The importance of integrating lessons learned on Management, Maintenance and Operations of Storm Surge Barriers

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Storm surge barriers and nature based solutions combined are increasingly becoming a major component part of flood risk management solutions worldwide. The presentation covers two main topics. The first is to understand the growing awareness in the Netherlands and worldwide to embrace the lessons learned in the coherence of nature based solutions and fixed constructions like dams, levees and storm surge barriers. And secondly the search to form conceptual guidelines for those looking to design new barriers to ensure they take account of the learning from those existing barriers which have been in operation for decades. The maintenance and management challenge of existing barriers will only increase with climate change as it looks to increase operations resulting in reduced time for maintenance. We need to start thinking differently now for existing barriers and make sure this thinking is incorporated now into any future designs.

Sea-level rise and changes in storminess, together with population growth and coastward migration, are increasing the risks of coastal flooding. The impacts are amplified in coastal cities due to the high concentration of inhabitants, infrastructure and services in low lying areas. Many coastal cities are located in estuaries, and storm surge barriers are often constructed to provide flood protection in these areas with long exposed coastlines. These complex, unique and costly structures have life spans in the order of 100 years. Due to their intricate nature, they require specialist management, maintenance and operation (MMO).

The unique structure of storm surge barriers presents challenges

One of the most important things to take into account when building or rebuilding movable storm surge barriers is their specific characteristics, as these have a major impact on the MMO of the barrier during its usually intended lifetime. Recognizing and incorporating this aspect could, for example, substantially reduce future maintenance budgets and increase safety and reliability in the long term.
Awareness of these specific characteristics is often low, as storm surge barriers are still rare and tend to be managed by organizations that mainly manage standard flood defense fixed walls and pumping station structures and are set up accordingly. Unique structures, such as barriers, are not part of the standard systems and their specific characteristics then become easily overlooked. Exploring some of the most important characteristics and highlighting their implications for MMO, can increase recognition of this important aspect and thereby help to ensure the storm surge barriers continued reliable operation. Broadly speaking, each major movable storm surge barrier can be considered a prototype, a unique structure.

On the one hand, this is because every barrier system as a whole is unique when looking at the combination of the specific physical environment, specific requirements, and the specific type of barrier. For example a storm surge barrier type will vary dependent on the tidal range / surge magnitude width of opening and frequency of operation. On the other hand, it's because of the unique application of parts: either the use of parts which are custom made - and thus unique per definition or standard parts being used in a non-standard way thus unique in application.

For MMO, the uniqueness of the components and system firstly creates a need for very specific expert knowledge and an elaborate training program. Secondly, incorporating unique components in the design means that in MMO many different spare parts have to be available since these parts cannot be bought 'off the shelf. Thirdly, when 'off the shelf' parts are used differently from what they were designed for, it can cause issues. Water pumps are a common example. They are designed for continuous submerged use, but at barriers, they are mostly used infrequently in an alternating wet and mostly dry environment. This will affect their reliability and maintenance requirements as against what they were originally designed for. Fourth, political decisions on infrastructure usually do not take into account the uniqueness of storm surge barriers; they are focused on the generic situation of common infrastructure such as locks and bridges which occur in much greater numbers than storm surge barriers. Finally, the fact that barriers contain unique components has an impact on the relationship between the designer—often a market party—and the commissioner—often a government agency. These projects are often not very

lucrative projects for the market, as design, construction, and MMO cannot rely on cost-saving and knowledge acquired from repetitive production.

Capturing Lessons Learned to be used worldwide

In 2006 recognizing the unique nature of Storm Surge Barriers Marc Walraven and Andy Batchelor (from the Environement Agency in England) founded I-STORM. I-STORM (www.i-storm.org) is an international knowledge sharing network for all those who have a role in achieving reliable storm surge barriers. It looks to facilitate knowledge exchange and collaboration between members to help them deal with common challenges at an international level and enable continuous improvement in storm surge barrier design, operation and management.

I-STORM now has many members worldwide. Within the Netherlands and England organizations such as Rijkswaterstaat and the Environment Agency have more than 50 years of experience on Management, Maintenance and Operations of these complex storm surge barrier structures.
Many unforeseen challenges have appeared as; on occasion components didn't achieve their expected requirements; design considerations weren't always being archived; environmental circumstances changed with a demand to adapt (parts of) a barrier and organizational changes did have more impact on the reliability of a storm surge barrier than was expected. These are just some of the examples of many that arise when talking with staff involved.

Recently the I-STORM community has started capturing all of these examples. This with the aim to discover a way to categorize them and to define what kind of lessons can be learned out of them.

1. Lessons to be implemented and practiced within established organizations such as Rijkswaterstaat and the Environment Agency in how it can best educate existing and new staff.
2. To provide those that worldwide start to consider designing new storm surge barriers, to be able to incorporate these lessons learned from others into their new design.
3. Or those that may want to adjust their existing storm surge barriers to enhance their life by again implementing these lessons.
4. And last but not least, to provide this collected experienced knowledge to students, the next generation that faces the challenges of designing adaptable structures under changing climate circumstances.

