Human Factors in Design of Sustainable Buildings

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ABSTRACT

Ergonomic approach is aimed at optimizing human interactions with systems, in order to make human activities more efficient, safe, comfortable and satisfying. Built environment influences people's everyday life because all human activities are executed in a built space. In this framework, architectural design can be enhanced by the consideration of human factors perspective, because it gives the cultural and practical references to envisage how technical solutions can fit the environmental needs derived from people's life and work activities they perform. Since the main objectives of sustainable design are to reduce, or completely avoid, depletion of critical natural resources and raw materials; prevent environmental degradation caused by facilities and infrastructure throughout their life cycle; create built environments that are livable, comfortable, safe, and productive, a broader consideration of the role of human factor has to be taken into account to enhance design process of sustainable buildings. Several studies evidence that to reach sustainable goals of buildings, particularly referred to energy and resources use and optimization, unexpected disadvantages for final users may occur. The paper shows recurring human side effects of building solutions and elements mainly adopted to address green strategy and technologies, in order to support building design to create working and living spaces actually fitting, in the same time, sustainable performance of buildings and needs of inhabitants.

Keywords: Building usability, Green Building Rating Systems, End-users

INTRODUCTION

It is generally accepted that sustainable development calls for a convergence between the three pillars of economic development, social equity and environmental protection (Drexhage and Murphy, 2010). As we know the concept was first introduced by Brundtland (UN,1987), who defines development as "sustainable" when it "meets the needs of the present without compromising the ability of future generations to meet their own needs". It considers a long term perspectives of the socio-economic system, to ensure that improvements occurring in the short term will not be detrimental to the future status or development potential of the system. Such kind of development implies minimizing the use of exhaustible resources, or at least, ensuring that revenues obtained from them are used to create a constant flow of income across generations, making an appropriate use of renewable resources (Bellù, 2011). Human organizations must act aiming at the same time at: the effective protection of the environment; the prudent use of natural resources; the social progress which recognizes the needs of everyone; the maintenance of high and stable levels of economic growth employment.

Literature shows sustainability has became today almost one of the main concern in human factors studies (Martin *et* *al*, 2013), but the issue is not new in ergonomics domain. It has been observed that even if ergonomics noticed global problems since two decades (Moray 1993, Moray 1995, Martin *et al*, 2013), sustainability has been part of the basic understanding of human factors/ergonomic discipline for long time, since several fundamental definitions refer ergonomics to the central principles objectives of sustainable development (Zink and Fisher, 2013). It is well known, for example, the emphasis on the optimization of human well-being and overall system performance that IEA attributes to ergonomic/human factors focus, in order to understand the interactions among humans and other elements of a system, providing theoretical principles, data and methods (IEA 2000). To break down general sustainability requirements and make discussion about human factors and sustainable development more tangible, Zynk recently summarized some exemplary lead principles for sustainable-oriented design of human factors/ergonomic concept and instruments: preservation and development of human and social capital, based on the understanding that social sustainability is only one part of the three dimensions model of sustainability; focusing on a broad systems approach including whole value creation chains; striving for a life cycle perspective in design; comprising impacts on society as well as impact on other related systems; addressing barriers for sustainable development (Zink and Fisher, 2013).

CONSTRUCTION SUSTAINABILITY: AN IMPERATIVE FOR SUSTAINABLE DEVELOPMENT

Buildings and the way they are realized and operate have a fundamental role on sustainable development as they impact on the environment, consume large quantities of resources, involve large numbers of workers, and represent a large proportion of economic activity. For this reason decisions made during all stages of the construction process are vital for maximizing sustainability (Boswell and Walker, 2005). Generally the construction sector is considered to be strategic in sustainability terms, since it involves different materials and activities, affects numerous stockholders, operators and users, moving huge financial capitals. Only in EU the construction sector represents more than 10% of EU GDP, more than 50% of fixed capital formation and employs directly almost 20 million people. It regards building and infrastructures design and construction stages, including: onsite activities embracing site preparation, construction of complete buildings, building installation; manufacturing of construction materials, including building products and components; building use, maintenance operation; building and infrastructure reuse or disposal. According to the assumption that often reduces sustainable development as an environmental issue (Drexhage and Murphy, 2010), sustainability of construction sector has been largely intended as a “green” question, considering the energy performance of buildings and resources efficiency in manufacturing, transport use of products for the construction of buildings and infrastructures have a crucial impact on energy, climate change the environment. EU estimates that since 40-45% of Europe’s energy consumption stems from buildings with a further 5-10% being used in processing and transport of construction products and components (FWC,2012). Nevertheless, more recently, sustainability development in construction has been intended to go over the so called environment “box” and beyond economic viability, addressing the wide sense of the concept. As ISO -TS 21929 premises in order to define sustainable indicators of buildings, sustainable construction brings about the required performance with the least unfavorable environmental impact, while encouraging economic, social and cultural improvement at a local, regional and global level (ISO TS, 2006). Construction is said to be sustainable when it meets environmental challenges, but responds also to social and cultural demands. The fundamental concept of sustainable construction is to deliver long term affordability, quality and efficiency, value to clients and users, whilst decreasing negative environmental impacts and increasing the economic sustainability (Bal et al., 2013).

