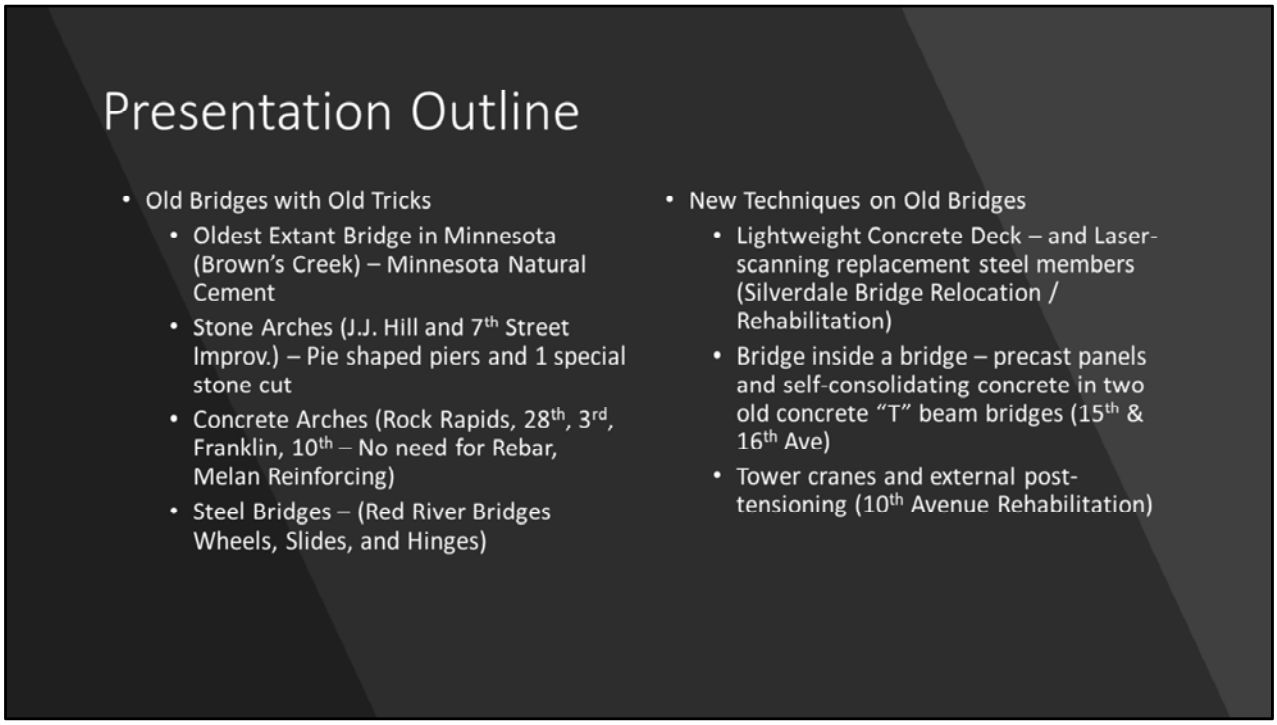
Good Morning – My name is Steve Olson.
It is a pleasure to be with you.

I'm hoping to present to you today some of the tricks used by old engineers as they worked on some of Minnesota's historic bridges.

I'll follow that up with some of the new techniques being used today to bridge some old bridges back to life.

The top photo shows you the wheels on the Sorlie bridge in East Grand Forks.

The bottom photo shows you the laser scan of the 1873 Silverdale bridge that is one of Minnesota's iron bridges.



Here's the outline of my presentation
We'll start with some stone bridges, move on to the old tricks used on concrete bridges before there was a rebar industry and then move on to some of the tricks used on supports or substructure units for the bridges in the Red River Valley.

For the second half of the presentation I'll talk about three rehab projects that illustrate new engineering techniques applied to these bridges that update the bridges yet retain their historic character.

Here's my only advertisement for our firm.
We're a feisty group of nine.
A couple talented technicians and seven engineers.

Here's the oldest bridge in Minnesota.

It's owned by a piano teacher. The bridge is over Brown's Creek just north of Stillwater.

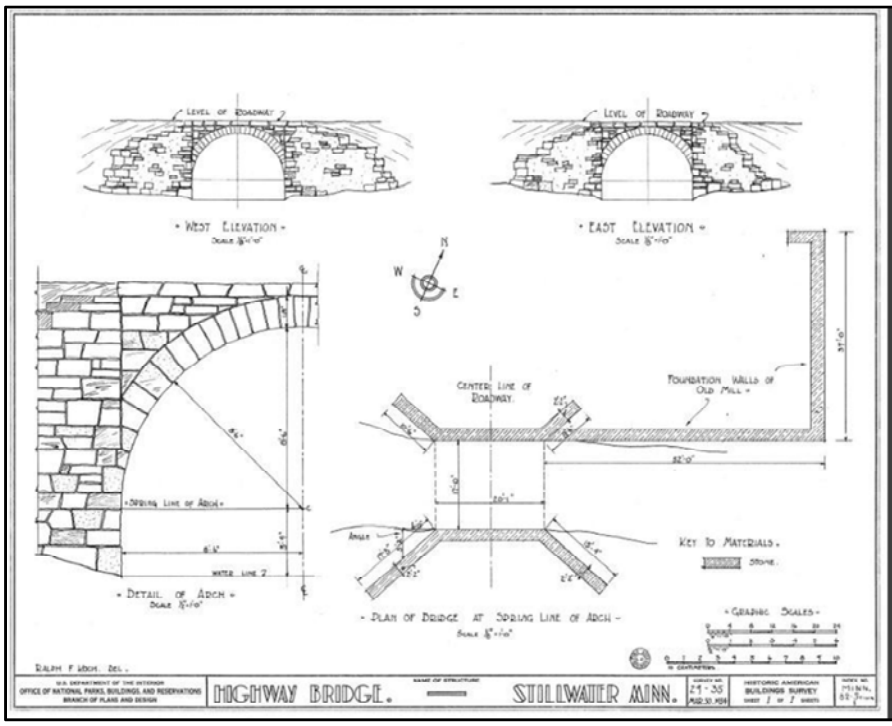
There is a little debate or the date of construction for this bridge. It is sometime in the 1850s or 1860s.

