Project:	**Forth Replacement Crossing Study**	Job No:	**49550TEDT**
Subject:	**Comparison of other Tunnels and Bridges**	Date:	**3rd November 2007**
Checked by:	**Simon James and Chris Dulake**	Date:	**2nd November 2007**
Approved by:	**Ian Dudgeon**	Date:	**6th November 2007**

1.0 Introduction

As part of the Forth Replacement Crossing Study, Transport Scotland has requested Faber Maunsell to prepare a report with a comparison of tunnels and bridges across the world with the options proposed in Report 4: Appraisal Report.

This study will briefly examine the following items:

- Location of tunnel or bridge
- Date of construction
- Length and size
- Construction duration
- Cost
- Multi-modal capacity
- Comparisons with the proposed tunnel or bridge
- Photographs

2.0 Tunnels

Sections 2.1 and 2.2 set out project data from bored and immersed tube highways tunnels. Table 1 below provides comparative data for the possible options suggested for the Firth of Forth tunnel crossing. Section 2.3 provides a discussion of key points.

Immersed Tunnel - Corridor C2				
Location	**Construction Type**	**Section Size**	**Section Length**	**Duration**
Northern Approach	Cut & Cover	W:30m H:10m	300m	5.5years
Forth Crossing	Immersed Tube	W:28m H:10m L:120m/unit	2425m	
Southern Tidal Zone	Cut & Cover	W:30m H:10m	600m	
Southern Approach	SCL	100m^2 , 12m wide	2825m	

Bored Tunnel - Corridor C				
Location	**Construction Type**	**Section Size**	**Section Length**	**Duration**
Northern Portal	Cut & Cover	W:30m H:10m	200m	
Northern Approach	SCL	$100m^2$, 12m wide	1300m	7.5years
Forth Crossing	TBM	12m Ext Dia	4400m	
Southern Approach	SCL	$100m^2$, 12m wide	2600m	

Bored Tunnel - Corridor D				
Location	**Construction Type**	**Section Size**	**Section Length**	**Duration**
Northern Approach	SCL	$100m^2$, 12m wide	2150m	
Forth Crossing	TBM	12m Ext Dia	3600m	7.5years
Southern Approach	SCL	$100m^2$, 12m wide	1550m	

Table 1 – Option Data for Firth of Forth Tunnel Crossing

2.1. Bored Tunnels- Option C and Option D

Figures 1 to 3 below set out key data associated with major international tunnelling projects constructed using tunnel boring machines. The tunnels are lined using precast concrete segments. This data has been extracted from Report 4: Appraisal Report: Volume 2; Tunnels Technical Annex. There are information sources available on the internet, one source is:

http://www.roadtraffic-technology.com/projects/#Tunnels

where several of the reference projects below are described.

