

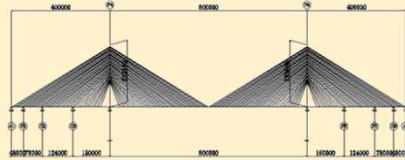
Evaluation of Wind-Induced Stability of the Half-Mile Bridge



Overview of the Study

Implementation of trial design of concrete bridge with span length of 800 m.

(1) Cable-stayed bridge case



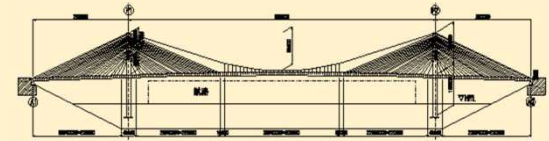
Developed a two-sided suspension section for a wide deck

Confirm the wind stability of the cross-section.



(Sectional Model Wind Tunnel Test)

(2) ED+Suspension Bridge



- Hybrid ratio
- Examining cable design methods

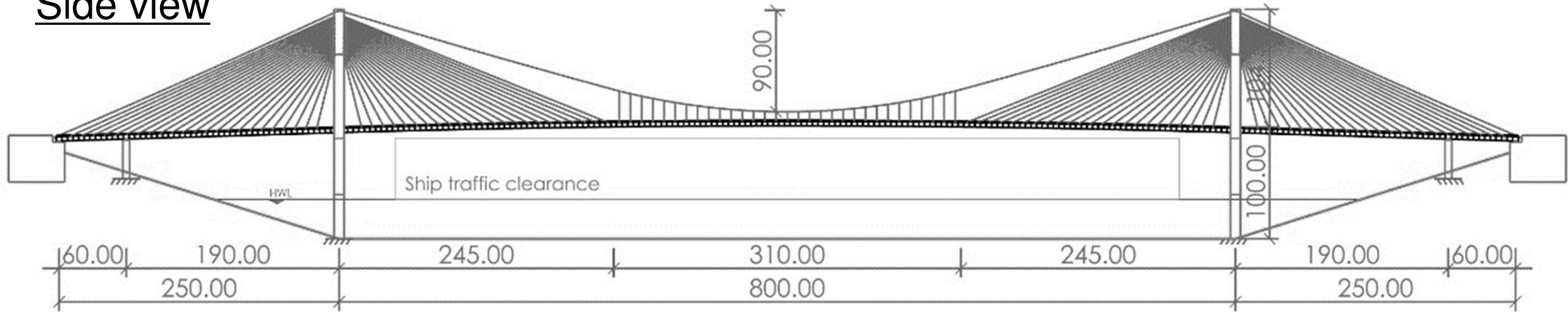
Confirm the wind stability of the entire bridge
(Wind Tunnel Test of the whole bridge model)

Purpose of the whole bridge model wind tunnel test

- Verification of aerodynamic stability of the Half-Mile Bridge with trial design.
 - Flutter Manifestation Wind Speed
 - Understanding the aerodynamic stability of a cross-section
 - Impact of the Butterfly Web into whole bridge
- Understanding design issues of Half-Mile Bridge on the stability design
 - Acquisition of design wind load distributions
 - Feedback to the bridge design

