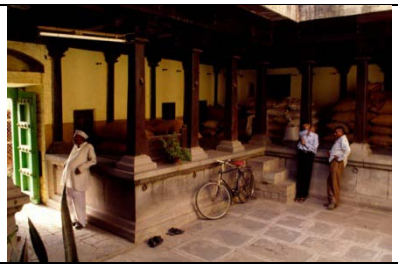
Strengthening Peoples' Architecture Against Disasters

By Rajendra and Rapul Desai

"We want houses on springs". One person was speaking from the crowd that had gathered on the outskirts of a village in the Latur region of Central India three days after an earthquake devastated the many villages near Latur town; it was October, 1993. The Chief Minister of the state was promising residents houses on springs, houses which are made from the latest technologies, like those in Japan. Never mind that we were in rural India. The ridiculous promise set the tone for the misunderstandings, doubts, and confusion that would dog a lengthy reconstruction program. It was, after all, the first such program in the history of India after the independence, and the emphasis placed on building technologies--real and imaginary--was intended to reassure people that their new homes would not only be safe but more secure than those they lost. The phrase "safety at any cost" became the program's mantra, and was repeated breathlessly by everyone and anyone, whether engineer or local volunteer. In short, the phrase meant that stone was out, brick was in; mud mortar was out, cement mortar was in; mud roofs were out, reinforced concrete roofs were in; and rural plans were out, suburban plans in. The new homes would, in the end, be more expensive and smaller, and resemble their urban counterparts.

Typical Latur House:
The typical Latur house took everyone by surprise. They use, in effect, climatically the most appropriate and environmentally least destructive method of building in the region. Built entirely of local materials like stone, mud and timber, which saves on transportation and energy costs, the houses can be readily dismantled and materials recycled. Massive stone walls and ornamental doorways are trademark features of the large, fortress-like introverted houses.

Massive stone walls

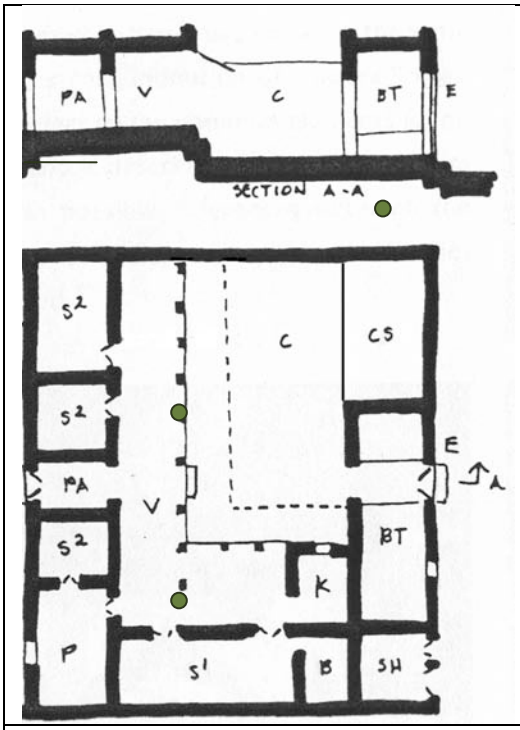


Semi-covered *veranda*

The square plan with rooms all around in richer households or rooms on two sides in poorer households opens onto a central courtyard. A semi-covered *veranda* extends the rooms into the courtyard. These rooms are used by newlyweds, as well as for storing seeds and agriculture tools. Interior temperatures are more or less uniform year round. On cold winter nights the rest of the family also sleeps here. On hot summer afternoons the rooms are naturally cool. The *veranda* is the most useful space. Large grain storage bins are placed in one part; other areas are divided and used for sleeping, resting, cooking, socializing, and studying. Wooden pegs are inserted into the walls to hang utensils and clothing, niches function as storage spaces. The central courtyard is a protected space but open to sky, and serves as a playground for children, as well as a utility space for washing clothes, pots and pans, and a place to dry food stuffs.

These houses ware built, in fact, with personal security in mind, a fact hard to reconcile with the reality that these same stone walls buried entire families. But this was the first earthquake of this magnitude in the area in five hundred years. This was the reason why local people had no sense of worry, or no active awareness that they were living in an area vulnerable to catastrophic seismic activity. That the disaster left a telling impact on individual psyches is not surprising. For months, no one would speak of stone or

timber, let alone consider using these materials to rebuild their homes. Stone and timber had snatched away their loved ones.



