



Research Article

An Investigation into the operations and Effectiveness of Earth moving construction Equipment for civil Engineering projects

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Abstract

Civil Engineering construction operations on a large scale requires the applications of standard Equipment for Effective operations especially in the area of infrastructural development. This is the true picture of large construction companies whose physical successful activities depends on men, materials and sophisticated machineries that will produce out put of operations during a particular period use. Thus, the effectiveness of construction machineries is a major factor that differentiates construction companies in terms of heavy construction and light construction. This paper has examined the operation and effectiveness of earth moving construction equipment for civil engineering projects execution in Nigeria with their production capacities during operations.

Keyword: operation, Effectiveness, Earth, moving construction Equipment, production capacities

INTRODUCTION

Whatever field of Civil Engineering it may be, the knowledge and the principles of operation and management of construction equipment and their most efficient field of operation is essential. Construction equipment have assumed a role of great importance to Engineers in the modern construction industry particularly construction of roads (paved and unpaved), dams, runways, power plants, irrigation schemes, water and wastewater works, etc involve a lot of earth moving a lot of earth moving works, which are equipment intensive operations. The use of construction equipment for accomplishing construction tasks is increasing rapidly. Plant and equipment now constitute a substantial portion of the construction costs in every Civil engineering project. The cost component usually depends upon the nature of the project and the extent to which equipment is employed. In a building project, the equipment costs may vary from 5% to 10% of the direct costs. While in highway construction projects, the plant and equipment costs may touch as much as 40% of the project direct costs. Therefore, understanding the fundamentals of the equipment is of vital importance to contractors and practicing professional Engineers in the field.

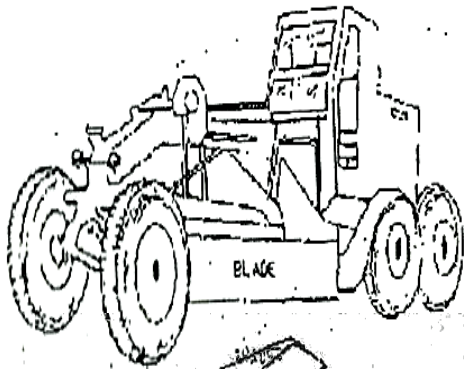
METHODOLOGY

(i) This study was carried out within the major Construction Companies in Kwara state. These are companies that are majorly civil and Building Engineering and are inclined in the execution of Housing and Infrastructural facilities development in the state.

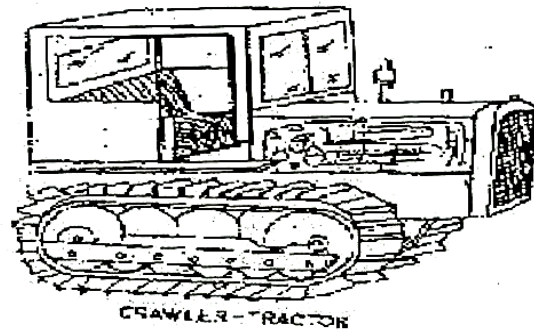
(ii) The visit to some of these companies in some local government within the state shows that these companies make use of construction Equipment for the execution of most of their projects. This is one of the reasons why these construction companies have a wider scope of operation and good performance in their construction activities.
(iii) The visit also awaits the opportunity of observing the practical operation of this construction Equipment with production and their effectiveness. The pictures taken for different construction Equipment were also reported for detail understanding and analysis.

Common Construction equipments available on most Civil and Building Engineering Construction sites

