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DESIGN FOR MAINTAINABILITY

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ABSTRACT

Buildings are meant to complete their service life before undergoing deterioration, but this has become a mirage in the building lifecycle because of negligence in the careful conceptualization of designs. Design for maintainability, with emphasis on access to maintenance deals with creating proper designs that will incorporate accessibility that will enhance and enable maintenance. This will mitigate building defects, combat inappropriate and buildings that are not conceptually sustainable in designs and thereafter increase the maintenance culture of buildings in Nigeria. The negligence of the subject matter has caused buildings to encounter multiple defects, deterioration, and obsolescence in edifice that would have served their functions completely before the end of their service-life. Therefore, this paper seeks to adopt an analytical approach through the comparism of related journals, books to resolving this ever-trending challenge in the building and construction sector.

Keywords: Design maintainability, building life cycle, sustainability, accessibility.

INTRODUCTION

According to Agus, (2016). the relationship between maintenance and building design is closely to avoid any harmful during construction stage or during the building is occupied. it has been aligned in four sectors to avoid the need for unplanned maintenance at the post-occupation stage, and also faulty design contributed to the number of building defects. Nonetheless, the failure in design at the early stage would lead to deficiencies in the next stage after construction. Error in design is not only compromising the building environment, but also affected the building users.

Seidar (1997), reported that when facilities have maintenance problems, they can be due to inadequate budgetary provision or inefficient custodial staff. In This Regard, Therefore, The Manager Should Be Responsible for Ensuring that the maintenance of facilities acquired for sports activities is guaranteed since maintenance is an important means of checking the rate and intensity of depreciation of most sports facilities. Although adequate facilities are necessary for effective instruction in physical education and sports, it is the responsibility of the management to provide adequate space/facilities, equipment and personnel for the sporting program (Venkatewarlu, 2000).

Since Maintainability Is Designed In, It Is Important to Specify Both Reliability and Maintainability Targets Early in The Design Cycle. This in Turn Requires Early Knowledge of The Anticipated Life of The Product and Its Constituent Parts, And the Degree to Which the Parts Are to Be Made Replaceable

Nurul (2016). Faulty design can occur due to an increase of maintenance cost. Some maintenance problems arise where the design is low probability of achievement in practice though it was satisfactory in principle. The good design achievement in the planning of buildings as worthy objects is understood and recognize, despite less understood and Appreciated Is The Need For Continuous Maintenance.

Maintainability

A building designed with good maintainability considerations, not only functions as intended but is also adaptable to current and future use. Ismail and Mohammad (2015). The purposes of incorporating good maintainability considerations into building designs are to achieve high building performance, ease day-to-day housekeeping tasks, make the building adaptable to future needs and maintain a stable usage cost throughout the building's design life. Lack of attention to maintainability considerations at the design stage, often lead to difficulty and costly operation to users. Hence users‟ expectation may not be achieved (Nicolella 2014, wood 2012, Williamson et al. 2010). Any studies on construction industry's productivity concluded that improving the maintainability of buildings will yield significant impacts in long-term use of the buildings (Egan 1998, 2010; furlough 2002; construction 21 report 1999; Latham 1994).

Maintainability does not just address reparability, but relates to the ease of restoring a defective item to its functional design state.

Ikpo (2009). the concept cannot be treated as discrete entities – maintainable or not maintainable – but as a continuum describing the extent to which the gamut of maintenance could be seen as being achievable. Smith (1981) defined it as the probability that a failed item will be restored to operational effectiveness within a given period, if maintenance actions follow the prescribed procedures. in quantitative terms, if maintainability is at zero level, then the life of the building reaches an end upon the failure. Maintainability has to do with the time it would take to maintain a defective item. If this is as easy as conceived at the design stage, then less time would be required for repairs. The maintainability level in such a case would approach 100 per cent.
The time required to effect the repair or replacement, technically termed the mean time to respect (MTTR), would be the same as the standard time estimated for initial construction or as determined by work study. This would be what a 100-rated operative would require to complete the work. Maintainability becomes low if the MTTR increases from the predetermined figure. Caution should be exercised in evaluating maintainability in relating to MTTR so as not to confuse an increase in MTTR because of the operator performing at less than 100 rating.

