Case Study
On
Hollow Concrete Block Housing, Bamboo Housing and Other Traditional Housing Technologies in Nepal

Table of Contents

1. Introduction

Housing sector contributes significantly to the local economy but it is also becoming one of the most polluting sector and promoter of unsustainable living. Nepal's population has increased to 26,494,505 over the past decade, according to a new census 2011, with the annual growth rate of 1.35 percent. The total number of households has increased to 5,427,302 from 4,253,220 in 2001. The annual urban growth rate in Nepal is about 3.62% and about 17.7 per cent of total population currently resides in urban area. It is estimated that 18% of total urban employment in Nepal is contributed by construction industries and there will be an additional need of 1 million urban houses from 2011-21 (UN-Habitat, 2011).

The sector imports most of its construction materials from its two big neighbors India and China, thus creating large carbon footprints. Brick one of the most used construction material in Nepal has a very high embodied energy level and to meet the need for 1million housing, billions of bricks will be needed. Brick has been a mainstay of building construction throughout and continues to be one of the most favored building materials around the world and urban and peri-urban centers of Nepal is not an exception. With sustainability becoming a basic requirement for all products and materials, conventional fire brick has come under increased scrutiny, in part due to the fossil fuel energy required to fire brick kilns and the associated CO_2 emissions. Fertile top soil is being used for brick making there by lowering the earth surface and losing the fertile top soil. It also has negative impacts on agricultural productivity and national economy. Kathmandu Valley itself is losing soil at least 217,000 cubic meter of top fertile soil due to uncontrolled excavation to produce 117 million bricks per year. Cement and Steel, one of the important components of housing in urban and peri-urban sector has very high embodied energy. Increasing use of cement also has adverse impacts on the environment and the ecology. Cement sales have been increased by 10% annually in 2013. In modern era building of construction, bricks, cement and steel are most common construction material and this can be reduced by promoting low carbon construction materials such as hollow concrete blocks, soil cement blocks, etc.

2. Objectives

The major objectives of this study are:

- To explore and identify various low carbon construction materials in Nepalese market
- To conduct a case study on different low carbon construction materials in housing like Hollow Concrete Blocks and Bamboo Housing.
- To identify the potential barriers in low carbon construction in Nepal.

3. Methodology

The literature review was conducted to collect the information about relevant researches. The technology mapping was done to identify available low construction materials in existing construction market of Nepal. Key informant survey was carried out to collect the required information on low carbon construction. The case studies regarding application of Hollow Concrete Block Housing and Bamboo Housing in different areas of Nepal were conducted.

4. Existing Building Construction Scenario

The current trend of construction in Nepal is such that 27% of houses are constructed with mud and stone; 8% of woods, bamboo and other temporary materials; and 57% houses with cement mortar. (National Housing Policy, 2012). The use of contemporary material like cement, brick, concrete, steel and aluminum for buildings are prominent in urban and peri-urban areas in Nepal.

With increasing urbanization, traditional buildings has decreased dramatically during past six decades and were gradually replaced by modern buildings made of contemporary building materials like brick, cement, concrete, steel and aluminum for past many decades. The traditional houses with mud and stone were common in the past that were designed to suit local climate using traditional knowledge. The materials used for traditional housing were mostly locally available materials like soil, stone, timber, bamboo and woods. Until the 50's in Kathmandu valley, construction was limited to brick walls in mud mortar and the building had to be topped with a sloping roof of tiles (or sometimes thatch).However, during the past six decades of modern development has not only ignored the past trend and knowledge but has also failed to fulfill the present days' needs. The building developed during the 1960's at that time was basically influenced by new building material of Reinforced Cement Concrete (RCC) with simple rectangular plan and elevation with flat roof, 'chattja' or 'vertical louver' projections (to protect sun and rain) over simple door and window openings which is being blindly followed till present with copied foreign architecture. Reinforced Concrete Cement (RCC) design is ubiquitous in the urban centers and cities these days. A RCC structured design is one in which steels are used as reinforcement along with the cement concrete to resist both compression and tension forces acting on the structure. Design may vary but the materials used in RCC houses are cement mortar and bricks, concrete mixture slabs as roofing material. Though these structures are sustainable, the construction is tedious and is energy intensive to use.

