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Polder2C's
European Regional Development Fund

1st Polder2C's Winter School Fieldwork for flood resilience Event Programme

Foto: Vilda-Yves Adams

Adaptation to climate change

AGENDA OF ACTIVITIES

Monday 1st March: Intro & Flood emergency response (online)		**Speakers / Instructors**
9:00 - 10:30	Introduction to the Winter School	Ludolph Wentholt Vana Tsimopoulou
11:00 - 12:30	Introduction to flood emergency response	Bart Vonk Mark Postma
13:30 – 15:00	Flood emergency response practice	Marian Booltink Anco van den Heuvel
15:30 - 16:30	Assignment instruction: Emergency levee repairs	Mark Postma Marian Booltink Bart Vonk Anco van den Heuvel
Tuesday 2nd March: Emergency levee repairs (fieldwork)		
9:00 – 15:00	Decommissioning of levee emergency repair measures	Mark Postma Marian Booltink Bart Vonk Anco van den Heuvel
Wednesday 3rd March: Flood defenses (online)		
9:00 - 10:30	Introduction to levee design and maintenance	Robert Lanzafame André Koelewijn
11:00 - 12:30	Data collection in the Living Lab	Davy Depreiter André Koelewijn
13:30 - 14:00	Tutorial: Polder2C's data management system	Nicolas Nerincx
14:00 – 15:00	Assignment instruction: Vegetated foreshores	Marte Stoorvogel Mario van de Berg
Thursday 4th March: Vegetated foreshores (fieldwork)		
9:00 – 15:00	Shear vane and penetrologger measurements	Marte Stoorvogel Mario van de Berg
Friday 12th March: Flood defences (online)		
11:00-12:30	Dike monitoring: why, what, how?!	André Koelewijn Wouter Zomer
Monday 15th March: Flood defences (online)		
13:30 – 15:00	Structural flood resilience: concepts and examples	Juan Pablo Aguilar López
15:30 – 16:30	Parallel sessions: 1. Assignment instruction: Resilient levees 2. Assignment instruction: Dike monitoring	Juan Pablo Aguilar López(1) André Koelewijn(2) Wouter Zomer(2)
Wednesday 17th March: Climate adaptation strategies (online)		
13:30 – 15:00	Managed realignment as a coastal management approach	Wietse van de Lageweg
Wednesday 24th March: Flood emergency response (online)		
13:30 – 14:15	Role of communication and risk perception in flood emergency response	Teun Terpstra
14:30 – 15:30	Flood emergency response in practice: making assets future-proof	Faye Lynch Phil Foxley Mark Fuller
Thursday 1st April: Final event (online)		
9:00-11:30	Final presentations of participants	Ludolph Wentholt Vana Tsimopoulou
11:30-12:00	Diploma award ceremony	

SPEAKERS AND INSTRUCTORS

Name	Title - Affiliation
Juan Pablo Aguilar-López	Assistant Professor of Structural Flood Resilience, Delft University of Technology, Netherlands
Mario van den Berg	PhD candidate, Delft University of Technology, Netherlands
Marian Booltink	Crisis Coordinator, Regional Water Authority De Stichtste Rijnlanden, Netherlands
Davy Depreiter	Researcher, Department of Mobility and Public Works, Belgium
Phil Foxley	Senior Advisor Asset Standards & Engineering, Environment Agency, UK
Mark Fuller	Flood Risk Adviser, Environment Agency, UK
Anco van den Heuvel	Calamity Team Flood Defences, Rijkswaterstaat, Netherlands
André Koelewijn	R&D Specialist, Deltares, Netherlands
Wietse van de Lageweg	Coordinator of Building with Nature Group, HZ University of Applied Sciences, Netherlands
Robert Lanzafame	Lecturer of Flood Defences & Probabilistic Design, Delft University of Technology, Netherlands
Faye Lynch	Project Manager, Environment Agency, UK
Nicolas Nerincx	Project Manager DN&T, Belgium
Mark Postma	Adviser of Water Safety, Rijkswaterstaat, Netherlands
Marte Stoorvogel	PhD candidate, Royal Netherlands Institute for Sea Research NIOZ, Netherlands
Teun Terpstra	Professor of Resilient Deltas, HZ University of Applied Sciences, Netherlands
Vana Tsimopoulou	Research Project Leader Building with Nature Group, HZ University of Applied Sciences, Netherlands
Bart Vonk	Senior Adviser of Water Safety, Rijkswaterstaat, Netherlands
Ludolph Wentholt	Polder2C's project coordinator, Foundation for Applied Water Research STOWA, Netherlands