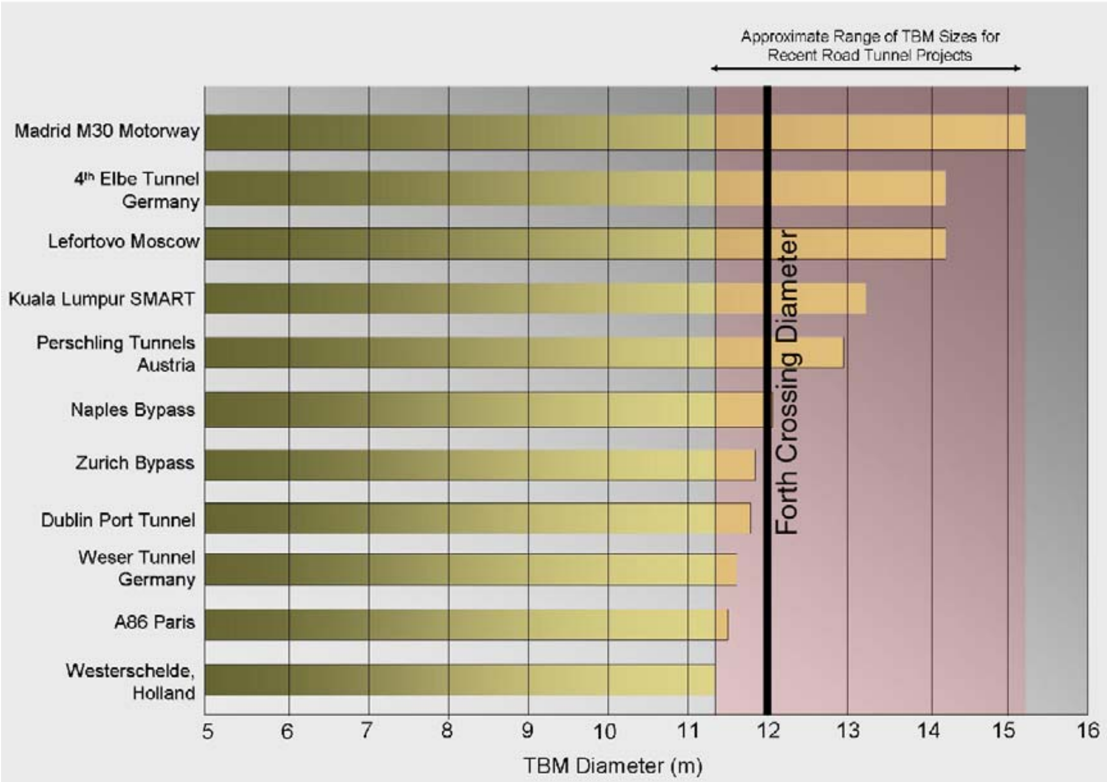


Figure 1: TBM Tunnels –external diameters

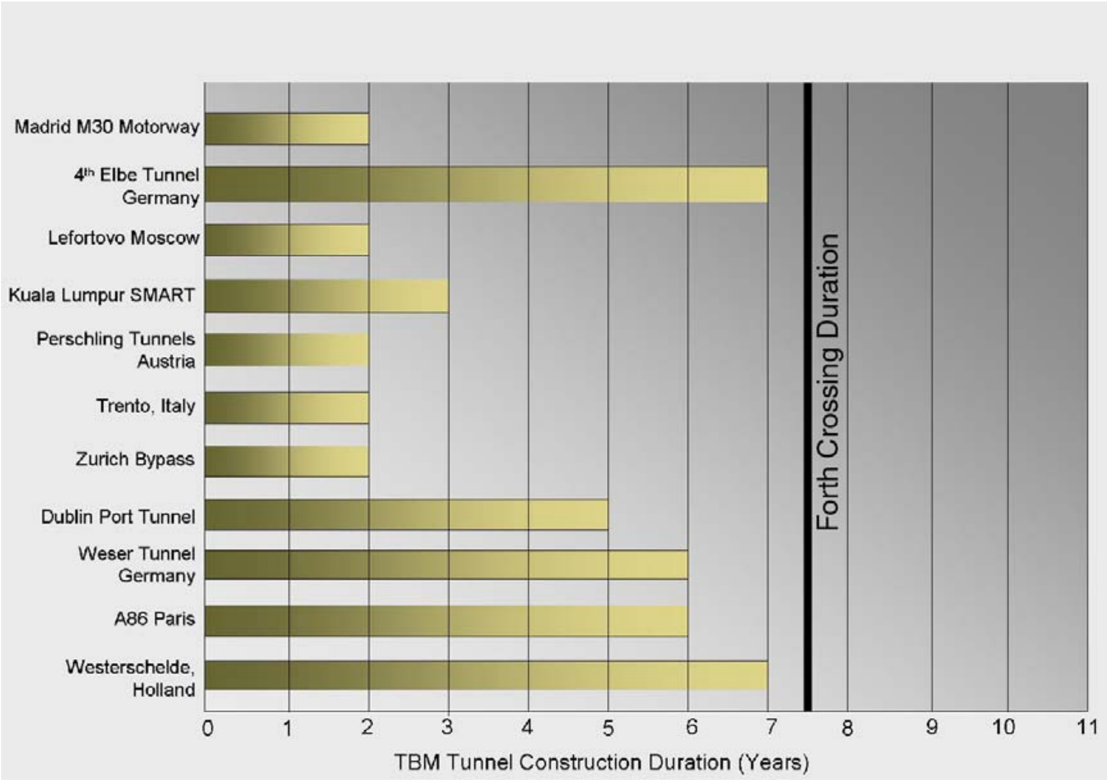


Figure 2: TBM Tunnels –construction programme

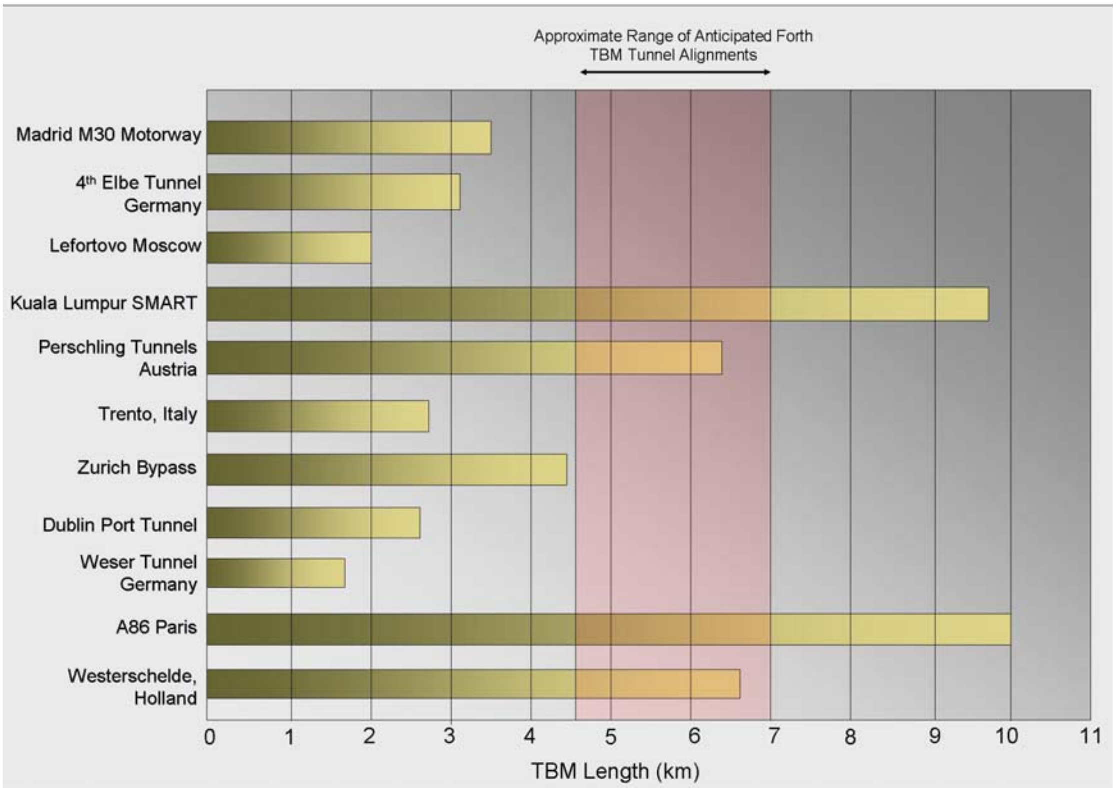


Figure 3: TBM Tunnels –tunnel length

PROJECT	DATE COMPLETED	COST	MULTI-MODAL
Madrid M30 Motorway	Ongoing	€792	No
4th Elbe Tunnel	2002	Not available	No
Lefortovo, Moscow	2003	Not available	No
Kuala Lumpur, SMART	2007	US $514M	Multi-functional. Includes storm sewer.
Perschling Tunnels, Austria	Not available	Not available	No
Trento, Italy	2002	Not available	No
Zurich Bypass	Not available	Not available	No
Dublin Port Tunnel	2006	€752M	No
Weser Tunnel, Germany	Not available	Not available	No
A86 Paris	2007	€2.23Bn	No
Westerschelde, Holland	2003	€726M	No
Additional Project: Chongming South Channel Tunnel	Ongoing	RMB 12.3 Bn	Yes, Utilities and light Rail on lower deck

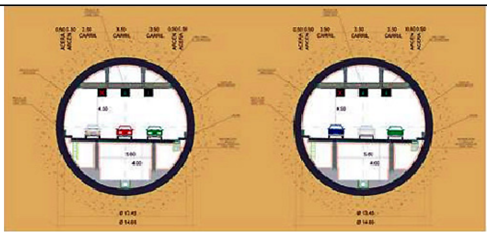
Table 2: TBM Tunnels-other data requested

Chongming South Channel Tunnel- Additional information

The 7.5 km Chongming South Channel Tunnel will be the world longest bored tunnel underneath water. This tunnel is part of the 25.5 km long Shanghai – Chongming expressway, linking the Changxing and Chongming islands to the city. The expressway consists of the tunnel and a cable bridge from Chang Xing Island to Chongming Island. The tunnel section comprises two 15.3 m OD tunnels, which are the largest TBM tunnels in the world, connected by eight cross passages. The length of each tunnel is approximately 7.5 km and there is a further 1.5 km approach road.

