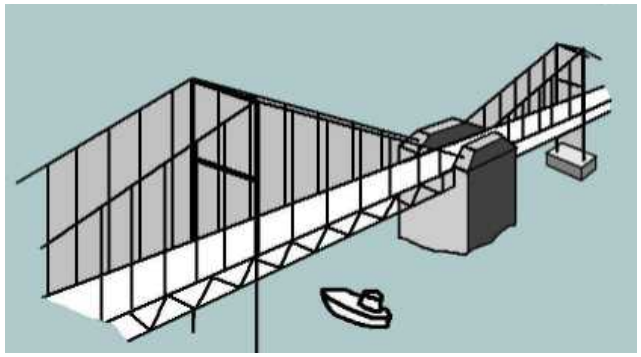
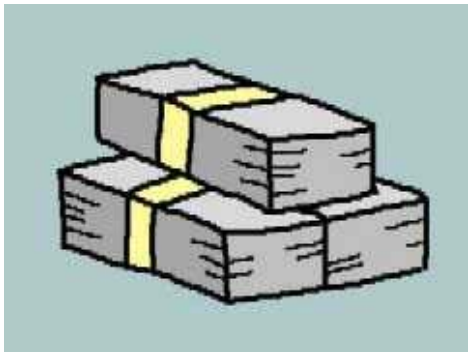
Recent Cost-Down of Suspension Bridge by Aerodynamics





Dr. Hiroshi TANAKA

Contents

- 1. Example of foreign Bridges
- 2. Recent long span bridges in Korea
- 3. Conclusions
- **Appendix 1**
- Samsung’s Research on Deck Sections
- ◎　Samsung’s Finding out

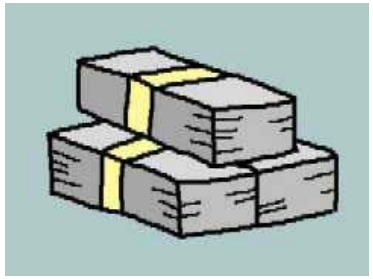
1. Example of foreign Bridges

- Until 1980 Truss Type is main stream
- Br. Akashi Strait Br.
- Until 2000 Stream-Lined Box Type
- Great-belt Bridge
- Present Multi-Box type
- Messina Strait Bridge (Italy)
- Xihoumen Bridge (China)

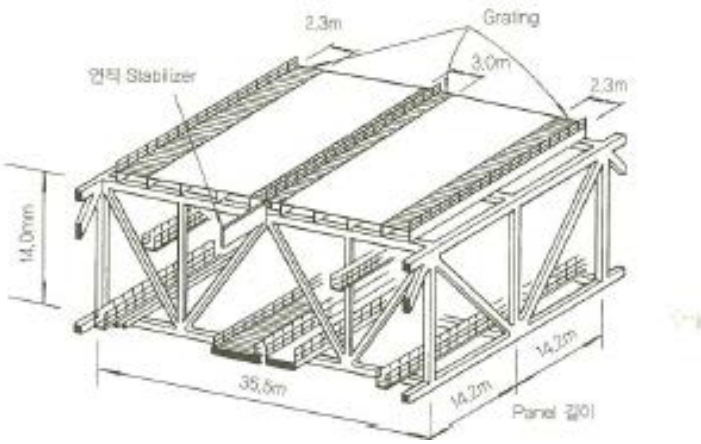
Strategy of Cost-Down

Aero-dynamically good and Light weight deck(Girder)

Cable , Hanger, Tower and Cable-Anchor become small



Akashi Strait Bridge (Truss Type)



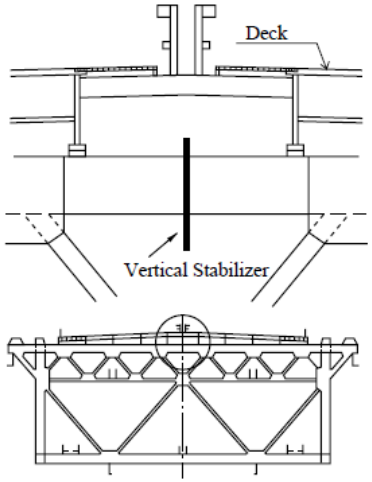
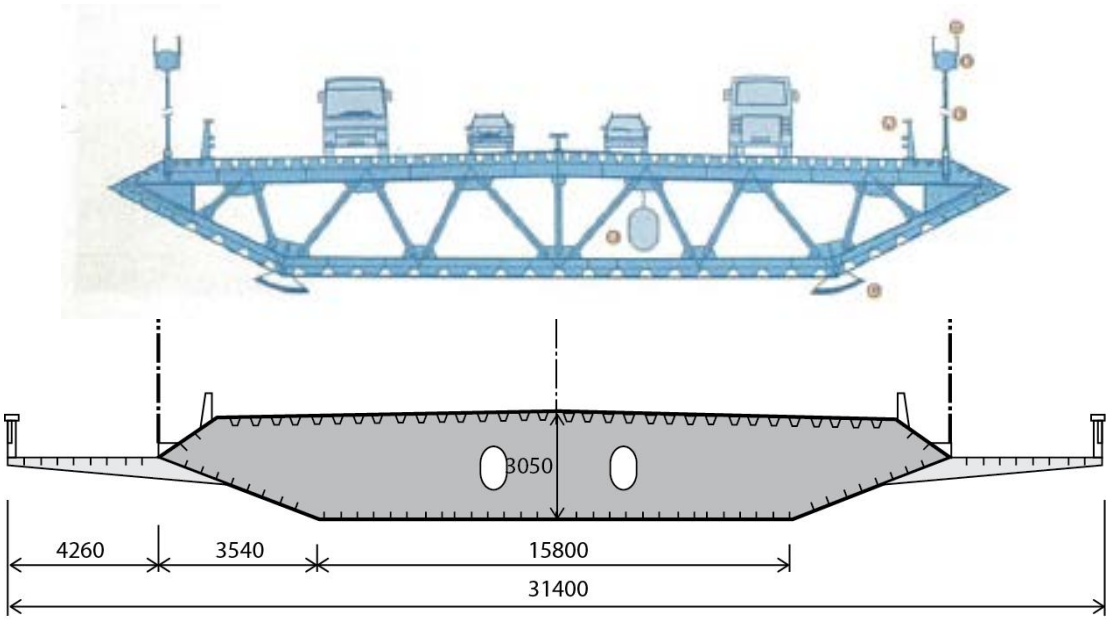


Fig. 1 Scheme of Vertical Stabilizer

Tanaka proposed vertical stabilizer to Akashi Bridge

- Vertical Stabilizer (this make flutter speed high)
- Open Grating (to reduce weight and high wind stability)
- Honshu-Shikoku-Authority tried wind tunnel tests on many truss-models and found cheap deck.
- However Japanese designers preferred safety to cost.

