A MULTILEVEL METHOD TO OPTIMIZE THE SUSTAINABLE CONSTRUCTION WORKS

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Abstract

The new European standard family of CEN TC 350, still in progress, is supposed to be as guidelines of the performance oriented building assessment.

The perspective suggested by the standard family is multidisciplinary. The future developments are expected to go more and more into the direction of the integration of the three major components in the life cycle: environmental, social, economic.

This is a sufficient ground to start managing any case of construction works as an interdisciplinary project, thinking and planning any action as the integration of a certain number of actions, with a multiscale and multilevel approach.

The paper reports on the research focused on the development of inductive, logical / operational guidelines, aimed at optimizing the sustainable management of construction works.

The identification of a multiscale and multilevel strategy aiming at supporting the decision-making process, applied to the "Leonardo da Vinci Sustainable Campus" project in Milan, with respect to the energy, environmental, social and economic performances, is focused on key objectives / criteria / indicators.

The holistic approach and the involvement of the stakeholders in the method, supported by multiple criteria decision making (MCDM) models and methods, aims at giving transparent and shared answer to the search of the best technical solutions and strategies in a large sustainable perspective.

Key words: Sustainable construction works, Multilevel, CEN TC 350, Stakeholders, Holistic

1. Introduction

After years of development and application of methods for *assessing* the sustainability of buildings in various parts of the world, and the related "labeling" of the buildings, the European Union has felt the need to adopt an "umbrella" policy, developing and sharing common framework methodologies and indicators between the Member States. The Standards are supposed to be voluntary and are still under construction, also considered the huge need of time required by a similar route, including the exchange of proposals and approvals of complex documents at both central and peripheral / national working groups and levels of the European Union.

In the meantime all the Standards are going to be adopted, it is necessary that a *virtuous process of implementation and monitoring* applied to real cases starts, so to *test the effectiveness* of the available *standards*, and identifying the gaps in the perspective of the future revisions of the first standards to be published.The research presented is still in progress, aiming to provide a contribution in this direction.

1. The context: the European framework

1.1 The current status

With no doubts one of the major merits of the environmental labels and rating systems for the assessment of sustainability in construction works is the start of a widespread process of awareness about the importance of the resource use and related limits.

On the other hand, it is widely recognized by the international community not only the researchers but also the operators of the construction supply chain that the worldwide proliferation in recent years has also produced several problems, first of all a sense of disorientation by the stakeholders (designers, contractors, public authorities).

The diffused application of the different *rating systems* has also showed, in addition to the difficult manageability of an even large number of indicators, the limits of such assessment methodologies with respect to aspects and impacts not expressly quantifiable.

1.2 The current and future developments

For the above reasons, the European scientific community, under the pressure of the European Commission, is involved in several research programs supporting the harmonization process of the existing standards, in particular attemping to:

- The definition of a *single tool* to assess the sustainability (and improve performance) for all stages of the process, including CED (Cumulative Energy Demand), LCA (Life Cycle Assessment) of products and processes with reliability of performance and assumed actual measured values TQA (Total Quality Assessment), LCC (Life Cycle Cost) for the evaluation of economic indicators such as economic risk investments, profitability, etc..

– The *simplification*, drastic reduction in the number and in the application of indicators
– The transition from a *first generation of indicators* (only environmental pressure-state-impact) to a *second* one (environmental, economic, social), easier to use.

The method adopted by CEN for managing the sustainability of buildings is essentially based on the following categories subject to analysis and evaluation:

– *Aspects*
– *Impacts*
– *Performance*
– *Indicators*.

Each category is declined in each *stage* of the building *life cycle*.
Referring to categories Aspect / Impact / Performance defined in the EN Standards, can be identified:
Aspect: aspect of the construction of an assembly (of the building), processes or services related to their life cycle that can cause changes in environmental, social / quality of life, economy;
Impact: any change to the environment, society / quality of life, economy (the users of the building, or the owner, operator and occupants, and neighbors), positive or negative, in whole or in part resulting from environmental / social / economic;
Performance: relative performance impacts and environmental aspects / social / economic.
The suggested methodology of performance evaluation will take into account aspects and impacts performance that can be expressed in *quantitative and qualitative indicators*, measured without value judgments.

