www.jcepm.org
http://dx.doi.org/10.6106/JCEPM.2018.8.3.001

Vol. 8, No. 3 / Sep 2018
Online ISSN 2233-9582

KICEM Journal of Construction Engineering and Project Management

Approaching Green Buildings Using Eco-Efficient Construction Materials: A Review of the state-of-the-art

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Received: Oct 4, 2017
Revised: Aug 13, 2018
Accepted: Sep 10, 2018

ABSTRACT

Since the protection the of human being from natural disaster and atmospheric factors have become an essential requirement, some attempts have been taken place to provide shelter and create a safe environment to a more comfortable life with welfare. For this purpose, using existing resources in nature and exploiting them in a different manner have been taken into account. Initially, the performed exploitations for construction had the least damage to the environment, but over time and as a result of population growth, aggressive exploitation of nature has led to destroying effects on the environment and resulted in consequences such as pollution and environmental destruction. Thus, the construction industry has been identified as the top pollutant factors of the environment. Among various construction factors, the building materials used in this industry are considered as the most important effective factors on the environment, as they have direct influences on the environment from the beginning of construction of the final steps. This research focuses on the review of the most of the existing green materials definitions and various approaches towards using eco-efficient construction materials. It presents and discusses possible ways of reducing the destructive effects on the environment by selecting and using green materials, review current literature and highlight the necessity of applying such materials in future constructions in all communities. This paper provides a base for this purpose that sustainable development communities and environment is realized by elimination of environmental pollution and approaching the criteria of green building by using sustainable materials.

Keywords: Construction materials, Durability, Sustainability, Recycled materials, Energy consumption, Green concrete, Low carbon building, Eco-Efficient Materials

INTRODUCTION

The pace of actions towards sustainable development depends upon decisions considered by lots of actors in the engineering process: owners, professionals, designers, businesses, etc. An important decision is the sustainable selection of building materials to be utilized in building tasks [1].

Accomplishment of the 'Green Buildings' target is performed both at an early stage of the design process and on the working plan [2]. Materials selection is a sensitive and complex task depends on the tremendous quantity of building material options. Likewise, multiple factors tend to be considered by the architect when evaluating the various types of building materials. As a total result, these collections of parameters or factors often present

tradeoffs that make your choice process even more technical [3].

The material selection process would integrate social, economic and environmental considerations at every stage in decision-making [1].

There is not an individual definite criterion of selection always, which means designers or architects have to take into account a large number of material selection factors. Therefore, the available information or data on building materials and product options must be constantly assessed to make well-considered and justifiable material choices [3].

Construction is one of the most significant end users of environmental resources and one of the most significant polluters of man-made and natural environments. Probably selecting sustainable building materials is the most challenging and trial facing the industry. Achieving the goal of green construction is one way that the construction industry can make an accound contribution towards guarding the environment. The operation and process of building construction consumes plenty of materials throughout its service life cycle, so the choice and use of sustainable building materials play an important role in the design and construction of green building [4].

Much like the design process, mindful awareness of contextual preconditions is essential to selecting appropriate building products or materials [3]. Buildings have a direct impact on the environment, ranging from the utilization of raw materials during construction, maintenance and renovation to the emission of harmful substances throughout the building's life cycle [4]. The building sector's environmental impact is enormous, as it accounts for the use of 40% of the natural resources extracted in the industrialized countries, the intake of 70% of the electricity and the 12% of potable water, and the creation of 45-65% of the waste disposed in landfills. Additionally, it is expected to increase, because of the development in global inhabitants from 6.5 billion in 2005 to roughly 9.0 billion in 2035. In this scenario, the mitigation of the environmentally friendly impact of properties is an initial issue [2].

The construction industry and the environment are associated inextricably. It had been inevitable that the industry has found itself at the center of concerns regarding environmental impact [4]. The earlier try to “establish comprehensive means of simultaneously assessing a wide selection of sustainability concerns in building materials” was the Building Research Establishment Environmental Examination Method (BREEAM). BREEAM known as the first commercially available & most widely used diagnostic method was proven in 1990 in Britain. Since then numerous tools have been launched across the world such as Leadership in Energy and Environmental Design (LEED). BREEAM, LEEDS, and other existing methods for assessing building whose remit is basically restricted to an environmental security and resource efficiency agenda has limited energy for evaluating sociol and monetary factors as opposed to environmental sustainability. It should be noted that achieving the goal of sustainable building is not about restricting the quantity of construction. It is concerning how to pay more attention to how the design and selection of green building materials can complement the environment to boost living quality, end-user health and comfort [4]. In order to be considered truly ecological, assessment methods shall need to be recast under the umbrella of sustainability environmental, social and economic. Broadening the scope of discussion beyond environmental responsibility and embracing the wider agenda of sustainability are increasingly necessary requirements [1].

METHODOLOGY

Sustainable development is the most vibrant and powerful force to impact the building design and construction field in more than a decade. The type of research that will be used in this study is qualitative and quantitative research. Sustainability of building materials depends on the local context. Due to the lack of available data in developing countries and the complexity of the life cycle assessment methodology, other relevant instruments can be applied on the analysis of sustainability, such as the international environmental product declaration system and certification schemes and labels.

Qualitative search has been done with an understanding of sustainable building using eco-efficient construction materials. Therefore, the literature search has been done based on keywords, and database, allowing for the identification of related journal articles across several research disciplines and sources.

Table I shows a list of keywords and database to this article:

TABLE I. LITERATURE SEARCH DESIGN

Keywords	- Construction materials - Durability - Sustainability - Recycled materials - Energy consumption - Green concrete - Low carbon building - Eco-Efficient Materials
Database	Elsevier onlinelibrary. wiley springer Scholar. Google Scopus Ebscohost Engineering village

THE USE OF GREEN MATERIALS IN BUILDING CONSTRUCTION

Generally, construction is not an environmentally friendly process and it includes major effects on the depletion of natural resources and on the emissions of Green House Gas (GHG) consequently of fossil gas combustion [4].

The selection of ecological building materials should not only give attention to the performance requirements but also attention requires for materials, which may have the lowest GHG emissions.

The construction, fit-out, procedure and ultimate demolition of properties are significant factors of real human impact on the environment both directly (through materials and energy consumption and the consequent pollution and waste products) and indirectly (through the pressures on often inefficient facilities). In response to these effects,

there is growing consensus among organizations focused on environmental performance targets that appropriate strategies and actions are needed to make construction activities more sustainable. Careful collection of ecological building materials has been discovered as the easiest way for designers to start incorporating sustainable ideas in building projects. Selecting building materials are undoubtedly a multi-criteria decision problem [5]. The following set of guidelines has been developed to aid the decision of standards to assess your options under consideration [1]:

Comprehensiveness

The conditions chosen should cover the four types of economic, environmental and social, to be able to ensure that the account is being considered for improvement towards the sustainability objective.

Applicability and transferability

The factors or variables chosen will be applicable across the range of options under consideration as well as transferable across regions irrespective of the geographical setting of the regions. This is needed to ensure the comparability and compatibility of the options regardless of the local conditions.

Practicability

The set of factors/variables selected will be used to form a practicable tool or system to enable potential users to reach a better solution of making effective decisions in selecting appropriate materials in less time, with fewer resources and errors. The choice of factors or variables is to influence the outcome of the decision being made, as well the method of comparison or aggregation is chosen.

Before years, a great effort was addressed toward the reduced amount of the energy required during the procedure period of the building (energy required for heating, cooling, ventilation, lighting, hot water, operating devices, etc.) and the adoption of more efficient technical solutions and materials led to an improvement in the fullness of energy performance of structures during their service life. The modern impulse to the exploitation of alternative energy sources led to a rapid development of the Zero Energy Building (ZEB) idea, implying a zero annual balance between your energy used for the building's procedure and the energy gained from renewable sources, such as in 'solar homes [2].