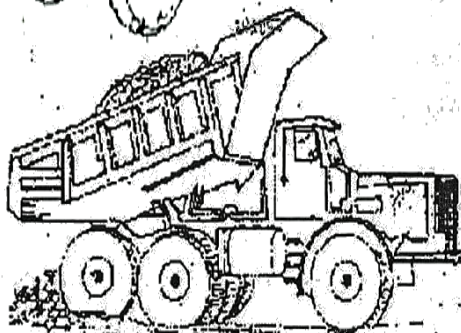
TRACTORS



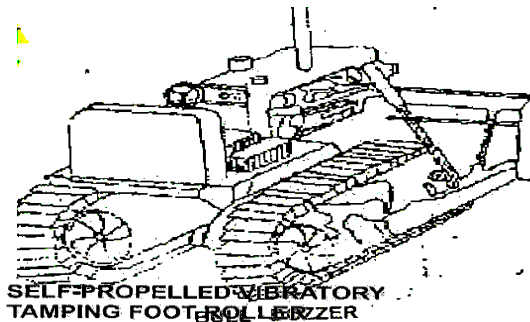
TRACTOR



CRAWLER-TRACTOR



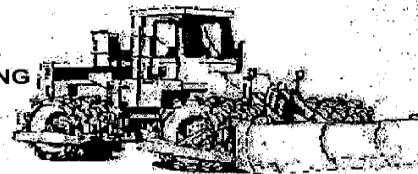
REAR DUMP TRUCK



SELF-PROPELLED VIBRATORY TAMPING FOOT ROLLER



SELF-PROPELLED TAMPING FOOT ROLLER

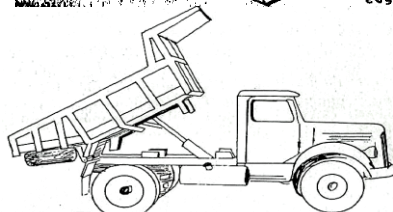
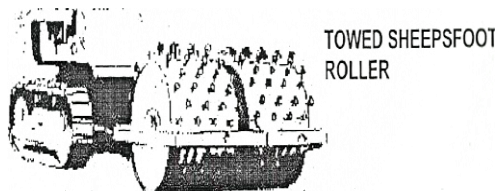
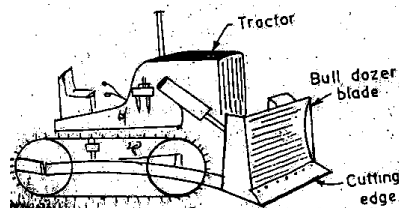


SELF-PROPELLED SEGMENTED STEEL WHEEL ROLLER



GRID ROLLER





5.3 Dumper. (Rear dumper)

Fig. 5.4. Dumper-in-un-load position

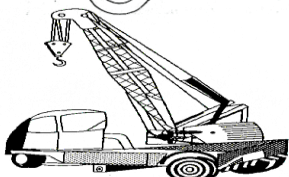


Fig. 5.19

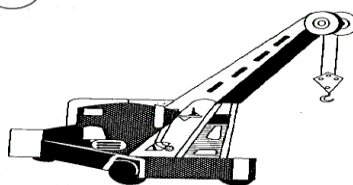


Fig. 5.20

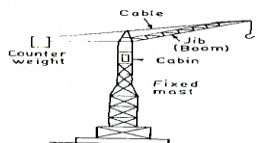


Fig. 5.21. Fixed mast tower crane.

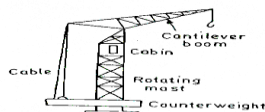
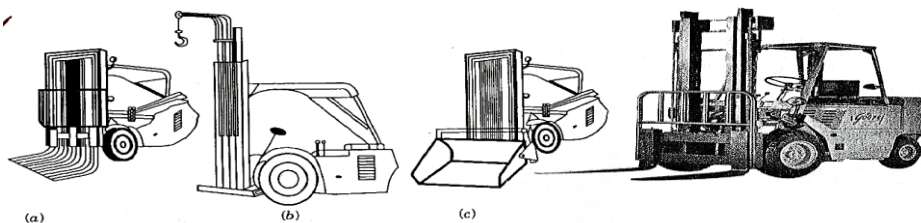
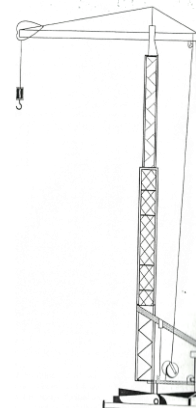


Fig. 5.22. Rotating mast tower crane.



