

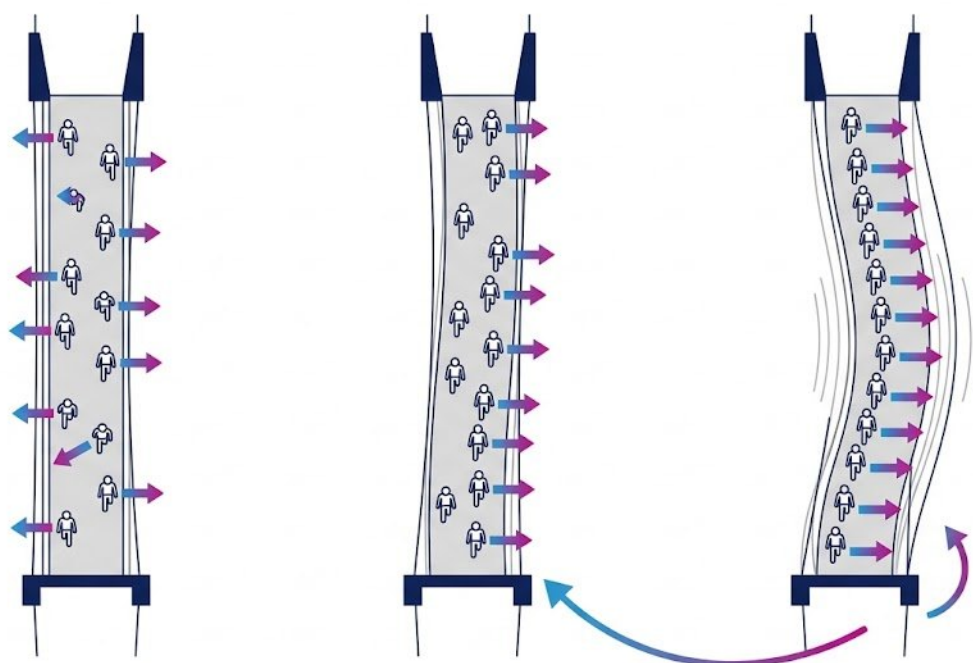
The Bridge That Wobbled

It had been calculated, modelled and approved. Then people walked on it.

5 min read

Before you read

- **lateral** — sideways, across rather than along
- **resonance** — the build-up of movement when a push repeats in time with it
- **amplitude** — the size of a vibration or swing
- **feedback** — a process in which an effect returns to influence its own cause
- **damper** — a device fitted to absorb and reduce movement
- **retrofit** — to add something to a structure after it has been built
- **empirical** — based on observation or experiment rather than theory alone
- **anticipate** — to expect something and prepare for it in advance



The feedback loop, in three stages: random sideways steps, walkers falling into step with the movement, and the sway that follows

¹ The Millennium Bridge opened across the Thames in June 2000, and it was shut again within two days. Nothing had broken. Nothing was close to breaking. The bridge had simply begun to sway from side to side under the crowd, firmly enough that people stopped walking and held the handrails, and the engineers watching had no entirely satisfactory explanation for why.

² The design was deliberately slender — a shallow suspension structure intended to look like a blade of light rather than a conventional bridge. It had been modelled thoroughly against the loads engineers

knew to check: weight, wind, and the vertical bounce that a crowd walking in step can set up. That last effect has been understood for well over a century, which is why soldiers are ordered to break step on bridges.

The effect nobody had modelled

³ What happened on the Thames was not vertical. It was lateral, and it involved the pedestrians in a way that the standard calculation did not.

⁴ Walking is not a purely forward motion. Each step pushes slightly sideways, left and then right, and in a crowd those small sideways pushes are normally random and cancel one another out. If the deck starts to move sideways, even slightly, people instinctively adjust their gait to stay balanced — and the natural way to balance on a surface moving beneath you is to step in time with it.

⁵ That is the whole mechanism. Once a few people synchronise with the movement, their pushes stop cancelling and start adding. A larger sway recruits more walkers into step, and more walkers in step produce a larger sway. It is a feedback loop, and it has a threshold: below a certain number of people on the deck, nothing happens at all; above it, the amplitude grows within seconds. On opening day the bridge carried a crowd far larger than the quiet trickle of a normal afternoon.

The expensive part

⁶ The response was neither a demolition nor a reassurance campaign. The bridge was closed for nearly two years while the behaviour was studied empirically — including tests in which volunteers were asked to walk across the deck in growing numbers until the sway began, so that the threshold could be measured rather than estimated.

⁷ The fix was a retrofit of dampers: dozens of them, fitted beneath the deck and at the supports, some absorbing energy as a fluid is forced through a restriction, others tuned to swing against the deck's own motion and cancel it. The cost approached that of a substantial fraction of the original build. The bridge reopened in 2002 and has behaved since.