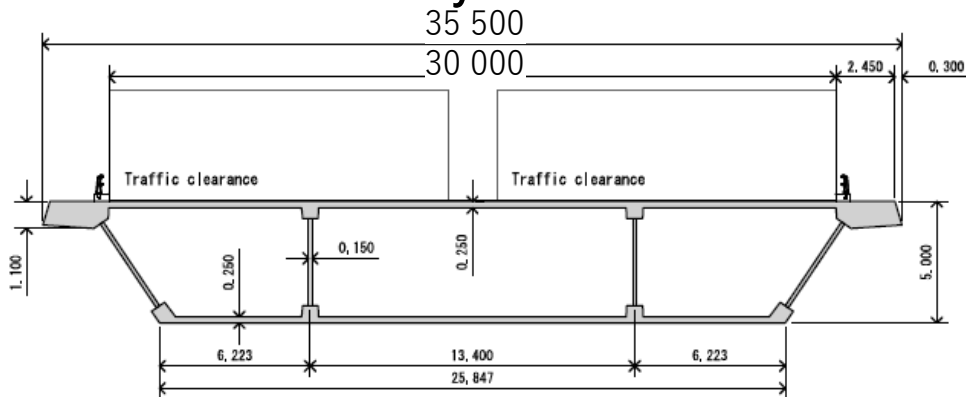
Targeted bridges

Side view

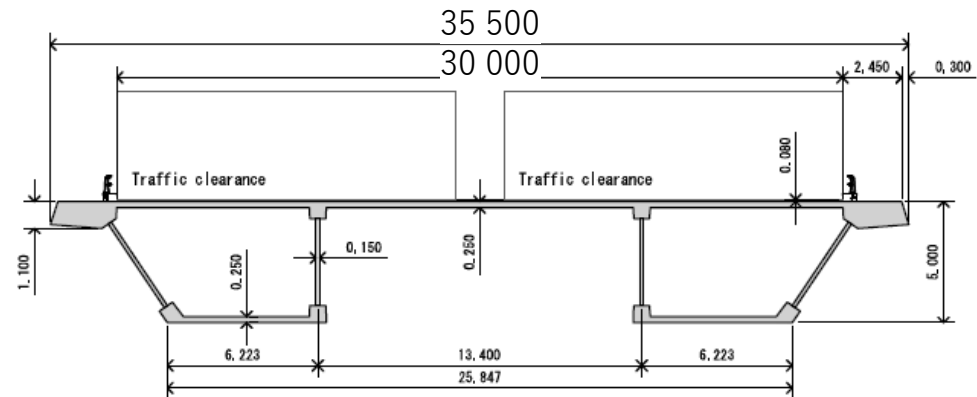


cross-section view

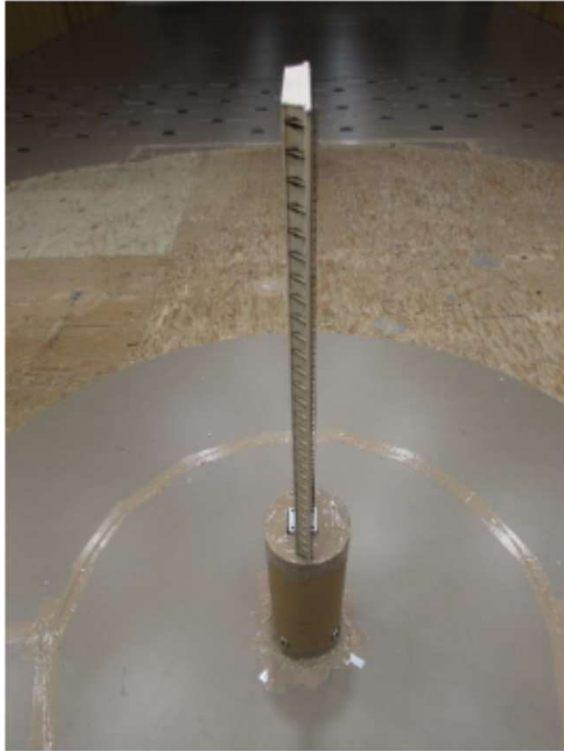
