

Proposed Sustainability Checklist for Construction Projects

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Received: April 9, 2018

Accepted: May 26, 2018

Online Published: June 1, 2018

doi: 10.23918/eajse.v3i3p154

Abstract: Sustainability is a vital and effective contribution to control the use of natural resources in a scientific and accurate manner without wasting work and preserving these resources to meet the current and future needs of societies. The goal of achieving sustainability in construction projects requires procedures that start from design through the use of recyclable materials or reuse. To ensure this, the standards must be defined and implemented in a precise and practical manner. Sustainability criteria for construction projects are organized in sets of questions to be answered by the construction projects officials. These questions take focus on the main building construction steps. The checklist considers weighting the questions according to their level of effect on the sustainability measures. In the current work, 22 construction projects were evaluated in the province of Erbil / Kurdistan region of Iraq through the inclusion of a set of sustainability criteria in the form of questions addressed to the engineers and project managers. The results were analyzed to determine the implementation approaches of the sustainability criteria. Economic, social and environmental factors were included and construction steps were weighed in the questions of the checklist according to these factors. The results confirm the effectiveness of the proposed checklist for estimating a sustainability score for construction projects. The results show high variations in applying sustainability measures in the various construction steps in all of the construction projects. The reasons are due to the absence or weakness of binding laws and the lack of adoption of comprehensive designs based on the pillars of sustainability.

Keywords: Engineering Sustainability, Checklist, Construction Projects

1. Introduction

In the modern engineering and architectural culture, sustainable design and energy efficiency have become paramount in design and application for architects, engineers and users as civic requirements and financial limitations mount. In all areas of civil engineering, engineers are encouraged to ensure that projects have the maximum lifespan for their intended use and employ the least amount of natural resources (e.g., raw materials and energy required for their production) while still meeting client, economic, social demands and code requirements. ASCE adopted a Code of Ethics, which is the "model for professional conduct" for ASCE members (ASCE, 2006). Within this Code, ASCE has four fundamental principles and seven fundamental canons. Sustainability is mentioned in the first principle: "using [engineer's] knowledge and skill for the enhancement of human welfare and the environment." This principle directly addresses two of the three pillars of sustainability, social and environmental. This act by ASCE of including sustainable principles into their Code of Ethics enforces the commitment of the civil engineering community in understanding and incorporating sustainable practices into the field (Kibert, 2016; Abraham, 2017). Al-Nu'man, Thamir, Tahir and Agar (2016) put a detailed checklist useful for construction officials to measure the sustainability

condition of construction projects. They applied the developed guidelines on 16 large projects in Kurdistan. Approximately 50% was the score for the application of sustainability measures.

2. Assumption

The current study is based on the following hypotheses:

1. A questionnaire has been adopted and has included more than 95 questions related to most sustainability measures criteria.
2. The results of the study were based on the answers of the engineer or the project manager and no physical or field investigation have been made.
3. The questions were given different weight of importance. For questions thought to cover the three pillars of sustainability namely, the economic, the social and the environment dimensions, they were given the higher weight (Class A of 3 points). For questions thought to cover the two pillars of sustainability namely, the economic, and the social dimensions, they were given the medium weight (Class B of 2 points). For questions thought to cover one pillar of sustainability namely, the environment dimensions, they were given the lower weight (Class C of 1 points).

3. Questionnaire and Projects Considered

The questionnaires were submitted to the managers of these projects or the engineers. The response and interaction of the concerned parties in these projects was good and within the acceptable and useful limits. The accuracy of the responses is relative but sufficient to determine performance and performance indicators. The following is a detailed description of the format of the questions that have been approved and are classified according to the stages of construction workers and have covered most of the basic elements that reflect the implementation of the sustainability criteria.

The following are questions presented to the projects officials.

“The answers required are only by (Yes/No).

The (Yes) means that sustainability measures are considered in a satisfactory way, the (No) means that sustainability measures are not considered. Reminding hereby that classes A, B and C were given to questions according to their greater impact on principle of sustainability, as mentioned in the assumptions.

Site and materials of construction

A1- Avoid construction on main agricultural land

A2- Avoid building on undeveloped land that is environmentally sensitive.

A3- Avoid building on public gardens or adjacent lands to water bodies.

A4- Choose a building that is well connected to existing public transport networks

A5- Minimize the impact of the building and protect and promote natural vegetation.

A6- Proper landscaping, use of contaminated rainwater, and recycled wastewater.

A7- Minimize the surface of an impervious surface (eg parking) and provide surface drainage system that conducts water to areas on site.