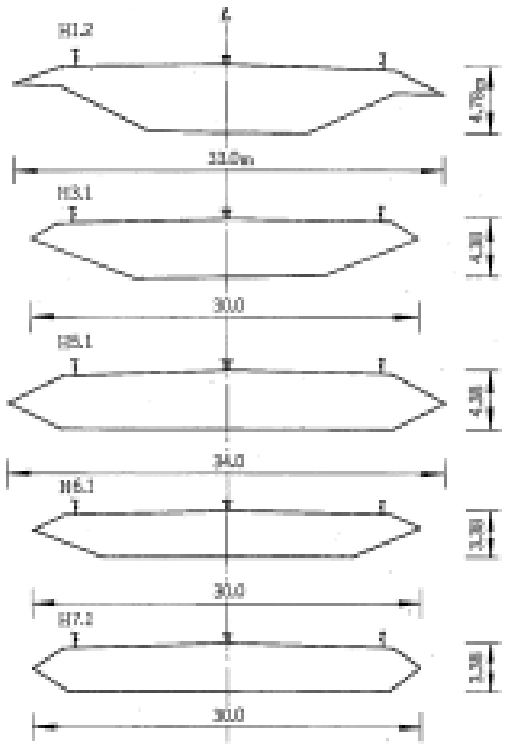
Great-belt Bridge (Stream-lined Box)



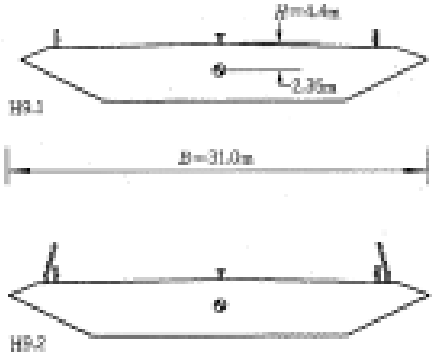
Severn Bridge

Great-belt Bridge did many wind tunnel tests (next page) but optimum section is similar to Severn Bridge.

