

Using Constructability for Commercialization of New Academic Ideas to Improve and Redesign Sustainable Construction by SMEs

Behrouz Andalibizadeh₁
Faculty of Civil Engineering
Universiti Teknologi Malaysia
Johor Bahru, Malaysia
bandalibizadeh@yahoo.com

Prof. Dr. Abdul Kadir Bin Marsono
Faculty of Civil Engineering
Universiti Teknologi Malaysia
Johor Bahru, Malaysia
akadir@utm.my

Abstract— Today universities and companies work with and supplement each other in knowledge based economy to respond the competitive environment in which both are placed. Therefore commercialization of new research ideas, innovation in designs for sustainable development in such countries is made by universities and small to medium size companies. As the world community has recognized weather changes, sustainable environment protection, decrease carbon emission from buildings and sustainability of construction materials are seem to be necessary by all nations. This has encouraged the companies active in construction to decrease carbon and other pollutant emission from current and new buildings the social and economic effects of which intensify competition between companies. Under this condition, small and medium size companies would be pushed out of competition for having no enough ground for research in designing such sustainable buildings. On the other hand, as universities can't provide the required financial sources and operational environment for commercialization of their successful research innovations, the connection between universities and small to medium size construction companies result in association of sources, distribution of profit between them so new ideas are commercialized, entering the world of knowledge and technology. The main objective of this study is to analyze construction project through the study of design, processing, services and innovation getting sustainability. As well leading role of university, customer, cooperation and collaboration of the community in the process of innovation is discussed and studied. Finally, guidelines are given for Iran, using experiences in other countries on the subject.

Keywords- *Constructability, Commercialization of Idea, innovations, Academia, SMEs, Sustainable Development.*

I. INTRODUCTION (*HEADING 1*)

In Iran we need about one million and six hundred thousand residential units each year which are currently constructed using traditional methods in public and private sectors. To this end 910 thousands units were planned to be constructed in 2011 [1]. Currently about 300 thousand units are being constructed in public and private sector using traditional methods. Prevailing construction methods can't meet annual required housing in the country, so to remove the problem we should use new construction methods for their benefits such as standard product, durability and stability, quality control and environment protection. To this end, government of Iran plans to decrease 30% of carbon dioxide pollutants up to March 20, 2016 (The 5th Development Plan, 2011-2016), as anticipated in the 5th Development Plan, to struggle for lowering pollution and prevent environmental damages through innovations in construction industry and using modern methods and to follow Low Carbon Standard Building Strategy depending on the climate. Chapter 19, National Building Regulations on Saving Energy has been a must for all public and private builders [2].

Today in countries of a knowledge based economy, universities and companies note operating as isolated entities but they complete each other in order to respond an increasing competitive environment in which both are included. In the study of construction industry in advanced nations, university is cooperated with as one of the main elements in propagation of innovation [3].

As Iran has not the enough experience on the subject and many small to medium size companies active in construction are unable to invest in modern researches in sustainable construction, the university can collaborate with them as main

element in propagation of innovation. The current study is trying to investigate construction industry in advanced countries including Britain, Scotland, Greek, Brazil... where universities are used and collaborated as one of the main elements in propagation of innovation in construction industry with small and medium size construction companies, and new innovative ideas are used in practice in the field of housing, which give an applied pattern suitable for Iran climate.

II. HISTORY OF SUSTAINABLE DEVELOPMENT AND TECHNOLOGY

History of sustainable development turns back to formation of United Nation Conference on Environment on June 1972. The conference added "Environment" to the international agenda and Stockholm Conference was a starting point for numerous UN gatherings in 70s about pollution, nutrition, human living regions, water, desert spreading, science, technology and renewable energy in the next decades.

One of the new attitudes to development which is now approved by different nations, international organizations and scientific gatherings is that of sustainable development which was came to life following socioeconomic (unemployment, poverty, inequality) and environmental problems and for the need to natural resources management. So sustainable development was defined in a process: Sustainable development requires the process of change in using resources, direction of investment, technical development and fundamental changes which are in harmony with current and future needs. So it may be concluded that sustainable development is a set of social and economic transformation which may optimize current economic and social benefits for obtaining such benefits in future without endangering possible potentials [4].

