Interaction between Theory and Practice in Civil Engineering and Construction
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INTEGRATED DESIGN APPROACH FOR BUILDING MAINTENANCE ISSUES

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Maintenance and repair is a principal task in building operation in terms of time spent and cost. Therefore, improving maintenance performance can result in remarkable operational benefits. Traditionally, maintainability is not fully considered when designing a building, whereas many decisions to influence building maintenance are taken in design phase. Because of this, there is a need for a new approach to handle design and maintainability as a whole. Integrating design with maintenance eliminates design oriented maintenance issues and promotes knowledge transfer between designers and facility managers. This paper aims to identify design requirements for maintainability and present possible acquisitions of maintenance integration in design. Design parameters which are important for maintainability of a facility management are considered as accessibility, flexibility, standardization, modularization and selection of materials and equipment. Designers should give more attention to these parameters in order to create more valuable buildings for the users and to prolong the life cycle of the facility. A facility manager's involvement in design steps would also improve maintainability of the building because of the specific technical details that a designer cannot fully designate. With a collaborative, new design approach considering maintainability, buildings profitability would be enhanced with less cost, time and labor.

Keywords: Building design, Maintainability, Facility management, Operation, Repair, Life cycle.

1 INTRODUCTION

Facility maintenance and repair is an important topic of Facility Management (FM) with intent to prolong building life and have maximum profit from the operation. Regrettably, it is not sufficiently considered by designers because of the limited knowledge and interest about operational details and maintenance requirements. However, design decisions are of vital importance for operating a facility. Thompson (1994) asserts: 'Designers should be aware of capital costs, plant reliability, operational economies, and maintenance, as the building operator will be interested in the lifetime costs of the building and not just initial purchase and installation'**.** Thus, early integration of facility management is needed to combine design parameters with operational needs. Otherwise, design originated operational problems that harder to solve would arise. Kuda and Berankova (2014) express this issue as: 'When architects design constructed facilities they commit errors in design which are not endangering as

to statical or engineering aspects, but these will ensue during exploitation of the facilities'.

Integrating design and operation requires better communication between design and FM professionals. Nutt (2000) points out that: 'Knowledge transfer between designers and facility managers ensures that; facility objectives support organizational objectives, facility provisions are aligned with end-user needs, and design concepts are compatible with property strategy overall'. As an ongoing attempt, the communication between designers and facility managers is getting more frequent. 'On average, design firms communicate with the property managers during the design process between sometimes and often' (Arditi and Nawakorawit 1999). But it is not always possible to meet designers and facility managers together, just because operational team is set up after the design (Liu and Issa 2013). For this reason, designers ought to be aware of core operational issues and design requirements for life cycle.

For high performance, high qualified and properly operated facilities; there are numerous matters that should be handled in planning and design which have significant impact on future costs and quality. As a great expenditure and also intense field of operation; maintainability comprises remarkable part of these considerations. Operational phase constitutes approximately 60% of the total lifecycle cost of a facility and the main activities during operations are related to maintenance and repair (M&R) (Liu and Issa 2013). This great expense requires more focus on decreasing and expediting maintenance. Integrating facility maintenance with design is able to reduce the cost of maintenance and improve operating profitability. 'If all the maintenance unfriendly design issues can be solved in the design phase, the maintenance cost would be reduced and the life cycle cost of a facility would be much lower' (Liu and Issa 2014).

Considering all of these, there is a need to determine design needs for maintenance. The purpose of this paper is to set a framework for design originated maintenance issues. First of all, maintainability and its context are explained. Then, important points to consider during planning and design are discussed. It is concluded with the possible acquisitions by integrating design and maintenance.

2 BUILDING MAINTAINABILITY

Maintenance and repair directly contributes to physical condition, performance, reliability and comfort of the facility. Eva and Katerina (2013) define maintenance as 'all works carried out to keep and restore an item at a current acceptable standard'. It is not possible to avoid a component to wear off, but is possible to minimize breakdowns, extend useful life and ease maintenance. Primary factors to lead maintenance are poor design, poor workmanship, detective materials and components, usage and age, climatic or environmental factors and nature of users (Olanrewaju and Abdul-Aziz 2015). Most of these factors are related to decisions taken in design phase. That means; design steps are so valuable to maximize physical performance, decrease component inefficiency and minimize maintainability issues. Fitzgerald (2001) argues that 'In the early phases of a project, flexibility is high and design change cost is low. Thus, product maintainability can eliminate maintenance cost, reduce downtime and improve safety'. Blanchard *et al.* (1995) also define maintainability as follows:

- Probability that an item will be retained in or restored to a specified condition within a given period of time, when maintenance is performed in accordance with a prescribed procedures and resources
- Probability that maintenance will not be required more than x times in a given period, when the system is operated in accordance with prescribed procedures by personnel with proper skills.
- Probability that the maintenance cost for a system or product will not exceed y dollars per a designated period of time, when the system is operated and maintained in accordance with prescribed procedures.