ABSTRACTS OF LECTURES

Introduction to the Winter School

Speakers: Ludolph Wentholt & Vana Tsimopoulou
Date & time: 01/03/2021, 9:00 – 10:30

Polder2C's is not a conventional research project but an initiative that contributes to development and transfer of knowledge through the unique possibilities offered by the Living Lab Hedwige-Prosperpolder. In the opening session of the Winter School participants will be introduced to the Living Lab activities and the work method of Polder2C's. The key concept of flood resilience will be analysed from a technical and a social-scientific perspective providing information about the context within which the Living Lab activities and topics discussed in the Winter School make sense. By the end of this session participants will be sufficiently primed to delve deeply into the content of upcoming lectures.

Introduction to flood emergency response

Speakers: Bart Vonk & Mark Postma
Date & time: 01/03/2021, 11:00 – 12:30

People defended themselves against floods for thousands of years. In ancient times they built their houses on higher grounds or artificial mounds. Later they started building flood defences around agricultural land and villages. Yet history shows that nature is unpredictable and harsh. Extreme conditions that may lead to failures of flood defence often occur. This session provides a theoretical step-stone to flood emergency response. Preparedness for floods is discussed using the 'Source-Pathway-Receptor' framing principle (fig.1).

Figure 1. The Source-Pathway-Receptor (SPR) framing (Redrawn from Sayers et al. 2002)

Emergency response is positioned in the stages of flood protection (i.e. design, asset management, assessments, emergency response and operational response) and its core activities are described through the Polder2C's exercise framework that consists of five steps; observation, diagnosis, prognosis, execution and evaluation. In the last part the spotlight goes to the 'receptors', i.e. people and vital infrastructure in flood-prone areas. How do we improve people's risk perception? How do we teach them to (re)act in the right way to flood threats? By the end of this session participants will be familiar with risks associated with flood defence failures and the means to manage such risks.

Flood emergency response practice

Speakers: Marian Booltink & Anco van den Heuvel
Date & time: 01/03/2021, 13:30 – 14:30

When flood defences do not operate as designed, measures have to be taken to prevent flooding. De-poldering of the Hedwige-Prosperpolder offers a unique testing ground, the Living Lab Hedwige-Prosperpolder where emergency management can be tested under controlled but realistic circumstances. In this session participants will be introduced to flood emergency response from a practitioners' perspective. The cornerstone of flood emergency response practice is to diagnose, prognose and operate under time pressure. Note your findings, share and discuss risks and solutions and make decisions. Think about the solutions in terms of timelines, staff safety and possible side-effects. Important for the team is to identify the main risks and share the so-called '5WH': What, Where, When, Why, Who and How. Realise that every situation is different, which means that the effect, the time and location factors will result in constant adjustment of the approach and the need for anticipation. By the end of this lecture participants will be able to recognize the value of situational awareness and prompt decision making and action in emergency response practice.

