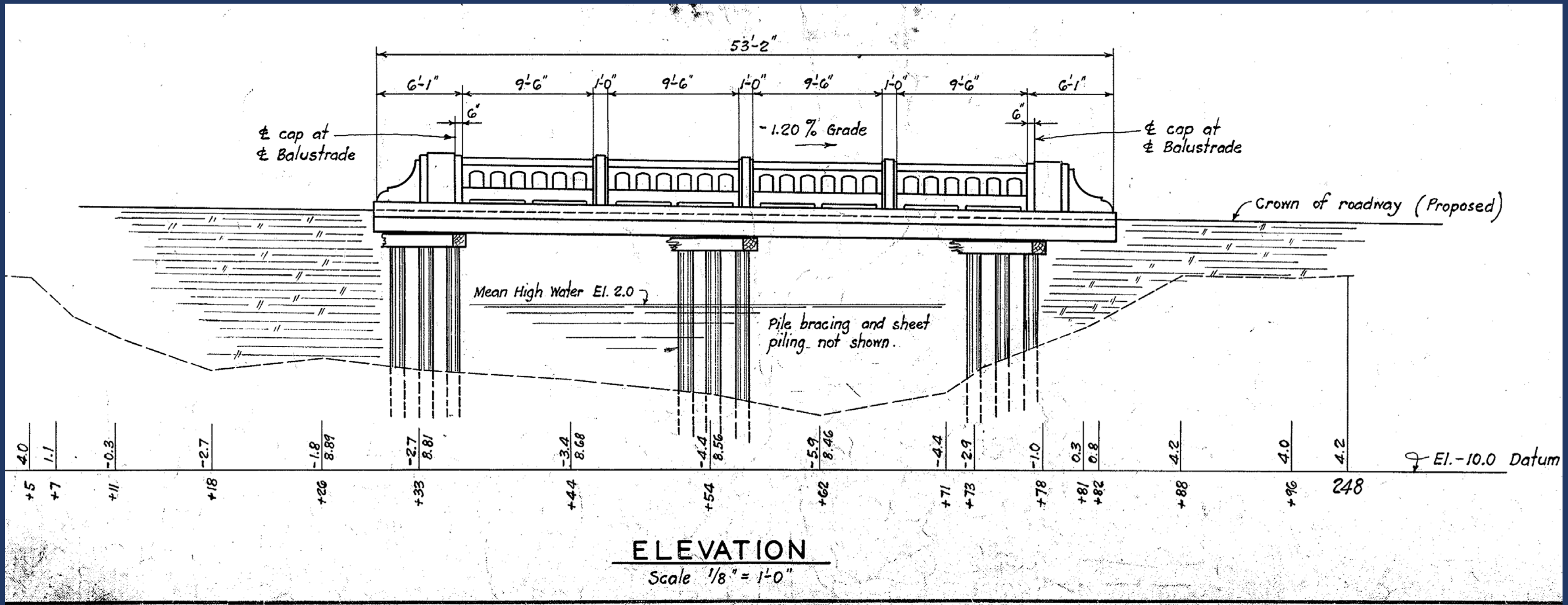
Bridging Maryland, Becoming Engineers



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A Lesson in the Engineering Design Process Linked to a Historic Maryland Bridge

Part 1

Objective and Overview

- In this unit, we will learn about the Engineering Design Process and how engineers use their knowledge about bridge forms and materials and how they work together.
- We will also build and test some model bridges.
- We will use hands-on activities to learn about how engineers have used the Engineering Design Process to solve real-world problems.

- **Essential Questions: How are bridges shaped by properties of their functions? How are they shaped by design constraints?**

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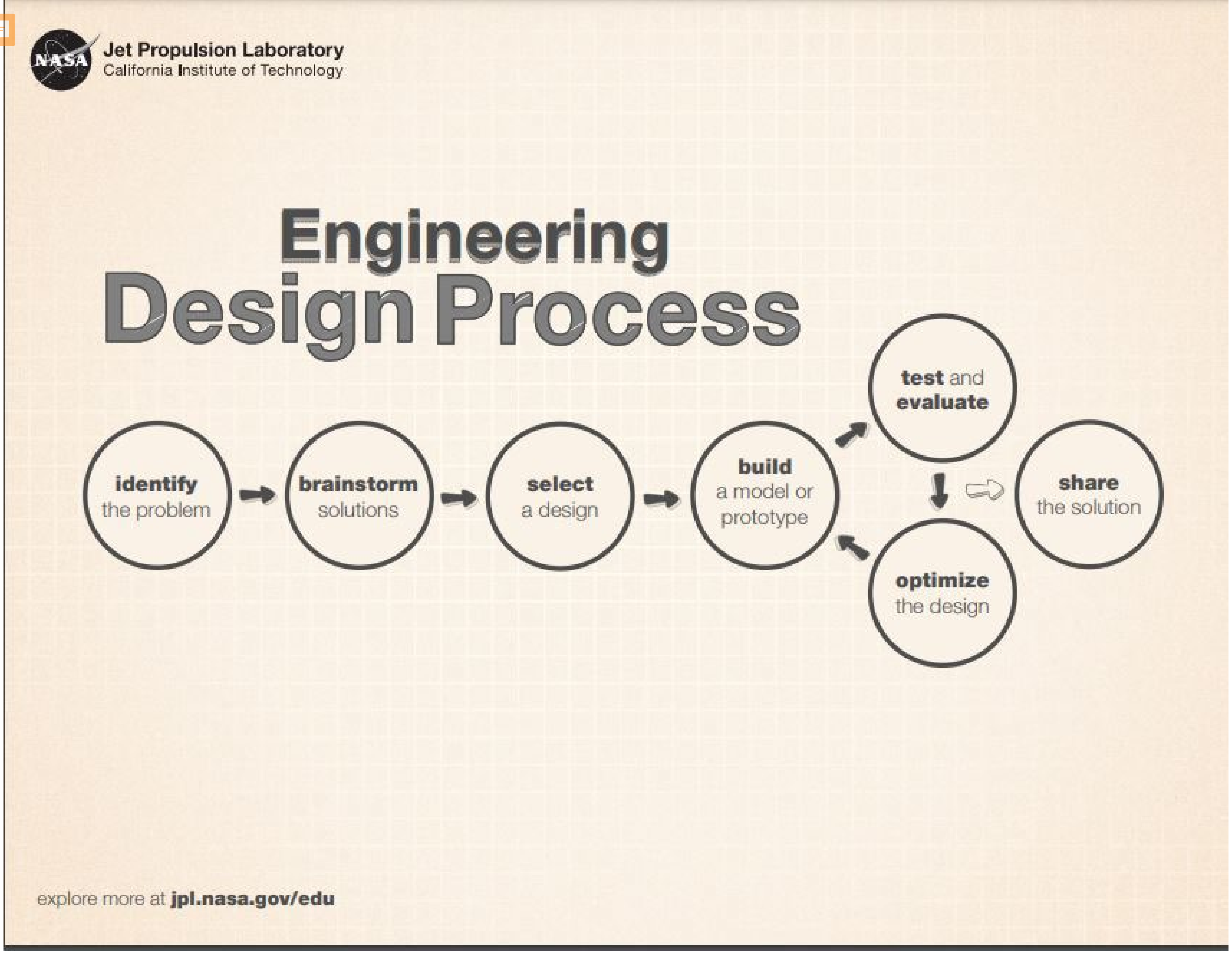

The Engineering Design Process involves:

- Identifying a problem
- Considering different ideas that could solve that problem
- Selecting one or more ideas to develop as a design
- Building a model or prototype to test that design
- Testing and evaluating the design
- Refining and improving the design
- Sharing the solution to the problem

Some of these steps need to be repeated many times before a good solution to the problem is reached.