A8- Grading the site to appropriate slopes and planting vegetation that holds the soil in place to

prevent erosion.

A9- Distinct location characteristics such as rock formations, forests, pastures, streams, swamps, trails and recreational facilities never be replaced.

A10- Shadow provision, surface or reflective surface surfaces, reflective paving materials. Identifying a building for the best exposure to sunlight and wind increases solar heat gain in winter and reduces it in summer to provide heating fuel and air conditioning.

A11- Protection of trees and areas sensitive to the site from damage during construction.

A12- Soil should be carefully stored during construction and reused on site.

A13- Construction waste is recycled.

A14- When the steel frame is demolished, its materials are recycled.

B1- Guard against soil erosion by water and wind during construction.

B2- Construction machinery should be selected and maintained so that air pollution is minimized.

B3- Clay and shale, raw materials for bricks, plentiful.

B4- These wastes usually go to landfills or buried at the site.

B5- When a brick building is demolished, the proper brick can be cleaned from the mortar and reused.

B6- Waste bricks can be crushed and used in landscaping. Brick and mortar debris can also be used as fill in situ.

B7- Steel is galvanized, or given long-lasting polymer coating, or made of more expensive stainless steel.

C1- Surplus extracted soil should be reused either on site or in another nearby location.

C2- Clay brick can include recycled brick dust, Post-industrial waste such as fly ash.

C3- Sellers apply to brick construction

C4- Are some spraying materials used on fire-resistant materials?

C5- Steel exposed to weather needs to be repainted periodically

C6- Steel framing members should be built in walls and the walls are thermally broken or insulated in such a way that they do not run heat between the inside and outside.

C7- Surface oil and protective coating, sometimes outgas and cause inhabitant discomfort, are not used.

Waste, recycling and green uses

A1- Use of waste materials from other industries such as fly ash from power plants and slag from iron kilns, copper slag, masonry sand, mill scale, sand gravel and other components of cement and concrete.

A2- Reduce energy consumption, waste, pollutants emissions from each step of the concrete construction process, from the quarries of raw materials through the eventual demolition of concrete construction.

A3- Templates can be reused many times.

A4- When a concrete building is demolished, the reinforcing steel is recycled.

B1- Use of concrete made from locally extracted materials and local processing plants to reduce the transport of building materials over long distances.

B2- Minimize the use of materials for molds and fixation.

B3- Concrete forms are reused.

B4- Fragments of crushed concrete can be crushed, sorted and used as new concrete complexes.

B5- Parking garages replacement shop surface parking.

- B6- Concrete thermal blocks are used to reduce heating and cooling costs.
- B7- Photo-catalysts are added to the concrete used for road construction and construction.
- C1- Waste materials such as powdered glass, recycled, used foundry sand, recycled concrete replace part of conventional aggregates in concrete.
- C2- Concrete that uses less water using super plastic materials, air entrainment, fly ash.
- C3- Excess concrete is often thrown on the site, where it is cut and removed later and transferred to the landfill for disposal.
- C4- The empty jumper mixing truck must be washed after each batch transfer, these wastes can be recovered and recycled as aggregates and mixing water
- C5- Release compounds and processing compounds are used.
- C6- Destroyed concrete is buried on site, used to fill other sites, or dumped in a landfill.
- C7- Previous concrete, made of coarse aggregate only, is used
- C8- In the field of brown field development, concrete packing materials can be used to stabilize the soil.
- C9- Concrete paving is used in black instead of asphalt pavers.
- C10- Internal concrete slabs made of white concrete are used.

Roofs

- A1- A Roof Rainwater can be made into a tank, or pond for use as domestic water, industrial water, or irrigation.
- A2- A surface can support solar heat collectors to save electricity
- B1- A roof is used properly to shade the windows from the high summer sun but recognizing the light warming from the sun in the winter is low.
- B2- The light-colored ceiling cover is used.
- B3- Reflective surfaces are used.
- B4- Bitumen is used to rely heavily on asphalt compounds derived from coal and petroleum
- B5- Materials resulting from the demolition of built roof membranes are usually burned or transported to waste dumps.
- C1- In hot climates, the shading layer is used above the ceiling, with a free ventilation space in between.
- C2- Cellulose insulation material is used in surfaces.
- C3- Glass wool and mineral wool thermal insulation materials are used in surfaces.
- C4- Polystyrene foam thermal insulation material is used in surfaces.
- C5- Roofing panels made of cellulose or glass fiber surfaces.
- C6- Adhesive bonding, solvent welding and thermal welding of the layers may give off volatile organic compounds (FOC), are not used.
- C7- Thermal membranes are used as single chips.