Introduction to levee design & maintenance

Speakers: Robert Lanzafame & André Koelewijn
Date & time: 03/03/2021, 9:00 – 10:30

The flood defences curriculum of the Winter School begins with a detailed look at the design and maintenance of levees. Attention is given to the failure mechanisms that must be considered to ensure a flood defence can withstand various types of hydraulic loads, with a focus on the underlying physical processes and analysis methods. Key maintenance practices are addressed in connection with the particular failure mechanisms, which can be investigated in the field. Design standards from a variety of countries are presented and used to illustrate how the details of a levee design can change depending on local standards, as well as maintenance practices. This session will have an international perspective but use local site conditions to motivate two short discussions on levee design and maintenance to give participants a chance to apply their own knowledge and the perspective of Polder2C's partner countries to local Hedwige-Prosperpolder conditions.

Data collection in the Living Lab

Speakers: Davy Depreiter & André Koelewijn
Date & time: 03/03/2021, 11:00 – 12:30

Experiments on the levee of the Living Lab aim at answering specific research questions and verify hypotheses. Numerical models, varying from conceptual to detailed, describe the processes under investigation. In order to feed the models data is needed. The collected data must match the models and hypotheses and thus be fit for purpose. Due and prior consideration must be given to data collection parameters, resolution, spatial and temporal frequency, accuracy, redundancy and reliability, as well as the act of data management itself.

This lecture provides insight into the process of data collection prior and during experiments in the Living Lab, i.e. during the so-called 'survey' and 'monitoring' phase respectively. Data acquisition that has taken place so far is presented with details and examples. Attention is paid to practical limitations that may influence a data collection process, such as health and safety in the field, site specific anomalies etc. By the end of this sessions participants will be able to recognise the key elements of a good data collection process in the context of a living lab.

Tutorial: The Data Management System of Polder2C's

Instructor: Nicolas Nerincx
Date & time: 03/03/2021, 13:30-14:00

Following their introduction to the data collection practices in the Living Lab Hedwige-Prosperpolder by Davy Depreiter and André Koelewijn, in this session participants will be guided through the online data management platform of Polder2C's. This will help them familiarise with this newly built virtual environment and possibly use it to access and download data for their Winter School assignments, or for their own research in the future. Since the platform is still under development, participants will also be given the opportunity to provide feedback and suggest further developments.

Dike monitoring: why, what, how?!

Speakers: Wouter Zomer & André Koelewijn
Date & time: 12/03/2021, 11:00-12:30

Levees are supposed to maintain their water retaining capacity throughout their life cycle. This requires means that can provide a reliable assessment of levee strength at any given moment. To this end algorithms and models have been developed, but their results often prove to be less accurate than needed. In order to provide the best possible information about levee strength, life cycle monitoring (LCM) is applied. This session provides insight into advances in the life cycle monitoring of levees in the Netherlands, with a special tribute to the decade-long research and development programme 'IJkdijk' ('calibration levee' in English). 'IJkdijk' managed to develop and validate a variety of innovative monitoring techniques, ranging from surface measurements to remote-sensing technology. Valorisation of the developed innovations within the context of organisations that are in charge of levee monitoring and maintenance seems to be the next challenge. Big data, data mining, trend analyses, artificial intelligence and machine learning will be the next step to eventually achieve '3D+t' insight into levee strength. During the lecture the development of dike monitoring techniques and their use, as well as monitoring strategies and plans will be discussed. This session will help participants familiarise with the gaps that need to be bridged in order to move from theory to practice.

Structural flood resilience: Concepts and examples

Speaker: Juan Pablo Aguilar López
Date & time: 15/03/2021, 13:30-15:00

Flood resilience aims to cope with unforeseen and undesired flood related events e.g. high water levels, heavy rainfall, storm surges and even drought. In order for a system to cope with such events, preparedness, adaptation and future recovering strategies are the most important components to conceptualize when designing and assessing the system flood resilience. The conceptualization and design of three listed components are highly dependent on time and space dimensions. In terms of space, the definition of the system varies in scale like for example dikes, polders, cities, regions or countries. In terms of time, they can be classified as shock or stresses. The former consists of instantaneous events whereas the latter develops over a longer period of time and fluctuates in intensity. All previous characteristics will also determine the structural design requirements of the flood defence systems and their synergies with other infrastructural components of the system. When designing flood defence systems and their future behaviour against undesired extreme event(s), structural hard and soft measures like flood defences, evacuation paths and maintenance strategies become of paramount importance in the expected protected system's response during flood events. The lecture presents some basic concepts on flood resilience through structural measures and their relationship with flood risk management practice. These concepts are later exemplified in the form of cases in which flood resistance and flood resilience are clearly observable and explainable. The lecture aims to give a broad view of flood resilience theory and practice and is designed for the general public, practitioners and researchers.

