Case Histories of Slopes, Dams, and Embankments. Paper No. GR-II

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INTRODUCTION

There were 28 papers available for the general reporter and co-reporter's review in Session II. Case histories in 12 countries were presented in these papers, as shown in Figure 1.

The papers for Session II can be broken down into general topic areas and subtopics, as listed in the table on the next page. The number of papers classified in each subtopic, based on their main themes, is shown in parentheses.

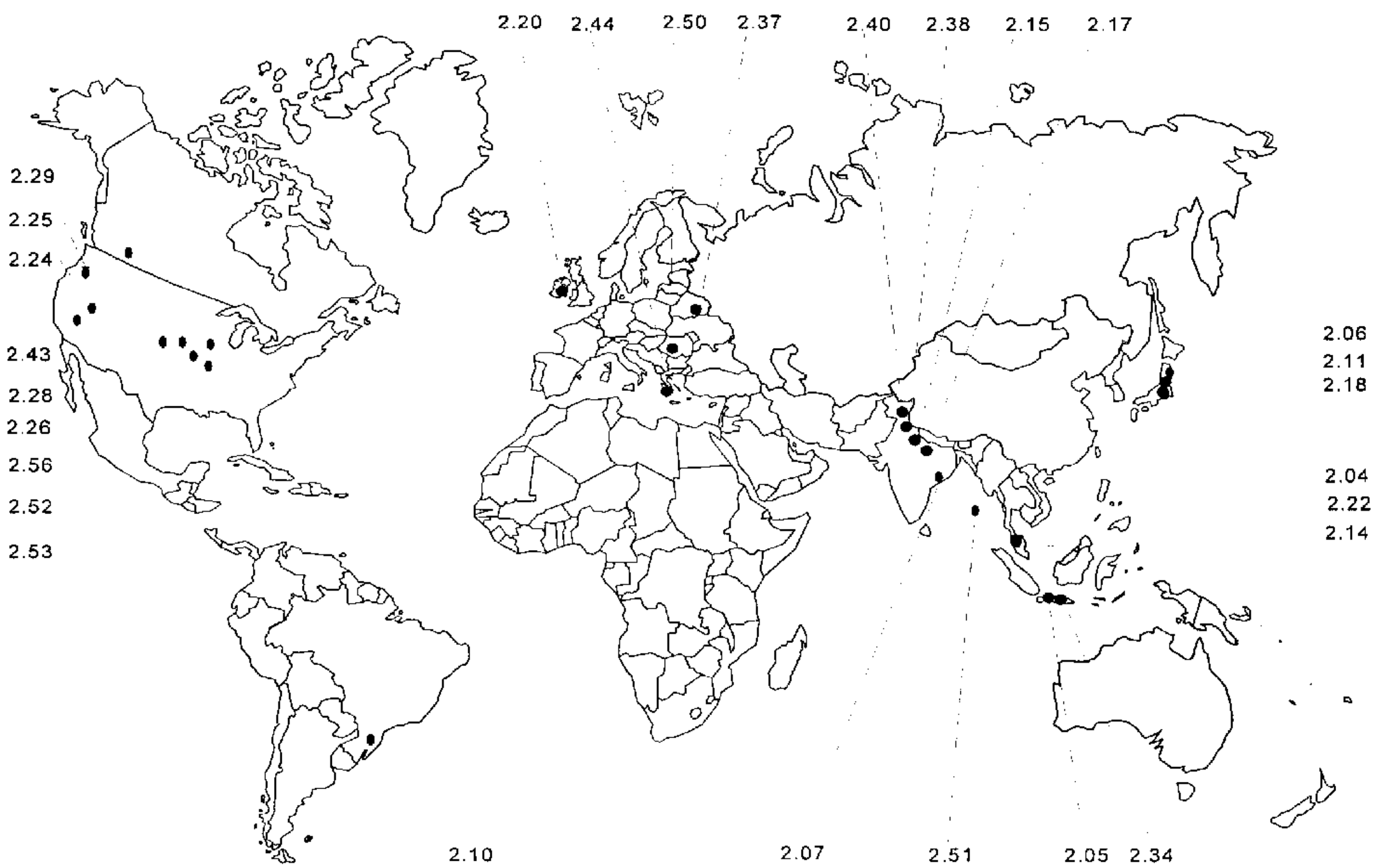

Fig. 1 Case History Approximate Location

1. LANDSLIDES / CUT SLOPES (13)
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LANDSLIDES / CUT SLOPES

Landslide Mechanism

Four papers (2.15, 2.17, 2.38, and 2.40) deal with natural and cut slope stability in weathered rock of the Himalaya region. Three of them have been classified under this subtopic.

