Holistic Energy Efficiency and Environmental Friendliness Analysis of Inland Ships with Alternative Power Systems

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ABSTRACT

In order to deal with the decarbonisation of the transport sector, many policies suggest the application of alternative fuels with an emphasis on the electrification, an increase in the energy efficiency of transportation modes and a shift of freight and passenger transport from road transportation to other modes of land transport such as inland waterway transport. The vessels engaged in the inland waterway transport are often outdated, powered by low-energy efficient diesel engines, operating near populated areas and thus directly impair the air quality of the nearby population. Therefore, their energy efficiency and environmental friendliness need to be improved. Furthermore, energy efficiency and environmental friendliness assessment of ships with alternative power systems represent a special issue, since such mathematical models regularly consider power systems that use fuel with carbon content only. In this paper, the retrofitting of different types of vessels (cargo ship and passenger ship) with alternative power systems (powered by electricity, methanol, natural gas hydrogen and ammonia) is considered, while the diesel power system configuration represents a baseline scenario. Their energy efficiency and environmental friendlies are assessed, considering their annual life-cycle emissions and benefit to the society, by means of the mathematical model recently published in the literature and applied to short-sea vessels only. Its applicability to other transportation modes/ship types is confirmed and differences in energy efficiency and environmental friendliness of different power system alternatives are outlined.

Recommendations for Fender Testing in PIANC WG 211

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ABSTRACT

Fenders are a crucial asset to ports and maritime structures. The maritime industry has made great strides in designing and developing fenders. Their primary function is to absorb the energy of a berthing vessel without placing excessive loads on the berthing structures. Globally, the construction of marine infrastructure is estimated to cost a large amount of money. Consequently, manufacturers are under increasing pressure to reduce the cost of marine fenders by offering cheaper alternatives, leading to an alarming number of low-quality fenders being introduced to the market.

Fenders must be manufactured and tested to guarantee performance throughout their service life in order for port operators to obtain optimal value from their investment. PIANC - Guidelines for the Design of Fender Systems: 2002 Working Group 33 (WG33) is the current accepted industry guidelines for designing and testing marine fender systems.

The following paper provides updated testing recommendations for marine fenders and describes "Fundamental testing" and "Type Approval" testing to establish fender performance as listed in a manufacturer's catalog.
A critical aspect of ensuring the technical accuracy of fenders purchased for a project site is to verify their performance. This paper also discusses the scope of "Verification testing."
Listed below are the verification tests that will be included in the upcoming WG211 Guidelines:

- Performance Testing – will be conducted on an actual size fender to determine its reaction and energy absorption. It also clarifies the pass/fail criteria for a fender during the verification test.
- Durability Testing – cyclic testing of repeated compression to evaluate fatigue of each fender type
- Physical properties – determination of material properties catering for strength, abrasion, tear, effects of aging, and environmental impacts. This is carried out on raw rubber compounds before manufacture.
- Chemical composition by Thermo-Gravimetric Analysis (TGA) – Samples taken from actual fender are validated against compound samples used for physical property testing to verify traceability.

Fender testing itself will be in accordance with WG211 guidelines, which include:

- Clarity in temperature stabilization periods and necessity for break-in fender.
- Clarity on CV (constant velocity) testing method and data reporting; RPD (rated performance date) has been eliminated.
- Clarity in creation and reporting of Velocity Factors, temperature factors, angle factors.

- The presence of an experienced/qualified/fully independent third-party inspector or organization.
- Maximum and minimum resting periods between test cycles
- The option to introduce compression with shear and compression testing on fenders depending on “fit for need’ purpose.
- WG211 has included material properties, performance testing, and different performance factors related to foam fenders, aspects that are not addressed in the current guidelines.
- WG211 has introduced testing of fender support accessories including testing methods for closed box steel panels, low friction facing pads, systems etc.

As part of the upcoming WG211 Fender Design Guidelines, a new chapter has been dedicated to fender testing to ensure that high-quality fenders are produced within the maritime industry, thus protecting port operators and their assets. It marks a significant change from the current guidelines, which included the testing chapter as an appendix.

Future of the Supply Chain Lies in Digital Twins

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ABSTRACT

What is a digital twin and why do you need it? and most importantly - what can it do for me? In this presentation, the audience goes through the data journey of high-fidelity digital twins and their current and future uses in the global supply chain.
We take a deep dive (pun intended) into a fascinating use case of depth monitoring in ports and rivers and how it is used to increase cargo on vessels and reduce navigation risks.

Management of Saltwater Intrusion on the Lower Mississippi River

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ABSTRACT

The Mississippi River waters enter the Gulf of Mexico through a number of outlets more than 100 river miles downstream of the City of New Orleans, the most prominent of these is Southwest Pass. The natural thalweg depths of these passes varies depending on river discharge, sedimentation patterns, coastal hydraulic processes, and sea level rise. The Lowermost Mississippi River serves many critical purposes for the local communities along its banks, such as a source of fresh water and the Port of New Orleans and South Louisiana rely on the commerce. Further, the River serves the economy of the entire nation as one of the busiest waterways in the world providing a economically superior method of transporting raw goods from all reaches of the US to port and around the world. In order to maintain and stay abreast in global commerce and navigation, the Lower Mississippi River has been deepened two times to allow the safe passage of deep draft vessels up the River over 200 miles.

Analysis has shown that the enlargement of the Mississippi River Channel could have the effect of increasing the duration and extent of saltwater intrusion. Saltwater intrusion occurred naturally in the Mississippi River because the thalweg of the river channel is below mean sea level for over 300 miles upstream. There are many areas where the river bottom is shallow, called crossings, that naturally prevented the saltwater from moving very far upstream. The deepening project has removed these crossings and allowed the saltwater to move freely up the river channel during low water periods. Saltwater, which is significantly denser than fresh water moves along the bottom of the River channel in the form of a wedge. Observations have shown that the face of the wedge, from the leading edge called the toe, to the top of the wedge face (i.e., minimum depth of salinity within the flow column) is approximately 15 to 25 river miles long.

This increase in the duration and extent of the saltwater in the Mississippi River channel poses a number of problems for the local communities along the lower River as well as all the industrial interests along the river. Municipal and Industrial freshwater intakes can be damaged by corrosive saltwater. The municipal drinking water supply is threatened each time this occurs. Industrial facilities in this area are not equipped with salt removal in their water treatment systems. These facilities, which include power generation facilities, face serious damage if forced to use highly saline water.

In order to mitigate for the increased duration and extent of the saltwater intrusion, the US Army Corps of Engineers, New Orleans District, built an underwater sill barrier to arrest the

progression of the saltwater wedge. The underwater sill creates an obstruction to the upriver movement of the salt water. The sill creates a barrier on the bottom of the Mississippi River to which the saltwater must fill the entire downstream channel before it overtops the sill. This delay in upriver movement of the salt water provides the necessary mitigation that the deep draft river channel induced.

Review of existing scour protection design guidelines with application to a proposed cruise terminal – what are their limitations?

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ABSTRACT

Large modern cruise vessels with limited Under Keel Clearance (UKC) within berthing basins present challenges to maritime engineers due to the high scour potential adjacent to port bulkheads. The use of Azipod® propulsion systems and transverse thrusters within basins creates significant bed velocities which lead to scour risks when combined with an erodible seabed. These scenarios require properly designed scour protection to ensure the stability of the bulkhead systems.

This study reviews and compares existing methodologies in the literature for estimations of propeller-induced bed velocities and design of a concrete mattress scour protection system. The methodologies are applied to a proposed confidential cruise terminal and a proposed scour protection design is described.

The limitations of existing methodologies for prediction of bed velocities and scour mattress design when applied to large modern cruise vessels (such as the Oasis class) are discussed. Recommendations are made to provide additional guidance on the most appropriate methodology depending on project-specific design parameters, and important areas for further research are identified.

How appealing is shore power for the Cruise market in USA

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ABSTRACT

Shore power in the cruise industry has been around for almost 20 years but this technology is still a mystery to many. In this quickly changing world in which energy efficiency has become one of the critical elements of the design of every new or upgraded maritime facility the possibility of reducing costs and reduce pollutant emissions should be considered in every new or upgrade project.

This paper discusses if this not-so-new technology can help the port industry to become more sustainable, financially and environmentally by attracting Shore Power vessels ready to Shore Power ready ports and at the same time reducing the pollutant emissions at the port by up to 98%. The paper discusses the historical implementation of Shore Power in The United States, existing technology, challenges, applications, efficiencies and potential local emission reductions by the installation or retrofitting a Shore Power system in a new or existing cruise port facility.

Proeclusas Brazil - National Locks Recovery, Operation, Maintenance and Management Program

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ABSTRACT

The Brazilian National Department of Transportation Infrastructure (DNIT) is responsible for the design, construction, operation, and maintenance of federal waterways in Brazil, including lock and dam infrastructure on federal waterways. DNIT is currently responsible for the operations and maintenance of eight existing locks on federal waterways. To ensure sustained operations of the existing navigation locks, DNIT plans to establish an asset assessment and inspection program.

The purpose specifically focused on operational and maintenance aspects of the various systems of the lock and dam facility: hydraulic, electrical, mechanical, structural, and other systems. The overall objective of this scope of work is developing an integrated view of the various technical and administrative aspects involved in the operation, maintenance and management of the Locks Program PROECLUSA, which configured as a National Locks Recovery, Operation, Maintenance and Management Program.

This program intends to implement the necessary structuring and governance of this transport infrastructure segment, in the time horizon from 2019 to 2026. To accomplish this objective, US Army Corps of Engineers (USACE) and DNIT, an Intergovernmental Partnership Agreement, performed an inspection on one of the locks and subsequently develop recommendations that DNIT will develop in the future.

Measuring and Visualizing Salinity Intrusion Within the Panama Canal

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ABSTRACT

The U. S. Army Corps of Engineers has been tasked with studying the impacts neopanamax lockages have on water quality within the Panama Canal. An in-depth study was recently performed to measure precise salinity and velocity data at Agua Clara Lock, between Gatun Lake and the Atlantic Ocean. As a result of historic salinity measurements and previous studies, it is thought that neopanamax lockages through this structure are contributing to higher salinity levels in the fresh water of Gatun Lake. To further investigate this theory, over sixty monitors were installed at Agua Clara Lock and recorded data at fifteen second intervals for a three-week period. During this time, Panama Canal Authority lock operators performed many locking scenarios, including typical operations and those designed to conserve fresh water.

Data science best practices were used to analyze the datasets generated during these operations. A robust and flexible database was developed, capable of relating millions of records of salinity values to lock operations via time-series and spatial relationships. The results were published to visualization software, such as Microsoft PowerBI and Esri's ArcGIS Enterprise. Researchers were able to use these tools to analyze the precise salinity measures during each locking scenario and devise potential mitigation strategies to reduce salinity intrusion.

This poster submission highlights the role data analysis and visualization played in helping identify determinants of salinity intrusion.

Using NOAA's Environmental Sensitivity Index Data to Support Climate-Smart Planning and Response

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ABSTRACT

A product of NOAA's Office of Response and Restoration, Environmental Sensitivity Index (ESI) maps and data provide a concise summary of coastal resources that may be at risk in a given geographic area. ESIs are a standardized, compiled data resource used to evaluate potential environmental consequences from coastal threats, including oil and chemical spills. They combine information about shoreline sensitivity to oil with biological and human-use resources, enabling planners and responders to consider all factors jointly when evaluating protection and clean-up priorities. ESIs exist for the entire U.S. coast, including the Great Lakes and the U.S. Territories, and the ESI guidelines have been used as a model in numerous other countries to develop similar tools.

Originally developed as a tool for oil and chemical spill responders, ESIs are now also frequently used across public and private sectors to assist in activities ranging from natural resource damage assessment, restoration planning, environmental permitting and compliance, vessel traffic routing, port development, marine debris removal, hurricane response, and selection of marine sanctuary and conservation site targets. ESIs are integral components of Geographic Response Strategies and Plans (GRS, GRP), Area Contingency Plans (ACP), and industry response plans. Any number of recent responses to oil spills, hurricanes, or other incidents have relied on ESI data.

This presentation will provide an overview of the ESI tool and its applicability to development and planning of coastal installations such as ports. By better understanding what resources are present in an area and at risk in the event of an incident, planners and responders can create more resilient infrastructure and systems in the face of climate change.

Anyone who has planned or managed coastal infrastructure projects knows how important it is to have accurate information about resources that might be at risk in the event of an incident, and to know ahead of time what the permitting process and timeline might look like. ESIs provide all of this information at your fingertips in multiple digital formats.

As rising sea levels, restoration activity, and climate change impact the nation's coastlines, it is important for industry and government agencies to have an accurate picture of the state of shorelines, biological, and human resources in the coastal environments. Updated ESI data can provide this information.

Shoreline classification is the key original insight that defined ESIs, as the shorelines are color-coded to show their sensitivity. For example, shorelines shown in red are sensitive areas such as salt marshes that are especially vulnerable to oil. Those marked in blue are less sensitive shoreline types, such as rocky coastlines. Shoreline types are ranked across this index from 1-10, where type 1 shorelines are the least sensitive and type 10 are the most sensitive.

Symbols along the shore mark locations important to planners and responders, such as areas where seals or sea lions congregate or breed (marked with the unique pinniped symbol), areas where different kinds of birds concentrate for feeding or nesting, and habitat types including wetlands.

Human use data and infrastructure is also captured in ESI datasets and displays a wide range of uses, land types, and critical facilities. Locations such as ports, marinas, water intakes, desalination plants, archaeological sites, and cultural highlights are captured by the ESI data. This allows planners and responders to get an accurate picture of an area's existing human footprint in addition to the natural features captured in the shoreline and biology layers.

This range of data makes ESI products truly a one-stop-shop for environmental planning. Some examples of how ESIs are used include shoreline planning, oil spill response and planning, and Natural Resource Damage Assessments. ESI data can also be used to plan for a possible expansion of a facility, to see what natural and human resources exist nearby and make plans to reduce impacts.

ESI also includes information about how to contact local resource experts. If a spill occurs, or more information is needed, ESI maps will point users in the right direction to find people who can help answer questions.

For more information: Visit https://response.restoration.noaa.gov/esi/esiintro.html or reach out to ESI Program Manager Nicolle Rutherford Nicolle.R.Rutherford@noaa.gov; 206-526-4913

PIANC USA
The US Section of the World Association for Waterborne Transport Infrastructure

Numerical sensibility investigation on a full-form hull a case study of a pusher-barge system navigating in restricted waters

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ABSTRACT

Inland waterways in some regions are the only mode of transport available, as is the case in the Brazilian Amazon territory, where the largest basin in the world is located. Brazil stands in the third position in the total length of navigable waterways covering almost all regions but from 50000km of navigable routes, of which only roughly 13000km are commercially exploited. It is clear that the pusher-barge system has the potential to carry more goods in these waterways. Nonetheless, ship maneuvering simulators must be used to perform nautical studies seeking safety operations in restricted water and overcoming inland navigation challenges. Marine simulators are used in many applications, such as predicting the vessel's trajectory in arbitrary maneuvers, training naval officers, and navigability analysis in restricted areas. Ideally, these quantities should be gathered thoroughly and as close to reality as possible, spending a minimum time and budget. Force prediction in the maneuvers context has some peculiar features as the necessity to obtain the hydrodynamic coefficients for different incidence angles. These coefficients will compose the mathematical models employed in marine simulators and will be responsible for describing the hull response during maneuvers. Conventional approaches to obtaining hydrodynamic coefficients can be classified into semi-empirical and experimental methods. Although accurate, experiment-based models are costly and limited by geometry, i.e., modifying the hull geometry or even altering the draft could be challenging. A new method that has been attracting attention is the hydrodynamic prediction of forces through virtual captive model tests, which has gained space in many practical cases due to its flexibility and low cost of implementing different hull shapes and flow conditions. Thus, a numerical method will be explored herein to obtain the hydrodynamics forces and moments to feed the current coefficients required by the simulator in a fast and reliable way for any hull, dispensing a costly experimental test. Convoy's design must obey the national and international rules for safety in inland navigation. Also, its dimensions must abide by existing waterway infrastructure, which frequently means limited water depth. This feature alludes to the fact that modeling the shallow water condition meets real requirements for convoy operations. This paper aims to bridge the gap in the detailed flow modeling in a pusher-barge system through CFD for use in maneuvering simulations. A pusher–barge system with one pusher and nine barges arranged in a 3x3 combination was investigated. Firstly, straight-ahead and static drift virtual tests were performed for the convoy at the model scale ($\lambda = 50$) and two different Froude numbers (Fr= 0.06 and 0.11). Shallow water effects are investigated numerically for model cases. Then, full-

scale Reynolds number (Re= 9 x 10^8) computations are conducted for deep water cases. Results show a weak sensibility on the Froude number (almost 2% for the cross-flow drag) and a strong dependence on the Reynolds number, where the longitudinal force is overpredicted for the model scale (Re= 3 x 10^6) by 43%. At the same time, lateral and moment were underpredicted by less than 17%.

The effect of friction on the berthing eccentricity factor in PIANC WG211

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ABSTRACT

If the vessel's berthing contact point is eccentric to the vessels center of mass, the berthing vessel begins to rotate directly after the first contact with the fender system. This implies that the fender system absorbs only a portion of the kinetic energy of the berthing vessel, since a part of this initial energy will be transformed into kinetic rotation. Several analytical methods, such as Vasco Costa and Saurin, were proposed during the 1950s and 1960s to estimate this effect introducing an eccentricity factor. These analytical methods are still embedded in most of the fender design guidelines that are presently in use. It is, however, unclear to what extent friction between the fender system and the berthing vessel influence the eccentricity factor. This paper quantifies the friction-induced force acting on the fenders system using a time-domain simulation. Furthermore, the effect of multiple-fender-contact and low berthing angels are discussed. The results of this study have been used to inform design recommendations for the eccentric factor to be included in the new PIANC WG211 Guidelines for the Design, Manufacturing and Testing of Fender Systems.

Combining Ecological and Performance Enhancements of Atypical Breakwater Designs

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ABSTRACT

Humans have long fought against Mother Nature in the pursuit of developing and stabilizing the shoreline. Historically, this consisted of a brute strength approach of rock revetments, concrete seawalls, and large riprap breakwaters. These grey engineering approaches resulted in coastal zones which lack biodiversity and were a visual and physical barrier to enjoying the water. Modern coastal engineering has sought to work with and learn from nature to leverage natural coastal processes to stabilize and enhance shorelines affected by coastal development. This approach adds an ecological value to shoreline stabilizing solutions.

Living shoreline designs have been explored and enhanced over many years yet their application is mostly relegated to sheltered areas with limited agitation. While the best wave defenses along navigable waters are hardened structures, basic structure designs with little to no ecological features are the norm. Unique geometries for the purpose of habitat creation rarely enhance the performance of the overall system. In reviewing design options for breakwaters, we sought to marry ecological benefit with system performance.

To do this, we developed and tested a series of atypical breakwater cross sections, all providing opportunities for sustainable habitat formation, in a 2-D wave flume measuring transmission and agitation on the lee-side. In these tests, we looked at the permeability of the armor layers, height of the internal core structure, emergent and submergent features, crest width, front side slope, irregular berms, and spawning pools. Through these tests, we were able to determine which features most effectively reduced lee-side agitation while allowing for lower crested structures and reduced material needs.

These model test results revealed enhanced performance from wider systems with higher core heights relative to the water level in the primary frontal structure. Frontal irregular berms, while effective at reducing wave overtopping and transmission, required large volume of additional material significantly reducing their cost-benefit. Structures with flattened front slopes allowed for reduced armor size but reach a limiting beneficial reduction in transmission while considerably increasing volume and seabed impact.

While wider systems provided the best reduction in agitation, they did not need to be singular or even connected structures. Tests were performed on structures of various spacing in relation to wavelength and critical reformation distances were discovered. For a system of structures to have the highest benefit, they must be spaced such that a harmonic heightening, or riding of the wave, does not occur. This presentation presents the findings of this laboratory testing and

provides guidance on how to effectively design shoreline stabilizing systems with ecological enhancing features.

PIANC WG211 - Design of Fenders

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ABSTRACT

We are suggesting this special session to be an overview of the new document form WG211, with presentations of special topics on new developments we think will have special interest. It can be a panel session with some of the committee members, or a series of presentations. This will be the first PIANC conference where we can present the majority of content from a final or very near final document, and we think this will be of great interest to many of the attendees at the conference. WG211 will meet in person during the week of October 16 and will talk about the format or special topics we think will be of the most interest and we can present those in more detail after the meetings.

Combination Wall Systems for Terminal Bulkhead Construction

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ABSTRACT

Seawalls and bulkheads provide shoreline stabilization for many waterfront properties. At marine oil terminal facilities, they often serve multiple functions. Besides providing soil retention and wave energy dissipation, bulkheads can delineate loading platforms and vessel berths, support mooring points, and function as perimeter containment for potential fuel product spills.

Historically, sheet piles are the preferred wall system for bulkhead construction because they are a schedule- and cost-efficient system to install. However, these systems are infeasible at sites with strong rock where sheet pile driving is infeasible, and other systems must be used. This presentation will focus on one such alternative—the combination wall system. We discuss this system's components and its strengths relative to other options. We will highlight design considerations, construction challenges, and our experience designing a combination wall system at a marine oil terminal located on an inland waterway in Illinois. Attendees will learn about what combination wall systems are and when they are appropriate to use.

Waterfront Design Solutions for Climate Change Resilience

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Matthew, Gilbertson

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ABSTRACT

Located in harsh marine environments, coastal and waterfront developments require special considerations to ensure climate change resilience over the project's design life. Owners and property managers must design for current operations while planning to address future hazards such as flood and sea level rise.

To balance these issues against budget and time constraints, project teams can use an adaptive engineering approach, finding cost-effective solutions to protect waterfront properties for their design lives while leaving options for future alterations.

In this presentation, we will review several project examples and share how innovative design strategies related to structural material selection, waterproofing details, drainage design and more can help owners and operators plan for climate change.

Attendees will be able to:
- Understand key issues impacting the resiliency of coastal and waterfront developments, and
- Recognize the advantages and disadvantages of common structural materials employed in marine environments and implications on permitting and project installation.

Design Considerations for Shoreline Developments in Urban Environments

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ABSTRACT

Whether it is due to preserving the shoreline, maintaining existing shoreline infrastructure, or repurposing abandoned infrastructure, the waterfront in urban environments is an ever-evolving landscape, and no two shoreline development projects are the same. Possible areas for shoreline developments include derelict shipyards and naval facilities, decommissioned power facilities, and deteriorating marinas. Across these sites, designers can expect to see pile-supported structures, seawalls and retaining walls, abandoned utilities and equipment, and varying degrees of slope protection. Additionally, the goal of the development project can vary significantly across the site.

This paper outlines the primary considerations designers should be aware of when involved with shoreline development projects, specifically in urban environments. It will explore factors including site access, varying site conditions, small project footprints, limited staging areas, permitting and environmental regulations, wave climate, and sea level rise. The paper will also highlight the importance of these considerations and their implications on a project's budget, timeline, and overall success.

Marrying Historic Preservation with Climate Change Adaption

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Robert Sloop, PE, Moffatt & Nichol

ABSTRACT

The stone seawalls which line Washington DC's historic waterfront are iconic as the towering memorials they protect. Built in the late 1800's to retain reclaimed lands created through extensive dredging of the Potomac River, the walls have undergone periodic enhancement and modification as the lands around it grew with our nation's capital. Sitting upon soft dredged soils, the walls have settled as much as seven feet in some areas and deferred maintenance have left stretches of the walls in disrepair. Rising sea levels in combination with settlement have resulted in daily flooding of the land adjacent to the Jefferson Memorial.

Recent funding has allowed the National Park Service to fix the walls and prevent flooding which damages the upland, kills the iconic cherry trees, and inhibits visitor access and enjoyment. While there is desire to raise the walls to elevations which will prevent overtopping for the next 100 years, this would greatly change the landscape, visitor experience, and preservation of this historic place.

Following an analysis of sea level rise and climate change impacts within the area, the NPS and their engineers must come to an acceptable risk level, now and in the future, with an understanding of the dynamics of this space. This talk will go through the climate analysis performed, the communication of risk to the client, and ultimately the decision making of allowable risk and what is acceptable flooding in the future. A decision making process applicable to any site/facility located along the waterfront influenced by climate change.

