INTEGRATION OF PERFORMANCE BASED MODELING TECHNIQUES WITH BUILDING DESIGN METHOD (INDUSTRY/FACTORY) CONSIDERING ENERGY EFFICIENCY IN BANGLADESH

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ABSTRACT: Climate changing has been a debated issue during the last few years. Some institutes in different countries have worked on this subject. Several future climate predictions have been generated. Each future climate is based on some assumptions and consequently has some uncertainties. These uncertainties are dragged to the building simulation results by using the climate data for assessing the future performance of buildings. Bangladesh is newly a developing country. Many more construction is going on in full swing now days. This rapid construction is changing our earth surface very quickly. So that it increases heat on earth surface, energy consumption, decrease the comfort level. The answer to this challenging situation is the adoption of a holistic design approach, whereby the different disciplines required is brought together and interacts since the first steps of the design process. This study revealed the present implementation status of factory building sector energy standards in Bangladesh, implications for sustainable energy efficient designs in factory building and increasing demand for sustainable energy efficient industrial building.

Keywords: *Sustainable Energy Efficient Design, Energy Consumption, Holistic Design Approach*

1. INTRODUCTION

Factories in Bangladesh have been heavily criticized over the last 30 years for the working conditions in which employees must labor. High internal gains from artificial lighting, poor natural lighting system and equipment produce an intolerably hot work environment and high energy consumption. Bangladesh is one of the largest products exporters in the world. This factory building has been expanding rapidly since the late 1970s. Many purpose built factories have their own compliance to maintain the quality. Among the environmental compliances recommended illumination condition, thermal comfort and reduce energy consumption are important factors that must be ensured. This paper consists of three parts such as;

(i) The status of energy standards for factory buildings in Bangladesh; (ii) Approaches to standards development in view of energy efficiency; (iii) Implementation and energy simulation. Energy saving did not happen in industrial sector in our country. Extra energy consumption (28.18 MTOE) in industry sector came from structural change (S-effect) and intensity change (I-effect) with the amount of 16.39 and 11.79 MTOE, respectively. In Fig. 1, it can be seen that the energy demand is changing rapidly in our industrial sector. From 1970 to 2020 the energy demand of the industrial sector in Bangladesh increased almost 10 times. So what can we do as professional bodies? There may have much kind of solutions. Building performance modeling while planning or designing a building may be one of the solutions to get rid of this kind of problem.

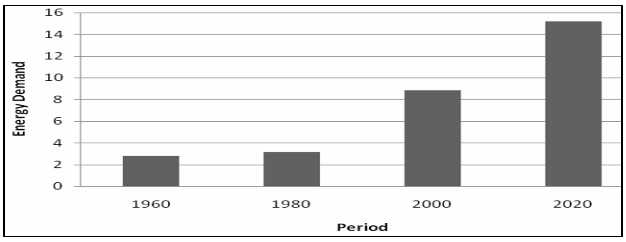

Fig. 1: Energy consumption in the industrial sectors of Bangladesh (Power development authority, Bangladesh, 2009)

In Fig. 2 it is seen that the ratio of energy demand increases day by day. And in 2010 it has reached in highest value. In the long run, more energy is needed from the limited resources. Therefore, our nation will face a tremendous energy problem in near future.

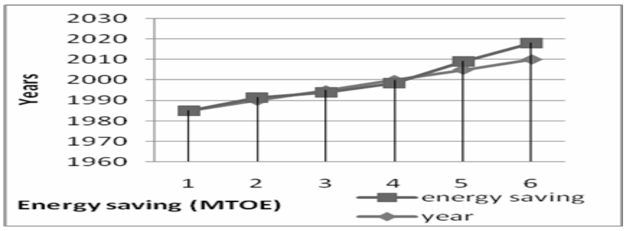

Fig. 2: Energy demand of industrial sectors in Bangladesh (Power development authority, Bangladesh, 2009)

The overall building behavior will be influenced by numerous climate parameters, including sun, wind, water, and geotechnical factors. Sun influences shading, orientation, and views of the building. Wind introduces concepts of protection, shelter, and energy capture. Energy Conservation factory buildings are very effective for restraint of global warming, because they can reduce CO2 emissions in building operation, which account for 70% of life cycle emissions.

