Post-earthquake Relocation, Reconstruction, Repair and Retrofitting of Buildings

Dr Anand S Arya
Professor Emeritus
University of Roorkee

Abstract

The experience gained in after - earthquake reconstruction in Maharashtra State of India is described herein. The items mainly presented are: the total rehabilitation program involving relocation of villages and reconstruction in-situ, damage assessment methodology and retrofitting and construction technology options Some issues are also discussed relocation versus in-situ construction, appropriateness of technology to be adopted, and role of NGO's and voluntary agencies and coordination with the governmental efforts. Lessons are drawn towards suitable time frame and reconstruction approach for developing countries such as India especially for the disastrous damage in rural areas.

Introduction

In the earthquake of Sept. 30, 1993 in Marathwada area of Maharashtra, India though of moderate Magnitude of 6.4 on Richter Scale, huge devastation occurred including complete destruction or collapse of 28,771 stone houses resulting in about 9,000 deaths and minor to heavy damage in 1,69,841 stone houses Besides this, severe damages occurred to schools, health centres, other public buildings and infrastructure These houses were mainly built using field stone laid in clay mud mortar, with very thick walls and heavy clay roofs. After the first phase of the relief operations a comprehensive Maharashtra Emergency Earthquake Rehabilitation Program' (MEERP) was launched. This aimed at not only the reconstruction of villages, housing, infrastructure and community services but also the social, economic, and psychological rehabilitation of victims to install in them a sense of dignity and self confidence. The rehabilitation program included the largest reconstruction program taken in hand in India after a natural disaster, involving a financial outlay of Rs. 1023.4 crores at 1994 prices by the Govt. of Maharashtra and the donors.

The Rehabilitation Program - Major Components

The major components of the rehabilitation included:

- construction of 25,000 houses in 50 relocated villages
- reconstruction of 30,000 houses in-situ on old foundations
- construction of 500 model houses and buildings to illustrate economical earthquake resisting techniques using appropriate materials
- repair and seismic retrofitting of 200000 houses; seismic retrofitting of 5,000 undamaged houses of various types in 12 districts around the epicentre to serve as examples to the house owners
- and other items of repair and reconstruction of community buildings, besides economic and social rehabilitation

A set of performance criteria were developed for the new houses which included:

- the plan types to suit the socio-cultural needs of the village people
- the thermal performance of roofs and walls
- the minimum earthquake safety measures (as per Zone IV of IS:1893-1984) and the foundations.
- besides, preferred specifications for walls, roofs and foundations were also brought out which would mostly use available building materials as well as skills, though in some cases, requiring additional training of the skilled artisans

Damage Assessment

Proper decisions to be taken regarding relocation of a village, demolition and reconstruction in-situ, or repair and strengthening, require a careful assessment of nature and extent of damage to the buildings under consideration. The first available manpower consisted of the staff of the Revenue Department, who are not trained in building damage assessment. Naturally the first damage reports were of very general nature, but good enough to bring to the notice of the Government, the affected villages and an idea of number of damaged and destroyed/ collapsed houses. The revenue staff did this assessment very quickly, as best as they could. It helped in the assessment of relief and sheltering requirements but, it was not sufficient for reconstruction planning.

The junior level engineers of the Public Works Department (PWD) carried out a second assessment after they were given a quick training by the author regarding the five categories of damage under MSK Intensity Scale. It is important to mention that as a result of this assessment, the number of houses earlier declared as 'fully damaged' category came down drastically inspite of large-scale vandalism of the unoccupied buildings in the elapsed time The decisions taken by the Government regarding rehabilitation of the buildings were based on the second assessment. For quantifying the damage to each building a scheme was devised in which symbols were chosen to indicate the type of damage and its extent. This scheme is very helpful in assessing the reparability of the building or otherwise

Relocated Villages

Relocation of villages involves several issues like selection of the site, layout of the new village, design of the new houses and community buildings etc. The site should be on stable ground, as close to the old village and farmlands as possible, should have adequate drinking water sources as well as effective drainage possibility. The village layout should be such that it facilitates local living pattern which is 'neighborliness' prevailing in the villages through cluster housing. Opportunity of improving the community facilities in the village should be utilized in reconstruction In the new house designs, the living pattern of the affected people, who in the present case are mostly farmers or those in trades related to farming, should be respected. In the planning exercises, participation of the affected communities could ensure the acceptability of the final layout and the buildings

