

Slope Stability Engineering

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VOLUME 2



A.A. BALKEMA/ROTTERDAM/BROOKFIELD/1999

Table of contents

6 Design strength parameters

Undrained flow and instability of anisotropically consolidated sand <i>Y.Tsukamoto, K.Ishihara, S.Nakayama & Y.Nosaka</i>	675
Model test on granular soil slope and determination of strength parameters under low confining stresses near slope surface <i>H.Matsuoka, S.H.Liu & T.Obashi</i>	681
Determination of shear strength parameters of unsaturated sedimentary residual soils for slope stability analyses <i>S.Mariappan, F.H.Ali & L.T.Huat</i>	687
The characteristics of landslides caused by the hydrothermal metamorphic clay <i>H.Yamashita, M.Saga, H.Fujita, K.Yokota & R.Yatabe</i>	693
Influence of clay minerals on strength characteristics of landslide clay in Mikabu <i>T.Ishii, R.Yatabe, N.Yagi & K.Yokota</i>	697
Strength of landslide clay from mineralogical point of view <i>N.Yagi, R.Yatabe, K.Yokota & N.P.Bhandary</i>	701
Role of soil composition on collapsible behavior of natural and stabilized slopes <i>V.R.Ouhadi</i>	705
Deformation characteristics of a compacted clay in wetting tests under isotropic and triaxial stress state <i>S.Kato & K.Kawai</i>	709
Development of an automatic cyclic direct shear test apparatus for landslide slope stability analysis <i>M.Okawara, T.Mitachi & M.Tanada</i>	715
Strength and deformation characteristics of clay subjected to pore water pressure increment <i>T.Umezaki, M.Suzuki & T.Yamamoto</i>	721
Parameters for curvilinear residual strength envelope <i>S.Gibo & S.Nakamura</i>	727
Pore water pressure loading tests of a clay <i>S.Ohtsuka, Y.Miyata & H.Toyota</i>	731

Shear behavior of clay subjected to change of normal stress <i>M.Suzuki, T.Umezaki & T.Yamamoto</i>	735
A simple model to predict pore water pressures during shearing along undulating surfaces <i>D.J.Petley & P.Taylor</i>	741
Modelling rapid shearing of cohesive soils along undulating shear surfaces <i>D.J.Petley & P.Taylor</i>	745
Apparent cohesion of unsaturated soils as correlated with suction <i>Y.Huang & K.Ishihara</i>	751
Unconfined compression shear strength of an unsaturated silty soil subjected to high total suctions <i>T.Nishimura & D.G.Fredlund</i>	757
Shear strength mobilization in shear box test under constant volume <i>I.Kobayashi, A.Iizuka, H.Ohta & M.Hirata</i>	763
Undrained shear strength of unsaturated compacted clays <i>V.Sivakumar & I.G.Doran</i>	769
Landslide at Malakasa, Greece: Investigation, analysis, remedial works <i>R.J.Chandler & S.Schima</i>	775
Method for determining design strength parameters for slope stability analysis <i>T.Mitachi, M.Okawara & T.Kawaguchi</i>	781
Evaluation of the shear strength for stability analysis of a heavily weathered tertiary rock <i>K.Tsuji, K.Suzuki & H.Hanzawa</i>	787
Effect of degradation on the strength of rock <i>A.Kobayashi, K.Yamamoto & K.Fujii</i>	793
Some considerations of Patton model on rock joint shear strength <i>M.Doi & S.Ohtsuka</i>	799
Behavior of jointed model material under biaxial compression <i>A.K.Tyagi, K.S.Rao & A.S.Gupta</i>	805
 7 Slope stability of landfills and waste materials	
Stability of slopes of hydraulic-fill dams <i>A.Zh.Zhusupbekov, A.S.Zhakulin & M.R.Nurguzhin</i>	811
Stability of embankment dams based on minimum-experience of safety factor <i>T.Morii, K.Shimada & T.Hasegawa</i>	817
Stability of embankment using foam composite lightweight soil <i>Y.Watanabe & T.Kaino</i>	823
Slope stability of embankment model composed of municipal bottom ash: Centrifuge model tests and FDM analysis <i>K.Gotoh, M.Yamanaka, T.Ikuta & T.Ogawa</i>	827

