

Influence of Walking and Standing Crowds on Structural Dynamic Properties

Stana Živanović
Aleksandar Pavić

Iván Muñoz Díaz

Vibration Engineering Section

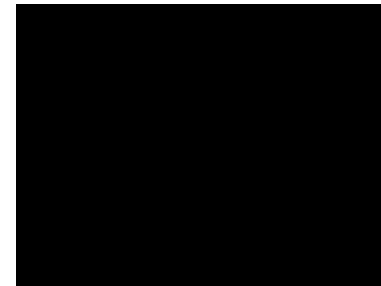
Department of Civil & Structural Engineering
The University of Sheffield
United Kingdom

Escuela Técnica Superior de Ingenieros Industriales

Universidad de Castilla-La Mancha
Av. Camilo José Cela s/n, Ciudad Real, 13071,
Spain

What can **pedestrians** do on a bridge?

Auckland bridge
(lateral vibration due to crowd load)

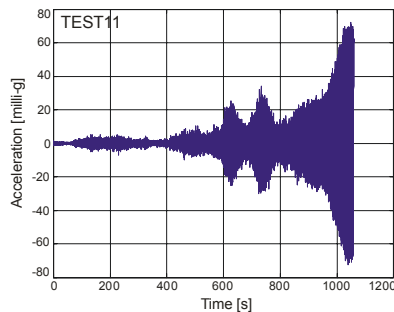


A lot of research since Millennium footbridge problem occurred in 2000

Usually this is a vibration serviceability (comfort) problem.

Lock-in (lateral direction)

Time history
gradually increasing crowd



$$Ma(t) + Cv(t) + Kd(t) = 300v(t)$$

↓
Negative damping!

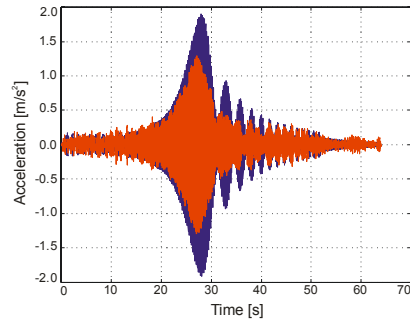
Lock-in (vertical direction)?



Literature: might happen if vibration amplitude >1cm?

Experimental data lacking.

Lock-in (vertical direction)?



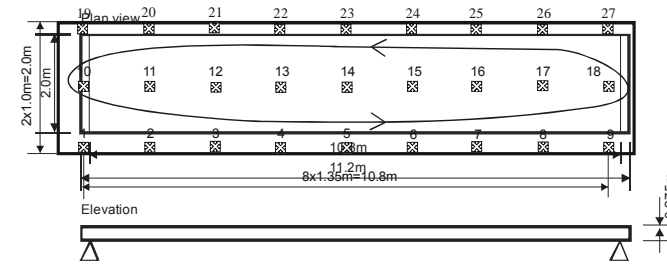
- response of empty structure to a shaker induced force
- response of the structure to a shaker induced force and six people walking over



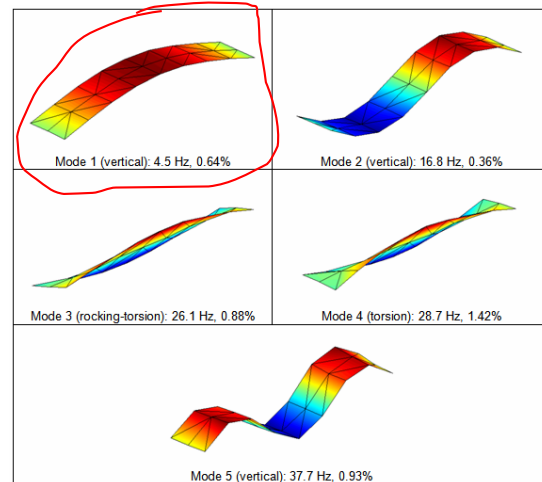
Positive damping?
Lock-in impossible?
(strongly perceptible vibration levels)

Willford (2002) and Brownjohn *et al.* (2004) felt this might be the case

Tested structure



Mode shapes



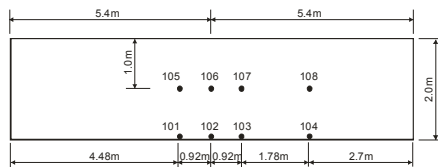
Only one low-frequency mode (at 4.5Hz)

Modal testing

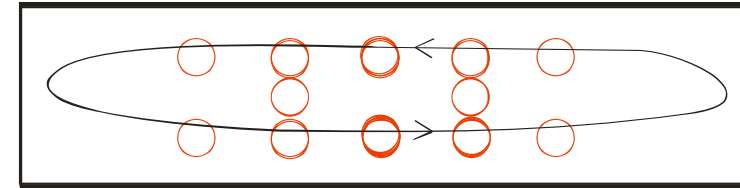
- 1] Empty structure
- 2] Structure with 2, 4, 6 or 10 standing (passive) people
- 3] Structure with 2, 4, 6 or 10 walking (active) people

