Influence of Project Setting on the Constructability Practices of Indigenous Road Construction Firms in Nigeria

[*]Ogbu, C. P. and Ebiminor, V. B.
Department of Quantity Surveying, University of Benin, Benin City, Nigeria
Correspondence email: chukwuemeka.ogbu@uniben.edu

Abstract

Previous studies on the constructability of construction projects hardly explain the influence of project complexity and setting on constructability practices. This study analysed the constructability practices of indigenous road construction firms (IRCFs) in Nigeria and ascertained the differences in the practices for different complexities of road work and project settings. Quantity surveyors and highway engineers were surveyed, and the data analysed using Kruskal Wallis H test, multiple comparisons and mean scores. It was found that environmental and social impact assessment (ESIA) is least carried out in roads of <1Km. Also, cost optimization and adequate allowance for temporary/protective works are practised more in federal government projects than in private sector projects. Constructability practices hardly lead to better stakeholder management and absence of construction disputes. Future studies on constructability should take into cognizance the effects of project complexity and setting since these could determine the extent of constructability practice, and the outcome of the practice. Constructability practices by IRCFs should cover dispute and stakeholder management strategies. This study explicates the differences in the adoption of constructability practices for road projects of different complexities and organisational settings. It also demonstrates the relationship between constructability practices and project performance.

Keywords: constructability; indigenous construction firms; project complexity; project funding; road construction

INTRODUCTION

Nigeria has the largest road network in sub-Saharan Africa with an estimated 195,000km of road 67.5% of which is untarred, while the paved sections are mostly in deplorable conditions (Pison Housing Company, 2013; National Planning Commission, 2015). Consequently, the Nigerian government is foreseeably going to make increasing investments in road infrastructure given the noted link between roads and economic development (National Planning Commission, 2015; David-West, 2015; Pison Housing Company, 2013). National Planning Commission (2015) recommended that 50% of Nigeria's infrastructural investment should be on roads. This entails a vast opportunity for road contractors, especially, the local firms. Previous studies had noted that foreign contractors handle 85% to 95% of major projects in the country (Adams, 1997; Ibrahim & Githae, 2014). However, recent procurement reforms and emphasis on local content utilization (Federal Government of Nigeria, 2018) have emboldened indigenous road construction firms (IRCFs) to increasingly bid for the design and construction of road projects within their capacities in the country. Excerpts from the contracts approved by the Nigerian Federal Executive Council between 30th April 2014 and 25th January 2017 (Bureau of Public Procurement, 2019) showed that about half of the 81 construction-related projects (n=42) (33% of the Naira value of the 81 projects) were awarded to indigenous firms.

The ability of IRCFs (consultants and contractors) to satisfactorily design and construct road projects, however, remains suspect. Oke, Aghimien, and Adedoyin (2018) surmised that the firms have considerable technical and financial weaknesses. They are also noted to be inexperienced, incompetent and poor project planners (Oladimeji and Ojo, 2012; Ibrahim *et al.*, 2014; Ugochukwu and Onyekwena, 2014). These raise questions on the ability of IRCFs to undertake proper constructability reviews of road projects at the pre-construction stages as well. Although studies like Mbamali *et al.* (2005) and Trigunarsyah (2007) identified constructability practices, it is hardly agreed by researchers that these practices are actually undertaken by Nigerian IRCFs. Akpan *et al*. (2014) stated that Nigerian professionals are familiar with the constructability concept, but construction firms have no formal policies for their implementation, but Amade (2016) found that most of the professionals are not acquainted with the concept yet. Insufficient project data is also seen as a leading cause of constructability problems in Nigeria, which leads to the inability to achieve value for money for clients (Aina, 2015). Consequently, a kilometre of road in Nigeria costs higher than similar roads elsewhere in sub-Saharan Africa (Ojo, 2019).

On the average roads experience a 35% overrun in costs (Africon, 2008). On-going debates (Flyvbjerg *et al.*, 2002; Love *et al.*, 2016) suggest that transportation projects are exceptionally prone to poor time and cost performances. Improper constructability practices prior to construction can worsen this observation for road projects handled by IRCFs. Yet, there are scant Nigerian studies on the effects of constructability on the performances of road projects. A related study by Windapo and Ogunsanmi (2014) found that organisational deficiencies, project size/complexity and poor knowledge of construction methods are barriers to constructability practices. However, besides not explaining the relationship between constructability and the performances of the projects, the study also relied mostly on building work methodology, and is limited in providing road builders with constructability practices before construction operations begin. Mbamali *et al*. (2005) which also focused solely on building projects concluded that technical knowledge of building production processes and site operations are not always available at the early stages of construction procurement in Nigeria. Typically, roads cover larger geographical areas than buildings, and traverse different soil types, topographies and communities. These characteristics increase the riskiness of road projects, toughens the jobs of designers and road constructors and threatens project performance. Thus, roadwork-specific constructability challenges such as geotechnical issues, obstructing utilities, right-of-way commitments, traffic control amongst others (Goodrum *et al.*, 2003) require specific research attention. Construction terrains differ widely across Nigeria, and the cases of kidnapping, terrorism, vandalism, unrest and other forms of insecurity are on the increase (Adebiyi *et al.*, 2019; Rebosio and Wam, 2011). While most constructability studies have made no distinctions between building and civil engineering projects (Arditi *et al*., 2002), the present study argues that road projects are so full of constructability risks to warrant a specific research focus.

