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Towards Urban City with Sustainable Buildings: A Model for Dhaka City, Bangladesh

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Abstract

Dhaka has experienced high economic growth escorted by rapid urbanization. Physical infrastructures of Dhaka city growing day by day with the swiftness of rapid urbanization. It revealed that most of the physical infrastructures i.e. buildings of Dhaka city did not follow the characteristics of sustainability resulting significant threats to well beings. In this perspective, ensuring sustainability in building is time worthy issue in Bangladesh. This paper tried to address the issues of sustainable building as well as propose a sustainable and smart design which will swathe criteria of environment, social and economic sustainability for Dhaka city. If the majority of the objects of proposed design are met, the building will be more probable to meet the changing requirements of the settlers, as well as make it a more sustainable, protected, secure, efficient and environmentally friendly place in which to stay.

Keywords: Dhaka city, Smart materials, Sustainable design, Sustainable buildings

INTRODUCTION

Dhaka is the nucleus city of Bangladesh and has come to be known as one of the mega cities of the world. The quick growth of population of Dhaka has been caused by high rate of in-migration, territorial expansion and natural growth. As it is capital city of Bangladesh, housing both residential and commercial purposes cannot keep pace with the population increase. It is an unpardonable fact that housing both residential and commercial areas have lost much of their sustainable building characteristics in order to cope with rapid urbanization.

The concept of sustainability in building and construction has evolved over many years. In fact, the United Nations Centre for Human Settlements acknowledged that housing is now universally recognized as a human right and that effort to implement this right must be strengthened and accelerated. Furthermore, the success and progress of human society depends on physical infrastructure, and a nation's economic strength is reflected in its infrastructure assets. With almost 60 percent of world population expected to be living in urban areas by the year 2030, massive construction activity is taking place globally. Sustainable construction is a way for the building industry to move towards achieving sustainable development, taking into account the environmental, socio-economic and cultural issues. Specifically, it involves issues such as design and management of buildings, materials and building performance, energy and resource consumption - within the larger orbit of urban development and management.

At the turn of the 19th to 20th century many Asian countries like Bangladesh have experienced high economic growth accompanied by rapid urbanization. Physical infrastructures of Dhaka city growing day by day with the pace of rapid urbanization. It revealed that most of the physical infrastructures of Dhaka city did not follow the characteristics of sustainability resulting significant intimidation well beings. Therefore, the study is an attempt to address the issues of sustainable building as well as propose a sustainable and smart design which will cover properties of sustainability (environment, social and economic characteristics).

THE CASE STUDY: DHAKA

Dhaka, the capital of Bangladesh, is located centrally and lies between East Longitudes 90°20′ and 90°30′ and between North Latitudes 23°40′ and 23°55′. The tropic of cancer is through the southern part of the city. A tremendous growth in urbanization took place and the population suddenly increased from 718,766 in 1971 to 2,068,353 in 1974. Within a decade one million new populations were added to the city within an area of about 510 sq. km. Dhaka was the only city on earth that experienced a population growth at an annual rate of 6.9% during the period 1974-2000. The rapid growth in population of the city was described as 'exceptional' by the United Nation. The city began to expand in all directions to meet the needs of the newly independent country's capital and the wetlands and low-lying areas within the city and the fringe areas started to disappear quickly.

The current population of Dhaka mega city is slightly over 15 million and still is growing due to rural urban migration at one of the highest annual rates (4.2%) in the world. Only 28% of the country's current population lives in urban areas; however, it has been projected that by 2050 this figure will increase to 58.75%. Dhaka will be inhabited by more than 20 million people in 2015 making it the second largest megacity on earth.

URBAN CONTEXT OF DHAKA CITY

Since the city expanded unexpectedly after the liberation war, the Government or development authority could not keep pace with the urbanization rate. To address the new pace of urbanization a new master plan was proposed in 1993. The goal of the plan was to provide a long-term strategy for the greater Dhaka development for a period of 20 years from 1995 to 2015. This plan is known as Dhaka Metropolitan Development Plan (DMDP) 1995-2015. The target population was 15 million; however, the city already has crossed the estimated projection of 15 million three years earlier. Inability of the development authority to meet the development demand has resulted in a numerous informal and spontaneous developments in Dhaka city. Evidently, Dhaka city represents a mixed character of formal and informal developments.

