THE WORKING GROUP ON LEVEES AND FLOOD DEFENCES UNDER THE EUROPEAN CLUB OF ICOLD

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LEVEES Working Group Newsletter

Heritage levee windmills, Schermer, NL

Note from the Chairman

By Rémy Tourment

Dear members and friends of the Working Group on Levees and Flood Defences of the European Club of ICOLD, dear members of the ICOLD Technical Committee on levees, dear levees and flood defences practitioners,

In this issue, the second of this year 2022, we have two "special feature" articles, one about temporary / mobile / demountable flood defences and one about risk assessment of levee systems in New Zealand. We have as well many other very interesting contributions from members and readers that I cannot mention all here. By the way, do not hesitate to provide a contribution for our next issue, whether you are in Europe or anywhere else in the world.

2022 was, after two years without ICOLD or EUCOLD physical meetings, the year of Reunion, during the Marseille ICOLD Congress, which was a success and a pleasure to meet again and work together. Our colleague Adrian shares his thoughts on this event in an article in this issue. Hopefully next year will give us even more opportunities to meet, with the ICOLD annual meeting in Gothenburg (Sweden) and the EUCOLD symposium in Interlaken (Switzerland). In the meantime, this year 2022 is soon over, I wish all of you a safe and wonderful holiday season, and lots of exciting and productive work on levees and flood defences for the next year and a lot of information to share.

Reflections of the ICOLD Congress

By Adrian Rushworth, Environment Agency, UK

Following the recent difficult years the ICOLD Congress in Marseille was a great opportunity to renew friendships in person and to meet new colleagues. This article gives a personal view and a few highlights of a very enjoyable and effective week.

As part of the Congress, the Technical Committee on Levees (TC LE) and its members were active which helped to promote the importance of Levees within ICOLD. The stature of the TC has continued to grow and this year demonstrated the progress that has been made. In particular, ICOLD President Michael Rogers often highlighted levees and demonstrated strong support. Issue 20 of the ICOLD newsletter gives a taste of the meeting https://www.icold-cigb.org/GB/news/newsletters.asp and also shows the growing importance of levees. The newsletter includes a four pages article "Levees as a natural expansion of ICOLD's focus" by Michael Rogers which makes the case exceptionally well.

Figure 1: Jonathan Simm and Adrian Rushworth enjoying the French sunshine. Copyright official congress photographer

On Friday 27 May Remy Tourment, the chair of the TC LE was the co-ordinator for a short course "Risk Analysis of Levee Systems".

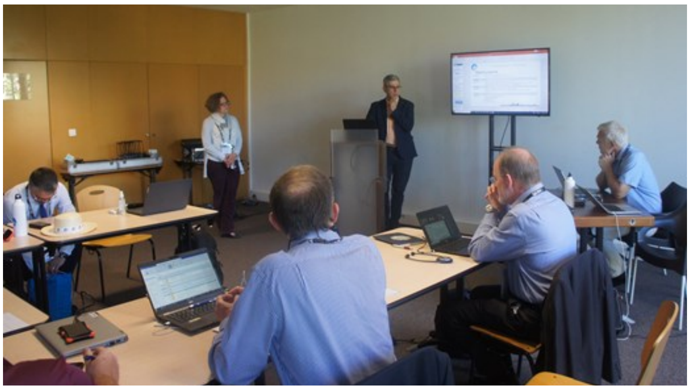

Figure 2: Photo from the TC meeting. Copyright Amir Farid Mojtahedi

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Figure 3: The short course. Copyright official congress photographer

As well as being informative it prompted good discussion. Presentation are available at https://barrages-cfbr.eu/Marseille_cours_condenses.html.

On Saturday 28 May 2022 the TC LE held a two hour workshop to give an overview of the of the two bulletins being prepared the TC LE over the past few years. Both the deliverables are on track. These are intended to become the foundation of all future work on levees in ICOLD.

- Levees and flood defences across the world - Characteristics, Risks and Governance: This was presented for approval at the Congress General Assembly. Attendees to the workshop, in particular those who were not members of the TC, gave feedback to help prepare the final version. Discussions included future updates and the possibility of creating a web space for updating country information in between formal updates of the Bulletin. It was noted that there was limited knowledge of the bulletin outside of the TC.
- Comparison of dams and levees - Similarities, differences and recommendations: This report is not yet ready for General Assembly and is planned to be presented at the General Assembly in 2023 in Gothenburg. Several ICOLD national committees have provided significant feedback. The report shows that there tends not to be a clear distinction the difference between dams and levees but a range.

On Sunday 29 May the TC LE held a Committee meeting. With so much on the agenda there was only limited time for many topics that deserved longer. The meeting included presentations and discussions;

- The Levees and flood defences across the world Bulletin was considered again. Marcel Bottema gave an interesting review of the current position, challenges and future actions. Jonathan Simm took the meeting through the next steps with the Dams-Levees Intercomparison Bulletin. One of the important outcomes will be to identify more focused topics for the TC to work on in the future, including with other ICOLD TCs.
- The TC is also working on a position paper with a number of key messages. The purpose is to build awareness of the role of levees, encourage the use of sound policies and practices, and advocate for appropriate funding. A wide and varied range of potential audiences have been identified. It is hoped that the paper will be ready to be approved in Gothenburg in 2023.
- The future of the TC was discussed including the need to re-consider the terms of reference next year.
- An interesting part of TC meetings is to hear from individual members about events and progress from their countries. This included introductions from new members of the TC from Canada and Poland.
- Finally, there was an update on the activities of the European Working Group on Levees and Flood Defences. This included webinars, the website and this newsletter.

At the ICOLD General Assembly Remy presented the work of the TC LE, our deliverables and their consistency, and the plan to finalise the "dams-levees comparison" during the next year. He called for more interaction with other TCs, and the involvement of national committees. Whilst Remy was at the General Assembly many members were able to go on a site visit to the Camargue levees. Several levees were visited with Thibaut Mallet from SYMADREM and his colleagues explaining the background and approach.

I have benefited from ICOLD meetings and the work of the LE TC over recent years. The difference this year was I felt a maturity and stature from the TC LE which will hopefully continue to develop.

Additional Information

The French National Committee CFBR also prepared some material at the occasion of the congress :

- in the commemorative book, prepared with a lot of attention and many contributors, there is a chapter about French Levees. Chapter 9 of this book is dedicated to levees.

You can download it here : https://barrages-cfbr.eu/Marseille_livres.html

- a monograph on levees has also been prepared by members of CFBR : you can find here a series of descriptive leaflets on levees and levee systems : https://www.barrages-cfbr.eu/Marseille_monographies_digues.html and also download all them together from:

  https://www.barrages-cfbr.eu/IMG/zip/monographiesdigues.zip.

IN THIS ISSUE

CIGB ICOLD

Investigation of a breached levee

A multidisciplinary investigation involving visual, morphological, geophysical and geotechnical methods was applied to a previously breached levee in NW Belgium.

By DAVY DEPREITER, Flanders Hydraulics Research, Belgium with Jeroen Vercruysse, Patrik Peeters (Flanders Hydraulics Research, Belgium), Leen De Vos, Ivana Vukotic Hiskjere (Geotechnical Division Flemish Government, Belgium), Timothy Saey (3D-Soil BV, Belgium) and Tinne Michielsen (De Vlaamse Waterweg NV, Belgium).

