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Harnessing Green Engineering for Eco-Friendly Housing and Utilities in South-Asian Countries

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Abstract

This paper reviews the recent development in green materials employed for eco-friendly construction in the context of developing countries, where climatic change and limited resource demand cost effective and sustainable materials of construction. The paper reviews some of the important fundamentals on which green engineering is based and shows how the advantages offered by green materials can be harnessed for societal, economic and technological benefits. The proliferation of nanotechnology in construction has filled many of the holes left by traditional technologies. The mountain and hilly regions is the primary target in South Asia in this review as these areas in Pakistan and similar geographical regions are still far behind in harnessing the benefits of green engineering. New methods of collection of safe drinking water, using Nano materials and treatment of snow melted and rain water are reviewed. The design of roofs in cold and snow bound areas and new green materials developed for such areas are also discussed. The article describes the latest Nano eco-friendly materials which may be employed to minimize energy, increase life cycle and decrease carbon foot points for longer and healthier lives. This paper also dwells on the proper use of green Nano materials for constructing houses in developing countries.

Keywords: Nano materials; Water harvesting; Rain water; Ecofriendly; Snow water

Introduction

Increasing global focus on environmental remediation has placed a heavy demand on architects, builders and environmentalists on the construction of eco-friendly buildings and production of green sustainable materials to reduce reliance on conventional resources. Green chemistry is the practice of creating buildings and using processes that are environmentally responsible and resource efficient. They act as storage houses for conservation of energy and water and are constructed by recycled or renewable materials to achieve maximum resource efficiency. Such materials are called green buildings. The green construction market in USA is expected to reach 145 billion dollars. The major characteristic of eco-friendly materials are shown in Figure 1.

Humans have been bestowed with the capability to make developments sustainable to meet the present needs without compromising the capability of future generation to meet their own needs. Sustainability has three pillars, environmental, social and techno-economic. The technique to monitor the progress of sustainability based on the above three pillars is called "triple bottom line approach [1]. The properties of sustainable materials are illustrated in Figure 2. The real challenge for the engineers an environmentalist is to improve the contribution of product service and infrastructure to a high quality of life. Most of our lives are spent indoors and the quality of our home needs to be compatible with the natural green environment which involve an integrated frame work of design, construction, operation and demolition practices that encompasses environment, economics and social impact of building (Figure 3). The houses must be able to provide basic healthy ingredients which satisfy human needs. The following are the major ingredients.

a. Applying innovative and creative methods of construction with green nanomaterials and make a clear understanding of the constituents of green environment.

b. Apply a holistic 'cradle to grave approach', which also implies proper selection of materials wherein sustainability is the key consideration [1-3] (Figure 4).

c. Awareness of coast cutting that masquerades as value engineering.

d. Selection of eco-friendly materials in the perspective of the environment with minimum emissions. The material selected must not cause adverse impact on health and environment compared to conventional approach adopted in buildings, like energy conservation, solid wastes, emissions, raw material use.

e. Evaluating life cycle assessment for procedures, processes and activities to environment.

f. Assessing the biodegradability and capability of re-use of materials. The materials must exhibit measured life span, reduced water and air pollution, lowers energy requirement and exhibit low embodied energy. The term of raw material need to be considered seriously for raw material.

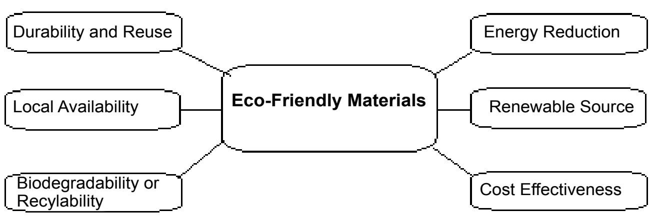

Figure 1: Characteristics of eco-friendly materials.

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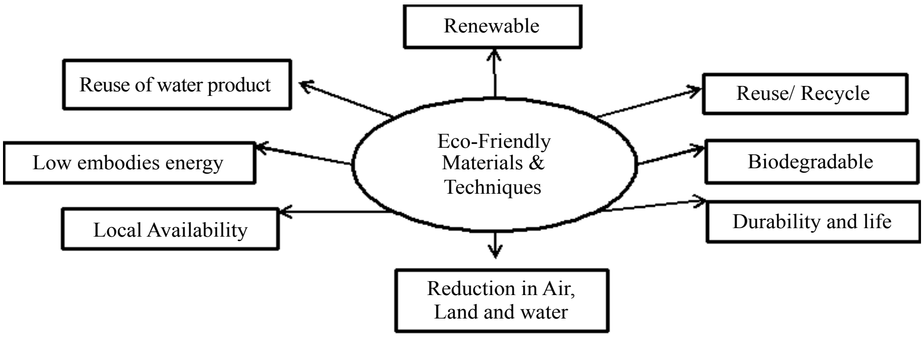

Figure 2: Properties of sustainable materials.

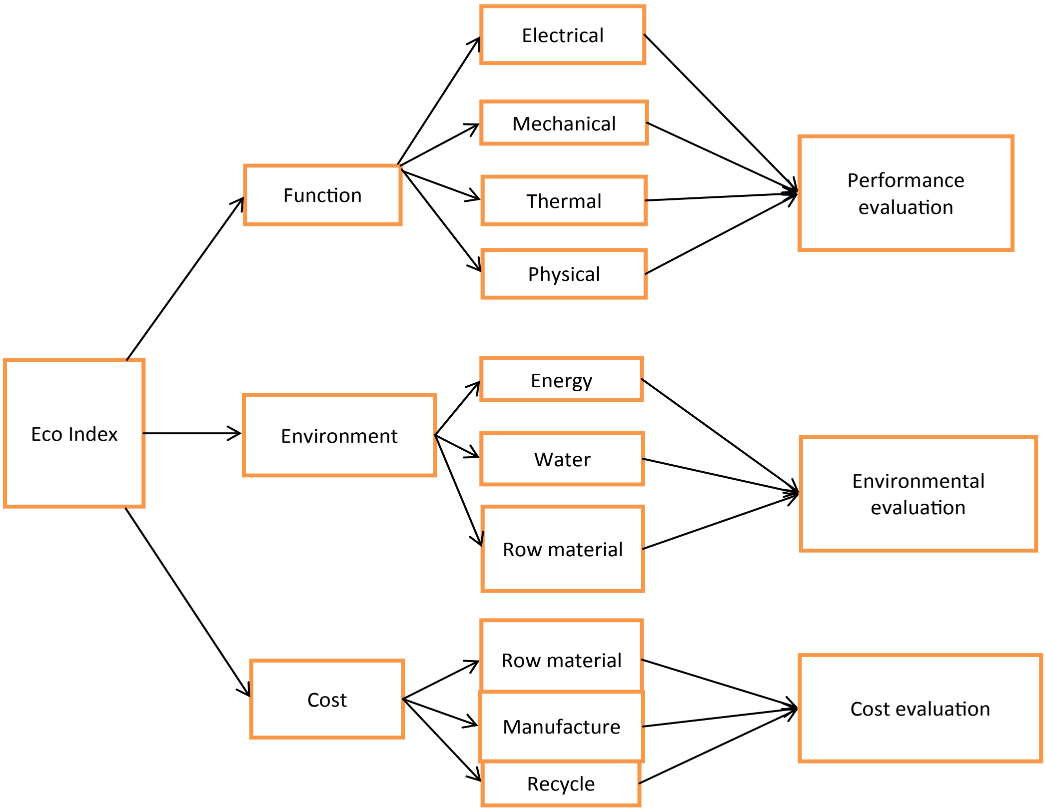

Figure 3: Scope and definition of sustainable material.

