Major Bridge Projects - A Multi-disciplinary Approach - The Future

Parameters influencing design decisions:
- Safety
- Risk Management
- Prefabrication
- Life Cycle Costs
- Environment
- Experience
- Politics
- CLIMA, CO2
- Aesthetics
- Natural Resources
- Life Cycle Management

Structural Bridge Design

Decision and cost impact vs. project development phases:
- High
- Impact of decision making, flexibility and design uncertainty
- Cost commitment & Cost certainty
- Low

Project development phases:
- Master Planning & Political Process
- Concept & Feasibility Studies
- Political Decision
- Planning - detailed
- Design
- Construction
- Operation & Maintenance
- Decommissioning

Parameters:
- Socio-Economic aspects
- Transport & Environment
- Aesthetics
- Technical Constraints
- Sketches & Concepts
- Client organisation
- Management strategies
- Financing
- Materializing Strategies and Aims in Design
- Realize Designs
- Risk & Navigation Studies
- Procurement Strategies
- Design Basis
- Environmental Baseline Studies
- Environmental Conditions & Loads
- Durability Strategy
- Life Cycle Cost Analyses
- Aesthetics

Decision making, flexibility and design uncertainty:
- Time
- Vision
- Concept
- Solution
- Design
- Construction
- Operation

Reduced solution flexibility and design uncertainty
Integrated Multidisciplinary approach

- Life Cycle
- Safety, Reliability and Risk
- Environment
- Transport Demands
- Cost and Time
- Aesthetics

3 Major Fixed Links in Europe

- The Store Belt Bridge, Denmark
  Main span 1624 m

- Great Belt, East Bridge, Denmark
  1,624 m main span
Great Belt East Bridge, Articulation

Elevation Main Span 1624 m

The Store Belt Bridge, Anchor structure design

Storebelt East Bridge, Denmark
Span optimization, decision basis
**Storebelt East Bridge**

*Navigation simulation, Domain theory*

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**Oeresund Bridge, Denmark - Sweden**

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**Key Disciplines**

- Optimized and Innovative Design
- Value Engineering
- Optimized Construction
- Contract Management
- Procurement Strategies
Øresund Placing Bridge Elements with “Svanen”

Oeresund Bridge, Denmark - Sweden
100 % prefab. Piers and superstr.

Steel box girder corrosion protection
Dehumidification principles
Main cable corrosion prevention

- Corrosion of cables - a serious problem
- New and stricter requirements
  - Design life up 200 years
  - Minimal Life Cycle Cost (NPV)
- Dehumidification, State-of-the-Art System
- Based on technology with more than 35 years of bridge experience
- Prevents corrosion - instead of just slowing it down

Main advantages

- Corrosion is completely prevented and this is well documented
- Condition supervised by continuous monitoring
- The Life Cycle Cost is much lower, approx. 50 - 80%
- Environmentally friendly
- Well suited in all cases
  - Existing or new bridge
  - Parallel wires as well as strands

Lillebælt Bridge
Dehumidification of Main Cables

Faroe Bridges, Denmark
Continuous steel box girder, 1700 m
Hoga Kusten Bridge, Sweden
Continuous aerodyn. steel box girder

Hoga Kusten Bridge, Sweden
Winter conditions

Key Disciplines
Aesthetics

- Aesthetics
Haalogaland Bridge, Norway
Slender continuous steel box girder
1345 m main span

Sutong Bridge, Jiangsu Province, P.R. China
Longest cable stay span, 1088 m

Sutong Bridge, China
500 m cantilever erection

Stonecutters bridge, Hong Kong
First double box design, 1018 m span
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Stonecutters Bridge, Hong Kong
Erection process

Stonecutters Bridge, Hong Kong
Double box segment erection,

Stretto di Messina

The crossing of the Strait of Messina

Key Issues
- The world’s largest suspended span of 3300 m
- Road as well as rail traffic
- Triple box concept for the deck
- Seismic
- Wind
- Design life 200 years
Messina Bridge

Towers - Key Issues

- Aesthetics
- Severe impact from seismic loading
- Aerodynamic behaviour
  - Vortex shedding
- Optimize thickness/stiffeners
- Tight construction schedule
  - Fabricate/Erection 100,000 ts in 24 months

Messina Strait Bridge, Italy
First triple deck - 3.300 m span

Triple Box Concept for the Suspended Deck:

- Main elements: cross girders spacing 30 m
- Secondary elements: two longitudinal roadway girders and one central railway girder spanning between the cross girders
Gibraltar Bridge proposal, 3.500 m spans, 300 m water depth

Troll off shore platform, Norway
300 m water depth
Yemen - Djibouti Link
3.300 m continuous susp. spans

Qatar Bahrain Causeway Alignment alternatives

Qatar - Bahrain Causeway
Evaluation matrix
Sheikh Zayed Bridge, Abu Dhabi, UAE

District heating tunnel, Copenhagen
Fiber reinforced concrete

Herning footbridge - Experimental use of carbon fibre stay cables, posttension, and reinforcing in concrete deck

Fibre composites and stainless steel
Pedestrian bridge, Herning, Denmark
Fibre composites and stainless steel
Pedestrian bridge, Herning, Denmark

Lillebelt Bridge, Denmark
Aerodynamic steel box girder

Store Belt East Bridge – Guide Vanes

Extreme Bridge Spans
Great Belt
Girder Edges

Great Belt
Moveable Flaps
Effect of Moving Flaps

FLV Placeholder
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Fehmarn belt Bridge, Denmark
3 x 750 m spans (prelim proposal)

Concluding remarks

- **International trend** - integrated multidisciplinary approach - one iterative process.
  Transport demands, cost & time, risk, safety & reliability, life cycle, environment, aesthetics etc.

- **Innovative design** - cost effective design, prefabrication, large element erection, durability, maintenance, lighter structures, new materials, active aerodynamic control.

- **Innovation** - accumulating of knowledge, education, new techniques, new materials, new methods

Thank you for your attention