Sustainable building concerns judgment and behavior to help ensure long-term environmental, social and financial growth in the construction. In buildings, it involves the efficient allocation of resources, minimize energy consumption, low embodied energy intensity in building materials, recycling and reuse, and other mechanisms to attain effective and effective brief- and long-term use of natural resources [4].

Recent studies now argue that the utilization of local and recycled building materials offers the advantage of reducing CO2 emissions, producing healthier building, while conditioning the local current economic climate. With the evolution of the low-carbon building motion, research and development are progressively more devoting considerable amount of resources to intentionally promote and prioritize the utilization of local and recycled

building materials in mainstream practice [3].

The improvement in environmentally friendly performance of properties will indeed encourage higher environmental responsibility and place a higher value on the welfare of future decades [4]. Some of the indexes for using sustainable materials in construction have been reviewed. This forum explores in below:

A. Reuse of waste materials in its original forms.

B. Environmental impact of selecting green materials.

C. The Durability of materials in sustainable construction.

D. Interaction between local economy and selecting local -green materials.

E. Influence of energy consumption in selecting materials.

F. Choosing materials and components with lower carbon emission and prevalence the low carbon building technology.

G. Using sustainable components for providing green concrete as a popular material in construction.

H. Use of in-site materials and recycled materials as a raw material for products

Reuse of a waste material in its original form

Considering the recent industrial development's construction, and world population growth and meanwhile demolition of residential & industrial buildings has imposed many undesirable expenditures to every society worldwide, which, according to Statistics almost 50% of consumable resources on earth are dedicated to this field. Energy consumption for construction and encountering a huge amount of structural waste has brought lots of environmental problems to most countries worldwide. Lack of raw material for construction and the increasing rate of environmental problems have drawn the attention of most governments to find a solution regarding sustainable development in this field.

Therefore, applying recyclable material or reusable ones in the process of building, renewal and returning into a nature cycle with an environmental adaptability and saving energy consumption is one of the many possible ways to cross this critical era successfully.

Every building material comes with an environmental cost of some sort. However, some principles can help guide your choice of ecological structure and materials systems. Careful analysis and collection of materials and the way they can be combined can yield significant improvements in the comfort and cost effectiveness of your house, and help reduce its life cycle environmental impact. The first step in any way sustainable materials is to lessen the demand for new materials. Instead of knocking down and rebuilding a home, it's worth trying where possible to refurbish or at least reuse materials from the existing home. Consider building smaller, well-designed, minimizing houses wastage by using prefabricated or modular elements and preventing unneeded surface finishes and linings. During construction and design, incorporate approaches that can make it simpler to adapt, reuse and finally dismantle the building. By choosing durable, zero-maintenance materials, you can minimize the need for new materials and finishes within the building's lifetime. The next thing is to choose materials with low environmental

impact put simply, a 'sustainable' material is one that will not impact negatively on non-renewable resources, the environment or real human health. Most products have a net-negative impact on the environment.

When looking at the environmental impact of any material or product. It is critical to decrease the negative influences of any materials you select, in another word, we should consider all phases of the life pattern - the upstream level (materials extraction and produce), the in-use or operational stage, and the downstream level (disposal or reuse).

Table II has indicated some of the research sources about reuse of waste material:

TABLE II. PUBLISHED RESEARCH RELATED TO REUSE OF WASTE MATERIAL

Ref.	Title of Article	Year	Result
6	Sustainable Use of Recycled Materials In Building Construction	2002	model to determine the degree of sustainability
7	Material efficiency: A white paper	2010	questions about the implementation of material efficiency
8	Development of sustainable construction material using industrial and agricultural solid waste: A review of waste-create bricks	2011	Enhance performance in terms of achieved lighter density, lower thermal conductivity and higher compressive strength of the various waste create brick (WCB)
9	Fired clay bricks manufactured by adding wastes as sustainable construction material -A review	2014	Depending on which standard is followed, almost all additives provide results in this paper the maximum allowed values.
10	Reuse of building materials	2015	method of constructing objects neglecting their lifetime and the possibility of cautious deconstruction
11	Durability against wetting-drying cycles of sustainable Lightweight	2015	fly ash improves flow ability of LCC mixture (before hardening) and durability of LCC material
12	Development of sustainable geo-polymer mortar using industrial	2016	palm-oil-fuel-ash (POFA)- fly-ash (FA)- blast-furnace-slag (BFS) and manufactured (M-sand) ,viable alternative to the conventional materials

Environmental impact of selecting green materials

The construction process can have a significant impact on environmental resources. Environmentally mindful development practices can markedly reduce site disturbance, the amount of waste sent to landfills, and the use of natural resources during building. Additionally, it may minimize the chance of adverse indoor quality of air in the finished building. In addition to yielding environmental benefits, many of these activities can lower project costs. Selecting environmentally preferable building materials is one way to improve a building's environmental performance. To be practical, however, environmental performance must be well balanced against financial performance. Even the most environmentally conscious building custom made or building materials maker will

ultimately want to ponder environmental benefits against economic costs. They would like to identify building materials that improve environmental performance with little or no increase in cost.

Table III introduces research source about environmental impact on green material:

TABLE III. ENVIRONMENTAL IMPACT ON GREEN MATERIALS

Ref.	Title of Article	Year	Result
13	Sustainable Building Material for Green Building Construction Conservation and refurbishing	2012	How sustainable building material can contribute to lessen the impact of environmental degradation

Durability of materials in sustainable construction.

Durability is the capability to last a long time without significant deterioration. A durable material helps the environment by conserving resources and lowering wastes and environmentally friendly impacts of repair and replacement unit. The development of alternative building materials depletes natural resources and can produce water and air pollution.

Producing materials with high durability prevents the repeated production costs so that in case of using the highly durable materials, the expenses of demolition, transport, recycle and reuse would be excluded. The related cost and energy can be spent in other parts of the construction. One method for recognizing the highly durable materials is testing and experimenting them, which there exists the specified codes and specifications in this regard.

Durability on materials in sustainable buildings are shown in table IV.

TABLE IV. DURABILITY OF MATERIALS IN SUSTAINABLE CONSTRUCTION

Ref.	Title of Article	Year	Result
14	life cycle sustainability and the transcendent quality of building materials	2007	Considers the possibility of creating durable works with ephemeral materials.
15	Optimization of Cementitious Material Content for Sustainable Concrete Mixtures	2012	A method to optimize the cement and fly ash contents in concrete on the basis of the hardened concrete properties testing and environmental effects.
16	Ultrahigh Performance Concrete: A Potential Material for Sustainable Marine Construction in View of the Service Life	2013	Constructed with UHPC have much longer service life than that of normal concrete (NC) and high performance concrete (HPC)
17	Achieving Sustainable Building Maintenance through Optimizing Life-Cycle Carbon, Cost, and Labor: Case in Hong Kong concrete subjected to elevated temperatures	2014	Suggest sensitivity analysis or fuzzy set theory should be incorporated.
18	Life cycle assessment (LCA) of sustainable building materials : an overview	2014	Sets out to present an overview of sustainable building materials and their impacts on the environment
19	A study of the durability of recycled green building materials in lightweight aggregate concrete artificial reef concrete containing high volume of ultrafine palm oil fuel ash	2015	Waste tire powder and waste liquid crystal display (LCD) glass sand use as recycled materials

Interaction between local economy and selecting local- green materials.