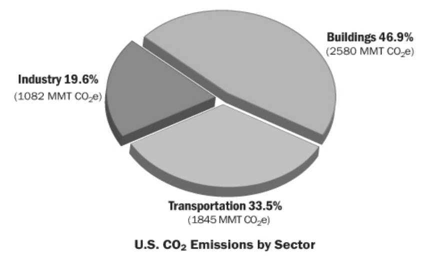

Fig. 3: US co2 emission by sector

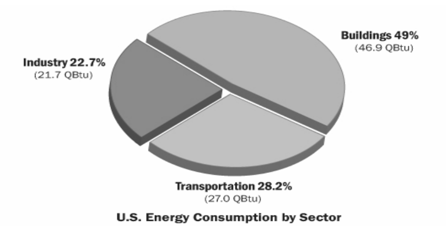

Fig. 4: US energy consumption by sector

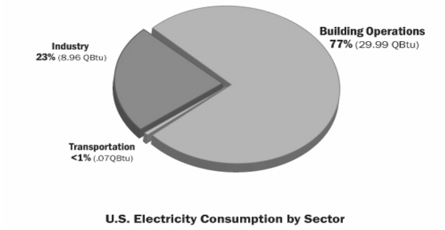

Fig. 5: US electricity consumption by sector (US energy international administration, 2010)

From Fig. 3 – 5 it is seen that energy consumption in industrial sector in US is 22.7%, the electricity consumption rate is about 23% and co2 emission is almost 19.6%. Now a day this is a big issue for the nation of the world. An essential condition for industrial development is uninterrupted supply of energy. Although the installed capacity for generation of electricity in Bangladesh is 2908 megawatt and energy consumption is about 25% in the industrial sector. It is seen from Fig. 6 that industrial sector takes the second position of energy consumption. The average level of system loss is still as high as 33.3%. The demand for power will increase by 300 MW annually and an investment of about 110 billion BDT up to the turn of the century will be needed to meet it.

This paper investigates the implementation status of factory building energy standards in developing countries and its implications for sustainable energy efficient designs in building. Important elements of the research that are described in the paper are:

- identifying the role that a factory building simulation can play at the different stages of design;
- developing a model description that evolves through the design process as the factory building design becomes more highly specified;
- simplifying the user interface at the early stage of the design where rapid feedback is required and where most impact can be made on the factory building's energy and environmental performance;
- customizing results presentation to be appropriate for the particular stage of design; and

• implementing these simulation concepts, observing their acceptability, and addressing quality assurance and training issues.

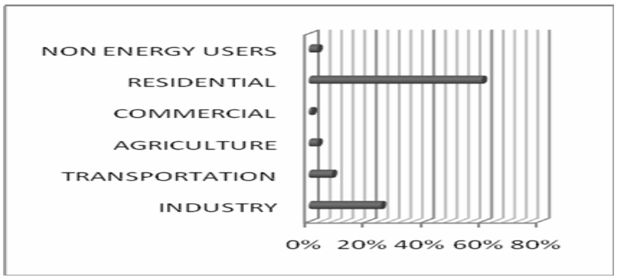

Fig. 6: Bangladesh electricity consumption by sector (Power development authority, Bangladesh, 2009)

2. IMPORTANCE OF ENERGY SIMULATION IN ARCHITECTURAL DESIGN

In early design stages, either in new or retrofit designs, one can estimate the energy consumption of the building being designed by using hand calculations. However, an energy simulation program can help the designer to get more reliable predictions because it is able to simulate the building with the weather conditions that obviously influence the thermal behavior of the building, and the operating schedules of the building. Carlo et.al. (2003) established energy efficiency parameters of a building code of a city in Brazil by using computer simulation.

Energy simulation can also help the designer to validate the preliminary estimation of the building's energy consumption, to correct some of the architectural features of the building and the mechanical systems and to improve the energy performance of the building. The form and thermal characteristics of the building largely run the amount of energy consumed by the building. Therefore, the building designers who are responsible to design the building have the primary control over the building's energy use.

When an architect starts to design a building, she or he simultaneously starts the design of the heating, cooling, and lighting of the building. To avoid major flaws of the design, an architect needs to include the evaluation of the building's energy consumption in the earlier stages of the design process. If energy efficiency is not adequately considered during these stages, higher operating cost will accrue over the life of the building.

3. IMPACT ON ENVIRONMENT

Building performance modeling will create new knowledge and assist in capacity building by improving our understanding about energy efficiency on climatic adaptation and mitigation. This will create more awareness to take more effective actions for mitigating climate change to make sustainable development feasible for green industry development in Bangladesh. It also generates innovative knowledge. This knowledge will impact on national programs and strategies for climate change adaptation and mitigation.

