Table (4.5b) GUIDE TO DAMAGE ASSESSMENT AND RECONSTRUCTION OF EARTHQUAKE AFFECTED BUILDINGS				
HEAVY DAMAGE				
FORM OF DAMAGE	**BUILDING TYPE**			
	Timber or Thatch roofed buildings on Stone or other masonry walls	*Slate roofed buildings on Stone or other masonry walls*	*CGI roofed buildings on Stone or other masonry walls*	*RCC framed or roofed buildings on Stone or other masonry walls*
Few large and deep cracks in walls	Reduce roof load on wall. Underpin affected wall section. Rake cracks and wet. Repair with long bond stones, steel reinforcing bars, wire mesh and rich cement mortar.	Remove Slates, timber sub-structure and dead load of upper storey wall (if necessary). Underpin affected wall section. Rake cracks and wet. Repair with long bond stones, steel reinforcing bars, wire mesh and rich cement mortar.	Reduce roof load on wall. Underpin affected wall section. Rake cracks and wet. Repair with long bond stones, steel reinforcing bars, wire mesh and rich cement mortar.	Prop roof slab. Reduce roof load on wall. Underpin affected wall section. Rake cracks and wet. Repair with long bond stones, steel reinforcing bars, wire mesh and rich cement mortar.
Failure of corner masonry bond	Reduce roof load on wall. Underpin affected corner section. Reconstruct using long bond stones, cast concrete blocks and vertical steel reinforcing bars where possible in rich cement mortar.	Remove Slates, timber sub-structure and reduce dead load of upper storey wall (if necessary). Underpin affected corner section. Reconstruct using long bond stones, cast concrete blocks and vertical steel reinforcing bars where possible in rich cement mortar.	Reduce roof load on wall. Underpin affected corner section. Reconstruct using long bond stones, cast concrete blocks and vertical steel reinforcing bars where possible in rich cement mortar.	Prop roof slab. Reduce roof load on wall. Underpin affected corner section. Reconstruct using long bond stones, cast concrete blocks and vertical steel reinforcing bars where possible in rich cement mortar.
Source:TARU field study; A Manual of Earthquake resistant Non-Engineered Construction, ISET, 1989;Mitigating Natural disasters, UNDRO, 1991				

Table(4.5c) GUIDE TO DAMAGE ASSESSMENT, RECONSTRUCTION OF EARTHQUAKE AFFECTED BUILDINGS				
HEAVY DAMAGE				
FORM OF DAMAGE	**BUILDING TYPE**			
	Timber or Thatch roofed buildings on Stone or other masonry walls	*Slate roofed buildings on Stone or other masonry walls*	*CGI roofed buildings on Stone or other masonry walls*	*RCC framed or roofed buildings on Stone or other masonry walls*
Gable wall damaged with large and deep cracks	Remove roof cladding and sub-structure. Demolish damaged wall. Reconstruct masonry using proper through, corner stones or cast concrete blocks with vertical steel reinforcement bars in rich cement mortar if possible. Rebuild roof with wall plate, trusses and then relay cladding. Buttressing the gable wall or tieing it at intermediate floor level with steel tie rods are useful techniques.	Remove Slates and timber sub-structure. Demolish damaged wall. Reconstruct masonry using proper through, corner stones or cast concrete blocks with vertical steel reinforcement bars in rich cement mortar if possible. Rebuild roof will wall plate, trusses and then relay cladding. Buttressing the gable wall or tieing it at intermediate floor level with steel tie rods are useful techniques.	Remove roof cladding and sub-structure. Demolish damaged wall. Reconstruct masonry using proper through, corner stones or cast concrete blocks with vertical steel reinforcement bars in rich cement mortar if possible. Rebuild roof will wall plate, trusses and then relay cladding with adequate bracing. Buttressing the gable wall or tieing it at intermediate floor level with steel tie rods are useful techniques.	No gable walls
Wall damage due to lack of wall plate restraint	Remove roof cladding and sub-structure.Repair damaged masonry using proper through stones. Lay and fix wall plate rigidly to the wall. Erect trusses and relay roof cladding.	Remove Slates and timber sub-structure. Repair damaged masonry using proper through stones. Lay and fix wall plate rigidly to the wall. Erect trusses and relay roof cladding.	Remove roof cladding and sub-structure. Repair damaged masonry using proper through stones. Lay and fix wall plate rigidly to the wall. Erect trusses and relay roof cladding with adequate bracing.	Flat roof
Source:TARU field study; A Manual of Earthquake resistant Non-Engineered Construction, ISET, 1989; Mitigating Natural disasters, UNDRO, 1991				

