



Comparison of labour – based/light equipment and heavy equipment-based methods of construction for a typical rural road in Nigeria

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Abstract

Road construction, being capital-intensive has been particularly plagued in the nineties in Nigeria due to the downward trend of the nation's economy coupled with the gross devaluation of her currency – Naira. For a country largely dependent on the use of imported heavy equipments for road construction, such currency devaluation had brought severely negative impacts on various facets of the country's development. Hence the current drive for prudent management of scarce foreign reserves and sustenance of the local manufacturing industry. Investigation was therefore made to the relative advantages and disadvantages of using labour-based/light equipment method and heavy equipment – based method to construct a rural road (Igboku access road) in Epe, Lagos, Nigeria. The parameters measured include cost (local and foreign), labour usage and completion time. It was found that the labour – based method (Ibm) is cheaper than the equipment – based method (ebm) Savings of about 40% of total costs of the equipment-based method was obtained. Moreover, the labour-based method required much less expenditure in foreign exchange, yielding a saving of as much as 85% of the foreign exchange requirements for equipment-based method. Furthermore, the labour-based method entailed the usage of far greater level of local labour thus generating up to 1000% more local employments than the equipment – based method. However, the labour-based method took four weeks longer to complete.



Introduction

In Nigeria before the advent of the British colonial administration, the main mode of transportation was draught animals over bush paths. The first motorable road in Nigeria was built in 1906 from Ibadan (the nation's largest city) to Oyo – an ancient town, about 70km away from Ibadan. By 1914, some other roads had been constructed bringing the motorable roads in Nigeria to well over 3200km. In 1962, Lagos (Nigeria's economic nerve centre and former capital city of Nigeria) was finally linked with Ibadan by road (Onakoimaiye[1]). The development of roads in Nigeria continued shortly until early seventies which marked the country's turning point in her history of highway development consequent upon the advent of her oil boom. With the oil boom, the construction industry became a potent motivator of Nigeria's economy, providing the driving force necessary for sustaining a buoyant economy. The output of the industry in Nigeria accounted for over 70% of the country's Gross Domestic Product (Ikpeze [2]). However the Nigerian construction industry has been bedeviled by a myriad of problems ranging from prohibitive cost of construction to wide discrepancies between planned and actual construction duration sometimes leading to outright abandonment of the project (Mbachu [3]). Evidently, viable solutions need to be considered in view of the present harsh economic climate in the country, hence the labour – based method. The lbm is an approach where the bulk of the construction activities are undertaken by properly trained, organised and supervised workforce augmented with light equipment in a step-wise manner. The ebm contrasts with the lbm in that the bulk of the work is undertaken by heavy equipments with some support rendered by a small number of skilled workers. The potentials and advantages of the lbm of construction have been recognised. Apart from savings in cost, the lbm provides productive opportunities and promote greater grassroot participation in rural development. High quality standards have also been achieved with appropriate level of supervision (Hussain *et al* [4]). Moreover, applying the System Input Productivity Concept, the lbm has yielded substantial naira savings compared to the ebm (Ofiabulu and Coker [5]).

The case study

Igboku road providing easy access to Igboku farmlands in Epe Local Government Area (LGA) of Lagos State, Nigeria was the case study. The road is 2km – long, traversing a loamy soil underlain by lateritic soil. The topography of the area is generally rolling but flattens out as it approaches the swamp. The vegetation consisted of dense shrubs with occasional clusters of trees, interspersed with farmlands. Epe LGA was selected for the location of the demonstration project because of its easy accessibility to Lagos and the fact that labour is abundantly available in the area.



Comparative analysis indicators

For the purpose of comparative analysis of the Igboku access road, the following comparative analysis indicators were prepared and used:

- (a) Longitudinal sections and cross sections
- (b) Bills of quantities
- (c) Method statements
- (d) Time and location chart
- (e) Cost estimates
- (f) Schedule of resources
- (g) Cost comparison schedules

Market price survey and overall costing

The market prices of handtools and hiring prices of light equipments and heavy equipments were collected from Epe LGA and from hiring firms based in the nearby metropolitan city of Lagos. Labour prices were collected from the labour office in Lagos supplemented with data from the field. The prices covered the periods 1990 – 1998. Similarly, the items of costs in the prepared schedule of resources and cost estimates were used to produce cost estimates of the project. The actual cost of construction of the Igboku farm access road is a summation of four components: labour, handtools, materials and equipments. The labour cost represents the labour wages as well as those of the lower level supervisory staff: headmen and gangleaders. The handtool cost represents the actual cost of purchase of the handtools as well as the cost of repairs and maintenance. In the case of the materials, the cost of purchase and transportation of the materials were taken. The equipment component is the cost of hire, running and lubrication of the equipment.