Formal developments are essentially undertaken by the formal public and private sectors and both sectors usually follow the same development formula or patterns. The most common type of development by the public sector is land development for housing or township projects along with infrastructural developments. The developed land is then divided into plots and is allocated to citizens to build their residential or commercial buildings. For land development, the private sector follows the same pattern of the public sector; however, in addition to land development, the private sector also develops individual apartment buildings in negotiation with the landowner. The most common form of negotiation is 60-40 or 50-50 share depending on the location of the land, where, developers build the apartments and give 40- 50% of the apartments to the landowner and sell the rest of the apartments to buyers. In addition to developing individual apartment buildings, some large-scale developers also build housing complexes with high-rise apartment buildings of 15-20 stories.

To cater the new population and to shift the pressure from central Dhaka city, numerous development projects & townships around Dhaka are being constructed both by public and private sector following the above-mentioned principles. Currently, the largest township of the country is being developed by the Government at the eastern side of Dhaka city with 25,000 residential plots and 62,000 apartments on 6150 acres of land with four more to come in the future.

On the other side, independent and individual landowners develop informal settlements. These developments are usually adjacent to the established formal developments with the common features include narrow streets with a serpentine character, irregular, inconsistent and asymmetric shapes and size of building plots. The main reason for such characters is that initially these were the fringe areas and lands were bought according to the affordability of a landowner when the area was under developed and cheap; however, eventually with the expansion of the city, these areas have become an integrated part of the city. Streets are narrow and serpentine in nature because landowners mutually left some of their lands to make an access form the main road network of the city to the plot. The landowner usually develops buildings in informal developments over a long period of time with the help of local contractors and in general without consulting a professional such as architect or builder. Usually these are the high-density areas.

BUILDING STRUCTURE AND SUSTAINABILITY IN DHAKA CITY

The buildings provided by the developers in Dhaka do not focus on sustainability. In fact, the government of Bangladesh has not adopted sustainable building and building energy codes in any form for building construction, despite the recognized fact that worldwide, 30%-40 % of all primary energy is used in buildings. By observing most of the buildings in Dhaka, it seemed that architects and developers are still not aware of the role they can play in designing smart and sustainable buildings. Architects are under constant pressure from the developers and clients to design multi-unit buildings with maximum space utilization and good project economy.

Designs of building, in general, are not responsive to the requirements of Dhaka's tropical climate. Buildings are designed without giving due importance to the parameters that are responsible for enabling thermal comfort without much dependence on energy use. Several studies have indicated that Dhaka city buildings have an unsustainable and inefficient energy consumption pattern. The main reason for this is the present planning and building laws mainly focuses on the density and development control related issues and not on the energy consequences of urban and building development practices. To date, Bangladesh is one of the very few countries that do not have any energy codes for the buildings even though the cities are highly dense. There are no regulations for the building envelope, materials or energy performance of a building. As a result, real estate developers are not obliged to follow sustainable design principles and to avoid additional costs which have

serious consequences on indoor thermal comfort and results in increased use of energy intensive active means such as air conditioners.
The present impede rules are related to a particular plot dimension without regard to any urban module or blocks thus resulting in an uneven building line, which often obstructs the natural airflow. In addition, the setbacks are narrow and do not allow ample daylight into the interior spaces of a building, therefore is resulting in the use of artificial lighting even in daytime. Significant variation in temperatures has been recorded in different parts of the city by several studies, which is suggestive of the growing problem of overheating due to Dhaka's inexorable urban growth.

