Bim based life cycle assessment tool

Life Cycle Assessment (LCA) is used to evaluate a particular product, process, or activity from cradle to grave the environmental effects. LCA is methodology for measuring and evaluating some aspects of all relevant costs, revenues, environmental impacts and performance associated in all stages of an asset over its life cycle (ISO15686, 2008), it compiles and evaluates an inventory of relevant input, output, and potential environmental impacts in relation to the objective of study throughout its life cycle (ISO14040, 2006). LCA provides a complete picture of the interactions of activities with the environment and it is one of the decision supporting tools providing information on environmental effects of these activities and identifies opportunities for environmental improvement for stakeholders to make decision.

The concept of LCA started from late 1960s, the earliest forerunners were the Resource and Environmental Profile Analyses (REPAs) and a research founded by Coca Cola funds study of different beverage containers and packaging system. LCA been extended used during global oil crises from 1973 emerged many countries began to explore substitute resources to produce energy. Energy analysis by comparing different substitute sources through life-cycle basis gave a true indication. The interest of LCA continued used for decision making policy through the 1980s. The REPA early studies emphasized on raw material, energy inputs and waste generation through environmental impact as LCA methodology and modern LCA methodology outlined the components of contemporary LCA from four distinct analytical steps: goal definition, inventory assessment, impact assessment, and improvement analysis in the late 1990's released ISO standards 14040 –

14043 by the International Organisation for Standardisation (ISO). The latest series includes ISO 14040: 2006 life cycle assessment principles and framework, ISO 14041: 1998 standards for goal and scope definition and inventory analysis, ISO14042: 2000 life cycle impact assessment and ISO 14043: 2000 life cycle interpretation. There still much development tacking place till today.

The stages of the LCA methodology based on international standards of series ISO 14040 consists of defining the goal and scope, creating the inventory, assessing the impact and finally interpreting.

Today, the usage of LCA is extended to the construction industry; works have been undertaken on both large and small aspects from internal to external. Internally, LCA can be used in process analysis, product evaluation, material selection (cement or bricks) and product comparison (heating systems). From externally use, LCA can be used for marketing, information and education, eco-labelling.

LCA is a comprehensive method to evaluate environment impact through whole life approach, LCA has 40-years history and still not been used widely due to there are limitations in using this tool. Firstly, expected life-time is various. Data collection and data reliability is always the question and difficulties to LCA tool. Further, uncertainty is everywhere and comparisons between studies are difficult. In all LCA is a decision supporting tool, no single methods can be used individually in providing a clear solution or decision.

There are various LCA tools have been developed based on qualitative and quantitative methods that can assess building environmental impacts from embodied energy, operational energy, CO2 emission and other emissions from buildings. These tools have been classified and categorized into five major categories: Detailed LCA Modelling Tool; LCA design Tool; LCA CAD tool; Green Product Guides and Checklist and Building Assessment Schemes.

Detailed LCA Modelling Tools:

This category of LCA tools to calculate embodied energy and environmental impacts based on materials used, building components and processes of the work. The most famous used software under this category includes SimaPro, TEAM, Gabi, KCL-ECO, Boustead, GaBi, PEMS, Athena, BEES, LISA, ECO-QUANTUM, EQUER, Green Building Advisor USA, SIA D0123, Energy Life Cycle Assessment Model for Building Design (SBI) [14].

SimaPro is one of the most widely used professional LCA software under detailed LCA modelling tool category and worked based on calculating of material used by consultants, research institutes and universities. It contains several impact assessment methods can direct calculate for each element in a project; inventory databases can be edited and expanded easily; open and transparent database (Pre4 database, FRANKLIN US LCI database, IDEMAT database, BIWAL250 database, FEFCO database) which helps in fast data entry and database consistency checks.

BEES (Building for Economic and Environmental Sustainability) USA be developed and to implement the most appropriate balance between environmental sustainability and economic performance. It can be used throughout all construction stages from preliminary design stages, construction or building product manufacture, maintenance of building and to building services. The data used in this software including inventory flow items of energy used and materials. It a typical detailed LCA modelling tool worked on building components.

LCA Design Tools:

LCA Design Tool is the yardstick for designers to measure environment performance of the building during design stage. By using this kind of LCA tools, designers can easily evaluated environment impact. Environmental information can be optimized measured.

Envest is one of the widely used software under category of LCA Design tools developed by Building Research Establishment (BRE) in the U. K. Designers input the basic design information such as building element choices, building height, number of storeys, window areas and building Gross Floor Area. Calculation of building associated impacts and different options' comparisons then performance. This software measures each environmental issue separately in their own units. Environmental issues data is more easily to use and gather on UK basis. Envest use weighting system based on BRE's Ecopoint score.

LCA CAD Tools:

Similar to LCA Design Tools, some of LCA tools integrated with CAD planning tool or CAD assessment tool. Tools under this category are able to read building component information from CAD. Some tools can work with 3-D CAD to work get the material information and building components from CAD directly in order to work out environmental impact analysis. Well known software under this category include EcoScan, ECOit, LCAiTLCAid, ECOTECT, ENER-RATEE, Energy 10, EQUER, PAPOOSE, Legoe, Ecopro, OGIP, EPCMB [15].