Equipment

Construction Equipment

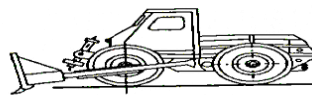
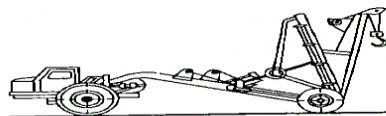
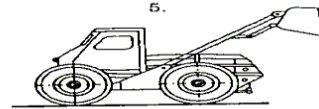
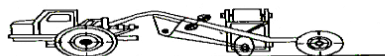
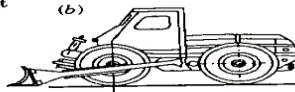
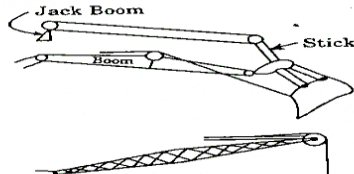
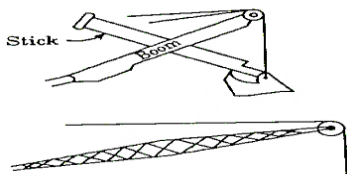
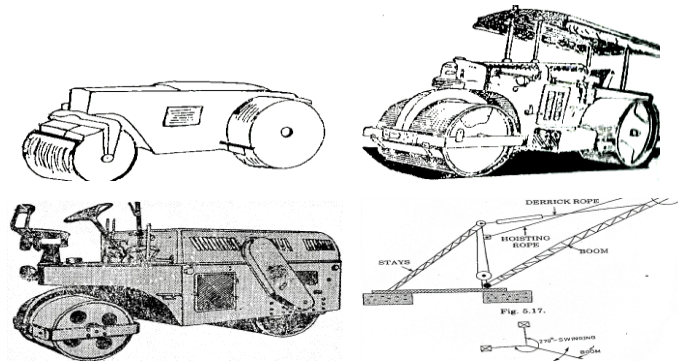
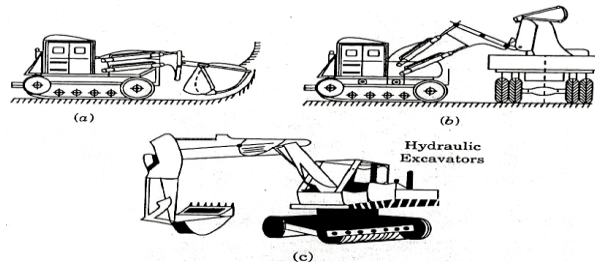


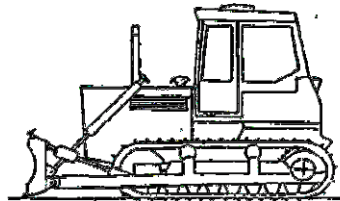
Fig. 5.27.



