SUSTAINABILITY IN BUILDING MAINTENANCE:
THE DESIGN RESPONSIBILITY

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ABSTRACT

Sustainability in building design is a practice that consists of design ideas and functions responsible to keep the building or object in working condition with minimum possible consumption of energy, resources and monetary cost. Conventionally, the building maintenance procedure used to be undertaking after the evaluation of the building condition. But in contemporary time building maintenance should become the part of good sustainable design proposal. The objective of this article is to appraise the responsibility of various factors of design contributing to stabilize the sustainability and initiates maintenance in building. In order to develop better understanding of subject this article aims to explain the issues of maintenance and design in systematic development. The methodology is the critical review of relevant literature. Among the main element to be enhanced in respect of design responsibility is the communication gap within the role of building professionals in order to minimize the design effect to the building maintenance. The contribution of this study is a set of sustainable design criterion, in which the absence of those is causing various types of maintenance issues in buildings. This research concludes that relation of Sustainable Design and Maintenance can be understood in terms of suggested conceptual model i.e. Architectural Eco-System.

Keywords: building maintenance, building professionals, design implication, maintenance issue, sustainability
PART I: INTRODUCTION OF FIELD AND DEVELOPING UNDERSTANDING FOR FORMULATED DEFINITIONS

1.0 INTRODUCTION

Responsibility of sustainable design towards building maintenance has remained neglected part in field of research, modern society and especially in underdeveloped nations. Designer usually does not realize that what mistakes or bad decision have been taken during design process and those are only revealed through post occupational survey or users’ feedback. Those decisions are mostly emerge in form of certain types of building defects (unplanned maintenance) and unfortunately such unforeseen conditions are the part of daily life for end user of the buildings.

The subject matter of this article has gained certain momentum and attracts good number of researchers to address the similar problem in other parts of globe. They have highlighted the vitality of topic through their publications and also developed a reliable link between the Design and Maintenance issues. According to Ramly (2006), design plays a major role in determining the conditions of the building after completion, mainly in aspects of defects and maintenance. Indirectly design influences the performance and physical characteristic of building and its durability to withstand against environmental condition, social interfaces such as graffiti and vandalism. The study further stress that the link between design and maintenance should not only seen from the point of increasing the repair work or cost involve, but it need to consider also the impact of design on structure and material installed as well as the life cycle of each component of building.

In near past it was considered that only old buildings are subject to maintenance because of material decay, weathering, etc but in contemporary time, thanks to designers, developers and construction teams as the concept has totally changed. Now even newly built structures are subject to intensive maintenance and sometimes require revised design and reworks. A poor/faulty design is not only concerned with designer of building but also concerned with construction team. Even the gap between these two professions has resulted in public concern and public confidences in both professional are undermined. Study by Foo (1989) highlights the issue of faulty design as, in recent years many defects, premature maintenance and failure are occurring in relative new buildings. Thus this situation has resulted in much public concern and it reached at a point that public confidence in both professionals and construction sectors are undermined. However it would be justified to declare that even new and modern designs of the building are more vulnerable to get infected with plague of unplanned maintenance, if there respective design has not been considered skillfully in terms of maintenance.

However Zavadskas (1998) have presents the correlation between design of building and its life cycle. A better building life is only accessible with skillful design consideration at design stage and is important issue to its owner and dedicated designer. The design stage begins when owner or client presents the set of requirement to designer and designer defines the demands for building and specifies the limitation. At this stage maintenance strategies and objectives should be considered and means should be determined to allow the building to enjoy longer life cycle. If the decision regarding maintenance issue and their means are considered well before the construction phase, it will prevent the building to fall in pool of bad design and this timely decision helps to enhance the life cycle of building.
Discussion above reveals that proportion of the maintenance is highly controlled or governed by the quality of sustainable design, in fact the maintenance factor of building is inversely proportional to design i.e. higher the quality of sustainable design lower the maintenance and lower the quality of sustainable design higher the maintenance. Considering this valuable contribution by researchers it is need of time to ponder the design and construction processes at various stages i.e. from 2D drawings to application of outer fabric and skin to façade. Such measures will not only prevent the building from highly taxed maintenance but also multiply the life span of buildings.

2.0 DEPICTION

This part of article evaluates the various descriptions and basic vocabulary related to title of research such as design defect, sustainable design and maintenance, same shall be précised through comments and figures. There are numerous definitions of a defect, but perhaps the simplest and most comprehensive definition of defect is that provided by the Oxford English Dictionary, which defines defect/faults as a shortcoming or falling short in the performance of a building element.

However sustainable design and maintenance is defined by various public organizations such as California Integrated Waste Management Board (CIWMB) and City Council of Edmonton Calgary Canada.

