ISSMGE - TC201

Geotechnical Aspects of Dikes and Levees

Newsletter July 2019

Dear TC member,

This is the seventeenth newsletter of the ISSMGE Technical Committee 201: geotechnical aspects of dikes and levees. The intention of the newsletter is to keep all members informed on coming activities of our TC and the ISSMGE.

Cor Zwanenburg (Chairman TC201)
Martin Pohl (Secretary TC201)

1. News from TC members

To improve the understanding of the interests of the TC201 members, members are encouraged to send in a description of projects they are working on. For this newsletter Dr Hendra Jitno and Dr Jeff Wang have provided a short description of the interesting projects they are working on, see attachment to this newsletter. The project descriptions show the wide range of activities contained by TC201 as Dr Jeff Wang, working at the city university of Hong Kong, describes his fundamental research on liquefaction while Dr Hendra Jitno, working at the National Technological Institute, Bandung, Indonesia, describes the work on construction of embankments retaining volcanic mud.

2. TC201 Workshop during the 17th ECSMGE 2019

TC201 has been given the opportunity to organize a workshop in advance of the Reykjavik conference.

The workshop will be held on Sunday September 1st 13:00 – 16:00 h, location Harpa. We have the following programme:

13:00 – 13:45 Ulrich Föster:
Large scale experiments with a coarse sand barrier as part of a multi-scale investigation of a novel remediation technique against backward erosion piping.
13:45 – 14:30 Rémy Tourment:
Levees breaching scenarios and the different deterioration/damage mechanisms; link with failure modes analysis and risk analysis.
Levee and dike survey using drones: the DIDRO project.
14:30 – 15:15 Joost Breedeveld:
The impact of the Eemdijk full-scale field test programme
15:15 – 16:00 Jonathan Black:
Internal erosion of earth flood embankments

We hope to meet you at the workshop.

3. TC201 Session in the 17th ECSMGE 2019

During the 17th European Conference on Soil Mechanics and Geotechnical Engineering, ECSMGE, Reykjavik, TC201 will organize a session on dikes and levees. The organizing committee received about 37 papers that by the authors themselves were indicated to fall in the TC201 interest. We are very pleased with this number of papers.

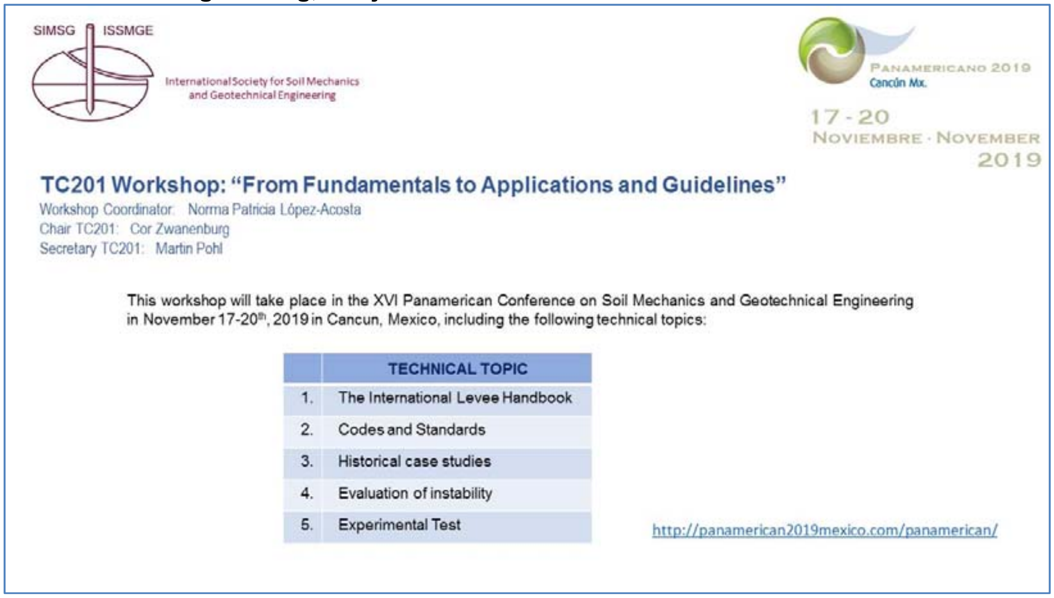
4. Committee meeting 2019

The next committee meeting will be held during the 17th European conference on Soil Mechanics and Geotechnical Engineering, ECSMGE, Reykjavik, http://www.ecsmge-2019.com/.

