



Royal Boskalis Westminster nv

Boskalis Westminster Middle East Ltd

Ras Laffan Port Expansion Project

TU Delft

Breakwaters and closure dams CT5308

Exercise 2009

Jeroen van den Bos



Contents

- Introduction
- Design: key figures
- Design: process
- Design: typical cross sections
- Construction



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Introduction

- Location Ras Laffan
North Field

910 . 10¹² cu. Ft, or
26 . 10¹² m³, or
26,000 billion m³

RLC End Users New Projects

 QATARGAS		
		
		





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Introduction

□ Ras Laffan Expansion

LNG

- 2005: 26 million T / annum
- 2010: 77 million T / annum
- Towards capacity of around 225 million tonnes of products per year

□ Ras Laffan Masterplan

- Current development
106 km² → 246 km²





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Introduction

- Nakilat (Qatar Gas Transport Company)
46 LNG tankers and 14 LPG tankers planned before 2010
total costs US\$ 15 billion
 - 25 Q-Flex LNG tankers: capacity between 210.000-217.000 m³
 - 21 Q-Max LNG tankers: capacity 265.000 m³

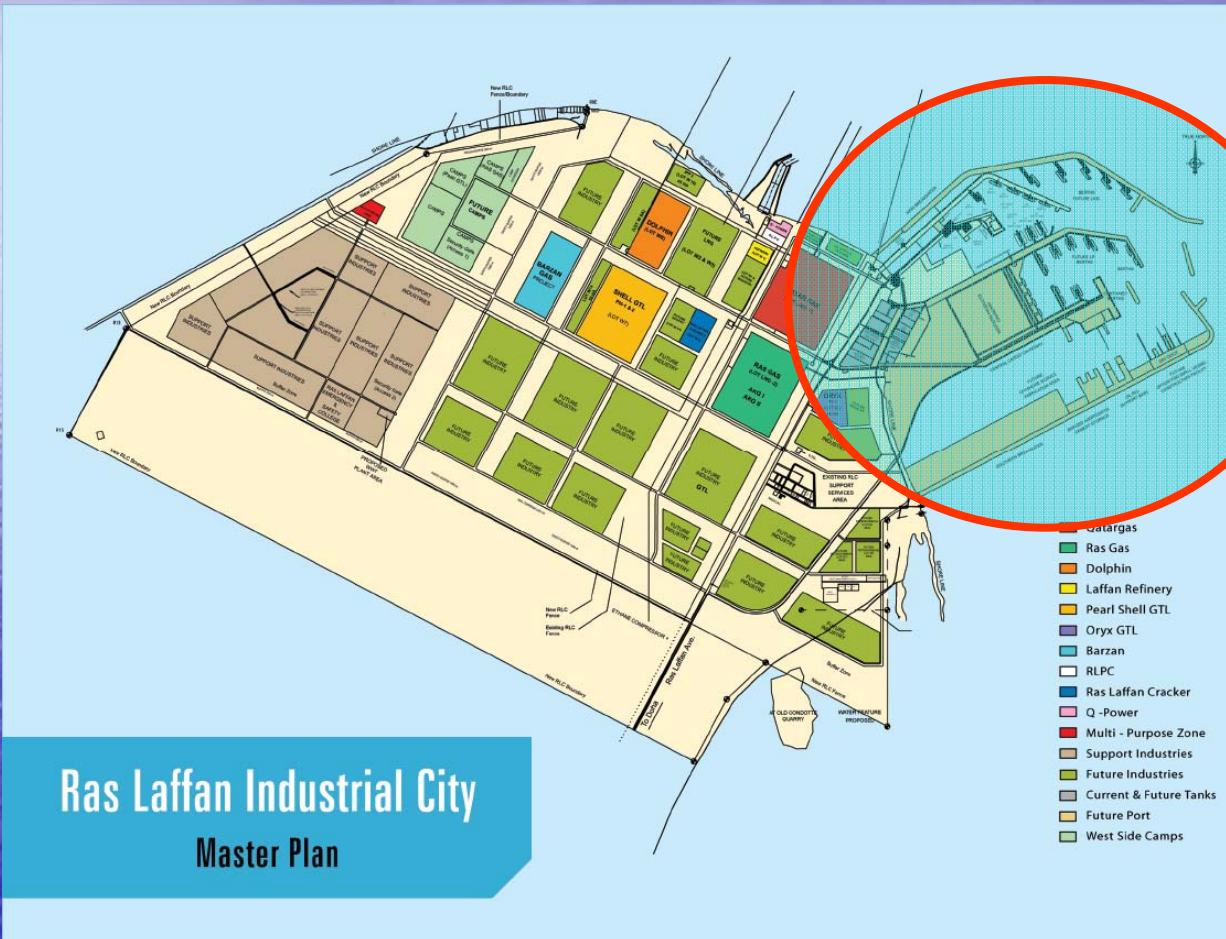


Q- Max LNG tanker at Daewoo Shipyard



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Introduction



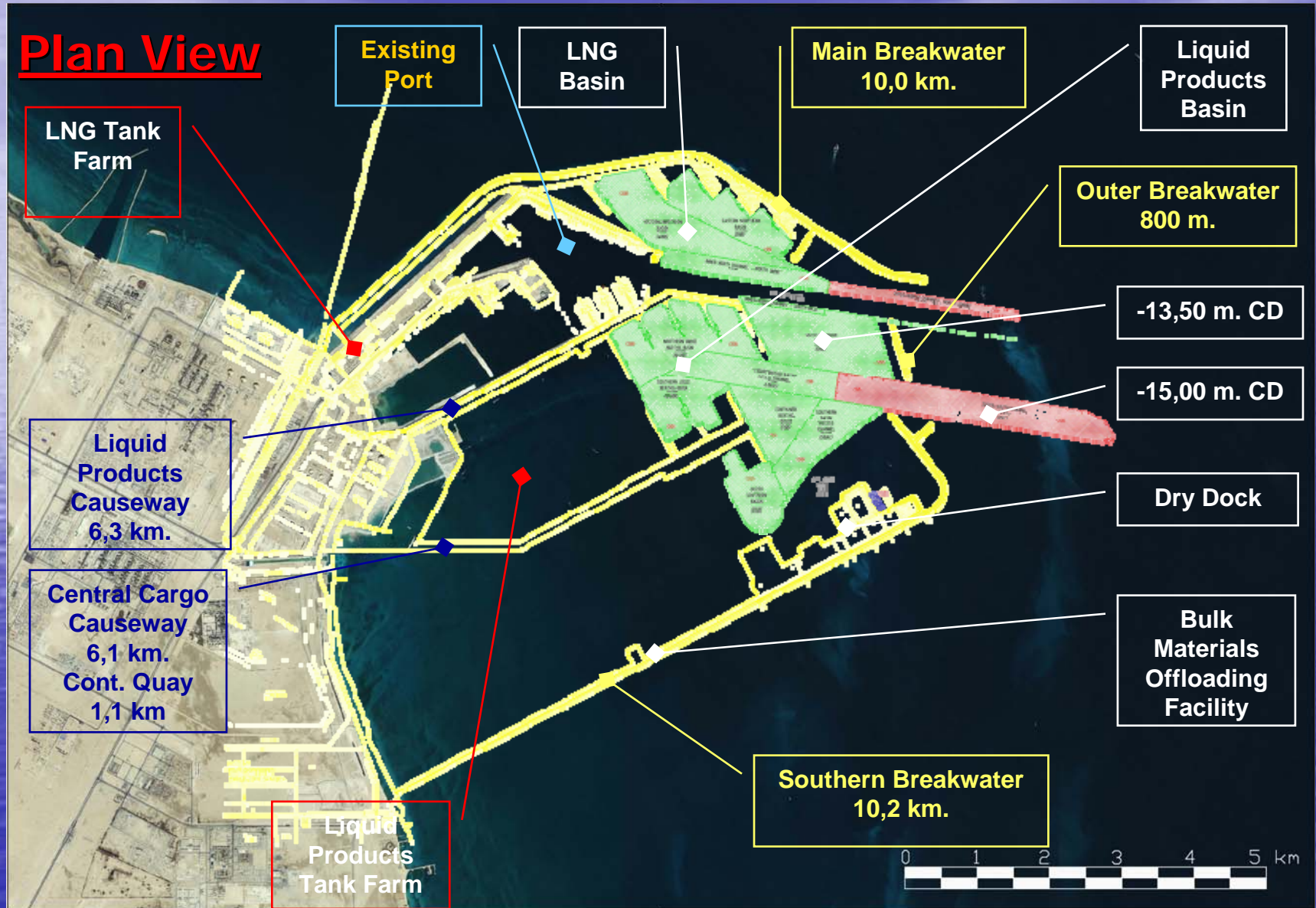
Ras Laffan Industrial City
Master Plan





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Plan View





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Contract

Client:

Qatar Petroleum

Main Contractor:

Jan De Nul Dredging Ltd

and

Boskalis Westminster Middle East Ltd

Ras Laffan Joint Venture

Contract Value:

Euro 677.253.666,00 + US\$ 1.291.570.750,71

Total Value: Euro 1.720.081.000,-



Start date: 17 November 2005

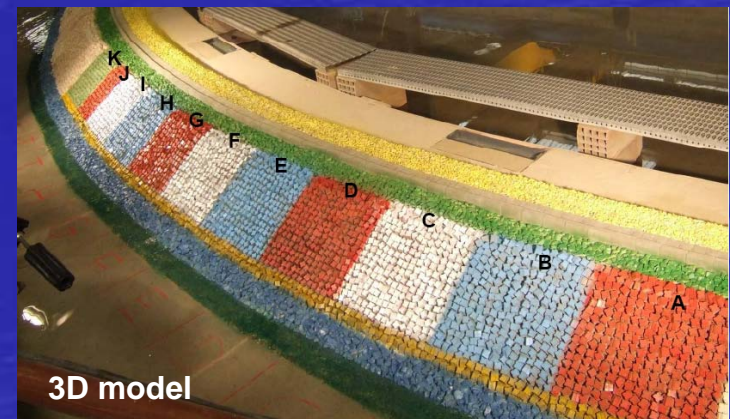
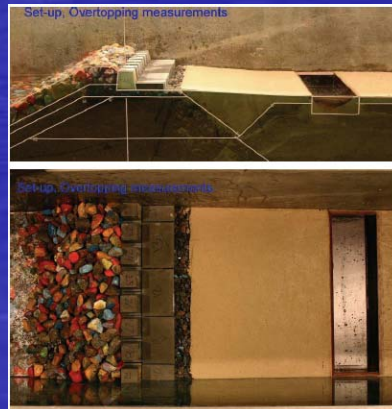
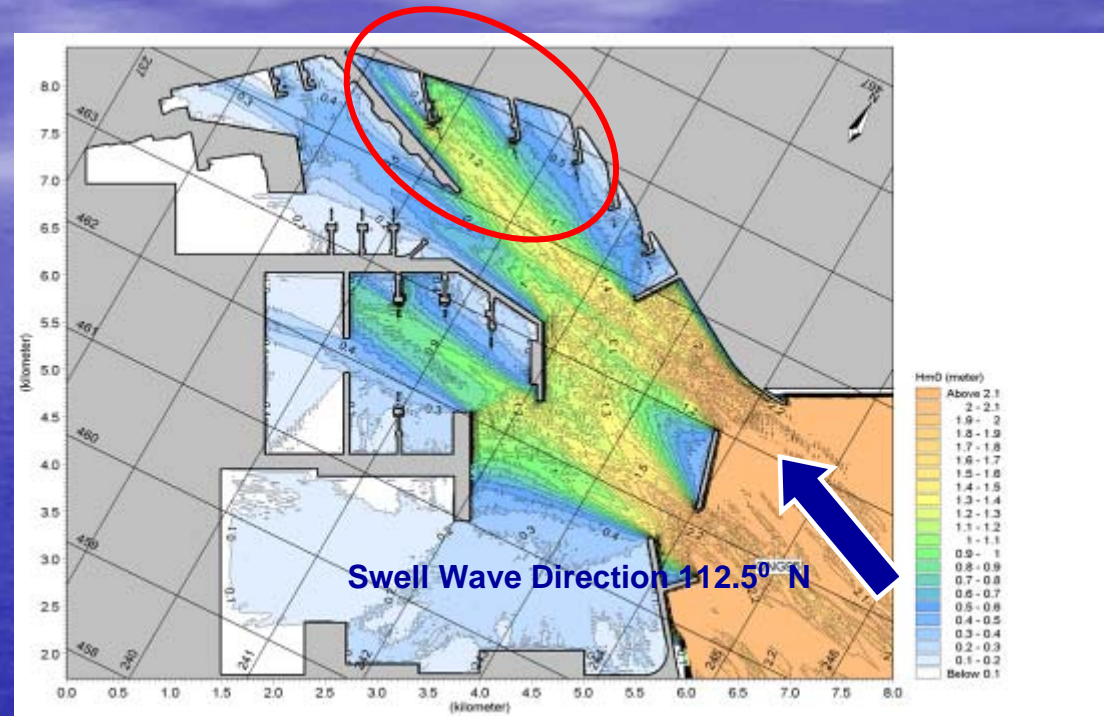
Completion Date: 30 October 2008