GREEN/SUSTAINABLE BUILDINGS

Nevertheless the building sustainability is greatly still intended as environmental footprint. In scientific and technical literature green buildings are seen as synonymous of environmental friendly, which design is aimed to reduce the overall impact of the built environment on human health and the natural environment (Bragança, 2010). By a more comprehensive view point it has been assumed that a sustainable building has to contribute to a sustainable development, through its characteristics and attributes, addressing some goals: safeguarding and maximizing functionality and serviceability as well as aesthetic quality; minimizing life cycle and protecting /or increasing capital; reducing land use, raw materials and resource depletion, but also reducing malicious impacts on the environment; protecting health, comfort and safety of workers, occupant, users, visitors and neighbors; preserving cultural values and heritage (Lutzkendorf and Lorenz, 2007). Recently the high performance building is called to integrate and optimize, on a life cycle basis, all major high performance attributes, including energy conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality and operational considerations (Fischer E.A., 2011,Attaianese, 2012).

According to the so called "environment box" affecting the sustainability dimension, sustainable building is mainly focused on environmental issue, since existing design and assessment methodologies share, in common, goals which involve energy and resources conservation concerns. The optimization of site potential, preservation of regional and cultural identity, minimization of energy consumption, protection and conservation of water resources, use of environmentally friendly materials and products, a healthy and convenient indoor climate, and optimized operational and maintenance practices are purposes can be found in several building sustainability assessment methods (Bragança et al, 2010). Assessment and certification schemes that measure the sustainability of buildings have been in operation for a number of years in many countries. Some of them are members of the World Green Building Council, and dozens more are in the process of forming national councils or adopting certification standards. Rating systems have an important role because they not only provide criteria for assessing sustainable goals of green buildings, but give also specific principles for design, operation and construction of high performance buildings.