Managed realignment as a coastal management approach

Speaker: Wietse van de Lageweg
Date & time: 17/03/2021, 13:30-15:00

The ongoing de-poldering of the Hedwige-Prosperpolder, which gave the opportunity to develop a living lab in the area is a so-called managed realignment project. Managed realignment is an ecosystem engineering coastal management approach motivated by concerns about ecological functioning and sea-level rise. It involves relocating the line of defense landward, thereby mimicking what would normally happen with marine environments during a period of sea-level rise. Despite the ongoing execution of managed realignment projects in various countries, it remains unclear whether managed realignment is able to deliver on expected socio-economic and environmental benefits. Assessing the ability of managed realignment as a more sustainable coastal management approach remains challenging. This session discusses two managed realignment sites in the Netherlands where interdisciplinary monitoring frameworks have been set up to record physical and ecological processes, the Perkpolder and Rammegors. Additionally, a Serious Game is used to get insight into the social processes involved in managed realignment projects. In the end lessons are

derived and transferred to the coastal landscape transition that is currently taking place in the Hedwige-Prosperpolder area.

Figure 2. Aerial view of Rammegors tidal restoration area. The area was re-connected with the Eastern Scheldt in 2016 and has since then been monitored in terms of groundwater development, morphological changes and colonization by benthos and vegetation.

Role of communication and risk perception in flood emergency response

Speaker: Teun Terpstra
Date & time: 24/03/2021, 13:30 – 14:15

In risk management 'risk' is often defined as probability times consequences or as a function of hazard, vulnerability and exposure. Social sciences however view risk as a subjective concept. In the words of risk psychologist Slovic (2000), "Risk does not exist 'out there', independent of our minds and culture, waiting to be measured. Instead, human beings have invented the concept of "risk" to help them understand and cope with the dangers and uncertainties of life. Although these dangers are real, there is no such thing as 'real risk' or 'objective risk'." According to Sjöberg et al. (2004) risk perception goes beyond the individual, and is a social and cultural construct reflecting values, symbols, history, and ideology. In this session Teun Terpstra will explain the social and psychological mechanisms that guide people's perceptions and behaviour. In the first part of the lecture he will explain risk perception and behavioural theories, using the Corona pandemic as an example. Choice experiment(s) with participating students will be performed to illustrate these mechanisms. The second part of the lecture focuses on flood risk perception and evacuation. Evacuation decision making (policy perspective) and recent empirical studies on flood risk perception and evacuation intentions among Dutch citizens are presented and discussed.

Flood emergency response in practice: making assets future-proof

Speakers: Faye Lynch, Phil Foxley & Mark Fuller
Date & time: 24/03/2021, 14:30 – 15:30

Due to a relatively high frequency of extreme events that threaten the structural integrity of flood defences, the UK has developed important experience in flood emergency response. This is reflected in incident response procedures, governance and tacit knowledge among incident respondents. In this lecture the flood emergency response and incident communication governance and structure in the UK is introduced. Subsequently the case of the York floods of 2015 is discussed with a special tribute to the climate-proofing upgrades that the York Foss barrier is currently receiving.

Figure 3. The overwhelmed York Foss barrier during the York floods of 2015.