A 20 km long 25 m wide levee situated in between two parallel discharge canals (and surrounded by 2 outer levees) in the northwest of Flanders, Belgium, has failed late 2018 for a reason unknown, yielding a breach of 25 m long. The canals and levees date from the 1860-1870'ies and are characterized by parallel rows of poplar trees, yielding a striking landscape feature. After repairs in 2019, a multidisciplinary study was conducted in 2020-2021 to identify drivers of the failure and prevent future events.

Figure 4: Breached central levee, end 2018.

The assessment involved a visual and morphologic analysis of the levee to describe the current state and localize anomalies, including animal burrows, erosion of the levee toe and vegetation anomalies. The inventory was based on visual inspections and 3D mobile mapping, including a high-density photographic dataset and LiDAR scanning from a 2015 region-wide survey and a local repeat survey in 2021. Also, a multibeam survey of the canal bottoms was conducted. Based on this, a geospatial anomaly dataset was built to localize damaged and anomalous zones.

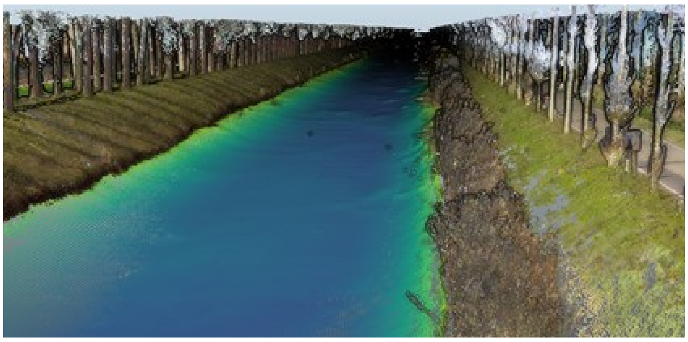

Figure 5: 3D LiDAR and multibeam point cloud visualization.

Because of the risk for the occurrence of unexploded ordnances (UXO) (left from World War II after shelling of the Zeebrugge port and other infrastructure) and to get an idea of the soil structure and presence of local anomalies, we applied geophysical methods to avoid extensive application of invasive techniques such as drilling and cone penetration testing (CPT). With the method of electromagnetic imaging (EMI), it became possible to better understand the internal structure of the levee (up to 5 m deep). A scan of the full levee crest was performed with different antenna configurations, so that simultaneously, shallow, and deep influences of soil variations on the EM signal could be detected. Repeated EMI scans during high and low hydraulic head difference between the canals did not indicate major differences and could thus not be used as a proxy for the presence of more versus less permeable zones or presence of piping zones across the levee. Through numerical inversion, a pseudo 2D profile of the levee core electrical conductivity was realized. The EMI interpretation led to identification and delineation of zones of similar levee structure and served to plan a geotechnical investigation less extensive than typical. Magnetometer cone penetration was performed prior to other invasive tests to prevent UXO related risks. Hydrogeologic and geotechnical modelling indicated that high hydraulic gradients (2 m head difference) between the two canals increased the risk for slope failure.

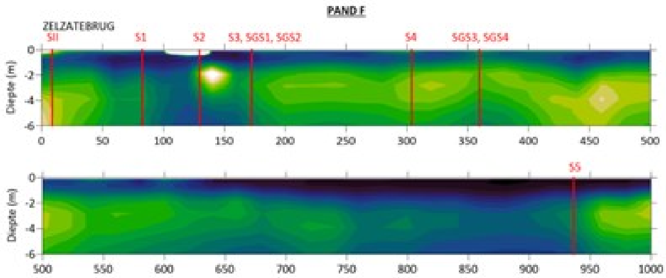

Figure 6: Example of the EM conductivity pseudo-2D profile.

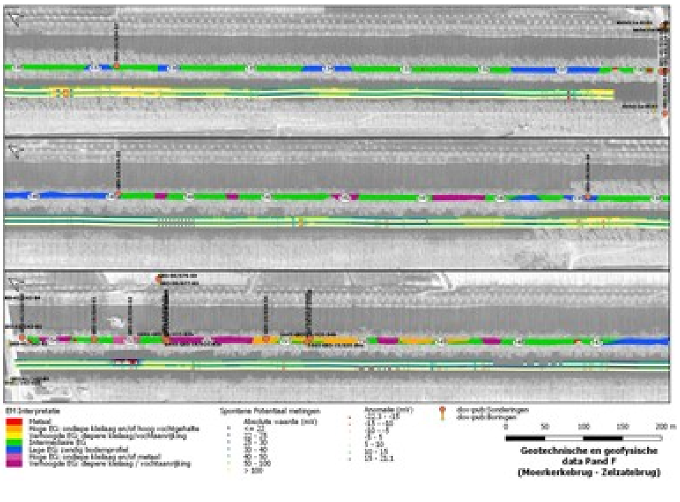

Figure 7: EM soil structure interpretation layer.

The investigation gave insight in the spatial extent of the (severity of) damage and its temporal evolution. Different factors contributing to the 2018 failure were identified: erosion of levee toe and slope, presence of burrows and old tree trunks, combined with an elevated hydraulic gradient between the canals leading to increased risk for piping and slope instability. Zones of increased vulnerability were identified based on the integration of all applied non-destructive methods and confirmed by limited drilling and CPTs.

After the investigation, restoration and strengthening works of the levee were planned and are currently underway.

The unseen: Onion-like cross-section of a levee

By Zsombor Illés (BME), László Nagy (BME), Örs Antal (OVF), HU

Hungary has a 4400 km long primary flood protection system. Overall, 92,9 % of these levees are made of cohesive soils. The construction of the dike system began in the 19th century along with the Tisza river regulation works. The soils used to construct the levees were built in at high water content, and proper compaction methods were not in practice back then. Over the decades, rivers became surrounded by dikes, the area of the natural floodplain was reduced, and the floods were peaking at higher levels. The hydrological cycle has become extreme in recent decades due to climate change. Heavy rains and floods are followed by extreme droughts. The levees in the past hundred years have been raised many times. As a result of heightening and strengthening, a heterogenous onion structure was created. This dike evolution is visible in Figure 8. Along river Tisza, northeast of Szolnok, a longer dike section was relocated further away from the river to give way to the floods. In consultation with the contractor, the levee cross-section was excavated in three places for investigation.

Figure 8: Cross-section of the levee, with visible layers (section 74+902 km)

The frequency of floods in the rivers of the Carpathian basin has decreased. The length of the drought periods between the floods, their spatial extent and volume have increased. As a result of successive periods of drought, the embankments dry out and crack. Several parameters influence the depth and orientation of the cracks. The distribution of the moisture content of the levee can be seen in Figure 9, in the excavated cross-section. The levee crest is extremely dry, while its core is moist.

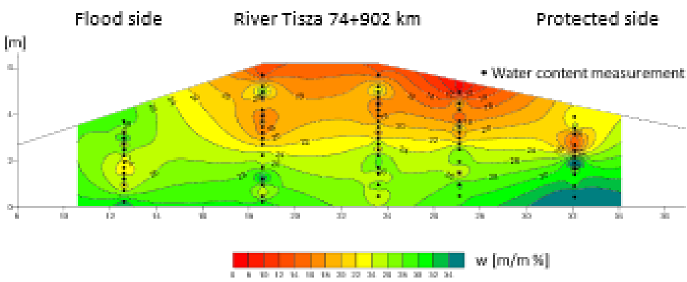

Figure 9: The moisture content of the levee cross-section (section 74+902 km)

The Geotechnical Group of the Budapest University of Technology and Economics and the General Directorate of Water Management cooperate in researching the change in the moisture distribution of levees and mapping the appearance and formation of cracks. In recent years, the first-order protection lines crack assessment has been completed (Illés and Nagy, 2022). The crack types were compared with the filling material. Furthermore, we had the opportunity to install a monitoring system along the Tisza not far from the presented cross-section. The monitoring system measures the moisture content and negative pore water pressure of the levee at several points (Illés and Antal, 2022).