Procedure of Final Selection of Great-belt Bridge

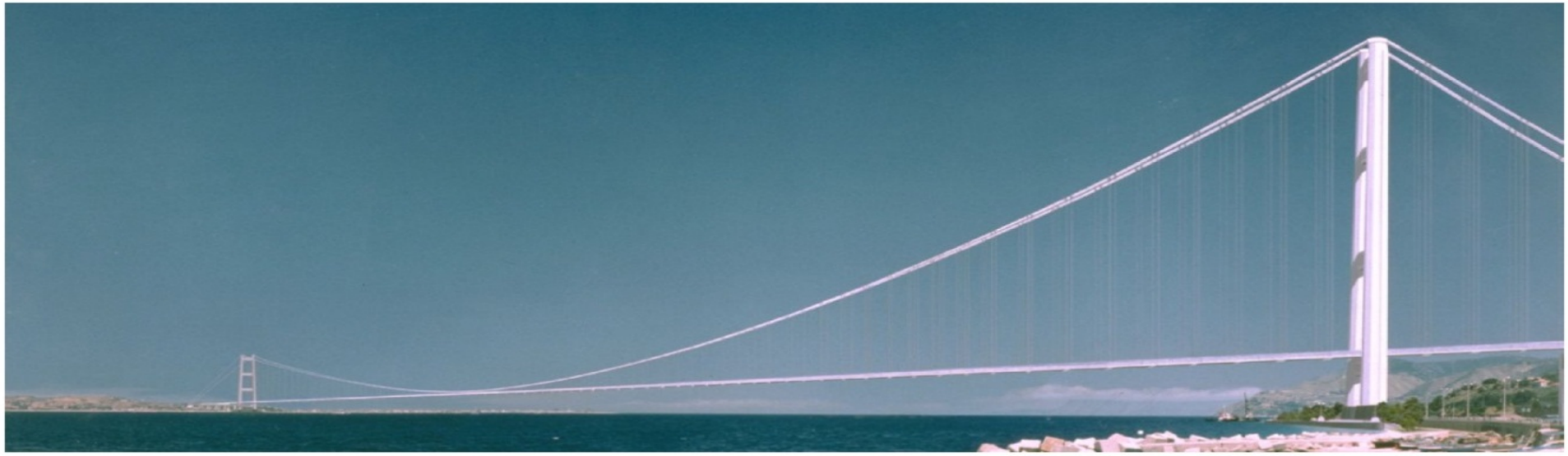


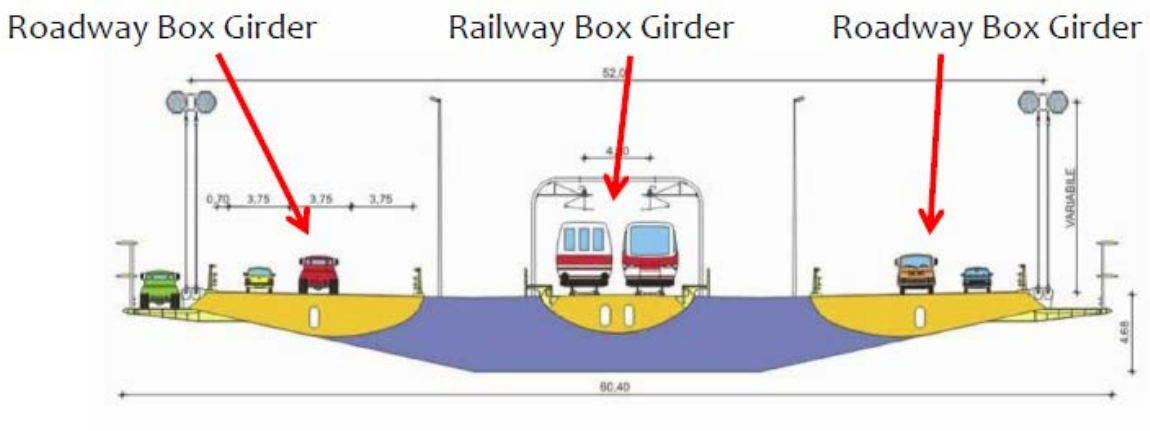
Tested Bridge Sections



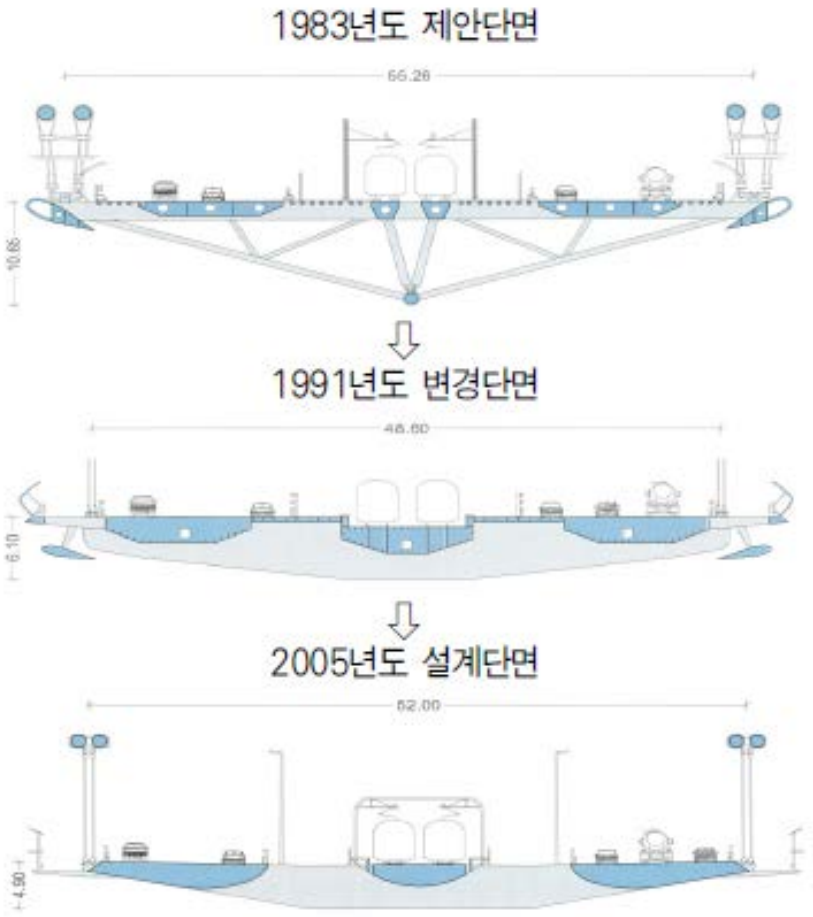
Final Section

Messina Strait Bridge
(Multi-Box Type)



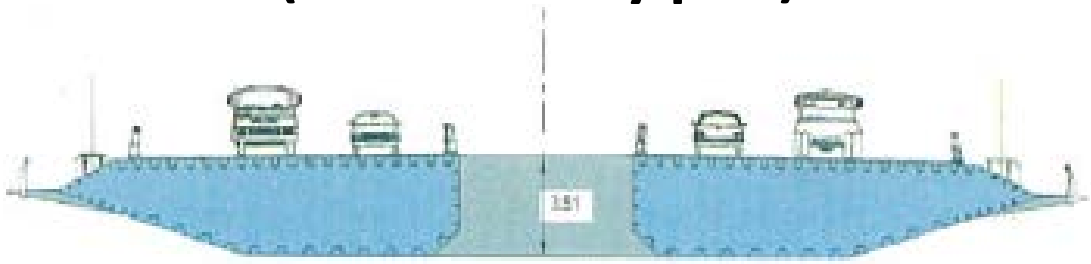


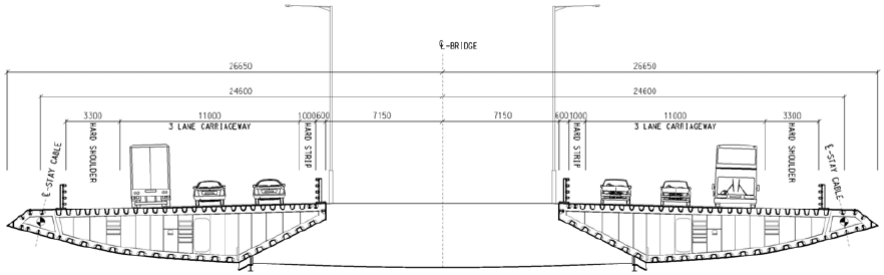
Procedure of Final Selection



Final selection model is thin and light therefore very cheap

Xihoumen Bridge (China) (2-Box Type)





Stonecutter Bridge

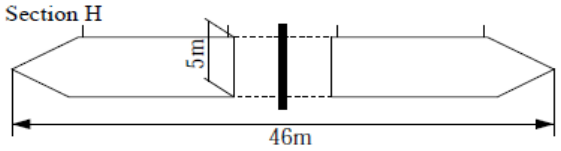


Fig 3 Application of V.S. for tapered box girder

Tanaka's Proposal

Xihoumen bridge's section above is quite similar to the Stonecutter's one (above left)and the multi-box which Tanaka proposed in 1995 in Hong Kong (Fig.3).

Tanaka's Proposal

- He proposed 2-Box type at the international conference of "Bridges into the 21st century"

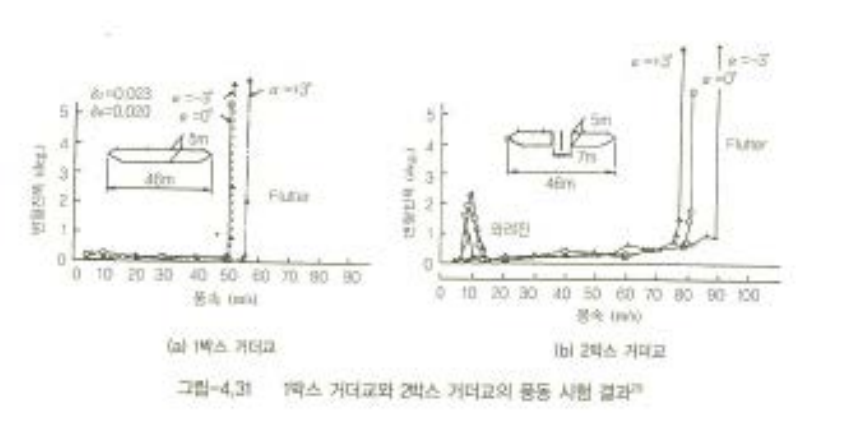


그림-4.31 1박스 거더교와 2박스 거더교의 풍동 시험 결과[23]

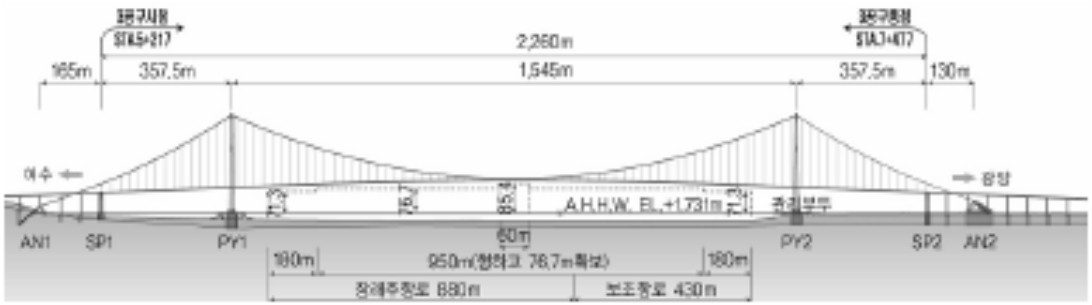
23) Tanaka, H., Yamamura, N. and Ueda,T. : "Design of Super-long-span Suspension Bridges Based on Aerodynamics", Proceedings of Bridges Into The 21st Century, Hong Kong, pp.729~737, October, 1995.

