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

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LEVEES Working Group Newsletter

NOTE FROM THE CHAIRMAN

Rémy Tourment

There is no need to detail why, as everyone is aware of this, but the COVID 19 pandemic situation has had and still has a very deep impact on our everyday life, in our regular work, and even more on our international community activities.

Last year the ICOLD meeting in New Delhi had to be postponed multiple times. It has finally been moved to 2023 with the replacement of 2020 by a virtual symposium held in February 2021, which was very interesting and a success in terms of content quality if not in terms of physical interaction. The FLOODrisk conference planned for 2020 in Budapest will happen on 21 - 25 June 2021 and will be 100% virtual. ISSMGE 2022 in Sydney, Australia, has also been postponed to 1 - 6 May 2022. The Marseille ICOLD congress initially planned in June 2021 is now planned for 12 - 19 November 2021.

FLOODrisk 2020

Registration for the FLOODrisk conference is now open (https://floodrisk2020.net/registration/), the program is online and will be regularly updated. I hope that many of you will be able to attend this event that the organizers are actively preparing. They are making a lot of effort for the event to be very interactive with Q&A sessions, special events and a virtual exhibition hall allowing all participants to network and discuss together.

Even with an uncertain future in terms of international travel and gathering, our international community has to carry on, so do not hesitate to take this opportunity to interact with colleagues from different countries and from different backgrounds (decision makers, engineering, scientists, …).

All of the program is of interest to our members, but of direct and particular interest in relation to levees, we can already note:

- A special session on flood defences transitions, in association with the UK Environment Agency,
- A special session on risk informed decision making for levees and flood defences, in association with the ICOLD TC on Levees,
- Two sessions on deteriorating flood defence infrastructure
- Three sessions on flood defence asset management

Check the program yourselves here: https://hub.floodrisk2020.net/programme/ and I look forward to "seeing" you online in June!

In regards to ICOLD, we will probably give more information on the Marseille congress in our next issue (and on the web site in the meantime), but rest assured that the French national dam committee, as well as ICOLD bureau and central office are working hard to prepare the Marseille congress and to make it a success. I hope that I will meet as many of you as possible in this Mediterranean city where I was born sometime ago. You can check the website: https://cigb-icold2021.fr/en/generalinfo/welcome to find a lot of information as well as an introductive video to tempt you to plan your attendance.

As usual, in this issue of our newsletter you will find interesting technical and scientific information, as well as news about projects. But don't forget that we are always expecting information that YOU can send to share, in the newsletter, but also on our website!

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 websites 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

IN THIS ISSUE

MARIA ELISABETH PARDINI

The sad passing of our Argentine colleague

It is with deep regret that we inform you that Prof. Maria Elisabeth Pardini passed away on the 1st November 2020. She was the representative of Argentina in the Technical Committee on Levees and Small Dams of ICOLD (TC LE). Prof. Maria Elisabeth Pardini was a great professional and her death, caused by COVID 19, has caused a great impact on the technical community of Argentina.

As one of the latest outstanding performances of María Elisabeth Pardini we can mention the conference held last October 18th 2020 with the registration of 800 attendees from 12 countries, at which she spoke specifically about levees.

Some words from Rémy: "*I am personally deeply touched by this information as I had the occasion to discuss with her, physically or by phone or email, in relation to our own TC LE, or in relation to TC 201 of ISSMGE of which we both were members. Let's all have a thought for her and her family, and always remember her dedication to the dams and levees family.*"

FLOOD RISK

Estimating flood risk in levee-protected river systems

By Alex Curran, TU Delft, NL

Flood risk analyses focused on small sections or regions of embanked river systems ignore the dynamics of large-scale floods through time and space. Resulting measures are oftentimes inefficient due to an over estimation of risk or because they simply transfer risk downstream. As part of the EU funded System-Risk project, the PhD 'Flood Risk Analysis of Embanked River Systems' has recently been successfully completed at TU Delft in the Netherlands. The research sought to develop methods to estimate risk on the Rhine and Po rivers, taking into account so-called 'system behaviour' effects caused when upstream levee breaches change risk elsewhere in the system.