In Nigeria, road projects are funded by different agencies. Although these agencies can be categorised loosely as public and private sector-based, it is also possible to group the public road funding agencies into: federal, state/local governments, and multilateral development banks (MDBs). Previous studies make no distinctions in the adoption of constructability for road projects of differing complexities undertaken under different organisational cultures or project settings. Project funding agencies usually influence the overall procurement culture for their projects, which could determine the extent of constructability practice. World Bank funded projects follow certain design protocols that may differ from those applicable in a private sector-based road project or in a state government project for instance. Usually, MDBs seek to introduce best practice design and procurement practices in beneficiary countries which entails careful implementation of constructability principles. Likewise, Federal Government of Nigeria funded projects ought to be exemplary in conceptualization, planning, design and execution to serve as models for the states. These differing project settings remain largely unaccounted for in constructability studies. Additionally, the complexity of a project is a justifying factor for the level of adoption of constructability in the project. Existing studies are unclear on whether higher road project complexities are associated with higher adoption of constructability practices, and whether the levels of constructability adopted are justified by the performance of the projects in terms of quality, time and cost.

Constructability attempts to unify the best expertise at the construction and design ends of a project with a view to optimizing the construction process. The outcome of this process should be a biddable, buildable and maintainable project (McManus *et al*., 1996). In Nigeria such interfaces are difficult at the early stages of road projects due to the statutory use of the design-bid-build approach in public procurement (Mbamali, *et al*., 2005). Consequently, constructability reviews are presumably undertaken independently by the designers and constructors. However, the poor performances of road projects, as well as their frequent redesign and reworks at the construction stage amplify the need for constructability review of road projects. Unlike Nigeria, consultants are sometimes engaged solely for conducting constructability reviews for road projects in advanced countries like the US [American Association of State Highway and Transportation Officials (AASHTO), 2000]. It is, therefore, important that the approaches to constructability are separately studied for different procurement climes as suggested by Trigunarsyah (2004). This study explores the influence of constructability on the performance of road projects of different complexities and organisational cultures from a developing country perspective.

Hypotheses of the study

Ho_1: There is no significant difference between constructability practices in road projects under different organisational settings.

Ho_2: There is no significant difference between constructability practices in road projects of different complexities.

Ho_3: There is no significant difference in the influence of constructability practices on the performance of road projects under different organisational settings.

Ho_4: There is no significant difference in the influence of constructability practices on the performance of road projects of different complexities.

Alternative hypotheses are to reject the null hypotheses.

Constructability Practices of Indigenous Road Contractors

Constructability reviews are aimed at better understanding projects and eliminating encumbrances by integrating engineering knowledge and construction experience (Arditi *et al*., 2002). Constructability envisages interfaces between designers and contractors and the intentional removal of issues that could undermine construction (Trigunarsyah, 2004). Constructability practices refer to the practices or actions of construction organisations and clients aimed at minimizing construction hitches by combining design expertise and innovation with construction knowhow.

Construction firms' practices are at the core of their existence and could determine their ability to thrive or complete projects profitably (Ogbu, 2018). Constructability practices can be broadly divided into design and construction stage practices (Building and Construction Authority, 2011). At the early design end, the design-consultants must conceptualize their projects to ease construction in terms of geometry, site conditions and design details (Mbamali and Kehinde, 2004). Liu (2016) described the early design stage as when the design is still incomplete and evolving. Up to 75% of construction problems are created at this stage, therefore, constructability reviews should begin as early as possible at the design stage (Mendelsohn, 1997). At the late design stage, the designs are being finalized and changes are too expensive to make (Xue, *et al.* 2021; Liu, 2016). Constructability issues are more foreseeable at this stage, and the early stage constructability should be re-examined by the design team with a view to making improvements.

Arditi *et al*. (2002) exemplified design constructability practices to include peer review, feedback system, brainstorming, computer and physical models. It is clearly doubtful that physical models are made for roads projects in Nigeria. Other approaches to constructability at the design stage such as designing for simple assembly/modularization, prior site investigations, designing for safe construction and minimized use of plants have also been suggested (Akpan *et al*. 2014; Lam *et al*., 2007). AASHTO (2000) recommended that the scope of constructability review at the design stage should include examination of logistical constraints, clarity of documents and their compatibility with standards and scheduling requirements. McManus *et al*. (1996) specified structured steps to be taken by road design teams in achieving constructability including development of environmental mitigation plans and obtaining rights of way.
The type of organisational culture, availability of critical data, and project complexity often influence the extent of adoption of these principles in practice.

Upon contract award, contractors can forestall project risks by identifying, analyzing and communicating constructability issues at project pre-start meetings (Skibniewski, 1999; Windapo and Ogunsanmi, 2014). They should allow practical sequence of construction, consider adverse effects of weather in selecting construction methods and develop project execution plans that include constructability (Trigunarsyah, 2004). Jergeas and Van der Put (2001) suggested modularization/preassembly of components, use of innovative construction methods, and development of construction sensitive work programmes. Most of these constructability practices are better suited to buildings than to road projects. IRCFs typically have to deal with security and safety provisions, careful selection of borrow pits, adequate logistical planning and proper location of equipment yards along the site. Informed choice of construction equipment, access road delineation, traffic control, right of way, and supply chain management are among the important constructability issues to be considered by road work contractors prior to the commencement of construction activities which in turn influence the cost performance of the projects. Table 1 shows constructability practices identified in previous studies.