Paper 2.15, "Major Landslides in Sikkim - Analysis, Correction and Protective Measures: A Case Study" by *Gupta* and *Tolia*, presents two major landslides which considerably affected important highways. The landslides were triggered by high and steep cuts in inmature geological settings, severe erosion of the slope toes during flash floods, deforestation, or faulty subsurface and surface drainage conditions associated with heavy rains. A carefully designed and properly lined drainage system proved to be the most effective measure in preventing or stabilizing a landslide. The efficiency of various remedial measures is discussed and the importance of implementing all necessary measures at the same time is emphasized. Periodical maintenance of protective works subsequent to their implementation is also needed in order to ensure better performance of such corrective works.

Paper 2.38, "Case Study on Landslide Investigations in Himalayas" by *Singh* and *Bhagwan*, discusses the mechanism of two typical landslides affecting roads on steep hillsides. The remedial measures consisted mainly in surface drainage and prevention of erosion at the toe. However, the slopes are so steep that the debris slope material is unstable even in dry condition, in spite of the relatively high angle of internal friction of the order of 40 degrees or higher. It is, therefore, the reporters' opinion that only costly measures changing the slope geometry may prevent future troubles.

Paper 2.40, "Instrumentation, Monitoring, and Analysis of a Landslide - A Case Study" by *Kumar* and *Panigrahi*, presents some results of a research program performed by the Central Road Research Institute of India on instrumentation and monitoring of landslides. According to the authors' statement "in the hilly terrain of Himalaya there is almost no day in snow melting and rainy seasons of the year without occurrence of either a new landslide or reactivation of an old one". This condition requires quick investigations and recommendation of suitable remedial measures in a timely manner. The selected typical landslide, a reactivated portion of an old slide that occurred some hundred years ago, was instrumented with surface monuments, piezometers, and inclinometer casings. The sliding surface was found to be at shallow depth, at the contact of debris material with underlying weathered rock. Recommended remedial measures consist of surface drainage, low cost retaining walls, sealing of tension cracks, and erosion control. Typical drawings of remedial measures would be welcome during discussions that follow and the reporters hope that discussions generated by such a presentation will improve our knowledge on economical actions for stabilizing shallow landslides on steep slopes.

Paper 2.53, "Landslides on Shale in Southern Illinois" by *Berry* and *Cooling*, describes the sliding mechanism of two different landslides. No. 1 occurred along a highway cut at the soil/rock contact, as determined with inclinometer measurements. It was efficiently stabilized by drainage. Other more expensive measures, with drilled piles or "Insert walls", were designed but not applied, waiting first for observations on the drainage efficiency. No. 2 was a complex slide in the dike forming a pond: an upper slide, through loose bottom-ash backfill in the foundation of an addition to the dike, and a deeper one, less evident but detected with inclinometers. What No. 1 and deeper No. 2 slides had in common was the back-calculated angle of internal friction of 15 to 17 degrees, that corresponded to the residual friction angle of the weathered shale. An important lesson was learned: when slickensided clay shales are detected, the stability calculations should consider the mobilization of the residual strength. It is the reporters' opinion that of major interest would be the determination of the direction of the slickensides and to consider the residual strength in calculation only along sliding surfaces having the same orientation as the slickensides. Assuming residual strength for any orientation of the potential failure surface may be a too conservative and costly assumption in the case of relatively thick glacial deposits. The use of residual strength in the presented case histories is well justified and the paper conclusions should be considered in similar cases.

Paper 2.10, "A Slope Instability Case History Involving Swelling Clay in Southern Brazil" by *Bressani, Bica, Gehling,* and *Bianchini*, describes the investigation of two failed slope cuts. Relatively steep slopes (about 40^0) were built, based on the apparent high strength of the material in the slope. However, soon after completion the slopes failed. The investigation and back-calculations showed that the soil strength dropped to its residual value, probably due to deformations associated to cycles of wetting/drying near the surface and swelling upon unloading.

A progressive failure was also determined, with decrease of shear strength after the initial failure. This phenomenon was modeled in laboratory through large-displacement direct shear and ring shear tests. It is unfortunate that the authors did not discuss possible remedial measures, probably because of space restrictions.

