Resilient Maritime Structures in the Pacific Islands

Stantec

Introduction

- Maritime structures in the Pacific Islands face significant challenges due to climate change, seismic threats, and the need to accommodate larger vessels, as well as the upgrading and rehabilitation of existing assets.
- By reviewing recent wharf upgrade projects, this study provides insights into developing new wharves and rehabilitating existing ones within the Pacific Island context. These insights are based on Stantec's extensive history of involvement in Pacific projects, ensuring that the designs meet the demands of modern maritime operations.

Main Challenges in the Pacific Islands

❑ **Climate Change Impacts**

➢ The Pacific Islands are at the frontline of climate resilience, confronting escalating climate change challenges, including sea-level rise.

❑ **Seismic Threats and Soil Liquefaction.**

➢ These islands are susceptible to seismic threats, Tsunami and soil liquefaction.

❑ **Lack of Crucial Data**

➢ There is a lack of crucial data, such as geotechnical and hydrodynamic conditions in the most projects.

❑ **Accommodation of larger vessels.**

➢ the need to accommodate increasingly larger vessels.

❑ **Rehabilitation and Upgrade of aging assets.**

➢ The necessity to rehabilitate and upgrade aging assets

Main Considerations for Design

❑ **Site Investigation and Seismic Considerations**

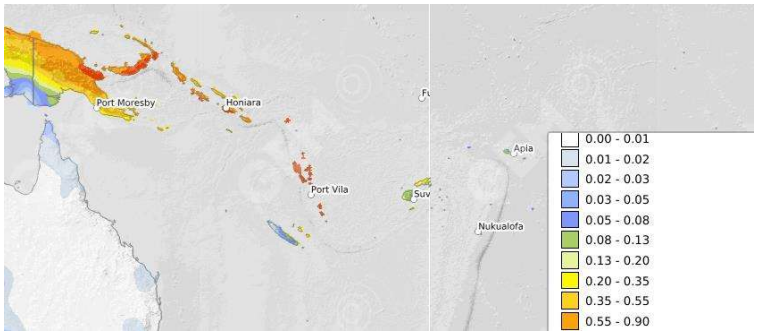
- Geotechnical investigations are essential for both foundation design and probabilistic seismic hazard assessment (PSHA).
- The available Global Seismic Hazard Maps are often insufficient as they typically provide Peak Ground Acceleration (PGA) values for bedrock conditions..
- Site stratigraphy should be used to estimate the PGA range at the surface level.
- An alternative to a site-specific ground investigation is a seismic survey combined with ground-penetrating radar.

❑ **Seismic Design**

- The Performance-Based Seismic Design (PBD) approach offers several advantages for designing maritime structures over traditional Force-Based Design (FBD).
- PBD provides a more accurate prediction of seismic damage and leads to more cost-effective designs by efficiently addressing risk and ensuring economic efficiency.
- PBD offers greater flexibility in both the design of new structures and the strengthening of existing assets. It can overcome the limitations of FBD, such as its poor correlation between force and damage.