EARTH COMPACTORS

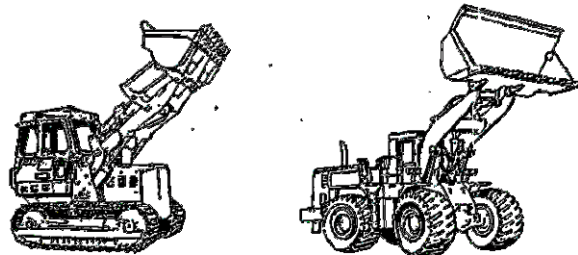


.. Bull dozers

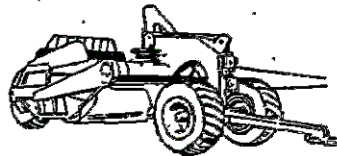


Tracked dozer

2. Front-End Loaders

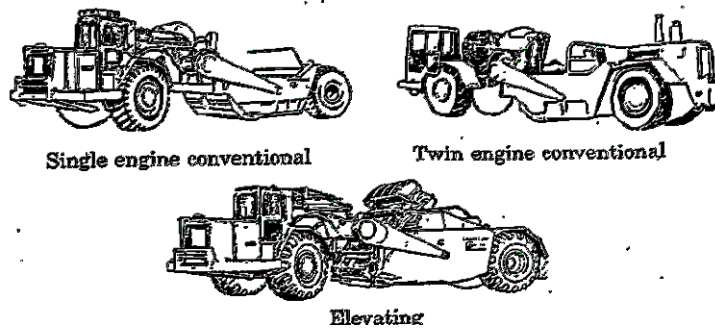


3. Towed Scrapers



Towed

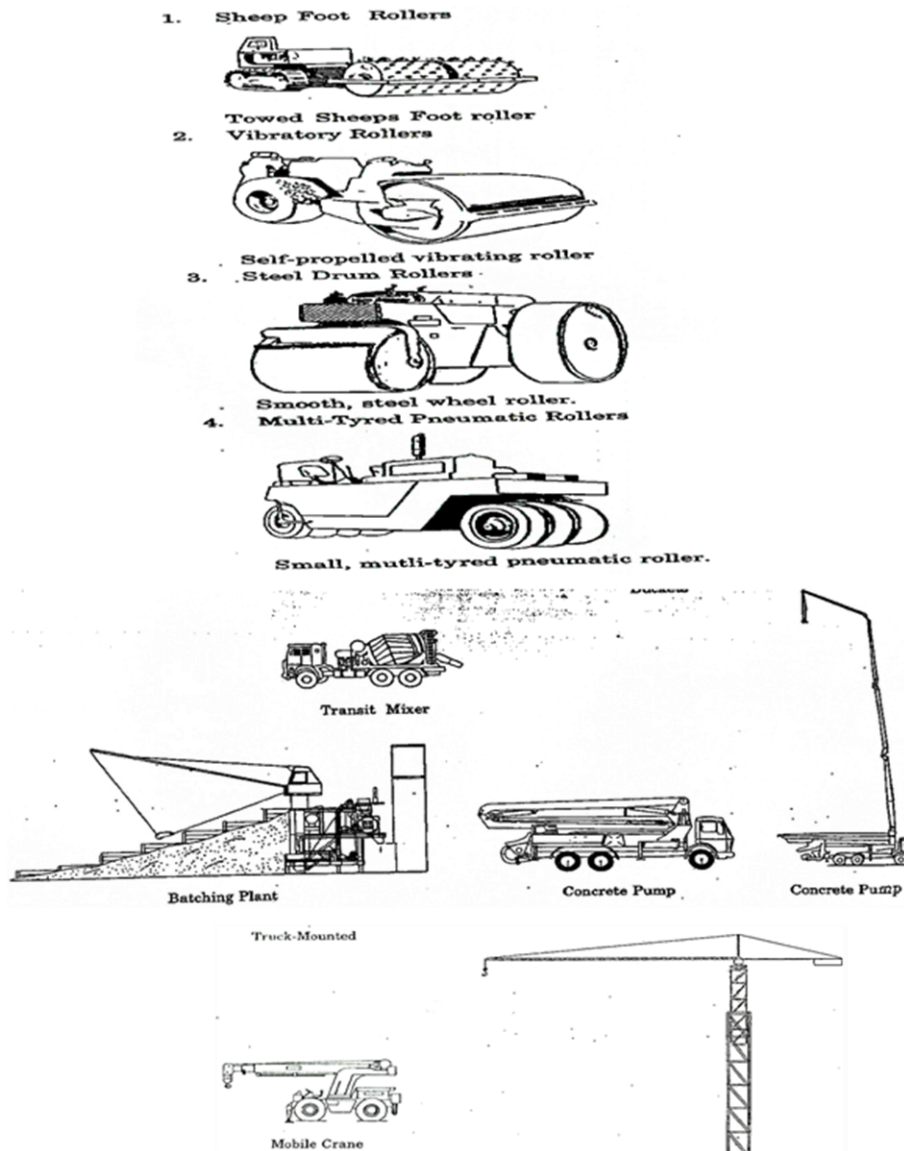
4. Motorised Scrapers



Single engine conventional

Twin engine conventional

Elevating



RESULTS AND DISCUSSION

(i) Results: - productivity Values of some construction Equipment. Field operations compared with standard records show that the productivity values of the stated construction Equipment below are real and obtainable during the field operations of the equipment. The quantities of material quoted below are found to be constant when this Equipment is in normal condition before being use.