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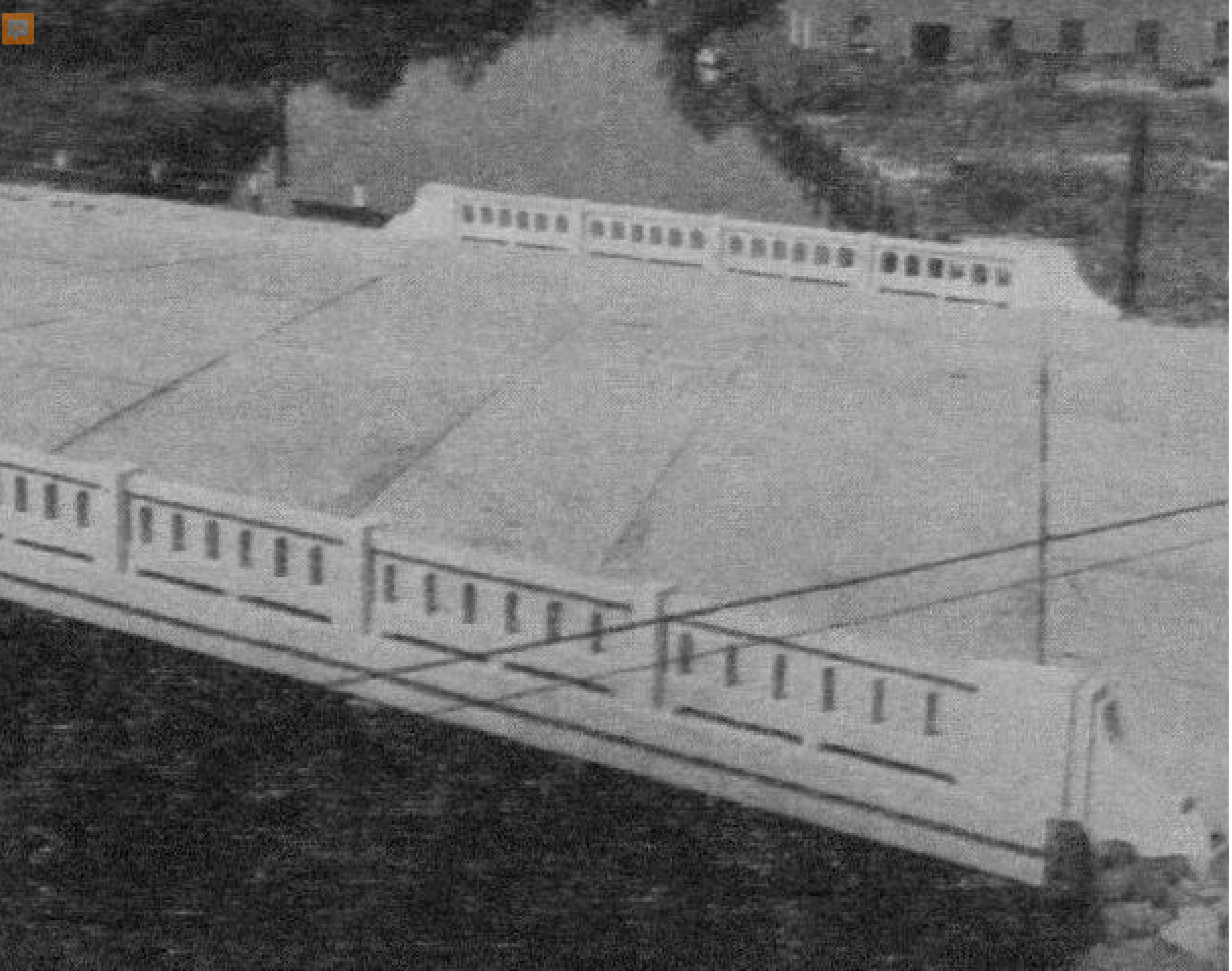

When engineers are tasked to design a bridge, what is the problem they are trying to solve?

identify
the
problem

The bridge shown here, over the Wicomico River in Salisbury, was built by the Maryland State Roads Commission in 1937.

Why do you think a bridge was needed in this location?

