International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 8 Aug 2021, pp: 1584-1590 www.ijaem.net ISSN: 2395-5252

Comparative Analysis on the Performance of Integrated Project Delivery and Design, Bid and Build System on Road Projects

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Submitted: 10-08-2021 Revised: 25-08-2021 Accepted: 28-08-2021

ABSTRACT: The selection of construction project delivery method is one of the most important decisions that determine project success. Integrated project delivery (IPD), is a new project delivery route that involves key project players very early even before the designed has started. As IPD is increasingly becoming notable in the construction industry, many organizations are indicating interest in its fruits to the construction industry. However, no research study has so far compared statistical analysis of project delivered using IPD and design, bid and build (DBB) system on road projects in Nigeria. Relevant literature was analysed, key performance metrics used in road construction projects were identified. A suitable questionnaire for data collection was developed to collect the quantitative performance data from recently completed projects across the two delivery systems under study (IPD and DBB). A sample of a total 51 project data was analysed, an independent sample T test was performed to compare costs and schedules. The results indicated that significant difference exist only in construction intensity (CI) at p. value=0.0033 and a mean difference of 0.44 with superiority of performances been recorded in IPD. These results would be of an immense important in providing necessary information to construction project stakeholders in selecting best construction project delivery system for their project.

I. INTRODUCTION

The selection of suitable project delivery methods is an important element in effective quality delivery of construction projects [12]. It is the way to coordinate and organize services (planning, design and construction) contractually to ensure proper project execution. It is the development of a framework to link various organisations or to establish contractual (formal) and informal relationships between parties essential to deliver a construction project effectively. According to [5], it is the key factor which determines overall project performance. Over the years, different types of project delivery methods were developed with the aim to overcome the shortcomings of the previous ones.

Road construction projects have been delivered over the years using the; design–bid–build (DBB) and design build (DB). Delivery systems are chosen by client to match ultimate goal in terms of project performance ensuring quality and timely delivery at an optimal cost. Despite the availability of many delivery options, the client's performance expectations are not met with in many projects [15]. The poor performance is largely attributed to failure of proper integration in these systems [16]. Hence, to overcome the problems related to project performance, there is a need for better collaborative approaches to procurement and improved coordination of project participants [7]. Recently, the construction industry is headed towards team's integration in design and construction process, [6].

Integrated project delivery (IPD) a recent method of construction project delivery which has been attainting high level of acceptance in the industry. The method integrates all participants into a collaborative process to optimize performance to gain best value, reduce waste and ensure maximum efficiency throughout project life cycle [3]. Several studies have been conducted on the potentials of IPD on building construction projects, but little to none of its potential on road construction has been studied. With the ongoing, this study aims to

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compare the performance of IPD with DBB project delivery systems of road projects in Nigeria.

II. LITERATURE REVIEW

Construction project procurement is wide in scope as it involves different organisations, companies and firms to design, manage and construct the product for clients and customers [13]. Procurement of construction projects mainly deals with specific methods, process and procedures of acquiring a construction product, it involves the coordination of people to achieve the desired goal. Procurement also entails the process of delivering project within budget, time and required quality by putting in place the appropriate framework and structure, assigning responsibilities and authorities of main parties in construction project [16]. Hence, procurement method is an important factor that determines the success of construction project.

Over the years, numerous methods of procurement emerged in the construction industry with the aim to overcome the limitations of the existing methods [2]. Main set back of common procurement methods is poor productivity, which is largely attributed to failure to a line schedule and budget, lack of sufficient details of construction drawings and material wastage.

Road construction projects were primarily completed under the Design Bid-Build (DBB) and Design and Build (DB) delivery method. As the construction market is becoming more competitive by the day, this leads to high demand of faster completion of construction projects [20]. This led to the development of new procurement methods with faster design and construction phases with optimal control on cost, improved product quality and operational safety.

Integrated project delivery.

Integrated project delivery (IPD) system was designed to counter the limitations associated to low productivity in previous methods [17]. Hence, IPD tends to contractually collaborate all team members and the integration of all is the main factor in this project delivery method. It promotes key stakeholders' early involvement to enable proper collaboration without fear to liability claims in sharing of risk and reward [4], this is mostly achieved where multiparty contract involved which is the main feature of IPD [8] & [20]. The method also improves the predictability in terms of cost and scheduling due to early involvement of project key players, [8]. According to [9], [7] & [15] better performance is achieved with IPD in terms of quality, stake holder communication, financing, and environmental aspect as compared to non IPD projects.

III. RESEARCH METHODOLOGY

This research was carried out by the examination of relevant literature followed by a field survey. The first stage consists of planning to develop performance metrics of road projects which was achieved through literature review in the domain of project delivery systems. Secondly, the performances of the two delivery systems were determined in line with the prior identified metrics and lastly, a comparison of the performance of the delivery systems was made.