Table(4.5d) GUIDE TO DAMAGE ASSESSMENT AND RECONSTRUCTION OF EARTHQUAKE AFFECTED BUILDINGS

HEAVY DAMAGE

FORM OF DAMAGE	BUILDING TYPE			
	Timber or Thatch roofed buildings on Stone or other masonry walls	*Slate roofed buildings on Stone or other masonry walls*	*CGI roofed buildings on Stone or other masonry walls*	*RCC framed or roofed buildings on Stone or other masonry walls*
Shear cracks in masonry between openings	Reduce roof load on wall.Underpin wall above damaged masonry. Reconstruct wall with small, centrally located opening. Bond new masonry to old with steel ties and rich cement mortar. Reinforce openings with a heavy timber frame or RCC band.	Remove Slate and wooden sub-structure to reduce load on wall. Underpin wall above damaged masonry. Reconstruct wall with small, centrally located opening. Bond new masonry to old with steel ties and rich cement mortar. Reinforce openings with a heavy timber frame or RCC band.	Underpin wall above damaged masonry. Reconstruct wall with small, centrally located opening. Bond new masonry to old with steel ties and rich cement mortar. Reinforce openings with a heavy timber frame or RCC band.	Prop roof slab to reduce load. Underpin wall above damaged masonry. Reconstruct wall with small, centrally located opening. Bond new masonry to old with steel ties and rich cement mortar. Reinforce openings with a heavy timber frame or RCC band.
Minor foundation settlement	Reduce roof load on affected wall. Shore and underpin overbearing wall and insert RCC plinth beam across settled masonry section. This may require technical supervision.	Remove Slates and timber sub-structure to reduce load on settled section. Shore and underpin overbearing wall and insert RCC plinth beam across settled masonry section. This may require technical supervision.	Reduce roof load on affected wall. Shore and underpin overbearing wall and insert RCC plinth beam across settled masonry section. This may require technical supervision.	Prop roof slab to reduce load on settled section. Shore and underpin overbearing wall and insert RCC plinth beam across settled masonry section. This may require technical supervision.

Source:TARU field study; A Manual of Earthquake resistant Non-Engineered Construction, ISET, 1989; Mitigating Natural disasters, UNDRO, 1991