In the 1850s, Abraham Lincoln would have been in his forties.

This bridge was built as part of a military road between Point Pleasant MN and Superior WI

As you can see it is a modest bridge.
Just downstream from thee bridge are the remnants of a mill.

Xcel energy wasn't here in the mid 1800s. Water power was what was available to grind grain and perform other tasks.



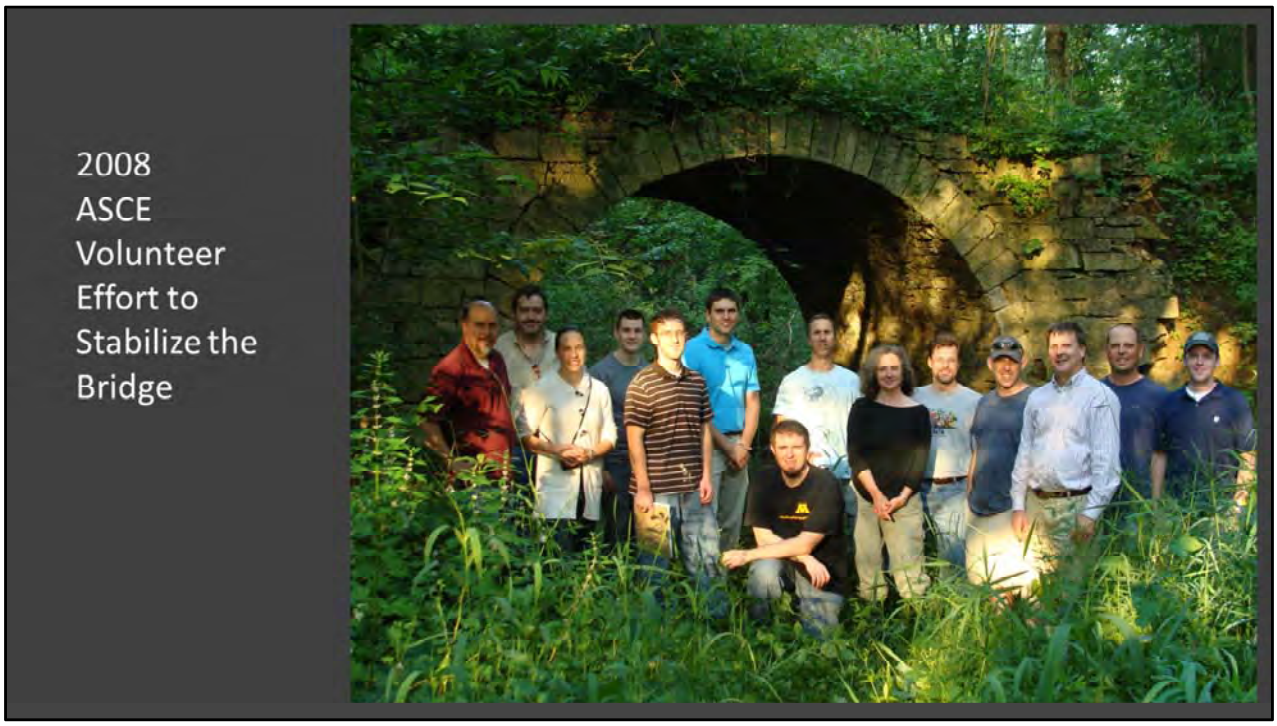
Petrographic studies show that the mortar is very lime rich, which was not unusual for the era, and was made with natural cement that is quite unlike Rosendale cement in appearance. The cement is likely **Minnesota natural cement**

Here's the documentation from the Historic American Building Survey on the bridge. As you can see it's a modest span of only 17 feet.

Here's the trick for this bridge. The old timers knew how to make mortar with Minnesota Natural Cement. I couldn't do that.

The petrographic analysis shows that the cement was the typical cement of the day shipped in from Rosendale NY.

I'm guessing they found limestone of some sort and ground and fired it in some manner to make the lime rich mortar.



There are times when a person is proud of their profession.
The volunteers who stepped forward to save the old bridge made me proud of ours.

Here's the group of volunteers with the piano teacher than owns the bridge.

After the workday by volunteers in 2008.

