Variation to the Marine Licence 06820 (dated 28 June 2019)

A 2021 wind tunnel specialist's computational analysis predicted a previously undetected vortex shedding response at high wind speeds in the 2nd bending mode (mode 7) that is inherent to the original bridge. Consequently structural damage under Mode 7 could start to occur for a steady windspeed above 33m/s in the north-easterly direction.

An assessment indicated that the mode 7 vortex induced oscillation (VIO) additional effect on the bridge was sufficient to exceed the capacity of several bridge components, causing structural damage and potential danger to road and pedestrian users.

Two remediation options are presented here as reference numbers 1 and 2 – Tuned Mass Dampers (TMDs) and aerodynamic modification Baffle Plates. Both are viable options, but further analysis is needed to determine the optimum solution. Initially, reference 1 is to be constructed and at a later date reference 2 may be added, and the Tuned Mass dampers left or removed.

Reference numbers 3 to 6 are additional work items to be constructed.

Reference Number	**Description**	**Estimated Build Cost**
1	Tuned Mass Dampers at the ¼ points of the mid-span	£500,000
2	Under-deck Baffle Plates	£350,000
Reference number 1 is to be constructed initially.		
3	Deck strengthening	£1,000,000
4	Installation of new weather stations	£50,000

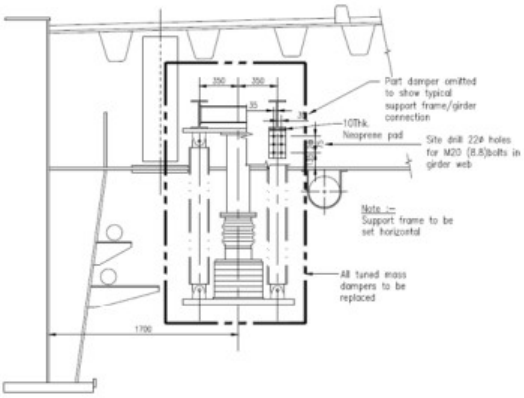
Variation Reference Number 1

Tuned Mass Dampers at the ¼ points of the mid-span £750,000

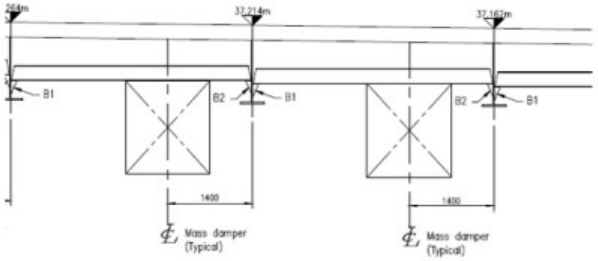
Works Description

Tuned Mass Dampers (TMDs) are units mounted under the bridge structure to reduce the amplitude of mechanical vibrations on the bridge caused by wind and vehicular traffic. There are four existing TMDs located in the main span of the A9 1350 Kessock bridge. These are located at mid-span on Span 8.

Additional Tuned Mass Dampers would be installed 60 metres and 180 metres north of Pier 8. Refer to drawing 19/NW/1203/001. The proposed TMDs would be similar to those fitted to the bridge deck in 2016. TMD's fitted adjacent to both the east and west main girders at each location.



TYPICAL SECTION ON CROSS GIRDERS



TYPICAL ELEVATION ON EAST AND WEST SIDES

The proposed TMDs would be tuned to a frequency of 0.783Hz to target the bridge's natural frequency in mode 7. The TMDs would be connected to a support frame that spans the cross girders.

Existing TMDs under the bridge deck

Summary methodology

- Establish temporary works access platform under the bridge deck
- Prepare areas for installation
- Install support frames under bridge deck
- Transport new Tuned Mass Dampers to site by boat
- Hoist TMD's into position from boat to bridge deck
- Complete installation and frequency checks
- Carry out paint repairs
- Removal of temporary works access platform

The following good practice and management measures will be adopted

- Protection around temporary works access platform to prevent loss of material
- Harbour Master will be consulted so that the Works do not affect shipping movements

Construction Timescale

Works to be constructed 2023 /24.