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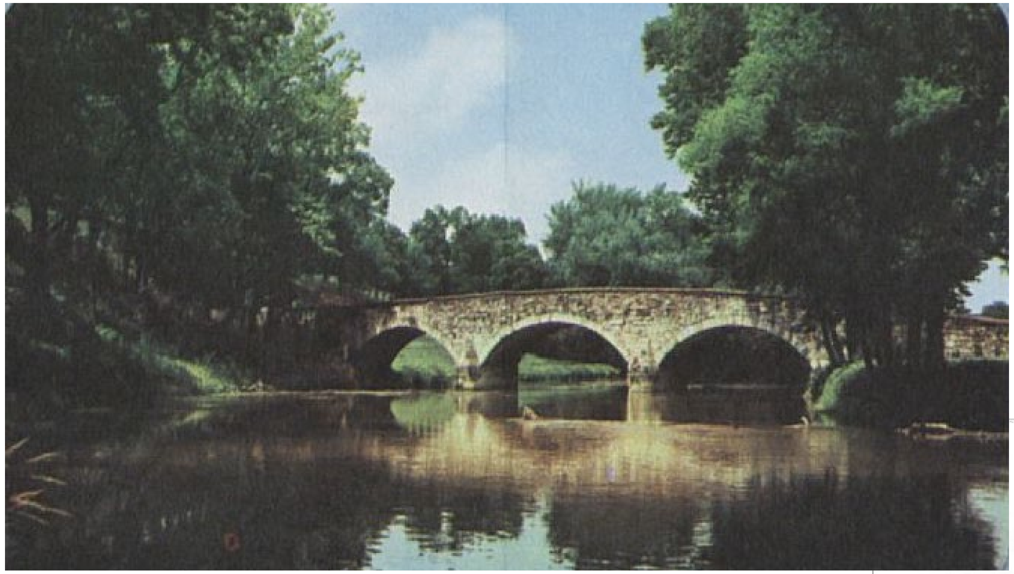
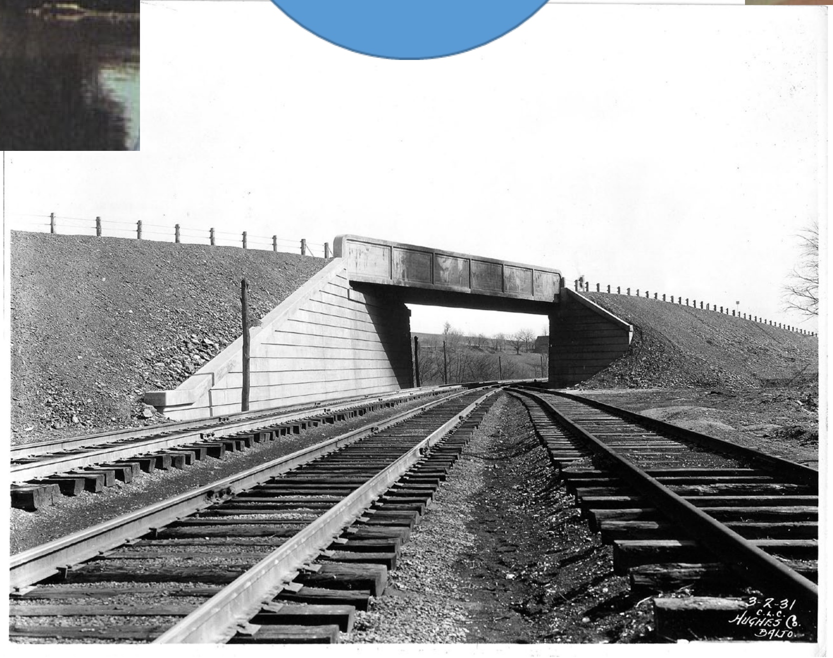
Simply put, bridges are built to provide a crossing over something. Think about some different types of crossings:



Roads over Water

identify
the problem

Roads over Other Roads



Roads over Railroads

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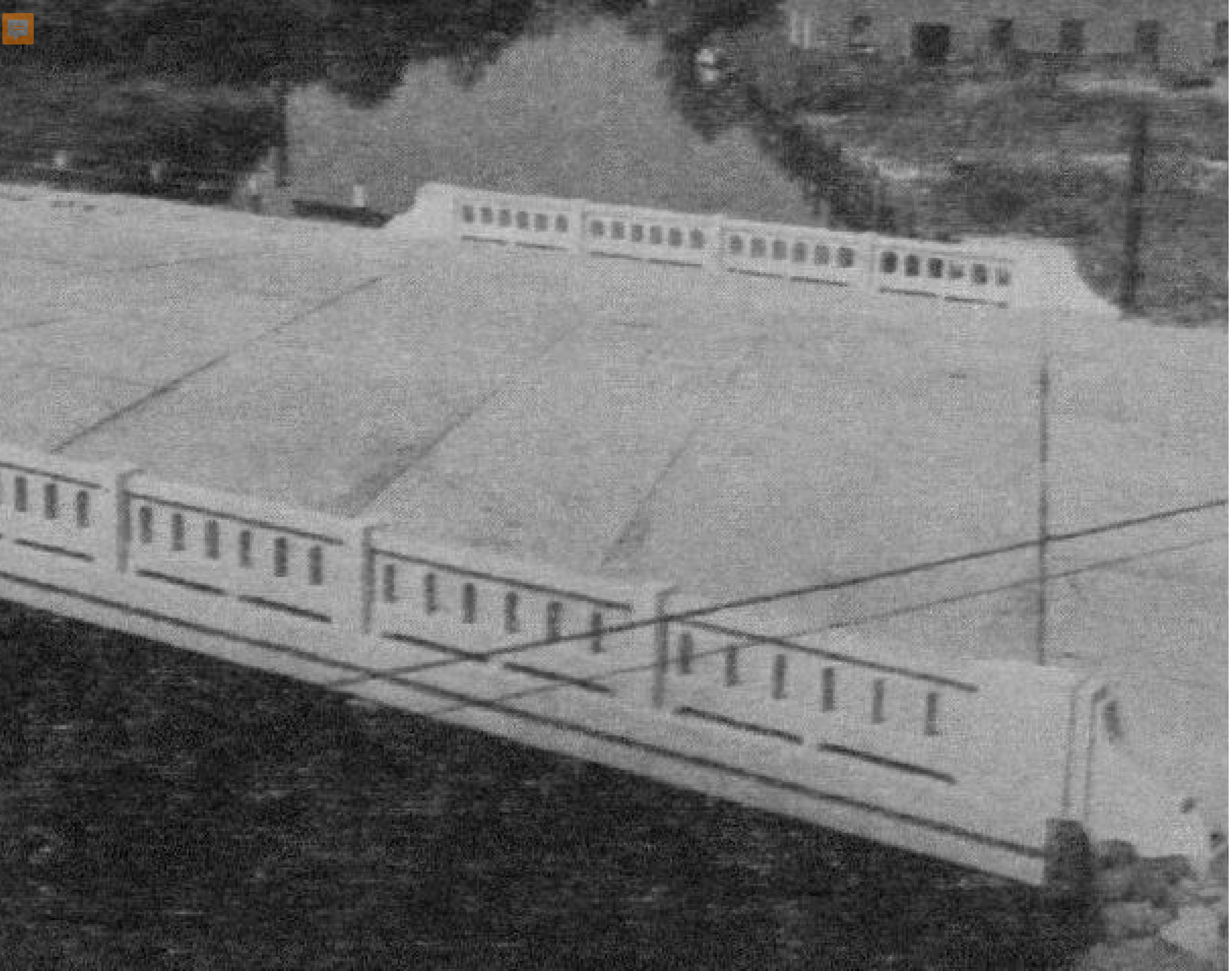

Look again at this specific location.

identify
the
problem

How wide is the river that needs to be crossed?

How wide is the roadway that needs to cross the river?

What is the land like next to the river?

The answers to these questions help define the project’s purpose and need.