The tunnel will be a double-deck tunnel. The upper part will be a three lane city road; the lower part will house the utilities and a light railway.

The tunnels will be excavated in soft ground. Ground freezing technique will be used for cross passage construction. Cast iron lining segments will replace the 650 mm thick concrete at the junction between the bored tunnel and cross passage. Maunsell AECOM was appointed as independent consultant to undertake design review of the preliminary designs done by the local design institute and providing expert advice on various technical matters, including civil, geotechnical, structural, electrical and mechanical aspects.

Madrid M30 Motorway		
Dublin Port Tunnel		
A86 Paris		

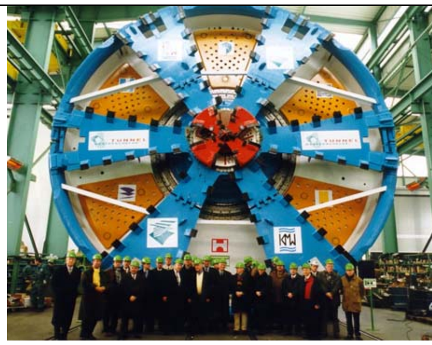
Westerschelde, Holland		
Additional Project: Chongming South Channel Tunnel		 

Table 3: Compilation of photographs from the above projects

2.2 Immersed Tube Tunnel

Table 4 below sets out key data associated with major international immersed tube tunnelling projects. There are fewer examples of this form of road tunnel. The base data has been extracted from Report 4: Appraisal Report: Volume 2; Tunnels Technical Annex.