Because of the nature of information that was required to meet the objectives of this research, a self-administered questionnaire survey was used. State Ministries of Work were chosen as the target respondents for the survey as the clients were considered to have a complete and more accurate knowledge about how any given project was executed, since they were directly responsible for the delivery of the project. Kano, Katsina and Jigawa states of Nigeria were chosen as the study area. The aforesaid, were chosen on the basis that they were amongst the Nigeria states undertaken projects with key participants early involved.

The sample size 75 was used considering assertions from [22], and in [2] that; "a required minimum sample size of 30 is sufficiently large to provide an effective normal approximation as a general rule of Thumb, regardless of the shape of the population". For the purpose of this research, a minimum of fifty (50) samples were set as a sample size. Also, based on [21] recommendation that if surveys or questionnaires are to be mailed out, an increase of 40% - 50% shall be made to account for lost mails and uncooperative subjects. Therefore, a total 75 questionnaires were issued out to respondents instead of the minimum of 50 set as a sample size. The scope of the study was limited to new road projects executed at earlier mentioned study areas that achieved final completion between 2007 and 2018. A large-scale convenience sample of projects under each delivery system (DBB and IPD) was obtained, and respondents were required to consider road projects most recently completed to eliminate biasness of choosing best-performing projects.

The analysis of the data involved both descriptive and inferential statistics available in the SPSS software version 23. The results of descriptive statistics obtained was presented in tables. The SPSS was further used to conduct an Independent Sample t-test test for comparing the

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variation in means of project delivery system performance.

IV. RESULTS AND DISCUSSION

Descriptive Statistics

Total Cost Growth Across Delivery Systems (DBB and IPD)

Table 1. Frequency Distribution Total Cost Growth (%)

Category (%)	DBB		IPD	
	N	%	n	%
up to 5	17	55	15	75
5 – 10	9	29	5	25
10 – 15	4	13	-	-
15 – 20	1	3	-	-
20 – 25	-	-	-	-
Total	**31**	**100**	**20**	**100**

Source: Field Survey, 2019.

The table1 showed the frequency distribution of total cost growth for the Design Bid and Build (DBB) and Integrated Project Delivery (IPD). The statistics revealed of the 31 DBB projects, 55% experienced cost growth below 5% and other 29% had cost growth between 5% to 10% while the remaining 13

% and 3% had cost growth between 10% to 15% 15% to 20% respectively. For the integrated project delivery system, 75% of the project experiences cost growth below 5% and 25% had cost growth between 5% to 10%.

The 75 percentage of project delivered under IPD system had cost growth below 5% and then followed by DBB with 55% respectively. For the second category ranged from 5% to 10% the statistic revealed that DBB had highest percentage of projects and then followed by 1PD which can simply conclude that DBB had of project with cost growing beyond 10%. This therefore, indicated that IPD system is the best option followed by DBB system when taking in to consideration the total cost growth of the project.

Unit Cost Across Delivery Systems (DBB and IPD)

Table 2 Frequency Distribution of Unit Cost (N/km)

Categories	DBB		IPD	
	N	%	n	%
100 - 200	15	48	7	35
200 - 400	14	45	10	50
400 - 600	2	7	3	15
	31	100	20	100

Source: Field Survey, 2019.

The table 2 presents the frequency distribution of unit cost. The statistics shows that of the 31 design and build projects, (48%) of the projects had their unit cost between 100 million to 200 million followed by (45%) with unit cost between 200 million to 400 million and lastly 7% with unit cost between 400 million to 600 million respectively. The statistics further revealed that of the integrated project delivery, (35%) of the project had unit cost between 100 million to 200 million

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followed by (50%) and (15%) with unit cost spanning between 200 million to 400 million and 400 million to 600 million respectively.

Additionally, the statistics shows that IPD projects had the highest unit cost and then followed by DBB projects which means that IPD system is more expensive in terms of unit cost.

Total Schedule Growth across Delivery Systems (DBB and IPD)

Table 3 Frequency Distribution of Schedule Growth (%)

Categories (%)	DBB		IPD	
	N	%	n	%
Up to 5	22	74	18	90
5 - 10	5	17	2	10
10 - 15	3	10	-	-
	31	100	20	100

Source: Field Survey, 2019.

The table above shows the frequency distribution of schedule growth for the design, bid and build and integrated project delivery. The increase or decrease in a contract life is measured with schedule of growth. Construction contracts have a contractual period of performance or a finite period of execution that define the schedule for construction project delivery. The category includes that below 5% and from 5% to 10% and lastly 10% to 15%. The statistic revealed that (74%) of the 31 DBB projects experienced schedule growth below 5% and (17%) had schedule growth between 5% to 10% while in the integrated project delivery system, (90%) of the project experienced schedule growth below 5% and (10%) had schedule growth between 5% to 10%. This suggests that DBB projects experience more schedule growth compared to IPD.

