C. GROUND-FAILURE HAZARD

MOUNTAIN RISK ENGINEERING FOR LINEAR INFRASTRUCTURES

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A simple and systematic technique for hazard and risk assessment at the prefeasibility and feasibility stage of an infrastructural project, such as roads and canals in the mountain terrain, is a first step toward engineering for mitigation of natural hazards influencing the road or canal. Roads in the mountainous region of Nepal have indicated that traditional engineering in planning and design of roads result in (i) either very expensive rehabilitations from frequent failure, or (ii) massive environmental deterioration from indiscriminate slide clearance, hill cutting, and spoils disposal due to cost and time constraints. Mountain Risk Engineering concepts and methods developed and applied so far have been presented with examples in Nepal.

CURRENT METHODS OF SLOPE PROTECTION IN TAIWAN*

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Taiwan has more than 75% of its land occupied by mountains, hilly lands, and lateritic terraces. Landslides, debris flows, and erosion of slope surfaces have long been the most frequent natural hazard in Taiwan.

Traditional methods of slope protection, such as reinforced-concrete retaining walls, earth anchors, gabion walls, drainage systems, etc., remain popular in engineering circle. However, the high costs and environmental conflicts involved in use of these methods have caused concern and opposition from the general public and environmental-protection agencies.

Since 1983, the National Science Council has sponsored research projects on landslides. Emphasis is partly given to developing methods of slope protection which are not only effective and economical, but also are in harmony with the environment. Vegetation, reinforced earth with geotextiles, surface treatments, soil improvements, and hybrid methods have been developed. Some full-size experimental slopes have been constructed in the field to demonstrate the superiority of the methods developed.

* Theme Paper

MITIGATION OF GROUND FAILURES IN THIRD WORLD COUNTRIES WITH SPECIAL REFERENCE TO INDIA

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In view of the population explosion in the third world countries and in the name of development, the hazard prone areas will continue to be inhabited leading to a heavy loss of life during a disaster. It appears appropriate to embark upon a mitigation programme to reduce damage to public utilities and loss of human life. The disaster under examination is ground failure. Various forms of ground failures are classified and a link between environment degradation and ground failures is established. The Indian scenario on environment degradation, possible solution strategies and hurdles are described. A general mitigation programme against mass ground movement is outlined. Finally, cost-effective structural systems are described to minimize environmental damage and to discourage further mass ground movement.

THE SUSCEPTIBILITY TO LANDSLIDING IN THE ENREKANG AREA, SOUTH SULAWESI, INDONESIA

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In order to mitigate the impact of landslide hazards it is important to determine its potential for sliding and to present the results into a map of the area.

A method for recognizing the potential of susceptibility has been introduced by the CTA-108 in Bandung. This scheme is based on factors and parameters of geology and especially lithology, slope inclination and landslide evidences, and other factors, such as rainfall, land use and seismicity.

Based on the parameters and the safety factor of the soil, the Enrekang area can be divided into four landslide susceptibility zones: very low landslide susceptible zone, low landslide susceptible zone, moderate landslide susceptible zone, and high landslide susceptible zone.

The critical angles of the soil of various rocks are: 16° for shale, 34° for conglomerate, 35° for sandstone, 42° for metamorphic rock and 44° for breccia.

RETENTION SYSTEMS FOR SLOPE STABILIZATION: ENGINEERING INNOVATIONS IN THE UNITED STATES*

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This paper reviews stabilization of rock and soil slopes in the United States utilizing innovative earth retention systems. New computerized approaches are being used in design of rock nets, fences, walls, benches, attenuators, and ditches for rockfall control. Placed and in-situ internal reinforcement systems are used to stabilize soil slopes and embankments. New and waste materials are being used as lightweight backfills in slope-failure repair.

* Theme Paper

MONITORING OF BENDOWULUH LANDSLIDE IN BANJARNEGARA REGENCY, JAWA TENGAH

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The Bendowuluh landslide is one of the landslide-prone areas in Banjarnegara Regency, Jawa Tengah, Indonesia. The landslide covers an area about 480,000 m^2, 800 m long and 600 m wide. The crown of the landslide is located at the western slope of Pawinihan Mt. and the toe is situated at the Simpar River.