The meeting will be on Monday, 2 September 2019, starting at 18:15, first floor Harpa building.

If you have suggestions for agenda items, please contact cor.zwanenurg@deltares.nl

5. TC201 Workshop during the 16th Pan American Conference on Soil Mechanics and Geotechnical Engineering, Canjun November 2019


SIMSG ISSMGE
International Society for Soil Mechanics and Geotechnical Engineering

PANAMERICANO 2019
Cancún Mx.
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NOVIEMBRE · NOVEMBER
2019

TC201 Workshop: "From Fundamentals to Applications and Guidelines"

Workshop Coordinator: Norma Patricia López-Acosta
Chair TC201: Cor Zwanenburg
Secretary TC201: Martin Pohl

This workshop will take place in the XVI Panamerican Conference on Soil Mechanics and Geotechnical Engineering in November 17-20th, 2019 in Cancun, Mexico, including the following technical topics:

	TECHNICAL TOPIC
1.	The International Levee Handbook
2.	Codes and Standards
3.	Historical case studies
4.	Evaluation of instability
5.	Experimental Test

http://panamerican2019mexico.com/panamerican/

TC201 will organize a workshop during the XVIth Panamerican conference on Soil Mechanics and Geotechnical Engineering. The workshop will be hold on Wednesday November 20th from 14:45 – 16:15. The workshop is concentrated around five topics:

- The international levee handbook
- Codes and Standards
- Historical case studies
- Evaluation and of instability
- Experimental test

For further information you can contact our fellow member Norma Patricia López-Acosta (nlopeza@iingen.unam.mx)

6. Initiative on joined document on failure paths for water retaining structures
TC201 initiates an initiative to create a joined document on failure paths for water retaining structures. The writing of this document is due for 2020. So, we have the possibility to introduce it during the ICSMGE in Sydney in 2021, in which we intend to organize a workshop and / or a session. If you are interested to join this initiative or if you have further questions, please contact me by e-mail; cor.zwanenburg@deltares.nl.

Regarding safety against flooding, dikes and levees exhibit different failure paths to reach inundation of the land which it protects. Generally, the occurrence of a single failure mechanism does not directly result in flooding and the dike or levee shows some residual strength. The residual strength can be endangered by a failure mechanism, different from the initial mechanism. In such a way, the succession of different failure mechanisms results in ultimate failure of the water retaining system. Typically, the condition of a dike is tested separately for the individual failure mechanisms and residual strength is not or hardly considered.

Considering residual strength would further improve the understanding of safety against flooding. It would for example provide insight in the possibilities for evacuation and thus reduce the consequences of flooding. When sufficient insight in residual strength is gathered, dike design can be adjusted to optimize residual strength and provide optimal time to take action during design load conditions in order to reduce the consequences of flooding.