Development and progress and construction industry during the years and its changes in the current time is the necessity to obtain sustainable industry in this field and assure continuation of the process and having a sustainable future while technology is defined to be "Using knowledge and resources to fulfill human requirements now and in future"

III. GOVERNMENTS, POLICIES, CONSTRUCTABILITY REGULATIONS AND SUSTAINABLE DEVELOPMENT

One of the main and ultimate objectives for all nations is to reach growth and development in all dimensions. Countries, depending on their ecology, climate, geography as well as other social-cultural conditions proceed to compile objectives and policies in the field of growth and economic development. It is obvious that there is such an ultimate objective in Iran and plans have been made to reach the country's development. In this direction general policies on housing have been notified tith the following objectives [5]:

- a) Land management to provide housing and urban, village development

- b) Renovation and reconstruction of worn out texture
- c) Strengthen research and improve scientific knowledge base in the field of housing
- d) Making construction standards and building national regulations mandatory
- e) Plans for energy saving
- f) Comprehensive urban and rural housing planning

IV. PROPAGATION AND EXECUTION OF INNOVATION IN CONSTRUCTION INDUSTRY

A competitive condition in the global economy is more subjected under severe effects of globalization. Developing countries are challenging developed countries in added value for high technology products and industries. In such a severe competition even those companies successful in past face with quick and fluctuating changes.

Porter [6] suggests that during the last 20 years, western companies in competition have replied to continuous improvement, Companies could show their competence in competition with IT technology, investments, reengineering and reverse engineering, Total Quality Management (TQM), pure production and similar techniques for optimization of productivity and creation of unique competitive situation with integration [7].

V. DEFINITION OF INNOVATION IN CONSTRUCTION INDUSTRY

The first definition of innovation is the new subjectivity in using technology by construction companies [8]. Using this definition, application of technology would improve a new organization significantly. Design and construction of living space would bring decrease in installation and commissioning charges, improved efficiency and/or improvement of business process.

Successful operation of new ideas is that in which a certain company can be connected to the process, market or management more than technologies related to new ideas. Successful operation of new ideas is used in a broad spectrum in construction industry and university in Britain and is an accepted subject [7].

In other word, commercialization of new university ideas is among the instances of success in research connection between the university and construction industry.

VI. SUPPLY SOURCES FOR RESEARCH AND DEVELOPMENT OF TECHNOLOGICAL INNOVATIONS

Technology is an important source for innovation in companies and determines how and where technological knowledge is used for development of products or gives a new process [9].

Internal sources of technology depend on the framework of research and development (R&D). One of the main objectives

in research and technology, however it may increase or decrease charges. Research and Development is considered as overhead charges in organization while it is a vital requirement for explorative researches and maintenance of technical skills in regions to be justified and are necessary for the competitive edge of research and development in future. A research and development company is not only trying to obtain new generation of knowledge, but it works toward creation of the capacity to absorb it [10].

However, global strategy of R&D required to be developed in the technical fields and organizational learning ability is in intermingled coalition with other companies and international centers for elevation of research.

To empower small and middle size companies in construction, the universities and professors should execute researches by the universities and make the operative in a joint cooperation.

VII. METHODOLOGY FOR COMMERCIALIZATION OF NEW UNIVERSITY IDEAS IN REDESIGNING AND RENOVATION OF SUSTAINABLE CONSTRUCTION BY SMALL TO MEDIUM SIZE COMPANIES (SMEs)

Today universities enter the global market of knowledge and technology through capabilities, capacities and their researches outcomes. Under such conditions commercialization of university ideas or Academic-Industrial entrepreneurship may be used in combination of university and companies sources toward innovation and providing such outcomes to the market.

However commercialization of successful university of technology requires interaction between both parties which in itself requires increased market oriented activity of universities and emphasizes on attraction of commercial partners satisfaction. In this way customer satisfaction and evaluation of satisfaction level is made a vital element in creation of long term relationship between university and industry. One of applied models in realization of this the subject is customer satisfaction/dissatisfaction model. Fundamental framework development is another model in which creation of a structure for new foundation of university-companies participation is followed. These models are defined in the following sections.