5. Case Studies on Existing Practices and Scenario of Low Carbon Construction Technologies

5.1 Hollow Concrete Blocks (HCB)

Hollow Concrete Block (HCB) is a walling material, applicable to both load bearing and framed structure buildings, designed with respective guidelines. HCB are the precast concrete blocks produced from appropriate mixture of cement, sand and aggregates (finely crushed stone chips) with manual or mechanical compressions that have hollow cavities in between the cells. A mixture of cement: sand: aggregate in the proportion of 1:3:5 is usually considered suitable for constructing blocks for load bearing wall. But the proportions can be altered as required based on the use of blocks. Very little cement is used to bind the sand and chips. It can be produced in different shape and sizes for wall construction to fit different construction needs and designs. There are usually three sizes of blocks produced. The common size of HCB ranges from 8*8*16 (units in inches), 6*8*16 and 4*8*16 which costs NRs. 60, 46 and 36 respectively. HCB can be alternative walling material to brick since it can be produced locally, or in a large scale with technical supervision.

With the price of clay burnt bricks on a consistent rise; HCB is very likely to be used widely in the future for economic purposes. Comparatively HCB has lesser embodied energy than traditional fire brick and thus is more cost effective. The CO_2 emission from HCB is much lower than fire brick. There are various advantages of use of HCB as walling material. The building construction with HCB is easy and speedy making construction more cost effective compared to clay burnt brick. The wall made of HCB has good thermal and sound insulation. Unlike clay burnt brick, HCB does not use top fertile soil for production thus having minimal impact on food security issues. Despite these advantages, HCB have not gained much popularity and market in comparison to clay burnt bricks in construction. The stereotype mentality that only bricks constitute strong structures is one of the main reasons behind it. HCB houses are 30-40% cheaper compared to RCC buildings made of brick and are more energy efficient, however the use of these materials has not been in substantial scale due to lack of incentives and supportive policies. Despite willingness and interest of people in HCB houses, there is no framework to define and assure strength of HCB. There are numerous small scale enterprises producing HCB but government has no proper record of it and there is also lack of assurance on quality of available materials in the market from these enterprises. To enhance the credibility of products, the government should set certain parameters and issue quality certification to correct the present situation. The bridging gap between producers and consumers and policy lapses has hindered the production and use of HCB though it has a huge potential market in housing sector in modern context when brick is being expensive and energy intensive. In fact, hand-made HCB are sometimes produced in small scale with very simple techniques and low investments which provides great opportunity to low-income and unemployed individuals to start a personal business. Though houses of HCB are not so common, it is being widely used now days in partition walls and compound walls, animal sheds and fencing of building compounds.

Some Examples

Many low-carbon HCB buildings constructed in recent years can serve as models to inspire engineers, architects, building owners, and policy makers. Some note-worthy examples of application of HCB in residential building development are described below.

I. Housing for People (Janata Aawas Karyakram)

There is government initiative on low cost housing, "**Housing for People** *(Janata Aawas Karyakram)"* program to support poor and marginalized groups and to promote ecofriendly and cost effective housing in districts like Sarlahi, Mahottari, Surkhet, etc. However GON's target failed due to the lack of social acceptance and public opposition. The general impression of low cost housing and for the people who are unaware of the technologies and its benefits, low costs means of lower quality. The people in the project area demanded government should make quality houses using the cement mortar and burnt bricks instead of soil cement blocks and bamboo if the government really wanted to build homes for the people. The people in the area general have the feeling that government was not giving value to marginalized groups by building low cost homes. So, the government was forced to construct cement brick masonry houses. This program has a target of construction some 3000 houses and about 2200 houses are already completed in Surkhet, Mahottari, Sarlahi districts of Terai Region.

II. HCB Housing at Sitapaila

HCB houses in Sitapaila were constructed by SLTDC. The houses were constructed using HCB, cement mortar and steel. There are four houses which are two and half storied. The houses were sold after construction to most of the families residing there.

Sailesh Shrestha; service holder of middle income family is very satisfied with the house and he has been living in one of the house since 5 years with his family. The main reason he bought the house was its cost which was about 4.5 million rupees including land that was almost half of the price to buy RCC house of the same size at the time and another reason was trust in assurance of quality of house. “This house is comfortable and inner temperature is maintained naturally in summer and winter so no heating and cooling is required” says Sailesh. He adds, “I had grown up in a traditional bungalow house in Kathmandu, and this HCB house is as comfortable as the traditional house compared to RCC houses”. Talking about the perception of general people, he shared that people generally perceive houses made of HCB to be weak.

