International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

An Assessment of Facilities Maintenance Management Strategy in Selected Industrial Estates in Lagos State, Nigeria

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Abstract

The study appraised the facilities and the maintenance management strategies employed in selected industrial estates in Lagos State by examining facilities maintenance strategies, with a view to establishing the optimal strategies. Data were sourced using structured questionnaire administered on the staff of maintenance department of the industrial firms located in the estates. Data obtained were analysed using descriptive and inferential statistics. Using the relative importance index (RII), the most widely used maintenance strategy was reactive maintenance strategy with RII value of 0.15. The most influencing factor for the choice of maintenance strategy was the reporting delay time with RII value of 0.41. The observed facility down time was over two weeks and the factors mostly responsible for delay in responding to maintenance request were lack of funds and inadequacy of maintenance staff.

Key words: Industrial Facilities; Industrial Estates; Maintenance; Management; Strategy.

1. Introduction

State Governments place emphasis on the establishment of new industrial estates in order to meet the needs of industrialists and investors in their domain as well as generate revenue.

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Allocation of industrial land use in Nigeria is the prerogative of the government (State and Federal) which plan and approve industrial layouts in both the urban and regional areas of the country [1]. According to the author in [29], the minimum land required for modern industrial estates is about 20 hectares. Of this 30-40% should be for roads and vehicular parking, 10% for recreation and public utilities while not more than 50-60% of the entire layout should be committed to actual industrial use.

A vibrant manufacturing sector has been acclaimed as a sure means of boosting economic growth and raising the standard of living of the citizens [14]. They further stated that manufacturing sector is the basis on which a nation economic efficiency can be compared, ranked and determined. Manufacturing in Nigeria consists largely of a handful of factories producing construction materials, plastics; clothing textiles, footwear and processed foods using simple assembly processes [41] with common support facilities such as power generation stations, warehouses, and data processing centres. The way these facilities are maintained reflects significantly on the effectiveness of the organization, productivity levels, as well as the wellbeing of the employees [44, 25].

Though industrial entrepreneurs regard facilities maintenance as economic expense due to the assumption that facilities maintenance generates cost but does not give much in return [44], it has been shown that high quality maintenance has many positive, indirect effects in business performance of all parties involved viz- facilities owners, users' organizations and companies providing facilities maintenance services (FMS) [27, 25].

Reference [3] noted that most of the manufacturing sectors have been facing difficult times for some years back. Reference [30] noted that manufacturing sector in Nigeria was characterized by increasing cost of production emanating from high tariff, increased cost of energy input, reliance on poor and inadequate public sector infrastructure and rising cost of import. Putting the country back on path of recovery and growth according to the author in [10] will require urgently rebuilding deteriorated infrastructural facilities and making goods and services available to the citizenry at affordable prices. This buttresses the view of Latino [22] that eliminating chronic failure in industrial plants can reduce maintenance cost to between 40-60%, and that a substantial amount of cost savings can be realized annually by industries without major restructuring, employees layoffs, or sacrifice of product quality. He however stated, that what were required were changes in existing mindset about how to maintain and operate facilities on a day to day basis.

There is a dearth of published work on maintenance of industrial facilities. Inadequate funding of maintenance operations all over the world made prioritization of maintenance demand a critical issue [34, 11, 7, 32, 37, 38, 33, 42, 47, 5, 8, 21, 31]. To this end there is need to search for a maintenance strategy that would be cost effective. Al Najjar [6] observed that effective maintenance aim to enhance organization's profitability and competitiveness through continuous cost- effective maintenance strategies.

Studies have shown that maintenance organizations tend to adopt reactive maintenance strategy rather than proactive strategy; this resulted in a problem of under-maintaining assets [20, 42, 16]. Reference [9] noted that under-maintaining asset is characterized by ineffective or non-existent preventive activities and that the effect of under-maintaining facilities often results in frequent and long breakdown, high level of unplanned work and loss of production and output. Reactive maintenance strategy is a problem because maintenance is supposed to be

holistic and that a piece meal approach to maintenance will result in the whole facilities collapsing. This led to the development of planned preventive maintenance (PPM) as an alternative option. Planned preventive maintenance (PPM) has been described as the most effective maintenance strategy against the frequency of breakdown [36, 45, 46]. However, planned preventive maintenance (PPM) is considered an ineffective solution because it makes too early and unnecessary replacement, ineffective in detecting the onset of failure, and costly [40, 9].