LCAidTM is a decision-making tool developed by Australia and aimed to help building designer, LCA practitioner, LCA researcher or building rating practitioner for evaluating the different options of building or building components' environmental performance and impact. It makes evaluation work easier and faster with working on 3D CAD system by importing materials' quantities and assigning materials to each building elements. It is based on Green Building Challenge's rating guide to weighing the elements. Life Cycle Inventories of building materials data are stored at LCAid library.

Green Product Guides and Checklists:

It is the most common use methods to assess environment impact currently. They are combine of ' global analysis' and ' problem analysis' take into consideration. Tools under this category provide qualitative guides of environmental issues to help stakeholders in decision making with consideration of environment performance at design stage when selecting alternative materials, or building components. Many countries or regions they have their own standards or guides to follow. Some guilds are famous and used worldwide like LEED from US and BREEAM from UK, International standards ISO 14040 to ISO 14043, and other famous guides include Environmental Preference Method (EPM), BEPAC, GREEN housing A-Z, ECDG, EcoSpecifier. [15].

Building Assessment Schemes:

Basically, tools under this category are used to predict or assess building performance during its operational stage. They normally can be used before or after building occupancy. Examples include GBTool, BEAVER/ESOII, BUNYIP, DOE2. 2, GSL-Giselle, Okoprofile, NatHERS, SEDA, ECOPROFILE, E2000 and BEE 1. 0. [15].

Building information (bim)

Changes in Information & Communication Technologies lead to a change in the way information represented and in particular, information is being fed more easily and distributed more quickly to different stakeholders by the use of tool such as the Building Information Modelling (BIM) [15]. BIM is a digital building model which generating, managing and sharing information during its entire life cycle. [17] The development of BIM results in fundamentally changes of building design. With design information input of product materials, specification, finishes, costs, ‘ carbon content’ and any other special requirement transfers into virtual building model. Different stakeholders have better collaboration by using BIM. Figure 3 shows the usage of BIM and its functions.

BIM has fundamentally changed how buildings are designed. There is now plenty of hard evidence that the wealth of information from virtual building models has completely transformed how the designers make their design decisions lead to a far better sustainable design buildings indeed.

Typically collaboration between design disciplines is a low level information exchange, via a simple electronic or published format, however it is a existing commonly form of information collaboration in construction sector, in which there is none of added-value to the design process. The maintained situation is due to today's software tools, in particular to the BIM, have merely facilitated meaningful information collaboration across the sustainable discipline.

Proportionally through adding time factor into BIM, BIM becomes a 4D modelling tool. The usage of BIM can then be expanded to planning, supply chain management, life cycle costing and assessment. The integration of LCA disciplines into BIM enables to assess both economic efficiency and sustainability of buildings. Its availability lies in a central building component repository. Further, BIM can be seen as a 5D modelling tool with element/material cost information, together with time information stored in BIM, it can work out the project estimating cost and its cash flow along the project life cycle. Comprising assessment to the environmental information into the BIM, BIM can further become a 6D modelling tool that can calculate the environmental impacts from buildings. Eventually, it can become even nD model with other special information added in [18].

Performance-based design supported by product models is becoming stage-of-the-art practice [19]. Therefore, one of the key advantages of using BIM as an analysis tool allows multi-disciplines to simulate building performance in a virtual environment. The number of performance criteria can be analyzed that are depended on several aspects includes architectural, structural, mechanical, energy. Therefore, BIM tool is a feasible approach for multidisciplinary team members to access and collaborate effectively

Current existing BIM tools like Autodesk Revit, Tekla Structures, Digital Project, Bentley Syetems, ArchiCAD, AutoCAD- based Application, DProfiler and so on. Through the applications of construction practices, they have been found on their own strengths and weakness, especially in terms of technique, operational ease and the facilitation of sustainable information across. The analysis to the usedBIM tools being used shown below:

Introduction

Strengths

Weakness

Revit

Introduce by Autodesk in 2002

Leader for the use in BIM

gbXML interface for energy simulation and load analysis

Direct interface to ROBOT and RISA structural analysis

Conceptual design tool

2D section of detailing

View interface: DGN, DWG, DWF, DXF, IFC, SAT, SKP, AVI, ODBC, gbXML, BMP, JPG, TGA, TIF