Santosh Man Shrestha; a retired medical doctor who has been residing in one of the houses since last 15 years with his family states his house is still in good condition and looks new. However he shared few bitter experiences that there is sometimes seepage of moisture during monsoon from the walls. He also add many people are interested and ask about HCB housing, but most people hesitate to go for HCB house as people perceive RCC are safe compared to HCB house which are built under load bearing system.

Mr. Bidur Pandey; a national daily newspaper journalist has been living in one of the house since last 10 years says, “Though I have a geyser, I rarely use it because the inner temperature is maintained well in summer and winter”. Beside many advantages, one problem he faces with HCB house is unable to pin the nails in the walls. Since it is hollow, it is impossible to insert nails to hang electrical appliances, racks and book shelves on the wall. The main reason he bought the house was due to its low cost and trust in the quality of house.

Mr. Rajesh Manandhar, 37 year old businessman from Sitapaila residing in one of the house is willing to construct a HCB house. He has been staying in a HCB house since last 3 years in rent and looking at its low cost and benefits, he is keen in building HCB house for his family in near future.

The families residing in these four HCB houses at Sitapaila are very satisfied with the multiple benefits of HCB houses. The main reason families bought this houses was due to low cost and because of assurance of quality of HCB homes from the person who advised and designed the house from SLTDC.

III. Housing in Satungal

There are three HCB houses constructed by SLTDC in Satungal, Kathmandu. The main purpose of constructing this house was to provide house for poor people living in that area. After the construction, in consensus with the ward office bidding was opened for the purchase of the house in very nominal cost. The houses were sold at NRs 0.5 million to people selected through application procedure based on the lucky draw.

Kamala Giri, owner of one of the house at Satungal is not happy at all with the house she bought as she feels cheated. She bought this house for NRs 1.65 million from the owner who bought this house for NRs five lakh within a year of lucky draw. She was unaware while buying house that this house was low cost only of NRs 0.5 million made of HCB which has made her perception that the house she owns is of low quality. Similarly, the other owner of one of the house who was very rude and unhappy to even give his name for the interview also bought this house for NRs 2 million from the owner who bought this house for NRs 0.5 million. He unwillingly states that he feels cheated knowing that this house is made of HCB and cost was only NRs 0.5 million and feels more aggravated that many come for interview but nobody can be savior.

The case here shows that people are totally unaware of building materials like HCB and that the cost of the homes built used this technology are relatively cheaper but have various benefits. The public usually perceive HCB to be cheap material of low quality.

IV. Housing in Lamatar by Bhatbhateni Group

HCB housing in Lamatar was the concept of Bhatbhateni Group; one of the most trusted business companies and Green Valley Housing. They are building more than 100 houses in 3 phases and each home would be two and a half storied with 3 rooms including kitchen. Of 100 houses being constructed, 70 of them are already booked. More than 30 peoples visit every day in their stalls to inquire about the house. Most of the houses have already been booked even prior to completion of construction work. The price for a two and half storied HCB houses in the area of 1324 sq. ft is NRs. 3.7 million including price of land. According to sales Manager of HCB houses from the Green Valley Housing Mr. Pukal Gurung, the main reason for sale of this house is because of prices being low with assurance of quality and presentation of their brand. Mr. Gurung adds that there is a big potential of HCB housing in the future due to its cost effectiveness and he feels it needs to be promoted for sustainable housing and eco-friendly construction practices.

The houses are built under load bearing system using HCB (1:3:5), iron, pre-cast and cement masonry. The HCB are produced on construction site and sample from production is tested for strength in Pulchowk Engineering Campus for quality control. The Green Valley Housing group also has future plans to construct more HCB houses to serve more people.

5.2 Compressed Stabilized Earth Block (CSEB)

Compressed stabilized earth block (CSEB) is a manufactured construction material formed in a mechanical press that forms a compressed block out of an appropriate mix of fairly dry inorganic soil, non-expansive clay, aggregate, and sometimes a small amount of cement. CSEB can be compressed in many different shapes, sizes and forms from plain blocks to hollow interlocking blocks for earthquake safety, U blocks for ring beams, coping blocks for the roof top and even tiles for the floor. The shape and size of the block depends on the size of formwork used. A very little cement (3-5%) is used to produce CSEB to bind the soil and sand.