Results and discussions

Tables 1,2 and 3 present the prices for equipments, materials and handtools respectively. Schedule of resources were then prepared using the specified quantity of all the resources (needed to complete the project) to multiply the unit rates. Cost estimates were prepared by building up the cost items of the project. That is, summing the total costs of labour, materials, handtools and equipments. Table 4 gives a comparison of costs and completion time for lbm and cbm. Savings of 39.7% was obtained by using the former. This amounted to 1.6143422.2 naira or about 19000 US dollars in 1998 when 1 dollar exchanged for 85 naira. As expected, the allotment of costs per resources item under the lbm revealed that labour constitutes 40.7%, handtools 37.2% and light equipments 10.5% (Table 4). In contrast, labour constitutes 5.8%, handtools 2.8% and heavy equipments 85% under the cbm (Table 4). This has obvious implications in terms of foreign exchange needs since the heavy equipments are all imported as at now in to Nigeria. The savings made in foreign exchange requirements translates to huge financial outlay moreso that 1 US dollar currently (year 2000) exchanges for slightly over 100 Nigeria's naira.



The two methods of construction are also different in the extent of their local resources utilisation. The lbm utilised local resources to the extent of 85% total construction cost in the form of labour, handtools and materials. But in the case of ebm, only 12.9% of total costs can be accounted for by local resources, as much as 85% being incurred on imported items.

To be able to make the comparison between the two construction methods as far as employment generation is concerned, the values of workdays spent throughout were estimated.

The workers engaged on the site were divided into two broad categories: skilled and unskilled workers. The skilled workers included site engineers gangleaders, carpenters, masons, bricklayers, ironbenders and welders who suffered substantial underemployment in their normal occupations in and around the project area. The unskilled workers were mostly fresh school leavers, retrenched workers and housewives. Among this category were persons who needed capital to start or continue their retail, service and repair business, and others who had no previous employment before being recruited to work on this site. The workers were engaged to work for 8 hours on each working day (Monday through Saturday) with a lunch break lasting for 1 hour from noon. Each of the 2 categories of workers were paid a fixed cash wage per workday. Skilled and unskilled workers made up 5% and 95% of the work force respectively.

Table 5 compares the employment generation under the two approaches in the construction of the Igboku access road. The results show that 20,624 workdays (wd) of employment were generated by constructing with lbm in contrast to only 1876 workdays of employment generated when conventional ebm was used. Thus a shift from ebm to lbm could result in the creation of as much as 1000% more employment opportunities for this case study.

The 2km-long Igboku farm access road was designed as an earth road with a sub-base and laterite surface and a road width of 6.0m. The horizontal alignment followed the most prominent ridge as much as possible to minimise earthworks and facilitate drainage. The minimum radius of horizontal curves allowed was 15m, while the maximum longitudinal slope was 5%. Provisions for drainage included cambering/superelevation of the roadway, trapezoidal side and the mitre drains on both sides of the road and one single-cell pipe culvert. The camber slope was 5%. Wherever the bed slope of the side drains was greater than 2%, scouring checks were provided. The activities involved in the construction of the road were bush clearing, tree felling, grubbing, stumping, topsoil removal, borrow pit activities, subgrade/sub-base formation, laterite surfacing, drainage excavation and concrete works. To ensure that the quality of lbm of construction for the Igboku road compares favourably with the counterpart ebm, definite technical specifications for each construction activity were met. Such specifications were with respect to the source of construction material, methods, workmanship, the handtools and light equipments involved. The quality of the road was further ascertained by carrying out an in-situ investigation on the base and sub-base courses and the subgrade.



Table 1. Price list (in Nigeria's naira) for equipments

Equipments		Year Hiring cost in Naira								
Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998
Bulldozer	wd	4000	4000	4500	5000	12000	15000	16000	17500	18000
Shovel loader	"	4000	4000	4500	5000	12000	15000	16200	17000	18000
Excavator	"	1750	2000	2000	2500	3500	3500	8300	9000	9800
Grader	"	2400	2400	2400	3000	4000	12000	12500	13000	14000
Dumper	"	400	600	1000	1600	2500	4000	4000	5000	5750
Tipper	"	400	300	1000	1900	2600	4000	4500	8000	9000
Roller	"	1600	1600	200	3000	5500	8000	8500	8400	9000
Water bouser	"	450	800	1800	2000	3000	4500	5000	5400	5500
Hand roller	"	840	1000	1000	1000	1200	3000	3500	4000	4500

Table 2. Price list (in Nigeria's naira) for materials

Materials		Year / Price in Naira								
Description	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998
Cement	Bag	45	80	135	200	300	450	450	450	480
Sand	Load	120	150	250	350	600	1000	1200	1200	1250
Gravel	Load	400	800	1200	1900	3400	5500	5800	5800	5900
Timber	No.	80	45	65	95	140	180	200	200	220
Nails	Kg	5	10	15	20	30	50	55	55	60
Culvert rings	No	175	220	350	420	550	900	1000	1000	1050
Water	Litre	05	10	30	40	60	1 00	1 00	100	1 50

Table 3. Price list (in Nigeria's naira) for handtools.