This article was prepared with the Professional Support of the Doctoral Scholarship Program of the Co-operative Doctoral Program of the Ministry for Innovation and Technology from the source of the National Research, Development and Innovation Fund. The authors are also grateful for the help of the local Water Directorate (KÖTIVIZIG).

ACRONYMS

BME: Budapest University of Technology and Economics

OVF: General Directorate of Water Management

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We are always looking for information from YOU to share in the newsletter and on our web site! We need diversity in terms of contributing countries, and are eager to learn from every member country. We welcome contributions from any countries, even non-European ones.

A CALL FOR CONTRIBUTIONS

- Information about levees and flood defences projects and works.
- News, media or press releases on current flood or storm events involving levees and flood defences.
- Current, ongoing or recently completed research projects.
- Documents related to levees or flood defences: handbooks, guidance, reports and regulations.
- Information on any event or conference relating to levees or flood defences.
- Links to informative / educational web sites and related organisations.
- Pictures to be used in the web site banner, randomly chosen every time a page loads (resolution has to be 1024x300)
- Contact the WG web site team: lfd-eurcold@irstea.fr

Could you help with our next new featured photo?

We're looking for exciting levee photos to feature on the front cover of our future newsletters! It could be something like an existing or construction or your favourite levee photo from all over the world.

Please email your pictures to lfd-eurcold@irstea.fr

Building a resilient system of defence against flooding in the Rhône delta

By Thibaut MALLET, SYMADREM, FR

SYMADREM is a public institution for management of river and sea levees in the Rhône Delta (south east of France). Since 2007, it implements an important program of safety works for the Rhône levees

The Rhône Delta faces a double threat from storm surge and river flooding. Since 1840, eight major Rhône floodings took place in the territory, leading to the spill of several hundreds of millions of cubic metres in protected areas, flooding of communities and cost several hundreds of millions of euros in damages. The current flood defence system was created during the 19th century, specifically after the 1840 and 1856 floods, whose return periods were estimated at 200 and 300 years respectively. The structures were erected on other ancient levees, including some dating back to the 12th century. Given their form of construction (compaction with manual tamping devices of 15 kg) and heterogeneous composition (alternating silt / sand) due to successive stages of construction, levees are exposed to failures by internal erosion. This intrinsic fragility is worsened by frequent badgers' burrows and many crossing pipes.

Following the 2003 floods, a global strategy regarding floods prevention was defined, by the State and regional authorities located in the Rhone catchment: the Plan Rhône. The SYMADREM has included the flood elements of this plan in a safety program for the levees from the Vallabrègues dam to the sea. **The Safety program goals are:**

1. Not to respond to flooding by raising the levees (as this was the case before the Plan Rhône) and to avoid transferring overflows, which are inevitable during large floods, to structures located upstream, downstream or on the opposite riverside.
2. Accept overflowing for floods with a return period over 100 years upstream Arles and over 50 years downstream Arles, with an equal amount of overflowing volumes on each bank.
3. Consider a levee breach as unacceptable during exceptional events like a 1,000-year flood.

These goals involve:

- Safety works for the whole system to avoid any breaches during an exceptional Rhône flood.
- Implementation of long spillways on levees to resist overflow. They are made of concrete rip rap blocks on crest and landward side. This allows them to resist to high velocities in case of an overflow, which can create breaches on non-reinforced levee sections.

Figure 10: Cross section of the levee resisting to overflow between Beaucaire and Fourques (right bank of the Rhône)

Figure 11: Levee resisting to overflow between Tarascon and Arles (left bank of the Rhône). Copyright SYMADREM.

Considering its scale (more than 450 million €), the safety program has been divided in several operations. As of today, 210 million euros have been invested in the delta of which 195 million euros for levees, from the Vallabrègues dam to downstream of Arles, including 10 km spillways on levees.

During exceptional floods with unavoidable inundations, spillways on levees will control water entries. Overflowing volumes will be 10 to 20 times less important than observed during historical floodings caused by levee breaches. Flooding of protected areas will be slow, known in advance and manageable by the competent authorities in charge of emergency plans.

The transformation of a defence system exposed to unacceptable hazard of flooding by breach but random and unpredictable to a lower hazard of flooding by overflowing without breach, but certain and predictable in terms of location, requires public consultation. Public meetings were organised by local authorities and government services. As a result of consultation, spillways on levees were renamed as levees resisting to overflow. They led local population to better understand the functioning of this new defence system and to accept in fine the implementation of spillways on levees.

The complete renovation of the protection system and the construction of safe and sustainable levees, is based on risk assessment and the restoring of following safety functions:

- Watertightness and resistance.
- Filtration and drainage.
- Stability and protection against external erosion and burrowing animals.
- Spillway (resistance to overflow).
- Surveillance.
- Environment.

An information booklet describing in detail this work can be downloaded in French or English.

A video clip in French with English subtitles can also be viewed here.

See also: "Spillways on river levees" publication here or on our website.

Thibaut Mallet is general manager of SYMADREM.

Internal erosion or (fast) liquefaction? Some interesting dyke failures in Hungary

By Emőke Imre[1], HU & Daniel Barreto[2], UK

The first specific, recorded case study of failure by internal erosion in Hungary was first witnessed and reported by Benedek in 1932 [1] and is referred more recently by Nagy in 2014 [2]. The embankment failed (rapidly) approximately five days after the first sand-boil was observed 10-12 m from the downstream side toe of the embankment. According to well-established practice, a barrel was put on the spring, and then reinforced by protective material. At the same time a boat/canoe about 10 m long and 2 m wide was put on standby. Two days before breach the water level in the counter pressure basin started to oscillate indicating pipe formation, therefore, preventive materials (boat to sink if needed, piles, sandbags, piles, etc) were prepared. The breach happened within minutes, and a mud geyser appeared at the location of the sand boil. Seeing this, the chief engineer immediately ran up to the embankment crest and glanced at a vortex about 30 m from there, which was constantly approaching the embankment. When it approached the levee at 15-20 m, the boat began to tilt into the vortex, its nose up, dived under dike and reached the other side of the dike (see Figure 12, due to a kind of sink-hole effect. Subsequently the crest began to crack, the embankment settled 8-10 m, the water began to flow into the saved area, and the breach widened to about 100 m. The depth of the washout at the rupture site was 24 m below the level of the flood.