Cable-stayed section



Suspended section

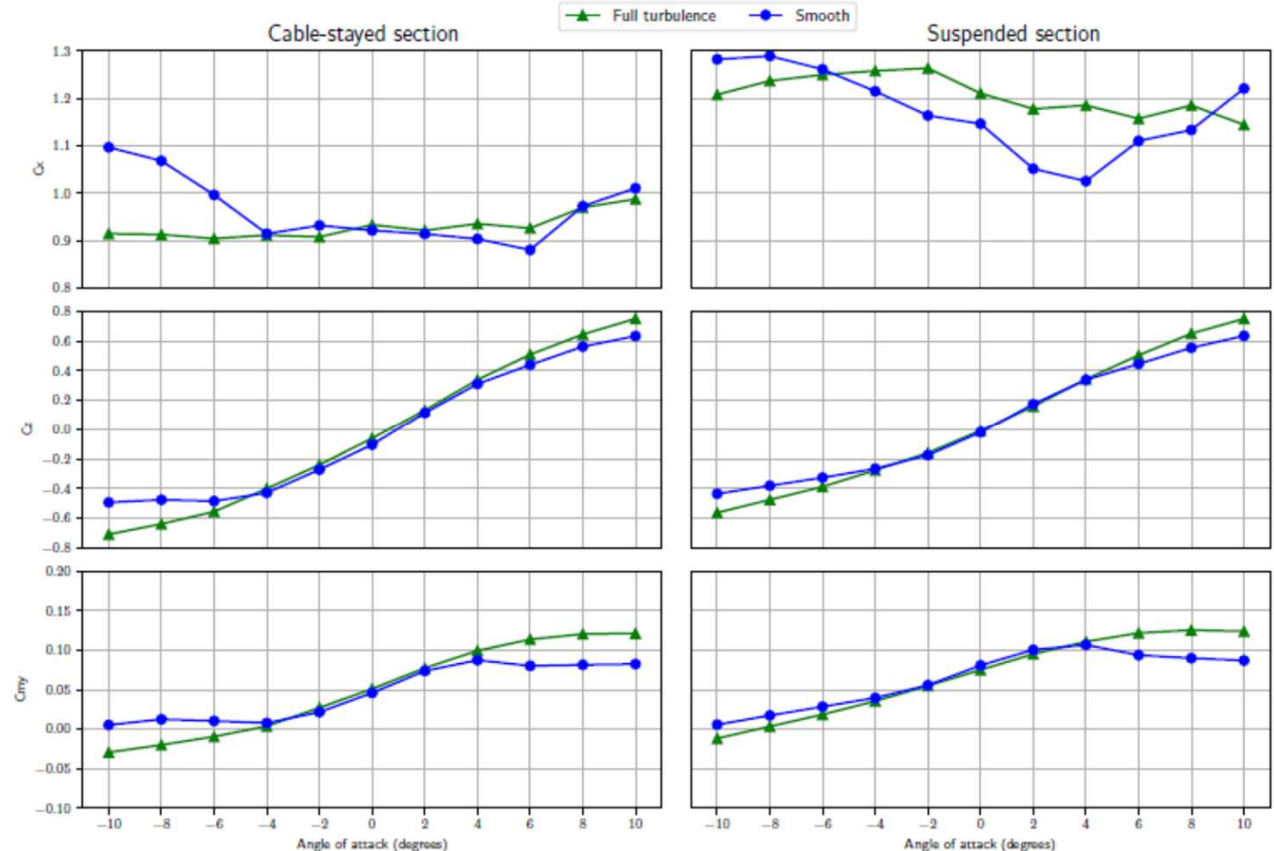


Static aerodynamic measurement test (High-Frequency Force Balance Test)