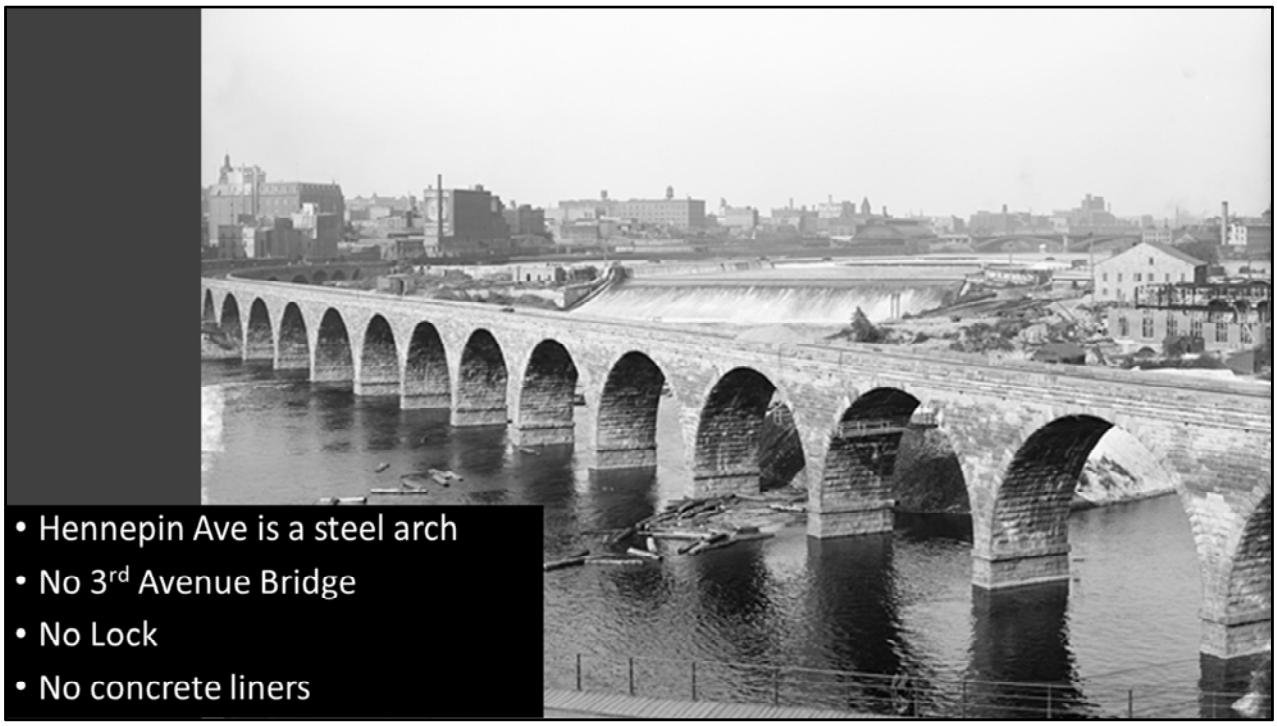
The project received an ASCE National History & Heritage Award

The group ended up winning an ASCE national history and heritage award for their work on the bridge.

A membrane was placed on the top of the bridge to prevent water migration through the arch barrel.

The embankments were stabilized with geogrid.

The spring lines were protected with additional stone to minimize future erosion of the existing spring line stones.



Here's the James J. Hill Stone Arch Bridge in Minneapolis.

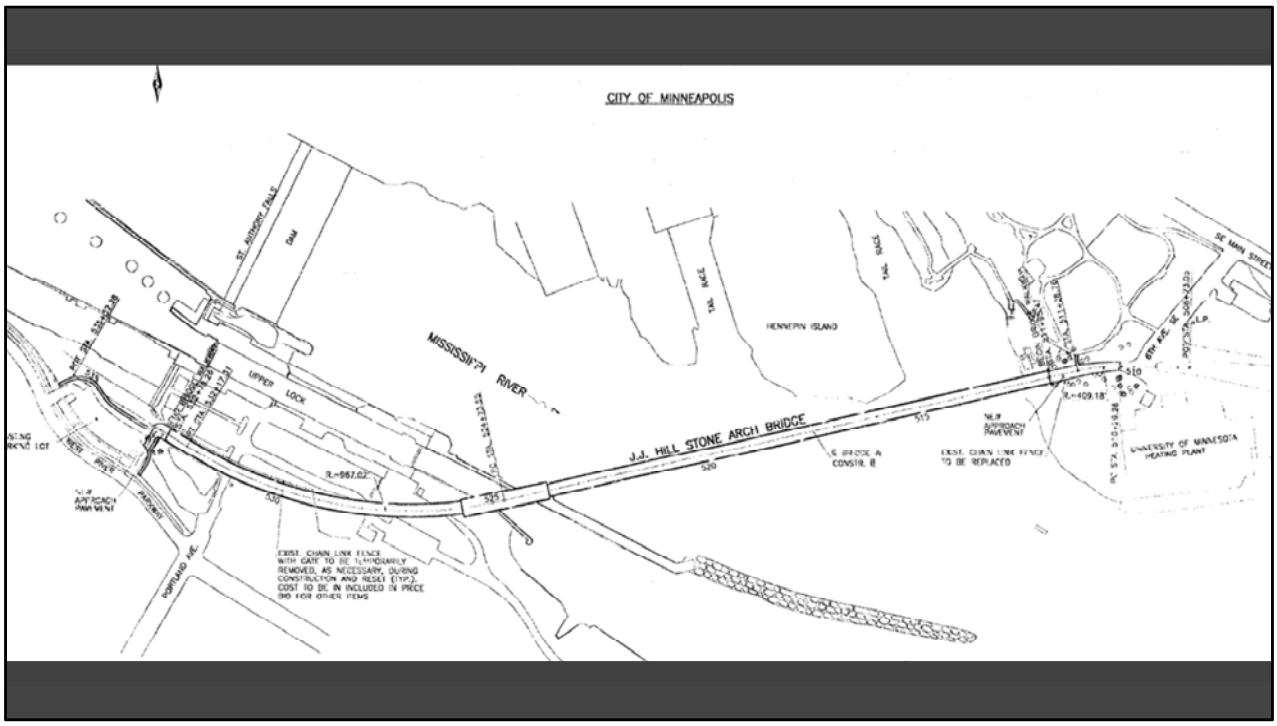
Does anyone know what time frame this might be?