Space Legend

E	Entry
BT	"Baithak"
C	Court
V	Veranda
K	Kitchen
B	Bath
CS	Cattle shed
S^1	Day to day storage
S^2	Long term storage
PS	Passage
P	"Punja" room
BC	Back compound
SH	Shop

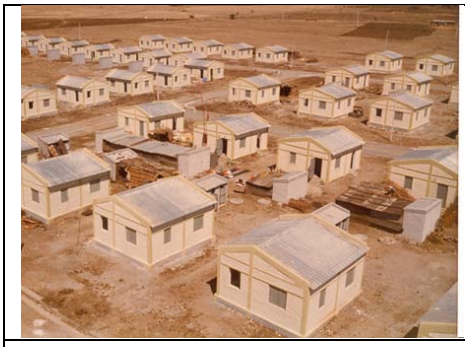
Middle Income Family's House

Rehabilitation-Reconstruction Process:

Though the vernacular houses were built without architects, for the most part, the various teams assisting the reconstruction effort brought with them the modern construction technologies suggested by city based architects that suited their personal preferences, habits, and expertise with good faith. They brought materials and technologies alien to the people, which generated the feeling among them that their traditional technology had no future and they argued in concert and with absolutely no justification that these tiny suburban structures, which were not houses in the sense of the traditional Latur home, would protect people in the case of future disaster.

Total Reinforced Concrete construction

Geodesic domes

		
Urbanised formal planning		Pre-cast hollow core panel house

In effect, local people were told that everything they had been doing was wrong or dangerous. In reality, it was neither the traditional plan nor the traditional building materials that made their homes vulnerable. It was the manner in which the materials were used, and the absence of certain features necessary to help the structure overcome its vulnerability in the face of destructive natural phenomena that put people at risk.

Typical house plans under the rehabilitation programme

The first set of official, state-recommended plans were of typical suburban houses that catered to urban lifestyles, all with a similarly configured living room, bedroom, and a kitchen. The plans, which were drawn by architects and engineers living in the city who knew nothing about and had little sensitivity for the specific needs of people in rural areas, would be adopted from village to village. For younger families, who dreamed of living in modern homes, the suburban plan was something of a god sent. But as people moved in, for many the allure quickly gave way to an increasing number of problems.

The suburban houses were incomparable. They were tiny and expensive. All the materials were bought and transported to the site. Owners had no say in the process of planning and designing. The feeling of personal security and privacy created by the introverted style of the traditional house was lost. Women felt more exposed and at risk in a local culture that demands discretion. The new houses were hot in the summer and cold in the winter. They needed fans. The white-washed walls, unlike mud plaster, turned black when women cooked over traditional wood burning stoves. Painters had to be called in. Even picture hanging was more difficult in concrete walls wherever they were used. Concrete walls require special electric drill and the power to drive them, whereas there was no need for special power tools when the walls were made of stone. During the monsoons, when the reinforced concrete roofs started to leak, helpless homeowners simply threw up their hands. When the roof was mud, all he had to do was to climb up, pull out the weeds, and spread some new clay soil over the leak. The large grain storage bins had to be left behind, because the doors in the new houses were too small to allow them through. New, metal containers replaced the old bins at additional expense, and now insecticides had to be used to keep the bugs away. The houses were so hot in the summer that residents worried about whether their seeds would survive the season.

The confusion over the relationship between building materials and structure’s vulnerability was nowhere more evident than when the government’s program ended and proud homeowners started adding extensions. As is the case nearly everywhere in developing countries, or, for that matter, in the developed north, most people have no idea why their houses collapsed or how to rebuild in a manner resistant to earthquakes. In Latur, people believed the stones were the culprit. And yet, after only a year, they no longer cared. The fear had subsided. The infatuation with steel and cement gave way to reality. Using new materials was expensive and inconvenient, especially if you have to pay for supplies out of your own pocket. People simply returned to cheaper, readily available, traditional materials and construction methods.

What people did themselves?:

In the village of Yelwat, one of the first villages to be rebuilt, a wealthy farmer started constructing an addition on his brand new three-room house just months after he moved in. The extension was three times the size of the new concrete-block house. He went back to the site where his home had collapsed, gathered up the stones left lying around, loaded his bullock cart, delivered them to his new home, and asked a local mason to build the addition.