Table (4.5e) GUIDE TO DAMAGE ASSESSMENT AND RECONSTRUCTION OF EARTHQUAKE AFFECTED BUILDINGS				
SEVERE DAMAGE				
FORM OF DAMAGE	BUILDING TYPE			
	Timber or Thatch roofed buildings on Stone or other masonry walls	*Slate roofed buildings on Stone or other masonry walls*	*CGI roofed buildings on Stone*	*RCC framed or roofed buildings on Stone or other masonry walls*
Overturning of gable walls	Remove remaining roof cladding and sub-structure. Demolish upper storey gable wall. Prop intermediate floor if lower gable is damaged. Reconstruct masonry using proper through, corner stones or cast concrete blocks with vertical steel reinforcement bars in rich cement mortar if possible. Rebuild roof with wall plate, trusses and then relay cladding.			Flat roof
Separation of masonry walls at corners	Remove roof cladding and sub-structure to reduce load. If corners of lower floor are damaged prop intermediate floor. Underpin floor and walls at corner. Reconstruct using long bond stones, cast concrete blocks and vertical steel reinforcing bars where possible in rich cement mortar. If more than one corner is damaged consider demolishing and rebuilding entire masonry.			Prop roof and intermediate floor slab to unload wall. Underpin floor and walls at corner. Reconstruct using long bond stones, cast concrete blocks and vertical steel reinforcing bars where possible in rich cement mortar. If more than one corner is damaged consider demolishing and rebuilding entire masonry.
Gaps in walls, delamination due to lack of through stones and buckling of slender walls	Remove roof cladding and sub-structure to reduce load. Demolish affected walls. Reconstruct masonry using proper through, corner stones or cast concrete blocks with vertical steel reinforcement bars in rich cement mortar if possible.If more than one wall is extensively damaged consider demolishing the storey or building.			Prop slab on timber or specially cast RCC columns under supervision. Demolish walls and rebuild according to good practice.If more than one wall is extensively damaged consider demolishing the storey or building.
Source:TARU field study; A Manual of Earthquake resistant Non-Engineered Construction, ISET, 1989; Mitigating Natural disasters, UNDRO, 1991				

<table>
<tr><th colspan="5">Table (4.5f) GUIDE TO DAMAGE ASSESSMENT AND RECONSTRUCTION OF EARTHQUAKE AFFECTED BUILDINGS</th></tr>
<tr><th colspan="5">SEVERE DAMAGE</th></tr>
<tr><th rowspan="2">FORM OF DAMAGE</th><th colspan="4">BUILDING TYPE</th></tr>
<tr><th>Timber or Thatch roofed buildings on Stone or other masonry walls</th><th>Slate roofed buildings on Stone or other masonry walls</th><th>CGI roofed buildings on Stone or other masonry walls</th><th>RCC framed or roofed buildings on Stone or other masonry walls</th></tr>
<tr><td>Collapse of rear wall due to ramming of retaining wall</td><td colspan="3">Remove roof along the whole length of the building. Demolish the building wall by wall attempting to conserve timber. Clear rubble. Repair the rear retaining wall if necessary. Reconstruct the building at least 1m. away from the rear retaining wall. Technical assistance may be necessary.</td><td>Demolish roof under technical supervision. Breakup RCC slab material for recycling. Clear rubble. Repair the rear retaining wall if necessary. Reconstruct the building at least 1m. away from the rear retaining wall.</td></tr>
<tr><td>Severe settlement of foundation or failure of hill-slope</td><td colspan="4">Demolish building. If slope is judged to be stable after treatment consider reconstruction. Else resite building at appropriate location. Technical assistance may be necessary.</td></tr>
<tr><td>Partial collapse of pitched roof</td><td colspan="3">Remove roof along the whole length of the building. Reconstruct masonry using proper through, corner stones or cast concrete blocks with vertical steel reinforcement bars in rich cement mortar if possible. Rebuild roof with wall plate, trusses and then relay cladding.</td><td>Flat roof</td></tr>
<tr><td>Failure of RCC columns</td><td colspan="3">Load bearing wall</td><td>If roof slab is undamaged then prop slab on timber or specially cast RCC columns under supervision. Strengthen existing column. Demolish walls and rebuild according to good practice. Technical assistance may be necessary.</td></tr>
<tr><td colspan="5">Source: TARU field study; A Manual of Earthquake resistant Non-Engineered Construction, ISET, 1989; Mitigating Natural disasters, UNDRO, 1991</td></tr>
</table>

