OVERVIEW OF THE MAHARASHTRA, INDIA EMERGENCY EARTHQUAKE REHABILITATION PROGRAM

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SUMMARY

This paper provides an overview of the large, comprehensive rehabilitation program initiated by the Government of Maharashtra, India, after the devastating earthquake in 1993. The program (Maharashtra Emergency Earthquake Rehabilitation Project) had as its primary objective the relocation of the 52 most affected villages (over 27,000 houses) and the repair and strengthening of another approximately 200,000 houses scattered over 40,000 square kilometers. This very complex rebuilding program has been described in detail in several other reports and is the subject of additional papers at this conference. This paper attempts to summarize the various rebuilding components, with an emphasis on housing, and some of the many features of the project.

INTRODUCTION

A strong earthquake of magnitude 6.4 on the Richter scale rocked the Marathwada region of the state of Maharashtra, India, on September 30, 1993. This earthquake took a tremendous toll in human life--over 8,000 people killed, another 16,000 injured, and over one million local residents rendered homeless. (For details about the earthquake see GSI 1996; Gupta 1993; Jain et al. 1994.) Approximately 67 villages were completely destroyed, and another 700 villages in the Latur district and 600 villages in the Osmanabad district suffered extensive damage. Eleven other districts in Maharashtra also suffered heavy damage to private and public property. The total property loss was approximately US $333 million.

The devastating effects of the earthquake were largely due to a vulnerable housing stock, the shallow focus of the earthquake, which caused widespread damage, the time of the event (early morning when many people were asleep in vulnerable structures), and the density of the population in the area. Based on historical records, Marathwada was considered an area of low seismicity; therefore no special seismic design provisions were required for residential buildings. Moreover, the affected area consisted mainly of rural settlements, where building construction is entirely in the hands of local artisans with limited technical skills. No form of development control existed in rural areas of the state before the earthquake. The majority of earthquake-damaged dwellings were nonengineered, stone masonry structures.

Soon after the earthquake, once the enormity of destruction was understood, the Government of Maharashtra (GOM) began designing a massive rehabilitation project to cover the entire earthquake-affected area. The reconstruction project was officially titled the Maharashtra Emergency Earthquake Rehabilitation Project (MEERP). The MEERP attempted to not only rebuild housing on a massive scale, but also to rehabilitate damaged buildings and infrastructure, to strengthen undamaged buildings, to train artisans and builders, to document earthquake-resistant design, to develop a comprehensive disaster management process, including mitigation strategies, and to develop a new approach to earthquake hazard mapping in a stable continental region. A large team of players, led by the Government of Maharashtra and including the Government of India

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(GOI), nongovernmental organizations (NGOs), the affected villages, the World Bank, the Department for International Development (DFID) of the United Kingdom, the United Nations Development Program (UNDP), and the Asian Development Bank (ADB), were involved in the development and implementation of the project.

This paper provides an overview of the accomplishments of this project. Details of the project are available in several more comprehensive reports, including EERI 1999; World Bank 1999; and GOM 1994a, 1998.

PROJECT COMPONENTS

This is one of the largest rebuilding projects in the world where two of its three guiding objectives focused on mitigation, rather than just recovery. These objectives, as outlined by the Government of Maharashtra in its initial project document for the Maharashtra Emergency Earthquake Rehabilitation Project [GOM 1993] are:

- *to enhance the earthquake resistance of buildings, and;*
- *to reinforce the capability of the government to respond more efficiently to possible future disasters.*

The individual components of the project are summarized in Table 1 below.

