PRELIMINARY RESULTS OF A RESEARCH INTO CARBON FOOT PRINT OF PORT INFRASTRUCTURE, PORT OF ROTTERDAM

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Abstract

This article describes the preliminary results of a study in the Port of Rotterdam to assess the carbon footprint of port infrastructures ,
In the study two types of port infrastructure have been selected, a road construction and a quay wall construction.
For both structures the individual components of these structures were categorized to assess of each element of the contribution to the carbon footprint .
The total carbon footprint has been derived for the whole process ,design, construction and demolition.
With this study first insight has been obtained over the carbon footprint of these structures.
On the basis of the results of this study further analysis for other types of other port structures will be performed to try to reduce carbon footprint in the construction chain of port structures.

Keywords: Port infrastructure, carbon footprint, roads, quay walls

1. Introduction

The city of Rotterdam supports durability and sustainability in its own environment as well as abroad with initiatives like Rotterdam Climate Initiative in which all Rotterdam organizations participate..
The Rotterdam Port Authority owns ,built and maintain the port area different kind of infrastructure like roads an quay walls.
To investigate whether the building and maintenance can made more sustainable a study has been initiated by Gemeentewerken Rotterdam (Public Works) and the Rotterdam Port Authority to assess as a first start the carbon footprint of a road and a quay wall structure.
The disciplines needed for this study are both environmental and civil expertise as the aim trying to reduce carbon footprint and also to fulfill the functional requirements.
This paper discusses the analysis method and the preliminary results .
Also recommendations are presented for further research.

2. Life Cycle Analysis

The carbon footprint of structures can be assessed by considering the whole life cycle of a structure .
This incorporates items like:
- Production of construction materials
- Transport of materials
- Fabrication of components
- Construction
- Demolisation
- Life time ;technically-, economically-, service lifetime

The carbon footprint considers specifically the green house effect contribution which is one of the items within Life Cycle Analysis (LCA). Today the carbon footprint is the accepted method to quantify the contribution to global warming.
The carbon footprint is quantified with indicators like global warming potential (GWP). The Intergovernmental Panel on Climate Change (IPCC) defines the GWP as an indicator that the potential effect of the relative climate change per kg of greenhouse gasses over a certain period, like 100 years (GWP100 indicates).

3. Study approach

3.1 General

To perform the carbon footprint analysis the following boundary conditions were used:

- Length of structure :100 meter
- Reference year : 2005
- Construction, transport and demolition are the items that were included in the analysis
- Infrastructure is built in “free field conditions”
- Design life ;road :36 year, quay wall 50 year
- The transport distances are selected such that the most logic transport route is used.

3.2 Road

An inventory of road types have been carried which lead to 7 types of road structures. These varied front roads with double lane with median bank up to cycle path. In table 1 the characteristics of each type considered is presented.

Location and type

Name/Location	Type	
Europaweg	2 x 2 lanes asphalt	including median bank with aspfalt
Vondelingenweg	2 x 2 lanes asphalt	including median bank with asphalt
Theemsweg	2 x 1 lanes asphalt	including median bank with asphalt
Moezelweg	2 x 1 lanes asphalt	without median bank
Magallanestraat	2 x 1 lanes asphalt	without median bank
Van Veeenendaalstraat	2 x 1 lanes cobblestones	without median bank
Bicycleroad Theemsweg	2 x 1 lanes asphalt	without median bank

Table 1:Road structures

For the road types selected the construction has been analyzed for the different components and for each component the Carbon foot print was determined for including hours and components.

