

DESIGN, DEVELOPMENT AND ASSESSMENT OF MAINTENANCE SYSTEM FOR BUILDING INDUSTRY IN DEVELOPING COUNTRIES

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ABSTRACT

This paper examines the problems of maintenance in developing countries. It acknowledges poor maintenance culture as a worldwide problem but notes that the situation is at an alarming rate in the developing countries. Usually building projects are packaged without provision for the future maintenance of the buildings during their service periods. Therefore, when the facilities are being used and deterioration sets in, it takes sometime to put an arrangement in place to correct the defect(s). Most maintenance operations fail qualitatively and quantitatively due to improper design, inappropriate maintenance approach, inadequate planning and inappropriate maintenance method and atimes lack of maintenance policies.

The author indicates that the use of labour-based method for maintenance operations in building industry would be more appropriate in developing countries as opposed to equipment-based or labour intensive approach. Labour-based method is considered to be more economical than either equipment based or labour intensive method. An operational concept for effective design and management of maintenance work is presented. The concept provides procedures for carrying out maintenance works, evaluating resources for maintenance operations and assessing the performance of maintenance works. The performance is assessed by cost control (cost indexes and performance checks through the use of man-hours per unit of work done. Good management in maintenance work would furnish such indexes as are necessary to permit evaluation of the performance of the organisation internally and provide top management with information they need to assess the performance of the maintenance.

KEYWORDS: Building Industry, Design, Development, Maintenance System, Maintenance Methods, Key Performance Indicators,

1.0 INTRODUCTION

British Standard Institution (1) defines maintenance as the work necessary to keep or restore a facility that is, every part of a site, building and content, to an acceptable standard including minor improvements. With insufficient or lack of maintenance, building deteriorates. Building maintenance possesses little glamour, it does not attract very much attention and is frequently regarded as unproductive, although many of the managing and technical problems are more demanding of ingenuity and skill than those of new works. Lack of maintenance affects us all, since we depend on the state of our homes, offices, factories etc not only for comfort, but more importantly for our economic survival. There is no doubt that dilapidated and unhealthy buildings in a decaying environment depress the quality of life and contribute in some measure to antisocial behaviour.

In any building project, the beginning of maintenance takes place the day the contractor leaves site. The usual maintenance free period included in the conditions of contract does not imply lack of the need to maintain the building but that the contractor shall be responsible for the maintenance during the stipulated period of 3-6 months. An unanticipated maintenance may even start before the completion of the project due to poor construction practice and use of low quality materials as observed in the case study presented in this paper.

It has been reported by Seeley (2) that 40% of the building labour force in Britain were engaged in building maintenance. In most developing countries where there is lack of data on this subject, it can be assumed that less than 5% of the construction labour force is involved in maintenance. Beheshti and Jonker (3) reported that social housing sector in the Netherlands is facing an increasing difficulty in maintaining housing stock to an acceptable level considering the increasing costs of maintenance. Imbert and Ali (4) indicated that the level of maintenance of many public buildings in Trinidad is unsatisfactory. Akagu (5) showed that building maintenance is one of the most neglected areas of the economy in Nigeria. He further noted that there is no existing national policy on building maintenance. The author believes that the situation is not different in other developing countries.

There are basically two types of maintenance approaches: Reactive and Proactive. It is reactive when maintenance is carried out in response to unplanned repair, usually as a result of imminent failure. Proactive maintenance may be either preventive or predictive. Preventive maintenance is usually carried out periodically during which a well-defined set of tasks, such as inspection and repair are performed. Preventive maintenance is important in the reduction of maintenance cost and improvement of buildings. Predictive maintenance, estimates through diagnostic tools and measurements, when a part of a structure is near failure and should be repaired thereby eliminating more costly unscheduled maintenance operations. Planned continuous inspection of buildings particularly public ones, will enable the authority to initiate corrective actions that will bring these buildings up to an acceptable level of maintenance.

The objectives of this study are to: (i) examine the problems of maintenance (ii) evaluate the existing maintenance methods (iii) develop an operational concept for the design and management of maintenance work using appropriate technology.