Gwang Yang Bridge

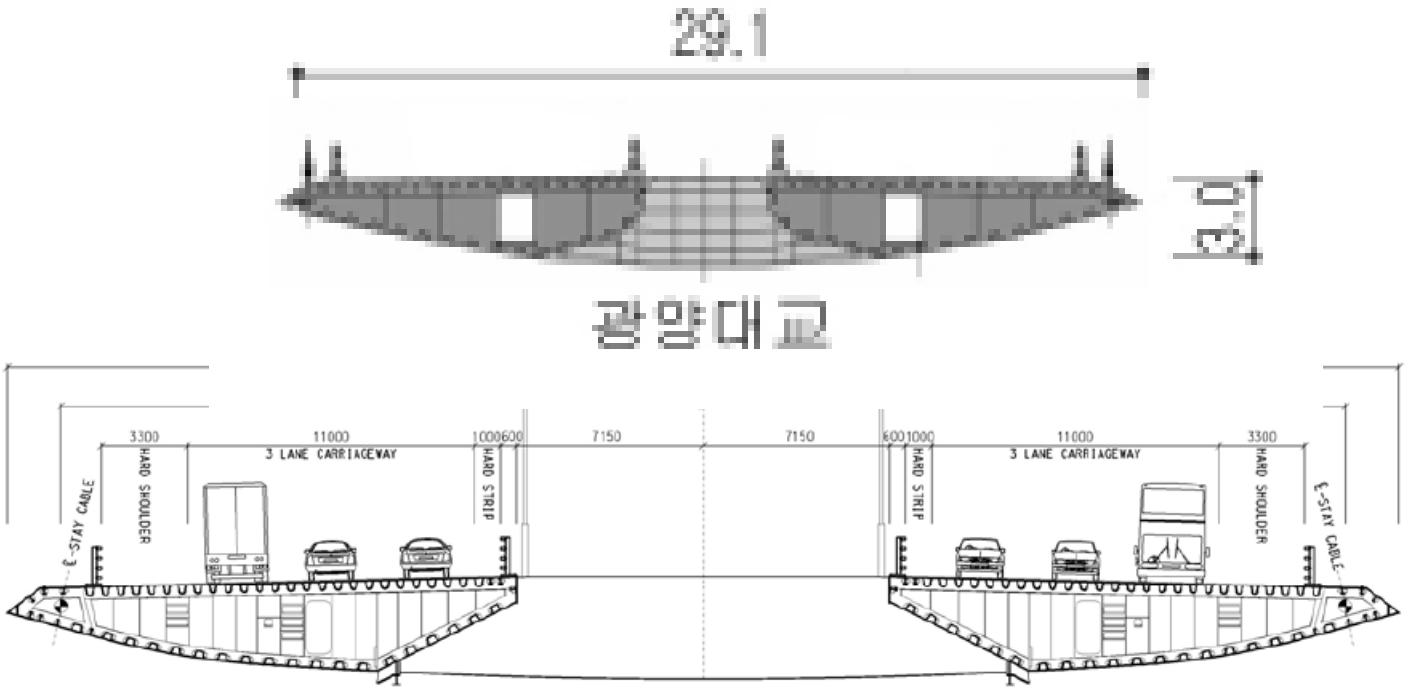
3-span suspension bridge

L: 357.5+1545+357.5=2,260m

B:27m(4 Lines)



The section is similar to Stone-Cutter Br.



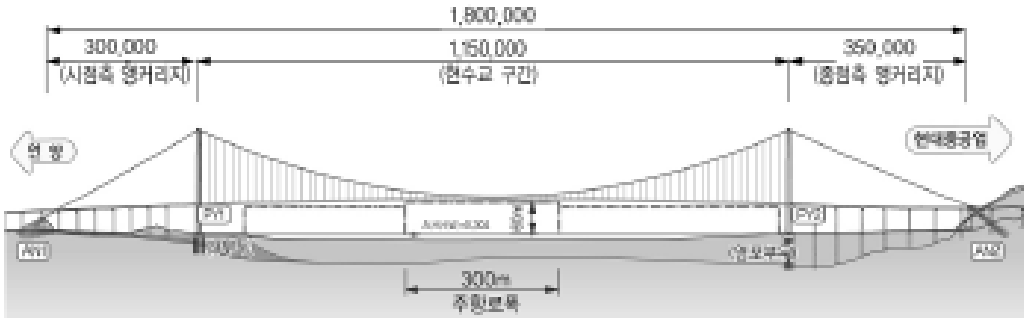
Stone-Cutter Bridge in Hong Kong

2. Recent long span bridges in Korea

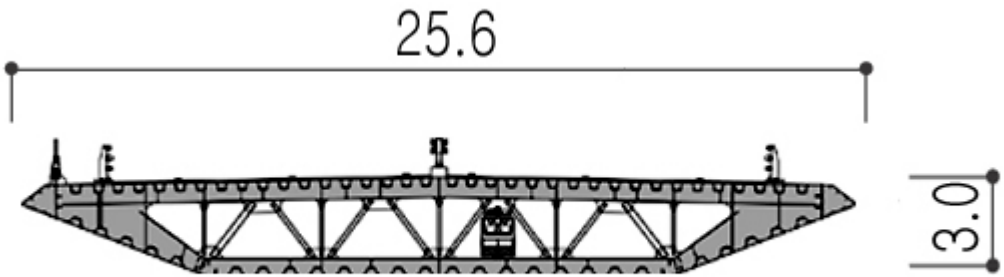
- Gwang Yang Bridge （2-Box Type）
- Ulsan Grand Bridge (Stream-line Box Type)
- The 2nd Namhae Bridge (Stream-line Box Type)
- New Millennium Bridge(Stream-line Box Type)

- **Wind Resistant design is first priority.**
- **The most economical section has been decided.**

Ulsan Grand Bridge



Great-Belt　Bridge is the model of Ulsan bridge therefore the section is quite similar each other. Hyundai neglected the deflector by many wind tunnel tests and cost-downed the fabrication fee.