Embodied energy

It is a measurement of inputs to extract a given material. The process includes acquisition manufacturing, installation of materials and the energy input required to produce products including transportation to the building site. The embodied energy is categorized as high if >5, medium between 0.5-5 and low if less than 0.5. It is expressed as unit of Gj/ton. Materials like aluminum, stainless steel, glass, cement fall in the first category Bricks, gypsum, concrete, and clay belong to medium energy intensity category whereas sand, gravel fly ash belong to the low energy category.

Typically the greater the embodied energy, the greater is the negative potential impact on environment due to emissions caused by energy consumption. The following characteristics need to be considered;

a. Toxicity of the material.

b. Recyclability, reuse and decomposition without generating waste.

c. Renewable source and abundance in nature.

d. Any negative answer to the above these would indicate the material is not suitable. The sustainability of the material can be determined from Figure 1, which defines the characteristics of sustainable material [4].

Green buildings

The green buildings are defined as buildings with minimum emission, minimum energy requirement, minimizing demand on natural resources and capabilities to minimize waste and reduce

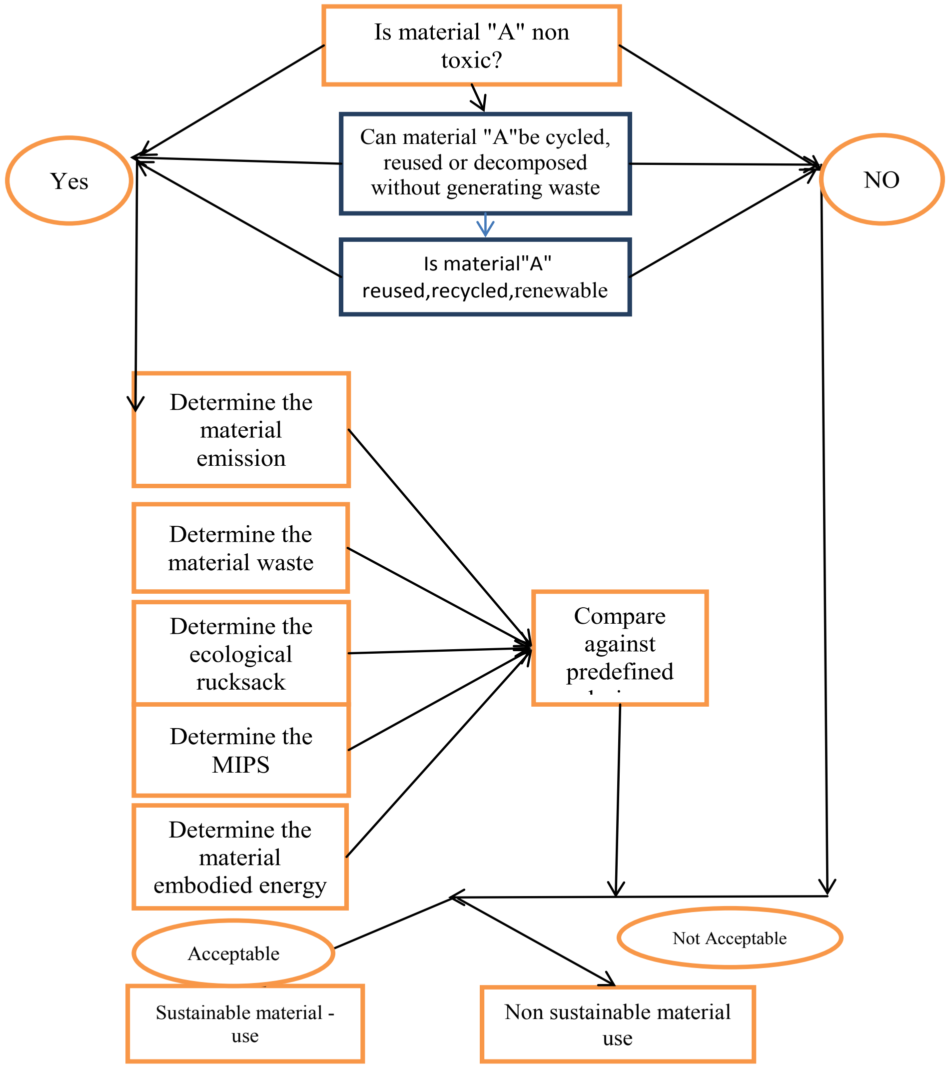

Figure 4: Analytical hierarchal for selection of environmental friendly material.

pollution. They need to be designed for zero carbon footprints. They use 100% outdoor air all with displaced ventilation.

Construction of greenhouse atrium enhances the uptake of natural light and reduces artificial light expenses. Small lightening system with automatic control, and computerized windows, smart sensor all lead to energy saving and making maximum use of natural light and heating. The employment of appropriate materials for insulating leads to passive heating will minimize demand in HVAC systems. These building used self-cleaning tiles, self-cleaning glasses, and hydrophobic paints for plumbing, nanopaints in interior and high corrosion resistance plumbing systems. For lightening photo repellent panels with thin films of silicon and light weight conductors fused to sheet metal or glasses to withstand high temperatures are used. Solar heating is used for water heating and the toilets are waterless [5-8].

Deforestation, soil erosion, environmental pollution, acidification, ozone depletion, fossil fuel depletion, global climate change and human health risks are all attributable to a large extent on building construction which plays an important role in our living problems related to environment. The use of green materials in construction leads to reduce maintenance costs, energy conservation, improved health of occupants, eco-friendly environment and creation of building as a comfort zone.

The recent focus of building researchers is on designing passive housing with low energy requirements to achieve thermal comfort by using air tight fabric insulators, maximizing solar and heat gains and keeping a specific demand for specific heating <15 kWh/h.

Recent advancement in nanotechnology have made a huge impact on the fabrication of green materials which have exhibited significant improvements over the conventional materials like new insulation devices, photovoltaics which could be fixed in a wall, energy saving and self-cleaning doors and windows [5-12].

Examples of constructional green and recycled base materials

A: Base materials: Light-weight aluminum alloys, thin corrugated sheets, thin polypropylene, reinforced clays.

Cement paints, cements mixed with flyash, clay adobe bricks (clay mix with straws and furnace fired at 2000°c), sun dried bricks, bamboo based board and play board, fly ash sand lime bricks, pavement brick, gypsum boards, portland slag cement, glass reinforced gypsum (to replace wood), ferro cement, granite, particular board, glass (recycled) and dried timber.

B: Concrete, recycle steel forms and bars

a. Blended Portland cement with pozzalana material up to 40% (pozzalana material and fly ash slag, clay and sun dried bricks and clay roofing tiles, cellular light weight cement.

b. Sand and aggregates from pulverized debris or sintered fly ash used in concrete and mortars

c. Recycled steel bars or cellular light weight concert bricks

d. Precast components for beam, slabs, staircase, lofts, balconies, pre-cast concrete blocks, and light weighed concert blocks.

Nano-concretes: Concrete is the prime material which constitutes 42% emission, only second to energy use. Research in nanotechnology has led the production of new composites, concretes, additives and fillers. By adding Nano fibers, the compressive strength of concrete is doubled and the cement consumption is reduced by 50%, compared to normal conditions [13]**.** Addition of Nano silver improves the mechanical properties and it also reduces the calcium level in the water that is needed for the soaking of the cement. It allows more addition of of flyash to the concrete, allowing durability of concrete to increase and the consumption of cement to decrease, thereby decreasing the emissions. Nanoparticles increase the strength to weight ratio and provide high compressive strength, thus making this concrete suitable for tall buildings.

C: Masonry: Gypsum blocks, pulverized debris and cement block have been extensively used as green materials.

D: Plastering: The following green materials have been extensively used to confer the limits of green region.

a. Industrial waste based bricks/blocks – phospho gypsum blocks.

b. Increase percentage of pozzolona material in blended Portland cement.

c. Calcium silicate/fiber reinforced clay plaster (fiber may be natural such as hemp, flex, bamboos, straws of wheat, barley woods and jute.

