The Storebælt Link

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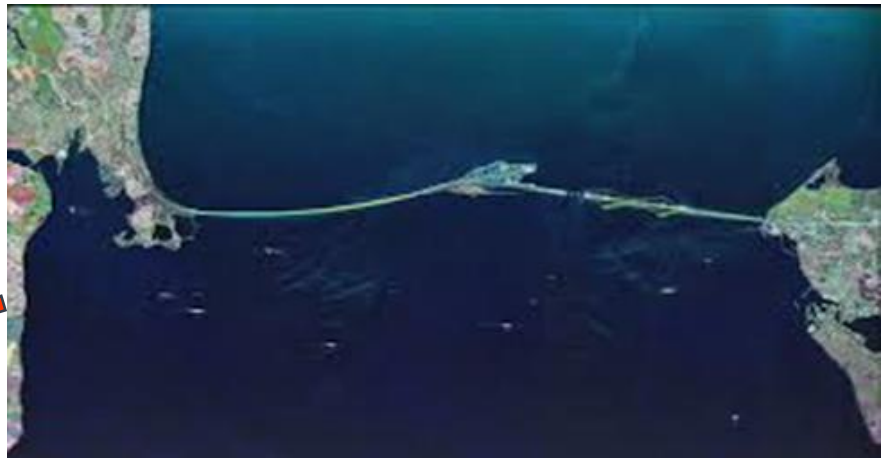
A Presentation for the ACI Technical Session:

«The Legacy of Per Fidjestøl»

Elkem
A Bluestar Company

Location



Project Parameters.

- **Eliminate Ferry Traffic**
  - **The journey time was approximately 1 hour**
- **Greatly increase travel flow**
  - **Fast traffic road**
  - **Full Rail Connection**
- **Permanent, long term link as part of the European Road Network.**
- **That is – a minimum 100 year design life (no major maintenance).**

Materials Specifications

Cement type:	**low alkali; sulfate resistant;**
	max. heat of hydration 320kj/kg.
Fly Ash:	**max. 25% >0.045mm; max. 4% LOI.**
Silica Fume:	**max. 10% >0.045mm; max. 2% LOI.**
Gravel:	**max. 5% stratification; max. 1% absorbtion;**
	min. 70% cubical grains.
Sand:	**max. 1% (vol) Alkali Reactive;**
	max. Alkali Expansion 0.5 (A), 1.0 (B)
	(ppt at 20 weeks);
	max. 1% mica.

Concrete Parameters

Design life: 100 years

Strength:	**50 MPa**	
w/cm:	**Mix A:**	**max. 0.35 (max. 135kg)**
	Mix B:	**max. 0.45 (max. 140kg)**
		(less severe exposure)
Cement:	**min. 300 kg/m^3**	
Fly Ash:	**min.15 % of total binder**	
Silica Fume:	**4 - 8 % of total binder**	
FA + SF:	**max. 25 % of total binder**	

Concrete Parameters

Air (< 0.035mm):	**max. 20% - min. 8% (of paste volume).**
Entrapped air:	**max. 7% (of paste voume).**
Specific Surface:	**min. 25mm^2/mm^3.**
Chlorides:	**0.1% of total powder.**
Alkalis:	**3kg/m^3.**

Cementitious Blends

kg/m³	East Bridge	Tunnels	West Bridge
Cement	315	335	320
Fly Ash	40	40	38
Silica fume	23	20	23