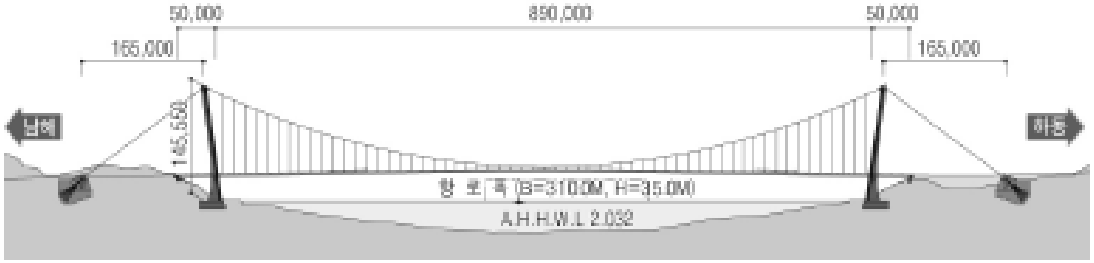


Deflector

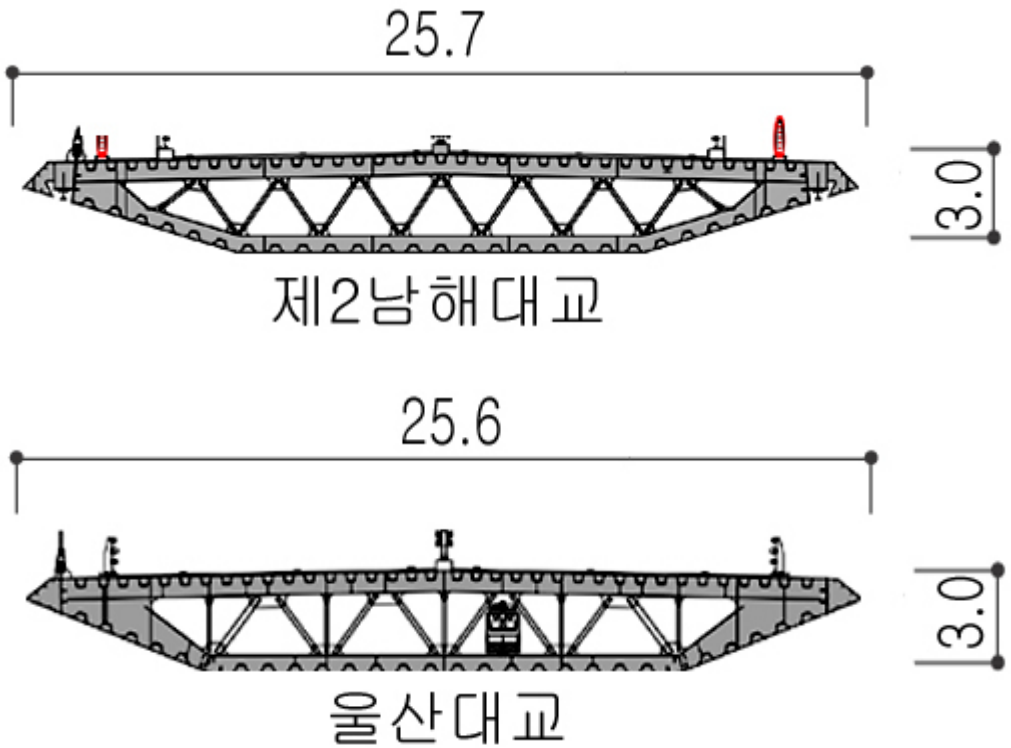
Great-belt Bridge

The 2nd Namhae Bridge

One-span suspension bridge
Inclined tower & 3D cable
L: 890m(Deck)
B:25.7m(4 Lines)

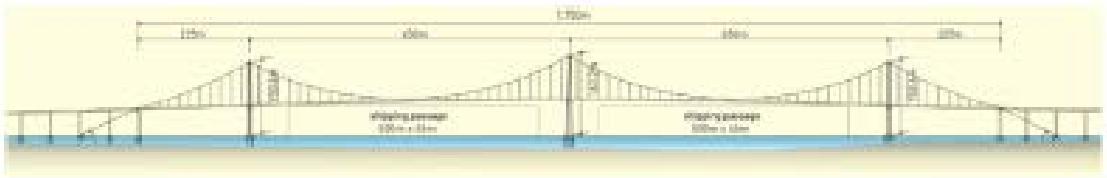


- The 2nd Namhae Bridge is quite similar to Ulsan bridge, GS used Hyundai's idea to reduce time for wind resistant design.

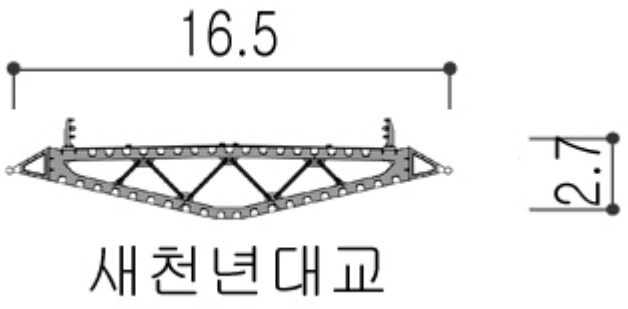


New Millennium Bridge

4-span suspension bridge
L:225+2@650+225=1.750m
B:16.5m (2-Line)



Korean's Original Section



Stream-lined Box

This section is stable for a narrow width deck and very economical. There is possibility that this type of decks will be prevailed in the world in future as Korean original.

3. Conclusions

- Trend of Deck for cost-down:

  Truss → Streamlined Box → Multi-Box

- Super long span suspension bridge:

  Multi-Box like Messina bridge is conventional

- **Narrow width bridge** like **New millennium bridge** will become leading stream.

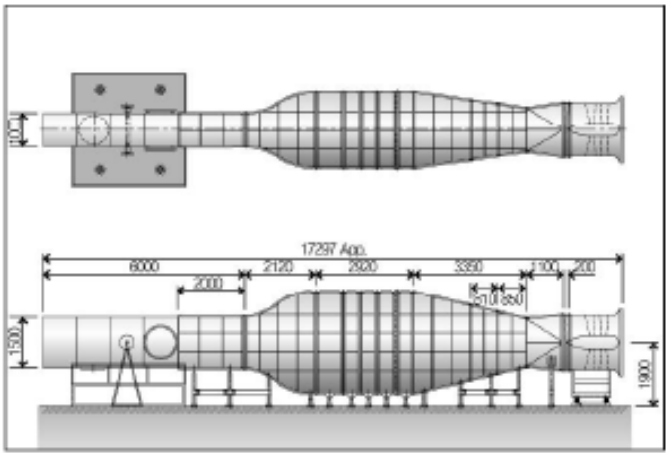
Appendix 1

Samsung's Research on Deck Sections

- We used TE SOLUTION'S Wind Tunnel facility

- 실험풍동
  - ㈜티이솔루션 소재의 단면모형 전용풍동에서 수행

분류	단면모형실험 전용풍동
Type	Open-circuit (Eiffel) Type
제작년도	2006년 5월
측정부	1.0(W)×1.5(H)×6m(L)
풍속범위	0.3~21m/s