2.0 PROBLEMS OF MAINTENANCE

2.1 Design Error

Usually, at the design stage, the scope of a building project is defined by what a client can afford except for buildings of commercial nature where funds can be sourced from financial institutions and a payback period is agreed upon based on good feasibility report. At this stage, no consideration is given to the future maintenance of the building. This, more often than not, is responsible for the design and construction of massive buildings without putting in place any maintenance system that enables the building retain its initial outlook. This may be due to lack of adequate advice to the building owner

from the consultants or inability of the client to accept the advice of the consultants on the need to cut down the scope of work to pave way for good maintainability during the service life of the building.

2.2 Inadequate Design Information

Sometimes, building owners do not give to the Structural Engineer the actual purpose for which they want to build. After the building has been designed and approved by the Town Planning Authority, the building owners commence construction of what they want with modifications on the already designed work on the site without reference to the consultants again. Such situation may give rise to over stressing of the structural members causing early deterioration. Also, in most cases, private building owners believe that it is wasteful to carry out soil test, therefore, designs of the substructural part of a building is based on an assumed bearing capacity of the soil, such design is supposed to be adjusted to the site condition when construction work starts, but such opportunity may not come if the building owner has dispensed with the service of the consultant at the design stage which often does happen.

2.3 Ignorance

Building maintenance is not attractive, even among the affluent. They cannot see the rational behind repairing or face lifting the existing structure while such funds could be invested elsewhere to bring in more money. This is responsible for the unsatisfactory state of privately owned and public estates. Unhealthy environment affects human health negatively and it adversely affects the productivity of labour in a working environment. Some building owners ignore the participation of consultants in their projects from inception on the grounds that their services are expensive and not required. Some of those who engage professionals do ignore their advice on the need to procure quality materials for their projects, simply because such materials are more expensive than the low quality ones. Before the completion of such buildings deterioration features of varying magnitudes set in resulting in early need for maintenance work.

2.4 Lack of Political Will

In Government quarters, there is complete absence of continuity in Government programmes. Succeeding one abandons the projects embarked upon by preceding governments. Political consideration takes preeminence over what are technical. Consideration is not given to our level of technology, cultural background and environment.

2.5 Attitude

Lack of maintenance culture is seen in our daily life, this is extended to such facilities as private residential and public buildings. The attitude of the populace to tenants occupier and public buildings is negative. There is a general non-chalant attitude towards their upkeep.

2.6 Funding

Generally, inadequate budgeting is made for maintenance works. Where adequate provision is made, the maintenance budget that eventually gets approved and the funds that get released are small fractions of the initial budget made. This scenario is always attributed to the fact that there are other competing areas of the economy like Health and Education.

2.7 Lack of Adequate Policy on Maintenance of Infrastructure

In most countries there is no government policy that defines the proportion of its fund that must be assigned to maintenance work. Each level of government defines its areas of priority and more often than not maintenance work is not as attractive as initiating new projects.

2.8 Research and Development

Little or no research work is carried out on maintenance of buildings. There are some deterioration features, which are expected to be diagnosed, causes identified and curative measures proffered through appropriate investigation but studies are not done because of lack of fund. Effective research on maintenance work in research institutions will be good for practical use in the field. Some of such research works are supposed to be funded by the industries (the end-users of the results) but there is lack of effective University-industry partnership (Falade & Ibidapo-Obe, 6)

2.9 Maintenance Management

Where fund is made available for maintenance work, the observed continued deterioration of buildings is attributable to poor management of maintenance resources (human and non-human). Inappropriate analysis and management of these resources result in failure of maintenance operations qualitatively and quantitatively.

2.10 Maintenance Methods

The existing maintenance methods adopt equipment-based and labour intensive technologies.

2.10.1 *Equipment-Based Method*

Reliance on equipment-based method evolved for a number of reasons:

- (i) The desire of the developing countries to emulate the more advanced ones.
- (ii) The tendency among international consultants and contractors to favour construction methods with which they are familiar.
- (iii) The basic tied-aid of the foreign consultants/contractors to help exports from their own countries. A particularly important factor is the educational background of the technical leadership in most developing countries.

Equipment-based methods are perceived to have production, costs and performance that are Predictable, they are associated with high quality results and they are surrounded by an aura of technology progress. However, the equipment-based method has its shortcomings:

- (i) Equipment-based operations entail heavy expenditure of foreign exchange such costs might be an unavoidable burden for urgently needed high technology projects considering the dwindling exchange rates in most developing countries.
- (ii) The method employs few skilled labours with limited number of unskilled labour.

