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Sustainability Strategies in Engineering Infrastructure Maintenance in Developing Countries: Selected South Western Nigeria States Case Study

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Abstract

It is an undeniable fact that production of maintenance- free infrastructure is not feasible. The reality is that all the elements and components that make up an engineering infrastructure unavoidably, deteriorates with time due to inherent defects in design and construction, and the effects of environmental agents and users activities.

All engineering infrastructures are subject to aging, wear and tear in the performance of their functions and deterioration by exposure to outside operating environment. Hence, left to themselves, engineering infrastructures will eventually become inefficient, unreliable and fail. The issue then is how the existing infrastructure can be sustained to the extent that the functions they are designed to perform will not be compromised. To this end, this study researched into sustainability strategies that can be adopted in engineering infrastructure maintenance. Data will be collected for purpose of extracting information on deployable strategies, including the use of Public engineering infrastructure in Southwestern part of Nigeria as case study. The study later recommended strategies than can be adopted to aid this present generation provide solution to their environmental needs without compromise ability of future generation to meet their needs, which concept of sustainability has birthed.

Key Words: Sustainability, Strategy, Infrastructure and Maintenance.

1.0 INTRODUCTION

1.1 SUSTAINABILITY PHENOMENON

Sustainability issue in recent times has dominated the arena of discussion in built environment. Billions of dollars worth of building investment are being initiated world over while little emphasis is placed on the aspect of maintenance of such infrastructure, this however could result into building an unsustainable buildings. In the tropic, careful consideration is often given to planning while proactive thought is not often accord the maintenance aspect, this however is common to the public utilities and infrastructure. Most sectors, unfortunately, are yet to give issue of sustainable design and building, an appropriate emphasis, buildings meant for human habitation are developed without much emphasis on design concept, space ergonomics, construction process, renewable material and post construction post occupancy requirement.

It is however pertinent at this juncture to appreciate the component of a sustainable building and infrastructure. Sustainable building are those that through their design, spatial orientation, choice of building components, construction and operational strategy, are highly efficient, also have low operating costs, environmentally friendly, and do not affect the health of their users and occupants negatively Solomon (2005)

An infrastructure that contains structure and form that are not sustainable can be describe as high and this has become a phenomenon in the tropic, it is high time however that paradigm should shift from non sustainable development to sustainable one, through proactive strategy which this study aimed to achieve.

2.0 PERSPECTIVES TO THE CONCEPT OF SUSTAINABILITY

There are existing views to the definition of sustainability concept; sustainable design/construction is one of such views. Sustainable infrastructure is viewed as the one that eliminates associated negative impact of infrastructures on user and environment. One of the schools of thought is the one that considers sustainability from the sustainable design/construction perspective, that, it is the design of and construction of infrastructure in a way that will enable the present generation meet their needs without compromising the prospect of future generation in meeting their needs. Sustainable design/construction can also be described according to Solomon (2005), Vijervaberg (2000), as the proper use of land, minimization of waste water, the use of less mechanical energy, understanding the site ecology, the application of eco-effective and recyclable materials among others. This can be generally described as producing an high performance infrastructure. Another school of thought,

viewed sustainable concept from the perspective of eliminating associated negative impact of infrastructure on users and environment, this school of thought emphasize maintaining infrastructure form and structure. Vijervaberg (2000) belong to this school of thought, that it is a design and construction practices that significantly reduce or eliminate the negative impact of building/infrastructures on the environment. It was established that this is achievable from the following six (6) key areas: Bioclimatic design indoor-environmental quality, construction of materials and resources, energy efficiency and renewable energy, and community design and connections; and sustainable design. So also another school of thought believed that sustainable infrastructure should benefit society at large, improves standard of living (socially financially and economically), and secures the users health and safe for habitation. Solomon (2005), Vijervaberg (2000).

3.0 INFRASTRUCTURE DETERIORATION PHENOMENA AND MAINTENANCE CONCEPT

Maintenance-free or self-sustaining infrastructure is highly desirable but not feasible. Infrastructures deteriorates with time due to wear and tear effect on the component, users and occupiers activity, inherent defects in design and construction and effects of environmental role in the deterioration of infrastructures' component; hence left to themselves, facilities will eventually become inefficient, unreliable and fail Iyagba (2005),Winderlich (1991), Vijervaberg (2005) opined that function change or function termination of the user, owner or manager is limited once the building's acceptance threshold has been passed. If such building is sold the risk will then be transferred to the buyer, as did the original owner, it is at this stage that maintenance of such infrastructure is of great necessity, only repair or rehabilitation can bring such building back to the improved state or as-good-as-new state Iyagba (2005),Winderlich (1991). Winderlich (1991), Vijervaberg (2005) submitted that infrastructural facilities depreciate at a rate varying between 6% and 10% depending on their physical conditions in a period of 10 years. When maintenance is ignored the effect is to aggravate the rate of infrastructures deterioration from year to year.