Table (4.5g) GUIDE TO DAMAGE ASSESSMENT AND RECONSTRUCTION OF EARTHQUAKE AFFECTED BUILDINGS				
COLLAPSE				
FORM OF DAMAGE	BUILDING TYPE			
	Timber or Thatch roofed buildings on Stone or other masonry walls	*Slate roofed buildings on Stone or other masonry walls*	*CGI roofed buildings on Stone or other masonry walls*	*RCC framed or roofed buildings on Stone or other masonry walls*
Total Collapse of storey or building	Demolish upper floor and strengthen lower floor, if only upper floor has collapsed. If the lower floor is severely damaged: demolish, clear site of rubble and reconstruct. If collapse is due to ramming of retaining wall: resite building away from wall and if due to settlement relocate building appropriately. Technical assistance may be necessary.			Demolish building under supervision. Break up and recycle RCC from slab. Clear rubble and reconstruct on or off-site based on cause of collapse. Technical assistance may be necessary.
Source: Mitigating Natural disasters, UNDRO, 1991; A Manual of Earthquake resistant Non-Engineered Construction, ISET, 1989 and TARU field study				

The previous section is an indicative guide to the assessment and classification of damage by the predominant house types and mechanism of damage in the region. It lists the major repair and reconstruction activities that will be required to be undertaken for each house type. It must be reiterated that these are only broad guidelines and will have to be modified to meet local conditions. The damage classification is based on the MSK scale (see Appendix A) and field data collected on the predominant mechanisms and form of damage.

REPAIR

The repair activities to be undertaken on buildings that are slightly or moderately damaged include: replastering, repairing of door and window frames and replacing broken glass, relaying displaced tiles, relaying cracked flooring and repairing cracks in walls. HUDCO, NHB, HDFC and the Scheduled Banks should provide low interest loans upto Rs. 10,000 in designated areas for repair work. This will have to accompanied with a detailed information campaign to make households aware of technical options.

REPAIR & STRENGTHENING

A range of techniques of repair and strengthening are listed below by building system (ISET,1989). These will need to be cross-referenced with Table (4.5a to c) for a particular house type.

Foundation

Inserting an RCC strip with keys on the outer edge of strip footing.

Walls

Minor cracking in walls can be dealt with by cleaning and raking the joint and filling with rich mortar cement sand (1:3 or 1:4) and steel 6mm (dia) reinforcement bars. The most effective technique would be to inject mortar or epoxy sealant under pressure, but this will not be practicable in the area.

In areas of severe damage, the wall may have to be rebuilt after suitable underpinning of supported structure. Else additional shear or flexural reinforcement may have to be added in the form of bars or welded steel mesh in rich cement mortar. Walls can also be stiffened by inserting bolts and tie-rods to tie end walls that have been damaged and contain further crack propagation. Long walls may be strengthened by external buttresses that are adequately bonded to the existing masonry. Buttress thickness must be more than 45 cm. and base width atleast 1/6 of height.

The cracks in walls can be repaired by underpinning and reconstruction using long bond stones or specially cast RCC planks (7.5 cm x 45 cm x 60 cm). In addition the provision of one 16 mm bar at the corners during failure will increase ductility.

Roofs and intermediate floor

Rafters and trusses of damaged buildings will have to braced and anchored to load bearing walls. This will usually involve dismantling the roof, rejecting rotten or damaged timber, strengthening joints by using steel connectors plates that are either nailed or screwed and preparing concrete bed blocks on which these roof elements can be firmly anchored down using bolts. Timber members that are damaged, can be braced with additional timber or steel strip or bar reinforcement or even by ferrocement bandages. Rafters and trusses must be connected with a continuous wall plate that is also firmly strapped to the wall. Diagonal bracing of the end rafters and the gable wall by using timber sections or planks are also desirable. In addition the gables of these buildings may have to strengthened or buttressed to reduce slenderness.

Intermediate timber floors, need to be strengthened by stiffening by diagonal timber bracing nailed to roof rafters and trusses. Stiffening the connection of supporting beams to the wall by using steel plates and bolts may also be necessary along with a cross layer of stiffening planks.

