Guidelines for Embracing Green Building Technology for Sustainable Development in Developing Countries

Pragyan Bhattarai, A.V.A Bharat Kumar, Rajendra Chaudhary, Dr. Shashi Kumar Gupta

Abstract— Of late construction industry is undergoing a lot of change and eco-friendly materials are slowly replacing the conventional construction materials in an attempt to protecting the environment and human health. This change in attitude has mainly come through because of overuse and abuse of different components of environment which has resulted in global warming, heat island effect and other hazardous effect causing negative impact on the current trend is also widely understood as Green Building concept. However due to lack of awareness and misconception about the green building, the use green building technology has remained mainly within the domain of developed countries and has not been very widely received in the developing world. It is imperative that the concept is spread in developing countries too because in these the rate of development is currently going on at a fast rate. To make this happen Governments in developing countries should take the lead in educating the masses, and should make basic grounds rules so people can start embracing the technology. It is important that government defines rules and protocols for certification/registration of buildings at a basic level. Some of these basic levels could be as simple as Sustainable site development, Water saving, Energy efficiency, use of locally available material, Indoor Environmental quality and eco-friendly designs, etc. This paper forwards the concept of green buildings and basic categories which can be promoted by governments of developing countries to start the Green building concept in a bid to save the environment.

Index Terms— Green Building, Environment, Indigenous materials, Eco-friendly designs, Human health, Construction Industry

1 INTRODUCTION

ENVIRONMENRT is the main component of the earth system. Man's overuse and abuse of different components of environment is threatening the survival of human beings on the planet. Global warming, increase in pollution, unusual calamities and other tantamount effects are the outcomes of the degradation of component of environment. The life span of living beings is decreasing year after year because of exposure to many harmful chemicals. In the name of sophistication we are degrading the environment to the extent that we could be in very difficult circumstance at any instant. If we continue to carry on with this types of activities and do not take any preventive or control measures we may end in an irreversible situation. So, this is a time to think seriously about protecting the environment and earn mileage and have a good life style in future. It's time to think for green and work for green. Environmental progress concept was started in 1970s and later culminated in the green revolution in 1990 which raised the attention of the need for preservation of environment and the role of human activities for environmental protection [4]. Many developing countries are working to make the world a green world. In spite of all this there is hardly any noticeable improvement. Developing countries are still struggling to embrace the concept and hence the implementation of green technology therein has made almost no progress. Developmental activities in developing countries like Nepal, India, Bhutan are getting along at a fast pace. It is believed that growth rate of construction industry in India, covering around 5% of the globe, is around 9.5%. It is worldwide understood that current construction practices in developing word use many non renewable resources resulting in large scale of deforestation whish hardly takes any account of environment protection. It is imperative that construction industry resorts to using the eco-friendly materials in an attempt to protect the environment [6].

A green building can also be perceived as a sustainable house or an eco- friendly house or an intelligent building which gives the reflection of a highly sophisticated and best performing building having high impact on human beings and environment. It results in improved health of the

- *Pragyan Bhattarai, A.V.A Bharat and Rajendra chaudhary are research students currently studying in Civil Department, K.L.University, India, PH-+919160451930. E-mail: pragyan25@hotmail.com*
- *Shashi Kumar Gupta is a professor and Head of department of Civil Engineering Department, K.L.University, India,E-mail:skguptanz@gmail.com*

inmates too. These types of building are designed to maximize human comforts by conserving the environment. Green concept is in short a creative use of the mind where simple things are given priority and use of locally available and astute materials in construction is promoted. This technology is spreading rapidly all over the world and people are more prone to this technology. The need of this type of technology in developing countries has become more crucial nowadays. There are different organizations which are responsible for spreading the green concept worldwide like US Green Building Council (USGBC), which is a third party certification body, Bureau of Energy Efficiency (BEE), Indian Green Building Council and several other non profitable government organizations. Literature released through these organizations also confirms that green buildings are proven to be environmental friendly and result in reducing consumption of natural resources, pollution and waste and also improves the health of people [5].

In nutshell a Green building or a Green house aims at:

- Use of indigenous material, and makes limited use of non renewable resources.
- Use of energy in effective/efficient way
- Recycling and reuse of materials for reducing generation of wastes and combating pollution.

This paper looks at identifying the causes as to why the concept of green buildings has not caught up and what can be done to promote its use in the developing world. The paper also presents the findings of survey done in developing countries and suggests some ground rules for the astute and effective implementation of green concept in the developing world.

2 PRESENT SCINERO AND IMPLEMENTATION EFFECTIVENESS

It is clear that in the developed countries like USA, Canada etc the effectiveness of implementation of Green building concept is more pronounced than in the developing countries like Nepal, Bhutan, India etc. For a building to be classified as a Green building it must satisfy certain basic criterion which may vary from one location to another. For example a building certified as green in India might not be certified as green in Nepal due to change in topography, climatic condition and other geographical considerations. Therefore different counties need to frame their own rules much like the standards of drinking water quality. The onus of framing these rules for India may rest with IGBC (Indian green building Council) [6, 1], much like the way as LEED, USGBC are in USA. On a similar basis other developing countries can also have their own councils, if not already existing. These councils should have the mandate not only to frame the rules but also to check whether or not the implementation is going on as defined in the rules set out by them. Quite simply the parameters for considerations should be e 1) Selection of site, 2) Planning of building, 3) Innovative and astute design, 4) Use of local material, 5) Management of wastage 6) Management of water and its effectiveness, 6) Use of energy and it's management 7) Selection of Materials 8) Management of indoor environmental quality.

