COMPLEXITY OF VALUE CREATION IN SUSTAINABLE BUILDING DESIGN (SBD)

Ali Vakili-Ardebili[1, 2, 3]

ABSTRACT

Value creation is a significant part of the sustainable building process. To understand the process of value creation, this paper identifies a number of important issues. First, the paper addresses the existence of and identifies reasons for complexity in the process of value creation over a whole lifecycle (WLC). Then, a conceptual framework model is developed and adapted to the WLC in order to monitor building process stages and intervals. Next, the concepts and strategies leading to WLC value maximization are addressed. Finally, a conceptual WLC value creation model is proposed that is based on sustainable building process stages and building asset stakeholders' benefits. The paper indicates how value created is an accumulation of values acquired through various operations over the building WLC.

KEYWORDS

Complexity, sustainable building design (SBD), sustainable building process, value, value creation, value maximization

INTRODUCTION

High performance buildings present a range of beneficial features to their surroundings; this being one of the main objectives sought in the sustainable building design (SBD) process. Although performance characteristics in an asset are a matter of quality and durability acquired over the building whole life cycle (WLC), both quality and durability attributes are dependent on the value created in a building asset. Based on rational interactions between level of performance and the rate of value created during different stages of the building process, this paper investigates the concepts underlying the integrated design process pertaining to value creation. A model of the process of value creation in SBD emerges from this investigation revealing the complexity of value creation especially when the benefits to multiple building stakeholders are considered.

BACKGROUND

"The term sustainable building is used interchangeably with green building. Its purpose is to reduce the adverse human impacts on the natural environment, while improving our quality of life and economic well-being" [Fullbrook *et al*, 2006). Norman Foster and Partners describe sustainable building (SB) as: "creating buildings which are energy efficient, healthy, comfortable, and flexible in use and designed for long life" [ARBE121, 2005). The quotes imply issues relating to value creation over the life span of the building asset. Such descriptions reflect a performance focused citation because performance is a long-term process dealing with buildings throughout their life spans in three aspects: customer expectation, operation, and maintenance. *Building performance* is defined as the behavior of an asset in use; therefore, it can also be used to denote the physical performance characteristics of a building as a whole and of its parts (Clift and Butler 1995). It thus relates to a building's ability to contribute to fulfilling the functions of its intended use (Williams 1993). This means that performance issues deal with quality and durability attributes in a building's design over its life span.

Optimal building performance is the product of good project development, where the traditional triangle of project objectives (Barnes, 1988) stress time,

[1] School of Architecture, the University of Liverpool, Liverpool, L69 3BX, the UK, E-mail: a.vakili-ardebili@liverpool.ac.uk
[2] Vakili and Partners Consultants, No. 158, Keyhan St., Sohrevardi St., Tehran, 1576984113, Iran, E-mail: vakili_ali127@yahoo.com, Tel: (+1) 647 834 8050
[3] India Steel Detailers Inc., 114 Goulding Ave., North York, Toronto, ON, M2M 1L4, Canada

cost, and quality (Chew *et al.*, 2004). In Barnes's triangle the meaning of quality carries ambiguities. The understanding of quality relies on the identification of its determinants and components.

Quality can be defined in four ways:

1. Quality of conception in terms of elegance of form, spatial articulation, contribution to culture [Design issues]
2. Quality of specification for the level of finishes required and achieving technical standards set for the building [technical and technological issues]
3. Quality of realization of project [Socio-economics and feasibility] and
4. Quality of conformance in which the objectives set out are realized in practice [socio-economics, reality and accountability] (Winch *et al.*, 1998).

Performance based building (PBB) relies on a flexible and non-prescriptive concept for building design, construction and facility management (CIB, 2003). The holistic performance outcome is a departure from the traditional approach of developing prescriptive, analytical codes and standards. Gibson (1982, p. 4) articulates that the performance approach is concerned with what a building or building product is required to do, rather than prescribing how it is to be constructed (Hattis, 1996). Therefore, the process of value creation in SBD should be synthesized based on building performance features simultaneously involved in time, cost and quality issues over its whole life cycle (WLC). As the performance concept focuses "on 'output' of the technical description," "performance should give sharper focus on quality instead of price only" (Brochner *et al.*, 1999, pp. 369–370). The overall objective of building performance is tied with the meaning of design effectiveness. Hence, this paper views durability and effectiveness from two angles; one could be related to longevity of function based on a building's physical performance and the latter focuses on longevity of use based on customer satisfaction and intension to exploit assets. This paper investigates the trend of value creation in the building process while considering what is acquired throughout the process of building compared to costs. To explain the process of value creation in SBD, this study attempts to clarify the following points:

- Layers of complexity in the value creation process in SBD
- Sustainable building process model
- A WLC focused Model for value creation
- Flow of design value in building
- Definitions of objectives in WLC value creation
    a. Durability
    b. Quality and effectiveness
- Strategies and concepts to maximize value
    a. Design for Maintainability (DfM)
    b. Design for Serviceability (DfS)
    c. Design for Flexibility (DfF)
    d. Design for Disassembly or Dismantling (DfD)

