



DESIGN, MAINTENANCE AND SUSTAINABILITY OF CONTAINER TERMINAL PAVEMENTS

PIANC WG165 updated to include sustainability of pavements

TERMS OF REFERENCE

1. Historical Background - Definition of the problem

PIANC Working Group Report No.165-2015, Design and Maintenance of Container Terminal Pavements, is to be updated to include consideration of the sustainability of container terminal pavements. The following ToR defines the scope of the proposed update, which is to be added to the existing report, including new text and new chapters and appendices as the Working Group decides.

The ToR of the original WG is included for reference as an Appendix to this ToR.

The construction and management of container terminal pavements impacts significantly the environment from the use of scarce materials over the generation of carbon dioxide when manufacturing, the use of (non-renewable) energy during the construction, the replacement of valuable nature, dealing with end of life of the pavement, etc.

A container terminal of quay length 1000 m and container handling width 500 m comprising pavements of thickness between 300 mm and 600 mm involves the installation of 150,000 m³ to 300,000 m³ of imported material, often installed over fill material of similar volume. Over 1 million tonnes of new material would be installed, including at least some whose manufacture includes high CO₂ ingredients such as cement and bitumen. Attempts have been made to ameliorate the situation by, for example, including waste materials as fill/pavement components, not always successfully. So far, the focus has been directed towards simply ensuring that the pavement performs successfully, but this is far from a straightforward ambition when the wheel loads applied by container handling equipment, often an order of magnitude greater than those applied on highway pavements, are factored in. WG 165 addressed those matters in PIANC WG Report No.165-2015 Design and Maintenance of Container Terminal Pavements. That report provided the methodology for design and maintenance of container terminal pavements.

2. Objectives

The focus of the proposed WG will be limited to the pavement itself combining the environmental and (socio-)economic aspects of the pavement design, construction, maintenance and end-of-life, excluding the environmental and (socio-)economic impacts related to the location itself.

The WG will build further on the existing WG 165 report.



The objective of the WG is to evaluate all sustainability aspects of different types of container terminal pavements in a qualitative and quantitative way to provide information designers can use for future developments. It is intended that the proposed WG will

- Provide criteria to design sustainable pavements that are able to minimize environmental impacts and consumption of natural resources throughout the whole life cycle of the pavement;
- Provide information that significantly improves the understanding of the whole life cycle impact generated by container terminal pavements with a commensurate decrease in the harmful environmental consequences of container terminal development while keeping the same level of stability risk in combination with the budget.

3. Earlier publications to be reviewed

- PIANC WG Report No.165-2015 Design and Maintenance of Container Terminal Pavements will be the starting point.
- Data provided in Embodied Carbon: The Inventory of Carbon and Energy by Hammond and Jones, University of Bath (2011) and similar data will be presented in the context of container terminal pavements.
- Data provided by SimaPro, Ecoinvent and GaBi databases
- In addition, Investigation of Carbon Footprints of Highway Construction Materials in India by Sreedhat, Jichkar & Biligiri (2016) will be referenced in order to assess the carbon footprint of pavement installation methods.
- Papers such as Assessment of Embodied Carbon in Conventional and Permeable Pavements Surfaced with Pavers (Cook & Knapton, 2012) will be reviewed.
- Existing Environmental Product Declarations of construction materials and products, including sustainability-certified materials.
- Other articles on experiences in port paving that have had a positive environmental impact.

4. Scope of work

The WG will carry out a review of the historic performance of pavement components in order to establish which materials and installation methods show most promise in increasing the sustainability of the pavement for its complete life. Historic performance of pavements will be also used to build consensual maintenance scenarios that permit undertaking rigorous life cycle analysis (LCA) and Life-cycle cost analysis (LCCA). This will include a survey of port owners/operators to identify experience with sustainability issues related to pavements throughout the world. Among other factors, the survey will address pavement carbon footprint over the entire service life, dimensions, material properties, sustainable sources of materials, environmental impacts of material extraction, design loads, typical timing/magnitude of pavement distress, initial costs, maintenance costs and pavement lives.

In that context, the activity of the WG will aim to provide engineering insight of the performance of container terminal pavements, by integrating design, construction and



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operational aspects, with an additional specific focus on a sustainable life cycle evaluation.

5. Intended product

The main purpose of the WG will be to create a technical guide that takes into account the entire life cycle of a pavement and supports the engineers in the choice of a solution.

6. Working Group membership

The WG members are expected to comprise practising/experienced engineers from: (1) terminal operators, (2) port authorities, (3) consultants, (4) contractors, (5) experts, etc.

7. Target audience

The intended users will be mainly engineers and port authorities.