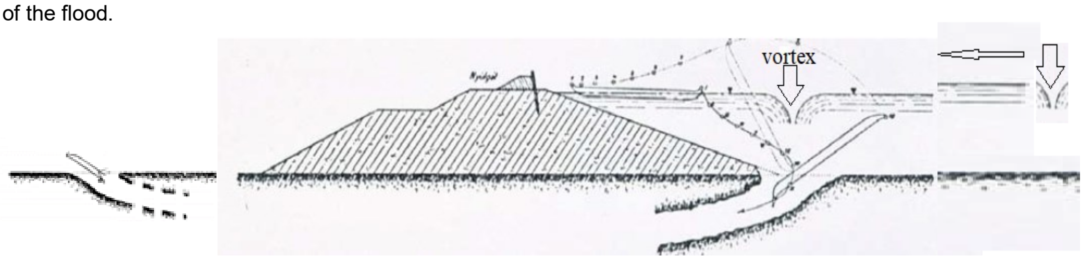

Figure 12: Illustration of the boat diving to the pipe, (a) condition some minutes before breach, (b) the path of the boat, which ended on the land side at around the first sand-boil spot. (after Benedek, 1932)

A similar failure occurred later at the river Danube in 15 July,1954 at Ásványráró and in river Kettős Körös, Hosszúfok in 1980 and these were reported by eg., Szepessy in 1983 [3] on the basis of witness' reports. In both cases, the formation of sudden mud geyser happened just before

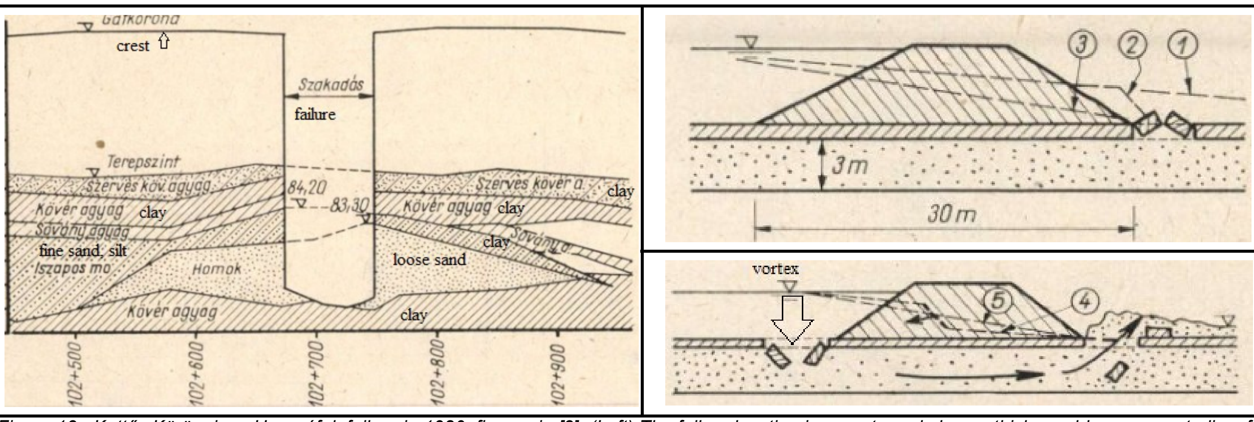

Figure 13: Kettős Körös river, Hosszúfok failure in 1980, figures in [3]. (Left) The failure location in an extremely loose, thick sand layer prone to liquefaction. (Right) The hypothesis of fast, liquefaction piping in [3] completed by the vortex sign

failure and witnesses described a moving vortex in Ásványráró. Furthermore, in both cases a process of pipe formation has been documented. In Ásványráró, chief expert engineer László Marek, government commissioner and witness described the event as follows. "During my inspection trip, I arrived at the 25.4 km section of the protective embankment at 10:10 a.m., where the flood level was about 20-30 cm below the crown and the embankment showed no harmful changes. The surface of the terrain saved here, as in long sections generally everywhere, was covered by 20 to 30 cm deep, clear seepage water. Then quite unexpectedly, about 5 m from the foot of the embankment in the saved field, a column of water with a diameter of 1 m and a slightly cloudy colour broke up to a height of 1.4 m. At the moment of breaking, the surface of river water was smooth, but approx. 2 seconds later, from the dam crown about 10 m away, a huge vortex appeared, which soon reached the embankment crown, and in its centre the water sunk deep like a funnel. The column of water with a diameter of 1 m widened to 1.50 m in about a minute and a half, and then suddenly stopped (probably due to the collapse of the embankment body). The dyke crown was in the original position. Then after half a minute, the column of water with a diameter of 1 m originally widened to approx. 4 m in diameter, the water column became 0.5 m high, with extremely cloudy, dark-colored water, and then another half minute later, the crown of the embankment and its crest suddenly collapsed deeply, and the water begun to flow above the collapsed dyke."

A third case study in the river Kettős Körös, Hosszúfok in 1980, the guards who were responsible for observing damages during this flood, did not notice any signs of damage until the early morning of July 28. At 6.35 a.m., at a distance of about 100 meters, a very strong water geyser jet was observed. They described the water as "black and thick with silt." The dam then broke in about 5 minutes. The width of the tear grew rapidly, reaching 10 meters by 7 hours, and its final width was 78 m.

Continued on the next page...

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In these three eyewitness reported cases, failure may be attributed to regressive erosion and/or concentrated leak erosion (while contact erosion is not possible according to existing filter criteria). It is however more likely that both static and dynamic liquefaction occurred. This is supported by the occurrence of sand boils, the formation of strong geysers from below a plastic, intact clay surface layer after being teared off suddenly, and the loose state of the deposit of silty sand in Hosszúfok. With similar observations, the occurrence of a vortex reported may also indicate that there is a hydraulic component in these failures. It is hypothesised that a kinematically admissible path was formed below the embankment comprising the entire layer. Hence the occurrence of liquefaction is more likely. It is likely that advanced continuum/discrete approaches coupled with continuum fluid dynamics may explain these failures, including dynamic effects such as the vortex being in contact with the riverbed. Research is ongoing. The possibility of high energy impact of the vortex at the riverbed, and its effect of on the liquefaction process of a deeper sublayer of soil may also need sophisticated numerical modelling for understanding.

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Methodology of levee investigations

Verifications of various investigations methods including active-thermal leakage detection

By Krzysztof Radzicki, Cracow University of Technology, PL

Reliable information about the state condition of levees, especially about the destructive processes and leakages which are taking place inside them, is of fundamental importance in optimizing the decision on the sequence of levees repairs. This, in turn, allows to increase the global safety level of the flood protection system for a given area / region and to minimize the operating costs of the levees owner/manager. As part of the grant from the Polish National Centre for Research and Development, between 2014-2019, a comparison of various investigation methods of levees was carried out on several hundred-meter section of the Vistula River levee located near Cracow city.

On the examined section of the levee during the great flood of 2010, leakages and minor internal erosion processes in several separate zones were observed in the toe of the land side slope. These places were provisionally secured with a layer of sandbags (white zones in yellow ellipses presented in Figure 14) during the flood. There were hundreds of such places just after the flood in 2010 in only one region of the Małopolskie Voivodeship. This raised the question of what methods, and which optimized methodology of levee investigations should be used during and after a flood, to clearly identify those levee sections that require in the first place renovation or even emergency reinforcement, e.g., with a sheet piling, preferably before the next flood. The answer to this question was one of the main goals of the aforementioned grant and the levee investigations.

Figure 14: View of the investigated levee of the Vistula River with marking of the leakage zones observed during the great flood in 2010. (Radzicki et al., 2021)

A wide spectrum of geophysical and geotechnical surveys of the levee were performed. They indicated zones of increased risk of weakening the levees. There are also places where leaks and internal erosion processes were observed during the flood in 2010 inside of these zones. However, geophysical, and geotechnical surveys did not pinpoint their exact locations.

2014–2016	DPL soundings and geological drillings as well as preliminary GPR and ERT
2018	Detailed GPR and ERT measurements, supplemented by GCM surveys and additional DPL soundings and geological drillings
2018	Installation of a pilot seepage thermal monitoring system
During flood of May 2019	Active thermal investigation including leakage detection and seepage velocity measurements
2019	Detailed GPR and ERT measurements, supplemented by CCR and high-resolution reflection seismic and MASW. Additional DPL soundings and geological drillings.

