



GUIDANCE ON THE DESIGN OF PARTED MOORING LINE ARRESTING SYSTEMS

PROPOSED TECHNICAL WORKING GROUP

TERMS OF REFERENCE

1. Historical Background Definition of the problem

Parted mooring lines are a frequent occurrence at ports around the world and present a significant risk to personnel at these ports. It is estimated that 1 in 7 interactions between personnel and parted mooring lines results in a fatality. Further, it is estimated that Australian ports see a fatality due to parted mooring lines approximately once every 5 years.

At current, no detailed guidance exists within international design guidelines or PIANC literature. Due to the absence of such guidance arresting structures and systems in operation currently have unquantified suitability for arresting parted mooring lines.

Recent research undertaken by various parties throughout the Asia Pacific region suggests that design energies at the tips of parted mooring lines are much higher than previously expected and that arresting structures do not perform as intended. This has been substantiated with some physical testing, though more is required.

The presentation of this research at the PIANC APAC Conference 2022 has encouraged conversations between port operators and owners, contractors, and design consultants on the matter who agree that a collective effort must be undertaken to quantify and design out the risk that parted mooring lines present.

The key challenges identified with the respect to the above are as follows:

- How frequently do mooring lines part and what are the primary contributing factors to the parting of mooring lines?
- What is the statistical distribution of parted mooring line events in terms of a percentage of the line's Minimum Breaking Load (MBL)?
- What is the current state of the art in mooring line manufacturing and what are the properties of these lines?
- What elimination strategies exist to remove the risk of parted mooring lines all together?
- How should an engineer quantify the energy and forces involved in a parted mooring line event?

- How should an engineer quantify the ability of a structure or other system in arresting a parted mooring line?

The proposed new guideline would address these (and other arising) questions to provide specific and detailed guidance on the quantification of design actions and performance of resistance structures using probabilistic distribution and limit state design in accordance with ISO 2394:2015. The organisation of an appropriately staffed working group to deliver this documentation would allow for a holistic and informed guideline that would aid in the identification of risks and improved safety in ports around the world.

2. Objectives

To provide guidance on risk and reliability informed design of parted mooring line arresting systems and guidance on the quantification of design energy, reactions, and probability of parted mooring line events.

3. Earlier reports to be reviewed

The following list of relevant PIANC and third-party reports on related issues (other published or unpublished sources of information), shall be used to inform the Working Group. This list is not exhaustive and as other information comes to light through the literature review phase of the working group it may be expanded upon.

- AS 3600 – Concrete Structures (or equivalent international standard)
- AS 4100 – Steel Structures (or equivalent international standard)
- AS 4997 – Guidelines for the Design of Maritime Structures (or equivalent international standard)
- MEG4-2018 – Mooring Equipment Guidelines
- BS 6349 Part 4 – Maritime Works – General – Code of Practice for Materials
- PIANC 153 - Recommendations for the Design and Assessment of Marine Oil and Petrochemical Terminals
- PIANC 186 - Mooring of Large Ships at Quay Walls
- 9780115534027 - Code of Safe Working Practices for Merchant Seafarers
- Relevant Australian Port Safety Documentation (AMSA)
- Published and Unpublished research of Jordan Butler/Wallbridge Gilbert Aztec on Snapback Analysis and Structural Response
- Published and Unpublished research of Holmes Solutions on Snapback Analysis and Structural Response
- Design event documentation from asset owners, operators, and stakeholders

4. Scope of work

Appreciating that much of the relevant research to snapback safety is emerging in real-time concurrent with the formation of this working group, the working group is expected to go through 4 key stages for formation of the final deliverable: A Design Guideline encompassing the state-of-the-art knowledge for snapback safety. Please note that the stages are not necessarily chronological and elements of the different stages are likely to be undertaken concurrently.

This summary of approach in the ToR shall be treated as a living document and shall be modified and adapted as required by the working group through the natural course of their development.

Stage 1: Discovery and Literature Review

Stage 1 – A: State of the Art - Research

The working group will undertake an international review of published research and works completed by engineering consulting firms relevant to the topic and invite relevant researchers to provide input to the working group.

Stage 1 – B: State of Affairs – Events and Operations

The working group will invite ports worldwide to provide feedback on frequency of events, contributing factors and, where possible, provide data on the events (line type, line material, %MBL at failure, concurrent events) etc. This information will drive two key deliverables for the Working Group: 1: it will inform commentary around best practices and contributing factors for snapback within the guideline with some degree of numerical quantification, including best practices for recording data for snapback events, and, 2: it shall be provided to the engaged researchers for calibration of the latest analytical methods to provide some assurance that the analytical methods presented in final documentation correlate to real world events.