The work addresses these effects through an analysis in which the complete river-levee-floodplain system is modelled and assessed using stochastic simulations of flood events and levee failures. Specifically, the work addressed four main topics related to this type of analysis;

- The representation of levee strengths in the system being assessed.
- Modelling the river-levee-floodplain system and inundation patterns.
- The representation of interdependent hydrological sources in the system.
- Methods to provide decision makers with useful flood risk information.

While all of the topics are of interest in flood management, the first topic may be particularly relevant for levee design and management. In the Netherlands, the hydraulic loads on levees are mainly characterised by their peak values. The duration of extreme load events (which has a significant influence on certain levee failure mechanisms such as piping and macrostability) is only partly and approximately accounted for. A method was therefore developed to adapt earlier probabilistic representations of the strength of Dutch levees in the Netherlands (fragility curves) to include duration as a variable (forming so-called fragility surfaces, see figure 1 below). These surfaces represent the failure probability as dependent on both the water level and the duration of time that a water level is exceeded.

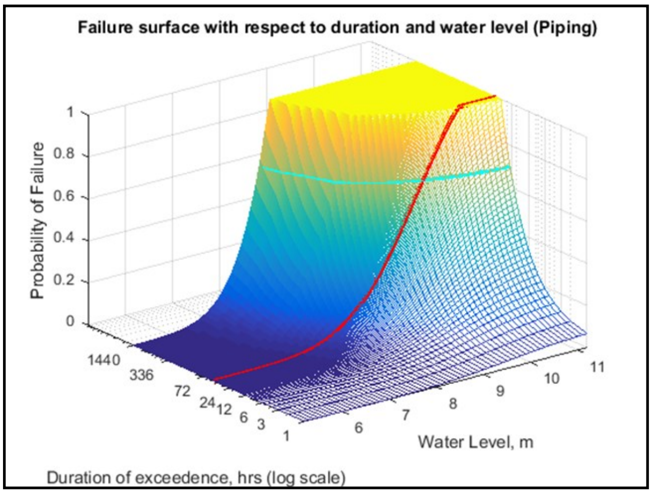


Figure 1: Example fragility surface for piping levee breaching mechanism. Red line shows original fragility curve and cyan line shows an example set of conditions for failure used in the Monte Carlo simulation process.

While these surfaces still simplify the levee breaching process, they can be easily incorporated into the probabilistic Monte Carlo simulations used to estimate large scale flood risk and system behaviour effects. A complete riverine hazard analysis of the Dutch river system using these surfaces was compared against a similar analysis in which probabilistic data based on water level alone (fragility curves) was used.

Including the duration was expected to reduce the impact of the system behaviour effect whereby upstream breaches reduce the discharge (and therefore risk) downstream. This is true at many locations, but the overall effect is more complex, as including the duration actually increases the expected number of breaches during extreme events compared to using fragility curves.

In general, the PhD research underlined the importance of assessing risk of complete systems, as it provided more accurate estimates of current flood hazard, defence failure probabilities and localised and system-wide risk. This will allow decision-makers to develop efficient and effective FRM strategies. Furthermore, it creates a repository of realistic flood event simulations that can be used for data mining and queries.

The thesis can be downloaded from the TU Delft repository .