Table 1: List of geoengineering (i.e., geophysical, geological, and geotechnical) surveys conducted on the levee. Where DPL- dynamic penetration light soundings, GPR- ground-penetrating radar, ERT- electrical resistivity tomography, GCM-ground conductivity meter, CCR- capacitively-coupled resistivity, MASW- multichannel analysis of surface waves.

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In 2018, a thermal measuring system for continuous leakage monitoring was also installed on the tested section of the levee. The key element of the system was MPointS (Multi Points Thermal Sensor) thermoactive sensors. Each sensor consists of a temperature sensor and a micro-heater integrated into it. The characteristics of the sensor heating and cooling cycles, which depend on humidity, and in particular on seepage velocity were determined firstly in the laboratory. This allowed the use of MPointS sensors to determine in-situ the seepage velocity in the soil as well as to detect leaks in levees or earth dams.

Two multi-sensor measuring lines were installed on the 50m section of the levee one above the other. The first line of sensors was installed in the levee body in its land toe, the second in the first layer of the permeable substrate. The sensors were installed close enough next to each other to have the effect of quasi-continuous monitoring of leaks along the levee. The installation of the system took 1 day. The sensors were quickly installed by punching them from the crest of the levees bench. The scheme of the system is presented in Figure 15.

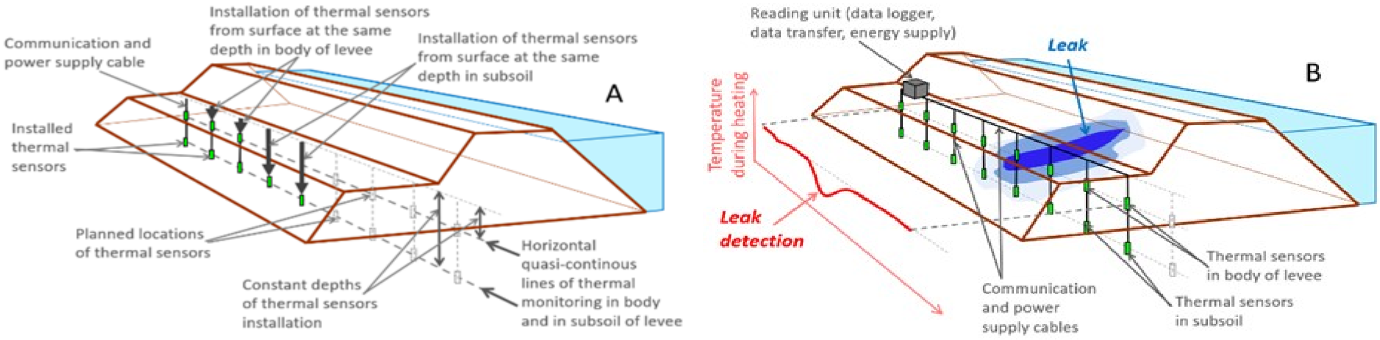


Figure 15: Diagram of leakage thermal detection system made with Multi Points Thermal Sensors: (A) installation in the body and foundation, (B) application for quasi-linear monitoring of leakages. (Radzicki et al., 2021)

In May 2019, the first higher rise of water in the Vistula took place in several years. However, the flood level was not very high and submerged the water side slope only on several dozen centimetres high. The leakage thermal monitoring system performed measurements. The MPointS sensors detected the leak in zone 4 (Figure 16) and measured its seepage velocity in the soil. This zone is the deepest located of the zones where leaks were observed during the great flood in 2010 (Figure 14). The seepage velocities were much lower than the critical ones necessary for the erosion process to occur. Other leakage zones observed during the 2010 flood require a higher flood level to fill them with water.

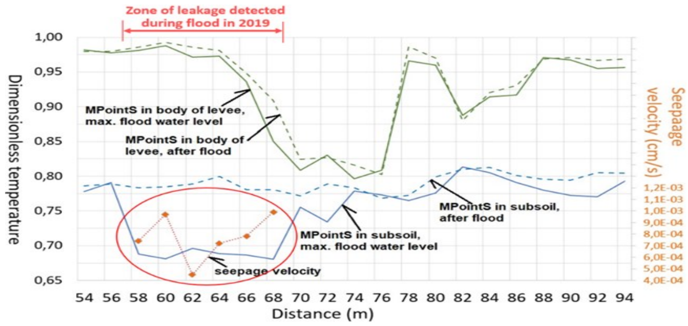
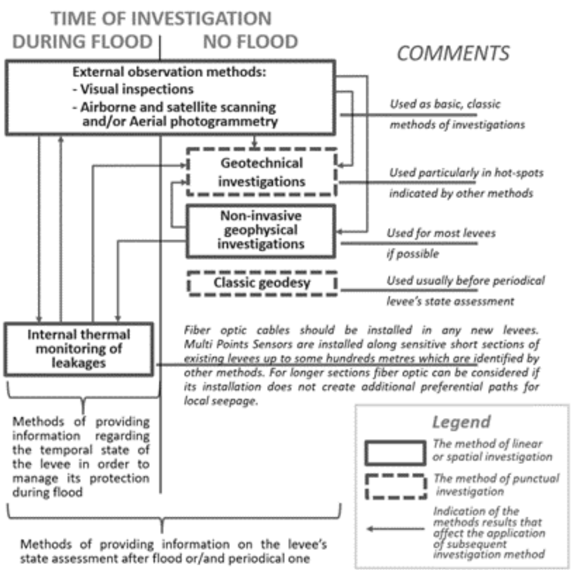


Figure 16: Results of measurements with active thermal sensors during and after the period of water level increase in the Vistula river in May 2019 and the corresponding values of the seepage velocity in the leak detected zone. (Radzicki et al., 2021)



This study proved that the use of a thermal monitoring system allows to detect leakage zones and to analyse the risk of internal erosion, also during not very-high floods. This applies especially to monitoring of the shallow zones of substrate below levee and to the zones of the contact of substrate and the levee body. The development of erosion processes in these zones is the most common cause of levee failures in Poland, apart from failures caused by the levees overflowing. As a result of the conducted research, an extended levee investigation methodology was proposed which includes also thermal monitoring of levees during a flood. Newly build levees or heavy modernized long sections of levees should be equipped with a thermal monitoring system using distributed temperature sensing with fibre optic cables. On the other hand, local zones of levees weakening or/and zones of already observed leaks on existing levees should be investigated during floods using easy-to-install multi-points thermal sensor systems, such as the MPointS technology. They could be particularly useful to detect early internal erosion problems and/ or leakages also during not high floods to support levees owner/manager in making local levee reinforcement in the most vulnerable places during the flood and in taking the most optimized decisions about levee renovation after the flood. A comprehensive description of the mentioned investigations and the proposed methodology is presented in the publication: K. Radzicki et al., A new levee control system based on geotechnical and geophysical surveys including active thermal sensing: A case study from Poland, Engineering Geology, vol. 293. https://doi.org/10.1016/j.enggeo.2021.106316. For more information on the outcome of the project, please contact the research team leader Krzysztof Radzicki - radzicki@hotmail.fr.

Figure 17: Block diagram of the methodology of levee surveys, including the thermal monitoring method. (Radzicki et al., 2021)

Upcoming Events!