The landslide area is built up by rocks of the Merawu Series, which are overlain by quarternary volcanic rocks. The Merawu Series consists of calcareous and marly claystones, and the volcanic rocks are made up of lavas, breccias, and lahar deposits.

Since 1989, the Bendowuluh landslide has been monitored using eight monitoring points which are measured from fixed points at Lumbung Mt. The result of measurements in 1991 shows that the landslide has moved the rocks horizontally as well as vertically. The horizontal movements range from 0.02 m to 0.60 m to the southwest, and the vertical movements vary from -0.17 m and -1.41 m.

In order to study the movement of the landslide, eight new points were added, and fixed points at the Bondan Mts. were established in 1991.

LANDSLIDE POTENTIAL OF THE HALANG FORMATION IN THE WALED AREA, CIREBON REGENCY, WEST JAVA, INDONESIA

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The constituent rocks of the Halang Formation (Tmh) generally consist of turbiditic deposits with clear sedimentary structures. The upper part consists of claystone and marl, the middle part is built up by coarse limy sandstones, and the lower part consists of conglomeratic limestones.

Landslides in the Halang Formation include debris slides and creep of 25 m to 45 m width in an investigated area about 50 km^2. These landslides occur especially along the boundary with volcanic rocks, frequently forming an elongated landslide scarp reaching a scarp height of 25 m to 75 m.

Landslides frequently occur in clayey soils which originate from the weathering of claystones. These soils have characteristic properties such as swelling and are sticky and crumbly when wet.

Tests on dry samples in the Soil Mechanics Laboratory yielded an average effective cohesion of c_{dry} = 0.05 g/cm^2, a dry unit weight, (γ_d) = 1.58 ton/m^3; and an angle of effective internal friction (ϕ) = 21.63°. The safety factor (SF = 1.2) gave the critical angle value of slope in this area at 20°.

The Halang Formation is widely distributed in the southwestern part of the Waled Sub District, so that this area is considered to be highly potential in landslides.

PREDICTION AND MAPPING OF LANDSLIDE HAZARDS

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The paper outlines a methodology for prediction and mapping of landslide hazard in shallow soils on hillside slopes. The principal steps are estimation of infiltration and groundwater response, estimation of failure probability, mapping and updating with results of landslide inventory.

D. VOLCANO HAZARD

THE VOLCANIC HAZARDS OF HYDROTHERMAL AREAS IN INDONESIA, AND MITIGATION EFFORTS

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In Indonesia there are 21 fumarolic and solphataric fields related to the geothermal systems of active volcanoes. The disturbance of such hydrothermal systems, e.g., by triggering tectonic activity, may result in phreatic eruptions or gas emissions. Occurrences of disastrous phreatic or gas emission events in historic time e.g. Mt. Papandayan (West Java, 1772), Suoh Antatai (Lampung, 1933), Dieng Plateau (Central Java, 1928, 1939, 1944, 1964, and 1979) and Mt. Gamalama (North Maluku, 1775). Hazards related to such events include primary lahars, phreatic surges, tephra fall and release of poisonous gases.

Some fumarolic fields have been developed for hydrothermal power, e.g., Kawah Kamojang and Mt. Salak (West Java), Lahendong (North Sulawesi), and Dieng Plateau (Central Java). However, these areas are still dangerous. Integrated investigations, e.g., hazard mapping and zonation, monitoring, and risk assessment are needed to reduce risk. Such investigations include geologic, geothermal and volcanological mapping, geochemical and geophysical (including microseismic method), and tectonic analysis, with the aim to identify hazard-prone areas caused by increasing hydrothermal activity.