It is clear that, maintainability is quite related with facility reliability, quality, performance and economy. A design approach considering all these factors is needed to enrich the building for operational efficiency.

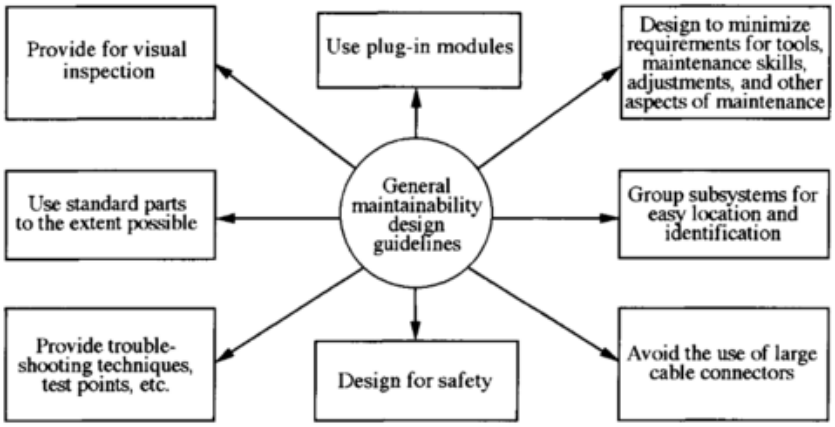

Figure 1. Design for Maintaibiltity Guideline (Dhillon 1999).

3 HOW TO INTEGRATE DESIGN AND MAINTENANCE

This paper aims to remark important points for design oriented maintenance issues and emphasize the importance of collaboration between designers and facility managers. For this purpose, there is a need to change the way facilities are designed. Even there are some basic design points for maintainability (Fig.1); a designer cannot fully designate the maintenance needs because of specific technical details. Integration of facility professional would result in more effective solutions for maintainability. A facility professional can involve in design by attending design meetings or reporting his opinions. But usually, their knowledge about building design is restricted and designers are disposed to exclude them from the process when designing the facility (Jensen 2008). Because of this, bi-directional collaboration is needed to share knowledge about both facility design and operation. That means, a facility manager need to have core competences and knowledge about building design, as well as designer has operational knowledge. Another way to integrate FM in design is the use of specialist consultants and/or involving specialists from FM providers (Jensen 2008).

Developing technologies also contribute to integrating maintenance to design. As a life cycle tool and promising technology, Building Information Modeling (BIM) Technology is also able to meet designers and facility managers on the same 3D model. BIM model not only visualizes the design defects that make maintenance activities impossible to perform but also acts as a bridge between design and operation phases.

3.1 Design Issues

Liu and Issa (2014) states that: 'While there is no cost or very low cost to correct such design defects in the design phase, it would lead to a much higher maintenance cost if the non-accessible equipment breaks down in operation'. Generally, facility managers are not involved in early phases of project and design considerations don't include operational details. These details include organizational requirements, technological requirements, HVAC requirements, lighting, security, signage and accommodations, and many other factors. If the facility manager is engaged to early design, an integrated project team is naturally developed and many problems like lack of constructability, operability, maintainability, and serviceability can be resolved (Meng 2013). If we look from the viewpoint of maintainability, there are some design points to consider.

Another study by Liu and Issa (2013) investigated facility personnel's problems about maintainability with a couple of interviews. Results indicate that, the lack of space designed in the ceiling to contain MEP systems is the most frequently occurring problem, followed by lack of adequate space for the mechanical room, limited space for AHU filter access, poor design of equipment layout, and lack of equipment accessibility (Liu and Issa 2013).

Main design requirements for maintainability include parameters like accessibility, flexibility, standardization, modularization and selection of materials and equipment, which are briefly explained in following sections.

3.1.1 *Accessibility*

All components must be easily accessible to perform maintenance and repair in minimum time. Moreover, the space that the maintenance operator will need must have been designated. Thompson (1994) asserts: 'The designer has to provide adequate access to plant and equipment, such as working space within ducts and the plant room, as well as working platforms for ladder access to equipment at high and low levels'. However, a designer can hardly designate the accessibility of all components, especially in high detailed technical equipment like HVAC. For example, on-end installed components cannot be installed without knowing the life expectancy and maintenance requirement of each. Maintenance frequency must also be considered; otherwise rarely maintained components are dissembled and assembled in every maintenance job unnecessarily (Liu and Issa 2014). Access openings are also important for maintainability. Operator size and the required actions of operator like turning, pushing and pulling in space must be designated (Dhillon 1999).