METHODOLOGY

In assessing the value creation process through design, this research developed a critical literature review of innovative approaches; a methodology that is employed in social science disciplines. As part of a three-year study, a literature search was carried out, together with informal interviews with architectural design practices, and an assessment was made as to which main parameters are essential to create value through SBD. Value created through SBD can be assessed and described or illustrated in both objective and subjective terms by design experts. A review of a wide range of literature as well as an analysis of all relevant information and results, obtained through this work, enabled key elements of the theoretical concept of value creation through SBD to be developed. The thoughts, concepts and findings including a theoretical paradigm are presented and discussed in the following sections.

MODEL DEVELOPMENT

1. Layers of Complexity in WLC Value Creation

The built environment is the result of a sustainable building process challenged to create a balance between form attributes and design contexts (Vakili-Ardebili, 2005). Based on such a theory: "the form is a part of the world over which we have control, and which we decide to shape while leaving the rest of the world as it is;" whereas "the context is that part of the world, which puts demands on this form; anything in the world that makes demands on the form is context" (Alexander, 1971). Thompson (1984) has called form the *diagram of forces* for irregularities. To deal with complexity encountered in sustainable building WLC value creation, this research employs a systematic scope, synthesized based on form and contextual terms.

According to form and context philosophy, there are two types of value creation; one is creating value regarding design attributes leading to the synthesis of form whereas the other creates value concerning contexts and building surrounding systems. In both, the building process creates a balance among design components and their correlations (Vakili-Ardebili and Boussabaine, 2006).

Since SBD is a complex process (Vakili-Ardebili, 2005), creation of value in a complex system seems to encounter unpredictable and irregular levels of complexity. There are different layers of complexity faced in sustainable building procurement and the operation of building assets. Mainly, the complexity found in the building process is derived from a large number of components and their asymmetrical, irregular and unpredictable correlations within building facilities and with the environment surrounding and impacting a building's assets over its WLC. The other reason for the existence of complexity relates to subjectivity regarding perception of value by various professions involved in the building process. As a matter of fact, each profession follows objectives that are beneficial to its business and clients. A list of benefits for each party depends on its perception of value. Hence, the main objective in value creation over building WLC is to provide a win-win situation for all parties involved in the process. If the concept that all participants should align their activities to the pursuit of value creation is accepted, then the development of ways to maximize value in the building process is the issue on which action needs to be taken.

Complexity is a matter of not having a model in mind to which the existing layers of reality can be adapted. Complex systems are related to multiple types or equivalent classes (McComick *et al.*, 2004) and to define their complexity, the actions one takes in order to turn the system into a class of simple things (Zellmer *et al.*, 2006). "Complex systems are deeply hierarchical, so the deeper the hierarchy the more complex they are" (Zellmer *et al.*, 2006). This fact confirms that complexity exists before simplicity, and clarifies how the characteristics mistaken for complexity are in fact descriptions of systems made simple (Zellmer *et al.*, 2006). Solving the problems in complexity involves making the system as simple as possible to understand. This means that an apparent view on the system should be obtained through either analysis of the system or even a change of the angle on the issue. The process dealing with complexity has two steps: first, it involves the system while attempting to analyze, simplify the system structure to find the hierarchy, chain of correlations and rules of the system; then, a model is developed based on the findings and understandings. Sustainable building (SB) as a building process is a method not to isolate a building system from its surrounding system [design contexts], but to act in concert with it (Graedel and Allenby, 1995).

The complexity in SBD based on its nature should be discussed within three layers (Kay, JJ, 2000):

1. Society and the need for design principles (Socio-economics)
2. Analysis of mass-energy flow systems (Building process)
3. Ecosystem and natural environment (Environment)

In addition to the complexity of building design, this paper draws attention to stakeholders' satisfaction as one of the main priorities for the success of building projects. In this regard, this paper shapes a set of issues leading to the development of a conceptual customer oriented framework which might be used in the early stages of building design to create value over WLC. To deal with complexity in value creation, a building process WLC model is presented enabling stakeholders to monitor and analyze the process of value creation according to certain criteria.

2. Sustainable Building Process Conceptual Model

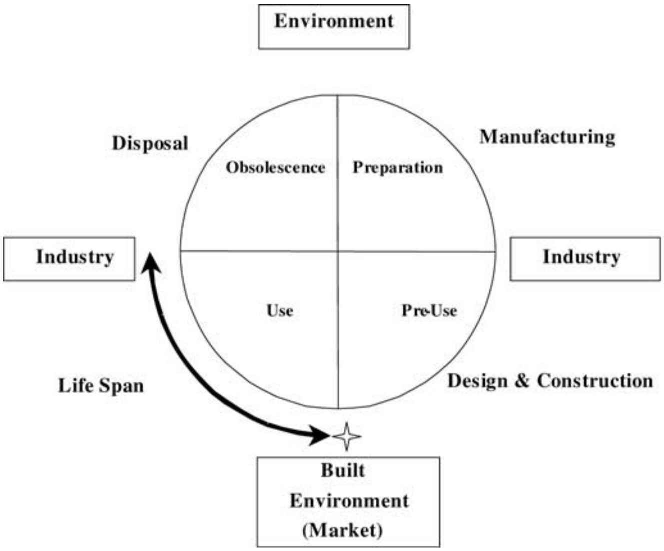
Whole life value extends over the life cycle (LC) of assets or services. In this paper building life cycle is divided into four main stages as illustrated in Fig 1.