CONCEPT OF SMART MATERIALS TOWARDS SUSTAINABLE BUILDING

There is broad unanimity that achieving sustainability is our prevalent human target, but there are numerous viable ways that must be integrated with each others to get there. The many distinctive areas to work with sustainability ambiguities are as well reflected in an increasing amount of research. Sustainability has been reflected with respect to how energy policies have an effect on the social, economical and environmental purposes of various countries, how business performances can be run lucratively with a pollution diminution focus, how product progression can combine aspects of sustainability, how refocusing to a product-application can enable the introduction of further sustainable ways, how consuming properly is alpha and omega for sustainability and how basically essential community work and education are to begin addressing the challenge. Smart materials, actually, a concept for newly developed materials and technologies working with transient behaviors and interactive response to their environment, are considered enabling materials and technologies for a wide variety of traditional and modern scientific disciplines. This has led to great expectations that Smart materials will be key materials and technologies for enhancing peoples' standard of lifestyle, in a short-term by considerably enhancing current procedures and products and in the long-term by supplying innovative and life-changing progresses across a various kinds of industries from smart colors, lightweight materials to renewable energy. The innovative characteristics that make Smart materials so fascinating have also raised many unanswered questions and concerns connected to the effects, negative and positive, smart materials may have on the society and the environment from the viewpoint of sustainability. The development of new technologies is customarily taught in universities outside the social and environmental system context. However, the connections between technology growth and sustainability are seen as indisputable and varied methods and schools of thinking have been developed to evaluate and manage these connections. Sustainable technologies are, in our opinion, described by huge advantages, low risks for the short- and long-term and social approval. It is essential to distinguish that technologies are not created in a vacuum, but appear from the interaction with a wide constellation of social activities and actors. Technologies are therefore, in fact, a product of social systems. This is also why technology growth has to be deeply embedded within united risk management approaches and life cycle thoughts. However, united risk management is a challenging task. The concept of risk comprises, besides the conventional criteria of possibility of incident and extent of damage, also the criteria of uncertainty, ubiquity, continuity, reversibility, delay impacts and potential of mobilization [4]. Therefore, with the aim of creating more firm decisions it is essential to work closely with stakeholders and other involved groups such as experts in industry or academia, technology measurement specialists, company managers, politicians and investors. They can contribute greatly in connection with their practical knowledge and notions of worthwhile solutions. Besides the approval of technologies by their respective communities, involvement of stakeholders and intensive discussions of advantages and risks also makes more advanced planning possible. The technology also needs to be evaluated by its full life cycle torrent of material and energy in the systems of production and consumption, thus preventing future environmental problem. This suggests a ''highly developed'' approach as they are ''protective and preventive'' strategies to protect life on earth. Through the deliberation of natural resources and human systems together, procedures to lessen the utilization of raw materials and energy, and to impede or diminish the production of waste, can increase efficiency and bring monetary profits to enterprises.

The innovative use of newly developed materials and technologies has historically been a driving force behind the development of new architectural ideas and forms. In our modern era, architects are fortunate to have access to a wide variety of materials that exhibit many interesting properties or characteristics that can be potentially utilized in the creation of new forms. These include "smart materials" that exhibit transient behaviors when their environments vary, or have properties that can otherwise be made responsive to changing needs. Photochromic materials, for example, change their color when exposed to varying light intensities, while a change in temperature causes a change in color in thermochromic materials. Many smart materials exhibit electroluminescent behaviors when the source of excitation is an applied voltage or electric field. Shape memory alloys exhibit a remarkable ability -- these materials can shaped into one configuration at a high temperature, deformed dramatically while at a lower temperature, and then revert back to their original configuration upon the

application of heat in any form, including an electrical current. Shape memory polymers exhibit similar capabilities. Other newly developed materials include a whole range of different types of materials whose transparencies can be varied to suit different architectural needs, e.g., suspended particle displays. These and other materials exhibit so-called "smart" behaviors.

These newly developed materials and technologies offer an architect exciting new possibilities for making new forms of buildings that are responsive to their surrounding environments and user needs. Many of these materials and technologies are already in widespread use in the product design sector, e.g., photochromics and thermochromics, and are rapidly finding their way into architecture. Others, however, remain in the early stage of development and their applicability to architectural needs is either unclear or problematic. Shape memory alloys, for example, are exciting but currently exist only in very small dimensions suitable more for products rather than buildings. With many smart materials, actual applications in an architectural setting remain largely unexplored. Perhaps this is one reason why the field is so exciting at the moment. This paper is an initial exploration of how smart materials might be used in architecture with sustainable approach, but by no means answers all questions. It seeks to bridge the gap between the world of sustainability and application of newly developed materials in architecture.