It's after 1890 because the Hennepin Avenue Bridge is a steel arch.

It's before 1914 because there is no 3rd Avenue Bridge present.

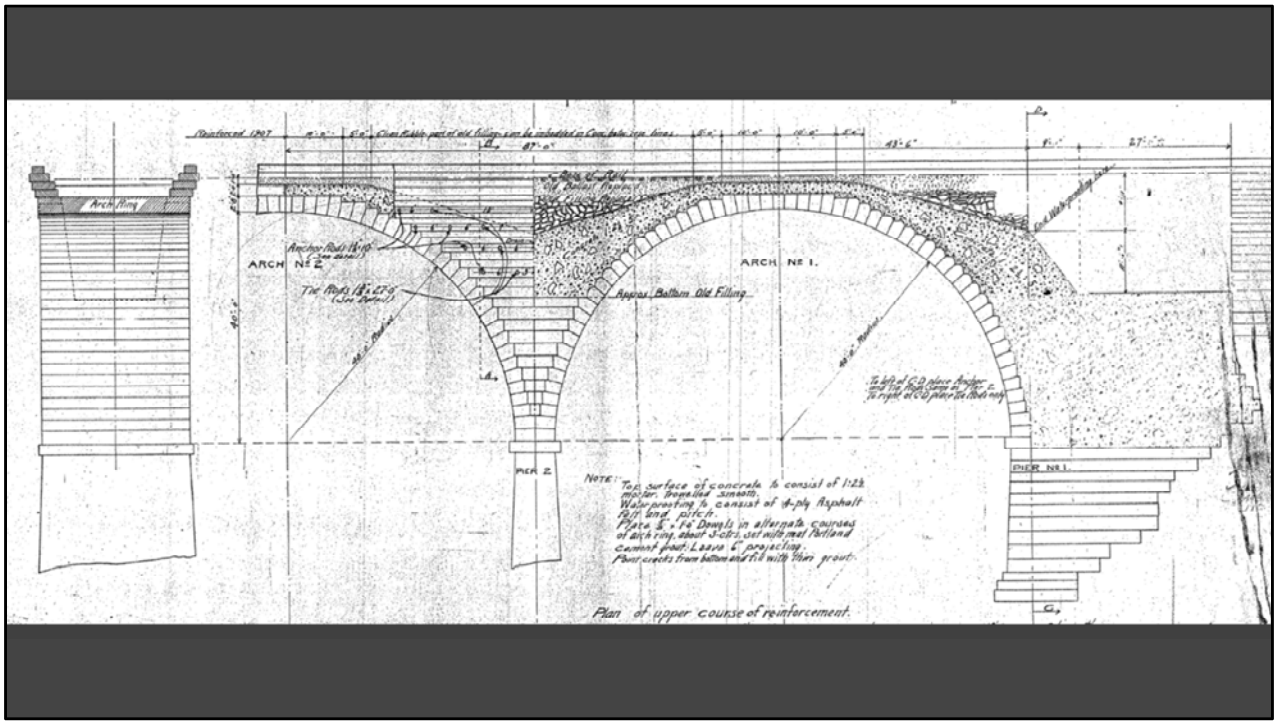
There lock would not be added until the 1960s.

There are no concrete liners in the arch spans either.



The story goes that Hill told his engineer that he wanted this alignment for his bridge. The engineer told him he couldn't have it because one can't build stone barrel arch spans on a curve. After giving Hill that response the engineer was promptly fired.

The curve is about a 6 degree curve on the west bank of the river.