In each stage value emerges according to the nature of activity needed for the development of that stage. Assessing value in each key milestone of asset or service life needs clear measures and evaluation methods. To facilitate the process of assessment and evaluation, each phase of the model is described in detail.

2.1. Manufacturing Stage

The preparation of construction materials begins with the extraction of raw materials from the natural environment, followed by processing them in factories. In

FIGURE 1. Sustainable building process and WLC conceptual model.



this stage issues such as industrial technology, product management, environment impacts, economics and efficiency are addressed and analyzed.

2.2. Production Stage (Pre-Use)

Production stage is divided into two main stages by this paper; design and construction stages. The Pre-Use stage includes all activities such as design and procurement whereas the construction stage is needed to develop a building asset. Production stage is assumed to be a part of the building process adding value to the materials through application of technology, design strategies and concepts as well as construction activities. In this stage technical, managerial and economical aspects are addressed. Time, cost, quality, safety and health issues are the main priorities and objectives followed in this stage.

2.2.1. Design Stage. Designers create services that are valuable to their business, clients, building stakeholders and the built environment. The design stage is recognized as the major effective factor in building functionality, performance, efficiency, WLC budget, service life, added value and risk mitigation (Vakili-Ardebili and Boussabaine, 2005). Both tangible and intangible value are established in the early stages of the design process and value materialize through operations carried out in the next building stages. Functional, environmental, technical, financial, operational and social factors are defined as competencies of the design stage (CABE, 2002). To generate the optimal level of value, WLC aspirations such as functionality, reliability, built ability, maintainability, serviceability, marketability, profitability, cost, flexibility of use, reusability and simultaneously other relevant concepts satisfied throughout the design process. This means that a value analysis mechanism should identify design objectives in terms of quality, performance, efficiency, and both capital and running cost reduction (Vakili-Ardebili, 2005).

2.2.2. Construction Stage. In the production stage design values are integrated with other values of construction organizations in order to create new values based on values created in previous stages. In the construction stage, participants add value to the process of building throughout their operations and conceptual frameworks. In other words, value is created through actions of construction parties transforming acquired design values for clients into operational value or use value. In value creation trends in the construction stage the realization of added exchange values created should be tangible for participants engaged in the process of building in a way that they can evidently recognize that the value of the constructed property is more than the costs of all the resources spent on the building asset.

2.3. Use Stage (Operation)

Existence of use stage is the main reason for building process. Hence, a process is more valuable when it is providing more values in the use stage for end users over a longer period of time. Here, one of the goals in the building process would be to create more durable buildings which conserve design values for longer periods of time. As soon as functionality and durability issues are established, terms related to customer satisfaction during the use stage should be addressed. Serviceability, maintainability, flexibility of use, eco-efficiency and cost are issues tied to durability to provide quality, performance and ease of use for the customer in asset. In the use stage all objectives should be followed according to social and cultural values in order to fulfill end users' expectations. Otherwise, the functionality of a building involves risk and it is obvious that adding value in such circumstances seems to be redundant. Hence, the success of a building process emerges from the use stage and this area should be prudently considered while advocating SBD. The extents of value created in the process of building can be indicated when the property is exchanged in the market and put to use. As shown in Fig 1, the market is a place where the highest value of a property at the beginning of its use stage is offered. In the use stage like in other stages, these are operations that create values. The materialization of design concepts, construction operations, and exploitation of resources figure the value in the use stage. Functionality, durability, serviceability, maintainability, flexibility, efficiency, performance and quality are attributes of design. The aforementioned aspects are expected to be materialized over use stage in order to fulfill customers' satisfaction during occupancy. The values obtained in the use stage are based on operations carried out in this stage and are founded on previous stages. Business, manufacturing, design, engineering, building operations and facility management are leading factors in the creation of value throughout the use stage.

2.4. End Life Stage (Obsolescence)

A building passes into obsolescence when it is not useable any further and there are no benefits found in property use from end user's point of view. In this stage the building asset encounters various scenarios. This stage is tied with values followed in waste management and environmental values. Different scenarios might occur regarding quality, performance and stakeholders' expectations for a building. Those are:

1. Dismantling
2. Reuse of facility
   a. Renovation of asset in order to regenerate the values
   b. Refurbishment of asset in order to create new values through establishing new functions
3. Transportation of building in order to conserve the values added due to local identity (e.g. historical buildings).

