Retrofitting – Going Green by Reducing Reconstruction

Green options are discussed when one is planning to construct a new building. Some try to identify the viable option having lowest energy input in the production of the materials used in the construction. Others identify the options and the design that will result in to lowest possible energy requirement such as that for cooling or heating, lighting, sanitation etc. during the use of the building.

But little attention is given to the energy consumed by the options that help reduce the vulnerability of the occupants of a building in the face of the likely disasters that may strike the building. Also, no attention is given to the energy consumed by the materials that will be used in restoring a building that has been damaged by a disaster, or reconstructing a building that has been destroyed.

India witnesses destructive disasters every year, in one part or another. Tens of thousands of buildings/houses are destroyed and many lives are lost, thus bringing much hardship and losses to the people. This includes earthquakes, cyclones, floods, landslides etc. **Table 1** gives indicative numbers on the damage and destruction brought by the earthquakes between 1993 and 2005 in the country.

The houses that were destroyed had to be rebuilt. Today with the emphasis on the use of "modern" cement-based technologies in the reconstruction it would mean that the severely damaged houses and the destroyed ones were rebuilt using bricks in cement mortar, with RC slab as the roof. Considering, that a typical house that is rebuilt is detached, has a built up area of 250 sft., and has one storey, the approximate quantity of the materials used could be as shown in the **Table 2.** .

A building collapses or suffers severe damage in a disaster because it is not adequately strong to withstand the forces of the disaster. The strength of the building depends on, among other things, the strength of the materials used, adherence to the rules of good construction practices, state of maintenance and the presence of the disaster resistant features. These features include reinforced concrete band at the lintel level and along the top of the gable walls, reinforcement around the doors and windows to encase them, and the single bar vertical reinforcement at the junction of the walls. On the other hand, it is possible to retrofit an existing building in order to improve its resistance against the likely future disaster, so that if the disaster strikes then its impact can be significantly reduced, the collapse prevented.

Retrofitting as a preventive measure is the most economical and most green option to ensure safety against future disasters, particularly the earthquakes. Its main advantages are…

- Involves the execution of substantially fewer items, on specific parts/portions of the existing building
- Costs only 10% to 20% of the cost of construction of brand new house.
- Is speedy
- Does not require demolition of existing structure
- Causes very limited disturbance/damage to the existing conveniences
- Does not have to be carried out on the whole house at once or can be carried out in phases

The features which are required to be executed include seismic ferro-cement belt on both faces of all the walls at the lintel level, similar belts just under the sloping top of the gable walls, encasement belts around door and window openings, and a single vertical bar in the inside corners of each wall to wall junction. The belts contain welded wire mesh of specific gauge of steel wires and some steel bars of 6mm or 8mm diameter. The encasement of the openings is done only on one wall face. The vertical reinforcing bars in the wall-to-wall junction are no different from those used in the new buildings. If any portion of the structure is damaged or is in dilapidated condition then that part is removed and rebuilt with care.

Thus it can be seen that energy input in the materials required for retrofitting is approximately **7%** of that used for the new construction. This analysis does not include (a) the energy input in the materials used in restoring all the internal facilities that would be lost when the existing structure is demolished, and (b) energy input in the disposal of the debris. When the numbers are compared at a different level as shown in **Table 4** the true impact on the carbon footprint can be realized. **Table 4** gives the rough estimate for the energy input in the production of the materials that could have been used in (a) the retrofitting of the buildings before they were severely damaged or destroyed in the earthquake and in (b) the reconstruction following the earthquake.

Thus far, the vulnerability reduction of houses has been considered in the above mentioned analysis. This may be a difficult proposition since at individual level the liquidity required for retrofitting is difficult to generate, and hence, some what hypothetical. On the other hand the public buildings where the risk is several folds higher than in the private houses, it is important that the vulnerability is reduced. In such buildings it is possible to generate the necessary funds if the government decides to set its priority in the right direction.

Recently, near Dehradun city, in the village of Thano, a 125 years old primary school building having tin roof and stone walls was retrofitted to reduce its vulnerability. Earlier, the school that is under Sarva Shiksha Abhiyan was set aside for demolition and reconstruction using bricks, cement and steel. But with a small assistance from BMTPC, Govt. of India this 125 years old building was retrofitted to reduce its vulnerability against a future earthquake. The net outcome was that upon spending approximately Rs.200,000 for retrofitting, not only a huge savings of nearly Rs.800,000 that would have been spent on reconstruction, but a heritage building was saved for the posterity. Being so old, every senior citizen from that area studied at this school.

Several months later, another primary school building 65 years old, this time in the heart of Dehradun city in Khudbuda Maholla, which too was destined for demolition was also saved. The building made of brick masonry with reinforced brick slab roof was retrofitted to ensure the safety of the kids studying there and was put back to use. This way very large carbon footprint resulting from the demolition and reconstruction has been prevented by an investment of a very small carbon foot print.