Challenges in sustainable buildings design

During the last years a general understanding about the importance of the occupants in order to achieve environmental goals of green buildings arose within energy building experts. The 2009 Passive Low Energy Architecture Conference (PLEA), for example, was themed "Architecture, Energy and Occupant's Perspective" with the ambition of positioning building inhabitants as key active determinants of energy performance in passive design through adaptive opportunities (Cole et al, 2010). Overcoming the traditional consideration of building users as passive occupants, to which IAQ and indoor comfort were usually referred (Guerin, 2013), the need of field studies considering users in term of "inhabitants" merged, capturing with this term, a more active users engagement in building energy concerns, since "buildings don't use energy but people do" (Janda, 2011). "Inhabitants are more directly involved with building systems and operation through opening and closing windows, doors, light, shading devices, thermostats, vents and other manual controls" so their behaviors significantly influence building energy use. Buildings supports human activities and energy needed for doing so depends on how they are designed, mainly in relation to inhabitants operation needs and expectances (Cole et al, 2010). Climate and building characteristics alone have been proven to be insufficient as determinants of energy optimization, and the roles of occupants behaviors and socio-economic factors have resulted as important components (Steemers and Yun, 2009, Vale and Vale, 2010), also in terms of energy demand (Haldi and Robinson, 2011). The challenging area of investigation for building performance and evaluation has been focused on human behavior, in order to assess and improve design affordance and provide comprehensive feedback for empowering users environment control and reduce energy use (Kobus et al, 2013, Peffer et al, 2013); to develop maintenance and operations as dimensions to be integrated in building performance and post- occupancy evaluations (Stevenson and Leaman, 2010, Monfared and Sharples, 2011), looking at the complete lifecycle of the building from initial procurement through build management process to eventual demolition (Preiser and Vischer, 2005); to better address diversities of inhabitants both in energy regulations and standards both in evaluation methods and design strategies, since the relationships between users and buildings changes over the time and each situation must be studied and assessed on its own merit (Gupta and Chandiwala, 2010). To reach these goals a better understanding of users expectations, attitudes, perceptions and behavior by interrelate human factors directly with the physical performance of the building is required (Stevenson and Leaman, 2010). The need to focus directly the human perspective in energy concerns of buildings design and evaluation clearly merges by user evaluation of energy-efficient buildings research outputs conducted in the last decade. Main concerns resulted in relation to the inhabitants and occupants perception of comfort and technical operation. In passive houses sensible differences between experienced thermal comfort and simulated indoor climate has been reported (Samuelsson and Luddeckens, 2009 in Hauge et al, 2011), confirming that people perceive indoor thermal conditions differently (they changes individually and vary over the time) and their perception may be influenced by several context factors (i.e. cold floor surfaces or draughts may decreased the perceived temperature, whilst the vision of fireplaces increases it). In green occupational buildings main occupants comfort dissatisfactions have been reported about temperature (Heerwagen and Zagreus, 2005, Leaman and Bordass, 2007), light and noise conditions (Abbaszadeh et al, 2006, Leaman and Bordass, 2007), frequently in association to offices open-plan layout, which characteristics have been also considered as factors inducing distractions, interruptions, lack of concentration negatively influencing occupants working ability (Heerwagen and Zagreus, 2005). Moreover the perception of thermal comfort has often resulted to be linked to occupants' ability and possibility to control indoor climate, by the effective use of manual thermostat (Peffer, 2013), opening windows (Goins, 2012) and controlling solar glare (Nicol and Roaf, 2005, Barlow and Fiala, 2007, Wagner, 2007). Occupants result more comfortable in buildings in which the amount of perceived control over temperature, ventilation and noise is high (Boerstra et al., 2013).Therefore the question of buildings controls usability, in terms of easiness to use and feedback, has been reported as crucial (Nicol and Roaf, 2005, Leaman and Bordass, 2007, Hauge et al, 2011). Thus research surveys conclude that energy-efficient buildings are experienced as satisfying more than conventional one but the incidence of occupants that perceive them uncomfortable or that are indifferent about green buildings in which they work is relevant (Paul and Taylor, 2008). In order to overcome the gap between energy efficiency simulations and occupant actual perceptions, longitudinal observations and building operation and maintenance over time assessment, together with perceived architectural and aesthetic qualities considerations, are needed to be taken into account. Thus more focus on human aspects in building users evaluation as important areas of focus for further research have been assumed (Hauge et al, 2011).

HF/E ISSUES IN SUSTAINABLE BUILDING DESIGN

Looking at the recent literature on ergonomic, design and sustainability, we can see that the contribution of human factors to sustainability and sustainable design are limited among ergonomics community reported studied, even through the goals of sustainability and ergonomics are implicitly congruent (Martin *et al*, 2013). Many studies states that sustainability goals can be better achieved realizing efficient durable systems, to be used in efficient manner (Martins et al, 2013). But even though few authors explicitly consider the supportive rule of human factors/ergonomics approach (Steimle, 2006, Brown and Leggs, 2011, Martin et al, 2013), the need to enhance design for sustainability involving systems users and their sustainable behaviors emerged (Bhramra et al, 2011). Recently the connection between sustainability and human factor/ergonomics has been exploited through the notion of green ergonomics that focuses human factors goals in a pro-nature view. It is oriented to support the development of efficient systems, that in addition to be healthy and safe, have to need less energy to be used and assist people in the comprehension of sustainable behaviors change (Hedge 2008, Thatcher, 2012, Hanson, 2012). In this view the linkage between humans and nature is bi-directional, so that green ergonomics considers both how human system can facilitate the conservation, preservation restoration of natural capital, both how human interactions with nature can facilitate wellbeing and effectiveness. The first goal can be achieved by supporting the design of low resources systems and product, so that they are also able to favorite conservative and sustainable behaviors by users (Thatcher and Milner, 2012). The second goal can be reached by designing systems and products inspired by effectiveness of nature (Thatcher and Milner, 2012, Obiozo and Smallwood 2013), able in the same time to stimulate humans ability and positive reactions (creativity, productivity, healing effects). One of the obvious place for green ergonomics to make impact on improving individual wellbeing is the built environment (Thatcher, 2013), but few ergonomic studies experimented the human component in actual sustainability performance of buildings, in two directions: both in terms of impact of occupants and inhabitants actions and behaviors on building performance optimization and both as effect of these performance on human reactions and perceptions in relation to sustainability issues. It seems to be recently acknowledged that green building specification may not automatically lead to improved physical and physiological wellbeing or perceived productivity gains and benefit of sustainable design are those also sought by ergonomists: improve well-being and productivity of all users of the design, due to improved design performance (Martins *et al*, 2013). It is stated that human factors can contribute to understanding how buildings are used and how people interact with their physical environment, also by identifying needs of people who will occupy the building (Hanson, 2013), but few field studies have been carried out by ergonomists addressing directly sustainability issues (Karwowsky, 2005, Thatcher, 2012). As Haslam and Waterson recently conclude ergonomics activity on this front appears limited and tentative (Haslam and Waterson, 2013).