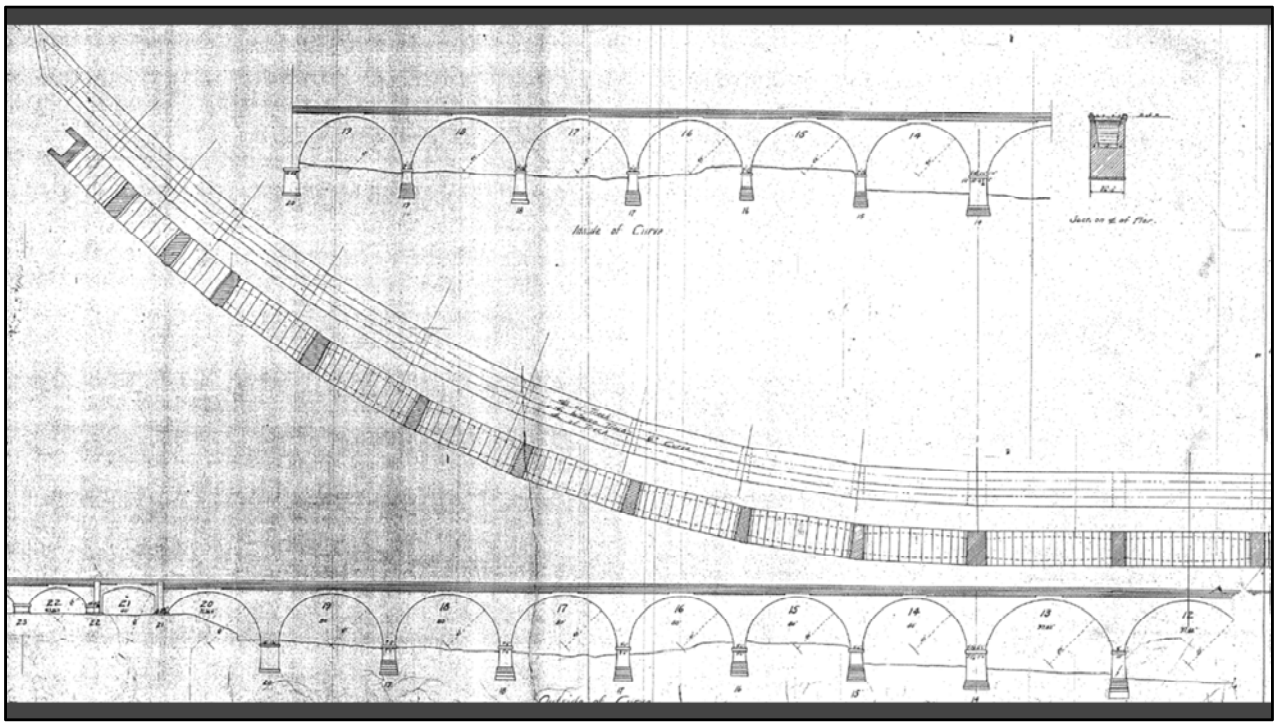


Here’s what the inside of the arch structure looks like.

Harder granite stone was placed at the water line and below.

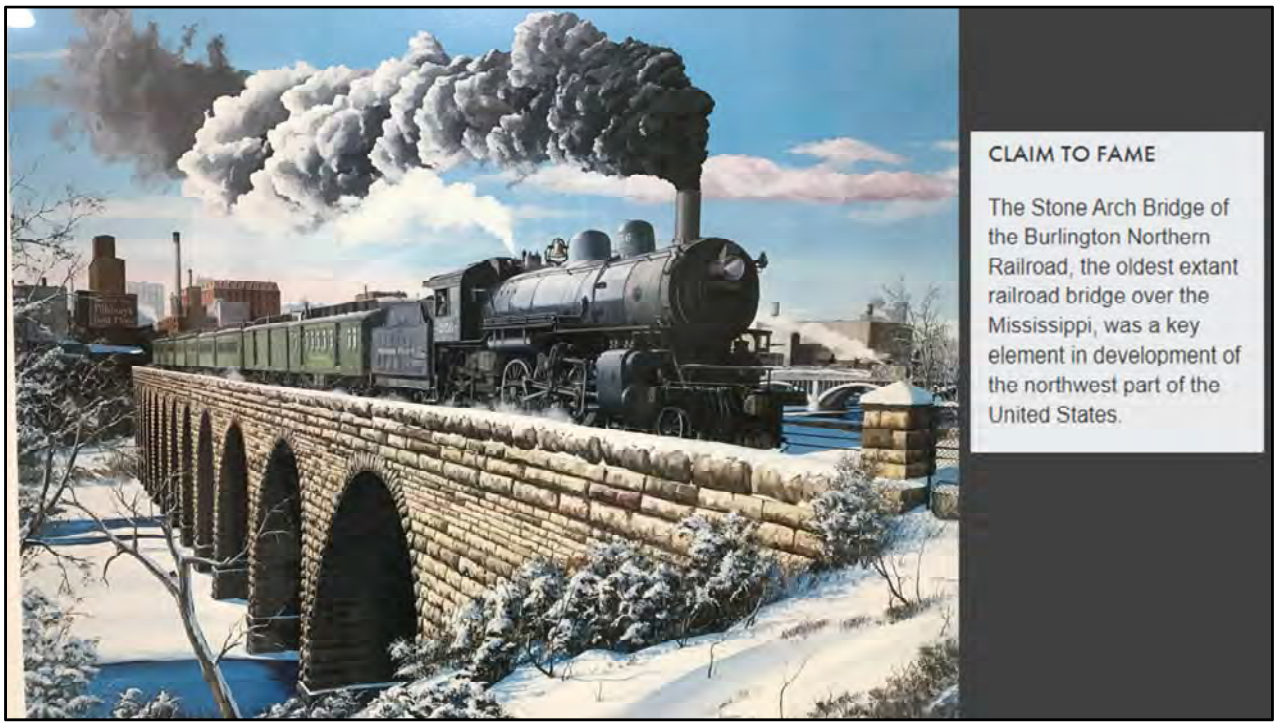
The limestone was placed above the granite and is the predominate stone that we see today.