The Low Bridge

Two parallel 6,500m bridges
Passage height: 18m
Concrete volume: 430,000 m^3

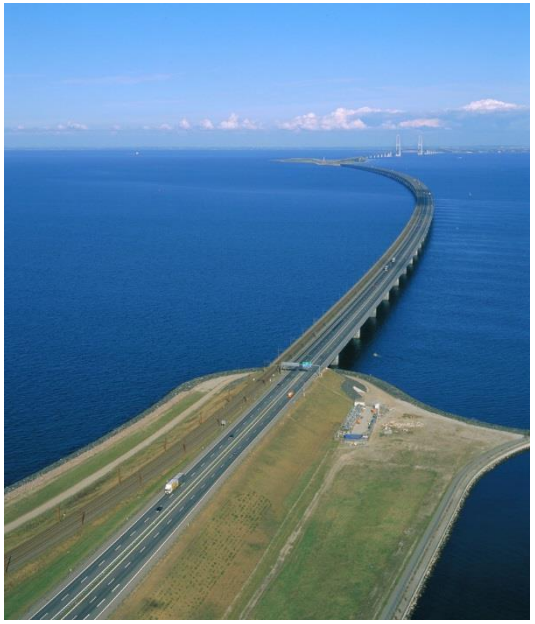
The Low Bridge

The Rail Tunnels

Two parallel 8,500m sub sea tunnels = 62,000 precast concrete lining elements

Concrete volume: 250,000m^3 + backfill

The Island ‘junction’



From the western shore, the twin bridges part company on the island

The High Bridge

Length of free span: 1,624m
Height of pylons: 254m

Main channel clearance: 65m
Concrete volume: 380,000m^3

The High Bridge

Bearing Out The Legacy

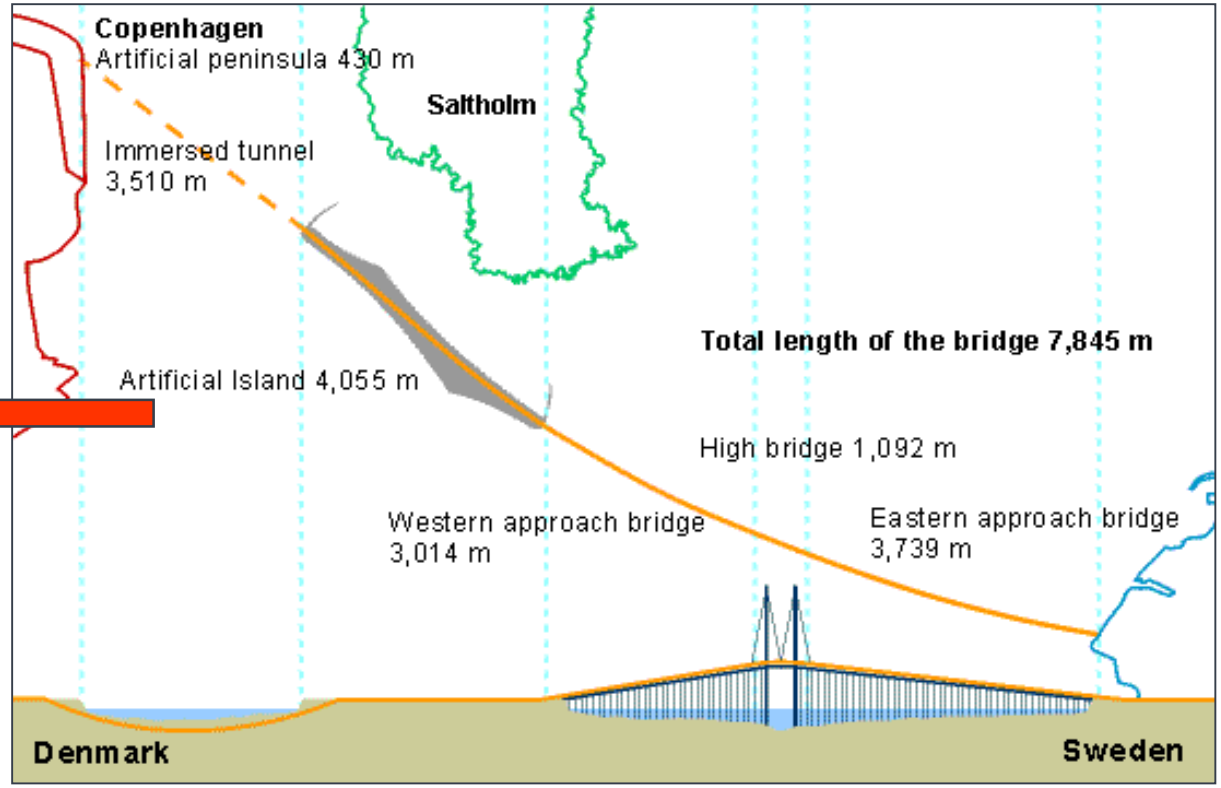
- **One of Per's major research areas was Marine Concrete: to improve the durability, strength and lifetime in that harsh environment.**