NB: ICOLD related events are listed first, before events organized by other organisations

In English

Early 2023

EUCOLD LFD WG webinar on Levee repairs

Exact date and topic will be advertised soon on the web site and will include a call for presentations. You can nonetheless already contact us if you have suggestions.

11 - 15 June 2023

ICOLD Annual Meeting in Gothenburg (Sweden)

See https://icold-cigb2023.se

Will include a meeting and a workshop of the ICOLD TC

5 - 8 September 2023

12th ICOLD European Club Symposium in Interlaken (Switzerland)

See https://ecsymposium2023.ch/en

18-22 February 2023

The 9th International Conference on Flood Management in Tsukuba, Japan

River Basin Disaster Resilience and Sustainability by All - Integrated Flood Management in the Post COVID-19 Era

See https://www.icfm.world/ICFM-Conferences/ICFM9

17-18 April 2023

Interpraevent 2023 International Symposium in Taichung (Taiwan)

Natural disasters occurrence, reduction, and restoration in mountain regions

See https://interpraevent2022.nchu.edu.tw/index.aspx?SendPage=&SendEC=1

17-21 September 2023

11th International conference on Scour and Erosion in Copenhagen (Denmark)

See https://icse11.org/

In other languages

26-27 January 2023 (in French)

CFBR (French National Committee) annual symposium

Will include a site visit of levees and flood retention reservoirs

See https://barrages-cfbr.eu/-Actualites-.html (the program is not available yet but it will be uploaded soon)

19 - 20 September 2023, Nuremberg (in German)

17th DWA Deichtage (Levee Days – German Association for Water, Wastewater and Waste)

Update for Levee Practitioners

See https://de.dwa.de/de/veranstaltungen.html

Special Feature Section!

Risk Assessment of Levee Systems in New Zealand

By David Bouma, Technical Director – Dams and Rivers, Tonkin + Taylor Ltd, New Zealand &

Ghassan Basheer, Principal Technical Advisor, Waikato Regional Council, New Zealand

Flood protection assets in New Zealand including levee systems are generally owned and operated by Regional Councils, with responsibility falling to Council staff with River Manager roles to manage these assets. There is no specific legislation in New Zealand that covers the design or operation of levee systems.

Funding available to River Managers for operation, maintenance and upgrade of levee systems is limited. The majority of funding comes from local land taxes with additional funding from central government for some specific projects. River Managers need to have a good understanding of where the highest risks are with their schemes so they can focus available funds on works that will provide the greatest overall reduction in flood risk for the money invested.

River Managers from the 16 Regional Councils across NZ have worked together to develop a Code of Practice for performance assessment of flood protection assets[1] (RMF 2015) which enables a standard approach to be used for assessing the "Performance of Flood Protection Assets where the assessment method and frequency is aligned to the amount of risk posed to the community. The overall performance is expressed by being able to state, with confidence, if you have the appropriate asset for the defined Level of Service, in the appropriate condition therefore knowing it will perform reliably".

This article summarises a case study project where the RMF 2015 method has been adapted and used to qualitatively assess risk associated with levee systems on the Motueka River and Brooklyn Stream in the Tasman District in New Zealand. The scope of the study included:

- Levee condition assessment (approximately 20km total length)
- Flood risk assessment including:
    - Failure mode / location assessment (based on condition assessment)
    - Flood modelling – to assess overtopping risk
    - Dam breach modelling – at selected vulnerable locations
    - Damage assessment
    - Using all of above to calculate risk
- Follow RMF 2015 as far as practicable
- Output: prioritised work programme targeted at cost effective flood risk reduction.

The approach used for the study is summarised in Figure 1, and the study location shown in Figure 2.

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[1]Flood Protection Assets Performance Assessment Code of Practice, River Managers Forum, 2015

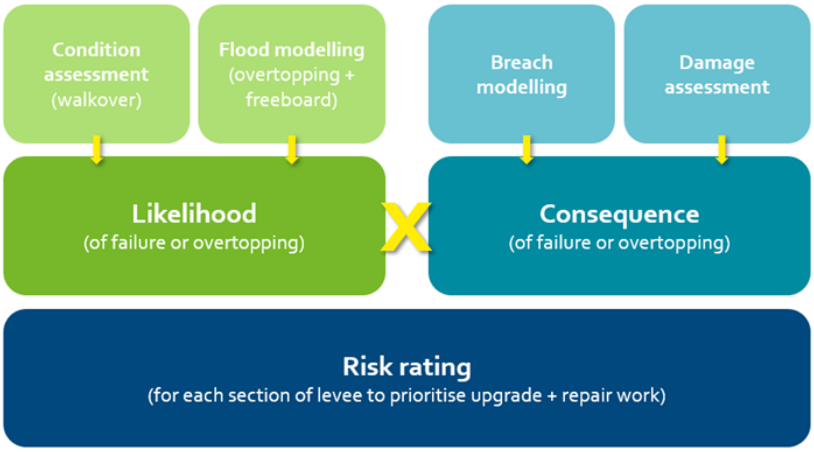

Figure 1: Risk assessment approach

Figure 2: Study location. Dashed black lines show levee alignment

We note that the approach used in this case study, while based on RMF 2015, has been developed to suit the particular needs of Tasman District Council and the Motueka community. Various approaches have been used by the 16 Councils around New Zealand for risk assessment of levee systems depending on the local context and needs, but River Managers are working towards a more standard approach by changing their systems to incorporate the RMF 2015 approach. For example, Waikato Regional Council developed a "Stopbanks renewal prioritisation manual"[2] in 2014 to use a risk-based approach to prioritising maintenance and upgrade works on their flood protection asset portfolio. This manual focusses on risks associated with overtopping failure only.

The performance assessment process included two main components – structural and hydraulic assessments along the length of each levee.

Hydraulic assessment:

Hydraulic modelling to understand the river capacity, overtopping likelihood, levee levels of services including freeboard allowance, and baseline and levee breach flood extents. A 2D hydraulic model using TUFLOW software was developed and used to assess the likelihood of overtopping in the design flood[3] event along the length of the scheme, as well as to model the consequences associated with failure of levees at six locations. The following parameters were considered to assess the likelihood of overtopping in the design flood event.

- Overtopping (lack of freeboard in design flood)
- River conveyance (factors that reduce conveyance capacity such as bed aggradation, debris, vegetation)

Each element was scored qualitatively on a 1-5 scale, and the combined scores used to rank each section of levee in terms of probability of failure. The intention with this approach is to identify sections of levee that are most likely to fail, rather than attempting to calculate a probability. Figure 3 summarises the combined results of the structural and hydraulic assessments.

Structural condition assessment:

Condition and structural integrity assessment, focused on using geotechnical information from previous work and a walkover assessment to identify those areas most vulnerable to failure through seepage, piping, defects or similar. To systematise the approach, the RMF 2015 approach was used. The following parameters were assessed by visual observations, and by collecting information on the performance of the levees during flood events:

- Levee surface condition

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[2]Waikato Regional Council Technical Report 2013/57. Note that in New Zealand, flood protection levees are referred to as stopbanks.

[3]For this scheme the design flood is a 100 year annual exceedance probability event. This relates to the level of service agreed with the community.

- Foundation softening (leading to settlement of slope instability)
- Levee embankment instability
- Seepage / piping through levee or foundation
- Erosion protection measures (assets designed to protect levees from erosion from the river)
- Berm between levee and riverbank – presence, size, and condition of berm
- Structures through levee.