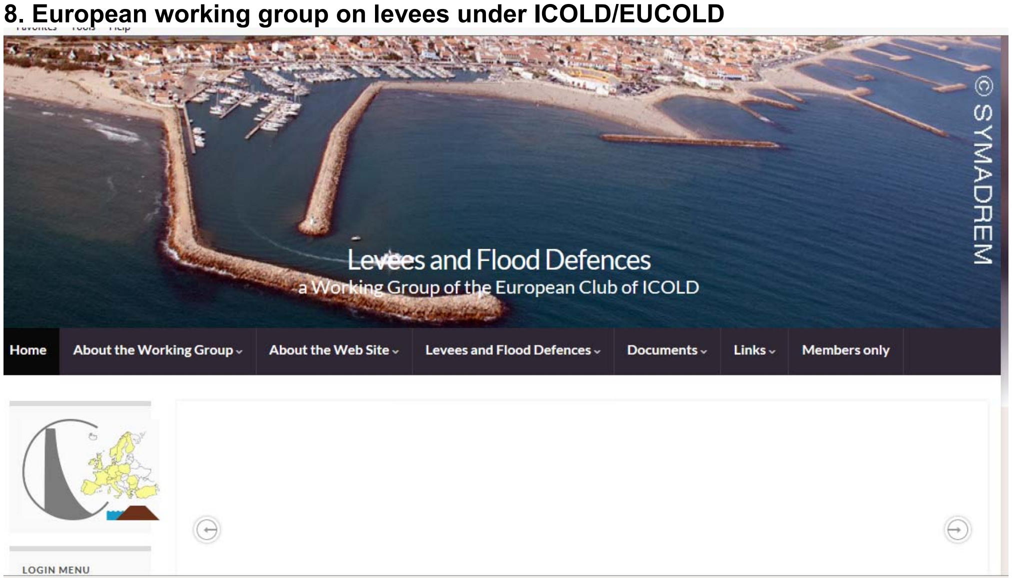
Within TC201 we would like to produce a document which makes an inventory of the different failure paths for the different failure mechanisms and makes a start on how residual strength could be assessed and taken in taken into account when establishing the safety of existing dikes or dike design. This document could be considered as an addition to the international levee handbook, IHL.

7. Initiative for setting up course on water retaining structures
The ISSMGE website contains webinars on geotechnical and geo-engineering topics. Recently these lectures have been grouped to form courses, see https://www.issmge.org/education/virtual-university

TC201 has taken the initiative to set-up a course on water retaining structures. A course should contain at least to 4 to 5 webinars. Each webinar should have a duration of approximately 45 minutes. The idea is to have one general webinar on dikes and levees including nomenclature, safety standards, general overview of failure mechanisms, design guidelines etc. The other webinars should discuss the state-of-the-art knowledge on the individual failure mechanisms.

The webinars will be produced at the first and second quarter of 2020. The course (the complete set of webinars) is intended to be launched during the summer of 2020. TC-members who are interested to join the development of the webinars are encouraged to contact cor.zwanenburg@deltares.nl.

8. European working group on levees under ICOLD/EUCOLD



The ICOLD/EUCOLD levees group is finalizing a report on the levee situation in USA and Europe. The ICOLD/EUCOLD levees group is also active on a dam – levee comparison with a workshop in Paris, 12-13 February. This report will be, with the levees situation report, a major basis for future activities on levees in ICOLD.

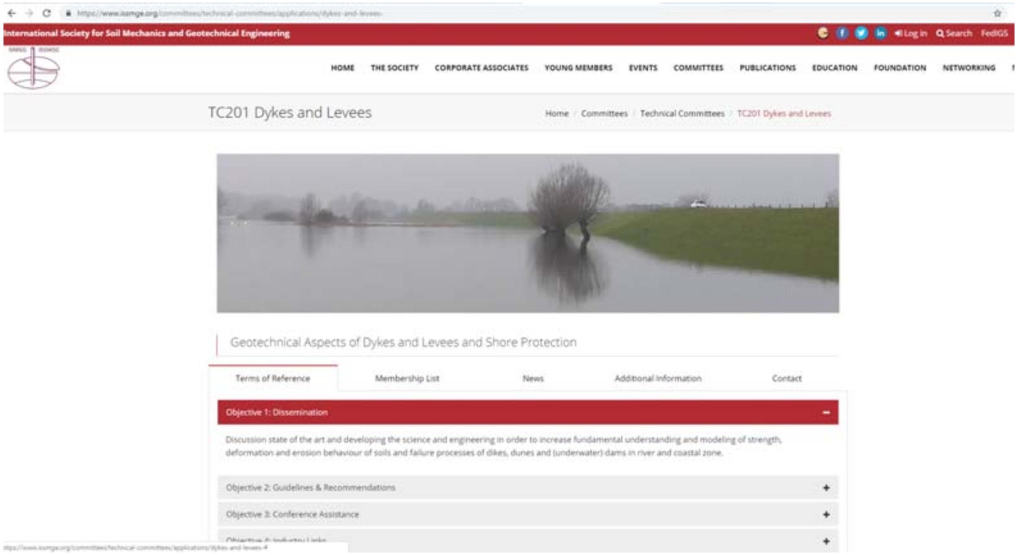
The ICOLD/EUCOLD levees group is organizing two events this year:

2-4 Oct 2019, European Club Symposium Crete, preliminary symposium themes: Topic A. Dam Safety and Risk Management. Social impact and awareness; Topic B. Dams to address Climate change issues; Topic C. European directives on dams and the water sector; Topic D. Managing ageing infrastructure; Topic E. Dam monitoring /surveillance and rehabilitation; Topic F. Advances in dam engineering. https://www.eurcold2019.com

9-14 June 2019, ICOLD Annual Meeting 2019 Ottawa, abstract deadline is 15/9/2018, Conference Theme is “Safety and Environment for Global Benefit”. http://icold-cigb2019.ca/

All TC members are invited to join the above mentioned events. Our colleague and TC201 member Rémy Tourment is actively joining EUCOLD and can be reached for questions and suggestions (remy.tourment@irstea.fr)

9. ISSMGE website



The ISSMGE has launched a new website. It provides a lot of useful information and is really worth visiting. However, for TC201 still little content can be found, (https://www.issmge.org/committees/technical-committees/applications/dykes-and-levees-) . We will be working on further improvement of the TC201 page. Members are encouraged to come forward with ideas and relevant content.

The archived webinars can be found on http://www.issmge.org/media/recorded-webinars
The TC members are encouraged to further promote watching the webinars.

10. Next Newsletter
The next newsletter will be sent in December. Please provide all available information, like TC related publications, news, research, to the secretary Martin Pohl, martin.pohl@baw.de.

1. (a) Contributions by TC members: Jeff Wang

The critical state soil mechanics (CSSM) is the most important foundation of the modern soil mechanics. This theory is suitable for almost all kinds of soils (e.g., sands, silts, and clays) and all shearing conditions (both drained and undrained). Many scientific problems, such as grain breakage, anisotropy fabric, unsaturated mechanics, particle shape effects, fines effects and special soil materials have been studied to explore the grain-scale soil mechanics within the framework of CSSM. Unfortunately, the excess pore water pressure is not involved in the existing framework of CSSM. While the pore water pressure is known to be a main cause for a wide range of natural and engineering disasters in geotechnical, earthquake, landslide, and levee and dike engineering, there is a lack of an understanding of the role of the excess pore water pressure in the undrained shearing and dynamic liquefaction process of sands within the CSSM framework.

This project aims to carry out a comprehensive investigation into the static and dynamic liquefaction behaviour of saturated sands using both conventional triaxial element tests and advanced synchrotron X-ray computed tomography. The former approach will allow us to collect accurate measurements of stress, strain and excess pore water pressure within the specimen and gain a new understanding of the relationship between the excess pore water pressure development, undrained shear failure, dynamic liquefaction and critical state behaviour of sands; while the latter approach will allow us to gain novel insights into the grain-scale processes and mechanism underlying the macroscopic phenomenon of soil liquefaction. To date, a significant progress has been achieved in the CT investigation of the sand particle breakage, particle morphology and microstructure and their mathematical and numerical modelling [1-12]. These works have laid down a solid foundation for the exploration of micromechanics of sand liquefaction which is vital for the engineering study and practice of dikes and levees.

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1. (b) Contributions by TC members: Hendra Jitno

LUSI Embankment in Sidoarjo, East Java, Indonesia

Hendra Jitno[1] and Abdul Hakim[2]