The bridge was built in 1883 - In 1907 the backfill was removed and the bottom replaced with concrete. Tie rods were installed to reinforce the spandrel walls.



Here’s the trick the old replacement engineer used to give Hill his curved alignment.

He chorded the arch spans and made the piers “pie-shaped” to accommodate the desired alignment.



The bridge is an ASCE National Landmark. It's a very early bridge over the Mississippi River and helped develop the Northwest part of the US.

Here’s a typical picture one sees of the bridge.

Do you see the difference in the stonework near the waterline?

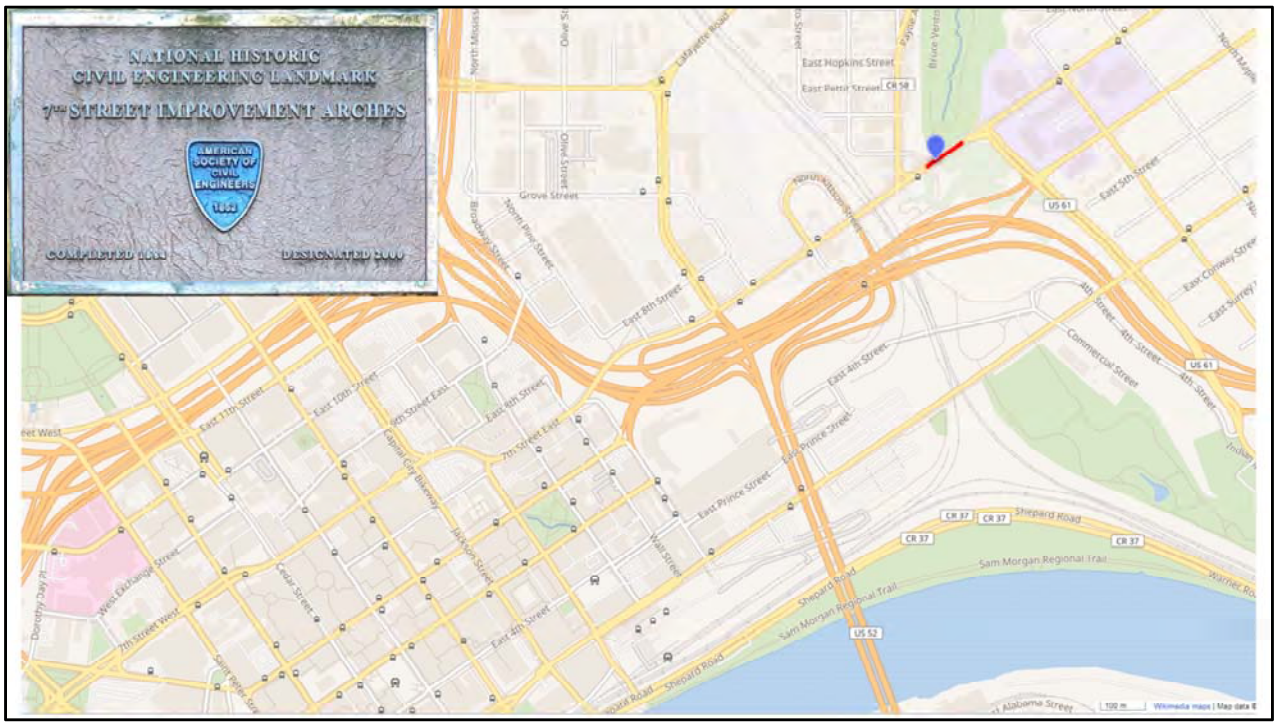
Do you see the “concrete” repairs to the arch barrel on the far right?

Those differences in the footings near the water line are easier to see in this image.

In 1965 there was a major Mississippi River flood event. As part of that event, the foundation for one of the piers was compromised. The railroad stabilized it and the two adjacent piers.

Concrete liners were installed in two spans.

If one looks carefully at the mortar lines one can see the evidence of 6-8” of settlement.



How many of you have been to the 7th Street Improvement Arches?

It's just east of downtown is a visit that is good for your engineering soul.

The arches are an ASCE National Engineering Landmark.

The arches lie just below 7th street. The old railroad bed carries the Vento trail and the railroad bed is slightly skewed to 7th street.

Grab your brown bag lunch. Pick up a sandwich from Subway or Jimmy John's and find your way to this little bridge.

You'll be happy you did.

Head east from downtown on 7th Street.

You'll find a little parking lot off to the right after you pass the Lafayette Bridge.

Pull in the parking lot. Look there's lot's of available parking today.

Grab your sandwich and walk down the trail.