PROJECT	DATE COMPLETED	COST	MULTI-MODAL	LENGTH & SIZE L X (H X W X UNIT LENGTH)	CONSTRUCTION PERIOD
Jack Lynch Tunnel Ireland. (Dual two lane)	1999	IR£70M	No	1.9km x (8.5m x 24.5m x 120m)	4 years
Ted Williams Tunnel, Boston, USA. (Dual two lane)	1996	Not available	No	2.6km x (1.2km underwater) x (6m x 24m x ?)	Not available
Thomassen Tunnel, Netherlands. (Dual Three Lane)	2004	DFL 350,000,000	No	1km x (9m x 34m x ?)	5 years
Warnow Tunnel, Germany. (Dual two lane)	2003	€224M	No	790m x (9m x 23m x ?)	Not available
Öresund Crossing, Denmark (Dual two lane plus Rail)	1998	DN KR 3.8Bn	Yes Includes cell for light rail.	3.5km x (9m x 41m x 120m)	7 years
Medway Tunnel, UK. (Dual two lane)	1996	£80M	No	585m x (9m x 24m x 126)	4.5 years

Table 4: Immersed Tube Tunnels

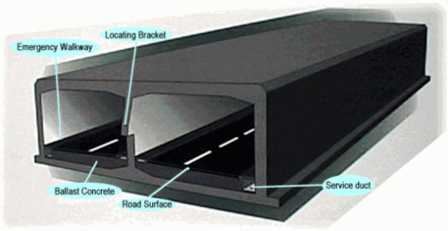
Jack Lynch Tunnel Ireland. (Dual two lane)		
Öresund Crossing, Denmark (Dual two lane plus Rail)		
Medway Tunnel, UK. (Dual two lane)		

Table 5: Compilation of photographs from the above projects

2.3 Discussion

2.3.1 Option Selection

The reason why each tunnel type was selected or why these were selected in preference to a bridge in each example project is not known. However, the driving generic criteria are highlighted below.

Marine Engineering

- A bridge would require less marine engineering than an immersed tube tunnel
- Large vessels and hence deep channels push tunnels deeper and the tendency is to adopt bored tunnels or bridges rather than immersed tube tunnels.
- High current velocities, highly mobile sediments and the presence of contaminants in silts present challenges with a tendency to adopt bored tunnels or bridges rather than immersed tube tunnels.

- The presence of rock in the marine trenches favours bored tunnels as drill and blast in a marine environment is not recommended and is expensive to execute.
- Bored tunnel in very soft sediments are not favoured as the circular segmental structures can be unstable and less watertight than immersed tube tunnels. Immersed tube tunnels perform well is these materials when they are constructed at shallow depth in low current environments. Bridges have higher founding pressures than immersed tube tunnels and hence can be precluded if ground conditions are poor.

Steepness of Land Fall on either side of the Channel
As highway tunnels require maximum gradients to be applied for safety and operational considerations, finding suitable shoreline landing sides is a difficulty for both immersed tube and bored tunnels. Bored tunnel solutions can be excessively long as maximum gradients are defined. This favours immersed tube tunnel solutions. However the approach structures which can be cut and cover, cause significant temporary disturbance at ground level.

Bridges overcome the problem associated with steep shorelines and hence alignment gradients.

Geology of the Crossing
If significant quantities of hard rock are present along the alignment in soft estuarine or marine soils at shallow depth, this may preclude the use of immersed tube tunnels. If the river channel is formed of hard rock with limited marine or estuarine deposits a bored tunnel or bridge would be the preferred choices. If geologically old (consolidated) soft soils are present over the length of the crossing an immersed tube tunnel would be favoured.

Environmental Impact
A balance will need to be drawn between the impact of the infrastructure in the temporary and permanent conditions. Bored tunnels are likely to pass beneath the channel with no noticeable signs of construction activity. Immersed tube tunnels will have an impact on the shoreline and marine environment but provide overall a shorter and probably cheaper alternative to a bored tunnel. Both generate large quantities of spoil that will need to be disposed of but the final solution is less visually intrusive.

Bridges can be iconic, aesthetically pleasing structures but have a higher visual impact than an immersed tube or bored tunnel.

Cost of Construction
The cost of construction of a bored tunnel per linear meter is cheaper than an immersed tube tunnel but the length of tunnel needed is longer. On balance immersed tube tunnels have a tendency to provide overall, cheaper tunnel solutions. Per linear meter bridges are the cheaper of the three solutions.

2.3.2 Programme Considerations.

The length of tunnel, rate of progress of tunnel construction and the overall programme do not necessarily show a consistent pattern. This can be for several reasons:

- Varying geology and hence progress

- Investment in plant. It is accepted that for shorter tunnels less than 1km the cost of buying bespoke plant is more expensive than accepting low production rates.
- Larger diameter tunnels are driven more slowly smaller ones.
- Some project data includes the construction of other infrastructure that cannot be separated to provide compatible base data.

2.3.3 Double stacked highways

The data indicates that double stacked bored tunnels have been adopted. This has only been achieved by compromising the size of vehicles accepted in the tunnel. For example, this is only possible for the A86 in Paris by limiting headroom to 2.1m. This means that only light vans can use the highway, hence precluding lorries.

Compromises can be made to achieve a higher number of vehicles using the tunnel but access would need to be restricted. It is understood that for the Firth of Forth crossing lorries will be accepted applying the headroom requirements for the Trans-European Road Network.

The maximum size of any bored tunnel in the world is 15.43m external diameter (see section 2.1). At this stage we do not believe that it is possible to double stack highway lanes using the currently defined headroom.