False ceilings of heavy materials that have collapsed will have to be replaced by lighter materials. This could be an opportunity to provide employment to the bamboo workers in the Terai and plain areas and use treated bamboo mat or hessian dipped in cement slurry to replace damaged false ceilings

The standard methods of strengthening RCC slabs by inserting steel or precast beams, using epoxy resins and guniting can be used here. Special care will have to given to reinforcement detailing, especially at junctions and the quality on concrete and curing. These are specialised tasks that require trained personnel and equipment. Higher-income households that have RCC roofs should be provided with this information to hire the services of these agencies from the plains.

RECONSTRUCTION

Reconstruction is similar to the process of new house design and construction, except that debris will have to be cleared and considerable amounts of building materials recycled. The following sections lay out the process of reconstruction:

SITE LOCATION

One of the most severe problems in the region after the earthquake is slope stability. A number of retaining walls below house sites have collapsed or are in danger of imminent failure. This implies that slope stabilisation operations will be necessary in some settlements before any demolition or reconstruction work is undertaken. In some cases based on the viability and the psychological pressure on the inhabitants of a site, it may be necessary to rehabilitate them on an alternate site.

A large number of villages will have to be resited because of very high risk collapse of the hill slopes because of landslides as reported in chapter 2. Five of the study villages will be exposed to considerable geological risk over the next six months. Houses that are located on potentially unstable slopes need to be demolished and rebuilt with government assistance. The provision of alternative accommodation over this period will have to be undertaken.

Slope stabilisation operations should be taken up under technical supervision. The use of traditional stone retaining walls would provide a major boost for local employment. These could also be adapted using geotextiles. This work will have to undertaken by with villagers (wherever possible) with the help of workers trained in these techniques from other areas of Uttar Pradesh (Kumaon) or Himachal Pradesh.

HOUSE DESIGN

The house plans in the region are typically long and rectangular. In specific location houses should be modified so that their length of the houses are not more than three times the length of the gable wall. This implies that with a gable length of 4.2 m. (14') the length of the house should be under 12.6 m. (42'). Houses should be constructed with effective cross-walls so that the maximum length of any unsupported wall should not exceed 6 m (20').

Two-storeyed buildings with heavy roofs are more prone to damage than single storey buildings. The local pattern however, is to keep cattle on the ground floor, while the people live above. This makes good functional sense, especially since land for housing in scarce in the hills. The cattle need protection from the weather and the heat from the cattle warms the living rooms, through the timber floor during the winter - an excellent passive thermal system. The recent propagation of RCC intermediate floors has much worse thermal performance than timber floors.

Projections on either side of the main block are also common in some areas. The size of these projections should not be larger than a third of the gable length. A minimum separation of 15 cm. should be maintained between two houses to prevent the hammering action of one on the other. This would need to be covered by slate or some appropriate flashing to prevent water and snow ingress.

Most buildings do not have cornices or fascia stone, but a projected narrow (60 cm.) stone cantilevered walk at verandah level is common in all two-storeyed traditional buildings. This has to be fixed firmly into the masonry.

The location of openings (especially doors) should be central to the wall and at no point closer than 45 cm. of the edge of wall or corner. The distance between should be atleast 60 cm. apart. The location of openings one above the other is not common in the region, but they should also be atleast 60 cm. apart vertically. Large openings should be reinforced either with a stiff timber frame, or a reinforced masonry of RCC band. RCC lintels are common in new buildings. Precast lintels could be used with reinforcement bars that are concreted into sill and jamb masonry.

FOUNDATION AND WALLING

Load bearing Random rubble masonry

Random rubble masonry in mud mortar should not be used, in its present degraded form, in this region. Since there is absolutely no alternative to using Stone, the following measures must be taken: keep wall thickness to a maximum of 45 cm.; through stones every 1.2 m (4') in each course; 16 mm. diameter vertical reinforcement bars or 75mm. pipe in corners and cross-wall joints. Only jagged and well graded stones should be used for the masonry. No rounded cobbles should be used. Cohesive mortar or Cement:Sand (1:6) should be used for normal masonry and richer for framing elements. Toothing of walls should be avoided completely and if used they should turn the corners/cross-walls upto 45 cm. from the joint. A lintel level tie beam in reinforced concrete is absolutely necessary. If the household can afford on RCC beam it this can be stiffened by tieing it to a reinforced plinth beam through vertical reinforcement bars. Conventional sand:cement or combination (cement:lime) plasters may be used. In low-income houses, traditional mud plaster and whitewash is more than adequate.