- Chirp excitation 3.5-5.5Hz by electrodynamic shaker
- Duration of a data block 64s (excitation 80%)
- 5 or 15 averages

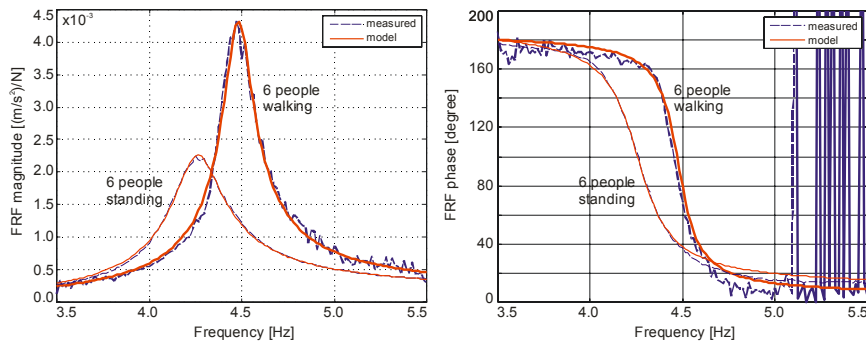
Modal testing setup



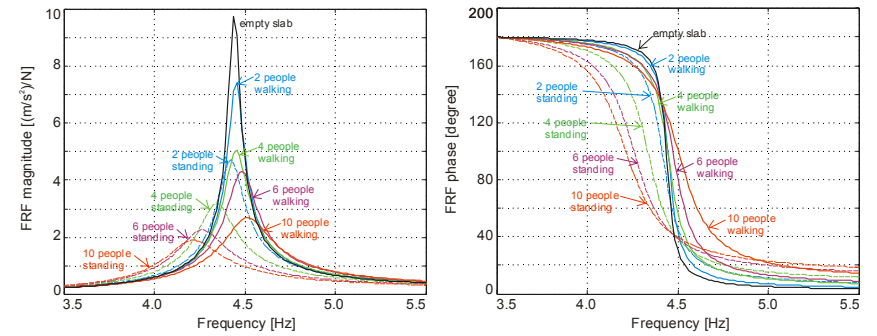
Standing/walking people arrangements



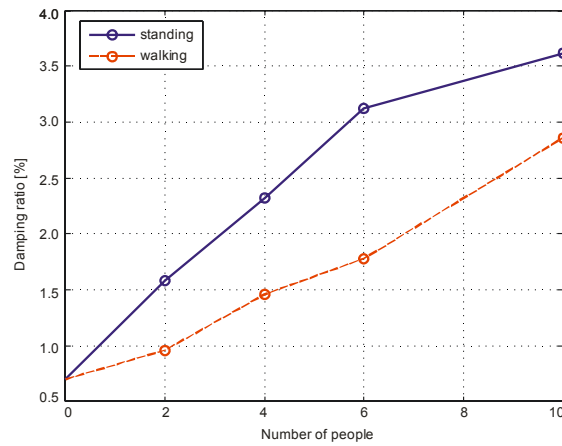
FRF fitting



FRFs for human-structure systems



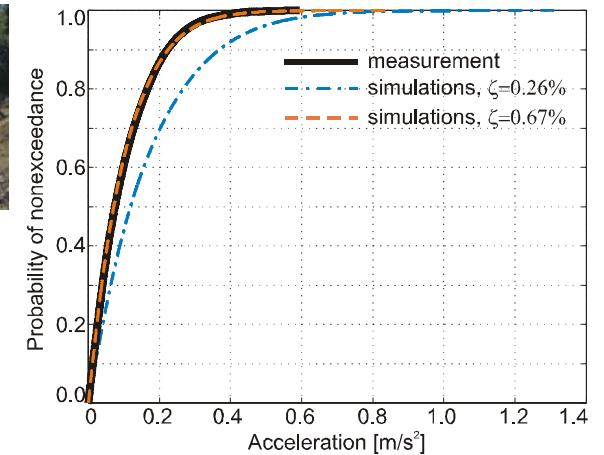
Dampening effect of people



Podgorica footbridge



Nat. freq.=2.0Hz
damping=0.26%



Conclusions

- Under strong vertical vibration, lock-in does not seem to occur (opposite to what happens in the lateral direction)
- People can be considered as dampers
- More studies needed to quantify the damping increase (probably dependent on vibration level and natural frequency, apart from the number of active people)

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6 people standing

6 people walking



THANK YOU!