Composition of the road

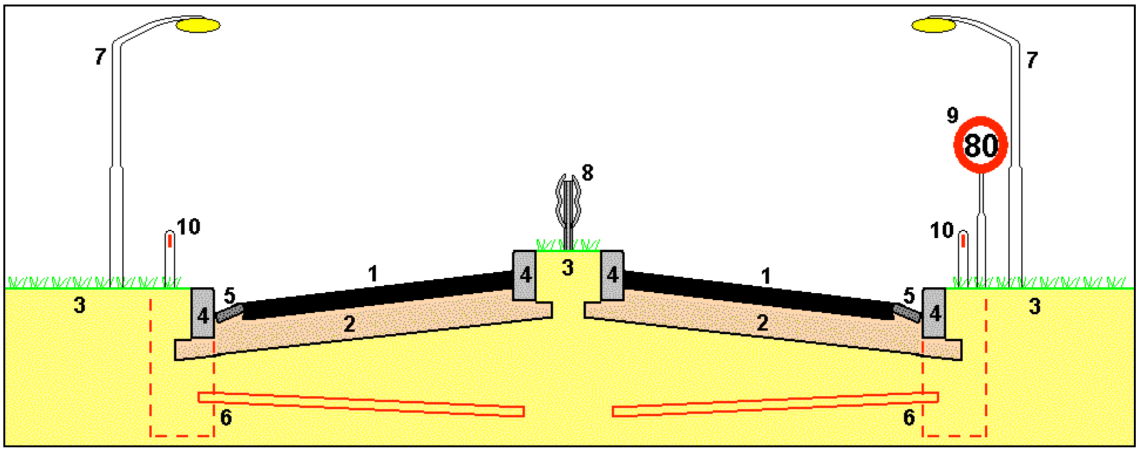


Figure 1 :Composition of road structure

For each cross section of the roads considered the dimensions and materials are determined. In figure 2 is indicated of which components the road is composed of:

1. width of asphalt or bricks top layer
2. width of foundation layer
3. width of median bank
4. number of edge confinement
5. number of roll layers
6. number of sewage connections
7. number of light masts
8. length of guiding rail
9. number of roadsignals
10. number of median bankplanks

3.3 Quay walls

In the port of Rotterdam several types of quay walls are available like sheet pile , combi wall, jetty diagram wall. For this study three quay walls have been selected.

Location and type

Quay wall Antarticaweg - sheetpile with concrete coping
Quay wall Amazonehaven - combi wall quay wall
Quay wall Euromax - diaphragm quay wall with relieving floor

Construction of the quay wall

The construction of the Antarticaweg is displayed in Figure 2.

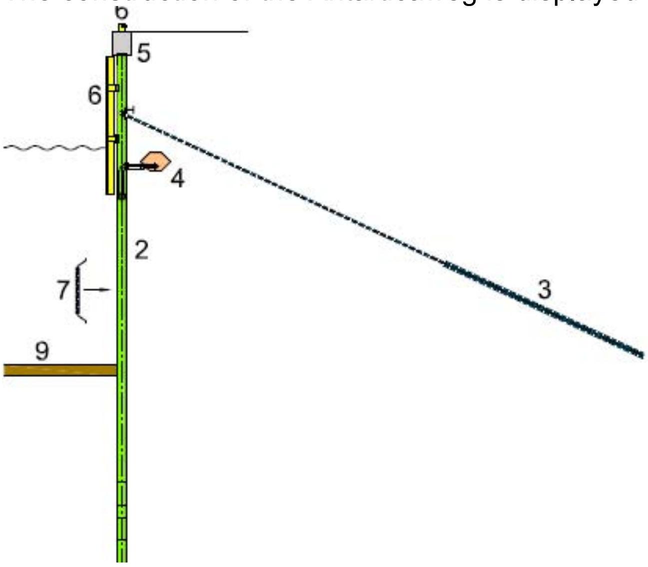


Figure 2: Anchored sheet pile wall quay wall

As can be observed the construction consists of a sheet pile elements wall system (2) with concrete cooping (5) and a bored anchor (3). At the front a simple wooden fender system is applied (6).

4. Results

4.1. Road

A typical result of the analysis is presented for the Europaweg, type: 2x2 lanes, median bank, emergency stroke, asphalt.
In table 3 and 4 is an overview for minimum and maximum transport distance.

	Transport	Productie	Material	Total
Construction	57200 kg CO_2-eq	4500 kg CO_2-eq	113000 kg CO_2-eq	174700 kg CO_2-eq
Demolization	55700 kg CO_2-eq	4100 kg CO_2-eq	44600 kg CO_2-eq	104400 kg CO_2-eq
Maintenance	14600 kg CO_2-eq	2200 kg CO_2-eq	40600 kg CO_2-eq	57400 kg CO_2-eq
Total	127500 kg CO_2-eq	10800 kg CO_2-eq	198200 kg CO_2-eq	336500 kg CO_2-eq