Loadbearing Brick masonry

Loadbearing Brick masonry is not appropriate to the region both because of the problem of transporting bricks from the plains and the resultant- costs..This is evident from Tables in Chapter 1 that the share of brick construction is less than 5 %. Contractors from the plains will apply pressure to use brick because their workers are used to building with it. It is however, totally inappropriate to the area, especially for mass housing.

If it becomes imperative to construct in brick, the following measures will have to be taken: vertical reinforcement bars in corners and cross-wall joints, the mortar used should be Cement:Sand (1:6) for normal masonry and richer for framing elements. Toothing of walls should be avoided completely and if used they should turn the corners/cross-walls upto 45 cm. from the joint. The wall masonry can be strengthened at the joints by using wire mesh in the mortar layer. It will be necessary to lay a base concrete layer before starting the foundation masonry. Openings and the joints between partition and load-bearing walls will need to be reinforced. A lintel level tie beam in reinforced concrete is absolutely necessary. If the household can afford it, this can be stiffened by tieing it to a reinforced plinth beam through vertical reinforcement bars. Since most houses in the region have gable walls: a combined gable and roof band of RCC can be laid.

Loadbearing stoneblock masonry

CBRI's modified Stone block in cement mortar is an effective stone construction technique. This could enable the use of recycled rubble from damaged or demolished buildings with on-site production. The only problem will be the transportation of cement and in many areas quality aggregate and sand. Local labor could be used to break stone for aggregate. A number of trained teams carrying the gang moulds and vibrators could move from village to village manufacturing these blocks. This would enable rapid erection of walls and incorporation of semi-prefabricated elements (e.g. lintels; door frames) due to clear definition of masonry layup. The economics of this technique will have to be well defined by CBRI, before it can be recommended for widescale adaption in remote areas.

The following additional precautions will have to be taken: vertical reinforcement bars in corners and cross-wall joints, mortar should be Cement:Sand (1:6) for normal masonry and richer for framing elements; toothing of walls should be avoided completely and if used they should turn the corners/cross-walls upto 60 cm. from the joint. The wall masonry can be strengthened at the joints by using wire mesh in the mortar layer. Openings and the joints between partition and load-bearing walls will need to be reinforced. A lintel level tie beam in reinforced concrete is absolutely necessary. If the household can afford it this can be stiffened by tieing it to a reinforced plinth beam through vertical reinforcement bars. Since most houses in the region have gable walls: a combined gable and roof band of RCC can be laid.

Timber framed buildings

Timber framed buildings have been very effective in resisting earthquakes.They are however confined to the upper elevations of this region. A number of measures will have to be taken to strengthen timber-framed buildings including: diagonal bracing members; spacing of horizontal framing members at less than 1 m. apart and verticals at 1.5 m distance.

The major problem however, is the very high price and problems of felling timber. The entire hill region that has been hit hardest by the earthquake has also been extensively deforested. Infact, the "*Chipko*" movement originated in this area. The deforestation and resulting soil erosion has had a major negative impact on the economy of the area. An large intervention in using timber for the reconstruction of upto 10,000 houses would need clearance at the highest levels of the Forest department, and promote greater deforestation in the area as illegal logging under the name of relief operations would flourish. This is not to suggest that timber should not be used for rehabilitating, the earthquake victims, but a careful analysis both of cost and administrative feasibility of wide-scale use of timber, must be undertaken in collaboration with Forest officials. Timber framed buildings are the only feasible alternative in the remote areas of Uttarkashi and Chamoli.