Slope Stabilization

Paper 2.17, "Use of Geofabrics for Controlling Landslides - Case Histories" by *Mukherjee* and *Kumar*, presents a method of stabilization of areas affected by landslides in the Himalayan region of India. A synthetic geogrid mantle is anchored in rock and becomes very effective in both catching falling rocks and promoting natural growth of vegetation, which ultimately improves stability. Other concurrent measures may be needed on a case-by-case basis, such as: slope regrading, plantation starting from the uphill end to the downhill end, or check wall construction. Perhaps the authors should say something about the long term durability of the geotextile, particularly when left exposed to sunlight and other weathering factors.

Paper 2.28, "Pile Design Procedure for Stabilizing Channel Slopes" by *Bateman* and *Walberg*, presents the case history of an unstable river bank that had to be stabilized with minor changes in geometry, because of limited right-of-way. The use of steel H-piles was found necessary. The design procedure, which included back-calculation of soil strength parameters and conjunctly application of both the concepts of limit equilibrium for slope failure and of laterally loaded pile capacity in terms of P-Y curves, is explained in detail. In the analysis two computer programs, a slope stability program (UTEXAS3) and a pile design program (LPILE), were used. Partial validation of the method of analysis was possible based on pile deflection measurements with inclinometers. Although the recommended procedure implies some oversimplified assumptions, the exercise should provide a suitable analysis in similar applications.

Paper 2.44, "Groundwater Conditions and Drainage of a Large Landslide" by *Satiropoulos, Dendrou,* and *Papanikolaou,* describes a landslide that disrupted road and rail traffic between Athens and Thessaloniki, in Greece. Although there was not a history of previous movements, at least in the last 130 years since the start of railway operation, a continuous failure surface in the slide mass was detected. The activation of the landslide followed an excavation at the toe of the slope and a rising of the ground water level. The groundwater conditions were found essential in landslide development and groundwater was determined as the main factor to be controlled for slide stabilization. Various draining systems and their efficiency were investigated using numerical 3D modeling, in order to design an optimum drainage system. The procedures used to evaluate the investigation findings and to justify the proposed remedial measures are impressive.

Paper 2.51, "Arresting the Moving Slopes of Andamans - A Case Study" by *Pal*, presents soil movements that induced damage to structures in Port Blair, Barren Island, India, the stabilization methods applied in the past, and recommends additional measures based on recent investigations. The proposed remedial measures took into consideration economic and practical reasons in addition to technical requirements. As the main cause of instability was found to be the rise of water table during heavy rains, the recommended stabilization measures were mainly directed to improvement of drainage using geosynthetic materials. In addition, bamboo piling and toe erosion control were found necessary in some areas. In analysis, piling was modeled as an increase in soil cohesion.

Paper 2.56, "Remediation of River Des Peres Slope Failure - A Case History" by *Fahoum* and *Jozwiak*, describes an emergency repair for stabilization of an active landslide, that was threatening a street and a high pressure gas line. A steel sheet pile wall installation was started next day after the slide occurrence and completed within two weeks. However, inclinometers showed that relatively large displacement continued to occur and a tieback anchoring system had to be added, as well as a rock buttress. The repair work have been performing satisfactory. Well balanced information on subsurface conditions, instrumentation findings, and remedial measures applied make this contribution noteworthy.

Mapping of Landslides

Paper 2.34, "Natural Slope Failure on Weathered Andesitic Breccia in Samigaluh Area, Indonesia" by *Karnawati*, presents some useful and important comments on the factors that triggered six shallowly located landslides which occurred after some heavy rain events in Central Java. A map of landslide susceptibility of the zone was developed, based mainly on slope inclination and soil type covering the bedrock. However, other important factors were determined to be the type of vegetation covering the soil and the rainfall intensity (per day or per hour). The author considers that soil type and vegetation cover are more important in slope failure triggering than slope inclination, although his "Landslide Susceptibility Map" is based almost entirely on slope inclination and all six observed landslides occurred in zones with steep slopes.

Liability Aspects

Paper 2.50, "Study of Ground Movement in a Mining Area" by *Chirica, Mlenajek, Olteanu,* and *Banciu,* describes the investigation of damages to dwellings believed to be connected to open pit mining and waste disposal activities in the vicinity. Damages to 129 houses were found not related to mining activity, but due to re-activation of old landslides or poor foundation design. The authors do not make clear to the reader what deficiencies provoked the damages to houses. However, the lack of displacements, proved by inclinometers installed around the village where damages occurred, was the main finding of the study and a strong argument against the mining company liability.

