14 Aug 2008, 4:05pm - 4:35pm

General Report — Session 2: Dams, Embankments and Slopes

George E. Mylonakis
University of Patras, Greece

Achilleas Papadimitriou
University of Thessaly, Volos, Greece

Qamar Kazmi
Schnabel Engineering Inc., USA

Scott G. Newhouse
Bechtel Power Corporation, USA

DAMS, EMBANKMENTS and SLOPES

George E. Mylonakis (General Reporter)
Department of Civil Engineering, University of Patras, Greece

Achilleas Papadimitriou (Co – Reporter)
Department of Civil Engineering, University of Thessaly, Volos, Greece

Qamar Kazmi (Co- Reporter)
Schnabel Engineering Inc., USA

Scott G. Newhouse (Co- Reporter)
Bechtel Power Corporation, USA

General Report – Session 2

INTRODUCTION

Session 2 includes a total of fifty four papers that may be broken down as follows:

- twenty-nine papers that deal with slopes and landslide failures and stabilization,
- nine papers that investigate embankment failures,
- eleven papers that refer to dams, and seepage issues, and finally
- five that present geo-hazard issues as flood control.

PAPER REVIEW

In what follows, the papers are briefly summarized and their conclusions discussed. The listing of the papers is based on their code number for this session.

2.01

In *"Evaluation of Dispersive Properties of Clays to be used in Embankment of Arsuz - Gonencay Dam"* **Ozguler** and **Aydin** present a case history of evaluation of dispersive clays in borrow areas for the construction of Arsuz-Gönençay Dam located 25 km southwest of Iskenderun in Hatay, south central Turkey. The 96m high embankment was planned as a zoned earthfill dam. Soil samples from 80 test pits excavated in six different impervious material borrow areas were subjected to physical (pinhole, double hydrometer, and crumb) and chemical tests. The degree of dispersibilty was evaluated based on method proposed by Sherard et al. (1976). Figures showing spatial distribution of soils and whether they are dispersive, semi-dispersive, or non-dispersive in accordance with Sherard, pin-hole, crumb tests are included. The design of the dam was revised to incorporate a clay core enveloped by upstream, downstream, and foundation zones. Since the use of dispersive clays as impervious material in embankment dams can result internal erosion (piping), dispersive soils were not used in the clay core. Instead, semi-dispersive soils were mixed with non-dispersive soils for use in clay core. The authors note that the design of the dam was further modified to a concrete-faced sand and gravel (pervious) fill dam.

2.03

Chun, Cho, Kong, Lim, and **Lee** present three case studies of cut slopes involving soil and rock cuts that underwent failure. Their paper "*Analysis of Problems in Cut Slope Survey and Design based on Case Studies*" attempts to present a discussion of investigation and procedures used in the original design, and alternative approaches that could be used.

2.04

In their paper "*Back Analysis of the Malakassa Landslide using the Multiple-block Model*", **Stamatopoulos** and **Aneroussis** present a back analysis of a 1995 landslide in Malakassa, near Athens, Greece, using a multi-block model based on the one proposed by Sarma (1979), Sarma and Chlimintzas (2001), and an extension to the multi-block model proposed by Stamatopoulos (2006). Conventional sliding-block models do not properly model slides that have undergone large displacements because the change in the geometry of the sliding mass is not taken into consideration. Multi-block failure model considers the critical acceleration required to start mass movement. The paper briefly presents the site geology, results of subsurface investigations, and the slide geometry. The slide was approximately 300 m long and had a maximum width of about 240 m, average depth of about 25 to 30 m, and it underwent a lateral displacement of about 7 m. The slide was triggered by high groundwater levels following heavy rainfalls.

The paper presents the equations used to model the multi-block failure and a step by step procedure applied to the Malakassa slide. Residual shear strength was assumed to act uniformly along the slip surface. The deformed geometry prediction using this model agrees well with that measured in the field. The back-estimated friction angle of 16 degrees is in the range of the tested values 8 to 19 degrees. The location of the slip surface was reasonably predicted by assuming that only the saturated soil below the water table loses its strength.

2.05

Padhye and **Ullagadi** present that failure of a counterfort retaining wall near the city of Sangli in Maharashtra state of India in the article "*Case Study of Failure of a RCC Counterfort Retaining Wall*". The wall was constructed in 2003 to protect a road from stream erosion and flooding and failed in 2006 after heavy rainfall in the area. Sliding, collapse, and rotational failure modes were observed. The paper presents the design considerations of the wall and concludes that the wall failed due to improper design and construction. It is pointed out that neither the hydrologic data was reviewed nor hydrostatic forces considered in the wall design.

2.08

In "*Investigation on Mechanism of Creep Deformation of Slopes in Woo-Wan-Chai lanslide Area, Taiwan*", **Chang, Chiang, Chen, Zhang, Liu**, and **Wu** present the results of an investigation into the mechanism of creep deformations of a landslide on Mt. Ali Road (Road 18) in the Woo-wan-chai area in southern Taiwan. Since the construction of the road in the 1980's slope movements were noticed. The 2003 landslide involving a 150 m-section of the road and a volume of 500,000 m^3 occurred after a period of prolonged rainfall. A long-term monitoring program was initiated in 2000. The paper discusses the results of the monitoring program that included groundwater observation wells, piezometers, inclinometers and survey. By comparing deformations on the north slope, where drains were installed and the south slope where drains were not installed, it was possible to see the difference in creep rate. Natural creep rates of 4.50 to 12 mm/month and 0.3 to 4.8 mm/month were recorded for north and south slopes, respectively. Sliding occurred along multi-layered, deep-seated slip surfaces. It was noted that the presence of subdrain system resulted in delaying the increase in deformation rate because the subdrain delays the duration of time needed for full saturation and increase in groundwater levels. Laboratory test results for undrained, drained, and creep strength parameters have been reported. Creep strength was found to be approximately 85 percent of the undrained strength.

2.09

"*Calculation of Features of Many Row Pile Landslide Protection Structures*" by **Gotman** and **Suvorov** presents the results of investigation of multiple rows of piles for landslide stabilization. Physical model studies were performed on single and multiple rows of 28 mm diameter, 2.1 m long piles in trays with fine uniform sand under the action of the lateral landslide soil pressure. Displacement and rotation of piles under loads with various pile spacings were measured. The paper presents a design methodology in which all land-slide pressure is transferred directly to the piles and distributed among all rows uniformly.

2.10

Manolopoulou, Papaliangas and **Dimopoulos** present the case history of analysis and stabilization of a failed rock cut slope in schist, located in the northeastern Greek city of Thessaloniki in their article "*Analysis and Stabilization of a Failed Cut Slope in Schist*". The 1 (H): 3(V) slope, located near the top of a hill, had an average height of 12 m and a length of 70 m. A few weeks after the excavation, a slide occurred along the schistosity plane of the slope. The slope failure was attributed to the effect of water from flooding of the slope resulting from the overflow of a water tank located near the crest. The paper highlights the need of accounting for accidental water forces in the design of slopes. The paper presents the results of both deterministic and probabilistic analyses. Design input parameters were obtained from simple in-situ and laboratory tests and also from back-analysis. Friction angles between 21.5 and 23.5 degrees were calculated. The remedial measures consisted of four rows of 20 mm diameter, 90 kN capacity fully grouted steel anchors at a spacing of 1.40 m. The anchors extended 1.0 m beyond the failure plane.

2.12

Ghanbari and **Noutash** describe a landslide in northwestern Iran near the city of Tabriz, that occurred in June 2005 in "*Mass Movement Landslide (June 10, 2005) Along Sarab-Ardebil Main Road (West Slope Savalan Volcanic Mountain) - Azerbaijan-Iran*". The landslide occurred on the main Tabriz-Sarab-Ardebil Road.

