

Research Article

Integrating Sustainable Construction Materials to Achieve Green Building

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Abstract: Green buildings integrate building materials and methods that promote environmental quality, economic vitality and social benefits through the design, construction and operation of the built environment. This study demonstrates potential actions including material selection that can be implemented to achieve green building. Also, we discuss the importance and environmental impact of sustainable material, the selection criteria of these materials and the different types of sustainable materials in the buildings construction in Jordan.

Keywords: Construction, durability, green building, sustainable materials

INTRODUCTION

Whole-building design views buildings as integrated systems of interacting components. This analytic approach offers opportunities for developers, builders, consumers, governments and the general public to analyze and evaluate the relative effectiveness of various building materials; construction techniques, operating procedures and fates of the materials when the building is ultimately retired (Cohen-Rosenthal, *et al.* 2000). The roles that buildings play in modern society are as diverse and profound as the persons that use them (Keung, 2009).

It is important to recognize that buildings significantly impact human comfort, productivity, efficiency and the social legacy and environmental footprint that future generations will inherit (Ashland Inc., 2011).

Green or Sustainable Construction is environmental friendly and it attempts to preserve Natural Systems and to reduce volume and improve quality of storm water (Build it Green, 2014). Also, Resource Conservation is a major aspect of sustainable construction, Reduced Demand for Virgin Materials and maximize utilization of reused and Recycled material (Langweil, 1999).

Healthy indoor environment is also considered, where air quality, Day lighting and Air handling are evaluated. Indoor Air Quality parameters such as reduced out-gassing of toxic substances and reduced dust and mold are evaluated (Natural Resources Defense Council, 2004). In addition, materials that offer Energy saving, Durability, Low maintenance are considered part of green material.

Sustainable and green measures can be applied on various stages of construction. The goal is to show and

demonstrate sustainable and green actions can be taken during construction process.

MATERIALS

The study focus is to evaluate potential actions that can be implemented to achieve green and sustainable construction. These actions can be implemented early in cycle of construction process.

On site:

Recycle job site construction and demolition waste: Construction waste generally consists of wood, drywall, metals, concrete, Dirt and cardboard-materials that can be reused or recycled if prepared properly, application of materials, Identify the types and quantities of materials generated at the job site and recycle at least 50% of the construction/demolition debris, benefits of this application, Recycling reduces pressure on landfills, saves money by reducing tipping fees and provides raw materials for future building products.

Normally, Building site is cleared of vegetation and the topsoil is removed. After building, sod is laid on subsoil, beginning a cycle of high water and chemical dependency, materials application, Design for minimum building and landscape footprints and little or no grading. Retain native vegetation. Delineate and limit the construction footprint; restrict heavy equipment that compacts soil, including cars, materials benefits Preserving native soils, along with nurturing the health of disturbed soils, can significantly reduce storm runoff, reduce fertilizer and pesticide requirements, improve water quality and conserve irrigation water (Spiegel and Meadows, 2010).

Designing landscapes to allow irrigation and storm water to soak into the soil recharges groundwater

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systems and filters out pollutants. Using permeable paving allows water to percolate into the soil, for walkways, patios and driveways which is consistent with green buildings. Design infiltration basins, swales and berms to keep water on site, materials benefits, allowing storm water percolation reduces the volume of polluted water that flows into rivers or the Bay, while replenishing soil moisture and local aquifers. Additional benefits include reduction in irrigation requirements, non-source pollution as well as lower risk of flooding.

Green foundation construction: Flyash is a byproduct of coal burning power plants and can be an inexpensive substitute for a portion of Portland cement used in concrete, application of flyash typically, 15-50% of cement can be replaced with flyash in residential concrete mixes (Wayne, 2011). However, installers should know that it has slightly different curing characteristics than standard concrete, benefits of this materials Flyash increases the strength and durability of the concrete. Using flyash also reduces the amount of cement needed, thereby decreasing the overall environmental impacts of cement production.

Use recycled-content aggregate: Concrete and rubble can be crushed and used for backfill and drainage purposes at the base of foundations, concrete application, Use recycled materials for backfill, concrete benefits, Using recycled instead of virgin Materials saves money and natural resources.

