The Fabrication of a Walk-Behind Vibratory Plate Compactor

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***Abstract:*-Potholes pose severe problems on Nigerian roads. The aim of the study is to fabricate a walk-behind vibratory plate compactor with high performance, for the purpose of repairing potholes on pavement structures. For optimum compaction delivery by the machine on a combined asphalt and sub-grade layer, a compaction depth of 30cm was chosen as the compaction capability of the machine. Hence, the fabrication was based on achieving this compaction depth when employing the dynamic method of compaction. Owing to the fact that all needed materials necessary for the functional and apt running of the compactor was carefully selected, standard dimensions were taken where necessary, to avoid congestion and unwanted discrepancies of working parts that could lead to failure or seizure in components. Taking ergonomic suitability of the operator into consideration, the fabrication of the vibratory plate compactor not only provides the solution to the need for proper compaction of potholes, but also ensures that operator's comfort is guaranteed. The total cost of the project which is approximately five hundred and thirty three Dollars covers the cost of materials and sub-assemblies, transportation of materials and sub-assemblies, machineries and equipment, fasteners, finishing, fueling, as well as other miscellaneous expenses. The objectives of the research such as cost effectiveness, use of locally sourced materials, and optimized ergonomics were achieved. The results gotten include; a high compaction force, minimized stresses on members, good aesthetics and body finishing, cost effectiveness, low maintenance cost, as well as optimized ergonomics.**

***Keywords:* vibratory plate compactor, vibration, ergonomics, compaction, road repairs, Nigerian roads**

I. INTRODUCTION

The development of potholes is a severe problem on Nigerian roads. This is evident as one travels through the length and breadth of the country on road. These roads usually are in form of flexible pavement structures. Jassal (1998), noted that a flexible pavement structure consists of Asphalt Concrete (AC - a type of road surface made of a mix of aggregate and bitumen) which can be heavy grade and light grade for areas with high temperature and cooler temperatures respectively, base layer which consists of granular material and a sub-grade (underlying soil that supports the applied wheel load) which consists of well-compacted soil.

According to Yoder (1964), high-type asphalt concrete pavements are applied where high loads are anticipated. He also pointed out that the quality of any pavement structure depends upon the stability of the asphalt concrete, which is defined by both cohesion and internal friction and they in turn depend upon grading quality of the aggregate particles, density of mix as well as quantity of asphalt. The quality of a pavement structure is greatly affected by water. Moisture usually penetrates the pavement structure from the road surface to cause stripping.

American Public Works Association (2019), explained that potholes are created when the top layer of pavement and the material beneath—called the base or sub-base—cannot support the weight of the traffic. They noted that the two factors that are always present in such road failures are traffic and water. When water gets underneath the pavement, it expands when cooled and contracts when heated up (from basic physics), this process weakens the asphalt and leaves cracks behind which eventually causes the pavement to collapse or fail under the action of traffic. An unstable pavement is primarily due to poor gradation quality resulting from poor vibration and applied pressure during construction process, which a vibratory compactor can correct.

According to Jassal (1998), cracking is a prerequisite for pavement deterioration and pothole formation. However, Sharad and Gupta (2013), observed that pavement deterioration is the process by which distress (defects) develop in the pavement structure under the combined effects of traffic loading and environmental conditions.

Navigating a pothole while driving can be aggravating, as problems and damages caused by potholes vary from minor to major. Some of these problems are as follows: a vehicle's alignment can be jeopardized due to repeated jolting caused by potholes; potholes can lead to scratches, dents and damages underneath a vehicle; a vehicle's shock absorber can be damaged when repeatedly exposed to potholes; the springs that make up the suspension system are worn off in normal cases and broken under prolonged exposure; navigating a pothole can lead to discomfort of passengers in a vehicle; also, potholes lead to minor injuries, accidents, and in severe cases deaths.

Marasteanu (2018), pointed out that pothole repairs has continued to be a major maintenance problem for many highway agencies. He explained that there is a critical need to find a long-lasting, cost-effective materials and construction technologies for pothole repairs.