Establishing Site-specific Load Factors for Fender Loads using LRFD Methodology

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ABSTRACT

During a berthing event, the resulting reaction force on the fender-supporting structure depends on multiple variables, including vessel size, berthing velocities, temperature, fender type, and many others. To achieve a consistent reliability level for the supporting structures, these variables should all be considered in developing and selecting the load factor applied to the reaction force. Some national codes provide a single load factor for berthing reactions without providing context for how this factor was derived. This single load factor creates inconsistencies in reliability levels, and it remains unclear which reaction force this factor should be applied to in the design process.

This study utilizes Monte Carlo statistical modeling to examine the effect of certain variables on the fender reaction forces to obtain a tailored, site-specific load factor that can provide a safe and economical design of the supporting structure. Specifically, the study explores how vessel size, temperature, manufacturer tolerances, fender type, vessel arrival frequency, and material uncertainty affect the reaction forces. The goal is to provide a clear path for selecting and applying load factors when designing the fender-supporting structure.

How Maritime Construction Can Prepare Buildings for Climate Change

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ABSTRACT

According to the 2022 Sea Leave Rise Technical Report from the National Ocean Service, sea level rise along the U.S. coastline is projected to average 10-12 inches between now and 2050, as much rise as has been measured over the prior 100 years. Coastal communities are nowhere near ready for this, and protecting the coasts requires far more than just building or raising seawalls.

In California's Bay Area, a first-of-its-kind project is creating a benchmark for marine construction. The new San Francisco Fire Department Fireboat Station No. 35 integrates the land with the sea, creating an emergency response building that will literally roll with the tides.

A Design/Build Joint Venture between Power Engineering Construction Co. and Swinerton Builders pulled off something that had never been done before in North America: designing, permitting, and constructing a floating emergency response fire station. The fire station was constructed in components, offsite, then towing across SF Bay and installed at a permanent mooring along the Embarcadero. A large steel float, held in place with steel guide piles, supports a two-story emergency response building and includes mooring for five emergency response boats. Additionally, a high capacity roll-on ramp provides access for ambulances and other emergency vehicles.

Designed and constructed with resiliency in mind, the new station can easily withstand earthquakes as well as projected ocean rises in the San Francisco Bay, positioning the building to be a key component of San Francisco's emergency response for many decades to come.

So how, exactly, do you construct an almost 15,000 sq. ft. building on a float weighing 3.3 million pounds and carefully tow it into position? And how did the project begin almost 6,100 miles away from its final location?

This program will entail a case study of the innovative project – alternate contract delivery, material choices with an eye on sustainability, design and construction approaches, options considered, challenges encountered, and success measurements.

Lessons from a World-Class Waterfront Redevelopment – The District Wharf, 5 Years In.

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Jessica McIntyre, PE, Moffatt & Nichol

ABSTRACT

The District Wharf in Washington DC is one of the largest and most successful waterfront redevelopments in the United States in the last 20 years. The $2.5 billion development has re-envisioned 27 acres of land and 24 acres of water as a 3-million-square-foot mixed-use development that serves residential, retail, office, hotel, and public uses. It incorporates waterfront parks, promenades, piers, docks, and marinas as well as homes, low-rise buildings, and underground parking.

On the water, the project includes:

- 1 mile of new boardwalk and “old-world” timber faux fendering
- 8 pier structures (99,000 sf+)
- 3 marinas with 400+ slips on concrete floating docks
- 6 over-water buildings
- Floating wetlands
- Moorings
- Jitney dock
- De-authorization of a Federal Navigation Channel
- $120 million+ construction budget

The presentation will highlight information gleaned from interviews from the design, regulatory compliance, construction, operations, maintenance, marketing, and programming teams that have been involved with the redevelopment of this Waterfront over the 10 years of design, permitting and construction as well as the subsequent 5 years of operations.

Construction of Piled Quays Using The 'Land Infill' Method

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George Hawkswood, Proserve Ltd

ABSTRACT

ABSTRACT
The Land Infill construction method for piled wharves will be outlined, which can offer time and cost benefits in comparison to construction methods using marine plant. Design which enables constructability is needed for this method, particularly for dredging and slope protection where access is limited by the piled platform.

Insitu concrete mattress protection is often more practical and cost effective than rock to piled slopes. It can also be installed under a newly constructed piled platform to enable construction sing the 'Land Infill' method. Case histories will be presented showing this method:-
Quetzal Port, Guatemala
Port Au Prince, Haiti
Belawan Port, Indonesia

Land Infill construction methods for wharf structures are being developed to save time and cost. The piling and platform construction is formed working from Land Infill with slope formation dredging pumping and scour protection formed in the wet underneath the platform. The need for appropriate scour protection will be outlined further with reference to recent case histories.

Berth Scour Protection Design For Azipods, Hinged Edges & Maintenance Dredging

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ABSTRACT

1. ABSTRACT
The paper seeks to advance knowledge to three important aspects of berth scour protection.

Azipods are increasingly being used particularly to large cruise vessels yet there is presently no established design method for scour protection subject to their action. These vessels can create high flow velocity to berths which makes rock protection impractical. Following scale model testing, design methods for scour protection will be presented for single and multiple azipods.

A 'falling hinged' edge detail has been developed for high velocity flows and as an alternative to rock falling edge aprons. The detail is used with insitu concrete mattress protection and comprises heavy in-situ concrete blocks which are linked to fall with edge scour. The relative merits of hinged edges and rock edges will be reviewed. A basis for the design and use of falling hinged edges is presented.

Maintenance dredging to berths with scour protection is an increasing issue with developing vessel size and often lower hull clearances, yet little up to date guidance is available. Views for the selection of resilient scour protection are given for common maintenance dredging actions with reference to PIANC WG22 (1997).

2. INTRODUCTION

2.1 Azipods

Azipods are driven by electric motors in the rotational hub behind the propeller. The rotational facility gives vessels good manoeuvrability hence Azipods are often used on cruise vessels. Azipods are often used in pairs with 3 or 4 Azipods being common on larger cruise vessels. Previous scale model testing of propellers has now been extended to Azipods. This includes testing of rock and in-situ concrete mattress. The testing demonstrated that Azipods are similar to propellers and similar design methods can be used. These design methods are presented initially allowing comparison of the test results.

2.2 Falling Hinged Edges

Edge protection is important to prevent damaging underscour of scour protection. Falling hinged edge arrangements have been developed following scale model testing under propeller Azipods flow. This has demonstrated its performance to react to edge scour and allow a design method

to be proposed for its falling protection depth. A method by Raes et al (1996) for the thickness design of hinged edge blocks to resist uplift is also presented.

2.3 Scour Protection Resilience for Maintenance Dredging

Maintenance dredging to remove siltation is frequently required to maintain vessel clearance. Near quay structures, siltation removal is needed over the top scour protection. Scour protection should be resilient to maintenance dredging methods likely to be used within the design life. The selection and design of scour protection needs to consider resilience to proposed dredging actions and bed levels to allow effective siltation management and removal.

2.4 Readership

The paper may assist with design and construction of berth scour protection, aid further testing, and development of design guidance. The paper may be of use to port authorities, design engineers, contractors, operators plus research and guidance authorities.

PIANC WG 231 Mooring Bollards & Hooks - Progress Update

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ABSTRACT

Mooring bollards and hooks are critical pieces of port and waterway infrastructure, whether existing or new, and will continue to serve the maritime industry for the foreseeable future. Ships and their mooring line loads are growing while waterfront facilities are aging, yet there is still a dearth of industry-recognized standards for material specifications, manufacturing, inspection, and testing of bollards and hooks. PIANC MarCom/InCom Working Group (WG) 231 is entitled "Mooring Bollards & Hooks: Selection, maintenance and testing". The WG's objective is to produce a benchmark document which provides clear guidance and recommendations when specifying shoreside mooring equipment (from 200 kN upwards) including mooring bollards and quick release hooks, including a list of types and typical capacities for different ship sizes, and guidelines for the full scope of testing during the manufacturing process and subsequently after installation (WG 231 Terms of Reference, 2020). This presentation will provide an overview of WG 231's scope, progress, and challenges, as well as a platform for discussion with waterfront facility owners, operators, contractors, and consultants.

Sustainability and Resilience Principles for Marina Planning

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ABSTRACT

Recreational and tourism navigation infrastructure requires a holistic and iterative planning process. By its nature, this type of infrastructure offers expanded opportunities to consider sustainability and resilience solutions, compared to transportation facilities.
PIANC's Working with Nature philosophy has been applied to recreational navigation infrastructure, documenting these new opportunities in Working Group 148, but the climate resilience are the focus of upcoming working groups.
This article revisits principles of sustainable planning and design of marinas in the context of climate change adaptation and mitigation.

Manzanillo Port

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Oscar Beltran, IADB

ABSTRACT

The Manzanillo Port Rehabilitation and Expansion program is an important project for competitiveness indicators and for the development of the northwest region of the Dominican Republic. It is consistent with the IDB Group's Vision 2025 "Reinvesting in the Americas: A Decade of Opportunities" in its first approach by promoting "sustainable and inclusive economic growth", through:

- Infrastructure for reliable and affordable logistics and port services;
- Contributing to climate change objectives by strengthening infrastructure resilience;
- Increased economic integration, facilitating access to export markets.
- Gender inclusion actions, with an inclusive employability model to empower the female labor force in the construction and operation of the Port.

Expected results of the program include a 10% increase in exports from the port in the medium term. Also, a reduction in transportation times and costs between 15-25% to the port, impacting the productivity of economic sectors such as agriculture and industry. And an increase in the resilience of the infrastructure, improving its availability in the face of climatic events. These goals are aligned with the Government's Development Strategy, especially with the objective of "expanding the coverage and improving the quality of transport and logistics infrastructure and services, aimed at integrating the territory, supporting productive development and competitive insertion in international markets".

The planned infrastructure works include a new off-shore terminal measuring 220 meters by 40 meters, at a distance of 200 meters parallel to the bay's coastline, with a natural draft of 16 meters, connected by an access bridge that will allow greater flexibility in operation, with minimal environmental impact and maintenance. The platform will allow the simultaneous berthing of two Panamax (4,500 TEUs) and Post Panamax (8,500 TEUs) vessels, expandable with more cells in the future to receive vessels of 10,000 TEUs. It also includes a new configuration of the port and logistics area with a modular structure that will allow its expansion to the east and west up to a total area of 20 hectares, in case it is required to increase storage and operation capacity.

This will be complemented by the modernization of mechanical and technological equipment, and new administrative and control facilities for port operations. The design was proposed with the objective of developing the best cost-efficient solution, which will allow for optimal operation in the long term.

Finally, the project contemplates mitigation and adaptation actions in terms of the environment and climate change. Attention will be paid to the care of protected areas with complete environmental management plans to prevent the construction and operation of the port from impacting the flora, fauna, and communities in the area. The development of a resilient design with a useful life of 100 years will also be sought through the application of the Blue Spot Analyses Methodology, which consists of an analysis of vulnerability to extreme climate within a framework of Decision Making Under Deep Uncertainty (DMDU), or Robust Decision Making (RDM).

Case Study: Vineyard Wind Offshore Wind Facilities

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ABSTRACT

Need to confirm with Owner.

PIANC USA
The US Section of the World Association for Waterborne Transport Infrastructure

IMPROVEMENTS IN THE PARANA - PARAGUAY AND ALTO PARANA WATERWAYS

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ABSTRACT

In South America, the Paraná-Paraguay and Alto Paraná waterways are approximately 4500 km long, involving main and secondary navigation channels. This waterways cross the countries of Brazil, Bolivia, Paraguay, Uruguay and Argentina; from Puerto Cáceres (km 3442, Paraguay River) and Puerto Iguazú (km 1927, Alto Paraná River) to the Atlantic Ocean (km -239). The total transportation of goods already exceeds 150 million tons per year, and has had a fast grown in recent decades. Throughout the waterway, the navigation channels take advantage of the natural conditions of the river and only in small stretches, called "critical sections", specific dredging works are required. The characteristics of the Waterway allow us to identify different stretches: From the Ocean to the Gran Rosario, (700 km of deep water with 36 feet). From Gran Rosario to Santa Fe (120 km with depths avaibles of 27 feet). The remainder constitutes a barge route (12 feet avaible depths). The design contemplates as a main criterion the maximum use of the deepest natural areas, which continually change their location, forcing the route of the navigation channels to be moved frequently. Nowadays, improvements in these waterways are being discussed, mainly focused in the deep water stretches, to achieve greater depths and thus to allow the transit of larger vessels, achieving a safer and more fluid navigation. These improvements include: a) Widening in all the channels, in order to adapt to the dimensions of the modern ships and barge trains that currently navigate them. b) Deepening from Timbúes (km 470) to the ocean (km -239) to reach 42 feet, gradually over the next 10 years. c) Modern navigation aid systems through the combined use of AtoN and VAtoN, also including AIS and River Information Systems. d) Larger areas of crossings and roadsteads for maneuvers and waiting at port entrances. e) Secondary routes in the Paraná Inferior, for ships in ballast. f) Hydrosedimentological and environmental measurements and controls to guarantee the natural preservation of the system. h) New layout of channel widening in curves. Of all these aspects, the deepening to 42 feet of the Tímbues – Oceáno section is the most important and perhaps the one that presents the most difficulties, both from a technical-economic and environmental points of view. In response to this observation, the gradual implementation of a new modality for the disposal of dredged materials in the Paraná River is proposed, which contemplates the natural tendencies of the river. This will be done not only for promoting a progressive reduction in dredged volumes over time, but also to promote an environmental approach that will make the Waterway more sustainable. In this work, these improvements are made explicit; in the frame of the particular situation that Argentina lives today, given the

expiration of the previous concession, an opportunity to include them in the new design of the Navigable Channels.

PIANC USA
The US Section of the World Association for Waterborne Transport Infrastructure

Propeller Wash Model to Predict Resuspension and Redistribution of Contaminated Sediments induced by Ship Traffic

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ABSTRACT

In areas of substantial ship traffic, the high-velocity jet flow generated behind rotating propellers, the propeller wash, may significantly impact aquatic ecosystems by resuspending and redistributing contaminated sediments. Over the years, several modeling approaches have been proposed to compute the propeller wash effects using numerical sediment transport simulations. However, the existing methods have shown limitations in the linkage of sediment erosion and subsequent transport processes, incorporation of propeller-induced energy into the flow field, and the ship path specification.

This study developed an approach to calculate the propeller wash effects (e.g., flow energy, sediment erosion rate) from one or more ships; the propeller wash results were then dynamically linked to a three-dimensional (3D) hydrodynamic and sediment transport simulation of Environmental Fluid Dynamics Code Plus (EFDC+). Ship position can be specified using data from the Automatic Identification System (AIS), but any ship location data can also be used. As ships pass through the model domain, sediments and accompanying contaminants eroded by propeller wash are added to the water column for transport, including advection, diffusion, settling, and deposition. The propeller-induced momentum can optionally be added to the 3D flow field.

This study used the U.S. Navy tugboat test events at San Diego Naval Base as a model verification test case. The model reproduced the field data, including flow velocities, sediment erosion depths, and suspended sediment concentrations resulting from the tugboat operation at a series of engine power levels, with Nash-Sutcliff Efficiency of 0.85-0.98. This approach was then applied to a full-scale 3D hydrodynamic and sediment transport model of the San Diego Harbor. In this case, the AIS ship traffic data was used to specify the ship type, position, and timing. This test showed vessels' berthing and unberthing around docking facilities produced much more sediment resuspension than their underway operation in the navigation channel. Additionally, the model results predicted more active advection and dispersion of the resuspended sediments when the propeller-induced momentum was added to the flow field computation.

The fully coupled approach presented in this study will allow more reliable predictions of resuspension and redistribution of sediments and any associated contaminants in areas of high

ship traffic. This approach will benefit researchers, engineers, and regulators in contaminant remediation planning, engineered channel designing, and long-term port management.

PIANC WG211 - THe new Guidelines for design of fender systems

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Erik Broos, Port of Rotterdam

ABSTRACT

In 2002 PIANC MarCom Working Group 33 published the 'Guidelines for the Design of Fenders Systems: 2002', shortly WG33. That report is the one reference document that all other national guidelines and codes that specify or prescribe fender design fenders refer to. Every country with a serious port has some guidance on the construction of marine Infrastructure, such as the internationally well-known design codes, standards, or guidelines, like the Spanish ROM, EAU, British Standards, ASCE, or OCDI.

As soon as a ship enters the port, it needs to be berthed. To protect the ship from the berth, or the berth from the ship, a fender system is installed on the berthing line to absorb the energy of the berthing ship, and to provide a buffer between the ship and the berth when the vessel is moored. A good and suitable design of the fender system is therefore necessary to avoid costly damage.

While the WG33 report is very valuable, it is also outdated in some areas. PIANC started a new working group in 2019, WG211, tasked with updating the current fender design guidelines. This paper presents an overview of the tasks of WG211, the structure of the new guidelines, and a summary of the new subjects or major changes compared to the old guidelines. Several key issues are presented to highlight the important technical changes to the document.

A WEB-BASED REGIONAL ECONOMIC SIMULATION TOOL FOR U.S. ARMY CORPS OF ENGINEERS' CIVIL WORKS PROGRAMS

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Kevin Knight, US Army Corps of Engineers

ABSTRACT

The U.S. Army Corps of Engineers (USACE) is one of the world's largest public engineering, design, and construction management agencies. The major Civil Works (CW) mission areas include navigation, flood risk management, hydropower, ecosystem restoration, coastal storm damage reduction, hydropower, water supply and recreation. To capture the regional economic benefits of water infrastructure and programs, the USACE Institute for Water Resources (IWR) developed the Regional ECONomic System (RECONS). RECONS estimates short-term and long-term economic activity resulting from federal investments within CW mission areas. Estimates of economic activity are measured as industry output, employment, labor income and value added and are provided for three levels of geography: local, state, and national. This information supports federal investment decisions and stakeholder communication. USACE's navigation mission alone services 41 states. USACE operates and maintains 25,000 miles of waterways and 236 lock chambers for commerce. Short-term economic activity is attributed to federal spending on infrastructures and operations and maintenance (e.g., spending to replace a lock) while long-term economic activity is supported by infrastructure users (e.g., lock utilization by shippers). RECONS facilitates widespread application of input-output (I-O) analysis through a user-friendly, web-based simulation tool customized for CW mission areas. RECONS enables users to conduct valid and consistent economic impact analyses without the degree of knowledge required by comprehensive I-O models. As a result, over 200 USACE economists have used RECONS to conduct hundreds of analyses each year. This paper describes RECONS' capabilities and applications, and its implications for federal decision-making regarding investments in inland navigation infrastructure.

SHIPPER RESPONSE SURVEYS AND THEIR IMPORTANCE IN THE EVALUATION OF U.S. INLAND WATERWAYS

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ABSTRACT

Shipper response surveys have been growing in favor in recent years and if administered correctly, can help quantify shipper's behaviors and opinions which present themselves as transportation demand functions by mode of delivery (water, rail or truck). Demand functions, defined by economists as "numeric demand elasticities" or changes in quantity demanded as a result of changes in rates/duration/reliability, have enabled to the Corps to analyze (1) lock reliability and component failures; (2) demand projections vs. system capacity to determine equilibrium waterway traffic and (3) selection and sequence of replacement, repair or modernization efforts over the planning horizon.

This paper highlights this innovative approach in predicting shipper behavior using shipper response surveys that were recently applied to two major waterways in the U.S.-- the Upper Mississippi River and Ohio Rivers) and how the resulting outputs could be used in to analyze lock investment priorities as well as impacts due to closures and other events.

Design Solutions for Waterfront Resilience

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ABSTRACT

Located in harsh marine environments, coastal and waterfront developments require special attention to improve resilience over the project's design life. Material selection, siting questions, protective coatings, waterproofing detailing, and drainage are all important considerations for the design team. Adding to these projects' complexity are the growing effects of climate change and sea level rise, which pose additional threats for continued operation and potential recovery.

With proper design, planning, and coordination, developments like ferry terminals, pier buildings, and other waterfront properties can greatly enhance the building and community resilience of urban areas. By understanding flood and storm risks and employing proper planning and mitigation strategies, project teams in marine areas can create successful designs that incorporate innovative features in structural material selection, waterproofing strategies, drainage considerations, and climate change planning, among others.

This paper will explore these best practices of increasing the resilience of waterfront properties through design.

DREDGING OF THE ACCESS CHANNEL TO THE MARITIME PORT OF GUAYAQUIL, FROM FORECAST TO EXECUTION

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ABSTRACT

The Maritime Port of Guayaquil, is made up of Public and Private Terminals and between all of them, by 2022, they mobilize more than 2 million TEUs, export and import. The Public Terminal was inaugurated in January 1963, the Access Channel had two sections, an External Channel with a depth of 8.8m to MLWS with a rock bottom and an Internal Channel with a depth of 8.8m to MLWS with silt bottom, that allowed the entry of operations of ships of 160m in length and draft of 9.75m with tide benefit, in 1964 the first Private Terminal operated. In 1997, the change in the Port Management Model began in Ecuador.

After the announcement of the Expansion of the Panama Channel in 2006, all the Ports of the region prepared themselves intensely for this challenge, with the exception of Ecuador. However, due to the pressure of Commerce and the Maritime Industry, in 2011 the Port Authority of Guayaquil contracted with CONSULSUA & GEOESTUDIOS, the complete Studies to Dredging the Access Channel and to propose the best Dredging Management Model (capital and manteince). In 2013, the Municipality of Guayaquil hired the same Association for the studies to update the dredging of the External Barrier.

The conclusion of these studies was that the most convenient thing was to grant a concession for the dredging of the channel and that the capital and maintenance andwork be paid for by a fee for use of the canal. While this was happening, the ships that entered the Port Terminals were getting bigger and bigger, but they maintained the draft of 9.75m with the benefit of the tide.

In 2017, the Project was resumed by the Municipality of Guayaquil for the "Delegation to a Private Manager of the Dredging, Deepening and Maintenance of the Access Channel to the Port of Guayaquil for 25 years. The Technical Analysis of this process was carried out by CONSULUA; the operation of NEOPANAMAX vessels was proposed, with an operating draft of 12.5m with tidal benefit, and the dredging depths would be 11.85m in the External Channel at the MLWS and 11.54m in the Internal Channel at the MLWS.
After the contractual process, on December 5, 2018, the Delegation Contract was signed with Compañía Canal de Guayaquil S.A. (CGUSA), a subsidiary of the JAN DE NUL N.V Company, the capital dredging was proposed to be executed in 02 years, however, it was carried out in 01 year, enabling the access channel for ships with a draft of 12.5m with benefit of tide since January 2020, maintenance dredging has been carried out successfully. In May 2022, the Municipality of Guayaquil has been requested by the Shipping and Port Sector to increase the

depth, to enter the NEOPANAMAX with 14m draft with tidal benefit, projecting the entry of the VLCS. Now this is the challenge.

"DREDGING OF THE ACCESS CHANNEL TO THE MARITIME PORT OF GUAYAQUIL, FROM FORECAST TO EXECUTION"

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depth, to enter the NEOPANAMAX with 14m draft with tidal benefit, projecting the entry of the VLCS. Now this is the challenge.

Optimization of Off Shore Segmented Breakwaters Using a 3D Physical Model

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Jack Cox, PIANC Member

Alejandra Lira, PIANC Member

ABSTRACT

Illinois Beach State Park is the only stretch of undeveloped Lake Michigan shoreline in the State of Illinois. The park is approximately six miles long and contains unique habitat features including a well-formed beach-ridge plain coastal landform and freshwater wetlands called pannes. Given the nature of the site, the Illinois Department of Natural Resources sought to find solutions to the erosion that were non-intrusive to the shoreline and preserve the aesthetics of the park.

For this reason, the design team employed creatively shaped and formulated breakwater island and submerged reef structures. The intent of the plan was to force a new, stable shoreline alignment that was relatively straight and void of salient and tombolo growth. The breakwater dimensions and alignments had to avoid a copy and repeat approach as well. Instead, the offshore breakwaters were carefully sculpted and positioned to maximize tip diffraction from the structures to achieve a straight beach form and throttle down the magnitude of the transport rate. A similar approach was used to rebuild Fort Pierce Marina, Florida, United States to direct sediment away from settling in the marina and reduce long-term dredging maintenance costs.

The first attempt at a design solution was completed numerically. The site's wave climate was analyzed, and the results used to orient and size breakwaters to maximize shoreline protection and balance the various design criteria.