Time, cost, safety, health and environmental impacts are those topics addressed in building end life stage.

The main objectives in this stage are:

- To minimize the cost of process;
- To minimize the time of process;
- To provide health and safety during the time the process is carried out;
- To control and minimize the rate of impacts while activity is carried out: and
- To eliminate this stage through reuse of asset (Optimum condition)

The process of value creation is formed based on objectives set in this stage.

3. A Value Creation Conceptual Model

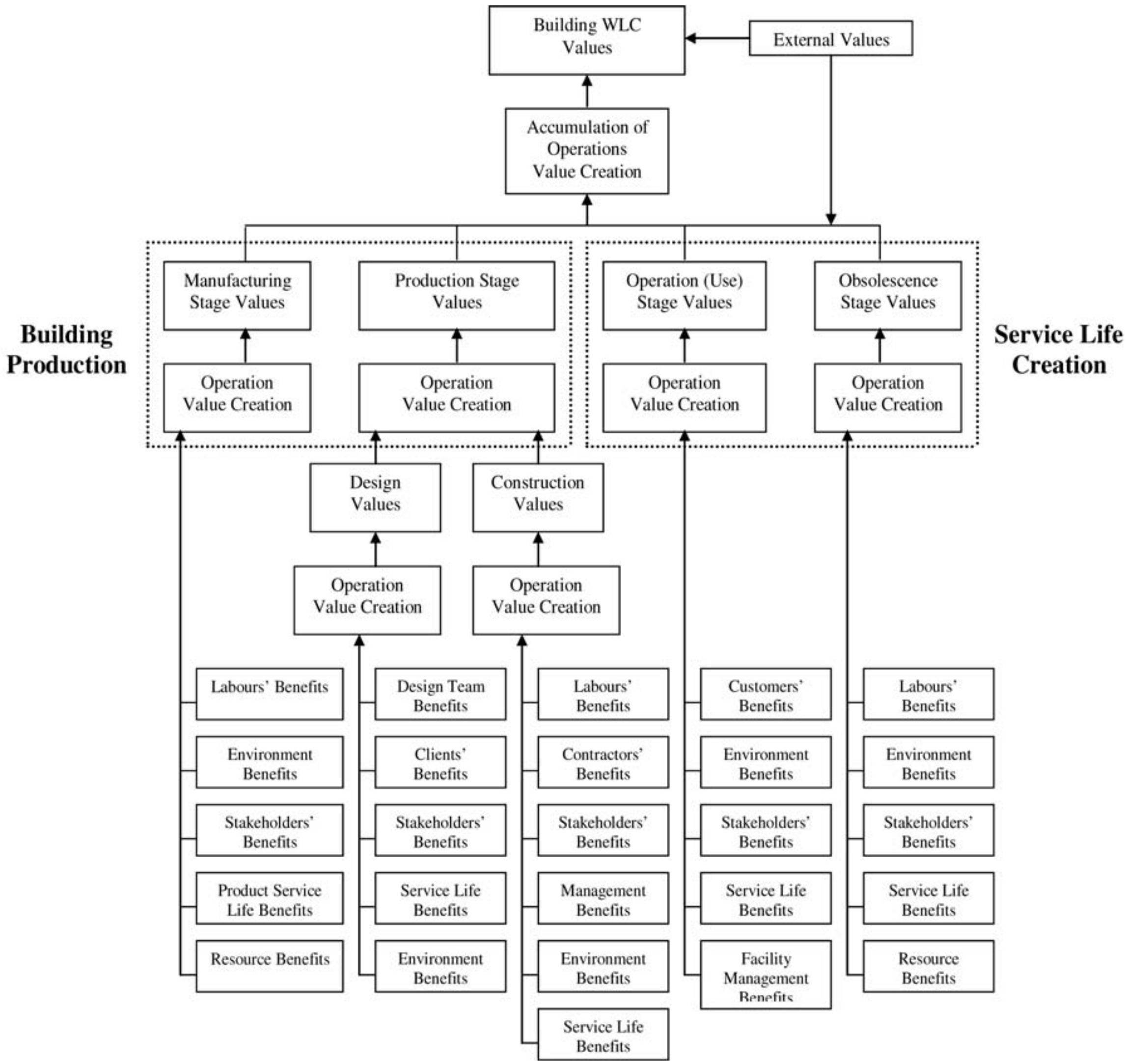
As mentioned, value is created throughout operations carried out in a process. Based on this theory the building process value creation could be the accumulation of value creation trends in building process stages. Fig 2 portrays the model of the building process value creation over WLC based on whole building activities and operational phases.

In this model the accumulation of values acquired in different stages of building process forms the trend of WLC value creation. The model is synthesized based on building WLC benefits acquired regarding design attributes and contextual frameworks. As demonstrated the process of value creation might generate benefits in building production while simultaneously creating service life over building asset life span.