One of the most notable and ongoing levee projects in Indonesia is the LUSI Levee project in the city of Sidoarjo, East Java. The levee was constructed to protect the surrounding areas from the hot mud volcano which was unexpectedly erupted in 29 May 2006, two days after a major earthquake hit the regional area. On the 27th of May 2006 at 5:54 local time a M6.3 earthquake struck the southern part of the island of Central Java followed by two aftershocks measuring M4.8 and M4.6 occurring respectively 4 and 6 h later (U.S. Geological Survey, 2006). The epicentre was located at ~25 km SW of Yogyakarta, or about 280 km from the site. Based on the regional seismic profiles and field observations, the LUSI site is situated on the regional fault which is partly buried by alluvial sediments. Several researchers believe that the mud eruption was triggered by drilling operation at the adjacent area (Tingay et al, 2015). However, field evidences showed that there were some movement detected along this fault related to the earthquakes and this fault movement may partially cause mud volcano eruption (Mazzini et al, 2007). Numerical analyses carried out Lupi et al (2013) also indicated that energy concentrations in the mud layer would have been sufficient to liquefy the mud source and reactivate the adjacent Watukosek Fault, which connects hydraulically to a deep hydrothermal system that continues to feed the mud eruption.
The mud volcano site was named LUSI (derived from LUmpur-SIdoarjo – Lumpur means mud), and the area covered by the mud flows reached more than 630 hectares in May 2007. Approximately 8800 families (~ 30,000 people) have been displaced despite the network of dams continuously built to contain the mud.

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Aerial view of the LUSI mud volcano in Sidoarjo, East Java.

As soon as after the eruption, embankment dam was constructed surrounding the LUSI mud volcano to manage and stop the hot mud flowing all over the area. The hot mud flow was diverted and discharged toward the nearby Porong river. Due to the time constraints, the embankment dams were not designed properly and only constructed from available materials on site. No compaction quality control was carried out and as such the quality of the embankment in terms of the strength is highly questioned. To make things worse, the site is located on weak ground with only few meters of stiff clayey silt underlain by soft to firm clayey-silt and silty clay layers up to depth of 30 m as shown below (Agustawijaya and Sukandi, 2012). As expected, several failures occurred at some locations due to either bearing capacity problems or over-steep slopes.

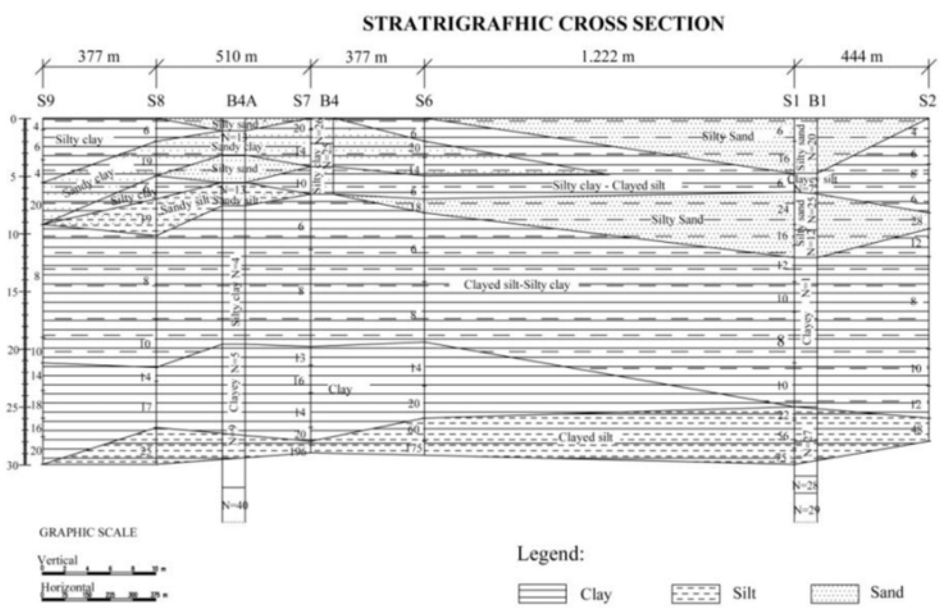

Figure 1. Typical geotechnical profile beneath the LUSI embankment. Numbers at each investigation hole indicates SPT N values.