Stone wall extension to concrete block house

The stone walls of the extension were built in exactly the same manner as they had been before, with all the faults that brought down the walls of his first house. When we pointed this out, the farmer consoled himself by telling us he would use the extension as a storage area and not for sleeping!

Some residents refused to sleep in their traditional houses that were still standing and built temporary structures with tin or thatch. Others came up with their own ideas about how to best address personal security. They removed the heavy mud and timber roofs which could have been retrofitted, and replaced them with a light tin roof supported on a simple framework of wooden posts. They dismantled the upper part of the heavy stone walls, reducing their height to no more than 1.25 meters, and reasoned that stone falling from that height would not kill a person. They salvaged heavy timber beams from the ruins of their home, cut them into planks, and used the pieces to fill in the gaps between the roof and wall. Through word of mouth and improvisation, people convinced one another that it was safer to trade the comfort of living under the cool mud roof for the unbearable summer heat under tin roof, and that the bits of cut up timber would stand in for a real structural solution. Many replaced the stone walls completely with brick, still without the earthquake resistant features, thinking, erroneously, that brick is lighter than stone, and therefore less likely to kill someone.

New house with wall bottom made of bricks and wall top of timber from old house

Existing house modified to replace upper part of stone wall with timber planks salvaged from old house

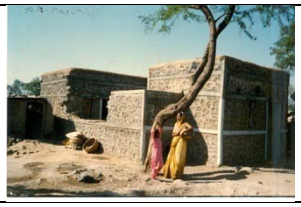
Our role in rehabilitation

Even though we had gone to Latur as part of a team that the government had sent to carryout the damage assessment, we decided to stay there longer since we realized that this was the area where the housing was the first priority of people at the time and because by this time we had a decade of experience assisting rural artisans. But as architect-engineer team, Latur was the first post-natural disaster situation we faced. We had far too little experience with how survivors would react to the rebuilding process, particularly given that the newly built homes were turned over to residents free of cost. What we knew about building technology and construction techniques was wholly inadequate to the situation. We had to first understand and take seriously the fact that local people were stuck; they were fixated on what materials they thought they could and could not use when rebuilding their homes to protect their families. And only after that we wanted to demonstrate that stone can be used to build safer walls, and how these same walls could also be built in combination with other materials, such as brick and adobe. We knew that earthquake resistant roofs can be made using traditional options such as mud on a timber deck, or pitched corrugated galvanized iron (CGI) sheeting, or by using such alternatives as a flat roof that saves timber by incorporating modern materials such as a deck made with pre-cast RC panels and joists and covered with mud roofing.

Although, people started going back to using local materials in post-disaster reconstruction after a gap of around six to eight months, the local mason/builders knew little of how to build with these materials in a way that mitigates the vulnerability in a natural calamity like an earthquake. Often the use of these materials is best suited to the climate and lifestyle, but has not been adapted to meet another level of security. So rather than working to rebuild one or more destroyed village, or repair all the damaged homes in a few villages, we selected many geographical areas, and worked with individuals, artisans, local NGOs, and government agencies to educate them about how they can tackle the vulnerability. We were absolutely convinced that the focus had to be placed on the use of local materials, namely stone and mud. We demonstrated to the local populations from different villages that by following the basic rules of rubble (stone) construction and by including hazard resisting features, the house would be stronger and safer, certainly more so than the aberrant pseudo urban houses being constructed by the local masons and contractors. This was so because masons, contractors and people had no opportunity to learn the better ways of building from the construction work under the rehabilitation programme, since that was done by big contractors from far off places with their own construction teams.

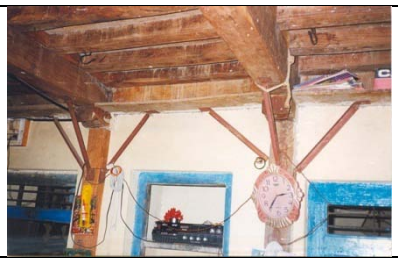
Construction Technology Transfer

To demonstrate the disaster resistant features, we decided to build two demonstration houses in Budhoda, a village easy to reach from Latur, the district headquarter. The first challenge was to select the individuals who would benefit from the homes. We were working on an NGO platform. This, needless to say, implied that we choose our future homeowners from among the most vulnerable residents. The houses used the commonly used local materials and looked no different than the local houses. The only difference was that they were earthquake resistant. We identified two widows. Aid agency workers, government officials, and donor agency representatives time and again visited the finished houses.