3.0 Bridges

Two bridge forms have been proposed for the Forth Replacement Crossing. One option is a cable stay option with 2 main spans of 650m with its central pylon founded on Beamer Rock. The second option is a Suspension bridge with a main span of 1375m which spans over the Grangemouth and Rosyth navigation channels.

Both bridge forms have multi modal capacity. The following table is Table A2 extracted from Report 3 and summarises the major long span bridges with multi modal capacity

Long Span Bridges with Rail Loading

Bridge	Type	Span	Rail loading
Tsing Ma, Hong Kong	Suspension	1377m	2 tracks, medium loading (airport shuttle trains)
Tagus, Lisbon, Portugal	Suspension	1013m	2 tracks, medium loading (passenger & goods)
Minami Bisan-Seto, Japan	Suspension	1100m	2 tracks, provision for 2 tracks for bullet train (See Note 1 below)
Kita Bisan-Seto, Japan	Suspension	990m	2 tracks, provision for 2 tracks for bullet train (See Note 1 below)
Shimotsui-Seto, Japan	Suspension	940m	2 tracks, provision for 2 tracks for bullet train (See Note 1 below)
Ohnaruto, Japan	Suspension	864m	Provision for 2 tracks for bullet train (See Note 1 below)
Rainbow, Japan	Suspension	570m	2 tracks, medium loading (passenger)
Øresund, Denmark/Sweden	Cable stayed	490m	2 tracks, heavy loading

Note 1: It is believed that, for these bridges the rail loading is medium to light loading with heavy locomotive.

Width of Bridge

In the following descriptions of various suspension and cable stay bridges, it can be seen that the width of the bridge varies from bridge to bridge. A comparison of the elements which make up the width is provided for each bridge considered in the following sections wherever this data is available. The width of the bridge depends on several factors, namely:

- Number and width of traffic lanes. The proposed New Forth Crossing would be Dual 2 with each lane at a width of 3.65m. In many parts of the world, lane widths are slightly less at 3.5m
- Presence of hard shoulder and width. The proposed New Forth Crossing has hard shoulders of 2.75m as stated in Report 4. It is understood that Transport Scotland are exploring the option of increasing the hard shoulder width to 3.3m. In many of the bridges researched for this report, the hard shoulder is significantly less than 2.75m.
- Legislation regarding working widths to safety barriers and central reserve widths. For the New Forth Crossing it was proposed in Report 4 to use a working width of 1.3m. The central reserve is proposed to be 3 m.
- Provision for cyclists/ pedestrians and provision of maintenance access ways. For the New Forth Crossing, an access way with a minimum width of 2.6m has been proposed. This access way will also act as a combined footway/ cycleway. In many of the bridges researched for this report, the access way is significantly reduced with no provision for access vehicles on a separate access way.
- Provision of wind-shielding. It was found during the Setting Forth studies in the mid 1990s that the deck width needed to be increased, if wind-shielding was provided, in order to ensure aerodynamic stability. As noted in Report 3, this extra width is used to accommodate the access way and pedestrian/cycleway noted above.
- Multi-modal capacity. As noted in Report 4, the bridge deck can be modified to provide multi-modal capacity. Report 4 describes how this capacity can be provided by either widening the deck or by providing a double deck solution. The report concluded that the provision of light rapid transit (LRT) at the centre of the bridge would be the most economic and most structurally favourable solution. A double deck solution would keep the deck width to a minimum, but the deck structure would need to be radically changed with the result that the deck would be heavier and would be more expensive. The sides of the deck could be enclosed by a structural cladding system in order to provide a stream-lined shape for aerodynamic stability. In addition ventilation would need to be introduced possibly along the centre-line of the bridge deck. Within the enclosed box emergency access routes would need to be provided either side of the LRT.

3.1 Cable Stay Bridges

The table below is Table A3 extracted from Report 3 and summarises the world's largest cable stay bridges

World's Longest Cable Stayed Bridges

Ranking	Name	Span (m)	Completion Date	Construction Duration (Years)
1	Sutong, China	1088	Expected 2009	
2	Stonecutters, HK	1018	Expected 2008	
3	Tatara, Japan	890	1999	6
4	Pont de Normandie, France	856	1995	7
5	Second Yangtze	628	2001	4
6	SkyBridge, Canada	616	1990	?
7	Rion-Antirion, Greece	560	2004	6 (including dredging)
8	Skarnsund, Norway	530	1991	?
9	ohlbrandbrucke, Germany	520	1974	4
10	Mumbai, India	500		

3.1.1 Examples of Cable Stay Bridges

Rion-Antirion Bridge

Bridge Data

Bridge Location	Greece
Date and Duration of Construction	1998 – 2004 (6 years)
Main Span length (m)	560
Total Bridge Length (m)	2880 including approach spans
Bridge Width (m)	27.2
No of Lanes	2 lanes in each direction, narrow (2m) emergency lanes
Original Cost (and currency)	800 million Euros
Multi – Modal Capability	No

Comparisons between Bridge and Proposed New Forth Crossing

The bridge has a direct comparison as it is a multi-span cable stay bridge. The tower type based on an inverted Y is also similar to the proposed scheme. However, the deck construction is a ladder style construction using steel girders composite with concrete slab. The main spans at 560 m are shorter than that proposed for the New Forth Crossing.

