Carbon Footprint Port infrastructure

The emmission of CO_2 during the life cylce of port infrastructure.

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Introduction

The Rotterdam Port Authority (RPA) at the engineering office of Public Works Rotterdam (IGWR) expressed the wish in the context of its climate targets to gain more insight into the amount of CO_2 that can be attributed to civil engineering objects in the port of Rotterdam.

Introduction

IGWR has civil engineering expertise to correct functional and manufacturing requirements, and has been working with IVAM in sustainable scrapping the CO2 and NOx impacts from demolition and processing of scrap products into view through a demolition tool

A combination of civil engineering and environmental expertise leads to balanced product enhancements: the goal is always to improve the CO2 characteristics without detracting from the technical (prerequisite)

Introduction

RPA owns, built and maintain in the port area different kinds of infrastructure like roads en quay walls. To investigate whether the building and maintenance can made more sustainable a study has been initiated by RPA and IGWR to assess as a first start the carbon footprint of a road and a quay wall structure

The specific question was formulated jointly:

The determination of the carbon footprint (quay walls and roads) in the Rotterdam port area. The desired effect level: Investments.

LCA

Approach made according to the **Life Cycle Assessment (LCA)** method.

This is a method to reduce the overall environmental burden of determining a product life cycle (from extraction of raw materials, production, transportation, use, disposal and recycling).

As each LCA, this process will also follow the steps to know:

1. Target Determination
2. Stocktaking
3. Characterization
4. Interpretation

LCA

Target Determination/Goal setting (1)

Questions by goal setting among others:

- why do we do this project
- what do we want to know
- the target group
- for whom the outcome is intended
- which products are part of the equation (type quay walls and road types)
- what alternatives are possible
- What is the functional unit (the comparison unit, eg 1 km quay wall of a given quality)
- what is the reference (the year of the baseline)
- the final years of the measurement system, define boundaries, etc.

This step is obviously in close consultation with RPA, IGWR and IVAM run through.

LCA

Inventory (2)

The inventory is, for the purpose laid down in that products determined from which materials and quantities these are built, how they are produced, number and type of transport is necessary for that, etc. and what all this environmental interventions (inputs / outputs) are.

LCA

Characterization (3)

In the characterization, the environmental interventions translate into environmental impact:

1 kg of CO_2 is 1 kg of CO_2 equivalents
1 kg methane is 23 kg CO_2 equivalents.

Then the CO_2 equivalents added as a measure of enhanced greenhouse effect (or carbon footprint).

LCA

Interpretation (4)

The interpretation addresses the priorities, the robustness of the results, the sensitivities of assumptions, the validity of the result, etc.

Study approach - General

Boundary conditions:

- 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

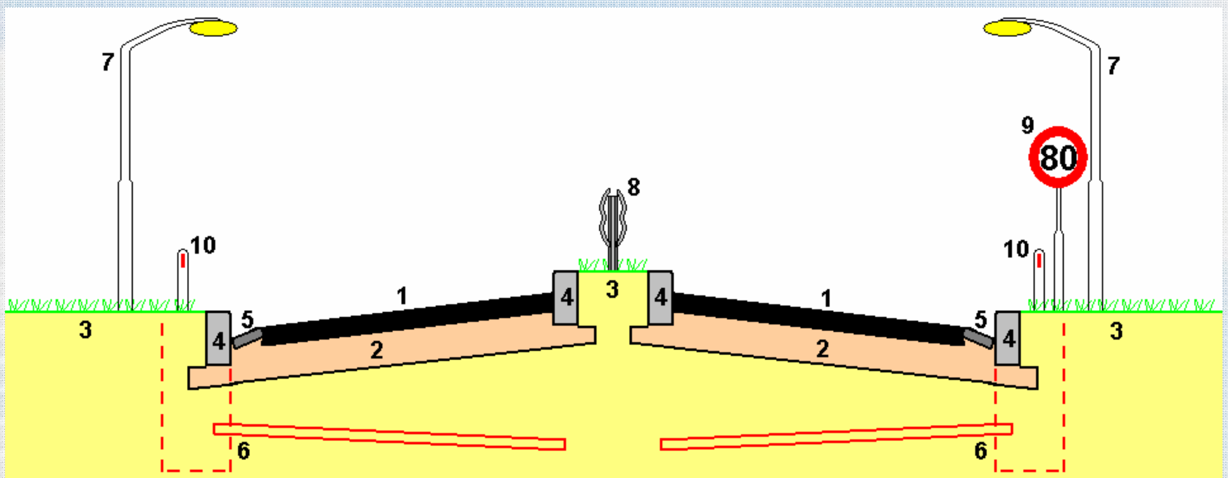
Study approach - roads

An inventory leads to 7 types of road structures:

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 Veenendaalstraat, 2 x 1 lanes cobblestoneswithout median bank
Bicycleroad Theemsweg, 2 x 1 lanes asphaltwithout median bank

Study approach - Roads

The indentitied profile:



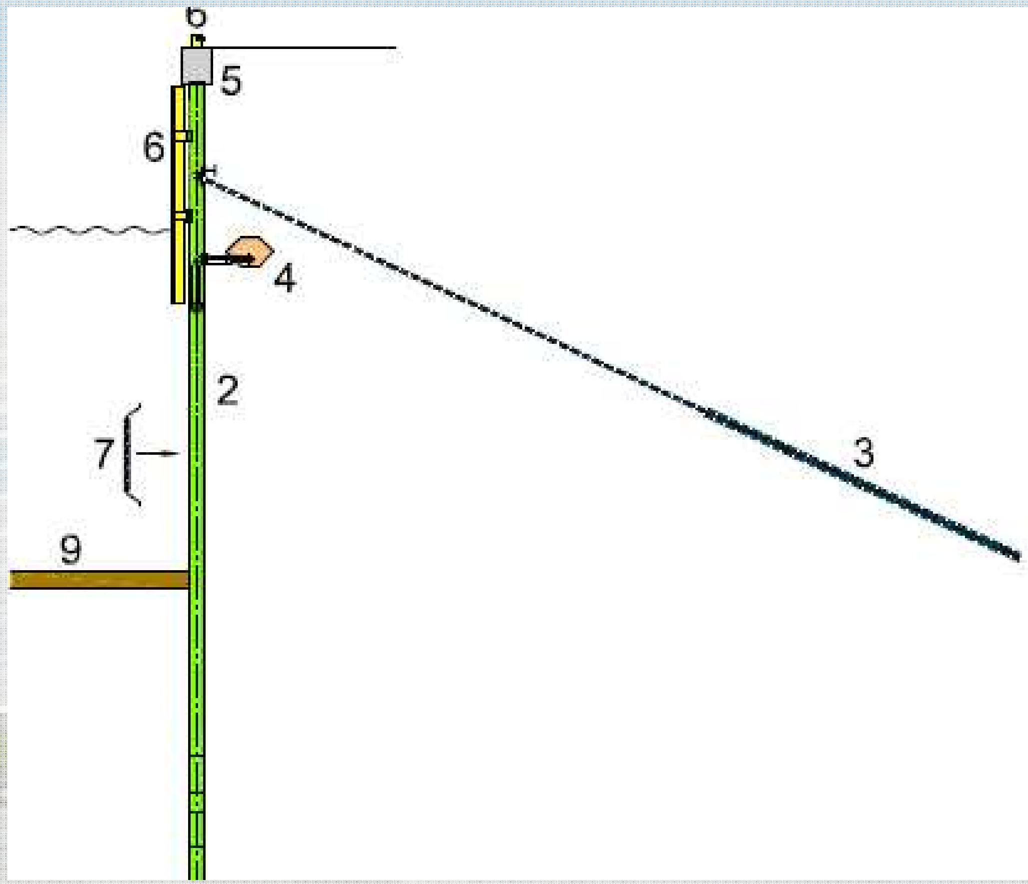
1. width of asphalt or bricks top layer
2. width of foundation layer
3. width of median bank
4. number of edge confinement
5. number of roll layers
6. number of sewage connections
7. number of light masts
8. length of guiding rail
9. number of roadsignals
10. number of median bankplanks

Study approach – 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.