Constructability and Project Performance by indigenous Contractors

Projects are goal-oriented efforts. Broadly, the goal of every project is to attain stakeholder satisfaction. In consequence, different authors have suggested diverse measures for project performance including time, quality, cost, safety, dispute, client satisfaction, ethics, amongst others (Irumba and Mwakali, 2007; Lim and Mohamed, 1999; Ogbu and Asuquo, 2018; Ogbu and Olatunde, 2019). Most studies agree that constructability is critical to the attainment of these project objectives (Francis *et al*. 1999; Trigunarsyah, 2007). Constructability helps to identify risks that can undermine a project's goals, and offers an opportunity to the project team to take mitigative actions early enough. Thus, constructability should be practised to forestall redesign and change order costs which are often vigorously opposed by clients, and, therefore, require odious approval processes for payment. The present study, examines the influence of constructability on road project performance particularly given the often cited construction ineptitude of Nigerian indigenous contractors.

Table 1: Summary of Constructability Practices in Literature

	Constructability Practices	Lam et al. (2007)	Francis et al. (1999)	Jergeas et al. (2001)	Trigunarsyah (2007)	Amade (2016)	Trigunarsyah (2004)	Pulaski et al. (2006)	Mohsenijam et al. (2020)	Saghatforoush et al. (2009)	Kifokeris and Xenidis (2017)
1	Economic use of contractor's resources	√									√
2	Use of visualization/(computer) models for easy coordination by site staff	√		√		√					
3	Contractors to develop and adopt alternative construction details	√									
4	Enabling contractors to overcome restrictive site conditions	√									
5	Enabling standardization and repetition	√		√	√			√	√		
6	Enabling freedom of choice between prefabricated and onsite works/modularization	√		√	√		√		√	√	
7	Enabling simplification of construction details in case of non-repetitive elements	√			√			√			
8	Minimize the impact due to adverse weather by enabling a more flexible construction program	√			√				√	√	
9	Allowing design to achieve safe construction sequence on site	√					√	√		√	
10	Initial constructability briefing		√								
11	Project team selection/Up-front involvement of construction personnel		√	√					√	√	
12	Strategic constructability workshop/Brainstorming		√			√					
13	Design progress meeting		√								
14	Constructability evaluation workshop		√							√	
15	Site progress meetings		√								
16	Post Construction review/Feedback Systems		√			√					√
17	Use of construction-sensitive schedules			√	√				√	√	
18	Designs that facilitate construction efficiency			√							
19	Use of innovative construction methods			√				√		√	√
20	Owner, designer and constructor personnel review specifications in detail				√	√		√	√	√	√
21	Designs and layout promote accessibility of manpower, material and equipment				√		√		√	√	
22	Corporate implementation manual					√					
23	Contract Incentive Clause					√					
24	Formal Implementation Process					√			√		
25	Corporate lessons learned log/file					√					
26	Non graphical computer models					√					
27	Design Checklist Reviews					√					
28	Quality Assurance and Control					√					
29	Plan the sequence of field tasks to improve						√			√	

30	Consider alternative water conservation and site drainage solutions	√		
31	Use structural elements as finished materials/selection of materials	√	√	
32	Advance information technologies are applied throughout the project	√		
33	Designs are configured to enable efficient construction	√	√	
34	Design and construction sequencing should facilitate system turnover and start-up	√		
35	Advice owner in the establishment of the project goals and objectives		√	
36	Execution of feasibility studies and advice in selection of site		√	
37	Advice owner in the contracting strategy		√	
38	Preparation of estimates and budget		√	
39	Pro-actively involved in developing project plans		√	
40	Use pre-construction plans as a basis for input to design		√	
41	Review and select constructability issues which are most important to the project including the need for special studies		√	
42	Make timely input to design to avoid the need for changes		√	
43	Implementation of construction expert knowledge		√	
44	Innovation			√

METHODOLOGY

Data Collection Instrument

Various constructability practices were identified in literature and used in forming the questionnaire. The survey instrument had four main sections: project characteristics, early design constructability practices (coded x), late design constructability practices (coded y), contractors' pre-construction constructability practices (coded z) and project performance. It was vetted for content validity by submission to two senior academics in the Department of Quantity Surveying, University of Benin, Nigeria. The process led to refining and rewording the practices obtained from literature, and inclusion of some roadwork-specific constructability practices. The survey was carried out by emailing the questionnaires (in excel and google form formats) to the members of the population between January 2020 and March, 2021. Respondents were requested to fill the questionnaire to reflect the latest road projects in which they participated. The study mainly targeted highway engineers, civil engineers and quantity surveyors in both construction and consultancy firms of Nigerian ownership. Emails of the professionals obtained from their professional bodies were used for the purpose of the study. First, the emails were verified, and only 443 of them were found to be functional and useful for the study. By applying the Yamane (1964) formula for finite population.

$$n = \frac{N}{1+N(e)^2} \qquad 1$$

where: 1 = constant value, n = sample size, N = population size (443), e = level of significance (0.05), a sample size of 139.41 was obtained. Emails were sent to 139 members of the population. Only 67 professionals acknowledged receipt of their emails after several reminders were sent. Forty-four (44) acceptably filled questionnaires were returned and analysed using mean score and Kruskal Wallis tests. The response rate (31.55%) was accepted because it exceeded the threshold response rate of 20% to 30% for adequacy of response in construction management studies (Babatunde et al. 2020).

