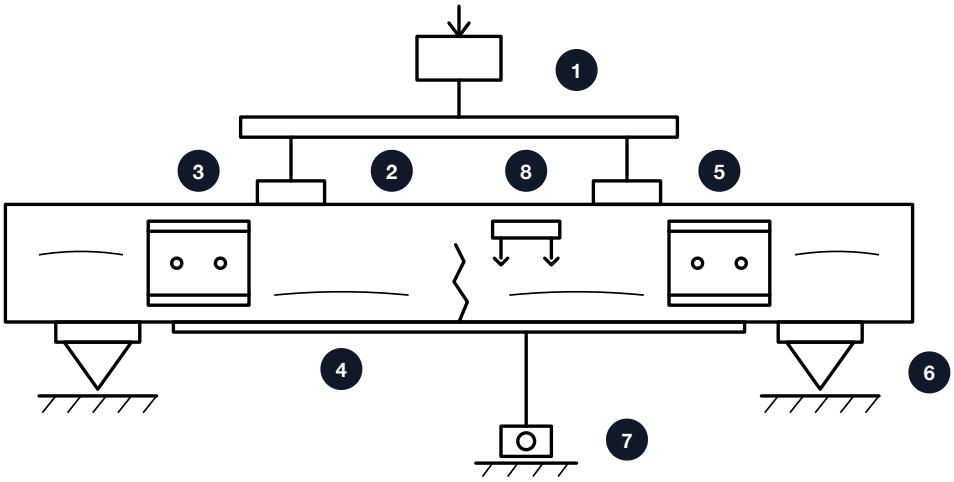
Episode 01: Can Carbon Fiber Save a Splitting Timber Bridge?

Two rural timber bridges over branches of Crow Creek near Toston, Montana

Name: Date: Class / Period:

PART 1 LOAD PATH CROSS-SECTION

Eight parts are numbered. Name each one, then circle the force it carries most of. Two parts only measure.



CALLOUT COMPONENT NAME	DOMINANT FORCE				
[1]	☐ Compression	☐ Tension	☐ Shear / friction	☐ Bearing	☐ None
[2]	☐ Compression	☐ Tension	☐ Shear / friction	☐ Bearing	☐ None
[3]	☐ Compression	☐ Tension	☐ Shear / friction	☐ Bearing	☐ None
[4]	☐ Compression	☐ Tension	☐ Shear / friction	☐ Bearing	☐ None
[5]	☐ Compression	☐ Tension	☐ Shear / friction	☐ Bearing	☐ None
[6]	☐ Compression	☐ Tension	☐ Shear / friction	☐ Bearing	☐ None
[7]	☐ Compression	☐ Tension	☐ Shear / friction	☐ Bearing	☐ None
[8]	☐ Compression	☐ Tension	☐ Shear / friction	☐ Bearing	☐ None

PART 2 INSTRUMENTED FIELD TELEMETRY

Left is the design assumption. Middle is what the field instruments measured. The gap is the story.

PARAMETER	DESIGN ASSUMPTION	MEASURED IN FIELD
Shear gain, strengthened 6x18 beam	Control shear capacity, 100%	+23.1% with GFRP channels
Shear gain, strengthened 8x18 beam	Control shear capacity, 100%	+48.5% with GFRP channels
Moment gain, C-S crack repair 8x18	Control moment capacity, 100%	+50.5% after C-S repair
Strip-only strengthening, 8x18 moment	Control moment capacity, 100%	+140.0% over controls
Split repair flexure, 6x18 beam	Restore full control capacity	97.1% of control capacity
Calculated versus measured moment capacity	Allowable-stress, perfect-bond prediction	Every tested beam exceeded calculation
Field installation time, two bridges	Heavy sister-girder repair, long closure	1.5 hours and 30 minutes
Seven-month follow-up inspection result	Long-term durability assumed	No visible deterioration or issues

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PART 3 APPLIED PROBLEMS

Show the unit conversion and the formula you used. A correct number with no work is worth half credit.

1. The salvaged test girders (main beams supporting the deck) were 6 in x 18 in and 8 in x 18 in. Using 1 in = 25.4 mm, find each cross-sectional area. Peak shear stress (sliding stress between internal wood layers) in a rectangular beam is proportional to V/A. Under the same shear force V, what is the ratio of peak shear stress in the 8 in beam to the 6 in beam?

2. For the same 6 in x 18 in and 8 in x 18 in girders, use 1 in = 25.4 mm and 1 kip-ft = 1.3558 kN-m. Compute each section modulus (shape's resistance to bending stress) for a rectangle. If bending stress (stretch or squeeze stress from bending) limits both controls equally, how much more moment can the 8 in control carry than the 6 in control?

3. A split (lengthwise crack running along the grain) repair using full-length GFRP channels (glass-fiber U-sections fastened along the girder) restored 6 in x 18 in beams to 97.1 percent of control moment capacity (largest bending moment before failure) and brought 8 in x 18 in beams to 112.2 percent. Each control has factor of safety (capacity divided by the applied demand) FS_c. Using 1 in = 25.4 mm and 1 kip-ft = 1.3558 kN-m, find each repaired factor of safety and the repaired 8 in to 6 in capacity ratio.

4. Channel strengthening raised shear capacity (largest shear force before the beam fails) by 23.1 percent for undamaged 6 in x 18 in girders and 48.5 percent for 8 in x 18 in girders. Assume each control's shear capacity scales with cross-sectional area. Using 1 in = 25.4 mm and 1 kip = 4.448 kN, find the share of strengthened capacity carried by the GFRP channels (glass-fiber U-sections fastened along the girder) and the strengthened 8 in to 6 in capacity ratio.

5. Strip-only (bonded strips without a channel) strengthening raised 8 in x 18 in moment capacity (largest bending moment before failure) by 140.0 percent, but its control underperformed; C-S (channels and strips used together) strengthening gave 45.0 percent. Field installs took 1.5 hours and 30 minutes, and inspection covered seven months on girders more than 80 years old. Using 1 kip-ft = 1.3558 kN-m, 1 hour = 60 minutes, 1 minute = 60 seconds, and 1 year = 12 months, decide which gain to design on and what to monitor next.