<u>Equipment</u>	<u>Quantities of materials</u>
(1) Face shovel	-- 300m ³ /hr
(2) Back hoe (Excavator)	- 240m ³ /hr
(3) Drag line	- 225m ³ /hr
(5) Scraper	- 110m ³ /hr
(6) Leader	- 149m ³ /hr
(7) Hauler	- 63m ³ /hr
(8) Bull dozer	- 271m ³ /hr
(9) Scraper	- 173m ³ /hr

(10) Grader – In many cases, a grader has multiple applications, therefore, the computation of its productivity is not always easy. It can however, be estimated case by case. The actual average productivity by leveling and spreading can be computed as follows:-

$$Q_a = \frac{BLF_N F_z 60}{T} \text{ [m}^2\text{/hr]}$$

Where B = Width per strip with due consideration of overlapping

Where L = Length of blade

Where A = Angle of blade with respect to the axis if the blade is not angled, A = 0, and CosA = 1

Types of each operation	Angle A in degrees
(i) Normal	30
(ii) Hard Earth	45
(iii) Loose and light material	20
(iv) Scarcity mix and spreading across	30 – 50
(v) Fine leveling and speeding alone	0 - 30

Where F_N = factor to take care of site conditions, operators effectiveness as follows;

	Very good	Good	Average	Poor
(i) site condition	0.95	0.9	0.8	0.6
(ii) operators effectiveness	1.0	0.85	0.75	0.6

Where f_y = Time factor as follows;

Length of Application	Hour	Day	Week	Month	Year
Factor	0.95	0.85	0.80	0.75	0.7

T = cycle Time

Or

$$T = \frac{V}{0.06 \sum p}$$

P = Number of passes

V = forward and backward average speeds in km/hr. The average speed depends on the following:-

(i) Material being handled

(ii) Working conditions

(ii) Operator's skill, etc

Different recommended speeds are as follows;

Types of operation	Speed in km/hr
(i) Road maintenance	4 - 5
(ii) Mix	8
(iii) Spread	4 - 9
(iv) Sub base work	4 - 8
(v) Fine leveling	9 - 22
(vi) Cutting slopes	7 - 9
(vii) Ditching	4 - 8
(viii) Backward and idle non operational speed manufacturers specification	10 -11 max as per
(ix) Bank sloping	4.0
(x) Finishing	6.5 - 14.5
(xi) Grading and Road maintenance	6.4 - 9.7
(xii) Mining	14.5 - 32.2
(xiii) Snow Removal	19.3 - 32.2
(xiv) Spreading	9.7 - 14.5

Grader production can also be estimated as follows:-

Area covered by a motor grader per hour = Effective width of the blade x average speed x efficiency

i.e $A = B \times V_{av} \times ?$

Where B = width per strip [m]

$$= 0.8 \times P \times \cos A$$

Where P = Length of blade

Where A = angle Wrt to the axis

Where V_{av} = average speed [m/hr]

Where? = efficiency

DISCUSSION

Construction equipment plays a very significant role in the execution of modern high cost time bound civil and Building construction projects, especially with infrastructural facilities in Nigeria. As an indispensable item of resources, it produces out put at a high accelerated speed and it usually enables the completion of project tables within a limited time, compared with the local method (manual) of carrying out Engineering construction works with the applications of local tools. The use of Engineering construction Equipment saves man power, which is gradually becoming scare, costly and more demanding day-by-day especially with the execution of Industrial and turnkey construction projects by the federal and state Government every where in Nigeria. The applications of Engineering construction Equipment improves productivity, quality and also safety when compared with the local or manual methods of carrying out construction activities especially on large projects.

The nature of production tasks which can be carry. Out with Equipment includes excavating, Hauling, transporting, compacting, grading, hoisting, concreting, pre-casting, plastering, finishing, trenching, pipe-laying, cable-laying. In addition, on any project site, there are supporting Equipment such as generators, pumping sets, treatment plants and other utility services Equipment that are always provided for constructional use when the need arises.

Classification of construction Equipments are classified as follow;

(1) Hauling Equipment

- (a) Tractors
 - i crawler mounted
 - ii wheel mounted
- (b) Trucks
- (c) Dumpers

(2) Earth moving machines

(a) Bulldozers and Anglodozer

- i crawler mounted
- ii wheel mounted
- iii tractor mounted

(b) Rippers

- i crawler mounted
- ii wheel mounted
- iii Tractor mounted

(c) Scrappers

- i crawler tractor mounted
- ii wheel tractor mounted

(3) Hoisting Equipments

- (a) Chain hoist or jib hoist
- (b) chain- pulley block
- (c) Jacks
- (d) Winch hoist
- (e) Cranes
 - i Dorric crane
 - ii mobile crane
 - iii tower crane
 - iv Hydraulic crane