Therefore, proper compaction is the key to ensuring a stable pavement and permanent repair of potholes. A properly compacted area should be overfilled to ensure it is able to withstand the weight of vehicles driving on it and other depreciative environmental factors affecting it daily. To give no room for lapses that can cause potholes, a vibratory compactor is used to ensure firm tightness of the pavement structure. The importance of this machine is to reduce the air voids and to cause densification of granular soil, thus, the static weight and/or mechanical advantage of this machine is applied directly on the soil layer.

It has also been observed that heavy and repeated actions of traffic, inadequate road network, rigid and unsophisticated modes of transportation, poor drainage system accompanied by incessant rainfall which in turn causes flooding, has proved to be a catalyst for the rapid formation of potholes. It is a tradition in Nigeria to neglect these potholes at infant stages because of the unavailability of simple compactors. This project is aimed at making the machine available and also affordable within the country using locally sourced materials.

Nigeria is over-dependent on importation of different goods of various types which has led to poor economic growth. This is due to poor technological know-how and lack of trust in locally produced goods. This study looks at building up the morale of Nigerians to begin to value the different materials found within the country and to promote local production which will in-turn bring about reduction in importation, thus leading to economic development and improved standard of living.

Jassal (1998), explained that when loads pass over pavement structures some deflection occurs at the surface and underlying layers. If they are excessive and the supporting layers are weak to withstand the loading conditions, repetitive loading and/or environmental conditions will cause roughing and cracking which leads to surface depression and deformation, and ultimately result in complete failure. Cracking generally is caused by repeated loading, occurring primarily due to bending deflections as a result of fatigue failure which is a gradual and progressive process.

The project aims at solving these problems caused by the occurrence of potholes on pavement structure by fabricating a machine that can be used to repair potholes on the roads.

II. DESCRIPTION OF A VIBRATORY COMPACTOR

CIMA (1994), describes a vibratory compactor as a machine having a compacting element (plate or drum) used to densify (compact) soil, asphalt or other materials through the application of combined static and dynamic forces (weight and vibrations) to increase the load bearing capacity of the surface. The machine is usually equipped with compacting element(s), which may or may not be powered for propulsion. The machine may have drive members such as rubber tires in the case of drum compactors. The centrifugal force is normally produced by one or more rotating off-center weights mounted on shafts, which produce a cyclic motion in drums and repeated up and down motions in plates. The amplitude and frequency of the compactor's movements cover a wide range of values.

The compacting element(s) and drive wheels may be smooth or may include projections designed for specific compaction purposes. These projections vary as to material, size and shape. Vibratory compactors may be self-propelled or towed, rigid framed or articulated and controlled by either a riding or walking operator, either manually or remotely.

The following are considerations made in the design of the vibratory plate compactor:

Cost Consideration

Khurmi and Gupta (2005), stated that the cost of construction of an article is the most important consideration involved in design. Hence, this is the main design consideration in the execution of the study.

This factor therefore, limits the project to the design of a single direction vibratory plate compactor as its execution will not cost as much as its counterparts with higher performance and versatility. The design features translate to a semi-automated forward moving vibratory plate compactor with different parts, for pothole repairs on asphalt.

Vibratory Mechanism

Vibration is the back and forth or repetitive motion of an object from its point of rest. All rotating parts of a machine produce vibrations in some form, and it is the vibration caused by unbalanced centrifugal force of the mass mounted on the shaft that will be harnessed to achieve compaction in this design. The vibrating component will consist of an eccentric of known mass mounted on a shaft and the shaft is then rotated at a certain speed by the power delivered from the engine, thus delivering the dynamic type of compaction.

Factors contributing to the formation of potholes such as poor construction quality, weight, speed and number of vehicles plying the pavement on an average day, as well as environmental conditions can be checked using adequate asphalt full-depth. According to National Asphalt Pavement Association (2018), "in many cases a 4 inch (10.16cm) may be adequate, but 5 or 6 inches (12.7 or 15.24cm) of full-depth assures a stronger, stable driveway under a wider range of climate and loads. As an option contractors use 6 to 8 inches (15.24 to 20.32cm) of compacted aggregate, or gravel, as a base for 3 inches (7.62cm) of asphalt pavement." i.e. 9 to 11 inches (22.86 to 27.94cm), total thickness for a combined thickness of asphalt and sub-grade layer.