According to CIWMB (1999), a sustainable building is a structure that is designed, built, renovated, operated, or reused in an ecological and resource-efficient manner. Sustainable 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. Furthermore CIWMB defines sustainable design and maintenance operation as; sustainable design measures cannot achieve their goals unless they work as intended. Building commissioning includes testing and adjusting the mechanical, electrical, and plumbing systems to ensure that all equipment meets design criteria. It also includes instructing the staff on the operation and maintenance of equipment. Over time, building performance can be assured through measurement, adjustment, and upgrading. Proper maintenance ensures that a building continues to perform as designed and commissioned.

Whereas City Council of Edmonton Calgary Canada (2008) defines sustainable design/building as, a sustainable building design integrates building materials and methods that promote environmental quality, economic vitality and social benefit through design, construction and operation of built environment.

There is an important note on design and maintenance published by Royal Institute of Chartered Surveyors RICS (1990), design and maintenance process in the construction industry needed to be more closely allied as in the motor industry where design and subsequent maintenance frequently have an equal consideration. RICS further stress that, early discussion between the designed and maintenance organization can result in building with lower maintenance liability, the economics of which can easily be demonstrated.
In order to prevent unplanned maintenance at post occupational stage of building, review of machine/auto design practice could help the building designers to control the unplanned maintenance at post occupational stage. Auto industry always considers the design of their products on the basis of its performance and its maintenance. Since the machine/auto are usually provided with manuals of planned and emergency maintenance, therefore similar practice in building industry can be introduced by providing manual of built forms. The manuals of built form may have contain the details of materials used, brands, replacement products, schedule of planned maintenance and emergency check list etc. Induction of similar trend in building industry would also develop the atmosphere of the healthy competition and may be a later stage the building industry comes up with some famous brands and their products similar to auto industry. This practice can introduce the features of sustainability in design and the resultant design could be term as sustainable design in context of maintenance, as shown in Figure: 1

![Conceptual Framework of Sustainable Design Formulation and Expected Outcome](image)

**PART II: REVIEW OF DESIGN FACTORS RESPONSIBLE FOR DETERRING SUSTAINABILITY AND CAUSING MAINTENANCE**

### 3.1 Design Phase

This part of the paper is responsible to uncover the mistakes made or emerged by activities of building professionals. The building design practice is consists of activities of various professions ranging from architect to public works engineer through the interior designers. It is therefore added that design process is hub of all good and faults driven from it. Recognizing the importance of this hub, Atkinson (1998) mentions that most of faults that occurs in construction results from design errors and omissions or carelessness.

Refereeing the results of case study, Seeley (1987) mention that one third of the maintenance cost of building can be saved if proper care has been taken at design and construction stage. Unplanned maintenance is considered as the tax on building and it could be explained as the poor design of cars whose operational hours are always coupled with some type of repair either mechanical or body works. One can imagine the amount of trouble and burden on user of that car. But a poor design of building can cost the user to carry even more monetary lumber and stress than the burden of that car since house remain in use for around the clock.
The availability of the right and appropriate material is very important to consider at design stage to avoid the maintenance at post occupational stage. But sometimes limited choices of material left no room for designer except to suggest the material which was already proven for weakness (Addleson, 1996). The study by Addleson (1996) suggests that this situation arises when designer deliberately opt for wrong or improper material since he/she don’t have any alternate material to use and the results are well predicted on early stage of design. Thus it can be mention that factor such as Non Availability or No Alternate of material are also among the causes of the faulty design.

3.2 Construction and Management

Study by Ambrose (1992) portrays the importance of construction and management factors in building design. Ambrose briefs that understanding of the construction management is necessary for intelligent design work. Regarding alternate materials Ambrose mentions that certain details are not feasible to achieve with a particular material or system. The study stresses that designer should accept the facts and provides some alternates to accomplish the design. Ambrose considers management of available time period as the important factor for good design and states that the time is important; design work is always done within some time constraints. Here the study of Ambrose notify the reader that designer should carefully distribute/schedule the time for each stage of design to avoid the faults in design which could occur in case of time shortage.

Communication Gap among the building trade professionals also causes faults in design. This idea is pronounced by the Gray (2002) as, there is lacking in understanding of design process and the way information flows between the people involved in process. The responsibility of designer has increased many folds since his traditional role as project leader has been upgraded to leader of design team. This includes all the works related with different stages of building development till its completion. Gray conceivably stress that designer or architect becomes the communication and coordinating hub of all activities/personals of building design. Efficiency of that hub is heavily relied on the proper communication and developing understanding between all the group of building trade professional and client as well. But if that hub fails to work accordingly that may cause multiple faults among the work of professionals engage in design process.