Insulate foundation before backfill: All foundations, including slab floors, can be insulated to minimize heat loss, Insulate foundation with extruded polystyrene

insulation of at least one inch or greater. Insulating the foundation minimizes heat loss from the floors and basement, reduces energy loss and therefore reduces utility bills (Kim and Ridgon, 1998).

Green exterior finish: Fiber-cement siding is composed of cement, sand and cellulose fibers. It is currently available in shingles, planks or 4×8, 4×9, or 4×10 sheets. It is usually textured to look like wood siding or stucco finish, Fiber-cement siding is more durable than wood, termite resistant, noncombustible and warranted to last 50 years.

Green insulation: Insulation in exterior walls and ceilings can reduce the demand for air conditioning and heating and make homes more comfortable, increased wall and ceiling insulation improves comfort, decreases heating and cooling requirements, saves money and makes the home quieter.

Install recycled-content, fiberglass insulation with no added formaldehyde: Many fiberglass insulation products include recycled glass, formaldehyde-free binders, no asphalt adhesives or colored dyes, Formaldehyde-free binders reduce indoor air quality problems and insulation contains up to 30% recycled glass.

Use cellulose insulation: Cellulose is a highly effective insulation made out of recycled newspaper, Damp-spray cellulose wall insulation is mixed with low-toxic binders to adhere to itself and the stud and joist cavity surfaces, Spray insulation completely fills cavities and penetrations, thus reducing air infiltration (,). The binder in the insulation reduces the chance of settling.

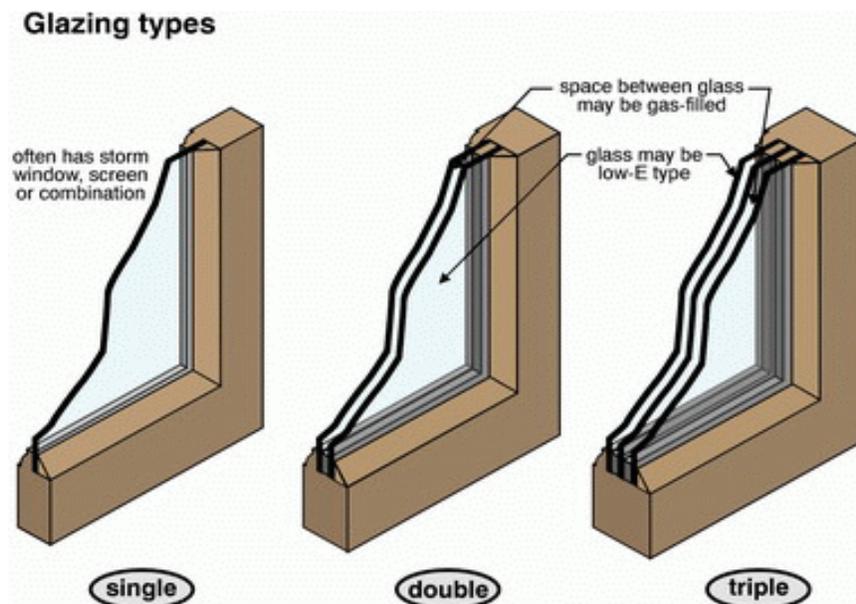


Fig. 1: Double panned windows cross section



Fig. 2: Cross section of low emissivity window

The cellulose is treated to retard insects and fire; use boric acid treatment only. Using Cellulose insulation makes the home quieter, more comfortable and reduces energy use.

Green windows: Windows play a big role in the energy efficiency of homes. In the summer, they can allow unwanted heat into the house and in the winter, windows can account for as much as 25% of the heat loss (Keung, 2009). There are window products designed to save energy.

Double-paned windows: Double glazing insulates almost twice as well as single glazing. High quality double-paned windows make the whole house quieter and more comfortable during all seasons, while saving energy and money (Fig. 1).