A. Applied Customer satisfaction/dissatisfaction model (CS/D)

In this section, applied model for commercialization of university ideas on cooperation between state research institutes and private companies are defined for creation and commercialization of innovations.

In the research work by Thorsten Kliewe and Todd Davey, Customer satisfaction/dissatisfaction model (CS/D) [11] was used as a framework in measurement of customer satisfaction from university-industrial entrepreneurship and experimental results on determining factors of customer satisfaction and effective factors on their expectations were studied, which brought the following results [3]:

Among theoretical models describing customer satisfaction, CS/D model may be considered as the most prevalent one. The model supposes that customers would evaluate their satisfaction through comparison of perceived performance of a product or service with its expected performance. So the model would interpret satisfaction as result of complicated information processing (Figure 1. CS/D graphical model).

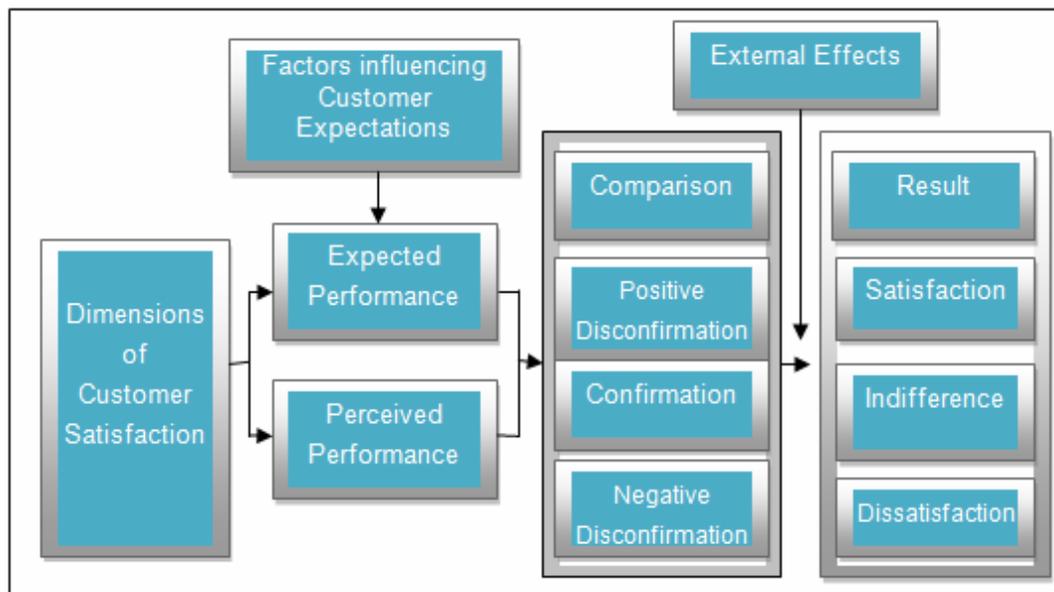


Figure 1. CS/D graphical model (Following Homburg & Stock, 2003)

Results from the research work would assist evaluation of customer satisfaction and university-industrial entrepreneurship, giving some recommendations for further researches:

First, to validate determining factors in customer satisfaction and effective factors on customer expectation, more researches in future are to be done using a bigger sample.

Second, the research should study if customer satisfaction is different from one country to another or from one industrial section to another. This may give more accurate CS/D models for certain conditions.

Third, where perceived performance is more than expected performance, positive cancellation would occur. In the same way if perceived performance does

not verify expected performance, negative cancellation would appear. Finally if perceived or expected performances are matched (In whole or partially) approval would be acquired.

Fourth, external factors which were pointed to in the model are referring to the factors effective on satisfaction (in addition to the result of comparison process).

So, result of comparison process should be considered as the initial stage for customer satisfaction and not supposed to be the same. External factors, would include the following as some instances: Recommendations, feelings, conditions and location. Conclusion: The result would give comparison component while external factors result in customer satisfaction, indifference or dissatisfaction [3].

B. B. Institutional Development framework model for Innovation in Construction

Higher Education institutes have critical role in producing knowledge and stimulation of innovation in construction industry. The subject has been organized and executed in the framework of an organized structure in industrial countries.

