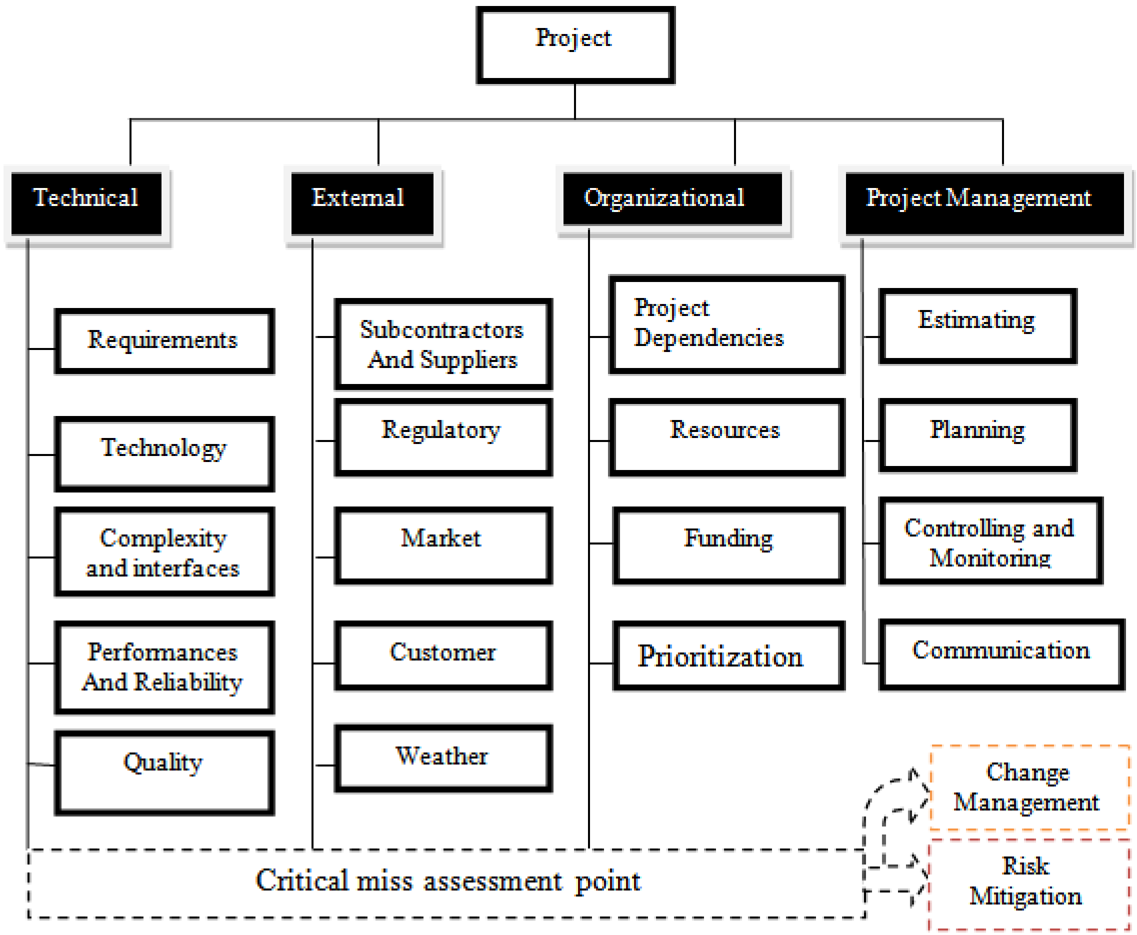

Figure 4 Construction projects risk analysis breakdown structure

Much of the research done on construction project performance in Ghana, Nigeria and some developing countries shows problems in planning issues; however the severity of the problem previously confirmed by the statistical analysis is more critical for Benin. The World Bank expertise's on overall Beninese development construction projects confirmed the poor performance obtained from statistical analysis by sorting out several factors among which are the inability, cost and schedule control, civil service reform and mediocre supervision. Most developed countries; United States, Japan, United Kingdom, and some selected countries such as China, Thailand and Singapore still face the problem of low construction, however the success of a large number of construction projects in China are indicative of a great level of construction technology methods, effective cost and schedule control during the construction process and good site management by construction managers. The same work performance was observed in the United States, Japan, and some Asian countries such as Singapore and Thailand. Therefore the problems of low performance construction projects for those countries are not of the same caliber as found in African countries. Instead these issues are related to the identification and management of the risks associated with unknown elements such as unusual ground conditions, co-ordination problems, accidents and injuries to employees, and an inadequately trained workforce. If a project manager has strong leadership skills, a project's performance can be monitored, controlled and managed in a high-quality fashion [22]. Effective schedule control involves managing the crew, equipment, and production rates that would be used to construct the project. As corrective actions for management, cost effective management is equally important as efficient planning, coordination of the site and craft labor. The early identification of quantity variances and, high labor productivity are major approaches for controlling construction costs.

The above corrective actions have been experienced in construction projects in developed countries and also in China, Thailand, and Singapore with satisfactory results. As a result, they are known by many construction project experts to be fundamental key issues in schedule and cost growth control. Therefore African countries construction projects can meet the same goal if project participants meet the challenge of successful implementation of these corrective actions.

IV. RECOMMENDATIONS AND CONCLUSIONS

This study was conducted to analyze the performance of Beninese development construction projects through statistical analysis, by using success index (SI) measure. It has been concluded after statistical analysis that poor performance in terms of budget achievement, schedule achievement, design capacity, and plant utilization, plagues Beninese construction projects. The complexity of these projects has an effect on the extent to which they are successful, and their poor performance results demonstrate poor planning and scheduling in scope of work, non-effective cost control system, poor management of design capacity and plant utilization which lead to non-productive time and cost variation.