What the episode is actually about

⁸ It is tempting to file this as a story about a mistake, and some accounts do. The engineers had not neglected a known effect; they had met a poorly documented one, in a structure slender enough and a crowd large enough to trigger it. Synchronous lateral excitation had been noted before, in scattered reports, but it was not in the design codes, and design codes are where an engineer is required to look.

⁹ The more useful reading is about what a code is. A design code is not a theory of everything; it is an accumulated record of what has gone wrong before. Every clause in it was written because something failed, swayed, cracked or fell. A structure that behaves in a way no code anticipates has not defeated engineering — it has just reached the edge of the record, which is precisely where the next clause

comes from.

¹⁰ That clause now exists. Pedestrian bridges are assessed for lateral synchronisation as a matter of routine, and the data came from the London crowd that walked out on a June morning expecting nothing more than a view of St Paul's.

Part A Choose the best answer

Circle the letter next to the right answer.

1. Why was the bridge closed two days after opening?

- A Part of the structure had cracked
- B It swayed sideways under the crowd and the cause was not understood
- C More people had crossed it than it was designed to carry
- D High winds had damaged the supports

2. What had the designers modelled before opening?

- A Lateral synchronisation of walkers
- B Weight, wind and the vertical bounce of a crowd in step
- C Only the weight of the structure itself
- D The effect of volunteers walking in growing numbers

3. What starts the feedback loop described in the passage?

- A People deliberately walking in step
- B Wind pushing the deck sideways
- C Walkers adjusting their gait to stay balanced on a deck already moving slightly
- D The dampers failing beneath the deck

4. Why does the passage mention a threshold?

- A Because the sway only begins once enough people are on the deck
- B Because the bridge could carry only a fixed total weight
- C Because the dampers work only above a certain speed
- D Because volunteers could not be asked to exceed a safe limit

5. How does the writer characterise a design code?

- A A complete theory of how structures behave
- B A legal requirement with no technical basis
- C An accumulated record of what has gone wrong before
- D A guide that applies only to conventional designs

Part B Write your answer

Answer in two or three sentences, using the passage as your evidence.

6. Explain in your own words why small sideways pushes normally cancel out, and what changed on the Millennium Bridge.

7. Why do you think the engineers tested the bridge with volunteers rather than relying on calculation alone?

8. The writer says it is 'tempting to file this as a story about a mistake'. What reading does he prefer, and why?

9. Explain the final sentence: what point is the writer making by returning to the crowd on opening day?

Part C Think deeper

There is no single right answer here. Say what you think, and say why.

10. Should a design be allowed to go ahead when it is more slender or more unusual than anything the codes were written for? Argue a position and address the cost of the alternative.

11. The passage argues that failures are how knowledge gets written down. Is that an acceptable way for a field to learn? Consider what it implies for whoever encounters the failure first.

12. Who, if anyone, should carry the cost of fixing the bridge — the designers, the city, or the public? Explain your reasoning and what your answer would discourage.

Answer key

For parents and teachers

Part A

1. **B** — It swayed sideways under the crowd and the cause was not understood | 2. **B** — Weight, wind and the vertical bounce of a crowd in step | 3. **C** — Walkers adjusting their gait to stay balanced on a deck already moving slightly | 4. **A** — Because the sway only begins once enough people are on the deck | 5. **C** — An accumulated record of what has gone wrong before

Part B

6. In an ordinary crowd the sideways push of each step is random in timing, so the pushes work against each other and produce no net movement. Once the deck moved slightly, walkers synchronised with it to keep their balance, so the pushes lined up and added together. Accept any answer contrasting random with synchronised.

7. Because the effect was poorly documented and not in the codes, so there was no reliable model to calculate from — the threshold had to be measured directly to be trusted. Credit answers noting that theory was unavailable or untested here.

8. He prefers to read it as a structure reaching the edge of the recorded knowledge rather than as negligence: the engineers checked what they were required to check, and the effect was not in the codes. Accept answers that distinguish an error from an unknown.

9. That the knowledge now protecting other bridges came from ordinary people unknowingly producing the data — the crowd was the experiment. Accept answers reaching the irony, or the point that the public bore the risk that generated the knowledge.

Part C

These answers vary. Mark the reasoning, not the answer.

10. A strong answer confronts the trade-off instead of choosing a side by instinct. Allowing it: codes only ever cover the past, so refusing anything new freezes the field. Refusing it: the public, not the designer, is exposed to the untested behaviour. The best answers propose a middle route — physical testing, staged loading, monitoring after opening — and admit its cost.

11. The question is close to the heart of the passage. Look for the shift from 'does it work?' to 'who pays for it working?' — the people present at the first failure carry a risk later users do not. Reward answers that distinguish failures that are survivable and informative from those that are not.

12. Any allocation can score well if the consequence is named. Designers pay: discourages ambitious design and encourages conservative copying. City or public pays: removes a reason for care. Watch for answers that notice no injuries occurred, and that this affects how harshly the failure should be treated.

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