Many authors including [19, 31, 18, 2, 23] have studied various aspects of the above process, on how to make building maintenance proactive rather than reactive. The authors in [17, 39, 43, 12, 28] examined various aspects of plant maintenance for industrial facilities, while Reference [13] examined sustainability related decision making in industrial building design using AHP analysis, and [4] examined the impact of exchange rate on industrial production in Nigeria, but none took a holistic approach. Planned preventive maintenance (PPM) for industrial facilities obviously is an improvement of reactive maintenance; however, it has its own short comings. The major disadvantage apart from not being cost effective is that it does not monitor the condition of facilities. Condition based maintenance (CBM) strategy is a predictive tactic that relies on the fact that failures may not occur instantaneously, but develop over a period of time. Mitchell [26] defines it as maintenance actions based on actual conditions obtained from in-situ, non-invasive tests, operating, and condition measurement. It is carried out each out time the value of a given system parameter exceeds a predetermined value. A survey conducted by Higgs, Reference [17] showed condition based maintenance (CBM) to be a globally accepted maintenance practice. Condition based maintenance (CBM) has been successful in the USA and other countries but no study has examined how emphasis on the state of industrial facilities would affect maintenance strategies in Nigeria. This study will attempt to fill this gap by appraising the maintenance strategies for industrial facilities vis-a-vis factors influencing strategies in selected industrial estate with a view to identifying optimal strategies.

2. Methodology

The study population was primarily the maintenance staff of building and plastics manufacturing industries registered with the Manufacturers Association of Nigeria (MAN) and located within the selected industrial estates in Lagos state. These maintenance staff comprised of technical and administrative staff of the maintenance departments, maintenance supervisors, and facilities maintenance managers.

Data collected for this study through structured questionnaire were primary in nature and included the frequency of maintenance operations, response times to maintenance requests [down times], factors responsible for delay in response to maintenance request, frequency of inspection of facilities, and the number of administrative and technical maintenance staff. Other relevant information had to do with sourcing of materials for maintenance operations, the maintenance strategies and policies, inventory data base of the organizations, factors influencing choice of maintenance strategy and organization level of maintenance activities. The sample frame covers all the industrial estates in Lagos. Twenty Two (22) Industrial estates were identified in Lagos State based on information on directory of manufacturing companies prepare by Lagos State Ministry of Commerce, Industry and Tourism (See Table 1).

Table 1: Industrial Estates in Lagos State

S/N	Location	Year of Establishment	Size in Hectares
1	Apapa	1957	100
2	Matori	1958	120
3	Ikeja	1959	180
4	Ilupeju	1962	110
5	Ijora	1965	160
6	Iganmu	1965	80
7	Oshodi/Isolo	1968	120
8	Amuwo-odofin	1969	200
9	Ogba	1969	150
10	Oregun	1981	100
11	Agidingba (CBD)	1969	97
12	Gbagada	1958	50
13	Ikorodu	1976	1,582.27
14	Surulere	1981	20
15	Badiya	1958	15
16	Oyadiran/Yaba	1970	20
17	Ilasamaja	1971	60
18	Lagos South-West	1972	317.04
19	Kirikiri	1981	30
20	Abesan/Ipaja	1981	100
21	Akowonjo	1976	50
22	Oko-afo/Ilogbo	1981	-

Source: Lagos state directory of manufacturing companies (1998)

Sample size

A total of twenty two (22) industrial estates were identified based on information from the directory of manufacturing companies. The sample size used followed the author in [35] i.e.

$n= n1/[1+n1/N]$

Where: n= sample size; n1 = S1/V2; N= total estimated population; and V= standard error of the sampling distribution = 0.05

S1= Maximum standard deviation in population. Total error = 0.1 at a confidence level of 95% and S2=(p)x(1-P)= (0.5) x (0.5) = (0.25) where p is a proportion of population elements that belong to a defined class. From this formula the sample size for the industrial estates will be:

n = 0.25/0.052[1+0.25/0.052/22] i.e. 18

A total of three hundred and twenty two (322) companies were located within the industrial estates in Lagos state. For homogeneity of data only building materials and plastic manufacturing industries were purposively selected. Of the 54 companies in this category on the register, using the same Sediary [35] equation 35 firms was calculated as the sample size and these were selected randomly.