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

Study approach – quay walls



Anchored sheet pile wall quay wall

This 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 (6).

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Results - road

Europaweg, type 2x2 lanes, median bank, emergency stroke, asphalt

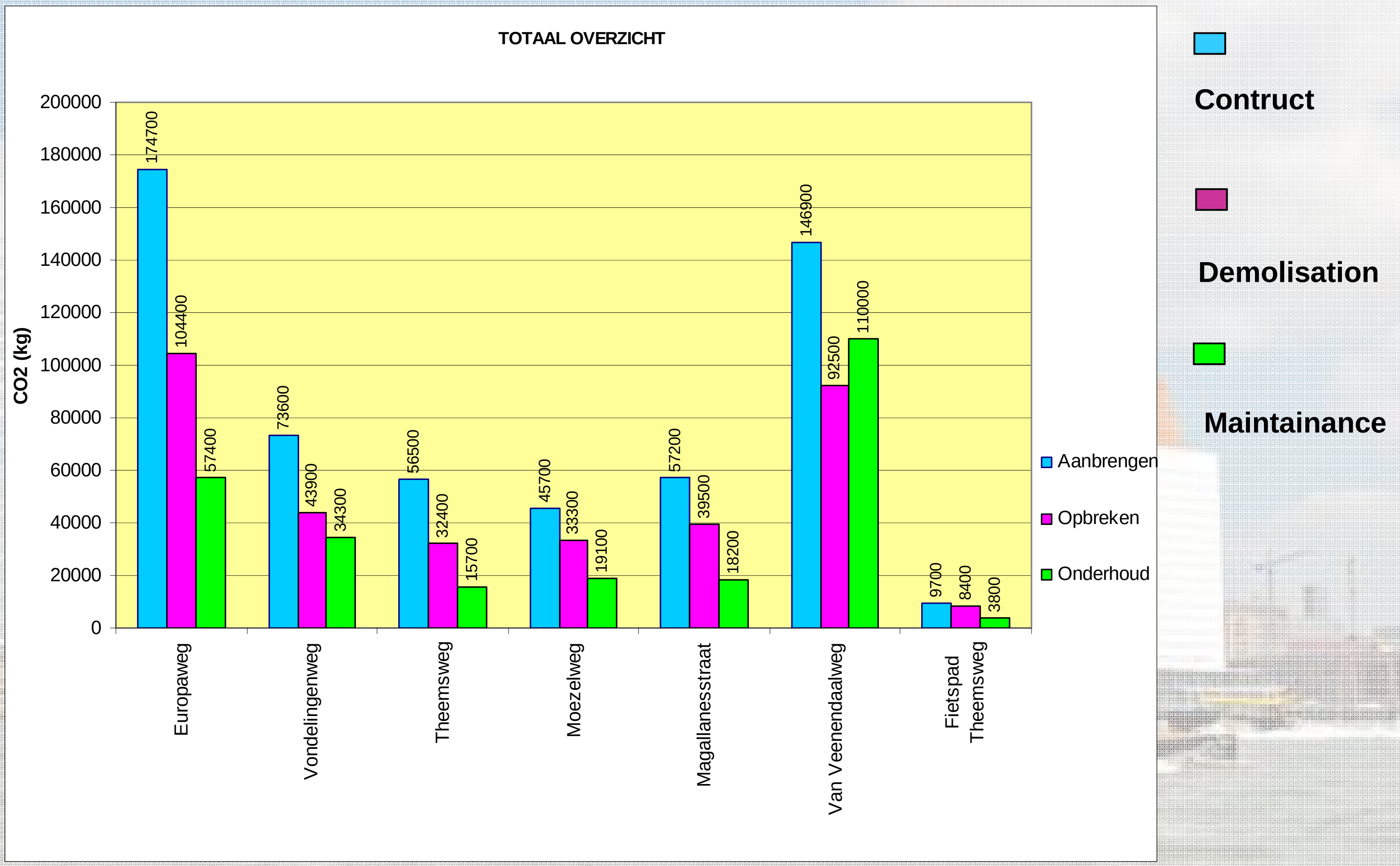
	Transport	Production	Material	Total
Construction	57200 kg CO_2-eq	4500 kg CO_2-eq	113000 kg CO_2-eq	174700 kg CO_2-eq
Demolization	55700 kg CO_2-eq	4100 kg CO_2-eq	44600 kg CO_2-eq	104400 kg CO_2-eq
Maintenance	14600 kg CO_2-eq	2200 kg CO_2-eq	40600 kg CO_2-eq	57400 kg CO_2-eq
Total	127500 kg CO_2-eq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