However, the design team recognized that this numerical approach would be insufficient to assess the complex diffraction and wave transformation caused by the structures and their effect on the shoreline morphology. A 3-dimernsional movable bed model was built to experiment with different breakwater configurations and make quick adjustments based on the shoreline response. Sandbags and anthracite were used to allow for quick changes in breakwater geometry with a corresponding rapid shoreline reaction to any change in configuration. After a few runs under a design wave, one could also observe where diffraction around the breakwaters was causing a salient to develop.

These rapid observations allowed for multiple improvements to be vetted in a short time period. By simply changing the length, shape, orientation or freeboard, the corresponding shoreline planform could be straightened or induced to accrete, in some cases locally reversing currents were formed to further slow sediment transport. Additionally, breakwaters were made

submerged, emergent, or a combination of to allow different levels of wave energy to pass through the structure and inducing the shoreline profile to change.

The design team refined and optimized the initial numerical design to best achieve the client's aesthetic criteria and the need to achieve a cost-effective design. The shoreline protection solution devised for this coast was unique when compared to a traditional approach. While numerical modeling was used initially, 3D physical modeling yielded more useful observations that were used to minimize the breakwaters footprint, material costs, and utilize diffraction around the breakwater edges beneficially to develop the type of shoreline desired aesthetically from the client.

A SYSTEMATIC TOOL FOR ASSESSING QUANTITATIVE RELATIONS ACROSS DISSIMILAR STAKEHOLDER OBJECTIVES: A CASE STUDY ON NATURE-BASED SOLUTIONS TO MITIGATE SALT INTRUSION IN A HIGHLY URBANISED ESTUARY

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ABSTRACT

In face of the global challenges ahead, society demands decision-makers to embrace integrated solutions that meet all stakeholder objectives. For water systems, this new thinking has resulted in the implementation of sustainable, multifunctional nature-based solutions (NBS). NBS can be applied through systematic methods, such as the Frame-of-Reference approach (FoR) [Van Koningsveld, 2003], which derives performance indicators from stakeholders' objectives to assess the implications of system interventions. Generally, several parallel objectives coexist that may be affected oppositely; a so-called trade-off emerges. However, a straightforward method to obtain quantifiable knowledge to understand how multiple stakeholders interact is lacking. Consequently, substantiated compromises for these trade-offs are hard to reach in practice. To bridge this knowledge gap, this research presents a new tool that quantitatively relates dissimilar and conflicting stakeholders' interests. The goal is to visualise the effect of measures on the separate stakeholder objectives that are part of the trade-off to provide decision-makers with the required information to make interventions. The tool consists of replicating the FoR decision recipe to assess impact on stakeholders individually. These impacts are then combined into one trade-off using concepts from Multi-Objective Decision-Making Problems methods. These systematically capture and relate quantifiable indicators which are strongly dissimilar. The tool's capability is demonstrated through the case-study of the shallowing intervention in the Rotterdam Waterways, a potential NBS to mitigate salt intrusion in a highly urbanised estuary in The Netherlands. The tool relates the effects on two main stakeholder objectives, namely freshwater availability and port performance. The assessment of implications for these objectives required modelling the estuarine hydrodynamics and salt transport. The freshwater availability objective was assessed by quantifying the exceedance duration of water quality standards at water inlets. The port performance objective was evaluated via the average waiting time of vessels over their total turnaround time. For the latter, a separate agent-based discrete-event model was deployed. Results revealed that an increase in bed level in the Rotterdam Waterways leads to an increase in freshwater availability due to salt intrusion reduction. Conversely, it leads to an exponential growth of the vessel's average waiting times due to heavier nautical traffic as deep-draughted vessels could not enter the port, and their cargo had to be divided over more lower-draughted vessels. The resulting trade-off curve showed that the improvement toward port logistics objectives always goes to the detriment of the freshwater availability objectives, and vice versa. Even though uncertainties in results are significant due to the curve fitting procedure, the tool can still reproduce general

trends of losses and gains in the trade-off curve. This work has demonstrated the successful implementation of a newly developed tool that can quantify trade-offs across dissimilar and conflicting stakeholder objectives in water systems through a case study. The latter is of great value for decision-makers when substantiating choices and compromises. The new method offers great flexibility for other problems, including challenges containing more than two dissimilar stakeholders' objectives with multiple performance indicators. This and further improvements in the methodology require more research to be conducted with the tool.

Damage diagnosis of miter gates using camera-based structural health monitoring

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Brian Eick, USACE-ERDC

ABSTRACT

Structural health monitoring helps to diagnose structural damage based on observations over time. While observations commonly come from contact sensors such as strain gages and accelerometers, cameras provide an attractive alternative avenue for observation because cameras require no installation or physical access to the structure. Observations can be collected during a short camera survey that does not interrupt lock operations. Each observed image is composed of many pixels forming features, such as weld-access holes or re-entrant corners. Computer vision techniques can interpret feature movement over a lock filling event as pixel displacements. This displacement interpretation scales up to measuring the pixel displacement of many miter gate features as water rises in the lock chamber. In turn, the displacement observations can be compared to displacement predictions from a computer model of a miter gate. Computer model boundary conditions and damage can be adjusted until displacement predictions closely match observations. The closely matched predictions and observations provide evidence that the boundary conditions and damage in the computer model match the boundary conditions and damage in the physical gate. Therefore, this procedure of camera observation collection and computer model adjustment enables damage diagnosis of miter gates. This presentation reviews the application of these concepts to The Dalles downstream miter gate on the Columbia River.

Advanced Visualization Tools for Navigation Lock Design

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ABSTRACT

3D modeling of design projects is already a common practice, but are we really taking full advantage of it today? New technologies and improvements to existing technologies have allowed us to experience our projects like never before. Technologies such as virtual reality (VR) allow us to walk through our projects before they are constructed, 3D printing allows us to touch our projects, and software such as Revit modernize engineering and drafting. This presentation focuses on ways that these technologies are were utilized to revolutionize the design of the New Lock at the Soo megaproject, and how we can take full advantage of them to improve communication, reduce costs, and train the next generation of lock designers.

The Role of Physical Modeling in Developing a Port Expansion Project at an Exposed Site

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ABSTRACT

This paper describes the role of physical modelling in the design and development of a new ship terminal as well as an adjacent existing ship terminal at an exposed site on the coast of Peru. The Port of Matarani operates an existing terminal (Terminal F) dedicated to exporting dry copper concentrate composed of a Jetty connected to shore by and access trestle, designed to accommodate vessels up to 58,000 DWT. Due to excessive ship motions, vessels currently loading at this terminal make use of a mutli-buoy arrangement, maintaining a separation space from the wharf. The owner was interested in investigating a more conventional mooring arrangement where the vessel is moored against fenders. Also, a new terminal (Terminal G) is proposed for construction to the northeast of Terminal F, and is a proposed general cargo facility composed of a finger pier connected to shore. Vessels at Terminal G will be moored against fenders located along the northern edge of the pier. Both Terminals F and G are located outside the main port and are exposed to waves and long-period swells generated in the Pacific Ocean. The nearshore bathymetry is highly irregular and includes many islands with steep shorelines that diffract, refract, reflect and attenuate waves approaching from southerly directions.

The Matarani port development team was selected by Tisur to undertake a Front End Engineering Design (FEED) study for the new and existing terminals. Physical modelling played a key role in the FEED study, the prime objective of which was to develop a recommended project layout and basis of design for costing and subsequent construction of the facility. The physical modelling focused on two of the key technical challenges / uncertainties surrounding the project: the risk of downtime due to the prevailing seas and swells, and the use of Trelleborg's Dynamoor dynamic mooring systems in reducing mooring line tensions, fender forces, and excessive vessel motions at both terminals.

This paper will describe the physical modeling undertaken to support the design of the facility, focusing on the operational considerations, including the response of two different moored ships in prevailing wave conditions with the current multi-buoy tethering arrangement, and also conventional mooring configurations on the terminal piers both with and without Dynamoor systems. The methods used to simulate the wave-induced ship motions in the physical model and measure their response will be described. The sensitivity of the moored ship motions and mooring loads to wave conditions and mooring arrangements will be discussed. The methods used to estimate downtime from the model outputs will also be described.

The physical model study was an essential element in the design development process for the Matarani project, and it provided a wealth of information to support the assessment of critical operational and structural design considerations. This study highlights the important role that physical modeling can play in optimizing and validating the design of coastal / port infrastructure.

PIANC USA
The US Section of the World Association for Waterborne Transport Infrastructure

Assessing Marine Borer Activity and Internal Decay in Timber Using an Underwater Resistance Drill

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ABSTRACT

Marine borers and internal decay can cause significant section loss in timber structures that is often identified too late. Species of marine borers penetrate through the treated layer of the timber and can quickly cause section loss that is often difficult to identify until the timber has already lost much of its cross-sectional area. Hammer sounding and timber coring are current practices for detecting marine borers or internal decay. Hammer sounding takes a keen ear and can be limited by a diver wearing a helmet . Coring timber is a time-intensive activity that can lead to marine borer infiltration if the core holes are not plugged properly. The underwater resistance drill presents a solution to the problem of early identification of marine borers that is more accurate than hammer soundings, less time intensive and less destructive than timber coring. Resistance drills have started being used in recent years to detect above-water decay in timber superstructures and substructures at bridges. The underwater resistance drill is an expansion of this practice, allowing inspectors to drill timber throughout the water column. The underwater resistance drill allows for inspectors to detect early stages of section loss due to marine borers or internal decay so that the pile(s) can be repaired or replaced before significant section loss that could affect the stability of the structure.

This presentation will compare and contrast the use of visual identification, hammer sounding, timber coring, and the underwater resistance drill as ways to identify marine borers and internal decay in timber from high water line to channel bottom. The presentation will also focus on the advantages and disadvantages of each. During this process, real-world data from investigations carried out in both fresh and saltwater will be shown.

Effect of the new PIANC WG211 design guideline on fender dimensions

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ABSTRACT

PIANC WG211 was tasked with updating the guidelines for design of marine fender systems. One of the changes to the new guideline is the change in approach to designing fender system. Whilst the load and resistance factor design approach is widely adopted in the design of marine structures, the PIANC WG33 (2002) design guideline utilises a global safety factor, referred to as the factor for 'abnormal' impact. Based on statistical data from recorded berthing velocities, fender manufacturers' data, and adjustment factors for uncertainties in berthing energy calculation, PIANC WG211 has established partial factors of safety for the selection of fenders. Due to the change in approach to calculating the berthing energy from PIANC WG33 to PIANC WG211, and to obtain clarity on what the effect of changes, this paper compares the outcomes of the two guidelines. Data from existing project fender design specifications that have been used in practice have been taken into account. Given similar input variables the new partial safety factor method generally results in marginally smaller fender dimensions. WG211, however, recommends, on the basis of PIANC WG145 (2019), higher berthing velocities for large sea going vessels compared to Brolsma's berthing velocity curves in WG33, which can result in quite large fender dimensions in the absence of site specific information. During this study, however, the higher berthing velocities recommended by PIANC WG211 were confirmed on the basis of new berthing records collected in a port in the northeast part of Europe. In general, when local information is used to evaluate the navigation conditions and the associated berthing velocity, the design method of PIANC WG211 will result in reasonable dimensions of the fender system. In addition, it was found that the fender dimensions can, in some cases, largely be optimised on the basis of a parametric analysis of the fender pitch. Consequently, the conclusion is that the new design approach of PIANC WG211 results in reasonable fender dimensions for majority of the ports and terminals around the world. Nevertheless, it is crucial to examine the influence of the local navigation conditions, such as wind, wave, currents and berthing manoeuvres, on the berthing velocity and that the asset owner, e.g. port or terminal authority, specifies the required safety level of the fender system specific to the berth.

Long Term Trends in Sea Level Experienced at 30 Sites in Coastal Louisiana

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ABSTRACT

An analysis of long-term tide gauge and stream gage data across coastal Louisiana show the rapid and spatially varying rates at which the "relative sea level" is rising throughout coastal Louisiana. The rising water levels experienced in waterways and at ports in these areas can inform sustainable planning and design of current and future projects. An analysis of historic gauge records through the year 2021 was completed on sites in south Louisiana. Stream gauges on the Mississippi river were treated specially to separate the influence of river discharge from the record. This effort built upon two previous efforts - in 2010 and 2015 - to estimate trends in relative sea levels. The purpose of this effort was to develop an up-to-date and useful tool for analyzing the sea level change trends in the coastal areas of Louisiana, where some of the highest relative sea level rise rates in the United States are observed (because of the significant subsidence in this region). The data were referenced to a common gage datum, analyzed for shifts, and any known adjustments removed. This 2022 update revised many of the records by extending the gage data through 2021 and recomputing the linear trend. New gages were added, expanding the atlas to a total of 30 gages. The new data were evaluated in the same manner as the previously studied gages: adjustments were made to remove shifts in the data, river discharge influences were separated where necessary, and linear regressions were computed. Continuous revisions of the atlas are intended to not only keep sea level change trends updated but also to expand data resources for ongoing and future projects.

Developing Hydraulic Modeling Tools to Support the Design of a Reference Plane for a Navigation Project on the Tocantins River

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ABSTRACT

For a proposed navigable waterway project in Brazil, 1-D and 2-D hydraulic modeling was used to evaluate approaches for determining a project design reference plane. The proposed project is located in the Northern region of Brazil on the Tocantins River in a reservoir-backwater-influenced reach. A proposed rock excavation project in the Pedral do Lourenco reach is intended to provide adequate depths and conditions for safe navigation during the dry season. Numerical models were developed using HEC-RAS software to determine water levels throughout a 35 kilometer section of river with significant rock outcrops and adverse navigation conditions. Recent high-resolution bathymetric surveys were used to adequately capture the abrupt changes in depth and width of the main channel of the river. Calibration was completed using a temporally-rich and spatially-rich dataset of records from staff gauges located throughout the project area. Water surface profiles - which informed proposed project design reference planes - were modeled for boundary conditions based on separate statistical analyses of upstream flow and downstream reservoir levels. One dimensional and two dimensional models were developed and compared. A period a record simulation was completed to establish duration exceedance relationships at numerous locations along the navigation channel throughout the project reach. A coincident frequency analysis was completed using the total probability method to incorporate the appropriate influence of the flow from upstream side and the Tucuruí Reservoir level on the downstream side. With-project conditions were modeled to determine the hydrodynamic response for several possible alternatives. An analysis of past hydrologic conditions on the system, revised to include the proposed navigation channel, determined the relative effectiveness of each approach. As necessary, iterations of modeling with-project conditions were completed until desired navigational criteria were met or desired probability levels were met. Modeling tools and results were used to hindcast navigation reliability had the project been in place, estimate rock removal quantities for the project, and estimate the probability of desired navigation conditions if the project is completed.

Practical Considerations for Seismic Design and Detailing of Pile-supported Piers and Wharves based on PIANC and ASCE 61 Guidelines

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ABSTRACT

ASCE/COPRI 61 and PIANC WG 225 are in the process of updating their worldwide-used guidelines for the seismic design and detailing of pile-supported piers and wharves. The design philosophy in these widely used design documents targets a so-called “strong-beam, weak-column (pile)” type of response of the structure to seismic loads, where the deck remains essentially elastic (capacity-protected) at the expense of inelastic action occurring in the piles.

Based largely on their preceding versions and in line with modern marine infrastructure construction techniques, the upcoming updates of these two design documents contain stringent recommendations and prescriptive requirements to ensure that piles in modern pile-supported piers or wharf structures possess sufficient ductility at plastic hinge zones at the deck and in-ground pile locations to achieve target material strain limits and displacements for either two (PIANC) or three (ASCE 61) seismic event levels. In order for the piles and the pile-to-deck connections in a pier or wharf structure to develop the expected deformation capacity and strength and respond in a stable manner during the imposition of inelastic deformations, it is necessary to understand in full the behavior of the pile-to-deck connection components.

This paper presents a summary of practical considerations, in light of PIANC and ASCE 61’s seismic analysis and design recommendations, to facilitate compliance with the design and response objectives listed above. Recommendations include guidance on the structural modeling of regular and irregular pile-supported piers and wharves accounting for soil-structure interaction effects, and a series of design and detailing “rules of thumb” for a wide variety of steel and concrete pile-to-deck connection types, including cast-in-place or precast reinforced concrete (RC) plugs, with due account of the effect of the type of deck system (flat slab versus precast concrete).

Beneficial Use of Dredged Material - Habitat Creation Case Studies in the Southeastern United States

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ABSTRACT

This paper explores four case studies that apply Working with Nature principles, known to some as Engineering With Nature, using dredged material. Dredged material management in the southeastern United States is challenging due to updated federal/state operational changes and progressively limited space in confined disposal facilities (CDFs), the traditional method of dredge disposal. A confined disposal facility is a large, diked area that is used to contain dredged material. Most CDFs are owned and managed by either a local port authority or the United States Army Corps of Engineers (USACE) and are heavily regulated. Because of these challenges, an emphasis has been placed on the beneficial use of dredged materials.

One form of Working with Nature is habitat creation, which involves protecting, restoring, and enhancing habitats. Habitat creation can serve numerous purposes including shoreline stabilization, ecological enhancement, climate change resilience, reduced flood risk, and improved water quality. This paper explores four case studies involving habitat creation with clean dredged material. Each case study reveals the challenges and opportunities of funding, regulatory permitting, environmental impact, design strategies, effectiveness, and successful collaboration across multiple groups.

The first case study is the Restoration of Crab Bank, a historic bird sanctuary in Charleston Harbor, SC, where 32 acres of critical nesting habitat were restored that otherwise would have been lost to erosion. The second case study will be the Dauphin Island Living Shoreline Project in Dauphin Island, AL, which involves the creation of 60 acres of salt marsh that will protect the existing causeway from coastal hazards. The third case study is the Daniel Island Avian Habitat Opportunities Report completed for the South Carolina Port Authority, which explored the challenges and benefits of several types of bird habitats that could be implemented within the active dredge spoil site on Daniel Island, SC. The last case study is a thin layer placement project on Jekyll Island, GA, which restored marsh habitat and increased marsh elevation. Projects like this pave the way for the future of dredge materials and increase opportunities to implement Working with Nature approaches.

Fender Systems Optimization Study at the Port of Corpus Christi

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ABSTRACT

This paper presents the results of a study sponsored by the Port of Corpus Christi Authority (PCCA) for the optimization of fender systems at twenty-one docks located at PCCA's Inner Harbor terminal in Corpus Christi, Texas. The docks handle a variety of cargoes consisting of liquid bulk, solid bulk, breakbulk, and general cargo, and experience vessel traffic ranging from barges to Suezmax tankers. PCCA has regularly had to deal with fender damage and repair in their marine terminal docks throughout the years. Damage due to natural wear and tear of fender system components or to berthing incidents is often found faster than PCCA can promptly react, sometimes due to a shortage of adequate equipment or manpower, and often involving long lead procurement time. Fender maintenance and repair is difficult as it requires coordination among multiple stakeholders, becoming more complicated given the various types of terminals and docks at the port, and the different fender systems on a given dock. The fender optimization study aims to better understand and find solutions to this problem.

The study includes a thorough review of previous design practices, current conditions of fender systems, an extensive review of current operations and vessel traffic, and an evaluation of environmental conditions related to fender systems. The study creates the framework for the development of a comprehensive berthing design rationale based on deterministic and probabilistic principles for the selection of fender systems at the docks subject to the study. Current American and international guidelines and standards on berthing design were consulted and compared as part of the recommendations in the study. Considerations on the docks' various typologies, in the form of structural response of fender reactions, were also considered. The docks consist of slip docks, T-shaped structures, L-shaped structures, marginal wharves, island structures, and shiploader platforms with various types of breasting dolphins, such as monopiles, caissons, and tripods, with different structural response.

This paper can be a valuable example of a successful study for American and international port entities and terminal owners facing similar problems and that are looking to improve current practices or to solve similar fender issues. It can also serve as a case study for future berthing design optimization efforts for maritime engineers and consultants.

Specification, Design, and Impact Analysis of a GFRP Spillway Lift Gate

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ABSTRACT

Over the past decade, the United States Army Corps of Engineers (USACE) demonstrated the use of Glass Fiber Reinforced Polymer (GFRP) composites on several inland waterway structures including weir wicket gates, miter gate contact blocks, and underwater concrete repairs with great success. The USACE recently identified an opportunity to install a GFRP composite vertical lift gate at a low-head spillway structure on the Okeechobee Waterway. The selected location provides a unique combination of challenging environmental conditions with respect to corrosion, ultraviolet index, and hydrodynamic loads during storms, along with low head and limited risk to the primarily recreational traffic. Recent developments in design guidance informed a design charrette and feasibility analysis that enabled the USACE to specify the design, construction, and instrumentation of the gate through a performance-based contract procurement strategy. Specifications outlined the expected extreme load cases, control dimensions, required durability, and quality control requirements, and then placed responsibility for validation testing of materials and prototypes on the contractor. An instrumentation option on the contract intends to enable collection of long-term creep and fatigue performance data while we continue laboratory efforts to explore non-destructive evaluation techniques capable of interrogating relatively thick GFRP composites intended for structural applications. USACE doctrine will require periodic inspection, maintenance, and repair throughout the service life of the GFRP gate, especially following allisions and other impact events. Laboratory testing and finite element analysis at the material scale provide insight to repair methodology and secondary failure modes following a repair.

Innovative applications of Cutter soil mixing/Geomix technique as seabed soil improvement

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ABSTRACT

In recent years, marine deep cement mixing was widely adopted in Asia as the ground treatment method for many mega reclamation projects. Compared to the traditional dredging solution of excavating the soft soil, the deep cement mixing method is renowned for its environmentally friendly and high-quality standard. The installation of the deep cement mixing works generates less impact to the surrounding and prevents bringing the eventual toxic substances trapped in the sediment into the open water. Also, from the geotechnical point of view, the deep cement mixing provides a stable foundation for the land formation and comparatively less settlement is expected. In seismic areas, this treatment can also be designed to act against the liquefaction process and its consequences. The Cutter Soil Mixing technique is a type of deep cement mixing method. It is developed based on the Hydrofraise Cutter technology, crushing the soil through two counter rotary cutters, and simultaneously mixed with a slurry binder to achieve the design required strength. This paper presents details of two recent marine ground improvement projects completed -- one in Asia for large land reclamation close to a major international airport, and one in Latin America for a port expansion in high seismicity area -- with the application of marine Cutter Soil Mixing technique, showing the wide range of applications of this technology within operating port environments.

Handbook for Navigation Design

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ABSTRACT

Status of PIANC WG 206 - To update the 1986 Final Report of the International Commission for the Study of Locks. The book is renamed more appropriately the Handbook for Navigation Design. It has been over 30 years since this benchmark document was produced and much has evolved and an updated report, second version is needed. The navigation design community will benefit from an updated second version design guidance. The original document was an outstanding document in its time, 445 pages, however much of it is simply outdated and now is of limited value. Many of the designs presented simply are not used as more efficient, reliable, cost effective, and environmentally friendly solutions are favored. There are multiple areas to update, as a second volume it is envisioned the basic outline of the book will be retained, updated with new chapters or headings for subjects that were not common at the time for such items such as sustainability and in-the-wet construction, etc. Many countries now have mature water transport infrastructure, and it is becoming clear the driving force for design are new efficient rehabilitation strategies when expanding or building a lock and maintain existing traffic in an overcrowded waterway. Other strategies such as in-the-wet construction can allow for much smaller footprint since a full-scale cofferdam is not needed. There have also been new exciting, innovative projects to highlight, such as, the Third Set of Locks for the Panama Canal, Three Gorges Locks, and the Falkirk Wheel. In addition there are many innovative navigation design improvements to discuss, such as, new lock filling and emptying systems, e-navigation, Computational Fluid Dynamics (CFD) and other advanced modeling has led to much better understanding of vessel behavior in the approach and during lockage, also a better grasp on mooring forces and salt water intrusion movements, asset management, life cycle cost, aids to navigation, gates, gate protection equipment, local coffer-boxes, innovative materials such as composites, hands free mooring, seismic effects, and security improvements (safety and terrorism). Many of these individual techniques and materials have been available for decades, but their broader acceptance has been limited. Their use will be more viable once published with the far-reaching PIANC network. The updated handbook will allow for inexperienced engineers to have a global understanding of defining the design parameters for a new project, i.e., capacity, lift, layout, required studies, etc. The handbook will also allow Lead Project Engineers a holistic view to understand all the design issues for the various design disciplines on the team. No other organization has the network and organizational infrastructure such as PIANC to compile a textbook of this scale and value. For experienced designers this a chance to give back to the navigation design community. “This effort will certainly be welcomed and appreciated by the navigation community.” Eng. Eric Van den Eede. This is a once in a generation opportunity to contribute to this legacy document, if you are interested please contact PIANC.