Table 1. Major Components of the MEERP *

*- Source: The World Bank, 1994

Component	Description
Housing	• Relocation of 52 villages (27,000 houses) • Reconstruction/repair and retrofitting in situ of 200,000 housing units in over 2,400 villages (RRSP)
Infrastructure	Reconstruction/repair and retrofitting of: • Bridges, culverts and roads, • Irrigation structures and minor dams, • Civic amenities, public buildings and schools, and • Historic monuments. Development of regional water supply schemes to serve the affected villages, repairs of damaged bore wells
Social Rehabilitation	Provision for special facilities and activities to address the needs of women and children affected by the earthquake, and marginal improvement of facilities throughout the affected area, such as: • Reconstruction and new development of hostels, ashram schools, old people homes, community centers, kindergartens, shelters for destitute women and female children, orphans and the handicapped; • Strengthening of industrial training institutions, setting up village development funds that would provide opportunities for self-help income generating activities for women affected by the earthquake.
Economic Rehabilitation	Provision for replacement and reconstruction, on a grant basis, of business losses; this includes replacement of lost farm implements, minor equipment, bullocks, milk cattle, sheep and goats, repair/reconstruction of dug irrigation wells, and rehabilitation of artisans and small businesses.
Community Rehabilitation	Costs of works and materials borne by the GOM when establishing the essential services in the transit housing (temporary shelter) areas in the post-earthquake recovery phase, including: (i) the replacement of medicine stocks for human and veterinary services, (ii) the construction of transit shelters, and (iii) the provision of services for the transit housing areas.
Disaster Management Plan	The preparation of a comprehensive disaster management program for the state, including the development of an earthquake hazard map for Maharashtra and a comprehensive approach at the state and district levels that included risk and vulnerability assessments, response planning, the development of mitigation strategies, the acquisition of a satellite-based communication system and the development of a GIS-based disaster information system.

REBUILDING STRATEGIES

Housing, the largest project component accounting for approximately 60% of the total budget, included: 1) rebuilding of housing in completely destroyed villages at the new locations, 2) severely damaged housing to be replaced in-situ, and 3) moderately damaged housing to be repaired or rebuilt in-situ. The GOM developed their housing rebuilding policy based on the extent of damage and the earthquake fatalities. Political, psychological, religious, technical, and pragmatic reasons all played a role in the government's decisions concerning available options. Packages of financial assistance were developed according to these three general damage categories, and corresponded to three different options for rebuilding and construction management: 1) The completely destroyed villages were to be resettled, with construction managed by contractors, under the supervision of the PMU, or by NGOs and donor agencies that adopted certain villages. 2) The severely damaged housing was to be repaired or replaced in-situ (although most of these villages were ultimately relocated close by, with construction managed by the PMU or supervised by owners and NGOs). 3) The repairs and rebuilding of moderately damaged housing in the in-situ Reconstruction, Repair and Strengthening Program was managed by owners with technical support from the government. The two basic approaches (relocation or rebuilding in-situ) are described in more detail below.

Relocation (Contractor-Managed Rebuilding)

The most affected villages, those practically reduced to rubble in the earthquake, were considered for reconstruction at new sites (relocation). Relocation villages were those with more than 70 percent of the houses either destroyed or substantially damaged according to the IAEE damage categories 4 and 5 [IAEE, 1986], and those villages located on soft soil (so-called black cotton soil) of more than 2 meters depth. Villagers believed that since most of the earthquake fatalities occurred in these villages, the villages had become cremation sites and burial grounds and were uninhabitable for psychological and religious reasons. Arguments for relocation also included the fact that because there was so much debris in the totally destroyed villages it was not economically feasible to clear it out and rebuild at the same sites; and, there was a fear that black cotton (expansive) soils would make villages vulnerable in future earthquakes. The expansive nature of black cotton soil not only necessitated the construction of deep foundations (i.e., either deep strip foundations or piles), it also had substantial cost implications. In addition, popular sentiment considered relocation an opportunity to provide earthquake victims with well planned and neatly laid out new villages at new sites without any segregated compartments for different castes and communities [GOM 1993]. Villagers, reinforced by prominent social science institutions, pleaded for relocation. The government responded politically to such strong sentiment by agreeing to the relocation. More than 27,000 houses were ultimately relocated in over 52 villages. The new villages were located in close proximity to the old villages.

Although an initial principle of the program was to involve the beneficiaries directly in the rebuilding, the GOM decided to let contracts for the construction of entire villages because of the scale of the relocation component and the limited number of local artisans available for construction. Different contractors were selected for each of the relocation villages and were then responsible for all the construction in the village. These contracts were managed by the Project Management Unit (PMU) created for this project. Engineering consultants and rural resettlement planners carried out village planning and design and supervised the contractors who did the construction. A total of 27,919 houses were constructed in the relocation villages; construction of the majority of houses (19,513) was managed by the GOM, whereas donor agencies and NGOs constructed the remaining 8,406 houses.