There are many advantages of the CSEB system compared to fire brick. CSEB is cost effective as on-site materials can be used reducing cost, minimizing shipping cost of materials, and increases efficiency and sustainability. The wait-time required to obtain CSEB is minimal as blocks are readily available after pressing and a short drying period. Along with this, uniformity of the blocks simplifies construction, and minimizes the need for mortar, thus reducing both the labor and materials costs. The blocks are strong, stable, long-lasting, water-resistant, and provides better thermal insulation.

There have been attempts to introduce CSEB in Nepal since past decade; however it does not seem to have exceled up despite being cost effective and ecofriendly. The reasons seem to be partly the prejudice in mind of people against earth as an inferior and backward material as compared to contemporary materials like brick and cement.

5.3 Bamboo Housing

Bamboo has been a very popular, indigenous construction material, associated with construction and cultural practice all over the world. Bamboo is used in different purpose and aspects of life from construction to livelihood in Nepal. There are about 23 genera and 81 species of bamboo in 73 districts of Nepal (htt). Bamboo is one of the fastest growing plants and can be harvested in 3 years. Bamboos being lightweight, pliable and yet very strong, can be brought into multiple uses. Bamboo has been used for scaffolding since many decades in Nepal. The demand for bamboo for this purpose is one of the biggest. Beside use for scaffolding, bamboo has been used in Nepal from centuries for house construction. Bamboo mixed with wood and other materials has been used in building houses in Nepal. Most of the components of the houses like walls, floors, roofs, furniture, scaffolding, ladders, fencing are made of bamboo in traditional house.

Use of bamboo in housing however, has some disadvantages, as it is a non-dimensional material and does not often come with uniform shape, size and age. As well if bamboos are not treated well then they are highly vulnerable to fungus and termite attacks. Even considering the above-mentioned disadvantages there is a great opportunity to promote bamboo for the construction of houses as all the above problems can be solved by converting or processing bamboo into engineered panels. All the disadvantages of natural bamboo would naturally be mitigated once it is processed and neither its hollowness nor the lack of uniformity would hamper it to use as a construction material. The other great advantage of the panel is that it could be fabricated according to the standard requirement for the housing such as that of timber housing and would solve the problems of building code. Bamboo houses can last for over 50 years and can be designed to be earthquake resistant. International codes for the bamboo building has been proved by ISO. However, due to lack of national codes of bamboo building in many countries including Nepal, it is difficult to build bamboo houses with raw bamboo.

Besides these multiple benefits of bamboo, they are being used mostly in luxury condominiums. Contextually in Nepal, in modern era, the bamboo is mostly used to construct a shed for animals, building temporary huts, garden, and for building lodges and hotel. Existing market for the engineered bamboo housing is almost non-existence in Nepal. Current bamboo applications in Nepal have failed to capture modern value added market for bamboo. The exploration of new market for the panel based bamboo housing may take lot of effort and some time until people start accepting bamboo housing which is one of the major reasons why use of bamboo in Nepal for commercial purpose other than scaffolding is untapped to its fullest. Bamboo prefabricated quality houses are much cheaper compared to bricks or stone made concrete houses and bamboo processing and production consumes less energy compared to other building materials like concrete, steel and brick. The promotion of bamboo-engineered housing can result to commercialization of bamboo farming, processing /production and marketing. The potential bamboo housing industries can go a long way in making the much needed transition to a low energy and carbon construction future in Nepal.

Some Examples

Many low-carbon bamboo houses constructed in recent years can serve as models to inspire engineers, architects, building owners, and policy makers. Some note-worthy examples of application of bamboo in residential building development and a school are described below.