2.16

"*Propabilistic Finite Elements with Dynamic Limit Bounds; a Case Study: 17th Street Flood Wall, New Orleans*" by **Rajabalinejad, Van Gelder** and **Vrijling** present a probabilistic reliability method for assessment of risk and safety of flood control systems. This method has been applied to the 17th Street Flood Wall failure in New Orleans during Hurricane Katrina. Plaxis software was used to assess the stability of 17th Street Flood Wall failure using Monte Carlo simulation coupled with dynamic limit bounds (DLB).

2.17

Gonzalez-Gallego, **Moreno Robles, Garcia de la Oliva** and **Pardo de Santayana**, report on the stabilization of an ancient landslide at a ski resort in northeastern Spain that was reactivated because of excavation at the toe in "*Stabilization of Large Paleo-Landslide Reactivated because of the Works to Install a New Ski Lift in Formigal Skiiing Resort*". The location of the failure surfaces, estimated by surface control points, were monitored by GPS and inclinometers were installed to estimate the depth of the sliding surface. The estimated failure surfaces were analyzed to back calculate the soil strength parameters. Stabilization procedures included change in slope toe geometry to a more stable configuration and installation of drainage measures. The continued monitoring indicated a reduction in slope movements.

2.20

In "*Horizontal Translational Failures of Levees due to Water Filled Gaps*" **Van, Zwanenburg, van Esch, Sharp** and **Mosher** present two case histories: the first a 2003 peat dike failure at Wilnis in the central part of the Netherlands, and the second the breach of the 17th Street Canal that failed in 2005 during Hurricane Katrina in New Orleans, Louisiana, in the United States. The paper notes that due to various global climate changes including extremes of moisture, subsidence, and rising sea levels, cracking will be more significant in assessments of levee safety.

The 5-m horizontal translation of the Wilnis levee was triggered by a combination of reduced weight by evaporation, shrinkage and cracking of the peat material, and an increased head in the sand layer under the dike. The paper cites the development of a research project (Brinkgreve and van Esch, 2005, Esch et al, 2007) to assess the development and influence of cracks (created due to drought) on levee stability utilizing a geo-hydrologic design procedure using a computer model (PLAXIS). The model predicts drying and wetting of levees due to climate changes. Application of the model to the Wilnis levee indicated that longitudinal cracks on the outer side of the levee crown that are or can be filled with water are the most dangerous critical. The design procedure was validated by applying it to another peat levee.

The paper discusses the performance of levees and floodwalls during Hurricane. The failure of the 17th Street Canal breach which resulted from the formation of a gap between the floodwall and the levee fill on the canal side is presented. Various limit equilibrium slope stability programs as well as PLAXIS and FLAC computer programs and centrifuge modeling were performed. For comparison purposes the analyses were performed using both the strength parameters used in original design and those determined based on more extensive post-failure field and laboratory investigations. The analyses showed that translational failure occurred through an underlying clay layer in which the sheet-pile walls terminated. The gap was formed when earth pressure against the wall was less than the hydrostatic at that depth. The paper references the Hurricane Katrina Interagency Performance Evaluation Taskforce (IPET) report of 2007.

2.22

"*Investigation on the Liquefaction of Clayey-Sandy Soil during Changureh Earthquake*" by **Ghahremani, Ghalandarzadeh** and **Konagai** discussess the performance of clayey sand soils during an intensity MW = 6.4 earthquake that occurred in Qazvin, in northwestern Iran, about 225 km west of Tehran, on June 22, 2002. Surface soil in this area is mostly clay; however, evidence of sand boiling, softening of soil, and consequent deformations were observed. Index tests on soil samples collected from the liquefied layer which occurred at a depth of 2 m indicated soil that might otherwise be interpreted as non-liquefiable (LL= 38, a PI= 18, and 44 percent of particles passing the No. 200 sieve). Cyclic triaxial test data is reported to suggest that the clayey sand deposit likely developed high residual excess pore pressures and significant shear strains during the earthquake, contributing to the observed lateral deformations. Several photographs of areas exhibiting liquefied soils are included. The paper describes the damage to a 10 m high earth dam embankment. Backanalysis was performed to compare the observed permanent displacements of the dam with those predicted by the Seed-Madiski method.

2.23

In "*An Investigation on Failure of Embankments in Bangladesh*" **Hossain, Islam** and **Sakai,** have attempted to address a major issue, i.e., reasons for failure of embankments in Bangladesh. Failures at two general locations have been presented briefly and in very general terms. The paper states that in spite of spending 20 percent of Bangladesh's budget on flood control embankments, the problem has not been solved due to "erroneous construction and wrong planning".

2.24

"Landslide Investigation at Phata Village on Rudraprayag-Kedarnath Road, Uttaranchal - A Case Study" by **Ghosh, Sarkar, Kanungo, Jain, Kumar, Ahmed** and **Patra**, reports on an investigation to assess the stability of a landslide that occurred in July 2001 in a village called Phata in the state of Uttaranchal in the Himalayas. Geotechnical investigations included seismic survey, laboratory tests for index and strength properties of the on-site soils. Both limit equilibrium and seismic stability analyses. Suggestions for reducing the impacts in a future slide event are provided. These include installation of a drainage network, construction of a retaining wall, and fences to catch rockfalls.

2.28

In "*Averted Piping Failure – Earth Dam on Permeable Foundation*", **Newhouse**, presents how seepage problems nearly caused failure of an earth dam, built on a permeable foundation, the events leading to the dam's first filling incident, the averting of failure and the renovating process followed successfully.

Although classified as high hazard, the construction plans did not address foundation treatment at all. The poor geotechnical investigation combined with lack of seepage control, demonstrate the erroneous detachment of a successful design from the soil conditions. Moreover, the homogeneous dam did not conform to the guidelines for construction of the US Bureau of Reclamation. The dam with no foundation seepage cutoff and no internal drain to control seepage pressure, developed intolerable water pressure and hydraulic gradient at the toe, long before the lake reached its design elevation (less than 50% filled). A shallow slide developed near the toe and a seepage boil appeared. Conditions at this stage clearly showed that continuous filling would result in failure. Supplemental soil exploration was conducted. Lowering the lake level and covering the boils averted dam failure by erosion\piping through the foundation. It is worth mentioning, that by the time the alarming signs appeared the design engineer attributed with naivety the boil to the consolidation of the ground, due to pressure from the embankment. To renovate the dam, a chimney drain was constructed, as well as toe and blanket drains and relief wells drilled into the artesian zone.

In addition, the Lake Mailande Dam, investigated herein, gave a handle to the writer to go beyond this specific case underlying the impact of permeable foundation soils on dams. The writer offers in brief, several case histories found in the literature of dams with permeable foundations and despite the common belief that permeable soil conditions can enhance dam safety or act against it, he stresses that permeable dam foundation is rarely a benefit and should always be treated with caution.

2.29

In their paper, entitled "*Prevention, Mitigation and Engineering Response for Geohazard in Thailand*", **Surinkum, Tabtiwanit** and **Tulyatid** present a civil protection program in Thailand, based on an engineering approach. The main geohazards are divided into two groups: those related to plate tectonics (earthquake and tsunami), as the region is close to the Indian Plate's subduction zone and those related to the monsoonal type, tropic climate (flush-flooding and land-mud-slide). The above geohazards are speeded up due to human activity, as is the deforestation and development over the forest area and the high-land agriculture. The program involves many stages for prevention and mitigation: recording of the hazards and updating the hazard maps, installing hazard monitoring systems and most importantly using a new engineering approach based on the concept of "living in harmony with nature". This new philosophy includes proper knowledge of the area and the hazard and mild interpositions with respect to the physical procedures. As an example for the application of the new approach, the case of the flush-flood and landslide at Ban Nam Ta, Uttaradit Province in 2007, is presented.