Results CO2 equivalents for minimum 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

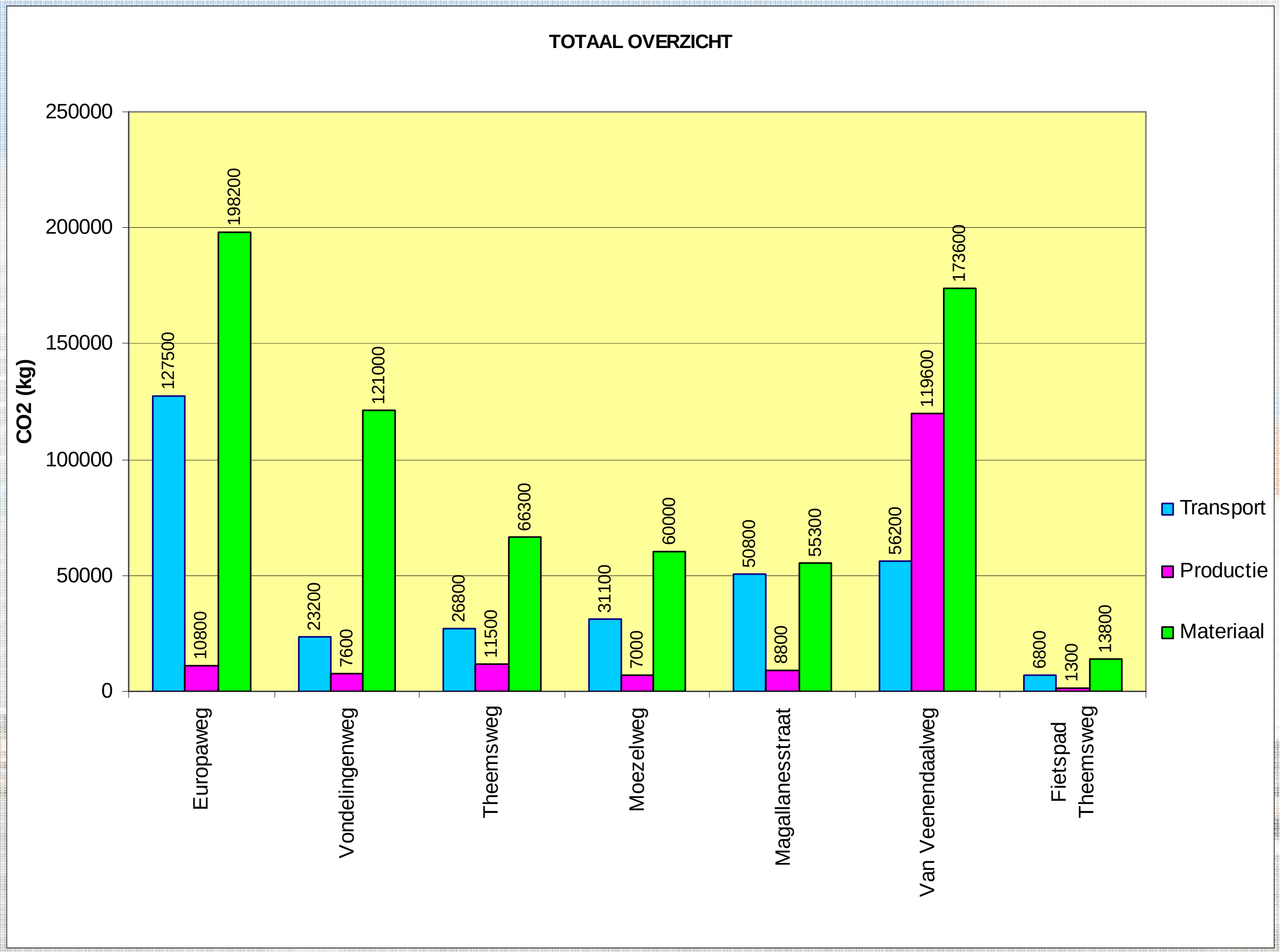
Results CO2 equivalents for maximum distance