DESCRIPTION OF FINAL ASSIGNMENTS

Assignment 1: Vegetated foreshores

Title

Stability of vegetated foreshores and their influence on the safety of flood defences

Coaches

Mario van den Berg & Marte Stoorvogel

Problem statement

Climate change and the associated sea level rise lead to elevated flood risks in delta regions. A recent study by Zhu et al. (2020) showed that a salt marsh in front of a dike enhances flood safety in two ways. First, salt marshes enhance wave attenuation due to their relatively high elevation compared to mean sea level as a result of sediment accretion over time. Second, if a dike does fail, the presence of a stable salt marsh reduces breach growth, leading to lower discharges through the breach. Thus, having a salt marsh present in front of a dike or between two dikes is valuable to make our coastline better protected against flooding, especially with regards to future sea level rise. This may make it desirable to restore or create a salt marsh at places where they currently do not occur.

When restoring/creating marshes for flood safety, it is important that they have very stable sediment to reduce breach dimensions when a dike fails and to make them sustainable. The stability of salt marshes is expected to depend on factors such as

i) the presence of vegetation
ii) elevation within the tidal range
iii) soil properties such as grain size distribution.

So far, it remains unknown how these factors exactly drive the development of sediment stability.

Suggested approach and anticipated results

The students will go into the field and take shear vane (to measure shear strength) and penetrologger (to measure penetration resistance) measurements, which give an indication of sediment stability and soil strength. If they take these measurements in the salt marshes and mudflats in front of the Hedwigepolder (mud) and in the salt marshes and mudflats in Sieperdaschor (sandy mud), they could investigate the relations between their measurements and the presence of vegetation, elevation within the tidal range and texture. Furthermore, this would allow their measurements to be related to critical erosion thresholds that were measured with a NIOZ flume by Marte in January and February.

Learning objectives

After this exercise students will be able to:

- independently perform shear vane and penetrologger measurements in the field;
- analyse and interpret the measurements taken in the field and correlate them to soil strength and sediment stability;
- and explain how vegetated foreshores could be created or restored in such a way that they enhance flood protection.

Logistical needs

Necessary equipment:

- Penetrologger
- Shear vane tester

These will be brought to the field by Marte (and/or Mario).

Necessary software:

- R Studio, Matlab or Python for data analyses (students can choose themselves which one they prefer)

Locations:

- Salt marshes and mudflats in front of Hedwigepolder
- Salt marshes and mudflats in Sieperdaschor

Fieldwork will probably take place in the end of the morning and afternoon of Thursday March 4.

Key literature

- Zhu, Z., Vuik, V., Visser, P. J., Soens, T., van Wesenbeeck, B., van de Koppel, J., Jonkman, S. N., Temmerman, S. & Bouma, T. J. (2020). Historic storms and the hidden value of coastal wetlands for nature-based flood defence. *Nature Sustainability*, 1-10.
- Brooks, H., Möller, I., Carr, S., Chirol, C., Christie, E., Evans, B., Spencer, K. L., Spencer, T., & Royse, K. (2020). Resistance of salt marsh substrates to near-instantaneous hydrodynamic forcing. *Earth Surface Processes and Landforms*.
- Visser, P. J. (1998). *Breach growth in sand-dikes*. Delft University of Technology PhD Dissertation.

Assignment 2: Emergency levee repairs

Title

Development of a framework for evaluation of emergency levee repairs

Names of coaches

Mark Postma & Bart Vonk

Problem statement

When the design load of a levee is exceeded damages start developing on the body of the structure that may eventually lead to a catastrophic failure. Due to climate change, the frequency and intensity of storm surges and high river discharges that may induce damages on a levee increases. When such situations arise levee management authorities need to be prepared to respond promptly with emergency repairs before the damages of the levee develop into a catastrophic failure. In November and December of 2020 Polder2C's performed a number of in-situ experiments of steady overflow on the earthen levee of the Hedwige-Prosperpolder. A number of damages were inflicted that in case of a storm could lead to a catastrophic failure (see pictures below). The regional water authorities ordered the repair of these damages within two weeks.