In the aftermath of the past earthquakes, notably Kutchch Earthquake of 2001, a large number of school buildings in perfectly good condition were demolished or abandoned, and replaced by new buildings of cement and steel, just because donors wanted to put to use the funds they had on their hands in building safe schools. Thus a huge carbon footprint was left behind in the name of safety while the same could have been achieved with a much smaller carbon footprint. On the other hand, with a larger foot print many more schools could have been made safer by retrofitting.

One more dimension has been observed in the name of safety against the future disasters. In some of the disaster prone areas of the country, people have begun to demolish the traditional houses that they have been living in and replace them with modern buildings made with lots of cement and steel. Unfortunately, what they are removing are truly green houses that are (a) made with low energy intensive materials that require little energy input in their production and require little energy in transporting the materials to the site, (b) thermally comfortable year around without having to use energy intensive devices like fan, or air-conditioning, and (c) 100% recyclable. On the other hand the houses they are building are not green by any parameter. They (a) use materials that are energy intensive in production as well as in transportation, (b) are thermally most uncomfortable year around and hence, require devices like fan, or air-conditioning, and (c) are virtually non-recyclable. There are several other advantages that the people have with the traditional houses. These traditional/vernacular houses could be most easily retrofitted at the cost of a very small carbon footprint, if they are really vulnerable against a future disaster. In short there is no need to demolish them and replace them with cement and steel based buildings just to ensure the safety of the occupants. Retrofitting of the vernacular buildings is the easiest way to preserve these green buildings.

Unfortunately, the new trends with large carbon footprint are an outcome of our education system. Our engineering and architecture graduates know little or nothing about the load-bearing masonry structures or the traditional building systems and local building materials. For most of them it is a sign of backwardness and, at times, even poverty. As a result even in single storey structures they promote the use of RC frame system that has an unduly large carbon footprint. All this is contrary to what is happening in the west that we readily ape. In England, even today there is a strong tradition of masonry structures. In the south western USA, the Pueblo Architecture consisting of adobe construction is greatly admired by the people for its environmental soundness. In Europe the old buildings are not demolished, but are taken care of, modified from inside to suit the modern day needs, and preserved since people have learnt to appreciate their virtues. In India we have a large number of green technologies that are traditional. It is important that we use them rather than abandoning them and searching for their alternatives.

Table 1 – Damage and destruction in recent earthquakes in India

Location	Year	Magnitude	Villages Affected	Cities Affected	Houses Damaged	Houses Destroyed
Latur	1993	6.4	1,200	0	200,00	35,000
Jabalpur	1997	6.1	45	1	57,000	5,600
Chomoli	1999	6.8	4,175	0	86,000	19,300
Kutchch	2001	7.7	8,000	6	850,000	150,000
Kashmir	2005	7.8	100	3	19,744	3,800

Source: Data compiled by the author from government publications. It is indicative only.

Table 2 – Energy input in material production for the material used in the construction of a typical 250 sft. masonry house having flat RC roof

Material	Unit	Quantity*	Energy Input per Unit Quantity MJ**	Energy Input MJ
Bricks	Each	11080	4.5	11,085
Cement	Kg	12130	6.7	81,271
Steel	Kg	112	32	3,584
Total				95,940

Source: * - Author.

** - Document distributed at Conference on Solar Passive Architecture in Mountain Region organized by Energy Systems Engineering, IIT, Mumbai and Ministry of Non-Conventional Energy Sources, GoI held at Dehrdun, in August 2006.

Table 3 – Energy input in material production for the materials used in retrofitting of a typical 250 sft. masonry house having pitched roof

Material	Unit	Quantity*	Energy Input per Unit Quantity MJ**	Energy Input MJ
Cement	Kg	406	6.7	2,720
WWM	Kg	35	32	1,120
Steel	Kg	86	32	2,752
Total				6,592

Source: * - Author.

** - Document distributed at Conference on Solar Passive Architecture in Mountain Region organized by Energy Systems Engineering, IIT, Mumbai and Ministry of Non-Conventional Energy Sources, GoI held at Dehrdun, in August 2006.

Table 4 – Energy input in materials for reconstruction and retrofitting

Location	Year	Magnitude	Houses to be rebuilt or retrofitted	Energy input in reconstruction in MJ	Energy input in retrofitting in MJ	% of energy in reconst. / in retrofitting
Latur	1993	6.4	35,000	3,357,900,000	230,720	1,455%
Jabalpur	1997	6.1	5,600	537,264,000	36,915	
Chomoli	1999	6.8	19,300	1,851,642,00	127,225	
Kutchch	2001	7.7	150,000	14,391,000,000	988,800	
Kashmir	2005	7.8	3,800	364,572,000	25,049	

Source: Data compiled by the author from government publications

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Green Technology, Retrofitting, Traditional Construction Systems, Load-bearing Masonry Structure, Vulnerability Reduction, Carbon Foot Print

	
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SHORT BIOGRAPHY OF RAJENDRA DESAI

Rajendra Desai is a structural engineer by education. He is presently working as a honorary joint founder director of National Centre for Peoples'-Action in Disaster Preparedness (NCPDP) based in Ahmedabad in India.

