A STUDY ON TIME, COST AND ENVIRONMENTAL IMPACT ANALYSIS FOR SUSTAINABLE DESIGN ON CONSTRUCTION OPERATION-REVIEW

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ABSTRACT-Environmentally conscious construction has become a subject of research during the last decades. Even though construction literature involves plenty of studies that emphasize the importance of environmental impact during the construction phase, most of the previous studies failed to combine environmental analysis with other project performance criteria in construction. To achieve environmentally conscious construction and successfully manage a complex construction environment, multiple project objectives and their relationships need to be considered. A framework on the basis of the concept of control accounts to determine optimal construction operations when project time, cost, and environment impact (TCEI) are considered as project objectives during project planning. The framework also supports decision-making by using sensitivity analysis. Life cycle assessment is applied to the evaluation of environmental impact in terms of global warming potential (GWP).

Traditionally, the main objectives of construction projects have been to build in the least amount of time with the lowest cost possible, thus the inherent and well-established relationship between cost and time has been the focus of many studies. In general, the trade-off relationship between time and cost is well understood and there is ample research on the subject. However, despite sustainable building designs, relationship between time and environmental impact, as well as cost and environmental impact, have not been fully investigated. There is a causal link between construction processes and environmental impact through resource consumption (e.g., labor, materials, equipment, energy, and water). The connection between construction process models and environmental impact will provide a mechanism to observe the effect of changes in construction operations on environmental impact.

Moreover, the time and CO2 emissions relationship presented trade-off behavior at the pre-use phase. The results of the relationship between cost and CO2 emissions were interestingly proportional at the pre-use phase. The same pattern continually presented after the construction to the usage phase. Understanding the relationships between those objectives is a key in successfully planning and designing environmentally sustainable construction projects.

KEYWORDS- **Environmental impact, Life cycle Assessment, CO2, trade - off behavior, Sustainable development**

INTRODUCTION

LUMINANCE

This study investigated the indoor luminance distribution caused by day lighting in a large space industrial building by both experimental measurements and numerical simulations. The mea-sacrament results showed that the average day lighting luminance during the four measurement periods, 9:00–10:30, 11:00–12:30,13:00–14:30, 15:00–16:30, were 373 lux, 397 lux, 360 lux, 254 lux, respectively. More than 33.3% of the factory area could meet the standard requirements for work spaces on the sunny day. [1]The simulated distributions of day lighting luminance agreed well with the measured data. The experimental method presented in this study was proved and could be used for the measurement of day light in gilluminance distribution in large space buildings. [26]The quantitative electricity saving potential of day lighting and the effect of reducing artificial lighting on the heating energy con-gumption were simulated using Energy Plus. It showed that the heating energy consumption increased with the reduction of artificial lighting. The electricity saving potential of the On/Off control and the dimming control integrated with day lighting were 36.1%and 41.5% for the present day lighting design, while the increase of the heating energy consumption due to the On/Off control and the dimming control were 7.1% and 8.7%, respectively. Either way, the heating energy consumption increases were much lower than the electricity saving of reducing artificial lighting. As a whole, the dimming control integrated with day lighting has a greater energy saving potential than the On/Off control for the industrial building. The results of the simulations done in this study show that taking solar energy into account when designing new urban district can provide a significant contribution to the local production of renewable energy. Also, solar zoning [22] can contribute to solar access for solar energy in denser cities. Certain designs of building blocks performed better than others in the simulations, especially when the blocks were surrounded by a dense built environment. When the plot ratio / FSI was 1, almost all design options were able to meet the energy need with energy produced by solar energy. When the FSI was increased, building blocks were not able to meet all the energy need with locally produced energy. In one case, the solar potential decreased by 75% when it was placed in dense built environment, which meant that the electricity coverage of this design was very low. [3]Urban planning is a process in which many factors play a role. Solar energy is just one of these components which urban planners have to take

into account. Urban planners should be informed about the consequences of building blocks' layout on the solar potential. In an ideal situation, one actor in the design process should perform the simulations and calculations regarding the solar potential as described in this article. This actor could be an external consultant, an urban planner or an architect. [20]The further in the design process, the more detailed the solar potential analysis can be done. Important issues in these analysis are: the production of the active solar systems (kWh), the production over the year, the ratio between PV and ST, architectural integration issues (colour, texture, dimensions) etc. It is also important that real estate developers are well-informed about the latest technology and prices, since they are a very important factor in the decision process. In the two cities of Lund and Malmoe, the urban planning department has set up meetings with real estate developers to talk about sustainability issues, of which solar energy is an important contributor. In general, the production of electricity did not meet the electricity need. In this study, only the electricity need was taken into account, not the heat / DHW need. If those two components will be taken into account, the question whether to produce heat or electricity on which places in the building will become very actual. Furthermore, the fact that the annual solar energy production is not able to meet the energy need of buildings in cities leads to the issue if it is right to force future all buildings to generate all their energy locally within cities. Another conflict of using the whole roof is the competition with the green roofs.