4.0 CRITICAL SUSTAINABILITY FACTORS IN ENGINEERING INFRASTRUCTURAL MAINTENANCE

Engineering infrastructures are required virtually at all facets of human endeavor, they are found at various stages of human economic and social economic life, buildings are common one around, it as well includes road, dam, equipment in building, production structures, drainage facilities, waste disposal and processing facilities, material production units, health facilities, transportation units, electricity outfits, and telecommunication systems. However, huge cost is always involved in infrastructures maintenance. Gambataella and Moroni (1991), Ghosh (2008) identified three sets of factors which influence maintenance requirement and costs. These are: (i) Internal parameters pertaining to intrinsic characteristics of the building such as design and construction and the interdependence of building component and elements (ii) Usage and environmental effects which exert stress on the infrastructure and (iii) The effects of the previous users actions and owners response to maintenance need.

(i) Previous users action (Vandalism): Users action often constitute a great source for maintenance need in infrastructure maintenance. This could be described as vandalism, it has its roots in the social fabric of the community, and its often out of psychological disposition to cause damage, it is as well often calculated intention to express dissatisfaction to authority or society at large (Apochi and Abdulhameed 2008). Among the factors adduced as responsible for act of vandalism are wrong choice of materials, poor space layout, poor lighting arrangements and lack of security among others. Vandalism impairs the aesthetic of building, and reduces its life span and cost intensive.

(ii) Environmental stress effects on infrastructure: (Sick building Syndrome) Environmental agencies such as climatic conditions (rainfall, humility, temperature, wind groundwater conditions), chemical agents like chlorides and sulphates impact stress building and occupants. These stressors acts base on orientation of the structure and on external elements of the structure. The resultant effect of these stressors on the building is referred to as sick building syndrome.

(iii) Deficiency in design construction and interdependency of building components: The nature in which some elements in building were designed often hinders their maintainability. This may result from non-

availability of replacement parts and components as in the case of many imported household items like lift, and air-conditioning (including Nigeria), in this kind of situation therefore, the most effective maintenance strategy should be one that minimizes the incidence of maintenance works through appropriate design. To be able to sustain a design or concept, it should be maintainable, and maintainability in the real sense of it is a measure of the ease of maintaining a building or its elements and components, which depends not only on the design and technical aspects but also on the availability of the building or components, when required for maintenance. (Sour and Yueng (1993).

5.0 STRATEGIES FOR SUSTAINABLE ENGINEERING INFRASTRUCTURE

Constructing sustainable engineering infrastructure is approached in different ways with different priorities in different countries ranging from ecological impact on the environment, economic, social cultural consideration, density and demography of population, availability of land and water, energy production and supply, loss of natural habitat to lack of adequate facility to handling and resultant waste processing. So also strategies that could be adapted varies, however the some of the proactive strategy recommend could be any of the following or combination of more than one. Integrated project delivery system, re-engineering of construction process, environmental quality of construction, new construction concepts, assembly and disassembly approach, public awareness, setting of benchmark for regulation and best proactive, research and development, capacity building of construction sector, and energy conservation.

(a) Integrated approach in infrastructural design and construction: (I. A. I. D. C.) Because there is tendency for design process to increase in importance and complexity, there is therefore an urgent need for an integrated approach requiring among others co-engineering partnership between designers, engineers, and manufacturers. This will engender work cohesion in changing design information for an optimized alternative. This will enable adequate feedback for future design and improvement and as well information on best approach to maintain the existing infrastructure, so as to sustain them in from, structure and function.

(b) Process management (P.M): Management and Organization of key factors that comes to play in sustainability issue is as important as the concept itself. The subject must engage other issues not only technical aspect, but as well social, legal, economic and political matter. A structuring of the maintenance problem must be done in such a way that the complex interrelationship can be modeled for communication purpose. Also, a system of measuring progress must be put in place so that the extent of progress achieved can be appraised. A management framework must be developed which allows for planning, design, construction, monitoring and feedback on sustainability, as a key element in the development occupation and maintenance of infrastructures.