2.30

Sadrekarimi and **Olson** investigate the influence of grain mineralogy and compressibility, sample preparation and shear strain level on the shearing behavior of sands, in their paper entitled "*The importance of mineralogy and grain compressibility in understanding field behavior of failures*". Various combinations of test procedure (undrained triaxial compression, constant volume ring shear), sand type (Illinois River sand, Mississipi River sand, Ottawa 20/40 sand) and preparation method (moist tamping, air pluviation) were chosen in order to perform ten different tests.

The results showed that: i) the constituent minerals of a sand influence its shearing behavior (sands consisting of minerals with low shear moduli exhibit contractive behavior whereas sands consisting of minerals with high shear moduli exhibit dilative behavior), ii) at very large deformations, the sand particles crushed resulting in a contractive behavior even for the dilative (for small strains) sands, iii) depositional method greatly affects the undrained behavior of sands at small to intermediate shear strains.

2.34

In their paper, entitled "*Back-analyses of landfill slope failures*", **Huvaj-Sarihan** and **Stark** investigate the shear strength of Municipal Solid Waste. The following lanfill slope failures have been back-analysed: i) Gnojna Grora landfill (Poland), which is a very old uncontrolled landfill (with a maximum height of 30 m) without liner or cover system. Landfill movements caused cracks in nearby buildings; ii) Istanbul landfill (Turkey), which has been in operation since 1976 and is located on the upper portion of a tributary valley. There was no liner or cover system and the maximum height was 45 m. Slope failure of this landfill (18th April 1993) caused 23 casualties; iii) Hiriya lanfill, Israel's largest landfill (in use from 1952-1998), which was located very close to the convergence of two rivers (Shappirim and Ayalon). There was no liner or cover system and the maximum height was 60 m. The slope failure (winter of 1997-1998) blocked Ayalon river for some days; iv) Payatas lanfill (Philippines), which in in operation since 1973 and is located within the boundaries of Quezon City. The maximum height is 30 m. Slope failure occurred on July 10, 2000 and caused 250 fatalities.

The study recommends a bilinear failure envelope for Municipal Solid Waste, which involves a cohesion value c'=6 kPa and a friction angle φ'=35º, for effective normal stresses less than 200 kPa, whereas for effective normal stresses more than 200 kPa, the above values become c'=30 kPa and a φ'=30º. Results were compared with published studies.

2.35

In his article "*Rehabilitation of Sliding Motorway Slopes on Deep Failure in Bulgaria*", **Kolev** presents three examples of motorway landslides in Bulgaria. All landslides occurred in faulted regions after heavy rainfall and snow melting. The sliding earth material consisted mainly of clay and marl.

Remedial measures included appropriate drainage systems, anchors, piles, grouting and reinforcement of the road embankment. Since the application of the remedial measures, no deformation has occurred in any of the locations.

2.36

Itoh, Timpong and **Toyosawa** investigate the case of a slope failure coming with a serious labor accident, in their paper entitled "*Case history of Labor Accident due to Slope Failure during Slope Excavation and its Countermeasure Work*". The results of a series of geotechnical centrifuge model tests that simulated the slope failure are presented. The study focuses on the influence of temporary wall stiffness and embedded depths on the prevention of slope failure. It is proved that the inadequate stiffness of the temporary system used, caused the accident. In contrast, if a sheet pile wall with higher stiffness had been used, its obvious deflection would have alerted the workers about the slope failure, and at the same time, it would suppress the deformation leaving enough space for the workers to escape safely from the trench.

2.37

"*Experimental and Numerical Analysis of the Behaviour of an Embankment Stabilized with Vertical Drains"* by **Francesco Castelli**, **Valentina Lentini** and **Michele Maugeri** deals with the settlement analysis of an embankment founded on soft soil within the framework of the construction of a reinforced concrete building in the industrial area of Catania. The soft soil deposit has a low bearing capacity and exhibits large settlements when subjected to loading. To avoid potential damages to the structure and intolerable soil settlement, the implementation of a ground improvement technique was considered compulsory. The strengthening of the soil (normally consolidated clayey deposit) was accomplished by dewatering; a preloading technique combined with a system of 33 prefabricated vertical drains, to accelerate the consolidation process, is adopted. To achieve preloading an instrumented circular embankment with a diameter of 65m and height 2.50m was placed on the soft subsoil. In particular, a numerical analysis, to simulate the consolidation of the soil beneath the embankment, has been carried out by means of the finite element program CRISP^{2D}, for axi-symmetric condition. The stress-strain-strength behavior of the soil was simulated by a simple elastic-perfectly plastic model, with a Mohr-Coulomb failure criterion. To conclude, comparison between measured and computed results, shows that the proposed analysis can be used successfully for the numerical modeling of the behavior of an embankment and provide a reliable evaluation of the future performance.

2.43

Rogers and **Watkins,** in their paper, entitled "*Overview of the Taum Sauk Pumped Storage Power Plant Upper Reservoir Failure, Reynolds County, MO*" investigate the factors that led to the complete destruction in 2005, of one of the most famous pumped storage hydroelectric power plants in North America, constructed in 1963. A sequence of serious errors in the construction and operation of the plant, combined with administrative inadvertences, are responsible for the catastrophe. Insufficient foundation preparation and improper embankment material used, without mechanical compaction led to substantial settlement and erosion of the embankment during its 42 year life and corresponding lowering of the crest of the concrete parapet wall on the top. Although the settlement problems were well-known to the company, they were not taken seriously under consideration during the redesign of the operating plan of the reservoir, due to increased utilization. Errors in placing monitoring instrumentation and programming safety probes, resulted in operation of the plant with minor margin of error against overtopping. Two incidents of overtopping noticed few months before the final disaster, could have helped the administrators to realize the danger and to take the necessary measures, as these gave clues of the catastrophic scouring of the embankment that overtopping could cause. In spite of the serious constructional and operational errors, the disaster is purely a result of a series of errors in human judgment.

2.45

Nelson, in his paper entitled "*Investigation and Repair of a Leaking Eatrhfill Dam*", presents the case of the reconstruction of two earthfill dams that were seriously leaking short after their initial filling. The problems in both dams were concentrated in the region of the outlet pipes. The type of the pipes and the pipe joints used were improper for the given project. Moreover, the contractor completely neglected the project specifications regarding the placement of the piles, the compaction of the soil material and the placement of a clay core, as a result of the complete lack of Construction Quality Control during the initial construction. The severe leaking due to the bad construction quality, made the dam unserviceable in its present condition and dangerous, as a catastrophic failure was possible. The necessary remedial measures, that is practically reconstruction of the dam, had to be taken, including the removal and replacement of the pipes, the placement of clayey material and GCL around the pipes and the construction of a clay core in the excavated section.

2.47

In "Lessons *Learned from Slope and Trench Failures in Japan*", **Toyosawa Yasuo, Timpong Sahaphol** and **Itoh Kazuya,** present case histories of slope and trench failure accidents in Japan during the period of 1989 to 2001 based on construction industrial labor accident reports, highlighting the importance of improving the safety standards and providing higher safety education and training in the construction projects.

The writers analyzed the failures from various aspects, reaching significant and deserving results. Location of accidents, types of construction, slope and trench geometries, scale of failure, time of occurrence and characteristics of workers involved in the accidents are investigated. In particular, the failures are likely to occur in small construction projects, involving retaining walls for stabilizing slopes and pipeline installation for trench excavation. Most of trench collapses occurred in trenches shallower than 3m, at an angle of 90° and in case of slope excavation, most failures took place at a slope angle from 60° to 75° and slope height from 2 to 10m. Both slope and trench excavation failures can be classified as small-scale, as the amount of collapsed soil is generally small, in order for the failure to occur rapidly. To conclude, labor accidents mainly occurred before/after lunch break and before the end of working time, involving mostly older and inexperienced workers, as well as experienced workers who took unnecessary risks.