I. Bamboo eco-housing project in Nepal

Bamboo eco-housing project was a social housing project by a Nepalese NGO "RES Nepal" that was supported financially by Global Environmental Facility- Small Grant Program (GEF/SGP) and International Network of Bamboo and Rattan (INBAR). The project was implemented in Kanchanpur district; the Western Terai region of Nepal. The main target group of the project was "*Kamaiya*" recently liberated bonded labor. Bamboo prefabricated quality houses were constructed for Kamaiya along with technology transfer. Bamboos were pre-fabricated by Himalayan Bamboo (affiliated with INBAR) in Hetauda. The constructed house consists of 9 panels and each panel is made with flattened bamboo in wooden frame. Flattened bamboos are woven to the both sides of wooden frame in such way that the inner parts of the bamboo are exposed towards the exterior of the wall. The prefabricated panels are then assembled in the light concrete foundation made with stone and concrete with about 40-cm depth. After the assembly of the panels in the foundations, all the walls are plastered with cement mortar. The roof consists of Zinc tins that were secured with bamboo trusses. The total area of a house is about 30 square meters with cost of one house estimated to be around US$1000. The houses are taken as earthquake proof, low cost and its duration is more than 30 years.

II. Samata Sikshya Niketan (Bamboo Schools)

Samata Sikshya Niketan; a privately managed community school was initiated with the only mission of the school and college is to facilitate easy reach of education to the economically deprived. This school provides education up to higher secondary (Grade 12) in only NRs. 100 per month. Samata Sikshya Niketan started its education 14 years ago from Jorpati in Kathmandu with 850 students, and now there are 38,000 pre-primary to secondary students at 19 different schools from around the country so far. The interesting thing about this school is that all the school building, compounds and furniture are made from bamboo. As the nickname implies, these schools are constructed mostly out of bamboo. Samata School is not only offering cheap and quality education; it has helped bring positive vibes in the community and people that bamboo can be used for construction as well.

III. Habitat for Humanity (HFH) bamboo houses

Habitat for Humanity (HFH) started bamboo housing for poor people to uplift the living standards of the rural poor. Mahottari, Dhanusa, Siraha, Saptari, Sunsari, Morang, Jhapa, Ilam, Pachthar are the districts covered by this project. The houses constructed in these areas are one stored, two room, two-way or four-way sloped roof houses. The building materials used are wood, bamboo, concrete, bricks, Corrugated Galvanized Iron (CGI) roofing sheets and mud tiles. A simple post and beam system is used for construction. The construction type popular nowadays is where people have 6inch X 6inch concrete pillar with lower time beam on which wooden frames are attached. These frames are used for making bamboo split woven infill wall. The walls are then plastered with cement mix. Wooden beam is used at the top and wooden/bamboo rafters are used to support CGI roofing sheets. By July 2009, HFH constructed 5,000 houses and reached the milestone of the 20,000 houses by 2012 using low cost bamboo housing techniques. So, this shows the very bright and potential future of bamboo houses and the bamboo market. Driven by the overall success HFH is envisioned to build 100,000 by 2016 in Nepal using low cost and eco-friendly housing techniques such as bamboo housing.

5.4 Earth Rammed Housing

Rammed earth is a technique for building walls using natural raw materials such as earth, chalk, lime or gravel. It is an ancient building method that has seen a revival in recent years as people seek more sustainable building materials and natural building methods. Modern day rammed earth technique uses a larger formwork into which mixture of earth that has suitable proportions of sand, gravel and clay (sometimes with an added stabilizer) is poured and tamped down, creating larger forms such as a whole wall or more at one time. Historically, such additives as lime were used to stabilize the material, whilst modern construction uses lime, cement or asphalt emulsions. Historically the earth rammed technology was used in different parts of Nepal for building mudstone houses. The modern earth rammed technology is very new and least used technology for building in Nepal.

While the cost of material is low, rammed-earth construction without mechanical tools can be very time-consuming; however, with a mechanical tamper and prefabricated formwork, it can take as little as two to three days to construct the walls for a 200 to 220 m^2 (2,200 to 2,400 sq ft) house. These earth ram houses are energy efficient and have high thermal properties. But the disadvantage of this type of house is that it is labor intensive to construct. Since the use of cement and steel are very less, this is also a low carbon construction.