Groups of experts came up with alternative concepts for those repairs. In the end design solutions were chosen based on availability of material and time constraints, and they were implemented on December 14th 2020. New overflow experiments in February 2021 tested the stability of the implemented solutions against overflow, but it remains unclear how these solutions would perform against different scenarios of levee overload. In fact the topic of emergency interventions on damaged levees is vastly under-theorised and there is no framework or methodology outlining considerations in the design, execution, maintenance and decommissioning of temporary measures.

Suggested approach and anticipated results

Students involved in this assignment will participate in the decommissioning of the temporary levee protection measures that were installed on the levee of the Living Lab Hedwige-Prosperpolder on December 14th 2020. Using this experience and the theoretical basis of levee design and flood emergency response that is offered in theory lectures of the winter school, students can develop a methodology for the evaluation of emergency levee repairs from a technical and operational perspective. Documentation about the preparation and execution of the repair action of December 14th can be used to reflect upon successful and less successful choices, possible omissions and so on.

Learning objectives

After this exercise students will be able to:

- Analyse the technical and operational needs of emergency levee repair operations;
- Recognise when an emergency intervention on a damaged levee is necessary;
- Provide guidance in future emergency levee repair operations.

Logistical needs

Students need to be present in the Living Lab on Tuesday 2nd of March. More information about the needs on that day will be shared by the coaches one day in advance.

Key literature

To be defined by the coaches in due course.

Assignment 3: Dike-monitoring

Title

Dike monitoring strategies as enabler of (international) knowledge sharing

Names of coaches

André Koelewijn & Wouter Zomer

Problem statement

Flood protection in this period of climate change becomes ever more important. Yet due to cultural differences, historical developments, policy and local choices complicate an objective and data-based comparison of dike-strength, optimal maintenance, dike-strength calculation models, etc. To be able to share knowledge and experience in international context will benefit the flood protection sector. Sharing knowledge and experience can be served very well by acquiring data with which insight in behavior, strength and the effectiveness of measures can be objectively determined and compared.
To be able to better compare behaviour of levees and their strength, data of specific parameters and behaviour of the levee in different circumstances is needed. Yet different countries have different merits to build, maintain and inspect their flood protection infrastructures, amongst which levees, dikes, embankments, dams, etc.
In this assignment the goal is to formulate a general applicable dike monitoring strategy and monitoring system that can enable the mentioned (international) comparison.

Suggested approach and anticipated results

Select a levee/dike/embankment in each country that are more or less sensitive to the same types of failure mechanisms. Determine if these are rather alike regarding structure, size and material. Determine the base of data and information about the levee needed. Determine the extent of the level of detail needed in most optimal but realistic form. Determine which static and which dynamic data and information should be acquired. Mind heterogeneity of soil structures in general and formulate a monitoring strategy with a phase-wise-approach.

Learning objectives

- Students are able to formulate the common bases for requiring insight in levee/dike/embankment behaviour by formulating relevant strategies and selecting applicable measuring and monitoring techniques.
- Students know how to look beyond algorithms and models to assess flood protection infrastructure as levees/dikes/embankments and use data beyond the data needed for model calculations.

Logistical needs

The living lab does not need to be visited for this assignment. Students may choose, with the consent of the project group they execute the assignment in, a levee in the region they live in. Visiting the levee yields the particle understanding that can be used to fulfil this assignment. However, this is not required.

Key literature

www.dijkmonitoring.nl (also available in English)