Understanding what a green material is, depends upon understanding relationships between nature and the Economy. It is an extremely complicated subject and always changing. What is considered a green material is also constantly changing. It's important to look closely at every individual product and material, certainly, but it is more efficient to look first at the building system. This is particularly clear whenever we see systems now being made to allow buildings to be easily dismantled rather than demolished. The context in which a material can be used is crucial. A conventional petrochemical-based building material might be used in innovations and structures that are quite ecological in overall impact. Similarly, a "green" material might be deployed or installed in destructive techniques completely negate their positive characteristics.

When salvaged and used again extremely standard materials might become a green material, it is a question of relationships that are multi-dimensional and constantly shifting.

That is an important question, and cannot be separated from the relevant question of how exactly we can reduce the use of materials. In a sense, they may be two articulations of the same dilemma: how to comprehend, revalue and reorganize flows throughout the market.

A green material is one which simultaneously does the most with the least, matches most within ecosystem techniques harmoniously, helps eliminate the use of other energy and materials, and contributes to the attainment of your service-based overall economy.

Due to the building industry's significant impact on the national overall economy, even humble changes that promote resource efficiency in building and businesses can make major contributions to economic wealth and environmental improvement.

Table V consist of research sources related interaction between local economy and local green materials:

TABLE V. RESEARCH SOURCES LOCAL ECONOMY AND LOCAL GREEN MATERIAL.

Ref.	Title of Article	Year	Result
20	Selecting Cost-Effective Green Building Products: Bees Approach	1999	Environmental and economic performance are combined into an overall performance measure using the ASTM standard for multi attribute decision analysis
21	Sustainable construction: some economic challenges	2000	Sustainable development across the national economy
22	A checklist for assessing sustainability performance of construction projects	2007	Provides a tool that enable all parties to assess the sustainability performance of the project
23	Optimization model for the selection of materials using a LEED-based green building rating system in Colombia	2009	mixed integer optimization model that incorporates design and budget constraints
24	Architects' considerations while selecting materials	2011	Basic material selection considerations for an architectural design project
25	Developed Sustainable Scoring System for Structural Materials Evaluation	2012	Sustainable development embraces issues in three dimensions: environmental, social, and economic

TABLE V. RESEARCH SOURCES LOCAL ECONOMY AND LOCAL GREEN MATERIAL. (CONTINUED)

Ref.	Title of Article	Year	Result
26	Economic and Environmental Evaluation Model for Selecting the Optimum Design of Green Roof Systems in Elementary Schools	2012	develop an optimal-scenario selection model that considers both the economic and the environmental effect in applying Green-roof systems to educational facilities
27	Evaluating Sustainable Building-Maintenance Projects: Balancing Economic, Social, and Environmental Impacts in the Case of Hong Kong	2015	Enhance the sustainability performance of the global building construction sector in overcoming the universal barriers
28	Selecting Globally Sustainable Materials: A Case Study Using Choosing by Advantages	2016	Practical advice for decision makers by demonstrating the application of a method, called choosing by advantages (CBA)
29	Sustainability Actions during the Construction Phase	2016	Construction Phase Sustainability Actions

Influence of energy consumption in selecting materials

Energy efficiency is one of the key objectives of green buildings [30]. There are numerous motivations to boost energy efficiency. Lowering energy use reduces energy costs. Reducing energy use is also seen as a solution to the problem of reducing greenhouse gas emissions. Buildings are constructed with a variety of building materials and each material consumes energy throughout its stages of manufacture, deconstruction, and use. There are several studies in the field of raw material extraction, transport, manufacture, assembly, installation as well as its disassembly, deconstruction and decomposition. The energy consumed in production is called the 'embodied energy' of the material and is the concern of energy consumption and carbon emissions on the other hand 'Functioning energy' means the expended in preserving the inside environment through procedures such as heating and cooling, light and operating gadgets [31].

Decreasing the vitality consumption of heating, ventilation and air conditioning (HVAC) systems is now remarkably significant anticipated to increasing cost of fossil fuels and environmental concerns [32]. According to the International Energy Agency, upgraded energy efficiency in structures, industrial functions and travel could reduce the world's energy needs in 2050 by one third, and help control global emissions of greenhouse gases.

Table VI has introduced research resources about influence of energy consumption in materials:

TABLE VI. RESEARCH RELATED TO ENERGY CONSUMPTION IN MATERIALS

Ref.	Title of Article	Year	Result
33	A review on energy conservation in building applications with thermal storage by latent heat using phase change materials	2004	Thermal energy storage systems incorporating phase change materials for use in building applications.

TABLE VI. RESEARCH RELATED TO ENERGY CONSUMPTION IN MATERIALS (CONTINUED)

Ref.	Title of Article	Year	Result
34	Development and performance evaluation of naturaltermal insulation materials composed of renewable resources	2011	develop a new insulating material from renewable resources with comparable building physics and mechanical properties
35	Renewable materials to reduce building heat loss: Characterization of date palm wood	2011	use palm wood material in the manufacture of thermal insulation
36	Life cycle assessment of building materials: Comparative analysis of energy and environmental impacts and evaluation of the eco-efficiency improvement potential	2011	the impact of construction products can be significantly reduced by promoting the use of the best techniques available and eco-innovation in production plants
37	Affordable construction towards sustainable buildings: review on embodied energy in building materials	2013	embodied energy and carbon
38	A multidisciplinary approach to sustainable building material selection: A case study in a Finnish context	2014	influence of building material choice on the embodied environmental impacts, environmental benefits and material cost of a building
39	Energy Efficient Materials for Sustainable Building	2014	energy efficient materials such as solar cells with super capacitors and efficient lighting materials in buildings
40	Development of green building standard in china	2014	Some suggestions are proposed for green building standards
41	Blue Star: The proposed energy efficient tall building in Chicago and vertical city strategies	2015	optimize the energy and resource efficiency design
42	Introduction of the standard for energy efficient building evaluation	2015	status of energy efficient building evaluation standards in China
43	Lightweight plasters containing plastic waste for sustainable and energy-efficient building	2015	reduction of energy consumption in construction
44	Insulation materials for commercial buildings in North America: An assessment of lifetime energy and environmental	2015	assessments of the lifetime environmental impacts of selected insulation materials for commercial buildings in North America
45	Sustainable target value design: integrating life cycle assessment and target value design to improve building energy and environmental performance	2015	combines life cycle assessment (LCA) and target value design (TVD) to rapidly produce more sustainable building designs
46	Multi objective optimization of mix proportion for a sustainable construction material	2015	mix proportion for designing the sustainable material
47	Energy Efficient Sustainable Building Materials: An Overview	2015	understand the role of sustainable building materials and use them intelligently
48	Advanced energy storage materials for building applications and their thermal performance characterization: A review	2016	the building incorporated phase change materials has ability to reduce energy usage and improve building comfort

TABLE VI. RESEARCH RELATED TO ENERGY CONSUMPTION IN MATERIALS (CONTINUED)

Ref.	Title of Article	Year	Result
49	Building Information Modelling for analysis of energy efficient industrial buildings - A case study	2016	the potentials and deficits of the modeling, analysis and optimization of energy efficient industrial buildings using BIM
50	Environmental performance of energy systems of residential buildings: Toward sustainable communities	2016	the analysis of the production, disposal and transportation of the materials used for the manufacturing processes of the building's energy systems
51	In-use office building energy characterization through basic monitoring and modelling	2016	proposing some modifications on the existing ISO 9869 method and co-heating method to make them usable with basic energy monitoring data of in-use buildings and obtain their main thermal characteristics
52	Simulating the Inter-Building Effect on energy consumption from embedding phase change materials in building envelopes	2016	embedded building envelopes could potentially mitigate negative thermal-energy impacts
53	System impact of energy efficient building refurbishment within a district heated region	2016	the impact that energy efficient refurbishment of multi-family buildings has on the district heating and the electricity production
54	User satisfaction and well-being in energy efficient office buildings: Evidence from cutting-edge projects in Austria	2016	energy use and well-being in energy efficient office buildings

