PIANC
The World Association for Waterborne Transport Infrastructure

InCom - MarCom WG 199

Health Monitoring for Port and Waterway Structures

Terms of Reference

Background

Structural health monitoring (SHM) principles, a damage prognosis (DP) strategy, and technology adoption can provide continuous measurements of aging infrastructure to support real-time operations, provide alerts concerning imminent failures, and provide longer-term monitoring to accurately quantify asset and component condition, including remaining service life, risk assessment, and maintenance requirements. These strategies are built upon a foundation of sensor and inspection measurement data and utilize physical models, numerical simulations, and statistical models to provide a probabilistic measure of condition and probability of failure along with confidence estimates of this quantity. Use of such a probabilistic measure of likelihood of failure will substantially improve confidence in the risk measures used to decide upon infrastructure maintenance and capital expenditures, while also providing defensible evidence as a basis for those decisions.

Note: SHM is a well formulated science used worldwide by many industries that provides a scientific, engineering, and logical framework for a sustainable Asset Management implementation. Its application to navigation structures is emerging as the need to accurately determine structure condition and remaining service life increases while the cost of smart sensors decreases. SHM of bridges is a mature program, considering steel and concrete conditions, so adapting and applying similar science, engineering and a framework is an achievable goal of this WG.

Objective

The main goal of structural health monitoring of Waterway and Port structures is to provide quantified probabilistic measures of risk and reliability necessary to make operational and financial decisions concerning the functionality and safety of those structures.

The objective of this working group is to compare current practices of:

- Monitoring the wide variety of port & waterway infrastructures
- Linking sensor data and inspection observations to quantify asset reliability and remaining life;
- Using monitoring data to provide early-warning indicators of impending catastrophic conditions (degradation of the structure, as first movement in a breakwater, fatigue damage, ...);
- Constructing and interpreting infrastructure degradation numerical simulation and statistical models to assess remaining useful life and consequences of repair and maintenance decisions;
- Define optimized inspection and maintenance strategy

and to make recommendations for common practices, where these would be helpful.

This working group seeks to gather input from a wide variety of port & waterway managers, field practitioners, academics, consultants and oversight organizations.

Boulevard du Roi Albert II 20, B 3 • B-1000 Brussels • Belgium
T + 32 2 553 71 61 • F + 32 2 553 71 55 • e-mail: info@pianc.org • www.pianc.org

Earlier Reports and Concurrent Working Group Activities

PIANC INCOM has had several Working Groups related to the subject or that helped mature the requirements. The following past and present related subjects and Working Groups are:

- Inspection, Maintenance and Repair of Maritime Structures Exposed to Material Degradation Caused by a Salt Water Environment PIANC WG 17
- Life Cycle Management of Port Structures – General Principles PIANC WG 31
- Manual for Life Cycle Management of Port Structures PIANC WG 103
- Inventory of Inspection and Repair Techniques of Navigation Structures both Underwater and In-the-Dry PIANC WG 119
- River Information Services PIANC WG 125
- Waterway Infrastructure Asset Maintenance Management PIANC WG 129
- Impacts of Seismic Loads and Ship Impact on Lock Gates PIANC WG 151
- Recommendations for the Design and Assessment of Marine Oil and Petrochemical Terminals PIANC WG 153
- Miter Gate Design and Operation PIANC WG 154
- E-Navigation for Inland Waterways PIANC WG 156
- Recommendations for Increased Durability and Service Life of New Marine Concrete Infrastructure PIANC WG 162
- Design of Small to Mid-Scale Marine LNG Terminals Including Bunkering PIANC WG 172

Matters to be investigated

- implementation of standardized and ad hoc instrumentation, both short- and long-term, for waterway structures,
- types and effectiveness of field measurements combined with physical and numerical simulation models used to assess current and future condition of port & waterways structures (probabilistic based),
- examples of operational and/or financial decisions made based, in part, on sensor and model data;
- methods for incorporating qualitative inspection observations with numerical simulations and remaining life assessments;
- structural degradation models for a structure type or class based on a test bed of sensor, inspection, and numerical model data of another archetypical system ;
- methods for predictive maintenance strategy;
- implementation of the “digital twin” concept in decision making and any efforts to standardize its use;
- economic value of SHM investment and feasibility for wide-spread application.

Method of Approach

Evaluation of actual SHM systems and approaches used for operational and financial decision making. This will include listing of sensors, numerical models, degradation models, and statistical procedures used to produce decision support information and their effectiveness. Though there are a variety of disparate types of hydraulic structures, many share similar materials and underlying deterioration mechanisms which lead to system degradation and failure. The principles of structural health monitoring can be consistently applied to a broad variety of structures.

Types of structures which may share similar underlying approaches include:

- Hydraulic control structures (gates, weirs, flood protection barriers,...) and concrete, steel, masonry, and timber fixed structures
- Rubble-mound and vertical breakwaters ;
- Shore and river bank protection including groins, dikes, and revetments,
- Berthing terminals and mooring sites.

Integration of SHM of early stage of conceptual design should be considered.

Suggested final product(s)

All results will be described in a published PIANC report. If practical and appropriate, participants will develop and distribute a technical brief and organizing workshop containing results.

Recommended Members

Organizations representing ports and inland and maritime waterway systems, especially artificial waterways/canals with hydraulic structures (e.g. waterway management organizations, governmental administrations, consultants), as well as academic and private researchers.
Port authorities and specialized maintenance companies are expected.
Few general experts in SHM, from other domains, will be welcome.

Relevance for Countries in Transition

Results may help inform CiT and should be considered in design of new inland waterway systems and components. SHM has the potential to aid in daily operation of new and existing inland infrastructure, as a risk reduction method, and provide valuable, accurate, quantitative data to formulate maintenance, repair, and recapitalization strategy over time.