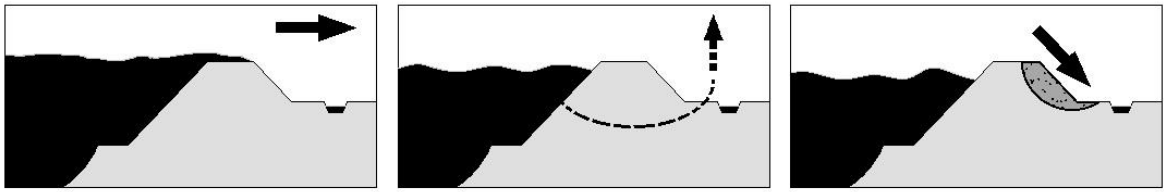
Assignment 4: Resilient levees

Title
Resilience indicators for levees

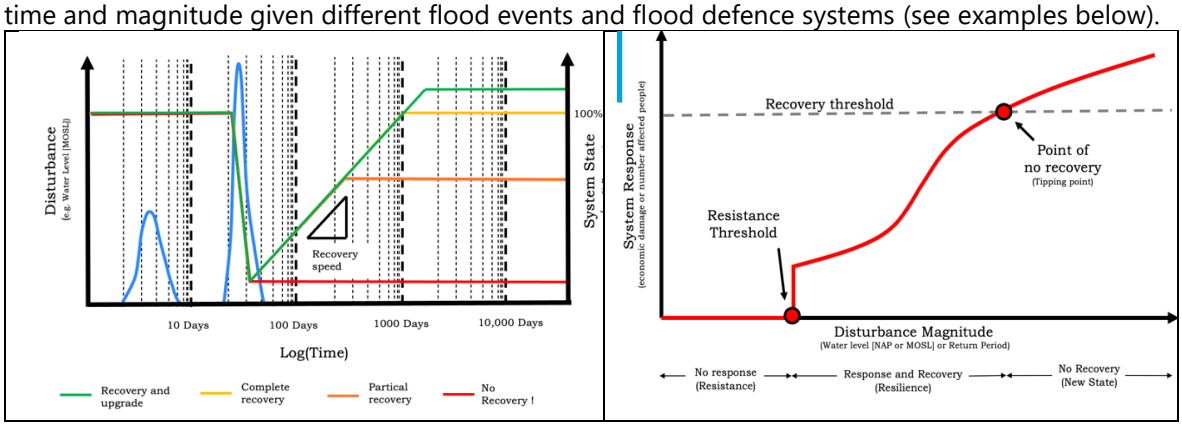
Names of coaches
Juan Pablo Aguilar López

Problem statement
Resilient flood defences are defined in the International Levee Handbook as structures that can fail, but they should not fail catastrophically. Given the broad range of interpretations that resilience has received in a variety of scientific fields, the aforementioned definition can be subject to multiple interpretations. It is unclear how the concept of resilience can be translated into concrete design and construction rules or how resilience of structures can be assessed or even measured.

Suggested approach and anticipated results
One of the main tasks before assessing and designing the resilience of a system is to conceptualize its spatial and chronological scales and characteristics. For the present exercise it is required to develop the resilience concept by assuming that the full system is just a levee. This will require to think and speculate which could be the main shocks and stresses, how the main failure mechanisms (e.g. overtopping, piping erosion or slope stability) are conceived in the 'system' resilience and which type or combination of resilience conceptualization (e.g. Engineering, ecological or socio-ecological) will better suit the exercise.



It is also expected that the group will develop their own 'dike resilience' definition and support why is it different from the definition given by the lecturer for flood resilience. Issues like resistance separation or addition in the dike resilience concept and its relation to the flood risk practice are expected. It is also expected that the group will propose descriptive curves of the dike's resilience in time and magnitude given different flood events and flood defence systems (see examples below).



As a final part of the exercise, it is also expected for the group to give hypothetical examples of dike systems which are conceived as fully resistant, fully resilient and a combination of both. The results from the exercise are intended to be used in the future improvement of the International Levee Handbook.

Learning objectives
After this exercise students will be able to:

- Recognise the key design aspects of resilience in a levee.
- Assess the degree of resilience of a levee based on its design and maintenance regime.
- Provide guidance for the design of a resilient levee.

Logistical needs
This assignment will be executed online.
Key literature
• Hosseini, S., Barker, K., Ramirez-Marquez, J.E. (2015). A review of definitions and measures of system resilience. *Reliability Engineering and System Safety*, 145 (2016) 47–61 • CIRIA C731. The International Levee Handbook. London 2013