Low-Emissive (Low-E) windows: Low-E coatings, virtually unnoticeable to the eye, are installed inside the air space of a double-paned window. The low-E coatings help prevent heat from escaping through the glass in winter and block heat from entering the home during summer. Low-E windows reflect heat, making the home more comfortable in cold weather and on hot summer days. The cost premium of 10-15% for low-E glass typically pays for itself in a few years. Low-E, double-paned glass coating increases glass R-value to 3 compared to R-1 for single glazed windows (Fig. 2).

Low-conductivity frames: Most window frames and sashes are made of wood, vinyl, fiberglass or aluminum. Wood, vinyl and fiberglass generally insulate better than aluminum frames. Wood windows create greater comfort and better energy efficiency and are an environmentally preferable material.

Install low Solar Heat Gain Coefficient (SHGC) window film on single-glazing: Low solar heat gain coefficient window film reduces solar heat gain through glass (particularly during late afternoon and evening hours) while still transmitting light and visibility. Low SHGC window film reduces overheating, improves comfort and can significantly lower the need for additional cooling.

Roofing materials: When radiant energy from the sun strikes the roof surface, it is converted to heat energy. This radiates downward into the attic. And the adjoining rooms. Radiant barriers reduce heat build-up in attic spaces by not re-radiating heat from the roof to the attic and eventually to the interior rooms. They can prevent up to 97% of the sun's radiant heat from entering the home and can bring attic temperatures down as much as 30° on hot days, keeping the whole home cooler and reducing energy consumption for air conditioning.

Indoor air quality/finishes: Salvaged building materials are selectively and carefully removed from



Fig. 3: An example of MDF



Fig. 4: An example of cork and bamboo flooring



Fig. 5: An example of ceramic tile

buildings for reuse. Many salvaged materials are superior to the products available today such as old-growth non-structural beams, flooring and interior trim. Using salvaged building materials keeps valuable resources out of landfills, reduces pressures on the landfills as well as offering the homeowner inexpensive and unique materials for the home.

Use engineered sheet goods with no added formaldehyde: Engineered sheet goods such as particleboard and Medium Density Fiberboard (MDF) typically uses adhesives that contain urea formaldehyde, a suspected human carcinogen. The formaldehyde is continuously released, referred to as "off gassing", for years after installation. Elimination of engineered sheet goods containing urea formaldehyde reduces exposure to residents, particularly children (Fig. 3).

Flooring:

Use rapidly renewable flooring materials: Bamboo and cork flooring are alternatives to hardwood flooring. Bamboo is a fast growing grass that can be harvested in three to five years. Cork is a natural flooring material that is obtained from the outer bark of the cork oak tree that is regenerated every 10 years (Fig. 4).

Use recycled-content ceramic tile: Recycled-content ceramic tile can contain up to 70% recycled glass. Originally developed for high traffic commercial conditions, recycled content tiles are very durable and

wear well in residential applications. Some recycled-content ceramic tile is very dense which significantly reduces the amount of moisture and stains that are absorbed into the tile, making it more durable and easier to maintain (Fig. 5).

Install natural linoleum in place of vinyl: Natural linoleum is manufactured from natural materials such as cork and linseed oil. Unlike vinyl, linoleum does not contain petroleum-based products or chlorinated chemicals such as PVC, which may be a source of VOC off gassing. There is also concern of byproducts such as Cancer causing dioxins, which may be produced during the manufacturing of vinyl; Linoleum is low-toxic, easy to repair, durable and stain resistant. Linoleum can last up to 40 years whereas vinyl lasts typically 7-10 years.

Use exposed concrete as finished floor: For slab-on-grade additions, the concrete can be polished, finished with expansion joints in various patterns or stained with pigments to make an attractive finish floor. This approach is especially appropriate for radiant, in-floor heating systems, when using the slab as a floor finish; it eliminates the need to use other flooring materials. It is durable and easy to clean and can be used to hold piping for active radiant floor heating or as a thermal mass for passive solar heating.

Install recycled-content carpet with low-VOCs: Recycled-content carpet is made from recycled plastic bottles, recycled nylon/wool or recycled cotton. Recycled-content carpet does not differ in appearance or performance and the price is comparable to conventional carpet. Recycled-content carpet saves resources and diverts waste from landfills. Approximately 42 L soda bottles are recycled per square yard of carpeting. Recycled carpet is often more resilient and colorfast than carpet made from virgin fibers.