Underlying theory:

For optimum compaction delivery by the machine on a combined asphalt and sub-grade layer, a compaction depth of 12 inches (30cm/0.3m) was chosen as the compaction capability of the machine. Hence, the design was based on achieving this compaction depth.

Mathematically,

From basic physics,

$$\text{Potential Energy} = \text{Mass} \times \text{Acceleration due to gravity} \times \text{Height}$$

Since it is intended to achieve a compaction depth of up to 12 inches (30cm), the vertical distance will be taken as 30cm (0.3m).

$$\therefore \mathrm{P.E_p} = \mathrm{M_p} \times \mathrm{g} \times \mathrm{h_c}$$

Where, $P.E_p$ = Potential Energy of the plate

M_p = Mass of plate

g = Acceleration due to gravity (constant)

h_c = Compaction depth

$$\therefore \text{Mass of plate} = \text{Volume of the plate} \times \text{Standard density of the plate material} \quad (2)$$

The potential energy of the plate is in terms of the desired compaction depth, the diameter of the eccentric is a function of the clearance from the base plate to the shaft and since the eccentric is mounted on the shaft the amplitude of vibration it induces will be a function of its mass and the difference between its diameter and desired compaction depth.

$$\therefore \mathrm{h_i} = \mathrm{h_c} + \mathrm{h_e} \quad (3)$$

Where, h_i = Impact distance for achieving compaction depth

h_e = Vertical distance from the machine base plate lifted by the eccentric

$$but, \mathrm{P.E_e} = \mathrm{M_e} \times \mathrm{g} \times \mathrm{h_i} \quad (4)$$

Where, $P.E_e$= Potential Energy of the eccentric; M_e = Mass of eccentric; g = Acceleration due to gravity (constant); and h_i = Impact distance

The plate and eccentric possesses equal P.E by virtue of their position at rest,

Hence, Potential Energy of the plate, $P.E_p$ = Potential Energy of the eccentric, $P.E_e$

$$\therefore \mathrm{P.E_p} = \mathrm{M_e} \times \mathrm{g} \times \mathrm{h_i} \quad (5)$$

Hence, Mass of eccentric, $M_e = \frac{P.E_p}{g \times h_i}$ (6)

Technical Information of the Machine

The specifications for the vibratory plate compactor and prime mover are given in tables 1 and 2.

Table 1: Specifications of the vibratory plate compactor

Plate compactor specifications	
Centrifugal Force	12kN
Plate Dimension	60 × 40cm
Compaction Depth	30cm
Water tank Capacity	10 liters
Compaction configuration	(1) Vibratory

Table 2: Specifications of the Prime mover

Engine Specifications		
Engine	Type	Honda GX 200 air-cooled 4-stroke OHV
	Bore x stroke	68 x 54 mm
	Max. Output/Power	5.5Hp @ 3600 rpm
	Fuel Tank Capacity	3.1 liters
	Fuel Type	Unleaded 86 octane or higher
	Lube Oil Capacity	0.6 liters
	Lubrication System	Splash
	Starting Method	Recoil Start
	Shaft Rotation	Counterclockwise
	Compression Ratio	8.5:1
	Carburetor	Butterfly
	Ignition System	Transistorized magneto
	Governor System	Mechanical
	Air cleaner	Dual element
Dimension(L x W x H)		321 x 376 x 346 mm
Dry Net Weight		16.1 kg

Steps involved in material selection process

The following steps were taken for the material selection:

- The functions that must be performed by the design was defined and translated into material properties requirement such as stiffness, strength, and market factors such as cost and availability.
- The production parameters involved with the project such as the number of parts to be produced, the size, and complexity of the part, as well as the required tolerance and surface finish were defined.