These are some of the key parameters which are most important to be maintained in order to improve the performance of building and also reduce environmental impacts. Table 1 below shows some suggested parameters that can be included for assessing the buildings for use by the different classes of people. It may be noted that Yes indicates that people of enlisted class can afford and No indicates they might not or can't afford which is based on the survey done in Nepal, India and Bhutan.

Table1. Effectiveness for different class people buildings under various criteria

Sustainable site development			
Parameter	High class building	Middle class building	Low class building
Building By-laws followed	Yes	Yes	No
Soil erosion measures	Yes	No	No
Landscape	Yes	Yes	Yes

Parking facility	Yes	Yes	No
Heat island effect	Yes	Yes	No
Electric charging	Yes	Yes	Yes
Innovative Design	Yes	Yes	Yes
Water efficiency			
Parameters	High class building	Middle class building	Low class building
Rainwater harvesting	Yes	Yes	No
Managing irrigation system	Yes	No	No
Grey water treatment	Yes	No	No
Energy efficiency			
Parameters	High class building	Middle class building	Low class building
CFC equipment	Yes	No	No
Energy performance	Yes	No	No
Refrigeration	Yes	Yes	Yes
Solar	Yes	No	No
Materials			
Parameters	High class building	Middle class building	Low class building
Separation waste	Yes	Yes	Yes
Waste reduction	Yes	Yes	No
Organic waste management	Yes	No	No
Indigenous material	No	Yes	Yes
Indoor air quality			
Parameters	High class building	Middle class building	Low class building
Day lighting	Yes	Yes	No
Fresh air ventilation	Yes	No	No
Low VOC	YES	NO	NO
Carpets	Yes	Yes	No
Day lighting	Yes	No	No

Innovation design			
Parameters	High class building	Middle class building	Low class building
Innovation design	Yes	Yes	Yes
Cost	Yes	No	No
Registration cost/certification cost			
Parameter	High class building	Middle class building	Low class building
Registration cost	Yes	No	No

The above survey considered following criteria:

1) Income of People

High class building	Middle class building	Low class building
People having more than 20 lakh income annually	People having more than 5 lakh and less than 15	People having less than 5 lakh

2) Land accessibility of people

High class building	Middle class building	Low class building
People having more than 9000 sq.ft land for construction	People having 1800-8000sq.ft	People having below 1800

3) Awareness

High class building	Middle class building	Low class building
Very low(as per IGBC)	Nil	Nil

3 COMMON PRACTICES AND COM-

PARATIVE STUDY

Many types of council are working in the same basis where the pointing system is being followed up and criteria are classified. Checking for every criteria and the granting of the pointing system accordingly is done by all council in common. Other councils like IGBC, LEED, and NABH etc are the third party councils which are for awareness as well as certification process

Division	Prerequisites			Max.points			Certified			Silver			Gold			Platinum		
	LEED	IGBC	NABH	L	I	N	L	I	N	L	I	N	L	I	N	L	I	N
ID	3		-	11		82	-	2		-	2	8	-	2	10	-	3	12
LL	-			10			-	-		-	-		-	-		-	-	
SS	2		-	22		-	5	12		5	18	100	5	21	100	5	24	100
WE	-		-	15		115	3	8		3	9	6	3	10	13	3	11	19
EA	2		3	38		338	-	-		-	-	37	-	-	62	-	-	100
MR	3		-	16		217	2	4		2	2	44	2	2	60	2	3	77
EQ	7		-	21		132	6	8		6	10	31	6	12	54	6	13	72
AE	1		-	3		18	-	17		-	20	3	-	24	5	-	27	6
Other	-		-			-	29			44		100	59		100	74		100
Total	18		3	136		921	45	51	100	60	61	237	75	71	311	90	81	395

Where:
L-LEED (Leadership in energy and environmental development)
I-IGBC (Indian Green Building Council)
N-NABH
ID- innovation in design
LL- Location and linkages
SS- Sustainable sites
WE- water efficiency
EA- energy and atmosphere
MR- material and resources
EQ- indoor environmental quality
AE- Awareness and education

LEED, NAHB, and National green building standard are the three green building certification organizations that seems to be same but the costs and the types of buildings are different from one another i.e., as per the cost that includes registration, certification and inspection. For instance the cost is more in LEED certification when compared to NAHB and National green building standard. Observing the types of buildings is all single family homes that can go for all the three organizations, for multistoried and commercial buildings we need to go for the LEED only and overall the pointing system is based on same principle [14].