Comparison of Bridge Width with New Forth Crossing

	New Forth Crossing (m)	**Rion – AntiRion (m)**
Carriageway	7.3 x 2 =14.6	7.0 x 2 = 14.0
Hard Shoulder/ Strip	2.75 x 2 = 5.5	2.0 x 2 = 4.0
Width for access way, cables	4.9 x 2 = 9.8 (includes space for access vehicles)	2.85 x 2 = 5.9 (insufficient space for access vehicles
Stream – Lined Shaping	1.2 x 2 = 2.4	0
Central Reserve	3.0	1.5
Set back for Safety Barriers	0.6 x 2 = 1.2	Included in Hard Shoulder
Working Width for Safety Barriers	1.3 x 2 = 2.6	0.6 x 2 = 1.2
Edge beams	0.45 x 2 = 0.9	0.4 x 2 = 0.8
Total	40	27.2

Tatara Bridge

Bridge Data

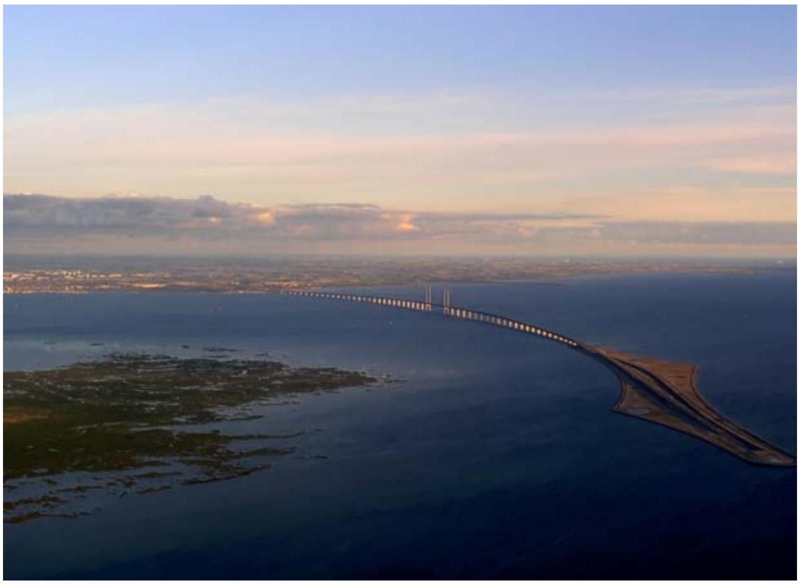
Bridge Location	Japan
Date and Duration of Construction	1993 – 1999 (6 years)
Main Span length (m)	890
Total Bridge Length (m)	1480
Bridge Width (m)	30.6
No of Lanes	
Original Cost (and currency)	
Multi – Modal Capability	No

Comparisons between Bridge and Proposed New Forth Crossing

This bridge is currently (in 2007) the longest span cable stay bridge in the world and is included for comparison. The deck construction is a steel box girder similar to the New Forth Crossing. Each pylon is a twin-legged inverted Y constructed from reinforced concrete. The proposed New Forth Crossing pylons consist of a 4 –legged inverted Y.

	New Forth Crossing (m)	Tatara
Carriageway	7.3 x 2 =14.6	7.0 x 2 = 14.0
Hard Shoulder/ Strip	2.75 x 2 = 5.5	1.75 x 2 = 3.5
Width for access way, cables	4.9 x 2 = 9.8 (includes space for access vehicles)	5.04 x 2 = 10.08
Stream – Lined Shaping	1.2 x 2 = 2.4	0
Central Reserve	3.0	2.5
Set back for Safety Barriers	0.6 x 2 = 1.2	Included in access way width
Working Width for Safety Barriers	1.3 x 2 = 2.6	Included in access way width
Edge beams	0.45 x 2 = 0.9	0.26 x 2 = 0.52
Total	40	30.6

Oresund Bridge



Bridge Data

Bridge Location	Denmark - Sweden
Date and Duration of Construction	1995-1999 (4 years)
Main Span length (m)	490
Total Bridge Length (m)	7845
Bridge Width (m)	32
No of Lanes	4 Highway plus 2 Rail
Original Cost (and currency)	
Multi – Modal Capability	Yes

Comparisons between Bridge and Proposed New Forth Crossing

The Oresund Bridge has multi-modal capacity. The deck consists of a double deck with highway traffic located on the top level and rail traffic located on the lower level. The main span at 490 m is less than that proposed for the New Forth Crossing. The pylons are H-shaped.

