Eco-Building Design (EBD): Design Strategies to Increase Building Compatibility

Ali Vakili-Ardebili and Abdel Halim Boussabaine

School of Architecture, The University of Liverpool, Liverpool, UK

ABSTRACT: The needs of a building owner and occupants change over the building whole life cycle (WLC); consequently, building must be designed to cope with these changes. In eco-building design (EBD) approach a set of strategies are adopted in order to enhance the compatibility of building to adapt with both its inner and outer systems over its WLC. In EBD application of design strategies and adding value are based on sustainable building design eco-concepts. EBD embraces issues such as building eco-efficiency and quality over its life span to satisfy stakeholders' needs. The implication of eco-concept application in building design could create building assets which present higher level of reliability based on their compatibility in a system. In addition to providing higher level of health, comfort and efficiency for their users such buildings will last for longer period of time. In this paper EBD is referred to environmentally–compatible design which comprises form, function, and cost as well as application of functional and environmental design strategies, eco-efficiency and social issues.

Keywords: Compatibility, Eco-Building Design, Eco-concept, Sustainable Building Design

1. INTRODUCTION

The longevity and obsolescence of a building over its WLC are concerns of both owners and occupants. Decisions and strategies leading to longer useful life span of buildings are those having effective influences on building facilities. Although longer life span of a building may lead to better investment and higher efficiency but it needs series of improvements in building longevity, durability and performance. Eco-building design (EBD) as an approach in sustainable building design (SBD) focuses on application of eco-concepts in design strategies to increase compatibility of building over its WLC concerning building characteristics such as functionality, performance and eco-efficiency.

This paper concentrates on the issue of changes in built facilities and attempts to introduce EBD as an approach in SBD aiming at higher quality of building design over its WLC through addressing eco-efficiency and application of design functional and environmental strategies. Here, EBD not only embraces suitable eco-concepts but also seeks new methods to enhance the quality of design by prudent overviews on functionality and efficiency issues.

Design for maintainability [1], [2], design for serviceability, design for durability [3], [2], design for Flexibility [4], [5]), design for disassembling [6], design for performance [7], [8] and design for simplicity are strategies addressed by researchers in different areas in order to enhance building compatibility and increase life span over WLC.

The pivotal objectives sought by this study are presented as following:

- To identify building components' interactions and liaisons as the causes for changes in a system;
- To identify the main sources of probable changes in building system; and
- To suggest EBD as an approach in SBD enabling building system to set a balance among components in order to improve building compatibility. In this study EBD comprises form, function and cost as well as application of environmental design strategies, eco-efficiency and social issues and the main objective is to set a balance among EBD components in building system.

This work addresses changes occurring in building WLC based on human functional needs and attempts to advocate EBD approach as a method of design enabling building stakeholders to accommodate the required changes in built facilities through increasing compatibility level within building complex system dynamism.

2. COMPLEXITY OF DESIGN DYNAMIC PROCESS

Architecture is a process of change consisting of various components, attempting to translate functional needs into forms [9] through dealing with various aspects like design, environmental, energy, resources and socio-economical issues over building WLC. According to Backlund [10] the component type and their level of interactions are always unsymmetrical and unpredictable and this makes the design process a complex system. Also this complex system is dynamic because it is based on essence of functional needs. The fact is human needs change over time and this requires a design with the ability of dynamism over building WLC and life span. It should be a design which could be reliable, achievable, maintainable, serviceable, and durable whereas it is flexible as well as considering energy and resources, environmental and socio-economical aspects [11].

Hence, improvement of quality of life over the time and building WLC remains as a responsibility of architecture. As “humans spend 90% of their lives indoors” [12] therefore providing a sort of building system enabling users to fulfil their expectations is a pivotal task.

3. TYPES AND LEVELS OF CORRELATIONS

There are two types of correlations known among components of a building system. These inter-relations could be described as internal and external correlations.