Results - road



Results split in construction, maintenance and demolisation

Results - road



Transport

Production

Material

Results split in transport, production and material

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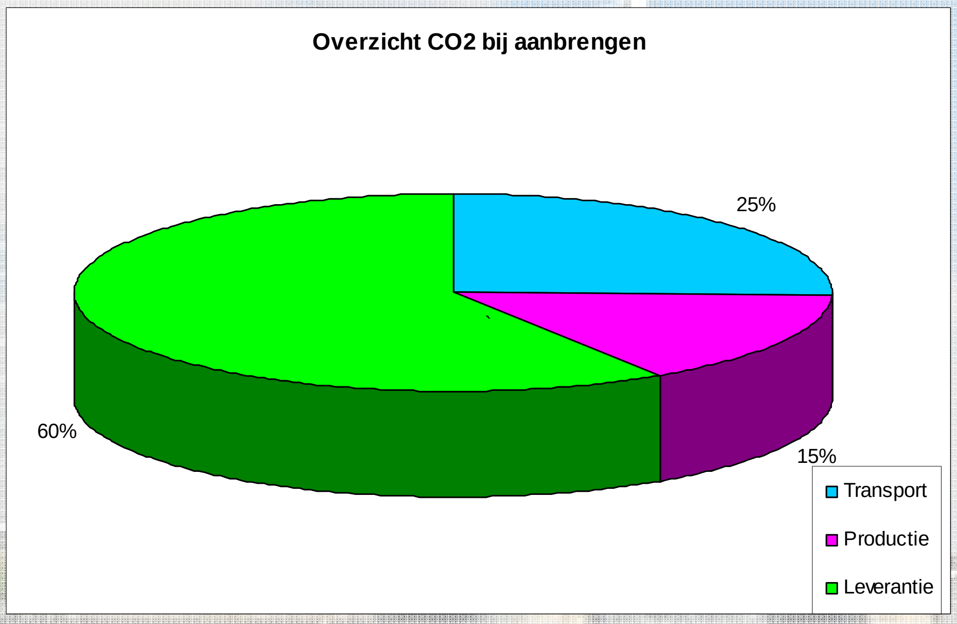
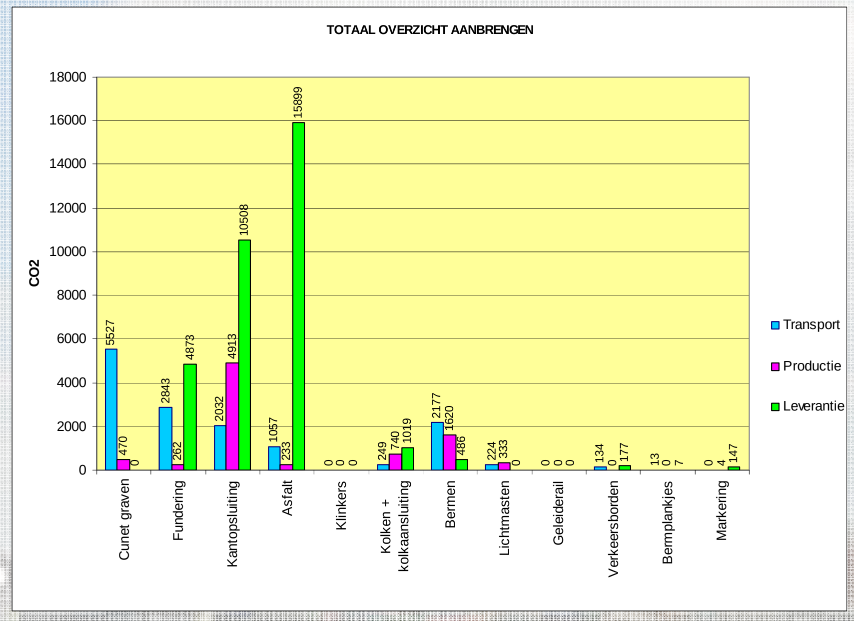
Results - production