These findings create a conducive atmosphere for establishing effective measures to prevent labor accidents caused during slope and trench excavation works in the future.

2.48

In their paper "*Case History and Numerical Analysis of Trench Collapse in Japan*", **Timpong Sahaphol, Itoh Kazuya** and **Toyosawa Yasuo** present a case history of collapse during trench excavation in soft ground. Using centrifuge modeling and numerical analysis they investigated the development of settlement and horizontal displacement, the generation of pore water pressure during construction and the dramatically simulated the trench collapse mechanism. They found that the occurrence of trench collapse was mainly caused by the excessive surcharge load of excavated material stockpiled on top of the trench.

2.50

In the paper entitled "*Controlled Wetting Test of a Soil Nailed Loose Fill Slope: Case study*", **Zhou, Tham, Li, To** and **Lee** present an in-depth investigation of the strengthening effect of soil nailing in loose fill slopes, that is, slopes formed by end-tipping method, without any compaction. The authors designed and constructed a full scale test slope and examined its hydro-mechanical response under circles of surcharge and wetting loading, by means of a comprehensive instrumentation system. The test slope was also simulated by a numerical FEM model. The experimental and numerical results are in very good agreement regarding deformations, stress and pore pressure distributions and the nail axial loads. Contrary to the widespread view that soil nailing cannot be applied in loose fill slopes, the present study shows how it significantly improves the overall stability of the slope.

2.52

In their paper entitled "*Evaluation and stabilization of an embankment at Sebastopol, South Wales, UK*", **Weltman** and **Yuan** present a stabilization study of slope and related track movement at Sebastopol, UK. Monitoring results and numerical back analyses are introduced for the problem. In 2005 "Grundomat" micropiles were installed alongside the track as remedial measures for the movements. However, further displacements were monitored and in 2007 additional

"Grundomat" micropiles were installed. Moniroting showed that rainfall accelerated movements.

2.57

In his paper entitled "*Stability Analysis of a Tailings Dam: Existing State and Planned Heightening*", **Tzenkov** presents the studies carried out to determine the stability of a rockfill tailings dam. Seepage analysis, consolidation anaysis – to assess stress stages at different building stages, time-domain analysis – to get maximum seismic response, and slope stability analysis have been made by GEO-SLOPE FE program. It is concluded that the facility has sufficient structural safety for both operational and seismic loads. Safety factors for different heightening options are computed.

2.61

Gehring and **Luna** present the case of a rock-fill dike/dam that failed by breaching and explain the theorized mechanisms that would cause the breach, in their paper "*Evaluation of the Taum Sauk Reservoir Failure"*. They discuss overtopping and related effects including scour of the dike rock-fill, and sliding of the rock-fill slope caused by a rising seepage line. The paper discusses the aspects of each of the theorized mechanisms and identifies the most likely.

2.62

Lee, **Shin, Kumar** and **Shin** present damage to roadway slopes and other crucial slopes caused by Typhoon Ewinar. "*A Case Study of Characteristics of Damages Caused by Typhoon Ewinar2006 in South Korea*" documents the storm and its impacts, including a lot of meterological data (e.g. rainfall amount and intensity). The paper describes and illustrates damage to roadways and other infrastructure. The authors identify and explain the mechanisms involved in damage, such as seepage and the effects of rock jointing patterns.

2.66

"*Stability of a 30m High Riverbank in Canada with Nails, Plates, and Roots*" by **Fabius, Bo** and **Villegas** presents the case of repair to a slope along a river in Thunder Bay, Canada, using a non-conventional approach. The slope is repaired using soil nails without grout. The nails are comprised of steel reinforcing bars installed with light, low-impact equipment operating on the slope. Shallow slump/slough type failure is prevented by use of a specially designed vegetation layer, counting on the strength of the root system. The paper presents data for design strength of the root system. The authors describe an elaborate design process including LPile analysis of the nails and determination of the required strength of the root system. The paper emphasizes the eco-friendly approach to the repair.

2.69

Arunkumar, Shivashankar and **Yaji** describe the development of a computer program to evaluate factor of safety for slopes. Their paper "*Case Study of Landslide in NH-13 at Kethikal near Mangalore- India*" describes the automated nature of the program. The authors use their program to generate a factor of safety fot the specified NH-13 landslide.

2.70

Basudhar and **Bhattacharya** describe the development of a computer program for evaluation of slopes. The authors present in "*Predicted Versus Observed Failure Surface: A Case Study*" discussion and critique of current methods of slope stability analysis, identifying the limitations and flaws in current methods. The program is checked against a documented case history.

2.71

Croce and **Modoni** present the case of a masonry dam in the Italian Alps built in the 1920s. The dam has significant measured displacement and seepage. "*Analysis of Dam Behaviour After Eighty Years of Service*" explains the seepage conditions through the foundation and right abutment, presenting seepage measurement data. The authors develop a finite element method to evaluate the seepage and displacement. Their results show how the developed finite element method can be used to predict displacement and seepage; the paper includes several supporting data plots.

2.72

In their paper, *"The Stability of Flood Defenses on Permeable Soils: The London Avenue Canal Failures in New Orleans"*, **Kanning, Van Baars** and **Vrijlin** explain the failure mechanism involved in the flood protection levee/wall along London Avenue, New Orleans, resulting from Hurricane Katrina. The authors compare flood protection measures in the US to those in the Netherlands. The paper presents forensic evidence from photographs and findings of previous investigations, including model testing to develop water levels. The authors present analysis based on this evidence to show the probability of piping through the foundation soils, and the probable results of the piping. They explain the failure mechanisms developing in 2 different breaches of the levee/flood wall- one by sliding, the other by over-topping due to subsidence. The authors contend that both mechanisms involved foundation piping.

2.73

Kwong and **Lee** present the results of a research project where a cut slope is constructed and fitted with soil nails in "*A Field Test Study on Instrumented Soil Nail Installed in Cut Slope*". The slope was instrumented with piezometers and inclinometers; the nails were instrumented with strain gages. The research team pumped water into the ground within the cut slope to raise the saturation level and load the nails. The paper presents data and photographs documenting the seepage/saturation conditions. Measurements during the test construction include piezometer readings and loads on the nails. The authors then compare measured loads in the nails to that predicted by finite element analysis; they report close agreement.

2.77

Yazdani, Fadaee and **Haghighat** present the case of a large landslide that took place at the site of a hydropower dam; associated material volume was about 300,000 cu m. The paper "*Application of Screening Analyses for the Stability of Landslide in Seymareh Dam Project*" gives an extensive presentation of local area and site geology. The authors identify causes of the landslide, including presence of faults and an ancient landslide; they identify triggers- excavation and related blasting for a new access road to the site. The paper presents analysis of stability of the slide mass, evaluating the use of flatter slopes through the slide zone to increase factor of safety. The paper focuses on seismic analysis. The authors indicate that the traditional pseudo-static slope stability approach leads to insufficient factor of safety. They show how use of the Southern California Earthquake Center method shows adequate factor of safety for the proposed stabilization measures.

2.78

Sadeghpour, Asgari and **Mojezi** present the case of a slide in a tall cut slope made for a dam spillway; slope height is about 140m. The paper "*Study of Instability Event of Rock Trench in Vanyar Dam Spillway*" presents significant background information on landslide nomenclature, definitions, and triggers. The authors present stability analysis of the slide by finite element analysis. They back-calculate shear strength parameters for the layers in the ground profile. The profile is comprised of sedimentary rock. The authors present conclusions about the causes of the slide- including rising groundwater level due to rainfall; weathering of the surface of exposed materials; freeze-thaw action, and loading change due to excavation and related blasting. They present remedial measures including flattening the slopes and construction of stability berms at selected levels.