(c) Integrated project delivery system (I. P. D. S): An integrated delivery system is needed if the sustainability of engineering infrastructure will be realizable. Key actors involved are to be galvanized, from federal government, state government, and local government to designer, client, manufacturers and suppliers. Research has revealed that public infrastructures are poorly maintained, the federal government then should ensure the development of clear national sustainable policies and plans, local governments on the other hand holds key responsibility for land use, planning and implementation of sustainability policies as formulated by the federal government. Designers, builders and clients are responsible for reducing construction energy in building as well as non renewable resources. Thus builders, management and designers, are also to be responsible for increasing the recyclable material contents of building, waste generation and detoxification to produce an eco-friendly by-products.

(d) Re-engineering of the building and maintenance process: The penetration of new technology will lead to better output. New technology that involves better management of infrastructure development process through total quality managements and improved project coordination facilities as well as proactive maintenance system will be of immense value. This will help to large extent in having sustainable development.

(e) Improvement of environmental standard in construction and maintenance of engineering infrastructures: There should be a clear policy as regards standard obtainable in design, construction and maintenance of infrastructures. Paradigm should shift in the direction of "Green building Concepts." According to Apochi and Abdulhameed (2008), Green buildings are designed to meet certain objectives such as protecting occupant health, improving employee productivity, using energy, water and other resources more efficiently and reducing the overall impact to the environment. In this vein however, Green infrastructure is being advocated. It is high time that construction stakeholders shift focus to the direction of Green infrastructure. The infrastructure

that will have less operating costs through increasing productivity and using less energy and water; improved public and occupant health due to improved indoor air quality and reduced environmental impacts.

(f) Introduction of new construction and maintenance concepts: The penetration of new technology and design concepts, construction and maintenance of infrastructure, will produce an economic and environmental valid construction products. Therefore, synergic approach in this respect, among designers, builders, and material manufacturers is needed to produce advanced products. The development and incorporation of subsystems however should not be cost intensive, the application should be flexible and environmentally compatible and sustainable. New concepts in maintenance should be introduced; introduction of Total Maintenance Operation Management (T. M. O. M.) is advocated. T. M. O. M. is a technique that involves appraising techniques used in maintenance of an item, with a view to establishing an optimized approach better in term of quality, and fair in term of cost and as well pliable in the aspect of environmentally friendly by-products.

(g) Incorporating eco-friendly construction materials: Studies reveals that people spent 80-85% of their time indoors, and most of the building materials often used in construction emits fumes and odour. The odour and emission from such are often poisonous, the effect can be carcinogenic or mutagenic, while other effects includes but not limited to the following: dizziness, memory loss, skin problem, respiratory tracts infection, migraine, headache, allergies of diverse kind, disturbance in biological functions and damage of cellular growth and genetics and destruction of ecosystem Sour and Yueng (1993). Therefore eco-friendly materials are needed in construction work in order to sustain life and structure, that uses the construction products and bye products.

6.0 ANALYSIS OF RESULT AND DISCUSSION.

Table 1: Sample frame for the study

State	No. of federal owned hospital	No. selected for study	No. of state owned hospital	No. studied	No. of federal owned road	No. selected for study	No. of state owned road	No. selected for study	Percent studied hospital	Percentage studied road
Lagos	5	4	16	15	20	19	32	30	76.0	52.70
Ogun	2	2	24	22	12	2	12	11	32.0	14.00
Osun	1	1	12	11	5	5	12	11	16.0	17.21
Oyo	1	1	20	19	3	3	13	12	26.67	16.13
Total	9	8	72	67	30	29	69	64	150.67	100.04

Source: Field survey 2009

Table 1 present sample frame for the study, it include the sample selected from population. Samples were picked from Federal owned Health infrastructure (hospital) and State owned infrastructure. Sixteen (16) Federal Hospitals were chosen from Lagos with fifteen (15) State Hospitals, twenty-four (24) federal from Ogun State, and twenty-two (22) State Hospitals, Twelve (12) Federal Hospitals from Osun with Eleven (11) State Hospitals, while twenty (20) Federal Hospital were selected from Oyo State and nineteen (19) State Hospitals.

Also, on Road infrastructure, a total number of thirty federal roads were sampled, while sixty-nine roads were selected. As regards sample selected criterion like road topography maintenance operation frequency, road size, road accessories, road design, surface feature among others were used to sensor users opinion on roads sustainability issue, the analysis of the respondents response is as presented in Table 9.