Port Master Planning process: analysis of existing guidelines in light of Bahia Blanca Master Planning experience.

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ABSTRACT

The Port of Bahia Blanca, located around 600 km south of the city of Buenos Aires, is the main deep-sea port of Argentina. In 2016, anticipating new market developments with potentially significant impacts on the port's future, the Port Authority decided to initiate a long-term strategic planning process. The goals were not only to get ready for future growth and become more attractive for new businesses but also to secure support from the local community and obtain the social license to grow. Awarded through an international tender, Port Consultants Rotterdam first elaborated the Port Vision Bahia Blanca 2040 and then the Master Plan Bahia Blanca 2040+.

There is currently a lot of literature available on how to approach master planning for ports, with several professional organizations and public entities having developed guidelines to carry out the different stages of the planning process. PIANC Marcom WG185 (2019) and WG158 (2014) reports, for example, deal respectively with new and existing port terminals master plans. The Port Planning and Investment Toolkit developed by the US Maritime Administration and the American Association of Port Authority (2017) also provides a comprehensive guideline for the entire planning process. The most frequently used guidelines in Spanish are the Recommendations for Maritime Works (ROM) from Puertos del Estado de España. Even if they don't provide specific guidance for the whole master planning process, they include valuable recommendations to estimate future requirements and for the overall design of port projects.

Bahia Blanca's master plan methodology adopts most of the traditional steps of port master planning depicted in the literature. The first phase of the process was to establish future requirements by comparing future demand with existing constraints and identifying capacity and function gaps. The second phase involved drafting several layout alternatives able to accommodate the demand and meet other future requirements and choosing the preferred alternative based on both a qualitative and quantitative analysis. Finally, the third phase of the master planning process focused on financial feasibility analysis and further refinement and optimization of the proposed layout. However, in the case of Bahia Blanca, the emphasis on financial sustainability was stronger than in most methodologies, with the implementation of a "business case steering approach," allowing to perform several loops of optimization of the master plan to improve financial parameters. Furthermost, several other stages of the process have been customized to better contemplate the Argentine market's specificities and the local port governance structure.

This paper first aims to identify and review the main available guidelines for Port Master Planning. Then, the tailored methodology adopted for the master planning of the Port of Bahia Blanca is introduced, showcasing selected results that illustrate the specificities of the process. Finally, the custom process for Bahia Blanca and the available guidelines are compared to identify their respective strengths and relevance and how they can be adapted for Argentina or other similar markets.

St-Lawrence Seaway Canal - Locks and Bridges Operation Training Simulator

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ABSTRACT

The locks and bridges of the St. Lawrence Seaway, the largest inland waterway in Canada, are operated remotely from two control and operations centers. These structures are imposing in size, just as much as the vessels passing through them. The safe operation of these structures represents a challenge for all employees, especially new employees. There are no other similar places where it is possible to train and gain experience, hence, traditional training programs for new operators requires lengthy on the job experience with experienced operators. Added to this is the additional difficulty caused by skilled labor shortages. It has therefore become necessary to improve and reduce the training time for new employees using modern methods and tools. Thus, the St. Lawrence Seaway is developing an operation simulator for its structures and to be used for the training of the operators.

Two options were evaluated. The first is that of a fully Stand-alone Simulator, where structures are modeled and animated and where software and programs for controls, operator interfaces and cameras are replicated and simulated within the same overall simulator software. The second option is that of an Integrated Modular Simulator, using software and control programs, operator interfaces suite and the camera system in the loop for real time operation of the structures, to which they are integrated with simulation software hence emulating the response of mechanical and electrical systems with the navigation modeling. All of this is superimposed by 3D animation, simulating all the feeds to a fully representative operator console.

The option of the Integrated Modular Simulator was selected. Although a fully stand-alone simulator would be to easier to develop, it had the negative advantages as it would be less flexible to future technological changes of the structures & systems and therefore would require significant modifications to the simulation software as systems evolved. An Integrated Modular Simulator allows for seamless modifications to the simulator as actual systems evolve without impacting other sections of the simulator and always maintaining the simulator up to date to the actual systems which will represent less costs to maintain.

With an Integrated Modular simulator, it has the added benefit of using the simulator as an engineering validation tool to test and validate new technological modifications and improvements in a safe and secure environment before the actual implementation in the field. Abnormal and failure scenarios, such as equipment failures, or accidents, can also be simulated in order to prepare operators to react appropriately when such situations occur.

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Prince Rupert Port Authority Transforms Local Waterfront into Environmentally Sustainable Landmark: A Case Study of the Seal Cove Salt Marsh Habitat Restoration Project

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ABSTRACT

This paper will provide a comprehensive overview of the Seal Cove Salt Marsh (SCSM) project executed by Hemmera, a subsidiary of Ausenco, for the Prince Rupert Port Authority (PRPA) in 2019. After scoping the region for various potential projects, Hemmera identified and designed the SCSM project to offset part of the marine habitat impact from the Fairview-Ridley Connector Corridor project (FRCC). FRCC aims to increase Fairview terminal capacity, and link Fairview to import/export logistics platforms on Ridley Island. FRCC will allow commercial trucks to be removed from local public highways and bypass the road network of Prince Rupert, including the downtown sector, reducing local travel distance to 25%. The connector road is projected to multiply incoming commercial truck traffic capacity by five, while reducing associated emissions by approximately 75%.

The SCSM rehabilitation is an important local project for the City of Prince Rupert, and is one of many projects in the municipal plan for achieving a sustainable city by 2030. After Hemmera identified SCSM as an offsetting project opportunity for FRCC, the PRPA worked with the City of Prince Rupert to rehabilitate SCSM, with Hemmera completing the conceptual design. The PRPA invested CAD$4 million into the SCSM habitat restoration. Prior to restoration, the salt marsh has been severely impacted by industrial and human activities, resulting in the inadvertent degradation of the native habitat, clearing out both vegetation and local wildlife. Thus, design of the restored SCSM focused on incorporating environmentally sustainable upgrades, while providing an aesthetic and accessible waterfront location that can be used for community recreation and to stimulate local economic development.

The SCSM design completely reconstructs the region to benefit local wildlife and marine environment. The new intertidal marsh design restores the existing region by rebuilding riparian sections, including an inlet from a freshwater creek into the marsh with stone and large-woody debris. Additionally, eelgrass beds were transplanted into the SCSM from existing local beds. These components of the SCSM will provide water oxygenation, improve water chemistry and encourage the fostering of wildlife with an ideal fish habitat within the cove. The salt marsh will be surrounded by newly planted trees and grassy vegetation, further enhancing the local habitat rejuvenation beyond the waterline.

In addition to being an environmentally sustainable marine habitat, the SCSM is designed to be a local waterfront landmark, enhancing community and economic value. The rehabilitated

SCSM is easily accessible for pedestrians to experience the shoreline, whose perimeter includes newly added benches, lookout areas and is encircled by a lighted pathway that includes a new pedestrian bridge and a rehabilitated trestle bridge. Furthermore, the proximity of the SCSM to existing outdoor pathways and the Seal Cove Seaplane Base provides an exciting landmark for locals and tourists alike to experience.
The salt marsh is currently open to the public for enjoyment; however, the recently transplanted vegetation still has yet to fully establish itself in the marsh, and could take up to 5 years. The ongoing vegetation development process will be monitored by PRPA until fully established.

Development of a Joint Agency Marine Transportation System Resilience Guide

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ABSTRACT

To successfully operate now and into the future, the Marine Transportation System (MTS) must be resilient. Resilience is the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. Hurricanes, riverine flooding, drought, pandemics, trade and labor disputes, the health of local communities - these all can be stressors and disruptions to the functionality of the MTS. There is great need to utilize the concepts of resilience when considering improvements to the MTS and the many systems that support it (e.g. communications, electric, roads, rail, governance, communities, etc.). Over time, many federal agencies, academic institutions, and private companies have responded to this need by developing a variety of data sources, methodologies, guidebooks, and emergency response protocols that are available to practitioners but are not consolidated. The Marine Transportation System Resilience Assessment Guide was created to integrate these information sources and experiences into a repeatable, step-by-step framework for conducting resilience assessments that Guide users can tailor and apply for their own systems and use. The Guide provides a process for organizing and understanding the complicated systems that comprise the MTS, advice for assembling a diverse group of public and private stakeholders and agencies that manage these systems, a framework for synthesizing and framing a resilience assessment, and assembles a variety of resources that make an assessment possible. The Guide was written by an interdisciplinary team of researchers, planners, academics, and operations professionals and was co-lead by the Cybersecurity and Infrastructure Security Agency and the U.S. Army Corps of Engineers Research and Development Center. In addition to the Guide itself, the project funded the completion of four case studies: a study on seismic resilience at the Port of Portland, petroleum supply chain resilience on the Tennessee and Cumberland waterway, and network resilience of Caribbean and mainland port traffic, and finally, a study on the benefits of completing port climate resilience assessments. In this final study, researchers interviewed professionals at 10 ports who had completed resilience assessments - the key benefits included a closer relationship with stakeholders and partners who may not traditionally be involved in planning exercises, a detailed understanding the MTS's most important functions and characteristics, an awareness of the dependencies and interdependencies that may be revealed during a disruption, and new alternative practices or investments that will save time, effort, and funding in the future. As the US looks to make a historic investment in domestic infrastructure, the Guide project's intent is to facilitate holistic resilience assessments at ports. If even a few of these benefits are achieved through a new assessment, than the project can be considered a success.

FENDERS IN TOUGH ENVIRONMENTS

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ABSTRACT

Recently, fender performance and durability, particularly in demanding environments, have been a topic of discussion among suppliers on social media

There are a number of berthing facilities being constructed, primarily for LNG, oil, and bulk cargo, mostly in remote locations with harsh conditions, including high temperatures and cyclic loading. Such conditions severely compromise the performance and durability of fenders.

For instance, cyclic loading causes a fender to partially compress within a few weeks. Meanwhile, arctic temperatures can significantly increase the fender reaction, three to five times depending on the minimum temperature. In extreme conditions, the wrong fender material and design can lead to its failure within a few weeks.

The paper will give readers a detailed understanding of fender selection, design, performance, and materials for preventing fenders from failing as well as highlight the use of inverted fenders.

PIANC WG211 “PIANC FENDER GUIDELINES 2023”

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ABSTRACT

PIANC WG211 was established in 2019 with the objective of updating PIANC WG33's 2002 "Guidelines for the design of fender systems". A public review of the report is expected to take place by the end of 2022 or early 2023, followed by publication later in 2023.
WG211 is sure to be a significant update even though it has much in common with WG33. The 2023 report will examine some of the changes in the industry since 2002, such as improved methods for designing fenders, the evolution of vessel dimensions, and hull shapes.
Several improvements to the WG33 guidelines have been requested by users, including improved testing and verification procedures, performance requirements for fender system elements, as well as guidelines for maintaining and repairing the fenders.
The PIANC WG211 will cover all of this and more. An overview of the new WG211 and its various chapters will be presented, along with a closer look at any changes from WG33.
In addition to analyzing berthing velocities and angles, WG145 addressed reliability design, vessel dimensions, and container vessel flare angles.

Garry Point Park: Ship-generated Wave Study

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ABSTRACT

In April of 2021, a ship-generated wave washed ashore at Garry Point Park in Richmond, British Columbia. The vessel passing the park was a 4,000 TEU containership. The wave mobilized a mass of logs and debris and swept across the walking path that runs along the shoreline, injuring one of the park visitors. Subsequently, the Vancouver Fraser Port Authority (VFPA) and the Pacific Pilotage Authority (PPA) commissioned a study to better understand the causes of the wave observed at Garry Point Park. The study was motivated by an interest in public safety and reducing risk of a similar event in the future.

The first phase of the study was based on analysis of Automatic Identification System (AIS) data, comparing the track (speed, location, tidal conditions, etc.) to other historic vessel tracks. The result of this comparative study was a perspective about what characteristics were unique with the transit of this specific event.

The second phase of the study included hydrodynamic modeling with MIKE modeling software. The goal of the modeling was to simulate wave observed. The MIKE MA module was used, which allows for simulating ships in motion within an active tidal model.

The study involved preparing and calibrating a tidal model for the lower portion of the Fraser River. This model was prepared in MIKE HD, a depth-averaged tidal model. Once the model was operational, the MIKE MA simulations were run on-line with the tidal model to simulate the generation and propagation of the primary ship wave and associated interaction with the tidal currents.

Using this methodology, the wave observed at Garry Point Park was simulated with reasonable accuracy (comparing simulated water flow to visual observations during the event). Subsequently, a range of sensitivity studies were performed to see how the event might have unfolded differently if the vessel had followed a different trajectory, moved faster or slower, or passed at a different part of the tidal cycle.

The conclusions of the study were presented as a summary of how each of the effects evaluated appear to have contributed to the incident, along with a brief discussion of how the shape of the park shoreline appears to amplify this sort of effect. This study provides a good example of a creative use of coastal modeling tools (in this case the MIKE MA mooring software) to illustrate the effects of a passing vessel along the shore.

Ecosystem-based Marina development

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ABSTRACT

Marina development regularly takes place in environmentally valuable areas, as these locations provide great conditions for boating and attractive surroundings. These areas however, are very sensitive as well and often suffer from coastal development and human activities. Coral reefs, mangrove areas and seagrass beds are common examples in practice.
Current marina practice shows that the marina's interaction with the natural environment is not considered adequately. Examples of ecological and economic damage are found around the world, as well as examples where marina proposals are not granted a license, based on an environmental impact assessment. A lack of practical guidance for the initial stages of marina development, like location selection and assessing the interaction between a marina and its environment, may be a major cause to this finding.
The Republic of Mauritius is a good example of an environmentally valuable and sensitive area, where marina development has not succeeded yet. In this paper, the case of Mauritius is considered and the interaction between a marina and the environment has been assessed.
The interactions between a marina and its environment relate to the ecosystem at hand. The interrelations between marina elements and ecosystem services prove to be a major source of input for important (early) development considerations like location selection and marina design.
A conceptual, ecosystem-based framework for the initial marina planning stages was developed, including an 'ecoystem- marina tool', and was tested for the case of a marina in Mauritius.
The application of the framework and tool led to a sketch layout for a marina in the South West region of Mauritius, which was based on important marina development criterisa like ecosystem integration, stakeholder integration, hydrodynamics, area use, destinations, bathymetry, socio-economics and cost.
Concluding the case study, the authors recommend the framework to be further developed, building on the ecosystem-based approach to marina development. The aim of such a structured approach should be that the marina is designed to contribute to socio-economic and ecosystem values.

Sustainability and Marine fenders

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ABSTRACT

Sustainability and fenders

The maritime industry, among many others, takes sustainability very seriously. In the face of climate change, environmental sustainability is often linked to carbon footprints. However, in a universal plan drafted in 2015, the United Nations developed The Sustainable Development Goals (SDGs) and defined sustainability across three components – social, economic, and environmental. Specifically, there are 17 goals for which 169 targets are included, and they are each related to the other.
The SDGs cover a range of topics, including “Industry, Innovation and Infrastructure,” “Reducing Inequality,” and “Responsible Consumption and Production”.
Universally, a sustainable and environmentally friendly approach is crucial for bridging the ever-widening gap between responsible production and consumption of any resource.

In the maritime industry, this is especially true for fender production. For instance, the rubber value chain is plagued by unsustainable practices, such as deforestation, irresponsible farming, and violations of human rights.

Fenders come in various types made from different kinds of materials, but most fixed fenders are made of rubber with a steel panel and UHMWPE facings. The recycling process is easier for metals such as steel but more challenging for rubber. The use of good quality UHMWPE allows it to be recycled easily. However, low-cost alternatives are seen to be more prevalent in many cases. These will likely wear out much faster and could lead to the rubber eventually ending up in the ocean, resulting in a major source of ocean pollution. There are a variety of other types of fenders, such as foam and pneumatic fenders, but each have their own benefits and drawbacks.

Despite recent progress, sustainability and sustainable practices as such remains relatively nascent in the fender industry. While a trend toward incorporating sustainability into fender design and acquisition is currently underway, a definitive framework has not yet been established. For this reason, PIANC WG211’s upcoming report “PIANC FENDER GUIDELINES 2023”, presents guidelines for sustainable fender selection, design, and recycling. In a separate chapter, the report discusses sustainability as well. Furthermore, it explains how to choose, design, or compare fenders sustainably and recycle them based on current best practices.

New Lock at the Soo

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ABSTRACT

The U.S. Army Corps of Engineers is constructing a new lock at the Soo Locks Complex in Sault Ste. Marie, MI on the St. Marys River. The New Soo Lock will replace two existing locks, the Davis and Sabin locks, which were constructed during World War I. The Poe Lock, put into service in 1969, is currently the only lock at Sault Ste. Marie capable of handling the Great Lakes system's largest vessels, both national and international flagged. In 2017, the Poe Lock handled 89% of the total tonnage that transited the Soo Locks Complex. Total tonnage through the Soo Locks in 2021 was 72 million tons, with 5,625 lockages providing safe passage to 6,926 vessels. Of these, 3,651 were commercial cargo vessels. Due to the need for redundancy at this vital point in the Great Lakes navigation system and the significant national economic consequences of a service disruption at the Poe Lock, the proposed new lock will have dimensions (110' x 1200') identical to the Poe Lock.

The construction of the New Soo Lock is being accomplished through three construction contracts, the Upstream Channel Deepening (Phase 1), the Upstream Approach Walls (Phase 2), and the New Third Lock (Phase 3).

Phase 1 (Upstream Channel Deepening) consists of removal of approximately 300,000 cubic yards of material, where two-thirds of the material is rock and one-third is overburden.

Phase 2 (Upstream Approach Walls) consists of rehabilitation of approximately 4,500 linear feet of upstream approach wall utilizing four different design treatments.

Phase 3 (New Third Lock) consists of three components: 110' x 1200' x 32' Lock, Pump Well and Bridge. The New Lock will be constructed primarily in the footprint of the existing Sabin Lock and will require a cofferdam for construction in the dry and demolition/removal of the existing Lock. Widening of the footprint to include rock excavation will be required in order to accommodate the 110' width. In addition, downstream approach wall rehabilitation is required similar to the upstream approach walls (Phase 2). The new Pump Well will be placed in the existing Davis Lock which will also be filled with construction material. A new Bridge will be placed across the existing Unit 10 tailrace to provide access to the New Power Plant.

The presentation will provide an overview of the New Lock at the Soo project and its importance, status of the three on-going construction efforts, and a description of the regional design approach for the New Third Lock (Phase 3) to include innovative tools utilized (3-D Model, Virtual Reality).

PIANC USA
The US Section of the World Association for Waterborne Transport Infrastructure

Reliability of Phased Array Ultrasonic Testing (PAUT) for Detection and Sizing of Discontinuities in Hydraulic Steel Structures (HSS) of Navigation Locks

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ABSTRACT

The term hydraulic steel structures (HSS) refers collectively to the various steel components of navigation locks and dams, such as gates, anchorages, and pintles. Damage accumulates in these structures as they are operated over time and periodically, it is necessary to evaluate their fitness for continued service. In many cases, establishing the fitness of an in-service HSS may involve detecting and sizing any discontinuities in the welds of its critical members. Phased array ultrasonic testing (PAUT) is a non-destructive testing (NDT) method that can be used to detect and size discontinuities. One of its main advantages is it provides a permanent record of each line scan. While this method has been used in several industries for many years, it has not been widely used in the structural industry and there is little information about its reliability when applied to the joint geometries and weld configurations that are frequently encountered in HSS. Experiments were conducted to quantify the ability to detect, size, and characterize flaws in HSS. This presentation will describe the results of those experiments and address the implications for fitness for service evaluations.

Twelve steel specimens, referred to here as the ERDC specimens, were designed by the Engineer Research and Development Center (ERDC) and manufactured to represent HSS weld and joint configurations. These included a variety of butt joints, corner joints, t-joints, and skewed joints including thickness transitions. The specimens were fabricated from ASTM A36 steel and welded in accordance with AWS D1.1. As is typical in older HSS, no weld access holes were included, and welds were not ground flush. The total weld length was established to provide a reasonable maximum ratio of damaged to undamaged weld (approximately 0.5). The width of the specimens (perpendicular to the weld axis) was sized to allow inspection in at least the first and second legs. An additional eight specimens, referred to here as the AWS specimens, were procured as part of an off-the-shelf kit intended for ultrasonic testing (UT) training specific to the bridge industry and the bridge welding code (AWS D1.5). After fabrication, all of the specimens were coated with a three-coat vinyl paint system (System No. 5-E-Z), a typical modern-day HSS coating. The 20 specimens contained 21 welds and 68 flaws representing a variety of types, sizes, and orientations distributed at known locations. Discontinuities included planar flaws (lack of fusion (LOF), lack of penetration (LOP), and cracks (CRK), including root cracks, base metal cracks, transverse cracks, center line cracks, and toe

cracks), volumetric flaws (porosity (POR) and slag (SLAG)), and laminar flaws (LAM). All flaws would be considered Class A rejectable per AWS D1.1 (2020) for primary members subject to tensile stress.

Eighteen PAUT technicians certified in accordance with Recommended Practice No. SNT-TC-1A conducted round robin testing of the specimens. Technicians were selected from among a pool of 27 candidates who had previously submitted to a prequalification test consisting of written and practical components. Testing took place over three one-week periods in the spring of 2022, with up to eight technicians participating in any given week. Round robin testing was conducted in a large conference room at the Coastal and Hydraulics Laboratory, US Army Engineer Research and Development Center (ERDC) in Vicksburg, MS. Each technician applied a consistent set of NDT procedures that were developed and validated specifically for this research project. These procedures included manual rastering, line scans from multiple index offsets, scanning from all faces, and the use of smaller probes. Technicians operated at their own pace, with most technicians scanning the full set of 21 welds within a five-day period. Each time a discontinuity was detected, the technician recorded start and stop locations in each dimension, estimated its length and height, and characterized its type. These data were analyzed to estimate the probability of flaw detection and assess the ability of NDT technicians to size and characterize flaws.

Exploratory data analysis showed that some flaws were always detected, and other flaws were usually missed. Logistic regression models, which estimate the probability of detection (POD) while accounting for multiple factors that may influence detectability, were used to explain the contribution of flaw and specimen characteristics and technician skill to those results. Skill was represented by a variable called technician TPR, defined as the fraction of flaws scanned and detected by each technician during round robin testing. Preliminary analysis showed that logistic regression models fit the data much better when the data were segregated by flaw type. For planar flaws, POD was significantly related to flaw height and aspect (the ratio of height to length), planar flaw category, plate thickness, skewed joints, and technician TPR. For volumetric flaws, POD was significantly related to flaw length, aspect, volumetric flaw category, joint type, plate thickness, specimen type (ERDC or AWS) and technician TPR. For laminar flaws, POD was significantly related to lamination area, technician TPR, and joint type. Together, these results demonstrate that larger flaws are easier to detect, that more elaborate joint geometries make flaws more difficult to detect, and that technician skill may be one of the most important variables in determining whether or not a flaw is detected.

Technicians estimated the length and height of each detected flaw. Proportional error in these estimates was described using the ratio of estimated to actual length and height for each detected flaw. Values less than one represent underestimates and those greater than one represent overestimates. Uncertainty is represented by 90% confidence intervals derived from lognormal probability distributions fit to these ratios. Over all estimates of length, the 90% confidence bounds ranged from 0.52 to 2.10. Over all estimates of height, the 90% confidence bounds ranged from 0.32 to 3.59. These results indicate that there is more uncertainty in estimates of height than length. Uncertainty in estimates of flaw length and height varied

considerably when grouped by flaw and specimen characteristics and by technician, suggesting that these are important variables to account for when characterizing uncertainty in flaw size estimates. Additionally, time constraints and the testing environment should also be considered. In this study, technicians were operating without time constraints and in ideal testing conditions (indoors, climate-controlled environment with good lighting). Technicians were also aware that their work would be evaluated.

Technicians characterized each detected flaw as LOF, LOP, CRK, POR, SLAG, or LAM. These characterizations were accurate 59% of the time. Accuracy increased to 80% when flaws were grouped by type (planar, volumetric, or laminar). For fitness for service evaluation, sharp, planar discontinuities such as cracks are the most critical because they act to intensify stress and propagate in the member. Therefore, if there is uncertainty about flaw type, NDT technicians will tend to categorize flaws as planar. This tendency was apparent in study results.