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Design

- Sogreah
- Grenoble, France
- DHI Denmark
- HR Wallingford UK
- Engineers Boskalis





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Design

- Return periods:
 - Operational conditions: 1y ARI
 - Survival conditions: 100y ARI
- Design wave conditions (100 y):
 - Main Breakwater: $H_{m0} = 4.52$ m; $T_p = 11.0$ s
 - Offshore Breakwater: $H_{m0} = 3.91$ m; $T_p = 9.4$ s
 - Southern Breakwater: $H_{m0} = 2.94$ m; $T_p = 8.7$ s
- Overtopping (at crown wall):
 - $Q = 0.02$ l/m/s (1y); $Q = 1.0$ l/m/s (100y)
 - No water on LNG pipes at all times
- Water levels:
 - Tide (MHHW): +1.47 m CD
 - Storm surge: 0.47 m (1y); 0.63 m (100y)
 - Sea level rise (50y): 0.50 m
 - TOTAL DWL: +2.45 m CD (1y); +2.60 m CD (100y)



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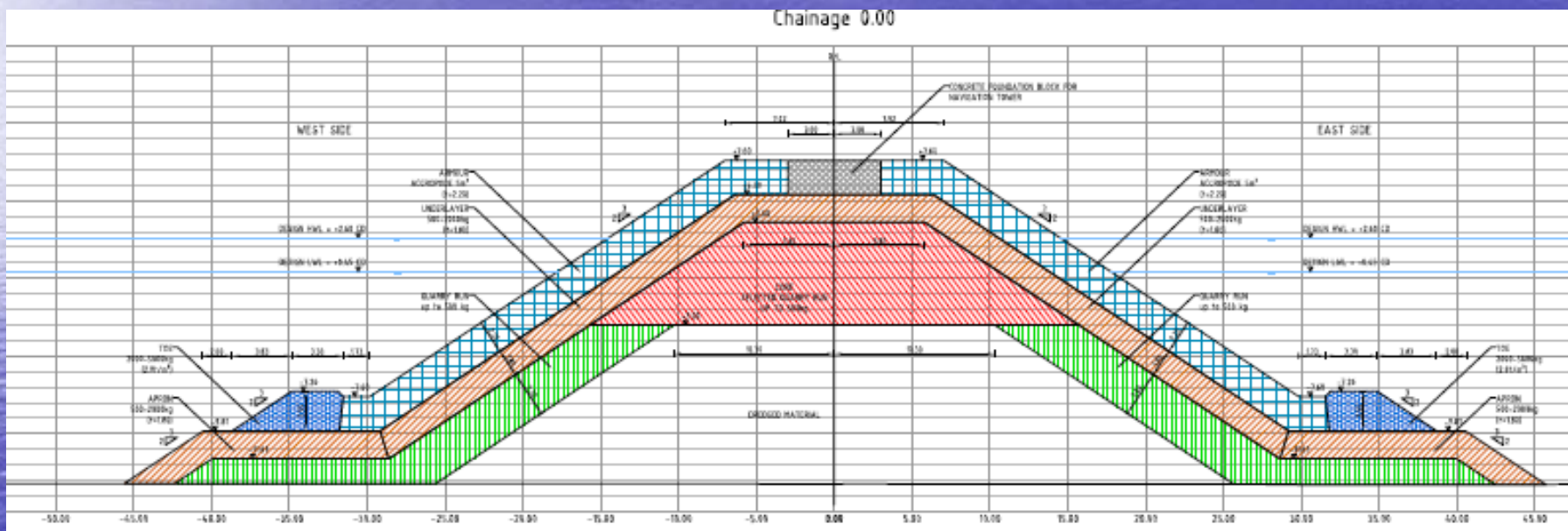
Design

- Waves inside the harbour:**
 - Main Breakwater:** $H_{m0} = 1.5 \text{ m}$; $T_p = 8.6 \text{ s}$
(Penetration of offshore swell)
 - Offshore Breakwater:** $H_{m0} = 0.90 \text{ m}$; $T_p = 3.0 \text{ s}$
 - Southern Breakwater:** $H_{m0} = 1.2 \text{ m}$; $T_p = 3.5 \text{ s}$
(Local wind waves generated in port basin!)
- Transmission:**
 - No criterion
- Method:**
 - Rock with Hudson and Van der Meer ($S = 2$)
 - Concrete elements with Hudson
 - Antifer units $k_D = 8$
 - Accropode $k_D = 15$
 - Toe stability
 - Overtopping: neural network and TAW formula



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Offshore Breakwater





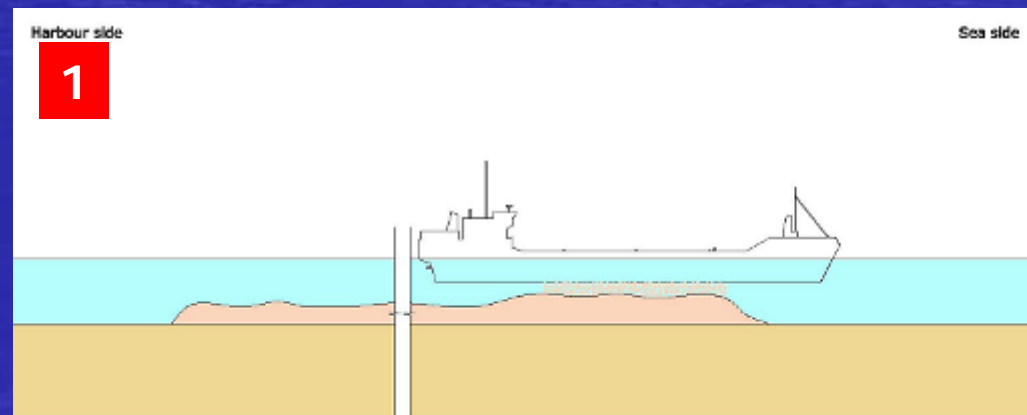
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Operations - Dredging