E: Flooring: Marble quartz, granite and glass may be used. It is poured with a binder, in old ages, goats milk was added as a binder. On the more sophisticated side, recycled glass from automotive and aeroplane windows may be used. Bamboo board flooring and non-vitrified tiles appears to be a good eco-friendly choice. Cork is a great eco-friendly building material and it provides a soft, durable material. A sustainable harvested tree is cut at the top in a least damaging way to surrounding trees. All sustainable trees should be cut at the top to obtain eco-friendly wood. One has to watch out for sustainable harvested label. Nanoparticles introduced in ceramics and glasses are have transformed their properties and anti-bacterial and self-cleaning tiles and glasses have been produced which prevent the spread of pathogenesis of bacteria, thus preventing the spread of several diseases.

F: Roofing: Fiber-reinforced polymers and bamboo matt and corrugated roof sheets may be used. Clay tile are 100% recyclable, and they are placed high in the list of eco-friendly materials.100% recycled tiles for roofing are now available.

G: Windows and doors: The hierarchial surfaces produced by using any of the nano techniques like etching, sandblasting, electrochemical treatment; anodizing and others are capable of acquiring water repulsion properties which do not allow water to spread. The beads of water which are formed on surface, roll down the surface and carry away any dirt that may be present, thus keeping the glass clean. Mostly nanoparticles of titanium dioxide are used in glasses to make them self-cleaning. Several companies including Pellington (UK) are manufacturing such self-cleaning glasses. This practice is mimicking the properties of Lotus flower whose leaves remain clean, despite exposure to dirty water. This is an important contribution of nanotechnology in the materials produced for cleanliness of the environment.

H: Insulators: Ferro cement and pre cast RCC; lintel may be used for insulation. Industrial recycled cotton fibers (0.5%), fiberboards, wood fiber and cellulose made from recycled news prints and insulation bricks from rice husk may be used. The sustainable design of houses requires good ventilation, six air changes per hour. Use of natural lighting, elimination of aerosol, less energy consuming and recycling facilities for water are essential, for both rural and in urban areas. Use of un-plasticized polyvinyl chloride (PVC) or high density (HDPF) product used materials with recycled aluminum and bars carpers is cost effective and beneficial.

Several patents on insulators have been produced through nanotechnology incorporation including hydromonoxide, a Nano composite insulator with very low conductivity. It can be applied to any building without any additional construction. It results in cost reduction and material saving. Nano insulators have the lowest thermal conductivity compared to polyurethane foams, fiber glass and cellulose [14].

Nano foams have been used with success. They are generally used for sealing of moulds, as anti-corrosion agents and prevention of molds, bacteria and microbes. The philosophy of insulator depends on the number of pores to trap as much air as possible and using the low conductance of air. Fluidity makes these applications easier on both metallic and non-metallic surfaces [15]. The presence of glass surfaces and insulator concepts of outer cladding are the major reasons for heat gains and losses in the buildings. Nanomaterial's act as ideal insulators because of their high surface to volume ratio and capacity to trap air.

I: Outdoor paving materials-(Examples): Fly ash/industrial waste/ pulverized debris, blocks. Easy Path is a patented nano product which acts as a soil stabilizer. The constituent element provides advanced mechanical properties to untreated soil, loose gravel and sand roads. It provides properties comparable to asphalt cement. It acts as a hardened bone and prevents the pollution caused by dust, soil, wear and erosion, and allows re-vitalization of asphalt road. It compacts and stabilizes pathways. It forms a compact mass and binds sand particles, thereby making it an excellent road material for urban areas. It is an eco-friendly material and acts as a photo catalytic material (Easy Path, TEK42, Spain).

J: Water transport materials: Products with recycled aluminum, brass component and polymer are used for hot/cold water system. However in large buildings and emergency situations, a rapid transport of water is required. Nanotubes (SWNTS) have been successfully used for ultra-fast transport of water. Some experiments have shown that the flowrates in CNTS are 10,000 times on the macro scale. Research based on computational models has been extensively done and the opinion differs between the works and real estimates suggest an enhanced need through hundred times fast. It has been argued that the water molecules fly through the carbon tubes without touching the hydrophobic walls which results in reduced friction and enhanced transport rate [16].

K: Wood working material: Renewable timber Phenol bonded plywood mica laminates and veneer on compatible boards instead of natural timber may be used. Bamboo plies/mat board, bamboo mat veneer composites, fiber reinforced polymer boards, bagasse boards are useful eco materials. Coir composites boards, Finger pointed timbers board, recycled laminated tube boards, aluminum foils, papers, plastic composite boards are also very effective in wood working.

L: Water proofing: Water proof chemicals should be preferred over solvent based chemicals such as epoxy resin. However it is possible to make water proof materials by applying hydrophobic surfaces (water repellent) of low energy compounds such as most of the silanes. These nano hydrophobic surfaces would not allow any water penetration. A thin layer of silanes is a novel replacement for costly and heavy asphalts, foams and conventional sealents, which add to the weight of the roof and are likely to damage the structure over a number of years. They possess anti-fogging, anti-corrosive, air purifying and anti-microbial properties and are capable of bringing huge benefits of photovoltaic.

M: Paints: The decision to employ the materials must be based on embodied energy, material life cycle and energy cost in terms of environment performance, mitigated degree of impact on environment. The life cycle would depend on the characteristics of the materials, local availability, recyclability, reusability, durability, life cast impact and energy efficiency embodied energy. Nano-coatings are increasingly becoming competition to conventional VOC coatings like polyurethane coatings. The Nano-coatings are non-toxic; they do not contain water, eliminate the need for curing and cut the cost by 75%.

New trends of material selection for ecofriendly environment

Following guidelines may be used;

a. Maximizing the use of renewable material

b. Reducing the embodied energy costs.

c. Have a mitigated degree of influence on environment and human eco system when compared with equivalent products.

d. Maximize the use of recyclable materials.

e. Cement/Concrete industry is causing resource depletion and greenhouse gas emission. Using about 4.2×10^9 GJ of total world primary energy consumption which equals the cost of 25% of finished cement constructions. Minimum 25% of cement replacement by weight of fly ash or granulated blast furnace slag meets the strength requirement.

f. Design for zero energy industrial waste for energy intensive materials.

g. Use precast technology for example iron cement system.

h. Use nontoxic materials.

Use of low energy materials for interior finishes is essential. Wood products are the best low energy materials such as hardboard, blackboards, lumbar core plywood and fiber brand veneer panels made from recycled wood scrap. Bagasse board, bricks foam, coal washery, burnt clay, fiber gypsum boards have been recently developed [17-22].

Nano eco-materials

Nano technology materials have made a huge impact on eco construction in the last decade. The advancement in nanotechnology has made a prominent impact on the fabrication of sustainable materials. Nano – technology is playing a leading role in fabrication of construction materials with significance impact on minimizing atmospheric pollution.

The major driving force is to improve the service life of materials with minimum impact on the environmental degradation. The major materials used for construction are Nano-silica and clinker which enhance the mechanical strength and durability of cementations materials. Photocatalytic titanium added to concrete reduces CO and NOx emission on roadways. TiO_2 and silica base compounds may be exploited in the construction of roads in desserts with no accumulation of sand [23].