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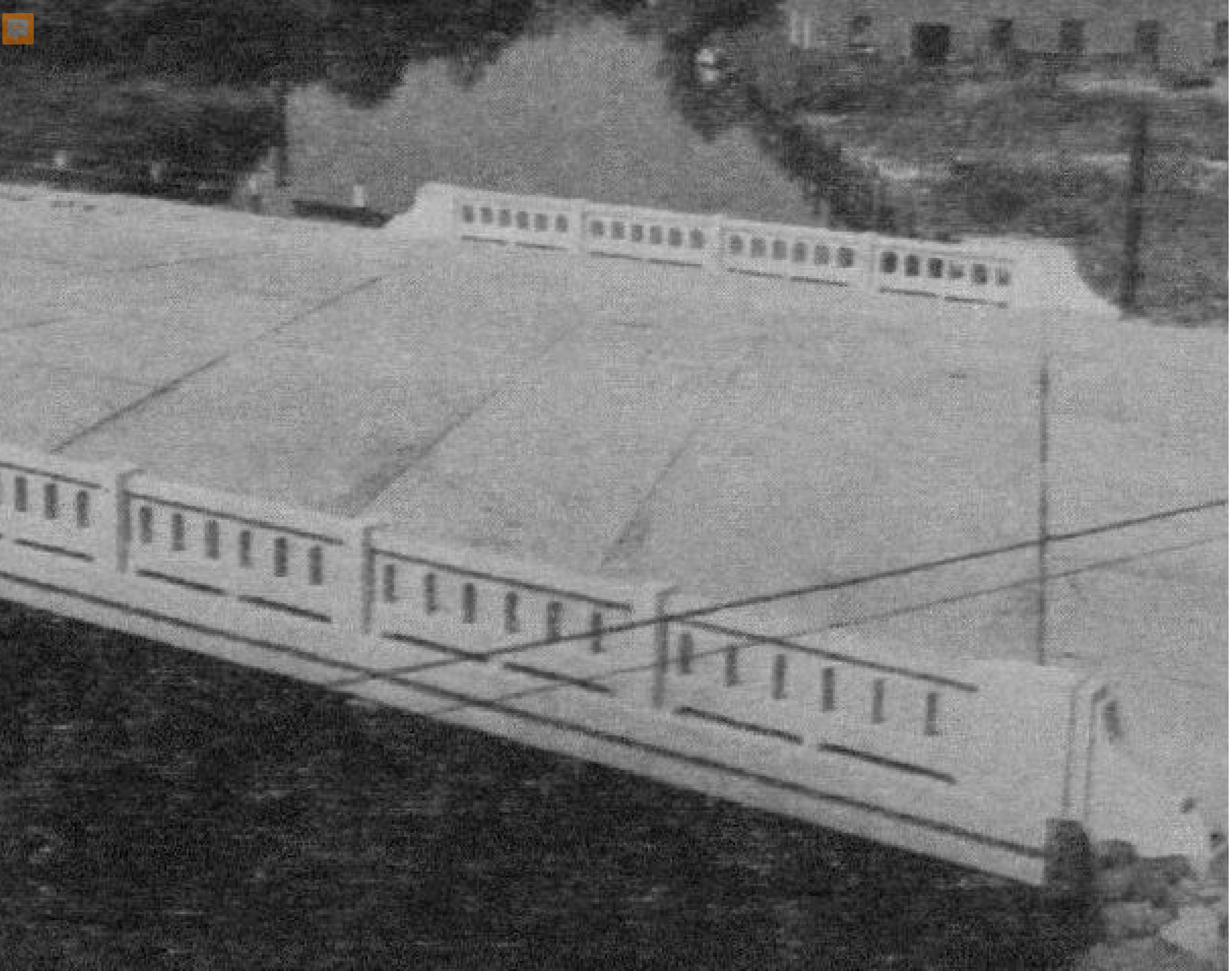

This bridge was needed because in the 1930s, the Maryland State Roads Commission built a new roadway, Salisbury Boulevard, to provide a north-south route around downtown Salisbury. The new road needed to cross the river.

identify
the
problem

What other factors, or design constraints, do you think the bridge engineers considered when they designed this bridge?

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identify
the problem

Design constraints can include certain characteristics such as strength. Bridges need to be strong enough to withstand many different forces, including:

- The weight of the bridge itself
- The weight of vehicles crossing the bridge
- Water below the bridge
- Weather (wind and temperature)
- Seismic vibrations (earthquakes)
- Crash impacts

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The timber bascule bridge in Crisfield was removed when bigger boats required access to Somers Cove.

identify
the problem

Design constraints can also involve concerns about the waterway. Some bridges are located over waterways need to remain **navigable.**

To allow boat traffic to continue, bridges either need to carry the road up high or the bridges need spans that can move out of the way when a boat approaches.

Draw bridges are a common name for a kind of **movable bridge**. Two types of movable bridges found in Maryland are:

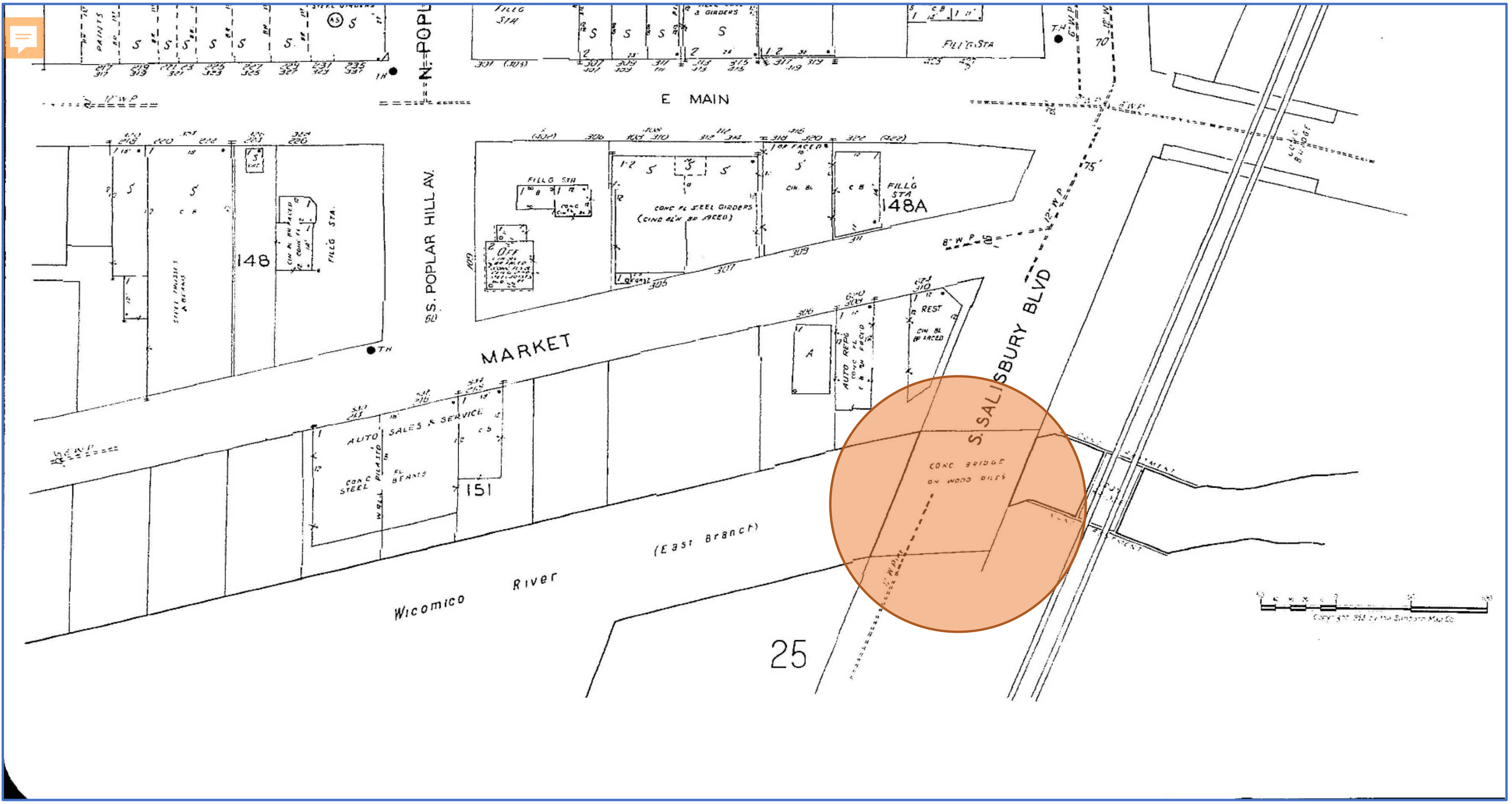
- **bascule bridges**, which have one or two sections that lift upward; and
- **swing bridges**, which rotate horizontally.