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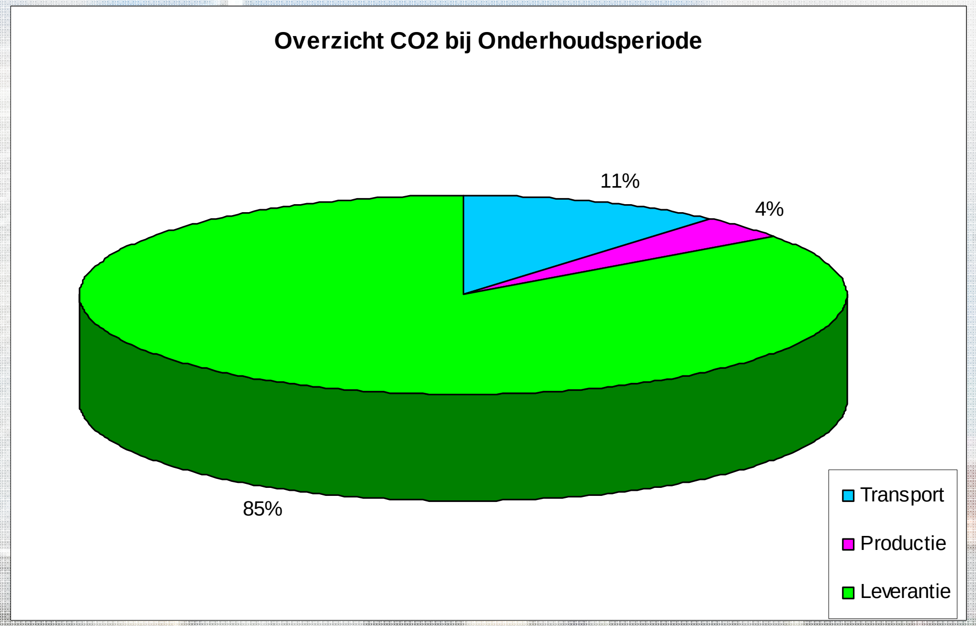
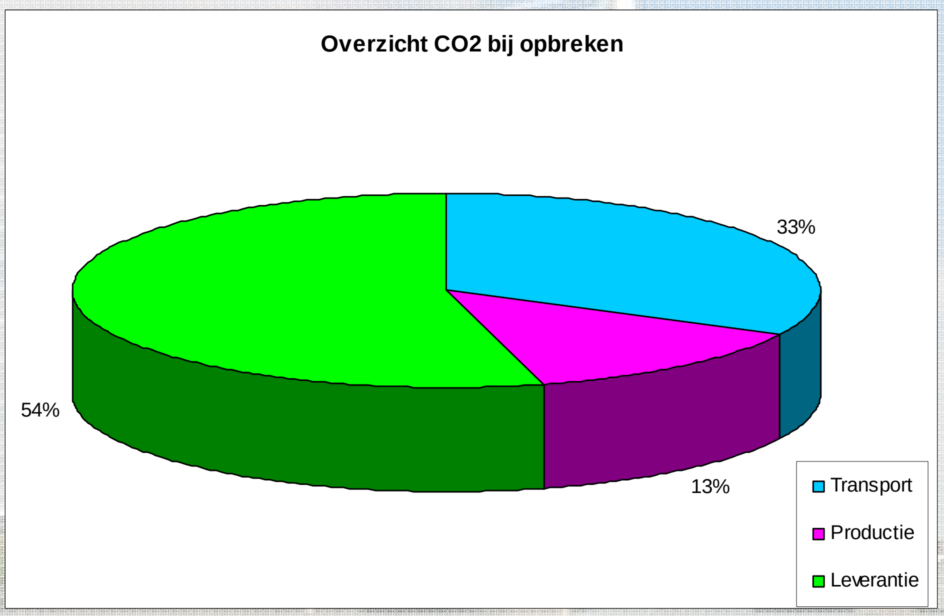
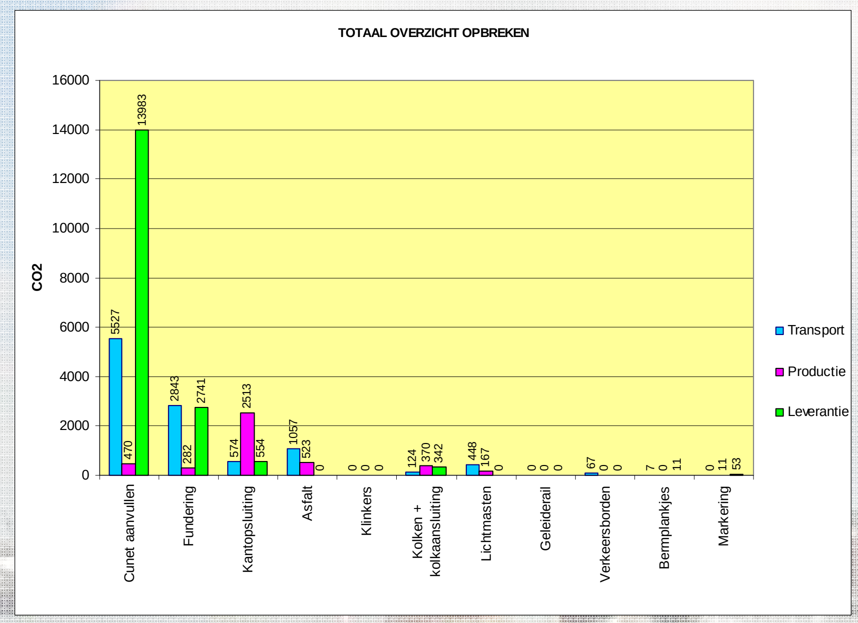
Results - maintenance