Comparison of deformation of a fill with results from a new elastoplastic method <i>T.Harada, A.Mochizuki & T.Kaneda</i>	831
Evaluation of slope stability incorporating pre-compression characteristics of cohesive soils <i>M.Yamaguchi, K.Narita & Y.Ohne</i>	837
Earth pressure acting on the side of core block in high embankment <i>K.Nomoto, T.Sugimoto & T.Fujiwara</i>	841
Case study of a liquefiable mine tailing sand deposit <i>W.Wehr, I.Herle, P.Kudella & G.Gudehus</i>	847
Bilinear model for stability calculation of domestic waste landfills <i>G.Ziehmman</i>	853
The stabilization of frozen technogenic dumps <i>V.I.Grebenets, S.N.Titkov, A.G.-o.Kerimov & V.M.Anishin</i>	859
Stability of MSW mass: Use of an improved limit equilibrium analysis <i>A.Bouazza & I.B.Donald</i>	863
Stability of bentonite wall by the unified method of molecular dynamics and homogenization analysis <i>Y.Ichikawa, K.Kawamura, M.Nakano, T.Seiki & T.Nattavut</i>	869
 8 Stabilization and remedial works	
Model tests of a new deep pile system for landslide prevention at Kamenose landslide area <i>K.Nishiyama, S.Tochimoto, H.Fujita, S.Kinoshita, S.Sakajo, M.Ohno, K.Ugai & M.Kimura</i>	877
Stability of slope reinforced with piles <i>F.Cai & K.Ugai</i>	883
Numerical study of landslide of bridge abutment in Surabaya, Indonesia <i>V.Tandjiria</i>	889
Application of FEM as a design method for slope stability and landslide prevention pile work <i>M.Gotoh & Y.Ohnishi</i>	895
Design and constructional aspects of an anchored slope and gabion revetment system <i>M.H.Kabir & A.M.Hamid</i>	901
Evaluation of pull-out capacity of repeat-grouting type ground anchor by in-situ and laboratory tests <i>H.Wada, H.Ochiai, K.Omine & Y.Maeda</i>	907
Design and observation of the prevention works for crystalline schist slope <i>N.Shintani, K.Kawahara, A.Ueda, K.Oka & T.Yamamoto</i>	913
Case study on slips in soft laterite cut-slopes on BG rail link in Southern Peninsular India <i>V.K.Jain & K.Keshav</i>	919
Hydrodynamic seeding with the use of sewage sludge and fly-ash for slope protection <i>M.Głazewski & J.Kalotka</i>	925
Investigation and stabilization of a sliding hillside <i>J.Farkas</i>	931

Stability reinforcement of the old embankment sanitary landfills for remediation works <i>E. Koda</i>	937
Stabilization and remedial works on some failed slopes along the East-West highway, Malaysia <i>A. Jamaludin & A. N. Hussein</i>	943
Landslide controlling measures at construction sites nearby King's palace at Narendra Nagar <i>D. Mukherjee, K. Kishor & O. P. Yadav</i>	949
Reduction of land cutting effects by the application of lightweight embankments <i>J. Nakano, H. Miki, H. Kohashi & A. Fujii</i>	955
Relaxation effect in retaining wall on passive mode <i>Erizal, T. Sakai & S. Miyauchi</i>	959
Stabilization and geoenvironmental restoration of the main central channel in the Fucino plain, Italy – A case history <i>G. Totani, P. Monaco, M. Leopardi, A. Farroni & A. R. Spena</i>	965
Slope stabilization in residual soils of Peru <i>A. Carrillo-Gil & A. Carrillo-Acevedo</i>	971
Case study of a cut slope failure in diatom earth <i>A. Yashima, H. Shigematsu, S. Okuzono & M. Nishio</i>	977
9 Stability of reinforced slopes	
Centrifuge model testing of reinforced soil slopes in the perspective of Kanto Loam <i>G. Pokharel, A. Fujii & H. Miki</i>	985
Dynamic behavior of vertical geogrid-reinforced soil during earthquake <i>A. Takahashi, J. Takemura & J. Izawa</i>	991
Model tests on some geosynthetics-reinforced steep earth fills <i>Y. Tanabashi, T. Hirai, J. Noshimura, K. Yasuhara & K. Suyama</i>	997
Field behavior of a reinforced steep slope with a cohesive residual soil backfill <i>A. Kasa, F. H. Ali & Z. Chik</i>	1003
Full-scale model test on deformation of reinforced steep slopes <i>T. Nagayoshi, S. Tayama, K. Ogata & M. Tada</i>	1009
Relation between wall displacement and optimum amount of reinforcements on the reinforced retaining wall <i>K. Okabayashi & M. Kawamura</i>	1015
Stability analysis of reinforced slopes using a strain-based FEM <i>T. Matsui, K. C. San & A. Porbaha</i>	1021
Numerical analysis on the stability of GHD-reinforced clay embankment <i>M. Kamon, M. Mimura, N. Takeo & T. Akai</i>	1027
New design method of composite fabrics – Reinforced earth fill <i>Y. Tanabashi, N. Wakuda, K. Suyama, K. Yasuhara, T. Hirai & J. Nishimura</i>	1033