FAIR

Integrated practices of adaptive asset management for flood protection

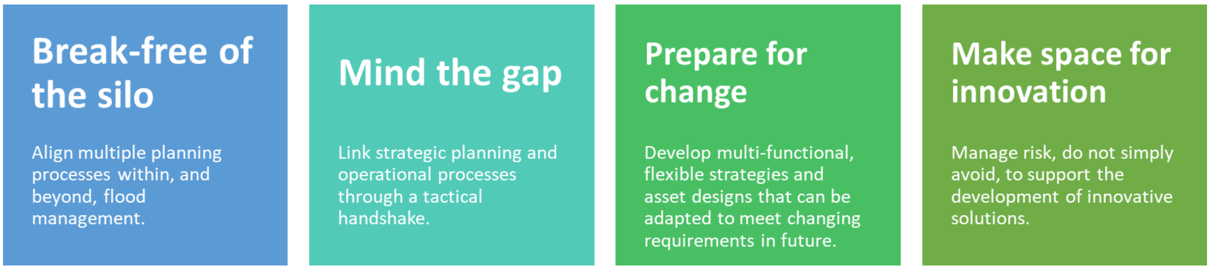
By Bart Vonk, Rijkswaterstaat, NL

Public organizations manage infrastructure to facilitate national or local needs. Asset management is the most efficient way to make sure that this infrastructure meets its demands, now and in the future. The EU member states jointly invest around 2.5 billion euros per year in their flood protection infrastructure. Much of this infrastructure was built in the decades after World War II. Meanwhile, existing assets are facing new challenges related to both climate change as well as demographic and economic developments.

Keeping the balance between quality, vulnerability and costs is becoming increasingly complex. The complexity increases as more functions and stakeholders become part of the same decision issue. This is particularly important in the water sector. Climate change, land subsidence, societal challenges and new knowledge are important drivers for decisions about the design, operation, maintenance and management of infrastructure. These decisions have to be based on a system-oriented and adaptive approach given the future uncertainties around the before mentioned drivers.

FAIR makes an integrated assessment possible
FAIR (Flood infrastructure Asset management & Investment in Renovation, adaptation, optimization & maintenance) is a European subsidised project, in which Belgium, England, Germany, Denmark, Sweden, Norway and the Netherlands collaborated. Rijkswaterstaat acted as the lead partner for the project. FAIR developed a model to meet the challenge of applying adaptive asset management to aging infrastructure that faces uncertainties related to climate change and demographic and economic developments. In this, FAIR has made a significant step forward by combining the ISO 55000 principles of asset management with the ISO14090 principles of climate adaptation.

Findings
The FAIR approach makes use of four basic principles:

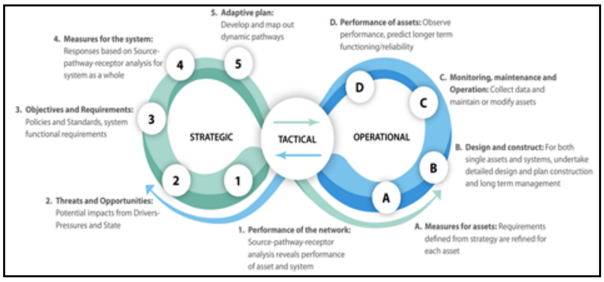


Using 5 pilot projects (given in the Table below), it was demonstrated that the FAIR approach helps to give adaptive asset management a foothold. With a digital learning environment, a knowledge agenda and a website (see: https://fairproject.org/), this knowledge is made accessible to be applied and further developed.

Pilot	Object type	Pilot case
Middelkerke, Belgium	North Sea levees	Combination of measures, including new stilling wave basin and sand dunes with beach nourishment.
Ribe Polder, Esbjerg, Denmark	Storm sluice, three locks and levees	Reviewing and enhancing the performance of the system, taking an integrated perspective.
Hamburg, Germany	Three public defence gates	Ensuring security and effective functioning of protection of the city of Hamburg from River Elbe.
Hollandsche IJssel, Netherlands	Levee in combination with storm surge barrier	Improving the performance, operation and reliability of the Hollandsche IJssel storm-surge barrier and the levee system along the Hollandsche IJssel river.
Helsingborg, Sweden	Sea wall in densely populated urban area	Improving the flood protection of the inner part of the city of Helsingborg.

The tactical decision level is the key to integrated and adaptive asset management

Essentially, integrated and adaptive asset management is all about connecting different decision levels. The first levels to be connected are the strategic (the 'why' and the 'what') and the operational level (the 'how'). Between these, the tactical level acts as an essential intermediate and connecting level, as shown in the FAIR Tactical Handshake below.



The second set of levels to be connected consists of the object level and the system level. The final levels that need connecting for a truly integrated approach are those related to other projects and actors in the same region. This implies that the organizations involved must be prepared to step out of their pre-defined responsibilities in order to connect with those of other stakeholders, while actively coordinating goals, budget and personnel availability. It goes without saying that shared and accessible information can greatly facilitate these connections, and allows to anticipate change, instead of just responding to change—when it may already be too late for an optimal solution.