- Rock dredging by heavy duty cutter suction dredgers
- Barge loading with dredged material by cutter suction dredgers
- Dumping by barges of dredged material in breakwaters till -3,0 m CD



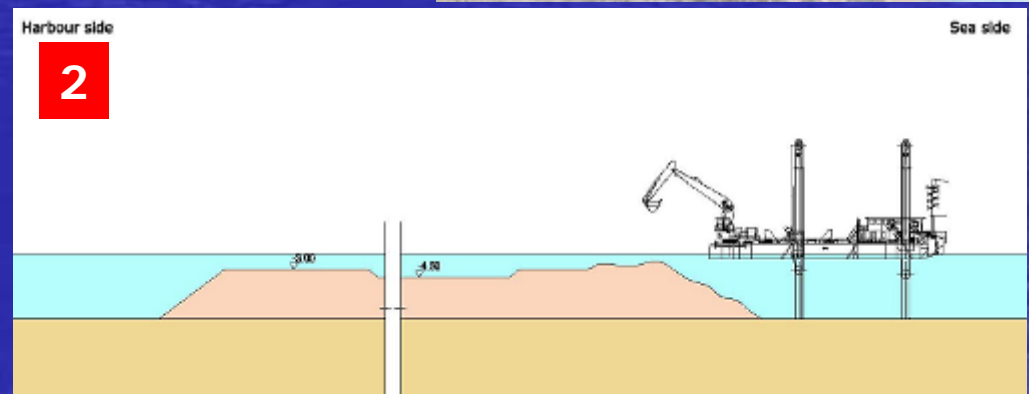
Cutter Suction Dredger 'Taurus II'





Operations - Trimming

- ❑ Slopes of dumped material in breakwaters trimmed by backhoes at designed slope (243 backhoe weeks)
- ❑ Surplus material loaded by backhoes and grab dredger in small barges and dumped elsewhere

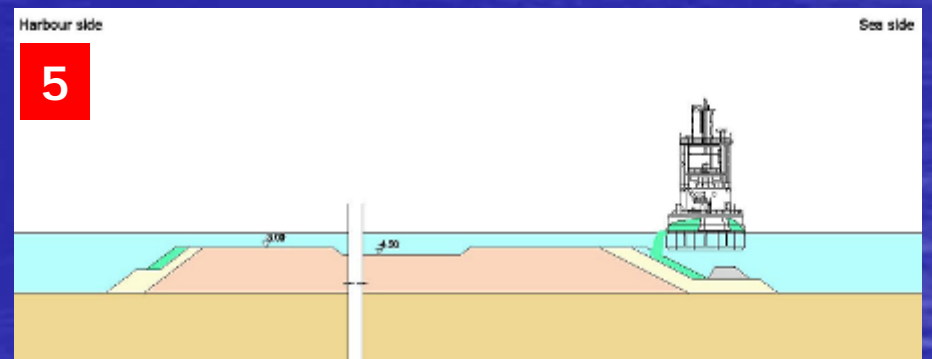
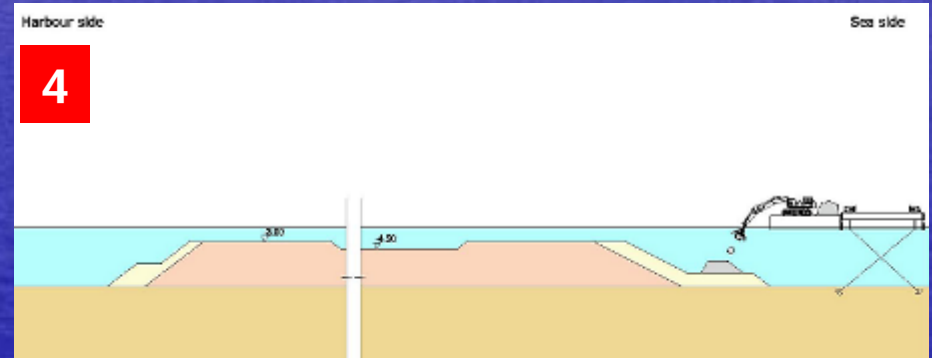
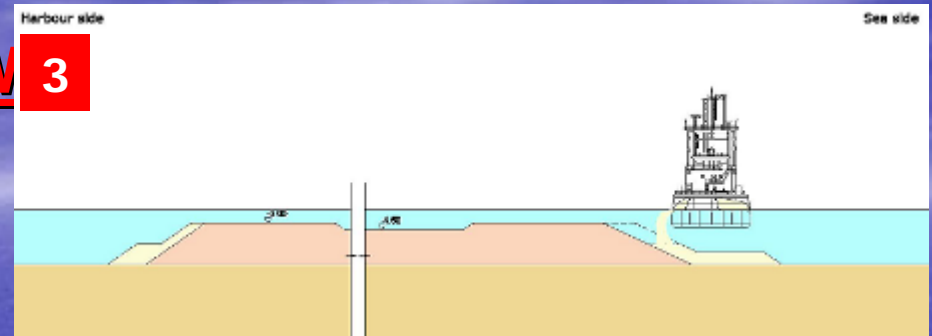




Operations - Protection BKW

- Slopes of dumped material in breakwaters protected till -3,0 m CD by selected quarry run and under layers of rock
- Use of SSDV's (Side Stone Dumping Vessels)

