INNOVATIONS IN DEVELOPMENT

MIZORAM STATE ROADS PROJECT

Using Bioengineering to Stabilize Landslide-Prone Hillsides

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Using Bioengineering to Stabilize Landslide-Prone Hillsides

One of the major challenges in building hill roads is stabilizing hill slopes with appropriate and cost-effective interventions. The Mizoram State Roads Project employed innovative bioengineering techniques that used the abundantly available local bamboo to stabilize the hill slopes at a fraction of the cost of conventional methods that use concrete structures for the purpose.

Bioengineering is the use of vegetation, mostly shrubs and grasses, either alone or in conjunction with stone and concrete protection works such as retaining walls etc. to enhance the stability of slopes. It benefits both road building agencies and users alike as it not only provides one of the best, and cheapest, ways to protect the road and its users from landslides, but also retains the hillside's productivity, unlike stone and cement works on which no vegetation can grow. A slope treated with bioengineering measures can therefore retain its forests, water bodies, farmlands and orchards while also covering up any unsightly scars that result from road widening activities. These environment-friendly measures also reduce the carbon footprint of roads.

Bioengineering techniques are now being implemented under the World Bank supported Himachal Pradesh State Roads Project.

Challenges

The Mizoram State Roads Project sought, among other objectives, to improve connectivity between Aizwal, the state capital, and Lunglei, its second largest town, by upgrading, widening and improving the old road between these two major towns. Connectivity is crucial for a distant hill state such as Mizoram which, like the other northeastern states, is geographically isolated from the mainland. However, long and difficult transportation routes over predominantly mountainous terrain have long hampered trade and development. As a result, Mizoram conducts virtually no trade with the mainland or with neighboring countries. The drawing of new borders following the partition of India in 1947, with the loss of access to the port of Chittagong, dealt a major blow to the region's economy. It particularly isolated the state's southern region and the town of Lunglei, situated near the Myanmar and Bangladesh borders.

While the new road would bring enormous benefits to the people, environmental and social assessments highlighted a number of challenges in project implementation:

Stabilizing hill slopes

The soft rock and immature geology of the project area, together with the region's heavy rainfall, would require the stabilization of hill slopes both above and below the road. Over 100 such landslide-prone locations were identified all along the 164 km project corridor.

Disposing of debris

Cutting the hillside to widen a road invariably generates debris. Disposing of this debris in the hilly areas is a challenging task as loose debris can potentially cause landsides, lead to unsightly scarring, and cause the hill slopes where it is dumped to lose their productivity. Although the road's technical design had reduced the generation

The region's soft rock and heavy rainfall would require the stabilization of hill slopes both on the valley side and the hill side

Disposing of debris in hilly areas is a challenging task as loose debris can potentially cause landsides

of debris by 40 percent - by filling the valley portions with the debris - about 0.7 million cu.m. of debris would still need to be disposed of.

Protecting biodiversity

The region is part of the Indo-Burma biodiversity hotspot. Roadside slopes support a rich variety of native flora including many medicinal plants. Parts of the corridor also support wildlife, including the endangered Chinese pangolin. Project activities would therefore need to be conducted in a manner that protected the area's rich flora and fauna.

Maintaining the productivity of hill slopes

A fairly large proportion of Mizoram's people use hill slopes for agriculture where they still follow the traditional practice of 'jhum', or shifting cultivation, a 'slash and burn' method of cultivation that requires large tracts of land. The productivity of these slopes would therefore need to be retained and any land acquisition for project work or the disposal of debris would need to be done in close consultation with the local people. This was especially so in Mizoram as, under Mizo tribal custom, a significant part of the land is jointly owned and administered by the community.

Meeting community needs

Considering the adverse impacts that road improvement activities could have on local communities and their livelihoods, the environment management plan (EMP) included extensive community consultations. These consultations covered a broad range of issues, such as identifying exclusion zones for construction activities to safeguard biodiversity patches, identifying measures to prevent deforestation and protect water bodies, and identifying prudent alternative road alignments and debris disposal sites to minimize impacts on communities and natural resources. Communities were also involved in project construction, and contractors were made responsible for involving them.

Project activities needed to be conducted in a manner that protected the area's rich flora and fauna

It was important to maintain the productivity of hill slopes as agriculture is the predominant activity for Mizoram's rural communities

Using locally available bamboo to terrace the hill slopes for cultivation is a well-known and age-old practice in Mizoram. Bringing in significant technical know-how from the Rural Access Project (RAP) in Bhutan, the World Bank team introduced the new concept of using this bamboo to bind and stabilize the hill slopes on both the hill and valley side of the road, as well as on debris disposal sites. This combined the traditional techniques long employed by the local people with new ideas about how to expand their use.

Pine logs were used to protect the hill slopes under the Bhutan Rural Access Project

In Bhutan, the RAP project used pine logs to create crib walls and other bioengineering measures to protect the slopes. In Mizoram, given the local people's traditional know-how and ease in handling bamboo, the World Bank team adapted the techniques employed in Bhutan to suit local conditions by using the abundantly available bamboo.

Using local materials and labour

Bamboo terracing, bamboo crib walls and bamboo knitting were developed to suit the requirements of each slope as well as for debris disposal sites. The Mizoram State Public Works Department (PWD), the project implementing authority, as well as World Bank staff and the supervision consultants together devised their own method of bamboo matting, working out as they went along the exact dimensions that were suitable for a particular slope.

Implementation was assigned to local village councils. The local people had retained the traditional skills of working with bamboo; they also

knew where to collect the raw material from as they knew where the bamboo forests were located. The new bioengineering techniques were demonstrated to them on small trial patches. Drawings/sketches were made of the various types of work needed at a particular site. Given their familiarity with the materials, the local labourers employed in the trial patches adapted these methods to suit particular conditions. They were then taken to other sites along the route to demonstrate these new methods to local groups working near their own villages.