Highlighting the relation of construction methods and defects, Cook (1992) states that the real significance for the occurrence of defect is the de-skilling caused by the departure from traditional methods of construction. Here Cook is indicating two factors causing defects in building. One is non availability of skill personnel and second is switching to new modes of construction. Departure of traditional forms of construction is also considered as the cause of faults in building. The rapid industrial growth gives rise to use pre-cast and industrial products of building components. But such components are not always results good design since they are not produced according to individual need of design. In addition the traditional methods were also responsible for producing good skilled workers.

The research by Peacock (1986) in context of designer’s failure in reducing the maintenance can be précised as below:

(a) Unsatisfactory detailing,
(b) Incorrect selection of building materials, components and systems,
(c) Lack of standardization, and
(d) Failure to appreciate how the structure is used and maintain.

The study of Peacock has identified these factors for causing costly unplanned maintenance in building. But also suggest to designers that they could avoid the maintenance and its high cost in
buildings if they would improve their design strategies in the light of these factors. Gilder (1989) also consider poor detailing as cause of multiple faults in building, poor detailing that makes incorrect assembly on site or in factory impractical to consider it a workmanship fault. Here the study of Gilder is stressing the need to understand the construction phase which is the second most important after design phase, towards achieving good design of building. There are number of factors present in this phase which implicate the maintenance. In fact workmanship and detail drawings are two interrelated factors of this phase. But faults emerged from the lacking of the detail drawings are often mistakenly recognized as faults cause by the workmanship.

Comments 3

The designer creates the building after passing through the several stages and construction team turns that 2D dream into reality. Thus it can be added that the process or stage of construction is also very important to the building to perform according to the ideology of its creator (designer). Construction phase can be considered as the link between the design and occupational stage of building. Therefore it could be stated that higher the quality of link most the chances for “maintenance free” building. Design excellence and ultimately a better performance of building can be achieved through key of construction phase. Construction phase is governed by the various factors like management of construction, knowledge of alternate materials, and time factor. These factors also act as source or cause of the design faults if not treated and considered timely.

3.3 Users Feedback

Considering the importance of users feed back to achieve the sustainable design with less maintenance, Gray (2002) mention that user oriented and research based design is the knowledge upon which a better future can be built. This statement of Gray also advocates that user’s participation can prevent the faults in design leading to maintenance or in other words we can say that user’s non participation can cause design faults.

Comments 4

The end-user is obvious target of all experiments sketched in laboratory of designer and architect during design process. End user would be lucky if experiments presents good results or otherwise the space which is suppose to act as a protective and peaceful enclosure for user would work as a money making machines for maintenance contractor and personnel. The feedback from the end user is very important towards better sustainable design because user can provide the first hand information of high claims of the designer. In fact user is very much similar to teacher who can easily access the potential of his students through the test.

4.0 CONCLUSION

This article will help is to remove the ivy from the mistakes of building designer and to discover its amazing implications. Second aspect of this study is to develop a viable relation between the Sustainable Design and Maintenance. In this hi-tech world, one should be aware of severity of maintenance in buildings and it could be only done through conducting research in different location.

During that course of action several causes of building maintenance have been identified at various stages of the design and construction phases. Among them some of the causes acting as an independent manner but most of them are correlated. But the common element among these
identified causes is that, their severity influences the maintenance procedure in building. Few of these causes implicate the building as a single defect but most of them implicate in multifaceted.

Literature review has guided this research to come with set of sustainable design criterion, absence of those causing various types of maintenance in buildings. This research concludes that relation of Sustainable Design and Maintenance can be understood in terms of Architectural Eco-System. Architectural Eco-System can be defined in terms of balance and imbalance design. Both balance and imbalance design results in from absence of any one or more than one criteria at stage-1, as shown in Figure 2. Furthermore it is added that Architectural Echo-System is comprises of design criterion, essential for better sustainable design. If one or more than one standard left unattended (dotted arrow) it could results design imbalance and resultant maintenance. Therefore it could be stated that resulting maintenance is directly proportional to quality of sustainable design. Maintenance at post occupational stage could be controlled through complete adoption of criterion designated for better design as shown in Figure 2. For example in comments 2 this research has established that quality of design and construction phase is highly govern by the various factors like management of construction, knowledge of alternate materials, standardization and time factor.

If designer fails to incorporate or accomplish any one or more than one factor shown in Figure 2, it would results imbalance in design and resulting unplanned maintenance in building.
Knowledge of materials... role of all building professionals... considerations... for established standards... adoption of regional bye laws... users feedback...
REFERENCES

Ramly, A. Link between Design and Maintenance, Builders & Engineers, Vol 81, No 5, May (2006)
RICS. Practice Note 4 on Building Planned Maintenance, Royal Institution of Chartered Surveyors, London UK (1990)

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