Exterior wall system

- A1- The outer wall system is used in the entire glass.
- B1- Glass is used where it can provide daylight lighting and provide views
The south facing surfaces are used from the outer wall to generate electricity.
- C1- Windows is opened and closed by occupants.
- C2- Thermal bridges are removed from the outer wall.

C3- Fresh air must be provided by the ventilation system in the building, not by air leaking through the outer wall.

C4- Glass is used to provide the solar heat of the building in the winter, but be careful to avoid glare, high local temperature, ultra violet degradation of internal surfaces and furnishings exposed to sunlight.

Interior wall system

A1- Gypsum waste generated during construction is minimized by scaling walls and ceilings to make effective use of entire boards or by ordering custom size plates for non-standard sized surfaces.

B1- Gypsum board scrap can be permanently stored in hollow cavities of finished walls, eliminate disposal of transportation costs and reduce the amount of material destined for landfill waste.

C1- Additives used in the manufacture of gypsum boards that are moisture resistant and fire resistant are not potential sources of volatile organic emissions (FOCs).

C2- Paints, adhesives that cover the wall used to finish gypsum surfaces can be significant emitters of VOCs, are not used.

Finishing materials

A1- The finished material has high recycled content.

A2- Floor plans that are flexible and easily adaptable are used with new uses and partitioning systems that are easy to modify and encourage building reconstruction.

B1- Finished materials eventually finish in landfills.

B2- Finished materials are processed, and manufactured locally.

B3- Indoor Finishing materials and coatings including emitters do not use? For example glue and folders used in wood panels and other manufactured wood products, the leveling compounds applied to supporting, fabrics, carpets, dressings, carpet cushions, carpet adhesives, antimicrobial treatments, carpet mothproofing, wall adhesives covering flexible flooring adhesives and vinyl in all its forms, gypsum board Common vehicles, curtains and upholstery fabrics, paints, varnishes, stains, and more.

B4- Formaldehyde gas is not used? It is irritating to build passengers, causing nausea and headaches, and can aggravate asthma.

B5- Organic compounds folate are not used. They're air pollutants.

B6- Use of high ceilings, low partitions, transparency, reflective surfaces, and light colors can maximize day lighting potential and views to the exterior.

B7- Areas designed with exposed structure and without suspended ceilings.

B8- Concrete, stone, construction, ceramic tile, cement mortar and plaster used. It is chemically inert and emission-free.

C1- Internal finishes derived from rapidly renewable sources, such as bamboo flooring or certified timber, reduce the depletion of limited raw materials and the protection of forest ecosystems.

C2- Chemical 4-phenyl cyclohexane is not used. Emitted rubber folders are used in some carpets and pads.

C3- Acoustic ceiling tile are not used? It can be a source of volatile organic emissions (FOC) as well as a repository of emissions from other sources.

C4- Light-emitting acoustic tiles used.

C5- Organic adhesives used in tiles and resins are not used. Could it be sources of emissions?

C6- Sealants applied to hardwood flooring materials to provide water repellent and protection against

staining potential sources of emissions, are not used.

C7- Self-leveling used in the preparation of Subfloors for flexible floor coatings are potential sources of emissions, are not used.

C8- Vinyl (polyvinyl chloride) is a component of many flexible floor coverings and other interior finishing products, is used.

C9- Carpets and pillows are made with at least some recycled material.

C10- The applied adhesives in the factory are used. They tend to have lower VOC emissions than adhesives applied to the construction site.

C11- Carpet tiles not full carpets are used. Tile allows easy spot replacement, reduces the need to replace the full carpet when the area becomes small worn or damaged, thus prolonging the life of carpet installation and reduce waste.

4. Conclusions and Recommendations

This work calls for the raise of awareness of the relevant issues through the media and the holding of seminars, as well as the enactment of laws binding the implementation of sustainability standards in all phases of projects initiated in the region. However, this study represented an attempt to indicate the strengths and weaknesses in the extent to which sustainability criteria were applied in selected projects. They may not live up to high levels of accuracy, but they remain important in determining the indicators that are useful in determining the path of treatments towards this strategic objective.

The current study is an attempt to create a vision of the overall engineering performance of the construction projects and the extent of convergence of the criteria of sustainability and the need to conduct research and studies to cover all aspects of this important subject. The questionnaire form should cover more work items and it is better if it is extent to the design. Also the assessments will be more strength if it is support by field observation. State institutions and ministries must take responsibility for formulating policies and setting standards and controls for all companies and sectors to adopt sustainability standards starting from design, implementation and operation.

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