Implementation in developed countries was found to be satisfactory. The suitability and effectiveness of green building were assessed by collecting data from LEED certified buildings and their consequent effects by direct and indirect mechanisms to the environment. This mechanism effects on environmental design features of a Green Building on occupants, environmental awareness (EA) and Organizational Image (OI) [15]. For the astute implementation of green buildings, its components must take care of energy efficiency. Energy consumed by heating; ventilation and air conditioning (HVAC) and lighting systems utilize 60% of the electric power of the buildings, which challenges the green concept. The level of utilization of such material need to be reduced and alternatives sought. These

could simply be use of photovoltaic solar cells [15] or reducing the consumption of lights through day lighting effects [16]. Energy saving can be imposed in different ways like considering the sustainable development site through proper building orientation, building insulation, roof insulation, and use of lighting indoor and outdoor etc in a best possible ways. The orientation of building should be made using 'Vastu' concepts. Also building insulation can be taken care of through plantation of trees on the periphery which aid in saving up to 25% of energy. The roof should be green roof which can be achieved light color reflective coating which aid the natural light to pass by curtailing the energy consumed (50-80) %. The area of the windows can also be intensified such that it gives more light in day time which helps to reduce the use of electricity in daytime as natural light can be used. If the light is not in use we can turn off the light, use CFL lamp, electric ballast etc which also helps for green concept to certain extend [15]. Most of the buildings are responsible for 40% of energy consumption and 36% of the CO_2 emissions. Energy performance of each building is a key element to achieve the climatic and energy objectives, such as 20% reduction of the greenhouse gases emissions and 20% of primary energy saving target by the year 2020. It should be possible by the use of solar powers and use of other abundantly available renewable sources [10]. The basic component which need to be implemented in an innovative way are (a) Sustainable Sites, (b) Water Efficiency,(c) Energy & Atmosphere, (d) Materials & Resources, (e) Indoor Environmental Quality, and (f) Innovation & Design Process, and (g) maintenance of good indoor environment quality (IEQ).

From the point of view of indoor air quality 10 components that are to be considered are (a) Minimum Indoor Air Quality Performance, (b) Environmental Tobacco Smoke Control, (c) Carbon Dioxide Monitoring, (d) Ventilation Effectiveness, (e) Construction Indoor Air Quality Management Plan, (f) Low-Emitting Materials, (g) Indoor Chemical and Pollutant Source Control, (h) Controllability of Systems, (i) Thermal Comfort, and (j) Daylight. If more attention can be given for reduction of these parameters then it is easy to get the credit and also make building green [4]. Emission of green house gases is the main factor due to which global warming occurs and other dangerous effect on environment and human health occur. An international treaty 'Kyoto Protocol' was signed in December 1997 to reduce discharge of greenhouse gas to fight global warming. It was agreed to reduce the greenhouse gas emissions at least by 5% by 2008-2012 in order to tackle global warming and climate change. Some of the measures of the governments to achieve this goal were to promote new buildings construction and to retrofit existing buildings which can also satisfies the low energy criteria. In the same manner other countries also did the same [2].

Indoor environmental quality is also another main concern as people invest most of their time indoor and the air quality is most important which has direct influence in their health. The indoor pollution can be caused by the building and materials which are used for building decoration. It may damage people's health more than outdoor pollutions. Nowadays human beings not only have to put up with outdoor factors such as: noise, water pollution and motor vehicle pollution that result from global industrial development, but also the indoor environment pollution that comes from the buildings and indoor decorative materials. 68% of diseases are related to indoor pollutions or poor indoor air quality, such as aging of skin, hair shedding, general fatigue, forgetfulness, infertile, leukemia, and cancer. Some of the main indoor pollutants are benzene, carbon dioxide, formaldehyde, carbon monoxide, nitrogen oxides and biological pollutants that come from infrastructure that we use inside the building e.g. cooking, heating, furniture, attached garages etc. In summery indoor environment is 70% more toxic than outer city environment [8].

Movement of air in a building can be controlled with the help of ventilation system and this helps in conserving the use of air conditioning. 'Concise Ventilation' technique can be used in order to reduce the consumption of energy that is used for heating the house in the winter. Manual ventilation techniques have been used for reducing the consumption of energy, but this creates lots of problem as warn air get displaced by cool air in this process [11]. The shock ventilation process is given preference for maintaining the air circulation in the house without any loss. More than shock ventilation if the tickle ventilation is used

than it helps to reduce the loss by around 20%. In many countries consumption of winter heating fuel is the major source of CO_2 emission and energy consumption, so tickle ventilation can save lots of money. An analysis depicted that 70% of street-facing windows are blocked from full opening as per the requirement for shock-ventilation, and half of these are single-paned windows which only can be opened slightly, by being put on the trickle-ventilation setting, due to these blockages. The proportion of blocked windows may be even higher on the non-street facing sides of dwellings. Profound observation leads to signify that proportion of windows are put on the trickle setting (which means 10 degree tilt of the window toward inside) in winter. It is also advised and recommended that policymakers address the major issues: material design for affordable window modification, and more focused numerical and scientific content in promotional aid in the development of the concept of the ventilation with simple techniques [11]. The analysis also provides knowledge on the contribution of each subsystem, e.g. glazing, sunshading devices, natural and mechanical ventilation, so as to achieve energy efficiency. Buildings usually suffers from unconditional indoor comfort conditions (due to the high energy loss in winter, the excessive thermal gain in summer, the poor natural ventilation, and the visual discomfort which is caused due to the absence of shading devices) and energy consumption like HVAC systems which is very essential component for indoor condition [12].

