

VI. Conclusion

China has suffered more fatalities from landslides than any other nation in the world. More than 150 people per year have been killed by landslides in China over the past 36 years. In the mountain areas especially, the impacts of landslides on development are great and are apparently growing. They destroy or damage residential and industrial developments, agricultural and forest land, and railways, and have caused at least \$ 0.5 billion (U.S.) in economic losses annually during the period from 1951 to 1987.

Earthquakes and rainstorms constitute two of the most important landslide-inducing agents. It is well recognized that a significant number of landslides occurs only when earthquake magnitudes are greater than 6.0. The two most seismically active regions are the Hengduan Mountain Area of Southwestern China and the Loess Plateau of Northern China where thousands of earthquakes have been recorded. Earthquakes trigger many large-scale rockslides or loess slides in the two regions; some of these block rivers and form lakes. Apart from the characteristics of the earthquakes themselves, environmental factors, such as geology, landform, and drainage, play an important role in the formation of landslides induced by earthquakes. In addition, the information on rainstorms shows :

- that if cumulative precipitation amounts to from 50mm to 100mm in one to two days and daily precipitation to about 50mm, somewhat small-scale and shallow landslides of debris and loess will occur;
- that when the cumulative precipitation within two days amounts to from 150mm to 200mm, and daily precipitation to about 100mm, the number of medium-scale landslides of debris and loess and fractured rocks has a tendency to increase with precipitation; and
- that when cumulative precipitation exceeds 250mm within two days, and has an average intensity of more than 8mm per hour in one day, the number of large and vast landslides of debris and bedrock increases abruptly.

Management of landslides is an integral part of environmental conservation and development activities in mountain areas. The methods for reducing the impact of landslide disasters in China have been summarized in the text. Considerable progress has been made during the past 40 years, especially in respect to:

- regional landslide studies and mapping and
- stabilization of landslides

Significant advances have been made especially in respect to regional landslide studies during the last ten years. Examples of the regional landslide programmes in China are shown in Table 14. Landslide susceptibility and risk maps are generally more useful for planners and decision makers than other landslide maps.

New and improved methods have been developed to monitor areas affected by landslides. The landslide monitoring systems at Xitan, Hubei Province, and the warning systems at Jianghia Ravine, Dongchuan, Yunnan Province are good examples. The main requirements for monitoring devices are that they should be simple, rugged, and inexpensive.

Advances have also been made in stabilization techniques. The effectiveness of different stabilization methods depends on understanding the driving mechanism of a landslide. A number of different stabilization methods can often be used for shallow slides and deep-seated slides, but the deep-seated counterfort drain is the main measure used to treat medium and small-scale landslides. In recent years, driven piles with large rectangular sections have been used extensively to control landslides. This involves the use of large volumes of rocks because of their capacity to resist landslides, the low amount of masonry needed, and the fact that they are easily constructed manually. The best and most common methods of landslide control in watershed areas are the reforestation of slopes and the construction of check dams in the valleys.

In China, although a great deal of effort has been expended in landslide mitigation since the 1960s, losses from landslides are increasing. This is largely due to residential and industrial developments that have expanded on to steeply sloping terrain which is most prone to landslides and partly due to the unusually heavy rainfall that has occurred in recent years. As development processes and interventions continue and even accelerate mountain environments will be further subjected to landslide hazards.

Despite the improvement in landslide management systems and the progress made in techniques for reducing the costs and damages brought about by landslides, the problem is far from solved. It will take years of sustained work to achieve a dramatic reduction in landslide disasters in such a vast country. The following landslide hazard management programmes are deemed necessary in order to effectively meet the need for reducing losses from landslide disasters.

- Identification of landslide hazard areas; compilation of landslide inventories and landslide mapping.
- Rehabilitation of lands subjected to landslides and development of regulations controlling unstable terrain.
- Specific standards of design and construction of physical control measures in the public and private sectors.
- Formulating land-use regulations in hazardous mountain areas.
- Strong support from research in the context of the mechanics of the landslide process, transport and deposition, mitigation measures, and warning systems.
- Provision of a central clearing-house for collection and distribution of publications and guidelines to professionals, agencies, and local governments.
- Development of a national landslide-loss reduction programme and the identification of a central organization for management of the programme.