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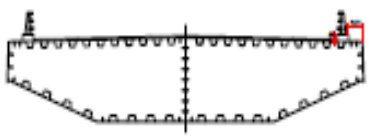
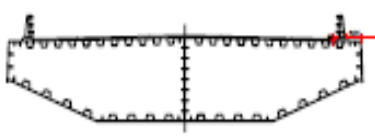
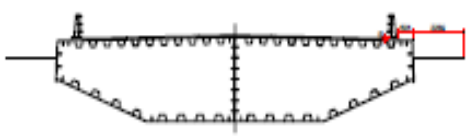
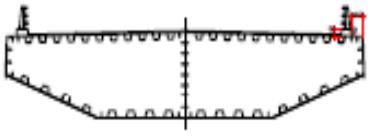
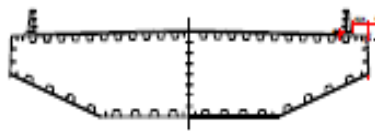
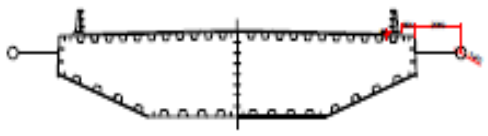
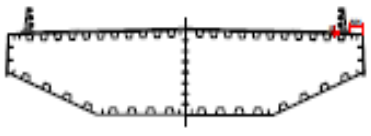
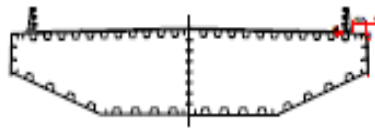
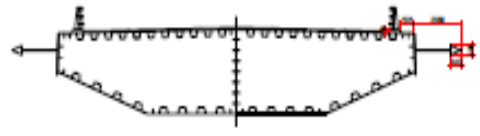
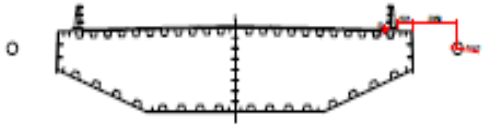
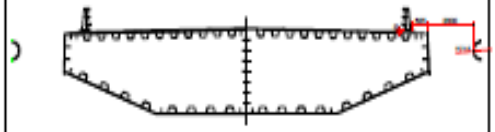
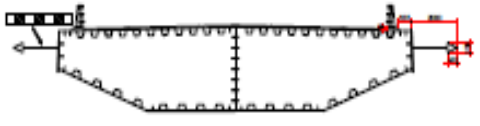
단면 1		단면 5		단면 9	
단면 2		단면 6		단면 10	
단면 3		단면 7		단면 11	
단면 4		단면 8		단면 12	

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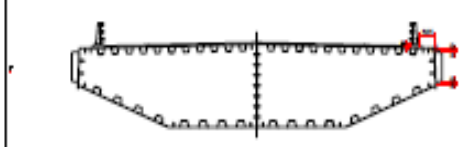
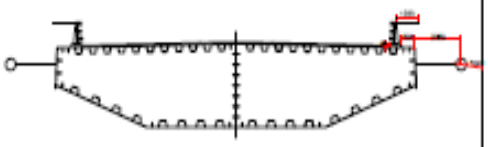
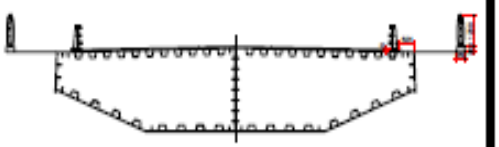
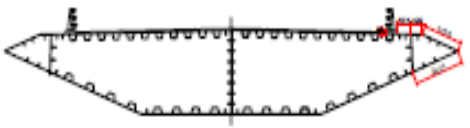
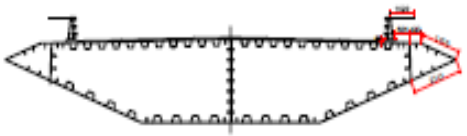
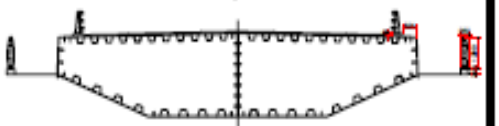
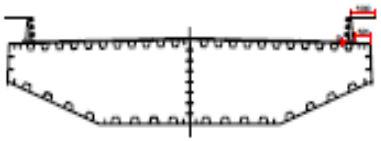
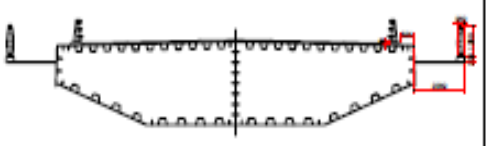
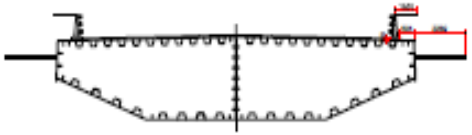
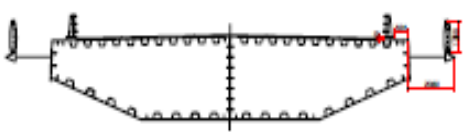
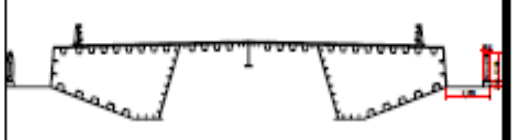
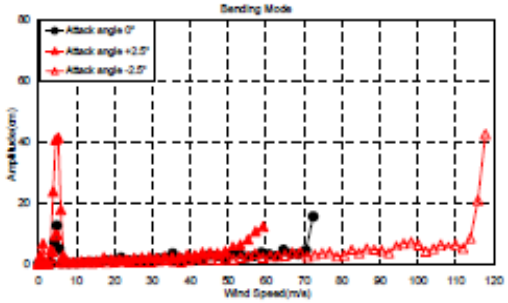
단면 13		단면 17		단면 21	
단면 14		단면 18		단면 22	
단면 15		단면 19		단면 23	
단면 16		단면 20		단면 24	

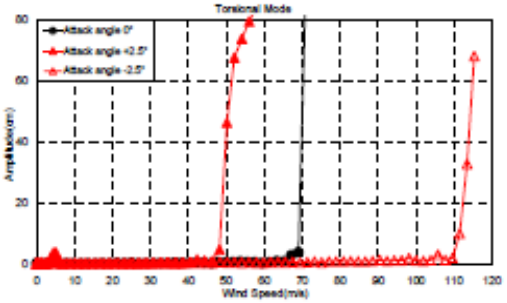
Bending & Torsion Vibration

- 단면13, 단면14 ·
(제진대책별 비교)

단면13



연직거동



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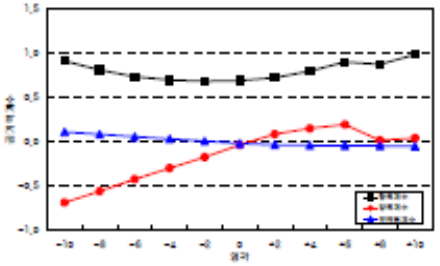