Kruskal Wallis test is a non-parametric alternative to the analysis of variance test. It was applied in this study to observe the differences in road work constructability and performance as a result of differing project settings/cultures (private, state, federal and MDB) and project complexity (measured by the length of the roads). Maylor (2003) recognized project size as one of the measures of its complexity. Where significant differences were observed in the important constructability practices, multiple comparison analysis was carried out to identify the source of the differences. The variables were categorized as important or unimportant using a cut-off mean score of 3.0 following the example of Sarhan *et al*. (2017). Most of the respondents were civil engineers and members of the Nigerian Institution of Civil Engineers (45.45%) followed by the quantity surveyors (38.64%). The respondents are knowledgeable enough to give useful opinions about the constructability of road projects given that most of them have construction industry work experiences of 6 to 10 years (40.91%) followed by those with 16 to 20years (25%) as shown in Table 2.

RESULTS AND DISCUSSION

Characteristics of Projects

Table 2 also shows the characteristics of the projects based on which the responses were given. Most of the projects (68.18%) were made of bituminous asphalt flexible pavements of >1 ≤10Km length. Single carriage ways were mostly (47.73%) reported on, and most (34.09%) of the projects were Federal Government of Nigeria funded.

Important Constructability Practices of Road Projects

Only 30 of the identified constructability practices were found to be important basedon the cut off mean score of 3.0 (Table 3). Overall, the most important constructability practice is the late design stage constructability practice *cost optimization* (y15), (ms=4.25) followed by the contractor's pre-construction constructability practices, *site visit/examination of site features (z2)* and *review of security situation (z10)*. The least ranking important constructability practice is the the contractor's pre-construction constructability practice *assessment of protective work needs (z14)* (3.07). Kruskal Wallis Test analyses of the responses showed that significant differences exist in the adoption of 12 of the important constructability practices in the 4 project settings: federal and state governments, MDBs and the private sector. This indicates that some constructability practices vary under different project settings.

Early Design State Constructability Practices

None of the early design stage constructability practices was found to differ significantly for the 4 project settings. In terms of project complexity, the Kruskal Wallis test showed that significant differences exist in x1, x13 and x14 of the important early design stage constructability practices. Multiple comparison analyses revealed that ESIA is significantly less practised in roads of <1.0km than in roads of >1km≤10km and >10km≤20km, availability of local materials is less considered in roads of <1.0km than in roads of >10km≤20km, and significantly fewer reconnaissance surveys are carried out in roads of <1.0km than in roads of >1km≤10km and >10km≤20km.

Late Design Stage Constructability Practices

A test of difference in the importance of the late design stage constructability practices for different project organisational settings revealed that *cost minimization (y15)* (p=0.03) and *adequate allowance for temporary/protective works (y10)* (p=0.02) differ significantly among the four project settings. Multiple comparison analysis revealed that y15 (p=0.026) and y10 (p=0.015) have significantly higher mean ranks for federal government projects than for private sector projects (see Table 3), implying that they are significantly more prevalent in federal government projects than in private sector projects. The only important constructability practice that differs significantly for different road complexities is *possibility of recycling asphalt (y17)*. The respondents considered its importance to be significantly lower for <10km roads than for 10km≤20km.

Table 2: Respondents' and Projects' Characteristics

Criteria	Categories	Frequency	Percentage (%)
Profession	Highway Engineers	7	15.91
	Civil Engineering	20	45.45
	Quantity Surveying	17	38.64
Construction industry work experience	1 – 5year	2	4.55
	6 – 10years	18	40.91
	11 – 15years	8	18.18
	16 – 20years	11	25
	Above 20 years	5	11.36
Respondents' Professional Body	Nigerian Institution of Highways and Transportation Engineers	7	15.91
	Nigerian Institution of Civil Engineers	20	45.45
	Nigerian Institute of Quantity Surveyors	17	38.64
	PROJECT CHARACTERISTICS		
Road Type	Flexible pavement	30	68.18
	Rigid pavement	14	31.82
Length of Road	less than one kilometre	10	22.73
	1 to 10Km	16	36.36
	10 to 20km	8	18.18
	Greater than 20Km	10	22.73
Number of Carriageways	Single carriage way	21	47.73
	Dual carriage way	18	40.91
	More than 2 carriage ways	5	11.36
Project Funding	State Government	12	27.27
	Federal Government	15	34.09
	MDBs	8	18.18
	Private	9	20.45

Table 3: Overall Ranking of Constructability Practices of Indigenous Road Construction Companies