Upstream View of Cable-stayed Section

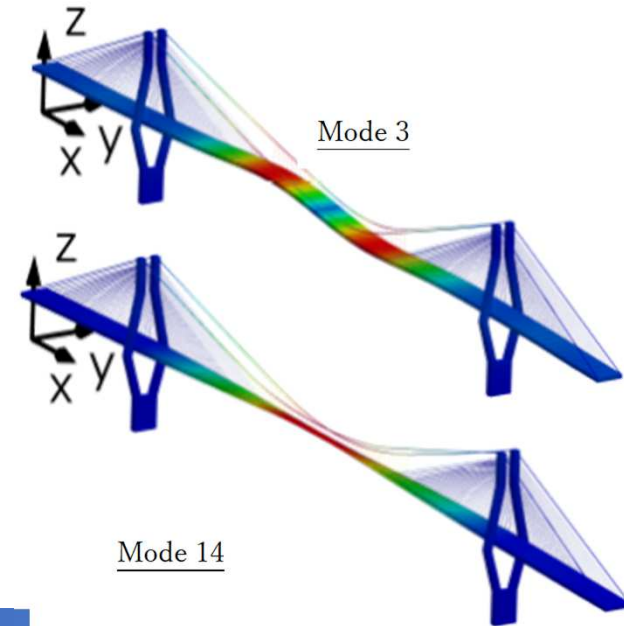
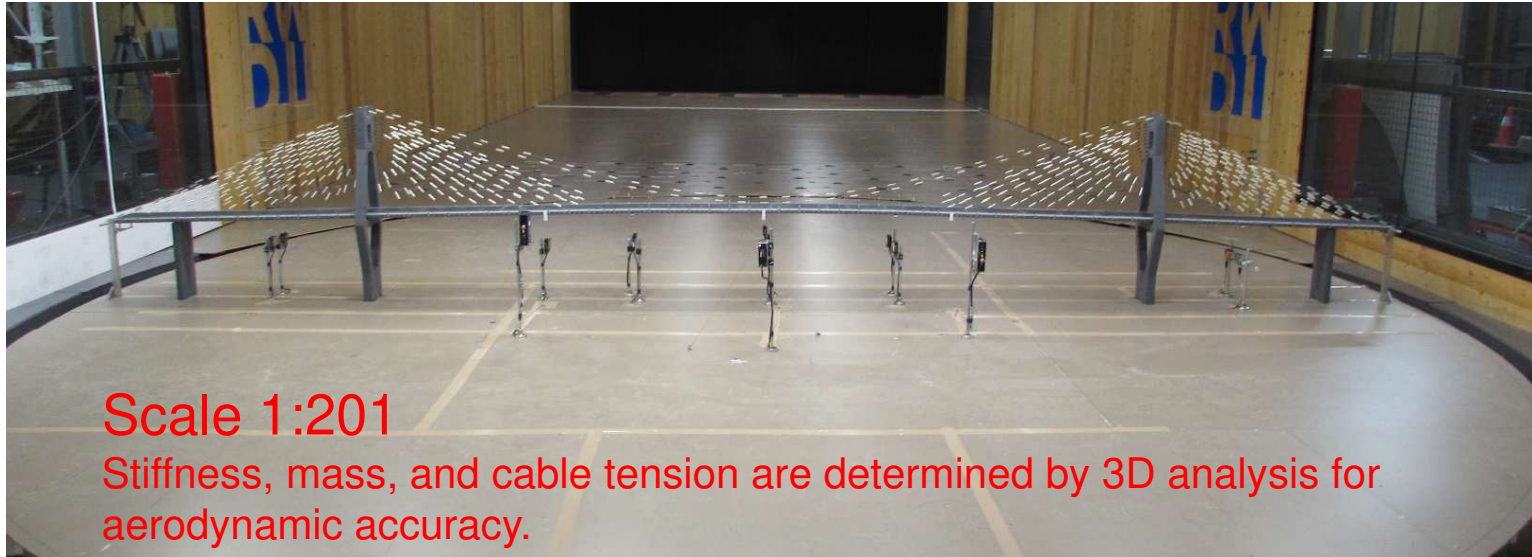
- One end of the main girder was fixed
- Two types of cross-sections



Galloping is unlikely to occur

Torsional flutter can occur around $\pm 4\sim 6$ degrees elevation angle

Wind Tunnel Test (Experimental Model)



Mode (No. / mode description)		Full-scale Frquency	Model-scale Target Frequency	Measued Frequency	Difference	Dumping
2	1 st vertical main span	0.18Hz	2.48Hz	2.71Hz	+9.2%	0.59%
3	2 nd vertical main span	0.24Hz	3.42Hz	3.40Hz	-0.5%	0.17%
7	3 rd vertical main span	0.38Hz	5.32Hz	5.15Hz	-3.1%	0.20%
14	1 st torsion main span	0.57Hz	8.14Hz	8.32Hz	+2.2%	0.29%