Figure 1 shows the different types of components and their correlations in a system. In the figure the correlation between two components in a system is illustrated by X, and the correlation between two components in two different systems is shown by Y whereas there is an interaction between two systems which is presented by Z in the whole system.

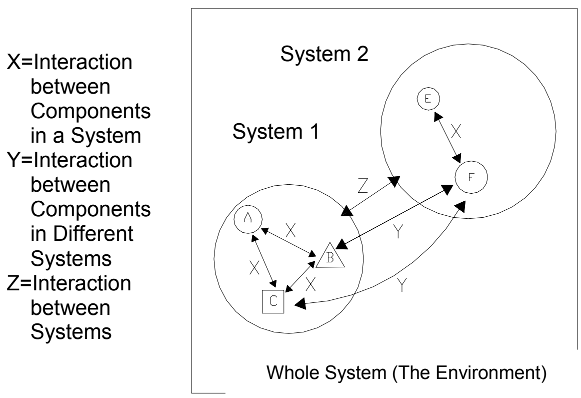

Figure1: Components Correlations in a System.

3.1 Internal Correlations

The relation between components in a building is defined as internal interactions. That indicates how much influence a component has on the other components and vice versa. Adjacency of different materials in building and their impacts on each other is an example of this category.

3.2 External Correlations

The relation between a component and its outer circumstance (surrounding) is defined as an external interaction. Apparently it is known that there are mutual influences between built environment and their environment. Each has effects on another. The existence of these effects is the main source for probable changes addressed in this study. Environmental impacts (built environment effect on the environment) and facade erosion (effect of environment on building) could be considered as examples of this group.

Level of correlations is based on the degree of interactions and impacts of component on each other and might vary over the time. Any change in the level of correlations leads to a need for a change in building. Therefore it can be concluded that the essence of change is laid in the level and the type of components interactions.

4. NATURE OF CHANGE IN A BUILDING

Changes in a building might be required as a result of change in interaction between components. The degree of change is detected based on the nature of change of component interactions and the level of their impacts on other components. Apparently, distinctive change of interaction between components is the main reason leading to changes in building assets. Hence, it is the level of change in the interaction which determines the emergence of change and occurrence of change arises in order to set a balance among correlation of components in the system. Changes in building facilities are grouped by [5] into three main categories as follows.

4.1 Changes in Function

Function is a response (activity or component) to fulfil a certain need of human. Since human expectations over time changes, therefore there is a need to review their needs and consequently the required functions based on the needs. In a building asset change in function is fulfilled by creating new, upgraded or modified function.

-New Function

New functions are those facility objectives that need new components and new system of building. Usually the new function is created as a result of a failure in functional aspect (feasibility) of the previous or current functions.

-Upgraded Function

Upgrading a function requires a set of activities carried out in order to improve the previous functional aspect of a system through limited changes in number of components of system to achieve higher functional efficiency of system. Usually a few components are added to the system to enhance the functionality of the system and its objectives.

-Modified Function

Sometimes a function is modified in order to achieve different objectives based on the matter of use over time. In this case there is a need for different components, systems and processes. This group are considered as the combination of previous categories aforementioned.

4.2 Changes in Capacity

As capacity deals with quantities and threshold of tolerance, thus, this category is divided into two major groups. One is change loads and conditions, and the latter is change in volumes. Both groups focus on quantities in use stage of facility over time.

-Change in Loads and Conditions

This group indicates the required needs for responding to an expected performance under specific conditions. It deals with better understanding of loads and conditions regarding increased expectations for performance.

-Change in Volumes

This group focus on the size of space required for a certain operation. The exact sizes are detected according to practice and use of room over time. It involves spatial dimensions in a building.

4.3 Changes in Flow

There are two types of change in flow regarding buildings which are change in environmental flow and change in people or other elements in the building flow. This category addresses the correlations of components within/with their internal and external environments in building facility system in practice. Practical use of facility shows the shortages and emergence of a series of changes in the system over time.