Selecting sustainable materials: Cost and function and design are the important factors influence sustainable materials choice in construction, the materials sustainability aspects that were found to be most prominent were embodied energy and carbon, recycled content and local sourcing. These are all featured in green building rating schemes. In addition, the health implications of materials (particularly from an in-use perspective) emerged as a theme that many participants were concerned about.

The end of life are less comprehensively dealt with in the green building rating schemes and came up less frequently as a priority. The factors that are mainly considered in green buildings are:

- Aesthetic quality
- Durability

- Ecological impact
- Embodied energy
- Performance
- Social impact
- Cost
- Raw material extraction and harvesting
- Manufacturing processes
- Construction techniques
- Disposal of demolition waste

RESULTS AND DISCUSSION

Pollution prevention measures in manufacturing: Pollution prevention measures taken during the manufacturing Process can contribute significantly to environmental Sustainability.

Waste reduction measures in manufacturing: The waste reduction feature indicates that the manufacturer has taken steps to make the production process more efficient, by reducing the amount of scrap material that results.

Recycled content: A product featuring recycled content has been partially or entirely produced from post-industrial or post-consumer Waste.

Embodied energy reduction: The embodied energy of a material refers to the total energy required to produce that material, including the collection of raw materials.

Use of natural materials: Natural materials are generally lower in embodied energy and Toxicity than man-made materials. They require less processing and are less damaging to the environment. Many, like wood, are theoretically renewable.

Reduction of construction waste: Minimal construction waste during installation reduces the need for landfill space and also provides cost savings. Concrete, for example, has traditionally been pre-mixed with water and delivered to the site.

Local materials: Using locally produced building materials shortens transport distances, thus reducing air pollution produced by vehicles.

Often, local materials are better suited to climatic conditions and these purchases support area economies.

Energy efficiency: Energy efficiency is an important feature in making a building material environmentally sustainable. The ultimate goal in using energy-efficient materials is to reduce the amount of generated energy that must be brought to a building site.

Table 1: Summary of sustainable/green actions suggested for Jordan market

Green features		
Manufacturing Process (MP)	Building Operation (BO)	Waste Mgmt. (WM)
Waste Reduction (WR)	Energy Efficiency (EE)	Biodegradable (B)
Pollution Prevention (P2)	Water Treatment and Conservation (WTC)	Recyclable (R)
Recycled (RC)	Nontoxic (NT)	Reusable (RU)
Embodied Energy Reduction (EER)	Renewable Energy Source (RES)	Others (O)
Natural Materials (NM)	Longer Life (LL)	

Water treatment/conservation: Products with the water treatment/conservation feature either increase the quality of water or reduce the amount of water used on a site.

Use of non-toxic or less-toxic materials: Non- or less-toxic materials are less hazardous to construction workers and a building's occupants. Many materials adversely affect indoor air quality and expose occupants to health hazards.

Some building materials, such as adhesives, emit dangerous Fumes for only a short time during and after installation; others can contribute to air quality problems throughout a building's life.

Renewable energy systems: Building sites are surrounded by natural energy in the forms of wind, solar radiation and geothermal heat. Renewable energy systems can be used to supplement or eliminate traditional heating, cooling and electrical systems through the utilization of this natural energy.

Longer life: Materials with a longer life relative to other materials designed for the same purpose need to be replaced less often. This reduces the natural resources required for manufacturing and the amount of money spent on installation and the associated labor. Durable materials that require less frequent replacement will require fewer raw materials and will produce less landfill waste over the building's lifetime (Table 1).

CONCLUSION

There is a range of actions can be taken at early stages of construction. This study compiles several actions can be considered during all stages of construction.

The study provides guidance to decision makers to select appropriate green and sustainable actions. The research suggests actions suitable for the Jordanian market. The study also lists the precautions related to some of the actions.

The selection of actions depends on the function and performance. Construction professionals select

materials for the benefits they can offer. The selection of material can change our homes and buildings to the healthy, comfortable, effectiveness spaces, to reduce the environmental impact.

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