Table 2: Analysis of number of building managed by maintenance department

Number of buildings	Frequency	Valid percent	Percentage cumulative
Fewer than 5 building	42	22.8	22.80
6 – 10 building	18	9.78	32.58
10 – 15	35	9.6	52.18
20 – 30	38	20.65	72.83
24 – 40	6	3.26	76.09
28 – 50	7	3.80	79.89
32 – 60	18	9.78	89.67
More than 60	20	10.87	100.54
Total field	**184**	**90.54**	**526.66**

Source: Survey 2009

Analysis of building infrastructure maintained by the maintenance department of the organization is presented in table 2. Results indicate 20-30 building which constitutes 20.65% of the organizations structures were maintained by the department.

Summarily the range can be stated as 19.54% building as being maintained by maintenance department of the organization

Table 3: Analysis of hospital facilities users

Department	Sample size	Population percentage	No returned	Response
Administration staff	92	32.86	85	41.46
Management staff	30	10.72	25	12.20
Medical staff	100	35.72	15	39.02
Patient	60	21.42	15	7.32
Total	**280**	**100.72**	**205**	**100**

From Table above, 35.75 of the sampled respondents are Medical staff, 32.9% are Administrative staff, 21.42 are Patient and 10.7% Management staff. Also 41.5% response was obtained from Administrative staff while the lowest response was from patient.

Table 4: Analysis of length of service hospital facilities maintenance staff

Length of service	Frequency	Valid percent	Cumulative percent
Lea than 2 years	92	44.88	44.88
2-5 years	43	20.98	65.86
5-10 years	30	14.64	80.50
11-15 tears	25	12.20	92.70
12 year an above	15	7.32	100.02
Total	205	100.02	100.02

Years of experience of the maintenance staff is necessary for sound judgment in their response to the question on this works, therefore, 44.88% of the respondent had been in the maintenance service of the institute for less than 2 years,20.98% for 2-5years, 14.64% for 5-10 years and 7% for 12 years and above.

Table 5: Users Perception of Federal Health Infrastructures (Hospital).

INFRASTRUCTURAL COMPONENT	MEAN INDEX	RANK
Internal Paintings	90.52	1
External Paintings	90.45	2
External Paintings	89.52	3
Environmental Sanitation	79.4	4
Blockwalls	76.19	5
Clean Water Supply	75.33	6
Floor slabs	75.24	7
Roof Structures	73.52	8
Lift Services	72.65	9
Garbage Disposal	71.69	10
Beams/ Collumn	70.52	11
Electricity Supply	69.16	12
Ceiling	63.56	13
Waste water disposal	63.04	14
Window	53.93	15
Doors	53.03	16
Escalator	52.54	17
Security	49.78	18
Sanitary Fittings	48.05	19
Communication System	46.88	20
Parking Facilities	46.67	21
Fire protection Appliance	46.57	22
Road Networks	46.36	23
Human Traffic Control	45.88	24
Adequacy of Albedo	45.68	25
Drainage Systems	45.15	26
Indoor Air quality	42.91	27
Shading by Vegetation	42.17	28
Courtyard Design	42.15	29
Floor/wall Tiles	42.09	30
Nettings	40.02	31

Table 6: Users Perception State Health Infrastructure (Hospital)

INFRASTRUCTURAL COMPONENT	MEAN INDEX	RANK
Internal Paintings	89.58	1
External Paintings	89.52	2
External Paintings	89.52	2
Environmental Sanitation	79.42	3
Blockwalls	76.19	4
Clean Water Supply	75.53	5
Floor slabs	75.44	6
Roof Structures	74.52	7
Lift Services	71.65	8
Garbage Disposal	70	9
Beams/ Collumn	69.52	10
Electricity Supply	68.16	11
Ceiling	63.56	12
Waste water disposal	63.04	13
Window	53.98	14
Doors	53.03	15
Escalator	52.5	16
Security	49.72	17
Sanitary Fittings	47.05	18
Communication System	46.8	19
Parking Facilities	46.67	20
Fire protection Appliance	46.67	21
Road Networks	46.26	22
Human Traffic Control	45.88	23
Adequacy of Albedo	45.78	24
Drainage Systems	45.35	25
Indoor Air quality	43.91	26
Shading by Vegetation	43.17	27
Courtyard Design	42.79	28
Floor/wall Tiles	42.3	29
Nettings	40.72	30

Users Perception Federal Health Infrastructure
(Hospital)