(4) Excavating and hauling Equipment

- (a) Power shovel
 - (i) Wheel mounted
 - (ii) Crawler mounted

- (iii) Tractor mounted
- (b) Drag line
- (c) Clamshells
- (d) Hoe or drag shovel
- (e) Dredgers
- (i) Dipper dredger
- (ii) Ladder dredger
- (iii) Suction dredger

(5) Soil stabilization

- (a) Tamping rollers
- (b) Smooth wheel rollers
- (c) Vibrating rollers
- (d) Pneumatic typed rollers
- (e) Self propelled vibrating plates
- (f) Manually propelled vibrating plates
- (g) Manually propelled compactors

(6) Pneumatic Equipments-Air Compressors

- (i) Stationary compressor
- (ii) Portable compressor
- (iii) Reciprocating compressor
- (iv) Rotary compressor
- (v) Centrifugal compressor
- (vi) Axial flow compressor

(7) Conveying equipments

- (a) Belt conveyer system
- (b) Pneumatic conveyor
- (c) Rope ways

(8) Rock drilling equipment

- (a) Jack hammer
- (b) Drifter
- (c) Wagon drills
- (d) Track mounted drills
- (e) Percussion drills
- (f) Rotary percussion drills
- (g) Blast hole drills
- (h) Shot drills
- (l) diamond drills

(9) Blasting equipments

(10) Pumping and dewatering equipments

- (a) Reciprocating pump
- (b) Centrifugal pump

(11) Pile driving Equipments hammers

- (a) Steam hammer
- (b) Hydraulic hummer

(c) Diesel Hammer

(12) Crusher

- (a) Primary crushers
 - (i) Jaw crusher
 - (ii) Gyratory crusher
 - (iii) Hammer mill crusher
- (b) Secondary crusher
 - (i) Cone crusher
 - (ii) Roll crusher
 - (iii) Hammer mill crusher
- (c) Tertiary crusher
 - (i) Roll mill crusher
 - (ii) Rod mill crusher
 - (iii) Ball mill crusher

(13) Concrete mixing plants.

- (a) Concrete mixing batchers
- (b) Mixers
 - (i) Tiling mixer
 - (ii) Non tiling mixer
 - (iii) Rotary mixer
 - (iv) Transit mixer
- (c) Transportation of concrete
- (d) Vibrators
 - (i) Needle vibrator
 - (ii) Platform vibrator

(14) Miscellaneous Equipments

- (a) Welding Equipments
- (b) Grouting Equipments
- (c) Tar mixing Equipments

Factors in the Selection of Equipment and Machines

The following factors must be kept in mind while selecting equipments and machines for civil engineering construction project:

- (1) Only standard equipment must be used only when it is required.
- (2) The equipment should be purchased only when it promises to pay itself, earning more money for the buyer than it cost.
- (3) Recurring cost, including depreciation, repairs, maintenance, investment, lubrication, fuel, etc should be considered.
- (4) Record of machines previously used should be studied as a guide for the selection of a particular type of equipment.
- (5) The demand for used of equipment in the market must be considered, in case the equipment is required to be sold
- (6) The engineer should know the production process. This will help to decide specifications that will permit utilization of equipment at low cost.
- (7) The final selection of equipment rest on the technical and economic stability of the process.

Factors relating to the activities (work related) of Construction Equipment

The type of earthmoving required varies with the nature of the soil and tasks to be performed. Typical job-related equipments used in building projects are given below:

(1) Excavating and lifting in soft earth

- (a) Deep pits excavation – clamshell and dragline.
- (b) Shallow pit excavation – Backhoes.
- (c) Ground level excavation – Shovels.
- (d) Shallow trenching – Trenchers, excavators (backhoes).
- (e) Wet soil excavation – Excavators (dragline or grab).

Earthwork Equipment

- Excavation and lifting equipment — backactor (or backhoes), face shovels, draglines, grabs or clamshell and trenchers.
- Earth cutting and moving equipment – bulldozers, scrapers, front-end loaders
- Transportation equipment – tippers dumps truck, scrapers rail wagons and conveyors.
- Compacting and finishing equipment – tamping foot rollers, smooth wheel rollers, pneumatic rollers, vibratory rollers, compactors and graders.