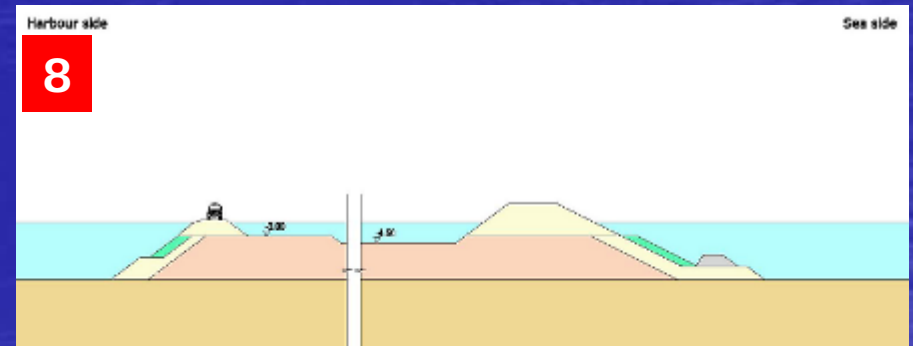
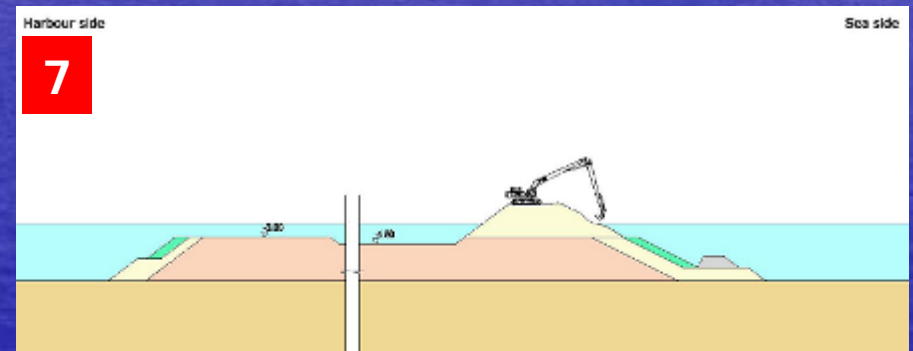
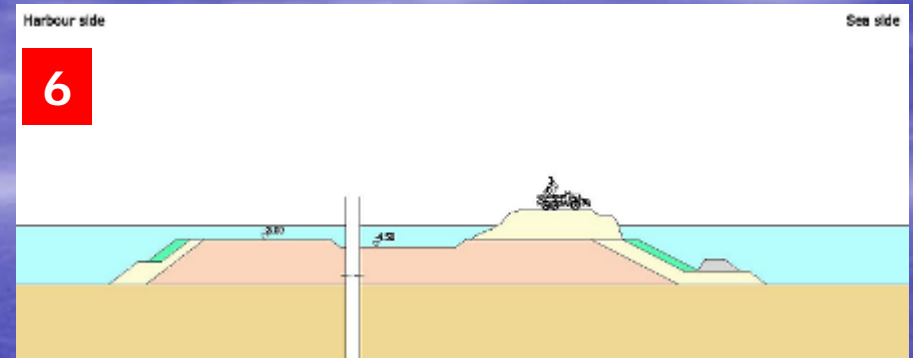
SSDV "HAM 602" dumping in MBK2





Operations - Bunds

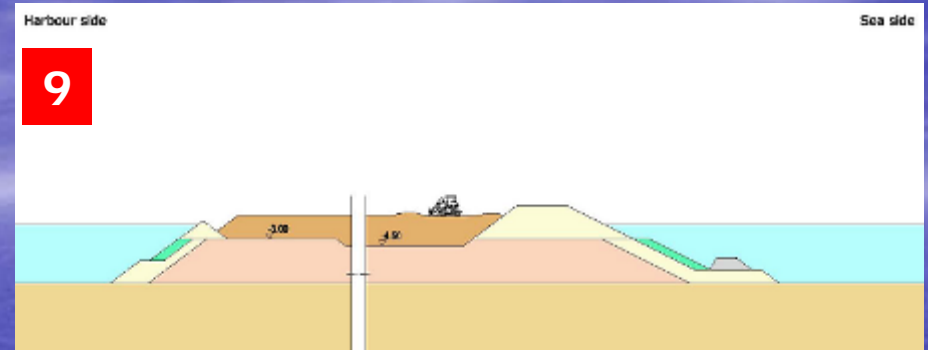
- Construction of bunds on both sides of the BKW's from general fill or quarry run or selected quarry run.
- Use of local rock transported and placed by trucks or dumpers





Operations - Reclamation

- Pumping of sand between bunds by TSHD's (Trailing Suction Hopper Dredgers)





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Operations - Reclamation Breakwaters





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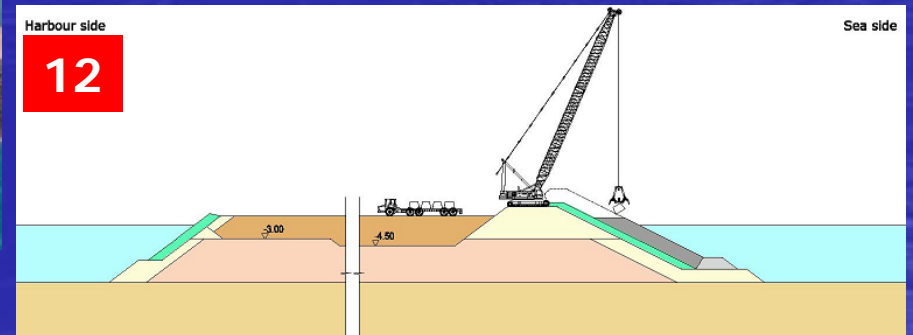
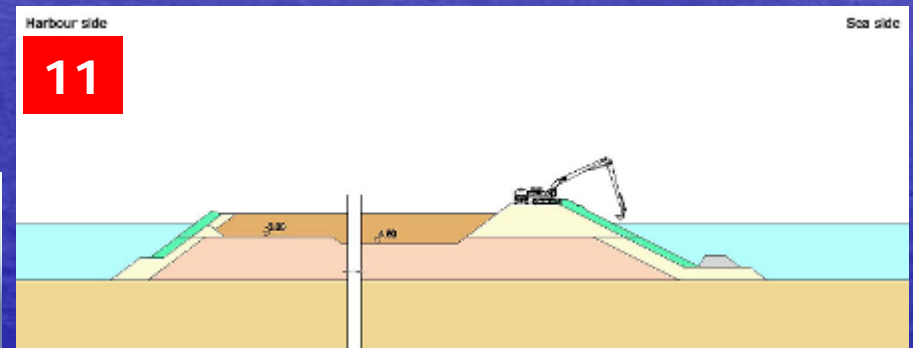
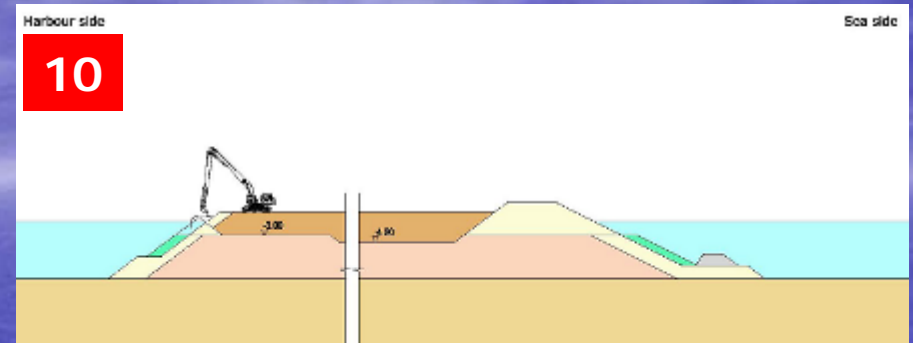
Operations - Reclamation Tank Farms