The five pilot project have all shown the benefits of the FAIR approach, each in their own way. In the Dutch Hollandsche IJssel pilot, connecting the three sets of levels mentioned above led to significant cost savings on a multi-million Euro flood protection project, as well as several additional benefits. Further lessons were to keep an open eye for innovation opportunities, to stay away from technical lock-in situations, and to consider extendable solutions as a potential alternative for once-and-for-all solutions, as the latter could be less suitable in the face of large future uncertainties.

Future challenges
The FAIR project identified the following knowledge gaps, which can be utilised as a starting point for future co-operation initiatives between European flood defence asset owners:

A. From (big) data to information
B. From uncertain information to asset management policy
C. From asset management policy to action
D. From stakeholder to shareholder
E. Engaging Society

Although not within the original scope of FAIR, it would also be useful to explore to what extent it would be worthwhile to extend these co-operations (and the use of the FAIR approach) into the world of large dams.

Contact
Bart Vonk (Rijkswaterstaat project manager FAIR) bart.vonk@rws.nl
Website: https://fairproject.org . Further reading: https://www.researchgate.net/publication/346580679

REGULATIONS FOR VEGETATION

Aspects regarding vegetation on and at levees

By Ronald Haselsteiner, Bjoernsen Consulting Engineers, DE

The current German codes and guidelines do not cover all practical aspects for the design, construction and operation of levees. Especially regulations for vegetation, grass-like vegetation layers or woody vegetation, on and at levees show inconsistencies. The main document, which can be downloaded here, describes mandatory design requirements as well as several case studies, some examples of levee and tree failures, and re-known and controversial projects in Germany. After sharing German experiences, the paper closes with design aspects including one up-to-date case study for which a self-moving press-in equipment for the placement of steel sheet piles was used to conserve existing trees in the near vicinity of a levee due to environmental reasons. The document will soon be available on the website.

Figure 2: Roots through levees exhibited after dike breaches (left: failed dike at the River Mulde 2002, Source: Landestalsperrenverwaltung Sachsen / right: dike breach at the River Ammer in Bavaria in 1999, Source: WWA Weilheim) .

POLDER2C'S LIVING LAB

Levee failure tests and damage repairs in Polder2C's Living Lab

By Francien Horrevorts, FranenVrij, BE

The rising sea level and extreme weather conditions are a serious threat to the Netherlands, Belgium, France and the United Kingdom. How strong are the levees in this region? And how can we best repair levee damage? These are questions that the INTERREG-project Polder2C's aims to answer. In unique circumstances, the levee failure tests and damage repair exercises are carried out under realistic conditions in the project's testing ground, the Living Lab Hedwige-Prosperpolder.

Research in the Living Lab

Numerous field tests have now been carried out in the Living Lab, mainly focusing on the question of how strong the levees are and which factors determine their strength. This has been studied with overflow tests. Patrik Peeters, levee breach expert at Flanders Hydraulics Research, explains: "We simulate extreme high water flowing over the levee with an overflow generator. This enables us to determine the erosion resistance of vegetation and cover layer. We used strips of the levee with a closed grass surface, a large rabbit hole, a tree near the toe and a so-called sheep cliff, where sheep damaged the slope at the toe of the levee. This way we see the effect of the amount of water, but also of, for example, animal activity and the type of covering."

Figure 3: Overflow generator in action.

The first results

The first tentative conclusion of the overflow tests is that the levee revetment is sturdy and can withstand a considerable amount of water flow. "As long as the grass cover is closed without trampled zones or holes, hardly any damage occurs. But holes in the grass cover or the levee cause significant damage. In that case there is hardly time to respond." explains Peeters.

Repair the damage

Where Patrik Peeters' work ends, Bart Vonk, Advisor Water Safety at Rijkswaterstaat, comes into action with his emergency management team. Vonk: "What is interesting about the Polder2C's project is that we use the levee damage caused by Patrik's research to test repair techniques. Two damages on the levee were significant; one in the Netherlands at the top of the levee and one in Belgium near the toe of the dike. A great opportunity to test innovative methods."

Sandbags and foil

Several repair methods were thought of but Vonk's team decided to use temporary repair method using sandbags and foil (EPDM) in December. A different innovative placing method has been tested for each damage.