It is proved that 80-90% of people's time is consumed indoor [17]. Due to the improper selection of materials the impact on human health is significant. Institute of Medicine (IOM, 2000) enlisted the chemical and biological indoor pollutants and their effect on human health such as respiratory allergies caused due to sick building syndrome. Sustainable development and green building movement have been adopted faster than any other recent movement in engineering field [16]. It is noted that Green concept is influencing many aspect but the awareness is still lacking which is also one cause why it is not being spread rapidly. A survey was made by the students and academician and it was noted that many people lacked understanding of fundamental concept of green buildings. The process need to be amended through the proper plan and its implementation. Firstly the awareness program must be targeted to include young engineers; academician then should be extended to the other users. The need for environment conservation should be well publicized. The planning in order to give awareness to students can be modeled by making a good curriculum at UG and PG levels of students training [16]. It is also important that the innovative design can help in making the system or anything more efficient and economical.

The above promulgates that a fundamental change is needed to promote green concept in developing country environment.

4. LIMITATION OF BUILDING DESIGNS

A building may cause negative impact to the environment as well as the health of human or living beings because of limitations of design. These may include oversight of 1) Local regulation 2) Rain water harvesting 3) Solar energy 4) Grey water treatment – management and reuse, 5) Innovation design 6) On site renewable energy 7)Rapidly renewable material 8) Certification cost 9) Cost of the materials 10) Lack of awareness 11) Government implementation and support 12) Lack of Public support 13) Paints using volatile organic compounds (VOC) being used for painting of houses 14) Industries emitting carbon dioxide and green -house gases, 15) the concrete admixtures, 16) Lack of parking facility causing traffic congestion on roads, and 16) CFC equipment's like ACs, refrigerators, micro ovens that create green -house effect.