So, developing countries can use industrial nations as a model for creation of new construction institutions for development and strengthening innovation in industries.

C. 1) Conceptual framework Institutional Process Esman's model

Universities have significant role in promotion of innovation in construction industry along with the institutions. This model would give a pattern for developing countries on how to direct and develop suitable institutional frameworks.

Esman, (1972) gives five main alternatives of the institutional process in the conceptual framework of his model known Institution general structure which as the necessary elements, as following [12]:

- a) Leadership: Innovative organizations require a powerful leader to meet their objectives, especially when they are new.
- b) Doctrine: Defining the institute objectives to found how the institute should be in terms of leadership, values and style
- c) Program: How to be in order to meet its objectives, services and defined functions considering the required sources
- d) Sources: The main charges in institutionalization which is usually staff employment.

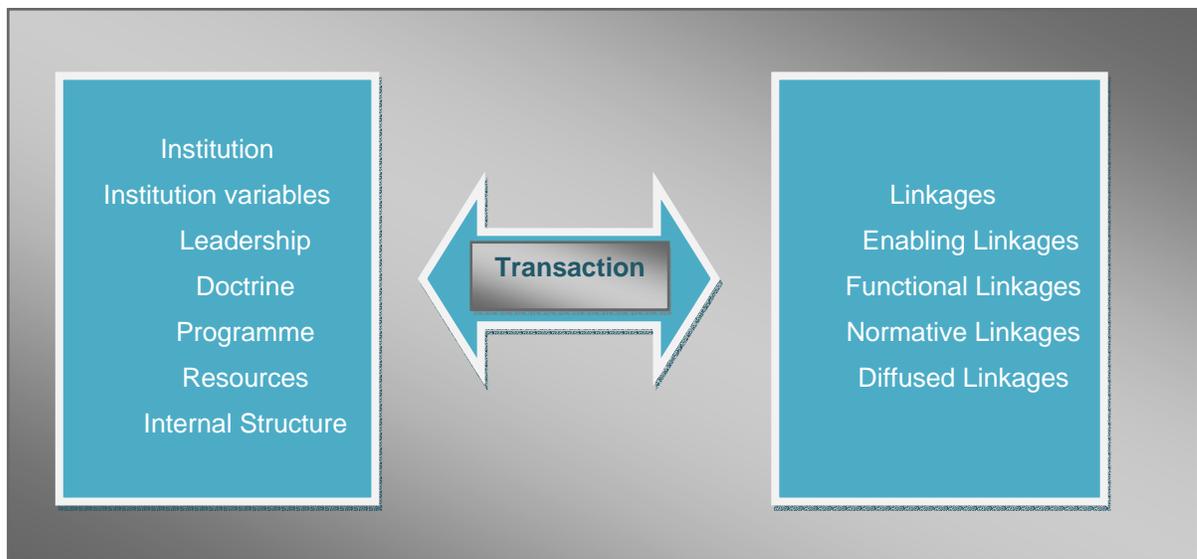


Figure 2. Structure of the institution based on the conceptual Esman's model(Esman,1972)

- e) Internal structure: The institute management framework, like powerful cultural dimensions based on suitable local requirements which should be innovated. Fig.2- General Structure of the institute according to Esman Conceptual Model
- f) Distribution connection: Individuals or groups which are not directly connected with this institute but may possibly have great influence in fulfillment of given objectives through their influence and agreeability

As an existence of an institute depends on connection with the condition in which it is living, the connections have been considered fewer than four groups as following:

- a) Make the connection active: Vital relationships of the institute, being legal, objective, resources and form
- b) Functional connection: Connection with supplementary or competitor organizations which generally assist or support fulfillment of the objectives
- c) Connection in principal: Relationships (friendly or cool) with institutes having similar benefits and objectives [12].

2) Compare general structure of (CCI)¹ With (SCRI)² centers by Institutional Development framework model in university and construction industry

First case study of general structure for new participation in university and company by conceptual framework Institutional Esman's model used in UK. In table1 we compare Construction Innovation (CCI) and Salford Centre for Research and Innovation (SCRI) centers by this model.