Embankment and Incision

Vonk explains "The first method for a damage near the crest of the levee, was to use sandbags to form a kind of embankment on crest of the levee. The foil was folded over the sandbags and then anchored in the levee with pins. All sandbags together form a large mass which is difficult to move by flowing water. Finally, all edges of the foil were reinforced with sandbags and anchored with pins. "

Figure 4: Embankment of sandbags.

Vonk: "For the second damage in Belgium, we tested making a grass incision with an excavator and placing the top layer and foil underneath. The cover layer and the edges of the foil were anchored with pins. A number of sandbags holds the middle part of the foil in place. An innovative way to repair damage with less sandbags and manpower."

Figure 5: Incision excavator.

Both methods successful

Both methods were successful. Vonk: "A big difference was the time and the number of people needed. The first method was labour-intensive. The second method took very little time and we could perform the repairs with only a handful of people and less sandbags. Time will tell whether both repairs are equally strong and weather resistant."

Further research

Curious about what else is going on in the Living Lab? Additional repairing techniques, wave overtopping and a breach exercise is planned. For more information, go to www.polder2cs.eu.

Polder2C's will receive a contribution of 3.9 million euros from the European Interreg 2 Seas program 2014-2020, co-financed by the European Regional Development Fund under subsidy contract No [2S07-023]. The total budget is 6.5 million euros. Interreg 2 Seas is intended to make the coastal area along the Channel and North Sea more climate-adaptive. More information can be found at www.interreg2seas.eu.

Interreg 2 Seas Mers Zeeën Polder2C's
European Regional Development Fund

RIVER LEVEES DURABILITY

A study on the durability of earthen river levees

By Yasmina Boussafir, Université Gustave Eiffel, FR

The durability of earthen river levees is a new concept. It could be assessed by estimating the time, in number of years, a structure will be able to protect land against flooding events. This time is represented as the working life or the life-time of the structure as standardised by EN 1990 (Figure 6). During this time, stakeholders have to maintain the performance with common maintenance techniques. After some time, the structure must be renewed or reinforced after evaluating the performance and the needs for repair.

The key to good asset management is to anticipate the need for maintenance and refurbishment of structures. That means that stakeholders have to think about the asset not only in terms of a binary performance (good / not good), but also as an asset that can get older with time, with a performance that can be poorly evaluated (from very good to very poor). This evolution can be represented as a deterioration curve of the performance, in red in Figure 1. The deterioration process can be fast, as many factors can deteriorate parts of the levee and make its life shorter. For example, the growth of vegetation, the occurrence of burrowing animals, but also, the quality of maintenance (from very good to non-existing) or the quality of the works and the initial design, etc.

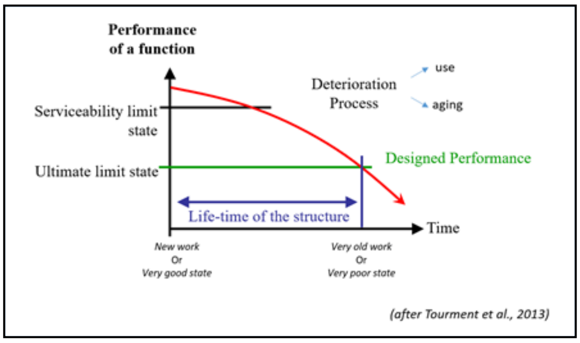


Figure 6: The structure shall be designed such that deterioration over its design working life does not impair the performance of the structure below that intended, having due regard to its environment and the anticipated level

A PhD thesis conducted at the Gustave Eiffel University (Paris-Est) on the subject of sustainability of river levees, has identified 4 topics that should be improved in the following years:

- Identify the environment of the levee and characterize their impact on the performance of each function of the structure.
- Work on each environment to define what factors really influence the performance and try to establish knowledge about the deterioration of performance.
- Define new laboratory tools to study and evaluate the performance during elapsing time and work on deterioration curves of performance, depending on the function of the structure and the type of materials.
- Define a new methodology to design the structure, giving indication to stakeholders about the lifetime of the structure and evaluate different possible designs depending on the budget and the strategy of maintenance of the stakeholder.