2. The research and the method

2.1 Case study

The title of the on going research is "Sustainable management of construction works from the building to the context". The purpose is the development of inductive, logical / operational guidelines, aimed at *optimizing the sustainable management* of construction works. The research would give a contribution to the methods / guidelines for the management of sustainability in constructions, aiming to *support a decision-making process* (by public and private managers, planners, developers, policy makers) with the *involvement of the stakeholders*. "Città Studi Campus Sostenibile" (http://www.campus-sostenibile.polimi.it) is an international *multi / inter - disciplinary* project, member of the ISCN network and inserted in the European Peripheria framework, promoted by the Politecnico di Milano and the University of Milan to transform the university district into a model part of the city in terms of quality of life and environmental sustainability.

The main goal is the identification of a *multiscale* operative strategy applied to the different phases of the construction process, aimed at improving energy, environmental and social performances, with respect to the building, the urban and the neighborhood context, helped by the setting of *key indicators* (environmental, economic, social) and the involvement of a wide range of representative stakeholders, both social groups and supply chain operators, asking their points of view and data.

2.2 Strategy

A method of managing sustainability and especially the introduction of its principles in construction and urban environment needs to be designed and developed as a *complex systems management method*, ie using logic and graphic techniques and tools that bring together different and interacting categories (variables), taking care to search for *cause-effect linkages*, convergences, divergences, and any reseanable relationship between one and the others.

Even the methods that CEN TC / 350 is developing to manage the environmental / social / economic interactions between the *internal and external variables* playing in the construction process along the whole life cycle are based on this principle. The research projects and applications to case studies that are taking place in the margins to support the work of the european (central and national) groups involved in the development of the new assessment system also have this common conceptual basis.

As previously mentioned, the entire system of procedures for the management of sustainability within CEN / TC 350 current process is necessarily based on an *integrated perspective* of the aspects involved in the construction process along the *life cycle*.

The common introduction to the european standards reports: "In the future, the assessment methodologies within this standard framework may be part of an overall assessment of *integrated building performance*. The assessment methodologies may also be extended to an assessment of the neighbourhoods and wider built environment".

And yet, in the definitions, sustainability assessment of buildings is described as a "*combination of the assessments of environmental performance, social performance and economic performance* taking into account the technical requirements and functional requirements of a building or an assembled system (part of works), expressed at the building level".

In other words, since the first draft writing, was already covered that future reviews will be set in a perspective, but also practically organized, based, not just on the analysis and assessment of the variables taking place, but on the integration of three (environmental / social / economic) components. And it means that *as much as we are able to manage integration as an aspect of complexity, the more we will be successful to achieve the sustainability goals*.

2.3 Reference models

The International Council on *Systems Engineering* (INCOSE) defines systems engineering as "an *interdisciplinary approach* and *method to enable the realization of successful systems*. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with the design of architecture and system validation, always taking into account the totality of the problem. The discipline of Systems Engineering integrates all the disciplines and specialties of various working groups forming a *structured development process that proceeds from concept to realization and commissioning of the system*. Systems Engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets *the needs of users*".

Another factor is related to the ability to identify and manage the *network of relationships, dependencies and dynamics between different components of a complex system*. The goal is to "guide them" into an overall behavior resulting from the *harmonization* of those parts, it would not be possible to obtain simply by putting them together. The skill lies in being able to predict the interactions between the different elements that contribute to the overall behavior and control them.

To avoid overlooking relevant aspects of the problem, or to minimize this risk, the system administrator typically adopts a "*top-down*" and proceed in a structured manner, often repeatedly *through the different levels and different dimensions in which the problem can be decomposed*.

2.4 Application to the case study

The conceptual model elaborated in the research is *multidimensional*, because, as anticipated, there are many variables involved. The solutions will be given by the intersection between the different set of variables involved in the case study project.

In synthesis, the *method and supporting models* are featured as:

- *Multi-dimensional*
- *Multi-criteria*
- *Multi-layer*.

The principle followed is that of simplifying the complex model, reducing it to a simple partial models and therefore manageable, then recomposing the results in order to find the output corresponding to the given input, as reported in the below logic chain:

Complex Input - *Simple Issues* - *Recomposition* - *Interpretation / Correction* - *Output*

In order to better manage the *multi-criteria* analysis, in line with modern theories and techniques of statistics, economics, and engineering involved in decision-making, the under development method is based mainly on the use of *matrices*, crossing one by one criteria and alternatives or set of variables to each other, and *multi-layer* tools, linking more than one set of variables to each other simultaneously.