Conclusive remarks

I-STORM looks to share knowledge within its membership but needs ways to increase awareness outside of its existing specialists. The World Conference for Tokyo Resilience in May is an excellent opportunity to share first examples of lessons learned at storm surge barriers in the Netherlands since storm surge barriers are in combination with nature based solutions increasingly becoming the major component part of flood risk management solutions. It is hoped by sharing these examples of lessons learned in the Netherlands a conversation can be started amongst Japanese and Dutch specialists to learn from and with each other.

高潮防御壁の管理、保守、運用に関して学んだ教訓を統合することの重要性

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高潮防御壁と自然ベースのソリューションを組み合わせたものは、世界中で洪水リスク管理ソリューションの主要な構成要素となりつつあります。 プレゼンテーションでは 2 つの主要なトピックについて説明します。

1 つ目は、自然に基づいた解決策とダム、堤防、高潮防御壁などの固定構造物の一貫性から学んだ教訓を受け入れるよう、オランダだけでなく世界中で意識が高まっていることを理解することです。そして第2に、何十年も運用されてきた既存の防潮壁からの学びを確実に考慮するために、新しい防潮壁を設計しようとしている人々のための概念的なガイドラインを形成するための探求です。既存の防潮壁の維持管理の課題は、気候変動によりますます増大する一方、運用の増加により保守時間が短縮されることが予想されます。 私たちは今から既存の防潮壁に対して新たなる考え方を始め、この考え方を将来の設計に今すぐ確実に組み込む必要があります。

海面上昇と嵐の変化は、人口増加と沿岸部への移住とともに、沿岸洪水のリスクを増大させています。 低地に住民、インフラ、サービスが集中しているため、沿岸都市では影響が増幅されます。多くの沿岸都市は河口に位置しており、海岸線が長く露出しているこれらの地域では洪水防御を提供するために高潮堤が建設されることがよくあります。 これらの複雑でユニークで高価な構造の寿命は 100 年程度です。 複雑な性質のため、専門家の管理、保守、運用（MMO）が必要です。高潮堤の独特な構造が課題を抱えているのです。

可動式高潮堤を建設または再建する際に考慮すべき最も重要なことの 1 つは、その特有の特徴です。これらの特徴は、通常想定される耐用期間中の堤防の MMO に大きな影響を与えるからです。 この側面を認識して組み込むことで、たとえば、将来のメンテナンス予算を大幅に削減し、長期的には安全性と信頼性を向上させることができます。

高潮防潮堤はまだ希少であり、主に標準的な水防固定壁やポンプ場の構造物を管理し、それに応じて設置されている組織によって管理される傾向があるため、これらの特有の特性についての認識は低いことがよくあります。 バリアなどの独自の構造は標準システムの一部ではないため、その固有の特性は見落とされやすくなります。 最も重要な特性のいくつかを調査し、その MMO への影響を強調することで、この重要な側面の認識が高まり、高潮堤が信頼性の高い運用を継続できるようにすることができます。

大まかに言えば、主要な可動式高潮堤はそれぞれプロトタイプ、つまり独自の構造と考えることができます。一方で、これは、特定の物理環境、特定の要件、および特定のタイプのバリアの組み合わせを見ると、全体としてすべてのバリア システムが個別の形式であるためです。 たとえば、高潮防御壁のタイプは、潮汐範囲や高潮の規模の開口部の幅、および運用頻度に応じて異なります。 一方で、それは部品のユニークな用途によるものです。つまり、カスタムメイドの部品を使用するため、定義ごとにユニークであるか、標準部品が非標準的な方法で使用されるため、アプリケー

ションがユニークであるかのいずれかです。

MMO の場合、コンポーネントとシステムの独自性により、まず非常に特殊な専門知識と入念なトレーニング プログラムが必要になります。 第2に、設計に独自のコンポーネントを組み込むということは、MMO では多くのさまざまなスペアパーツを入手可能にする必要があることを意味します。これらのパーツは既製品では購入できないためです。 第三に、「既製」部品が設計目的とは異なる方法で使用されると、問題が発生する可能性があります。 ウォーターポンプが一般的な例です。これらは継続的に水中で使用できるように設計されていますが、防潮壁では、湿潤な環境とほとんど乾燥した環境が交互に繰り返される環境でほとんど使用されません。 これは、本来の設計目的とは異なり、信頼性とメンテナンスの要件に影響を与えます。 第 4 に、インフラに関する政治的決定は通常、高潮防御壁の独自性を考慮に入れていません。 それらは、高潮防潮堤よりもはるかに多く発生する水門や橋などの一般的なインフラストラクチャーの一般的な状況に焦点を当てています。 最後に、バリアに独自のコンポーネントが含まれているという事実は、設計者（多くの場合市場関係者）とコミッショナー（多くの場合政府機関）との関係に影響を与えます。 これらのプロジェクトは多くの場合、それほど重要ではありません

設計、建設、MMO はコスト削減や反復生産から得られる知識に頼ることができないため、市場で儲かるプロジェクトを実現できません。今後、この学んだ教訓を活かさなければなりません。