2.79

In their paper "*Stability Analysis of a 70m-High Cut at an Ancient Landslide Area in Patras, Greece*" **Papantonopoulos, Kloukinas** and **Mylonakis** present the case of a 70m tall cut slope made for new highway construction. The ground profile consists of marl, with groundwater level below the excavation bottom. The authors show that an old slide had taken place on the proposed site, along the slope to be excavated. The authors use Finite Element Analysis for various configurations- initial slope, temporary excavation, final proposed profile. Their results show the need for stability measures to increase factor of safety. Chosen stability measures include passive anchors through the slope face and vertical piles placed at the slope toe.

2.82

Lobo-Guerrero, Fannin, Ulinski and **Gutta** present a case of embankments built for highway bridge construction where measured settlement exceeded the predicted amount. The paper "*Lessons Learned from the Performance of a Degradable Shale Embankment: Case Study*" includes monitoring data showing that the embankment settlement exceeded the amount expected. Investigation revealed the placement of shale fragments in the embankment comprised of material subject to slaking, and consequential particle size change and strength loss. The authors present extensive laboratory data showing the change to engineering properties of the shale used in the embankments in the post-construction period. They present conclusions that the laboratory data show that non-durable shale is the root cause of the excessive settlement.

2.83

Marques da Cunha, Bello, Coutinho, and **Gusmão** present the case of an embankment on soft soil, built for construction of an industrial facility. The embankment failed by sliding through the soft foundation, causing damage to the facility. The paper "*Failure of the Embankment on Soft Soil in Recife-Brazil*" presents slope stability analysis to identify the shearing surface in the ground, and to back-calculate soil shear strength parameters. The paper focuses on adjustment required to shear strength measured by field vane shear methods in soft soils of high Plasticity Index. The adjustment is required to derive the accurate shear strength for use in analysis.

2.84

The paper "*Rapid Recovery of Demolished Young-Dong Highway 205.4 km Due to Heavy Rain*" by **Jeon, Kim, Youn** and **Kim** presents the case of a slope supporting a major highway along a river in South Korea. The river runs along the slope toe. The slope failed during heavy rain, apparently from erosion of the toe cause by high flow in the river. The paper describes rapid construction of a rock-fill embankment to put the highway back in service as quickly as possible. A reinforced concrete, tied-back retaining wall was built as the permanent repair.

2.85

In "*Geotechnical Schemes for Constructing Light Structures on Instable Slopes*" **Farrokhzad** and **JanAli-Zadeh** present the use of a perforated pipe within a gravel-filled trench as a drain system for stabilizing Noabad's aviculture in Iran. The authors use Janbu's method of slices for analyzing five cross-sections, before and after using the drain system and their analyses show an increase of the factors of safety from 0.82-0.90 to 1.06-1.21. The authors also mention the use of berms for stabilizing the aviculture. The same area in Iran is used as the test site for the analyses of paper 2.86.

2.86

Farrokhzad, JanAli-Zadeh and **Barari** show how the results of slope stability analyses performed for five cross sections of Noabad's aviculture in Iran were used for training and validating an artificial neural network (ANN) in "*Prediction of Slope Stability Using Artificial Neural Network (Case Study: Noabad, Mazandaran, Iran)*". The slope stability calculations were performed using Bishop's method of slices. The ANN was fed with the following data from each analysis: the shear strength parameters (c′, φ′) of the soil, the angle of the slope, the vertical and horizontal seismic coefficients, the degree of saturation and the coordinates of various points within the cross section and whether the point was within or outside the sliding mass predicted by the analysis. The ANN was then used for predicting the factor of safety, and whether the coordinates of any given point lie within or outside the sliding mass. In particular, the ANN used 800 cases for training and 200 cases for validating its reliability, and the results show the ANN is capable of predicting the stability or not of any given point (as compared to the limit equilibrium analyses) in at least 92% of the cases. The same area in Iran is studied before and after stabilization in paper 2.85.

2.88

In their paper "*Predicting Hydraulic Fracturing in Hyttejuvet Dam*", **Haeri** and **Faghihi** present the use of the results of 2D fully coupled non-linear finite element (FEM) analyses (using ABAQUS) for predicting hydraulic fracturing in Hytterjuvet dam in Norway. This is an earth dam with a rather narrow core for which leakage was observed on first impounding, caused by arching of the core which eventually led to hydraulic fracturing. The FEM analyses used the modified Drucker-Prager/Cap model for the core, while all other zones of the dam were considered elastic. The analyses that took into account the construction sequence of the dam do predict the arching effect, since the vertical stress in the core is smaller than the overburden stress. Then, the authors proceed in simulating the first impounding of the reservoir. Based on their results in terms of stresses and pore pressures in the core, they proceed in applying two (2) known criteria of hydraulic fracturing (Komakpanah 1989, 1990 and Lo & Kaniare 1990), but also one of their own that predicts hydraulic fracturing if $\sigma_3+\sigma_t \leq p$, i.e. if the minor principal stress plus the tensile strength of the material is smaller than the pore pressure. These analyses show that while the first two criteria predict hydraulic fracturing in the upstream side of the core, their own proposed criterion depicts hydraulic fracturing from the upstream all the way to the downstream side of the core, a result that could be viewed as a horizontal crack from the upstream to the downstream side of the core that could be the cause of the observed leakage.

This very interesting study provides insight to hydraulic fracturing of embankment dams and also provides a practical tool for predicting this type of failure.

2.89

Zoorasna, Hamidi and **Ghanbari** present in "*Seepage Through Different Concrete Cut Off Wall Connection Systems. Case Study: Karkheh Storage Dam*" the results of 2D fully coupled non-linear finite element (FEM) analyses (using PLAXIS) for modeling Karkheh storage dam in Iran. The emphasis of the analyses was not on the response of the dam, but on the efficiency of six (6) alternative concrete cutoff wall connection systems to the clayey core in terms of total flow discharge and maximum hydraulic gradient, as compared to the case of the cut-off wall without any connection system. The parametric results show that the total flow discharge is mostly affected by the cut-off wall permeability, rather than the connection system used. Yet, the connection system does play a significant role in reducing the maximum hydraulic gradient, and in that respect, the most efficient system is a combination of cut-off wall penetration into the core with a concrete slab at the base of the core. On the contrary, the least effective system is the use of clay material underneath a concrete cap. The stress-strain response of the six (6) alternative concrete cut-off wall connection systems is studied in paper 2.90.

This interesting study provides insight to design issues related to seepage obstructed by cut-off walls below the core of embankment dams.

2.90

Zoorasna, Hamidi and **Ghanbari** in "*Stress-Strain Analysis of Different Concrete Cut Off Wall Connection Systems. Case Study: Karkheh Storage Dam*" present the results 2D fully coupled non-linear finite element (FEM) analyses (using PLAXIS) for modelling Karkheh storage dam in Iran. The emphasis of the analyses was not on the response of the dam, but on the stress-strain response of six (6) alternative concrete cut-off wall connection systems to the clayey core, as compared to the case of the cut-off wall without any connection system. The analyses were performed using the Mohr-Coulomb model as the constitutive model of all zones, and following the construction sequence of the dam. The parametric results show that for all six (6) alternative connection systems, shearing is the critical failure mode and not tension thus reducing the possibility of hydraulic fracturing. In terms of all the stress and strain criteria analyzed, it seems that a connection system consisting of a thick concrete slab at the base level of the core provides a smoother stress distribution, lower shear strains at the base level of the core. The seepage through the six (6) alternative concrete cut-off wall connection systems is studied in paper 2.89.

This interesting study provides insight to design issues related to the stress and strain response at the base of the core of embankment dams due to the cut-off wall connection system.