The aim is to obtain, crossing logically variables between them, much information as possible about the different *combinations*, to discover the *effects of possible actions* with a view of *integration* and *synergy*.

The target of the analytical work in support of the decision maker is to identify a panel of indicators suitable for subsequent stages of decision-making processes, to submit to the stakeholder groups.

The following set of variables (and related *key factors*) have been identified as characterizing the different attributes of the case study:

– *Multi-role (A)*	Responsibility
– *Multiactivity (multi-function) (B)*	Functional requirements
– *Multi-scale (C)*	Spatial interconnections
– *Multi-sector (D)*	Integration with the city
– *Multi-objective (E)*	Decisional roles
– *Multi-stage (F)*	Life Cycle
– *Multi-stakeholder / multi-interest (G)*	Corporate Responsibility
– *Multi-impact (H)*	Cause-effect relationships
– *Multi-performance (I)*	Efficiency
– *Multi-indicator (L)*	Evaluation.

For each one of the above sets are identified a certain number the actual *variables* and the profile as involved in the project.
By way of example, following are presented the profiles of the Multi-impact (H) and the Multi-performance (I) sets of variables.

- *Multi-impact (H) profile*:

Each action by the D.M. (Decion Maker) determines such impacts. With a view to sustainable development, the impacts are broadly grouped into three categories:

– environmental
– social
– economic.

Actually, any action, such as deciding whether to use a particular component / product / material in a building or to build using a given structural material (eg wood, or reinforced concrete) causes an impact or generates a number of impacts that may also not be inscribed in one of three main categories. For example, a certain material, permanently inlaid in a room, eg. a classroom, produces a measurable impact on the environment in CO2 equiv., but it is also due to effects on the health of the occupants. Therefore, it impacts on the environment and society. And if the same material is put in place in an office room, it generates a third impact: economic, since the effect on the health of the employee is reflected in his work productivity.
Taking as reference the relevant indicators, as identified by CEN / TC 350 and in related European projects (SuPerBuildings, Open-House), the impacts can be substantially the following way.
Direct:
- environment (land use, water, energy, resources, placing of waste)
- on the health of the occupants
Indirect:

– fallout on the global environment and ecosystems at different scales (photochemical pollution, global warming, carbon footprint, etc.)
– level of user satisfaction and consequent productivity / social diseases, etc. (society - economy)

effects on the quality of life of external social groups (eg residents of adjacent neighborhoods)
- effects on the macro economy (employment in industry and manufacturing, purchasing raw materials, contribution to recycling, imports, etc)
- effects on the micro economy (LCC, in particular energy consumption during the various stages and especially that of use)
- reflections on the local economy (value or devaluation of the site).

The impact on the outside, the so-called "externalities" especially in a context such as that particularly dense urban environment are too often neglected in practice, more or less consciously by decision makers (especially politicians), and consequently also of domino effects are difficult to control in a step subsequent to that decision. As we know, all too often end up further to fall in the sphere of health and well-being (environmental and social), and a little later also economical for the high costs associated with health.

- *Multi-indicator (I) profile*:

If performances are normally in relation to the impacts (negative effects), the other category of the results of actions and therefore the choices (technical solutions, design, use of materials and components) to be taken into account in an assessment of the sustainability of a intervention, in certain contexts, such as structures of excellence, are a key factor.

This is due to their direct reflection on the "total quality" of the object of evaluation, as well as to a number of indirect effects on the user. The performance is expressed by the indicator, which measures the "behavior", that translates into how far away the object number of performance-evaluation with respect to a reference value (benchmark). Obviously the goal is to minimize or maximize the impact and effect depending on the specific case where the impact is positive or negative, so that the construction / operation will respond in the best way possible with the established requirements (functional / technical, environmental, economic, social / cultural).

The expected performances in the case study concern to:
- the Reputation of the University (parameters used in the common methodologies for evaluating the level of quality of the University - international benchmarking)
- the Reputation of the Stakeholders (good performances can be certified as much qualified are the construction actors, eg. investors, designers, contractors, suppliers, etc.)
- the Environment (efficiency of design and technical solutions for saving water, energy, resources and waste minimization)
- the Users (level of functionality: accessibility, space and functional efficiency)
- the Owner / the tenant (fexibility, adaptability).