All these points were realized quite early. However, due to the natural haste to start reconstruction work as early as possible, political pressures of various kinds and insensitivity of urban decision-makers to the rural context, what actually happened is not fully satisfactory. In order

to avoid foundations on 'black cotton' soils some of the villages were sited quite far away from the old village agricultural areas causing permanent inconvenience to the residents. In most cases, 'grid' pattern (the modern city plan) of houses has been used instead of the rural cluster' pattern. The house designs adopted are not the inward looking' courtyard type but the outward looking rectangular blocks type. The few villages, such as Tapse Chincholi where the life style of the villages has been expressed in the layout (Fig.1) and house designs (Fig 2), are the ones most liked by the allottees who had been fully involved during the planning process

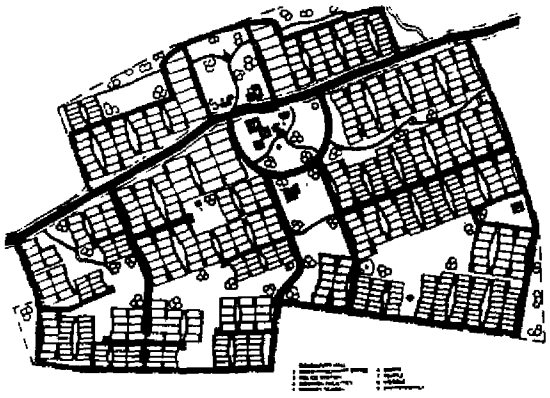

Fig 1 Cluster plan of village Tapse Chincholi

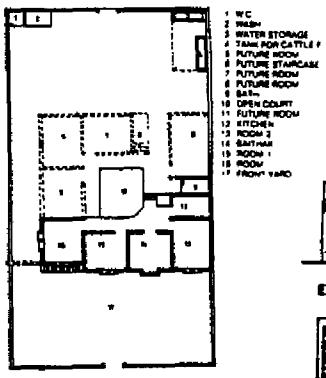

Fig 2 House plan showing present construction and future extension (with inner courtyard)

Reconstruction In-situ

In contrast to relocation, village Tembhi of 77 households was reconstructed at the old site on existing foundations (Fig. 3). The external walls were constructed using stone from the demolished house, but using earthquake-resisting features such as.

(i) Cement mortar instead of clay mud

(ii) 350 mm thickness using 'through' stones instead of original 600 to 900 mm thickness without the 'through' stones

(iii) reinforced concrete 'bands' at plinth and lintel levels and

(iv) vertical steel bars at corners and junctions of walls going from foundation into the roof slab

The internal walls were constructed using solid concrete blocks of 200-mm width. The coarse aggregate used in the blocks was obtained from the demolished stones. The internal and external walls were integrated by physical penetration and dowels at intervals besides the horizontal seismic bands. Opportunity has been utilized to improve architectural planning and internal detailing. As a result of thinner walls, the rooms have become larger than before and the earlier narrow streets widened The original external facade of stone was maintained (Joglekar and Das, 1994). The village is thus 'reborn' keeping the originality of hundreds of years (Fig. 4)!

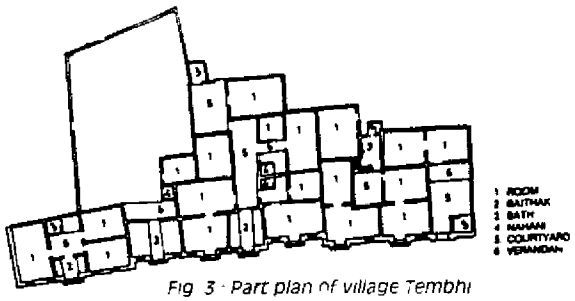

Fig 3 · Part plan of village Tembhi

The reconstruction at original site has offered the advantages:

(i) direct participation of the house holder in decision making during planning and execution