In the relocation villages, concrete technology was used frequently. This area of Maharashtra has extremely hot weather and an acute water scarcity, making this use of concrete technology somewhat problematic. Ultimately the extensive use of concrete there was a trade-off so that the work could be accomplished within the three-year time period imposed as a condition of the World Bank's emergency loan. In the relocation villages where construction was managed by the GOM, the majority of the houses were constructed using concrete block masonry, and concrete slab as a roof structure; cement-based mortar was used in the construction. The use of stone masonry would have required additional time in cutting and shaping stones; also, stone would have needed to be recycled from the original village sites, and that also had certain cost implications. The use of brick masonry was discarded because of the limited availability of bricks (brick kilns) in the area; the bricks needed to be transported from faraway locations; concrete blocks were the only masonry units that were possible to be manufactured at the construction site.

In addition, designs of houses in the relocation villages that were constructed by donor agencies or NGOs early in the rehabilitation program (starting early in 1994) were mainly based on massive use of concrete technology. Some of these agencies used inappropriate construction practices, e.g., concrete frames, concrete wall panels, and prefabricated construction, but since they were not part of the government program, there was no easy mechanism to influence their chosen design or approach.

Reconstruction, Repair and Strengthening Program (Community-Managed Rebuilding)

The Reconstruction, Repair and Strengthening Program (RRSP) sought to reconstruct, repair and strengthen approximately 212,000 moderately damaged houses scattered over 2,400 villages, in 13 districts, and covering 40,000 sq. km. using earthquake-resistant technology appropriate for the unreinforced masonry construction of the area; ultimately, 189,000 were completed under this program, as a number of beneficiaries failed to complete the construction according to the government specifications. This undertaking was one of the most complex and challenging components of this massive rebuilding project. The beneficiaries took the initiative to repair, strengthen and reconstruct the damaged houses with financial grants and technical support from the government. There were three categories of financial assistance provided to the beneficiaries in the RRSP; the GOM financial assistance was limited to a fixed amount, given in the form of cash and kind. The beneficiaries used materials from old damaged houses wherever feasible, supervised construction work and, in some cases, provided family labor. Owners were given the choice: if severely damaged, they could completely reconstruct their home using earthquake-resistant technology; if moderately damaged, they could repair and strengthen their home, or they could build one new room attached to the existing structure, using earthquake-resistant technology for the new room. In fact one of the major challenges in the entire exercise was to introduce basic earthquake-resistant construction technology and know-how into nonengineered rural construction practices. To achieve this, the GOM provided hands-on training to all those involved in the RRSP implementation, particularly the beneficiaries, local artisans (especially masons), and engineers who were providing technical assistance to the beneficiaries.

Building technologies used to rebuild the damaged houses in-situ (RRSP) were based on traditional practices followed in the area prior to the earthquake (mainly unreinforced stone and brick masonry construction); however certain modifications in construction practices, including the replacement of some indigenous building materials with modern ones, were included (e.g. mud mortar was replaced with cement mortar, and reinforced concrete bond beams were introduced in masonry construction practice). These modifications were made to improve the seismic safety of the buildings, and were mainly based on the provisions of Indian seismic standards and also the experience from other earthquake prone areas of the world with similar construction. In this way, maximum use was made of traditional artisan skills, and the improvements in the construction practices were ensured through the training provided by the GOM.

A considerable number of houses in the RRSP suffered only moderate damage in the earthquake, and consequently the GOM offered a package of financial and technical assistance to those beneficiaries whose houses were considered feasible for repair and retrofitting. A series of simple and cost-effective retrofitting technologies, suitable for application in traditional unreinforced masonry construction, were proposed to be used [GOM, 1994b; GOM, 1998b]. The GOM made a considerable effort to promote this retrofitting option, however the idea of retrofitting was simply not acceptable to the large majority of beneficiaries for various reasons. As discussed in EERI 1999, the idea of building new construction with seismic features incorporated appears to have been much more attractive to the large majority of people (only approximately 0.2% of all beneficiaries in the RRSP chose retrofitting). This is not considered a weakness of the program, given the poor condition of much of the existing masonry construction.