The second step of the method development has been the creation of a navigational matrix ("framework", *Tab. 1*), which identifies the objective relations (constraints in either direction, interference) with a view of sustainability, in particular related to the construction process / transformation of the city, present / not present between the set of variables, taken two by two. They also indicate the "relevant aspects" of these reports, to focus the thematic areas of *sensitive relationships* to have an overall idea of the problems and areas where the search for solutions. But they can also be considered as the *strategic aspects* on which to intervene on the basis of *environmental / social / economic criteria*, activating solutions today considered "sustainable".

Below is the *Legend of Tab. 1:*

■ existence of relevant relationships
◻ absence of relevant relationships / existence of not relevant relationships
R real estate
P public procurement
A environmental (impacts, performances)
S social (impacts, performances)
E economic (impacts, performances)
Table 1: The navigational matrix to manage the complexity of the relationship between the sets of variables involved

Variables Set / Variables Set	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**L**
A – Multi-role	-	■	■	■	■	■	■	■	■	□
		R/ S/ E	A / S / E	R / P / A / S	P / R	P / R / S / E	S	A / S / E	R / A / S / E	
B - Multiactivity (multi-function)	■	-	■	□	■	■	■	■	■	■
	R/ S/ E		S		P / R / A / S / E	R / A / S / E	S	A / S	S / E	S / E
C - Multi-scale	■	■	-	■	■	■	■	■	■	■
	A / S / E	S		A / S / E	A / S / E	A / S / E	A / S / E	A / S / E	A / S / E	A / S / E
D - Multi-sector	■	□	■	-	■	□	■	■	■	□
	R / P / A / S		A / S / E		P / A / S / E		R / A / S / E	A / S / E	R / A / S / E	
E - Multi-objective		■	■	■	-	□	■	□	□	■
		P / R / A / S / E	A / S / E	P / A / S / E			R / S			P / R
F - Multi-stage	■	■	■	□	□	-	■	■	■	■
	P / R / S / E	R / A / S / E	A / S / E				P / R / S	P / R / A / S / E	A / S / E	A / S / E
G - Multi-stakeholder / multi-interest	■	■	■	■	■	■	-	■	■	■
	S	S	A / S / E	R / A / S / E	R / S	P / R / S		R / S	A / S / E	P / R / A / S / E
H - Multi-impact	■	■	■	■	□	■	■	-	■	■
	A / S / E	A / S / E	A / S / E	A / S / E		P / R / A / S / E	R / S		A / S / E	A / S / E
I - Multi-performance	■	■	■	■	□	■	■	■	-	■
	R / A / S / E	A / S / E	A / S / E	R / A / S / E		A / S / E	A / S / E	A / S / E		A / S / E
L - Multi-indicator	□	■	■	□	■	■	■	■	■	-
		A / S / E	A / S / E		P / R	A / S / E	P / R / A / S / E	A / S / E	A / S / E	

3. Discussion and conclusions

3.1 First results

From the observation of the above navigational matrix, some first considerations can be made.
The *social aspects* are very present both at the levels linked to a geographic / spatial / functional (together with those related to the building project management), as well as to those more closely related to the themes "green" (sustainable development). They can therefore be considered "cross" to all the sets and substantially on 3 areas:

- territory / population
- building
- social groups (stakeholders).

They can also be divided in social aspects:

- relating to the *physical* characteristics (accessibility of the site and building, technical accidents on health and welfare, etc.)
- relating to the *sociological* sphere (consequences of behavior, relationships among stakeholders, etc.)

Because of their sheer number, heterogeneity and often difficult to focus, however, as deemed by the scientific community that is helping with the most advanced studies in european standardization work, their development certainly deserve a lot of effort and attention. From this point of view, also the DM (decision maker) covered with a "social responsibility", an obligation which requires him to include actors and social groups (stakeholders) affected by its choices in the decision-making process both as the advisory and proponent actors.