Paper 2.52, "The Tale of Two Slides" by *Beck*, presents the case history of an expensive home, recently built, that was damaged by both a shallow and a deep landslides. The owner and the developer looked for defective sewers as the cause of the slide.

However, the investigations that included inclinometer casings and groundwater observation wells, showed that the storm and sanitary sewers were actually victims of the slope movement. It appears that the home owner's geotechnical engineer was liable for damages. The lesson learned was that the conventional exploration is not suitable for special geotechnical conditions and a conservative approach should be taken in developing these sites. The author makes good points saying that "too often construction methods for flat sites are used without modification for steeply sloping sites" and that "local building codes do not require developers to investigate slope conditions for hillside construction". Actually, development on a steep hillside is a high risk business; all parties: the City, engineers, and developers alike must try to address the issue. In some tropical countries like Malaysia, there has been a number of incidents leading to, in some cases, catastrophic collapse of buildings on hill slopes because of landslides due to heavy rain and/or hazardous development in the surrounding areas: e.g. deforestation, or alteration of favorable drainage pattern.

DAMS AND LEVEES

Foundation Treatment

Paper 2.06, "Grouting in Consideration of Predominant Direction of Joints in Rock Masses" by *Kawasaki, Yamaguchi,* and *Yoshida*, advocates the usefulness of considering the predominant direction of joints in rock mass in preparation of specifications for grouting in such materials. A grouting test was conducted in the foundation of a dam consisting of rock with steep joints with a predominant direction. Both vertical holes and inclined holes, that potentially cross more joints for the same length, were separately applied. The conclusion of the study was that grouting using inclined holes may, in some cases, be more efficient and/or economical than grouting with vertical holes. The authors admit, however, that some problems generated by the use of inclined holes may overwhelm the advantages. Although generalization of the test results is not appropriate and quantification is not possible, the presented aspects should be given consideration.

Paper 2.07, "Geotechnical Problems and Treatment of Weathered Rock Seams Occurring in the Foundation of Karjan Dam, Western India" by *Prakash* and *Vyas*, presents design modifications generated by detection during construction stage investigations of weathered rock seams with low strength and high permeability. To prevent sliding, concrete shear keys were provided in the foundation, in addition to modification of dam design to provide a wider base. Curtain grouting was performed to depths of 42 to 60 meters to reduce seepage. The initial grouting had to be supplemented by additional grouting during partial filling of the reservoir to seal remaining permeable gaps in the grout curtain. It is a possibility that the conspicuous seepage observed during excavation is due to the additional path ways created by the grouting itself, as it may happen when the specified criteria in terms of groutability could not be maitained. Although the weathered seams were up to 2 meters thick, no settlement problems arose. This case history is a good example of how the original dam design can be altered after the foundation rock had been uncovered and prepared for construction. The paper contains excellent geotechnical information and a solution to the problem.

Paper 2.18, "A Study on Prediction of Improvement of Watertightness of Rock Mass by Grouting" by *Nagayama, Ota, Niitaka,* and *Yamashita,* presents a proposed method of predicting the improvement of watertightness of foundation rock from the analysis of grouting data. This method was developed based on data acquired during curtain grouting the foundation of a 85 m high concrete gravity dam. A first finding of the study was that a linear relationship exists between cement take and permeability (described by the Lugeon value) in a double logarithmic plot. Different relationships correspond to various stages of grouting. Secondly, two prediction procedures were developed: one based on permeability determined before a given stage of grouting and another one based on cement take within that stage. Through extrapolation, the limit of possible improvement of watertightness can be estimated. It is the reporters' opinion that the recommended procedure has direct application into practice. Although the relationship parameters should be case specific, the proposed methodology can be efficiently used in similar cases, with adequate calibration.

Paper 2.25, "Safety of Dams Modifications of Ochoco Dam, Crooked River Project, Oregon" by *Carter* and *Link*, describes a very interesting history of a Bureau of Reclamation dam, originally built in 1920 as a hydraulic fill structure, that experienced numerous safety problems. Successive modifications along the years prevented development of potential critical conditions, in particular due to internal erosion. The insufficient original instrumentation was corrected and efficient monitoring became possible. A recent sudden rise in piezometric level signaled formation of a dangereous sinkhole and prompted forensic investigations and repair measures. The duration scheduled for presentation of this general report, as well as space restrictions in publication of the paper, did not allow the writers to present in detail many interesting aspects. A presentation of highlights of this case history during discussions would be welcome.