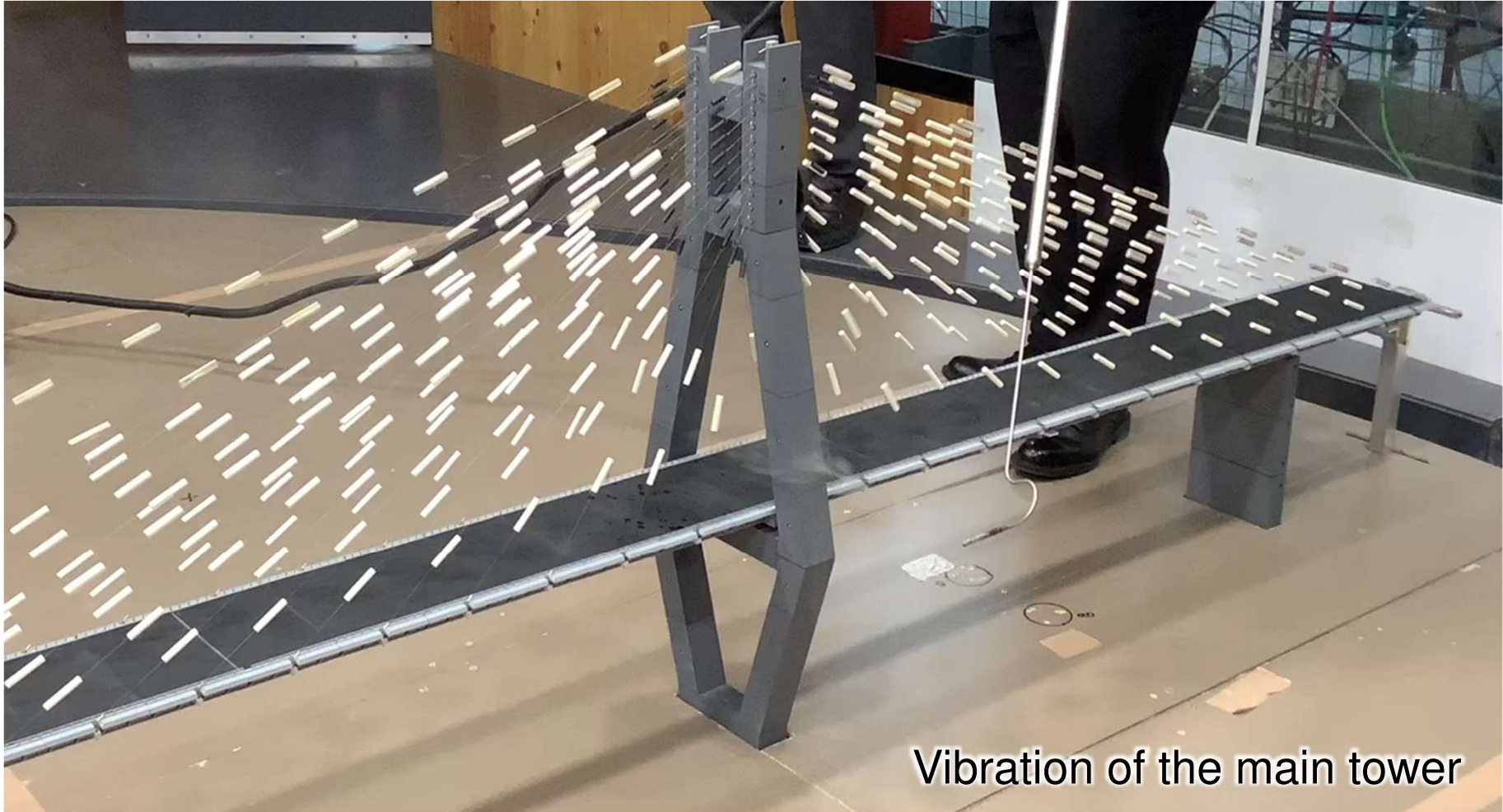
Validating the model from the natural frequencies of the main vibration modes.

Wind Tunnel Test (Smooth Flow)

Flutter was Observed at Wind Speed: 135m/s

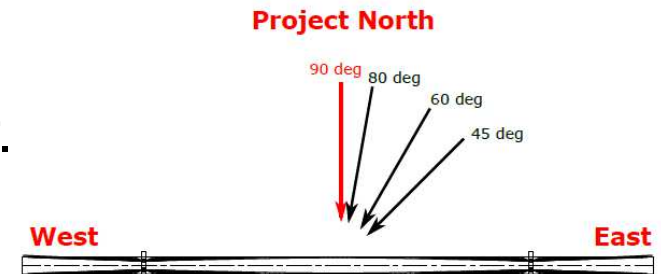
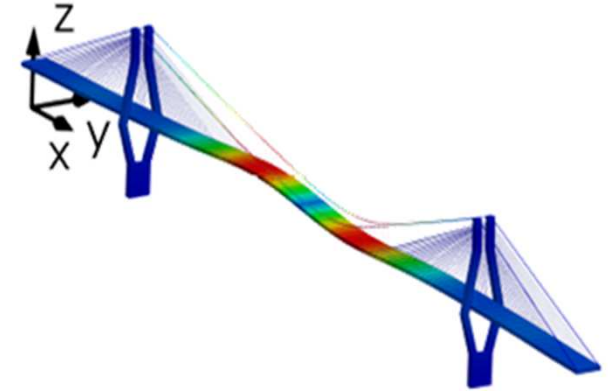