Construction projects around the world are plagued with the same problem of schedule and cost growth, but the level and the causes of the problem differ from country to country and are even more critical for African countries especially Benin. Therefore it is necessary to remind all of the participants of such projects of their important role during the process of construction. Based on these findings, some recommendations have been offered to the project participants:

In the design process, cost control teams must ensure that the tender can be prepared such that the lowest tender will confidently equate closely with the feasibility budget.

Perform work according to schedule and identify change of order and adjust accordingly to schedule.

The Project manager and construction manager must work together at the construction site to strengthen the day to day execution of the work.

The owner needs to effectively communicate the scope of work desired to the other parties and facilitate payment to the contractor in order to avoid delays, disputes and claims

Cost estimation should consider environmental risk and provide an adequate contingency allowance to cover increases in material cost, and implement formal construction quality control and quality assurance programs.

Training programs for construction contractors should be implemented to facilitate the use of latest construction technology methods.

The successful completion of any project depends on the coordination of the efforts of all parties involved, hopefully to the financial advantage of all. The success of Beninese and African countries construction projects can be ensured if all these aspects are taken into account over the life of the project. Only serious hard work and perseverance can change challenge into opportunity and then into a positive result.

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REFERENCES

[1]. W. F. Chen, J. Y. R. Liew, The Civil Engineering Handbook" 2nd ed , (CRC Press LLC). (2003)
[2]. G. Ballard, G. Howell, Shielding production: Essential step in production control. Journal of Construction and Management ASCE, 124(1), 1998, 11-17.
[3]. D. K. H., Chua, L. J. Shen , Constraint-Based Planning with Integrated Production Scheduler over the Internet, Journal of Construction Engineering and Management ASCE, 129(3), 2002, 293-301.
[4]. X. Meng, The effect of relationship management on project performance in construction, International Journal of Project Management, 30(2), 2012, 188-198.
[5]. R. Takim, A. Akintoye, J. Kelly, Performance measurement systems in construction., 19th Annual ARCOM Conference, 1: 2003, 423-432.
[6]. J. D. Steven, Blueprint for measuring project quality, Journal of Management in Engineering ASCE, 12(2), 1996, 34-39
[7]. D. Sinclair, M. Zairi, Effective process management through performance measurement: part III- an integrated model of total quality-based performance measurement., Business Process Re- engineering & Management Journal, 1(3), 1995, 50-65.
[8]. L. M. Mbugua, P. Harris, G. D. Holt, P. O. Olomolaiye, A framework for determining critical success factors influencing construction business performance. In: Hughes, W. (ed) Procs. 15Th Annual ARCOM Conference, September 5-7, Reading: ARCOM 1, 1999, 255-264.
[9]. P. E. D. Love, G. D. Holt, Construction business performance measurement: the SPM alternative, Business Project Management Journal, 6(5), 2000, 408-416.
[10]. A. Chan, A Quest for Better Construction Quality in Hong Kong, Construction Paper131, CIOB Construction Information Quarterly, 3(2), 2001, 9-16.
[11]. L. Koskela, An Exploration towards a Production Theory and Its Application to Construction, 'PhD thesis'. Helsinki University of Technology, Helsinki, Finland, 2000
[12]. D. E. Jr. Ralph, S. Lee, Measuring Project Level Productivity on Transportation Projects, Journal of Construction Engineering and Management, 132(3), 2006, 314-320.
[13]. L. S. Pheng, Q. T. Chuan, Environmental factors and work performance of project managers in the construction industry, International Journal of Project Management, 24(1), 2006, 24-37.
[14]. X. Wang, J. Huang, The relationships between key stakeholders project performance and project success: Perceptions of Chinese construction supervising engineers, International Journal of Project Management, 24(3), 2006, 253-260.
[15]. O. O. Ugwu, T. C. Haupt, Key performance indicators and assessment methods for infrastructure sustainability: A South African construction industry perspective, Building and Environment, 42(2), 2005, 665-680.
[16]. K. C. Lam, D. Wang, P. T. K. Lee, Y. T. Tsang, Modeling risk allocation decision in construction contracts, International Journal of Project Management, 25(5), 2007, 485-493.
[17]. D. K. Ahadzie, D. G. Proverbs, P. O. Olomolaiye, Model for Predicting the Performance of Project Managers at the construction Phase of Mass House Building projects, Journal of Construction Engineering and Management ASCE, 134(8), 2008, 618-629.
[18]. J. F. Y. Yeung, A. P. C. Chan, D. W. M. Chan, Developing a Performance Index for Relationship-Based Construction Projects in Australia: Delphi Study, Journal of Management in Engineering ASCE, 25(2), 2009, 59-68.
[19]. P. Shrestha, J. O'Connor, G. Jr. Gibson, Performance Comparison of Large Design-Build and Design-Bid-Build Highway Projects, Journal of Construction Engineering and Management ASCE, 138(1), 2012, 1-13.
[20]. M. E. Georgy, L. M. Chang, K. D. Walsh, Engineering Performance in Industrial Construction, Construction Congress VI", 2000, 917-927.
[21]. A. F. Griffith, G. E. Jr. Gibson, M. R. Hamilton, A. L. Tortora , C. T. Wilson, Project Success Index for Capital Facility Construction projects, Journal of Performance of Constructed facilities, 13(1), 1999, 39-45.
[22]. K. C. Iyer, K. N. Jha, Factors affecting cost performance: evidence from Indian construction projects, International Journal of Project Management, 23(4), 2005, 283-295.