Several conclusions about the potential for using PAUT for fitness for service evaluation of existing HSS can be made. While PAUT can be used to detect, size, and characterize flaws, the weld configurations and joint geometries in HSS will make it more difficult to apply. The ability to detect, size, and characterize flaws is highly dependent on the test procedures employed and technician skill. Although the permanent record PAUT provides of each scan is an advantage, the single line scans (no raster/one index) advocated by the UT testing industry are potentially misleading. The ability to detect and size flaws in our test specimens improved with the addition of the following elements to UT procedures: manual rastering, line scans from multiple index offsets, scanning from all faces, and smaller probes. Some technicians exhibited much more skill applying PAUT than others, and the ability to use NDT testing results for fitness for service analysis will depend upon this skill. Therefore, it is necessary to prequalify NDT technicians before engaging them for work on HSS. As PAUT and flaw sizing are not widely practiced in the structural industry, it will be necessary to train these technicians first. Even with qualified technicians, there will be uncertainty in detection and flaw size estimates. Project owners should independently verify the work of NDT technicians in the field and factors of safety should be applied in fitness for service evaluation.

Design of a Voyage Management System for the St. Lawrence Seaway

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ABSTRACT

This paper will explore the experience gained to date and review the major goals for the St. Lawrence Seaway Voyage Management System.

Navigation technology advancements and the need for greater certainty in managing transportation supply chains are revolutionizing vessel traffic management. In the St. Lawrence Seaway, an initiative is underway to modernize the Seaway's vessel Traffic Management System (TMS) by developing a new "Voyage Information System" (VIS) to better manage vessel transits through the international waterway. The two entities responsible for overseeing the Seaway, the Canadian St. Lawrence Seaway Management Corporation (SLSMC) and the U.S. Great Lakes St. Lawrence Seaway Development Corporation (GLS) see the VIS improving not only vessel traffic management, but also transforming vessel voyage planning in the Seaway and beyond.

The Voyage Information System will be a collection of applications that will assist our stakeholders (vessel owners, vessel operators, service providers, pilotage authorities, the public and the Seaway) seamlessly share information about vessel transits through the St. Lawrence Seaway system. The Voyage Information System will build on new features and functions of the existing Traffic Management System and add applications to assist vessel owners and operators to better plan their transits. Service providers will have more accurate arrival times to better schedule their deliveries and resources. The public will have more accurate information regarding bridge lifts. The Seaway will be better able to deploy staff and schedule critical maintenance.

The St. Lawrence Seaway is an international waterway jointly managed by Canada and the United States since its creation in 1959. The Seaway is comprised of 15 locks (13 Canadian and 2 U.S.) between Montreal and Lake Erie. On average, there are approximately 4,000 vessel transits a year, consisting of internationally flagged and Canadian-flagged vessels. A vessel transiting the full length of the Seaway crosses the international border 27 times as it traverses the St. Lawrence River, Lake Ontario, the Welland Canal, and part of Lake Erie. Due to this unique geography, the GLS and the SLSMC collaborate on all operational aspects of managing the Seaway. This includes jointly managing a binational Traffic Management System that encompasses the Seaway's four vessel traffic sectors.

Optimal Design of a Slotted Wavescreen Breakwater: A Numerical-Physical Model Analysis

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ABSTRACT

Slotted wavescreens are widely used at marinas and harbors exposed to wind generated waves and vessel generated wakes. Wave screens typically provide a more economical alternative to traditional rubble mound breakwater structures, and also offer a smaller construction footprint. These structures are traditionally designed with a series of slots of a fixed width such that the wave energy is dissipated in the viscous eddies formed by the flow through the perforations. In this work, we analyze the effects of the slit width and the height of the wavescreen in the wave attenuation performance (WAP) of the wavescreen. The WAP is a function of the transmitted wave height and the wave reflection. This work bridges experimental analysis with numerical analysis to model the WAP. We meet our numerical analysis needs by developing a multiphase computational fluid dynamics (CFD) model to study impact of the waves on the wavescreen under varying wave conditions. The orbital velocities, dynamic pressure and water level are measured and validated with a benchmark experimental analysis to validate our numerical model. We combine the CFD analysis to with an optimization study to determine the optimal slit width and height for the wavescreens to maximize the WAP. We use a machine learning method to develop a model application for the slotted wavescreen. This model was then used as the basis for the optimization study to determine the optimal wavescreen design based on varying wave conditions.

Resilience Assessment at a Container Terminal using Probabilistic Networks

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ABSTRACT

Resilience assessments are aimed at characterizing the ability of systems to maintain and recover their function following a disruptive event. This presentation demonstrates a quantitative approach to resilience assessment using probabilistic networks. Networks offer an intuitive way to model the dependencies among system components and probabilistic methods offer a rigorous way to deal with the many uncertainties that exist when considering the consequences of potential events with which there may be limited past experience. Together, these methods are critical to modeling system behavior and the benefits of proposed investments aimed at enhancing resilience. The methods and lessons for resilience assessment that are demonstrated in this presentation are transferable to other types of systems supported by networks of components and other types of disturbances that might interfere with the functioning of those systems.

In this presentation, resilience assessment is demonstrated at the Port of Portland's Terminal 6, located on the Columbia River in Portland, Oregon. The terminal is equipped to handle containers, automobiles, and breakbulk cargo. This study quantifies the seismic resilience of the container handling function and evaluates alternatives for strengthening that resilience. While the primary function of the terminal is to transfer cargo between waterways and road or rail networks, the Port of Portland has also prioritized supporting emergency operations and response and regional long-term recovery efforts following a disaster. Therefore, this study also considers the readiness and ability to support a federal staging area (FSA) at Terminal 6 and assesses the impact of the proposed FSA on container terminal operations.

The terminal and the navigation channel are exposed to seismic hazards, which arise from the presence of geologic faults located throughout the region. Seismic loads could damage critical infrastructure components (CIC) and reduce annual throughput capacity (ATC). Probabilistic seismic hazards analysis was used to estimate the probability and severity of seismic loads, which included ground shaking and ground deformation. Maximum ATC was estimated at the

container terminal and modeled as a function of the availability of CIC accounting for infrastructure dependencies. CIC include electrical circuits and substations, the structural and non-structural components of buildings, bridges that provide air clearance over the navigation channel, pavement, wharves, ship to shore gantry cranes, and rail line segments.

The damage to CIC caused by a seismic event, the functionality of CIC given those damages, and the time required to restore CIC to service are uncertain. These uncertainties were defined using fragility curves and restoration functions obtained from the Federal Emergency Management Agency's HAZUS MH 2.1 Earthquake Manual, which is widely used for planning purposes. Uncertainties are propagated through the network to characterize uncertainty in the restoration of ATC and estimate the residual ATC over a one-year restoration period following the seismic event. This simulation produces many realizations of the resilience curve, which plots ATC at points in time during the restoration period. Measures of resilience and the potential benefits of resilience enhancing alternatives are estimated from the resilience curve.

Five alternatives for strengthening resilience are considered in this study. The first two alternatives secure critical functions to ensure that they could be performed under any circumstances. The Security (SEC) alternative secures the ability to perform optical character reader and radiation scans that are required to move containers in and out of the terminal. The Communications (COMM) alternative secures the ability to track containers and communicate with equipment operating in the container yard. The third and fourth alternatives involve structural retrofits to reduce the probability of damage to infrastructure components. The Electrical (ELEC) alternative involves a seismic retrofit of substations and electrical circuits. The Berth 603 (B603) alternative involves a seismic retrofit of the wharf at Berth 603 and a restoration of three disabled Panamax cranes. The fifth alternative, Navigation (NAV), is a non-structural measure that is aimed at streamlining administrative processes. NAV shortens the time required to restore navigation in the Columbia River by preparing contracts for the removal of collapsed bridges from the navigation channel in advance.

The potential benefit of each alternative is the expected increase in residual ATC (TEUs/year) that would be realized by implementing that alternative over a fixed restoration period. Benefit estimates may be conditional or unconditional. Conditional benefits describe the expected increase in residual ATC given the occurrence of a seismic load with a specific return period. While conditional benefits provide a useful way to compare the efficacy of alternatives, investments in resilience strengthening measures should be based on an analysis of benefits and costs over an investment planning horizon. Unconditional benefits describe the expected increase in residual ATC over thirty years and account for the frequency and severity of potential seismic events during that period. In this study, unconditional benefits are much lower than conditional benefits. This reflects the shorter length of the investment planning horizon relative to the return periods of seismic loads being considered in the resilience assessment. This result may suggest that resilience planning at Terminal 6 should focus more on managing for seismic loads with shorter return periods than those considered in this study.

The security and communications subsystems are critical to maintaining ATC at Terminal 6. Results show that both of these subsystems are more fragile than other infrastructure subsystems at the terminal. Failures of these two subsystems tend to be correlated with one another, but security failures are more likely than communications failures. When the benefits of the SEC and COMM alternatives are simulated by themselves, SEC is more effective than COMM because the security subsystem is more fragile. However, when the two alternatives are implemented jointly, the benefits of SEC and COMM are super-additive. When estimating the benefits of two or more alternatives combined, it is necessary to model the alternatives simultaneously because benefits may not be additive. The joint benefits may be sub-additive or super-additive, depending upon the extent to which they address similar or dis-similar vulnerabilities within the infrastructure network.

All critical functions at the container terminal depend on a connection to the electrical grid. Therefore, intuitively, it may seem obvious that strengthening electrical components through seismic retrofits of substations and circuits would increase resilience. However, results show that ELEC is not an effective alternative. This counter intuitive result can be explained by the rapidity with which electrical systems are restored relative to other components. Whereas electrical connections are some of the first components to be restored following a disaster, other structures and subsystems may take much longer. If damage to these components limit ATC, the benefits of restoring the electrical system will not be manifest in terms of increased container handling capacity. However, there may be other benefits associated with electrical retrofits that have not been accounted for in this resilience assessment.

If a seismic event were to cause bridges to collapse into the navigation channel, the contracting process could delay their removal by many months. The NAV alternative addresses this issue by eliminating the contracting lead time. Results show that NAV is more effective than either of the structural alternatives, ELEC and B603. This demonstrates the importance of accounting for two key attributes of any alternative: 1) the frequency and severity of damages that are mitigated; and 2) the length of the restoration times avoided. The NAV alternative mitigates damages caused by the most severe and least probable seismic events because only the most severe seismic events are likely to cause bridges to collapse into the navigation channel. In contrast, the two structural alternatives mitigate damages caused by more moderate seismic events and are less effective against the most severe events. The lesson for resilience assessment is that, given these variables, probabilistic analysis is essential to resolving which of these alternatives would yield greater benefits.

In order to support decisions about investments in resilience strengthening measures, resilience assessments must support benefit-cost analysis of those alternatives. In this study, the benefits of resilience strengthening alternatives have been estimated by simulating ATC at a container terminal using probabilistic networks. Benefits have been expressed in TEUs/year to facilitate monetization. Both conditional and unconditional benefits have been calculated. Conditional benefits describe the effectiveness of an alternative given a seismic event, but that information has limited value when choosing among potential investments in resilience strengthening

measures. Unconditional benefits are needed to account for the probability and severity of potential events over an investment planning horizon.

This study demonstrates that a probabilistic analysis is essential for quantifying the potential benefits of resilience strengthening alternatives to support decision making. Whereas, in this study, benefits have been quantified in terms of avoided losses in ATC, benefits should really be quantified in terms of avoided losses in productivity. Measures of productivity account for both capacity and demand over an investment planning horizon. This is important because, unless the demand for container handling capacity exists, the benefits of increases in capacity will not be realized. Finally, resilience assessments quantify benefits in terms of avoided losses in system function, but there may be other benefits associated with resilience strengthening alternatives such as avoided property damages that should also be considered in a benefit-cost analysis.

Effectiveness of a Forced Air Bubble System at Clearing Entrained Live Fish Between Barge Junctions

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ABSTRACT

Invasive carp species introduced to the United States to manage algae in aquaculture and wastewater treatment have escaped to the Mississippi River and expanded to its tributaries, including the Illinois River. Invasive carp range expansion from the Illinois River to the Great Lakes is possible through the Chicago Area Waterway System. To abate the spread of invasive carp and other invasive species to the Great Lakes, the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, and the U.S. Geological Survey are evaluating multiple new technologies. Scaled physical modeling and field studies have demonstrated that juvenile fish can be transported through locks and upstream significant distances by commercial tows, potentially aiding in the expansion of this invasive species. Such studies also indicate that bubble plumes can produce flows that penetrate barge junction spaces and flush out entrained materials, preventing further transport by the vessel.

This study assesses how effective a forced air manifold system is at flushing small live fish from barge junctions of a six-barge flotilla making an upstream approach into the Peoria Lock on the Illinois River. The influence that bubble plumes have on lockage maneuvers is also assessed to ensure that such a system would not affect navigation. The team completed field trials in September 2022. For each trial, the team released small live fish, golden shiner (Notemigonus crysoleucas), within the barge junction before navigating over the bubble array and then recaptured what remained after completing the approach. Over 100 trials were completed with half being control, with bubbler system off, and half as treatment, with bubbler system on. Hydrodynamic effects at the barge junction, towboat navigation responses, and fish recapture rates were measured with each trial. At the time of the submission of this abstract data analysis is incomplete, but full results and conclusions will be completed prior to the conference proceedings.

ISAT: The Interagency Water Working Group Science & Applications Team

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ABSTRACT

The Interagency Water Working Group Science & Applications Team (ISAT) is a United States State Department led group of several government agencies (e.g., OAS, NASA, USACE) whose missions align to support the technical and institutional advancements required to fill knowledge gaps on transboundary water issues. The ISAT works to facilitate accurate global fine-scale hydrologic/hydraulic predictions, deliver authoritative products for decision making, and improve the data-to-decision workflow for disaster response, water resources management, and environmental security (sustainability/resilience) across nations in light of a changing climate. The ISAT has been actively involved around the world including within the Nile River Basin in Africa, the Mekong River Basin in Asia, and the La Plata River Basin in South America. Through this cross-agency working group, scientists and engineers work to improve communication and collaboration among science developers, lead new development and integration of science and technology support for transboundary water issues, and support training and education in science and technology across nations.

PIANC USA
The US Section of the World Association for Waterborne Transport Infrastructure

Impacts of Climate-Driven Changes in Storm Surges and Waves on Shore Protection at the Port of Prince Rupert, Western Canada

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ABSTRACT

Storm surges and waves are important climate-driven parameters affecting coastal engineering design. However, there is limited understanding of how coastal storm surges and wave heights will respond to climate change at spatial scales and resolutions relevant to design, or resulting impacts on the performance of shore protection structures. This paper makes use of downscaled future storm surge and wave projections for western Canada (Cousineau & Murphy, 2022) to investigate the potential impacts of changes in extreme storm surges and waves on shore protection along a major transportation corridor at the Port of Prince Rupert, in northern British Columbia. The storm surge and wave height projections comprise four-member mini-ensembles driven by different regional climate models, all corresponding to the RCP8.5 emissions scenario. Projections for a location adjacent to the transportation corridor were sorted into three 20-year samples corresponding to early-, mid-, and late-21st century time periods. Extreme value analyses were performed by fitting the Generalized Pareto Distribution to independent storm surge and significant wave height events from each sample using the peaks-over-threshold methodology. Return values of storm surge and significant wave height derived from the extreme value analyses were used to evaluate rock armour stability, and mean wave overtopping discharges at the connector road for the three time horizons. Minimum flood construction levels, based on provincial guidance, were evaluated at the mid-century time horizon for direct comparison to the design criteria. The results suggested that the shore protection is expected to continue to meet rock stability criteria (0-5% damage during the 50-year return period event) and wave overtopping criteria to mid-century, primarily due to projected decreases in extreme significant wave heights over the first half of the 21st century. The most pessimistic projections for the 200-year return period storm surge, in which there is relatively low confidence when extrapolating from samples of 20 years, indicate that the flood construction level could increase by up to 0.15 m by mid-century. This is within the 0.6 m freeboard allowance, which was designed to accommodate uncertainty from climate change effects. There is low confidence in the end-of-century projections of storm surges and waves, as demonstrated by high variability among ensemble members. The most pessimistic projections suggest a possible decrease in stability of the rock armour (to 10-15% damage during the 50-year return period event) at the end of the century. However, wave overtopping design criteria for vehicle operation along the connector road are expected to continue to be satisfied. This case study demonstrated how this new tool and database could be practically applied to support

climate risk assessment for coastal infrastructure and engineering design. Limitations and needs for future improvement and expansion of the tool and underlying databases were also identified.

References:

Cousineau, J. and Murphy, E., 2022. Numerical investigation of climate change effects on storm surges and extreme waves on Canada's Pacific coast. Atmosphere, 13(2), p.311.

Lock Dewatering in the Upper Mississippi River Basin

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ABSTRACT

The U.S. Army Corps of Engineers (USACE) Rock Island District operates and maintains 11 navigation locks on the Mississippi River, from Saverton, MO to Dubuque, IA, and 6 navigation locks on the Illinois Waterway, from LaGrange, IL to Joliet, IL, and is the location of the USACE Inland Navigation Center Headquarters. Each of these projects were constructed in the 1930s and 1940s, thus requiring a significant level of effort to maintain and repair. Since 2016, the Rock Island District has completed one to four annual lock dewaterings for the purposes of supporting a wide scale of efforts including maintenance, special construction and/or major rehabilitation. This significant increase in the historical frequency lock dewaterings has led to a broad collection of case histories relevant to inland waterway navigation stakeholders, including experience with simultaneous dewatering of multiple locks in a single inland waterway system. This summary article will present the technical approach and processes employed by the Rock Island District, covering risk-based engineering analysis, automated and remote instrumentation and monitoring procedures for real time assessment of probable failure modes, means and methods of dewatering, observed performance, and innovative approaches to documentation of site condition through the use of aerial and bathymetric survey.

Fatigue Repair of Underwater Navigation Steel Structures using CFRP

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ABSTRACT

Steel hydraulic structures (SHS) such as locks, spillway gates, reverse tainter valves. and maintenance closure structures may have fabrication defects and flaws that can be large enough to threaten the integrity of the structure. In addition to the fabrication defects and flaws, the nation's SHS is suffering significant deterioration caused by combined effects of several complex phenomena including for example corrosion, cracking and fatigue. Effective and economical retrofit practices are essential for ensuring continuous operation and for mitigation of the level of risk associated with possible catastrophic failure or unscheduled repairs. Current methods of repair of SHS are adopted primarily from the bridge engineering industry, but have proven ineffective. This paper presents the implementation of an innovative retrofit method of CFRP. The need for a retrofit method is first motivated through fitness-for-purpose fatigue and fracture assessment. The repair retrofit was then developed and analyzed using finite element analysis (FEA) of the valve with and without the retrofit. Following the completion of the analysis, the CFRP retrofit was installed on the Pickwick Lock and Dam's tainter valve. The repairs have shown 2-4 folds increase of fatigue life of the repaired sections.

Advancing Concrete Sustainability

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ABSTRACT

The optimization of sustainability with reinforced concrete relies on concrete mix designs as well as proper selection of structural systems and materials. Sustainaiblity can be further enhanced with proper repair and maintance that extends the life of existing concrete structures. Resources continue to be devleoped to aid in acheiving desirable levels of sustainaiblity as related to concrete structures while not compromising the intended performance. The use of supplementary cementitous materials (SCMs) has long be recognized as a method to improve the sustaianiblity of concrete. This current practice of SCMs is reviewed along with concrete structural system selection and use of glass fiber reinforced polymer reinforcement (GFRP). GFRP is well suited for corrosive enviroments such as salt water and air. Further, there is possibility of using sea water to produce concrete that is reinforced with GFRP. GFRP wraps may be employed to provide external reinforcement and corrosion protection for structural concrete elements. Resources are readily available to assist the desing professional in meeting the sustainaiblity goals and challenges of current and forthcoming owner requirements.

Floating pontoons for tugboats, the case of Tanger Med in Morocco

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ABSTRACT

Introduction
For years, commercial harbours have hosted floating pontoons for sport, fishing and service boats due to their advantages as a relocatable infrastructure adaptable to climate change.
The dynamic evolution of cargo traffic puts pressure to make the mooring of larger vessels such as tugboats, deep-sea fishing vessels and medium-sized cargo ships more flexible.
The use case described is an example of the evolution of the floating pontoon concept to this type of larger units.
The case of the Tanger Med tugboats
The Port of Tanger Med is one of the most dynamic in Africa, strategically located in the Strait of Gibraltar with a very aggressive commercial strategy is achieving an exceptional increase in traffic.
This dynamism requires a continuous growth of its berths and storage yards, the port is continuously expanding and the terminals are changing its use from one year to another, which makes it essential to make the location of tugboats and port pilots more flexible.
That is why they asked us for a floating pontoon solution capable of safely accommodating their fleet of tugboats.
The presentation will describe the different typologies studied and the solution chosen, as well as the lessons learned during the process.
The project included the selection of the right spot within the port for installing the pontoons, which should be one that does not interfere with commercial operations nor blocks any available.
The type of floating pontoons more appropiate for each type of tugboat or service unit.
The type of attachment of those pontoons to the botton or rock slope to make the installation both secure and easy to move to another location in case the operational needs change.
Conclusion
The use of floating pontoons on medium-sized tugboats and cargo ships opens up a wide range of possibilities for the use of unused space in commercial docks with a relative low investment.
Also floating solutions are ideal for fulfilling the increansing environmental requirements faced by commercial harbours, while adding an interesting resiliency layer againts unpredictable water level variations due to climate change.
A new generation of floating concrete docks can now handle the bigger loads those ships will produce on them.
But maybe the most important factor that has opened this new application is the availability of new mooring systems, which are elastic and allow a high energy reduction of peak loads, specially during the docking manouvres.

Update on WG 213 - Design Guidelines for Marine Multipurpose Terminals

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ABSTRACT

Only a few documents about planning, design and management of multipurpose terminals are available now for the use of port planners, designers and operators of this kind of facilities. Existing ones are out of date due to dramatic changes experimented in technology, as well as vessels dimensions, cargo handling equipment, civil structure design and construction, etc.

PIANC has produced a set of guidelines oriented to the planning and design of specialist terminals including “Design Principles for Small and Medium Marine Container Terminals” (WG 135), “Guidelines for Cruise Terminals” (WG 152), “Recommendations for the Design and Assessment of Marine Oil and Petrochemical Terminals” (WG 153) and “Design of Small and Medium LNG terminals including bunkering facilities” (WG 172). At this time, others like “Design of terminals for
RoRo and RoPax vessels” (WG 167) and “Design principles for Dry Bulk Marine Terminals” (WG 184) are under preparation. The present guidelines for planning and design of multipurpose terminals will aim to form part of the set mentioned before.

It is well known that the concept of a multipurpose terminal is “flexibility”, word oriented to describe the possibility for the port facilities to deal with different kind of cargo, volumes, ships dimensions, cargo handling equipment and others, along its life span. In this case, “flexibility” could be perfectly associated with another word, “uncertainty”, which will be present during the whole process of the project of the terminal, especially regarding structure design and construction.

Even in multipurpose terminals, designed for well-defined requirements in terms of cargo volumes, ships, etc. and their evolutions along time, there is an important degree of “uncertainty” due to the port business characteristics, which is very complex to evaluate in the very early step of the process of investment analysis.
Sometimes, especially in countries in transition, the decision to invest in the construction of a multipurpose terminal is coming from a national or local port authority, encouraged by the requirement of different users (multiusers) interested in handling small amount of diverse type of cargo (multipurpose). This scenario becomes more complex the problem of economically justify the investment, taking into account the difficult of cargo forecast analysis under these conditions.

The objective of the proposed Working Group 213 is to gather existing technical documents, literature, codes and standards, and any other relevant information, analyze them, as well as

research about new theories for the planning, design and calculation of multipurpose terminals, in order to produce an up-to-date technical report. Such a manual can be of special interest to port planners, port authorities, National/Regional and/or Local Agencies, marine consultants and contractors, especially those involved in planning and design of this kind of terminals.

This presentation will provide an update on the progress of the Design Guidelines and seek feedback on the direction and content of the document.