- **That research work – and the development of mixes on the Storebælt Project has led to the major use of binary, ternary, and even quaternary blends, on some of the major infrastructure bridges in the world.**

- **The durability and lifetimes of the spectacular bridges stand as statement to the work that Per initiated and worked on, along with respected colleagues from around the world, who have continued to develop these high durability concretes.**

- **Here are just 4 of those:**

The Øresund Connection



The Øresund Connection

Concrete requirements:

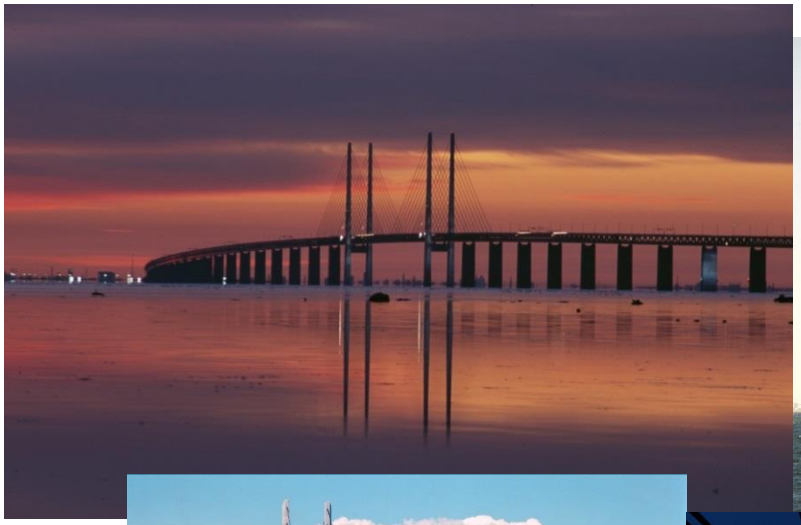
- **Service life 100 years**
- **w/cm < 0.40**
- **Low alkali cement**
- **Crack width < 0.20 mm**
- **High quality aggregates**

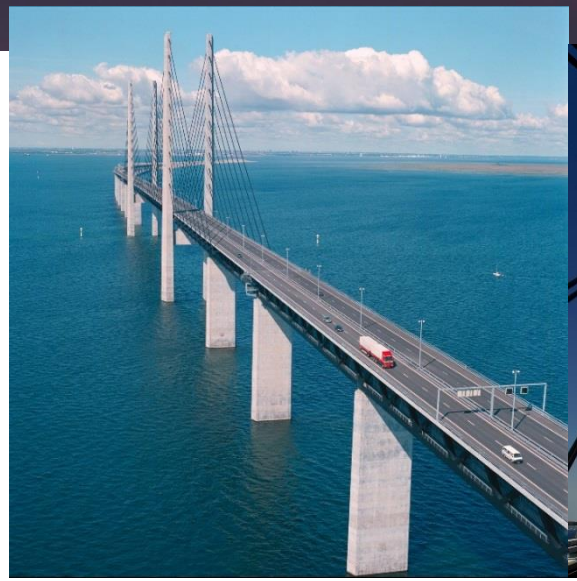
Danish side: **Concrete contains 15% fly ash and 5% silica fume**

Swedish side: **Concrete contains 5% silica fume**

Approximately 2 million cubic metres of concrete.