INFRASTRUCTURAL COMPONENT	RANK (Fed)	RANK(Stat)
Internal Paintings	1	2
External Paintings	2	4
External Paintings	3	3
Road Networks	23	23
Environmental Sanitation	4	3
Sanitary Fittings	19	21
Blockwalls	5	5
Clean Water Supply	6	7
Floor slabs	7	8
Roof Structures	8	9
Lift Services	9	9
Garbage Disposal	10	11
Electricity Supply	12	11
Ceiling	13	12
Waste water disposal	14	14
Beams/ Collumn	11	19
Window	15	17
Security	18	15
Escalator	17	16
Doors	16	18
Communication System	20	18
Parking Facilities	21	20
Fire protection Appliance	22	21
Human Traffic Control	24	24
Adequacy of Albedo	25	25
Drainage Systems	26	28
Indoor Air quality	27	29
Shading by Vegetation	28	29
Courtyard Design	29	31
Floor/wall Tiles	30	30
Nettings	31	29

Table 8 Perception to the Pattern of Maintenance of Facilities

INFRASTRUCTURAL COMPONENT	MEAN INDEX	RANK
Internal Paintings	89.52	2
External Paintings	89.52	4
External Paintings	89.52	3
Environmental Sanitation	79.42	3
Blockwalls	76.19	5
Clean Water Supply	75.53	7
Floor slabs	75.44	8
Roof Structures	74.52	9
Lift Services	71.65	9
Garbage Disposal	70	11
Beams/ Collumn	69.52	19
Electricity Supply	68.16	11
Ceiling	63.56	12
Waste water disposal	63.04	14
Window	53.98	17
Doors	53.03	18
Escalator	52.5	16
Security	49.72	15
Sanitary Fittings	47.05	21
Communication System	46.8	18
Parking Facilities	46.67	20
Fire protection Appliance	46.67	21
Road Networks	46.26	23
Human Traffic Control	45.88	24
Adequacy of Albedo	45.78	25
Drainage Systems	45.35	28
Indoor Air quality	43.91	29
Shading by Vegetation	43.17	29
Courtyard Design	42.79	31
Floor/wall Tiles	42.3	30
Nettings	40.72	29

Users perception of the extent of maintenance work carried out on the Federal infrastructure and the state of the infrastructure is presented in table7 and 8, statistical methods were used for the analysis.
The severity index is given by (11)

$$I = \frac{\sum_{i=0}^{5} ai \times i}{5\sum_{i=0}^{5} xi} \times 100\%$$

RAF=$\frac{\sum AEQB}{N}$

PRAF=$\frac{RAFmax - RAFi}{RAFmax}$

Where a_i = Constant expressing the weight given to I; and x_1 = variable expressing the frequency of the response for I = 0, 1, 2, 3, 4 or 5 and is illustrated as follows:

x_1 = frequency of "very bad factor, (V. B. F) x_2 = frequency of "Bad factor", (B. F)

x_3 = frequency of "Average factor", (A. F) x_4 = frequency of "Good factor" (G.F) and x_5 = frequency of "Very Good factor" (V.G.F).
RAF max= Maximum RAF, N= number of variable factor ranked, $\sum$ = sum of the order of rankings by the respondents.

The rank agreement factor can be greater than 1, with a higher factor implying greater disagreement. For the ranking of perception of users on facilities maintenance,for the 31 parameters used, the Maximum RAF is 1.94. An RAF of Zero imolies perfect agreement.
For Table 8, External paintings was regarded as most maintained with index of 89.52%, followed by good environment, the environment was well kept, with 79.42%. Well maintained internal paintings was ranked 3rd with 77.83%, Blockwall, with 76.19% ranked 4th while clean water supply to the buildings with 75.53% ranked 5th.
The most poorly maintained is courtyard, which was poorly designed, inadequate Albedo, poor human traffic control, communication system, drainage system, parking facilities and shading by vegetation.
Questionnaire was distributed to collated the response of Road infrastructure users, severity index of the response was measured as well using Sanyal (2008), Solomon (2005) approach as in the Hospital infrastructure above. The outcome of the analyses indicated that, road camp for rapid response to emergency repair on roads were not adequate, road surfaces were poorly maintained, little or no pedestrian walkway exerting unnecessary stress on the road, regular maintenance of the roads is poor and the pothole on the roads are little or not maintained.