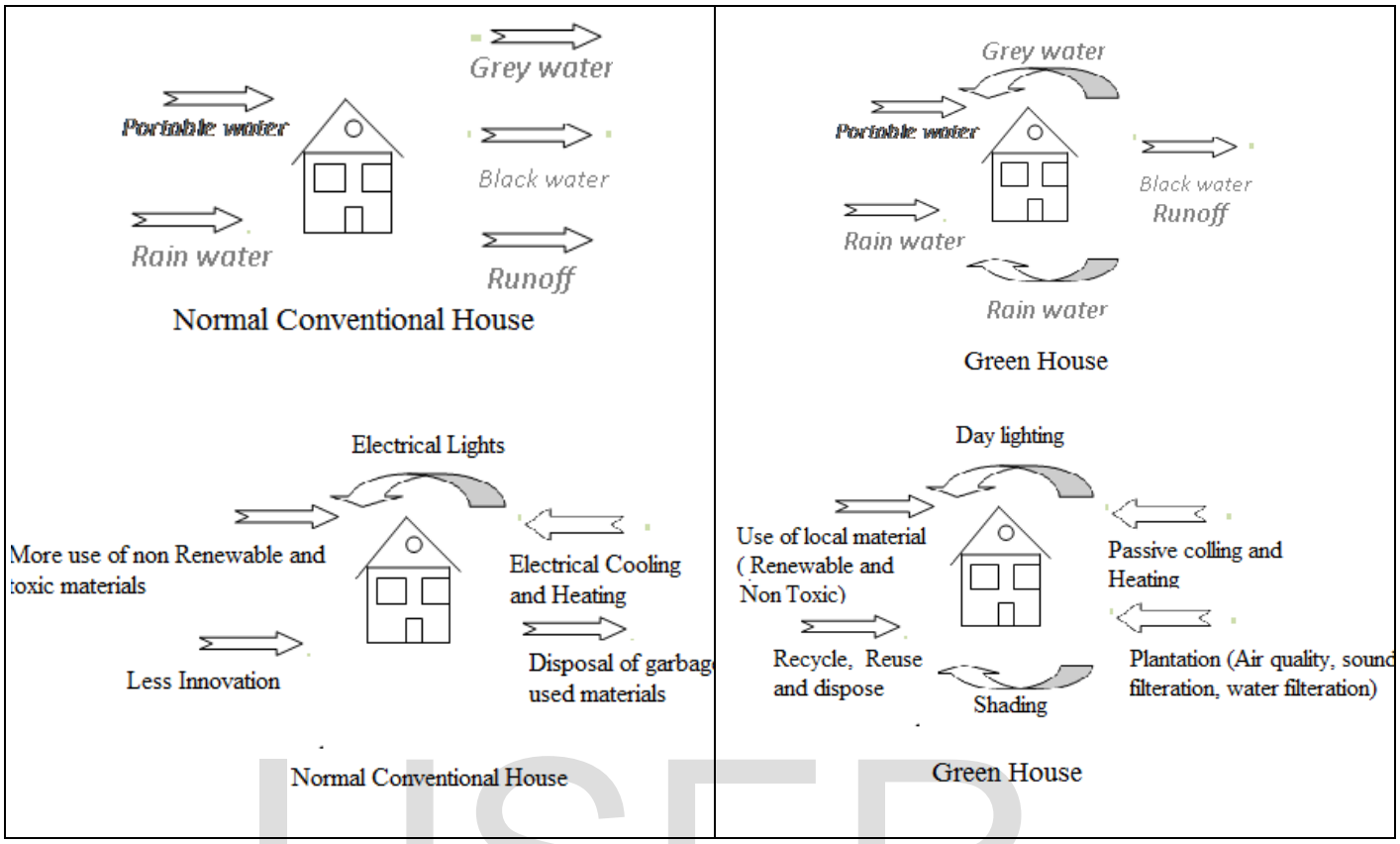


Fig.1 limitation of conventional building over green building

The above figure clearly speaks that Normal building and green buildings are not two different things but the implementation of ideas and Engineering concept is vastly different in these two cases. The use of green building can be beneficial for the environment as well as human beings as depicted in figure 2 below:

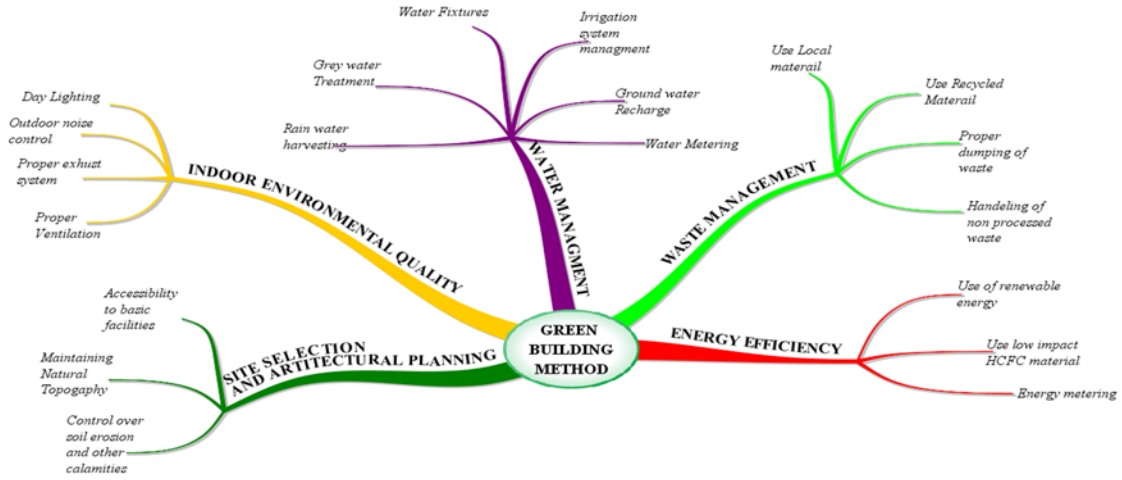


Fig.2 Mind mapping for Green Building Methods

It is not necessary to get the sophisticated and expensive materials for the construction of green house. Green house is like a common house that one might be staying in but the implementation of ideas and innovation would be more in a green house.

There are certain criteria which can be workout in a general building also for the conversion into green house. Normally any upcoming building must be checked and the following criteria and innovative design and innovative implementation must be given more priority. The criteria for this are:

1) Sustainable site Development

Mainly this sustainable site development encompasses the planning phase and also the conservation of grey water and other deeds which can be related to sustainable site. Proper planning of this helps a lot in reducing the negative impact over the life of development and also environment. The orientation of the building and its suitability for the user is another important component. Normally, grey water coming from household purposes are not very much polluted so we can reuse this again for general purposes and the heating island effect in house also make some negative impact which must be addressed and planning must be done accordingly.

Management of the grey water must be done within the house itself as grey water is used water after general purposes so we can reuse the water after certain level of natural filtration process which can be setup within the house boundary itself. For instance grey water can be collected in one place and it can be passed through the plants which absorb micronutrients for their growth and then it can be sand filtered and so collected water can be reused for flushing, cleaning, gardening etc. This water can also be used for planting tree which release maximum oxygen. Plants also help to increase Evapotranspiration and can be used for shading purposes basically in northern part which helps to reduce the energy consumption indirectly. It also helps to enhance infiltration and reduce the runoff. One tree is enough to provide oxygen for 20 people for lifetime and also it helps to reduce the sound pollution. For this deep rooted herbaceous plants need be selected. Heat island effect is also another problem which has concluded many problems so this also can be reduced from the simple engineering implementation. Green roof helps to reflect the sunlight and prevent from heating the house.