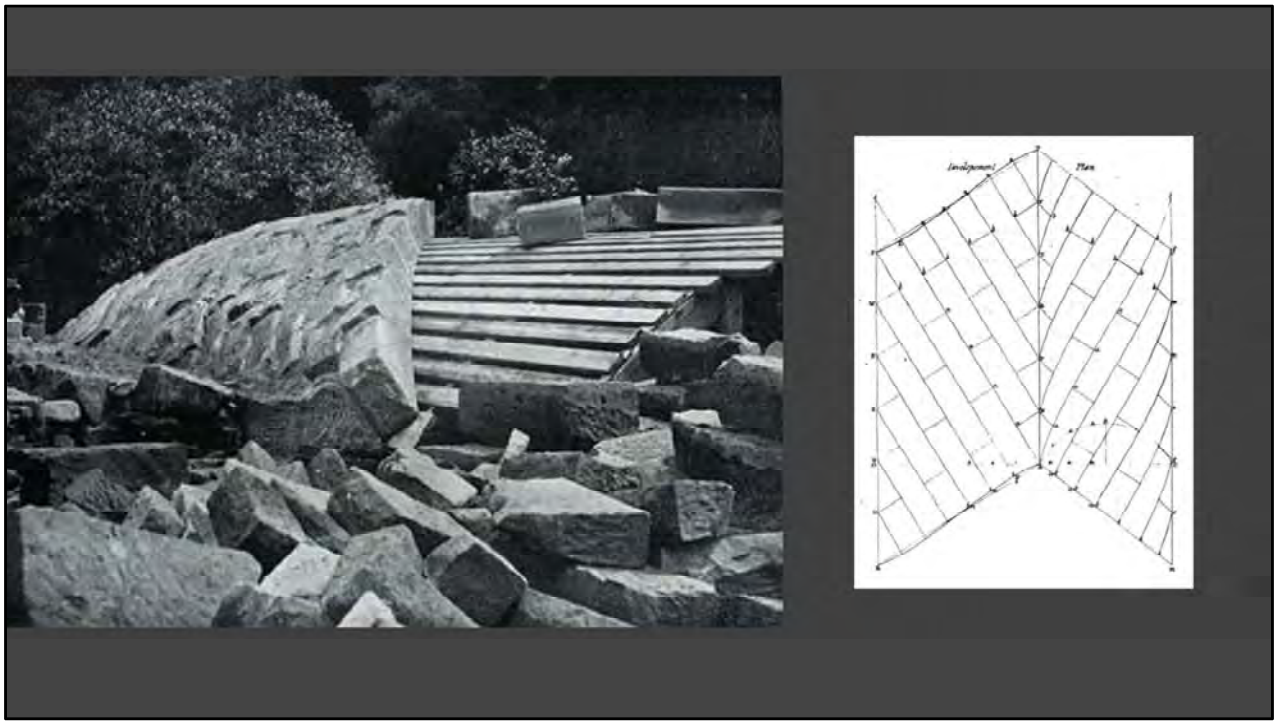
You'll come around the corner and you'll see this odd looking structure.

There really is no way to phrase it other than to say odd or goofy.

There are a couple types of stone, there is a modern retaining wall and fence on top. Etc.

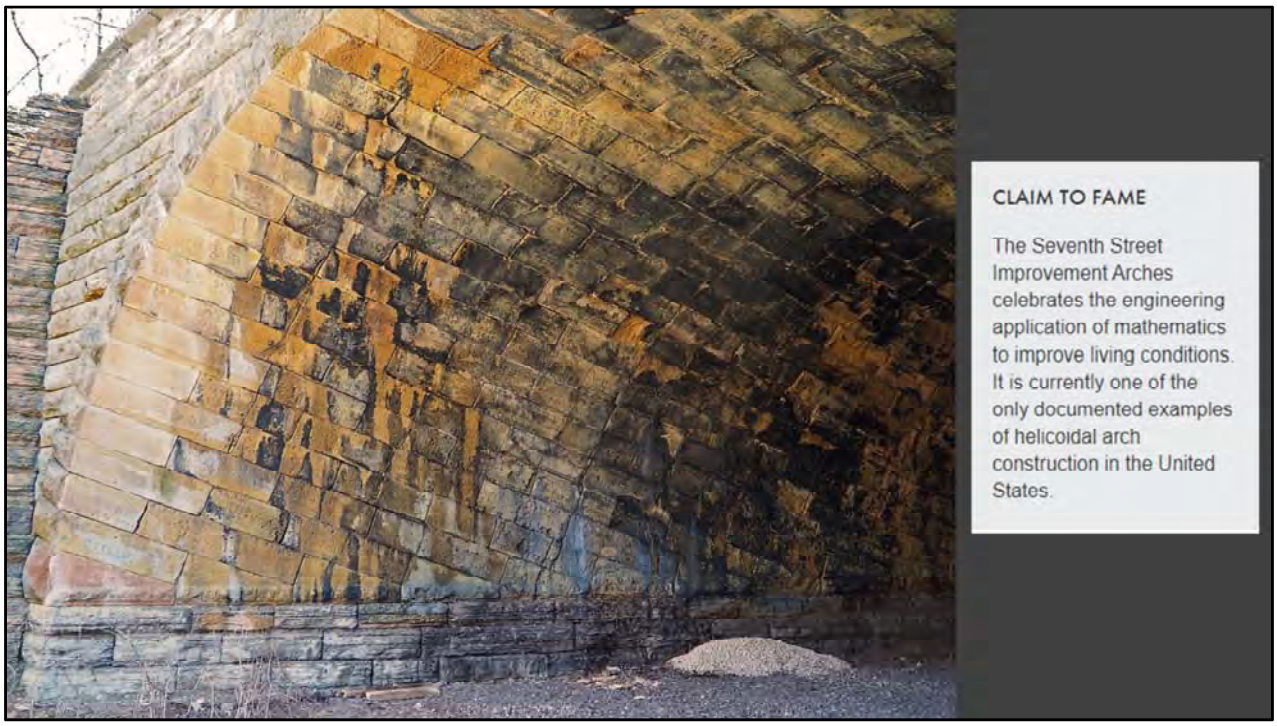
- The Seventh Street Improvement Arches bridge posed a special engineering challenge because the street crossed the St. Paul and Duluth tracks at a 63-degree angle. The bridge also had to carry sewer and water pipes and match the rest of the profile of the regraded hill, making a substantial amount of fill necessary. This precluded the construction of a bridge with ribbed arches, because this method could not support all the weight of the fill. Truesdell also considered using the classical French method of skewed arch construction, but the amount of skilled stonecutting necessary would have made the cost prohibitive.[2] He turned to the helicoidal or spiral method, introduced by British architect Peter Nicholson in 1828.[3] This method was mathematically rigorous, but since Truesdell studied mathematics as a hobby, he decided to accept the challenge. The voussoir stones were cut with curved surfaces to form a series of parallel spiral courses. The initial calculation of the curves was difficult, but once the calculation was performed, all of the voussoirs (except for the ring stones) could be cut from the same pattern. This required the stonecutters to work with more precision than they were used to, but a skilled foreman helped to organize the work.[2]