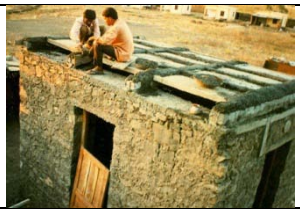
		
Earthquake resisting house - Stone for lower walls with adobe for upper having CGI roof		Earthquake resisting house – All stone walls with mud roofing on Pre-cast panel roof structure.

Everyone was happy with the result. But what we didn't count on was a simple yet overlooked cultural reality: our beneficiaries were poor widows, so people identified our construction techniques with poor people. And, frankly, who wants to go and see a poor person's house? No less live in one just like it. Unfortunately, and it is sad to say, these women would never be looked on by their community as spokespersons for new ideas on the traditional building technologies. For our ideas to become acceptable and widespread, the right strategy could be to have right individuals promoting them. It may seem obvious and naive to point out, but this calls for a spokesperson that people can identify with, someone they trust and look up to.

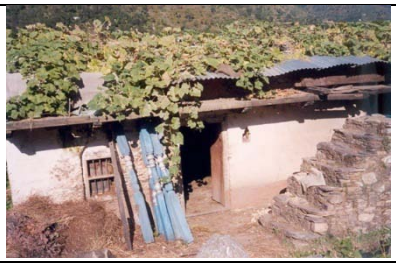
We found our spokesperson in the ex-*Sarpanch* (elected village head) of Almala village, ten kilometers from Budhoda. We met to talk about *seismic retrofitting* and how individuals could reduce the vulnerability of their existing vernacular homes rather than demolish them and start over, which was what the engineers were promoting. At the end of the meeting, the *ex-Sarpanch* offered his house along with his entitlement from the government. He followed the process through every step. His two wives and four children also worked on the site to help speed things along! While we retrofitted his house, he learned the basics and convinced two of his friends to retrofit their houses. Once three houses were done, there was no turning back. In less than a year, one retrofitted house resulted in thirty-four more retrofitted houses. Ironically, people in the surrounding villages continued to demolish their perfectly good, sometimes new houses in order to make space to build a 10'x10' CGI-brick shed with the entitlement from the government. It is important to realize that it was the engineers who promoted new materials and untenable solution as an option for investing government money in long-term safety. In the absence of well informed and sensitive architects/engineers, and with a complete disregard for vernacular building practices that, although not yet outfitted for seismic safety, were very well suited to the region and could be easily upgraded, peoples' rebuilt suburban homes made them more vulnerable.

		
Removing top portion of wall to install roof level RC band for wall strengthening		Knee bracings at column-beam junctions to reduce the side sway in the roof by stiffening the joint

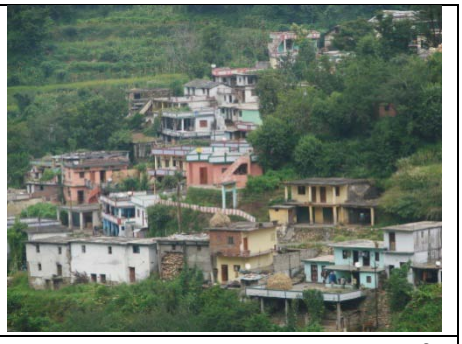
In Latur, although our efforts were centred around the maximum possible use of the local materials, the only non-local option that we included in our demonstration was the alternate roofing technology that consisted of pre-cast doubly curved concrete panels supported on partially pre-cast RC joists, since mud-timber roof used large quantity of timber that was already in short supply. Most of the trees in the area are gone as a result of centuries of indiscriminate logging. In this way we tried to preserve the traditional modular nature of the roof in the new design, because it bears directly on the proportions of individual rooms. But later we stopped doing so because we realized that by using the new technology we were telling the people that their timber/mud roof was no good. In reality, their technology was an excellent example of the "green-technology". But in our zeal as the proponent of technology alternatives we completely overlooked that aspect.