- The needed properties and parameters with actual material properties for the application were considered.
- Investigation of the selected materials in more detail, particularly in terms of performance, cost, machinability, grade, size, and availability needed for the application were performed. Here, Ashby material selection chart was employed for the material property test simulations.
- Development of design data and/or design specifications. Design data properties are the properties of the selected material in its manufactured state to enable the part to function with a high level of reliability.

Bill of Materials (BOM)

The bill of materials and cost evaluation for the fabrication of a walk-behind vibratory plate compactor is depicted in Table 3.

Table 3: Bill of engineering materials

S/N	DESCRIPTION	QTY	UNIT	UNIT PRICE (Dollars)	TOTAL PRICE (Dollars)
1	**CHASSIS**				
i.	60 x 40 x 0.06 Metal plate	1	cm	50	50
ii.	70 x 40 x 0.04 Sheet metal plate	1	cm	5	5
iii.	50 x 6 x 4 x 0.02 Hollow bar	1	cm	15	15
iv.	32 x 30 x 0.03 Mounting plate	1	cm	30	30
v.	Springs	4	-	5	20
vi.	Mounting pins	4	-	5	20
vii.	Eccentric	2	-	-	20
viii.	Shock absorbers	8	-	2	16
2	**POWER SYSTEM**				
i.	Engine	1	Hp	100	100
ii.	3 x 40 Solid circular machine shaft	1	cm	10	10
iii.	UCP 206 Pillow block bearing	2	pair	10	20
iv.	2.5 x 20 Solid Transmission shaft	1	Qty	10	10
v.	Pulleys (200mm and 100mm)	2	Qty	-	20
vi.	Belt drive	1	Qty	5	5
3	**BODY/FRAME**				
i.	30 x 30 x 0.012 Sheet metal	1	cm	10	10
ii.	Handle and roller wheel bar	2	-	5	10
iii.	Hand cushion	2	-	4	8
4	**LIGHTING SYSTEM**				
i.	Head lamp	1	-	5	5
ii.	Circuit board	1	-	5	5
iii.	Switch	1	-	5	5
	FASTENERS				
i.	Bolts	10	-	2	20
ii.	Nuts	10	-	1	10
iii.	Washers	12	-	2	24

	MACHINERIES AND EQUIPMENT				
i.	Safety gloves	2	pairs	2	4
ii.	Packets of electrodes	½	pack	6	3
iii.	Cutting Discs	1	-	10	10
iv.	Grinding discs	2	-	5	10
v.	Water tank	1	-	8	8
vi.	Water tank cage	1		10	10
vii.	Discharge hose	1	-	3	3
viii.	Discharge valve	1	-	3	3
ix.	Measuring tape	2	-	4	8
x.	Roller wheels	4	-	3	12
xi.	White chalk	3	-	1	3
	FINISHING				
i.	Filler	1	Tin	2	2
ii.	Sandpaper	5	inch	1	5
iii.	Tin of paint	2	Tin	4	8
iv.	Painting brush	2	-	2	4
v.	Wire brush	1	-	2	2
	TOTAL				533

III. FABRICATION

These activities were carried out with the operational schedule developed using Johnson's sequencing rule while observing safety precautions. The chassis which comprises of several mating parts and functional components were held together by welding, and with the use of fasteners that are strong enough to carry the average load exerted by the engine and other components, such as the water tank.

Taking ergonomic suitability of the operator into consideration, the fabrication of the vibratory plate compactor not only provides the solution to the need for proper compaction of potholes, but also ensures that operator's comfort is guaranteed.

Owing to the fact that all needed materials necessary for the functional and apt running of the compactor was carefully selected, standard dimensions were taken where necessary, to avoid congestion and unwanted discrepancies of working parts that could lead to failure or seizure in components.

Some modifications which were included in the scope of the research were actualized in order to ensure the machine's uniqueness when compared to other models. Some of the modifications include; head lamp for operations in tunnels or dark areas, multi-positioning adjustable handle to suit operators of all sizes, and the addition of transport wheels for easy mobility when the machine is not operational. According to Okpala et al (2019), "the handle bar is also equipped with an ergonomic padthat ensures a soft and gentle grip by the operator or handler, which helps to prevent discomfort, slipperiness and blisters whenworking with the machine over a period of time."