identify
the problem

Another design constraint can involve the type of bridge users. Some bridges need to keep pedestrians safe from traffic.

identify
the problem

Many bridges require considerations of the costs and longevity of their materials. Bridges are an expensive part of a transportation budget, and these factors can also be design constraints.



For the Salisbury Boulevard bridge, the Chief Bridge Engineer of the Maryland State Roads Commission, Walter C. Hopkins, laid out certain objectives he wanted in a bridge:

- Rust resistant.
- Would not deteriorate like a bridge made just from concrete.
- Would not be eaten by insects.
- Rot resistant.
- Strong enough to withstand hurricanes and floods.
- Strong and wide enough to carry lots of cars and trucks.
- Durable enough to last a long time.
- Aesthetically pleasing.
- Not too expensive- this was during the Great Depression!

identify
the problem

The new bridge would carry a new boulevard that bypassed the central business district. Salisbury Boulevard paralleled a railroad and crossed the river at a channelized section lined with a timber bulkhead.

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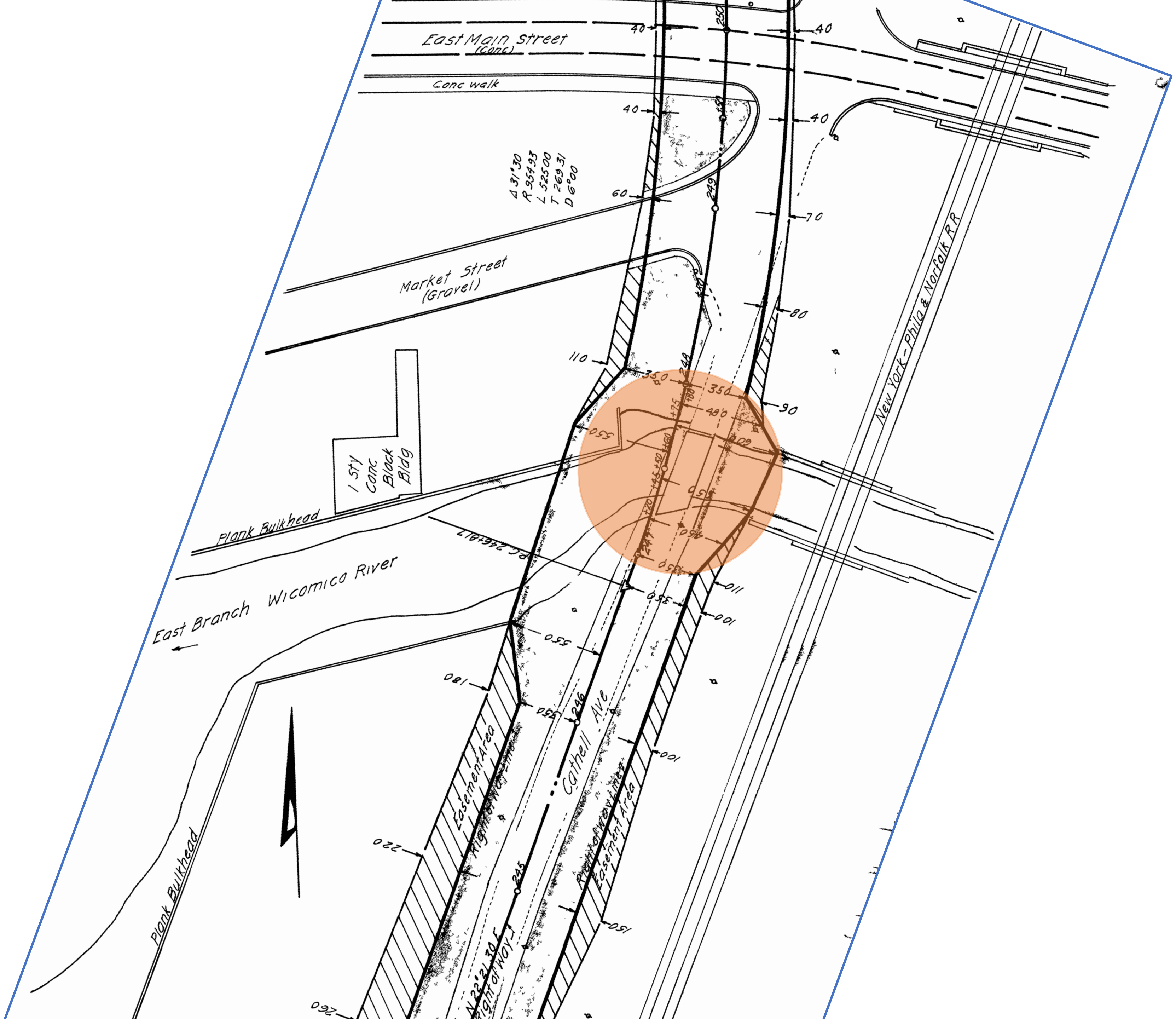

brainstorm
solutions

How did the engineers working for Mr. Hopkins begin to think about designing a bridge over the Wicomico River in Salisbury?

The engineers used their existing knowledge about different bridge forms, materials, and how bridge parts work together to begin to brainstorm solutions that would meet the site's design constraints.