Choosing materials and components with lower carbon emission and prevalence the low carbon building technology

Low-carbon buildings (LCB) are structures which are constructed with GHG lowering specifically. So by definition, a LCB is a building which emits less GHG than a regular building. The developed professional country should use the production technology that reduces the emission of CO2, to be able to protect the environment while maintaining the financial growth. The CO2 and ozone in the atmosphere can absorb the glowing heat from sunlight and avoiding its escape from the earth, therefore empowering the atmosphere of the natural greenhouse result. If the density of greenhouse gases such as CO2 rises, the absorbed radiant heat shall increase and heat given out by the planet earth will be reduced, thus resulting in global warming. Global warming shall melt the glacier, improve the sea level, reduce the continental area, set up harbors and ruin the marshland and river plain, because of this, getting great unwanted effects to the Economic of coastland area. Moreover, global warming shall shift the climate zone to high latitude, change the ecosystem using the increase and area infectious diseases and the consumption of ozonosphere. The average temperature of the earth's surface in China has increased by 1.1 degrees of centimeter over the last 100 years. Going back 30 years, the sea level has increased by 90mm typically. The low-carbon technology has relationships with electricity sector, travel sector, structure sector, chemistry industry and a great many other new systems. From the real point of low-carbon building technology, it ought to be taken into

consideration of choosing materials and components with lower carbon emission during the designing and

development process [55].

Table VII represents some of research sources about materials with low carbon emission:

TABLE VII. RESEARCH SOURCES ON MATERIALS WITH LOWER CARBON EMISSION

Ref.	Title of Article	Year	Result
56	Emissions of Volatile Organic Compounds from Several Green and Non-Green Building Materials A Comparison	2005	measured and compared the volatile organic compound VOC emissions from decking wood pressure treated decking wood ceramic floor tile
55	Discussion on low-carbon economy and low-carbon building technology	2009	introduced low-carbon economy and low-carbon technology
57	Regulations and robust low-carbon buildings	2009	Naturally ventilated
58	Performance-based low carbon building technology screening	2012	low carbon technology screening under different building function and climate conditions
59	A review of benchmarking in carbon labelling schemes for building materials	2015	consumer-purchasing habits to low-carbon alternatives
60	An investigation on life-cycle energy consumption and carbon emissions of building space heating and cooling system	2015	System operation stage is the key stage of life cycle energy consumption and carbon emissions
61	Comparing carbon emissions of precast and cast-in-situ construction methods - A case study of high-rise private building	2015	recommended to adopt precast concrete in building construction
62	Design strategies for low embodied carbon and low embodied energy buildings: principles and examples	2015	presents five examples of environmental optimizations of construction elements, structures and whole buildings
63	Low carbon buildings: Sensitivity of thermal properties of opaque envelope construction and glazing	2015	investigated the sensitivity of building envelope construction comprising multi-layered wall construction
64	Methodological challenges and developments in LCA of low energy buildings: Application to biogenic carbon and global warming assessment	2015	life cycle assessment results for low energy buildings
65	The indispensability of good operation & maintenance (O&M) manuals in the operation and maintenance of low carbon buildings	2015	need for a change in the way O&M manuals are being prepared particularly for LCBs
66	What leads to low-carbon buildings ?A china study	2015	low carbon building developments
67	A detailed analysis of the embodied energy and carbon emissions of steel-construction residential buildings in China	2016	the embodied energy consumption of steel members, concrete and cement account for more than 60% of the total energy consumption of all building components
68	A novel roof type heat recovery panel for low-carbon buildings: An experimental investigation	2016	results of a novel heat recovery system developed for low-carbon buildings

TABLE VII. RESEARCH SOURCES ON MATERIALS WITH LOWER CARBON EMISSION (CONTINUED)

Ref.	Title of Article	Year	Result
69	Assessing the impacts of preferential procurement on low-carbon	2016	How bid discounts change owners' procurement costs and the magnitudes of emission mitigation.
70	Challenges for energy and carbon modelling of high-rise buildings: The case of public housing in Hong Kong	2016	challenges for energy and carbon modelling of high-rise buildings
71	The effect of carbon reduction regulations on contractors' awareness and behaviours in China's building sector	2016	carbon reduction regulations positively correlate with carbon reduction awareness and behaviours
72	Towards a computer based framework to support the low carbon building design process	2016	integrate the range of activities, tools and information that constitute the low carbon building design process

Using green components for providing green concrete as a popular material in construction

Concrete is one of the most trusted building materials. CO2 emitted from concrete creation is one of the man-made source of CO2 in the atmosphere; consequentially, its environmental burden is considerable in conditions of environmental emissions. Therefore, investigations and explorations on the development of greening technology for concrete vigorously have been done by researchers [73].

Cement, which is the concrete constituent in charge of the vast amount of energy use and Green House Gas (GHG) emissions has been partly replaced by Supplementary Cementations Materials (SCMs) in such “green” mixes. Also, there were numerous studies that looked into the alternative of aggregates in cement by solid spindle, for example by Thomas et al. (2014) who investigated the suitability of misuse tires in cement as an incomplete substitution of natural fine sand [74]. Extensive research works have been carried out to utilize farming waste materials such as those from palm oil, coconut, sugarcane as well as the paddy industry and these studies signify potential of utilizing such materials in concrete. Recently, there is an emerging trend in utilizing alternative farming spend for concrete, such as those from agriculture (bamboo, banana, corn, whole wheat, sisal, lawn etc.) (Pappu et al., 2007; Karade, 2010) as well as aquaculture farming, such as oyster, cockle, clam and periwinkle (Prusty and Patro, 2015). Commonly, researchers have applied agricultural farming residues as partial cement replacement material in concrete [75].

Table VIII shows a list of research related to sustainable components for providing green concrete:

TABLE VIII. RESEARCH SOURCES ON GREEN CONCRETE WITH GREEN COMPONENTS

Ref.	Title of Article	Year	Result
74	A life-cycle approach to environmental, mechanical, and durability properties of “green” concrete mixes with rice husk ash	2016	Fly ash, rice husk ash (RHA) a highly-reactive pozzolanic material
75	Green concrete partially comprised of farming waste residues: a review	2016	Usage of farming waste materials in different form in concrete, such as partial cement and aggregate replacement

TABLE VIII. RESEARCH SOURCES ON GREEN CONCRETE WITH GREEN COMPONENTS (CONTINUED)