-Change in Environmental flow

This group is considered as a response to higher performance requirements for both internal and external interaction conditions including indoors and outdoors. This need is detected precisely after practical use of assets and better understanding of interactions of component among themselves and their correlations with their surroundings and the environment.

-Change in flow of people/things

This group addresses the expected performance required for movements, activities of the user within building facility. This need can be precisely distinguished through use of facility over time.

5. EMERGENCE OF DESIGN FOR COMPATIBILITY

Compatible is defined as 'able to exist, live together, or work successfully with something or someone else' [13]. Compatibility incorporates a vast area of research. It covers meanings such as flexibility, adaptability and adjustability. In building facility, dealing with changes over time, it is important to provide a system or design method which is capable to handle changes. In other words design of building assets should address the compatibility issue. This means that the more compatible building is designed, the more durable, flexible, adaptable, maintainable and reliable building is emerged. To follow up the objectives of this study, the authors of this paper believe that compatibility of a building system could not be achieved unless the sources of changes are identified. Hence, this paper looks at compatibility issue through components correlations in facility internal and external systems.

5.1 Components Compatibility and System Internal Correlations

This section involves the microscopic point of view on the issue of compatibility and deals with components internal correlations in the building system.

-Technology Use and Materials Adjacency (Detailing and Design)

As far as two components are adjacent to, a correlation between them is established. The level of the interaction depends on the rate of their impacts on each other. Therefore, in detail design, material adjacency and application is a pivotal issue which should be considered in building design. The prudent selection of compatible materials is a concern in building durability and maintainability issues which has an important role over building WLC.

-Quantities (Dimensions and Volumes)

This aspect involves in proportions and quantities which should be applied in accordance with design attributes and user expectations. It is important to set a balance between expectations and facility available capacities in a building as a dynamic system over its WLC.

-Design attributes (Function, space, Form)

Functions are emerged from needs, and spaces and forms in building are generated to respond the functional needs. Adjacency of functions, and consequently the required spaces and forms to fulfil those functions is an important issue in a building design. This means in design stage, functional zoning should be addressed and compatible functions should be adjacent otherwise any ignorance regarding compatibility of functions will end to a change in future both in functionality and efficiency of building.

5.2 System External Correlations: Components Compatibility with Surroundings Environments

Building should be compatible with its surroundings. There are generally two types of surroundings that cause possibility of change. Those are:

-Environment and Building Interactions

The environment affects building assets. This means there are many reasons for change occurrence caused by the environment. In total this group of impacts are related to the external interactions made by a system component with other component in another system.

-Human and Building Interactions

Human and their expectations because of their influential roles on building change are classified as a main surrounding reason for change in building. There are many impacts made by human and their decisions on the building assets over WLC.

6. RESPONSES TO COMPATIBILITY

There are different methods in design to increase the compatibility and performance of a building over its WLC. Design for Flexibility, durability, serviceability, maintainability, reliability, simplicity, disassembling (ease to uninstall) and concepts such as dematerialisation are all examples emerged from concept of design for compatibility. All these concepts attempt to enhance the components correlations in a dynamic system such as building facility.

The proposed objectives of design for compatibility concept over the time are to set stable component interactions in a system or a sort of flexibility to enable components to upgrade the level of their interactions, over WLC. The range of the activities embraces all correlations that a component has in a system (microscopic view) and with other external (adjacent) systems in the environment (macroscopic view). Therefore it deals with various aspects such as design, environmental, socio-economical, energy and resources consumption issues. Regarding this, the authors of this paper believe that EBD as an approach based on design issues as well as environmental strategies, energy, material, and socio-economics might be one of the best responses to enhance compatibility of building in design stage.