4. GAPS FINDING IN DESIGN PROCESS (FACTORY BUILDING)

A worker’s ability to do his/her job is affected by working in hot environments. One of the most important conditions for productive work is to maintain a comfortable temperature inside the workplace. Of course the temperature inside the factory varies according to the season. Natural cross ventilation is another important factor for a factory building. Instead of natural cross ventilation extra cooling and heating loads are needed for a factory building. Most of the factory building in our country has no or less option of natural ventilation system and use of daylight and water efficiency techniques and also no option about indoor air quality and energy efficiency building envelop. Noise is also another problem that comes from a number of different sources such as the sewing machines, weaving looms, compressors, radios, background noise, etc. This noise in the form of sound waves transmits directly through the air and reflects off walls and ceilings and passes through the factory floor. This can be easily removed by the way of simulation process. In our country there are no considerations about local climate, building shape and orientation in building design. Also there is no consideration about passive design process. Therefore, gaps are always found in building design.

Fig. 7 presents the basic three gaps of factory building design. Most of the factory building owner wants just make a floor for production. They don't think about the other factors that are very important for the factory building. Health hazardous condition of the factory building is a common scenario in our country like Bangladesh.

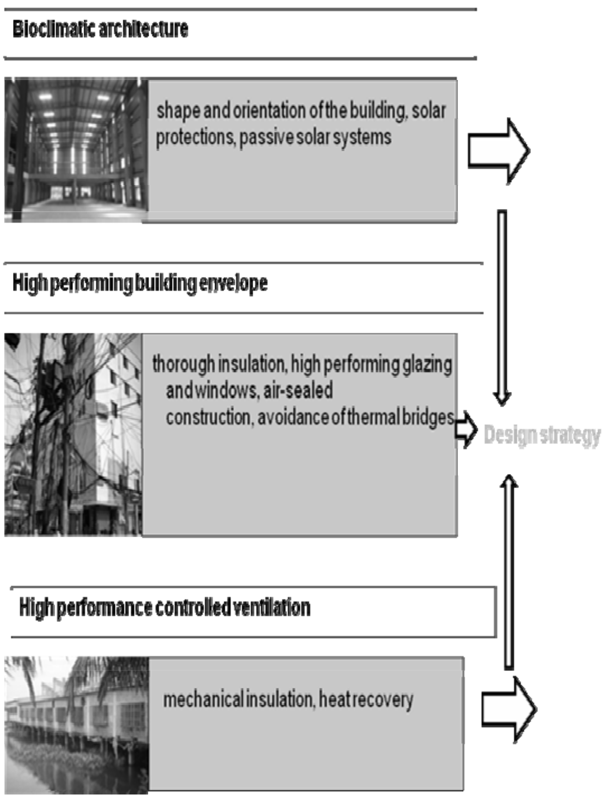

Fig. 7: The condition of present factory building in Bangladesh and gaping element

5. SIMULATION IN THE DESIGN PROCESS

Degelman and Soebarto (1996) established a holistic design approach with simulation, an analysis bed for architecture practice. The Royal Institute of British Architects (RIBA, 1995) identified three main building design stages in design plan of work. These are; (i) Outline Design Stage; (ii) Scheme Design Stage and (iii) Detailed Design Stage. However, different design objectives and scopes can be observed in the design stages of different factory building.

In outline design stage, a concept based on feasibility studies is prepared. It shows the design, analysis and options being considered. It includes diagrammatic analysis of the requirements on the site, solutions of functional and circulation problems, relationships of spaces, massing, construction and environmental methods and also a cost appraisal to enable an approximation of construction cost.

This design stage is extremely time constrained. Elevation treatment, materials selection, construction and environmental analysis then are taken place in out line design stage. In environmental analysis, simulation will focus on problem areas or on typical factory building sections.

In scheme design stage design solution is worked through in detail. Detailed design and drawing are produced for coordinating structure, services and specialist installation. Details of internal spaces such as fitting, equipments and finishes may be included.

At this design stage the application of simulation relates mainly to engineering issues. They will use simulation for purposes such as designing a natural ventilation strategy (sizing of openings, establishing control strategies, confirming minimum and maximum air flow) or to model other building services applications such as chilled construction systems or air conditioning systems.

Basic structure of whole design evaluation process is shown in Fig. 8. In this figure it is seen how simulation is used in design.