PROPOSE A DESIGN USING SMART MATERIALS CAN ENSURE SUSTAINABLE BUILDINGS IN DHAKA CITY

Smart and Sustainable buildings characterize good exercise in scheming, planning and building buildings to make them more publicly, environmentally and profitably sustainable. This chart is a summary of the tenets and goals that are itemized in— applying to this chart for the necessities to attain each criterion. If the majority of the objects below are met, the building will be more probable to meet the changing requirements of the settlers, as well as make it a more sustainable, protected, secure, efficient and environmentally friendly residence in which to stay. A minimum of 80% of the crucial criteria need to be met to attain the necessities of the Design Objectives. There is also scope to supply an alternative to the necessities outlined in the Design Objectives.

Table 1: Role of smart design to ensure sustainable building

		Environment				Social						Economic						
Criteria	**Objective**	**Energy**	**Water**	**Materials and Waste**	**Site Impact**	**Human Comfort**	**Human Health**	**Safety**	**Security**	**Universal Design**	**Sense of Community**	**Initial Costs**	**Maintenance Costs**	**Running Costs**	**Future Modifications**	**Community Costs**	**Achieved**	**Alternative**
Site and landscape	Relates to site selection, landscaping, plantingand pest protection																	
Objective 1	Site conditions are assessed for a passively designed home to be constructed	■					■							■				
Objective 2	The loss of biodiversity is minimized				■													
Objective 3	Soil degradation (need for fertilizers), sediment runoff and storm water runoff has been reduced				■	■										■		
Objective 4	Landscaping reduces need for water, chemical and energy inputs	■	■		■		■							■				
Objective 5	Creating a secure home and neighborhood								■		■					■		
Objective 6	Consider all natural hazards				▬			▬								▬		
Dwelling access	Access by owners, visitors, emergency services and prevention of uninvited access																	
Objective 1	Access to the main entry of the home from the street is easy for all occupants and visitors							■		■					■			

Objective 2	The risk of children being run over by vehicles is minimized							▮										
Objective 3	The home is secured from Illegal entry								▮					▮		▮		
General dwelling design	Relates to overall design, safety, access, storage, passive design etc.																	
Objective 1	People can quickly leave the home in the case of an emergency							▮										
Objective 2	The risk of a child falling from a window is minimized							▮										
Objective 3	Movement through the home is easy and safe for people of all ages and abilities							▮		▮								
Objective 4	The risk of injuries on stairs is reduced							▮		▮								
Objective 5	The dwelling facilitates indoor and outdoor living	▬					▬											
Objective 6	Balconies are designed to be safe for children							▮										
Objective 7	There is adequate storage space							▬		▬								
Objective 8	Reduce energy consumption for drying clothes	▮												▮				
Objective 9	People of all ages and abilities can easily and safely open and close doors, cupboards and drawers							▮		▮					▮			

Objective 10	Injury from sharp corners is minimized																	
Electrical, lighting and gas	Relates to energy consumption and safety in the dwelling																	
Objective 1	Electrical layout maximizes the safety of electrical appliance																	
Objective 2	Stoves and ovens are safe to use																	
Objective 3	Reduce the likelihood of electrical items coming into contact with water																	
Objective 4	Occupants can use light and power switches and telephone outlets easily																	
Bathroom / Toilet design	Relates to the safety and universal design in the bathroom																	
Objective 1	A bathroom can be used by a diverse range of people																	
Objective 2	A toilet can be used by people of all abilities																	
Objective 3	The growth of mould and bacteria is inhibited by good ventilation																	
Bedroom design	Universal design of at least one bedroom in the dwelling																	
Objective 1	A bedroom can be used by a diverse range of people																	
Objective 2	Good visibility to the outside from the bed																	

Outdoor living area design	Relates to making the outdoor living area safe especially for children																
Objective 1	Sun protection is provided for outdoor areas																
Objective 2	Outdoor areas are safe for children's play activities																
Garage and shed design	Relates to access and safety of the garage																
Objective 1	The garage can be used by a diverse range of people																
Objective 2	Exposure to car fumes is minimized																
Objective 3	Minimize the risk of injuries with outdoor tools and outdoor chemicals																

CONCLUSION

The buildings in Dhaka do not focus on sustainability. In fact, the government of Bangladesh has not adopted sustainable building and building energy codes in any form for building construction, despite the recognized fact that worldwide, 30%-40 % of all primary energy is used in buildings. By observing most of the buildings in Dhaka, it seemed that architects and developers are still not aware of the role they can play in designing smart and sustainable buildings. Architects are under constant pressure from the developers and clients to design multi-unit buildings with maximum space utilization and good project economy. In these viewpoints, ensuring sustainability during scheming, planning and building buildings is time demanding issue for Bangladesh. Government and private sectors should come ahead to ensure this and must develop policies for smart materials either by regulatory based or by industrial self-regulatory that includes industrial commitment to research the potential impacts of their technology.