Construction Monitoring

Paper 2.05, "Lessons Learned From the Analysis of a Wet Core Dam" by *Kerkes*, presents the case history of a zoned earth and rock fill dam 400 feet (120 m) in height that was constructed in an equatorial climate using the wet core method of construction. The core zone was constructed of residual soil containing mostly hydrated halloysite in the clay fraction and with a natural moisture content about 10% above the Standard Proctor optimum value. The theoretically predicted pore pressure was in good agreement with field measured data when mean value minus two standard deviations was assumed in calculation; the use of this value is not justified or referenced by the author. In "Conclusions" the author states that a finite element analysis did not yield a better estimate of the stresses in the embankment than an elastic solution, but he does not provide details on the assumed boundary drainage conditions, which are essential in proper finite element modeling. Except for these few comments, the paper appears to be an excellent exercise for the field and contains valuable information for specialists interested in construction of earth structures in regions of excessive humidity. During discussions, we would like to hear how the concern of core cracking and the potential for subsequent hydraulic fracturing was addressed, based on construction monitoring data. This aspect was mentioned by the author, but no detail was given, probably because of limitations of space. The author summarizes observations and lessons learned from construction monitoring and provides useful advices about instrumentation types to be used in similar conditions and their distribution in cross section. Details on piezometer types, filter, and drain used in the dam would also be welcome.

Seepage and Internal Erosion Control

Paper 2.11, "Survey of Seepage Through Heightened Earthfill Dam With High-Density Electrical Prospecting Method" by *Yamaguchi, Imabayashi, Yoshida,* and *Sakamoto*, presents details of the application of the high-density electrical prospecting to investigate a 2000-year old zoned embankment in view of its rehabilitation and heightening. The electric resistivity survey was found valuable in both investigation of dam zoning and in evaluation of the extent of zones affected by seepage. Of particular interest is the use of an electrical survey in seepage monitoring and, as the electrical resistivity of the soil-water system is measured in this method, chemical characterization of the water (e.g. pH-value) would be of interest for future use of the presented data. Although it probably needs calibration in each particular site, an electrical resistivity survey seems to be an efficient method of prospecting zoned earth structures for which design records are not available, or that are believed affected by internal erosion or other types of deterioration.

Paper 2.20, "The Performance of Turlough Hill Upper Reservoir" by *Long* and *Godden*, describes the case history of a circular soil and rock fill embankment, up to 34 m in height, that was built in 1974 to contain a 2.3 million m^3 reservoir on the top of a mountain in Ireland. Both the reservoir and the embankment were lined with an asphaltic concrete lining. No significant movement and only minor seepage were observed after 23 years of operation. The performance of the asphaltic concrete lining was rated by the authors as excellent. This is a case history of good performance and the authors summarize the measures being adopted to ensure the continued good performance of the reservoir beyond the typical design life of asphaltic concrete lining of 20 to 30 years. The authors' recommendation for the use of asphaltic concrete in reservoir lining is well supported by the monitoring results.

Paper 2.43, "Seismic Evaluation, Soil-Cement Mix Wall and Outlet Pipe Installation, Ivins Bench Dam, Utah" by *Owens*, describes the condition of a dam constructed in the early 1900's, that required repair work to stop internal erosion and to improve seismic stability. A post-earthquake inspection had signalized sand flowing from the dam drainage collection system. A seismic deformation analysis was performed using the program FLAC, capable to simultaneously integrate the effects of real-time pore pressure buildup, shaking-induced deformation and post-earthquake stability. This dynamic and liquefaction analysis lead to the conclusion that a remediation concept using a central soil-cement mix wall would limit displacements to acceptable values. The paper describes the design and construction of the soil-cement wall, as well as replacement of the original outlet pipe for the dam with a new one, penetrating both the embankment and the soil-cement mix wall by microtunneling method. The reporters consider this paper an important contribution to the field of dam rehabilitation. Unfortunately, the amount of information generated by this case history was much too big for a conference paper; therefore, details related to the wall installation process and the horizontal boring for the new outlet would be welcome during our general discussions.