The Øresund bridge





Tsing Ma Bridge, Hong Kong

80MPa: 390kg mix at 30% OPC, 65% GGBS and 5% SF - Slipformed
Chloride Diffusion at less than 10^{-14}

The Bandra-Worli Sea Link, Mumbai

4.5 km twin bridge, two shipping channels

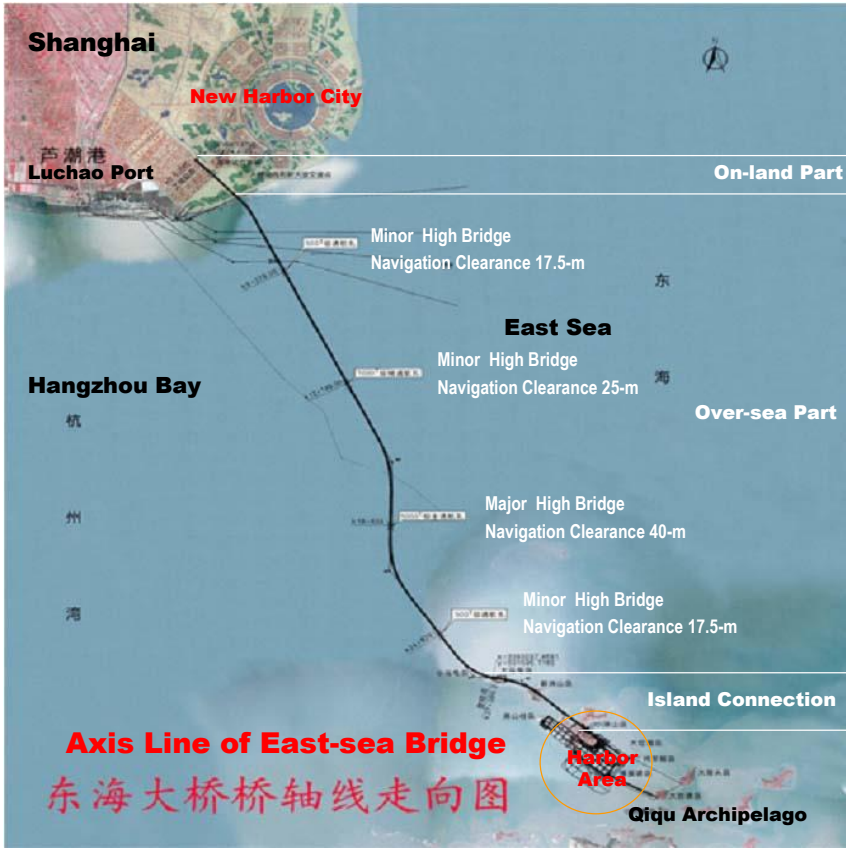
50 / 60 MPa mixes:
OPC/SF
OPC/FA/SF

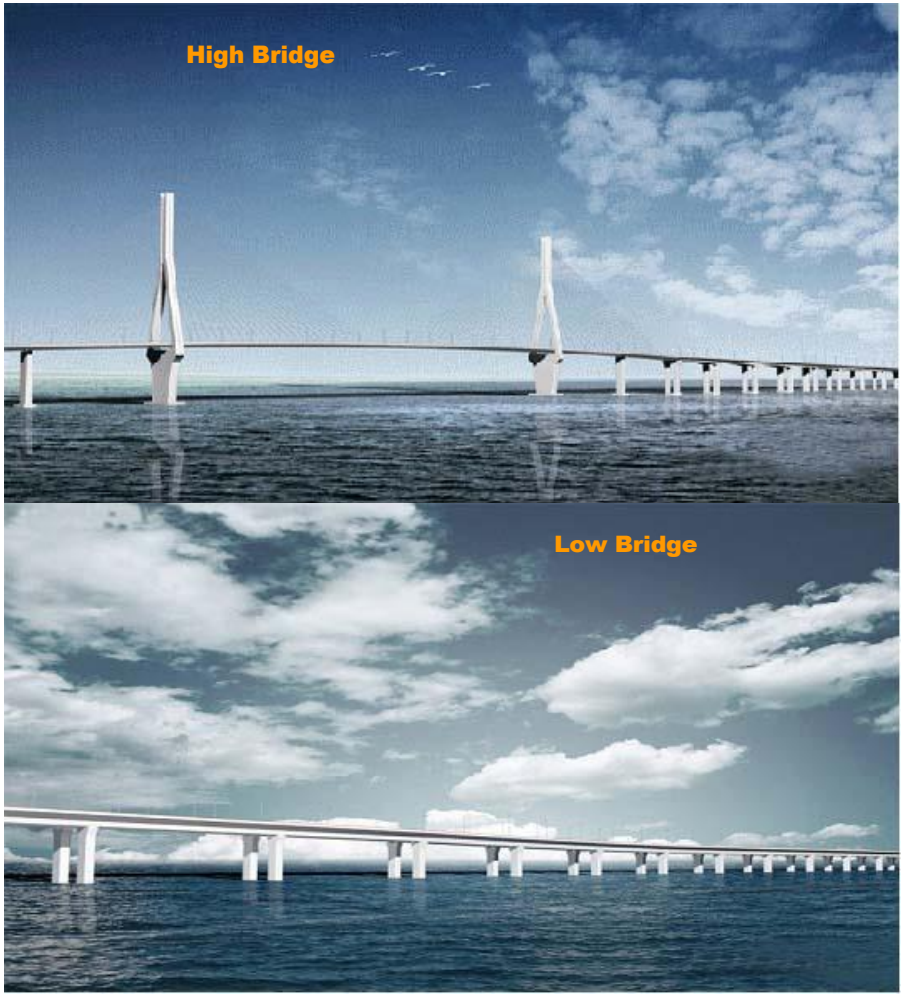
Strength and Marine durability:

75MPa at 28 days
RCPT – 600 coulombs
Water (Din 1048) - Zero

Four Lanes of Mumbai Traffic…

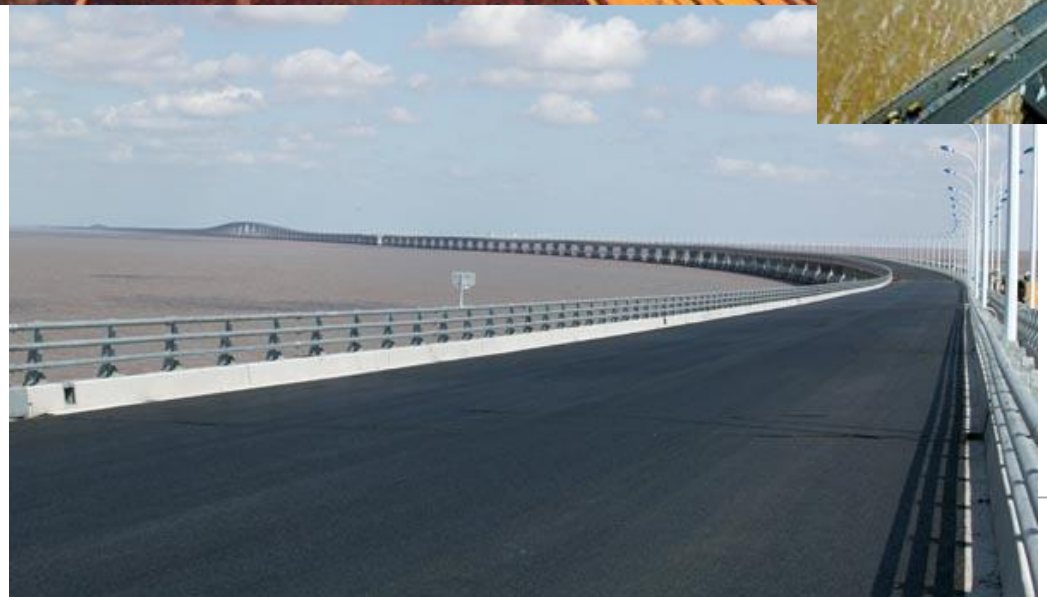
Shanghai East-Sea Bridge





32.5km road bridge.
35MPa and 50MPa
High Durability

Shanghai East-Sea Bridge



Design life: 100 years
Quad blend (PC/GGBS/FA/SF)
Built in less than 3 years.
Speed limit 50mph…

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THANK YOU.

Any Questions?

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