(ii) use of material available at site

(iii) use of local construction skills

(iv) economy in cost, and

(v) maintaining socio-cultural continuity of the community

It may be mentioned that the cost of these houses per unit area (excluding the cost of acquiring land for relocation of villages) has worked out to about 40 percent only as compared with the construction in relocated villages. This is under the condition that the construction agency (HUDCO) and the consultant (the author) were the same in both cases

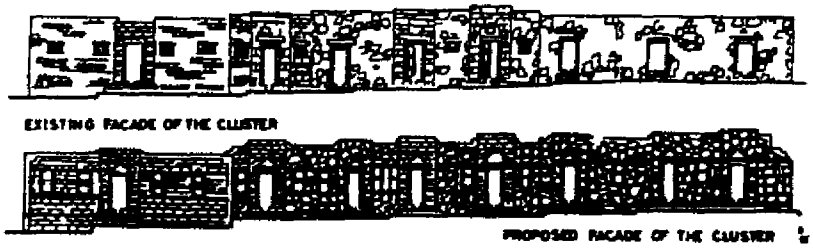

Fig 4 · Existing and proposed facade of Tembhi

Building Materials and Construction Technologies

In view of the volume of construction program of houses and community buildings a large number of innovative technology options were offered by prospective contractors. These varied from

(a) earthquake resistant bearing wall types including adobe, fired brick solid concrete block, hollow concrete block, stone masonry, cast-in-situ reinforced concrete wall, prefabricated reinforced concrete panel walls, Bison panels, etc.; to

(b) framed construction using reinforced concrete columns and beams or prefabricated light steel columns and beams with various types of filler wall panels.

From the view points of availability of materials and skills along with the considerations of cost, replicability and extendibility, the construction technology using solid and hollow concrete block walls with stone-in-cement strip foundation, reinforced concrete slab roof and seismic reinforcing with R C. bands and vertical bars at junctions and corners of walls, has turned out to be the most appropriate for one storey housing in the area

To transfer the block making technology a number of Building Centres were established by the Government in the area with the financial and technical assistance from the Housing and Urban Development Corporation (HUDCO), Government of India. This technology has remained available in the area even after the post-earthquake reconstruction project was completed in 1997.

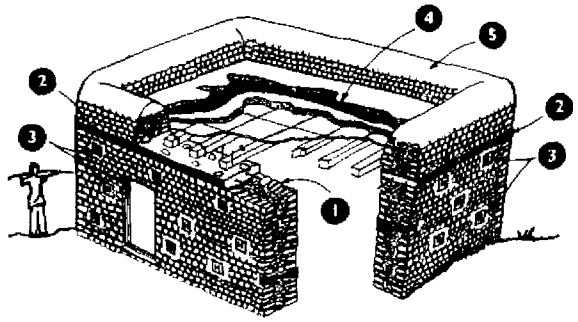

Fig. 5 Stone houses without wooden posts

Repair and Retrofitting

As stated earlier a large number of houses, with slight to moderate damage, needed repairs and retrofitting against future earthquake shocks. The scheme worked out by the author and used on a large scale for the stone houses consisted of five steps shown in figure 5 and 6 as stated below

1. removing the parapet wall and the roof (fig. 5) and where wooden posts exist fix the new braces. (fig. 6)
2. casting reinforced concrete bands on all walls (fig. 5) and stitching of stone wythes. (fig. 6)
3. stitching the inner and outer stone wythes by installing RC elements (fig. 5) and installing of ferrocement belts (fig 6)
4. relaying the roof with reduced soil cover and having a waterproof membrane of black polythene sheet at mid-thickness (fig 5 and 6)
5. building low height parapets (fig 5) and finishing the roof and parapets with water proof mud plaster. (fig 5 and 6)

It was found that this retrofitting could in most cases be achieved at about 15 per cent of the cost of reconstruction. Retrofitting in place of full reconstruction offered the advantage of economy in cost with much less evacuation period for the residents who could themselves participate in the process.