Advances in Structural Health Monitoring of US Army Corps Navigation Locks

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ABSTRACT

To mitigate the challenges of traditional inspection to obtain condition information of navigation locks, the US Army Corps of Engineers (USACE) has been developing and implementing structural health monitoring (SHM) technologies. These technologies collect data from sensor systems, process the data using machine learning/artificial intelligence approaches as well as physics based models, and ultimately make decisions on the ability of infrastructure assets such and navigation locks to meet its intended function. In this talk, the latest developments in USACE SHM for navigation locks will be discussed. Particular topics discussed during this presentation will be: vision based monitoring, where commercial off-the-shelf cameras are used to obtain dense, high-resolution information of engineering quantities of interest in condition assessment such as strain and displacement; the use of UAV/ROVs for monitoring, including underwater, and leveraging sonar, etc.; the development of digital twins for seamless integration of physics-informed models to the decision making process.

Assessing remote lock operations on U.S. Army Corps of Engineers inland waterways

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ABSTRACT

The U.S. national commerce depends on the availability and reliability of its waterways system, particularly the consistent operation of inland navigation locks. Recent global events have shown how quickly vulnerabilities can impact the supply chain and disrupt commerce. Implementing remote lock operations on the U.S. Army Corps of Engineers (USACE) inland waterways may alleviate unforeseen system impacts and improve overall system operations.

Implementation of remote lock operations plays an essential role in the ability of USACE to deliver its navigation mission by enabling enhanced, reliable, and efficient waterborne transportation systems and helping develop an innovative, long-term plan for the inland waterways. While USACE is beginning to assess an enterprise approach to the remote operation and automation of locks, many USACE hydropower plants have already implemented solutions.

This presentation will provide the methodology used to guide USACE to move toward remote lock operations. It will summarize the USACE perspective on remote infrastructure operations, including how USACE has formulated its nationwide concept for implementing remote lock operations. It will also outline the future of USACE lock operations in a remote setting.

Participants will understand lessons learned from recent assessment efforts within USACE, the approach taken to assess and plan implementation, and how recent PIANC publications aided in the development of the effort.

Participants will understand lessons learned from recent assessment efforts within USACE, the approach taken to assess and plan implementation, and how recent PIANC publications aided in the development of the effort.

Brandon Road Interbasin Project

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ABSTRACT

Description
The U.S. Army Corps of Engineers completed a feasibility study that was authorized for implementation by Congress to develop controls at Brandon Road Lock and Dam to prevent the upstream interbasin transfer of Aquatic Nuisance Species (ANS) while minimizing impacts to Illinois Waterway users. The State of Illinois is serving as the non-federal sponsor on the project and is working in partnership with the other Great Lakes states, and stakeholders.

Location
Brandon Road Lock and Dam, Joliet, Illinois is located on the Des Plaines River approximately 36 miles (58 Km) from downtown Chicago, Illinois.

Status
A National Ecosystem Restoration (NER) Plan was signed on 23 May 2019 as a federal risk management plan to include a layered system of structural controls and non-structural measures at the Brandon Road Lock and Dam. The Corps structural plan for the Brandon Road Interbasin Project includes the creation of new technology alternatives to create a gauntlet of deterrent systems to maximize project efficacy in the effort of ANS management. This plan includes acoustic fish deterrent system, bubble curtain system, electric barrier system, engineered channel, and flushing lock. The structural measures are described in more detail below.

Air Bubbler
Air bubble curtains are to be installed at the leading downstream edge of the engineered channel with a purpose of removing entrained fish located in the small gaps in between the barges.

Acoustic Deterrent System (ADS)
Acoustic underwater speakers are to be installed in strategic arrays in the Engineered Channel. The acoustic deterrent system will create underwater sound in frequencies targeting invasive carp to create a behavioral response and deter upstream passage beyond the Brandon Road location

Electric Barrier
The Electric Barrier measure will be installed across the engineered channel. The electric barrier is a proven technology with a high efficacy level and will be capable of being adjusted to

meet onsite conditions to maximize effectiveness of the barrier. Operation will be adjusted for safe navigation transit.

Engineered Channel
The Engineered Channel measure creates an engineered structure that completely lines the lower approach channel with concrete. The structure will house the electric barrier, acoustic fish deterrent, and air bubble curtain structural measures. The engineered channel will provide space for future adaptive management measures.

Flushing Lock
The Flushing Lock measure was developed to reduce the risk of the upstream transfer of floating ANS by displacing the tailwater, which may contain floating ANS, with pool water within the lock chamber. The goal of this measure is to reduce the risk of any aquatic nuisance species, to include fish eggs and larvae, from floating or being carried via barge movement to the upstream pool through the lock.

This project will reduce risk of Mississippi River Basin aquatic nuisance species from establishing themselves in the Great Lakes Basin to the maximum extent possible while providing continued navigation use and minimizing the impacts to other waterway users and uses.

Rehabilitation of The City of Key West's Historic C-Dock and Turtle Kraals

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ABSTRACT

The City of Key West, Florida contracted GHD to perform an engineering assessment and provide subsequent design and construction services for the rehabilitation of C-Dock located in the Key West Bight Marina. C-Dock is a 210 linear foot concrete finger pier constructed in the early 1900s. The historic Dock is registered with the National Register of Historic Places and played a central role in early Key West fishing commerce. Today, the dock provides access to the Bight Marina Harbor Master Building and is a busy hub for fishing charters and private vessel mooring. GHD's preliminary roles included public records searches, a comprehensive engineering inspection including underwater inspection and GPR survey, and completion of an Engineering Assessment & Recommendation of Repairs Report. This work was conducted between November 2021 and May 2022 and guided the City's decision to move forward with a complete rehabilitation of the existing structure. The work performed to-date found that C-Dock was likely constructed in 1918 of and comprised of cast-in-place concrete walls and backfilled with conch shells and sediment. Major repairs were completed on C-Dock in 1996 and included installation of utilities and rehabilitation of the above water concrete. The inspection conducted in November 2021 identified large voids in the historic structure above and below the waterline for which short-term, immediate repair recommendations were provided.

In addition to C-Dock, an adjacent and concurrent task order is also being completed at the Key West Turtle Kraals by GHD for the City of Key West. Also, a National Register of Historic Places location, this area is comprised of historic concrete piling fences encompassing two pens in the Marina. These pens, or "Kraals," held captured green sea turtles prior to their processing at the Turtle Soup Cannery. Legal until 1971, turtle fishing, processing, and commerce were key pillars of early Key West economy. The City wishes to recreate the kraals as a historic educational attraction in the Bight Marina. During the C-Dock underwater inspection, GHD evaluated and quantified the remaining concrete piles in the kraals and provided aesthetic recreation alternatives and recommendations.

GHD is working with the City of Key West to kick off the next phase of both projects. For C-Dock, two options were presented to the City: a complete dock replacement that matches the existing historical aesthetic features or a full rehabilitation of the existing structure with ground improvement methods, new piling and concrete deck, and outer wall stabilization with scour protection. Both options will involve considerable coordination with marina operations, management of existing utilities, and a careful selection of construction materials and methods that minimize the impact to the environment. For the Turtle Kraals, new concrete piles will be installed in various locations to mimic the original pen design. Additional signage and historic

artifacts will be incorporated to the design for educational purposes. Detailed design of these projects will be underway soon, with construction anticipated to commence in 2023.

PIANC USA
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Illinois Waterway Consolidated Closure Major Maintenance Program

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ABSTRACT

The Illinois Water Way (ILWW) navigation system consists of 268 miles of waterway with 8 locks and 7 dams. It is one of busiest waterways in the US with a diverse portfolio of products being shipped. Annually, it is estimated that the ILWW generates over $3 billion in national benefits and supports over 580 manufacturing facilities, terminals, and docks.

Much of the ILWW was constructed during the early part of the last century and many of the structural, electrical, and mechanical components and systems are approaching 90 years old. The Corps of Engineers has undertaken an extensive renovation program for the entire system and the program has 3 goals:

1. Restore the systems for reliable operation and eliminate future unscheduled down time for the locks due to malfunctioning equipment.
2. Reduce future operations and maintenance requirements through standard, simplified systems and reducing the number of components.
3. Minimize downtime during upgrades preventing economic losses during the closures.

The complicated modernization program consists of multiple fabrication, supply, and construction projects requiring numerous levels of coordination among several levels of Corps of Engineers management, Congressional interest, multiple agencies, major industries, and numerous states. The total value of the work is nearly $300 Million. The first round of closures took place during the summer of 2020 and was successfully completed with construction cost and time growth well below 0.5%. The second round of closures are scheduled for the June of 2023

The presentation will discuss an overview of the ILWW, the desired end state, the nature of the repairs, standardization and simplification efforts for the entire navigation system, the execution of the project over numerous years, and the design tools used to make the project successful to date.

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"DREDGING OF THE ACCESS CHANNEL TO THE MARITIME PORT OF GUAYAQUIL, FROM FORECAST TO EXECUTION"

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ABSTRACT

The Maritime Port of Guayaquil, is made up of Public and Private Terminals and between all of them, by 2022, they mobilize more than 2 million TEUs, export and import. The Public Terminal was inaugurated in January 1963, the Access Channel had two sections, an External Channel with a depth of 8.8m to MLWS with a rock bottom and an Internal Channel with a depth of 8.8m to MLWS with silt bottom, that allowed the entry of operations of ships of 160m in length and draft of 9.75m with tide benefit, in 1964 the first Private Terminal operated. In 1997, the change in the Port Management Model began in Ecuador.

After the announcement of the Expansion of the Panama Channel in 2006, all the Ports of the region prepared themselves intensely for this challenge, with the exception of Ecuador. However, due to the pressure of Commerce and the Maritime Industry, in 2011 the Port Authority of Guayaquil contracted with CONSULSUA & GEOESTUDIOS, the complete Studies to Dredging the Access Channel and to propose the best Dredging Management Model (capital and manteince). In 2013, the Municipality of Guayaquil hired the same Association for the studies to update the dredging of the External Barrier.

The conclusion of these studies was that the most convenient thing was to grant a concession for the dredging of the channel and that the capital and maintenance andwork be paid for by a fee for use of the canal. While this was happening, the ships that entered the Port Terminals were getting bigger and bigger, but they maintained the draft of 9.75m with the benefit of the tide.

In 2017, the Project was resumed by the Municipality of Guayaquil for the "Delegation to a Private Manager of the Dredging, Deepening and Maintenance of the Access Channel to the Port of Guayaquil for 25 years. The Technical Analysis of this process was carried out by CONSULUA; the operation of NEOPANAMAX vessels was proposed, with an operating draft of 12.5m with tidal benefit, and the dredging depths would be 11.85m in the External Channel at the MLWS and 11.54m in the Internal Channel at the MLWS.
After the contractual process, on December 5, 2018, the Delegation Contract was signed with Compañía Canal de Guayaquil S.A. (CGUSA), a subsidiary of the JAN DE NUL N.V Company, the capital dredging was proposed to be executed in 02 years, however, it was carried out in 01 year, enabling the access channel for ships with a draft of 12.5m with benefit of tide since January 2020, maintenance dredging has been carried out successfully. In May 2022, the Municipality of Guayaquil has been requested by the Shipping and Port Sector to increase the

depth, to enter the NEOPANAMAX with 14m draft with tidal benefit, projecting the entry of the VLCS. Now this is the challenge.

PIANC WG194 – A Framework for Early Contractor Involvement in Marine Infrastructure Projects

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ABSTRACT

The PIANC Marcom WG 194 Report - A Framework for Early Contractor Involvement in Infrastructure Projects was published in 2022 with intended usage by infrastructure owners, contractors, and engineers.

Introduction

It is increasingly acknowledged that the complex nature of planning infrastructure works, and potential for severe cost overruns, can negatively affect implementation for many projects. In the effort to 'de-risk' their projects, industry practitioners are increasingly applying alternative contracting methods which engage parties at earlier stages.

Early Contractor Involvement (ECI) is a strategy initiated by infrastructure owners towards prime contractors, optionally expanded with consultants, stakeholders and subcontractors. The intention is to optimize values in project delivery and objectives, through their participation and knowledge-sharing in the early stages of project planning and design, prior to project execution.

ECI Development

Previous efforts have initiated knowledge exchange and discussions addressing various aspects of ECI related to maritime infrastructure construction, however, these efforts did not address frameworks relating to how the relevant parties in an ECI process should act. The lack of guidelines often results in inefficiencies, misaligned goals or distortions in the relationship between the parties involved. Therefore, there was an industry need to form a set of structured and well accepted guidelines for ECI processes. To address this need PIANC Working Group (WG) 194 was established.

An understanding by all parties of the implications of going down an ECI path, and a shared willingness to accept the implications, are crucial to the achievement of benefits of ECI.

Throughout the formation of the WG194 report, involving extensive global ECI experience sharing, research and case study review, the hallmarks of a successful ECI process have been identified as addressing:

- Good faith
- Transparency

- Equal treatment of all parties
- Fairness
- Clarity through clear rules of engagement
- Protection of intellectual property

The WG 194 Report examines the factors influencing the decision to adopt ECI, ECI types, and factors influencing the use of ECI.
The intent of the first five chapters of WG 194 Report are to:

- Collate and review available information and reporting on ECI;
- Give an overview of the trends and existing approaches driving ECI future developments;
- Analyze relevant factors in ECI (benefits and barriers);
- Explore the range of existing ECI approaches;
- Evaluate the effectiveness of the different ECI approaches;
- Assess the application of ECI and how it fits in with the different procurement regulations.

Further guidance on ECI implementation is provided including a framework that can assist in the selection of the most suitable procurement process, the selection of the most appropriate contract model and the further management of the ECI process.
Finally, the Report provides case studies and lessons learned from marine infrastructure projects worldwide that have employed ECI.

References

PIANC MarCom WG 194 - A Framework for Early Contractor Involvement in Infrastructure Projects. (June 2022).

PIANC USA
The US Section of the World Association for Waterborne Transport Infrastructure

2-D HEC-RAS Modeling at Navigation Restrictions along the Madeira River, Brazil

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ABSTRACT

The Madeira River Waterway is an important transportation link for agricultural products from western Brazil to the deep-draft ports on the Amazon River. Navigation on the Madeira is frequently restricted along critical reaches during low flow conditions by shoaling. Dredging has had limited success given the high sediment loads. The Brazilian Department of Transportation Infrastructure (DNIT) together with the US Army Corps of Engineers (USACE) prepared the Madeira River Navigation Improvement Planning Study in 2018 with the purpose of improving navigation reliability. The purpose of this follow-on hydraulic analysis is to evaluate the ability of river training structures to maintain the navigation channel at eight critical reaches identified in the Planning Study. Structure alternatives included dikes and chevrons. At anabranch sections weirs across secondary channels were evaluated. The USACE Hydrologic Engineering Center's River Analysis System (HEC-RAS) was used to develop eight 2-dimensional (2D) models for each critical reach and evaluate improvement alternatives. The river terrain was based on a 2016 bathymetric survey and was also used in developing a 1D HEC-RAS model of the Madeira during the Planning Study. Grid files representing training structure dimensions and elevation were created and added over the 2D river terrain using tools in RAS Mapper. The effectiveness of the alternative was evaluated by comparing the change in shear stress along the channel bottom with the alternative in place. One benefit of using the 2D version of HEC-RAS included a better representation of crossing bar flow where the navigation channel switches from one bank to the other and passes over a bar along the middle of the river. At three critical reaches the crossing flow is not well concentrated during low flow conditions with shallow flow passing over the middle bar for a length of 3 km. Model results indicated that a series of dikes at the Tamanduá, Curicacas and Miriti reaches were effective in concentrating the flow and maintaining navigation depths. The 2D model revealed the difficulty in using structures where the Madeira is divided into multiple channels by islands. A weir placed in the secondary channel was effective in concentrating flow in the navigation channel during low flow conditions but would likely result in sediment rapidly filling the secondary channel with negative impacts. A submerged weir was also effective but with potential flanking erosion during high flow. The submerged notched weir proved to be the better option with less sedimentation and erosion. The 2D HEC-RAS model was a useful screening tool to evaluate potential navigation improvements on the Madeira River with the recommendation to include sediment transport in the next phase of modeling and design.

Implementation of the Brazil Waterways Monitoring Plan

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ABSTRACT

Brazil, a country with an immense waterway network, is in the process of developing and expanding inland navigation to support development of sustainable economic opportunities. The process is guided by the National Waterway Transport Policy and Strategic Waterway Plan. These works establish general guidelines for promoting inland navigation in Brazil with a focus on supporting multiple uses of the waterways and integrated planning of water resources.

To support development of inland navigation resources, the Departmento Nacional de Infraestrutura de Transportes (DNIT) has developed and implemented the Waterway Monitoring Plan. The plan includes extensive data collection and analysis efforts for rivers across the country including geodetic control, bathymetry (single beam, multibeam, side scan sonar), Acoustic Doppler Current Profiling (ADCP), sediment sampling, and hydrodynamic monitoring stations. The data is used to develop hydrologic models and support informed water resources development decisions. Current five-year monitoring contracts have been established for the Madeira River, Sao Francisco River, and Southern Waterways (Jacui River, Tapajos River, Taquari River, Uruguay River, Lagoa Mirim). For several rivers, these monitoring efforts are the first time data has been collected and serve as baseline data.

The presentation will provide an overview of the program, present preliminary findings and applications, and highlight lessons learned and programmatic adaptive management strategies.

River Information Services Enterprise - A Framework for Inland Waterway Digital Infrastructure

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ABSTRACT

Inland waterways involve many different stakeholders who regulate, manage, operate, and move cargo on them. This has resulted in a mix of standards and regulations that can hinder the exchange of supply-chain data among those using the rivers. Many of the tools that other transportation industries (e.g., rail and trucking) take for granted are missing on the rivers. In parallel, a growing need exists to improve data collection capabilities to predict water levels of rivers for voyage planning and flood management. Trabus Technologies (TRABUS) developed the River Information Services Enterprise (RISE), a software cloud-based ecosystem, that offers U.S. inland waterways digital infrastructure for waterway management in support of the U.S. Army Corps of Engineers and U.S. Coast Guard. RISE uses predictive analytics, artificial intelligence (AI). machine learning (ML), and data visualization tools to provide real-time and forecasted situational awareness on river conditions through the integration of disparate data sources and software web services under a common framework. RISE's AI/ML capabilities include river level forecasts, bridge air gap predictions, travel time estimates, marine safety information harmonization to improve voyage planning, waterway operations and river/lock maintenance management. Employing an open-architecture, common interfaces, and shared services, RISE offers broad international community appeal as a to assure timely, secured and accurate information sharing of marine transportation information and river information services for other countries. Keywords: river information services, predictive analytics, cloud, marine supply chain

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FLUID MUD IN PORTS AND NAVIGATION CHANNELS: THE TERMINAL 2 OF PORT OF AÇU (RJ, BRAZIL) APPROACH

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ABSTRACT

The issue of fluid mud is a concern at many ports and waterways around the world because the presence of fine sediment layers and silting can cause reduction in nautical depth and the impact into the navigation cannot be directly assessed. In particular, understanding how fluid mud can limit the depth available for navigation, known as the nautical depth, is extremely important for safe port operations. Fluid mud is complex, and the management of it requires a comprehensive understanding of rheology (the way matter flows), methods of field measurements and data analysis and interpretation. In this context, the existence of fluid mud layers makes the definition of the bottom ambiguous because the location of interfaces between water, fluid mud, and consolidated mud is dynamic and cannot be identified easily in some cases. In particular, the bottom composition is important since the consequences of a bottom touch shall be combined to the probability of occurrence for a proper risk assessment. This article presents an integrated approach to the study of muddy layers in port regions, being discussed in Terminal 2 of Port of Açu, the only private port complex in operation in Brazil. Although Port of Açu is not an estuarine port, the region where it was established is influenced by the great sedimentological activity seen at the mouth of the Paraíba do Sul River, about 25 km north of the complex. The combination of density profiles using tuning fork with rheological and grain size data, laboratory tests, dual-frequency echo sounder, and sedimentological modeling allow estimating a potential increase in draft depending on location, nautical depth criteria and hydrodynamic conditions. At the nautical bottom approach, part of the fluid mud layers can be included in the available depth if they present favorable rheology. As it is difficult to perform in situ rheological profiles, the most adopted procedure is to correlate these properties with other ones that can be measured easier, typically density, but the errors in this approach shall be quantified to provide reliable predictions of the fluid mud. It is expected that the combination of techniques and in situ measurements will allow the development of tools to support the studies regarding the navigation in fluid mud, which shall provide more safety and efficiency to the channel navigation. The approach aims to identify the existence of a layer of fluid mud on the seabed of the area of interest and based on this knowledge, to evaluate the management possibilities that open up, namely its use for navigation purposes such as improving the net UKC available based on a risk assessment approach to the safe transit of vessels and its input in dynamic UKC systems, the reduction of volumes and/or spacing of dredging campaigns, changes in the technique adopted for the handling and deposition of material, etc., aiming at obtaining positive externalities to the port. The paper intends to provide

technical evidence/data to support the discussions regarding this subject in Brazil, which may evolve to a technical guideline in the future.

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How a proper design of reliable marine fender systems ensures smooth and safe operations at ports, waterways and marinas

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ABSTRACT

The aim of this paper is to address a critical issue for the marine industry: the proper design of a fender system following a holistic approach and its influence on ports, waterways, and marinas - to ensure safety during their operations.
After a brief introduction, this paper's focus is having an open-minded look at the typical problems of poor fender system design, the resulting consequences and the corresponding corrective measures to always ensure smooth and safe operations in the marine environment. It is followed by highlighting the three different aspects of the holistic approach and their influence on the performance of fender systems. Finally, the paper closes with a final review of the importance of a holistic approach to fender system design for the maritime industry.

Introduction

A fender system is the interface between a vessel and a berthing structure. A safety equipment to protect vessels, infrastructures, and people, that needs to perform as the user expects throughout its entire service life, even in the most remote locations and under harshest conditions. For this to happen, all the components of a fender system must be designed in the correct balance and work together properly. And this can only be achieved with the so-called 'holistic approach to fender system design'.
The consideration of fender system design is applicable to professionals working with waterfront structures and fenders for ports, inland waterways, and marinas, as well as operators and port authorities. Users and engineers should be aware of the fact that "what looks good in a drawing, might not work in the field".
We see it as vital, to openly discuss the issue, raise awareness of it and share proven experiences to foster engineering approaches that will, in the long run, increase productivity and safety in ports, inland waterways and marinas.

Typical problems

As industry experts, we would like to highlight that the rubber unit is a crucial component of a fender system, however, stakeholders should be aware that these units are for the most part already standardized by the industry, and that focusing exclusively on them while ignoring other requirements is a dangerous one-sided approach to fender design.
Furthermore, numerous fender systems around the world show signs of premature failures due to incorrect designs. An example is the positioning of the rubber unit on the steel panel; on the drawing, the panel might be shown straight and stable, but installed in the port, the panel could

show drooping and tilting under its deadweight due to an incorrect positioning of the rubber unit on the panel – this cannot be 'seen' on a drawing.
Another example is an incorrect tension chain design; again, the panel and corresponding chain might look correct on the drawing, but in the field an incorrect tension chain design could reduce the energy absorption of the fender system for low level contacts.
Other typical problems are the steel panel's internal structure, UHMW-PE protection pads, and coating system.
Poor fender system design has many aspects with severe consequences. When fenders fail or are not working properly due to low quality or incorrect designs, there is a cost in terms of repair, downtime, or even accidents.
How to avoid all of the above?
Several measures help to prevent failures and minimize risks, including correctly positioning the rubber unit on the steel panel, a balanced chain design, high-quality UHMW-PE or coating systems according to specifications. However, the proper overall solution is to start at the very beginning, the moment the design is conceived.
To design a reliable fender system, the interaction of the most diverse project conditions as well as the different components and characteristics of different fender types need to be considered. In order to get a high-quality and durable fender system, to ensure smooth and safe operations at ports, waterways, and marinas, a complex but comprehensive route lies ahead: the holistic approach to fender system design.

Highlighting the Holistic Approach
We have already discussed that although industry standards guide the way, there are still many examples of poor fender system designs in ports around the world. Also, that shortcoming of addressing the importance of a holistic approach and following it during the design process can be identified as being one of the reasons.
The current guidelines from PIANC [1] and British Standard [2] address the topic but not to the fullest extent. So far, there is no standard which fully covers the concept of a holistic approach to fender system design and considers a fender system as a whole, taking into account the project conditions, its different components as well as its manufacturing process.