Initial delays

Despite these efforts, however, many bioengineering measures could not be effectively implemented in the initial years of project implementation. The contractors who were from outside the northeastern region lacked the local bioengineering skills and were unable to take local communities into confidence. They also placed a higher priority on achieving construction targets and, with a stake in maximizing the constructed area, resorted to using conventional civil construction techniques such as retaining walls, stone pitching, etc to protect the slopes. This led to long delays as the stones for building the masonry works had to be imported from Silchar in Assam and skilled masons were in short supply in the state. As a result, many slopes identified for stabilization could not be covered before the onset of the 2004 monsoon season, leading to several slope failures and road damages.

Bamboo terracing, bamboo crib walls, and bamboo knitting were developed to suit the requirements of each slope

Subsequently, the Mizoram PWD took special initiatives jointly with the World Bank and the supervision consultants to address the damage caused. A concerted effort was made, led by the Executive Engineer (Environment) of the Mizoram PWD, to reach out to local communities, improve understanding and benefit from local knowledge and skills. It was also ensured that the project benefited local livelihoods and enhanced community assets.

The flowering of the bamboo in 2005-06 provided an opportunity to use the dying bamboo for construction purposes. (This is a cyclic ecological phenomenon that occurs every 48 years in a particular species of bamboo in Manipur and Mizoram; the price of bamboo falls at this time and a great deal of bamboo is traditionally extracted for construction purposes.) With the bamboo becoming abundantly and cheaply available, the bioengineering works proposed for the slopes were redesigned to make the maximum use of this resource.

Planting useful shrubs and grasses

The abundantly available bamboo seeds were then planted over the bamboo structures to complete the process of slope stabilization quickly and cheaply over large areas. Project staff also ensured that local species

The flowering of the bamboo in 2005-06 made it abundantly and cheaply available. The dying bamboo was then used to stabilize the hill slopes

With the bamboo seeds too becoming abundantly available, these were planted over the bamboo structures to complete the process of slope stabilization quickly and cheaply over large areas

Construction of bamboo knitting structures and the planting of local species of flora in progress

of vegetation were planted on the bioengineered sites, including fruiting trees and shrubs as well as species of grasses which are used by the local people to make brooms etc. In fact, different grasses were used in the Aizawl and Lunglei areas to keep the local ecology intact. Special care was also taken to provide chute drains to avoid erosion when the saplings were young and their roots shallow. The quick-growing local flora ensured that the slopes became green very soon.

The bioengineering works remained stable even during fierce monsoon rains in 2007

In 2007, when the highest rainfall in the region in ten years was recorded, causing severe damages to road works, the pilot bioengineering works remained stable with minimal damage.

Impacts

Since resources were scarce, using the abundantly available local bamboo to stabilize the hill slopes proved to be the most appropriate and cost-effective intervention, leading to a 'win-win' situation:

Huge savings

The bioengineering works were very labor-intensive and required little capital investment. The involvement of local skills, labor and materials resulted in considerable cost savings. Bioengineering measures for slope protection were implemented on 105 sites, covering an area of about 140,000 sq. m., at a total estimated cost of about US$90,000. (Costs ranged from US$40 to US$100 per sq. m. depending on the type of slope and the nature of the treatment). By contrast, the estimated cost of conventional civil works would have been about US$650,000 to US$1million for the same area.

Quick implementation

The bioengineering measures were also quicker to implement than conventional civil construction techniques. This was especially important in Mizoram which has a short construction season of just 6 to 7 months when it does not rain.

Productive hillsides

The bioengineering works also helped retain the productivity of the hill slopes whereas masonry works would not have done so. This was of major importance to local communities, given that agriculture is the predominant land use along the project corridor. Where the bioengineering works have been completed, communities have been able to resume their traditional 'jhum' cultivation.

Rural livelihoods created

While stone masonry and cement concrete protection works would have required skilled masons from outside the state, generating very minimal local employment, the bioengineering measures involved local labour and generated substantial local employment in the short term for

Conventional methods of protecting the road would cost US$62,000 at this site. By using bioenginering measures, the cost was reduced to about US$5,000. This also prevented the cutting of the hillside

The bioengineering measures were also quicker to implement, especially important when there is a short construction season

the residents of about 20 villages. An estimated 130,000 man days of employment were generated. This also enabled local communities to develop their village areas, led to strong community ownership, and encouraged the local people to take responsibility for safeguarding the structures over the long term.

Labour shortage solved

Using local labour to stabilize the hill slopes also did away with the need to deploy labour gangs at numerous sites along the project corridor. This was especially important in Mizoram as mobilizing labour from outside the state was difficult.

Carbon emissions reduced

An indirect benefit was that the carbon emissions associated with cement concrete construction were significantly reduced. The plants used for the bio-protection works will also help absorb more carbon.

The hillsides remained productive and communities were able to resume their traditional cultivation practices

Spreading the Innovation

Building on the successful experience gained from this project, the World Bank team introduced the concept of bioengineering in the Himachal Pradesh State Roads Project as a fundamental part of the project's environmental management plan.

Based on the experience gained in Mizoram, as well as the technical specifications and training materials prepared for the Mizoram project, a comprehensive manual was prepared. This detailed about 12 to 14 bioengineering techniques as well as the various types of grasses, shrubs and trees that can be used in Himachal Pradesh depending on the temperature, rainfall, altitude, and soil conditions prevailing at different locations in the state. The Himachal Pradesh PWD as well as the state's Road and Infrastructure Development Corporation have now incorporated these practices into their regular operations.

By using local labor, substantial short-term employment was generated for the residents of about 20 villages

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