Nanotechnology generated materials have unique characters and have the capability to fix many construction problems. The major nano materials which have been used are nano silica, TiO_2. Nano materials are playing an important role not only in construction industry but human lives [23-26]. Recent development in nano coating containing titanium dioxide nano pigments has shown the way to sustainability and green environment. Nanocoatings are projected to make up 73% of nanocomposite market. They provided self-cleaning and antimicrobial surfaces in addition to corrosion resistance, toughness, strength and color steadfastness [24,25,27-31]. These coatings are dust and water repellent. It is playing a dominant role in construction industry because of the materials being light, eco-friendly and enhanced capability to introduce novel properties in construction materials. Some examples of nano materials used in construction are shown below [27-34]. Some major examples of applications of nano-construction materials are shown below;

a. Nano-coatings such as coatings containing α TiO_2 which are self-cleaning and antimicrobial.

b. Self-cleaning glasses for windows which repel dust, fog and water.

c. Eco friendly coatings containing n-titanium dioxide.

d. Self-cleaning glass (dust and water repulsion).

e. High strength Al-Sc-Mg alloy containing nanoprecipitates of Sc_2O_3.

f. Photo-catalytic surface for clean air.

g. Nano membrane for water filtration.

h. Nano-composites (e.g., TiO_2 polymer composites/porous silica).

i. Photo-catalytic tiles containing TiO_2 (e.g., porous silica, polymer composite).

j. Self-healing concrete.

k. Smart windows (change of color with temperature).

l. Nano steels such as SANDVIK nanoflex and MMFX2 have very high strength and corrosion resistance. Flame retarders like silicon oxides coatings or aluminium oxide coatings are finding increased uses in green building.

m. Wood tissues (lignocellulose) for self-healing, sterilizing surfaces, internal repair and electronic lignocellulosic devices.

n. Silane based nano-water porosity products such as iso-butyltrialkoxysilane and n-octyltrialkoxy silane which do not allow water to penetrate.

o. Wood tissues (lignocellulose) for self-heating, sterilizing surfaces, internal repair and electronic lignocellulosic devices.

p. Particles of TiO_2, ZnO and SiO_2 provide resistance to the penetration of water.

q. Nano carbon tubes, Nano ZnO, CeO_2 are used for wood coatings.

r. Wood lacquers containing nano silicon- dioxide are used as inhibitor for coating of barrels and silicon based coatings.

s. Carbon nanotubes with capability for modifying the self-healing properties of concrete.

One interesting development in nanocoating for glass is in the area of thermo-chromic, photo-chromic and electro-chromic technologies sensitive to temperature light intensity and voltage. By changing their absorption to infrared lights, the building can be kept cool. By changing voltage, surface become more opaque and absorbs more infrared light [32]. This offers the chance for controlling the indoor climate in green buildings [35]. Products like NOXER pollution reducing pavements improve the air quality. They may be used in paving blocks and pre-cast embedment facing. Pavement and cementageous asphalt coatings have been developed to control the pollution caused by traffic [21]. This material can be used on asphalt which is impregnated on site with titanium dioxide containing cement slurry.

Nano porous insulation material like aerogel (dried gel) and certain polymer nano foams are in the market in recent years as Asphen Aerogel [33]. They consist of fine network of bubbles cell walls just a few atoms thick. Inside the cells there is simple air.

Nanotechnology is to play a leading role in energy market. For instance, carbon nano tubes have been applied to produce solid state energy saving light devices for light sources, which may save 77% of energy saving. They are most sought after for their thermal resistance. They are several times more effective than common insulation materials. Nano-porous insulation blanket have been produced for effective insulation. They are specially designed for extreme temperature applications, for hot and cold protection of roof. A polyurethane binder with particles of photo-catalytic iron oxide (top layer) has been developed for extreme temperatures to which the roofs may be subjected. Cryogel Z [33] based on nano porous silica has been developed by Aspen Aerogel. It is a flexible, aerogel blanket insulation with integrated vapor barrier for cryogenic application. It combines a silica aerogel with reinforcing fibers and leads to eco-friendly thermal performance. It is hydrophobic and prevents surface contamination. It is ten times stronger.

Nano materials actually applied in construction

Forces are accelerating nano-technology in construction industry and its proliferation in building construction provides environmental benefits and increased demand for sustainable buildings. Advanced and rich nations have been exploiting this technology and it may take ten to twenty years for developing nations to adopt nano-materials for constructions. Despite the development of roof tiles embedded with photovoltaic cells, use of carbon nanotubes in concrete, nano paints, self-cleaning indoor climate regulation materials, and the use of nano-materials is still relatively in infancy due to high coasts and doubts about the effect of nano particles on human health. The two scenarios presented show two different routes to achieve sustainability in design and construction which ever route is adopted would depend on the economics of the region. However, some components of the nano constructions materials such as insulating foams, nano tiles, nano-paints could be used with eco-friendly materials. Globally the use of nano material is at a low level. The most commonly used materials being n-TiO_2, silica foam and nano-composite coatings. High price and occupational risks may limit the growth of nano-material for construction. The next five years work would witness a big boom in the growth of green buildings constructed with ecofriendly green techniques for water harvesting in urban and rural areas.

Harvesting in urban and rural areas

In the northern area in Pakistan, India, Afghanistan and Iran there is abundance of snow and up to 4 meters of snow has been recorded in area surrounding Muree hills and adjoining areas in Pakistan and heavier snow fall in Afghanistan and many parts of India and Iran.

Most hilly areas in Pakistan are abundant in rain and snow. Hilly resorts like Bhurban, Ayobia, Khanaspore, Patriata and other are full of tourists and an acute water supply exists in these areas because of deep underground water and lack of fresh water resources. There are several similar geographical regions in South Asia.

Despite heavy rainfall, a little has been done to harvest drinking water from rain and similar is the case far for harvesting drinking water from snow and fog.

Majority of the population lives in small villages in hilly tracks. However the pattern has changed to better houses in certain hilly areas of Pakistan and other similar regions with a hot climate in summer. With the economic growth in recent years, the housing pattern changed from mud houses to modern villas made from brick and stones, with metallic-tiled roofs.

Most of the development lacked the foresightedness, for eco-friendly environment, creation of sustainable water resources and protection from snow in hilly areas with abundant snow fall.

A new era for housing requires independent water supplies, food and sanitation and an eco-friendly structure. The amount of rainfall collected would depend on the size of tank, roof top area and the amount of the rainfall.

Design of an ecofriendly water collection systems from roof tops

The system consist of four major components; catchment area (for collection), a conveyance system (pipes and gutters), a filtration system (for filtering rain water), a storage facility (tank) and a delivery system (Figure 5).

Conditions: The system should be able to harvest maximum waste drinking water, water should healthy for drinking and it should be made from eco- materials

A: Catchment area: Roofs are ideal as catchment areas provided they are constructed from proper material and designed for complete drainage. For roofs, fibers reinforced polymers and bamboo matt, or 100% recycled clay tiles may be used. Sloped roofs made from aluminum containing recycled tiles (100%) impregnated with TiO_2 may be used. Galvanized or corrugated sheets may be used in place of recycled aluminum.

B: Pipes and gutters: One opened water collector (Bamboo) with an end-cap would receive the rain water which would ultimately enter a gutter made of 100% recycled polyethylene. Typical gutters are shown in Figure 6. The simple rule of 1 cm^2 gutter cross section area per meter

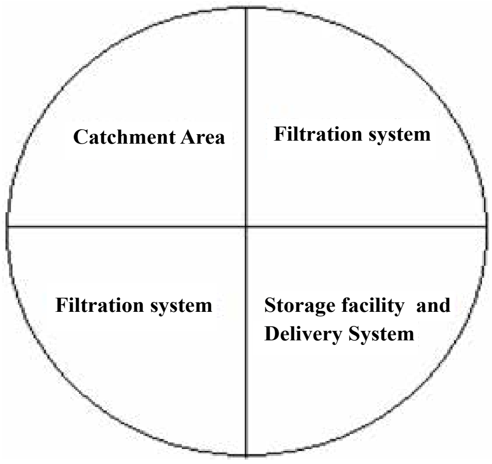

Figure 5: Design of ecofriendly water collection systems from roof tops.