2.91

Thamer, Megat, Huat and **Azlan,** in their paper **"***Assessment of Some Old Earth Dams in Malaysia through Observation and Computer Simulation***",** present the results of 2D finite element seepage analyses (using SEEP/W) regarding the flow through two existing earth dams in Malaysia: a) Labong dam: a 10.5m high non-homogeneous earth dam, b) Bukit Merah dam: an 11.5m high homogeneous earth dam. The analyses referred to two cross sections of Labong dam and one of the Bukit Merah dam and took into account the flow in the capillary zone above the phreatic surface. Comparison of the results in terms of seepage rates and phreatic surfaces with the measured values show reasonable accuracy.

2.92

In "*An Analysis of Causes of Urban Landslides in Residual Lateritic Soil*", **Goswami** and **Singh** present an engineering geological approach for studying the causes of landslides in the urban environment of Guwahati city in India, whose geological setting is residual lateritic soil. In particular, seven areas around the city were chosen for the analyses, naming the respective devastating landslides that took place between 1982 and 1991. The paper presents details on: a) the environmental setting of the area (temperature, rainfall), b) the mineralogy and petrography of the underlying rock (usually granite gneiss), c) the weathering of the underlying rock forming the residual lateritic soil and d) structural features and mechanical properties of the rock units. The analysis shows that although the hill slopes of the landslide areas of Guwahati consisted of hard rock, their stability had been impaired by weathering and the amount of water that found access underground, the latter being the most crucial factor in initiating the landslides. In addition, the structural analysis of the joints in the underlying rock showed that their distribution and orientation was also a significant causing factor of the landslides.

This interesting study provides an integrated engineering geological approach to a problem of landslides.

2.93

"*Slope Stability Study of External Dump of Sonepur-Bazari Opencast Coal Mine, India – a case study*" by **Roy** presents the results of a parametric slope stability analysis aiming at ensuring a factor of safety of 1.2 in the construction of external dumps with specific dump, foundation and ground water table characteristics in Sonepur-Bazari opencast coal mine in India. The limit equilibrium analyses are performed using the Fellenius and simplified Bishop's methods. The authors conclude to a table of maximum height and average slope angle to be used for constructing external dumps with the specific dump, foundation and ground water table characteristics.

2.95

Sai, Shukla, Prasad, Vishnoi and **Singhal** present measurements from various drainage galleries in terms of flux, as compared to the reservoir level during the initial filling of the 260m high Tehri embankment dam in India. The article "*Initial Filling of Tehri Reservoir – Analysis of Seepage Data*" describes the geological setting, the dam characteristics and the analysis of seepage data in great detail. Their analysis leads to the general conclusion that the core and its underlying grout curtain seem to be very effectively designed and constructed, despite the fact that steady state seepage has yet to be established.

2.96

Jamnogpipatkul and **Chupanit** in "*Repair of a Failed Slope Using Geogrid Reinforcement*", present an analysis of the response of a reinforced earth slope in Thailand. The analysis is performed by calibrating a FEM model to the insitu measured response via inclinometers, piezometers, observation wells, surface settlement plates and total pressure cells. In the sequel, the calibrated FEM model is used to study the effects of the rise of the ground water table and the reduction of the length of the geogrids used to reinforce the slope. In both cases, an increase of the horizontal movement is predicted. The authors conclude that long term stability of the reinforced slope can be achieved by installing horizontal drain pipes and by increasing the length of the geogrids.

2.97

Ram and **Goyal** present an engineering geological description of the stability of open pit in Goan iron ore mines in Goa India. The paper, "*Pit Slope Failure Problems in Goan Iron Ore Mines, Goa, India*", focuses on describing slope stability failures (reaching heights of 100m) in terms of geologic features and their relation to variation of water pressure (related to the raining season), surface erosion, tension crack formation etc. The data presented will be used as input in the slope stability analyses currently under way.

2.98

Sai, Shukla, Prasad, Vishnoi and **Routela** present the back-analysis, but mostly the stabilization of the Varunavat Parvat landslide that took place in 2003. The paper, "*Integrated Approach for Stabilisation of Varunavat Parvat Landslide – A Case Study*", first presents in full detail the engineering geological information regarding the landslide, that practically outline the basic factors contributing to the landslide, namely steep topographic inclination, orientation and fragmentation of rock joints, occurrence at the end of the (rainy) monsoon season, an unlined canal running across the crown of the slide, man-made steep cut slopes near the base of the slide and possibly the proximity to an earthquake epicenter zone. Then, the paper proceeds in demonstrating the results of slope stability analyses, that used back-analyses to estimate the shear strength parameters of the upper soil of the sliding mass. These were not performed with limit equilibrium analyses, but via the "strength reduction" technique incorporated in the finite difference code FLAC. This also enabled analyses to be performed for various other factors affecting the stability, like the increase of the pore pressures due to increased rainfall as well as earthquake effects. In addition, this enabled the simulation of various stabilizing techniques before their implementation in practice. Three dimensional analyses using 3DEC enabled the simulation of the effects of discontinuities. In closure, the paper presents the stabilization measures, implemented insitu, that included excavation and flattening of the slopes near the crown of the slide, a retaining structure at the chute of the slide hooked at competent rock at the sides of the slide and a combination of retaining walls at the toe of the slide.

This paper presents an interesting combination of an engineering geological and a geotechnical engineering approach to dealing with a complex massive landslide.

Table 1: Summary of papers submitted to this session

Paper No. & Authors	Title of Paper	Field of Application	Summary of Content	Approach	Country
#2.01 Ozguler, Aydin	Evaluation of Dispersive Properties of Clays to be used in Embankment of Arsuz - Gonencay Dam	Embankment	Evaluation of dispersive clays in borrow areas for the construction of Arsuz-Gönençay Dam located 25 km southwest of Iskenderun in Hatay, south central Turkey	Physical and Chemical testings	Turkey
#2.03 Chun, Cho, Kong, Lim, Lee	Analysis of Problems in Cut Slope Survey and Design based on Case Studies	Cut Slope	Reports of three case studies of cut slopes involving soil and rock cuts that underwent failure.	Numerical Analyses	Korea
#2.04 Stamatopoulos, Aneroussis	Back-analysis of the Malakassa landslide Using the Multiple-block Model	Landslide	Back analysis of a 1995 landslide in Malakassa, near Athens, Greece, using a multi-block numerical model	Numerical Analyses	Greece
#2.05 Paddhye, Ullagaddi	Case Study of Failure of a RCC Counterfort Retaining Wall	Retaining Wall	Investigation of the failure of a counterfort retaining wall near the city of Sangli in Maharashtra State, India.	Numerical Analyses	India
#2.08 Chang, Chiang, Chen, Zhang, Liu, Wu	Investigation on Mechanism of Creep Deformation of Slopes in Woo-Wan-Chai landslide Area, Taiwan	Landslide	investigation into the mechanism of creep deformations of a landslide on Mt. Ali Road, Taiwan	Monitoring, Laboratory Testing	Taiwan, R.O.C.
#2.09 Gotman, Suvorov	Calculation of Features of Many Row Pile Landslide Protection Structures	Landslide	Presents results of investigation of multiple rows of piles for landslide stabilization.	Physical model studies	Russia
#2.10 Manolopoulou, Papaliangas,Dimopoulos	Analysis and Stabilization of a Failed Cut Slope in Schist	Cut Slope	Presents the case history of analysis and stabilization of a failed rock cut slope in schist, located in the north-eastern Greek city of Thessaloniki	Deterministic, Probabilistic analyses	Greece
#2.12 Ghanbari, Noutash	Mass Movement Landslide (June 10, 2005) Along Sarab-Ardebil Main Road (West Slope Savalan Volcanic Mountain) - Azerbaijan-Iran	Landslide	Investigation of a landslide in north-western Iran near the city of Tabriz, that occurred in June 2005.	Lab Testing, Numerical Analyses	Iran
#2.16 Rajabalinejad, Van Gelder, Vrijling	Probabilistic Finite Elements with Dynamic Limit Bounds; A Case Study: 17th Street Flood Wall, New Orleans	Probablistic Design	Probabilistic reliability method for assessment of risk and safety of flood control systems. This method has been applied to the 17^{th} Street Flood Wall failure in New Orleans during Hurricane Katrina.	Numerical Analysis	Netherlands