Concreting plants and Equipment

- Production equipment-batching plants, concrete mixers.
- Transportation equipment-truck mixers, concrete dumpers
- Placing equipment-concrete pumps, concrete buckets, elevators, conveyors, hoists, grouting equipment.
- Pre-casting special equipment-vibrating and tilting tables, battery moulds, surface finishes equipment, pre-stressing equipment, GRC equipment, steam curing equipment, shifting equipment, erection equipment.
- Concrete vibrating, repairing and curing equipment.
- Concrete laboratory testing equipment.

Support and utility services Equipment

- Pumping equipment.
- Sewage treatment equipment
- Pipeline laying equipment
- Power generation and transmission line erection equipment.
- Compressed air equipment.
- Heating, ventilation and air-conditioning (HVAC) equipment.
- Workshop including wood working equipment.

Special purpose heavy construction plant

- Aggregate production plant and rock blasting equipment.
- Hot mix plant and paving equipment.
- Marine equipment.
- Large-diameter pipe laying equipment.
- Piles and pile driving equipment.
- Cofferdams and caissons equipment.
- Bridge construction equipment.
- Railway construction equipment.

Factors affecting the cost of owning and operations of construction equipments

- (8) Cost of equipment
- (9) Delivery of equipment
- (10) Number of hours it is be used
- (11) Care with which it is maintained
- (12) Conditions in which it is used
- (13) Demand for used

- (14) Depreciation cost
- (15) Operating cost of the equipment
- (16) Cost of replacement
- (17) Maintenance and repair cost
- (18) Investment costs, including interest, insurance and storage
- (19) Cost of lubrication
- (20) Cost of fuel required to operate it
- (21) Economic life of construction equipment.

Factors affecting the productivity of Earth Moving Construction Equipments

- (1) Bucket fill factor- the amount of materials to be handled per cycle is dependent on the type of material being handled.
- (2) Load factor- this is a factor which relates to the loose state and the banking state of the material.
- (3) Cycle time- this include excavation, lifting turn loaded, travel time dump time turn empty travel empty optional and readiness to commence excavation again. This again depends on fire materials and machine type.
- (4) Haulers exchange- This is the time taken to place haulers in position. This time depend on the site conditions and comes pending planning.

Major Construction Equipment usually Owned by Contractors

I. Earthmoving Machinery

- (1) Dozers
- (2) Loaders shovels
- (3) Excavators
- (4) Compressors
- (5) Soil compactors

II. Concreting Machinery

- (1) Batching plants 35m³
- (2) Transit mixers 6cm
- (3) Concrete pumps
- (4) Concrete mixers 21/4
- (5) Screed pumps
- (6) Cement bag cutters

III. Erection and Handling machinery

- (1) Cranes 55 Tons
- (2) Cranes 20 to 35 tons
- (3) Cranes 6 to 10 tons
- (4) Forklifts
- (5) Tower cranes

IV. Transport fleet

- (1) Heavy duty tractors/tippers/ dumpers/tankers
- (2) Dumpers 2 ton capacity
- (3) Form tractors with trailers
- (4) Water/fuel tankers

V. Power Generation and water supply machinery

- (1) Generators 500 KVA
- (2) Generators 175 KVA
- (3) Generators 25 to 55 KVA
- (4) Pumps

VI. Pre-cast Factory Machinery

- (1) Batching plant 100 m³/hr

- (2) Gantry cranes
- (3) Steam boilers
- (4) Moulds-vibratory
- (5) Electric cars
- (6) Prime movers for traitors
- (7) A frame traitors
- (8) Flat head traitors

CONCLUSION

Just like construction is very vital for economic growth and National development of a country, the same applies to the operations of civil Engineering construction Equipment. In addition, construction reflects activities and values of a society, so also is the part play by civil Engineering construction Equipment. The level of social development in terms of infrastructural activities has been tied to great contribution of Big. Civil Engineering construction companies with standard equipment of different size for operations in Nigeria. It is worth while to appreciate the contribution of such companies like Julius Berger Nigeria limited and Dantata and sawoe for their notable records in the area of development in Nigeria. The Nigeria Government should encourage and support other smaller and younger companies to grow and bigger ones. This will serve as the platform for other foreign investment and also promote the country beyond National and sustainable development.

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