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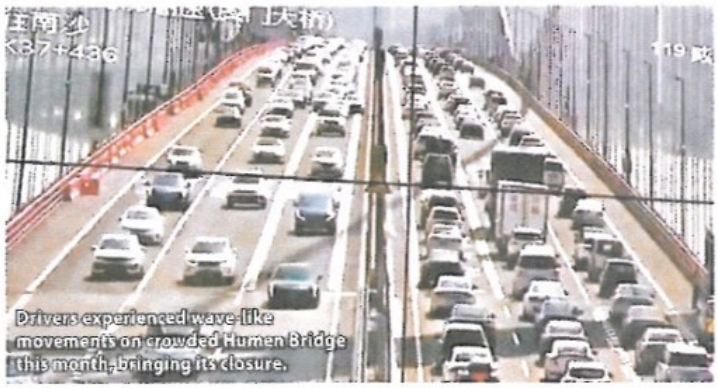
Drivers experienced wave-like movements on crowded Humen Bridge this month, bringing its closure.

NO TROUBLED WATER UNDER THIS BRIDGE


Nuts and bolts
Edmund Leung

Humen Bridge, which links the Pearl River estuary's east with its west, has been a vital link in Guangdong for over 20 years.

It was closed to traffic this month after suffering serious vibrations that caused a lot of concern among commuters, some of whom were worried it could lead to the failure of the bridge structure.

I have it on good authority the problem is not that serious, but was most probably caused by maintenance activity that resulted in structural resonance.

All objects have a natural frequency.

Wine glasses "ping" with a pleasant note when struck, and musical instruments use this phenomenon to produce distinctive tones and harmonics.

When excited, they will vibrate, but vibrations will only be sustained if the source continues to excite the object at or near its natural frequency.

In extreme cases, such vibrations can cause exceptionally large amplitudes of movements, resulting in breakage or failure.

We hear stories of soprano voices causing wine glasses to shatter, and once in a while, soldiers marching over bridges may cause them to vibrate violently and if they continue with the same marching steps, the bridge may eventually fail.

Engineers are aware of this, and in designing bridges, they perform computerized analyses to ensure the natural frequency of the bridge structure is nowhere near the vibration frequencies that can be caused by all foreseeable weather and loading conditions.

They also conduct wind tunnel tests to confirm the stability of the structure under all conceivable weather conditions.

Most suspension bridges, before being allowed to open for commercial operation, also undergo loading tests by putting lines of heavy lorries on the deck to prove that the structure behaves as it was designed to.

This is why there has been very few recent cases of bridge failures due to natural vibrations.

Suspension bridges have slender and light bridge decks that are almost like aeroplane wings, with reversed aerofoil sections to create downward forces instead of lift, to give better stability.

The deck will inherently cater for high winds and gusts without fluttering. Also, bridge loading is controlled by limiting the maximum weights for lorries and other vehicles, so such dynamic loads will not be allowed to exceed the designed load, and should not cause excessive vibrations.

Experts looking at the Humen bridge incident now point to the placing of water barriers on the deck, presumably for traffic diversion during maintenance activities.

These barriers are not only heavy, but have flat surfaces that attract gusts that may affect the bridge.

Furthermore, they were placed on only one section of the bridge deck, aggravating the loading imbalance.

Sudden gusts could have excited some vibrations on the deck.

With the bridge's natural frequency altered by these barriers, such vibrations could have caused resonance.

Unfortunately, the slender bridge deck offered very little damping resistance and the vibrations continued for a long time before they died down naturally.

The operator is justified in closing the bridge to traffic under these inconceivable circumstances. Inspections were conducted immediately to ensure there were no safety issues for traffic and that no permanent damage to the deck and structure had resulted.

With the removal of the water barriers and upon satisfactory inspection, the bridge has been reopened.

Once again, this shows the importance of the maintenance team understanding the design parameters of all engineering devices and structure. They have the responsibility to ensure total safety for those who use the facilities.

Veteran engineer Edmund Leung Kwong-ho casts an expert eye over Hong Kong's iconic infrastructure