The water tank found in only a few models of existing walk-behind vibratory plate compactor was also included in the project design.

Workshop Facilities

Some of the machines and equipment used during the fabrication of the compactor include the following: lathe machine, drilling machine, bending machine, bench vices, Gand F-Clamps, spanners, pliers, allen keys, hacksaw, disc cutter, disc grinder, arc welding machine, wire brush, file, try-square, screw-drivers, hammers and mallet.

Project Operational Schedule

This is a project tool that shows the operations to be performed, which resources will be utilized as well as the time frame in which the operations needs to be performed. It helps to ensure timely completion of the project.

Table 4: Developed project operational schedule

S/N	Components	Tools	Specification	Operation	Time (hrs)
1.	Base Plate	Tape &Try-square	60 × 40cm inclined to an angle of 45° at a distance of 5cm from both 40cm edges.	Measuring	7
		Disc Cutter		Cutting	5
		Bending jig		Bending	2
		Welding machine		Welding	3
		Disc grinder		Grinding	9
		Paint and Brush		Painting	4
2.	Chassis	Tape &Try-square	50 × 30cm rectangular chassis with holes for mounting bearing and mounting plate.	Measuring	6
		Disc Cutter		Cutting	6
		Welding Machine		Welding	4
		Hand Drill		Drilling	5
		Welding Machine		Welding	10
		Paint and Brush		Painting	3
3.	Shaft	Tape & Try-square	40 × 3cmcylindrical shaft to be coupled with 15cm pulley on one end	Measuring	4
		Disc Cutter		Cutting	7
		Lathe		Turning	3
		Drilling Machine		Drilling	4
		Wire Brush		Polishing	2
4.	Eccentric	Disc Grinder	2.26kg Unbalanced mass	Grinding	8
		Drilling Machine		Drilling	6
5.	Tank Cage	Tape & Try-square	Made to contain35×20×15cm 10liters water tank capacity	Measuring	5
		Cutter		Cutting	6
		Welding Machine		Welding	6
6.	Mounting Plate	Tape & Try-square	30×32cm inclined to 90° from both 30cm edges at 8cm and curved to 125° from the 32cm edge with an overhang of 15cm	Measuring	5
		Disc Cutter and Grinder		Cutting/Filing	4
		Bending Jig		Bending	5
		Hand Drill		Drilling	6
		Welding Machine		Welding	8
		Paint and Brush		Painting	7
7.	Handle Bar	Tape & Try-square	Fabricated based on Anthropometric measurements for operator's comfort	Measuring	8
		Disc Cutter and Grinder		Cutting/Filing	3
		Metal Bender		Bending	3
		Hand Drill		Drilling	2
		Welding Machine		Welding	6
		Paint and brush		Painting	5

Application of Johnson's Sequencing Rule

Johnson's sequencing rule is an operations sequencing technique developed by Selmer Martin Johnson, for determining the optimum sequence of carrying out operations in a workshop in order to minimize the total elapsed time between the start of the first job in the first machine and the completion of the last job on the last machine.

From the project operational schedule as shown in table 4, there are multiple number of jobs to be carried out using different machines, therefore Johnson's sequencing rule for scheduling *n* jobs through *m* machines is adopted and utilized, using the processing time for operations in the table.

For the purpose of applying Johnson's sequencing rule to the fabrication operations of this design, components 3, 4 and 5 from table 4will not be considered since component 3 requires different machines and operations, and components 4 and 5 does not require much operations, also painting operation is not sequenced since it was a manual operation.

Let Job A, Job B, Job C and Job D be components 1, 2, 6, and 7 to be sequenced for operation from table 4on different machines. Let M1, M2, M3, M4, M5, and M6 be the machines for carrying out the different operations in table 9 on Job A, Job B, Job C, and Job D to specifications.