3.1.2 *Flexibility*

At the present time, business conditions are quite changeable. Besides, organizations are under pressure of market competition. As a result, business itself and the way of

handling the business changes by time. Naturally, facility that the business is operated in also must be changed not to become useless or underperformer. This issue is a part of maintainability; building must proceed to be used against any changes. Nutt (2000) defines five design criteria for future flexibility as use flexibility, operational flexibility, operational flexibility, physical flexibility, property flexibility and market flexibility.

3.1.3 *Standardization*

Standardization is an important parameter for maintainability which can be defined as: 'Minimizing the variety of parts and components that a product or system will need' (Dhillon 1999). By this way, different products can use common and interchangeable parts. Moreover maintenance process is standardized and carried out faster and more reliable way. Interchangeability is result of standardization, which means any item can be replaced within a product by any similar item (Dhillon 2006). Both standardization and interchangeability remarkably minimize the effort for maintenance and repair.

3.1.4 *Modularization*

Modularization separates the component into units to quickly assemble, dissemble, maintain and repair. By this way, operator can work on only the problematic part of the component and minimizes the effort, cost and time consumed. Modularization also helps dividing up maintenance responsibilities, less costly and less time consuming training of maintenance personnel, lower levels of skills and tools needed to maintenance and reduced equipment downtime (Dhillon 2006).

3.1.5 *Selection of materials and equipment*

In the selection of materials and equipment; designers cannot easily make operationally right decision. This is because of the wide variety of products, furthermore pressure from dealers can make designer to choose the wrong product (Arditi and Nawakorawit 1999). This decision process is so valuable for the rest of the building life, the quality, reliability and efficiency must be in accordance with operational needs. In terms of maintainability, materials and equipment mustn't need maintenance for a designated period of time, or mustn't cost more than designated maintenance cost. A study carried out by Arditi and Nawakorawit (1999) shows that, when selecting materials, maintenance is considered as the third important factor, after cost and aesthetics; however, while selecting equipment, it is the most important one.

4 CONCLUSION

In the discussion of building maintenance issues, it is seen that maintainability of facilities needs wider recognition by designers. Decisions that determine maintainability are taken in design phase; thereby a facility manager's guidance in design would improve operational efficiency. Main design considerations for maintainability are considered as accessibility, flexibility, standardization, modularization and selection of materials and equipment. If these parameters are thoroughly embedded by designers, design originated maintainability issues can be averted. Furthermore, building performance would be enhanced with minimum

breakdowns and maintenance related complaints. In terms of cost, time and labor, designing buildings for maintainability is not an option but a requisite to increase life cycle value.

References

Arditi, D., & Nawakorawit, M., Designing buildings for maintenance: designers' perspective. *Journal of Architectural Engineering*, 5(4), 107-116, 1999.

Blanchard, B. S., Verma, D., & Peterson, E. L., *Maintainability: a key to effective serviceability and maintenance management (Vol. 13).* John Wiley & Sons, 1995.

Dhillon, B. S., *Engineering maintainability: how to design for reliability and easy maintenance*. Gulf Professional Publishing, 1999.

Dhillon, B. S., *Maintainability, maintenance, and reliability for engineers*. CRC Press, 2006.

Eva, Š., & Katerina, M., The Effect of Implementing a Maintenance Information System on the Efficiency of Production Facilities, *Journal of Competitiveness*, 5(3), 60-75, 2013.

Fitzgerald, A., "Design for maintainability", *START*, Vol. 8 No. 4, pp. 1-4, 2001.

Jensen, P. A., Integration of considerations for facilities management in design, *Design Management in the Architectural Engineering and Construction Sector: CIB W096 Architectural Management & TG49 Architectural Engineering*, 191-199, Rotterdam, Holland, 2008.

Kuda, F., & Berankova, E., Extending the life cycle of buildings using Project and Facility managements, *Applied Mechanics and Materials*, Vol. 584, 2291-2296, 2014.

Liu, R., & Issa, R. R. A., BIM for facility management: Design for maintainability with BIM tools, *Proc., 30th Int. Symp. of Automation and Robotics in Construction and Mining (ISARC 2013),* Montreal,Canada 2013.

Liu, R., & RA Issa, R., Design for maintenance accessibility using BIM tools. *Facilities*, 32(3/4), 153-159, 2014.

Meng, X., Involvement of facilities management specialists in building design: United Kingdom experience, *Journal of Performance of Constructed Facilities*, 27(5), 500-507, 2013.

Nutt, B., Four competing futures for facility management, *Facilities*, 18(3/4), 124-132, 2000.

Thompson, P., The maintenance factor in facilities management, *Facilities*, 12(6), 13-16, 1994.