USERS AND BUILDING USABILITY

A field strongly focused on user involvement in building performance evaluation is building usability. The starting point of this issue was in 2001 when CIB Working Commission on the Usability of Workplaces (CIB W111), began to investigate the application of the ISO 9421 international standard on usability, previously applied in the evaluation of consumer products, to the built environment, although some studies on the issue were conducted earlier (Attaianese, 1997, Attaianese 2001). Particularly it included all aspects of the 'user experience' in an organizational setting - encompassing the end-user's interaction with an organization and its facilities and with processes of design and management (of the built environment). According to the definition from the international standard on usability as '….effectiveness, efficiency and satisfaction with which a specified set of users can achieve a specified set of tasks in a particular environment' (ISO, 1996), building usability, or functionality in use, is concerned with a building's ability to support the user organisation's economic and professional objectives. From the user perspective, usability means that artifacts are easy and fast to learn, efficient to use, easy to remember, allow rapid recovery from errors and offer a high degree of user satisfaction. The usability of the built environment focuses on user perceptions of the ease and efficiency with which they can use the building, considered as a facility. While functionality can be evaluated on the product (building), usability cannot be evaluated only analyzing the building, but looking at the context of its use, depending on users' values in culture, context, time, and situation (Alexander, 2008). Even though a partial vision of building usability, dealing with aspects of accessibility management in buildings (i.e. constructional aspects of access to buildings, to circulation within buildings, to egress from buildings in the normal course of events and evacuation in the event of an emergency) has been recently introduced in an new international standard (ISO, 2011), some practical application of usability on specific buildings and activities show a more comprehensive consideration of the concept, where usability requirements and their related markers have been formulated (Afacan and Erbug, 2009, Haruna et al., 2011, Duca, 2012). Some recurring usability areas or criteria associated to building are: accessibility, spatial orientation, in terms of way finding and paths efficiency, aesthetic and affective elements, comfort and well being, flexibility and safety aspects. More recently the concept of sensory design architecture emerged (Leheman, 2011). Taking an occupant-centred approach, it is aimed to optimizing the 'health' within the building, in terms of the health of an individual occupant, the health of a building's effectiveness and the health of its ability to harmonize with surrounding environments, considering the effects of architecture on occupants, and how it can be better attuned through sensory design for healthier mind and body connection – physiologically, cognitively, emotionally, behaviorally and spiritually (Leheman, 2011).

THE HUMAN SIDE EFFECT OF SUSTAINABLE SOLUTIONS

As discussed above a comprehensive approach to building usability criteria may be applied to design and evaluate how a building, by spatial features and technical solutions, is really fitting real needs and expectations of users. In the case of sustainable buildings, not all elements and attributes of green strategy and technology, singularly or combined, match human needs, giving negative effects on objective and perceived health, safety, well being and task efficiency of occupants and users in general. Some examples of these effects are reported in the following tables.

Table 1: Samples from green strategy and technology for optimizing thermal performance of the exterior envelope

Usual elements and attributes	Human side effects	References
Structural integrated panel Exterior insulation materials & finishes (rigid & spray foams, foil insulation)	Insulation increases interior temperature, growing burning characteristics of interior and exterior materials; it can contributes to flame spread and fuel load.	Tidwell & Murphy , 2010, Meacham B. et al., 2012
	Increased exposure to mineral fibres in demolitions.	EASHW, 2013
	Increased exposure to volatile organic compounds from, for example, paints or adhesives, and to dust, including crystalline	