Duration of the works is 12 weeks.

Materials deposited

Paint removal at connection locations

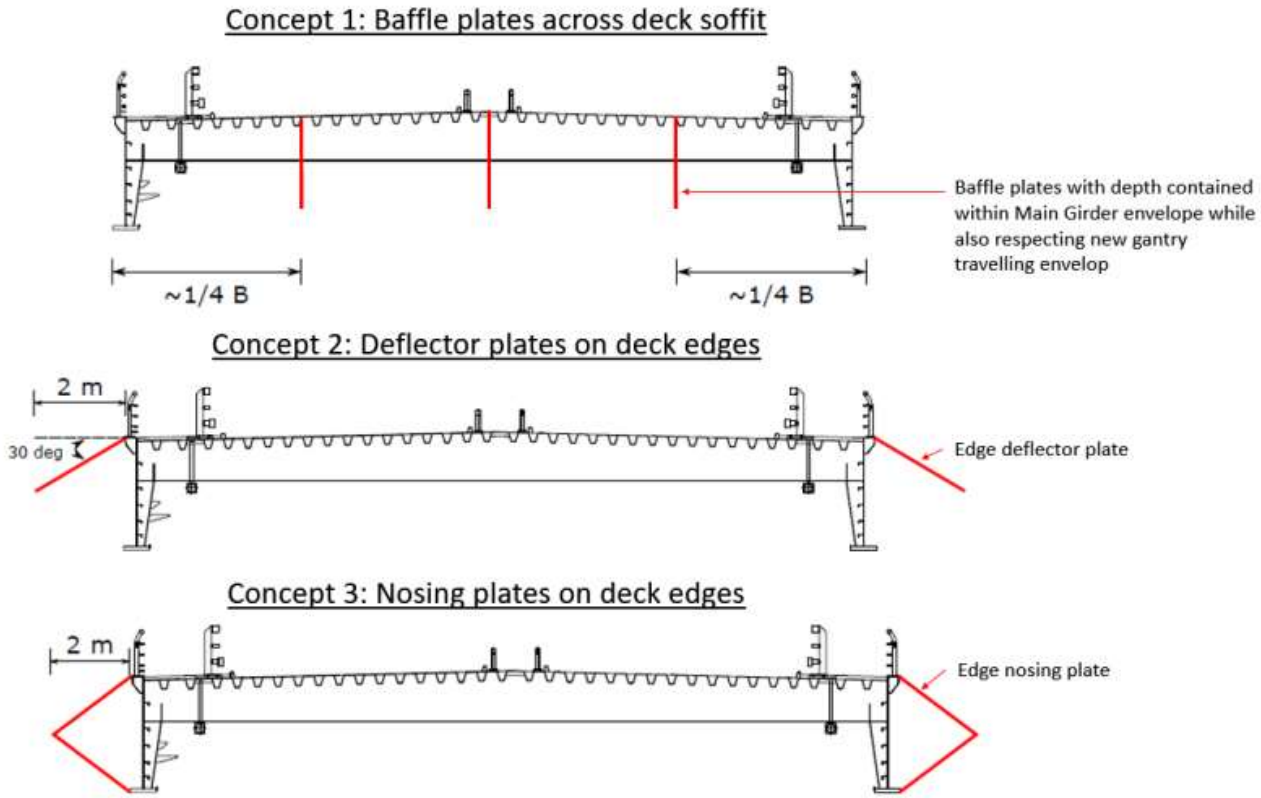
Metal from drilling holed connections

Variation Reference Number 2

Under-deck Baffle Plates **£350,000**

Works Description

The proposed under-deck baffle plates would be designed such that the modification of the deck geometry and wind flow on the deck would provide passive stability against both the VIO and flutter response.



Concept 1 above would be the preferred solution as the baffle plates are concealed under the bridge deck.

Baffle plates would not be needed along the whole of the bridge and are likely to be installed locally on Span 8 or on Spans 7, 8 and 9.