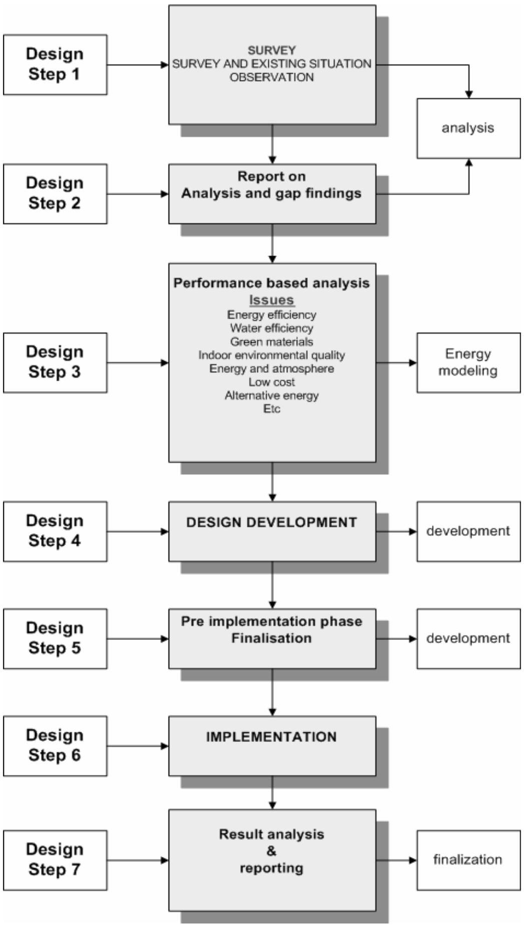

Fig. 8: Basic structure of the design evaluation process (Chowdhury, 2010)

6. PARAMETERS EVALUATED BUILDING PERFORMANCE TOOLS

Designers are always interested about the indication of the energy consumption of a building. Energy simulation in design process tries to fill this designer's desire.

Simulation parameters deal to the factory building envelope (glazing properties, ventilation rates) as well as whole building per year energy cost. They also point out problem areas, identify parameters that cause the problem and assess the scale of the problem. Various types of simulation engine (tools) are used for these purposes. Use of same simulation tool throughout the design process has additional advantages. It is possible to pass a model directly from one design stage to the next. It is easier to include environmental issues in a holistic approach. Ecotect, Energy Plus, Dia lux, E-Spr, Radiance, Design Builder, etc., like energy simulation engines are frequently used in simulation process. The parameters considered during design stage are given in Table 1. From this table it is seen that various variables depend on the three design stages. It comes one after another. To make a factory green it is needed to analyze every components of energy simulation.

Table. 1: Chart various design stage, (Morbitzer et.al., 2001 and Morbitzer, 2003)

Design stage	Parametric consideration
Out line design stage	Orientation, U-values, Heat recovery systems, Air change rate
Scheme design stage	Detailed analysis, Material adjustment in overheating areas, Lighting strategy
Detailed design stage	Different heating systems Different cooling systems: Mechanical, ventilation

7. MODELING PROCEDURE

A number of key developments are part of the user Outline Design Stage (ODS) Interface. The program interface is structured to permit a step-by-step, rapid input procedure for the base case model and design options. 3D CAD software is used to define the model geometry. Detailed support databases are provided that distinguish building types, room function and zone location with the emphasis on rapid user selection**.** Computer generated model of a factory building is shown in Fig. 9.

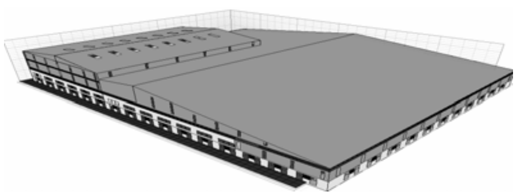

Fig. 9: A physical factory building (Ecotect, 2009)

8. RESULTS ANALYSIS

Presentation of performance data is another vital element of building simulation interface design. This should help the designer to judge the environmental performance of the design and point out potential problems in the building. This includes the following key components: i) Ranking of the results against benchmarks; ii) Identifying areas in the building that cause poor performance; iii) Identification of the reasons for unsatisfactory performance.

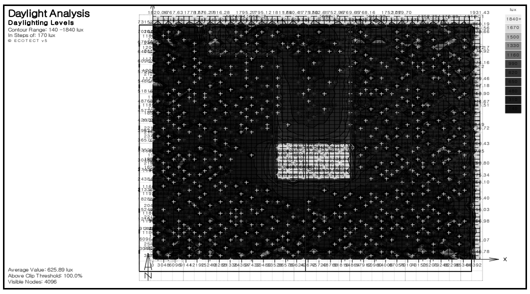

Fig. 10; Daylight analysis by Ecotect simulation tool

After performing the simulation, hourly result data is read into the database structure. Using these data software itself determines annual energy figures and compares them with benchmarks. It has also capability to view the energy flows in the building with respect to time of day, external temperature, occupancy, only certain zone(s), etc. An example of contour plot of day light obtain from this simulation is shown Fig. 10. Red marks indicate high intensity of daylight.

9. CONCLUSION

Building simulation is currently not an integrated element of the design process. Integrating modeling would raise awareness of energy and environmental issues and give it an adequate status in design decision making. In developing countries this type of integration is going on in full swing in present day for their betterment of environmental aspect and to make the zero carbon community. Therefore, it should be given more emphasis on this issue. We have to always think about "plus o_2 community" development instead of "zero carbon community" for our upcoming generation so that they can live in green space with the help of this kind of prediction techniques.

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