

Structures: Where Does It Actually Fail?

Lesson at a glance

Open by lowering a bean tin onto one newspaper tube so the class watches it fold in the middle, then name buckle, splay and twist with quick demos. Groups sketch a free-standing tower, build from newspaper, tape, straws and card (string held aside), and load weights one at a time until it fails: recording load held and failure type in the Investigation Journal. They add one matching tie or strut at the failure spot, re-test, then pool before/after loads on the IWB chart and talk about matching the fix to the force.

Learning objectives

- Load a tower to failure and name how it failed (buckle, splay or twist)
- Add one tie or strut where the structure actually failed, then compare the load held before and after

Before the bell: prep

Night before: gather newspaper, masking tape, drinking straws, card offcuts and string per group, plus bean tins or 200 g masses as shared test weights. Pre-roll one tight newspaper tube for the demo. Clear smooth desk space so splay is visible; keep scissors adult-supervised.

**Materials**

Item	Qty	Per	Source	Low-cost substitute
newspaper	6	group	brought from home	any scrap paper or old flyers
masking tape	1	group	classroom	sticky tape
drinking straws	10	group	classroom	tightly rolled paper tubes
card offcuts	4	group	classroom	cereal-box card cut into strips
string for ties	1	group	classroom	wool or garden twine
test weights: about ten identical small items to add one at a time (bags of 20 washers, 100 g masses, or small bean tins)	10	group	school kit	ten matching pebbles or full glue sticks; anything the same weight as each other
metre stick (optional: to compare tower heights if groups ask)	1	group	school kit	a 30 cm ruler used end over end
round-tip scissors	2	group	classroom	one shared pair per group

Safety watch-point

Adult supervises scissors and makes awkward cuts. Pupils stand back as towers collapse; mind eyes and fingers under falling weights and frames.



Teaching moves

- **Getting Started:** Roll one newspaper tube, stand it up and lower a bean tin onto the top so it bows and folds. Ask only where it went (top, bottom or middle), take a few guesses, and keep the folded tube for Step 2. Do not name the three failures yet.
- **Three ways a tower gives way:** Demo each failure before naming it: fold the saved tube for buckle; let two straw feet skid apart for splay; push a straw square so it leans for twist. Put only the five words on the board. Think aloud through the tube: predict middle fold, load it, name buckle, so the strut goes across the middle, not more tape at the top.
- **Sketch your tower and mark the weak spot:** Two minutes sketching on the Design Brief section of the Investigation Journal, one minute marking the predicted weak spot. Nudge specificity only: a predicted splay should already eye the feet; a predicted buckle should eye the middle. Do not hand them the fix.
- **Build the tower:** String stays unused in the middle of the table. Show one tight newspaper roll to any group whose tubes are floppy. Adult makes awkward scissor cuts. Keep builds free-standing and taller than wide.
- **Load it until it gives way:** Load one weight at a time with the group counting together; pupils stand back as it fails. Insist they name the failure out loud (buckle, splay or twist), not just 'it broke'. Check both the load number and the failure type are on the Investigation Journal page before you leave the table.
- **One fix, exactly where the force was:** Keep the decision tree on the IWB: feet slid → tie; middle folded → strut; twisted → diagonal strut. One part only, at the failure spot. Re-test the same way with the same weights so before/after can be compared fairly, and get the new load written beside the first.
- **Pool the class results:** Drive the IWB recorder yourself while groups call out their two numbers. Note each group's failure type as you go and ask whether the matching fix earned the extra load: a tie should lift a splay; a strut a buckle. Press the chart button so the after bars show where the fix worked.
- **Make sense of it:** Display-only talk: the right fix matches the failure; engineers add material where the force is, not everywhere. Link to the Samuel Beckett Bridge: cables as ties in tension, deck squashed like a strut. Tidy tape and offcuts; recycle newspaper.

What it should show

Expect most towers to fail by buckle (tall thin tubes fold mid-height), splay (feet skate out on a smooth desk) or twist (square frames rack sideways). A matching fix should raise the load held: tie across splayed feet, strut across a fold, diagonal strut against twist. Little or no gain usually means the wrong fix type or the fix was not placed on the actual failure spot; re-identify and re-test once.

**Misconceptions & interventions**

- **‘Just put more tape everywhere and it’ll hold more.’** Hold up the failed tower and point at the spot that moved first. Remind them engineers add one part where the force actually is: that is why a bridge is full of gaps, not a solid block. Send them back to the decision tree.
- **Pupils write ‘it broke’ instead of naming buckle, splay or twist.** At the moment of collapse, freeze the group and ask: did it fold in the middle, spread at the feet, or turn over? Have them say the word out loud before they record it.
- **A group adds a tie to a buckle (or a strut to a splay) and expects a big gain.** Point at the chart pattern: the fix only works when it matches the failure. Ask what the failed part was doing (folding, sliding or leaning), then match tie or strut to that action and re-test.

**Differentiation**

Emerging	Developing	Proficient
• Offer a simple four-tube tower brief and sit with the group to name the failure together from the three words on the board before they record. • Partly mark the Investigation Journal row so they only fill load-before, failure type, and load-after.	• Nudge a more specific weak-spot prediction on the sketch (feet vs middle vs corner) before the first load. • After the fix, ask why that one part matched the force they saw.	• Allow a triangular or braced base and a prediction of a different failure mode. • Stretch: critique another group’s before/after pair. Did the fix match the failure, and what would a second matched part do?

**Cross-curricular hook**

Tie to Maths Data: read the class before/after bar chart for the biggest gain and the typical improvement.