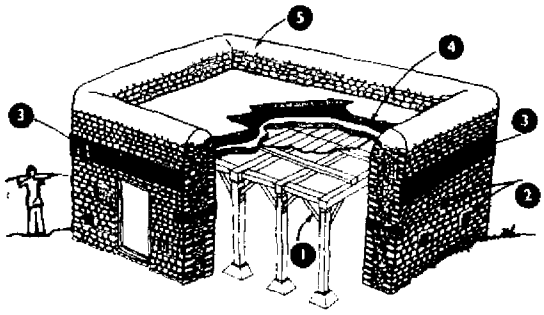

Fig. 6 Stone houses with wooden posts

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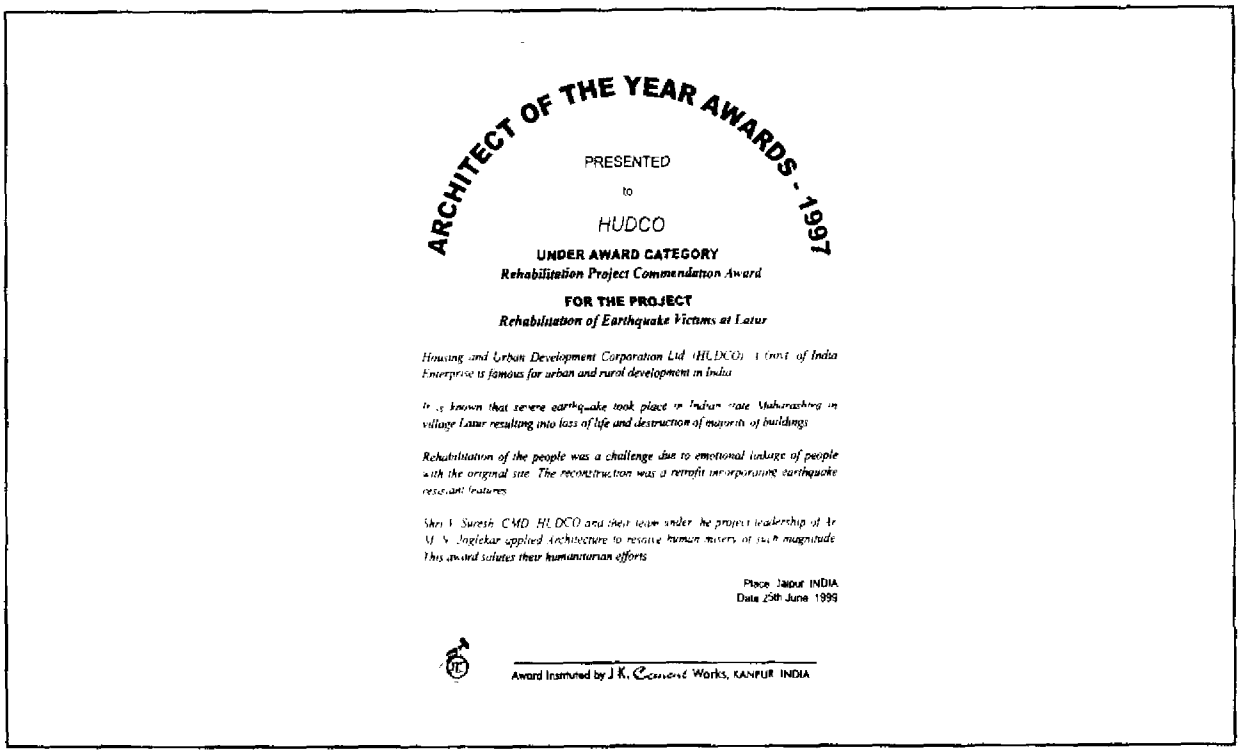
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Rehabilitation Project Commendation Award

FOR THE PROJECT

Rehabilitation of Earthquake Victims at Latur

Housing and Urban Development Corporation Ltd (HUDCO), Govt. of India Enterprise is famous for urban and rural development in India

It is known that severe earthquake took place in Indian state Maharashtra in village Latur resulting into loss of life and destruction of majority of buildings

Rehabilitation of the people was a challenge due to emotional linkage of people with the original site. The reconstruction was a retrofit incorporating earthquake resistant features

Shri V. Suresh, CMD, HUDCO and their team under the project leadership of Ar. M. S. Joglekar applied Architecture to resolve human misery of such magnitude. This award salutes their humanitarian efforts

Place Jaipur INDIA
Date 25th June 1999

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