❑ **Tsunami Preparedness.**

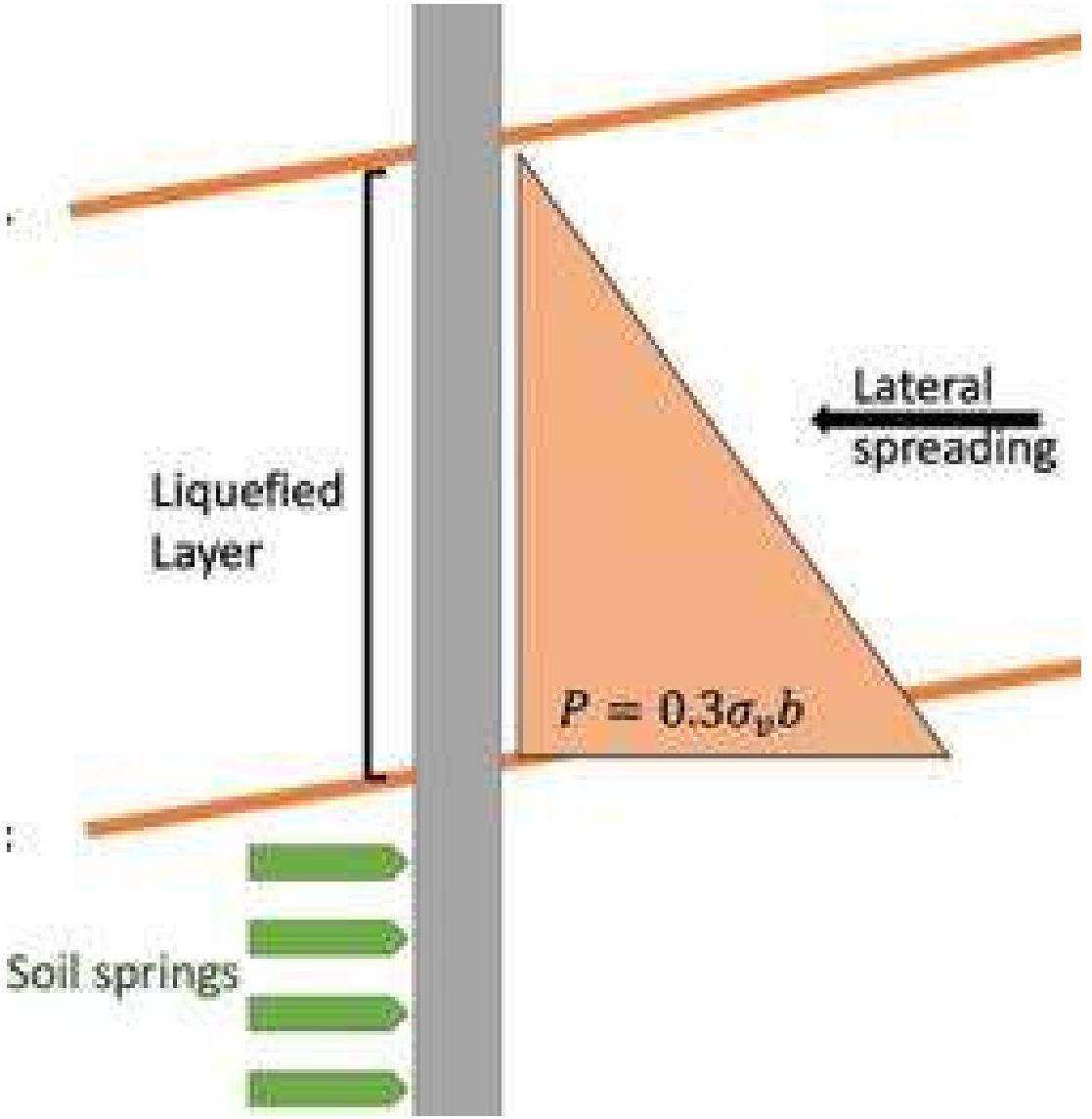
- Incorporating tsunami-resistant features is essential to protect against sudden and extreme wave events. This includes the design and implementation of infrastructure that can withstand or mitigate the force of a tsunami.



Main Considerations for Design

❑ **Soil Liquefaction Mitigation**

- When designing foundations in seismic regions, it is crucial to consider the effects of soil liquefaction. This includes the potential reduction in foundation capacity and the additional lateral loads on piles due to liquefied soils during an earthquake.
- Conducting a realistic liquefaction assessment is essential. It is important to note that the triggering of liquefaction and subsequent strain-softening may not be necessary for depths greater than 15 meters below ground level.
- The potential for lateral spreading needs to be evaluated carefully to avoid overestimation.