Comparison of Bridge Width with New Forth Crossing

	New Forth Crossing (m)	**Oresund (m)**
Carriageway	7.3 x 2 =14.6	7.0 x 2 = 14.0
Hard Shoulder/ Strip	2.75 x 2 = 5.5	2.5 x 2 = 5.0
Width for access way, cables	4.9 x 2 = 9.8 (includes space for access vehicles)	4.4 x 2 = 8.8
Stream – Lined Shaping	1.2 x 2 = 2.4	0
Central Reserve	3.0	3.0 (Approx)
Set back for Safety Barriers	0.6 x 2 = 1.2	Included in Hard Shoulder
Working Width for Safety Barriers	1.3 x 2 = 2.6	Included in Hard Shoulder
Edge beams	0.45 x 2 = 0.9	0.6 x 2 = 1.2
Total	40	32 Approx

Kap Shui Mun Bridge

Bridge Data

Bridge Location	Hong Kong
Date and Duration of Construction	1997 completed
Main Span length (m)	430
Total Bridge Length (m)	820
Bridge Width (m)	35.7
No of Lanes	6 lanes plus 2 Rail tracks
Original Cost (and currency)	
Multi – Modal Capability	Yes

Comparisons between Bridge and Proposed New Forth Crossing

The Kap Shui Mun Bridge has multi-modal capacity. The deck consists of a double deck with highway traffic located on the top level and rail traffic located on the lower level. The main span at 430 m is less than that proposed for the New Forth Crossing. The pylons are H – shaped.

Comparison of Bridge Width with New Forth Crossing

	New Forth Crossing (m)	**Kap Shui Mun**
Carriageway	7.3 x 2 =14.6	10.5 x 2 = 21
Hard Shoulder/ Strip	2.75 x 2 = 5.5	2.5 x 2 = 5
Width for access way, cables	4.9 x 2 = 9.8 (includes space for access vehicles)	2.25 x 2 = 4.5 (No space for access vehicles)
Stream – Lined Shaping	1.2 x 2 = 2.4	0
Central Reserve	3.0	3.5
Set back for Safety Barriers	0.6 x 2 = 1.2	0.6 x 2 = 1.2
Working Width for Safety Barriers	1.3 x 2 = 2.6	Included in carriageway width
Edge beams	0.45 x 2 = 0.9	0.25 x 2 = 0.5
Total	40	35.7

Second Severn Crossing

Bridge Data

Bridge Location	UK
Date and Duration of Construction	1993 – 1996
Main Span length (m)	456
Total Bridge Length (m)	5125
Bridge Width (m)	33.7
No of Lanes	6
Original Cost (and currency)	£331 million
Multi – Modal Capability	No

Comparisons between Bridge and Proposed New Forth Crossing

This bridge has been included as it has been constructed within the UK. The span length at 456 m is considerably less than that proposed for the New Forth Crossing. The deck consists of a ladder type steel composite deck compared to the steel box girder of the New Forth Crossing. The pylons are H-shaped compared to the 4-legged inverted Y towers of the New Forth Crossing

Comparison of Bridge Width with New Forth Crossing

	New Forth Crossing (m)	Second Severn
Carriageway	7.3 x 2 =14.6	10.1 x 2 = 20.2
Hard Shoulder/ Strip	2.75 x 2 = 5.5	2.6 x 2 = 5.2
Width for access way, cable clearance	4.9 x 2 = 9.8 (includes space for access vehicles)	2.1 x 2 = 4.2
Stream – Lined Shaping	1.2 x 2 = 2.4	0
Central Reserve	3.0	2.0
Set back for Safety Barriers	0.6 x 2 = 1.2	0.6 x 2 = 1.2
Working Width for Safety Barriers	1.3 x 2 = 2.6	Included in cable clearance
Edge beams	0.45 x 2 = 0.9	0.45 x 2 = 0.9
Total	40	33.7

3.2 Suspension Bridges

The following table is Table A1 extracted from Report 3 and summarises the world's largest suspension bridges.

World's Longest Suspension Bridges

Ranking	Name	Main Span (m)	Completion Date	Construction Duration (Years)
1	Akashi-Kaikyo, Japan	1991	1998	10
2	Great Belt Bridge, Denmark	1624	1998	7
3	Runyang, China	1490	2005	5
4	Humber, UK	1410	1981	8
5	Jiangyin, China	1385	1999	5
6	Tsing Ma, HK	1377	1997	5
7	Verrazano Narrows, USA	1298	1964	5
8	Golden Gate,USA	1280	1937	4
9	High Coast, Sweden	1210	1997	4
10	Mackinac, USA	1158	1957	2.5

In addition to the list above, the following suspension bridges are at the construction, planning phases or have recently been completed:

	Name	Main Span (m)	Completion Date	Phase
1	Messina, Italy	3300		Planning
2	Chacao, Chile	1100		Planning
3	Tacoma Narrows, USA	853	2007	Completed
4	Carquinez, USA	1056	2003	Completed
5	East Bay, USA	385		Under construction
6	Hardanger, Norway	1200		Planning

Various other suspension bridges are also in the planning phase in Japan and South Korea. It can be noted from the above table that modern suspension bridges are generally considered where the clear main span is greater than 1000m. The maximum span that can be achieved by a cable stay bridge is now in excess of 1000m and cable stay bridges can compete economically with a suspension bridge up to this span.

3.2.1 Examples of Suspension Bridges

Tsing Ma Bridge

Bridge Data

Bridge Location	Hong Kong
Date and Duration of Construction	1992 – 1997 (5 Years)
Main Span length (m)	1377
Total Bridge Length (m)	2160
Bridge Width (m)	41
No of Lanes	6 lanes plus 2 Rail
Original Cost (and currency)	880 US$
Multi – Modal Capability	Yes

Comparisons between Bridge and Proposed New Forth Crossing

The proposed span is equivalent to the proposed Suspension Bridge span for the New Forth Crossing. The deck construction consisting of a box girder is similar to the New Forth Crossing.