5.5 Traditional mud stone houses

Traditional Nepali houses are mud stone masonry with thatched roofs. These houses use locally available materials from their locality. The walls are made of mud stone and doors and windows of woods. The roofs are thatched or flat suiting the local climatic conditions. CGI sheets are fixed over the truss of wood or bamboo. Sometimes paddy straw are also used which is much cheaper. But it has high fire risks and water seepage problem sometimes during monsoon. These traditional houses are very energy efficient and strong that can last for hundreds of years. The doors and windows in these types of houses are wooden frames. In a study done by the Institute of Engineering, it was found that 67% residents like to construct their house in the same traditional way with same materials & technology. It indicates that still majority of the people prefer traditional houses with low embodied energy. So, traditional houses should be promoted with some technological and structural improvements which will help develop a low carbon path for housing sector in Nepal.

6. Existing Government Policies and Programs

The government of Nepal drafted the National Shelter Policy in 1996 which provided the government a role limited to facilitate provision of basic services and regulatory mechanisms, while the private sector was envisaged to take the lead role in housing provision. The government revised the National Housing Policy 1996 in 2012 so as to make housing facilities accessible to the urban poor and better manage the urbanization process. The National Shelter Policy 2012 has one of the strategies to use energy efficient and low carbon construction technology. With increasing impact of climate change the concept of low carbon development has originated to mitigate GHG emission. The climate change policy 2011 has main goal of improving livelihoods by mitigating and adapting to the adverse impacts of climate change, adopting a low-carbon emissions socio-economic development path and supporting and collaborating in the spirits of country's commitments to national and international agreements related to climate change (Climate Change Policy, 2011). One of the quantitative targets of Climate Change Policy, 2011 is to formulate and implement a low carbon economic development strategy that supports climate-resilient socio-economic development by 2014. Government of Nepal with financial support of DFID and EU has initiated the Nepal Climate Change Support Program (NCCSP) with main objective to implement the Climate Change Policy 2011 and develop and implement necessary strategies. NCCSP is to support GoN to formulate and implement important climate change strategies including Low Carbon Economic Development Strategy with main objective to develop concrete actions and interventions that support low carbon development which will foster the for sustainable socio-economic growth of the country. Under Low Carbon Economic Development Strategy, six thematic sectors and one cross cutting sector: Energy, Agriculture, Forestry, Industry, Transport, Building and Waste and Cross Cutting are identified for development of strategy. Alternative Energy Promotion Centre (AEPC) has been designated by MoSTE as implementing agency to formulate the Low Carbon Economic Development Strategy.

The draft of Green Building Technical Guidelines has been developed by DUDBC. Under this guideline, it has guideline on site layout and building orientation to make it energy efficient. There is also guideline regarding use of building material with encouragement of use of recycled and reused materials for building house if possible; use of locally available materials available; and use of building materials with less embodied energy as much as possible. However this guideline is not mandatory. In a bid to promote ecological and sustainable housing, the Department of Urban Development and Building Construction (DUDBC) in collaboration with UN Habitat is all set to introduce detailed guidelines for sustainable housing by the end of this fiscal year (mid-July).

Only policies and some regulatory frameworks will not encourage the adoption of low carbon materials in construction sector. The Nepal National Building Code was prepared in 1994 to specify the minimum standards for constructed buildings structures. This standard deals with the requisite quality and effectiveness of construction materials used mainly in building construction. The code requires the use of materials confirming to Nepal Standard (NS) or Indian Standard (IS) or any other approved standards agency to satisfy this Standard which is referred to IS. The use of appropriate, adopted or new materials is encouraged, provided these materials have been proven to meet their intended purposes provided that these materials comply with the requirements of this code. But the code has no reference to any criteria (better in quality, strength, effectiveness, fire resistance, durability, safety, maintenance and compatibility) that required to be checked. There are several other building materials that are commonly used in the market whereas these materials are not included in the Codes or Standards. There should be a mechanism where these new materials and technology could be permitted for use under the code provisions.

The government intervention such as providing subsidies can be an encouragement for the adoption of low carbon construction materials. For example, Lalitpur Sub Metropolitan City is planning to categorize houses in A, B and C classes on the basis of five major areas of the green agendas such as use of eco-friendly construction materials, passive solar design, energy efficiency, water conservation and sustainable management of solid and liquid waste. Internationally, voluntary building rating systems have been instrumental in raising awareness and popularizing green building and most of the rating systems devised have been tailored to suit the building industry of the country where they were developed. There are various rating systems around the world such as LEEDS in USA, DGNB in Germany, BREEAM in UK, Griha in India, etc. The voluntary green building certification system can also be one of tool for moving towards low carbon construction.