Main Considerations for Design

❑ **Structure Type and Material Selection**

- The choice of structural type and materials is crucial for the durability of maritime structures ensuring that the structures can withstand the challenging maritime environment, reducing the frequency and cost of maintenance.
- Incorporating materials that require minimal maintenance not only lowers long-term upkeep costs but also enhances the sustainability of the structures and reduces the environmental impact
- Adopting a modular design approach, where concrete or steel elements are prefabricated off-site and assembled on location, is particularly advantageous in remote areas.
- For wharves, concrete piles, such as the secant pile design , are preferred over open wharves with steel piles or sheet pile wharves.
- When steel piles are used, they should be protected with HDPE encasement or wrap and cathodic protection system to extend their design life and reduce maintenance needs.
- The use of unreinforced precast concrete blocks, similar to the quay wall designed in Nanumaga, Tuvalu Islands, would be a good choice for the construction of quay walls if the geotechnical consideration allows.
- Concrete elements should be precast concrete as much as possible because of better quality control.

Main Considerations for Design

❑ **Adaptability for future needs**

➢ Designing maritime structures with future needs is crucial for maintaining their functionality and relevance as maritime demands grow. This involves anticipating changes in vessel sizes, technological advancements, and environmental conditions.

❑ **Climate Change Adaptation**

➢ As climate change continues to impact global weather patterns and sea levels, it is crucial to design maritime structures that can withstand these changes including sea-level rise and increased storm intensity and wind and wave design forces.

❑ **Cultural and Environmental Sensitivity**

➢ Respecting local cultural values and environmental heritage. This includes engaging with local communities and considering the environmental impact of construction activities.

❑ **Cost-Effectiveness**

➢ Balancing initial investments with long-term benefits. This involves strategic planning to optimize resources and achieve economic efficiency while maintaining high standards of safety and performance.

Challenges for Rehabilitation Design of Existing Structures

❑ **Lack of Original Design Information**

➢ In some projects, there is a lack of critical data such as as-built drawings, geotechnical data, existing pile toe levels, anchoring system details, and reinforcement details.

❑ **Lack of Original Seismic Design Considerations**

➢ Many existing structures were not designed with seismic activity in mind, making them susceptible to soil liquefaction and other seismic threats.

❑ **Threats Posed by Sea-Level Rise**

➢ Rising sea levels pose a significant risk to existing maritime structures, such as flooding and erosion.

❑ **Increasing Vessel Sizes**

➢ The increasing size of vessels visiting the structures compared to the original design can apply excessive lateral forces and surcharge.

❑ **Corrosion and Deterioration:**

➢ Corrosion and deterioration in piles and decks can lead to a loss of original capacity,

❑ **Logistical Difficulties Due to Remote Locations**

➢ Rehabilitation projects in remote areas face logistical challenges, including transportation of materials and equipment, and a lack of experienced construction teams. Additionally, strict environmental regulations and potential socio-economic impacts on local communities during construction.

Approaches in the Upgrade Design of Existing Assets

❑ **Berthing and Mooring Strong Points or Adding Raked Piles**

➢ This approach reduces the lateral loads applied to the existing structure, enhancing stability and safety.

❑ **In-Situ Topping Deck**

➢ This method utilizes a new deck, providing a durable surface and increasing the load-bearing capacity of the structure.

❑ **Tie Rods and Anchoring Piles**

➢ Integrated into the existing bulkhead wharf, these elements are designed to withstand increased lateral soil loads during seismic events and facilitate the elevation of the apron level in response to rising sea levels or additional dredging.

❑ **Submerged Sheet Pile Structures**

➢ Positioned in front of the existing berth line, this structure enables seabed dredging beyond the original design specifications.