Usual elements and attributes	Human side effects	References
	silica for construction workers	
High performance glazing (i.e. insulated double glazing, triple glazing or double pane glazing with a suspended low-e film)	Double-glazing or other type of highly insulated glass are heavier than conventional glass. (a double-glazed window of the same size has about twice that weight)	EASHW, 2013
	Can impact fire force access because they are difficult to break for ventilation or rescue purposes	Tidwell & Murphy , 2010, Meacham B. et al., 2012
	While glass can be completely recycled, most high performance glass has little recycled content	
	The creation of glass utilizes a great deal of energy (high embodied energy)	
	Too cold in warm weather, frequently due to big glass openings, also with the impossibility to operate a window/shades control	Heerwagen & Zagreus, 2005 Guerin D.A et al, 2012
High performance blocks	High performance blocks may be heavier than conventional one, may show inadequate grip and present injuries part.	Attaianese & Duca, 2012
Double skin facade and cavity walls	Can present chimney for vertical smoke and flame spread	Tidwell & Murphy , 2010, Meacham B. et al., 2012
Bamboo & other cellulosic materials	Can contribute to flame spread, smoke development and fuel load	Tidwell & Murphy , 2010, Meacham B. et al., 2012
Recycled paper flakes and flax wool	They are impregnated with 8% boric acid (sodium tetraborate), which serves as a fire retardant and an antimicrobial agent]. Boric acid has been classified as toxic to the reproductive system in the EU.	EASHW, 2013
Vegetative roof systems	Can contribute to fire load, spread of fire, risk of external fire	Tidwell & Murphy , 2010, Meacham B. et al., 2012
Exterior vegetative covering	Can impact with fire forces access	Tidwell & Murphy , 2010, Meacham B. et al., 2012
Automatic windows programmed to be opened upon weather conditions	Can impact with fire forces access and with rescue purposes	Tidwell & Murphy , 2010, Meacham B. et al., 2012

Usual elements and attributes	Human side effects	References
	Lack of personal control of windows opening can impact on perceived comfort influencing occupants ability to achieve their desired conditions	Stevens S., 2001 Heerwagen J.H, 1998
Increasing vestibules and atriums in the floor plane	Vestibules used to inhibit the migration of outside air to the interior of the building will increase the degree of difficulty to deploy hose lines to the interior of the building	Tidwell & Murphy , 2010, Meacham B. et al., 2012

Table 2: Samples from green strategy and technology for maximizing natural day lighting

Usual elements and attributes	Human side effects	References
Awnings	Can impact with fire forces access also inhibiting the deployment of ladders	Tidwell and Murphy , 2010, Meacham B. et al., 2012
Increased glass windows Increased internal glass walls Decreased interior hard walls and opaque partitions	Lower sound isolating capabilities. Reverberation can be significant in rooms with speech privacy and speech clarity issues due to large amounts of glass Increased transmission of outdoor noise “Acoustical” glass products highly priced and ongoing costs. Glass is expensive to maintain. While glass can be completely recycled, most high performance glass has little recycled content The creation of this kind of glass utilizes a great deal of energy (high embodied energy) Too much daylight or incoming sun with problems of refection and dazzling and visual discomfort	Muehleisen, 2010
Increasing open spaces	Increased ground noise level Loss of privacy Distraction and loss of concentration Too much air movement Way finding problems and lack of orientation	Goins J. et al, 2012 Heerwagen and Zagreus, 2005 Guerin et al, 2012

Usual elements and attributes	Human side effects	References
Use of light shelf	The lack of windows views, especially views of nature and proximity to windows, impact on emotional health and occupants productivity	Loftness et al, 2006 Edwards and Torcellini, 2002
Use of solar tubes	Tubes provide an additional means for fire transmission and smoke migration through spaces	Tidwell and Murphy , 2010, Meacham B. et al., 2012

Table 3: Samples from green strategy and technology for optimizing natural ventilation

Usual elements and attributes	Human side effects	References
Increased openings in the building enclosure	Increased transmission of outdoor noise (negative acoustic impacts due to more and larger penetrations between the interior and exterior environments)	Muehleisen, 2010
	Increased outside air rates can bring unwanted outdoor pollution and humidity	
	Production of unwanted air flows	Loftness et al, 2006
Limited use of partitions so that air can flow nearly unimpeded	Increased noise transmission between rooms	Muehleisen, 2010
More open spaces horizontal More open space vertical	Increased ground noise level Loss of privacy. Distraction and loss of concentration. Too much air movement	Heerwagen and Zagreus, 2005
	In case of fire, faster fire growth due to the greater air volume and the more readily available of fuel sources. Lack of compartimentations to limit fire spread to smaller areas. Natural ventilation can impact ability to control smoke, can influence smoke movement depending on environmental conditions. High volumes can influence sprinkler and detector performance.	Tidwell and Murphy , 2010, Meacham B. et al., 2012