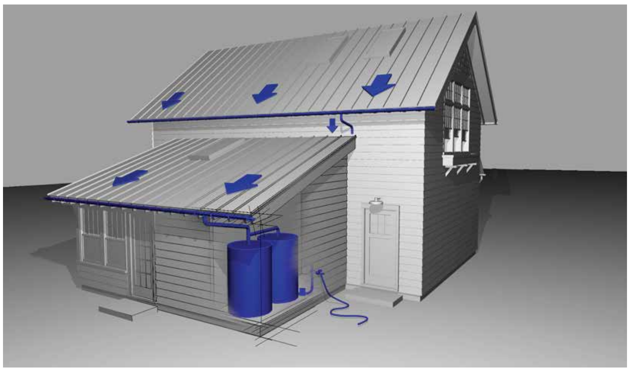

Figure 6: Showing gutters by arrows on roof top.

square of the surface is to be considered. The passage of rain water through gutters and collection is shown in Figures 6 and 7.

C: Screening: The water from the gutter flows in a flush reservoir fitted with a 316 recycled polyethylene mesh to filter out the debris and dusk. The reservoir would be fitted with an over flow device.

D. Filtering: After screening the water would pass through a filter column comprising of gravel and recycled junk rubber powder. The column would be fitted with a tube to measure head loss.

E: Storage tanks: The tank is made of torroficated straw bricks coved by a polyurethane layer. The bottom of the tank is strengthened by Portland cement and flyash to prevent any leakage. The tank buried at least 6ft deep to prevent evaporation due to strong sunshine. The drain pipe is to be constructed from bamboos.

The roof water would be fitted with an eco-mesh recycled polypropylene screen. The pump need to be glass lined stainless steel. The drains (metallic) need to be coated by paint containing pigments of TiO_2. To keep the water cool, double walled clay will be made with torrificated straw and embedded on concrete with fly ash.

Calming inlets in the collecting tank prevents the settling of fine particulates on the bottom of the storage tank. In larger tanks several calming inlets may be needed. The complete rain water collecting system from roof is shown in Figure 8.

F: Delivery system: A calmer is fitted in the telling tank. For distribution, pipes of recycled high density polyethylene are recommended.

G: Calculations of rain water system: When it rains 500 mm, and the roof area is 100 square meters, the amount of rain water in 50,000 liters. For example in a certain region, where the total rain fall is estimated to be 1865 mm, the amount of water falling would be 1865000 mm.

If we assume 80% efficiency plenty of water can be collected. 10 mm of the rain would be equal to 100,000 liters of water per hector. The calculations for the estimated harvested water are shown below.

Typical calculations: From the information on the amount of the rain fall per year, we can estimate the quantity of affectively harvested rain water. Following example show the calculations.

Data given;

Yearly rain fall = 400 mm

Area of catchment = 200 sq-m

Height of the rain fall = 0.4 m

The harvesting potential is given by:

(a) Rainfall (mm) × efficiency.

(b) The rain water endowment is given by Vol = Area of the catchment × Height of the rain fall.

(c) Coefficients: Two coefficients are involved.

(1) Roof coefficient for the surface of the roof (it is formed from standard tables for various materials).

(2) Coefficient of vaporization (it is normally taken as 0.80).

The effectively harvested water is given by:

Rain water endowment × coefficient for evaporation × surface coefficient.

From the data above,

Rain water endowment = 200 × 0.4 m = 80 sqm = 80,000 liters.

The amount of effectively harvested rainwater = 80,000 × 0.70 × 0.85 = 47,600 liters.

Considering the water requirement of 15 liters per family the harvested is more than sufficient to fulfill the needs.

Harvesting water from the snow

Harvesting water from the snow is a more complicated problem compared to rain water. Sliding snow, falling ice and ice formation pose serious hazards to roofs and people entering and leaving the buildings. Because of the load of the snow, the roof needs to be carefully designed. Extra maintenance may be required below the eaves to keep them clear of snow. Because of an acute storage of water in winter, the only option at several locations may be to harness water from the melting snow. Due to avalanches, high pitch storms blizzards, and high winds fetching drinking water from other sources becomes impossible. Even the supply pipe lines get frozen despite insulation. Unfortunately the water from snow needs sterilizations and addition of minerals due to its lost, [34,35] below shows the physical and chemical characteristics of water from ladakh, and other high mountain ranges like Satlag and Antarctica.

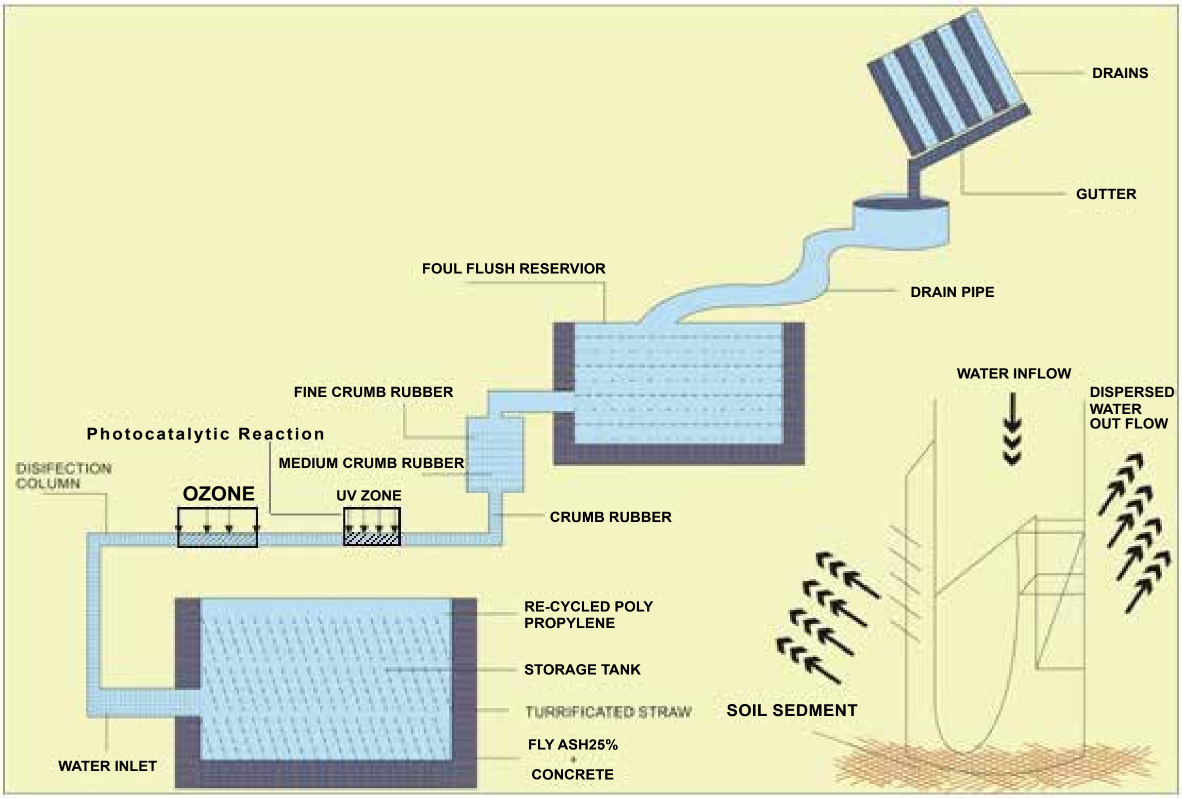

Figure 7: A new design for the rain harvesting from the roof.