Environmental aspects (use of resources and energy, emissions and waste), properly studied in the context of ecology or starting point of the work of setting standards CEN TC 350, are *transverse to the scales* and abide by the direct responsibility of the DM and those who work with him in the process of implementation of the decisions as in the building. These must bear in mind that the setting of each goal among the possible alternatives (build a new building rather than rent or renovate another, for example) inevitably generates effects (impacts) on the shared environment. The involvement on the part of D.M. stakeholders in the choices means not only have a voice to protect the interests of the represented part, but, as is clear in this case, to become co-responsible, as in the positive so in the negative reversible / not reversible impacts due to the choices on the environment.
The *economic* aspects, as evidenced by the matrix, have the characteristic of being present in many areas and relationships. And of being different depending on the scale.
They range from those related to micro-economics and real estate procurement (more easily controlled and controllable) to the macro-economic effects of the choices that the DM does within a plurality of variables most elusive in its control and very even to his knowledge. The latter are only partly controllable and require extensive knowledge of the subject. Social responsibility in this area is actually a field rather "mined" for the DM.
The close connection with the cycle of life, both at the macro level (involving different spatial scales) and micro (building or part of it, the whole Campus) requires the DM to consider all items of LCC (Life Cycle Cost) and examine their correlations with all possible aspects. Ensure

that the LCC, which is actually a methodology widely known and applied, becomes in effect a strategic support for decision-making.

3.2 Conclusions

The research is still going and will go on with the development and application of the method, attempting to achieve the fixed goals.
However, such first general conclusions from the first step and related application of the method have been drawn and are below reported.

1. The decision making process in construction works belongs on its own to the *general area of complexity*.
2. Sustainability is a wide concept and even if the first attempt to understand and manage sustainability is to *divide the aspect and impact by single components* (environmental, social, economic), considering sustainability in construction works as a multidisciplinary challenge is only a start point to deal with the complexity of any single case of process, because of the *high level of the variables and the relationships* engaged.
3. Disciplines and andvanced knowledge areas as ie SE (Systems Engineering) or MCDM (Multicriteria models and methods for decision making) are able to offer models and methods to help the management supporting the decision making.
4. Any multi- dimensional/criteria problem in construction works can be managed using a *Top-down and Multilevel approach*, dividing the complex input into simple parts, described by sets of variables and analysing the relationships between the sets.
5. Thinking to any process in construction works as the *integration* of aspects / impacts / performances is nowadays the way to achieve what we currently intend as sustainable goals.

References

Daniotti B (2012) *Durabilità e manutenzione edilizia*, Torino, Italy, Editore UTET scienze e tecniche.

Daniotti B, Re Cecconi F (2010) *Test methods for service life prediction*, CIB.

Masera G (2004) *Residenze e risparmio energetico – Tecnologie applicative e linee guida progettuali per la costruzione di abitazioni sostenibili*, Milano, Italy, Il Sole 24 Ore.

Palazzo D, Masera G, Grecchi M, Malighetti L, Sesana M *International Journal for Housing Science and its Applications* (ISSN: 0146-6518), 35/1:11-21.

Bruglieri M, Ciccarelli D, Colorni A, Lué A (2011) *PoliUniPool: a carpooling system for universities*, 14th Meeting of the Euro Working Group on Transportation, Poznan, Poland.

Capello R (2007) *Regional Economics*, London, UK, Routledge.

Camagni R, Capello R, Chizzolini B, Fratesi U (2008) *Modelling regional scenarios for the enlarged Europe*, Berlin, Germany, Springer.

Ginelli E (2010) “Caratteri e potenzialità per il costruire contemporaneo”, Bosio A, Sirtori W, *Abitare. Il progetto della residenza sociale fra tradizione e innovazione* (ISBN: 9788838757648):135-147, Santarcangelo di Romagna, Italy, Maggioli.

Lavagna M (2008) *Life cicle assessment in edilizia. Progettare e costruire in una prospettiva di sostenibilità ambientale*, Milano, Italy, Hoepli.

Campioli A, “Eco-towns. Energia, ambiente e paesaggio per nuovi modelli di sviluppo urbano”, *Trasporti & Cultura* (ISSN: 1971-6524), 10(26): 52-59, Venezia, Italy.

Scudo G, Piardi S (2008) *Edilizia sostenibile. 68 Progetti bioclimatici, analisi e parametri energetici*, Pozzuoli (NA), Italy, Sistemi Editoriali.