Design method for steel grid reinforced earth structure considering bearing resistance <i>T. Matsui, Y. Nabeshima, S. G. Zhou & N. Ogawa</i>	1039
A promising approach for progressive failure analysis of reinforced slopes <i>T. Yamagami, S. Yamabe, J.-C. Jiang & Y. A. Khan</i>	1043
3-D stability analyses for asymmetrical and heterogeneous nailed slopes <i>C. C. Huang, C. C. Tsai & M. Tateyama</i>	1049
Numerical analysis of reinforced soil slopes under working stress conditions <i>B. T. Dantas & M. Ehrlich</i>	1055
Design method of vertical reinforced slopes under rotational failure mechanism <i>X. Q. Yang, S. X. He & Z. D. Liu</i>	1061
Reinforcement mechanism in soil nailing for stabilization of steep slopes <i>T. Nishigata & K. Nishida</i>	1065
The study of direct shear tests of woven geotextiles with granular soils <i>M. Matys, T. Ayele & S. Hric</i>	1071
10 Probabilistic slope stability	
Localized probabilistic site characterization in geotechnical engineering <i>S. Pumjan & D. S. Young</i>	1079
A localized probabilistic approach for slope stability analysis <i>D. S. Young & S. Pumjan</i>	1085
Probabilistic analysis of structured rock/soil slopes – Several methods compared <i>D. Xu & R. Chowdhury</i>	1089
Reliability analysis and risk evaluation of the slopes of open pit mine <i>Q. Yang, J. Jiao, M. Luan & D. Shi</i>	1095
Risk evaluation for slope failure based on geographical information data <i>Y. Kitazono, A. Suzuki, N. Nakasone & T. Terazono</i>	1101
Gray system evaluation for slope stability engineering <i>H.-C. Wu, T. Bao, X.-B. Zhang & X. Hu</i>	1105
Statistical variability of ring shear test results on a shear zone in London Clay <i>E. N. Bromhead, A. J. Harris & M.-L. Ibsen</i>	1109
Overall stability of anchored retaining walls with the probabilistic method <i>L. Belabed</i>	1115
11 Landslide investigations	
Methodological study of judgement on landslide occurrence <i>M.-B. Su, L.-C. Chan & G.-S. Lee</i>	1123
The retrogressive slide at Nipigon River, Ontario, Canada <i>K. T. Law & C. F. Lee</i>	1129