For uniformity and convenience ten sets of questionnaire were administered to the maintenance staff in each of the 35 industrial firms selected making a total of 350 questionnaire.

3. Data Analysis and Discussion of Results

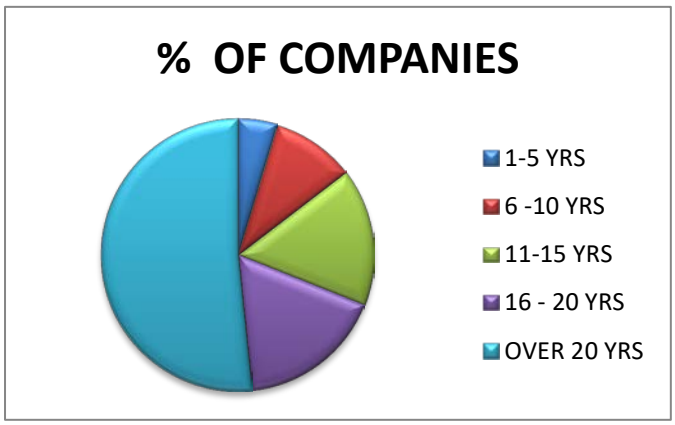
The field data collected was analyzed and the results discussed in line with the methodology laid down. The analysis focused on general particulars of respondents, maintenance strategies used in the study area and factors influencing the choice of maintenance strategies. The adequacy of maintenance strategies and the type of maintenance strategy were analysed and the results discussed.

General information of respondents

General information concerning the industries was collected. The information included the date of establishment of the company, profession of the respondents, nature of business set-up, respondents working experience, number of permanent employees, registration of company with corporate affairs commission, type of construction and functional use of the buildings. These were discussed in Tables 2 to 8.

Table 2: Distribution of Companies According to Age

AGE	% OF COMPANIES
1-5 YRS	4.7
6 -10 YRS	9.9
11-15 YRS	16.4
16 - 20 YRS	17.4
OVER 20 YRS	51.6



The chart shows that most of the companies sampled were not new comers into the Nigeria manufacturing industry.

Table 3: Professions Accommodated in Companies

	Frequency	Percent
Electrical engineering.	68	31.9
Architecture	7	3.3
Building	6	2.8
Civil engineering	16	7.5
Mechanical engineering	83	39.0
Material engineering	8	3.8
Administrative officers	25	11.7
Total	213	100.0

Table 3 shows that mechanical engineers and Electrical Engineers formed the core of the crew though the respondents cut across the various professionals who possess the required knowledge about the subject under survey to contribute meaningfully to this research.

Table 4: Nature of Business

	Frequency	Percent
Sole proprietorship	18	8.5
Partnership	23	10.8
Limited liability company	157	69.0
Public liability company	25	11.73
Total	213	100.0

The result shows that 18 of the firms were operating sole proprietorship outfit, 23 of the firms were into partnership, 157 operated limited liability companies while 25 firms were operating public liability companies respectively.

Table 5 shows the respondents working experience.

This table shows that 71% of the respondents sampled had more than five years' relevant experience in the respective industries to be able to respond to the questions asked.

Table 5: Respondents working experience

	Frequency	Percent
less than 2 years	26	12.2
2 to 4 years	60	28.2
5 to 7 years	37	17.4
8 to 10 years	58	27.2
Above 10 years	32	15.02
Total	213	100.0

Table 6: Type of construction

Description	Frequency	Percentage
Bungalow(load-bearing sandcrete blockwork)	3	1.41
Concrete Framed structures.	177	83.10
Steel framed structures.	33	15.49
Total.	213	100

Table 6 represents the type of construction. Only three were constructed of sandcrete load bearing walls, one hundred and seventy seven (177) were concrete framed structures and thirty three (33) were steel framed structures. This has a direct bearing on the nature, frequency, and severity of defects, particularly where over eighty percent (80%) of the buildings' space in the industrial estates sampled were used for production and workshops.

