

Why did the London Millennium Bridge 'wobble'?

17 December 2008



The London Millennium Bridge seen from the south bank of the Thames. Photo by Adrian Pingstone

(PhysOrg.com) -- On its opening day, the London Millennium Bridge experienced unexpected swaying due to the large number of people crossing it. A new study finally explains the Millennium Bridge 'wobble' by looking at how humans stay balanced while walking.

The same pedestrian-structure interaction has also been identified on several other bridges, including Bristol's famous Clifton Suspension Bridge. The phenomenon is not related to the structural form of the bridge, but rather the behaviour of the pedestrians. The paper by civil engineers at the University of Bristol, published in the Royal Society journal *Proceedings of the Royal Society A*, examines the basic way humans maintain balance.

Balance is achieved by changing the position of foot placement for each step, based only on the final displacement and speed of the centre of mass from the previous step.

The same balance strategy as for normal walking on a stationary surface was applied to walking on a laterally swaying bridge.

Without altering their pacing frequency, averaged over a large number of cycles, the pedestrian can

effectively act as a negative damper to the bridge motion, which may be at different frequency. Hence the pedestrian can inadvertently feed energy into bridge oscillations.

Dr John Macdonald, Senior Lecturer in Civil Engineering, said: "It is clear that the motion of the bridge affects the force from the pedestrian, rather than the pedestrian simply applying an external force."

It has generally been thought the Millennium Bridge 'wobble' was due to pedestrians synchronizing their footsteps with the bridge motion. However, this is not supported by measurements of the phenomenon on other bridges.

The researchers found, to their surprise, that pedestrians walking randomly, keeping balance as normal can cause large bridge sway. This finally seems to explain the initiation of the Millennium Bridge 'wobble' and gives new insight for designing bridges to avoid vibration problems.

The paper: Lateral excitation of bridges by balancing pedestrians; John H. G. Macdonald, *Proceedings of the Royal Society A*, 17 December 2008.

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