VOLCANOES AND THEIR VOLCANIC HAZARD MAP PREPARATIONS

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Indonesia is known to have many volcanoes that have been active since 1.8 million years ago (Quaternary in age). Until recently, only 128 volcanoes were considered to be active, but the total number of active volcanoes was increased to 129 after Anak Ranakah Volcano erupted in 1987. The youngest rock of pre-1987 eruption was dated in 14,570 + 320 years BP. In the Philippines, Pinatubo Volcano erupted in 1991 after over 600 years' dormancy. These two volcanoes are not listed in the available Catalogue of Active Volcanoes in the World. In addition, other destructive eruptions such as Mt. St. Helens (1980) and Unzen Volcano (1990-1991) have occurred after very long repose times (more than 200 years). These suggest that it is necessary to inventory not only volcanoes having recorded historical eruptions and volcanic manifestations but also all Quaternary volcanoes.

Volcanic eruptions vary in magnitude from small (e.g. Slamet, Semeru and Gamalama Volcanoes) through moderate (Mt. St. Helens, Pinatubo Volcano) to large scales (Tambora in 1815 and Krakatau in 1883). So far, we cannot predict whether a volcanic activity will produce small, moderate or big eruptions. In the mean time, available volcanic hazard maps in Indonesia are only for overcoming small scale volcanic eruptions, in which the danger zone covers an area less than 20 km in diameter. The 1991 Pinatubo eruptions affected areas about 50 km in diameter, and, damaged areas caused by the 1883 Krakatau eruption reached over 100 km in diameter. These suggest that volcanic hazard maps for moderate and large scale eruptions must be provided besides those for the small eruptions.

Damage from volcanic eruptions occur not only on the ground but also in the air. The Galunggung eruptions in 1982 forced Boeing 747 Jumbo Jets of the British Airways (BA09) and Singapore Airlines (SQ21A) to make emergency landings at Jakarta International Airport. Another Boeing 747 (KLM 747-400 aircraft) entered a cloud of volcanic ash from Redoubt Volcano, Alaska, in 1989. Although the aircraft landed successfully, extensive and costly repairs were required. Recently, the Pinatubo eruptions affected 14 big airplanes and caused the temporary closure of Manila International Airport. These incidents suggest that preparations of volcanic hazard maps for aviation safety are necessary.

In addition, submarine volcanic eruptions might threaten sea transportation. Further detailed studies are needed in order to prepare volcanic hazard maps of the volcanoes.

THE POTENTIAL HAZARD OF SECTOR COLLAPSE OF ALTERATION FROM MT. ILI LEWOTOLO, NTT

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Some facts show that a sector collapse of volcanic flank is a potential hazard for the people who live in surrounding of a volcano. It can be caused by lack of flank stability of active hydrothermal alteration. The alteration is now clearly shown by eastern peak and flank of Ili Lewotolo and as a weakness area. The volume of alteration materials (blocky lavas and pyroclastic rocks) in a Lewotolo crater is about 400,000 cubic meters. These will becomes a potential hazard if a collapse sector occurs in the future. The collapse can be triggered by an earthquake, a crypto dome activity or a magmatic eruption.

THE 1991 MT. PINATUBO ERUPTIONS: VOLCANIC HAZARDS AND IMPACTS

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The June 1991 Mt. Pinatubo eruptions is considered as one of the biggest eruptions this century by world class standards. Its paroxysmal phase on 15 June 1991 produced an approximate volume of 7-11 cu. kms. of pyroclastic flow deposits and extensive air fall tephra, the thickest portions averaging 50 cms at 2-9 kms from the summit caldera. This caldera, formed during the 15 June 1991 eruption, measures about 1.5 kms and 300 m. deep. It is the site of numerous post-eruption ash ejections, the last on 02 September 1992. After almost a year from its June 1991 eruptions, volcanic activity have been mostly characterized by tectonic adjustments probably due to rocks adjusting within and around the vacuum caused by the removal of a big volume of magma beneath the volcano. However, equally threatening hazards are present and are still expected:

a. Lahars. During the 1991 rainy season, about 10-15% of pyroclastic flow deposits and most of the thick tephra fall deposits were washed down as lahars. Drainage systems where these flows occurred were: O'Donnell-Tarlac, Sacobia-Bamban, Abacan, Pasig-Potrero, Porac, Gumain, Marella-Sto. Tomas, Maloma, and the highly complex Bucau-Maraunot-Balin-Baquero river systems. Flows may have a highly erosive to channel-filling character while in the distal ends, may silt up or flood low lying areas. Our estimate is that the threat from lahars will continue until about 40% of the pyroclastic flow deposits have been washed out by annual precipitations. Worst-case scenario maps were prepared and distributed which delineated pyroclastic flow sources, areas already affected and/or buried and areas which will continue to be affected or at risk within the next several years.

b. Secondary Explosions. Temperatures of the very thick (maximum of 220 kms) pyroclastic flow deposits are expected to cool down within four to five years time. These deposits, when rained upon, caused secondary explosions whose heights could be as high as 10 kms and could cause light to heavy ashfall in nearby areas.

c. Volcano-tectonic Quakes. Tectonic adjustments are still occurring. Epicentral locations are along several areas around the volcano with maximum depths of 15 kms. Magnitudes vary from less than 1 to 4. The bigger and shallow ones are usually felt over a limited area.

d. Secondary Pyroclastic Flows. At least three significant secondary pyroclastic flows have been documented. These are when previously deposited pyroclastic flow deposits are remobilized by rainwater seeping into and generating the sliding block, occurrence of local and moderate magnitude earthquakes, or a combination of the two.

VOLCANIC HAZARD MITIGATION IN INDONESIA*

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Volcanic hazard mitigation program in Indonesia constitutes volcanic monitoring, hazard map preparation, public education, engineering construction and public awareness. In the last 200 years, 175 thousand people were killed by volcanic eruption. The number has significantly decreased due to intensive implementation of the program. Six eruptions that occurred in the last 10 years claimed 38 lives in comparison with 5870 persons killed in the previous eruptions at the same volcanoes.

The advances in volcano monitoring technology haves also been important contributors to the success of the volcanic hazard mitigation program.

* Theme Paper

VOLCANO MONITORING AND ERUPTION PREDICTION: STRATEGY, TECHNIQUES, AND LIMITATIONS*

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The capability to monitor volcanoes and to warn of impending eruptions has improved over the years. This paper presents a critical appraisal of the state-of-the-art. The most useful monitoring tool is seismic monitoring, the determination of earthquakes per unit time, their energy release, and source characteristics. Deformation monitoring has proven useful at some volcanoes, and gas monitoring has been conducted with variable success. Field observations must not be omitted. From these data, predictions are traditionally developed by pattern recognition, augmented by interpretation of evolving processes. Where data values accelerate prior to eruptions, the "materials science method" may be helpful. However, volcanoes are such extremely complex systems that with all techniques, warning of impending eruptions is difficult and not necessarily reliable, even under optimal circumstances.

* Theme Paper

E. EXTREME-WIND HAZARD

COMPUTATIONAL METHODS FOR ESTIMATING EXTREME WIND SPEEDS

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In order to provide a better method of estimating extreme winds at an ungaged site, computational methods of estimating 50-year or 100-year extreme winds from short-term data collected at various weather stations in a large region are being developed. In the current state-of-the-art, there are four approaches for estimating extreme wind speeds from short-term records. The first approach is based on the analysis of the largest monthly wind speeds of at least three years' data. The second approach is the determination of extreme wind speeds from a parent distribution. The third and fourth approaches are simulation models based on short-term continuous hourly wind speed records. Application of the methods will be presented.

DETERMINATION OF WIND EFFECTS ON AND AROUND TALL BUILDINGS

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In this paper, an aeroelastic model which simulates the shear flexure mode using distributed mass and stiffness is described In order to obtain the distribution of loads along the height of the building, an experimental technique is presented herein where the fluctuating pressures from the aeroelastic model are sampled simultaneously from two tappings at a time. The measured data are later converted into the frequency domain in the form of auto and cross power spectral densities for the computation of modal forces. From which, the acceleration at any height and hence the variation of shear and moments along the height of the building are determined.