Operations - Profiling

- Profiling of selected quarry run by long boom hydraulic excavators
- Placing of under layers and armour (rock) by cable cranes



Placing geotextile



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Operations - Profiling

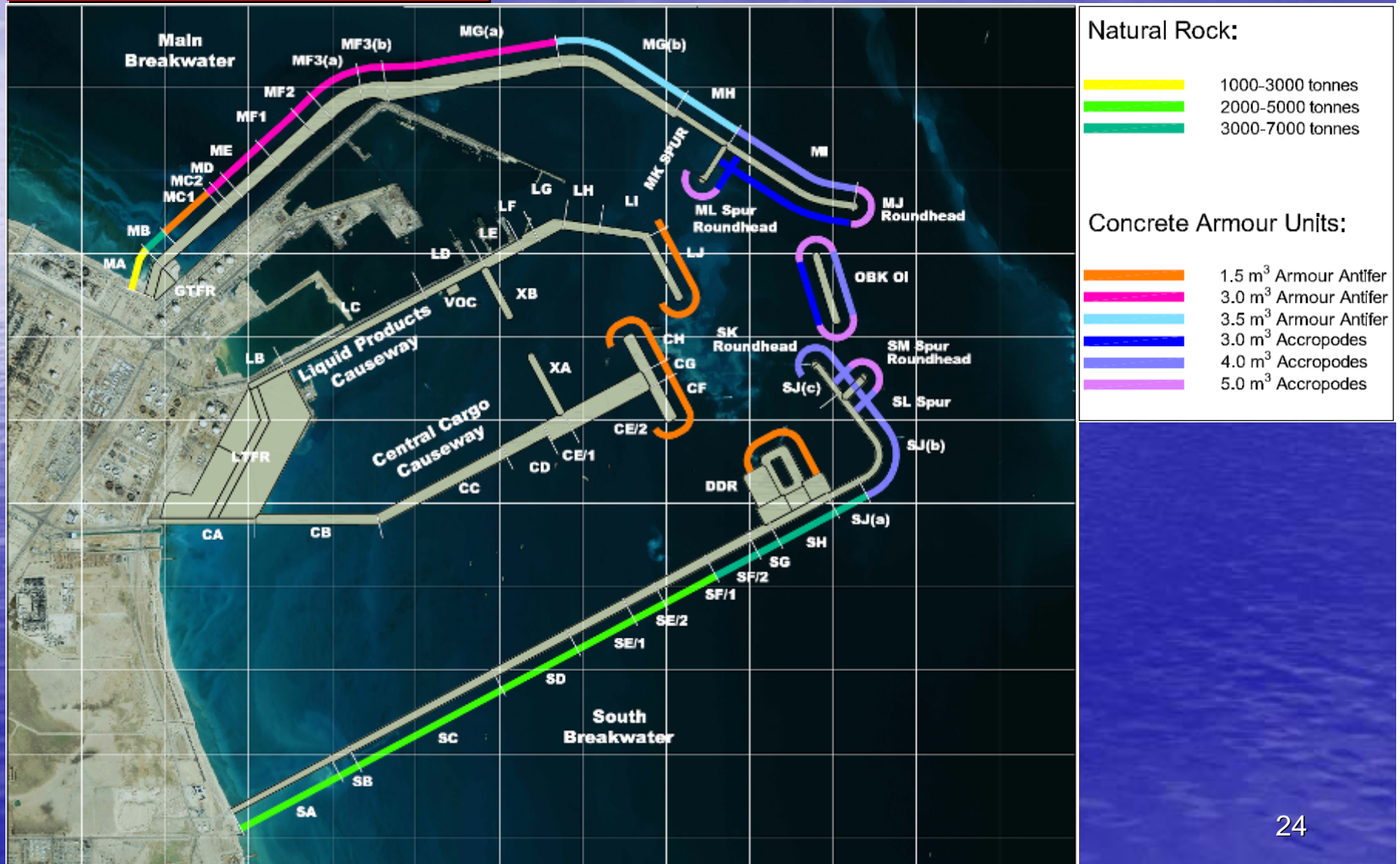
- Under layer and armour of rock (SBK)





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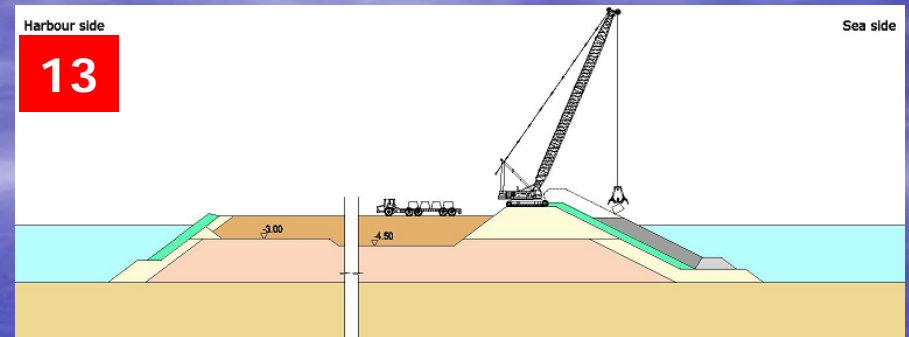
Operations - Armour





