Episode 01: Can Carbon Fiber Save a Splitting Timber Bridge?

Two rural timber bridges over branches of Crow Creek near Toston, Montana | Video https://www.youtube.com/watch?v=Em-NaGK4CLM | 09:45

01 STANDARDS AND COURSE ALIGNMENT

STANDARD OR COURSE	ALIGNMENT
NGSS HS-PS2-6	Explain how carbon-glass strip fibers carry tension across cracked timber girders, citing measured C-S crack repair moment gains of 29.9-50.5 percent.
NGSS HS-ETS1-3	Weigh GFRP channel and carbon-glass strip repair against steel sister girders using measured capacity gains, 30-90 minute installs, and a seven-month inspection.
AP Physics 1	Apply static equilibrium to four-point bending of timber girders, separating midspan bending moment from support shear resisted by GFRP channels.
University civil engineering	Compare allowable-stress and perfect-bond predictions of timber girder bending and shear capacity with measured capacities, which exceeded calculation in every test.

One 50 minute period. The episode runs 09:45; the remaining time is discussion, worksheet, and debrief. No prior knowledge of the report's discipline is assumed: every term the class needs is glossed in the vocabulary table on page two, and every number used in class appears on the student worksheet.

02 BELL TO BELL PACING GUIDE

CLOCK	ACTIVITY	WHAT HAPPENS
0–5 min	**Hook and force map**	Show a split timber girder. Students sketch where compression, tension, shear, and bearing act under a truck.
5–23 min	**Video with four pauses**	Screen 01:44-02:45. Pause at 06:15, 08:04, 05:20, and 08:18 for prediction, test evidence, repair choice, and limits.
23–40 min	**Diagram and Problems 1-3**	Trace badges 1-8 on the diagram, then solve Problems 1-3 in pairs, carrying US and SI units in every step.
40–50 min	**Problems 4-5 and exit check**	Teams finish load share and the trade-off problem, then defend one damage-matched repair and one monitoring item.

FOUR PAUSE AND DISCUSS CHECKPOINTS

Build the pause list on the board before the bell. Each one is a two minute stop; skipping them turns a field investigation into a video.

PAUSE	SEQUENCE	ASK THE CLASS	LISTEN FOR
01:44	**Part 1: The everyday question**	How could fiber-reinforced polymer (strong fibers held in hardened resin) help a cracked girder (main beam supporting the deck) carry traffic?	The fibers resist tension, and a channel (U-shaped reinforcement around the girder) resists shear; tests must verify the gain.
02:45	**Part 2: The field test**	In four-point bending (two loads create a central bending region), why track deflection (movement of the beam under load) instead of failure load alone?	Deflection shows damage growth before failure, while a load cell (sensor that measures applied force) links that growth to force.
06:15	**Part 3: Where it's happening on the ground**	Match C-S (channels and strips used together) and strip-only (bonded strips without a channel) to a broken girder and a minor crack.	Use C-S on the broken girder and strip-only on the minor crack, matching each retrofit to damage severity.
08:04	**Part 4: What comes next**	Calculated moment capacity (largest bending moment before failure) was below every measured value. Is a safe-side prediction enough for widespread use?	No. Few specimens, two bridges, and a seven-month visual check leave fatigue, fastener, and durability questions open.

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03 KEY VOCABULARY AND UNITS REFERENCE

TERM	WORKING DEFINITION	US CUSTOMARY	SI
Shear capacity	Largest shear force a girder resists before its fibers slide apart along the grain.	kip	kN
Moment capacity	Largest bending moment a girder resists before cracking or crushing ends its strength.	kip–ft	kN–m
Allowable stress	Design stress limit after reductions for wet service, load duration, member size, and stability.	psi	kPa
Section modulus	Section property linking bending moment to peak bending stress; larger values mean lower stress.	in^3	mm^3
Composite action	Timber and FRP strain together under perfect bond so both share internal force.	dimensionless	dimensionless
GFRP channel	Pultruded glass-fiber U-section fastened along a girder to resist shear and close splits.	in	mm
String potentiometer	Cable-reel sensor that converts beam deflection into an electrical displacement reading.	in	mm
Capacity factor	Measured capacity divided by a control or calculated capacity; above one means a gain.	dimensionless	dimensionless

Conversion factors for the board: 1 kip = 4.448 kN. 1 psf = 0.04788 kPa. 1 in. = 25.4 mm. 1 ft = 0.3048 m. Pressure and stress share units because stress is force per unit area.

BEFORE THE BELL

- Print one worksheet per student, double sided.
- Set the pause points at 01:44, 02:45, 06:15, 08:04.
- Sketch the unlabelled section on the board before pressing play.

TEACHING MOVES THAT WORK HERE

- Anchor every number to the physical load path in the diagram.
- Require units at every step in both the US and SI systems.
- Close on the design trade-off, not on the arithmetic.

04 ASSESSMENT MAP

The full 20 point rubric, with one criterion per task, is printed in the Answer Key and Grading Rubric handout. Grade the numbered load-path table and the five problems; a correct number with no units earns half credit.

Suggested weighting: the diagram table and the five problems carry the grade. A student who can draw the load path and compute both ratios has met the standard even if one arithmetic step slips.