In that way, Yasmina Mankour-Boussafir, in her PhD thesis, has studied the effect of the meteorological environment, on compacted soils, assuming that climate, with alternatively dry and wet periods, has some effects on the performance.

The first part of the thesis confirmed the existence of specific zoning in the earthworks, through site monitoring (Bicalho et al., 2018). She identified a specific zone in the levee that is specifically affected by interactions between the soil and the meteorology of the site. The description of the zone has been based on the analysis of an instrumented earth structure located in Héricourt (Haute-Saône) near Belfort, and confirmed by the geotechnical analysis of a historical levee located in La Ville-aux-Dames (Indre-et-Loire) near Tours. As a result, she proposed to identify this zone, based on a classical levee cross section, as illustrated in Figure 7.

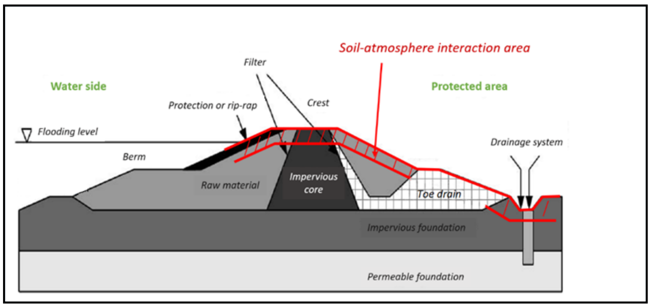


Figure 7: Inside the zone in red dotted lines, fine soil material can be strongly affected by shrinkage-swelling effects. Inside this zone, cracks can easily appear and permeability should be deteriorate.

The soils analyses, in the axis of La Ville-aux-Dames Levee, from the top to 3 meters depth, revealed that the soils were very dry, from 1 to 6% of water content, instead an optimum water content of 11%. This situation is probably the result of the intensity of the dry periods in this region.

According to this observation, the thesis presented a map of France, based on the Thornthwaite indicators, combining IHU (Humidity Index), Ra (Aridity Ratio) and Rh (Humidity Ratio): this was conducted to identify geographical zones with equal water stress on the levee, from high impact on the soil water content to low impact. In sectors with high meteorological impact, we should observe developments of cracks and decreasing permeability, as presented below.

The effect of water cycles, alternating dry and humid conditions have been studied on initially wet compacted soils, sampled in the La Ville-aux-Dames levee (France). Each drying and wetting period modifies the microstructure and leads finally to an increasing permeability: after 12 cycles, the permeability at the end of the process is 10 times bigger than the permeability after compaction (Figure 8).

This result indicates a deterioration of the performance between the initial state and 12 cycles later, which can approximately correspond to 12 years in corresponding weather. This approach is the frame for a study on the durability of the impervious function of a levee.

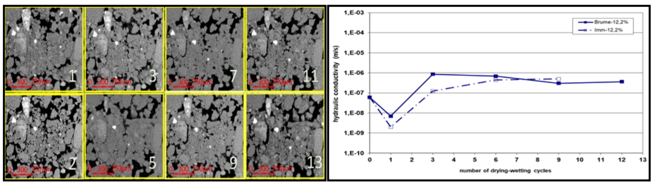


Figure 8: (a) Evolution of the microstructure of the compacted soil under hydric cycles The initial shape of the aggregate, due to compaction, progressively disappears. (b) Evolution of the hydraulic conductivity on a wet compacted soil after 0, 1, 3, 6, 9 and 12 cycles.

This work should be reproduced for other functions and other intensities of drying and wetting, in order to collect case studies on the impact of various climates on soils. Monitoring performance as permeability in a real levee at real scale, would also improve the concept and the reality of these laboratory observations.

GEOPHYSICAL METHODS

Combined geophysical methods for levee assessment and monitoring

By Adrian White, British Geological Survey, UK

Levees are most often constructed from natural materials excavated from local flood plain deposits of clays, sands, gravels, and peats. Levees weather and erode, just like natural landscapes, driving deterioration processes that may lead to failure. The dominant weathering and erosional mechanisms on an embankment are strongly dependent on:

1. the local environmental conditions and
2. the properties of the embankment materials.