VIII. PARTICIPATION OF UNIVERSITIES WITH INSTITUTES FOR DESIGNING SUSTAINABLE BUILDINGS- COUNTRIES EXPERIENCE

Innovation in designing sustainable buildings and reconstruction in practice with the objective of collaboration and participation between universities, institutes, small and medium size SMEs companies in developed countries is a suitable pattern for developing countries to use their experiences and operations in order to take positive steps in construction based on environment protection and sustainable development. Below is the brief summary of different research projects on universities-institutes participation for innovation and construction in different countries the used in the country: (in none axes):

1- Heat transfer 2- Carbon decrease 3- Integration, heat transfer and carbon decrease 4- Standardize and improve construction 5- Sustainable construction materials 6- Deciding for designing and reconstruction of sustainable building 7- Vital sustainable systems infrastructures 8- Residue/demolition management 9- Recovery./reuse management of construction waste materials in the same line with designing sustainable buildings.

¹ Centre for Construction Innovation(CCI)

² Salford Centre for Research and Innovation(SCRI)

A. A. Heat transfer

Many researches are performed for optimal usage of energy in the building, considering different climates in the project, such as solar hybrid, thermal mass which are consisted from:

1) Development of Hybrid Solar Thermal Mass (HSTM)

To be used by residents of Housing Cooperation upon zero carbon construction program and economic houses (joint project by Glasgow Scholl of Art, Edinburgh Nipere University and Tenants First Housing Cooperative, Aberdeen, Scotland) [13]

2) Approval of building energy scales, independent form climate trough the world (GCU and IES Ltd., Glasgow) - (Kumar and Emmanuel, 2010).

3) Solar wall system for internal heating, economic method for fuel shortage (HWU, Change Works Resources for Life Ltd., and Ormandy Ltd., Edinburgh) (Wang and Roaf, 2010).

4) Critical augmentation between energy and protection of old and historical buildings (ENU and the Morrison Partnership, Edinburgh).

5) Designing new solar heating set (HWU and AES Ltd., Forres).

Based on solar findings and heat loss, operation conditions and relative design, it was necessary to emphasize on analysis of mechanisms form energy benefits, losses from collection, such as material coating, housing materials, insulator properties, level, weather conditions, entry water temperature, ambient temperature, mass current velocity, collection point, dimensions, gross area to collector, area proportion, absorbents, best thickness, gradient and collector. Four sample units were produces and provides to HWU University for thermal performance test (Roaf and MacLennan, 2010).

B. B. Carbon decrease

1) Anticipations from carbon spread using virtual medium software (HWU and IES Ltd., Glasgow)

2) Preparation of low carbon construction materials in apartment purchase list (USG abd Holmes Partnership, Glasgow) (Cockroft et al, 2010).

3) Development of project evaluation for innovative low carbon housing projects (GSA and John Gilbert Architects Ltd., Glasgow) [13].

4) Sustainable housing project and economic housing of Terry Holmes in Irving (USG and Assist Design, Glasgow) (Howieson and McCafferty, 2010).

C. C. Integration strategy, heat transfer and carbon decrease in sustainable construction

1) Project for effective evaluation on integration of heat recovery system in making zero energy housing and carbon decrease (USG and Assist Design, Glasgow)

Robert Ryan Timber is designing and developing ideas and solutions for making house in two “Zero Energy” and “Zero Carbon” methods which has been recognized by Britain government. Broad studies have been performed on optimization of Photovoltaic Thermal (PV/T) Design (Masau and Noguchi, 2010).

2) *Disturbed strategies against active ventilation and evaluation of air quality and comfort balance avoiding fuel deficiency (USG & Assist Design, Glasgow)*

Primary results of the project are recommended as following after evaluation: Designing a house of low energy consumption, quick and easy construction would be of low charges in terms of time and experimental skills and would significantly affect the potential charges for carbon decrease for more than 60% ((Howieson and McCafferty, 2010).

3) *Compare theoretical performance of a set of environment friendly installations in the building with true performance and application experience (USG & Assist Design, Glasgow).*

Lowering carbon in reconstruction project for Hillcrest Housing Association at Edinburgh is the world heritage site. The project is laborious duty of reconstructing existing buildings to minimize CO2 emission and dependency to nonrenewable energy sources), (Sharpe and Jack, 2010).