The economic situations in developing countries calls for more realistic and sustainable methods of construction/maintenance, which must utilize all the available local resources particularly labour.

2.10.2 *Labour Intensive Method*

In most building projects, both construction and maintenance are labour intensive. Labourers are used for operations as much as possible without consideration for their cost effectiveness. Emphasis is not laid on adequate resources analysis.

The appropriate method for developing countries for maintenance operations in buildings is labour-based method. The method is both efficient and less costly. It is less sophisticated and can easily be transferred to the rural and unskilled labour.

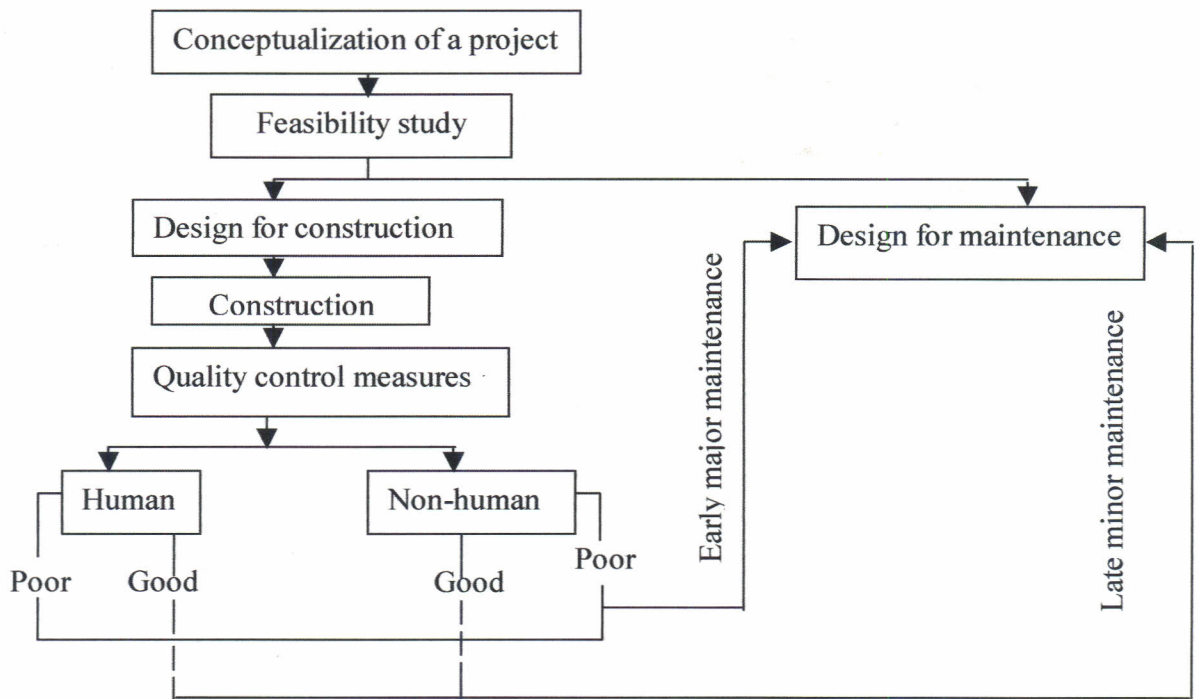
2.10.3 *Labour-Based Method*

The labour-based method describes an approach where the bulk of the activities are undertaken by properly trained, organized and supervised work force with equipment introduced in a step-wise manner from the very light to heavy if this is necessary to obtain good quality output or maximize cost-effectiveness objectives. Often, mention is made of labour-based/light equipment-supported, and it is also possible to have labour-based/animal-supported where animal power is employed usually for

haulage operations. But in the context of this paper, labour-based is restricted to labour-based/light equipment supported.