A reliable marine fender system is "a safety measure to protect vessels, infrastructures, and people throughout its entire service life, even in the most remote locations and under harshest conditions" and can only perform as expected if these aspects are considered during the complex way ahead from its conception:
Project conditions
These might be very individual and comprise, amongst others, of the local climate, vessel types and berthing speeds, location, berthing approach, or berthing structure. A holistic approach considers all the many conditions to design a unique fender system. Additionally, the review of different characteristics of various fender types should also be incorporated in the design process at this stage.
Components

Following the customized approach, and to ensure the fender system is up to its task, the designer must keep an eye on the big picture, while paying attention to every little detail. The rubber unit is a crucial component of the system, but it is only as good as the system's overall design, as a fender system is made of several different components: rubber unit, steel panel, chains, anchors, fixings and PE plates.
All of them and their interaction should be assessed as one, to make sure they are all designed in the correct balance and work together properly.
Manufacturing
From a technical point of view, the road to a good rubber fender is completed with the combination of high-quality source materials and a fender manufacturer expertly skilled to guarantee the performance of the final product to the individual project requirements, and international standards.
The manufacturing process of the rubber unit plays a vital part in the ultimate performance of a fender system, same as for steel parts and PE, thus the holistic approach ensures as well that all manufacturing steps are linked.

When all these three aspects are valued equally in the design, are interconnected, and seen as one single process, the fender system will perform as expected: reliably over the full-service life and beyond.
Following the conference topic “Sustaining Ports, Waterways, and Marinas through a Changing Climate”, reskinning of foam fenders - so they can be used again and do not need to be replaced with completely new fenders - is a way to reduce emissions and environmental impacts, now that sustainability has moved further to the center of attention.
Also ‘reduce from the beginning’ is another aspect, which means working with a sustainable and green design to extend the life cycle of fenders. Following this approach, it will not be necessary to waste more raw material and other resources for early refurbishments or even new fenders in cases of damages.

The importance of a holistic approach
If a rubber fender system does not perform as required, safety in marine operation and efficiency for marine terminals cannot be ensured. This is why it is important to take all aspects into account that influence the performance of a fender system and treat them as an interconnected process, being a holistic approach as described in this paper.
The lack of this concept in industry standards and the many examples of poor fender system design around the world emphasize the need for a holistic approach to fender system design in the industry.
In a first step, the awareness of all the aspects and their interconnection will increase the understanding in the industry about potential problems with fender system design. In a second step, including this process in industry standards and guidelines will further ensure that all fender manufacturers follow the same route to a high-quality and durable fender system.

In summary, this paper discusses the typical problems of poor fender system design as well as the resulting consequences to the final user: ports, waterways, and marinas. Furthermore, it addresses what steps need to be taken to rectify and avoid improper designs by recommending the correct approach for a reliable and durable fender design. Finally, to complete its content, it is showing examples of sustainability in fender design and operation.

The paper is based on findings of the PIANC Working Group Report 33 about fender design, the Working Group Report 145 about berthing velocities as well as updated standards such as BS6349.

The Inland Waterway Transportation Regulatory Structure in Brazil: Considerations on the Current Model and New Challenges

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ABSTRACT

The inland waterway transportation in Brazil has undergone profound changes in the last 25 years. From a model linked to the direct participation of the State whose provided infrastructure and services, to the current regulatory panorama based on the private participation. The regulatory frameworks sought to expand the private participation in the market with port facilities, shipping companies and expansion of the fleet.

A Federal Law published in 1997 established the guidelines for shipping companies, national fleet and foreign vessels. This legal instrument contributed to the establishment of a regulatory State. In the waterway sector, it was consolidated with the creation of the National Waterway Transport Agency (ANTAQ) in 2002.

Under ANTAQ's competence are: the creation of regulations, the granting and monitoring of grants in maritime and inland navigation, the concession of port facilities (public and private) and waterway infrastructure. In this sense, the implementation of services and infrastructure in waterways was important. However, old gaps remain.

In parallel with the gaps still present in the arrangement of waterway transport, new challenges have arisen. From a national perspective, recent proposals for concessions for the exploration of waterway infrastructure emerge as an alternative to increase the national transport matrix. At the regional scale, two subjects dominate the discussions involving crossing navigation: the development of models for public operators selection, due to the huge number of interested parties in some crossing lines; and the improvement of berthing infrastructure, in order to adequately allow the flow of passengers, cargo and vehicles.

In summary, the present work aims to analyze the regulatory structure of waterway transportation developed in Brazil in the last 25 years, including advances and setbacks inherent to the process, especially with regard to inland waterways. It intended to present also initial considerations about the new regulatory challenges such as the concession of waterways and the public operators' selection for crossings inland navigation.

Adapting Hydrodynamic Dredging Throughout the US

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ABSTRACT

Maritime authorities are continually confronted with the siltation of their waterways. Therefore, regular maintenance dredging is necessary to ensure safe navigation depths. Local facilities and the US Army Corps of Engineers (USACE) dredge roughly 250 million cubic yards of material from federal waterways at an estimated $1.3 billion each year. Sediment handling and disposal are crucial issues with associated permitting and operational constraints. Once a local or national entity has identified the most efficient, lowest-cost alternative with the most flexibility, the next logical step is to identify the permitting implications and seek permits to use the technology.

Innovative hydrodynamic dredging techniques, which are cost-effective and environmentally sound, utilize natural forces (currents, tides, gravity, etc.) to facilitate sediment transport, making them a possible low-impact dredging solution for the industry. Since all hydrodynamic dredges avoid excavation of sediments in the means that traditional dredges do, there is no need to obtain disposal facilities or transport material, creating cost savings and typically less environmental impact. Furthermore, hydrodynamic dredges tend to have fewer constraints in mobilization to a site. Generally, they are highly maneuverable, allowing them to operate in places that other types of equipment cannot safely reach, for instance, near jetties and underneath moored vessels. Additionally, hydrodynamic dredges pose less risk of damaging underwater infrastructures, such as cables and pipelines, bulkheads, lock aprons, and dry docks.

Innovative hydrodynamic dredges have been permitted throughout the greater US, including providing a reliable means for the North Carolina State Ports Authority (NCSPA) to provide access to its berths, removing sediment over the Chesapeake Bay Bridge-Tunnel (CBBT) to minimize potential harm to the existing tunnel structure, and maintaining federal navigational depth within the Mississippi River. Meanwhile, demonstration projects and permitting efforts have been proposed across the US, including promoting sustainable long-term reservoir sediment management while maintaining existing reservoir benefits for the Kansas Water Office (KWO) and handling persistent shoaling issues within the North Carolina Department of Transportation Ferry Division (NCDOTFD) terminal basin without delaying terminals use. Renourishing wetlands within sections of the Atlantic Intracoastal Waterway that have been damaged by storms and boat wakes within the federal navigation channels they adjoin.

This paper aims to provide an understanding of the hydrodynamic dredging methodology while identifying and evaluating the challenges of bringing this innovative technology to a maritime facility within the US. The paper proposes means to work within the current challenges and approval system to provide maritime interests the ability to apply innovative technologies to US facilities.

Designing the Substructure to Support the World's Largest Mobile Boat Hoist

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ABSTRACT

The design of a haul-out basin within an existing pier and support structures proved to be challenging as they not only had to support the boat hoist, but had to do so amidst existing foundations, adjacent bulkhead anchoring systems, and variable soil conditions. It required strategic planning and creativity from the Cummins Cederberg team as limited information was available on the existing structures, some of which were estimated over 100 years old. To accomplish these tasks, the structures to support this mobile boat hoist consisted of an 852 CY of reinforced concrete relieving platform, 535 linear feet of steel sheet pile bulkhead, 274 auger cast-in-place concrete piles, six 14-inch square pre-stressed pre-cast concrete piles, and six HP18 steel piles.

The team performed multiple structural condition evaluations and exploratory geotechnical excavations to confirm existing soil conditions and conditions of the existing structures to ultimately design a supplementary foundation and anchoring system for the new and existing structures. In addition to leading the marine engineering and environmental permitting efforts for the project, Cummins Cederberg provided an active support role during the construction phase to rapidly evaluate and address field conditions as they arose.

Derecktor Ft. Pierce is now home to the world’s largest mobile boat hoist with a maximum capacity of 1500 US-short-tons and a deep-water (-20’ NAVD) hoist basin. The shipyard was specifically designed to accommodate megayachts, powered- and non-powered vessels over 200 feet long and 900 tons.

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Economic Viability of Deep Draft Navigation in the Tapajós River, Brazil

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ABSTRACT

The Tapajós River is currently the most utilized shallow draft waterway in Brazil, with the transport of over 12 million tonnes of commodities in 2020 and projections of over 40 million tonnes per year by 2035. The waterway is an important link in the transportation chain for agricultural commodities (specifically soybean and corn) produced in the Brazilian state of Mato Grosso. Currently, agricultural products are transported approximately 1000 km by truck and then loaded onto shallow-draft barges on the Tapajós River at the city of Miritituba, Pará. The commodities are then transported to and loaded onto deep-draft vessels at ports along the Amazon River in either Santarém or Belém. However, the Tapajós River offers an opportunity for conversion to a deep draft system where commodities could be directly loaded onto ocean-going vessels. This is due to the deep-water conditions along the majority of its length and the very low sediment supply, which limits depositional rates of proposed deepening projects. The Brazilian Department of Transportation Infrastructure (DNIT) together with the US Army Corps of Engineers (USACE) developed a feasibility study that explored sixteen (16) separate transportation scenarios, including conversion of the Tapajós River to a deep-draft waterway up to Miritituba. The geologic setting demonstrates the potential for the deep-draft conversion (similar to the Trombetas River – an Amazon tributary in the same geographic region). A hydrology study combined with the development of a one-dimensional unsteady hydraulic model was used to determine system reliability of each of the proposed scenarios. In addition, several design tools were developed to estimate the benefit-cost ratio associated with the transportation scenarios. These tools included: 1) dredging cost estimator for various design vessels, drafts, and channel reliability; 2) sediment transport model to determine future maintenance dredging volumes and costs; and 3) an economic assessorial model to calculate total transportation costs under each scenario. The alternatives that included deep draft navigation up to Miritituba provided a cost savings of $3.4 per tonne when compared to the current transportation strategies; or a potential future annual savings of over $100 million USD per year. Average annual dredging costs associated with the deepening scenario is a fraction of the total savings to the navigation sector, resulting in a significant benefit-cost ratio.

PIANC Working Group 236: Sustainable Management of the Navigability of Natural Rivers

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ABSTRACT

The PIANC InCom/Envicom Working Group 236 was established in early 2021 to develop PIANC guidelines for improving navigability conditions on natural or quasi-natural rivers, while maintaining morphological processes and natural river form and function. The Working Group calls these morphologically active rivers "free-flow rivers". Its key objectives include: 1) development of guidelines to improve and maintain the navigability in free-flowing rivers; 2) assess the sustainability of river training works designed to improve the navigability; 3) assess the sustainability of dynamic river management (monitoring and shifting of navigation aids to adapt the navigation channel to the river dynamics); 4) highlight the technical, operational, economic and environmental considerations for navigation in free-flowing rivers compared to that in regulated rivers and canals; and 5) improve the understanding of the physical processes in free-flowing rivers, developed with or without river training works. The developed guidance includes a planning framework for developing a navigability improvement masterplan for a free-flowing river system, and the integrated and adaptive management strategies that can be applied at a system scale. Specific interventions and measures have been identified that are analyzed to meet the dual goals of maintaining morphological river function and improving navigability conditions. These measures include dynamic charting; morphological dredging and disposal management; Temporary, Adaptable, and Flexible Training Structures (TAFTS); riverbed armouring and sediment nourishment; rock excavation; meander cutoffs and oxbow development; localized traditional river training structures; and channel closure structures. The impacts and strategies for mitigating impacts associated with some of the measures are analyzed and discussed. Finally, the continual monitoring, management, and operational tools available for improving navigability in a morphologically active river system is presented. It is recognized that free-flowing rivers will typically be more fluvially active and dynamic than systems that have used traditional methods for navigability improvements including heavily trained rivers or systems with locks and dams. These unrestricted and unconfined river systems, therefore, will require new and innovative strategies to monitor the fluvial and geomorphic changes of the system in order to inform managers and navigators of the river. Case studies are presented that include the Madeira River (Brazil); Magdalena River (Colombia); Niger Delta (Nigeria); Yangtze River (China); the Brahmaputra-Jamuna River (India); and the Red River (Vietnam).

Ecologically Engineered Solutions for Resilient Port Infrastructure

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ABSTRACT

Ports are at the forefront of environmental challenges associated with climate change and coastal development. To adapt and build climate resilient infrastructure, ports require innovative technologies and novel design considerations beyond the mandatory industry standards. In recent years, there has been a growing interest among coastal stakeholders and engineers to integrate nature-based structural solutions into the designs of port infrastructure - exploring how natural processes and ecologically engineered technology can provide solutions to reduce their ecological footprint. Ports are uniquely positioned to demonstrate innovative approaches to build resilient infrastructure and transform how waterfronts look and function.

In 2016, the Port of San Diego (Port) in California launched a Blue Economy Program to seek innovative solutions to address environmental and coastal resiliency challenges. The program allows the Port to partner with companies in testing new technologies and approaches to help bridge the gap between sustainability and coastal development. In 2019, under this program, the Port partnered with ECOncrete, an eco-engineering company developing bio-enhancing concrete technology, to demonstrate a new and innovative design of ECOncrete's interlocking coastal armor unit element, the CoastaLock. The main objective of the project was to develop a specific design to address not only the structural and coastal engineering requirements for shoreline protection and stabilization, but also the need to promote native marine habitats, increase biodiversity, and restore local coastal ecosystems. The CoastaLock interlocking armor units are designed to create well-defined local ecosystems that mimic natural rock pools, which ultimately provide structural, ecological, and community engagement benefits, including carbon sequestration and regeneration of local marine biodiversity. The project was launched in 2021 and the results from the first biological monitoring event showed development towards a richer and more diverse community compared to adjacent control rocks.

In 2020, ECOncrete, the Port of Vigo (Spain), Cardama Shipyard, and Technical University of Denmark (DTU) were awarded funding from the European Commission's (Horizon Fast Track to Innovation) to launch a Living Ports project, designed to demonstrate ecological alternatives to traditional concrete infrastructure. The Living Ports project will be deployed at the Port of Vigo where ECOncrete's eco-engineered technology will be installed as a solution for 310 m² of seawall as well as 100 CoastaLock shoreline armor units, which will provide stabilization and water-retaining intertidal habitats. The project will also feature a moored underwater observatory that will provide the public interactive access to observe the marine life developing on the

ecologically engineered seawalls. Biological monitoring will be conducted by DTU, and for the first time, underwater sound reduction due to marine life growing on concrete will be studied.

With these port-based projects, ECOncrete aims to provide examples of nature-inclusive design for coastal protection and sustainable port infrastructure, which can be applied to urban, natural, and working waterfronts around the world. These projects are designed to catalyze a fundamental change in best practices for the design and construction of ports by moving away from obsolete ‘grey’ infrastructure towards innovative nature-inclusive ‘blue’ infrastructure with associated structural, environmental, and socioeconomic benefits.

Operation of hydraulic engineering structures

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ABSTRACT

Key elements to the life of hydraulic structures are regular inspections, assessments, and records of the structure's condition.

Inspections provide timely detection of damages that could affect a structure's load-bearing capacity and serviceability. This allows the persons in charge of maintenance to take responsibility for ensuring the safety, load-bearing capacity, and serviceability of the structure. Careful, regular and consistent inspections of the structure also help in the planning and management of maintenance work. Higher refurbishment costs or the premature replacement of a structure can therefore be avoided. Regular inspections extend the service life of the hydraulic structures and thus contributes to sustainable inland waterways as well.

The frequency and the manner to carry out these inspections depend on the respective potential risks and the robustness of the structure or the structural design.

PIANC report 129 recommend that “an organisation must have appropriate written standards for the inspection of infrastructure assets. These standards should clearly define the hierarchy of inspections, their cycles, the inspection outputs and the training and competency requirements of the inspectors. …”

The Recommendations of the Committee for Waterfront Structures Harbours and Waterways EAU 2020 provide a brief overview of what these standards might look like. The EAU 2020 of which the Author is a Co-Author will be published in English at the end of 2022. Inspection intervals for hydraulic structures are also suggested,
depending on the robustness and the the risk potential of the waterfront structure.

Assessing the loadbearing capacity of an existing waterfront structure is also necessary in this context.

In principle, the as-built calculations for a structure are valid and should be referred to when assessing the stability of the structure, provided:
• the calculations are correct,
• there have been no structurally relevant changes to loads or usage,
• additional structurally relevant knowledge has not become available (e.g. numerical models, load paths), and
• the structure does not exhibit any damage or abnormalities.

Should one or more of the above points no longer apply, then an assessment of the loadbearing capacity must be carried out.

EAU 2020 provides an overview of how this recalculation is to be carried out: The guidelines for quay walls (Hamburg Port Authority, 2019) contain a step-by-step procedure based on the recalculation guidelines for bridges (NRR). For massive hydraulic structures and gates in hydraulic steel structures, the BAW (Federal Waterways Engineering and Research Institute) codes of practice ‘Assessment of the load-bearing capacity of existing, massive hydraulic structures (TbW) and ‘Assessment of the load-bearing capacity of existing gates in hydraulic steel structures (TbVS) should be taken into account.

Statistical analysis of shoaling rates in the Ohio River

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ABSTRACT

The US Army Corps of Engineers operates and maintains 25,000 miles of inland and coastal waterways to facilitate commerce and national security. With a multi-billion annual budget for operation and maintenance, channel dredging is the primary maintenance task. Dredging is necessary to remove sediment that naturally settles within the channels, a process known as shoaling. Because shoaling is a random process that varies greatly with location and time, the cost-effectiveness of dredging operations is highly dependent upon the responsiveness to dynamic channel conditions. Therefore, knowledge of the governing shoaling processes is needed in order to efficiently allocate and deploy dredging resources.

Through its Enterprise Hydrographic (eHydro) Survey Program, the USACE has standardized and compiled the channel surveys conducted routinely for navigation projects nationwide. This chapter focuses on surveys for channel sections along the Ohio River in the USACE Great Lakes and Ohio River Division (LRD). Through its Navigation R&D program, the USACE has produced the Corps Shoaling Analysis Tool (CSAT) and derived the time-inferred shoaling rates for individual channel reaches. The CSAT results provide 10-ft gridded, geo-referenced point locations, each with an average infilling rate based on the historically available surveys. The Corps' National Channel Framework is used to obtain channel as-built dimensions and the baseline for measuring shoaling activity. This grid covers all the areas in the coastal navigation channels and is designed to be fixed. These surveys are updated each year and have the ability to get updated at the desired time for any specific channel or district [17]. And usually, these surveys are taken after the dredging events.

There is a need to understand and model the spatial distribution in the estimated shoaling rates. The methodology calculates stochastic shoaling rates and compares them between reaches. We use statistical analysis to find the best distribution fit. We also measure the goodness of fit of each of the distributions. These statistical analyses aim to generate a shoaling value and find the best-fitted distribution corresponding to each reach. In this regard, we also visualize the variation of the shoaling rates and compare the values in each of the sub-reaches. Finally, we cluster the reaches into different groups based on the shoaling distributions.

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Machine learning modeling to forecast short-term dredging needs at Southwest Pass

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ABSTRACT

The primary outlet for the Mississippi River at the Gulf of Mexico, known as Southwest Pass (SWP), is one of the most highly utilized commercial deep-draft waterways in the United States. Disruptions in navigation due to hard-to-predict accumulation of sediments in SWP affect the access of deep-draft vessels to four of the nation's top 15 ports measured by tonnage that connect the U.S. Midwest with global markets, and handle around 500M tons of cargo annually. The SWP is maintained by the U.S. Army Corps of Engineers (USACE) at a depth of 50 feet. The USACE spends on the order of $100M annually on dredging operations to maintain a reliable shipping channel throughout SWP, and the unpredictability of rapid-onset shoaling has been known to drive annual costs to more than twice that amount (Hartman, et al., 2022). Presently, USACE New Orleans District project managers rely on rules of thumb with seasonal river stage trends and thresholds to get 10-14 days of lead time for shoaling conditions at SWP. This work covers the development of a machine learning regression model to increase both the lead times for and accuracy of shoaling forecasts and associated dredging requirements in SWP. The machine learning regression models are embedded in a multi-variate, multi-step time-series forecasting framework. Results obtained with a Random Forest (RF), and two Artificial Neural Networks (ANN) (a Multi-Layered Perceptron (MLP), and a Long Short Term Memory (LSTM)) are compared, for different scenarios of input days, to forecast 45-day channel shoaling volumes. An increase trend in daily shoaling values indicates a need to mobilize dredges to the SWP area. Model performance is evaluated with normalized Root Mean Squared Error (nRMSE). In the absence of metrics to evaluate the state of the practice, an univariate Auto-Regressive Integrated Moving Average (ARIMA) model is used as baseline. The variable to predict is based on daily volumes of sediment accumulated in the 35-mile stretch of the Mississippi River between Mile 13.4 Above Head of Passes, and Mile 22 Below Head of Passes. Historical values of sediment accumulated on SWP between 2012-2022 are obtained from the Corps Shoaling Analysis Tool 2.5 (CSAT) (Dunkin, Coe, & Ratcliff, 2019), and used as proxy for dredging needs. This time-series is not stationary, thus CSAT estimates were transformed to 7-day rolling averages. The result is used both as variable to predict and input to the forecasting model.

Following a physics-informed approach, the data preselected to feed the time-series forecasting model is in line with variables that may affect shoaling (USGS, 2018) (Nel, Dalu, & Wasserman, 2018). In addition to the variable to predict, 99 potential input variables were considered. One of them was the week of the year when the data was collected. In addition, a

pool of 98 variables from 57 stations located along the Mississippi and Ohio Rivers are automatically collected from USGS and RiverGages websites through APIs. Type of variables include: river stage, discharge, turbidity, water temperature, precipitation, relative humidity, and air temperature. Precipitation and relative humidity were not correlated to the variable to predict, and were removed from the pool. Only variables available for more than 90% of the historical period of record were considered. The remaining 39 variables are subject to replacement of erroneous values by linear interpolation, a minimum-maximum scaling, 7-day rolling averaging (in line with the data preparation of the variable to predict). Feature selection is completed through a decision-tree based gradient boosting regressor (XGB). The top-6 variables ranked by importance are used to feed the sediment forecasting regression model. This approach allows the framework to automatically adapt to potential future changes in data availability.

Machine learning models learn repetitive patterns from relatively big data. To allow for a single historical time-series to be used for supervised machine learning, the 10 years of historical data are broken down into smaller time-series (i.e. “instances”). The size of the instances considers a number of days used by the model as input, or “in-lag”, plus the 45-day prediction. For this work, models were applied and compared to the following scenarios of in-lags: 45; 60; 90; 120; 150, and 180 days. After removing the last 45-days used for model evaluation, for each scenario, as many as possible instances are created, each starting one day apart from each other. In this way, the machine learning regressor benefits from an increased number of instances to be trained and tested, without the need to generate synthetic data.

For each regression model type (RF, MLP, and LSTM) several architectures and parameter set-ups were tested. The combination that produced the higher average nRMSE for each type of regressor was selected. The MLP regressor was constructed with two hidden layers of 10 and 5 nodes respectively, using hyperbolic tan activation function, and stochastic gradient descent for optimization of weights. The RF had 75 trees, and mean squared error was the loss function. To prevent overfitting, the maximum depth is limited to one layer, and the minimum number of samples required to split an internal node is two. The sequential LSTM was made with a dimensionality of 50-75 LSTM layers all with hyperbolic tan activation function. The final layer is a dense layer with a linear activation. During the training phase of each epoch, the model has dropout layers after each LSTM layer to prevent overfitting on the training data.

For model evaluation purposes, in each in-lag scenario, the nRMSE is calculated over all evaluation instances. In addition, it is desirable to select a model with low variability of forecasted results. Thus, a confidence interval at 95% confidence level is calculated. Results indicate that all multivariate machine learning models outperformed the univariate baseline. Moreover, to evaluate future dredging needs, it is particularly interesting to observe the behavior of model predictions in the subset of instances with increasing shoaling trends. In this context, the lowest nRMSE was obtained with the MLP model for the 60-day input scenario. Acting as a digital twin of predicted SWP sediment volumes, the proposed model will modernize and accelerate dredging operations decision-making at SWP. The approach adopted for SWP in this work may be applied to forecast dredging needs at other critical waterways.