Comparison of Bridge Width with New Forth Crossing

	New Forth Crossing (m)	**Tsing Ma**
Carriageway	7.3 x 2 =14.6	11.0 (assumed) x 2 = 22.0
Hard Shoulder/ Strip	2.75 x 2 = 5.5	2.0 (assumed) x 2 = 4.0
Width for access way, cable clearance	4.9 x 2 = 9.8 (includes space for access vehicles)	
Stream – Lined Shaping	1.2 x 2 = 2.4	4.5 (assumed) x 2 = 9.0
Central Reserve	3.0	6.0 (assumed) including offside hard strip
Set back for Safety Barriers	0.6 x 2 = 1.2	Included in hard shoulder
Working Width for Safety Barriers	1.3 x 2 = 2.6	Included in hard shoulder
Edge beams	0.45 x 2 = 0.9	included
Total	40	41.0

Jiang Yin Bridge

Bridge Data

Bridge Location	China
Date and Duration of Construction	1995 - 1999
Main Span length (m)	1385
Total Bridge Length (m)	Approx 3000
Bridge Width (m)	
No of Lanes	6 lanes
Original Cost (and currency)	495 US$
Multi – Modal Capability	No

Comparisons between Bridge and Proposed New Forth Crossing

The main span is approximately equal to the proposed New Forth Crossing suspension bridge.

Comparison of Bridge Width with New Forth Crossing

	New Forth Crossing (m)	Jiang Yin
Carriageway	7.3 x 2 =14.6	14.0 x 2 = 28.0
Hard Shoulder/ Strip	2.75 x 2 = 5.5	Included in carriageway
Width for access way, cable clearance	4.9 x 2 = 9.8 (includes space for access vehicles)	2.2 x 2 = 4.4
Stream – Lined Shaping	1.2 x 2 = 2.4	1.5 x 2 = 3.0
Central Reserve	3.0	1.5
Set back for Safety Barriers	0.6 x 2 = 1.2	Included in carriageway
Working Width for Safety Barriers	1.3 x 2 = 2.6	Included in carriageway
Edge beams	0.45 x 2 = 0.9	Included in access way
Total	40	36.9

Humber Bridge

Bridge Data

Bridge Location	UK
Date and Duration of Construction	1972 – 1981 (8 years)
Main Span length (m)	1410
Total Bridge Length (m)	2220
Bridge Width (m)	28.5
No of Lanes	4
Original Cost (and currency)	£ 98 million
Multi – Modal Capability	No

Comparisons between Bridge and Proposed New Forth Crossing

This UK bridge has a main span slightly greater than that proposed for the New Forth Crossing suspension bridge.

Comparison of Bridge Width with New Forth Crossing

	New Forth Crossing (m)	Humber
Carriageway	7.3 x 2 =14.6	7.3 x 2 = 14.6
Hard Shoulder/ Strip	2.75 x 2 = 5.5	0.8 x 2 = 1.6
Width for access way, cable clearance	4.9 x 2 = 9.8 (includes space for access vehicles)	3.0 x 2 = 6.0
Stream – Lined Shaping	1.2 x 2 = 2.4	1.9 x 2 = 3.8
Central Reserve	3.0	2.0
Set back for Safety Barriers	0.6 x 2 = 1.2	Included in hard strip
Working Width for Safety Barriers	1.3 x 2 = 2.6	included
Edge beams	0.45 x 2 = 0.9	0.25 x 2 = 0.5
Total	40	28.5

Minami Bisan Seto

Bridge Data

Bridge Location	Japan
Date and Duration of Construction	Completed 1988
Main Span length (m)	1100
Total Bridge Length (m)	1723
Bridge Width (m)	37.0 (approx)
No of Lanes	Highway bridge includes 2 rail tracks and provision for 2 further rail tracks

Original Cost (and currency)	
Multi – Modal Capability	Yes

Comparisons between Bridge and Proposed New Forth Crossing

The main span is less than that proposed for the New Forth Crossing. The bridge carries highway and rail traffic.

Comparison of Bridge Width with New Forth Crossing

	New Forth Crossing (m)	**Minami Bisan Seto**
Carriageway	7.3 x 2 =14.6	7.0 x 2 = 14.0
Hard Shoulder/ Strip	2.75 x 2 = 5.5	2.5 x 2 = 5.0
Width for access way, cable clearance	4.9 x 2 = 9.8 (includes space for access vehicles)	6.25 x 2 = 12.5
Stream – Lined Shaping	1.2 x 2 = 2.4	0
Central Reserve	3.0	3.5
Set back for Safety Barriers	0.6 x 2 = 1.2	included
Working Width for Safety Barriers	1.3 x 2 = 2.6	Included
Edge beams	0.45 x 2 = 0.9	1.0 x 2 = 2.0 (approx)
Total	40	37.0 (approx)