Controlling flood levels: flexible flood barrier systems

Work package leader : dr.ir. M. Kok

Content

1 Description work package 1
1.1 Problem definition, aim and central research questions 1
1.2 Interdisciplinarity and coherence between the projects 2
1.3 Stakeholders 2
2 Project 1.1 Impact of flexible flood barrier systems 3
2.1 Problem definition, aim and central research questions 3
2.2 Approach and methodology 3
2.3 Scientific deliverables and results 4
2.4 Integration of general research questions with hotspot-specific questions 4
2.5 Societal deliverables and results 4
2.6 Most important references 4

1 Description work package

1.1 Problem definition, aim and central research questions

The Dutch 'Delta Works' were world famous flood control innovations in their times, but nowadays it is sometimes believed that dams and barriers in river mouths and estuaries are not sustainable in a changing climate, and that a more open defense system is preferable. However, open systems have disadvantages too; we could state that a sustainable modern adaptive flood protection is neither open nor closed, but as open as possible, as frequently as possible.

Key hypothesis in this research is that a system with flexible flood barriers may serve a broad range of changing objectives (flood protection, healthy ecology, living with water, shipping, etc), better than one without them and that our desired robustness of the system lies exactly in this flexibility. A flexible water system is less likely to become obsolete or inadequate. The problem definition is simply that the dams, barriers and dikes that shape the current water system are not flexible enough to serve changing circumstances the coming decades (even centuries) but also over a single year. Current barriers should probably be altered and new ones added.

Flexible barriers can run parallel to a water body (dikes that can be easily heightened or relocated), or cross a water body (moveable flood barriers). In this research, policy analysis, hydraulics, ecology and urbanism/landscape pivot around these physical elements. Hydraulic engineering research will be addressed, as the by many beloved engineering innovations ('Deltaworks 2.0') will result from objectives

and border conditions that are 'new' but also realistic (engineerable, buildable and affordable). The research question is how and where flexible flood barriers can optimally serve water policy objectives that ongoingly alter under climate change and in a changing society.

Apart from an historic analysis and an analysis of current projects such as the redesign of the Afsluitdijk, the research will adopt three cases in which the researchers are actively involved.

1. 'Closeable Open Rijnmond' – flood proofing Rotterdam. Innerdike flood safety of primarily Rotterdam and the Drechtcities', as well as outerdike and on-dike buildings, are of high value and can probably be sufficiently protected by moveable flood barriers ("Veerman-recommendation number 10").
2. River Branches, IJsselmeer and Southwest Delta – these are the water systems adjacent to the Rijnmond that have a strong connection with the possible Rijnmond barriers, and could themselves benefit from flexible flood barriers (for example a barrier in the Pannerdensch Kanaal and a redesign of the Volkerak Dam and Haringvliet sluizen).
3. International Case – Sacramento-San Joaquin Delta in California. In this delta, flood protection is one of the functions of the water system. Objectives are conflicting and a flexible system could solve the complex equations and make the system more robust (eg the 'two gates' and the '9 gates' concepts). Through the Knowledge for Climate international programme 'Delta Alliance' the researchers are working on relations with current leading researchers and policy consultants in California.

1.2 Interdisciplinarity and coherence between the projects

The researchers are based at the departments of hydraulic engineering and water management, but PhD candidate Ties Rijcken graduated as an industrial design engineer and worked in housing, planning and urbanism for five years.

Relationships with the departments of urbanism, architecture and policy analysis are excellent. More ecological input is needed and will be carried out by Deltares (project 3). The impact on Hydraulic load and the probability of failure will be assessed by HKV consultants (project 2).

1.3 Stakeholders

- ∇ relations with the City of Rotterdam and the Province Zuid-Holland are excellent
- ∇ the project will maintain close ties with the Delta Programme organisation (DGW, regional stakeholders, Deltares)

2 Project 1.1 Impact of flexible flood barrier systems

Project leader: dr.ir. M. Kok

2.1 Problem definition, aim and central research questions

The work package consists primarily of the PhD research (project 1); therefore the project 1.1 description largely comes down to the work package description.

Within this research, special attention will be paid to:

A. Impact on Hydraulic load and probability of failure: Location and shape of a flexible flood barrier alter water levels and flows in the system, and these affect flood safety, design of waterfronts, ecosystems, etcetera. Some support on hydraulic calculations will give the research quantitative depth. Another important issue that will be addressed is the probability of failure of several flexible barriers together forming one defence system. Since such barriers are subject to human failure (even if they are automatically closed, since the software is written by humans), it is important to investigate the failure trees and composite failure probability of these systems. The failure tree research will be based on the probabilistic methods of the Dutch Ministry of Public Works and Water management.