The baffle plates are not structural elements and are made of metal, aluminium or Glass Reinforced Plastic.

Summary methodology

- Establish traffic management as required
- Establish temporary works access platform under the bridge deck

- Install support frames under bridge deck
- Transport Baffle plate materials to platform from bridge deck
- Prepare areas for installation
- Install Baffle plates
- Removal of traffic management
- Removal of temporary works access platform

The following good practice and management measures will be adopted

- Protection around temporary works access platform to prevent loss of material
- Harbour Master will be consulted so that the Works do not affect shipping movements

Construction Timescale

Works to be constructed 2024 /25.

Duration of the works is 16 weeks.

Materials deposited

Paint removal at connection locations

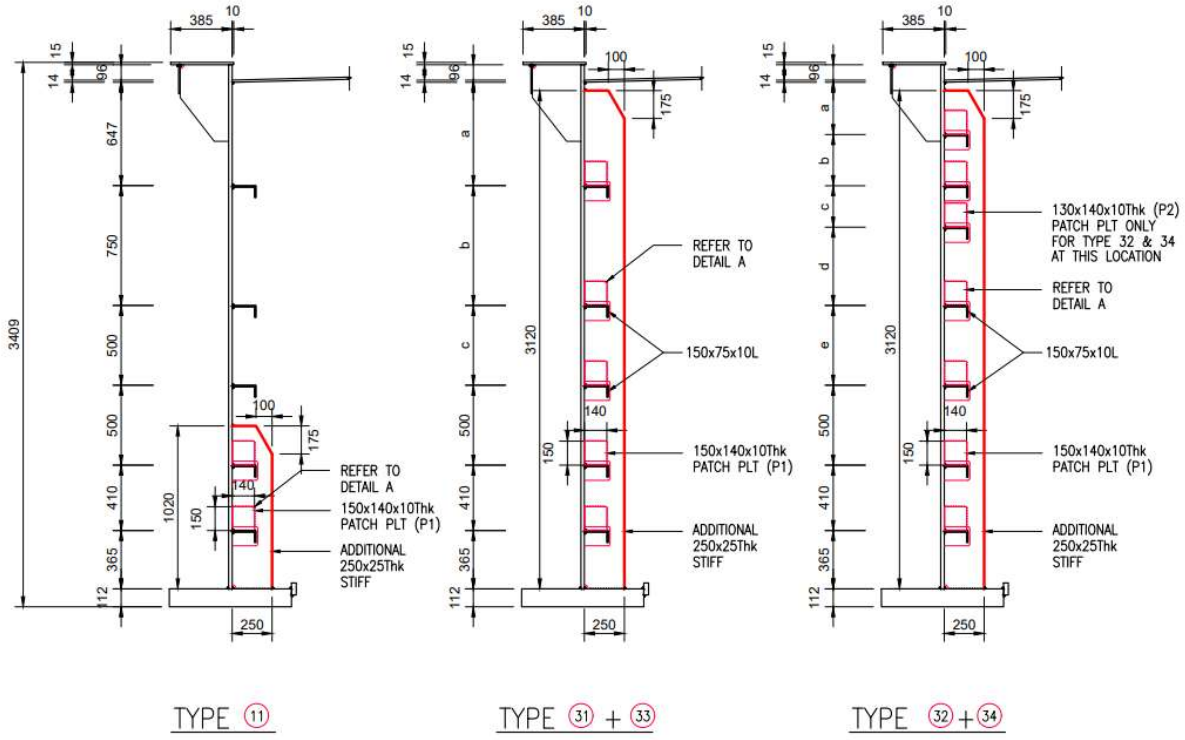
Metal from drilling holed connections

Variation Reference Number 3

Deck Strengthening **£1,000,000**

Deck strengthening work is proposed on the east and west main girders at various locations on Spans 6 to 9.

Steel plate stiffeners will be fixed to the inside of the main girders by welding.