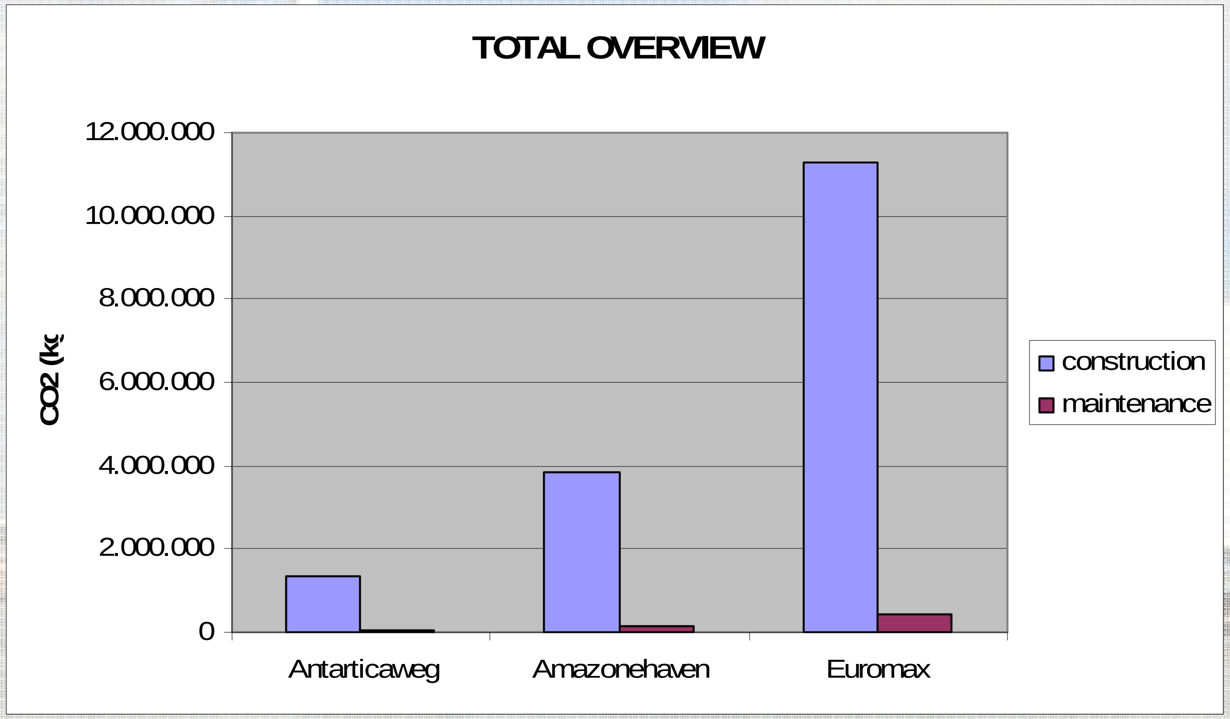
Results - demolisation





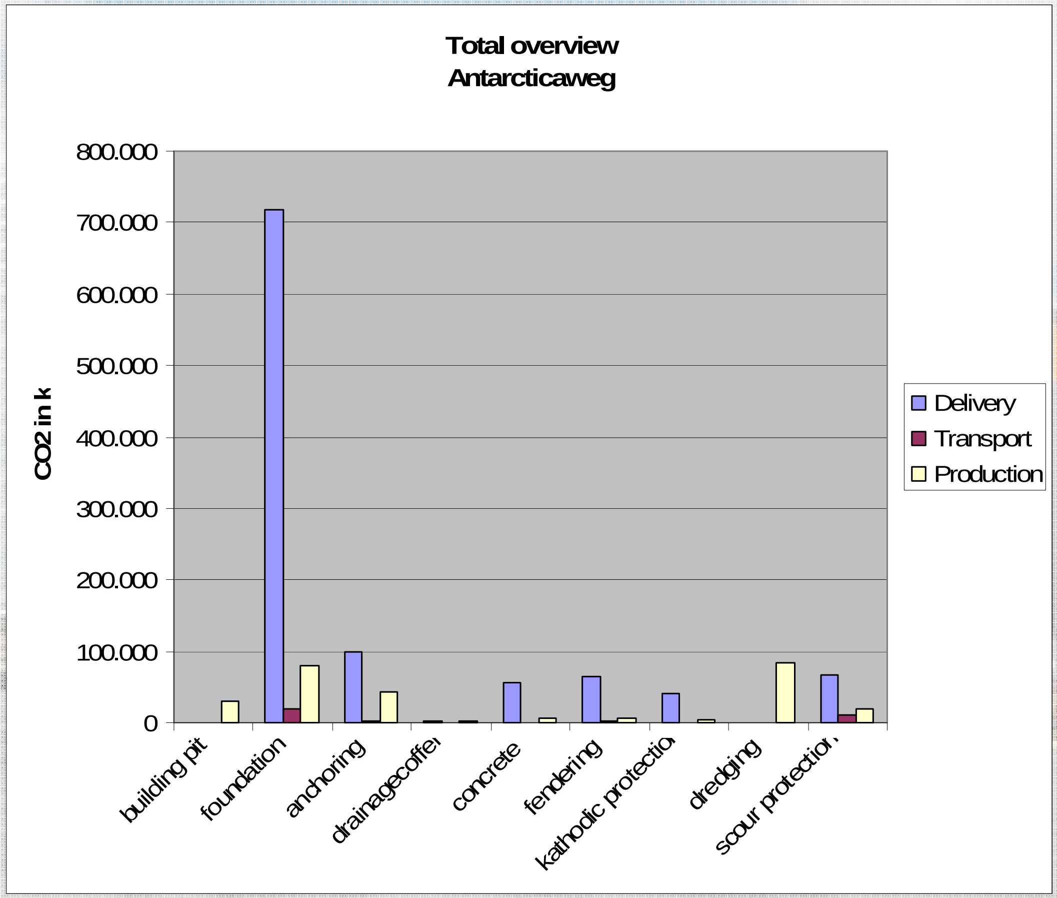
Results – Quay wall

Total overview



Results – Quay wall

More in detail



Findings - 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.

Findings – 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.

Recommendations

Further research should be directed to improve production techniques and to limit transport distances

Conclusions

- With this study a first insight in the carbon footprint of port infrastructure has been obtained.
- Transport and the production of materials are the governing parameters.
- At the construction site only minor carbon emission takes place.

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