MAINTAINABILITY INDICES

- **Standardization**

Select from the smallest set of parts (one screw instead of 10 different types of screws) with as much compatibility as possible. Minimize spare parts inventory is just one benefit.

- **Modularization**

Create a set of standard sizes, shapes, modular units. If we expect to different models with different features, using a standard structure allows the interchange of compatible parts to alter functionally without changing the majority of the product. A good example is light bulbs. You can select the functional bulbs (brightness, intensity, color, etc.) and they will fit in the same socket.

- **Interchangeability**

If you have to create a custom fit for a part, consider the ramifications. Single source, lack of compatibility with other similar functioning parts, another spare part in inventory, and limitations on future design changes if you want to stay in that custom form factor.

- **Malfunction Annunciation**

A key step in performing maintenance is to know what caused the problem or which parts are damaged and require replacement.

A bicycle flat tire is obvious to visual inspection or you may notice a change in the sound and feel of the ride. On complex systems which circuit board requires replacement may not be obvious. Minimizing the need for inspection tools and diagnostic tasks minimizes the time/cost of the corrective maintenance tasks. Let the system inform the technician what requires attention.

- **Fault Isolation**

There are two parts to this factor. One, make the system as informative as possible such that it not only signals a failure mode, it also narrows down the possible failure mechanisms. Replacing a blown fuse does not fix the problem and just finding the problem may take significant time. Second, a failure in one part of a system can cause failure of other elements in the system. When possible, contain the damage to minimize the amount of damage caused by a failure of one item.

- **Identification**

Name the parts with unique identifiers. This streamlines documentation, procedures, and maintenance tasks As maintainability may be measured using a time-dependent variable (MTTR), basic indices may be needed for its evaluation. The indices identified below are essentially aspects that would directly inhibit maintenance or greatly affect the repair time, hence MTTR.

- **Accessibility.**

  One of the problems of design is the provision of a structure in a complicated form. Complex buildings more often would have portions or appurtenances located where visitation after construction becomes an issue, if not totally impossible. examples of this abound, but the most striking relating to public buildings is the. ***Headroom.*** The soft's of public buildings are usually beyond the reach of the routine cleaners. cobwebs, plant life and dust deposits remain perpetual features.

Overhead water tanks are also usually placed where periodic cleaning is not practicable, resulting in the formation of a progressive layer of scum towards the lid.

General Design Maintainability Rules

The rules are largely common sense. Put yourself in the place of the maintenance engineer, and try to design out any obstacles to easy maintenance:

• Maintainability is created during the design process. It cannot be added later.

• Establish the maintenance philosophy in terms of 'repair versus disposal' of the product or components. Do this before starting any design work.

• Consider where maintenance will take place (1st. 2nd or 3rd line).

• Consult the maintenance engineer during the design phase and agree upon a set of documents to be handed over to the maintenance people. • Keep it simple. Complex arrangements are usually harder to maintain.

• Make it testable. Reactive (faultfinding) tests often reveal latent problems that will become faults in the near future. Include diagnostic test points in electrical circuits. Include mechanisms that provide early warning of impending failure.

• Design reliability into items that are difficult to maintain (such as components deep within an engine), to reduce the need for maintenance access.

• Reduce maintenance frequency overall by ruggedizing and over-specifying components to withstand occasional overload.

• Provide warning labels where a maintenance engineer may be exposed to danger. For example, on hot or heavy items or where there is stored mechanical or electrical energy.

• Provide maintenance instructions and information panels if the routine is difficult to remember, and fix them as close to the point of maintenance as possible.

• Design equipment to fail-safe so that risk of injury to maintenance engineers is reduced.

• Avoid the requirement for special tools.

Handling and Access Rules:

For every process, basic rules are always necessary to imbibe. Below are some findings from the study gathered by ***Andrew Taylor*** (2016t) that seem necessary in handling accessibility because it could be applicable to all area where a design for maintainability is required.