Table 9: Strategies for sustainable infrastructure (users perspective)

Parameters	Mean index	Rank
Total maintenance technique management	89.98	1
Proactive Maintenance Approach	89.75	5
Rainwater harvesting	60.75	17
Green building technologies	88.65	10
Using VOC volatile organic compound free material	40.25	18
Curtailing harmful emission from industrial materials	64.35	16
Material recycling	85.72	12
Using Eco friendly building materials	85.70	13
Pre-environmental auditing of building materials	65.25	15
Good social economic habit of user	89.83	3
Proper supervision of maintenance project	88.89	7
Impressing less tress on infrastructure	89.90	1
Integrated approach in infrastructural design and construction	88.77	9
Construction process management	86.66	11
Integrated project delivery system	88.78	8
Reengineering of the building and maintenance process	82.78	14
Introducing new construction and maintenance concepts	88.98	6
Improving environmental standard in construction	89.90	2

Field survey 2010

Users perception on sustainability strategy that could be adapted in infrastructures maintenance is presented in table 10 above,
Adopting system of total maintenance operation management (TMOM) is advocated, this is ranked first (1st) alongside with imposing less stress on infrastructures, this will prolong the shelf life of the infrastructures. Provision of an improved environmental standard in construction is ranked second (2nd), developing good social economic ideology among users, (3rd), proactive maintenance approach (5th) proper supervision of maintenance project (6th), adopting an integrated project delivery system (8th) and green building technologies adoption.

7.0 Total Maintenance Operation Management (T.M.O.M.)

However, total maintenance technique management is advocated. This is system that will make managing quality at f\different phases of development project or construction of infrastructure possible. The system incorporates the aspect of construction, design and maintenance to be able to provide an insight into ingredients for sustainable development. The detail of the aspects involved in Total Maintenance Technique Management (T.M.O.M.) from infrastructural user perspective is presented in the Table 10.

Table 10: Analysis of Response on Total Maintenance Operation Management (T.M.O.M.) structure.

Total Maintenance Operation Management				
S/N	**T.M.O.M Principle**	**Total**	**M.I.S Val**	**RK**
A	**Quality Policy**			
	1.Policy of maintenance method to be used should be clearly defined	52	0.92	4
	2. Employee should be involved in decision making.	62	0.85	28
	3. Standard of works and operational quality should be clearly communicated.	55	0.91	7
	4. Quality assurance team should be formulated.	55	0.92	4
	5. Period retrospective check on successful implementation essential.	57	0.91	7
B	**Communication, Authority and Responsibility**.			
	1. There should be effective communication of information on work quality standard to the maintenance personnel.	61	0.88	16
	2. Management should convey meeting on quality in maintenance issue periodically.	57	1.00	1
	3. Policy implementation committee need to be established	59	0.54	32
	4. Delegation of responsibility is essential for over operation success	57	0.88	16
	5. Establishing line of command is essential.	54	0.89	14
C	**Work Environment**			
	1. Work environment should conform to international standard.	45	0.92	3
	2. Adequate ventilation, first aid and personal protective items should be available	55	0.91	7
	3. Work schedule should be flexible to minimize error and accident.	43	0.88	16
	4. Man-machine convenience should be given consideration	45	0.86	23
	5. Provision of incentive to enhance productivity.	55	0.91	7
D	**Manpower Training and Development**			
	1. Skill workers should be sufficient in companies/ organizations maintenance operations.	44 43	0.86 0.96	23 2
	2. Workshop, Conference should be organized for workers.	43	0.93	3
	3. Refreshers courses is essential for on-job development.	43	0.89	14
	4. Rotational of job-bits for workers job-experience universality	48	0.92	4
	5. Mechanization of production processes operation			
E	**Measurement and Precision**			
	1. Emphasis is usually on getting the work done correctly once and always	34		21
	2. Periodic measurement of maintenance quality management.	46		21
	3. Item repaired last long before developing faults.			
	4. Fault developing period on maintained items are as follows:			
	Below 5 months.	42	0.50	35
	5-10 months.	47	0.55	34
	10 months and above	48	0.85	28
F	**Performance Monitoring**			
	1. Conventional method of detecting faults should be in place.	59	0.88	16
	2. Human-based inspection method should give way to conventional method	65	0.80	30
	3. Personnel should be taught fault recognition techniques.	55	0.91	7
	4. Personnel should be taught ways of assessing maintenance works done.	56	0.90	12
	5. Frequency of corrective operation (rework) should be noted as performance index	71	0.88	16
G	**RESOURCE ALLOCATION BUDGETING**			
	1 Resource should be allocated for works in every fiscal years.	50	0.86	23
	2 Financial allocation should exist for emergencies.	40	0.74	31
	3 There should be budget for routine maintenances.	48	0.90	12
	4 Progressive auditioning of operations.	51	0.86	23
H	**QUALITY COST OBJECTIVE.**			
	1 Minimizing Expenditure to maximize profit.	45	0.59	33
	2 Having maintenance expenditure base on machine/equipment age/utilization	50	0.85	23
	3 Allowing contingencies for tools and incidental: internals and external failure	50	0.90	12