MAJOR PROJECT FEATURES

Large-scale Project Implementation

The size of the tragedy and the resulting scale of the required rebuilding dictated the use of certain strategies and limited the use of others. The enormous number of deaths as well as the large number of housing units (over 227,000), spread out over an extensive geographic area (40,000 square kilometers) and requiring either relocation or in-situ rehabilitation, contributed to difficulties in implementation. Differences in how severely villages were affected also contributed to the development of different options for rebuilding. In the most severely damaged villages that bore the brunt of devastation, the GOM was convinced that villagers were too traumatized to undertake rebuilding themselves. The GOM took responsibility to relocate these villages and to accomplish this relocation in a very limited time frame. Contractors were used to build the new houses in the relocation villages for consistency and better quality control, but also because it was easier for the government to manage the construction process with a small number of contractors than for thousands of individual homeowners to assume that task. Some NGOs, working in relocation villages, were able to successfully rebuild villages with certain designs or amenities that the GOM-managed projects were unable to consider, in part because the GOM was rebuilding many villages simultaneously.

In the less severely damaged villages the GOM did not take responsibility directly. As noted above, in the repair and strengthening program, which was the largest component of the rebuilding, an owner-driven program was the preferred strategy; people were in a far better position to reconstruct their houses themselves, physically and psychologically.

Project Management

The MEERP was managed by an independent Project Management Unit (PMU), led by a team of top Government of Maharashtra administrators with the authority necessary to achieve results. The PMU had autonomy with all administrative and financial powers. A three-tiered framework was created: 1) A **cabinet subcommittee chaired by the Chief Minister** for program policy and guidance; the committee was installed in December 1993; 2) **Central Implementation Group** (CIG) under the chairmanship of the Chief Secretary for monitoring and facilitation. The CIG was composed of all secretaries of the State, including the Principal Secretary (Finance), Secretary (Planning), Secretary and Special Commissioner (Earthquake Relief and Rehabilitation); and 3) the **Project Management Unit** (PMU) with the overall responsibility for implementing the program. The Secretary and Commissioner (Earthquake Relief and Rehabilitation) (SCER) headed the PMU, which was a special post created for implementing the program. This Secretary was the Project Director, with full administrative and financial responsibility including the approval of village and house planning, project preparation, contract awards, construction supervision, monitoring and reporting. A team of high-ranking GOM officers supported the Project Director: two chief engineers, two deputy secretaries, and a financial advisor. External project management consultants were also available to provide support in coordination and management of the construction program, and for project monitoring and reporting.

An important element to project management was the Project Management Information System (PMIS), a database management system customized to automate the data collection, data storage, and report generation of the various MEERP components. This was the first time that such data collection and report preparation were undertaken on a large scale within the GOM. The skills learned by contractors and GOM officials in the development of this system are already proving useful in other projects within Maharashtra. The PMIS should be viewed as a major innovation and skill-building activity of this rebuilding project with direct application to many other aspects of state government. The PMIS was operational for the final three years of the project implementation on 12 PC stations distributed throughout the affected region.

Comprehensive Disaster Management Program

The Government of Maharashtra supported the development of a comprehensive disaster management program that includes the development of response plans at the state and district levels; the identification of risks and vulnerability for each district and the state; the identification of mitigation strategies and training at the state, district and village levels, the development of state and district Emergency Operations Centers, the development of satellite communication capabilities, and the development of a GIS-based database for disaster management. (See GOM 1998.) Interest and commitment to the disaster management program at all levels throughout the state, from the chief secretary and chief minister to the district and village level, has contributed to the success of this far-reaching program. The GOM also adopted a program of strengthening public buildings and supported the construction of two base isolated demonstration buildings (the first application of seismic isolation technology in India).

Earthquake Hazard Map

With support from the World Bank, the Government of Maharashtra supported the development of an earthquake hazard map specifically for the state. Up until this point the earthquake hazard maps for each state in India had been developed by the central government. The hazard map for the state represents an innovation in hazard mapping because not only does it use geologic data and historic seismicity, but it factors in triggered seismicity, specifically the influence of reservoirs (see EERI 1999).

Use of Junior Engineers

The RRSP program used Junior Engineers (JE), primarily from the earthquake-affected area, to work with individual beneficiaries, providing technical assistance in the repair and retrofitting/ rebuilding of their homes. In total, over 700 JEs were retained for the MEERP at the height of the project. These engineers were each assigned to one or more villages and were expected to assist beneficiaries to work out the design for the repair or new construction. They also acted as intermediaries between the Government of Maharashtra and the local villages. As the majority of JEs had a very limited background related to earthquake-resistant construction, GOM retained the national seismic consultants to develop and deliver a series of training programs for JEs related to seismic engineering design and construction issues.