The processing time is represented in table 5.

Table 5: Processing *n* jobs on *m* machines

Jobs	Machines				
	M1	M2	M3	M4	M5
Job A	7	5	2	3	9
Job B	6	6	4	5	10
Job C	5	4	5	6	8
Job D	8	3	3	2	6

Sequencing conditions:

The optimal solution for sequencing *n* jobs on *m* machines can be obtained if either or both of the following conditions hold;

- Min $(t_{M_1 j}) \geq$ Max(t_{ij}) ; j = 2, 3, 4,…, m – 1
- Min $(t_{mj}) \geq$ Max(t_{ij}) ; j = 2, 3, 4,…, m − 1

Validation of sequencing conditions

Considering the processing time for the jobs in table 3.16

Min $(t_{M_1 j}) = 5 = t_{M_A C}$, Min $(t_{M_5 j}) = 6 = t_{M_5 D}$

Max $(t_{M_2 j}, t_{M_3 j}, t_{M_4 j})$ = (6, 5, 6) respectively.

Since the conditions of Min $(t_{M_1 j}) \geq$ Max $(t_{M_2 j}, t_{M_3 j}, t_{M_4 j})$ is satisfied, therefore the operations can be converted into a four jobs and two machines problem as X and Y. The processing times of the four jobs denoted by $t_{Xj}$and t_{Yj}on Machine X and Y respectively can be determined as follows:

$$t_{Xj} = \sum_{i=1}^{m-1} t_{ij} \quad (7)$$

$$t_{Yj} = \sum_{i=2}^{m} t_{ij} \quad (8)$$

Table 6: Conversion into four job and two machines problem

Jobs	Job A	Job B	Job C	Job D
Machine X	17	21	20	16
Machine Y	19	25	23	14

Using the optimal sequence algorithm, the optimal sequence can be obtained as follows:

Table 7: Optimal sequence solution table

Itera tion	Sequence				Comment
1	–	–	–	Job D	The shortest processing time is 14hrs for Job D on machine Y, therefore it was scheduled as late as possible.
2	Job A	–	–	Job D	Eliminating Job D, The next shortest processing time is 17hrs for Job A on Machine X,hence it was scheduled as early as possible.
3	Job A	Job C	–	Job D	Eliminating Job A, The next shortest processing time is 20hrs for Job C on Machine X, therefore it is scheduled as early as possible.
4	Job A	Job C	Job B	Job D	The last job to be scheduled is Job B, with the next shortest processing time,hence it was placed in the last remaining position.

Therefore, the total elapsed time corresponding to the optimal sequence can be calculated as shown in Table 8 using the individual processing time given in the operational schedule:

Table 8: Calculation of minimum elapsed time

Job Sequence	Machines				
	M1	M2	M3	M4	M5
Job A	0 – 7	7 –12	12– 14	14 – 17	17 – 26
Job C	7 – 12	12 –16	16 –21	21 – 27	27 – 35
Job B	12 – 18	18 –24	24 –28	28 – 33	35 – 45
Job D	18 – 26	26– 29	29– 32	33 – 35	45 – 51

From Table 8, it could be seen that the minimum total elapsed time is 51 hours, while idle time for machines M1, M2, M3, M4 and M5 are 25, 33, 37, and 18hrs respectively.

Therefore, from the optimum sequence determined, the base plate should be fabricated first, followed by the mounting plate, then the chassis and finally the handle bar.

Assembly and Finishing

This is the final stage of the project implementation phase and the initial stage in the project closing phase. Here all fabricated parts and sub-assemblies were assembled and completed. The orthogonal array of the machine, the exploded view of the unassembled machine parts, and completed assembly of the walk-behind vibratory plate compactor are shown in figures 1 and 2.