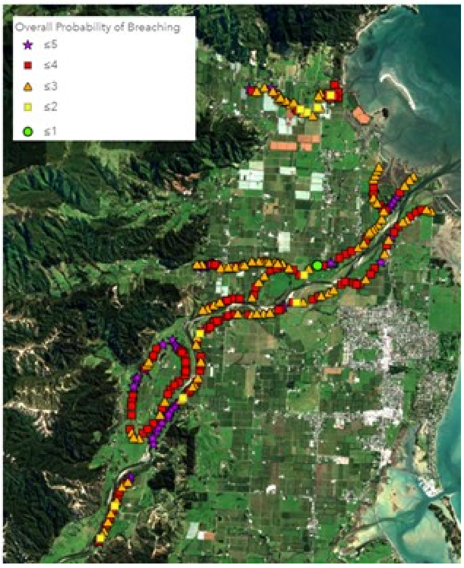

Figure 3: Relative likelihood of levee failure

Consequence assessment

The TUFLOW 2D hydraulic model was used firstly to simulate flooding that may occur due to capacity constraints in the local stormwater drainage system in the design flood event (baseline), then to assess the incremental additional flooding that would occur from a levee breach. Six locations for levee breaches were selected on the basis of having the highest likelihood of failure. The results of the breach analyses are summarised in Figure 4 with the flood extent from each breach location being represented in a different colour. The following criteria were considered to assess the incremental consequence associated with each breach location.

Criteria	Scores based on
Safety and health	Estimated people at risk (assuming 2 people per building on average)
Loss of service (extent/duration)	Qualitative assessment of disruption
Corporate image for Tasman District Council	Qualitative assessment of impact
Environmental damage	Qualitative assessment of likely time to recover
Residential property and infrastructure damages	Damages (assuming $50,000 per property)
Non-residential property damages, including business disruption costs	Damages (assuming $10,000/ha of affected horticultural land, $100,000 clean-up costs per industrial/commercial building)

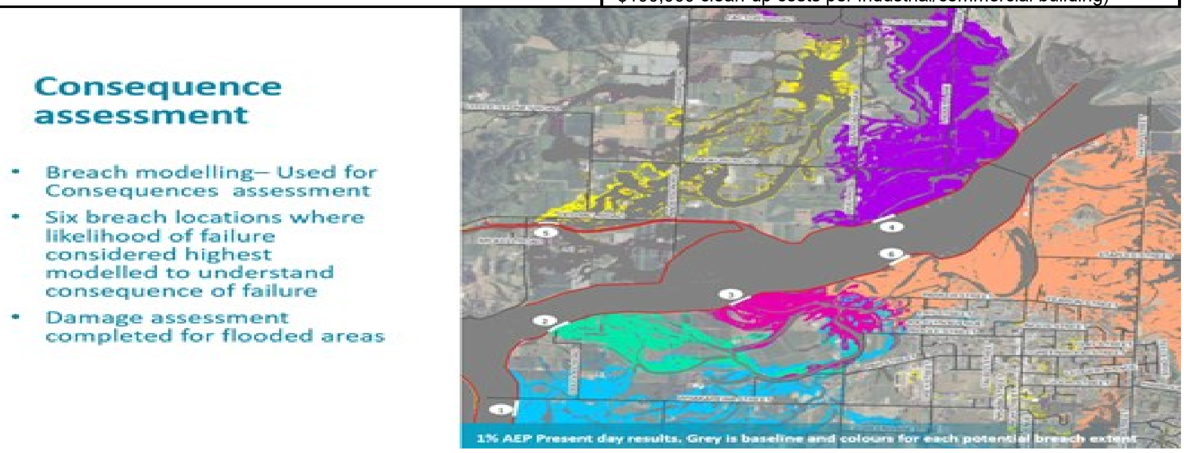

Figure 4: Breach modelling results for each breach location

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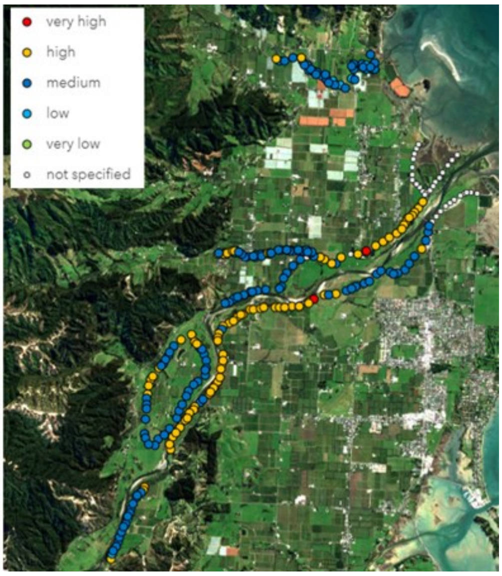

Figure 5: Flood risk score

Once consequences were assessed for each baseline and breach scenario, each breach scenario was “mapped” to levees by considering sections of similar consequence. Thus, each inspection point picked up during the walkover was assigned a consequence rating. This was combined with likelihood scoring derived using a combination of the condition/ structural integrity and hydraulic modelling assessments to derive an overall flood hazard risk score. Figure 5 presents the risk scores assigned along the Motueka River levees.

The results of the risk assessment were used to develop a prioritised programme of maintenance, repairs and upgrades designed to achieve the greatest reduction in flood risk for the available funds. The upgrade and repair works were focussed on the sections of levee with the highest flood hazard risk score. Works included rebuilding some sections of levees with structural deficiencies, and raising the crest of some sections where the likelihood of overtopping was unacceptable.

The RMF 2015 approach was used and customised to suit this location. The risk assessment component was extended and further developed to provide an on-line graphical interface of the structural, hydraulic, and risk assessment results. The graphical presentation of results proved to be a useful communication tool with the community and Council.

Temporary / mobile / demountable flood defences

By Rémy Tourment, INRAE, FR

Flood protection, in addition to fixed structures and systems, relies on a growing use of temporary, mobile, demountable flood defences. In October, our Working Group organized a webinar on this particular topic to gather and exchange ideas.

Figure 1: Illustrations taken from the International Levee Handbook (courtesy USACE)

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74 people from 16 different countries registered to the webinar which shows the interest these solutions attract. The presentations from the webinar are available on our web site (see https://lfd-eurcold.inrae.fr/index.php/working-group-webinar-2/).

There is a wide range of available solutions. Many commercial solutions are available, as well as simple "home-made" possibilities (big bags, …). A lot of issues have to be considered when designing a system involving such solutions:

- terminology/typology for the different temporary / mobile / demountable flood defences,
- hydraulic design: as a local, independent protection system (first line of defence or secondary line), or as part of an existing system involving other types of defences (as a closure, for raising or for enlarging the existing system),
- structural design: stability against all failure modes is required, for the temporary items themselves as well as for their foundation (existing defence or natural ground),
- consequences on other defences have to be checked too (in the same system and in other neighbour systems) as it will probably result in an increase of loading,
- operational considerations (flood warning, storage, transport, staff, exercises, O&M manual, maintenance of specific items (fixations, open spaces, …), repairability, …),
- regulations.

We are working on a tentative future document on this topic, taking into account ideas shared during the webinar and during further exchange with the presenters and participants. If there is enough interaction and contributions it will turn into a valuable document that will be disseminated by the LFD WG. Its ambition is to be a list, as comprehensive and organized list of related issues, but also to provide some solutions and examples of good practice where possible. Let us know if you want to be associated to this initiative.