4. Flow of Design Value in the Building Process

Fig. 3 shows the flow of design value in the building process over time. As illustrated, there is a constant increase of value for materials from the time they are extracted from the natural environment and then processed and manufactured. Materials are subsequently used, developed and combined in the construction process in order to turn into facilities. With the materialization of the building asset, design value is at the peak of the curve. As shown in the figure, this peak refers to the market, assumed as a place where maximum price or value is offered. From this point on, if no new value concept is integrated, the property starts to lose existing design values. The main objective of SBD is to create conditions enabling assets to conserve design values close to maximum value simultaneously not to let the value drop down while attempting to add new values while creating services

FIGURE 2. The model of value creation in sustainable building WLC.

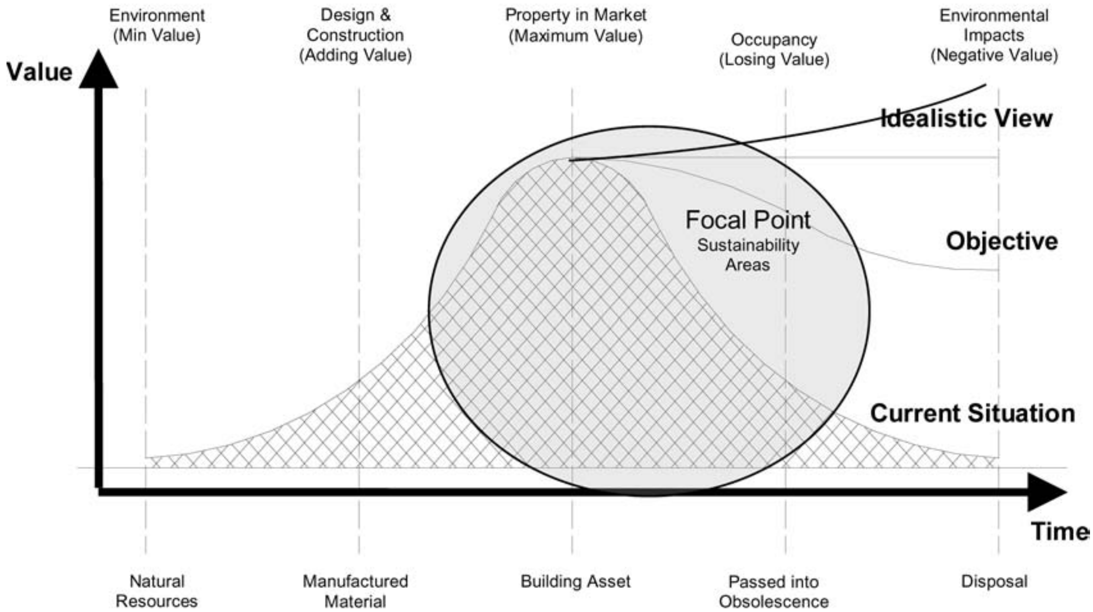


over WLC particularly in the use and obsolescence stages. As illustrated in Fig. 3, the current situation demonstrates a decrease of value after the market exchanging point. The paper focuses specifically on the creation of value after passing into the building asset use stage. Then it proposes strategies and concepts which might be applied in the early stages of design in order to generate more values over the use stage and the end life of asset through service life designated in the design stage. In SBD the main challenge is to answer how more efficient services could be created instead of creating new buildings or restoring them. The main objective advocated in this paper is how a building can conserve created values for a longer period of time or even to add new values to building asset over its life span.

5. Requirements for Emergence of Value Creation in SBD

As noted earlier in this paper, the SBD approach is a performance focused concept dealing with durability, quality and efficiency issues over building asset WLC.

FIGURE 3. Flow of design value in building process.



The main objective of design in a sustainable building process is to establish strategies enabling buildings to create a balance between design objectives and existing surrounding systems as design contexts while focusing on environmental, economical, social, energy and resources issues as well as design functionality, quality, performance and efficiency. Based on building design characteristics and contextual frameworks, SBD components are presented in Fig 4.

6. WLC Value Creation Objectives

Performance and efficiency attributes in a building are the principal core values sought in SBD and consequently building asset WLC. The conservation of these created values over a long term is a matter dealt with in the building process. Hence, in this paper the durability of asset and its functionality are proposed as the main objectives addressed in the SBD trend of value creation.