Maintenance strategies used in the study area.

From the respondents, multiplicities of strategies were observed to have been in use over the years. Eight were identified as being commonly adopted across the sampled industries as represented in Table 7. The respondents rated these eight maintenance strategies, by indicating their perception of importance on a 5-point scale ranging from 1-very low, 2-low, 3-average, 4-high, 5-very high.

The Relative Importance index technique was used to order the maintenance strategies mostly used in the selected industrial estates. From the results above, the traditional reactive [corrective] maintenance strategy ranked first, closely followed by renovation based maintenance, planned preventative maintenance and condition based maintenance. This infers that failures result in downtimes thus reducing productivity, but that

the situation is usually addressed promptly since planned preventive measures rank second.

Factors Influencing Choice of Maintenance Strategy

The suggested factors influencing their choice of maintenance strategies were culled from literature and the respondents were asked to indicate their perception on a 5-point scale ranging from 1-not responsible, 2-less responsible,3-responsible, 4 –next most responsible, 5 –most responsible.

Table 7: Ranking of observed maintenance strategies

Types of maintenance strategies	Relative importance index (RII)	Ranking
Reactive/corrective	0.1502	1
Renovation based	0.1155	2
Planned preventive	0.1042	3
Condition based maintenance	0.0460	4
Time based	0.0402	5
performance based	0.0188	6
Integration based	0.0160	7
Breakdown based	0.0104	8

Table 8: Factors influencing choice of maintenance strategy

Factors	R.I.I	Ranking
Delayed Reporting time	0.41197	1
The extent to which users can be relied upon	0.4049	2
Rate of determination of components	0.3662	3
Predictability of failure	0.2695	4

From the analysis the respondents agreed that reporting delay time, the extent to which users can be relied upon to report defects and the rate of determination of component were the major factors influencing their choice of maintenance strategy.

Adequacy of maintenance strategies

In order to be able to examine the adequacy of the maintenance strategies used by each firm, there was the need to ascertain if each firm had a maintenance department, and if so if professionals headed the departments.

In addition, maintenance policies, staffing of maintenance department, frequency of inspection and maintenance operations, and the response to maintenance requests.

Table 9: Number of industries having maintenance department

	Frequency	Percent	Cumulative Percent
yes	181	85.0	85.0
No	32	15.0	100.0
Total	213	100.0	

The result is obvious that majority of the manufacturing firms sampled have maintenance departments.

Table 10: Professional heading maintenance department

	Frequency	Percent	Cumulative Percent
Builder	6	2.8	2.8
Architect	2	0.9	3.7
Quantity surveyor	4	1.9	5.6
Civil engineer	37	17.4	23.0
Mechanical engineer	115	54.0	77.0
Electrical	49	23.00	100.0
Total	213	100.0	

With industrial buildings, builders, architects and quantity surveyors are relegated to the background as mostly mechanical engineers and to some extent, electrical and civil engineers head the maintenance departments.

Table 11: Number of manufacturing firms with building maintenance unit

	Frequency	Percent	Cumulative Percent
Yes	73	34.3	34.3
No	140	65.7	100.0
Total	213	100.0	

Table 12: Number of Firms with maintenance policy

	Frequency	Percent	Cumulative Percent
Yes	173	81.2	81.2
No	40	18.8	100.0
Total	213	100.0	

Table 13: Structure of maintenance organization

	Frequency	Percent	Cumulative Percent
Centralized	111	52.1	52.1
Decentralized	102	47.9	100.0
Total	213	100.0	

Table 14: Facility maintenance programme

	Frequency	Percent	Cumulative Percent
Yes	99	46.5	46,5
No	36	16.9	63.4
i do not know	78	36.6	100.0
Total	213	100.0	

It was found that over 60% percent of the companies sampled did not have a unit in charge of the maintenance of their building facilities. Of this, over 70% of them outsourced this service through contractors fixing defective items not just when the need arose, but as a matter of policy since 82% of the firms operated under strict maintenance policies (see Table 12). Table 13 showed the maintenance organization structure, 111(52.1%) have centralized structures 102(47.9%) have decentralized structures. The implication is that those having a centralized structure might be faced with bureaucracy in decision-making as regards to maintenance request, especially if the organization is large.