Handtools	Year / Price in Naira								
Description	1990	1991	1992	1993	1994	1995	1996	1997	1998
Cutlass	54	100	130	200	300	420	430	435	450
Axe	115	180	250	385	550	700	720	740	750
Hoe	45	45	50	65	80	100	150	150	180
Pickaxe	45	60	95	130	200	250	300	300	300
Spade	75	90	150	280	420	600	650	650	670
Shovel	85	100	150	280	430	600	650	650	650
Headpan	75	75	100	165	200	350	400	400	400
Watering Can	60	60	100	165	300	400	420	450	450
Hand rammer	80	80	100	150	180	100	200	200	200
Wheel barrow	480	650	1000	1440	2000	2500	2750	2750	2800
Drum	300	320	400	550	800	1300	1380	1350	1380
File	20	40	68	100	150	200	200	200	200
Grinding	150	300	500	1000	1800	2500	2600	2600	2700
Spreader	50	65	120	150	200	300	345	345	350



Table 4. Cost comparison of labour – based and equipment – based method

Item	lbm	lbm	ebm	ebm
	Amount (Naira)	Percentage of total cost (%)	Amount (Naira)	Percentage of total cost (%)
Labour	998,768.00	40.7	236,037.5	5.8
Handtools	913,557.60	37.2	113,949.1	2.8
Equipment	258,400.00	10.5	3,459,169.5	85.0
Materials	173,700.10	7.1	173,700.1	4.3
Supervision	109,550.10	4.5	85,461.8	2.1
Total	2,435,975.80	100	4,068,318.0	100

Table 5. Comparison based on level of employment generation

Category of workers	lbm	ebm
	No. of workdays (wd)	No. of workdays (wd)
Unskilled labour	19,488	1,747
Skilled labour	1,136	129
Total Employment	20,624	1,876

Moisture tester was used to measure the moisture contents. The undisturbed samples were collected in the base course/sub-base course for unconfined compressive strength tests. The technical assessment made has shown that the quality of work using the lbm for the Igboku road was adequate. However, the lbm took a longer duration than the ebm in the construction of the Igboku road. The time and location chart gives the duration of each construction tasks. It is really a graphical representation of the tasks to be performed, time and the resources involved. It is prepared on the method statements and usually follows the ridge of the longitudinal sections. For the Igboku road construction, 16 weeks were spent using lbm compared to the 12 weeks spent using the ebm.

Conclusions and significance of findings for an urban setting

The following conclusions can be drawn based on the above comparison of lbm and ebm of construction for a 2km rural road in Nigeria:

- Lbm is a substantially cheaper approach particularly for constructing a short rural road. The economic realities prevailing in Nigeria where construction equipments are largely imported into the country have made the ebm a very expensive method.
- Large percentage of the construction cost in the lbm is required for locally-fabricated handtools which ultimately enhances the development of the local manufacturing sector of Nigeria's economy.
- The labour content in the lbm is significantly higher than the ebm. For a country such as Nigeria with labour surplus, the lbm offers employment to the teeming jobless people including women particularly in the poverty-stricken rural areas. Such involvement of the rural populace in rural-based



projects such as the Igboku farm access road would have tremendous socio-economic benefits on the long run.

- (d) Four weeks longer period was taken by the lbm compared to the ebm of construction for the 2km-road case study.

Although the Igboku case study is a rural road, the findings of this study are quite significant for an urban setting. Firstly, Epe, the location is becoming increasingly urbanised due to the influence of the ever-sprawling Lagos city. Secondly, the preparation of the aforementioned comparative analysis indicators such as section diagrams, bill of quantities, method statements, time and location chart, cost estimates, etc afforded the predictability of the cost implications and completion time of the project. This predictability had been a key edge of heavy equipment construction over labour - based construction in Nigeria. Moreover, the quality of the road was quite comparable to what is obtainable with ebm. Nevertheless researches are currently being undertaken in Nigeria to investigate what the scenario would be as per the investigated parameters if the road project is a large scale one in an urban setting e.g. an expressway.

References

- [1] Onakomaiye, S. O. *Highway Development in Nigeria: A review of policies and programme between 1900 – 1980*, Teton, Ibadan, Nigeria, pp. 270, 1987.
- [2] Ikpeze, N., *Technological Development in Nigeria: Obstacles and Policy* In: C.S. Ige and F.E. Onah (eds), *Production Problems in Nigeria Economy*. Jos, Nigeria, pp. 235 – 250, 1986.
- [3] Mbachu, J.I.C., *Prediction of the Construction Duration of Institutional Building Projects in Nigeria*; *Nigeria Journal of Construction Technology and Management*, **1(1)** pp. 88 – 92, 1998.
- [4] Hussain, M.I., Nwune, T.C. and Obi, A, *Introduction of Labour-based Construction Technology in Nigeria: Field demonstration and Experience*, The World Bank, Geneva, pp. 300, 1992
- [5] Ofiabulu, C.E. and Coker, A. O., *System Input Productivity Analysis: The Case of Road Construction. Proc. of the 1st Int. Conf. of the Nigerian Institute of Industrial Engineers*, University of Ibadan, Ibadan, Nigeria, Vol. 1 pp. 235-245, 1998.