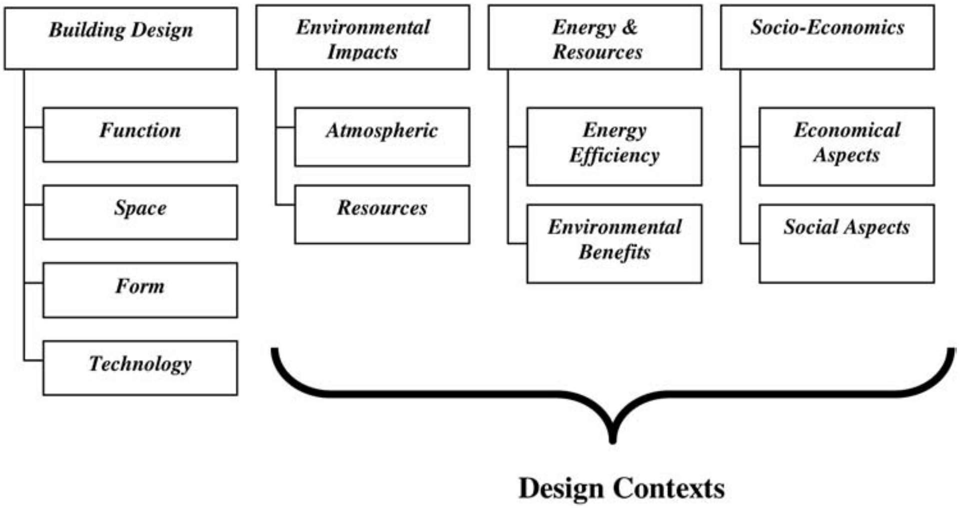
Durability. Durability of a building is defined as the capability of the building to achieve longer useful life. This attribute enables the asset to conserve the values created over a longer period of time in order to be utilized by inhabitants and building asset stakeholders.

Functionality and Longevity of Use. Function is defined as a set of activities or components applied to achieve a specific objective. As far as a function is properly working in a system, the use stage lasts. Longevity of use is the result of such a condition.

Performance. Performance attribute is defined as the capability of a building to achieve the highest appearance and characteristics over life span. Durability, quality and efficiency are considered as requisites in the materialization of performance.

Quality. Quality is defined as standards and characteristics expected in a building. The quality is a matter of building stakeholders' expectations fulfillment. The final quality expected is an average of aspects found in the process of building. The definition of quality issue is not possible unless time and cost terms are addressed. Quality is an issue dealing with stakeholder satisfaction in the WLC of a building. Consideration of attributes increasing the quality of building are conjectured as values added to building asset directing to customer satisfaction as a key in the success of a project (Vakili-Ardebili, 2005).

FIGURE 4. Sustainable Building Design (SBD) and the contexts.



Efficiency. Efficiency is defined as the rate of value of construction or its performance compared to its contextual burdens over a life cycle. Efficiency is an issue which should be monitored along WLC. Since, in SBD, the synthesis of form is developed within the context, therefore design attributes including efficiency are discussed based on sustainability issue concerns. SBD deals with the question of how to gain more from less. Also the emergence of the creation of service life in SBD is based on the efficient use of building asset.

Dematerialization. Dematerialization concept (Kibert *et al.*, 2000) mainly addresses the efficiency attribute in the building process. Industries often attempt to lower the cost of production through the intensity of use (IOU) and reduction in per unit mass consumption (Bunker, 1996). The idea can be developed beyond material and resources consumption and is capable of embracing energy amount use as well. Generally, dematerialization discusses '*how to produce concise but efficient*'.

7. Durability as a Principal Objective in SBD Value Creation Process

Durability is defined as the capability to achieve longer useful life. Durability is an attribute of design presented as a main objective of the building process which enables asset to conserve the values acquired over a longer period of time for the use of building asset inhabitants. The concept of durability is not a new concept and its consideration belongs to ancient times. The perception of durability is tied with the meaning of efficiency. Among the users, durability is always a positive factor in the selection of goods. The durability attribute in a product provides more exploitation of items consequently directing to higher levels of efficiency in production, use and end life. Despite the fact that durability is a major attribute of design affecting the building process WLC, its essence strongly depends on other features of design. In this paper two aspects of durability are presented, namely physical durability and spiritual durability. The paper presents aspects of durability and then advocates strategies enhancing the durability of an asset over a building life span.

7.1. Physical Durability

Physical durability is of those attributes of building causing long-lasting characteristics of an asset regarding the contexts surrounding buildings. In other words, durability could be the result of a balance created in correlation with building system components with other components (Vakili-Ardebili and Boussabaine, 2006) in natural and built environments like surrounding systems. The more stable type of correlation could be established through the early stages of design, the more durable asset might be created. Achieving physical durability is not feasible unless considerations of certain points in the early stages of a building design are carried out. Here, these concerns are divided into two main groups of materials and substantial quality and combinations of components and their adjacencies.

Materials and Components. The quality and performance of a product rationally depends on the materials used in the development of that specific merchandise. The more durable and proper materials are used the more long-lasting the product produced could be. The production of a durable functional product is usually tied with value concerns over long terms.

Combination and Adjacency of Components. Building components detailing and the technology applied in the development of facility play a crucial role in the durability of a building asset. The compatibility of components and their adjacency is a matter of building process in the early stages of design enabling a building to promote functionality, performance and efficiency issues in building over a life span.