S/N	CODE	CONSTRUCTABILITY PRACTICE	MEAN	RANK	Project setting		Project Complexity	
					Sig	Decision	Sig	Decision
1	y15	Cost minimization	4.25	1	0.031	Reject Ho	0.096	Accept Ho
2	z2	Site visit/examination of site features	3.75	2	0.043	Reject Ho	0.018	Reject Ho
3	z10	Review of security situation	3.68	3	0.208	Accept Ho	0.027	Reject Ho
4	x2	Route optimization	3.55	4	0.076	Accept Ho	0.081	Accept Ho
5	x10	Logistics	3.48	5	0.049	Reject Ho	0.189	Accept Ho
6	z5	Site layout planning	3.48	6	0.048	Reject Ho	0.082	Accept Ho
7	z8	Project scheduling	3.48	7	0.048	Reject Ho	0.082	Accept Ho
8	z16	Development of safety manual	3.43	8	0.040	Reject Ho	0.057	Accept Ho
9	x13	Environmental and Social Impact assessment (ESIA)	3.36	9	0.192	Accept Ho	0.016	Reject Ho
10	x8	Policy of project execution during the dry season to minimize the effects of weather	3.34	10	0.050	Accept Ho	0.050	Accept Ho
11	y4	Designing for minimized use of earthmoving equipment	3.34	11	0.045	Reject Ho	0.056	Accept Ho
12	z17	Reference to lessons learned from other projects	3.34	12	0.050	Accept Ho	0.05	Accept Ho
13	y1	Pavement standards	3.32	13	0.092	Accept Ho	0.096	Accept Ho
14	z7	Development of method statement	3.32	14	0.061	Accept Ho	0.073	Accept Ho
15	z3	Study of contract/construction documents	3.25	15	0.048	Reject Ho	0.039	Reject Ho
16	x7	Location of borrow pits	3.23	16	0.056	Accept Ho	0.084	Accept Ho
17	y11	Soil tests	3.23	17	0.240	Accept Ho	0.075	Accept Ho
18	x3	Obstacle avoidance	3.18	18	0.220	Accept Ho	0.043	Reject Ho
19	y17	Possibility of re-cycling asphalt	3.16	19	0.064	Accept Ho	0.029	Reject Ho
20	z6	Supply chain management plan	3.16	20	0.157	Accept Ho	0.029	Reject Ho
21	z12	Development of an equipment plan	3.16	21	0.091	Accept Ho	0.038	Reject Ho
22	x1	Availability of (local) materials	3.14	22	0.124	Accept Ho	0.02	Reject Ho
23	x4	Security	3.14	23	0.066	Accept Ho	0.151	Accept Ho
24	x11	Obtaining accurate survey/topographical map	3.11	24	0.079	Accept Ho	0.095	Accept Ho
25	x14	Reconnaissance survey	3.11	25	0.470	Accept Ho	0.019	Reject Ho
26	y10	Adequate allowance for temporary/protective works	3.11	26	0.020	Reject Ho	0.047	Reject Ho
27	z9	Optimization of materials haulage	3.11	27	0.062	Accept Ho	0.046	Reject Ho
28	z11	Analysis of major risks	3.11	28	0.117	Accept Ho	0.029	Reject Ho
29	z15	Development of quality assurance manual	3.11	29	0.069	Accept Ho	0.064	Accept Ho
30	z14	Assessment of protective work needs	3.07	30	0.027	Reject Ho	0.068	Accept Ho

The inference for all the items are termed 'Important'

Pre-construction constructability practices

Amongst the important pre-construction constructability practices, only *site visit/examination of site features* and *assessment of protective work needs* were significantly different for the different project settings. Multiple comparison analyses showed that these practices are more prevalent in federal government funded projects than in private sector projects. In terms of road complexity, the Kruskal Wallis Test showed that 4 of the important constructability practices vary significantly for different lengths of road (Table 9). These are *site visit/examination of site features (z2)* (p=0.02), *review of security situation (z10)* (p=0.03), *supply chain management plan (z6)* (p=0.03) and *analysis of major risks (z11)* (p=0.03). Multiple comparison analyses revealed that while z2 and z10 are practised significantly more in roads of 1 to 10Km than in roads of <1Km, Z6 and Z11 are practised more in roads of 10 to 20Km than in roads of <1Km.

Influence of Constructability Practices on Project Performance

Tables 4 and 5 show the respondents' perceptions of the influence of constructability practices on the performance of road projects for roads of different complexities and organisational settings. The respondents consider constructability practices to have their highest influences on project schedule followed by cost, quality and safety. Based on the research data, constructability practices have the lowest influence on whether the stakeholders get satisfied or not.

Table 4: Influence of Constructability on Measures of Project Performance

Code	Project Performance	N	Mean	Std. Deviation	inference	Rank
P1	Time	44	3.82	1.17	High	1
P2	Cost	44	3.73	1.23	High	2
P3	Quality	44	3.57	1.37	High	3
P4	Safety	44	3.34	1.35	High	4
P5	Absence of disputes	44	2.84	0.89	Low	5
P6	Stakeholder satisfaction	44	2.68	1.16	Low	6

Significant differences exist in the perceived influence of constructability practices on project time and cost (Table 5). Multiple comparison analyses showed that the schedule of roads of less than 1Km are less significantly influenced by constructability practices than roads of ≥1<10Km and ≥10 <20Km. Similarly, the cost of roads of ≥10Km<20Km are more significantly influenced by constructability practices than the cost of roads of less than 1Km.
In terms of project settings, the study reveals that constructability practices have higher influences on the safety of federal government road projects than on privately funded road projects.

DISCUSSION

An overall ranking of the important constructability practices (Table 4) shows that the late design stage practice *cost optimization* (y15) is the most important constructability practice employed by the IRCFs. This is followed by two contractor's pre-construction constructability practices: *site visit/examination of site features (z2)* and *review of security situation (z10)*. Road designers seriously attempt to keep the cost of road projects low at late design stage. However, after the award, contractors acquire information about the physical characteristics of the site and the security situation along the road alignment. Since the data for this study was obtained from IRCFs from different parts of Nigeria, it means that the impact of insecurity on construction activities is not restricted to the North-Eastern parts of Nigeria which Adebiyi and Sanni (2019) focused on.