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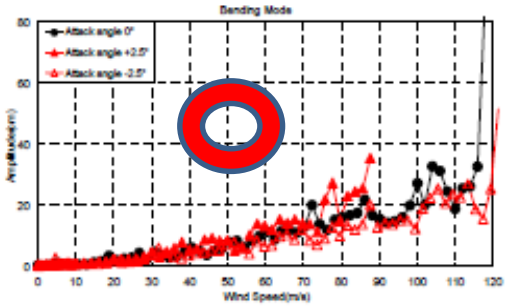
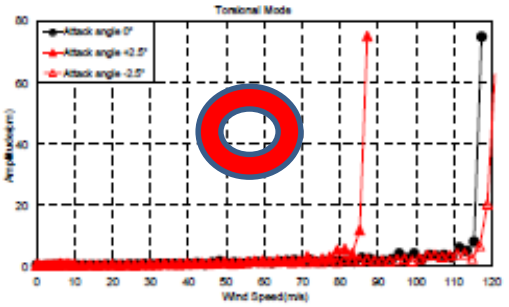
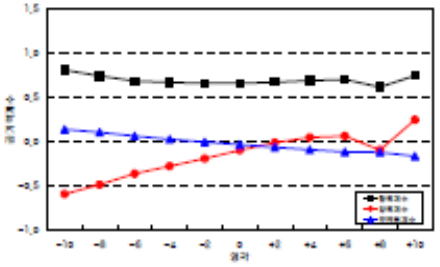
단면14



연직거동



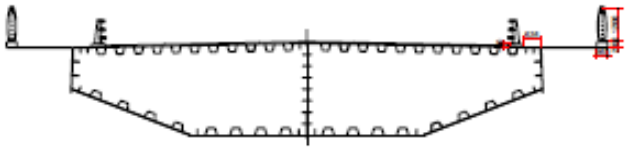
비틀림거동

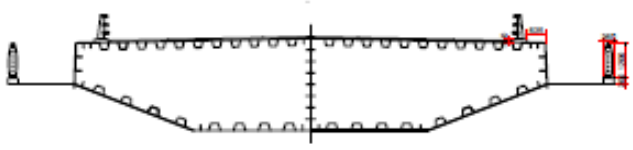


공기력계수
(C_D:0.659, C_L:-0.099, C_M:-0.034)

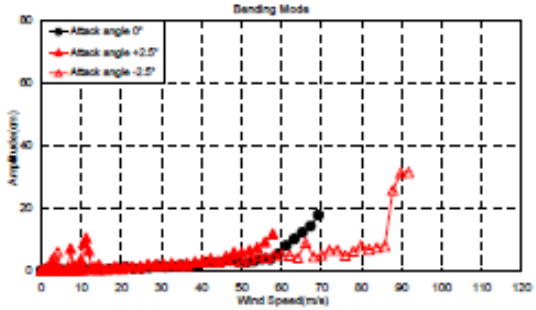
Bending & Torsion Vibration

- 단면21 & 단면22
(보도의 위치변화)

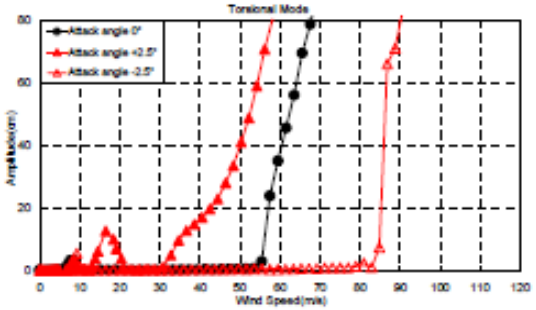




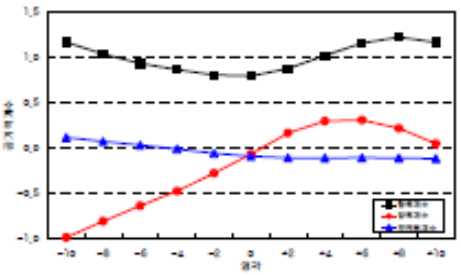
단면21



연직거동

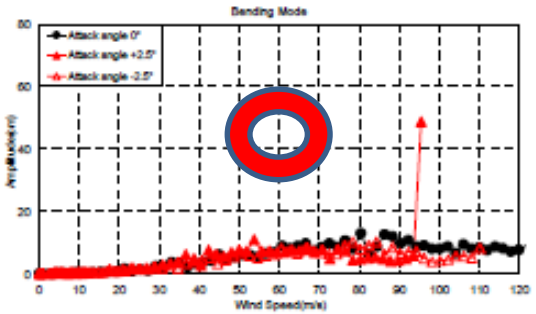


비틀림거동

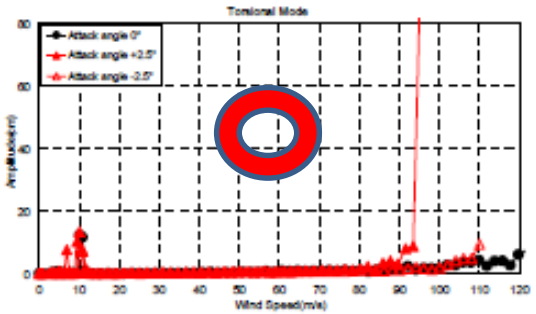


공기력계수
(C_D:0.786, C_L:-0.076, C_M:-0.100)