7.2. Spiritual Durability (Psychological Aspect)

This aspect of durability relates to a building and human interactions and is addressing the feelings inspiring users to stay on in a property and to continue using it. This aspect strongly relies on customer satisfaction fulfillments, a key for project success. The spiritual attribute of durability, as related to the social dimension of SBD, is considered as the motif for the creation of durable assets carrying higher rates of values in them. Spiritual durability could be the result of a balance established in building component interactions with human expectations as one of the surrounding systems in a building process WLC (Vakili-Ardebili and Boussabaine, 2006).

8. Design Strategies Enhancing Building Durability

Durability is the result of building compatibility with existing contextual frameworks materialized as surrounding environmental factors affecting the building process over WLC. In this paper, few design strategies and concepts are presented. These attributes of design proposed affect the building process stages over asset life span through dealing with building compatibility concerns. The value creation process and its focus on building stakeholder satisfaction fulfillment makes SBD concentrate on the building behavior over its whole life cycle (WLC). The concepts are briefly explained and the paper attempts to clarify their roles in the materialization of durability as a fundamental objective of SBD in the value creation process.

8.1. Design for Maintainability (DfM)

The military service of the United States, in 1954, was the pioneer for creating and developing the concept of Maintainability (Blanchard and Lowery, 1969). Maintainability attribute is defined as the capability of a building to conserve performance. DfM is a concept addressing issues enhancing building performance over its life span. The outcome could lead to performance, quality and efficiency issues as the requisites for building durability.

8.2. Design for Serviceability (DfS)

Serviceability is defined as the ability to maintain the product in the optimum conditions in order to fulfill its proposed functions regarding product performance, quality and reliability. In Wikipedia, the online encyclopedia services are grouped in two main categories namely, preventive and corrective services. The first is presented in order to prevent failure and the latter is done to fix and repair a fail. The existence of appropriate services in a building could lead to customer satisfaction fulfillment over WLC.

8.3. Design for Flexibility (DfF)

Flexibility attribute is defined as the capability of a building to change according to the newly required needs. The changes might be carried out in order to achieve better function and performance compared to previous conditions. DfF (Slaughter, 2001) places the emphasis on function longevity depending on the building system components internal and external correlations over building life span (Vakili-Ardebili and Boussabaine, 2006). In other words, acquiring more efficiency over the use stage of a building process is what DfF is dealing with.

8.4. Design for Disassembly, Dismantling or Deconstruction (DfD)

The main reason not to recycle is the time and labor required to separate materials. DfD is an approach in SBD concerning value creation over WLC through addressing functionality, quality, performance, durability, efficiency, service life creation in the use stage and waste management (Vakili-Ardebili, 2006). DfD in sustainable building design (SBD) as a customer-oriented approach not only addresses users' needs but also concentrates on the assets' behavior over a building life span. Basically DfD is developed in order to facilitate the ease of dismantling as well as focusing on the environmental impacts in the obsolescence stage simultaneously concerning issues such as time, cost, quality, safety and health leading to higher levels of comfort, life quality and performance through creating service life over building use stage.

9. Implication of WLC Value Creation in SBD

There are two types of benefits in the process of value creation in a building procedure: tangible and intangible benefits. Tangible benefits mostly involve the financial aspects of projects and are a matter of costs whereas intangible benefits are those created and developed for long term beneficiations and their influence should be considered over WLC. As shown in the value creation conceptual model, tangible benefits could be discussed in building production phases where capital investments are carried out and intangible benefits should be addressed in service life creation phases where efficient use of property over operation stage is essential. In this stage design concepts, strategies and solutions enabling a building to create service over facility life span are employed in order to enhance performance. In this paper SBD is advocated as a performance focused approach which is able to create and develop new service life for building assets while focusing on increasing the compatibility of a building based on sustainable development dimensions (Vakili-Ardebili and Boussabaine, 2006).

CONCLUSION

The value creation process proposed by this paper, embraces two main steps in SBD. The first step deals with design attributes and involves building production while acquiring tangible benefits whereas the next step deals with design contextual frameworks and involves service life creation over the WLC, attempting to create intangible benefits over long term life span. The idea presented, advocates development of *service instead of product*. The creation of these services is carried out in accordance with building behavior over its life span meanwhile achieving performance and efficiency are of the fundamental priorities. Simultaneously, customer satisfaction fulfillment is a necessity. Even in some cases like ecological building design, the concept might go beyond and eco-service would be an appropriate substitute for eco-buildings in the process of sustainable building development.

REFERENCES

Alexander, C., *Notes on the Synthesis of Form*, Harvard University Press, Cambridge, 1971

Fullbrook, D., Jackson, Q., and Finlay, G., (2006), Value Case for Sustainable Building in New Zealand, Ministry for the Environment Website, ME Number:705, ISBN: 0-478-25944-1 [Online source, accessed on 9/11/2007]

www.mfe.govt.nz/publications/sus-dev/value-case-sustainale-building-feb06/html/page13.html

ARBE 121, Sustainability, Sustainable Development Definitions [Online source, accessed on 24/8/2005]

http://www.liv.ac.uk/~jabr05/ARBE121Sustainabledevelopment.ppt#12

Barnes, M. (1988), Construction project management, *International Journal of Project Management,* No. 6, pp 69–79.