Table 5: Importance of Constructability to the Performance of Road Projects by complexity and type of funding

			Length of Road Mean Rank						Project Setting Mean Rank			
Project performance	Length of Road Sig.	Inference	less than one kilometer	1 to 10Km	10 to 20km	Greater than 20Km	Funding Sig.	Inference	State government	Federal Government	MDBs	Private Sector
Time	0.012	R	12.68	27.14	28.2	21.7	0.136	A	21.00	26.93	24.8	15.50
Cost	0.026	R	13.18	26.14	28.1	22.65	0.112	A	20.10	27.61	24.5	15.75
Quality	0.050	A	13.77	25.46	28.1	22.9	0.093	A	21.05	27.39	24.75	14.85
Safety	0.056	A	14.36	25.04	28.9	22.15	0.039	R	21.35	27.82	25.3	13.40
Absence of disputes	0.032	R	14.18	25.43	29.2	21.5	0.055	A	21.4	26.96	25.85	14.00
Stakeholder satisfaction	0.079	A	14.86	25.43	28.2	21.7	0.095	A	20.9	27.36	24.9	14.90

A=Accept null hypothesis, R=Reject null hypothesis

This study's data generally demonstrate that constructability practices are considered important during the early and late design stages of road construction projects by IRCFs in Nigeria, albeit, to varying degrees. Some of the important constructability practices at the early design stage include route optimization (x2), logistics (x10), and environmental and social impact assessment (ESIA) (x13). This result is similar to the findings of Trigunarsyah (2004) and Akpan *et al*. (2014) to the effect that constructability practices are commenced at the conceptual planning stage of road projects. The result, however, differs from Akpan *et al*. (2014) in which all identified constructability factors were rated important. It is apparent that while construction professionals consider constructability practices to be important, it does not translate to actual implementation of all the practices on the projects in which they actually participated.

Further analysis using the Kruskal Wallis test indicated that some of the important constructability practices are less practised in projects of less than 1Km. This could be due to practitioners' expectation of higher cost-benefit ratios for roads of lower length (size)/complexity. African Development Bank (AfDB) (2014) found that project size has a high explanatory power over the cost growth of road projects. Africon (2008) noted that roads of less than 50Km cost significantly more than roads of greater than 50km length. Supportively, the results of this study reveal that schedules and costs of roads of less than 1Km are the least affected by constructability practices. Longer (more complex) roads are given more constructability attention than shorter roads particularly those of less than 1Km contrary to Windapo and Ogunsanmi's (2014) conclusion that project complexity is a severe barrier to constructability practices in building projects. The result aligns with Arditi, *et al*. (2002) that project complexity dictates the extent of constructability to be carried out on a project.

Further, the study signifies greater use of constructability practices in federal government roads than in privately funded ones. The lower practice and influence of constructability in private sector road projects may be related to the sector's profit-to-risk optimization drive (Moles and Williams, 1995).

Poh and Chen (1998) found that a relationship exists between buildability scores and project time performance, but not with project cost performance. While collaborating the findings of Poh and Chen to the effect that constructability practices affect the time performance of projects, this study reveals that constructability practices also *highly* affect project costs. This latter aspect aligns with the findings of Trigunarsyah (2007). It also supports Low's (2001) finding that constructability is positively related to construction productivity and quality.
Arditi, *et al*. (2002) identified fewer lawsuits as the second highest benefit of constructability. Contrariwise, this study indicates that constructability poorly influences the absence or therewise of construction disputes in Nigeria. Indicatively, further efforts at identifying and mitigating dispute pathogens at the early stages of procurement are required during constructability reviews for road projects in the country.

CONCLUSION

This study explored the constructability practices of IRCFs. The study considered the practices at different stages prior to commencement of site operations, namely: early design and late design stages, as well as contractors' pre-construction constructability practices. Further, it differentiated between the practices for different road complexities (measured by length of road) and project settings.

The most important constructability practice at the early design stage is route optimization, while the most important practice at the late design stage is cost minimization. The most important constructability practice by indigenous contractors for road projects is site visit/examination of site features. These should form the pre-construction constructability focus of IRCFs in future road projects. Constructability practices are less practised in less complex road projects. For example, at the early design stage, important constructability practices like ESIA are least carried out in roads of <1km. At the late design stage, the data showed that cost optimization and adequate allowance for temporary/protective works are significantly practised more in federal government funded projects than in private sector projects.

The measures of project performance, namely, cost, quality, time and safety are highly influenced by constructability practices for the data obtained for this study. However, the results show that absence of disputes and stakeholder satisfaction are hardly influenced by constructability practices.

Future studies on constructability should take cognizance of the effects of project complexity and organisational setting since these could determine the extent of constructability practice, and therefore, the outcome of the practice. Additionally, the private sector should take steps to improve on their use of constructability practices, particularly, in order to improve on the safety of their road projects, which this study found to be significantly lower than the safety outcome of federal government funded road projects. Professionals should give attention to reducing the possibility of construction disputes and attaining better stakeholder management during constructability reviews.

References

Adams, O. (1997). Contractor development in Nigeria: perceptions of contractors and professionals. *Construction Management & Economics*, *15*(1), 95-108. https://www.tandfonline.com/doi/abs/10.1080/014461997373141

Adebiyi, J., Sanni, G. A. & Oyetunji, A. K. (2019). Assessment of political risk factors influencing the corporate performance of multinationals construction companies in northeastern Nigeria. *Global Journal of Business, Economics and Management*, 9(2), 63-75. https://doi.org/10.18844/gjbem.v9i2.4232

African Development Bank (2014). Study on Road Infrastructure Costs: Analysis of Unit Costs and Cost Overruns Statistics Department (ESTA) of Road Infrastructure Projects in Africa https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/Study_on_Road_Infrastructure_Costs-Analysis_of_Unit_Costs_and_Cost_Overruns_of_Road_Infrastructure_Projects_in_Africa.pdf

Africon (2008). Unit costs of infrastructure projects in sub-saharan Africa. http://www.eu-africa-infrastructure-tf.net/attachments/library/aicd-background-paper-11-unit-costs-summary-en.pdf

Aina, O. O. (2015). Buildability problems in construction projects in Nigeria; causes and impacts. *European Scientific Journal*, *11*(27), 353 - 366

Akpan, E. O. P., Amade, B., Okangba, S. E. & Ekweozor, C. O. (2014) "Constructability Practice and Project Deliver Processes in the Nigerian Construction Industry". *Journal of Building Performance Vol 5, Issue 1, 2014 pp 10-21.*

Amade, B. (2016). Constructability tools and techniques in use in the Nigerian construction industry. *PM World Journal*, *5*(2), 1-19..