Ref.	Title of Article	Year	Result
76	Engineering and transport properties of high-strength green concrete	2012	The engineering and transport properties of high-strength green concrete (HSGC) containing up to 60% of ultrafine palm oil fuel ash
77	Green building materials evaluation and empirical research based on the regional endowment Materials: A Comparison waste materials concrete subjected to elevated temperatures	2012	Introduces the data envelope method to solve the evaluation of green building materials
78	The use of stabilised Spanish clay soil for sustainable construction materials 2012 Engineering Geology	2012	Producing an economical, ecological and sustainable building material
79	Investigating the properties of lightweight concrete containing high	2013	Recycled green building materials can increase the slump of lightweight concrete
80	Green recycled aggregate concrete	2013	Concrete made with recycled concrete aggregate, low cement content and high content of different mineral supplements
81	Investigating the properties of lightweight concrete containing high contents of recycled green building materials	2013	Influence of high contents of recycled aggregate and recycled pozzolanic admixtures on the properties of the concrete.
82	Environmental assessment of green concrete containing natural zeolite on the global warming index in marine environments	2014	Environmental impact of concrete containing zeolite and conventional one on the global warming
83	Nano-mechanical behavior of a green ultra-high performance concrete	2014	Most fly ash and about half of cement remain un reacted after curing. Theses un reacted particles show hight mechanical behavior
84	Static properties and impact resistance of a green Ultra-High Performance Hybrid Fibre Reinforced Concrete (UHPHFRC): Experiments	2014	Static properties and impact resistance of a ‘‘green’’ Ultra-High Performance Hybrid Fiber Reinforced Concrete
85	The advantage of natural polymer modified mortar with seaweed: green construction material innovation for sustainable concrete	2014	That natural polymer modified mortar with seaweed powder
86	Toward green concrete for better sustainable environment contents of recycled green building material	2014	Substituting relatively high percentage of cement by fly ash (upto 100%), the use of other natural pozzolans
87	A study of the durability of recycled green building materials in lightweight aggregate concrete	2015	waste tire powder and waste liquid crystal display (LCD) glass sand are used as recycled materials
88	Blue is the new green - Ecological enhancement of concrete based coastal and marine infrastructure	2015	the ability of design substrate alterations to facilitate competition for space between local and invasive species on Concrete based coastal and marine infrastructure (CMI)
89	Designing more sustainable and greener self-compacting concrete	2015	Mixing proportion parameters of self-compacting concrete (SCC) and its environmental impact and thus developing more greener SCC.
90	Investigating the properties of lightweight concrete containing high	2015	The removal of contaminant from recycled aggregates is a more

TABLE VIII. RESEARCH SOURCES ON GREEN CONCRETE WITH GREEN COMPONENTS (CONTINUED)

Ref.	Title of Article	Year	Result
91	Usage of green concrete technology in civil engineering contents of recycled green building materials	2015	New ecological geopolymer binders
92	Influence of recycled coarse aggregates on normal and high performance	2016	Recycled concrete aggregates
93	On the use of blast furnace slag and steel slag in the preparation of green	2016	The density of developed green artificial reef concrete(GARC) is 2765.5 kg/m3 higher than normal concrete with a typical density of 2400 kg/m3.
94	Palm oil fuel ash as potential green micro-filler in polymer concrete	2016	The potential of utilizing an agricultural waste; palm oil fuel ash (POFA) as micro-filler in polymer concrete
95	Retrofitting of damaged reinforced concrete beams with a new green	2016	Green-USM-Reinforced Concrete
96	Developing Sustainable High Strength	2016	Development of high strength concrete by using both local materials and recycled concrete aggregate
97	Looking for Oil free Building Materials Clay Pipes to Replace Polymer Pipes 2016 Procedia Technology	2016	Search for alternative oil-free building materials

Use of in-site materials and recycled materials as a raw material for products

With the progression of the low-carbon building movement, research and development are significantly devoting. The significant amount of resources to intentionally promote and prioritize the use of local and recycled building materials in mainstream practice. Recent studies now claim that the use of local and recycled building materials supplies the advantage of minimizing CO2 emissions, producing healthier buildings, while also building up the neighborhood market [3].

This part focuses on two aspects of ecological construction building materials; local use of constituent materials and the use of recycled materials. Building materials dispatch long ranges and internationally oftentimes usually, raise the cost of the material. Therefore by focus on local materials, construction projects can become more affordable to wide selection of construction applications. Using local products decreases emissions associated with long shipping routes drastically. Replacing new materials used in production with recycled materials drastically increases the sustainable impact of the material. By using discarded waste material in new construction, the strain for new and virgin materials is alleviated while also lessening the demand for landfill space [96].

Some studies about this matter have been introduced in table IX:

TABLE IX. PUBLISHED ARTICLES RELATED TO USE OF IN-SITE AND RECYCLED MAT

Ref.	Title of Article	Year	Result
98	Recycled construction and demolition materials in permeable pavement systems: geotechnical and hydraulic characteristic	2014	Geotextile layer increases pollutant removal efficiency of the construction and demolition (C&D)materials
99	Environmental life cycle assessment of lightweight concrete to support recycled materials selection for sustainable design	2016	Convert ornamental stone and ceramic wastes into raw resources for producing new materials
100	Comparative environmental evaluation of aggregate production from recycled waste materials and virgin sources by LCA	2016	Recycled aggregates production from construction and demolition C&D waste and waste glass and saving of 58% non-renewable energy consumption

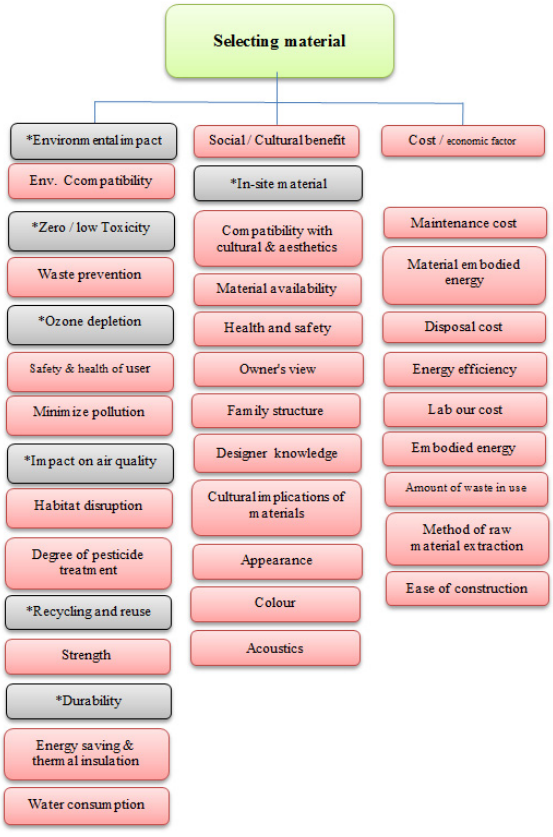
DISCUSSION

Nowadays, in order to produce building materials, due to the low price of raw materials, there is no tendency to use environment-friendly materials. The least damaging in some societies which unsystematically applying and exploiting natural resources are irrecoverable damages the environment, whose effects would remain for so many years. Understanding this fact that damage to the environment would cause hazards in daily and future life and in order to solve this issue, some decisions must be made to prevent progress continuance. In this respect, using and producing green materials through persuasive and mandatory codification by stakeholder organizations in building area should be increased.

However, before performing any action in this respect, it is necessary to make culture, provide production base, and train involved agents and citizens for using green materials in construction. For this purpose, at first the environmental advantages and necessity of energy conservation as the most important reasons for using green materials must be explained for societies and inform them on protecting resources and healthy life situations for future generations. In this respect, we could proceed to creat an essential base to produce green materials by codifying tax laws, investment incentives, funding and lending and also codifying environmental regulations, so that could promote the community awareness on this respect by paying more attention to education and awareness. Therefore, the necessary culture, making could be taking place either by organizing meetings and conferences in construction area or using specialized press and newspapers and cooperation of mass media such as radio and television. In the following classification (Fig 1) there is some category as a guideline for selecting sustainable materials in construction building. This article introduces several of them and there are many subjects for future research. One of the most considerable issues on this topic would be the amount of water consumption in the production and utilization of material in constructing buildings.

