Selecting the Right Bridge for Your Trail

Sustainable Bridge Design and Construction Guidance for Trails Organizations

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Outline

- Introduction
- Overview of Bridge Options
- Factors Affecting Bridge Type Selection
- Costs
- You Pick It: Which Bridge Makes Sense?
- Problems that Develop / Designing for Prevention and Maintenance

Introduction

- Who I am
- My qualifications and limitations
- Four parts of a bridge:
  - Approaches
  - Deck
  - Superstructure
  - Substructure
- Guidelines/Specifications and Regulations
  - http://www.fs.fed.us/eng/bridges/

Bridge Type Options

SUPERSTRUCTURE AND DECK MATERIALS

- Timber or Rope
- Steel
- Concrete
- Polymer

TYPES

- Slab
- Multibeam
- Arch
- Box Culvert
- Girder/Floorbeam or Truss/Floorbeam
- Suspension / Cable Stay
- Stress Ribbon

Bridge Type Options: Timber / Rope

- Slab
  - Nail-Laminated
  - Transversely Post-tensioned
  - Engineered Lumber Systems
- Multibeam
  - Basic Logs and Planks
  - Stringers with Decking
  - Engineered Lumber Systems
- Arch
  - Rare for Deck Arches
  - Through and Tied Arch Systems
  - Engineered Lumber Common
- Box Culvert
  - Common in Mines
  - Still Exist
- Girder/Floorbeam or Truss/Floorbeam
  - Covered Bridges
  - Engineered Lumber
- Suspension / Cable Stay
  - The classic bridge in the movies
  - New takes on the old
- Stress Ribbon
  - Engineered timber
  - Post-tensioned catenary deck

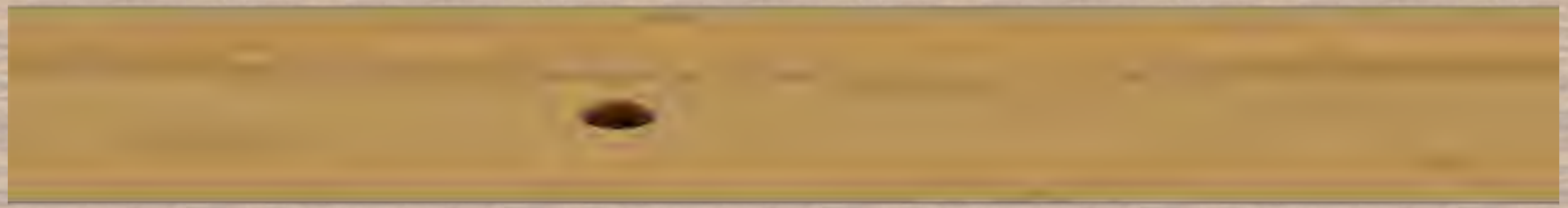
Pros and Cons of Timber or Rope

PROs

- Relatively Lightweight
- Easily Seperated into Separate Pieces
- Carpentry can be done on site
- Surprisingly fire-resistant
- Fairly inexpensive
- Parts relatively easy to replace
- Material is flexible

CONs

- Not as strong as other materials
- Subject to insect infestation
- Subject to rot
- Buoyant
- Prone to splitting / splinters
- Requires fasteners that are nails/screwed drilled into materials



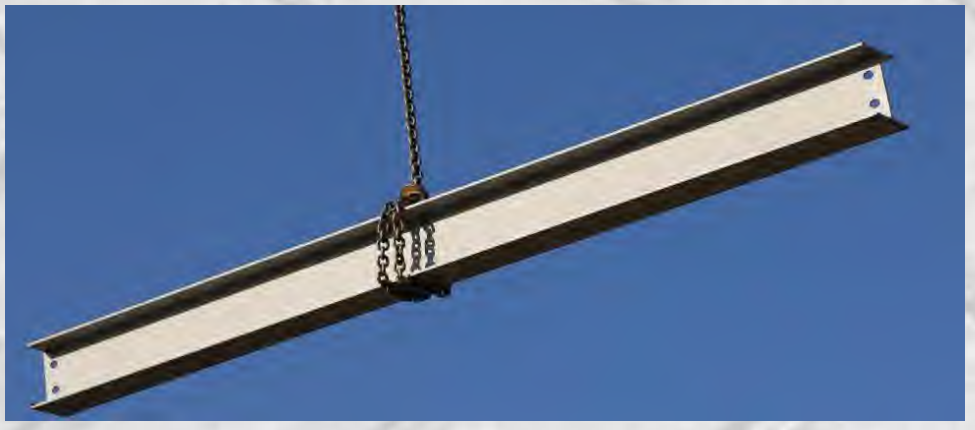
Bridge Type Options: Steel

- Plank or Panel
  - Steel Plate or Corrugated Metal
  - Orthotropic Deck
- Beam Bridges
  - Rolled Sections
  - Welded/Bolted Plates / Box Girders
- Arch
  - Deck Arches
  - Through and Tied Arch Systems
- Culverts
- Girder/Floorbeam or Truss/Floorbeam
  - Pre-fabricated
  - Built on site
- Suspension / Cable Stay

Pros and Cons of Steel

PROs

- Strong
- Usually easy to assemble
- Readily available
- Not buoyant
- Easily protected from elements by painting (or using weathering steel)



CONs

- Heavy
- Subject to Rust Losses
- Fairly Expensive
- Easier to build with power tools, hoisting equipment
- Not easily altered in field
- Subject to fatigue cracks
- Significant expansion / contraction