After graduating from IIT, Bombay with a degree in Civil Engineering in 1970 he got his MS in Structures from Rutgers University in NJ, USA IN 1972. After working professionally in the USA for 12 years he returned to India in 1985, and began working on people friendly green building alternatives with a focus on rural and semi urban housing.

A damage assessment assignment in the aftermath of 1993 Latur earthquake in Central India took him in to the field of disaster mitigation, which soon became his principal field of work. During the six years that followed he spent all the time in Latur focusing on building peoples' awareness about disaster safety and on training of artisans in earthquake resistant construction. He devoted much effort on the promotion of retrofitting of the existing buildings. This work on disaster preparedness earned him and his wife the first A.S.Arya Award of IIT-Roorkee.

He has also been involved in similar work in Uttarakhand, in Jabalpur-MP, in Kutchch-Gujarat, and in Kashmir during the last sixteen years since 1993. He, with his wife, has been an author of several publications including Manual for Restoration and Retrofitting of Rural Structures in Kashmir (UNESCO) and Manual for Hazard Resistant Construction in India (UNDP).

SHORT BIOGRAPHY OF RUPAL DESAI

Rupal Desai is an architect by education. She is presently working as a honorary joint founder director of National Centre for Peoples'-Action in Disaster Preparedness (NCPDP) based in Ahmedabad in India.

After graduating from Sir J.J.School of Architecture, Bombay with a degree in Architecture in 1967 she got her M.Arch. from Pratt Institute in New York City, USA IN 1974. After working professionally in the USA for 12 years she returned to India in 1985, and began working on people friendly green building alternatives with a focus on rural and semi urban housing.

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Abstract of the Paper

Green options are discussed when one is planning to build a new building or one is trying to improve the energy efficiency of the existing building. But little is given to green option when one is aiming to reduce the vulnerability of the people in the face of a disaster. In the post disaster situation tens of thousands of buildings are severely damaged or destroyed and they are rebuilt, generally, using modern technologies having high carbon foot print. Lots of vulnerable load-bearing masonry public buildings are summarily abandoned and replaced with new safer building of RCC having a large carbon footprint. But such buildings that are still standing could be easily made safer with retrofitting having a very small carbon footprint.

Today it has also been observed that in the name of safety against future disasters, people in the disaster prone areas are also demolishing their perfectly good traditional buildings that are truly green. They are being replaced with buildings that have a much larger carbon footprint. These traditional buildings in various areas of the country can easily be made safer through retrofitting them.

Unfortunately, architects and engineers know little to nothing of load-bearing masonry buildings or the traditional buildings. These buildings are generally green. Instead they recommend the use of RC construction, even in case of single storey construction. In India we have a large number of green technologies that are traditional. It is important that we use them rather than abandon them and search for their alternatives.

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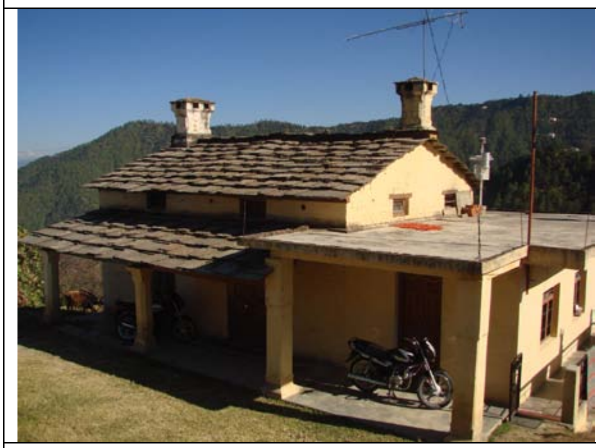
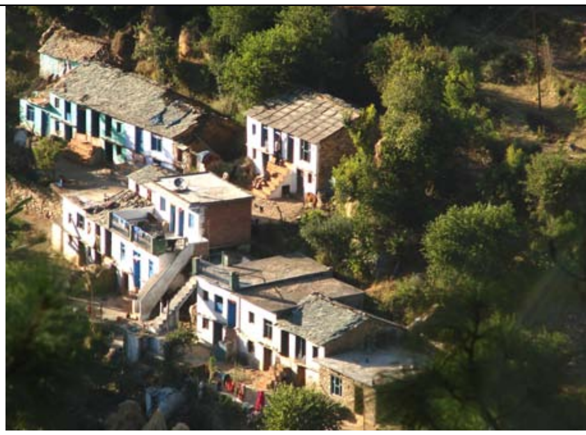
Photographs

	
Retrofitted vernacular school building in Kashmir	Retrofitted vernacular school building 125 years old at Thano in Uttarakhand
	
Finishing the Seismic Belt of Ferrocement	Installing reinforcing weld mesh for the Seismic Belt
	
RC extension to a small, old, Vernacular house	New trend of RC buildings replacing the Vernacular green buildings