Simplified model for estimating a scale of sliding debris <i>M.Fukuda & S.Suwa</i>	1135	Investigation of landslide damage in Korea, 1998 <i>D.Park, K.Oh & B.Park</i>	1233
Landslide prediction using nonlinear dynamics model based on state variable friction law <i>K.T.Chau</i>	1139	Monitoring of the Vallcebre landslide, Eastern Pyrenees, Spain <i>J.Corominas, J.Moya, A.Ledesma, J.Rius, J.A.Gili & A.Lloret</i>	1239
Characteristic weathering profiles as basic causes of shallow landslides <i>M.Chigira & E.Ito</i>	1145	12 <i>Landslide inventory, landslide hazard zonation and rockfall</i>	
Long-term movements of an earthflow in tectonised clay shales <i>L.Picarelli, C.Russo & A.Mandolini</i>	1151	Disaster prevention and sustainable development in Central America <i>S.Mora</i>	1247
Characteristics of groundwater quality in fracture zone landslides at Shikoku area <i>F.Nishimura, R.Yatabe, N.Yagi, K.Yokota & T.Shibata</i>	1159	Preliminary landslide hazard mapping along a hill road in western Nepal <i>B.P.Mainalee, N.Morishima & H.Fujimura</i>	1253
Use of H ₂ O(+) for landslide investigations and mapping <i>U.de S.Jayawardena, E.Izawa & K.Watanabe</i>	1165	Hazard evaluation of landslide in Iran <i>G.R.Lashkaripour</i>	1259
The mechanism of creep movement caused by landslide activity and underground erosion in crystalline schist, Zentoku, Shikoku, Japan <i>G.Furuya, K.Sassa, H.Hiura & H.Fukuoka</i>	1169	Zonation of areas susceptible to rain-induced embankment failure in Japan railways <i>K.Okada, T.Sugiyama, H.Muraishi & T.Noguchi</i>	1263
Mechanism of large-scale collapse at Tue Valley in the Shikoku mountainous region, Japan <i>F.Ochiai, H.Sokobiki, T.Noro & S.Nakayama</i>	1175	An estimation of slope failures based on erosion front and weathering front <i>H.Inagaki & T.Yunohara</i>	1269
Causes and mechanisms of slope instability in Dessie town, Ethiopia <i>L.Ayalew & A.Vernier</i>	1181	Typical case study on destabilization and genetic mechanism of urban slopes in China <i>Y.Liu, F.Niu & Z.Cheng</i>	1275
Structural deterioration of residual soils and the effect on landslides <i>J.Suárez</i>	1187	Estimation of the slope failure using remote sensing data <i>S.Shima & H.Yoshikuni</i>	1281
Study of a huge block slide with relevance to failure mechanism <i>I.Lazányi, I.Kabai & B.Vizi</i>	1193	Application of hazard and risk maps for highway slopes management and maintenance <i>Y.A.O.Fiener & F.H.Ali</i>	1287
Landslide clay behavior and countermeasures works at the fractured zone of Median Tectonic Line <i>R.Yatabe, N.Yagi, K.Yokota & N.P.Bhandary</i>	1199	Application of hazard and risk mapping to a mountainous highway in Malaysia <i>A.Jamaludin, Z.Muda, S.Alias & N.M.Yusof</i>	1291
Geological and soil mechanical study of Sawatari landslide in Ehime <i>H.Kono, M.Tani, R.Yatabe, N.Yagi & K.Yokota</i>	1203	A landslide risk assessment in a hydropower plant area <i>D.Paunescu & D.Deacu</i>	1297
The general characteristics of landslide along the Median Tectonic Line due to the road construction <i>Y.Momiyama, K.Kumano, M.Tanaka & T.Ishii</i>	1207	Applications of quantitative landslide risk assessment in Hong Kong <i>C.K.M.Wong & C.K.T.Lee</i>	1303
An investigation on the stability of two adjacent slope movements <i>G.Gottardi & L.Tonni</i>	1211	Landslide risk assessment – Development of a hazard-consequence approach <i>C.K.Ko, P.Flentje & R.Chowdhury</i>	1309
Evaluation of stream-like landslide activity based on the monitoring results <i>L.Petro, P.Wagner & E.Polaščinová</i>	1217	Data-bases and the management of landslides <i>R.M.Faure</i>	1317
Snow induced landslides in Japan <i>T.Ito</i>	1223	Seismicity in the development of the geological process in the Republic of Tajikistan <i>S.Vinnichenko</i>	1331
Physical properties of clay from landslides in large fracture zones <i>N.Ogita, Y.Kito, T.Kimizu & R.Yatabe</i>	1229	Evaluating rockfall hazard from carbonate slopes in the Sele Valley, Southern Italy <i>M.Parise</i>	1337
		Effect of soil slope gradient on motion of rockfall <i>S.Kawahara & T.Muro</i>	1343

Study of accidents caused by rockfall in Kochi Prefecture <i>T.Ushiro, Y.Matsumoto, N.Akesaka & N.Yagi</i>	1349
The coefficient of restitution for boulders falling onto soil slopes with various values of dry density and water content <i>K.T.Chau, J.J.Wu, R.H.C.Wong & C.F.Lee</i>	1355
The May 5th 1998 landsliding event in Campania, Southern Italy: Inventory of slope movements in the Quindici area <i>D.Calcaterra, M.Parise, B.Palma & L.Peella</i>	1361
13 Simulation and analysis of debris flow	
A proposed methodology for rock avalanche analysis <i>R.Couture, S.G.Evans, J.Locat, J.Hadjigeorgiou & P.Antoine</i>	1369
The Otari debris flow disaster occurred in December 1996 <i>H.Kawakami, H.Suwa, H.Marui, O.Sato & K.Izumi</i>	1379
Dimensional analysis of a flume design for laboratory debris flow simulation <i>L.C.P.Chan & K.T.Chau</i>	1385
Shear characteristics at the occurrence and motion of debris flow <i>Y.Yamashita, N.Yagi, R.Yatabe & K.Yokota</i>	1391
Three-dimensional numerical modeling of muddy debris flows <i>H.Chen & C.F.Lee</i>	1397
Mechanism of soil deformations during the displacements of flow slides <i>O.V.Zerkal & V.N.Sokolov</i>	1403
Author index	1409