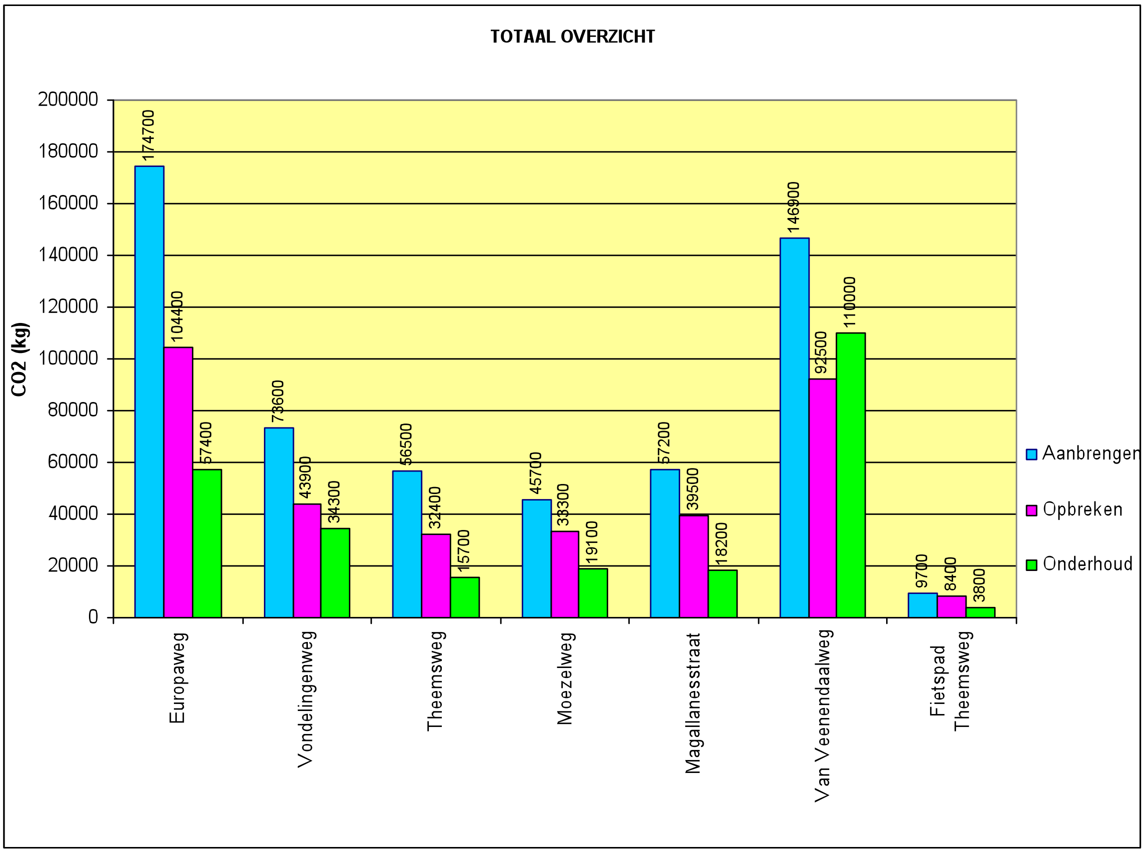
Table 3 Results CO_2 equivalenten for minimume distance

	Transport	Production	Material	Total
Construction	65400 kg CO_2-eq	4500 kg CO_2-eq	113000 kg CO_2-eq	182900 kg CO_2-eq
Demolisation	64000 kg CO_2-eq	4100 kg CO_2-eq	44600 kg CO_2-eq	112700 kg CO_2-eq
Maintenance	29200 kg CO_2-eq	2200 kg CO_2-eq	40600 kg CO_2-eq	72000 kg CO_2-eq
Total	158600 kg CO_2-eq	10800 kg CO_2-eq	198200 kg CO_2-eq	367600 kg CO_2-eq