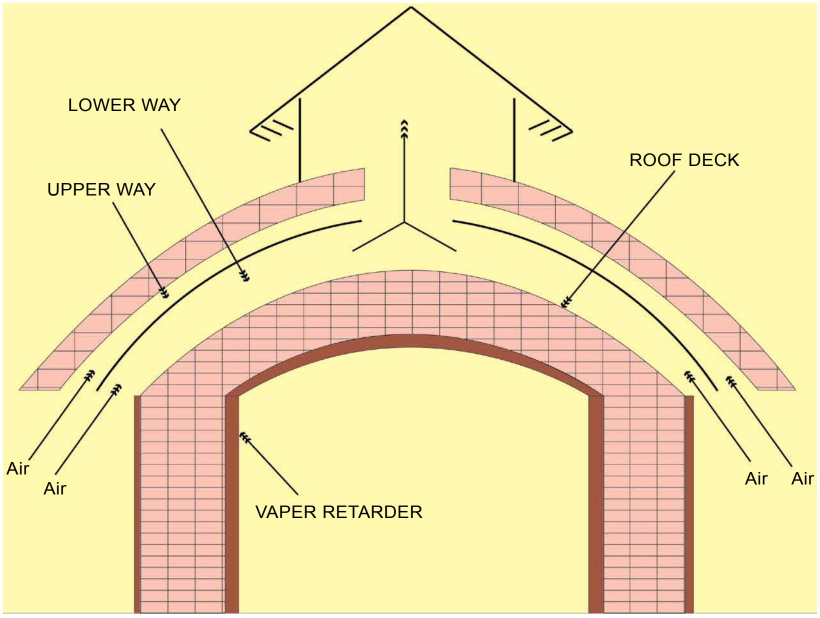

Figure 8: A dome shaped roof for a house show bound.

The water from snow need to be treated with sterilizing tablets and mineral tablets to improves the taste. The sterilizing tablet is made from halogen benzoic acid (P-N-dichlorosulphoamide) to release chlorine. The mineral tablets contain salts of the sulphate, sodium potassium, magnesium and potassium iodide. These need to be locally manufactured.

The weight of the snow is a major factor which affects the strength and effectiveness of the roofs of the house and shortens the life cycle. The roof requires ice melting, removing load of snow, avoiding formation of ice dams and providing a drainage system. Snow is piled where the depth of the ground is at least 30 inches. As a general rule roof should with stand 20 Ibs per square feet of snow, with nearly 5 ft of snow. Water weighs 1000 kg per cubic meter (at 4°C) and snow melted to water becomes 1/10th of that of water = 100 kg. The density of snow is 481 kg/cm³. The density of pure water is 62.4 lbs/cu. ft. (Kg/cu. m/16.02 gives lbs/cu. ft) [34].

Calculation of peak load: The example below illustrate the calculation of for instance the peak loaded on a 90 × 90 m roof was formed to be 11.5 Kpa (235 Psf) in geographic regions of low ground snow.

To calculate the following factors need to be considered:

- Shape factor (fallen or drifted snow).

$S_{peak} = 3S_s + S_r$

Where, S_s = Snow load for a geographic location (kPa).

S_r = Rain on snow load.

$S_{peak} = [0.35\ \gamma/S_s - 6(\gamma\ h\ p/S_s^2) + 0.8] + S_r$

γ = Assumed density of snow peak.

hp = height of the parapet surrounding the upper roof which retains snow.

$l^* = 2W - W^2/l$

l^* = Characteristics length of upper level roof which provides the source of snow drift.

W = Shortest plane dimension of the rectangular roof.

L = Longest plane dimensions of rectangular roof.

The ground snow loaded on 30 m × 30 m roof varies between 30 kpA 39 kpd.

Peak loads on roof of various dimensions have calculated e.g. the peak loaded on a 90 × 90 m, roof was found to be 11.5 kPa (235 Psf) in a geographic low ground snow reign.

Snow load calculations are extremely important to prevent the roof from collapse. More examples are given below.

Example of calculation of snow load for flat roof

The formula is $P_f = 0.7\ Ce\ Ct\ l\ P_g$

Ce = Exposure factor (1608.3.1 (building code of New York estate).

Ct = Thermal factor (1608.32) A (ASCE-7, 1998).

l = Importance factor (1604.5) A (ASCE-7, 1998).

P_g = Ground snow load (for an area obtained from mapping).

The values giving in the formula can be plugged to obtain the snow load.

$P_f = (0.7)\ (0.9)\ (1)\ (1)\ (55) = 34.5$

(C) Example for sloped roofs

The formula is $Ps = Cs \times P_f$

If area is assumed to be 34.5 sq-cm.

Ps = Sloped snow load.

Cs = Slope factor from ASCE-7 (graph for determining roof slop factor).

Pf = flat roof snow load.

Time to shovels the snow and determination of time to shovel the snow

The formula is S × 1.25 = P

S = Inches of snow on any roof.

1.25 = weight of 1 sq feet of snow.

If the snow load exceeds 20 Ibs/sq-ft, it should be shoveled.

Measures to be taken if the snow is 20 inches deep: 20 inches roof snow depth × 1.26 Ibs sq/ft = 25 Ibs sq/ft. Moisture ranging between 1% to 33% is related to snow weighing from 1 pound per cubic feet to 21 pound per cubic feet. The snow therefore needs to be shoveled if the weight exceeds the limit (25 pounds/sq-feet).

Salient points for the roof design

Salient points of roof design in snow bound areas are:

a. Freedom from moisture and building of ice dam.

b. Control of air pressure difference across the roof system by installing an air barrier system.

c. Prevention of heat loses by insulation of a good insulation system.

d. Rigid control of humidity.

e. Minimizing warm, moist indoor air in the ceiling. Simple roofs are easy to ventilation but roofs with cross purling interconnect air waves make ex-filtration difficult.

f. Use water proof membrane at eaves, walls and penetrator.

g. Air barriers should be designed to control the sliding momentum of snow.

h. Water proof membranes need to be placed to prevent ice dam formation.

i. In cold climate antique ventilation and water proofing membrane are essential requisites whereas in mild and hot climates water proofing membrane may not be needed depending on the climate data. A recommended design of dome shaped roof for sliding of snow is shown in Figure 9.

Roof materials for cold climate

Roof materials depend on whether the design is vented or un-vented in any hydro-thermal zone. A vented design is not connected to the conditioned space. In the vented design and air barrier must be present to isolate the upper structure of the building. In un-vented design the condensing systems are controlled. The important factor is to keep the roof assembles warm.

(**a**) Clay or concrete with 25% fly ash is recommended for warmer climate. Clay is an excellent eco-friendly material. It is very resilient and can withstand harshly weather environment. Clay roofs can last one hundred years. Most roofs in USA are made with asphalt shingle wooden (dried) roofs, but they may be subjected to growth of molds and fungi if not properly maintained. Recycled aluminum roofs are suitable in areas which are wet.

(**b**) Material for the roof insulation: The insulation material must reduce evaporating, dampness, moist air and temperature fluctuation. These should be resistant to water vapors and capable of providing a cold contact surface upon which cold moist air can condense.

