Teaching Sustainability Concepts for Cities through a BIM model

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Resumen: Within the scope of the Erasmus+ project "Essence" a new approach for teaching the relevance of materials into sustainable cities was developed. It is difficult for students to assess the impact of materials selection into sustainability and during the project BIM models for a city area were developed and parameterized for assessing the impact of materials onto relevant sustainability indexes under given selected conditions..

Palabras clave: BIM, building materials, Sustainability.

1. Introduction

The use of materials in architecture is lacking a systematic approach allowing the adequate comparison of performance from well established criteria and international standards. Sustainability of materials in architecture requires a thorough analysis on the concepts of the ecology of contemporary construction, and the relevance for the final user. This effort involves standards and databases for defining attributes for our existing buildings. After considering all relevant information a Life Cycle Analysis (LCA) approach is introduced for the correct evaluation of materials in the sustainable building. This paper provides a systematic approach to this evaluation. The impact of hybrid materials is also explored as an alternative strategy for the architectural use of materials today. At the final stage the relevance of materials is performed through commercial software solutions and incorporated to the design.

The students identify building types according to city standards and create an associated building materials bill for assessing the neighbourhood situation regarding energy efficiency for façades. Later they develop an strategy regarding the façade (and roof) materials) for optimizing the overall LCA performance of the neighbourhood. Relevant conclusions are identified for the design and use of new materials in architectural design.

The implementation of a joint analysis using a BIM model of a real neighbourhood poses a very relevant learning environment for assessing all materials relevant concepts on the built environment sustainability

2. Built Environmental sustainability

Environmental life cycle assessment (LCA) has evolved over the last three decades from merely energy analysis to a comprehensive environmental burden analysis in the 1970s, full-fledged life cycle impact assessment and life cycle costing models were introduced in the 1980s and 1990s, and social-LCA and particularly consequential LCA gained ground in the first decade of the 21st century. Many of the more recent developments were initiated to broaden traditional environmental LCA to a more comprehensive Life Cycle Sustainability Analysis (LCSA).

It is possible to distinguish two main periods in the past of the LCA: the first period is from 1970 to 1990: Decades of conception. And the second period is from 1990 to 2000: Decade of Standardization.

The first studies to look at life cycle aspects of products and materials date from the late sixties and early seventies, and focused on issues such as energy efficiency, the consumption of raw materials and, to some extent, waste disposal. Because of this, there was little distinction, at the time, between inventory development and the interpretation of total associat-ed impacts. The period 1970-1990 comprised the decades of conception of LCA with widely diverging approaches, terminologies, and results.

In the second period standards began to settle. The 1990s saw a remarkable growth of scientific and coordination activities worldwide, which is reflected in the number of workshops and other forums that have been organized in this decade and in the number LCA guides and handbooks produced. Also the first scientific journal papers started to appear in the Journal of Cleaner Production, in Resources, Conservation and Recycling, in the International Journal of LCA, in Environmental Science & Technology, in the Journal of Industrial Ecology, and in other journals.

Through its North American and European branches, the Society of Environmental Toxicology and Chemistry (SETAC) has set a framework, terminology and methodology for LCA. Next to SETAC, the International Organization for Standardization (ISO) has been involved in LCA since 1994. Whereas SETAC working groups focused at development and harmonization of methods, ISO adopted the formal task of standardization of methods, and procedures. There are currently two international standards in place:

- ISO 14040 (2006): Environmental management; Life cycle assessment; Principles and framework.
- ISO 14011 (2006): Environmental management; Life cycle assessment; Requirements and guidelines.

The next period (1990-2000) can be summarized by the word "convergence" through SETAC.s coordination and ISO.s standardization activities, providing standardized framework and terminology, and platform for debate and harmonization of LCA methods. Note, however, that ISO never aimed to standardize LCA methods in detail: "there is no single method for conducting LCA" [1].

The rapid surge of interest in "cradle to grave" (or cradle to cradle, C2C) assessment of materials and products through the late 1980s and early 1990s meant that by the 1992 UN Earth Summit there was a ground-swell of opinion that life-cycle assessment methodologies were among the most promising new tools for a wide range of environmental management tasks. The most comprehensive international survey of LCA activity to date., The LCA Sourcebook, was published in 1993.

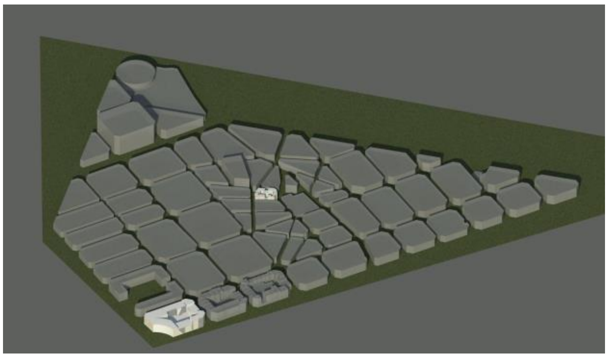
Although the pace of development is slowing, the methodology is beginning to consolidate, moving the field toward a long-awaited maturity. Yet the usefulness of the technique to practitioners is still very much in debate [2].