If both of these can be determined at the asset scale it should be possible to assess which deterioration and failure mechanisms are most likely to be of concern. With the focus of my PhD on developing novel geophysical imaging methods to assess levee condition, this article explores the challenges of mapping subsurface material properties and what the solutions could be.

To be able to map the material properties of levee fill and foundation strata along the entire levee network at sufficiently high resolution, a combination of methods is required. Intrusive measurements can provide very accurate but localised information about the material properties. Geophysical methods are non-intrusive and can provide volumetric subsurface information making them an ideal candidate to map large areas. Geophysics has been routinely used on levees to detect anomalies within the embankment or foundations but to be able to map material properties several challenges must first be overcome:

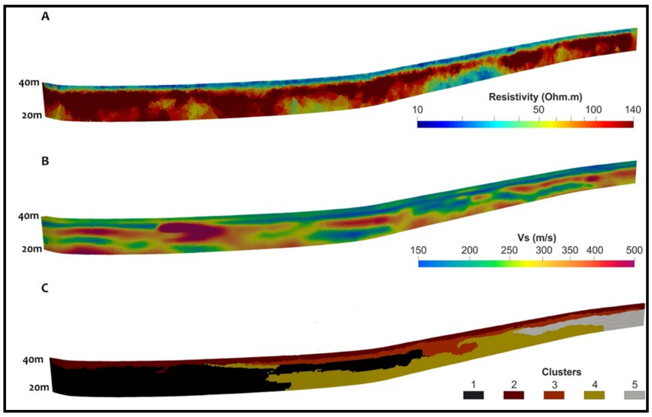


Figure 9 : A: Electrical resistivity map of an embankment picked out by the blue horizon and its foundations material showing in red. B: Shear wave velocity map collocated with electrical resistivity measurements. C: Resistivity and shear wave velocity grouped into 5 regions. Each region represents a specific set of resistivity and shear wave velocity values.

1. Geophysical data have to be used quantitatively, where properties are assigned to particular volumes in the subsurface. To assess the reliability of these property estimates a good understanding of the uncertainties and limitations of each geophysical method is required.
2. More information can be obtained by using several complementary geophysical techniques but this poses a problem of how best to derive a single ground model from a combination of distinct datasets.
3. Geophysical measurements do not directly measure geotechnical and hydrological properties of interest (e.g. moisture content, pore pressure, strength), so geotechnical properties need to be derived via laboratory-calibrated petrophysical relationships.

With recent developments focussing on each of these challenges, we are now in the exciting position to make real progress with the use of geophysics mapping subsurface properties. Recent success in combining electrical resistivity and shear wave velocity data using a clustering algorithm (Figure 1), allow us to identify regions of the subsurface with similar properties. It can identify the embankment fill as a unique region, which auger measurements confirm is different to its foundation strata. This potentially cost effective, non-intrusive approach allows detailed maps of the subsurface to be made. In the future this information could be used to allow predictions of how a levee may respond to changing environmental conditions and flood events, greatly assisting with asset decision support.

WORKING GROUP UNCERTAINTY

A UK view on the current global situation and the Working Group

By Adrian Rushworth, Environment Agency, UK

The year 2020 was exceptional, with COVID-19 affecting the whole world. The global spread of the virus has brought disruption and uncertainty. Sadly, many have seen the impact in our lives including the loss of loved ones.

It has also affected the activities of ICOLD. The ICOLD meeting in New Delhi in 2020 was postponed to 2023 and the Congress in Marseille had to be moved to later in 2021. It has also affected the work of the European Working Group on Levees and Flood Defences. As co-ordinators of the Working Group; Remy Tourment, Patrik Peeters and I are interested in your ideas on how the Group can adapt and develop in these new circumstances. We will be meeting in March to plan for 2021 through to the Congress in November. If you have any suggestions for the Group please send them to Patrik (patrik.peeters@mow.vlaanderen.be) or me (adrian.rushworth@environment-agnecy.gov.uk). For instance, are there ways to enhance the interaction and exchange of experiences between levee managers in the field?

In the meantime, don't forget to visit the website and send articles or updates for the newsletter.