❑ **Shotcrete and Patch Repair**

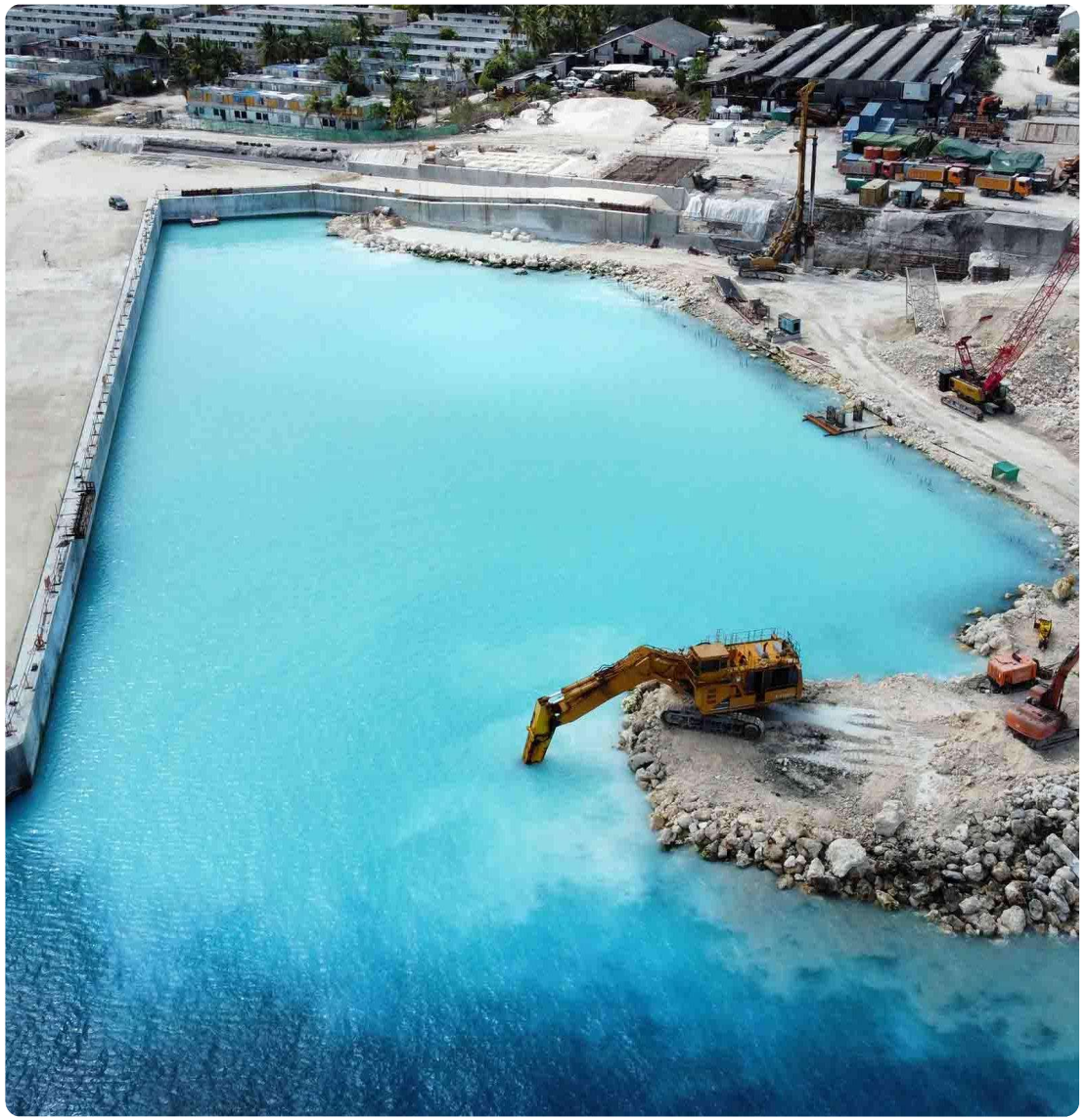
➢ This method involves repairing the structure by means of concrete breakout and patch repair to deteriorated members, restoring the asset to its original capacity.

❑ **Emerging Technologies to Reduce Chloride Ingress**

➢ These technologies are applied to concrete in piles, beams, and deck soffits to prolong structural integrity by preventing chloride-induced corrosion.

Conclusion

- The unique challenges posed by the Pacific Islands' environment necessitate innovative and adaptable solutions for the design and upgrade of maritime structures.
- A comprehensive, forward-thinking approach is required, balancing engineering excellence, environmental consideration, and community involvement.
- By addressing immediate needs and anticipating future challenges, we can create maritime structures that are not only functional and resilient but also sustainable for the future.



Thank you

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