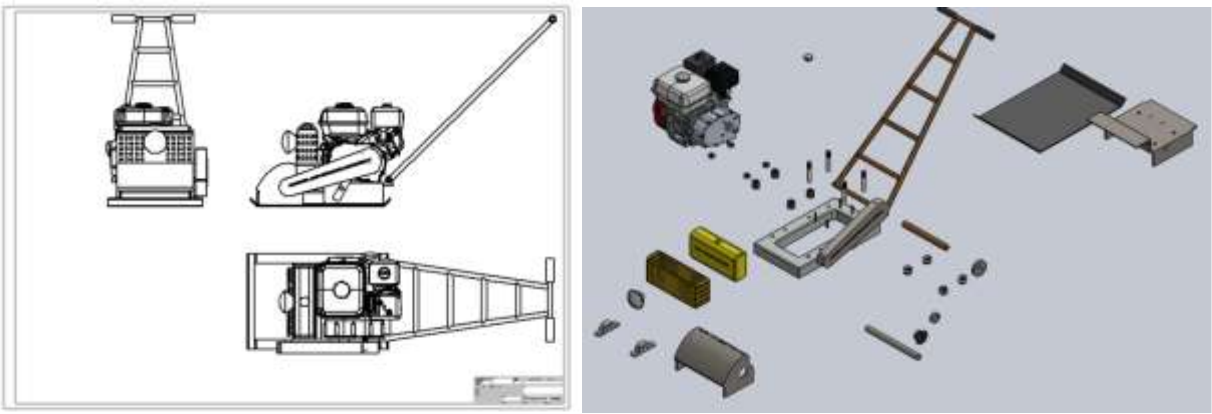

Figure 1: The orthogonal array of the machine, and exploded view of the unassembled machine parts.

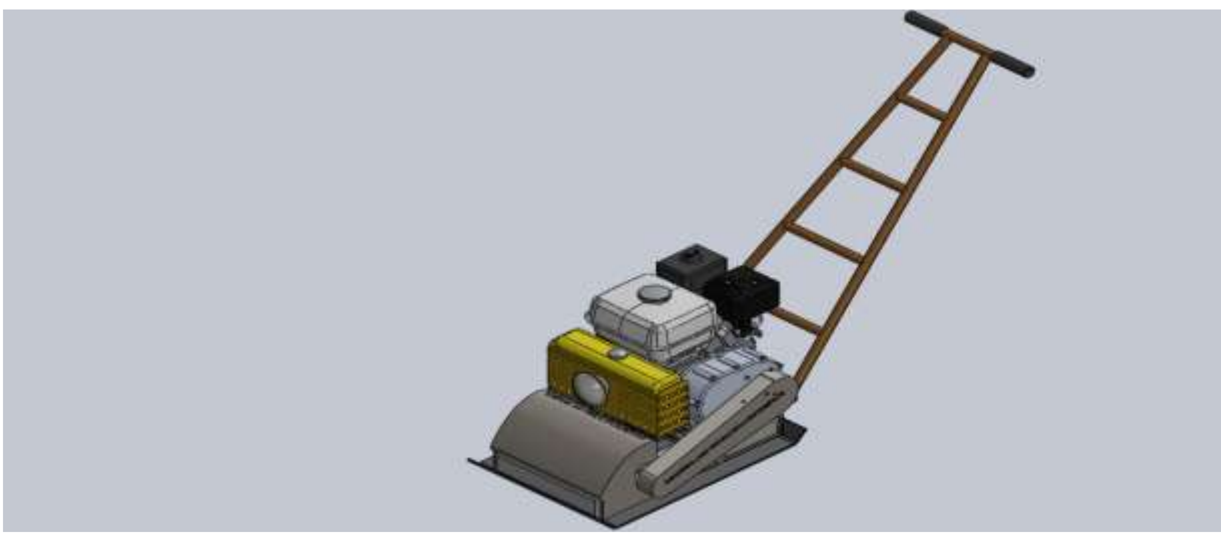

Figure 2: Complete assembly of the walk-behind vibratory plate compactor

IV. ANALYSIS OF THE MACHINE PERFORMANCE

Testing

Efficiency = $\frac{\text{Output}}{\text{Input}} \times 100$

The efficiency test was carried out to ascertain the efficiency of the machine in carrying out the compaction operation for the expected compacting depth of 30cm.