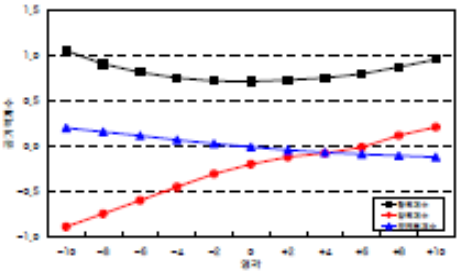
단면22



연직거동



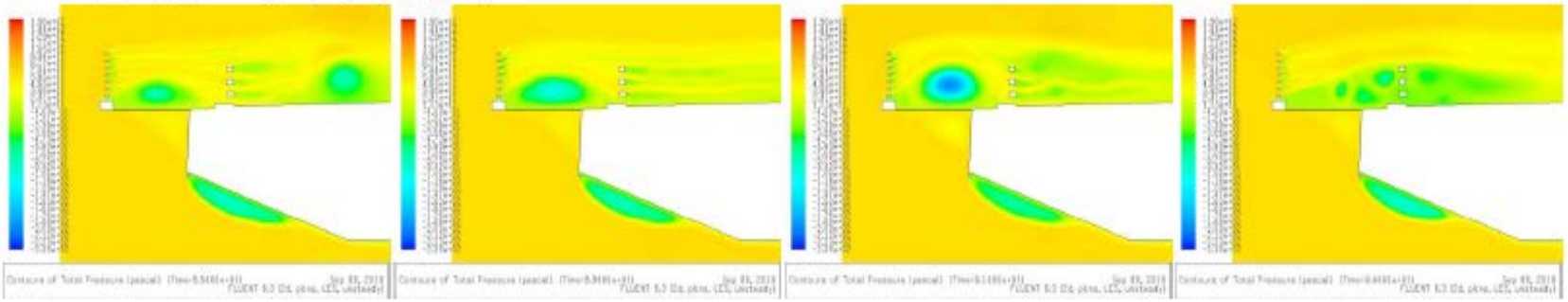
비틀림거동



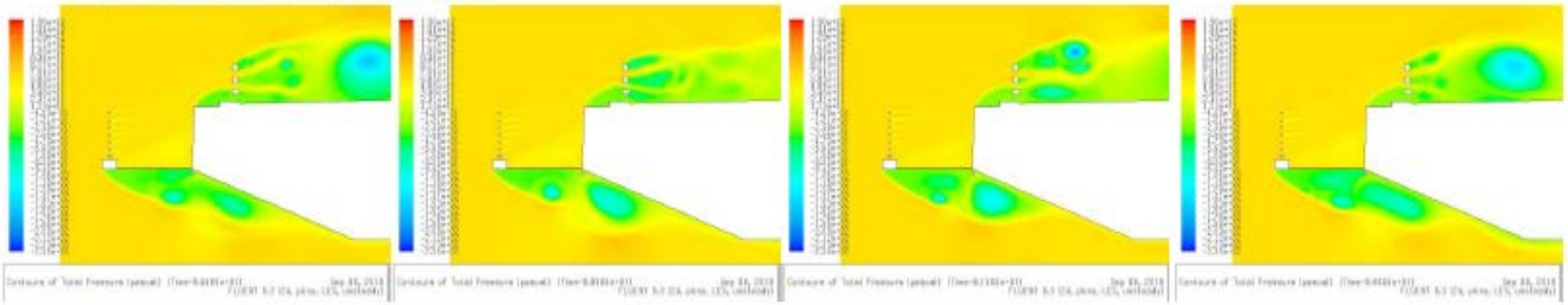
공기력계수
(C_D:0.714, C_L:-0.198, C_M:-0.009)

LES (Large Eddy Simulation)

• 압력분포의 변화 (단면21)

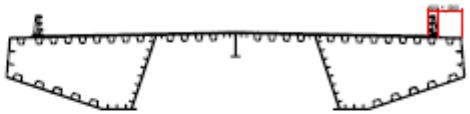


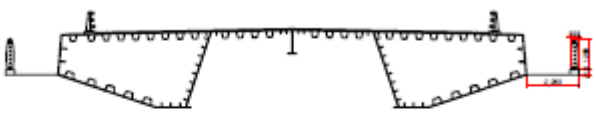
• 압력분포의 변화 (단면22)



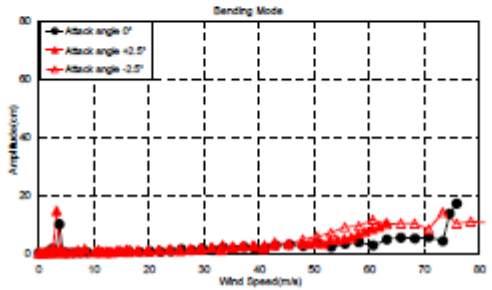
2- Box type

• 단면23 & 단면24
(단부박스 단면)

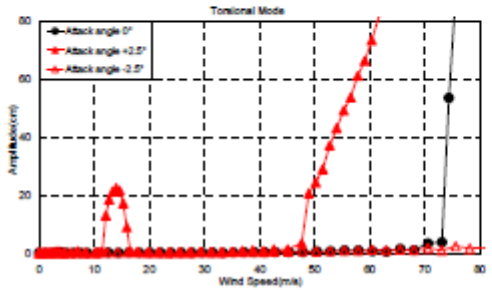




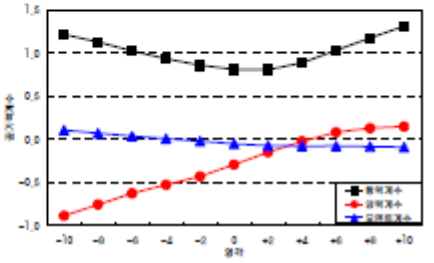
단면23



연직거동

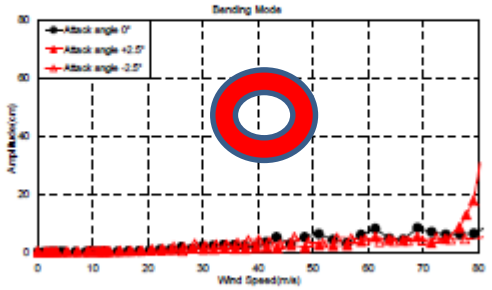


비틀림거동

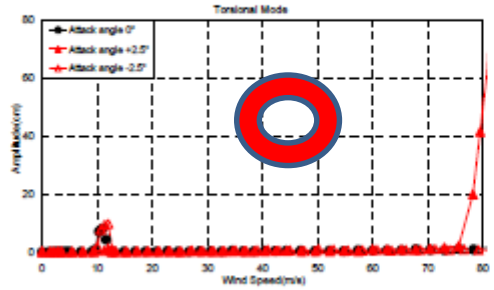


공기력계수
(C_D:0.811, C_L:-0.294, C_M:-0.054)

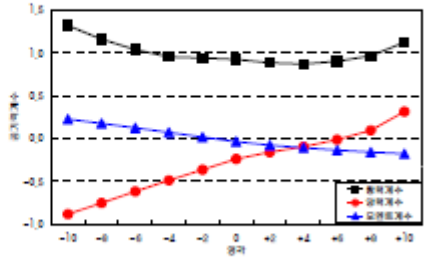
단면24



연직거동



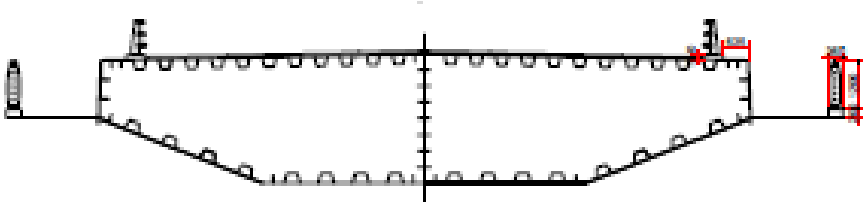
비틀림거동



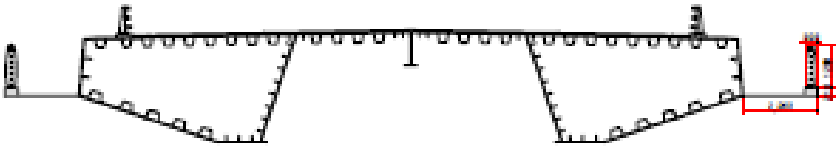
공기력계수
(C_D:0.923, C_L:-0.243, C_M:-0.038)

◎ Samsung's Finding out

The following deck section is economical to use narrow deck suspension bridge. The width deck is less than 20m or so.



Stream-lined Box



2-Box Type

- THANK YOU FOR WATCHING THIS PPT!!