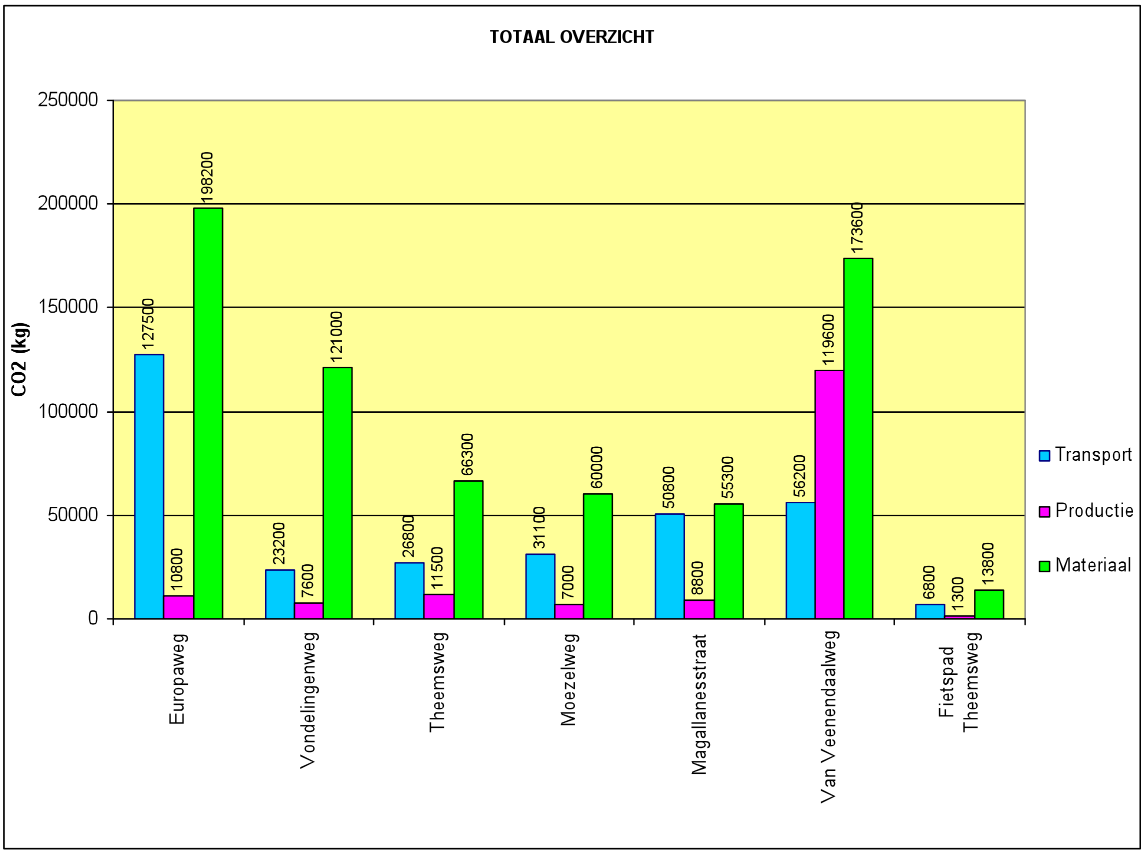
Table 4 Results CO_2 equivalenten for maximum distance

Comparison of the selected roads

The graphs 3 and 4 show the results for all the selected roads . Thereby are the results valid for a section of 100 meter and the minimal distance.



Graphic 3 Overview of results split in Construction, demolisation and maintenance



Graphic 4 Overview of results split in transport, production and material

4.2. Quay wall

Comparison of the selected quay walls

A overview of the results for the investigated quay walls is presented in graphic 5. This graphic shows that the diafragm type quay wall has the highest Carbon foot print while the relative quay wall Antarticaweg has the lowest.