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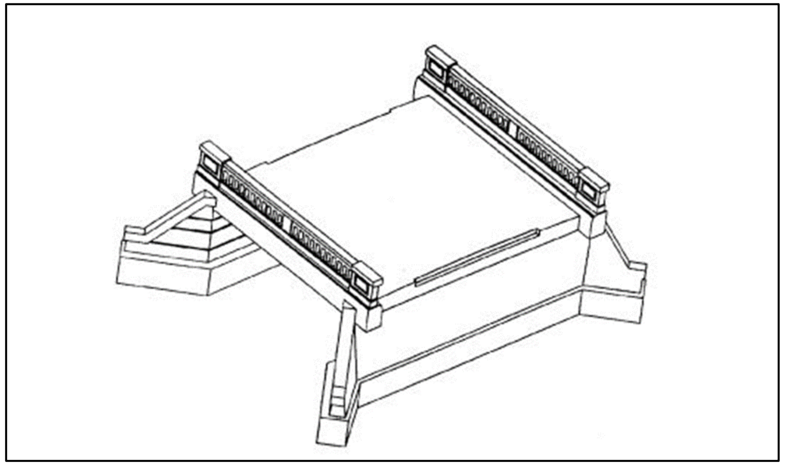
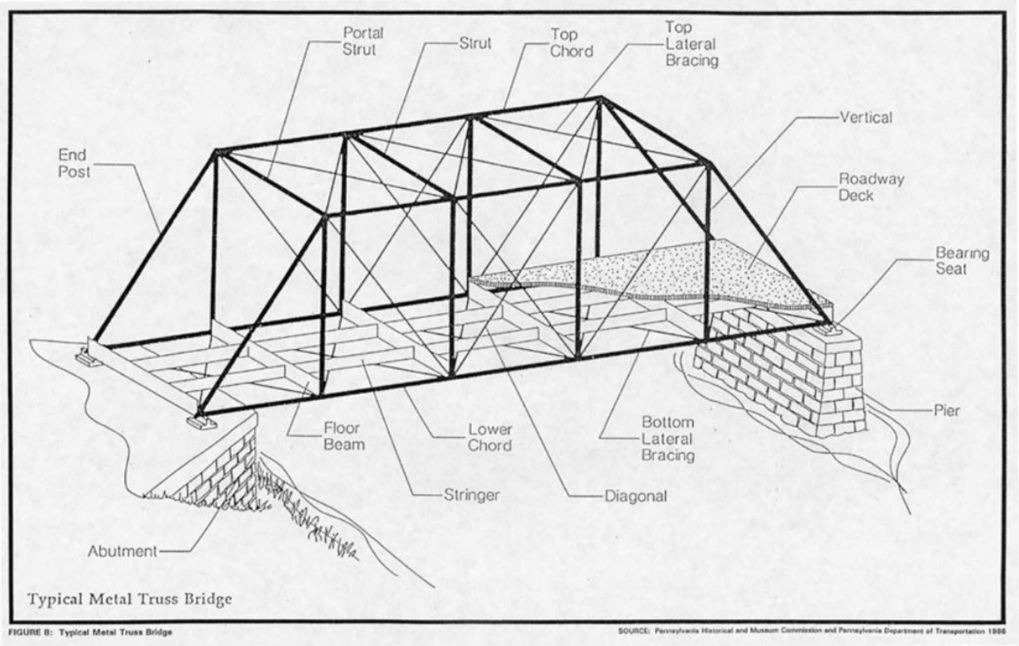
Four major bridge forms the engineers would have known were:

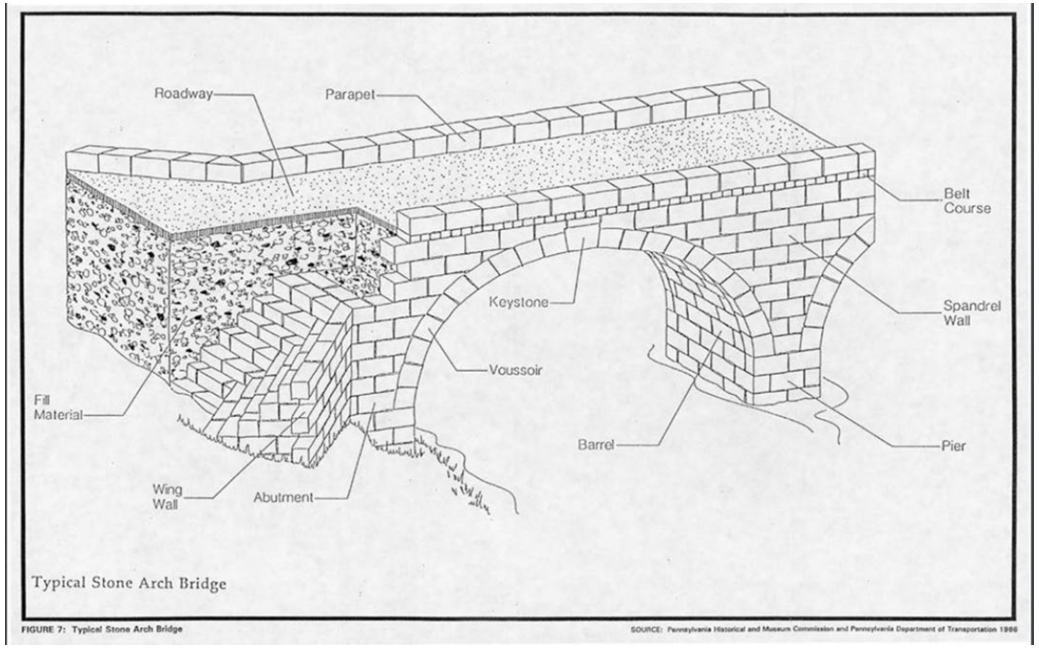
Slab



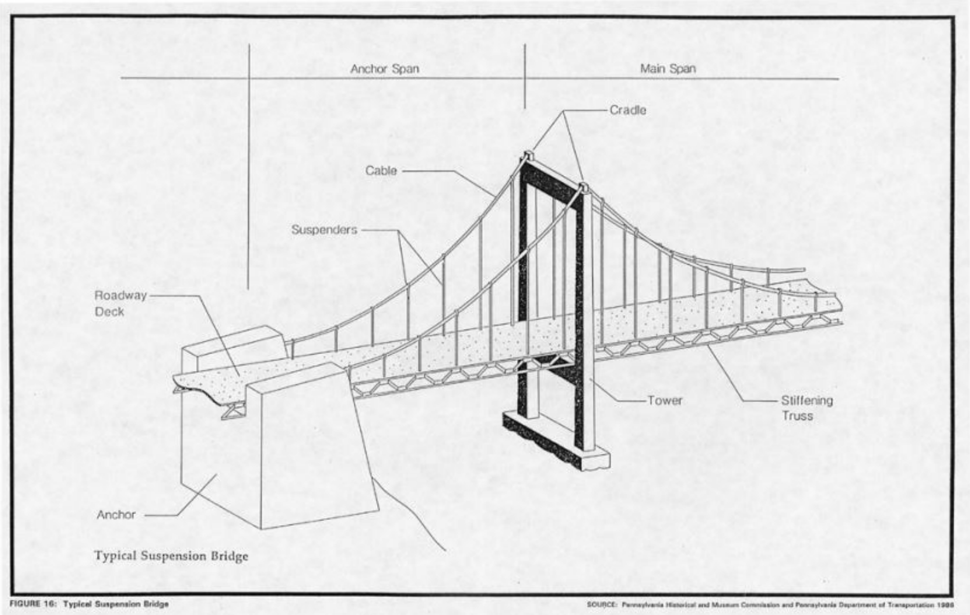
Truss



Arch



Suspension



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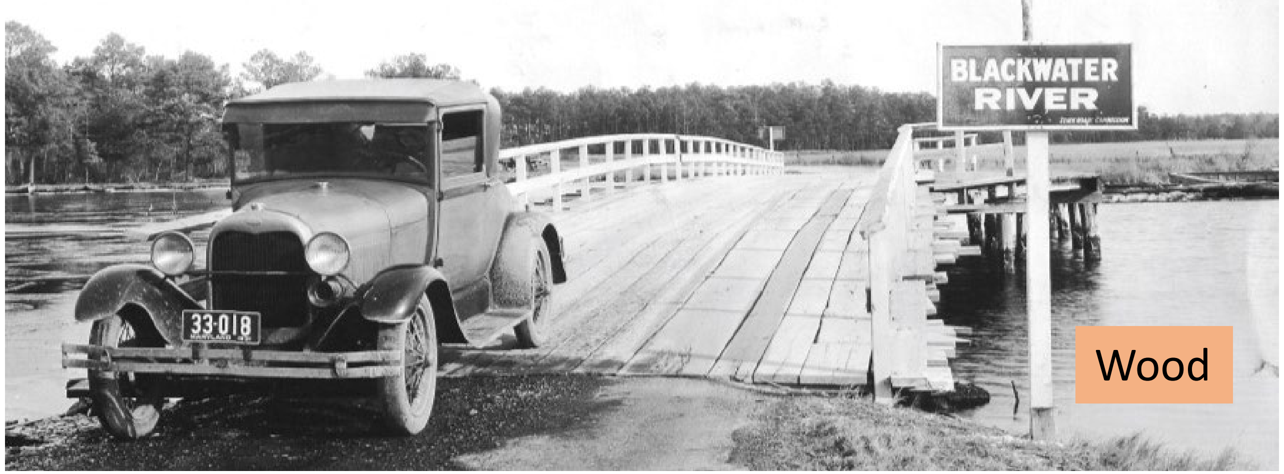
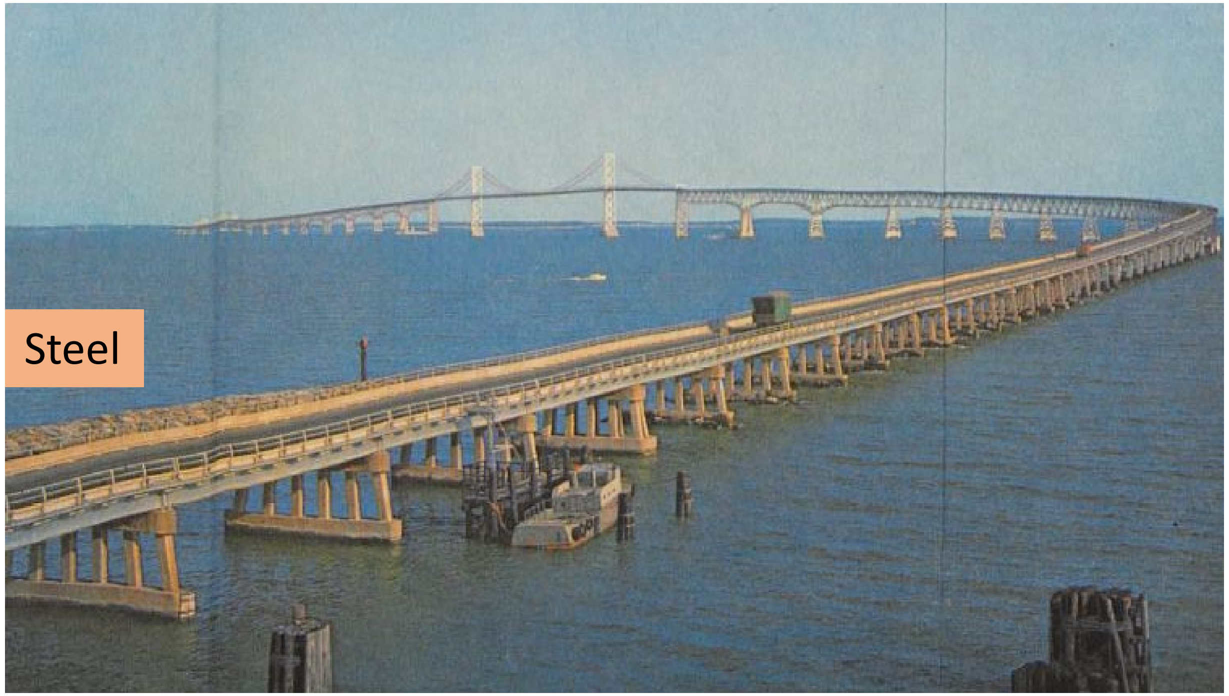
Different bridge materials the engineers could have considered included:



Wood


Steel


Concrete


Iron and stone

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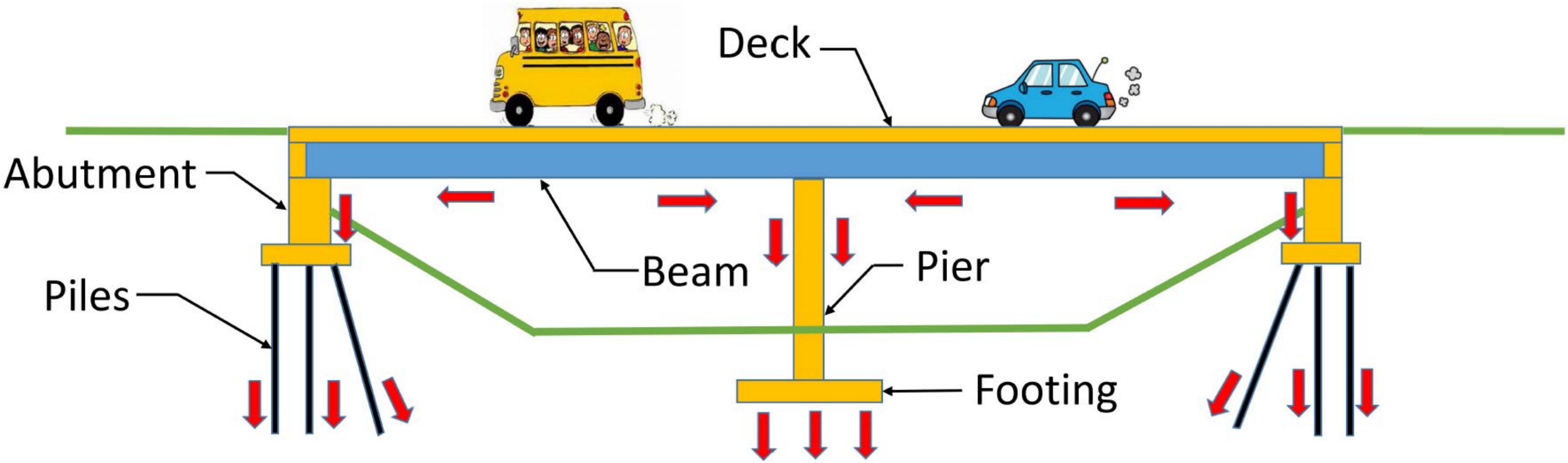

This diagram shows the names for different parts of a bridge. The arrows show how forces are directed between the bridge parts so that the bridge stays standing and supports its loads.