Construction Intensity Across Delivery Systems (DBB and IPD)

Table 4 Frequency Distribution of construction Intensity(km/month)

Categories	DBB		IPD	
	N	%	n	%
up to 5	28	90	14	70
5 – 10	1	3	3	15
10 – 15	2	7	3	10
15 – 20	-	-	1	5
	31	100	20	100

Source: Field Survey, 2019.

The table 4 presents the construction intensity (CI) of the design, bid and build and integrated project delivery. CI measures the speed of the construction per every kilometer of a given road. It determines the rate at which a particular length of road can be delivered. Out of the 31 DBB projects, (90%) had their construction intensity below 0.5 followed by (3%) of the projects between 0.5 to 1.0 and (7%) between 1.0 to 1.5. Concerning the IPD system, (70%) of the projects had their construction intensity below 0.5 and (15%) of the projects were between 0.5 to 1.0 followed by (10%) and (5%) all having construction intensity between 1.0 to 1.5 and 1.5 to 2.0. This results indicates that the IPD system has outperformed the DBB system in terms of speed in delivery of the project.

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Comparison of the performance of DB with that of IPD using Independent T-test

This section compares the performance of design, bid and build (DBB) delivery systems with integrated project delivery (IPD) through four performance metrics (total cost growth, unit cost, total schedule growth and construction intensity) across two performance areas of cost and schedule of the contract. DBB and IPD delivery systems were compared for each performance metrics individually using an independent sample t-test. Table 5 below Summarised the results of the analysis, for each individual test, a p. value greater than 0.05 shows no significant performance difference between DBB and IPD systems.

Table 5. Result of comparison of schedule performance of DB and IPD delivery systems

			leven's test		t. test for equality of means				
Metrics	**PDS**	**N**	**F**	**Sig.**	**T**	**df**	**sig. (2-tailed)**	**Mean Diff.**	**Std. Error Diff.**
TCG (%)	DBB	31	10.118	0.003	0.62	48	0.538	0.083	-0.11
	IPD	20							
UC (#)	DBB	31	0.000	0.983	-1.15	37.28	0.259	-.219	-.191
	IPD	20							
TSG (%)	DBB	31	12.659	0.001	1.166	49	0.113	0.225	0.158
	IPD	20							
CI	DBB	31	13.952	0.000	-2.14	49	0.037	-0.44	0.205
	IPD	20							

Comparison of total cost growth and unit cost of DBB and IPD delivery systems

Contracts data for total cost growth and unit cost were investigated and compared. Total cost growth is measured in percentage by comparing final construction costs to the original estimated construction costs. Unit costs are measured in naira per every kilometer of road. Independent sample t-test was used to investigate whether significant difference exist between the performance of DBB and IPD projects. The test results in p. value for DBB and IPD in total cost growth and unit costs are 0.538 and 0.259 with mean difference of 0.083 and -0.219 at 95% confidence level respectively. The mean difference though, not statistically significant but, depicts superiority of IPD over DBB delivery system in terms of total cost growth of the contracts as DBB is 8% cost growth greater than IPD. The reason may be that early involvement of key participant in IPD projects make it to be within predetermined financial yardstick of the contract. The results further showed that IPD projects experienced 17% greater unit costs compared to DBB. However, this may be due to the number of participants in IPD project with likely higher professional fees resulting in high unit cost.

Comparison of schedule performance of DBB and IPD systems

The schedule performance metrics investigated in this research are the total schedule growth and construction intensity. Construction schedule growth is measured in percentage terms by comparing the final construction schedule to the original construction schedule while construction intensity in this research is measured in kilometre per month, starting from construction start time to the completion time. Although, the statistics revealed no significant difference between DBB and IPD in schedule growth, the mean for DBB projects is slightly higher than that of IPD projects which suggest that DBB projects experience more schedule growth 23% greater compared to IPD projects. Superiority of IPD in this metrics can be attributed to the early Contractor's involvement in the design stage and client/designer involvement in construction stage resulting in a common understanding of the project needs and therefore improved in completion of the project on schedule. Construction intensity revealed significant difference at p. value = 0.033 but the difference in mean score between DBB and IPD showed that IPD is 44% construction intensity greater than

DBB which may be because the design and construction rest on the contractor and construction can start earlier before project design can be hundred percent completed.

V. CONCLUSIONS

The study analysed the performance of integrated project delivery and design, bid and build system on road projects. Although significant difference in the performance of DBB and IPD delivery systems exist only in construction intensity, superiority of performances of IPD over DBB have been recorded in total cost growth (TCG) and total schedule growth (TSG). The authors recommend an effective dissemination of IPD literature for its wider understanding and application in the construction industry so that the fruits of the new development can be appreciated. There is need for the investigation of the potential causal factors of the slight variations on the performance of the two delivery systems studied. The authors believed that the result of this study will be useful in increasing the popularity of the IPD and its potential characteristics and will also help in alleviating the fragmented approach of the more established delivery systems.

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