The embankment was constructed in five stages. The first stage was constructed with the dam crest at elevation of +5.0m from mean sea level (MSL) and the mud levels of +1.2 m from the mean sea level, leaving about 2.8m freeboard. This stage was constructed to temporarily hold the hot mud within the ponds and comprised of inner and outer embankments. The inner dam was built to contain the mud while the bigger outer dam was constructed.
The elevation of the dams was increased in stages with the increase of mud level with crest level reaching elevation +11.0 m from the MSL at stage 5 (Figure 1). At this stage, due to limited available space downstream of the embankment along the railway and main road from Sidoarjo to Surabaya, gabion wall must be constructed to replace the stabilising berms. Typical cross section at one of the critical area along the embankment is shown in Figure 1.

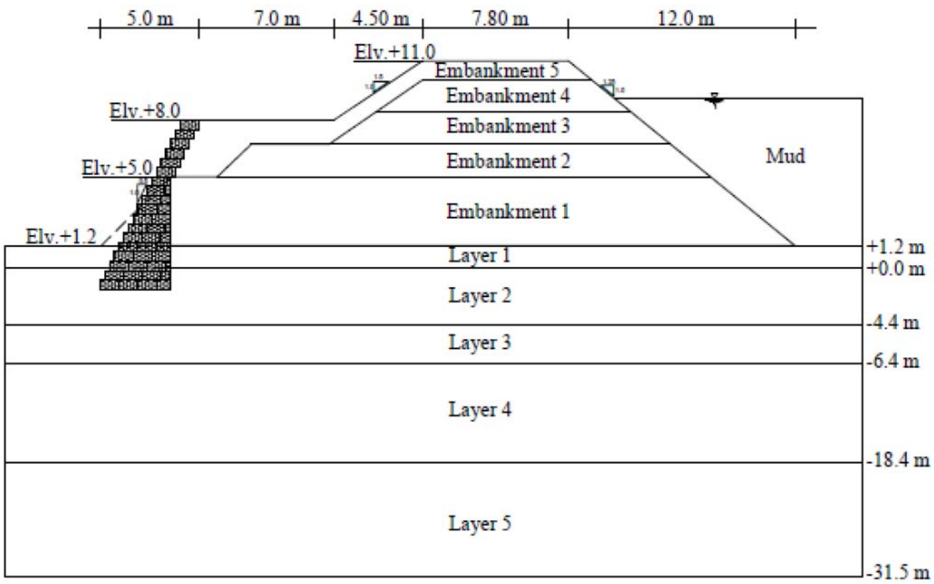

Figure 2. Typical embankment cross section at the critical area of the embankment.

Due to the construction of gravity retaining wall instead of stabilising berm at this section, the downstream stability of the embankment is lower than those computed at the other part of the embankment. The calculated factor of safety at the end of construction was found to be marginally stable at FOS of 1.1. Agustawijaya and Sukandi (2012) calculated the factors of safety of the embankment at this section for each stage of construction and the results are presented in Table 1.

Table 1. Computed factors of safety against instability for LUSI embankment at critical locations (Agustawijaya and Sukandi, 2012)).

Dam and mud elevations (m)	Factor of Safety
Dam +5.0; mud + 3.5	1.88
Dam +6.7; mud +5.2	1.54
Dam +8.4; mud 6.8	1.47
Dam +10.0; mud +8.5	1.32
Dam +11.0; mud + 9.0	1.14
Dam with retaining wall	1.12

Figure 3. Local failure at the critical section along the railway and main road.

Despite marginal computed factor of safety at the end of construction, the embankment at this section have been in operation safely for more than 13 years with only some local failures occurred few times (Figure 2), but no catastrophic failures in terms of major breach of the embankment has occurred.
This is expected as the pore pressures in the foundation dissipate, the foundation strength increases and in turn the factor of safety against global failure increases. Using PLAXIS software, Widjaja and Alfionida (2017) have carried out a fully-coupled hydromechanical effective stress analysis to calculate the increase of factor of safety and the rate of pore pressure dissipation with time. They showed that after 6 years from the end of construction, the computed factor of safety increases from about 1.0 to about 1.6, with maximum factor of safety of 1.7 after all pore pressures have dissipated.

The cost to manage the LUSI mud volcano has been estimated to be about USD 100 million up to now, excluding the cost of the damage to the people and surrounding areas.

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