Abutments and **piers** are two bridge parts that are affected by a bridge's site location.

Bridge **abutments** are built into the ground at both ends of a bridge to keep the bridge in place.

Bridge **piers** are sometimes built between the abutments to divide the bridge into multiple **spans** and provide additional support. A bridge over a small river may not need any piers.

Abutments and piers descend into the ground deep enough so that they keep the bridge secure. Abutments and piers use the pressure and friction of the ground to accomplish this.

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brainstorm
solutions

The Maryland engineers also knew about new bridge innovations.

A few years earlier, an engineer named James Seiler had developed a method for building bridge decks that combined concrete with timber that was treated with chemicals to resist rot and insects. The wood and concrete materials cost less than metal.

In 1935, the Delaware State Highway Department had built a bridge of this type, which was called a timber-concrete composite bridge.

Could this idea be used in Salisbury?

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Slide Image Sources

Bridging Maryland, Becoming Engineers: A Lesson in the Engineering Design Process Linked to a Historic Maryland Bridge, Part 1

Slide 1: MDOT SHA Bridge Archives, Bridge No. 2200400 carrying US 13 Business (BU) over East Branch of the Wicomico River

Slide 2: No image.

Slide 3: NASA/JPL-Caltech. https://www.jpl.nasa.gov/edu/teach/resources/engineering-in-the-classroom.php

Slide 4: Two-Span Composite Bridge over Wicomico River, Salisbury, Md. In Walter C. Hopkins, Treated Timber in Heavy Duty Composite Highway Bridges, published in the Proceedings of the Annual Meeting of the American Wood Preservers' Association, Vol. 26-35, 1939, pg. 272.

Slide 5: Images from Left:

1. Burnside Bridge, Antietam, Washington County, Maryland. Official Highway Map of Maryland, 1962, Prepared by the Maryland State Roads Commission Planning and Programming Division Showing the State Highway System and Main Connections.

2. During the early 1930s, the Maryland State Roads Commission enacted an ambitious grade separation project that eliminated many dangerous at-grade railroad crossings throughout the state. Photograph showing Ridgeville Road over the B&O Railroad in Frederick County, 1930. Maryland Department of Transportation State Highway Administration Archival Bridge Photograph Collection.

3. Queenstown Bridge carrying US 50 over US 301 in Queen Anne's County. Official Highway Map of Maryland, 1954, Prepared by the Maryland State Roads Commission Traffic Division Showing the State Highway System and Main Connections.

Slide 6: Two-Span Composite Bridge over Wicomico River, Salisbury, Md. In Walter C. Hopkins, Treated Timber in Heavy Duty Composite Highway Bridges, published in the Proceedings of the Annual Meeting of the American Wood Preservers' Association, Vol. 26-35, 1939, pg. 272.

Slide 7: Two-Span Composite Bridge over Wicomico River, Salisbury, Md. In Walter C. Hopkins, Treated Timber in Heavy Duty Composite Highway Bridges, published in the Proceedings of the Annual Meeting of the American Wood Preservers' Association, Vol. 26-35, 1939, pg. 272.

Slide 8: Collapsed Metal Truss Bridge, MD 355 over Monocacy River, Frederick County, 1930. Maryland Department of Transportation State Highway Administration Archival Bridge Photograph Collection.

Slide 9: Official Highway Map of Maryland, 1959, Prepared by the Maryland State Roads Commission Traffic Division Showing the State Highway System and Main Connections.

Slide 10: MD 355 over B&O Railroad in Gaithersburg, March 2, 1931. Maryland Department of Transportation State Highway Administration Archival Bridge Photograph Collection.

Slide 11: MD 214 over Patuxent River in Anne Arundel County, MDOT SHA.

Slide 12: Sanborn Fire Insurance Map, Salisbury, Maryland, 1931.

Slide 13: Maryland State Roads Commission Plat Number 1902, Dated February 20, 1935.

Slide 14: Clockwise from top left:

1. Isometric view of slab structure. Maryland State Roads Commission, 1930 Standard Plans.

2. Isometric view of typical metal truss bridge. Pennsylvania Historical and Museum Commission and Pennsylvania Department of Transportation, 1986.

3. Isometric view of typical suspension bridge. Pennsylvania Historical and Museum Commission and Pennsylvania Department of Transportation, 1986.

4. Isometric view of typical masonry arched structure. Pennsylvania Historical and Museum Commission and Pennsylvania Department of Transportation, 1986.

Slide 15: Clockwise from top left:

1. MD 335 across the Blackwater River near Robbins in Dorchester County, ca. 1930. Maryland Department of Transportation State Highway Administration Archival Bridge Collection.

2. Chesapeake Bay Bridge, Official Highway Map of Maryland, 1954, Prepared by the Maryland State Roads Commission Traffic Division Showing the State Highway System and Main Connections.

3. Bollman Suspension Truss Bridge in Savage. Maryland Historical Trust, National Register of Historic Places in Maryland Website. Photograph by Mark R. Edwards, April 1985. https://mht.maryland.gov/nr/images/nr101p.jpg

4. Open-spandrel concrete arch bridge, carrying US 40 over the Patapsco River in Baltimore County, MDOT SHA.

Slide 16: MDOT SHA Office of Structures.

Slide 17: Blue Bridge (MD 942 over Potomac Rover) in Cumberland, Maryland (Allegany County), MDOT SHA.

Slide 18: Historic American Engineering Record, Creator, American Wood Preservers' Association, J F Seiler, W D Keeney, C Douglass Buck, A G Livingston, Warren W Mack, Richard M Casella, Louis Berger & Associates Cultural Resource Group, and Sponsor Delaware Department Of Transportation. Mill Creek Bridge, Spanning Mill Creek at State Route No. 6, Smyrna, Kent County, DE. Kent County Smyrna Delaware. Documentation Compiled After 1968. Photograph. https://www.loc.gov/item/de0418/.