SOURCE: 2005 SURVEY

8.0 DISCUSSION OF RESULTS/FINDING

The cumulative figure of respondents' opinion as regards issues on application of Total Maintenance Operation Management principle in maintenance operation is presented in Table 5, the Mean item score is also calculated of the Data generated therefrom. However it was discovered from Table 5 that:Sensitization of personnel i.e communication on the issue of quality as regards various maintenance operations top the list, with mean item score 1.00 that Management of organization should convey periodic meeting of the employee, which will provide a forum of discussion on quality issues; this will enable issues of bottlenecks in operation to be discussed and solved.

Manpower base of the organization needs be consolidated, through driving qualitative personnel development programme, this was ranked second (2^{nd}) with mean item score 0.96, that qualitative knowledge and skill could be acquired through workshop, seminar, vocational skill acquisition programme and organization of refresher courses was ranked third (3^{rd}) with mean item score 0.93, this is essential to keep personnel abreast current technological development in their area of discipline since organization at all facet in life has been the order of the day since the inception of concept of globalization .So also communication of main tenancy policy to all and sundry, mechanization of production processes operation and formulation of quality assurance team, were ranked fourth (4^{th}) with mean item sore 0.92. Hand/manual work tends to be monotonous and tedious, is slow and retards efficiency. Certain operation could be carried out more rapidly and efficiently if machine were used in carrying them out. The nature of maintenance policy in place should be well defined and communicated to personnel, this will enable them to share the vision burden, clear communication of the policy gives an organization focus and direction and results in a well structure that favours productivity.

As well important is the formulation of quality assurance team, this teams major preoccupation is check and control of the quality in production system. This culminates in a concept of self-driven team, they generate/originate ideas, formulates quality policy and set up framework for its implementation.

So also, an organization that desires enhance output will hold in high esteem the upholding of standard work among its workers, thus from table 5, clear communication of standard of work and operational quality, periodic retrospective check on adherence to quality in maintenance operations, provision of incentives to enhance productivity and teaching of personnel the art and skill of fault recognition in maintenance operations, were ranked seventh (7^{th}), with mean item score value 0.91.

The personnel needs taught skill and techniques useful in recognizing fault during maintenance works; this lessens the burden on supervisors, and would held forestall delay and unnecessary re-work.
Incentive provision is also essential in encouraging workers on to higher productivity, the incentive induces higher productivity, when well managed and administered. The incentives could be Financial incentive, Non-financial incentive or combination of both. The incentive nullifies dissatisfaction among workers and enables them to put in their best. An incentived maintenance workers will be effective at work, efficiency is high, waste is reduce and productivity per head is enormous. However, the incentive mentioned above alongside with provision of first aid and personal protective items are all means of eliciting higher productivity from workers.
Periodic retrospective evaluation of result achieved as regards policy implementation is necessary; this should be observed, in order to determine the extent of success attained, in order to call for policy reformation or re-programming.
From the Table (5), Establishing line of command, Job-bits rotation, were ranked fourteen (14^{th}) with mean item score 0.89; Establishing line of command is necessary for effective instruction and information dissemination as well as job-bits rotation, this prevent exhaustion, job burnt-out, and work monotony, it also allows for experience universality.
In line with the above is establishing flexible work schedule, delegation of responsibility, effective communication work/operations quality, and using conventional methods in fault detection for purpose of maintenance work, were ranked sixteen 916^{th}) with mean item score 0.88. Work schedule should be flexible, this prevents overwork, work fatigue and dissatisfaction that could lead to work accident or exhaustion, which is counter-productive, authority, needs be delegated for effective administration, and overall success. So also conventional method should give way to primitive fault detection method that are ancient and outdated, computerized fault detecting gadget should be employed e.g. calibrated electronic fault detecting devices.
Minimizing Expenditure to maximize profit is ranked thirty-third (33^{rd}) with mean item score 0.59, maintenance operation incurs expenditure by its nature, thus it is not profit oriented, thus adequate expenditure programme should be in place. Emphasis here should be getting the operation carried out correctly once and always, with periodic measurement of maintenance quality management to ensure consistency, this will enable items

maintained to last before developing fault, to this end however, the suggested window fault detection period that could be abstracted is benchmarked at period of 10 month and above, this will tend to lesson expenditure.