B. Ecological parameters as parallel input to the flexible flood defense operations: As stated before, the flexible barriers will not only provide flood protection, but also serve other goals. For example: a more flexible Volkerakdam (possibly operated in coordination with flexible barriers around Rotterdam and perhaps even at the Rhine Branches in the East) will buffer river water at times of a storm surge, but might also be able to enhance nutrients flow in the South West Delta or allow for better fish passage. Ecological ‘steering parameters’ are required for the operating equations of the flexible barriers, and also for the comparison between alternative locations and conceptual designs of the flexible flood barriers.

2.2 Approach and methodology

A ‘classic’ policy analysis approach will be applied for investigating ‘how and where flexible flood barriers can optimally serve water policy objectives under continuous climate change and in a changing society’. The various cases will be decomposed in structural problem and/or solution components; different combinations of components form alternatives; the objectives will be clearly formulated and the alternatives weighed against the objective attributes. In practical policy making, generating alternatives is often done in – from a scientific point of view – seemingly ‘political’ or ‘arbitrary’ ways. In this research the policy analysis will be more rigorous: the decomposition of the problem cases, the choice for alternatives, the formulation of objectives, and the scores on objective attributes will be done more thoroughly, transparently, and possibly quantitatively. Risk Analysis will be used to assess the reduction of risk attained by a system of flexible barriers. From these excercises general conclusions will be drawn in order to answer the research question.

But please note: some policy analists argue that the above method is old-fashioned and 'in practice doesn't happen like that anyway'. The researchers in this project however think that it is still the only way to deeply grasp a case and to extract general conclusions from multiple cases. However, 'non-linear' factors such as political statements, international reputation, personification and 'marketing' of specific alternatives will receive special attention.

2.3 Scientific deliverables and results

4 scientific papers, and a PhD thesis

2.4 Integration of general research questions with hotspot-specific questions

Between climate change and Hotspot Rotterdam stands the national water system policy.

Rotterdam requires (a.o.) answers to the following questions: what are the consequences of the national water system policy (flood safety- and other objectives) to the local (outerdyke and on-dyke) building practices (and possibly other water-related municipal practices), and: which building regulations and recommendations should Rotterdam apply while the national policy remains uncertain.

The viewpoint of this research is the other way around: what will the effects for Rotterdam be of various national policies (a policy consist ao of various uses of flexible flood barriers), and how do these effects affect the choice between various alternatives. This should ideally boil down to the same, however: Rotterdam will want more attention to the consequences of a specific policy (or the lack of a clear policy) for Rotterdam, while this research will emphasize more on the national policies. The researchers and their Rotterdam associates are well aware of these two national (longer term) and local (shorter term) perspectives.

2.5 Societal deliverables and results

The research aims for a serious contribution to the national "Delta Programme" and the national debate on the billions of euros expected to be invested in the water system in general, and to the consequences for Rotterdam in particular. The research will similarly contribute to the debate in California.

2.6 Most important references

4. Jonkman, S.N., 2007. Loss of life estimation in flood risk assessment; theoryand applications. doctoral thesis. ISBN:978-0-9021950-9
5. Jongejan, R.B., 2008. How safe is safe enough? doctoral thesis, ISBN:978-90-9023432-8
6. Zhou, H.-M., 2008. Towards an Operational Risk Assessment in Flood Alleviation : theory, operationalization and application, doctoral thesis ISBN:90-407-1146-1
7. Van Vuren, B.G., 2005. Stochastic modelling of river morphodynamics, doctoral thesis, ISBN:90-407-2604-3
8. Quy, N.M, 2005. Approach channels: risk- and simulation-based design. doctoral thesis, ISBN:978-90-9023201-0,

9. Klein, M.D., 2006. Modelling rhythmic morphology in the surf zone, doctoral thesis, ISBN:90-902-0185-8
10. Tuan, Thieu Quang, 2007. Seasonal breaching of coastal barriers, doctoral thesis, ISBN:978-90-9021954
11. Theunissen, RPGJ, Kok, M, & Vrijling, JK (2006). Compartimentering van dijkringen: niet altijd de oplossing. H2O: tijdschrift voor watervoorziening en waterbeheer, 21, 29-31. (TUD)
12. Jonkman, SN, Vrijling, JK, & Kok, M (2008). Flood risk assessment in the Netherlands: a case study for dike ring South Holland. Risk analysis 05(28) 1357-1373
13. Brinkhuis-Jak, M., Holterman, S.R., Kok, M, & Jonkman, SN (2003). Cost benefit analysis and flood damage mitigation in the Netherlands. In T. Bedford & P.H.A.J.M. van Gelder (Eds.), Safety and Reliability Esrel 2003 (pp. 261-270).Lisse: A.A. Balkema Publishers.