2. Teaching implementation

A simplified BIM model of a neighbourhood using blocks as envelopes for buildings, was used for providing an in depth analysis of the main sustainability parameters for a city from LEED, ISO 14040, and ISO 37120. The blocks are parameterized and checked with different materials combination for assessing sustainability performance.

The students developed different building typologies and studied refurbishment alternatives from the sustainability point of view. The different strategies were then tested and optimized using the BIM model of the Ruzafa neighbourhood in Valencia. Different building solutions and materials were used on the parameterized buildings. The influence of materials selection on different sustainability measurements was used as optimization criteria. The results were analyzed and relevant conclusions reached.

The results obtained are shown on the following figures.



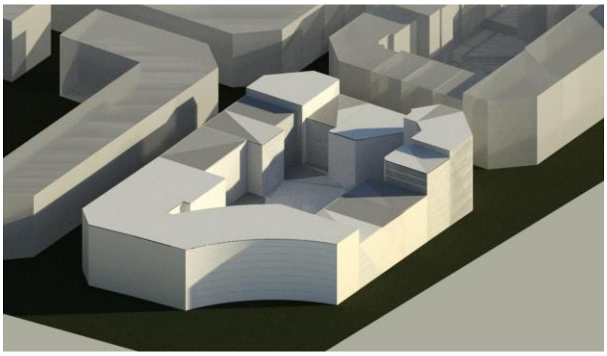


Fig.1 Ruzafa neighbourhood model.

The main impacts indicators on this LCA procedure are the energy consumption (energy breakdown in terms of direct and indirect contributors, MJ per functional unit), the global warming potential (in terms of CO_2 equiv. per functional unit) and the end of life possibilities (in terms of effective practicable scenarios, i.e. of recycling).

The choice to adopt the first two impact indicators (energy consumption and global warming potential) is due to the above mentioned need of simplification, maintaining, at the same time, a global vision of the whole environmental load.

Among the typical LCA impact indicators energy consumption and global warming potential probably have the ability to cover each life cycle phase of the considered system and they are understood by most of the public. The environmental stressors are considered as a limiting restriction

The end of life is then taken into consideration to specify the practicable scenarios referred to a component or material after the use phase. At this level, it could be useful to conduct a qualitative analysis about the possibility of disassembling the components of the product in order to identify the amount of material really reusable or recyclable.

By comparing the figures obtained through a balance on these parameters for the building life phases detailed before, a numerical criteria is formed for the sustainability of the building as a whole.

The structured procedure used is as follows:

- Prepare a draft project.
- Analyze properties of the candidate materials per building subsystem criteria.
- Prepare assemblies by detailed calculations from hybrid materials composition.
- Select optimum options and quantify them.
- Develop alternative optimum design options.
- Introduce the data into Excel spreadsheets and compare the sustainability evolution.
- Fine-tune the sensitivity of the solution to use and recycling criteria.

And the results are presented in a chart format as shown on figure 2.

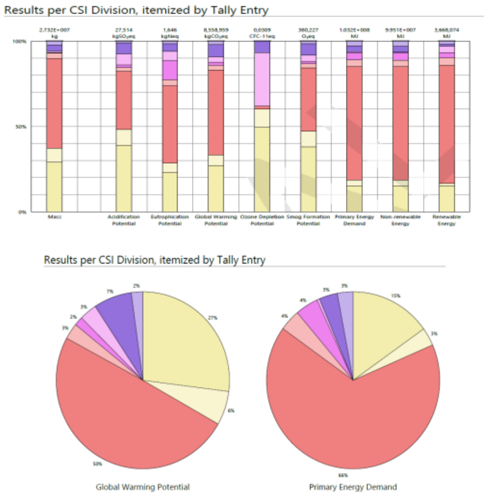


Fig.2 Charts for Ruzafa

3. Conclusions

The use of models for identifying the relevance of materials in real contexts provide not only a useful tool for decision makers, but in a controlled and simplified environment, a powerful instrument for enthusing students through evidence of the relevance of materials in their core disciplines.

The project identified further areas for improvement:

- Include a wider approach by alliance with budgeting soft (Presto).
- Create standards for environmental info on materials.
- Fine tune architectural design procedures concurrently with materials.
- Evaluation of recycling practices/standards.
- Evaluation of energy policies impact.
- Assessment of future neighbourhood plans.

And the most relevant result is developing a new strategy for "learning by doing" which resulted in excellent personal development for the students (see final group picture below).

Essence

Fig.3 Pilot "Essence" group.

4. Acknowledgements

This work was supported by Erasmus+ KA2 strategic partnerships initiative (Grant number 2014-1-NL01-KA203-001292).

5. References

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