#2.17 Gonzalez-Gallego, Moreno Robles, Garcia de la Oliva, Pardo de Santayana	Stabilization of Large Paleo-Landslide Reactivated because of the Works to Install a New Ski Lift in Formigal Skiing Resort	Landslide	Report on the stabilization of an ancient landslide at a ski resort in northeastern Spain that was reactivated because of excavation at the toe	Lab Testing, Numerical Analyses	Spain
#2.20 Van, Zwanenburg, van Esch, Sharp, Mosher	Horizontal Translational Failures of Levees due to Water Filled Gaps	Levee	Reports that due to various global climate changes, cracking will be more significant in assessments of levee safety.	Numerical analyses	Netherlands, USA
#2.22 Ghahremani, Ghalandarzad-eh, Konagai	Investigation on the Liquefaction of Clayey-Sandy Soil during Changureh Earthquake	Liquefaction	Discusses the performance of clayey sand soils during an intensity $M_W = 6.4$ earthquake that occurred in Qazvin, in northwestern Iran	Laboratory tests, Analytical procedures	Iran, Japan
#2.23 Hossain, Islam, Sakai	An Investigation on Failure of Embankments in Bangladesh	Embankment	States that in spite of spending 20% of Bangladesh's budget on flood control embankments, the problem has not been solved due to "erroneous construction and wrong planning".	Observations, Analytical Approach	Japan, Bangladesh, Japan
#2.24 Ghosh, Sarkar, Kanungo, Jain, Kumar, Ahmed, Patra	Landslide Investigation at Phata Village on Rudraprayag-Kedarnath Road, Uttaranchal - A Case Study	Landslide	Investigation to assess the stability of a landslide that occurred in July 2001 in a village in Uttaranchal close the Himalayas.	Seismic survey, Laboratory tests. Limit equilibrium & Seismic stability analyses.	India
#2.28 Newhouse	Averted Piping Failure – Earth Dam on Permeable Foundation	Dams	Presents the case of an earth dam with seepage problems that nearly caused its failure.	Site Investigation	USA
#2.29 Surinkum, Tabtiwanit, Tulyatid	Prevention, Mitigation and Engineering Response for Geohazard in Thailand	Geohazard	Civil protection program in Thailand based on an engineering approach. Study of three main landslide events.	Instrumentation, Analysis, Education.	Thailand
#2.30 Sadrekarimi, Olson	The importance of mineralogy and grain compressibility in understanding field behaviour of failures	Geohazard	Investigate the influence of grain mineralogy and compressibility, sample preparation and shear strain level on the shearing behaviour of sands.	Laboratory Testing	USA
#2.34 Huvaj-Sarihan, Stark	Back-analyses of landfill slope failures	Slopes	Investigates the shear strength of municipal solid waste (MSW) using back analysis of failed waste slopes.	Lab Testing, Analysis	USA

#2.35 Kolev	Rehabilitation of Sliding Motorway Slopes on Deep Failure in Bulgaria	Slopes	Reports three case histories related to landslides on motorway routes in Bulgaria, caused by deep failure, underground water and increasing traffic.	Observations, Analyses	Bulgaria
#2.36 Itoh, Timpong, Toyosawa	Case history of Labor Accident due to Slope Failure during Slope Excavation and its Countermeasure Work	Slopes	Focuses on the influence of wall stiffness and embedded depths of sheet piles or pipes on the prevention of slope failure.	Centrifuge Modelling, Analysis	Japan
#2.37 Castelli, Lentini, Maugeri	Experimental and Numerical Analysis of the Behaviour of an Embankment Stabilized with Vertical Drains	Embankments	Settlement analysis of an embankment on soft soil for the construction of a reinforced concrete building in Catania.	Laboratory & In situ tests. Numerical analysis.	Italy
#2.43 Rogers, Watkins	Overview of the Taum Sauk Pumped Storage Power Plant Upper Reservoir Failure, Reynolds County, MO	Embankments	Reports the catastrophic failure of the upper reservoir of a storage powerplant.	Observation, Interpretation	USA
#2.45 Nelson	Investigation and Repair of a Leaking Earthfill Dam	Dams	Describes the investigation performed and the remedial measures undertaken to repair two leaking earthfill dams.	Observation, Forensic Investigation, Re-Design	USA
#2.47 Toyosawa, Timpong, Itoh	Lessons Learned from Slope and Trench Failures in Japan	Slopes	Presents case histories of slope and trench failures in Japan during the period of 1989 to 2001 based on the database from construction industrial labor accident reports.	Observations, Statistical Interpretation	Japan
#2.48 Timpong, Itoh, Toyosawa	Case History and Numerical Analysis of Trench Collapse in Japan	Slopes	Describes a trench collapse during excavation in soft ground.	Centrifuge modelling, Numerical analysis.	Japan
#2.50 Zhou, Tham, Li, To, Lee	Controlled Wetting Test of a Soil Nailed Loose Fill Slope: Case study	Slopes	Case study of the coupled hydro-mechanical response of a test slope during the recharge process with surcharge.	Instrumentati on, Monitoring, Numerical analysis.	Hong Kong
#2.52 Weltman, Yuan	Evaluation and stabilization of an embankment at Sebastopol, South Wales, UK	Embankments	Reports a slope and related railway track movement at Sebastopol, UK.	Monitoring, Site exploration, Numerical analysis	United Kingdom
#2.57 Tzenkov	Stability Analysis of a Tailings Dam: Existing State and Planned Heightening	Dams	Studies to determine the stability of a tailings dam for its existing state and for planned heightening.	Numerical analysis	Bulgaria
#2.61 Gehring, Q. and Luna, R.	Evaluation of the Taum Sauk Reservoir Failure	Dams	Presents theorized failure mechanisms for rock-fill dike/dam breeching failure	Root cause failure evaluation	USA

#2.62 Lee, S.H., Shin, B.W., Kumar, S., Shin, S.U.	A Case Study of Characteristics of Damages Caused by Typhoon Ewinar2006 in South Korea	Slopes	Documents damages to slopes along roadways and details the mechanisms causing damage (e.g. seepage)	Site investigation, Remediation methods	South Korea
#2.66 Fabius, M., Bo, M.W., Villegas, B.	Stability of a 30m High Riverbank in Canada with Nails, Plates, and Roots	Slopes	Describes stabilization of a waterfront slope emphasizing eco-friendly methods- use of low-impact methods and vegetation	Site investigation, Remediation methods	Canada
#2.69 Arunkumar, B.K., Shivashankar, R., Yaji, R.	Case Study of Landslide in NH-13 at Kethikal near Mangalore- India	Landslide	Describes development of a computer program for evaluation of factor of safety for slopes. Program is used to compute factor of safety for the NH-13 landslide.	Numerical Analysis	India
#2.70 Basudhar, P.K., Bhattacharya, G.	Predicted Versus Observed Failure Surface: A Case Study	Landslide	Describes development of a computer program for analysis of slopes. Program is checked against a documented case history	Numerical analysis	India
#2.71 Croce, P, Modoni, G.	Analysis of Dam Behaviour After Eighty Years of Service	Masonry Dam	Discusses the case of a masonry dam built in the 1920s that has experienced displacement and seepage. Presents finite element method to predict seepage and displacement	Instrumentation, Numerical analyses	Italy
#2.72 Kanning, W., Bears, S.V. Vrijling, J. K.	The Stability of Flood Defences on Permeable Soils: The London Avenue Canal Failures in New Orleans	Embankments	Presents forensic evidence from levee breach explaining mechanism causing failure in 2 breech locations	Analytical analyses,	USA
#2.73 Kwong, A.K.L., and Lee, C.F.	A Field Test Study on Instrumented Soil Nail Installed in Cut Slope	Slopes	Reports results of university research project where a slope was built with instrumented soil nails and the slope saturated to load the nails. Paper compares measured nail loads to predicted.	Construction of instrumented slope, Numerical analysis	Hong Kong
#2.77 Yazdani, M., Fadaee, M., Haghighet, A.E..	Application of Screening Analyses for the Stability of Landslide in Seymareh Dam Project	Landslides	Presents case of a landslide at site of hydropower dam. Presents analysis of remedial construction modelling earthquake loading with Southern California Earthquake Center methods.	Site investigation, Analytical analysis, Numerical Analysis	Iran
#2.78 Sadeghpour, A., Asgari, J., Mojezi, M.	Study of Instability Event of Rock Trench in Vanyar Dam Spillway	Slopes	Presents case of a slide in a 140m tall cut slope for a dam spillway. Presents finite element analysis of the failed slope.	Site Investigation, Analytical analysis,	Iran