6 Design strength parameters

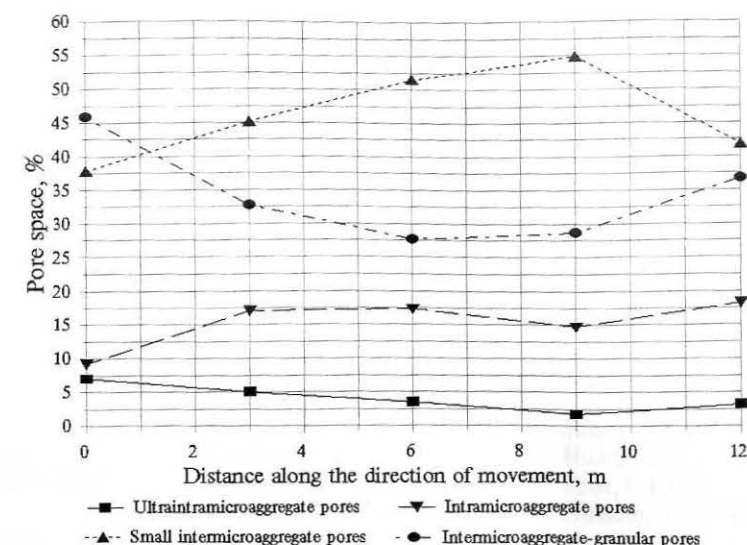


Fig. 4. Transformation of the pore space of soils during flow slide displacement.

practically not followed by sufficient changes of the degree of structural elements orientation ($K_a=1.2-9.5\%$). The highest orientation of the structural elements is observed in the zone of landslide movement, and the lowest - in the zone of accumulation. As a whole the microstructure of all the samples can be classified as medium or low oriented types.

4 CONCLUSION

The studied changes in the soil microstructure during the formation and development of flow slides confirmed, that the process of initiation and displacement of landslide is followed by a sufficient reconstruction of the soil microstructure. The start of deformation is marked by the more intensive alteration in the distribution of the different categories of micropores in pore space, which can be considered as one of the criteria of the beginning of slope displacements.

The very displacement of a landslide appears to begin from the formation of the aggregates. The movement of a flow slide is a relative "rolling", slipping of aggregates. One of the causes of the observed landslide deposits consolidation is the redistribution and denser "packing" of aggregates, having an angular shape in the foot of a landslide which changes to the "rounded particle" one with the landslide movement.

The study of soil microstructure may improve the reliability and the quality of the landslide hazard forecast if included into the complex of investiga-

tions for stability of landslide slopes evaluation.

5 REFERENCES

- Sokolov V.N., Kuzmin V.A. 1993 The application of the SEM images processing for estimation of the capacity and filtration properties of oil and gas contained rock. *Bull. of RAS. Physics.*, 57(8):94-98.
- Sokolov V.N., Yurkovetsh D.I., Razgulina O.V. & Melnik V.N. 1997. A method of qualitative analysis of the microstructure of solids on SEM images. *Zavodskaya laboratoriya (materials diagnostics)*. 9: (in Russian).
- Tsaryova A.M. 1985. Classification of rock textures, forming in the landslide displacement zone. *Investigation of the development mechanism of exogenic geological processes and their causing factors*. VSEGINGEO: 45-52 (in Russian).
- Zerkal O.V. 1994. Seismic landslides caused by Gissar earthquake in 1989 (Tajikistan). *Geological Bull.*, 49(2): 57-63.
- Zerkal O.V. & Sokolov V.N. 1995. Changes in the microstructure of silt loams during the formation of seismogenic liquefaction slides. *Geological Bull.*, 50(6): 59-64.
- Zerkal O.V. 1996. Mechanism of formation and development of deep seismogenous landslides due sudden liquefaction of loessal soils. *Landslides. Proc. of the Seventh Internat. Symp. on Landslides*. v.2: 1055-1060.