2) Water Saving

Water is one of the scared resources everywhere in the world. More than half of the population in the world has no good access to quality water. Water table is plunging down yearly and people are encountering many diseases and other problem due to lack of quality water. The grey water can be treated and can be used again as stated above. If people start to conserve the water from now itself then it is sure that they won't face any problem in the future. Normal calculation of water essential for one house is

For single family of 5 Members- Drinking purpose= 5 liter per person=25liter, Other purposes=100 liter per person*5=500liter/day. I.e. 525*30*12=189000liter (app.5000gallon)

This much of water is needed for a family per year which can be stored in the house itself through different techniques as described below:

Firstly, some portion of the water can be saved with the grey water reuse after filtration purposes. The plants must be deep rooted so that they won't easily die. Another good method is to go in for Rain Water Harvesting where water is collected from the rain and then it is stored for future purposes. Rain water is clean and can be used after wards in need or when water is in short supply. However, this water must be checked for its quality as environment consists of various harmful gases and microorganisms which might pollute the water. Such water can be reused after treating with SODISH method. In this water is stored in 2 liter white bottle and stored in sunlight for 6 hour and then it can be used for drinking purposes which is the basic but effective means. The extra water from rainwater can be used to recharge the water table by various means. This helps to store water in the house as well as store water in the form of water table which also can be used for drinking after certain level of filtration. This solely helps to address the water problem and make people not to depend upon poor water sources.

3) Energy Efficiency

Energy is also one of the major considerations in green concept. Almost everything needs energy like TV operation, Light operation, Heating, Cool-

ing, lightening and other HVAC etc. Energy is being consumed in every step of our life. The need of energy has racketed so much that demand is far exceeding the supply especially in developing world. So there is need to find alternatives.

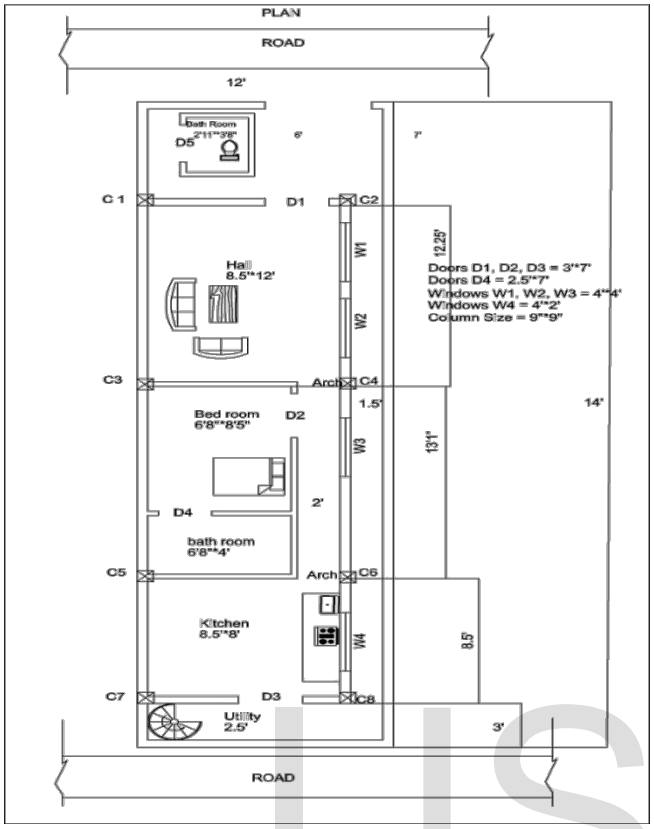
Innovative design such as passive cooling and heating methods which are economical and highly effective can be used. Likewise passive heating process such as enclosed design of house with less ventilation probability can be also used. Windows can be of tilt type which can be only tilted to certain angle which limits the flow of hot air inside the house. Passive cooling can be used by making plant to provide shading to the house. Making green roof or green parfaits and green surrounding, smarts designs also helps to reduce the consumption of energy in sufficient amount etc. The use of day lighting technique also can be implemented for limiting the use of lighting during the daytime. Lighting amplification techniques such as making curved place for bulb placement and using glass in that curve which reflects the light and helps to amplify the light may also be tried. Solar systems can also be used.

4) Material selection and Indoor air quality

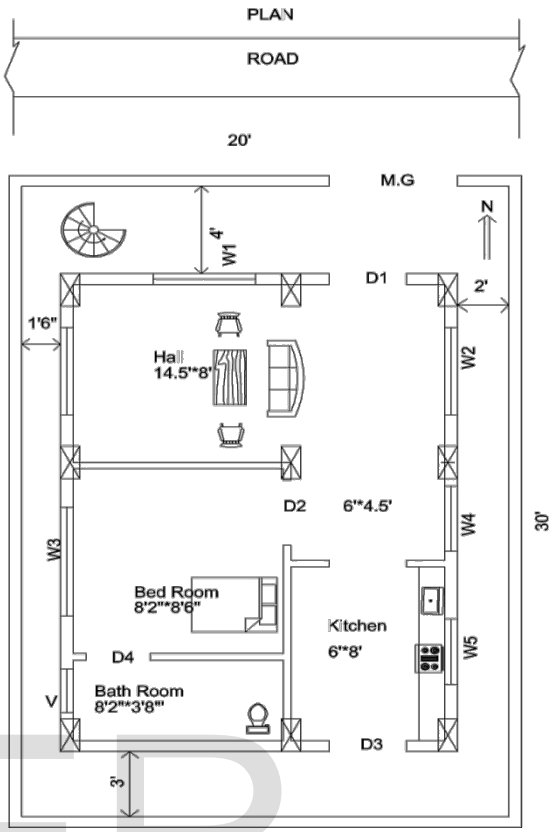
The selection of material is also crucial part as this shall influence our health and also impact in many other ways. Bricks used in houses are made of clay which is extracted from non renewable resources and also uses lot of energy for its production. Concrete also has many health related disadvantages. Plastics are not easily decayed and they create lots of problem if burned. Stones used as aggregates are quarry of rock impact natural resources. Marbles and granites and other materials are also non renewable materials. As people spend lots of their time indoor so air quality inside room must be fresh and clean.