BUILDING INFORMATION MODEL (BIM)

A study of the application of BIM for the case-study building, which was a sample of single, residential, house, was conducted. [23]The results of the study will be useful to architects and building designers as they use the BIM concept to develop more energy-efficient buildings in the future with the goal of achieving sustainable development for society. [6]Government should provide incentives for designers and engineers to use the BIM tool, specifically in the pre-construction stage, to investigate problems that are likely to occur in the future so they can deal with such problems in the preliminary stage. [24]Education and training also are significant factors that should be taken into account by government for improving BIM in each society. Building simulation and investigating the performance of the building virtually in the pre-construction and/or even during the construction stage will help decision makers, designers, engineers, and architects to select specifications with the least detrimental impact to the environment. In the building construction sector, BIM can be beneficial to building designers in determining the best building orientations and designs. In the design and pre-construction stages, the Building Information Model (BIM) should be taken into account as a comprehensive simulation method that can be used to create opportunities to assess and improve the performances of buildings.

[17]This integration of the BIM concept into the design stage can and be used to select the best green building designs and reduce the need for later design modifications that require extra time and cost. [7]Efforts to prevent adverse environmental impacts and to minimize energy costs are beginning to show beneficial effects in terms of more efficient and sustainable building designs, improved building performance, and minimization of environmental risks. In addition to BIM technology as an effective solution, the use of various architectural solutions can be helpful in reducing energy consumption. So, BIM planners and architects should cooperate in the preconstruction stage to achieve the best sustainable solutions.

VIRTUAL ENVIRONMENT

This exploratory study indicates that BIM can facilitate the very complex processes of sustainable design such as day lighting and solar access, as well as automate the drudgery of activities like material takeoffs, cost estimation and construction schedules while capturing and coordinating information into a single integrated model. Based on the evaluation of three building performance analysis software, it was found that Integrated Environmental Solutions' Virtual Environment™ software appears to be both the most versatile and powerful in terms of analysis capabilities. Ecotect™, although stronger than Green Building Studio™ in numerous categories, including *Thermal, Solar,* and *Lighting and Daylighting,* is apparently the least versatile of the three. This is due to its lack of *Value and Cost* and *LEED®* capabilities, both heavily weighted items in our analysis. Green Building Studios™, by Autodesk, received the lowest overall score. However, it appears to be more versatile program than Ecotect™, lacking only in *Acoustic* capabilities. [10]The results produced from the three software (namely Ecotect™, IES-VE™ and GBS™) have not been directly validated against DOE Energy Plus™ software. However, one of these software, GBS™, is based on the DOE-2 engine. [12]The comprehensive GBS™ error check report helped reduce the number of errors while creating a useable gbXML file. Therefore, the authors are confident that the results are 'in the ballpark'. Meanwhile, though Ecotect™ and IES-VE™ are not based on the DOE-2 engine, they provide inputs that allow users to define materials, room types, system types, etc. for more detailed study within the programs. This study was limited in scope and involved professionals from one company only; hence it may have overlooked several factors. The study is expected to be completed in summer 2009 and authors plan to publish complete findings in the ASC journal.

LCA

From this case study, it can be concluded that BIM and Ecotect can be very helpful in performing LCA, since they can provide majority of the necessary information and calculation tools for performing LCA, which may alleviate the difficulty that, when executing building LCA, there is not enough available information. [13]This difficulty has deferred the extensive utilization of LCA technique in the building/construction sector. Life cycle energy consumption comparison showed the operation stage is the biggest contributor to energy consumption. More than 90% of the total energy was used during operation. [16]The embodied energy in raw materials and manufacturing stage only accounted for 7.8% of the total energy. The construction stage consumed less percentage (<1%) of the total energy. Steel products owned the most energy, more than 60% of the total embodied energy for all materials, due to large amount of steel used in this building. It showed the same order of three stages for the CO2 emission. For raw building materials and manufacturing stage, the order of materials utilized in this building in term of CO2 emission was

similar to the order in terms of embodied energy. The only difference lied in the order of ready-mixed concrete and doors. [14]Different effects were produced as designs changed. Some actions, like replacing curtain wall by brick walls for top three floors and changing indoor temperature, were more effective in reducing energy consumption and CO2 emission than others. [15]From the process of sensitivity analysis, based on the linear relationship assumptions, the annually consumed operation energy is more sensitive to the curtain wall area change and indoor temperature change among the chosen factors except the change of building orientation. However, these two changes produced contrary effects on annual energy consumption for using the building. Although it is difficult to quantify the sensitivity degree between annual operation energy consumption reduction and building orientation change, it really showed that the orientation of the building could affect the annual operation energy consumption. Different rotation directions may lead to different environmental effects.

REFERENCES

[1] D.H.W. Li, J.C. Lam, S.L. Wong, Daylighting and its implications to overall ther-mal transfer value (OTTV) determinations, Energy 27 (11) (2002) 991–1008.