Labour-based method can be considered an appropriate technology for the maintenance of infrastructure given the situation “as exists” in developing countries. Labour-based technologies are postulated to make minimal use of unskilled labour and minimum use of capital equipment to build/maintain works at a speed, quality and cost comparable with those of any other method. The methods are efficient for maintenance of engineering facilities when the defects are of a manageable magnitude. Labour-based method is extensively used for road maintenance and rural road development (Watermeyer, 7 & 8; Clifton, 9; Tournée, 10; Yanney, 11;)

3.0 INTEGRATION OF MAINTENANCE WITH PROJECT PLANNING



In Fig. 1 the activities at design and construction stages of a project determine the level of durability of the structure and therefore its resistance to the applied load and the environment. The human measure includes supervision of all tasks of a project while the non-human comprises materials and environment. Poor quality control measures will necessitate early deterioration of building and unexpected high maintenance cost particularly if the defects are associated with the use of poor quality materials and poor construction practice. But when good quality materials are used with adequate supervision and construction method, minor maintenance operations would be required when the building is being used and such minor work will be required after a long period of use assuming that adequate precautions have been taken against the environmental conditions.

4.0 CONCEPT FOR THE DESIGN AND MANAGEMENT OF MAINTENANCE WORK

For effective maintenance operations, a system is required that will identify the sequence of operations that are necessary for maintenance work. The use of labour-based calls for consistent appraisal of economy of labour to determine when its use ceases to be cost effective and therefore the need to introduce light-equipment in a step-wise manner for effective management of maintenance operations. Fig. 2 shows an operational concept for maintenance work using labour-based method. The concept entails a structured maintenance system with a maintenance manager as the head of the department. Down the maintenance team are the inspection team, supervisory team and materials procurement unit. The inspection team is responsible for the diagnosis of the type of deterioration in a building and proffer appropriate technical solution. After the inspection, a decision is taken as to whether to demolish the building and replace it with a new one or to improve or adopt it to make it more suitable for either present use or new use. The volume of work is determined while the required resources are analysed. The resources can be categorised into human and non-human; the human can be grouped into Internal (within the maintenance organisation) and External (outside the organisation). The external is majorly at operative level. The labour force required is estimated based on the volume of work and the appropriate productivity of labour for each task and the number of hours worked per day.

The non-human resource comprises materials, light equipment and money. The volume of work determines the quantity of materials while the required number of equipment is determined based on the real output of the item of equipment selected for the work. For effective combination of resources, requirement schedules (labour, equipment, materials, suppliers, sub-contractors and information) are prepared to guide the movement of resources to and from site to avoid congestion on site. Also cash flow analysis is prepared to ensure steady flow of cash to ensure continuity in site operations.

5.0 PERFORMANCE INDICATORS

Performance indicators are essential tools for the assessment of the effectiveness of maintenance work. A good management in maintenance department should provide such indicators that permit evaluation of the performance of the department and furnish top management with information that it needs to assess maintenance performance. Some of the indicators that are commonly used are:

5.1 Time

Usually when the volume of the work is determined, duration is allocated to each task based on the method of executing the task. The total of all the separate durations for all the tasks give the contract duration.

The performance of the maintenance can be measured via the ratio of time allocated to the project and the actual time spent in carrying out the entire work. When the ratio is less than 1 it indicates good

management of resources but when higher than 1 it indicates that the performance is bad. When the ratio is unity it shows that the performance is as per schedule.