CONCLUSIONS

Base on a systematic review of journal publications on green material, this research introduces the eco-efficient materials and their benefits to our environment. Then explored potentials for achieving sustainable construction by using eco-efficient materials. In this manner, eight categories for discussing about using and selecting green materials for construction have been provided and their benefits highlighted. There are many different reported benefits for using green materials in construction, one of these benefits is the potential for reducing G.H.G emission to be able to protect the environment and reduce global warming. In order to solve real world problems and improve environmental protection while maintaining the financial growth, the review also highlights using of local and recycled materials as a raw material for products. This study tries to consider a need for all stakeholder organizations' participation in this area by planning and changing the attitude of replacing the usage of raw productive materials with green materials in the construction industry. Life cycle assessment items for each step as above can be applied to the material and resource items in green building, and the database establishment is required to build the database and set up reference values on a variety of building materials for the future life cycle assessment. Therefore, people participation, structure modification and necessity of applying green materials could be effective actions in reach stability in construction building.



*Topic contents in this article

FIGURE I. GUIDE LINE FOR SELECTING SUSTAINABLE MATERIALS IN CONSTRUCTION

REFERENCES

[1] P.O. Akadiri, P.O. Olomolaiye, E.A. Chinyio, “Multi-criteria evaluation model for the selection of sustainable materials for building projects”, Automation in Construction 30, pp. 113-125, 2013.

[2] E. Franzonia, “Materials selection for green buildings: which tools for engineers and architects?”, International Conference on Green Buildings and Sustainable Cities , Procedia Engineering 21, pp. 883 - 890, 2011.

[3] I. Ogunkah, J. Yang, “Investigating Factors Affecting Material Selection The Impacts on Green Vernacular Building Materials in the Design-Decision Making Process”, Buildings 2, pp. 1-32, 2012.

[4] G. K. C. DING, “Life cycle assessment LCA of sustainable building materials an overview”, Woodhead Publishing Limited, 2014.

[5] Z. Alwan, P. Jones, P. Holgate,“Strategic sustainable development in the UK construction industry, through the framework for strategic sustainable development, using Building Information Modeling”, Journal of Cleaner Production, pp. 1-10, 2016.

[6] Ir. Gabriella, M.T. Janssen, Ch.F. Hendriks, “Sustainable Use of Recycled Materials In Building Construction”, Advances in Building Technology, pp. 1399 - 1406, 2002.

[7] J. M. Allwooda, M.F .Ashbya, T.G. Gutowskib, E. Worrell, “Material efficiency: A white paper”, Resources,ConservationandRecycling 55,pp 362-381, 2011.

[8] S. Raut, R. Ralegaonkar, S. Mandavgane, “Development of sustainable construction material using industrial and agricultural solid waste: A review of waste-create bricks”, Construction and Building Materials 25, pp. 4037-4042, 2011.

[9] P. Munoz Velasco, M.P. Morales Ortiz, M.A. Mendivil Giro, L. Munoz Velasco, “Fired clay bricks manufactured by adding wastes as sustainable construction material - A review”, Construction and Building Materials 63,pp. 97-107, 2014.

[10] J. Charytonowicz, M. Skowronski, “Reuse of building materials”6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015) and theAffiliated Conferences, AHFE 2015, Procedia Manufacturing 3,pp. 1633 - 1637, 2015.

[11] A. Neramitkornburi, S. Horpibulsuk, S. L. Shen, A. Chinkulkijniwat, A. Arulrajah, M. M. Disfani, “Durability against wetting-drying cycles of sustainable Lightweight Cellular Cemented construction material comprising clayand fly ash wastes”, Construction and Building Materials 77 ,pp. 41-49, 2015.

[12] I. I Bashar, U. J Alengaram, M. Z Jumaat, A. Islam, “Development of sustainable geopolymer mortar using industrial waste materials”, Advances in Functional Materials (Conference 2015), AFM 2015, Materials Today: Proceedings 3,pp. 125 - 129, 2016.

[13] U. A. Umar, M. F. Khamidi ,“Sustainable Building Material for Green Building Construction Conservation and refurbishing“,Management in Construction Research Association (MiCRA) Postgraduate Conference, 2012.

[14] E. P. Mora, “Life cycle, sustainability and the transcendent quality of building materials”, Building and Environment 42,pp. 1329-1334, 2007.

[15] R. Liu, Stephan A. Durham, Kevin L. Rens, A. Ramaswami, “Optimization of Cementitious Material Content for Sustainable Concrete Mixtures”, J. Mater. Civ. Eng, pp. 745-753, 2012.

[16] C. GU, W. Sun, L. Guo, Q. Wang, “Ultrahigh Performance Concrete: A Potential Material for Sustainable Marine Construction in View of the Service Life”, Applied Mechanics and Materials Vols. 438-439 ,pp. 108-112, 2013.

[17] Y. H. Chiang, Lu Zhou, Jing Li, P. T. I. Lam, K. W. Wong, “Achieving Sustainable Building Maintenance through Optimizing Life-Cycle Carbon, Cost, and Labor: Case in Hong Kong”, J. Constr. Eng. Manage ,pp. 05014001-1- 05014001-10, 2014.

[18] G. K. C. Ding, “Life cycle assessment (LCA) of sustainable building materials: an overview”, Woodhead Publishing Limited, 2014 .

[19] Li-Jeng Hunag, Her-Yung Wang, Shi-Yang Wang, “A study of the durability of recycled green building materials in lightweight aggregate concrete”, Construction and Building Materials 96, pp. 353-359, 2015.

[20] B.C. Lippiatt “Selecting Cost-Effective Green Building Products: Bees Approach”, Journal of Construction Engineering and Management, 1999.

[21] R. Bon, K. Hutchinson, “Sustainable construction: some economic challenges”, Building Research & Information, 2000.

[22] L.Y. Shen, J.L. Hao, V. W.Y. Tam, H. Yao, “A checklist for assessing sustainability performance of construction projects”, 2007.

[23] D. C. Lacouture, J. A. Sefair, L. F. rez, A. S. L. Medaglia, “Optimization model for the selection of materials using a LEED-based green building rating system in Colombia”, Building and Environment , 2009.

[24] L. Wastiels, I. Wouters “Architects considerations while selecting materials”, Materials and Design, 2011.

[25] E.S. Bakhoum, D.C. Brown, “Developed Sustainable Scoring System for Structural Materials Evaluation”, Journal of Construction Engineering and Management, Vol. 138, No. 1, 2012.

[26] J. Kim, T. Hong, C. W. Koo, “Economic and Environmental Evaluation Model for Selecting the Optimum Design of Green Roof Systems in Elementary Schools”, Environmental Science & Technology, American Chemical Society, 2012.

[27] Y. H. Chiang, V. J. Li, L. Zhou, F. Wong, P. Lam, “Evaluating Sustainable Building-Maintenance Projects: Balancing Economic, Social, and Environmental Impacts in the Case of Hong Kong”, Journal of Construction Engineering and Management, ASCE, 2015.

[28] P. Arroyo1, I.D. Tommelein, G. Ballard, “Selecting Globally Sustainable Materials: A Case Study Using Choosing by Advantages”, Journal of Construction Engineering and Management, ASCE, 2016.

[29] J. T. O’Connor, N. Torres, J. Woo, “Sustainability Actions during the Construction Phase”, Journal of Construction Engineering and Management, ASCE. 2016.

[30] M. Ornetzeder, M.Wicher, J .S.Berger, “User satisfaction and well-being in energy efficient office buildings: Evidence from cutting-edge projects in Austria”, Energy and Buildings, 118, pp. 18-26, 2016.

[31] L. F. Cabeza1, C. Barreneche1, L. Miro, M. Martı´nez, A. Ferna´ ndez, D. U. Vorsatz, ”Affordable construction towards sustainable buildings: review on embodied energy in building materials”, Environmental Sustainability, pp. 229-236, 2013.