7. Barriers for low carbon construction materials

Barriers	Description
Concept of low carbon construction material as an alternative	Construction practitioners are not totally aware of the low carbon construction material as an alternative to contemporary building materials like brick and its importance in protecting environment from continuing waste generated and reducing GHG emission by the construction industry. Low carbon construction is still a relatively new concept for construction industry in the developing countries like Nepal. The readiness of construction practitioners such as developers, and contractors, along with general public in adopting sustainable materials in construction sectors is still low. The general concept of public towards alternative low carbon construction material such as HCB and soil cement block is that of weak materials and that used by poor people due to its low cost compared to conventional materials and are totally unaware of the benefits of low carbon construction material. Most of the people only consider RCC frame houses made of conventional materials like brick, cement and steel as a strong house. There is still lack of knowledge concerning the usage of alternative sustainable materials to conventional materials. Awareness and knowledge are the first challenge that must be conquered in creating a sustainable low carbon construction sector.
Code and Regulation	Only policies and some regulatory frameworks will not encourage the adoption of low carbon materials in construction sector. The lack of code and regulation in contribution to low carbon construction is one of the barriers in the adoption of materials alternative in place of conventional material. There are several other building materials in the market but these materials are not included in the Codes or Standards. When there is no code and regulation that is able to guide the developers, it will become an obstruction for the stakeholders in using sustainable materials. The provision of code and regulation compliance for these sustainable building materials will motivate more developers to adopt these materials. Thus more stringent building codes can be important motivators for engineers and architects to move markets toward lower carbon buildings.

Limited Availability of low carbon construction materials and lack of information	The application of low carbon construction materials in construction sector is still not popular also due to the very limited and variable availability of these materials. There are quiet fewer choices of sustainable materials in the current Nepalese construction market which is also one of hindrance for practitioners to adopt these materials. The market is also only reachable to limited knowledgeable practitioners and also lacks enough production. There is also lack of readily accessible and reliable information comparing alternative structural materials and systems. This poses a significant barrier during the design and selection process and makes difficult for stakeholder to make proper decision to adopt these alternative sustainable materials.
Quality assurance and aesthetic value of materials	One of the barriers in acceptance of alternative building materials is also because of lack of quality assurance of available materials in the market. There is no existing norm and guidelines for manufacturing these alternative materials plus there is no monitoring mechanism from government to ensure quality and strength of these alternative sustainable materials. Labeling of such construction materials is necessary to ensure quality and strength of materials. The other barrier is appearance of these alternative sustainable materials in the finished building. Aesthetically the available alternative material does not seem attractive to the public which puts off the general public from adopting it. There is need of innovation and research to make available alternative material appear aesthetically attractive for housing.

8. Conclusion

The adoption of low carbon construction materials as an alternative of the conventional construction materials is essential for construction sector to reduce GHG emission. Barriers identified in the above section can play an important role in identifying the strategies in promotion of sustainable building materials. The increased usage of low carbon construction material can be made possible by improving awareness and knowledge and encouraging construction practitioners to place their investment in long-term low carbon construction future along with provision of code and regulation compliance for these sustainable building materials to motivate more developers to adopt these materials. Furthermore, government intervention such as providing subsidies can be an encouragement for the adoption of these alternative materials. The voluntary building rating systems can also be instrumental in raising awareness and popularizing low carbon construction. The increased adoption of alternative building materials through increased awareness, knowledge and stringent building codes and regulation will thus drive the market with more investment. There is also need of norms, guide and regulation from government to assure quality of alternative building material in the market.