Table 15: Number of administrative staff in all maintenance departments

	Frequency	Percent	Cumulative Percent
1-3	182	85.4	85.4
4-6	21	9.9	95.3
7-9	4	1.9	97.2
10-12	2	.9	98.1
above 15	4	1.9	100.0
Total	213	100.0	

From Table 15 the number of administrative staff in maintenance departments appears to be grossly inadequate, especially as there was no indication that computerized maintenance management systems [CMMS] were used. Apart from administrative staff, the situation seemed worse with the operatives.

Table 16: Number of Carpenters in All the Maintenance Departments

	Frequency	Percent	Cumulative Percent
None	127	59.6	59.6
1-3	66	31.0	90.6
4-6	12	5.6	96.2
7 and above	8	3.8	100.0
Total	213	100.0	

An examination of a basic technical unit- the carpentry unit as in Table 16 revealed 59.6% of the 213 firms had

no carpenters in their maintenance departments. Similarly, Table 17 shows that 54.0% out of 213 firms sampled were not having plumbers in their maintenance departments.

Table 17: Number of Plumbers in Maintenance Department

	Frequency	Percent	Cumulative Percent
None	115	54.0	54.0
1-3	74	34.7	88.7
4-6	19	8.9	97.7
7 and above	5	2.3	100.0
Total	213	100.0	

Painters were no exception as shown in Table 18 in which 62.9% of the 213 firms sampled were not having painters in their maintenance departments.

Table 18: Number of Painters in Maintenance Department

	Frequency	Percent	Cumulative Percent
None	134	62.9	62.9
1-3	58	27.2	90.1
4-6	10	4.7	94.8
7 and above	11	5.2	100.0
Total	213	100.0	

Table 19: Number of Electricians in Maintenance Department

	Frequency	Percent	Cumulative Percent
None	26	12.2	12.2
1-3	109	51.2	63.4
4-6	43	20.2	83.6
7 and above	34	16.0	99.5
4	1	.5	100.0
Total	213	100.0	

However, there was a twist in the number of electricians in maintenance departments as only 12.2% had none.

Table 20: Number of Masons in Maintenance Department

	Frequency	Percent	Valid Percent	Cumulative Percent
None	176	82.6	82.6	82.6
1-3	25	11.7	11.7	94.4
4-6	12	5.6	5.6	100.0
Total	213	100.0	100.0	

Table 20 shows that 82.6% of the 213 firms were without masons in their maintenance departments.

Table 21: Source of Material for Maintenance

	Frequency	Percent	Cumulative Percent
From suppliers	178	83.6	83.6
Directly from markets	23	10.8	94.4
Materials store	12	5.6	100.0
Total	213	100.0	

Table 21 shows how manufacturing firms sourced the materials for their maintenance operation, with more than 80% from suppliers. Stock keeping which is primary to downtime minimization was observed lacking.

Table 22: Availability of Materials for Maintenance

	Frequency	Percent	Cumulative Percent
Yes	183	85.9	85.9
No	30	14.1	100.0
Total	213	100.0	

Table 22 shows the availability of materials for maintenance works. The materials used for building maintenance operations were ready available in the country.

Table 23 shows the frequency of maintenance operations, 78.4% indicated that maintenance operations were periodically carried out inferring that preventive [pro active] maintenance rarely carried out. This is further evidenced in Table 24.

Table 23: Frequency of Maintenance Operations

	Frequency	Percent	Cumulative Percent
periodically	167	78.4	78.4
Rarely	46	21.6	100.0
Total	213	100.0	

Table 24: Frequency of Facilities Inspection

	Frequency	Percent	Cumulative Percent
Very often	32	15.0	15.0
Often	45	21.1	36.1
not often	118	55.4	91.5
Never	18	8.5	100.0
Total	213	100.0	

Table 25: Response Time to Maintenance Requests

	Frequency	Percent	Cumulative	Percent
within a week	49	23.0	23.0	
1 -2 weeks	21	9.9	32.9	
within a month	72	33.8	66.7	
1 -2 months	53	24.9	91.6	
More than two months	18	8.5	100.0	
Total	213	100.0		

Table 25 shows the duration of time it takes to respond to maintenance request (down time).