[32] P.M. Cuce, E. Cuce, S. Riffat,“A novel roof type heat recovery panel for low carbon buildings An experimentali nvestigation”,Energy and Buildings 113, PP. 133-138, 2016.

[33] A. M. Khudhair, M. M. Farid, “A review on energy conservation in building applications with thermal storage by latent heat using phase change materials” , Energy Conversion and Management 45, pp. 263-275, 2004.

[34] A. Korjenic, V. Petranek, J. Zach, J. Hroudova, “Development and performance evaluation of natural thermal-insulation materials composed of renewable resources”, Energy and Buildings 43 ,pp. 2518-2523, 2011.

[35] B. Agoudjila, ∗, A. Benchabaneb, A. Boudennec, L. Ibosc, M. Foisc, “Renewable materials to reduce building heat loss: Characterization of date palm wood”, Energy and Buildings 43, pp. 491-497, 2011.

[36] I. Z. Bribián, A. V. Capilla, A. A. Usón, “Life cycle assessment of building materials: Comparative analysis of energy and environmental impacts and evaluation of the eco-efficiency improvement potential” , Building and Environment 46, pp. 1133-1140, 2011.

[37] L. F Cabeza, C. Barreneche, L. Miro, M.Martinez., A I.Ferna ndez, D. Urge-Vorsatz, “Affordable construction towards sustainable buildings: review on embodied energy in building materials” , Environmental

Sustainability, pp. 229-236, 2013.

[38] A. Takano, M. Hughes, S. Winter, “A multidisciplinary approach to sustainable building material selection: A case study in a Finnish context”, Building and Environment 82 , pp. 526-535, 2014.

[39] Akin C, “Energy Efficient Materials for Sustainable B uilding”, 1st International Electronic Conference On Materials, 2014.

[40] L. Ye, Z. Cheng, Q. Wang, H. Lin, C. Lin, B. Liu, “Developments of Green Building Standards in China”, Renewable Energy, pp. 1-8, 2014.

[41] X. Wang, X. Liu, “Blue Star: The proposed energy efficient tall building in Chicago and vertical city strategies”, Renewable and Sustainable Energy Reviews 47,pp. 241-259, 2015.

[42] W. Qingqin, Z. Miao, “Introduction of the standard for energy efficient building evaluation”, Sustainable Cities and Society 14,pp. 1-4, 2015.

[43] V. Corinaldesi, J. Donnini, A. Nardinocchi, “Lightweight plasters containing plastic waste for sustainable and energy-efficient building”, Construction and Building Materials 94, pp. 337-345, 2015.

[44] K. Biswas Som S. Shrestha Mahabir S. Bhandari Andre O. Desjarlais, “Insulation materials for commercial buildings in North America: An assessment of lifetime energy and environmental impacts”, 2015.

[45] S. V. Russell-Smith, M. D. Lepech, R. Fruchter, Y. B. Meyer, “Sustainable target value design: integrating life cycle assessment and target value design to improve building energy and environmental performance” , Journal of Cleaner Production 88, pp. 43-51, 2015.

[46] M. Madurwar, V. Sakhare, R. Ralegaonkar, “Multi objective optimization of mix proportion for a sustainable construction material”, Procedia Engineering 118, pp. 276 - 283, 2015.

[47] A. Hussain, M. Arif Kamal, “Energy Efficient Sustainable Building Materials: An Overview”, Key Engineering Materials Vol. 650, pp. 38-50, 2015.

[48] T. Khadiran, M. Z. Hussein, Z. Zainal, R. Rusli, “Advanced energy storage materials for building applications and their thermal performance characterization: A review”, Renewable and Sustainable Energy Reviews 57 ,pp. 916-928, 2016.

[49] G. Gourlis, I. Kovacic, “Building Information Modelling for analysis of energy efficient industrial buildings - A case study”, Renewable and Sustainable Energy Reviews, 2016.

[50] D. Anastaselos, S. Oxizidis, A. Manoudis, A. M. Papadopoulos, “Environmental performance of energy systems of residential buildings: Toward sustainable communities”, Sustainable Cities and Society 20,pp. 96-108, 2016.

[51] A. Erkoreka, E. Garcia, K. Martin, J. Teres-Zubiaga, L. Del Portillo, “In-use office building energy characterization through basic monitoring and modeling”, Energy and Buildings 119, pp. 256-266, 2016.

[52] Y. Han, J. E. Taylor, “Simulating the Inter-Building Effect on energy consumption from embedding phase change materials in building envelopes”, Sustainable Cities and Society, 2016.

[53] T. Lidberg, T. Olofsson, L. Trygg, “System impact of energy efficient building refurbishment within a district heated region”, Energy 106, pp. 45-53, 2016.

[54] M. Ornetzeder, M. Wicher, J. Suschek-Berger, “User satisfaction and well-being in energy efficient office buildings: Evidence from cutting-edge projects in Austria” , Energy and Buildings 118. pp. 18-26, 2016.

[55] X.G. Shuai, H.Q. Li, “Discussion on low-carbon economy and low-carbon building technology”, Natural Science 1, pp. 37-40, 2009.

[56] J. P. James, X. Yang, “Emissions of Volatile Organic Compounds from Several Green and Non-Green Building Materials: A Comparison” , Indoor Built Environ, pp. 69-74, 2005.

[57] P. Tuohy, “Regulations and robust low-carbon buildings Building Research & Information 37(4), pp. 433-445, 2009.

[58] L. Liao, H. Wang, “Performance-based low carbon building technology screening”, International Journal of Low-Carbon Technologies , pp. 174-180, 2012.

[59] P. Wu , Y. Feng , J. Pienaar, B.Xia ,“A review of benchmarking in carbon labelling schemes for building materials“,Journal of Cleaner Production, pp. 1e10 , 2015.

[60] L.Xiang-Li, R.Zhi-Yong, D. Lin,“An investigation on life-cycle energy consumption and carbon emissions of building space heating and cooling systems“,Renewable Energy 84, pp. 124e129, 2015.

[61] Y.H.Dong, L. Jaillon, P. Chu, C.S. Poon,“ Comparing carbon emissions of precast and cast-in-situ construction methods - A case study of high-rise private building “,Construction and Building Materials 99, pp. 39-53, 2015.

[62] A. Lupíšek, M. Vaculíkováa, Š. Mancíka, J. Hodkováa, Jan Ružicka, “Design strategies for low embodied carbon and low embodied energy buildings: principles and examples”, Energy Procedia 83, pp. 147 - 156, 2015.

[63] R. M. Dowd, M. Mourshed, “Low carbon buildings: Sensitivity of thermal properties of opaque envelope construction and glazing”, Energy Procedia 75, pp. 1284 - 1289, 2015.

[64] M. Fouquet, A. Levasseur, M. Margni, A. Lebert, S. Lasvaux, B. Souyri, C. Buhe, M. Woloszyn, “Methodological challenges and developments in LCA of low energy buildings: Application to biogenic carbon and global warming assessment”, Building and Environment 90, pp. 51-59, 2015.

[65] O.L. Frank, S.A. Omer, B. Riffat, B. Mempouo,“The indispensability of good operation & maintenance (O&M) manuals in the operation and maintenance of low carbon buildings”,Sustainable Cities and Society 14, PP. 1-9, 2014.

[66] Q. Shi, T.Yua, J.Zuo, “What leadstolow-carbonbuildings? A China Study”, Renew able and Susta in able Energy Reviews 50, pp. 726-734, 2015.

[67] Xing Su, Xu Zhang, “A detailed analysis of the embodied energy and carbon emissions ofsteel-construction residential buildings in ChinaXing” Energy and Buildings 119, pp. 323-330, 2016.