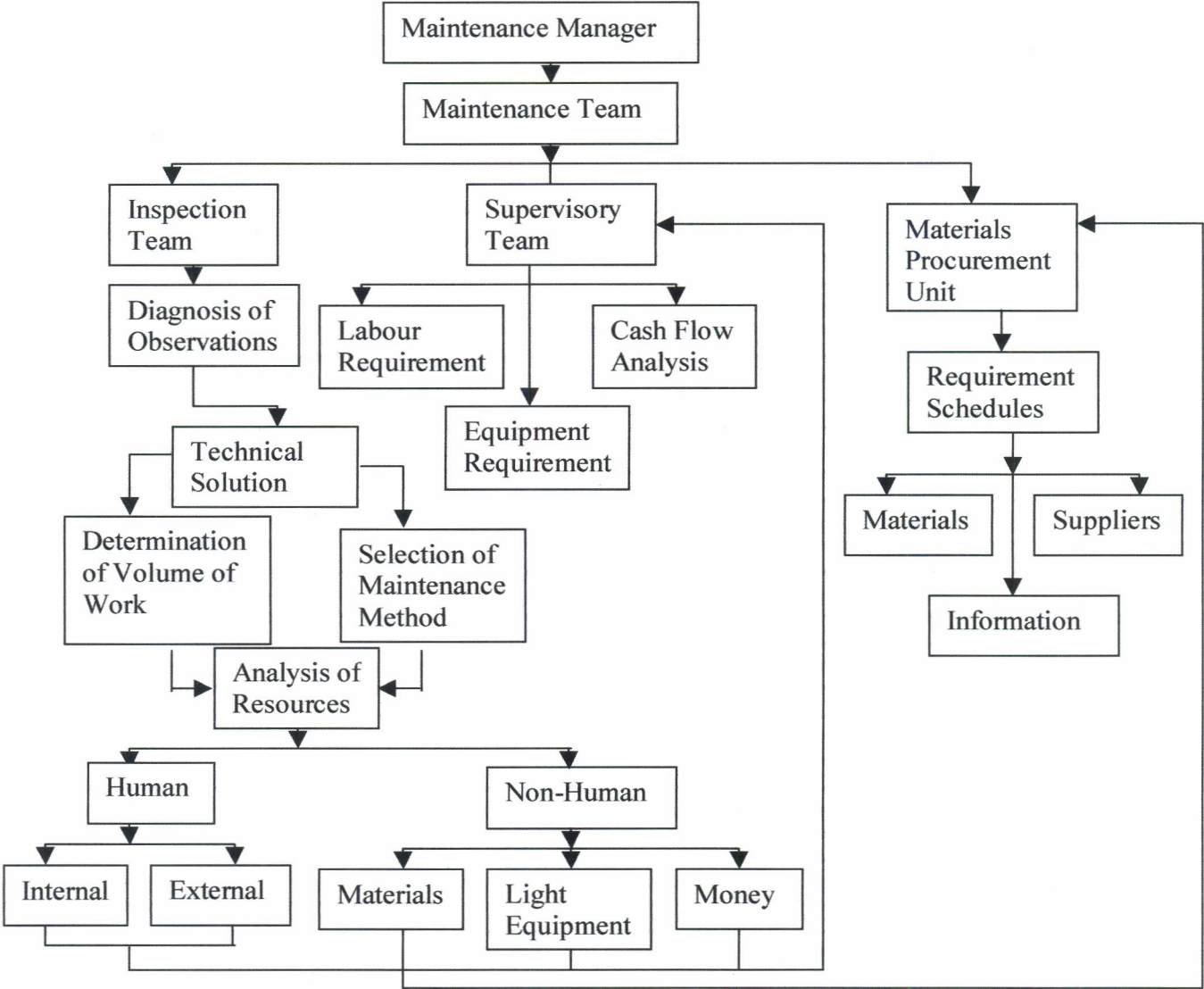


Fig 2: Operational Concept for Effective Design and Management of Maintenance Work

5.2 Cost

The performance of the maintenance can be evaluated based on the cost over-run expressed as the ratio of the estimated cost to the actual maintenance cost. When the ratio is less than 1 it shows inappropriate analysis of maintenance resources or their inadequate management towards the realization of maintenance objectives. When the ratio is higher than 1 it shows good management of resources but if the ratio is unity it indicates that the estimated cost equals the amount expended.

5.3 Quality

This ensures that the specifications are adequately adhered to during the implementation of maintenance operations. This calls for effective total quality management of the maintenance operations. It indicates good supervision and workmanship.

5.4 **Income**

If buildings are given a face-lift, they command higher rental values. The increase in value depends on the location of the building. If the building is used for sales of goods it generates better income because higher prices are charged on goods and services.

Some of the benefits of maintenance operations are intangible and not apparent but exist within the work culture. For example, in residential buildings maintenance results in good health while in offices it results in higher productivity of labour and good health.

6.0 **CONCLUSIONS**

From the foregoing, the following conclusions are made:

- (i) Lack of maintenance is due to some factors such as design error, funding etc.
- (ii) Labour-based method is more appropriate to developing countries because of availability of labour.
- (iii) Integration of maintenance into project from conceptualization stage will improve maintenance culture.
- (iv) Effective quality control of project resources at construction stage results in minor maintenance at later stage during the service life of the building whereas poor quality control and poor construction practice result in early major maintenance work.
- (v) A good maintenance system ensures result-oriented maintenance operations
- (vi) The performance of a maintenance system can be assessed by some performance indicators.

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