"A field pilot test on different emergency flood defences "

By Wim van Steeg, Program Manager Water Board Limburg, NL; Jean Koken, Advisor Crisis Management Water Board Limburg, NL & Juus Teensma, Specialist Crisis Management Regional Water Authority Limburg, NL

1. Background

In July 2021, the Dutch province of Limburg experienced unprecedented flooding due to overland flow and along tributaries to the Meuse River. Some flooded urban areas along tributaries were protected by dikes (which overflowed due to backflow from the Meuse on the tributary) and some were not (e.g., Valkenburg). The Limburg Water Board (hereafter WL) intends to take further measures in particular to combat flooding from its water systems. To this end, a market consultation was conducted to expand the range of measures that WL will take in both the short and long term.

During the flood event of July in 2021 a lot of emergency measures were carried out. Most measures had to do with reinforcing levees around inhabited areas for the primary flood defences along the Meuse. The protection level was hardly affected, water levels on the Meuse were not influenced. The main purpose was not to have a failure of the flood defences.

Most sandbags/big bags along primary flood defences were used:

i. To provide stability for the temporary floodwalls (on fixed foundations), because the steel walls had been replaced by aluminium, which is easier to install.

ii. To provide weight and mass against piping (an extra shoulder) or with counter pressure.

Some big bags and sandbags at Maastricht were used for extra crest height.

Some temporary dikes (built by the inhabitants) should protect houses in areas which are allowed to flood. The soil dike (with no compaction) failed (at Horn).

There was little time to protect the areas around tributaries to the Meuse River. That is one of the main reasons for this pilot project.

2. Context

The focus for this market consultation was on being able to respond adequately to rapidly developing flooding from the water systems in the hilly southern part of the province, which shares some hydrologic catchments with the neighbouring countries of Belgium and Germany. It concerns the catchment areas of the tributaries to the Meuse River: the Geul, Gulp, Worm, Geleenbeek and their tributaries.

To be able to act quickly in case of locally occurring flooding due to extreme precipitation, it is desirable to have sufficient emergency materials for the first intervention.

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Important criteria that WL considers when considering these materials for general use are:

i. Deployable at various locations to reverse or conduct water up to 0.5 meters high with a total length of at least 400 meters or more.

ii. Easy to install with little manpower and without heavy equipment.

iii. Rapid deployment by decentralized storage in the deployment areas by means of 7-metre-long containers with a hook-lift system.

iv. Durable deployability in the sense of long-life span with frequent reuse and recyclability after replacement.

3. Purpose of the market consultation

WL wanted to gain insight into possible solutions to apply quickly deployable emergency materials in case of local (overland floods) and/or regional floods (floods along regional water systems). In addition to written input from parties, a pilot test was conducted. This market consultation will inform further steps to be taken by WL to eventually procure these emergency materials through a tendering procedure.

4. Target group and invitation

The market consultation was intended for companies active in the "flood emergency materials to be deployed" market that could play a role in supplying these materials.

5. Questions

The Water Board requested written responses from interested companies to the questions below:

i. Brief description of the organization also in relation to any parent company / subcontractor to be used.

ii. What solutions can be offered (taking into account the context described), being both emergency resources and necessary tools?

iii. A description of the proposed emergency resources with specific reference to:

- Speed of construction;
- Level of complexity and specific knowledge required to operate the system use;
- The extent of the number of specifically required components and the risk of incompleteness/not being complete;
- The manageability and use of hand power required;
- The ability to keep water out and the stability of the emergency barrier;
- The ability to keep water out in relation to underflow;
- The degree of stability in the event of overflow;
- To what substrates the emergency means can be applied;
- The vulnerability of the system in long-term deployment e.g. theft or vandalism sensitive;
- The labour required to prepare the system for subsequent use; and
- The applicability in relation to storage in containers with a hook-lift system and the logistic operations required.

i. A description of the maintenance after deployment and during storage of the materials?

ii. What certifications and test data do the materials to be deployed have?

iii. References with examples of actual deployment in emergencies?

iv. An estimate/directive price for the emergency materials to be deployed per component.

v. Participation in order to test deployment.

vi. What is the cost you would like to charge?

vii. What is the cost you would like to charge?

viii. What should a follow-up procurement for purchasing these resources look like?

6.Pilot test by invitation

WL invited between three and five parties to set up their equipment to set up, so that WL could get a good idea of the options available on the market.

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About five interested parties (see below) responded to the invitation by answering the questions included in the invitation.

- Altena Civiele techniek BV, Kampen, NL.
- Boxbarrier BV, Hoofddorp, NL.
- Geodesign AB, Saltsjöbaden, Sweden.
- Mobile Dikes Netherlands BV, Aalsmeer, NL.
- Slamdam BV, Montfoort, NL.

The documents submitted provided a good picture of the products offered and their share and (international) applicability in flood control. The answers to the questions also clearly showed where the similarities and differences lay. After examining the answers, WL invited four parties to provide a test setup. The following parties were invited: Boxbarrier BV, Geodesign AB, Mobile Dikes Netherlands BV and Slamdam BV. Afterwards as a result of the media attention, another company 'Waterschot BV' came forward with whom the same process was gone through.

Figure 1: Boxbarrier BV

Figure 2: Slamdam BV

Figure 3: Waterschot BV

Figure 4: Geodesign AB

Figure5: Mobile Dyke

The test setup took place near the Roer River in Roermond on April 6, 2022. Both in the morning and in the afternoon two setups were tested. Using pumps from WL, a high-water situation was simulated and approximately 40 meters of all systems were set up. WL had constructed two temporary culverts in advance for this purpose to enable the test to be carried out. The test set-up was attended by various advisors from WL from crisis management to employees responsible for equipment maintenance. Also present were representatives of the Safety Region, the Fire Department and Delft University of Technology. There was also administrative interest from various representatives as well as from WL's communications department. In addition, interested media were also present on this day.

7. The general findings and conclusions of the trial were summarized as follows:

- All products proved to meet the demand to turn back 50 cm of water.
- Construction time was diverse and, in the case of the water-filled systems, rather heavily dependent on the filling capacity of the available pumps. The conclusion here is therefore that additional manpower does not significantly improve set-up time.

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- The applicability strongly depends on the accessibility and soil conditions of the terrain where these resources may have to be deployed. The final call for tenders will focus on describing different scenarios which may lead to multiple best practice choices.
- The application of different foils has made it clear to us to pay attention to this in a further call for tenders. We have in mind additional requirements for the quality of any foils to be applied, in particular that they should be of sufficient quality to allow for repeated use. The option of possibly integrating the reinforcement may be integrated into the foil in advance.
- It was concluded that the choice of such a system should always involve physically connected components/modules to reduce the risk of failure.
- Due to a lot of interest in the media, after the test day we were able to receive a few more responses from suppliers who had missed the moment to react on time in the tendering procedure (via the website TenderNed). Part of a future call for tenders may again include a test moment (Proof of Concept) in the form of a test setup.

8. The follow-up

The market consultation provided valuable input to understand what solutions are commercially available. The Water Board has continued to prepare the project with the help of the insights gained. A follow-up to this market consultation is the actual procurement.

Installation of a system in Krakow, Poland

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Feedback Request!

We are always seeking for ways to improve this newsletter content and topical areas, and would welcome your feedback to lfd-eurcold@irstea.fr

NEWSLETTER TEAM CONTACT – lfd-eurcold@irstea.fr

Rémy Tourment, Adrian Rushworth and Petros Andreou