Antonini E, Giurdanelli V, Zanelli A (2010) “Reversible Design: Strategies to Allow Building Deconstruction and a Second Life for Salvaged Materials”, *Second International Conference on Sustainable Construction Materials and Technologies*, Università Politecnica delle Marche, Ancona, Italy, 1207–1217.

Ilomäki A, Lützkendorf T, Trinius W (2008) “Sustainability Assessment of Buildings in CEN/TC350 Sustainability of Construction Works”, *Proceedings of the World Conference SB08* (ISBN 978-0-646-50372-1), Melbourne, Australia.

Lützkendorf T, Lorenz D P (2006) “Using an integrated performance approach in building assessment tools”, *Building Research & Information*, 34(4): 334–356.

Foliente G (2006) *Performance Based Building*, Melbourne, Australia, R&D Roadmap.

Salat S, Bourdiv L (2011) “Factor 10: Multiplying by 10 resource productivity in the urban world”, *SB 11 World Sustainable Building Conference*, Helsinki, Finland.

Schalcher H R (2008) *Systems Engineering*, Zürich, Switzerland, IBB - Institut für Bauplanung und Baubetrieb, ETH Zürich Departement Bau, Umwelt und Geomatik.

Stoy C (2004) *Benchmarks und Einflussfaktoren der Baunutzungkosten*, Switzerland, Institut fur Bauplanung und Baubetrien, ETH Zürich.

Stoy C, Schalcher HR (2007), „Residential Building Projects: Building Cost Indicators and Drivers”, *Journal of Construction Engineering and Management*, 2007(2):139-145.

Stoy C, Beusker E (2010) *BKI Objectdaten: NK1 Nutzungkosten* (ISBN 978-3-94167-914-6), Stuttgart, Germany, Baukosteninformationszentrum Deutscher Architektenkammern (BKI).

Beusker E, Stoy C, Pollalis S N (2012), “Estimation model and benchmarks for heating energy consumption of schools and sport facilities in Germany”, *Building and Environment* 49(2012):324-335.

Hagmann C (2011) “Information System for cost estimation of communal infrastructure”, *Management for a Sustainable Built Environment*, ISBN: 9789052693958, 20-23 June, Amsterdam, The Netherlands.

Wallbaum H, Krank S, Teloh R (2011), Prioritizing Sustainability Criteria in Urban Planning Processes: Methodology Application, Journal of urban planning and development, 2011(3):20-28.

König H (2008) *Orientierungswerte für die Bewertung von Hochbauten - erste Stufe: Bürogebäude*. Forschungsprojekt, Aktenzeichen, Germany, 10.08.17.7-07.29

Kopfmüller J, Lützkendorf T (2009) “Sustainability Assessment: Conceptual approach – methodological needs – practical implementation. The case if the building and construction sector”, *Sustainable development in Policy Assessment. Methods, Challenges and Policy Impacts Conference*, Brussels, Belgium.

Thiébat F (2009) *Architettura e Sostenibilità: sviluppo di un modello di valutazione economico-ambientale basato sul ciclo di vita*, doctoral thesis in “Innovazione dell’edificio e degli elementi che lo compongono, Tecnologica per l’Ambiente Costruito”, Politecnico di Torino, Italy.

König H, De Cristofaro M L (2012) “Benchmarks for life cycle costs and life cycle assessment of residential buildings” *Building Research & Information* 1:1-23.

Gargiulo C (2011) “La grande partita (business) della sostenibilità (Azioni concrete nella direzione della sostenibilità!)”, *Serramenti + Design* - ISSN 1824-4696, 2011(4):45-48, Milano, Italy, Tecniche Nuove.

Gargiulo C (2012) “Performance oriented building assessment: time and space the two dimensions of sustainability”, *CIB W115 Green Design Conference Proceedings* ISBN: 978- 90- 365- 3451- 2, 2012(366):146-149, 27-30 September 2012, Sarajevo, Bosnia and Herzegovina.

Gargiulo C (2012) “European Standards for the Assessment of Sustainability in Construction works: role of Stakeholders and opportunities for the Construction industry”, *The Missing Brick: Towards a 21st-century Built Environment Industry Conference Proceedings* ISBN 88-387-6164-7: 470-489, 18-19 October 2012, Milano, Italy, IsteA Italian Society of Science, Technology engineering of Architecture.