Wind Tunnel Test (Smooth Flow)



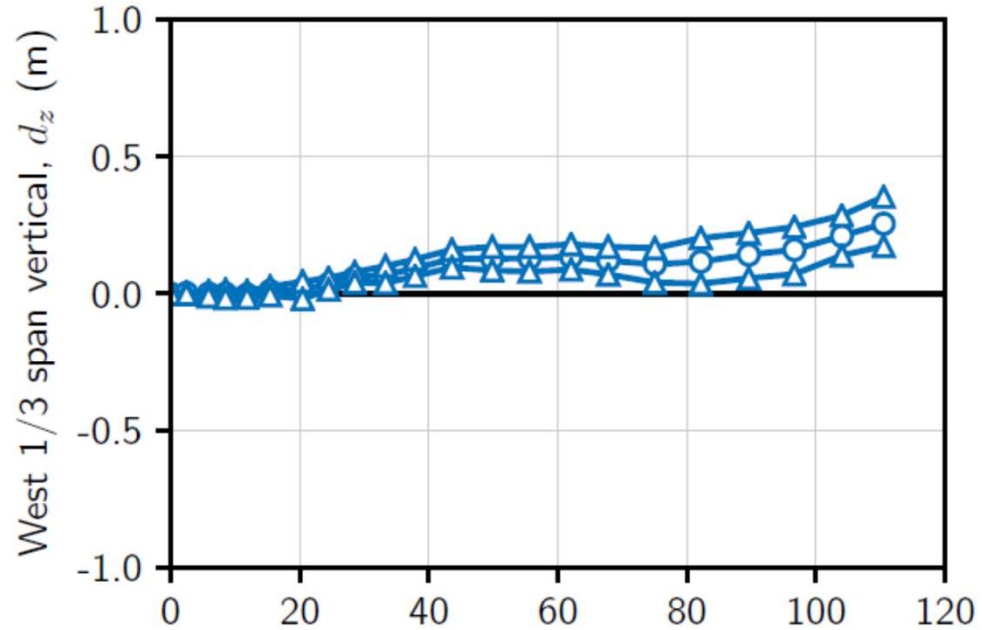
Wind Tunnel Test

- Aerodynamic Stability (Smooth Flow)
 - Flutter Wind Speed 135 m/s > Design Wind Speed 72 m/s
 - At wind speeds around 40 m/s, the unsteady vibration of Mode 3 became relatively large. However, it is not an instability such as vortex excitation (see next page).
- Buffeting Response in Turbulent Flow
 - Responses are greater than the result of the smooth flow.
 - It is aerodynamically stable design wind speed.
- Influence of wind angle
 - The influence of the wind attack angle was not clear.

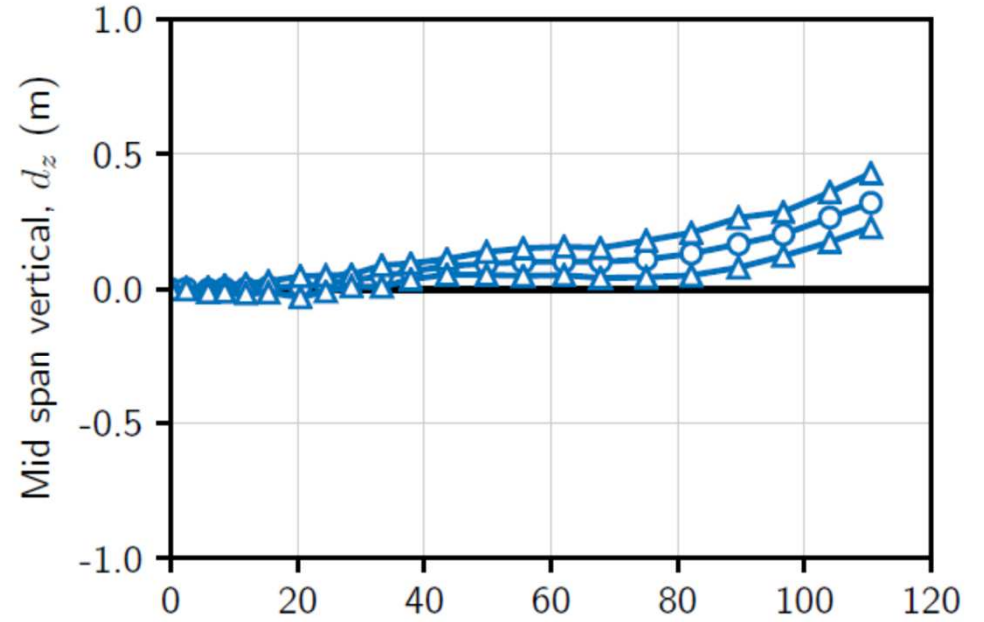


Experimental Results in Smooth Flow

(Wind Speed vs Maximum Displacement of the Main Girder)