IX. INNOVATION BY THE UNIVERSITY OR INSTITUTE TO STANDARDIZE AND DEVELOP CONSTRUCTION- SCOTLAND EXPERIENCE

Project for identification of min standards and improvement in construction of houses (Enkelt project, GSA Simple Living, Ballyconnelly Construction Company, Ltd), (Sharpe and Stewart, 2010).

X. COOPERATION OF UNIVERSITY WITH THE INSTITUTE TO PROMOTE SUSTAINABLE CONSTRUCTION MATERIALS

Sustainable construction materials, homemade components and products under development, natural insulator fiber (GCU and Craft Architecture Company, Glasgow) (Baker and Newlands, 2010).

XI. FEASIBILITY STUDY BY THE UNIVERSITY OF INSTITUTE IN DECISION DESIGNING FOR SUSTAINABLE CONSTRUCTION AND RENOVATION

Study of low carbon technologies in housing in Scotland (RGU and Anderson, Bell and Christie Architect, Glasgow) (Moore et al, 2010).

XII. JOINT GUIDANCE BY UNIVERSITY AND INSTITUTE TO REUSE WASTE MATERIALS FROM CONSTRUCTION/RECYCLE MANAGEMENT

National strategy for innovation in recycles management - Brazil experience

1) *Cooperation between universities with institute in study of “Sustainable order management” approach (Vanderley M. John, Vahan Agopyan, 2009)*

Topics are:

- Prevent illegal dumping
- Arrange construction and demolition waste materials
- Order management in demolition
- Order management and decrease waste materials in construction sites

- Order recycles class type
- Plaster waste management
- Waste materials disposal
- Tax from waste material disposal and production of natural materials
- Order relative standards
- Relative research requirement

2) *Approaches to Waste materials management to be used in construction projects/recycle management, Britain experience*

Approaches to Waste Materials Management in Construction Projects by Departments of Property and Construction University of Westminster and The Powerhouse, The Gunpowder Mill Powder mill Lane, Ltd, UK)Yang, Julie, David Mitchell, 2010) [14].

XIII. JOINT COOPERATION OF UNIVERSITY AND INSTITUTE TO STUDY CONSTRUCTION AND DEMOLITION WASTE MATERIALS/WASTE MANAGEMENT

A. *Replace system for waste materials management, construction and demolition*

Preliminary study for the management of construction and demolition waste by Unit of Environmental Science & Technology, School of Chemical Engineering, National Technical University of Athens, Greece [15].

B. *Collection and methods of waste materials management considering the quantity and composition (C&D), construction and demolition and their sources [15].*

XIV. CONCLUSION

Participation by university and industry through joint development projects in a broad range of innovations and creativity in designing sustainable building or in other word improvement of the project partners power, having significant role in design and execution of project and investments in practice, are necessary. To do this in Iran, as general policies in the field of housing have been compiled by Expediency Council and the government has taken steps in this regard, the executive body should be established by the government, university, small and medium size institutes and for the executive structure a model should be used from successful countries which have enjoyed cooperation between university and small and medium size institutes toward commercializing university ideas with the institutes in certain and specified framework including graphical model, customer satisfaction/dissatisfaction resulting in customer satisfaction and improvement of construction condition toward sustainable development. As well Osman conceptual model, of certain structure and necessary elements like leadership, doctrine, program, sources, internal structure and connection, should be used. Both models are used in Britain and brought good results. Our proposal for Iran is to execute a programmed project which finally include the following items: Higher education bodies and their connection with higher education institutes in order to support development of required skills for creation of sustainable construction, use new ideas in application of suitable materials, recycling such materials, energy transfer to

decrease fuel consumption, lower carbon rate in buildings and protect environment. In addition, more powerful links with local construction associations are planned to reach all participants in the range of supply and construction using foundations and principles of project management and construction.

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Corresponding Author:

*Behrouz Andalibizadeh,
Faculty of Civil Engineering
Universiti Teknologi Malaysia
Johor Bahru, Malaysia
bandalibizadeh@yahoo.com
A lecturer in SRTTU.Tehran Iran*