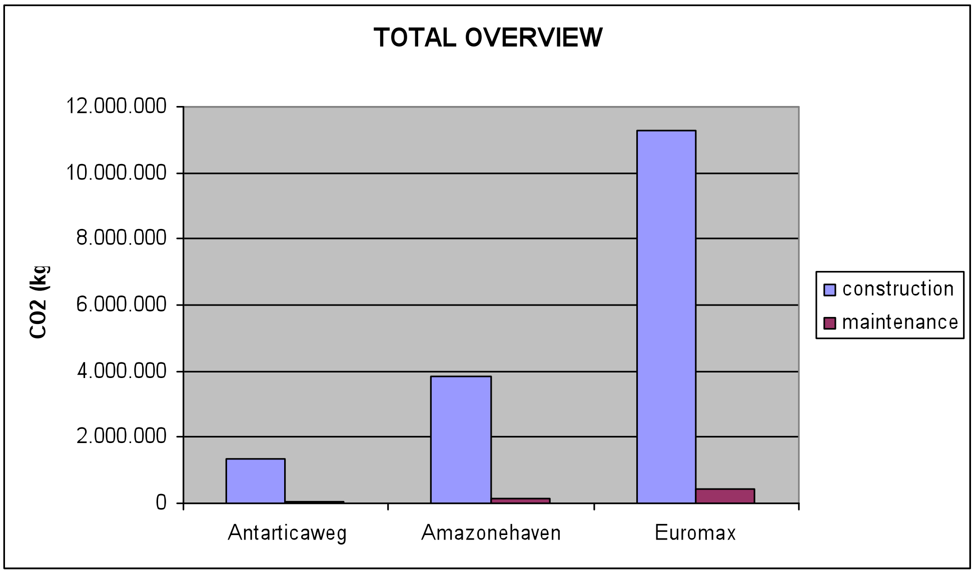


Figure 5 Overview Carbon footprint quay walls investigated

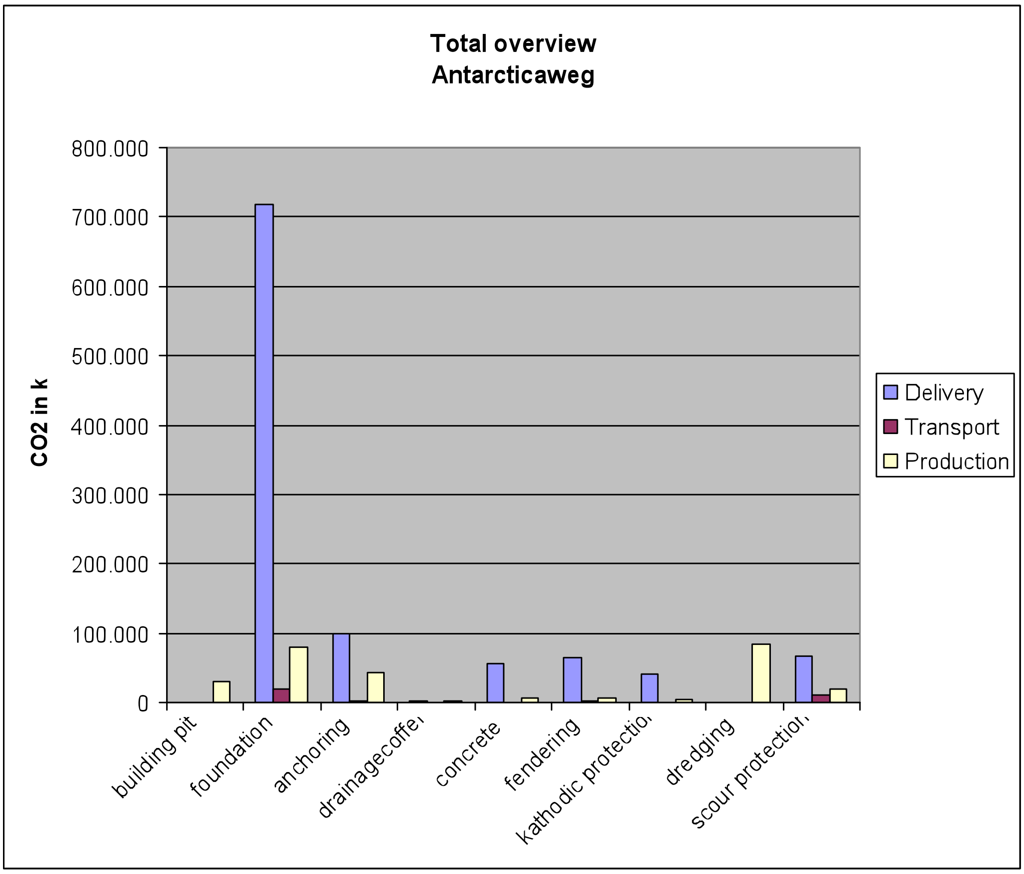


Figure 6 Carbon footprint for Antarticaweg quay wall in more detail

5. Discussion of results

The following findings can be characterized:

5.1. Roads

Most roads section have approximately the same carbon footprint with the only exception of the van Veenendaalweg .

- This road has a brick composition which more labor intensive while the production of bricks has a higher CO2 consumption.
- The production of materials like asphalt , bricks, rails generate more carbon emission.
- The transport distance is a very important parameter for assessing the carbon footprint. It is even so that with long transport distances the carbon foot print is for more that 70 - 80% related to transport.

5.2. Quay walls

- In this study only three quay walls have been investigated as to obtain a first impression for assessing the carbon footprint impact of this type of structures.
- The result of the quay wall indicate that carbon foot print is by far determined by the material component steel. Approximately sevenfold more then the other items that contribute to the carbon footprint.

6. Recommendations and conclusions

- With this study a first insight in the carbon foot print has been obtained.
- Transport and the production of materials are the governing parameters.
- At the construction site only minor carbon emission takes place.
- Further research should be directed to improve production techniques and to limit transport distances.

7. References

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