[68] P. M. Cuce, E. Cucea, S. Riffat, “A novel roof type heat recovery panel for low-carbon buildings:An experimental investigation”, Energy and Buildings 113, pp. 133-138, 2016.

[69] X. Liu, Q. Cui, “Assessing the impacts of preferential procurement on low-carbon building”, Journal of Cleaner Production 112, pp. 863-871, 2016.

[70] W. Pan, H. Qin, Y. Zhao,” Challenges for energy and carbon modeling of high-rise buildings:The case of public housing in Hong KongWei”, Resour Conserv Recy, 2016.

[71] L. Zhang, J. Zhou,“The effect of carbon reduction regulations on contractors' awareness and behaviors in China's building sector”, Journal of Cleaner Production 113, PP. 93-101, 2016.

[72] A. Dunsdon,A. Day, P. Jones, “Towards a computer based framework to support the low carbon building design process”, International Journal of Low Carbon Technologies, pp. 1-4, 2016 .

[73] G. Long, Y. Gao, Y. Xie, “Designing more sustainable and greener self-compacting concrete”, Construction and Building Materials 84, pp. 301-306, 2015.

[74] A. P. Gursel, H. Maryman, C. Ostertag, “A life-cycle approach to environmental, mechanical, and durability properties of “green” concrete mixes with rice husk ash” , Journal of Cleaner Production 112, pp. 823-836, 2016.

[75] K. H. Mo, U. J. Alengaram, M. Z. Jumaat, S. P.Yap, S. C. Lee, “Green concrete partially comprised of farming waste residues: a review”, Journal of Cleaner Production 117, pp. 122-138, 2016.

[76] M.A. Megat Johari , A.M. Zeyad, N. Muhamad Bunnori, K.S. Ariffin, “Engineering and transport properties of high-strength green concrete containing high volume of ultrafine palm oil fuel ash”, Construction and Building Materials 30, pp. 281-288, 2012.

[77] L. Lia , P. Wang, H. Wang, M. Zhang,” Green building materials evaluation and empirical research based on the regional endowment”, AASRI Procedia 3, pp. 381 - 386, 2012.

[78] L. Miqueleiz , F. Ramírez, A. Seco, R.M. Nidzam, J.M. Kinuthia, A. Abu Tair, R. Garcia, “The use of stabilised Spanish clay soil for sustainable construction materials”, Engineering Geology, pp. 9-15, 2012.

[79] S. H. Chen, H. Y. Wang, J. W Jhou, “Investigating the properties of lightweight concrete containing high contents of recycled green building materials”, Construction and Building Materials 48,pp. 98-103, 2013.

[80] V. Radonjanin, M. Malešev, S. Marinkovic´, A. E. S. A. Malty, “Green recycled aggregate concrete”, Construction and Building Materials 47, pp. 1503-1511, 2013.

[81] S.H. Chen, H. Y. Wang, J. W Jhou, “Investigating the properties of lightweight concrete containing high contents of recycled green building materials”, Construction and Building Materials 48, pp. 98-103, 2013.

[82] M. Valipour, M. Yekkalar, M. Shekarchi, S. Panahi, “Environmental assessment of green concrete containing natural zeolite on the global warming index in marine environments”, Journal of Cleaner Production 65, pp. 418-423, 2014.

[83] S. Zhao, W. Sun, “Nano-mechanical behavior of a green ultra-high performance concrete”, Construction and Building Materials 63, pp. 150-160, 2014.

[84] R. Yu, P. Spiesz, H.J.H. Brouwers, “Static properties and impact resistance of a green Ultra-High Performance Hybrid Fibre Reinforced Concrete (UHPHFRC): Experiments and modeling” , Construction and Building Materials 68, pp. 158-171, 2014.

[85] M. I. R. Susilorinia, H. Hardjasaputra, S. Tudjono, G. Hapsari, R. WahyuS, G. Hadikusumo, J. Sucipto, “The advantage of natural polymer modified mortar with seaweed: green construction material innovation for sustainable concrete” , Procedia Engineering 95, pp. 419 - 425, 2014.

[86] B. Suhendro, “Toward green concrete for better sustainable environment”, Procedia Engineering 95, pp. 305-320, 2014.

[87] L. J. Hunag, H. Y. Wang, S. Y. Wang, “A study of the durability of recycled green building materials in lightweight aggregate concrete”, Construction and Building Materials 96, pp. 353-359, 2015.

[88] S. Ido, P. F. Shimrita, “Blue is the new green - Ecological enhancement of concrete basedcoastal and marine infrastructure”, Ecological Engineering 84, pp. 260-272, 2015.

[89] G. Long, Y.G. Youjun Xie, “Designing more sustainable and greener self-compacting concrete”, Construction and Building Materials 84, pp. 301-306, 2015.

[90] S.H. Chen, H.Y. Wang, J.W. Jhou, ” Investigating the properties of lightweight concrete containing high contents of recycled green building materials”, Construction and Building Materials 48, pp. 98-103, 2013.

[91] T. Błaszczyński, M. Królb, “Usage of green concrete technology in civil engineering”, Operational Research in Sustainable Development and Civil Engineering - meeting of EURO working group and 15th German-Lithuanian-Polish colloquium (ORSDCE 2015), Procedia Engineering 122, pp. 296 - 301, 2015.

[92] C. Laneyrie, A.L. Beaucour , M. F. Green, R. L. Hebert, B. Ledesert, A. Noumowea, “Influence of recycled coarse aggregates on normal and high performance concrete subjected to elevated temperatures”, Construction and Building Materials 111,pp. 368-378, 2016.

[93] X. Huang, Z. Wang, Y. Liu, W. Hu, W. Ni, “On the use of blast furnace slag and steel slag in the preparation of green artificial reef concrete”, Construction and Building Materials 112, pp. 241-246, 2016.

[94] N. H.A. Khalid, M. W. Hussin, J. Mirza, N. F. Ariffin, M. A. Ismail, H. S. Lee, A. Mohamed, R. Putra Jaya,” Palm oil fuel ash as potential green micro-filler in polymer concrete” , Construction and Building Materials 102, pp. 950-960, 2016.

[95] M.A.A. Aldahdooh, N. Muhamad Bunnori, M.A. Megat Johari, A. Jamrah, Ali Alnuaimi, “Retrofitting of damaged reinforced concrete beams with a new green cementitious composites material” , Composite Structures 142, pp. 27-34, 2016.

[96] A. Torres, A. Burkhart, “Developing Sustainable High Strength Concrete Mixtures Using Local Materials and

Recycled Concrete", Materials Sciences and Applications, pp. 128-137, 2016.

[97] R. Salhaa, F. V. Tosaa, "Looking for Oil-free Building Materials Clay Pipes to Replace Polymer Pipes", Procedia Technology 22, pp. 343 - 350, 2016.

[98] Rahman MA, Imteaz MA, Arulrajah A, Piratheepan J, Disfani MM, "Recycled construction and demolition materials in permeable pavement systems: Geotechnical and hydraulic characteristics" Journal of Cleaner Production, 2014.

[99] L. Napolano, C. Menna, S. F. Graziano, D. Asprone, M. D'Amore , R. D. Gennaro, M. Dondi," Environmental life cycle assessment of lightweight concrete to support recycled materials selection for sustainable design", Construction and Building Materials 119, pp. 370-384, 2016.

[100] M. U. Hossain, C. S. Poon, I.M.C. Lo, J. C.P. Cheng," Comparative environmental evaluation of aggregate production from recycled waste materials and virgin sources by LCA ",Conservation and Recycling 109, pp. 67-77, 2016.