Blanchard, B. S. and Lowery, E.E. (1969). *Maintainability: Principles and practices*, McGraw-Hill, New York.

Brochner, J.; Ang, G.K.I. and Fredriksson, G. (1999), Sustainability and the performance concept: encouraging innovative environmental technology in construction. *Building Research and Information,* Vol. 27, No.6, pp. 368-373.

Bunker, S.G. (1996), Raw material and the Global Economy: Oversights and Distortions in industrial ecology, *Society & Natural Resources*, Vol.9, pp 419-429

CABE (2002) The value of good design: How buildings and spaces create economic and social value, Commission for Architecture and the Built Environment London.

Chew, M.Y.L., Tan, S.S. and Kang, K.H., (2004), Building Maintainability—Review of State of the Art , *ASCE, Journal of Architectural Engineering,* Vol. 10, No. 3, pp. 80-87.

CIB (International Council for Research and Innovation in Building and Construction) (2003), *Performance Based Building, 1st International State-of-the-Art Report*, Annex: *PeBBu Domain Synthesis Reports*. Report No. 291, CIB, Rotterdam

Clift, M., and Butler, R. (1995), The performance and cost in use of buildings: A new approach. *BRE Report*, Building Research Establishment, Garston, UK.

Gibson, E.J. (1982), *Working with the Performance Approach in Building, Report 64,* CIB, Rotterdam.

Graedel, TE and Allenby BR (1995), Industrial Ecology, New Jersey: Prentice-Hall

IEEE electronic and the environment committee, White Paper on Sustainable Development and Industry Ecology [Web Page] 1995; Accessed 2006, computer.org/tab/ehsc/ehswp.htm

Hattis, D. (1996) Role and significance of human requirements and architecture in application of the performance concept in building, in Proceedings of the 3rd CIB–ASTM–ISO– RILEM International Symposium, National Building Research Institute, Haifa, Israel.

Kay, JJ (2002), "On complexity theory, Exergy and Industrial Ecology: Some Implications for Construction ecology" in Kibert, C., Sendzimir, J., Guy, B. (Eds), construction Ecology: Nature as the Basis for Green Building, Spon Press, pp.72-107.

Kibert, C. J., Sendzimir, J. and Guy, B. (2000), Construction ecology and metabolism: natural system analogues for a sustainable built environment, *Construction Management and Economics,* Vol.18, No. 8, pp. 903-916.

McCormick, RJ; Zellmer, AJ; Allen, TFH, (2004), Type, scale and adaptive narrative: keeping models of salmon, toxicology and risk alive to the world. In: Kapustka, LA; Gilbraith, H; Luxon, M.; Biddinger, GR; (Eds), Landscape Ecology and Wildlife Habitat Evaluation: Critical Information for Ecological Risk Assessment, Land-Use Management Activities, and Biodiversity Enhancement Practices. ASTM STP 1458, ASTM International, West Conshohocken, PA.

Thompson, D.W., *On Growth and Form*, edited by John Tyler Bonner, Edition; Abridged ed., 1984

Vakili-Ardebili, A., *Development of an Assessment Framework for Eco-Building Design Indicators*, PhD Thesis, the University of Liverpool, Liverpool, UK, 2005

Vakili-Ardebili, A. (2006), *Design for Disassembly (DfD): A Customer Oriented Approach in Sustainable Design (SD),* Proceeding CD, Eco-design 2006, Asia Pacific Symposium, Tokyo, Japan, December 2006.

Vakili-Ardebili, A. and A.H. Boussabaine, *The Intricacy of Eco-Building Design (EBD)*, Proceeding CD; Eco-Design 2005; 4th International Symposium on Environmentally Conscious Design and Inverse Manufacturing, pp. 649-654,Tokyo-Japan 2005, session: 3B-1-2F, ISBN: 1-4244-0082-1

Vakili-Ardebili, A. and Boussabaine, A.H., *Eco-Building Design (EBD): Design Strategies to Increase Building Compatibility*, PLEA2006 Proceeding; the 23rd Conference on Passive and Low Energy Architecture, Volume II pp. 177-181, Geneva, Switzerland, 2006

Wikipedia, [online encyclopaedia] [Accessed on 23/8/2005] (http://en.wikipedia.org/wiki/Repair_and_maintenance)

Williams, B. (1993), What a performance! *Property Management, Vol.* 11, No. 3, pp. 190–191.

Winch, G., Usmani, A., and Edkins and A. (1998), Towards total project quality: A gap analysis approach, *Construction Management and Economics,* Vol.16, No.2, pp.193–207.

Zellmer, A.J.; Allen, T.F.H.; Kosseboehmer, K. (2006), The nature of ecological complexity: A protocol for building the narrative, ecological complexity: 3 (2006): 171-182.