Concrete block can be use for construction of walls. These blocks can be reused as aggregates by crushing them subsequently when house is demolished. Autoclaved aerated concrete (ACC) must be used utmost. Granite or tiling can be replaced by veneer flooring or other economical and useful materials. We must use low VOC materials and materials which are toxic in nature must be avoided. Replacement of cement with fly ash and other innovative stuff should be practiced without sacrificing the strength. Straw bale can be also used for the wall construction as being economical and effective indigenous material. Separate compost site and dump for all the decomposable materials should be constructed and useful materials recycled and reused. These can be used as valuable manure using aerobic/anaerobic decomposition processes. Reuse and recycle shall also reduce the area requirement for sanitary land filling, as and when needed.

5) Design

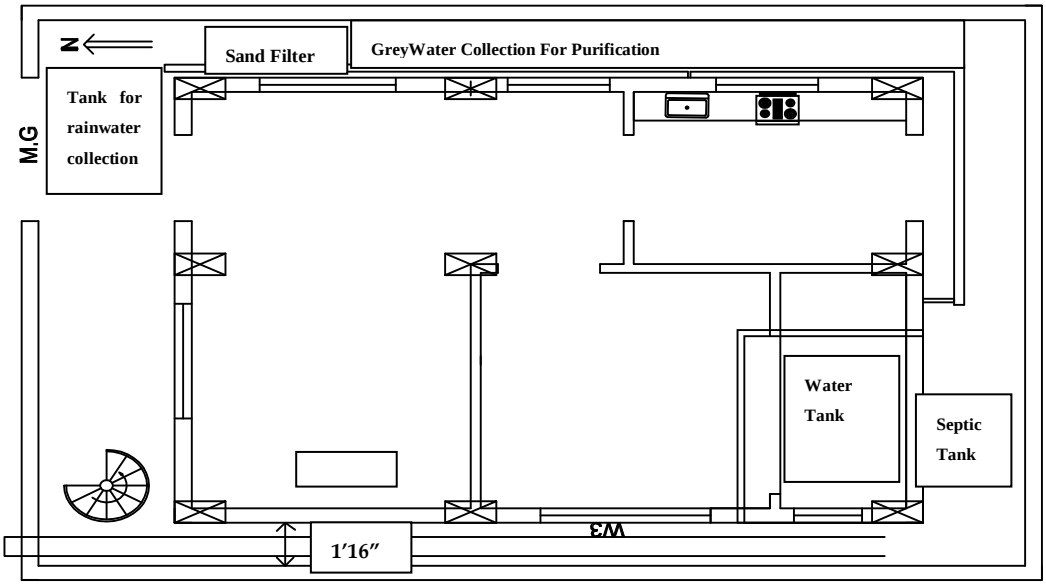


PLAN A



PLAN B

Fig 5. Design for Planning Of buildings



GROUND PLAN C

The innovative design in term of all of these parameters must be given high priority in the green house. Anything waste material can be turned over and made useful if common engineering concept along with innovative design is used and practiced. Some suggestions for design that can be followed are drafted above.

5 RECOMMENDATIONS FOR EFFECTIVNESS OF GREEN BUILDINGS

Though this technology is purely the application of basic science and engineering in construction and planning in an economical way for the assurance of good health of people but progress is not at a rate which can be appreciated. The main drawback behind it is lack of awareness among the people and less interest from the governmental sector. We should educate all the students about green concept from primary school level by including it in course, provide more and more trainings to engineers and other responsible people through organizing, conferences and other innovative programs. This should be initiated by the government itself within depending on LEEDS, IGBC and others to do it for them. Government should make some ground rules for initiation of basic concepts of Green buildings in design and ensure that these are included prior to registration certification being awarded. Consultants may be empanelled to provide services at a moderate cost, if needed y any home owner. The ground rules should be made in such a way that all the above recommended methods can be implemented easily. Soft term loans may be granted to buildings using green concept designs. For the poor and middle class family who can't afford high technology the common things guidelines and procedures must be provided for free and separate advisor for them must be arranged without any cost and the innovation that might be of any level must be accolade and government must provide discount for the registration process. These suggestions must be implemented with all earnestness then only the number of green building certification would increase within short span of time. Government may seek assistance from developed countries to support such education programs in developing countries. If this method is applied in a prompt manner then it would be possible to turn the world green in a reasonable span of time. The flexible pointing system along with the flexible registration charge with free advisor for construction from government itself can only make a world of difference..