9.0 Conclusion/Recommendation

With reference to the discussion above sustainable approach to maintenance of engineering infrastructures could be achieved using the following benchmarked parameters:

(a) Introduction of new construction and maintenance concepts.
(b) Integrated approach in infrastructural design and construction.
(c) Empowering workers through knowledge base consolidation approaches such as: Seminars Workshop, Vocational acquisition course, and Refresher course
(d) Clear communication of maintenance policy to all stakeholders.
(e) Incorporating eco-friendly construction material into building at building stage
(f) Formulation of quality assurance team to oversee various maintenance operations.
(g) Mechanization of production processes where necessary.
(h) Periodic retrospective check on process/success achieved at various policy and operations.
(i) Provision of good environment, well ventilated workspace, first aid and protective items.
(j) Site work environment
(k) Reengineering of building and maintenance process.
(l) Improvement of environmental standard in infrastructures construction and maintenance
(m) Provision of incentives (financial and Non-financial).
(n) Adoption of
(o) Teaching of maintenance personnel/crew the art and technique of fault recognition for purpose of maintenance.
(p) Provision of contingencies for tools and incidentals: internal and external failures.
(q) Provision of budget for routine maintenance.
(r) Teaching personnel ways/method of assessing quality of work married out.
(s) There should be effective communication of information on work quality-standard to personnel
(t) Delegation of responsibility
(u) Work schedule should be flexible to minimize error and accident.
(v) Using conventional method in fault detection during maintenance operation.
(w) Financial allocation should be put in place for emergency.
(x) Maintenance allocation should be ranged based on frequency of equipment utilization, and period of purchase.

If the above could be observed, productivity will increase among maintenance workers, accident will be reduced, incidence of rework and waste will be eliminated and there will be quality job output.

REFERENCES

[1] Solomon, N (2005) ''The Pick of the Sustainable Crop'', Architectural Record Pp 160.
[2] Nadel, B. A. (2007) Windows and Sustainability: ''An Environmental Perspective''. Architectural Record, pp 257-261
[3] Iyagba, R. O. A (2005) ''The Menace of Sick Buildings: A Challenge to all for its Prevention and Treatment''. An Inaugural Lecture Delivered at University of Lagos. Nigeria.
[4] Winderlich N. O. (1991) ''Probabilistic Method for Maintenance'': A SCE Journal of Engineering Mechanics. 117 9a), 2065-2066.
[5] Vijervaberg, G. (2000) ''Busing Maintenance Needs on Accommodation Policy'': Building Research and Information. 28CD 18-25.
[6] Gambataella, L. M and Moroni, M. (1991) ''Expert Systems Application to Building Pathology Diagnosis: Methodology'' Proceeding of the Second European Conference on Application of Artificial Intelligence and Robotics to Building, Belgium. Pp 252-254.
[7] Olubodun, F.O. (2000): ''A factor approach to the analysis of components' defects in housing stock''. Structural Survey, 18(1), 46-57
[8] Sour, L. H. and Yueng, G. C. S. (1993) Building Maintenance Technology. The Macmillan Press LTD. London.

[9] Ghosh, S. K. (2008) ''Waste Water Recycling for Sustainable Development World'' Congress on Housing. Kolkalta India pp 1-20
[10] Apochi M. and Abdulhameed, A. (2008). ''Building for Environmental and Economic Sustainability''. Technical Manual and User Guide. Pp 8
[11] Sanyal, D. (2008) A Search for Eco-Friendly Building Materials for Sustainable Urban Mass Housing. World Congress on Housing. Kolkalta India pp 1-15
[12] Balasubramanya M. C. and Sampath Kumar (2008) Green Building Technologies and Solutions to Global Warming. World Congress on Housing Kolkalta India pp 1-9
[13] Al-Hammad A. M. and Assaf, S. (1996). Assessment of Work Performance of Maintenance Contractors in Sandi Arabia. Journal of Management and Engineering. Pp 1-3
[14] Hussaini, I. U. (2008) Landscaping for Energy Conservation: An Overview. Nigerian Journal of Construction Technology and Management. Pp 66-69