Operations - Armour

- Placing of Antifers and Accropods
- Cable cranes or hydraulic cranes are used





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Operations - Armour

- Outer side of main breakwater covered with antifers





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Operations - Armour

- ❑ Inner side of outer part main breakwater covered with accropods
- ❑ Placing last antiflers on outer part of main breakwater





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Operations - Armour



Trimming under layer before placing accropods

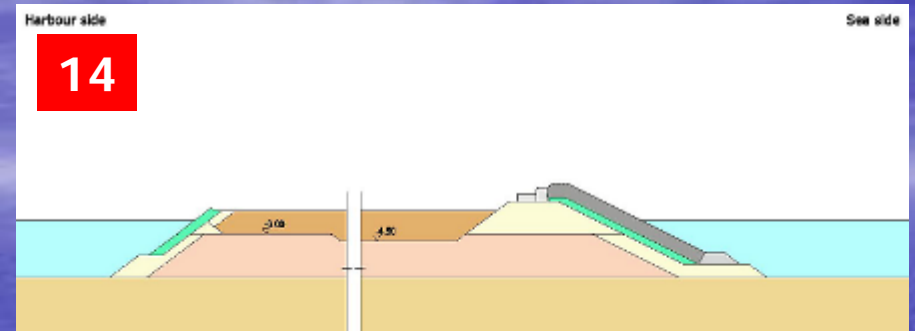


Operations – In-situ concrete

- Concrete road (slab) and crown wall on Main and Lee breakwater



Batching Plants





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Operations – In-situ concrete





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Operations – In-situ concrete

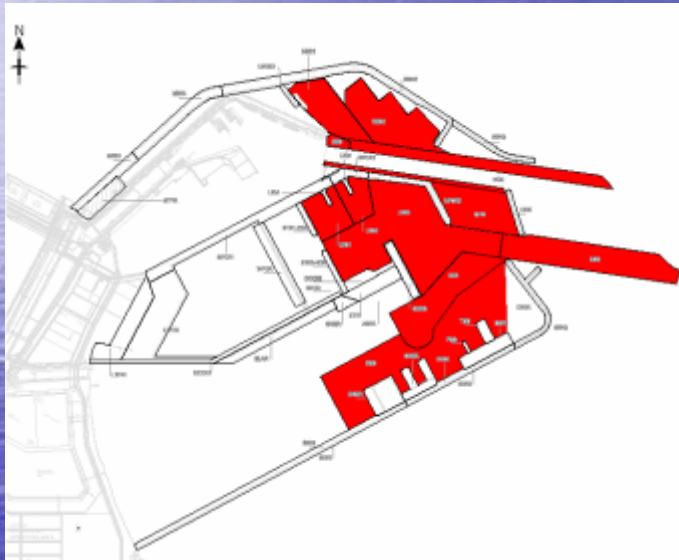




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Materials - Dredged Rock

- 23,8 million m³'s, but 26 million m³'s placed in core and reclamation BKW's and Dry-Dock





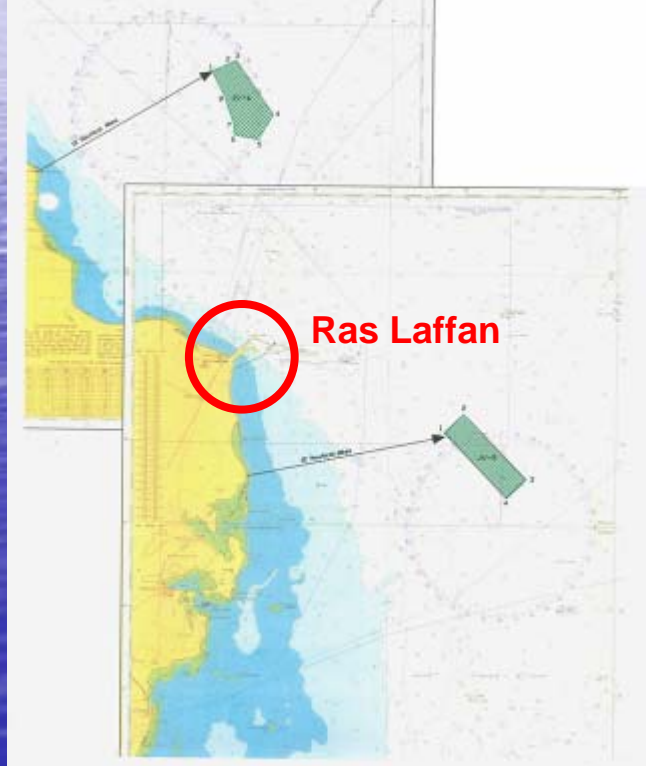
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Materials - Offshore Sand

□ 28,6 million m³'s (measured in TSHD)



2 borrow areas at 12 nautical miles from the shore



“Prins der Nederlanden”



“Queen of the Netherlands”