#2.79 Papantonopoulos, C.I., Kloukinas, P.G., Mylonakis, G.E.	Stability Analysis of a 70m High Cut at an Ancient Landslide Area in Patras, Greece	Slopes	Presents case of a 70m tall cut slope for new highway construction within the zone of an ancient landslide. Presents finite element analysis to show need for remedial measures.	Site investigation, Analytical analysis	Greece
#2.82 Lobo-Guerrero, S., Fannin, N.W., Ulinski, J.G., Gutta, S.	Lessons Learned from the Performance of a Degradable Shale Embankment: Case Study	Embankments	Presents case involving settlement of embankments for highway bridges that show settlement exceeding predicted amount. Presents laboratory data showing change to particle size and loss of strength of the shale placed in the embankments.	Laboratory tests, Instrumentation,	USA
#2.83 Marques da Cunha V. Bello, M.I., Coutinho, R.Q., Gusma~o, A.D.	Failure of the Embankment on Soft Soil in Recife-Brazil	Embankments	Presents the case of sliding failure of an embankment 6m tall, built on soft clay soils. Presents slope stability back-analysis, focuses on correction to field vane shear results for determination of shear strength to use for analysis.	Laboratory tests, Monitoring, Remediation, Observational method	Brazil
#2.84 Jeon, KS., Kim, NY., Youn, HJ., Kim, NJ.	Rapid Recovery of Demolished Young-Dong Highway 205.4 km Due to Heavy Rain	Slopes	Presents the case of a highway slope along a major river that failed during heavy rain-evidently from scour at the toe from high river flow. Describes rapid temporary construction to restore the highway to service, and describes the permanent repair.	Analytical analysis, Remediation, Monitoring	South Korea
#2.85 Farrokhzad, F., JanAli-Zadeh A.	Geotechnical Schemes for Constructing Light Structures on Instable Slopes	Slopes	Use of trenches with perforated pipes as a drain system for stabilizing a clayey slope suffering from heavy rainfall (relation to paper #2.86)	Limit Equilibrium Slope Stability Computations	Iran
#2.86 Farrokhzad, F., JanAli-Zadeh A., Barari A.	Prediction of Slope Stability Using Artificial Neural Network (Case Study: Noabad, Mazandaran, Iran)	Slopes	Use of ANN for predicting the Factor of Safety and the location of the failure surface, after training with results from limit equilibrium computations (relation to paper #2.85)	Limit Equilibrium Slope Stability Computations – Training and performance of ANN	Iran

#2.88 Haeri S.M., Faghihi D.	Predicting Hydraulic Fracturing in Hyttejuvet Dam	Embankment Dams	FEM analyses are used for estimating the stress state at the end of construction throughout the dam and these results are used for predicting hydraulic fracturing upon first impounding based on established analytical criteria. The comparison shows that the foregoing criteria fail to predict the hydraulic fracturing reported in the case study, while their proposed criterion (minor principal stress plus the tensile strength of the core material being smaller than the pore pressure) is shown successful	FEM analyses for stress-strain response	Iran
#2.89 Zoorasna Z., Hamidi A., Ghanbari A.	Seepage through Different Concrete Cut Off Wall Connection Systems. Case Study: Karkheh Storage Dam	Embankment Dams	Parametric FEM analyses for 6 alternative concrete cut-off wall connection systems depict that the combination of cutoff wall penetration into the core with a concrete slab at its base is the most efficient system for reducing the maximum hydraulic gradient (relation to paper #2.90)	FEM analyses for seepage	Iran
#2.90 Zoorasna Z., Hamidi A., Ghanbari A.	Stress-Strain Analysis of Different Concrete Cut Off Wall Connection Systems. Case Study: Karkheh Storage Dam	Embankment Dams	Parametric FEM analyses for 6 alternative concrete cut-off wall connection systems depict that a thick concrete slab at the base of the core provides the smoother stress-strain distribution (relation to paper #2.89)	FEM analyses for stress-strain response	Iran
#2.91 Thamer A. M., Megat J.M.M.N., Huat B.B.K., Azlan A.A.	Assessment of Some Old Earth Dams in Malaysia through Observation and Computer Simulation	Embankment Dams	FEM analyses for simulating the flow through 2 old embankment dams show reasonable comparison with measurements of seepage rate and phreatic surface location	FEM analyses for seepage	Malaysia
#2.92 Goswami R. K., Singh B.	An Analysis of Causes of Urban Landslides in Residual Lateritic Soil	Slopes	Urban landslides in residual lateritic soil are attributed to groundwater rise, as well as to the distribution and orientation of rock joints	Engineering geological study	India
#2.93 Roy I.	Slope Stability Study of External Dump of Sonepur-Bazari Opencast Coal Mine, India – A Case Study	Embankments (of dump material)	Based on limit equilibrium analyses, the paper proposes a series of combinations of height and slope angle that provide a factor of safety 1.2 for embankments of dump material.	Limit Equilibrium Slope Stability Computations	India

#2.95 Sai R.S.T., Shukla S.K., Prasad G. M., Vishnoi R. K., Singhal S.	Initial Filling of Tehri Reservoir – Analysis of Seepage Data	Embankment Dams	Analysis of seepage related dam instrumentation data during initial reservoir filling indicate good performance of the core and grout curtain	Analysis of dam instrumentation data	India
#2.96 Jamnogpipatku l P., Chupanit P.	Repair of a Failed Slope Using Geogrid Reinforcement	Slopes	A FEM model of a geogrid reinforced failed slope is calibrated on the basis of insitu measured response (via inclinometers, piezometers etc) and then used for estimating the effects of groundwater table rise and reduction of geogrid length.	FEM analysis for stress-strain response – Insitu Monitoring data	Thailand
#2.97 Ram A. S., Goyal S. P.	Pit Slope Failure Problems in Goan Iron Ore Mines, Goa, India	Slopes (of pits)	Description of slope stability failures (of open pits as high as 100m) in terms of geologic features and their relation to variation of water pressure, surface erosion etc	Engineering geological study	India
#2.98 Sai R.S.T., Shukla S.K., Prasad G.M., Vishnoi R.K., Routela T.S.	Integrated Approach for Stabilization of Varunavat Parvat Landslide – A Case Study	Slopes	A massive landslide is presented in full detail and back-analyzed to estimate the critical strength parameters. The paper also presents the stabilization measures that were implemented on the basis of engineering judgment and numerical analyses	FEM analysis for stress-strain response – Discontinuous analysis of rock joints – Stabilization measures	India

ACKNOWLEDGEMENTS

I would like to thank the Organizing Committee and particularly Dr. Shamsher Prakash for inviting me to serve as General Reporter for Session II.