RCC framed buildings

Good quality RCC framed buildings have been effective in resisting the '91 earthquake. The conventional column-beam-slab architecture however, is inappropriate for the climate and local lifestyle. It will have to be modified to cater to the heavy precipitation and low winter temperatures, by using innovative design and passive solar techniques (e.g trombe walls). The other constraint of these systems is their cost, especially in remote areas due, to long transportation distances by mule and lack of available technical skills.

Joint detailing and construction is very crucial as a number of failures at the column-beam interface have taken place. In addition, reinforcement detailing (especially for columns) and quality of concreting are crucial (low temperatures cause a number of problems in concrete construction). The infill walls in RCC structures need to be designed to withstand tensile and shear forces. **RCC construction should not take place except when designed and supervised by qualified by engineers.**

Flooring

The traditional flooring using timber, stone or earth are adequate for reconstructed houses. Timber planks can be laid even on RCC floor slabs for insulation. One problem that has to be resolved in the design of buildings is that most households possess very little furniture and work off the floor.

PITCHED ROOFING

Roof sub-structure

The roof sub-structure in many areas could be rebuilt using recycled timber along with new (seasoned) timber. Considerable technical support will have to be made available to sort, treat and saw old timber on site to make trusses, rafters and purlins using engineering techniques like steel connectors, bolts and nail joints. The new timber will have to be seasoned or made available on a barter basis from seasoned stock of the Forest Department. Mobile treatment facilities of the FRI Dehradun, may be utilised for this process. Standard truss designs for common spans, from local timbers will have to be made available for various roof cladding materials (Slate, CGI sheet) so also with standard precut sections. A set of mobile LCV's with generator, timber sawing, planning and fabrication facilities can extend this facility to remote areas and help hasten the reconstruction process.

Special construction details that will have to be carefully propagated include: steel connectors, gusset plates with nailed or bolted connections; wall plates to transfer lateral load; bed blocks to transfer load to and anchor the structure to the wall; diagonal bracing along gables. In addition, modifications will have to be made in traditional designs to incorporate false ceilings in CGI roofed houses.

Roof cladding

Traditional slate roofs are heavy and have been an important factor in the collapse of a number of buildings. There is little possibility to reduce the mass of these roofs without cutting the slate and thereby reducing the overlap and substructure required. The quality of slate from a large fraction of the existing houses may make this difficult.

The other roof cladding system that has been used in this area is CGI sheet, which has a number of advantages (e.g. light to transport, easily erected, resistant to hail and snow) and limitations (e.g. low thermal insulation). Red mud plastic sheet could also be used, though its resistance to large hailstones may not be as large as the CGI sheet. Asphaltic sheets are inappropriate due to the risk of hail damage and snow loading in some areas.

PROCESS OF RECONSTRUCTION AND DISASTER MITIGATION

The reconstruction and disaster mitigation programme for Garhwal will have six sub-programmes:

Damage assessment and identification of risk prone settlements

The pre-condition is a detailed computerised damage assessment database on a building basis and detailed hazard assesment of settlements in the region by specialists.

Demolition of severely damaged buildings

The first priority is to demolish severely damaged buildings under technical supervision and prepared the building materials for recycling. This can be done on an individual or community basis in material Banks.

Relocation of hazard prone settlements and buildings

The second priority is to identify alternative sites and relocate all hazard prone settlements and buildings with the participation of the village community and NGO's and specialised agencies wherever possible.

Repair and Reconstruction of buildings

The third priority is to reconstruct demolished buildings using recycled material along with new material acquired through government financial aid. This aid could be provided in the form of building materials and a wage component. The buildings could be built according to the guidelines provided in the BMTPC reconstruction manual that can be made available to all artisans and households.

Provision of building services

The fourth priority is the restoration of the water and electricity service, which will be useful during the reconstruction process.

Strengthening of damaged buildings

The fifth priority is the strengthening of buildings that have sustained damage. Government aid an technical support should be made available for this activity.