Table 4: Samples from green strategy and technology for reducing the use of materials and resources

Usual elements and attributes	Human side effects	References
Increased use of lightweight structural component (in wood, steel or concrete)	They will rise earlier in temperature and fail more quickly than heavier Lightweight concrete can spall more explosively if not treated with fiber Fibers can be toxic in construction phase for workers, and for occupants if broken	Tidwell and Murphy , 2010, Meacham B. et al., 2012
Increased low-impact storm water technologies and other technologies that support on-site retention and ground water recharge or evapo-transpiration	The use of pervious bituminous paving and/or concrete for paving and walkways may affect pooling of flammable liquid and resulting pool fire, containment, runoff containment issues	Tidwell and Murphy , 2010, Meacham B. et al., 2012
Increasing use of renewable organic material (i.e. bamboo, straw, sheep wool, flax and cork)	Might bring elevated risks of exposure to protein-based allergens, and micro-organisms such as bacteria, moulds and fungi or endotoxins	EASHW, 2013
Recycled asphalt with fly ash	Fly ash contains heavy metals and may contain polycyclic aromatic hydrocarbons (PAHs), some of which are carcinogenic	EASHW, 2013

CONCLUSIONS

Cited studies show that the fulfillments of green goals often produces unexpected negative effects on users due to conflicting situations emerging from the massive use of materials, construction techniques and spatial layout, decreasing overall building usability. Fire forces studies, mostly based on reported fire incidents that are related to green issues (Tidwell & Murphy, 2010, Meacham B. et al., 2012), demonstrate that energy efficiency measures are critical component of green construction, worsening substantially users safety in case of fire: fire load and flame spread increasing due to the massive use of insulation materials and finishes; smoke development and flame spread rising due to the large open plans, the higher room volumes and the use of solar tubes; obstructing evacuation plans and rescues purposes by the large use of high performance glasses (i.e. insulated double glazing, triple glazing) that are usually not operable windows, difficult to break for way in and way out, and for ventilation. On the other hand green strategies to reduce heath loss in winter and sun access in summer can bring in some region to reduce openings on the building envelope, adopting design solutions with less windows and more light shelf and solar tubes This solutions are reported as negative for occupants since the lack of windows views, especially views of nature and window proximity, impact on emotional health and productivity. Most evident health concerns refer to the use of insulating and organic materials in green buildings, since they contains fibres and volatile substances, dangerous if inhaled, furthermore open issues are under investigation for what concerns newest and recycled materials effects. Post occupancy studies report more frequent perceived discomfort associated to acoustics of green buildings. It is particularly due to open plans and light partitions increasing ground noise level, or amplifying transmission of outdoor noise for the larger penetrations between the interior and exterior environments, with consequent loss of privacy and concentrations of occupants. Also lower sound isolating capabilities and reverberation of glasses, frequently used for daylight maximization, brings to negative acoustic effects.

From reviewed literature and discussion a complex and multifaceted relationship between ergonomics/human factors and sustainability in buildings emerged. On one hand it is acknowledged that sustainable buildings have to take care of users, as part of the environment in a global term, since the sustainable design, construction, and use of buildings are based beyond the evaluation of the environmental impacts and the economic aspects related to the life-cycle costs, where humans are indirectly involved, but also on the direct role they have in the social aspects of sustainability. Despite that buildings sustainability rating systems show brief sections containing indicators mainly referred to the users comfort and less to the social benefits. On the other hand evidence based studies and post occupancy evaluations, reveals that green strategies suggested elements and solutions to implement building design and construction, are often triggering factors of undesirable effects on users. To design really sustainable buildings it is crucial that solutions and details must be selected on the basis of users needs and their related tasks, taking into account human capabilities and limitations, diversities and uniformities. To do this more ergonomics issues in whole-building design is needed. Architects education programs need providing adequate knowledge about HF/E data and methodologies, in order to enhance architectural design by the consideration of human factors perspective and envisage how technical solutions can fit human and environmental needs derived from people's life and work activities they perform. Designers and producers of building components need to take advantage from HF/E issues in order to reduce the impact of green design construction on health and safety of construction workers, and to improve operability and usability of building controls for increasing end-users comfort and wellbeing. HF/E expert should be a component of the design team. Since usability may express how building supports end-users in their activities, whole building usability could be enhanced as one of the key areas of green building design and assessment.

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