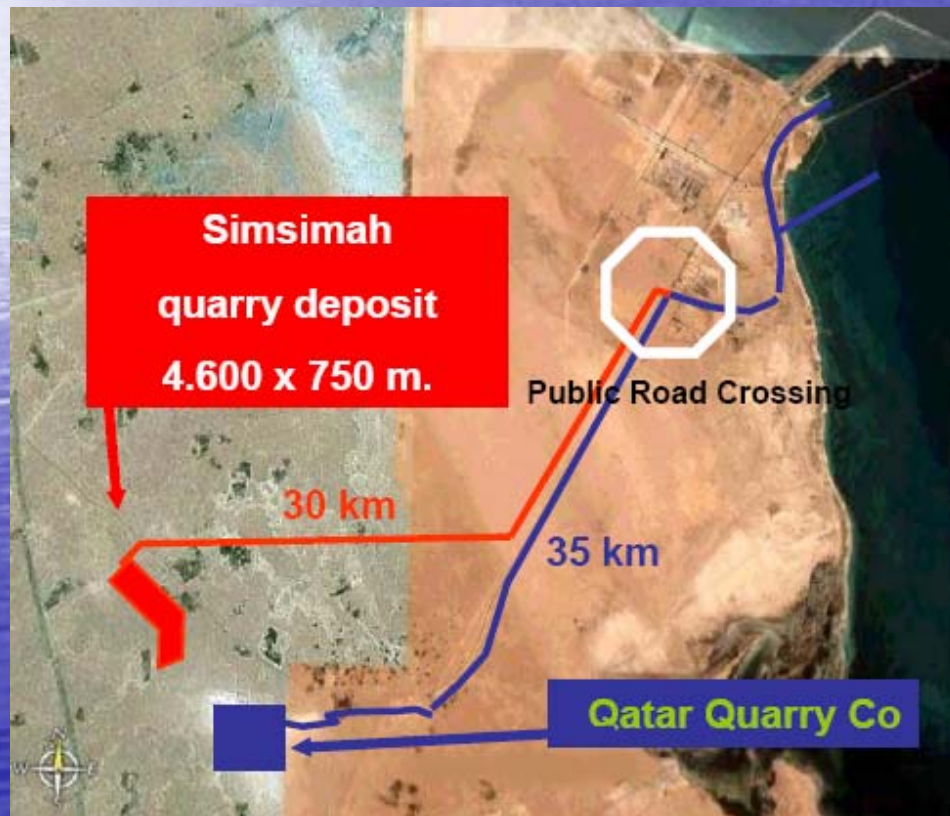




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Materials - Local Rock

□ 30 million tons





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Materials - Local Rock

Local trailers and trucks: average 1.500 trips/day
Around 350 trailers/trucks

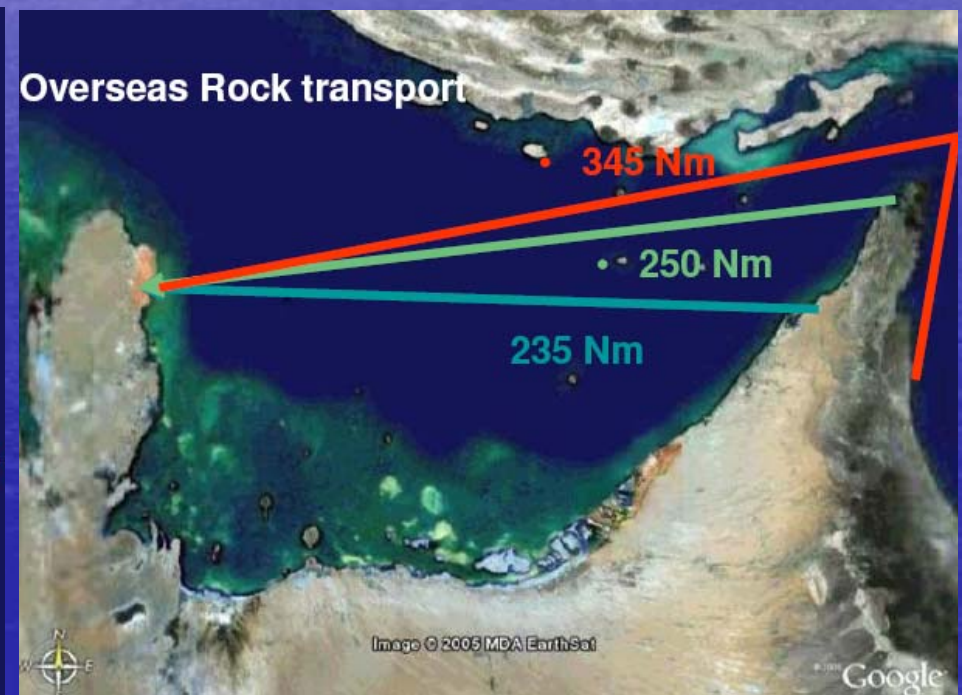
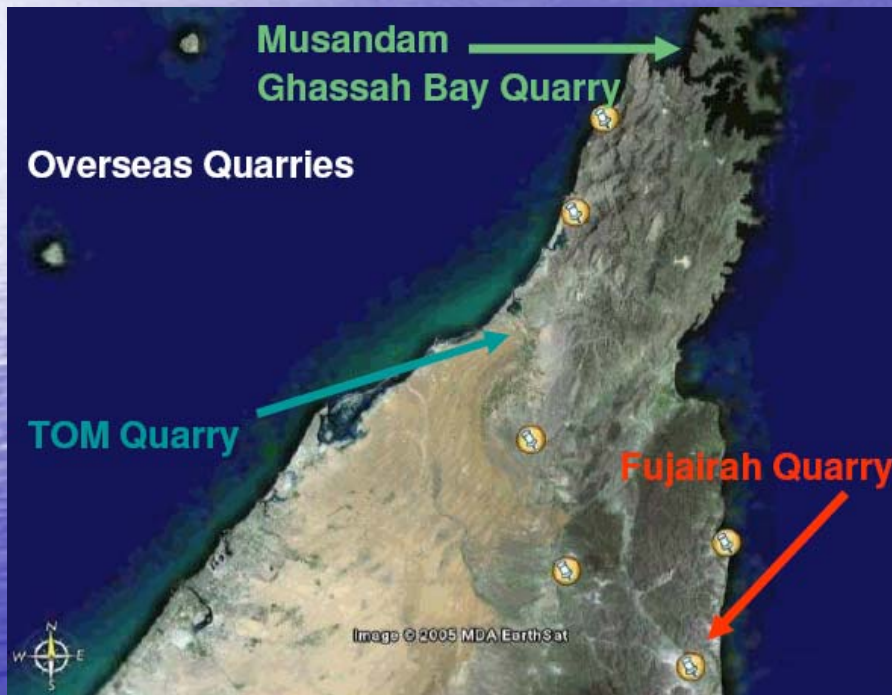




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Materials - Overseas Rock

- Transport on Pontoons towed by Tugboat





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Materials - Overseas Rock

□ 7,86 million tons

Tom Quarry of Archirodon in
Ras Al-Khaimah



Musandam - Oman



United Quarry in Fujairah





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Materials - Pre-cast concrete

□ Ajman Be-Six/Interbeton

Quantities	Total Required	Casted Units Approved by QP + Stock UAE *
Concrete units		
Antifer 1,5m ³	38,903	18,877 48.5%
Antifer 3,0m ³	86,311	84,080 97.4%
Antifer 3,5m ³	41,141	38,480 93.5%
Accropode 3,0m ³	27,605	11,628 42.1%
Accropode 4,0m ³	52,282	28,079 53.7%
Accropode 5,0m ³	3,504	1,459 41.6%
Total	249,746	182,603 73.1%

Total 770.744 m3 of concrete



28/03/2008





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Materials - Pre-cast concrete





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Materials - Pre-cast concrete





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Materials - Pre-cast concrete





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Questions?