Tailing Dams Evaluation

Paper 2.29, "A Case History of Liquefaction Flow Failures In Mountainous Mine Waste Dumps" by *Gu, Dawson, Morgenstern,* and *Robertson*, presents an excellent study of flowslides in Rocky Mountain coal mine waste dumps, in British Columbia, Canada, based on the concepts of steady state and progressive failure soil mechanics. These end-dumped fills with repose angles of about 38^0 and heights between 100 and 400 meters are evaluated as stable using conventional methods of stability analysis, although several of them already failed under static conditions. The authors, using finite element techniques succeeded to explain the mechanism of failure of a typical flowslide, taking into account the effect of local failure on shear stress distribution. The proposed procedure can be considered a significant contribution in evaluation of long term stability of nearly saturated waste dumps. This paper may generate discussions on strain softening behavior of cohesionless materials and their undrained residual strength.

Paper 2.37, "Procedure for In-Situ Evaluation of Geotechnical Parameters of High Dams" by *Mlynarek, Tschuschke,* and *Wierzbicki*, presents detailed field tests performed at a tailing dam in Poland to determine the geotechnical properties of the hydraulically deposited copper mine waste. The compressibility parameters evaluated with the piezo-cone penetrometer, the dilatometer, and the dilato-cone penetrometer are compared with laboratory consolidometer test results. The paper contains some very interesting and useful information on in-situ testing and its ability to provide a continuous picture of changes of geotechnical parameters with depth, which would enable one to minimize the number of samples to be taken for laboratory tests. The use of field testing in geotechnical properties evaluation of hydraulically deposited materials is of major interest especially because undisturbed sampling of these materials for laboratory tests is extremely difficult.

Levee Repair

Paper 2.26, "Repair of Scour Holes and Levees After the 1993 Flood" by *Perlea, Lust, Pearce,* and *Detrick*, presents the effects of the flood of 1993 on levees in the Missouri River basin, an approximately 500-year event, and methods used for rehabilitation of damaged portions of the flood protection system. The extent and duration of flooding caused many levees to be overtopped with associated severe erosion of river banks and bed. The paper is focused on levee repair in the vicinity of scour holes which, in some cases, were deep and to the top of bedrock. No unique method of repair was possible and each case had to be individually investigated and the appropriate solution designed. Restoration of the original degree of safety and efficiency was a complex process that had to consider cost, modification of river hydraulics, environmental restrictions, and political and local economic concerns.

In summary, it is obvious that only two papers deal with dam incidents (2.25 and 2.43) and none with dam failure. Only one paper each deals with waste dumps failure (2.29) and levee failure (2.37). Unfortunately, this does not imply that few incidents related to retaining structures occurred in the last 5 years, since the last Case History Conference.

The "National Performance of Dams Program" (NPDP), sponsored by Stanford University, Stanford, California, identified 987 incidents that occurred between January 1, 1994 and December 31, 1997 in the United States only. Of these incidents, 336 involved failures (most of them due to flood events; 235 of these failures occurred during the 1994 Georgia floods). An approximate inventory of failures due to geotechnical problems affecting earth dams or the earth portion of earth-combination (e.g. earth-gravity) dams is as follows:

Cause of Failure	Number of Failures per Year 1994	1995	1996	1997	Total Failures Since 1/1/1994
Deterioration	1	1	0	2	4
Seepage	2	2	1	1	6
Piping	2	2	7	3	14
				Total:	24

We may expect some of the failures or incidents which occurred in recent years to be the object of presentations at future Conferences on Case Histories. Until then, we have the opportunity to find the description of many of them, including relevant photos, in "NPDP Digital Image Database" at World Wide Web URL: http://npdp.stanford.edu.

EMBANKMENTS ON SOFT FOUNDATIONS

Settlement Control

Paper 2.04, "Effect of Smear Due to Vertical Drains on the Behaviour of Two Embankments Constructed on Soft Clay" by *Indraratna* and *Redana*, is an excellent presentation that includes description of full scale tests, instrumentation data, extensive laboratory testing, and successful mathematical modeling. Both trial embankments were constructed on soft clay, one in Thailand and the other in Malaysia. Various densities of vertical sand drains as well as no stabilization method were applied in the field tests. Laboratory and mathematical modeling were devoted to determination of the effect of smear around the mandrel driven drains on the soil permeability and, consequently, on the drain efficiency. The soft clay consolidation was modeled by the modified Cam-clay theory and the coupled Biot-consolidation model. It was determined that the smear effect can significantly affect the settlement. The proposed mathematical model is a valuable contribution for improving the methodology of prediction of vertical drain effectiveness in consolidation of soft clay. However, the reporters believe that major improvements to the model can be obtained if the authors would: (1) conduct the numerical analysis on the whole structure, instead of limiting simulation on an individual vertical drain and (2) use 8-node quadrilateral elements with four pore pressure nodes, instead of 6-node linear strain triangular elements with three pore pressure nodes, in settlement prediction by finite element analysis.