American Association of State Highway and Transportation Officials (AASHTO), (2000). Constructability review best practices guide http://sp.construction.transportation.org/Documents/AASHTOConstructabilityFinal.pdf

Arditi, D., Elhassan, A., & Toklu, Y. C. (2002). Constructability analysis in the design firm. *Journal of construction engineering and management*, *128*(2), 117-126.

Babatunde, S. O., Perera, S., Ekundayo, D., & Adeleke, D. S. (2020). An investigation into BIM uptake among contracting firms: an empirical study in Nigeria. *Journal of Financial Management of property and Construction*. 1366-4387 DOI 10.1108/JFMPC-06-2019-0054

Bureau of Public Procurement (2019). Federal Executive Council Approved Contracts. https://www.bpp.gov.ng/wp-content/uploads/2019/01/FEC-FY2016.pdf

Building and Construction Authority (2011) Code of Practice on Buildability. Retrieved from https://www1.bca.gov.sg/docs/default-source/docs-corp-news-and-publications/publications/for-industry/buildability-series/copbdapr2011.pdf

Cheetham, D. W., & Lewis, J. (2001, September). Productivity, buildability and constructability: is work study the missing link. In *17th Annual ARCOM Conference* (pp. 5-7).

David-West, M. (2015, December 10). Road sector reform: imperative for sustainable road development. Second National Conference and Annual General Meeting of the Nigerian Institution of Highway Engineers. *http://pearlconsultantsng.com/resourceshub/roadreform.pdf*

Federal Government of Nigeria (2018). Presidential executive order for planning and execution of projects, promotion of Nigerian content, in contracts and science, engineering and technology. http://statehouse.gov.ng/wp-content/uploads/2018/02/PRESIDENTIAL-EXECUTIVE-ORDER-5.compressed.pdf

Flyvbjerg, B., Holm, M. S., & Buhl, S. (2002). Underestimating costs in public works projects: Error or lie? *Journal of the American planning association*, 68(3), 279-295.

Francis, V. E., Chen, S. E., Mehrtens, V. M., Sidwell, A. C., & McGeorge, W. D. (1999). Constructability strategy for improved project performance. *Architectural Science Review*, *42*(2), 133-138.

Goodrum, P. M., Hancher, D. E., & Yasin, M. (2003). A Review of Constructability Barriers and Issues in Highway Construction. In *Construction Research Congress: Wind of Change: Integration and Innovation* (pp. 1-9).

Ibrahim, I.I., Githae, W., and Stephen, D., (2014). Indigenous contractors involvement and performance in construction procurement systems in Nigeria. Global Journal of Research In Engineering. 14(1), pp. 1-15 https://globaljournals.org/GJRE_Volume14/2-Indigenous-Contractors.pdf

Irumba, R. & Mwakali, J. A. (2007). Factors Responsible for Preference of Migrant Skilled Construction Artisans to Their Indigenous Counterparts on Construction Sites in Nigeria. CIB world building congress 2007. Retrieved from https://www.irbnet.de/daten/iconda/CIB4994.pdf

Jergeas, G., & Van der Put, J. (2001). Benefits of constructability on Construction Projects, *Journal of Construction Engineering and Management*, 127(4), 281-290.

Kifokeris, D., & Xenidis, Y. (2017). Constructability: Outline of past, present, and future research. Journal of Construction Engineering and Management, 143(8), 04017035.

Lam, P. T., Chan, A. P., Wong, F. K., & Wong, F. W. (2007). Constructability rankings of construction systems based on the analytical hierarchy process. *Journal of architectural engineering*, 13(1), 36-43.

Leiringer, R. and Hughes, W. (Eds) *Procs 4th West Africa Built Environment Research (WABER) Conference*, 24-26 July 2012, Abuja, Nigeria, 1095-1109.

Liu, H. (2016). BIM-based Automated Planning for Panelized Construction in the Light-Frame Building Industry.

Love, P. E., Ahiaga-Dagbui, D. D., & Irani, Z. (2016). Cost overruns in transportation infrastructure projects: Sowing the seeds for a probabilistic theory of causation. *Transportation research part A: policy and practice*, 92, 184-194.

Low, S. P. (2001). Quantifying the relationships between buildability, structural quality and productivity in construction. *Structural Survey*, 19*(2)*; 106 – 112

Maylor, H., (2003). *Project Management*. (3rd ed). FT Prentice Hall, Harlow, UK.

Mbamali, I., Aiyetan, O. A., & Kehinde, J. O. (2005). Building design for buildability: an investigation of the current practice in Nigeria. *Building and environment*, 40(9), 1267-1274.

McManus, J. F., Phillip, N. A., Stanton, J. F., & Turkiyyah, G. M. (1996). A Framework for the Constructability Review of Transportation Projects. *Washington State Transportation Center (TRAC), WARD, 409*. Retrieved from shorturl.at/xFJN7

Mendelsohn, R. (1997). The Constructability review process: a constructor's perspective. *Journal of Management in Engineering*, 13(3), 17-19.