		
House in village Lohata with stone-brick wall and pre-cast panel roof		Installing doubly curved pre-cast concrete panel roof

In the years to come, we encountered the same story. People were, more or less, willing to rely on myth and fear, or on hear-say and the peer pressure. Technical expertise continued to be limited to advising simply to abandon the existing building practice in favour for another, promoting expensive and inappropriate alternatives. In the April of 1999, we visited Chomoli region of Uttarakhand state in the Himalayan foothills soon after a moderate earthquake. The majority of the traditionally built, two story stone houses had developed cracks in the corners of the upper story. Again we served on the government's team for damage assessment. Someone in a village concluded that the upper story was unsafe and dismantled it. The panic spread, and people started pulling down the second story. No one bothered to ask why the cracks occurred, and not one of the local engineers took the pains to explain the cause or its remedy to the people**.** The construction guidelines were published by the state government covering the stone, but for all new construction brick was brought in to replace the stone.

	
Traditional vernacular house with stone walls and stone/slate roofing	Upper story removed out of fear

A study done recently by us in the year 2009 reveals that almost all new construction is done with steel, cement and bricks. As a result the landscape has been changing rapidly.

	
Village landscape with stone roof	Changed landscape with RC roof

In late 2005 there was a moderate earthquake in Kashmir, and the stone houses again suffered extensive damage for reasons that had already been well recognized in the earlier earthquakes. We travelled for over two months to many of the affected villages talking to people about what they were doing to take care of the housing needs. Fear coupled with the inappropriate advice from the local engineers had

already prompted people to abandon local materials in favour of the non-local materials that local artisans knew nothing about. As a result people paid astronomical sums to haul bricks, cement, and steel over a 10,000' pass that becomes snow bound and can be closed for over six months. In the end, their houses were more vulnerable than the vernacular standard, as the local builders were not skilled in working with the new materials. Along with the information on the weaknesses in the local construction practices, the knowledge of disaster resisting features also did not reach people even tough the technical guidelines were prepared an ready in few months after the disaster by UNDP.

Long-Term Safety

Now after some twenty years of field work we are convinced that the only way to break this cycle of ignorance and fear is to demonstrate that appropriate building technologies are capable of withstanding the forces of natural hazards. We must train artisans, village level architects, engineers, and promote confidence among local people. We also must make a special effort to engage women in the community. In one school in Kashmir Rupal, the only female member of our team, conducted a special meeting with the girls. In several villages, she called separate meetings, so the women could freely interact. We had also tried to interact with school children in Latur. The experience was very good. Through them we were able to reach to their parents.

By any measure, our approach in Latur had limited success. There, large scale reconstruction was under the sway of a government and donor agencies that promoted modern construction technologies that hinged around the use of cement and steel. We were helping a donor group that wanted to facilitate the recovery of a village through an NGO. While we were talking about the use of load bearing masonry, the NGO was talking about reinforced concrete frame structures for just single storey houses. Once we had convinced the donor and the NGO that traditional materials would perform well, we had to convince the local masons and the residents. We designed two houses for the purpose of demonstration in that village. Their construction was taken up by twenty local masons, who were instructed at every stage and their work was closely monitored through.full-time supervision. Three weeks later, standing in front of the finished homes, the masons unanimously claimed that their newly built houses would hold against a future earthquake. But we were still not sure if they had full confidence in the technology we had trained them on. We were not sure if they were fully persuaded that building made with stone could be cheaper and safer. We still had to generate the similar confidence among people. What were missing in our process were effective communication tools that would help people relate their own safety to various technical measures. There was a need for tools that impart understanding and build confidence.

Working with community groups we finally hit upon the idea that simple objects from daily life could help explain important concepts in earthquake engineering. We used the 'stitches through cotton mattress' to convince people of the need of "through stones" that hold together the wythes in random rubble wall. A plastic bucket with bent rim demonstrated how a stiff band of wood or reinforced concrete at eave-level works to strengthen the walls. The stiffness of a canister with its lid tightly shut showed the importance of the roof securely connected to the walls. We kept adding to the list. Even abstract concepts like "inertia forces" could be explained to people with little education by holding a flexible twig with a lump of clay attached at its far end and shaking its base. We also introduced shock tables that subject half-scale models to sideways shocks, which crudely imitate earthquake forces. This allows us to demonstrate how a particular type of vernacular structure would perform in the event of an earthquake. Even lay persons went home fully convinced that they could improve their safety by adding bands, through-stones, and vertical reinforcement embedded within the masonry.