7. ECO-BUILDING DESIGN: AN APPROACH TO ENHANCE COMPATIBILITY OF BUILDING

"Buildings and their multitude of components and systems have serious impacts on the environment. These effects are not limited to the local or immediate environmental surroundings of a building but include regional and global effects. The environmental impacts of buildings as well as those associated with other human activities (e.g. transport) are assuming greater and greater importance as society accepts the seriousness of the environmental problems that face the world today." [14]

Since design process as an important stage, involving financial return, social contributions, and energy efficiency and minimal environmental impacts objectives [14] therefore it should be viewed prudently due to its influences on the future of planet and negative resulting impacts. "There are many ways in which built facilities can reduce their dependence on environmental resources. Such strategies range from appropriate material selection to radical designs that embody both passive and active solutions to create more comfortable spaces at reduced cost and energy overhead" [14].

Hence, in this work passive and active solutions to create designs creating comfortable spaces with low costs and energy overheads, derived from renewable energy sources like solar and wind energies are considered as a part of environmental design strategies in EBD. The quality of building and its components play a crucial role for occupants' health, feelings and comfort. The building should be designed in a way that provides user with comfort, health and safety of natural conditions. It should not act just like a shelter; it should be a place that occupants enjoy their stay at.

Here, EBD is referred to environmentally–compatible design which comprises the form, function and cost as well as application of environmental design strategies, eco-efficiency and social issues to provide higher building performance and quality for the end users. Figure 2 illustrates how EBD as an approach in architecture should be considered as a process of change that turns constructional materials into building assets through aspects such as technology, environment, socio-economics, and energy and resources consumption.

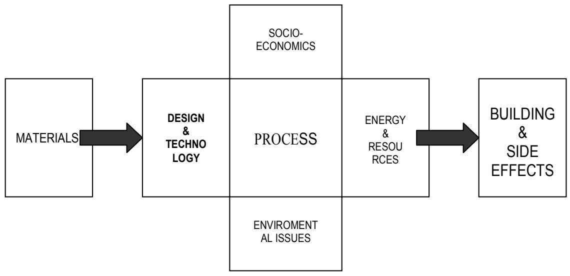

Figure 2: Input-Process-Output in Eco-Building Design (EBD) Approach

In EBD, design environmental strategies and building requirements are addressed in order to enhance efficient components correlations with surroundings in two dimensions. The dimensions include both micro and macro scopes in building system in the environment (as described in Figure 1). The main objectives of EBD are to seek and to establish a set of stable or quite flexible correlations between building components and with the other components in the surrounding environments. Stability of a correlation, theoretically, indicates a sort of perfection in function or fulfilment of a need in a system. In spite of the existence of change in expectation types and levels, the issue of flexibility as a sub-set of compatibility are recommended for coping with the problems caused by nature of change in building management. The compatibility of a system over time is a possible solution towards problem of change over WLC based on desired needs. Hence, compatibility is dealt in EBD according to categories presented in the process illustrated in Figure 2. Here, the process of architectural design (EBD approach) attempts to present compatibility in connection with design and technological attributes, environmental and socio-economical, energy and resources consumption dimensions. As the design is carried out based on setting more reasonable components interactions, therefore the result could be more reasonable and efficient buildings with higher quality of life provided as well as generating less negative impacts as side effects of building activity.

8. DISCUSSION AND CONCLUSION

EBD is not the only approach which enables the building design to be more compatible but it might be one of the most efficient approaches to assist design for compatibility in building facilities which is addressing both building design attributes and user expectations. The main objective in this approach focuses on establishing a stable correlations between components of a system (in the case if the perfection could be achieved) otherwise a dynamic flexibility called compatibility should be considered when the system is designed. Compatibility attributes in a system provides the system with a dynamism enabling the facility to cope with the future required changes based on new desired functional needs. EBD enhances the mutual interaction of building and its surroundings. In this study the surroundings of a building are assumed as both human and environmental factors that have different impacts on a building. Since EBD approach embraces both environmental and user focused approaches it attempts to improve the level of mutual interactions between these surrounding systems and the building as a complex dynamic system.

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