This shows that over 60% of the facilities have a down time of over two weeks before any maintenance action is attempted by the organization.

Table 26: Inventory Data of Organisation Facility

	Frequency	Percent	Cumulative Percent
0-10%	68	31.9	31.9
11-25%	58	27.2	59.2
26-50%	33	15.5	74.6
51-75%	40	18.8	93.4
76-905	5	2.3	95.8
91-100%	9	4.2	100.0
Total	213	100.0	

Table 26 shows the percentage of the detailed inventory data available to the maintenance departments. The result shows that 68(31.9%) have less 10%, 58(27.2%) have between 11-25%, 33(15.5%) have between 26-50%, 40(18.8%) have between 50-75%, and 14(6.5%) have between 76-100%.

The implication is that over 60% of the maintenance departments sampled have less than 50% of their organizations facilities data.

The implication of this is that the maintenance planning for the organization facilities is not done or was carried without planning.

Table 27 shows the result of the ranking of factors responsible for delay in responding to maintenance request. Respondents were asked to rate the factors they perceived to be responsible for delay in responding to building maintenance request. A percentage of these factors were computed in order to be able to rank the factors.

The result shows that lack of fund to execute maintenance work came first, followed by lack of maintenance manual, lack of maintenance personnel and accessibility respectively.

The implication of this is that maintenance operation were not adequately funded in the manufacturing firms sampled, and most of the maintenance staff do not have maintenance manual and also majority of the companies do not have maintenance personnel in their employment.

Table 27: Factors Responsible for Delay in Responding to Maintenance Request

FACTORS	PERCENTAGE	RANKING
Fund (non-availability)	24.23	1
Lack of maintenance manual	18.54	2
Lack of maintenance Personnel	16.75	3
Accessibility	1626	4
Design flaw	1057	5
Building shape	8.46	6
Others (Bureaucracy)	2.76	7
Lack of appropriate technology	2.44	8

4. Discussion of Findings

The objective of the research was to identify and examined the facilities maintenance strategy used in industrial facilities maintenance. Findings showed that the most widely used maintenance strategy in the industrial Firms sampled was reactive/corrective maintenance. The strength of the factors responsible for the choice of maintenance strategy was also tested Using relative importance index. The results showed that: reporting delay time, the extent to which users can be relied upon to report defects and the rate of determination of the component and the corresponding increase in the cost of ratification and were the most influencing factors for the choice of maintenance strategy.

The inadequacy of administrative staff in their maintenance department, as well as key operatives such as carpenter, plumbers, masons, painters indicated that industrial organizations could not respond effectively to building maintenance request. The finding also revealed that materials for building maintenance were available in the Nigerian market and were source through supplier, but most Firms do not maintain of stock of the building components that fail frequently.

The findings also revealed that over 60% of the facilities have a down time of over two weeks before any maintenance action is attempted. Over 80% of the industrial organizations were not proactive in their approach to maintenance. The above finding reveals that the maintenance strategy currently used in the manufacturing

industries were not adequate.

5. Conclusion and Recommendation

The study was focused on appraising the maintenance strategies adopted the adequacy of these strategies and the impact of the strategies on the physical condition of the facilities. The most widely used maintenance strategy by maintenance department of building manufacturing and plastic industries in Lagos state was reactive/corrective maintenance. The staff strength of maintenance department is inadequate, over 60% of the maintenance department lacked technical maintenance staff and craftsmen such as carpenters, masons, plumbers, and Painters. The observed facility down time was over two weeks and the factors mostly responsible for delay in responding to maintenance request were lack of funds and inadequacy of maintenance strategies.

In the light of the research findings, it is highly recommended that industries need to establish building maintenance departments or create building units in their maintenance department in their establishments to perform specialized functions. Trained professional builders should be employed in the preparation of maintenance manuals.

It is desirable that trained craftsmen such as carpenters, masons, electricians, plumbers be employed in the maintenance department of organizations in order to cope with the maintenance requests thereby reducing facilities downtime. Adequate funds should be made available to the maintenance department to enable them hold stock of building materials and components frequently used as this will also help in improving response rate to maintenance request and reduce maintenance down time.

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