For the test, the vertical depth of the area to be compacted was measured for a thickness of 30cm. The machine was used to perform compaction on the area and the compacted thickness was recorded. This test was carried out on 4 different soil textures including Asphalt concrete.

$$\frac{30\ - 6.2}{30} \times 100 = \ 79.33\%$$

$$\frac{30 - 5.0}{30} \times 100 = \ 83.33\%$$

$$\frac{30 - 6.10}{30} \times 100 = \ 79.67\%$$

$$\frac{30 - 6.80}{30} \times 100 = 79\%$$

Average value:

$$\frac{79.33 + 83.33 + 76.33 + 79}{4} = 80.408\%$$

The obtained results revealed that the machine has high efficiency.

Risk Analysis

Risk analysis was carried out to ascertain the effectiveness of the machine. It is an essential part in the design and fabrication process, and the first step of risk analysis is the identification of possible cause of risk.

The possible risks associated with the use of this machine are;

- Explosion: The presence of combustible fluid in the petrol tank may explode if exposed or not properly sealed leading to burns, fire or death. This could be prevented by keeping/storing the machine in a secure place and ensuring tight sealing of the petrol tank openings, and most especially keeping away from naked flame or ignition source. The engine should be allowed to cool before refueling.
- Noise: Due to constant vibration initiated by the offset of rotating mass, there is a huge noise associated with the operation of the machine. This could lead to discomfort in the operator's auditory organs, unstable emotional health and in some cases partial deafness under long exposure. This can be prevented by wearing appropriate safety gears or protective equipment such as ear muffs, by the operator and workers in the vicinity.
- Sprains and strains: This is as a result of the heavy weight of the machine and the apparent difficulty encountered when maneuvering the machine in relation to the topography of the pavement. The operator may try to lift or move the machine while it is not in use or to avoid a mound of soil which in turn may lead to sprains and strains. Possible solutions to this include;
  - Operators must maintain an upright position.
  - The machine should be lifted using mechanical lift if it is not operational.
  - Over short distances, the machine should be transported with the transport wheels.
- Burns, white finger disease from vibration, crush injury to feet. The following can be prevented by;
  - Wearing appropriate protective gloves.
  - Keeping away from hot parts of the machine.
  - Wearing appropriate safety footwear.
  - Relieving operators at regular time intervals.

The knowledge of the risks led to a painstaking design and fabrication, in order to ensure maximum safety during operation.

V. CONCLUSION

The machine was designed to give operators comfort by isolating vibration on the part which the operator will come in contact with during operations, which in this case is the handle. The handle of the machine is fastened to the mounting plate that will also hold both the engine and water tank. These components are fastened to the mounting plate in order to isolate them from the vibration caused by the vibratory unit attached to the chassis on which the mounting plate is also positioned.

The mounting plate is isolated from vibration by employing the use of spring and robber shock absorbers to separate it from the chassis which houses the eccentric. The springs and shock absorbers dampen the effect of vibration on the tangible parts placed on it, hence ensuring both protection and comfort to operator. Also, the handle of the walk-behind vibratory plate compactor was ergonomically designed to be adjustable. This aims at ensuring that the machine can suit and accommodate operators of different heights, so that operators can easily adjust to any terrain or topography.

The total cost of the project is approximately five hundred and thirty three Dollars which covers the cost of materials and sub-assemblies, transportation of materials and sub-assemblies, cost of machineries and equipment, fasteners, finishing equipment, fueling cost, as well as other miscellaneous expenses.

As at the time of publication, walk-behind vibratory plate compactors are being imported into Nigeria at the range of six thousand Dollars to nine thousand seven hundred and twenty two Dollars, depending on its type and configuration. From this deduction, it is evident that there is a high discrepancy in cost between the locally fabricated machine and the imported brands which both serve the same function at the same capacity. Hence, the objective of cost effectiveness was accomplished.

The benefits of the fabricated machine include: cost effectiveness, low maintenance cost, minimized stress levels, high compaction force, good aesthetics and body finishing, as well as optimized ergonomics.

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