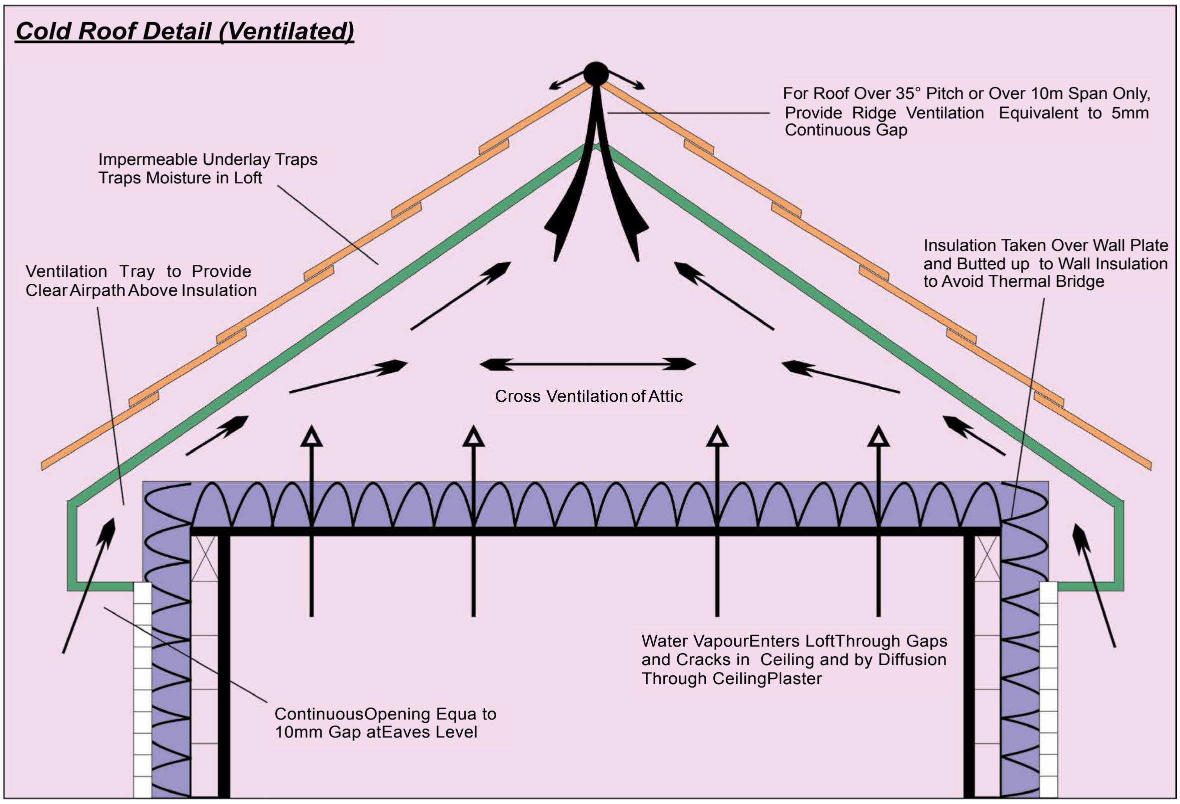

Figure 9: Design of cold roof configuration.

Insulator is better laid in contact with a felt which should not be imperious as water would run down and absorbed in the insulator. Recycled fiber glass is excellent moisture absorber. Roofing felt are now available which retain moisture. It provides dual advantage and prolongs the life of insulating material. The water vapor barriers should be constructed on the warmer side of insulator. The best eco-friendly material is sheep wool, which is 100% eco-friendly and is abundantly available in hilly tracts and in plains with cold climate. It is derived from a renewable source, breathable and non-irritating despite bonding of fibers. It has a low embodied energy. This insulation maximizes permeability as reduce condensation. An eco-friendly gypsum board may be used as an air barrier shown the air barriers, insulation, water protection membrane and roof insulation.

As mentioned earlier non porous aerogel blankets insulation are now available. They are an excellent choice compared to conventional material to prevent 100% condensation.

Wall insulation

The guiding principles are air sealing, moisture control and prevention from air penetration. Air sealing prevents water from entering the wall. Moisture control makes insulation more efficient. It is necessary to create a drainage plan within the wall system.

Cellulose insulation is very useful and it may be made from recycled news prints. They are packed by moist spray techniques. On the more expensive side is the rigged foam insulation. Nano foams are very expensive, however they are ideal insulators. The foam is often used as an outer layer of insulator. Vapor barriers must be placed on the warmer side of the wall in cold climate. In hot climate they should be placed exterior to the wall. Recycled polyethylene with a low perforation can be used as a vapor barrier.

Roofs in snow bound reigns in hot climate: There are special requirement of which the designs lacks awareness. Particular the design of eco-friendly houses is completely lacking. Even at high altitude one come across mud-houses or concert houses with sloping roofs. Following are considerations are important for designing the roofs

Building configuration and thermal design can influence the distribution of snow and ice on its roof. Moving snow can be very dangerous as it may drag plumbing fixture, vents and other roof penetration. It can bend the seams of metal roofing, reducing their strength and deteriorate the water proofing.

Precautions for preventing collapse of roofs: Following precautions are important to prevent roof collapse.

a. Keep roof drains clear of the debris and ice.

b. Keep gutter and downspout clear so they will flow freely.

c. Do not install air conditioners transformers where it could have an impact with snow and sliding ice.

d. The roof load design must be correct. Incorrect roof live load design may cause collapse of the roof.

e. Avoid inadequate drying of roofs and imbalance of snow on load or roof.

f. Remove snow when 50% of the design strength is reached.

g. A dome shaped roof configurations for hilly region abundant

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in snow is recommended (Figure 8). A design of a cold ray configuration is shown in Figure 8.

A model ecofriendly tent house for residents of arid and desert regions in South Asia

There is a large population of nomads and beduins living in deserts and arid areas who need dust repellent ecofriendly tents with utilities. The residents also need clean water for drinking and biogas for cooking provisions of which have been made for the design of tent. A green filteration system based on crumb rubber coupled with a photocatalytic system is also suggested. The provision of energy conservation has been made in the tent by coating the tent fabric roof with a special wax which would protect the inmates from the heat of the sun during the day and act as insulator. At night the desert would allow preservation of the coolness of the desert to be felt by the inmates (Figures 9 and 10).

Conclusions

Ever since 1992 after the earth summit in 2010, sustainable construction is making quantum leaps. It has involved extraction and beneficiation of new materials, manufacture of eco-friendly construction materials are based on ecofriendly life cycle assessments. Insulation light weight and strong material for insulation, ultra-high