[2] United States Department of Energy, Buildings Energy Data Book, 1998.

[3] J.C. Lam, D.H.W. Li, S.O. Cheung, An analysis of electricity end-use in air-conditioned office buildings in Hong Kong, Building and Environment 38 (2003)493–498.

[4] DOE (The United States Department of Energy) (2010a). Weather Data [WWW document].URL http://apps1.eere.energy.gov/buildings/energyplus/cfm/weather_data.cfm [Accessed: March, 2010].

[5] DOE (The United States Department of Energy) (2009). 2009 Buildings Energy Data Book [WWW document].

[6] Crawley D., Hand J., Kummert M., Griffith B. (2008). Contrasting the capabilities of building energy performance simulation programs. Building and Environment, 43(4), 661-673.

[7] Cole R. J. & Kernan P. C. (1996). Life-cycle energy use in office buildings. Building and Environment, 31 (4), 307-317.

[8] Catalonia Institute of Construction Technology (CICT) (2009). BEDEC PR/PCT ITEC materials database [WWW document]. URL http://www.itec.es/nouBedec.e/presentaciobedec.aspx

[9] BuildCarbonNeutral (2010). Construction Carbon Calculator ["Citing sources on the internet"]. URL http://buildcarbonneutral.org/. [Accessed: March, 2010].

[10] Bilec M., Ries R., Matthews S. (2010). Life-Cycle Assessment modeling of construction processes for buildings. J.Infrastructure Sys., 16 (3), 199–205.

[11] Kriegel, E., and Nies, B. (2008). Green BIM. Indianapolis: Wiley Publishing, IN. Schueter, A., and Thessling, F. (2008). "Building Information Model Based Energy/Exergy Performance Assessment in Early Design Stages". Automation In Construction (unpublished paper, available online)

[12] CIFE. (2004). A Survey on the Needs for Sustainable Design, Available online at www.stanford.edu/cife.

[13] Azhar, S., Hein, M., and Sketo, B. (2008). "Building Information Modeling (BIM): Benefits, Risks and Challenges". Proceedings of the 44th ASC Annual Conference (on CD ROM), Auburn, Alabama, April 2-5, 2008.

[14] Azhar, S.; Nadeem, A.; Mok, J.Y.N.; and Leung, B.H.Y. (2008). "Building Information Modeling (BIM): A New Paradigm for Visual Interactive Modeling and Simulation for Construction Projects." Proceedings of the First International Conference on Construction in Developing Countries (ICCIDC-I), August 4-5, Karachi, Pakistan.

[15] Autodesk, Inc. (2008). Improving Building Industry Results through Integrated Project Delivery and Building Information Modeling. White Paper, Available online at www.autodesk.com.

[16] Autodesk, Inc. (2005). Building Information Modeling for Sustainable Design. Autodesk, Inc. White Paper, Available online at www.autodesk.com.

[17] Jelle Bjorn Petter, Gustavsen Arild. The high performance thermal building insulation materials and solutions of tomorrow.Buildings 2010, <http://web.ornl

[18] U.S. Energy Information Administration, Emissions of Greenhouse Gases in the United States. <http://www.eia.gov/environment/reports.cfm?t=176>.

[19] Operational Energy Use-wiki common language. http://www.sccommonlanguage.eu/index.php?title=Operational_Energy_Use>.

[20] Zabalza Bribia´n I, Aranda Uso´ n A, Scarpellini S. Life cycle assessment in buildings: state-of-the-art and simplified LCA methodology as a complement for building certification. Build Environ 2009;12:2510–20.

[21] Junnila S, Horvath A. Life-cycle environmental effects of an officebuilding. J Infrastruct Syst 2003:157–66, 9_4.

[22] Energy Conservation, http://powermin.nic.in/upload/pdf/ecact2001.pdf,(Accessed on 3rd January 2014) (2001).[5] M.W. Ellis, E.H. Mathews, Needs and trends in building and HVAC systemdesign tools, Build. Environ. 37 (2002) 461–470

[23] S. Kumar, R. Kapoor, R. Rawal, S. Seth, A. Walia, Developing an energyconservation building code implementation strategy in India, in: ACEEESummer study on Energy Efficiency in Buildings Pacific Grove, CaliforniaAugust, 2010.

[24] S.N. Srinivas, Energy-efficiency improvements in commercial buildings inIndia, International Conference

on Energy Efficiency in Buildings (ICEEB2015), December, 2015, New Delhi.
[25] L. Doulos, A. Tsangrassoulis, F. Topalis, Quantifying energy savings in daylightresponsive systems: the role of dimming electronic ballasts, Energy and Build-ings 40 (2008) 36–50.
[26] H. Wan, Y. Li, W. Yang, Analysis on the state, composition, and characteris-tics of industrial building energy consumption in Dongguan, Building EnergyEfficiency 33 (1) (2007) 230–231.
[27] Climate work Foundation, http://www.climateworks.org/insights/.