Paper 2.22, "The Behaviour of Two Trial Embankments at Perlis, Malaysia With Different Rates of Construction" by *Hussein* and *McGown*, is an excellent description of test embankments built on soft clay, one rapidly, in 36 days, and the other slowly, in one year. Site investigation works included borehole logging, piezo-cone and field vane testing, and chemical, mineralogical, and geotechnical laboratory tests. The field instrumentation included settlement plates, pneumatic and standpipe piezometers, extensometers, inclinometers, and heave markers. The conclusions are interesting, though obvious. The amount of settlement, pore pressure at the end of construction, and lateral displacement were all higher for the slowly constructed embankment compared to the rapidly constructed embankment. The authors made available the full characterization of foundation soil together with a complete description of soil behavior under rapid or slow loading, based on adequate instrumentation.

Paper 2.24, "Stage 1 Geotechnical Studies for Interstate 15 Reconstruction Project, Salt Lake City, Utah" by *Gunalan, Lee,* and *Sakhai*, describes various problems arisen by reconstruction of a highway in a urban zone of high seismicity. The thickness of unconsolidated deposits in the embankment foundation ranged from 3 feet (1 m) to more than 2000 feet (600 m). An active fault in the vicinity required consideration of seismic stability of various structures and liquefaction potential of saturated sand lenses. Original construction, between 1959 and 1969, provided valuable information on settlement and efficient methods to accelerate it; this information was used to estimate settlements at 54 bridge sites. An impressive volume of additional laboratory and field (CPT) tests were statistically processed in order to identify the areas of concern and to develop guidance for staged construction or methods to accelerate settlement. Comparative tests, in areas under the influence of the embankment and in free field, showed an increase in strength averaged by hole in the range of 20% (based on lab data) to over 40% (based on CPT-derived data). The authors' experience advocated using unidimensional consolidation theory in calculation of settlement of soft lacustrine deposits of Salt Lake City, including in the design of wick drain spacing. Staged construction was also considered necessary to prevent overall bearing capacity failure. The study presented in this paper can be considered an excellent interim report for future use of geotechnical engineers.

Failure Evaluation

Paper 2.14, "An Investigation of an Embankment Failure in Soft Clay" by *Huat*, describes the failure of a 3.2-meter well instrumented highway embankment founded on soft clay; the embankment included a 1.5-meter surcharge. The embankment failed over a length of approximately 100 meters, 5 days after completion of construction that lasted 140 days. The settlement rate dramatically increased just prior to the failure; the ratio between the horizontal and vertical displacements also increased about 10 times, and the increase in pore pressure became significantly greater than the increase of the applied vertical stress at this time. Total stress analysis with shear strength from vane test results, corrected with Bjerrum's factors for the effect of anisotropy and shear rate, adequately modeled the failure, when the lower bound of the field data were assumed. The author found the total stress method adequate for the short term stability analysis (end of construction) of embankments on soft clay.

TOPICS FOR DISCUSSION

Valuable information on many interesting subjects has been provided by the papers in this section. Based on the topics presented in the various papers, which probably reflect the current major interests of the authors, the reporters suggest the following topics for discussion:

* Stabilization of landslides with piles:

  - Methods of analysis including consideration of the possibility of soil flow between piles
  - Type of piles and construction technologies

* Dam construction and monitoring:

  - Evaluation of fissured rock grouting efficiency
  - Signs of internal erosion and methods for its stabilization
  - Core cracking prevention and detection
  - Liquefaction of sands under static conditions
  - Old dam remediation

* Embankments on soft ground:

  - Effect of method of installation on the effectiveness of vertical drains
  - Use of field tests for evaluation of strength parameters of soft clay foundation
  - Shear strength gain under loaded zones of foundation soil and their vicinity.

It is hoped that the discussions that follow will deal with these aspects and that a better understanding will emerge from the interchange of ideas among participants.