Bridge Type Options: Concrete

- Slab
  - Cast-in-place
  - Prestressed
- Girders
  - Cast-in-place T-Beam
  - Prestressed I-Girder
  - Segmental Girders
- Arch
- Culvert
- Stress Ribbon

Pros and Cons of Concrete

PROs

- Strong
- Usually easy to assemble
- Any shape can be made
- Readily available
- Not buoyant
- Easily protected from elements by painting (or using weathering steel)

CONs

- Heavy if precast
- Quality can vary if cast-in-place
- Rebar bending difficult in field and heavy to carry to site
- Subject to rebar corrosion, alkali-silica reactions and numerous other forms of deterioration leading to cracks and spalls

Bridge Type Options: Polymer

- Slab
  - Orthotropic
- Girders
- Arch
  - Bridge in a Backpack
- Culvert
- Truss or Girder/Floorbeam Systems
- Suspension or Cable Stay
- Stress Ribbon

Pros and Cons of Polymers

PROs

- Can be very strong
- Lightweight
- Small pieces can be attached together in field
- Typically does not require power tools to assemble or arrange components
- Large color selection

CONs

- Can deflect and deform
- Behavior varies with weather
- Subject to cracking and splitting, splintering
- Can deteriorate from direct sunlight
- Stronger polymers can be expensive

Factors Affecting Bridge Type Selection

- Access for Construction & Maintenance
- Usage Needs
- Need for Vertical Clearance or Long Spans
- Environment/Geology and Associated Issues
- Cost

Access for Construction and Maintenance

- If the bridge is difficult to access, it follows that it may be difficult to build and maintain.
- A bridge can only be made of the materials you can get to a site, and utilizing the tools you can operate there.
- A bridge first and foremost needs to be SAFE, so if it is tough to maintain, it better not demand too much maintenance!

Usage Needs

- All bridges must meet design criteria, but requirements vary based on usage criteria.
- Even with criteria, misuse will happen.
- In highly populated areas, bridges need accessibility features, special safety features, be vandal-proof, and able to handle whatever comes at them from whatever direction.
- Is the bridge a landmark structure or monument?

Need for Vertical Clearance / Long Spans

- Greater vertical clearance often means either long spans or a tall substructure
- Sometimes you just can't touch the ground beneath a bridge for a long distance

Environmental and Geological Issues

- Bridges must not have negative environmental impacts.
- Bridges need to handle their environments.
- In the natural world, the earth erodes, rain falls, rivers meander and animals do whatever they want.

Cost

- Don’t do a thing until you understand what you need.
- Several types studies are worthwhile, depending on number of options that seem viable for construction. Sometimes, higher priced materials require smaller quantities, and there is a balance between the two factors.

Cost vs. Strength

- Timber – 1500 psi vs. $70/sf
- Concrete – 4000 psi vs. $120/sf
- Steel girder – 36000 psi vs. $130/sf
- Polymer – 72000 (Kevlar is 525000) psi vs. $130/sf

THIS IS NOT A FAIR COMPARISON – TOTALLY DIIFERENT STRUCTURE TYPES – APPLES VS ORANGES!!

STUDY SEVERAL TYPES AND IMAGINE CONSTRUCTION

What would you pick?

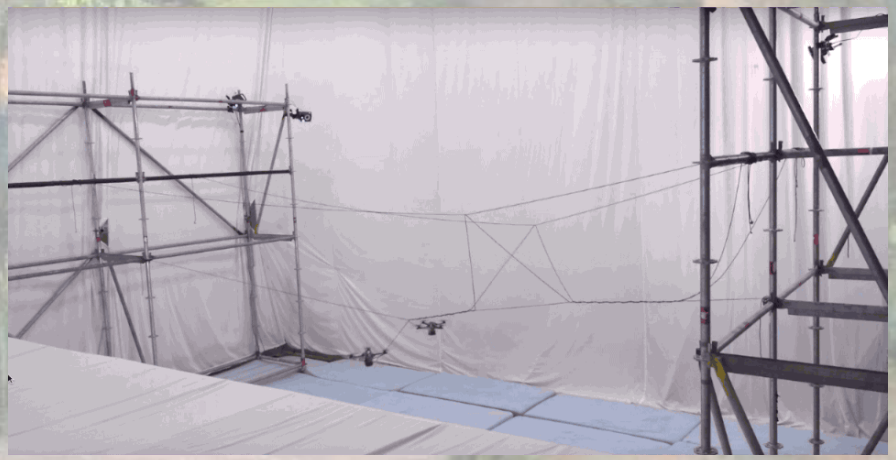
- **Trail within suburban park; level area crosses a brook that is about 20 feet wide**

- **Narrow, popular hiking trail in a mountainous state forest, over a mile in from the trail head**

- **Old rope bridge across a ravine is deemed unsafe and a new bridge, about 75 feel long, is needed. Trail is well known to tourists.**

Trail within suburban park; level area crosses a brook that is about 20 feet wide

Narrow, popular hiking trail in a mountainous state forest, over a mile in from the trail head



Old rope bridge across a ravine is deemed unsafe and a new bridge, about 75 feel long, is needed. Trail is well known to tourists.

Problems that Develop / Designing for Prevention and Maintenance

- The earth does what the earth does. Weigh these factors heavily in the design.
- Keep It Simple
- Avoid “water catchers” and “nooks & crannies” in design
- Consider what it will take to replace parts.
- It’s not about load capacity: it can’t blow away, float away, rot away or slide away, either!
- Know the durability of the parts and have a maintenance plan in mind!