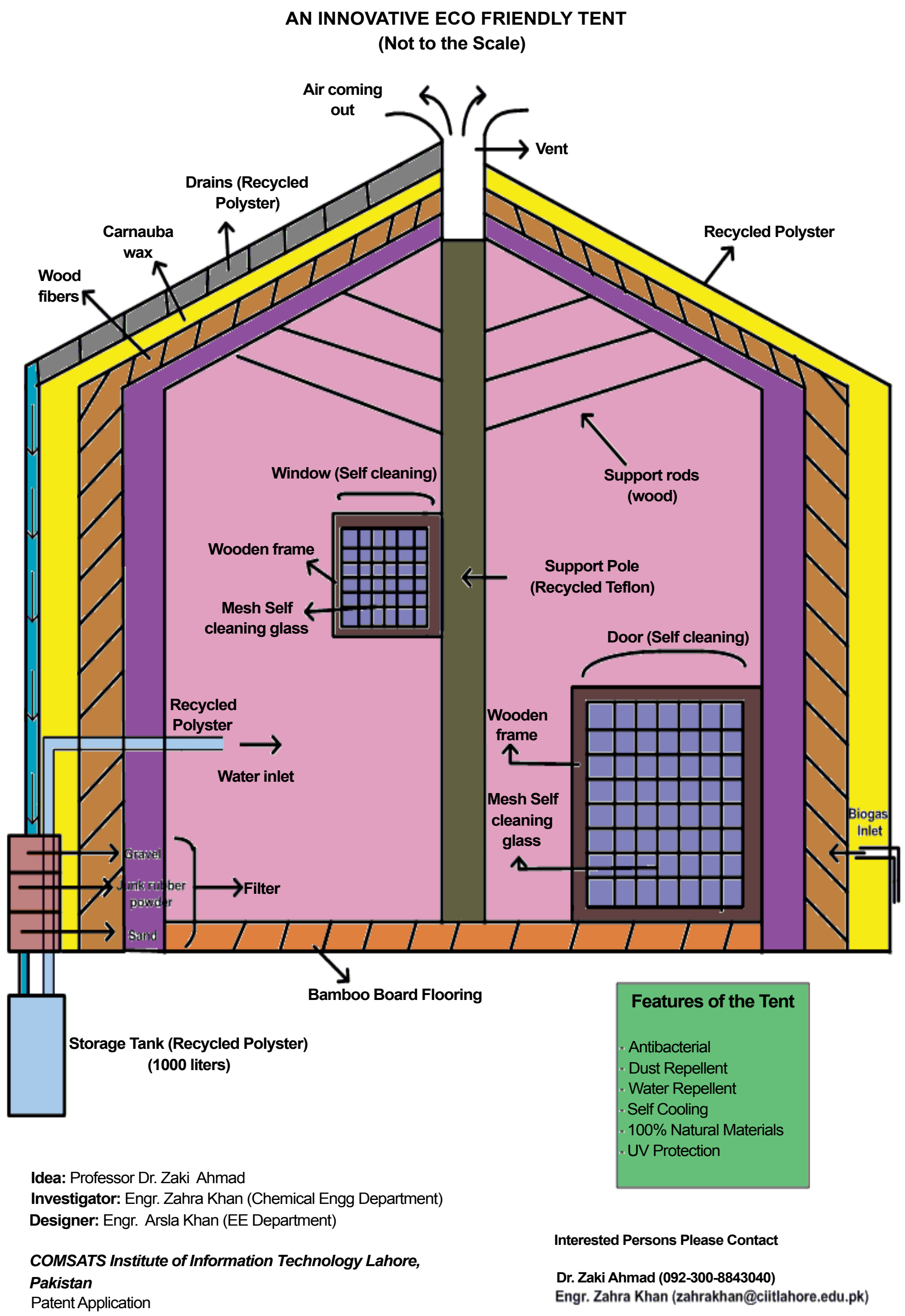

Figure 10: An ecofriendly tent.

strength new steels, reinforced composites, ultra-light weight heat resistant insulation materials, super hydrophobic surfaces for dust and water repulsion, recycled materials for roofs, plumbing, storage and structure have now been developed. Novel design using a hybrid of eco and conventional material for roof tops in cold countries and novel methods for harvesting drinking water from rain and snow have now been designed. The Sustainable design would alleviate poverty; bring a greater comfort in providing a productive life harmony with nature local culture and spiritual values. Now design for roof tops and water and snow harvesting are described in the paper. It is expected that sustainability in construction the key consideration in future and it would help to bring improvements in the region stricken by poverty.

References

1. Ljungberg LY (2007) Materials selection and design for development of sustainable products. Materials & Design 28: 466-479.
2. Khan KM, Faizan A, Tahir S, Shiraz A, Afaq A (2013) Experimental study to compare the effects of Gradation, Additives and Filler Materials on performance of CIR Mixes. Life Sci J 10.
3. Dylla H, Hassan M, Mohammad L, Tyson R, Wright E (2010) Evaluation of environmental effectiveness of titanium dioxide photocatalyst coating for concrete pavement. Trans Rese Rec: J Transp Res Board 2164: 46-51.
4. Kibert CJ (2012) Sustainable construction: green building design and delivery. Wiley.
5. Desarnaulds V, Carvaloh A, Arlaud B (2005) Sustainability of acoustic materials and acoustic characterization of sustainable materials.
6. Hammond GP, Jones CI (2008) Embodied energy and carbon in construction materials. Proceedings of the Institution of Civil Engineers-Energy 161: 87-98.
7. Jönsson A (2000) Tools and methods for environmental assessment of building products-methodological analysis of six selected approaches. Building and Environment 35: 223-238.
8. Kirchhoff S (2000) Green business and blue angels. Envir Res Eco 15: 403-420.
9. Baldo G, Sara R, Fieschi M, Gerhard S (2002) The use of LCA to develop eco-label criteria for hard floor coverings on behalf of the european flower. The Intern J of Life Cycle Assess 7: 269-275.
10. Gerilla G, Teknomo K, Hokao K (2007) An environmental assessment of wood and steel reinforced concrete housing construction. Build & Environ 42: 2778-2784.
11. Manzini R, Noci G, Ostinelli M, Emanuele P (2006) Assessing environmental product declaration opportunities: a reference framework. Business strategy and the environment 15: 118-134.
12. Traverso M, Rizzo G, Finkbeiner M (2010) Environmental performance of building materials: life cycle assessment of a typical Sicilian marble. The Internat J Life Cycle Assess 15: 104-114.
13. Zhi Ge, Zhili G (2008) Applications of nanotechnology and nanomaterials to construction.
14. Elvin S (2008) Nanotechnology for green buildings. Technology Forums (Karachi, Pakistan).
15. Talai E, Aminpur P (2011) Applications of nanotechnology in construction industry, In the proceedings of National Conference of New Technologies in the Construction Industry in Iran 37: 461-463.
16. Wallher JH, Ritos K, Cruz ERC, Megaidris CM, Petros K (2013) Barriers to superfast water transport through Carbon Nanotube Membranes, Nano-Letters 3: 1910-1914.
17. Basinger M, Montalto F, Lall U (2010) A rainwater harvesting system reliability model based on nonparametric stochastic rainfall generator. J hydrol 392: 105-118.
18. Fortus D, Charles DR, Joseph K, Ronald WM, Rachel MN (2004) Design-based science and student learning. J Res Sci Teach 41: 1081-1110.
19. Van Broekhuizen P, Fleru VB, Ralf C, Lucas R (2011) Use of nanomaterials in the European construction industry and some occupational health aspects thereof. J Nanoparti Res 13: 447-462.
20. Moriarty P (2002) Environmental sustainability of large Australian cities. Urban Policy and Research 20: 233-244.
21. Homes S (1999) Embodied energy in residential property development: a guide for registered social landlords. Harlequin House.
22. Khan KM (2011) Sustainability of different pakistani building systems.1: 1-52.
23. Chuck W, Kim JT (2011) Building environmental assessment schemes for rating of IAQ in sustainable buildings. Indoor and Built Environment 20: 5-15.
24. Lantagne DS, Quick R, Mintz ED (2006) Household water treatment and safe storage options in developing countries: a review of current implementation practices.
25. Guo Y, Baetz BW (2007) Sizing of rainwater storage units for green building applications. J Hydrol Enginee 12: 197-205.
26. Dutta S, Lawson R, Marcinko D (2006) How the nanotechnology revolution will affect cost management. J Corpor Account& Finance 17: 37-46.
27. Gould J, Nissen-Petersen E (1999) Rainwater catchment systems for domestic supply. IT Publications London.
28. Biswas AK, Faruqui NI, Bino MJ (2001) Water management in Islam. IDRC.
29. Abderrahman WA (2006) Water management in Ar-Riyadh. Water Resources Development, 22: 277-289.
30. Worm J (2006) AD43E Rainwater harvesting for domestic use. Agromisa Foundation.
31. Farreny R, Morales-PinzonaT, Albert G, Carlota T, Joan R, et al. (2011) Roof selection for rainwater harvesting: quantity and quality assessments in Spain. Water research 45: 3245-3254.
32. Leydecker S (2008) Nano materials: In Architecture, Interior Architecture and Design. Walter de Gruyter.
33. Rhine W, Wang J, Begag R (2006) Aerogel metallic compositions. Google Patents.
34. Gopal R, Ghosh P (2013) An outfit for improving potability of water in snow-bound areas. Defence Science J 41: 39-43.
35. Van Broekhuizen F, Van Broekhuizen P (2009) Nano-products in the European Construction Industry-State of the art 2009. Report commissioned by EFBWW and FIEC.