REFERENCES

Adamson, Bo (2010) Passive climatization of residential buildings in tropical climates-A parametric study with respect to Ho Chi Monh City climate. Lund Centre for Habitat Studies, Lund University, Lund, Sweden. ISSN 1101-797X.

Ahmed, A. L., (2004). Weber's perspective on the city and culture, contemporary urbanization and Bangladesh. United Nations, World Urbanization Prospects: The 2003 Revision, NY, UN.

Ahmed, N. & Khan, N. (2004). Evolution of House form in Dhaka City, Global Built Environmental Review (GBER) Vol. 3 (3): 38-48.

Ahsan, T. (2009) Passive Design Features for Energy-Efficient Residential Buildings in Tropical Climates: the context of Dhaka, Bangladesh. MSc thesis (unpublished). KTH.

Ali, Z.F. (2007). Comfort with Courtyards in Dhaka Apartments. BRAC University Journal, IV (2):1- 6.

Amin SMN, Dewan AM, Kabir MH (2008) Urban development and environmental degradation: the case of Dhaka metropolitan, Bangladesh. In: Annual Meeting of the Association of American Geographers, Boston, MA, USA, 15–19 April 2008

Åstrand, Johnny (ed.) (1996) Construction in Developing Countries-A Guide for the Planningand Implementation for Building Projects. The Swedish Mission Council, SIDA, Stockholm, Sweden. ISBN 91-85424-44-7.

BBS. (2008). Statistical Pocket Book of Bangladesh 2007.Bangladesh Bureau of Statistics Planning Divison: Ministry of Planning.

Chowdhury AM, Faruqui S (1989) Physical growth of Dhaka City. In: Ahmed SU (ed) Dhaka: past, present and future. The Asiatic Society of Bangladesh, Dhaka, pp 43–61

Chowdhury A. M. and Faruqui S., (1990), Physical Growth of Dhaka City, in: Ahmed S. U., ed., Dhaka Past, Present and Future, The Asiatic Society of Bangladesh, Dhaka.

Clarke ,J.A. & Maver, T.W. (1991). Advanced Design Tools for Energy Conscious Building Design: Development and Dissemination. Building and Environment, 26(1): 25-34.

Dhaka City Corporation (2004) Profile of Dhaka City (Brochure). Urban Planning Department, Dhaka City Corporation, Dhaka, Bangladesh.

Garde, F., Adelard,L., Boyer, H. & Rat, C. (2004).Implementations and Experimental Survey of Passive Design Specifications Used in New Low-Cost Housing Under Tropical Climates. Energy and Buildings, 36 (4): 353–366.

Islam, N. & Shafi, S.A. (2008). A proposal for a Housing Development Programme in Dhaka City. Dhaka: Centre for Urban Studies.

Lam, J.C., Tsang, C.L., Li,D.H.W. & Cheung, S.O. (2005). Residential Building Envelope Heat Gain and Cooling Energy Requirements. Energy, 30 (7): 933–951.

Liping, W. & Hien,W.N. (2007). The Impacts of Ventilation Strategies and Facade on Indoor Thermal Environment for Naturally Ventilated Residential Buildings in Singapore. Building and Environment, 42 (12): 4006-4015.

Reza, S.I. (2008). Housing Crisis. The Financial Express, Dhaka. [Online]. Available: http://www.thefinancialexpress-bd.info/search_index.php?page=detail_news&news_id=41131. [accessed 20 December, 2008].

Seraj T. M., (2001), Real estate, housing and construction industry in Bangladesh in 2001 and beyond: scope and prospects, in: Ahmed, S. U., ed., Dhaka Past, Present, Future, Dhaka, The Asiatic Society of Bangladesh.

UNEP. (2006). Eco-housing Guidelines for Tropical Regions. Bangkok: United Nations Environment Programme Regional Resource Centre for Asia and the Pacific.