Stage 2: Collate, Calibrate

Whilst the working group undertakes a review of the collated State of the Art from Stage 1, collected data from operators and asset owners, particularly that of design snapback events, shall be provided to the engaged researchers and consultants (with consent from the owners of the data) for calibration of their theoretical models to inform closed form algebraic expressions that can be documented in the final deliverable of the Working Group.

From Stage 1, it is anticipated that some of the particularly well documented events will form case studies that will provide real-world justification for the recommendations and findings of the Design Guideline.

Stage 3: Alternate Strategies

The working group shall engage industry leading vendors and manufacturers to provide insight into the state-of-the-art for material science (line manufacturing and structural response),

arresting systems, and other mitigation strategies that warrant inclusion in the final Design Guideline.

Stage 4: Documentation and Review

Over the course of Stages 1 to 3 it is anticipated that concurrent research will have completed and reflect calibration to the case studies identified by the working group. The outcomes of this research, the information provided by manufacturers, and the information provided by port operators and asset owners will be collated into a structured document outlining what a design event is, what considerations a designer should make for informing design (i.e. exposure of the berth, importance level (i.e. exposed personnel, civilians etc.), climate, vessel size and other relevant factors), what the magnitude of design actions are to be considered, and how a designer might resolve these design actions through arresting systems (either in line technologies or in arresting structures).

This documentation will be disseminated throughout PIANC for comment and review.

Throughout the above stages the working group will remain in constant liaison with other working groups (such as WG 186) to ensure accuracy of the documentation to other concurrent publications and to ensure that the document is well informed by the various outcomes that would arise as a result of those documents (such as changes to mooring arrangement, passing vessel speeds, and other such relevant information).

5. Intended product

A Design Guideline covering the best current practise for parted mooring line safety, separated into 4 main categories:

- a. Design Inputs:** Including lookup tables for probabilistic design energies based on line length, line type, geometry of the berth, probability of exceedance and other relevant design inputs required for making an informed decision about what constitutes a “design event”.
- b. Design Loading:** Providing simplified closed form expressions for the quantification of energy and forces imparted by a parted mooring line using the inputs defined in Section A.
- c. Resistance Structures:** Providing the best current practice advice for the design considerations for resistance structures and methods for analysing their performance.
- d. Alternative Risk Reduction Methods:** Providing a general overview of other best practices adopted to reduce the likelihood of parted mooring line events, such as shoretension devices, quick release hooks, vessel monitoring and so on.

6. Working Group membership

The working group should include:

- Port authority representatives
- Port asset owners and operators

- Design engineers specialised in the latest literature on parted mooring line action and resistance models
- OCIMF
- IMO/Classification Societies?
- Line manufacturers
- Contractors and consultants experienced in physical testing of mooring lines and resistance structures
- Available members of WG 186

The working group should be structured such that there is impartial and adequate representation of port operators and asset owners to provide valuable input data, as well as relevant technical specialists to provide design methodologies and technical literature. The working group shall be structured with probity as a core principle such that explicit purpose of the working group remains the advancement of safety and design of port infrastructure and not the codified representation of proprietary products to advantage the constituents of the working group. It is anticipated that the working group shall organise into sub-groups dealing with the respective sections of the documentation as they relate to the members individual expertise and the value they can generate within each of these topics.

7. Target audience

The primary target audience of the documentation would be technical design engineers (primarily in structural and maritime disciplines). The nature of the documentation will be to provide adequate technical detail to enable the quantification of design actions and structural response with closed form empirically validated equations similar to the best practices of other international design standards.

8. Relevance

8.1. Relevance to countries in transition, etc.

Snapback events pose a risk to personnel regardless of the geographical location and/or the economic status of the country their port resides in. For these reasons, snapback design guidance is as relevant to protecting human life in countries in transition as it is in the busiest ports in the world; perhaps morseo, depending on the level of development of safety practices at these ports.

8.2. Climate Change and Adaptation

Though not directly relevant, it is expected that changes in metocean conditions such as tidal variations and windspeeds, as a consequence of climate change, will have a direct impact on the prevalence of snapback events.

8.3. Working with Nature

Though not directly relevant, improved port safety enables other undertakings within a port environment to be done so with a reduced risk, in turn supporting how those undertakings facilitate working with nature.

8.4. UN Sustainable Development Goals

The works directly support UN Sustainable Development Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all, by way of ensuring that port safety is improved, thereby providing a safer workplace and enabling the economic growth that is afforded by having safe port operations.

9. References

References will be populated after the Discovery and Literature Review Phases. In the interim, references shall be considered to be constituted by the list of documents provided in Section 3. and with inclusion of the latest publications from the PIANC APAC 2022 conference.