List of Person Interviewed

Name	Department	Contact number
G.P. Gorkhali	DUDBC	9849732828
Shivahari Sharma	Division of Urban Development	9851058699
Dwarika Shrestha	Division of Environment, DUDBC	9841272236
Prem pokhrel	AEPC	15539390
Er. Ramita Shrestha	Division of Environment, DUDBC	9841294742
Kedar Prajapati	MOUD	9841219285
Ramesh Singh	Division of Urban Development	14262365
Er. Machaakaji Maharjan	Building Division, DUDBC	9841462414
Ms. Meera Gyawali	Building Division, DUDBC	9841312742
Mr. Rajaram Shrestha	KMC	9841360750
Mr. Thamba Raj Shrestha	DUDBC, Housing Division	9851087088
Er. Gopal Bhattarai	DUDBC, Housing Division	
Ms. Rojita Maharjan	Minergy Nepal, Pvt. Ltd.	9841608226
Pabitra Neupane	Habitat for Humanity	01 4432801
B.L. Shrestha	SLTDC	4280187
Mr. Chakrabarti Karn	DUDBC, Saptari	9844020948
Mr. Krishna Aryal	Himalayan Bamboo, Ktm/Hetauda	057 523632/9841320599
Ms. Sunila Shrestha	Bhatbhateni, Patan Krishna Galli	5520988/5523555
Ms. Pramila Rai	Bhatbhateni, Head Office KTM	4419181
Ms. Gayatri Karki	Bhatbhateni, Narayan Gopal Chowk	4016130
Mr. Bisharjan Lawati	Bhatbhateni Koteswor	46013000
Mr. Puskal Rai	Bhatbhateni, Boudha	4485395
Mr. Nilkantha Shrestha	Sitapaila	9841252249
Er. Mohan Poudel	KMC	9851064690
Mr. Badri Rajbhandari	SLTDC	9849211108
MS. Bal Devi Pokhrel	HFH, KTM	9801033806/4432801 (ext. 103)
Dr. Santosh Man Shrestha	Sitapaila Ktm	
Sailesh Shrestha	Sitapaila Ktm	9851027997
Mr. Bidur Pandey	Sitapaila Ktm	9851026126

Mr. Arjun Thapa	FNCCI/AEC	14262245
Mr.Keshav Nath Adhikary	AEC	9851165332
Mr. Yakraj Pokhrel	HFH, Jhapa	9802700445
	Gharelu tatha Sana Udhyog Bivag	14267993
Mr. Uttam Sanjel, Coordinator	Samata Sikshya Niketan (Bamboo School)	9851071468
Mr.Keshav Nath Adhikary	AEC	
Mr. Damodar Neupane	Dept. of Cottage and Small industries	15521502
Mr. Rajendra Man Shrestha	Federation of Nepal Cottage and Small Industries	9841272073
Mr. Sudan Gurung/Pukal Gurung	Green Valley Homes Nepal	9818332784/9841264079
	Samata School, Banepa	16922255
Mr. Nripal Adhikari	Community Learning Center/Abari, Dhulikhel	9843112859
Mr. Pritam Bajagain	Princpal, Banepa Samata School	9851029762
Ms. Kamala Rai	HCB House owner, Satungal	

REFERENCES

(n.d.). Retrieved 7 2014, from http://abari.org/bamboohousing

(n.d.). Retrieved 7 2014, from http://www.globalcement.com/news/itemlist/tag/Nepal

Aparicio, E. M. (2013). *Urban Growth and Spatial Transition in Nepal: An Initial Assessment.* World Bank.

Bajracharya, D. S. (2014). Comparision of Traditional and Conventional Building Materials and Technology.

(2009). *Bamboo Resource Mapping and Feasibility Assessment for Preprocessing.* Federation of Nepalese Chamber of Commerce and Industries (FNCCI), Agro Enterprise Center (AEC).

Bodach, S. (2014). Energy Efficiency Opportunities at Household Level in Nepal. Kathmandu.

Brilhante, D. O. (2104). Energy Efficiency and The Use of Renewable Technology for Housing Sector. Nepal.

C.I.Jones, G. a. (2006). *Inventory of (Embodied) Carbon & Energy (ICE).* University of Bath, United Kingdom.

(2011). *Climate Change Policy.* Government of Nepal.

EEC-FNCCI. (2014).

Habitat for Humanity International. (n.d.). Retrieved 04 2014, from http://www.habitat.org/where-we-build/nepal

(2012). *National Housing Policy.* Government of Nepal, Ministry of Urban Development, Kathmandu.

Pokhrel, U. R. (2011). CHALLENGES AND OPPORTUTNITIES FOR BAMBOO ENGINEERED (PREFABRICATED) HOUSING IN NEPAL.

Shrestha, B. L. (2013). *Low Cost Housinh for Practicing Engineers and Artchitects* (2nd ed.). The Rising Sun Printers.

UN-Habitat. (2010). *Nepal Urban Sector Hpusing Profile.* United Nations Human Settlements Programme (UN-HABITAT).