RELIABILITY-BASED WIND-RESISTANT DESIGN OF TRANSMISSION TOWERS

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This study is intended to develop probability-based design wind loads as well as reliability-based LRFD criteria for transmission towers based on the investigation of the safety levels of various types of towers designed by the current design practice in Korea. In the study, the AFOSM reliability method and an Importance Sampling Technique are

used for the element and system reliability evaluation of actual transmission towers subjected to weather-related loadings. Based on the selected target reliabilities, a set of load and resistance factors for the LRFD criteria are calibrated using the AFOSM and the code optimization technique.

NEW TECHNOLOGY APPLICATIONS FOR IMPROVED SEVERE STORM WARNINGS

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We shall treat some of the current and future technologies in weather forecasting, especially as related to extreme winds and floods. The importance of accurate forecasting and the warnings issued for mitigating damage and fatalities from these two natural hazards have often been underestimated. In the United States, flash floods account for more deaths and damage on an average yearly basis than any other natural hazard, including tornadoes and hurricanes. The National Weather Service during the decade of the 1990's has begun an ambitious Modernization and Associated Restructuring Program. The cornerstone of this program is the field deployment, now underway, of some advanced technological tools that will permit increased staff productivity and more accurate and timely forecasts and warnings. These new technologies include the Next Generation Radar (NEXRAD, WSR-88D Doppler), wind Profilers, Automated Surface Observing Systems (ASOS), and an interactive processing and display system, AWIPS-90. The capabilities and limitations of each of these systems are assessed, along with examples of actual data sets from recent windstorms and flood events. Planned future enhancements to these observing systems will also be described. Some specific potential applications to the improved tracking and warnings of typhoons and flash floods will be described. The importance of establishing "ground truth" networks of automated sensors, especially anemometers and rain gauges, along with trained storm spotters will be highlighted from recent experiences in the U.S. and elsewhere.

STRONG WIND DAMAGE TO HOUSES IN YANAGAWA CITY BY TYPHOON 9119

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Typhoon 9119 struck the northwest area of Kyushu Island, Japan, during the afternoon of September 27, 1991. Significant damage occurred throughout the city of Yanagawa due to strong wind. Time-variations of damage to roofs were investigated using video camera records. The primary weakness of tile or sheet-metal roofing designs was clarified. It is estimated that the velocity of the maximum peak gust was at least 40 m/s at 6 m above ground level at the height of the eave of houses.

HOLISM, EUROCODES AND NATURAL HAZARDS IN THE PACIFIC RIM*

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This paper discusses the risk of damage to housing throughout the Pacific area, from the passage of cyclones and typhoons. Construction techniques throughout the area are considered and the experiences of different communities are highlighted. The appearance of changes to the traditional paths of cyclones has severe implications for regions not traditionally associated with cyclone activity. Interestingly, the communities most at risk appear to be located in richer countries.

* Theme Paper

NEEDS FOR DISASTER MITIGATION RELATED TO NON-ENGINEERED AND PARTIALLY ENGINEERED BUILDINGS SUBJECTED TO WIND STORMS

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Coastal zones of many countries, namely Australia, Bangladesh, China, Hong Kong, India, Philippines and U.S.A., frequently experience severe cyclones apart from high velocity inland storms. Cyclones are generally followed by heavy rain and storm surge resulting in loss of lives, crops, animals and severe damage to structures specially dwellings leaving thousands homeless. In most of the wind storms, the damage to non-engineered or marginally engineered buildings is considerably larger compared to engineered buildings. This is partly because scant attention is paid to details in case of the non-engineered buildings and partly due to the lack of comprehension and application of information available regarding wind effects on structures. Today there is great awareness for the need to mitigate disasters due to hazards including wind storms. The prime need is to coordinate the efforts being made to study the influence of storms on structures in wind tunnels as well as through post-disaster surveys in the field, innovations in design ideas and the technology being followed at the "grass roots" level. The relief and rehabilitation work needed will reduce sharply, if disaster preventive measures are taken up in earnest. The present paper puts together some ideas on the developmental and training needs required for reducing wind disasters.