8. Relevance

8.1. Relevance to countries in transition

Sustainability and long-term impact are highly relevant aspects especially for countries in transition. The report can support them in choosing the right solution taking into account not only the initial cost but also all the variables in the life cycle of the pavement.

8.2. Climate Change and Adaptation

The choice of a long-term lasting solution combined with an appropriate maintenance will have a positive impact in the environment. The analysis of the impacts and carbon footprint and the preference for solutions with less impact are in line with the PIANC Declaration on Climate Change (available at <https://www.pianc.org/uploads/files/COP/PIANC-Declaration-on-Climate-Change.pdf>)



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Appendix A : Terms of Reference of original report

MarCom WG 165 (Report published 2015)

Design and Maintenance of Container Terminal Pavements

Terms of reference

1. Historical background – Definition of the problem

Container terminals require special types of pavement to resist the heavy and continuous loads of container handling equipment including straddle carriers, reach stackers, top picks, rubber tire gantries and automatic guided vehicles (AGV). Typically, container terminals use either asphalt or concrete block pavement systems. The design of these “structures” has been largely based on highway pavement technology. Load repetitions associated with port pavement, however, can be much slower, much heavier and more confined to single wheel paths than roadway conditions. Under such conditions, port pavements can be subject to rutting and other distresses that require repair, maintenance. In some cases, traditional asphalt/block pavements are not optimal for container terminals. Designers do not always know how to design pavements properly. Terminal operators do not always recognize the need for maintenance and do not plan for same. This can give rise to problems. The proposed WG would address:

- Asphalt and Portland Cement Concrete pavement design procedures
- Concrete block pavement design procedures
- Roller Compacted Concrete pavement design procedures
- Methods for quantifying equipment repetitions
- Differences in between port, highway and airport pavement design
- Foundation design including the need for specialized treatment of reclaimed material in order to limit pavement settlement
- Container terminal pavements for inland ports and multimodal terminals (railway)
- Detailed survey of port owners/operators to quantify pavement experience throughout the world. Among other factors, the survey will address pavement dimensions, properties, design loads, typical timing/magnitude of pavement distress, initial costs, maintenance costs and pavement lives
- The WG will comprise engineers, terminal designers, terminal operators and construction experts

2. Objective of the Working Group

The objective of the WG is to provide information regarding design procedures, maintenance costs/procedures, construction oversight, and impact of terminal operations on pavement. Information regarding port pavement design, maintenance, construction and general performance is scarce. It is hoped that the proposed WG will provide information that significantly improves the understanding of port pavements with a commensurate improvement in performance.

3. Earlier reports to be reviewed

Presently, there are various references for port pavement: (1) Fourth Edition of the British Ports Association Heavy Duty Pavement Design Manual, John Knapton, Interpave, 2008, (2) The



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Asphalt Institute. Thickness design: asphalt pavements for heavy wheel loads. College Park: The Institute, 1986. 72 p. Manual series n. 23, and (3) Meletiou, Marios and Knapton, John. Container terminal pavement management. Geneva: UNCTAD, 1987-1990. 2 vol. UNCTAD monographs on port management n.5; (4) ROM 4.1-94 Guidelines for the Design and Construction of Port Pavements (Puertos del Estado, Spain).

While these reports offer a plethora of information, the proposed WG will extend the state of knowledge with new developments informed by recent experience of terminal operators, designers, academics, construction management professionals, and contractors

4. Matters to be investigated

Geotechnical and structural design criteria for pavements, life cycle analysis for pavement systems, manufacture of blocks for block paving, innovative alternative solutions for Container Terminal Port Pavements.

5. Method of approach

Review existing standards and recommendations regarding structural and geotechnical design, bibliography, analysis of main geotechnical, structural and soil-structure interaction problems involved, available technologies and analysis of Case Studies with special focus on design and construction criteria and final results achieved in several case studies.

6 Suggested final product

Recommendations in the form of a guide relevant for designing, maintaining, constructing and testing container terminal pavements.

7. Desirable disciplines of the members of the Working Group

The WG members are expected to be comprised of practising/experienced engineers from: (1) terminal operators, (2) port authorities, (3) consultants, and (4) contractors. We expect to be able to attract a serving member from most PIANC participating countries. We know from literature and experience that numerous countries are likely to participate including: Australia, Dubai, Germany, Japan, Netherlands, Spain, UK, US and others.

8. Relevance for countries in transition

Many of the new container ports being planned and constructed throughout the world are slated for Countries in Transition. Accordingly, these countries will be the beneficiaries of new technology and preferred design/construction methods. This WG will help such countries to avoid any problems or misunderstandings from the past. Manufacture of blocks for block paving will also be a topic of interest for countries in transition.