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Hands Free Mooring for United States Inland Waterway Locks

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ABSTRACT

The U.S. Army Corps of Engineers (USACE), Engineer Research and Development Center (ERDC) has begun evaluating the feasibility of a Hands Free Mooring (HFM) system for the locks on the United States navigable inland waterways. HFM systems are used in ports throughout the world, and have been implemented on the locks of the St. Lawrence Seaway along the eastern border of the United States and Canada. Of particular interest with HFM systems is increasing safety associated with mooring practices for barge crews throughout the navigation industry and improving the overall efficiency of the lock operation process. Applying HFM systems on inland waterways where the vessel traffic is predominately commercial barge tows presents unique challenges such as various barge surface conditions, multiple barge configurations, and varying vessel drafts. Incorporating a system that could work for both large commercial barge tows and smaller recreational traffic, and be easily implemented to the existing lock infrastructure are also desired. Through a contracting effort, different HFM devices that incorporate magnets, vacuum pumps, mechanical arms, and winches have been proposed by private companies. One of these proposals will be chosen for further development and after the design is complete, a prototype HFM system will be built and implemented at a pre-selected USACE lock and evaluated. If proven to be successful, a system could then be implemented throughout the United States inland waterways.

Development of New PIANC Guide on Sustainable Inland Waterways

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ABSTRACT

PIANC Inland Navigation Commission (InCom) Working Group (WG) 203 was tasked with developing an international guide that focuses on increasing the social and environmental awareness of managers responsible for operating and developing inland waterways (IWs). This report addresses the opportunities and challenges for IW managers resulting from the multiple functions and uses of the waterways and provides IW managers with a guide to generate and create a more sustainable society. In addition, it provides practical lessons for IW managers by presenting case studies implementing sustainable IW best practices as well as projects that did not fully meet their intended sustainability objectives.

The report describes the concept of incorporating Corporate Social Responsibility (CSR) into the culture of public IW organizations. CSR is relevant to all IW infrastructure development, including maintenance and operations. Incorporating CSR into an organization's workflow by using the multifunctionality of IW as a baseline can improve outcomes and increase efficiencies and benefits. Using CSR means an organization will consider multifunctionality of IW including participation of all stakeholders and integration of their values into the project.

The report recommends users implement a five-step approach for achieving sustainable IW.

Step 1 – Conduct a cost-benefit analysis that considers all expected costs (including the external and indirect costs) as well as an assessment of the short- and long-term benefits, to ensure the project will be economically reasonable. Consider also the multifunctionality of the IW, including its ecosystem functioning. Include public participation and feedback throughout the process to build on the benefits of local stakeholder involvement and community knowledge.

Step 2 – Define the goals for the inland waterway infrastructure project and ensure that these goals do not undermine the waterway's multi-functionality. Integrate ecosystem services to increase sustainability.

Step 3 – Define further goals of sustainability for consideration, in particular aspects on mitigating the impacts of climate change and enhancing biodiversity of the natural environment.

Step 4 – Consider social responsibility using CSR as a guideline.

Step 5 – Evaluate project alternatives and select the most preferable solution with respect to the principles of CSR.

IW managers can utilize this 5-step approach to help reduce or mitigate climate change and other impacts to IW and use the UN's Sustainable Development Goals (SDGs) as a sustainability guide. Because many waterway organizations are public authorities who are responsible for the common welfare, they have a unique opportunity to serve as an example for implementing sustainable IW best practices. For IW organizations, the concept of CSR provides a means for accomplishing this objective. CSR is relevant to all IW infrastructure development, including maintenance and operations. In the day-to-day activities of IW managers, this philosophy requires practical solutions that can be implemented in practice. In response, this report serves as a guide for IW managers to apply CSR to address current realities and to promote the concept of a multifunctional IW – both a challenge as well as an opportunity for IW managers to develop a more sustainable IW future.

Development of New PIANC Guidance for the Beneficial Use of Dredged Material

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ABSTRACT

Annually, billions of cubic meters of material are dredged globally to maintain safe navigation for commerce and recreation. Navigational maintenance is integral to the world economy, without which the safe waterborne transport of cargo, cruise ships, and pleasure craft would not be possible. With the need to sustainably manage dredged material over time, there are concerns about disposing these materials in confined and open water disposal areas due to capacity constraints and lack of achievable benefits beyond removal from channels. Yet, several challenges to sediment beneficial use exist due to concerns over impacts to surface waters, displacement of aquatic habitat, release of contaminants into the environment, or logistics. These challenges in the face of growing societal needs motivate the development of innovative and sustainable alternatives, including identifying sediment beneficial uses that foster engineering, economic, social, and environmental benefits.

Sediment beneficial use is naturally aligned with sustainability, life-cycle analyses, and circular-economy approaches. The use of sediment as a resource represents a substantial opportunity to more fully embrace sustainable practices that can realize engineering, environmental, social, and economic benefits. Sediment beneficial uses that achieve multiple benefits include coastal resiliency management to counteract coastal erosion, beach, and dune nourishment, and creating or restoring habitats, including marshes, wetlands, uplands, and islands. Infrastructure and community resilience, climate-change impacts, habitat management, and costs all can be leveraged to successfully identify and integrate beneficial use into coastal projects.

PIANC Working Group (WG) on Beneficial Use (WG214), consisting of multiple subject matter experts from around the world, is developing a report that will provide technical information and guidance regarding the state of the practice for sediment beneficial use as a resource, drawing from existing approaches and best practices worldwide. In this manner, the report builds on relevant reports published by PIANC, the Central and Western Dredging Associations (CEDA and WEDA), the International Association of Dredging Contractors (IADC), and the European Sediment Network (SedNet), among others. The report considers and evaluates the following: Concepts of sediment use and existing scientific knowledge related to different uses; sediment contamination and how contamination can constrain sediment reuse alternatives; and use of cost-benefit and ecosystem services as tools to better understand how the value of different beneficial use alternatives can be quantified, and to compare different beneficial use and disposal alternatives. Aspects of the report we will present include an overview of global

sediment beneficial use practices, technologies, and limitations. One or more case studies will be presented to illustrate recent successes and challenges associated with increasing the beneficial use of dredged material.

Perfil de conectividad fluvial para Sudamérica

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ABSTRACT

Sudamérica posee un sistema potencial para la navegación fluvial con una longitud total superior a los 50.000 km lineales, en los cuales el transporte fluvial de carga y pasajeros es trascendental debido a la dificultad geográfica para construir carreteras o ferrovías, así como el alto costo o la escasa disponibilidad de infraestructuras aeroportuarias y servicios aeronáuticos. No obstante, en la mayoría de los países, las zonas más ricas en términos hidrográficos son justamente las más pobres y atrasadas. En general, cerca de la mitad de los habitantes de la región amazónica vive por debajo de la línea de pobreza. A pesar de esta enorme potencialidad, el continente sudamericano se encuentra en un bajo nivel de integración física fluvial. En efecto, cada una de sus tres principales redes hidrográficas (Amazonas, Río de la Plata y Orinoco), que cubren alrededor de dos tercios de la superficie sudamericana, cuentan con variados niveles de desarrollo y al mismo tiempo muestran diversas oportunidades de interconexión e integración fluvial, la mayoría de las cuales están detenidas o poco desarrolladas. Asimismo, la presencia de diversas redes viales, tanto de carreteras y autopistas como de ferrocarriles, así como de aeropuertos y líneas de transporte aéreo ofrecen oportunidades de intermodalidad que no se están aprovechando plenamente.
La pandemia del COVID-19 ha agudizado aún más los problemas económicos, sociales y de integración física de la región sudamericana, que ha sufrido su mayor caída del Producto Interno Bruto (PIB) en más de un siglo, según la Cepal. En ese contexto, los países sudamericanos que se han contraído más en el 2020, primer año de la crisis sanitaria, fueron Venezuela (-30%), Perú (-13%), Argentina (-11%) y Ecuador (-9%). La contracción económica ha impactado profundamente en el transporte de carga y pasajeros, ya sea por la necesidad de restringir el desplazamiento de personas como por la propia retracción de la logística que es una derivación de la actividad económica. Agregando a ello la postergación de diversos proyectos de integración, así como la desigualdad de la marcha de los distintos países sudamericanos en el tránsito de convertir sus ríos navegables en verdaderas hidrovías, el escenario post-COVID 19 puede verse como una oportunidad de rescatar la agenda de la integración fluvial del subcontinente.
Se ha identificar, en base a trabajos previos de diversos organismos nacionales e internacionales, a los 48 proyectos de integración fluvial más importantes de la región sudamericana y se les ha priorizado en base a cinco criterios:

- Relevancia Regional
- Viabilidad Económica
- Impacto en el transporte de carga
- Impacto en el transporte de personas y
- Menor Complejidad Técnica

Para su ejecución o culminación, será necesario contar con el apoyo técnico de organismos internacionales como CEPAL, la CAF o PIANC, a fin de consolidar la integración fluvial de la región, encontrando los mejores mecanismos técnicos y financieros con dicha finalidad.

Design for Ship Collision with Bridges using AASHTO and CAN/CSA S6: Clarifications and Recommendations

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ABSTRACT

Design of bridges against ship collision is carried out in accordance with AASHTO LRFD Bridge Design Specifications for bridges located in the United States and in accordance with the Canadian Highway Bridge Design Code S6 for bridges located in Canada. Both codes adopt an identical design methodology, which include a standard approach consisting of a probabilistic analysis to determine the annual likelihood of bridge collapse due to ship collision and comparing it against a pre-established acceptance criterion that varies with bridge importance classification. This probabilistic approach is one of the methods described and examined in PIANC's 2001 INCOM Report of Working Group 19 titled Ship Collisions due to the Presence of Bridges. In Canada, the S6 code constitutes only a condensed version of AASHTO's requirements for vessel collision design, referring the reader to the American code when information is not available in the Canadian publication. AASHTO publishes a complementary technical resource titled Guide Specifications and Commentary for Vessel Collision Design of Highway Bridges which provides additional clarification and working examples for practitioners. However, there are several instances where the commentary includes little, or in some cases, contradictory supporting information. Examples of these instances include the theoretical definition of the vessel collision load, the provisions behind the application of the collision force, the references to water levels, the correction factor for bridge location in navigation channels, and the correction factor for cross currents. This lack of clarity can result in inconsistent implementation of the methodology and potential application of its coefficients in a manner that is not intended by the codes. The requirements of AASHTO and S6 were reviewed, assessed, and compared to identify areas of potential contradiction, lack of clarity, or differences attributable to regional practices such as use of customary units or technical nomenclature. This paper identifies key areas where seemingly conflicting, erroneous, or incomplete information is presented in the codes, and provides recommendations for possible improvements to AASHTO and S6.

The utilization of Applied Hydraulics (AdH) software in the design of upper/lower navigational guard walls for a new lock on the Ohio River

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ABSTRACT

The adequate design of the lock guard walls is vital to ensure navigation safety. The selection of length/type of the approach walls must be government by balancing multiple factors such as river hydraulics, lock capacity, first cost, life time of the project, maintenance and operations and navigation safety. To ensure the most refined design is evaluated using physical models, it is proposed that 2D numerical models be used to screen out designs based on the simple criteria listed above. Numerical models were developed to evaluate the upper and lower pool navigation conditions using the US Army Corps of Engineers(USACE) Adaptive Hydraulics(AdH). The AdH code is a finite element, numerical modeling package that can be used to model a wide range of flow conditions and dam gate operations. The Surface Water Modeling System(SMS) is a modeling package developed and distributed by Aquaveo, Inc. for building models, running simulations utilizing the AdH code, and visualizing results. The navigation approach hydraulics are evaluated using 2-D,depth-averaged models developed with the SMS modeling package and simulated using the AdH code. This approach is meant to increase the efficiency of the design process while being able to consider numerous alternatives, prior to costly and time-consuming physical modeling. The following river conditions were evaluated :

- Existing conditions for calibration and validation purposes.
- Deconstruction conditions to ensure the safety of navigation during that phase.
- Proposed conditions which included the modeling of various configurations (i.e., lengths/types) of guard walls.

A ported guard wall design for the upper navigation approach was found to alleviate the significant outdraft present at the existing lock approach. The proposed upper lock approach guard wall is approximately 1000 feet long, with 9 ports configured to allow an equal flow distribution to pass through the wall. The proposed lower lock approach guard wall with a nose cell is approximately 1000 feet long, with four circular coffer cells (40 feet diameter) at the downstream. This arrangement of four coffer cells downstream of the solid guard wall was found to help reduce the strength of the eddy current, which are commonly found at lower lock approaches on a river and diminish navigation conditions. The spacing between these coffer cells was also evaluated using the AdH code. The proposed configurations were sent to be confirmed using physical models.

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The utilization of LockSim and computational fluid dynamics (CFD) in the design of filling/emptying system of a new navigational lock on the Upper Ohio River

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ABSTRACT

Computational methods are now more common in the hydraulic design of navigation locks. Their utilization is advised to reduce the high cost of endless physical modeling experiments. The most complex models requiring the greatest computational effort are three-dimensional (3D) models based on the Navier-Stokes equations, commonly called computational fluid dynamic (CFD) models. The goal of utilizing CFD modeling is to ensure that the purpose of any physical modeling is to confirm/refine the design recommended by the CFD model. The conceptual design of the filling/emptying system of the new lock involved the use of a 1-dimensional (1D) modeling program, LockSim, to screen out potential design alternatives that were empirically developed. LockSim is a numerical model for simulation of 1D filling and emptying in navigation locks, which was developed from water hammer code called TFSIM by the Tennessee Valley Authority in the 1980's. Locksim results showed that two in-chamber Longitudinal Culverts System (ILCS) for lock filling and emptying is recommended to reduce construction costs while ensuring good hydraulic efficiency (e.g., acceptable filling/emptying and law hawser forces) . The preferred design alternative selected from this screening process was then refined in a 3-dimensional (3D) CFD modeling program prior to physical modeling of the lock design. The FLOW3D CFD software was utilized to calculate flow velocities, pressures, and streamlines to evaluate for potentiality of vortices, flow separation, cavitation, and to evaluate the overall hydraulic efficiency of the lock culvert filling and emptying system. Providing efficient hydraulic shapes for entrances, bends, expansions, and contractions are important for efficient and smooth filling operation and prevention of flow separation. To reduce the time required for lockage and still maintain safe operating conditions the filling system is designed to reduce surging and vortex action and provide culverts that are as hydraulically efficient as possible. The CFD modeling approach was divided into two phases. Phase 1 CFD modeling excluded the flow valves, with the goal of evaluating the overall culvert geometry and making any refinements as applicable to increase hydraulic efficiency. The Phase 2 CFD modeling incorporated the flow valves, with the main goal of evaluating the hydraulics near the valves and assessing if the location of the valve and bulkhead recesses are appropriate. Using CFD modeling results, Locksim can then be re-simulated to resemble the recommended results from the CFD model. This approach is meant to increase the efficiency of the design process while being able to still consider numerous alternatives. This approach recommended the most refined design for

physical modeling. The CFD results were also utilized by other engineering disciplines to compute loadings inside the culverts, on the flow valves, and at bends to ensure structural stability.

Montgomery Lock Navigation Approach Physical Model Study

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ABSTRACT

The U.S. Army Corps of Engineers (USACE), Pittsburgh has begun the design process for a new navigation lock at the site of the existing Montgomery Locks and Dam on the Ohio River near Pittsburgh, Pennsylvania. This new lock will have a 600-ft long x 110-ft wide chamber and will replace the existing 360-ft long x 56-ft wide auxiliary lock that is currently located on the riverside of the 600-ft long x 110-ft wide main lock chamber. The existing main lock will remain operational during the construction of the new lock. Safe navigation into and out of the lock must be ensured both once the lock has been constructed and throughout lock construction. A 1:100-scale physical model study was conducted by the USACE Engineer Research and Development Center, Coastal and Hydraulics Laboratory to evaluate the navigation conditions for barge tows entering and exiting the locks, to inform the design of the guard walls and the placement of proposed dikes and to evaluate the navigation conditions during the different construction phases of the new lock. A remote-controlled model barge tow was used during this study to identify and resolve navigation issues. The information obtained during the study was used to develop a final design recommendation for the new lock.

Montgomery Lock Filling and Emptying System Physical Model Study

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ABSTRACT

The U.S. Army Corps of Engineers, Pittsburgh District has begun the design process for a new navigation lock at the site of the existing Montgomery Lock and Dam on the Ohio River near Pittsburgh, Pennsylvania. This new lock will have a 600-ft long x 110-ft wide chamber and will replace the existing 360-ft long x 56-ft wide auxiliary lock that is currently located on the riverside of the main lock and will require the removal of a section of the dam. This lock placement introduces restrictions to the filling and emptying (F/E) system that must be evaluated before construction to ensure that safe and efficient operation is ensured. The F/E system is an in-chamber longitudinal system with the intakes and outlets located on the riverside lock wall. A physical model study of the lock F/E system has been conducted to evaluate the hydraulic performance of the new lock. During this study, measurements of the Hawser forces acting on vessels in the chamber, the velocities at the ports along each culverts, and the velocities exiting the outlets were recorded. The flow behavior in the chamber – particularly the interaction of the jets through the ports – and at the intake was evaluated. The information obtained during this study was used to inform decisions on necessary design changes to improve the hydraulic performance and ensure navigation safety.

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Maritime Cruises in Brazil: diagnosis of economic and regulatory problems

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ABSTRACT

The Brazilian cruise industry has experienced a period of exponential growth over the past decade, carrying more than 800,000 passengers per season. Although this activity continues to grow worldwide, Brazil experienced a decrease and a tendency towards stabilization at low levels. According to the association of cruise operators, CLIA Abremar, the explanation of this scenario are the high costs and poor infrastructure of the country, which has scared away the companies. This article, after assessing the sector's bottlenecks, aims at showing that the cruise market is restricted by economic and regulatory factors. In particular, the controversy about regulatory competence stands out, whether it is the Ministry of Tourism´s or the National Waterway Transportation Agency´s jurisdiction, and how this affects sectoral public policy. One concludes that the resumption of growth in the cruise sector in Brazil depends on overcoming economic and regulatory bottlenecks.

Considerations and Lessons Learned from the Construction of a New Downtown Passenger Ferry Terminal in San Francisco, California

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ABSTRACT

In San Francisco, expanded ferry service is an essential part of an urban design strategy aimed at increasing intermodal passenger capacity and efficiency as well as revitalizing the waterfront by reconnecting it with the larger city. In March 2020, the San Francisco Bay Area Water Emergency Transportation Authority (WETA) completed its largest ferry expansion project to date – tripling the number of ferries that can stream in and out of downtown. The 3-year construction project was executed with no hindrance to public conveyance, including an ongoing ferry service of 130 arrivals and departures each day. This paper describes the unique design and construction challenges of the $78M project within the bustling urban waterfront of San Francisco, immediately south of the world-renowned San Francisco Ferry Building and surrounding the historic Agriculture Building. The work included construction of 35,000 square feet (sqft) of overwater structures supported on 180 steel piles to provide three new ferry gates, a 106-ft pedestrian bridge, and a pedestrian plaza clad with a granite relief map of the San Francisco Bay. Challenges faced by the design and construction teams included very poor site soil conditions, high seismicity, stringent post-earthquake operational goals, a congested urban site with many access constraints for construction materials, the close proximity of a critical underground transit and a fragile historic structure, as well as environmental requirements to minimize construction noise for the surrounding downtown public and nearby office spaces. This paper discusses lessons learned from the design and construction process as well as highlighting the innovative features employed by the team to mitigate the challenges faced to deliver a successful project. The lessons learned are applicable to other waterfront projects located in urban, historic, or environmentally sensitive locations.

Design of Longitudinal Air Bubbler System Inside Ship Lock

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ABSTRACT

Design of Longitudinal Air Bubbler System Inside Ship Lock

This study investigated the expected behavior installing a longitudinal air bubbler system in the St Lambert Lock, Quebec, Canada to bring “warm” water from the depths of the lock chamber and reduce ice buildup on the lock walls during the winter navigation. The bubbler manifold would be installed near the bottom of the lock chamber and extend along the entire wall of the lock chamber. Compressed air would be provided to the manifold and the air would be released through a series of holes (orifices) installed along the length of the manifold. A vertical water current would be induced in the lock chamber by the rising air bubbles. The continuous supply of water to the surface should reduce ice formation along the wall of the chamber.
This use of a longitudinal air bubbler system to reduce ice buildup along lock walls during the winter season is a novel use of an air bubbler system in North America in a navigation lock. The proposed longitudinal air bubbler system would not be required to create substantial horizontal flow velocities at the water surface. Rather the goal of the proposed system would be to provide a constant supply of relatively “warm” water (above 0o C) to the surface in order to suppress or a least reduce ice formation at the surface.
Unfortunately, nothing is known about the vertical temperature structure of the water contained in the St Lambert Lock during the winter, and little is known about the environmental conditions in the lock at the water surface during the winter season. Therefore it is not possible to determine the required supply of water that must be brought to the surface. This conceptual design will estimate the longitudinal air bubbler performance over a range of practical orifice diameters, orifice spacing, manifold sizes, and air compressor sizes. A best design will then be selected based on the estimated performance, practicality of installation, likelihood of success, and potential for future modification, if required.

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Design of a High Flow Air Curtain for Brash Ice Retention in Strong Ambient Crossflow

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ABSTRACT

Design of a High Flow Air Curtain for Brash Ice Retention in Strong Ambient Crossflow

This study investigated the expected behavior of an ice retention air curtain in strong ambient cross flow. A computational fluid dynamics (CFD) model was constructed and used to reproduce the field-measured velocity fields from literature at an air curtain installed in stagnant water and laboratory observations of an air curtain exposed to crossflow. The model was then used to simulate the conditions at a proposed air curtain located near Bridge 21 on the Welland Canal in Port Colborne, Ontario, Canada. This site experiences a relatively strong constant crossflow current of 1 foot/sec (0.3m/s). The model results show that installation of an air curtain similar to those installed elsewhere on the canal system would be capable of producing an upstream eddy that can hold back ice. Increasing the air flow through the curtain increases the intensity of the upstream eddy improving the air curtain's ability to hold back ice.
The location of the proposed air curtain installation was reviewed using results from the CFD model and an analysis was conducted to estimate the ice hold back potential of the system incorporating the effects of the channel banks and the channel currents. The analysis suggested that the air curtain would likely be most effective if installed at the downstream end of the narrow section of the channel that Bridge 21 spans. This proposed location would enhance the effects of bridging, where the longitudinal forces in the ice cover are transferred laterally to the channel walls.

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The implementation of River Information Services in the United States

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ABSTRACT

The concept of River Information Services (RIS) has been in place for over two decades, and robust RIS implementations exist in several countries, primarily in Europe. However, in the United States RIS has not been implemented in a formal manner. This presentation will provide a brief overview of the RIS concept and the PIANC RIS Guidelines and then provide details on how the United States is working to implement RIS.

The aim of River Information Services is to make navigation data more accessible and usable in support of navigation operations and maintenance, for all waterway stakeholders. PIANC has issued RIS Guidelines which lay out the required components for RIS implementation. These consist of a set of information services that are delivered using various technologies. The guidelines also define the functions that must be accomplished to deliver these services. In the United States, there are existing services and technologies that mostly fulfill the requirements in the RIS guidelines, however they are not well coordinated and several are the responsibility of different Federal agencies. The US Army Corps of Engineers recognized the value that RIS can bring to waterway operations and created a team to implement RIS. This team was initially internal to USACE, but has evolved to include participation of other federal agencies and the navigation industry. There has been substantial progress made in better coordinating the various capabilities and services, and new technologies and capabilities have been developed. The paper will include details of the progress made and of the capabilities that have been developed.

Automated Monitoring of Coastal Port Vessel Demand and Capacity

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ABSTRACT

Extreme weather events, labor disruptions, shoaling, accidents - all of these can affect coastal ports' ability to perform as a critical point in the nation's freight supply chain. During these events waterway stakeholders want to know how many ships are waiting to call at the ports and for how long they have been waiting. This presentation will be on a newly developed tool that provides daily automated counts of how many vessels are within a port's anchorage areas, drifting areas, and also calling at the terminals. The cumulative time spent dwelling at the respective locations is also provided. The tool is enabled by a live feed of vessel GPS position reports, referred to as Automatic Identification System (AIS) data, combined with high powered computing. The tool has been applied to coastal ports within the United States.