ON THE QUESTION OF THE ROLE OF BUILDING CODES AND STANDARDS IN MITIGATING DAMAGE DUE TO HIGH WINDS*

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Although our basic understanding of the nature of wind and its effects on buildings and structures has improved dramatically during the past three decades, the translation of this knowledge into codes of practice continues to present a formidable task. The after-

maths following the passage of recent hurricanes in the United States have served as reminders that we are not doing enough to address the wind threat. Wind damage in the U.S. on an annual basis now exceeds that induced by all other natural hazards.

Following each major wind event, the following statement is frequently heard:

"The wind climate was predictable and most of the damage was preventable."

What then, are we doing wrong? The answer is not a simple one, but is rooted in the complex manner in which building codes are promulgated, adopted and enforced. The issue of affordability vs. risk is always centerstage and the political/economic systems in place in some jurisdictions in the U.S. do not always permit the adoption of proper strategies for mitigating damage.

The objectives of this paper are to:

- review current practices in the United States with regard to the wind threat,
- discuss the adequacy of wind load provisions currently in place to mitigate damage, and
- suggest what new measures should be adopted to reduce wind damage to acceptable levels while at the same time safeguarding the economy.

* Theme Paper

INTEGRATED APPROACH AGAINST CYCLONIC WIND HAZARD AND ROLE OF VOLUNTARY AGENCIES

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The natural disasters in India are mainly caused by earthquakes, floods and severe winds. In India the damage caused by tropical storms is very high as compared with tornadoes, local storms and thunder storms. An integrated approach is directed against the hazards caused by cyclonic winds. The cyclones on the eastern coast of India occur in the months of April and May, and between October and December. The cyclones that originate in the Bay of Bengal affect the coastal belts of Tamilnadu, Andhra Pradesh, Orissa and West Bengal, whereas, those originating in the Arabian Sea affect Konkan and Saurashtra coast. The cyclones on east coast are amongst the most destructive of all the natural disasters. These cause destruction to man-made structures meant for housing and shelters. It is not feasible to economically design the housing and community structures that are fully resistant to cyclones and therefore safe against loss of life and damage to material assets. There are three categories of structures, (a) storage structures for safe storage of household goods, (b) community structures and shelters for livestock and local population and (c) large span shopping and distribution complexes away from the cyclone affected areas. The structures belonging to the categories (b) and (c) may be designed to safely resist the cyclones. Such a system with a proper warning system may result in practically fully safe against loss of life and damage to material assets. It is therefore equally important, if not more, to mobilize assistance from voluntary agencies alongside the affected population and the government agencies for mitigating the hazards. The other measures may include (a) dykes and sea walls and (b) shelter belts and land use zoning. The paper discusses an integrated approach for cyclone disaster.

ENGINEERING OF STRUCTURES FOR WIND HAZARD REDUCTION

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Every year a large number of buildings, industrial structures, and houses ranging from well-engineered type to non-engineered type, are severely damaged by tropical cyclones in many parts of the world. Mitigation of the effects of cyclone disaster is a problem of international importance. Assessment of wind loads due to cyclones and prediction of structural response of different structures subjected to such wind forces are highly complex to be dealt with using theoretical models alone. The present level of understanding of characteristics of cyclonic winds and causes of damage to houses, buildings, towers and other wind-sensitive structures is far from satisfactory. Post-disaster field surveys on structural damage provide invaluable information that will help in understanding the modes of failure of structures and in developing cyclone-resistant designs. The paper deals with the details of the post-disaster surveys and assessment of structural damage caused by the two recent severe cyclones which hit Kavali and Guntur regions of Andhra Pradesh in India. Based on the observations of typical modes of failures of structures, and assessment of causes of such failures, methodologies for improvement of designs of structures are discussed. Emphasis is also laid on training to be imparted to design and field engineers with a view to achieving transfer of R&D results to reduce cyclone hazard to structures.