6 CONCLUSIONS

The pace of development and rising need of people is increasing day by day which ultimately has increased the impact on environment. Human activities especially in construction industry impact various components of environment so working in collaboration with environment must be the main motto of today's world. Green building mythology is only the mean to get this done and there are various organizations which are working for spreading this concept. In spite of all this the pace is not so smooth and in developing countries this process is stagnant so this must be paced up. Firstly people must be made aware that green house is not an expensive house but the implementation of science and engineering in a tactful way with innovation is the basis of green technology. This approach can be spread by updating the green concept course from the primary school level itself. Various program, conference and training workshops must be launched on a regular basis. The ground rules for all the upcoming constructions should be made at government level and these should be strictly implemented while granting registration. Point grading should be given based on the parameters satisfied for green buildings. Some discounts and accolades for registration must be given for middle and low class people. Green building is a boon to the society where energy and water consumption can be reduced while still maintaining an, increase in productivity from occupants, their health and safety benefits. This means that if this concept can be effectively implemented then it will bring benefit to greater section of society.

6 ACKNOWLEDGEMENTS

The authors wish to extend gratitude to K.L.University, India. They also wish to acknowledge the help received from Venkata Hanuman Textiles Pvt. Ltd, India; Kathmandu University, Nepal; Government of Nepal (Auditor General Office); Government of Bhutan and Kinley Penjor, a student from Bhutan for assisting them in survey work.

REFERENCES

[1] Chris Pyke, Sean McMahon, Tom Dietsche, Green Building and Human Experience , U.S. Green building Council(USGBC),June 10, 2010.

[2] McGraw-Hill Construction. 2008. The Green Home Consumer: Driving Demand for Green Homes

[3] Lisa fay Matthiessen, Peter Morris, Davis Langdon, Costing Green: A comprehensive Cost Database and Budgeting methodology, July 2004

[4] Andrew J. Nelson, Oliver Rakau, Philipp Dorrenberg, Green Buildings A niche becomes mainstram, Deutsche Bank Research, April 12, 2010.

[5] National Association of Home Builders. (2009). ICC 700-2008 National Green Building Standard. Washington, D.C.: National Association of Home Builders.

[6] Rebecca Brownstone, Patricia Medina, Jon Schlemmer, James Skutezky, Proposed Western Engineering Green Building, The University of western Ontario faculty of Engineering, Preliminary Research Report and Proposal, July 2004.

[7] David Rodman and Nicholas Lenssen, "A Building Revolution: How Ecology and Health Concerns are Transforming Construction," Worldwatch *Paper 124* (March 1995), 41

[8] IGBC Home page, www.igbc.in

[9] IGBC Green Homes Rating System, Version 2.0, Indian Green Building Council, Abridged Reference . Guide, April 2012.

[10] Hamdy, Mohamed, Ala Hasan, and Kai Siren. "A Multi-Stage Optimization Method for Cost-optimal and Nearly-Zero-Energy Building Solutions in Line with the EPBD-Recast 2010." *Energy and Buildings* (2012).

[11] Galvin, Ray. "Impediments to energy-efficient ventilation of German dwellings: A case study in Aachen." *Energy and Buildings* (2012).

[12] Goia, F., Perino, M., Serra, V., & Zanghirella, F. (2010). Towards an

Active, Responsive, and Solar Building Envelope. *Journal of Green Building*, *5*(4), 121-136.

[13] Hepner, C. M., & Boser, R. A. (2006). Architects' Perceptions of LEED Indoor Environmental Quality Checklist Items on Employee Productivity. *International Journal of Construction Education and Research*, *2*(3), 193-208.

[14] Reposa Jr, J. H. (2009). Comparison of USGBC LEED for Homes and the NAHB National Green Building Program. *International Journal of Construction Education and Research*, *5*(2), 108-120

[15] Rashid, M., Spreckelmeyer, K., & Angrisano, N. J. (2012). Green buildings, environmental awareness, and organizational image. *Journal of Corporate Real Estate*, *14*(1), 21-49.

[16] Wolcott, M., Brown, S., King, M., Ascher-Barnstone, D., Beyreuther, T., & Olsen, K. (2010). Model for Faculty, Student, and Practitioner Development in Sustainability Engineering through an Integrated Design Experience. *Journal of Professional Issues in Engineering Education and Practice*, *137*(2), 94-101.

[17] Singh, Amanjeet, Matt Syal, Sinem Korkmaz, and Sue Grady. "Costs and benefits of IEQ improvements in LEED office buildings." *Journal of Infrastructure Systems* 17, no. 2 (2010): 86-94.

[18] Seifert, B. M. (2008). District of Columbia Green Building Act of 2006 and Its Implications for Sureties. *Journal of Professional Issues in Engineering Education and Practice*, *134*(1), 84-86)

[19] Sharrard, Aurora L., H. Scott Matthews, and Michael Roth. "Environmental Implications of Construction Site Energy Use and Electricity Generation 1."*Journal of Construction Engineering and Management* 133, no. 11 (2007): 846-854.

[20] Papadopoulos, A. M., and E. Giama. "Environmental performance evaluation of thermal insulation materials and its impact on the building." *Building and environment* 42, no. 5 (2007): 2178-2187.