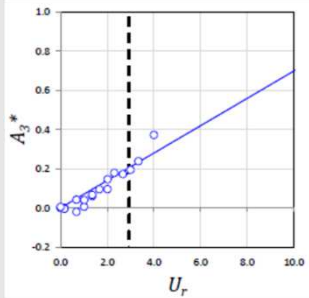
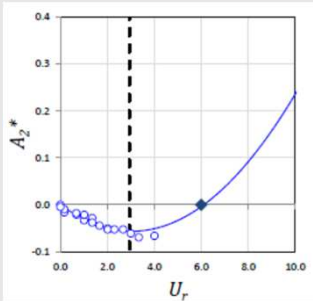
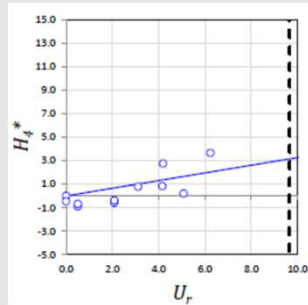
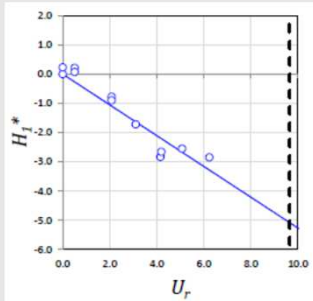
10-minute mean wind speed at deck level (m/s)



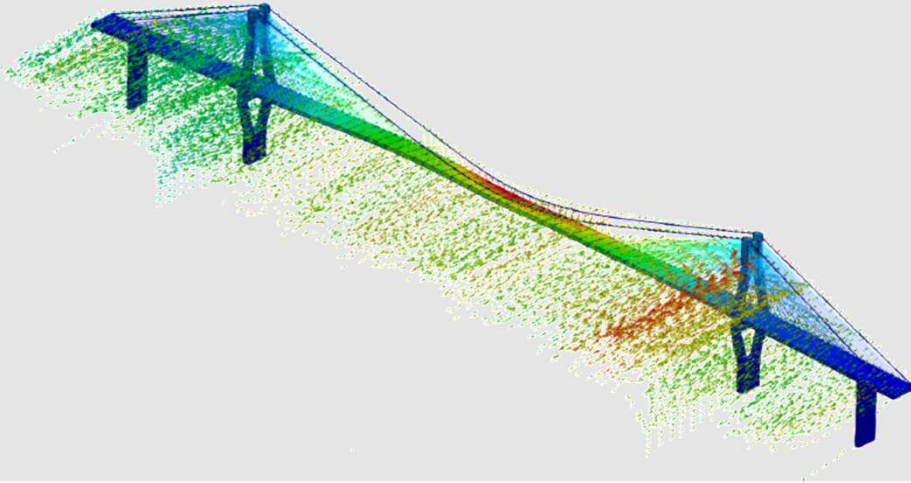
10-minute mean wind speed at deck level (m/s)

Buffetting Analysis and Feedback to Prototype Design

Aerodynamic Derivatives
Estimate from experiments



Calculating wind loads by response analysis



Feedback to the design model and review it

Summary

- Aerodynamic Stability of Half-Mile bridge
 - Flutter Wind Speed → 135m/s > Design wind speed 72m/s
 - Force and Moment Coefficients of a cross-section
 - Static Aerodynamic Coefficients were required.
 - Applying to Buffeting Analysis
 - Butterfly web impact check → NO Wind Attack Angle Effect
- Aerodynamic Design Issues of Half-Mile Bridge
 - Acquisition of design wind load distributions
 - 67 load cases are determined from buffeting analysis
 - Feedback to the design model
 - The design of the main tower needs to be revised.