• Adjustment should not require the removal of components to access the adjustment point.

• 'Access' means enough space for the component, tools, hand, arm, and possibly head or head and body of the maintenance engineer.

• Where a tool is required to remove a component, there must be access for the tool and the engineer's hand, in normal grasp. Where tool access may be restricted, as a last resort add tool guides to steer the tool into a mating position.

• Consider reducing the number of fasteners used by 'hooking' modules into position and fastening at one edge only (but beware vibration risk).

• Design access holes and spaces for the full range of human body shapes and limb sizes, not just the average.

• It must be possible to see the maintenance point while hand and arm are manipulating components, tools and fasteners. Access hatches must allow for this, and must not restrict the opening to that required to accommodate hand or arm only.

• Access hatch covers and doors should open through 180 degrees and have a fasten-back clip, or be wholly removable. Doors that open to 90 degrees cause obstruction.

• The most comfortable working height is between waist and chest height.

• Units with the lowest life expectancy should be the easiest to access, and components requiring frequent routine maintenance should be at the outer edge of the product in a position suitable for convenient access. This includes points requiring routine lubrication or visual inspection.

• Lighting and visibility. No peering into the gloom. Visibility must be direct, not needing mirrors or cameras. Light levels must be appropriate to the level of detail inherent in the task – fine detailed work requires bright light.

• Dexterity becomes impaired at arm's length compared to up close. If fine positioning is required, get it up close, otherwise use a less position-sensitive mounting arrangement or add locating guides.

• Large modules should be mounted on hinges, slides, or runners so that they can be pulled or swung into a position offering better all round access. Rack mounted modules in electronic cabinets are an example of this approach – fit travel stops.

• Do not design access in such a way as to require heavy lifting by the maintenance engineer. Fit weight indicator labels where manual lifting is expected.

• Consider handling and lifting of units, especially the location of grab handles and lifting eyes. Fit lifting / hoisting points on large heavy items. Show where lifting straps should go – a heavy module may have weak points.

• Ensure that there is room enough to maneuver parts and tools into position without causing secondary damage by fouling on adjacent components

- **Maintenance Manuals.** Manuals are common features of electro-mechanical contraptions. Even with the position of the national building code, this feature eludes the building construction sector. Maintainability is defined with a provision that the remedial measure must follow the prescribed procedures. These procedures constitute manuals, but are never considered in building production, except for items falling under services. the inference is that building surveyors require greater time to evaluate the defects before embarking on repairs in the absence of the basic guide – the manual. the choice of alternative materials or components to replace a defective unit equally becomes problematic.
- **Available Technology** manuals without appropriate technology would not enhance maintainability. technological advancement contributes to accessibility in the form of moving trestles, underpinning equipment and even resins for concrete repairs. technology makes maintainability take off from zero level. it provides solutions to the problems resulting from the combination of compatible and incompatible materials in building design. technical knowledge and acquired skills on the part of artisans are a component of the technological index. in specifying building components, due consideration

should be given to the possibility of procuring each one in the event of future failure, as well as the availability of installation skill. Etc

CONCLUSION

It is a fact that it is widely known and accepted that, it is better to avoid mistake than to correct. The principles that guide the maintainability of any design seem to be common but it is obviously not common. every design if carefully thought of at it conceptual stage will obviously result to adherence to these rules that will lead to a better design with ease of maintenance. Design maintainability if achieved will foster a sustainable design. Every component of a design should be ease to independently access and maintenance. In the situation where preventive maintenance which was to be conceived from the conceptual stage of every design is not achieved, corrective maintenance should be the next approachable alternative.

RECOMMENDATION

When Designs does not meet their service life, it results to deterioration. However, this can cause a serious, deface to the building and environment. This study having considered, highlighted and analyzed the basic rule, general rules and emphasis on a factor which when considered can be enable a functional Economical and sustainable design can be considered a working tool as this is the and objective in the world millennium goal.

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