Summary methodology

- Establish temporary works access platform under the bridge deck
- Transport stiffeners to platform from bridge deck
- Prepare areas for installation
- Weld stiffeners to the main girders
- Carry out paint protection and paint repairs
- Removal of temporary works access platform

The following good practice and management measures will be adopted

- Protection around temporary works access platform to prevent loss of material
- Harbour Master will be consulted so that the Works do not affect shipping movements

Construction Timescale

Works to be constructed between 2022 and 2025.

Duration of the works is 8 weeks.

Materials deposited

Paint removal at connection locations

Variation Reference Number 4
Installation of new weather stations **£50,000**

An existing non-working anemometer is located in the mid-span on the west main girder. A second anemometer was located at the top of the north-east Pylon, but was removed some years ago.

Existing redundant anemometer on west (left) side of the Bridge
North-east Pylon is on the right of the picture

Following the assessment that the mode 7 vortex induced oscillations could induce structural damage to the bridge at a steady windspeed above 33m/s in the north-easterly direction, it is proposed to install new anemometers. These will provide an early warning of potentially dangerous winds.

Anemometer sensor

These new anemometers will send data via mobile transmitters. One would be installed in the mid-span on the east side, and two more would be installed at the top of the north-east and south-east Pylons. The redundant anemometer at the mid-span on the west side would be removed.

Summary methodology

- Access locations for new anemometers via Pylons and underbridge Gantry
- Install power supply to each location from existing mains supply
- Install anemometers on new mounting poles
- Remove redundant anemometer and support pole
- Test and commission new anemometers

The following good practice and management measures will be adopted

- Special work methods for working inside a confined space
- Harbour Master will be consulted so that the bridge Gantry movements do not affect shipping movements

Construction Timescale

Works to be constructed in 2022 or 2023.

Duration of the works is 2 weeks.

Materials deposited

Redundant anemometer and support pole

Deposits and/or Removals

These are all above MHWS

	Deposits		Removals	
Type of Deposit/Removal	Description	Quantity & Dimensions (metric)	Description	Quantity & Dimensions (metric)
Steel/Iron	Deck Strengthening and Baffle Plate	Various Dimensions Various 100T Weight (tonnes)	Metal arisings	Various Dimensions Various 10T Weight (tonnes)
Timber	Not applicable	No. Dimensions Weight (kg/tonnes)	Not applicable	No. Dimensions Weight (kg/tonnes)
Concrete	Not applicable	No. Dimensions Weight (kg/tonnes)	Not applicable	No. Dimensions Weight (kg/tonnes)
Plastic/Synthetic	Not applicable	m2	Not applicable	m2
Clay (< 0.004 mm)	Not applicable	Volume (m3) Weight (kg/tonnes)	Not applicable	Volume (m3) Weight (kg/tonnes)
Silt (0.004 ≤ Silt < 0.063 mm)	Not applicable	Volume (m3) Weight (kg/tonnes)	Not applicable	Volume (m3) Weight (kg/tonnes)
Sand (0.063 ≤ Sand < 2.0 mm)	Not applicable	Volume (m3) Weight (kg/tonnes)	Not applicable	Volume (m3) Weight (kg/tonnes)
Gravel (2.00 ≤ Gravel < 64.0 mm)	Not applicable	Volume (m3) Weight (kg/tonnes)	Not applicable	Volume (m3) Weight (kg/tonnes)
Cobbles (64.0 ≤ Cobbles < 256.0 mm)	Not applicable	Volume (m3) Weight (kg/tonnes)	Not applicable	Volume (m3) Weight (kg/tonnes)

	Deposits		Removals	
Type of Deposit/Removal	Description	Quantity & Dimensions (metric)	Description	Quantity & Dimensions (metric)
Boulders (≥ 256.0 mm)	Not applicable	Volume (m3)	Not applicable	Volume (m3)
		Weight (kg/tonnes)		Weight (kg/tonnes)
OTHER Wind oscillation and vibration dampening	Tuned Mass Dampers	Volume (m3)	Not applicable	Volume (m3)
		Weight 64 (tonnes)		Weight (kg/tonnes)