In Kashmir, as in Latur, the most pressing need was to demonstrate that long-term safety can be ensured in houses built out of the local stone. We were there to help a donor group train master masons who would, in turn, train other masons. In Kashmir the stone walls had simply disintegrated, but their CGI-timber roofs performed well. Some of these masons were in their fifties and enjoyed such impressive reputations that people were willing to wait two years for their services. These master masons habitually build large two storey houses without a single drawn plan. They said that they were confident about their roofs, but wanted to know why the walls had collapsed. This was the only reason they joined the training.

Of all the masons (approx 10,000 in numbers) that we have trained, this group of 28 masons in Kashmri was the best. Based on our past experiences we made sure that the training was a two way affair and that made the interaction the most effective. Many years ago in Uttarakhand, during one of the video presentations in a village, fifteen masons had walked out. They thought that by talking about the mistakes we were pointing fingers and denigrating them. But the group in Kashmir turned the exchange into an opportunity. There was so much that we, as architects and engineers could learn from them about the region and their construction practices. The design for the two houses that we were building was developed together to make sure that what was designed was feasible to build in remote villages. So, as each house evolved, we refined the details together. The training program with the building artisans always parallels our work with the community. Villagers are asked to observe what their masons are learning; many visit the site, some come from adjoining villages. For example, people were particularly surprised when we told them they should instruct their masons to make only enough cement mortar to last for an hour, since it begins to set by then. One villager confided in us that he had sacked a mason who made small quantities because he thought the fellow was taking too many breaks.

Our biggest challenge is to make sure builders understand certain fundamental concepts, such as ductility, and the need to install reinforced bands and single reinforcing bars within masonry at various locations. They need to be able to understand the concept and practice to the extent that they can teach other masons, as well as defend their work in the face of market forces and misguided engineers. Today, the videos of shock table testing, simple working models, and brochures make our task a great deal easier than what it was in the early 1990s in Latur.

We have developed a comprehensive process of technology transfer based on building demonstration housing units that use a building plan similar to local plan; use mainly local materials while exercising discretion for the use of non-local materials; meticulously follow the basic rules of construction; incorporate all necessary earthquake resisting elements; use shock-table videos and other tools of communication for confidence building, rely on a hands-on training program for artisans and at the same time promotes awareness in the community.

After the training programs, the chance of running into one or more trainees again is rare. As a result, it is hard to judge how many new ideas they adopt and use consistently and with authority. The training program in Kashmir was a rare exception. After the program, the donor group retained almost everything that we had put in to the construction technology package. Under the rehabilitation program funded by that donor, the masons built hundreds of houses over the next couple of years using the techniques we taught them, and trained three times as many masons than we were able to train personally. Seeing what these masters accomplished, we are reassured that--for the first time--using hazard resistant random rubble masonry with selective mix of modern materials will take root in the region. Besides the new construction we had trained the same batch of masons in retrofitting. The training was through retrofitting of a small existing school building in the village. Later on they retrofitted two more school buildings in the nearby villages with the same donor agecny support.

Although, the Kashmir intervention was on a rather small scale, the intensive work in Latur had prepared us for a large scale intervention. Large scale interventions become the need of the hour after a large disaster. Such interventions are multi-pronged to be effective. In the aftermath of Kutchh Earthquake in 2001, we got an opportunity to work on one such project for the government. After taking up programs of rapid on-site training of 1200 government engineers followed by a program for sensitization of the village level government functionaries, we took up an unusually ambitious project for the government. It involved full size technology demonstrations coupled with intensive training of masons and engineers, and confidence building for the village level government functionaries in some four hundred eighty villages with over a million inhabitants in five districts that span nearly 300 kilometres.

Conclusion

In the developing countries the vernacular architecture, or the "architecture of the people by the people", is the backbone of traditional housing. In most cases it is also the identity of the region integrally linked to the local culture. The post-disaster reconstruction phase is a unique opportunity to usher in changes that can bring a significant improvement in the long-term safety of people who are otherwise not in a position to reduce the vulnerability of their homes. But unless the most affordable and replicable options are selected and the right strategy adopted, people will remain vulnerable, in spite of unprecedented rehabilitation assistance. Only an architect who is sensitive to the crucial linkages between the peoples' lives, their surroundings and their own architecture can do justice to the task of getting involved in such a rehabilitation program.

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