Mohsenijam, A., Mahdavian, A., & Shojaei, A. (2020, November). Constructability Concepts, Significance, and Implementation. In Construction Research Congress 2020: Project Management and Controls, Materials, and Contracts (pp. 475-484). Reston, VA: American Society of Civil Engineers.

Moles, P., & Williams, G. (1995). Privately funded infrastructure in the UK: Participants' risk in the Skye Bridge project. *Transport Policy*, 2(2), 129-134.

National Planning Commission (2015). *National Integrated Infrastructure Master Plan* Abuja; National Planning Commission.

https://nesgroup.org/storage/app/public/policies/National-Intergrated-Infractructure-Master-Plan-2015-2043_compressed_1562697068.pdf

Ojo, M. (2019, August 5-7). *Cost of construction projects in Nigeria -challenges and ways forwards.* West Africa Built Environment Research (WABER) Conference 10th Anniversary Conference, 5-7 August 2019, Accra, Ghana DOI: https://doi.org/10.33796/waberconference2019.23.

Ogbu, C. P. (2018). Survival practices of indigenous construction firms in Nigeria. *International Journal of Construction Management*, *18*(1), 78-91.

Ogbu, C. P., & Asuquo, C. F. (2018). Ethical and cost performances of projects: a canonical correlation. *International Journal of Ethics and Systems*.34 (*3*), 352-371.

Ogbu, C. P., & Olatunde, N. (2019). Relationship between Organisational Effectiveness and Project Performance of SME Contractors: a Developing Country Perspective. *Journal of Construction Business and Management*, *3*(2), 1-16.

Oke, A. E., Aghimien, D., & Adedoyin, A. (2018). SWOT analysis of indigenous and foreign contractors in a developing economy. *International Journal of Quality & Reliability Management*, *35*(6), 1289-1304.

Oladimeji, O., & Ojo, G. K. (2012, July). An appraisal of indigenous limited liability Construction Company in South-Western Nigeria. In *Proceedings of the 4th WABER Conference* (pp. 1095-1109).

Olatunji, A. A. (2010) Influences on construction project delivery time, A thesis submitted in fulfillment of the requirements for the award of philosophiae doctor in construction management in the faculty of engineering, the built environment and information technology at the nelson mandela metropolitan university. Retrieved from https://core.ac.uk/download/pdf/145049538.pdf

Pocock, J. B., Kuennen, S. T., Gambatese, J., & Rauschkolb, J. (2006). Constructability state of practice report, *Journal of Construction Engineering and Management*, 132(4), 373-383.

Pison Housing Company (2013), "Compendium report on road infrastructure and related developments in Nigeria – an investor's manual", Obtained from http://www.casafrica.es/casafrica/Newsletter/2017/Compendium-Report_PPP_Nigeria.pdf

Poh, P. S., & Chen, J. (1998). The Singapore buildable design appraisal system: a preliminary review of the relationship between buildability, site productivity and cost. *Construction Management & Economics*, *16*(6), 681-692.

Pulaski, M. H., Horman, M. J., & Riley, D. R. (2006). Constructability practices to manage sustainable building knowledge. Journal of Architectural Engineering, 12(2), 83-92

Rebosio, M. & P. E. Wam (2011). Violent conflict and the road sector: Points of interaction. Technical report, The World Bank.http://documents.worldbank.org/curated/en/209351468325285558/pdf/697680ESW0P1100onflict0roads0sector.pdf

Saghatforoush, E., Hassim, S., Jaafar, S., & Kadir, R. A. (2009). Constructability implementation among Malaysian building contractors. *European Journal of Scientific Research*, *29*(4), 518-532.

Sarhan, J. G., Xia, B., Fawzia, S., & Karim, A. (2017). Lean construction implementation in the Saudi Arabian construction industry. *Construction Economics and Building*, *17*(1), 46-69.

Skibniewski, M. J. (1999). Quantitative constructability analysis with a neuro-fuzzy knowledge-based multi-criterion decision support system. *Automation in construction*, *8*(5), 553-565.

Trigunarsyah, B. (2004). Constructability practices among construction contractors in Indonesia. *Journal of construction engineering and management*, *130*(5), 656-669.

Trigunarsyah, B. (2007). Project designers' role in improving constructability of Indonesian construction projects. *Construction Management and Economics*, *25*(2), 207-215.

Ugochukwu, S. C., & Onyekwena, T. (2014). Participation of Indigenous Contractors in Nigerian Public Sector Construction Projects and their Challenges in Managing Working Capital. *International Journal of Civil Engineering, Construction and Estate Management* Vol.1, No.1, pp.1-21, March 2014.

Uhlik, F. T., & Lores, G. V. (1998). Assessment of Constructability Practices among General Contractors, *Journal of Architectural Engineering*, 4(3), 113-123.

Windapo, A. O., & Ogunsanmi, O. E. (2014). Evaluation of the barriers to the use of appropriate constructability practices on construction projects. *Journal of Construction Project Management and Innovation*, *4*(1), 734-754. Washington State Department of Transportation.

Xue, K., Hossain, M., Liu, M., Ma, M., Zhang, Y., Hu, M., & Cao, G. (2021). BIM Integrated LCA for Promoting Circular Economy towards Sustainable Construction: An Analytical Review. *Sustainability*, *13*(3), 1310.

Yamane, T. (1964). Statistics: An introductory analysis. (New York, Harper Row Publishers).

Ying, L. J., & Pheng, L. S. (2007). Enhancing buildability in China's construction industry using Singapore's buildable design appraisal system. *Journal of Technology Management in China*.