Training Program for Artisans

In order to ensure the successful transfer of knowledge regarding earthquake-resistant construction technology to the rural communities, the GOM developed training programs for artisans in the earthquake-affected area. Since the in-situ rebuilding strategy was to be managed by the local communities with construction carried out by local artisans, the GOM launched three training initiatives: a two month training for unskilled laborers covering four trades: masonry, carpentry, electric works and welding; a two-day training course developed for traditional masons (mainly orientation related to earthquake-resistant construction features); and hands-on training initiatives in the villages by the PMU engineering field staff. This last training initiative was on-going throughout the project.

Involvement of Women and Community Organizations

In part because of difficulties in convincing villagers to participate in the rebuilding in-situ program, he community participation consultants involved in the RRSP adopted the strategy of involving womens' groups and community based organizations to communicate with the beneficiaries. The strategy proved to be very effective in reaching the villagers and involving them in the reconstruction. It also empowered the women in particular to be more vocal leaders in their communities.

Incorporation of Broader Development Issues

The local community-based organizations working in the villages showed a great capacity to work not only on reconstruction, but also on other development issues. As community organizations involved in cultural and social issues prior to the earthquake rebuilding program, they were positioned well to advocate for broader development issues such as health, education, savings and credit, self-employment, and water resources management.

Demonstration Initiatives

A number of demonstration initiatives were undertaken as part of the rebuilding, to educate, build confidence and transfer earthquake-resistant technology:

Confidence-Building Project

The poor performance of stone masonry buildings in the earthquake led people to lose confidence in stone as an appropriate building material, so the Government launched the *Experimental Verification and Confidence Building Project* under the leadership of Professor Arya of the University of Roorkee. Shake-table tests on stone masonry building models were conducted in the field; one model was retrofit using the seismic strengthening methodology recommended in the MEERP and the other was tested in an unstrengthened condition.

Pilot Strengthening

The GOM had an initial strategy to strengthen 5000 undamaged buildings throughout the region as a demonstration of earthquake-resistant technology. Ultimately, it proved difficult to successfully implement on a wide scale. However at a later stage the PMU managed the strengthening of 46 undamaged public (mainly school) buildings. This program was more successful in terms of quality of technical solutions and construction, and easier to implement compared to the strengthening program for private buildings.

Model Buildings

In the initial year of the project over 500 houses scattered throughout the affected area were constructed to demonstrate cost-effective building techniques, the use of local materials and the incorporation of earthquake-resistant construction features. The objective was not only to demonstrate the improvements in traditional building practices, but also to generate confidence among the residents about the use of stone and its by-products for housing construction. The seismic features were usually highlighted with a bright color, and in front of most model buildings was a sign, written in the local Marathi language, which described the salient seismic features of the particular building.

Base Isolation

To demonstrate effective strategies for earthquake mitigation that could be used in future projects of building important facilities in Maharashtra, the GOM decided to construct two base-isolated demonstration buildings close to the epicenter of the 1993 earthquake. Public buildings of masonry construction typical for the rural area were selected. Although rubber bearings had to be imported for this application, the entire construction was carried out using local artisan skills and tools, and was supervised by the PMU engineers. This was the first reported application of base isolation technology in India, and one of the very few applications in rural areas worldwide.

CONCLUSIONS

This paper has provided a brief overview of a very complex earthquake rebuilding project, which used different strategies for rebuilding, depending on the severity of damage: relocation for the most devastated villages and repair and strengthening (retrofitting) or rebuilding in-situ for more moderately damaged villages. The project made an effort to address the particular needs of women, and to involve community-based organizations in providing education and training. The Government of Maharashtra took the opportunity to develop procedures and project management skills that will be useful in many other activities undertaken by state government. A major emphasis was placed on mitigation of future risk throughout the project, explicitly incorporating mitigation into project objectives and then designing various aspects of the project to build on the concept of mitigation. Villagers and artisans were taught the importance of earthquake-resistant technology, undamaged buildings were strengthened and a major initiative was directed to preparing a comprehensive disaster management plan for a range of hazards. This planning process is ongoing and has received the commitment from the highest levels of state government.

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