Functionality is well-design and user-friendly

Broad set of object libraries

Direct link interface

Bi-directional drawing

Slow down on project larger than 200MB

Limitation on parametric rules with angles

Bentley Systems

Introduce in 2004 by Bentley Architecture

Integrated with others Bentley software

Broad range of building tools

Supports modeling with complex curved surfaces

Multiple support for custom parametric objects

Provide scalable support for large projects

Large and non-integrated user interface

Hard to learn and navigate

Less extensive object libraries

ArchiCAD

Produce by Graphisoft in early 80’s

Serve MAC platform in addition to Windows

Support range of direct interface

Contains extensive object libraries

Suite interfaces for energy and sustainability

OBDC interface

Intuitive interface and relatively simple to use

Large object libraries

Rich suite in supporting applications in construction facility management

Only strong BIM product for MAC

Limitation to parametric modeling

Encounter scaling problem with large project

Partition large project to manage them

Digital Project

Develop by Gehry Technologies

Require a powerful workstation to run well

Able to handle even the largest projects

Model any type of surfaces

Support elaborate custom parametric objects

Complete parametric modeling capabilities for controlling surfaces and assemblies

Relies on 3D parametric modeling for most detailing

Steep learning curve

Complex user interface

High initial cost

Limited object libraries (including external)

Architectural drawing are not well developed

Output section to drafting systems for completion

AutoCAD- based Application

Architectural Desktop (ADT)

Autodesk original 3D building modeling tool prior to Revit

Provide a transition for 2D to BIM

Relies on AutoCAD well-known capabilities for drawing production

Interface: DGN, DWG, DWF, DXF, and IFC

Easy to adopt for AutoCAD user

Drafting functionality and interface

Not parametric modeling

Limited interface to other applications

Scaling problem

Tekla Structure

Offered by Tekla Corp.

Multiple divisions: building and construction, infrastructure and energy

Support fabrication-level detailing of precast concrete structure and facades

Structural analysis

Interface: IFC, DWG, CIS/2 DTSV, SNDF, DGN, and DXF

Export CNC

Model structures that incorporate all kinds of structural materials

Support very large model

Concurrent operations on some projects

Multiple simultaneous users

Support complex parametric custom component libraries

Too complex to learn and fully utilize

Parametric component require sophisticated operators with high skill

Not able to import complex multi-curved surfaces

Relatively expensive

Dprofiler

Product of Beck Technologies in Dallas, Texas

Provide feedback for construction cost and time

User gain a set of drawing with financial and schedule reporting

Can input own cost data or data from RS Means

Support Sketchup and DWG

Interface with Excel and DWG

Market as a closed system for feasibility studies before actual design begins

Ability to generate quick economic assessments

Not a general purpose of BIM tool

Purpose is economic evaluation of construction project

Interface to support development in BIM

Design tools is limited to 2D DWG files

As presented above within the existing BIM tools, they provide less supports in sustainable information discipline across the models throughout the whole construction stages.

Life cycle assessment in relation to carbon and energy emission

Bim-based lca tool

There is a high level of demand for sustainable construction due to the rising awareness of climate change and the most important building's sustainable features are decided at design stage. Designers need to analyses sustainable features including building type, building forms, major materials used, context, MEP system. As mentioned in the previous section, BIM allows for multi-disciplinary information to be combined within one container and it creates a platform for multi-disciplinary to conduct sustainability analyses at construction initial stage.

Adopting LCA concept integrate into BIM technology take consideration of low impact building design decision in time, embodied carbon, waste and cost (as shown in Figure 2).

The principle of BIM-based holistic modelling in the building lifecycle, LCA can be available in the form of static visualization analysis at design stage whilst its dynamic simulation can be achievable through all stages of construction till demolition. During design phase, associated sustainability issues like energy consumption, carbon emission, waste generation, involved in building design and materials can be accurately quantified on the basis of a unique visualized static 3D information building model. From the phases of construction, to operation and demolition phases, LCA are a dynamic process where building sustainability are being embedded in those phases. For instance, carbon emission and waste production are likely to occur in the boundaries of manufacturing for building construction, maintaining for building operating and routine repairing, as well as recycling and disposing of building components and materials. These dynamic features are suggested to using a simulation approach for analyzing, while popular 4D/5D CAD techniques provide a viable approach to this dynamic simulation.

The BIM-based LCA tool is therefore being considered as an enabler for multidisciplinary collaboration across specialty boundaries throughout the building lifecycle. The viability of model-based collaborative work has been verified by an interactive approach targeting on 4D CAD [21]. Planners with different specialties can collaboratively perform planning and 4D simulation underpinned by the 3D model. Similarly, taking the advantage of integrating LCA into BIM can realize optimal design decisions from a holistic perspective in multidisciplinary coalition. Sustainability issues and related costs in HVAC, structure, for instance, in a building can then be examined using the same BIM environment. In this kind of design decision process, the central information repository provided by the BIM model can create a collaboration context for potential stakeholders. Different specialties’ information in the repository can be accessed not only by information owners but other collaborators. Therefore, sustainable design decisions on LCA can be made on the basis of informed rather than isolated approaches. The convenience of central information repository from the BIM model also brings the flexibility in applications. Given an online BIM model, distributed LCA application can be available through network support for geographically dispersed stakeholders.

Conclusions

This document provides authors with basic guidance on how to prepare the full papers. It is highly advised to use the Paper Template or strictly follow the instructions provided. A paper that does not meet the requirements will be returned to the author(s) for revision.