Here' why these arches are so special.



If you do some Wikipedia investigation on helicoidal arches you'll get pointed to Truesdell and these images.

Based on the skew angle and the span length of the arch barrel, there is one "common" curved stone that "fits" and can be used over and over to construct the bridge.



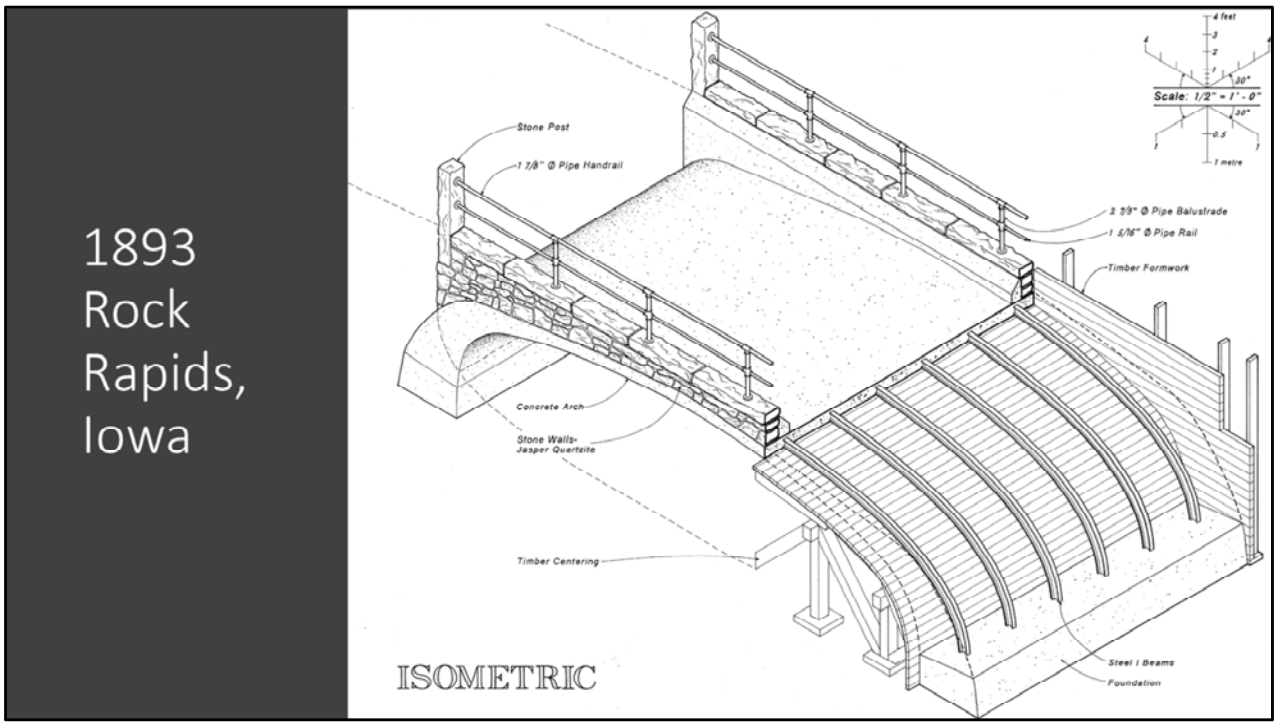
Here's what you'll see as you walk through the barrels of the arches.

The claim to fame note is on the ASCE History and Heritage Website.

Now let's shift gears a bit and talk about early concrete arches.

Here's an old concrete arch bridge that was moved from a township or county road to a park in Rock Rapids, IA.

It's not often people can relocate a concrete arch bridge.



The bridge was originally constructed in 1893.

In 1893 there was no rebar industry to provide the standard reinforcement we know today.

They ended up using steel sections and a design approach called “Melan Reinforcing”.

There was no rebar industry, but there were lots of railroads.

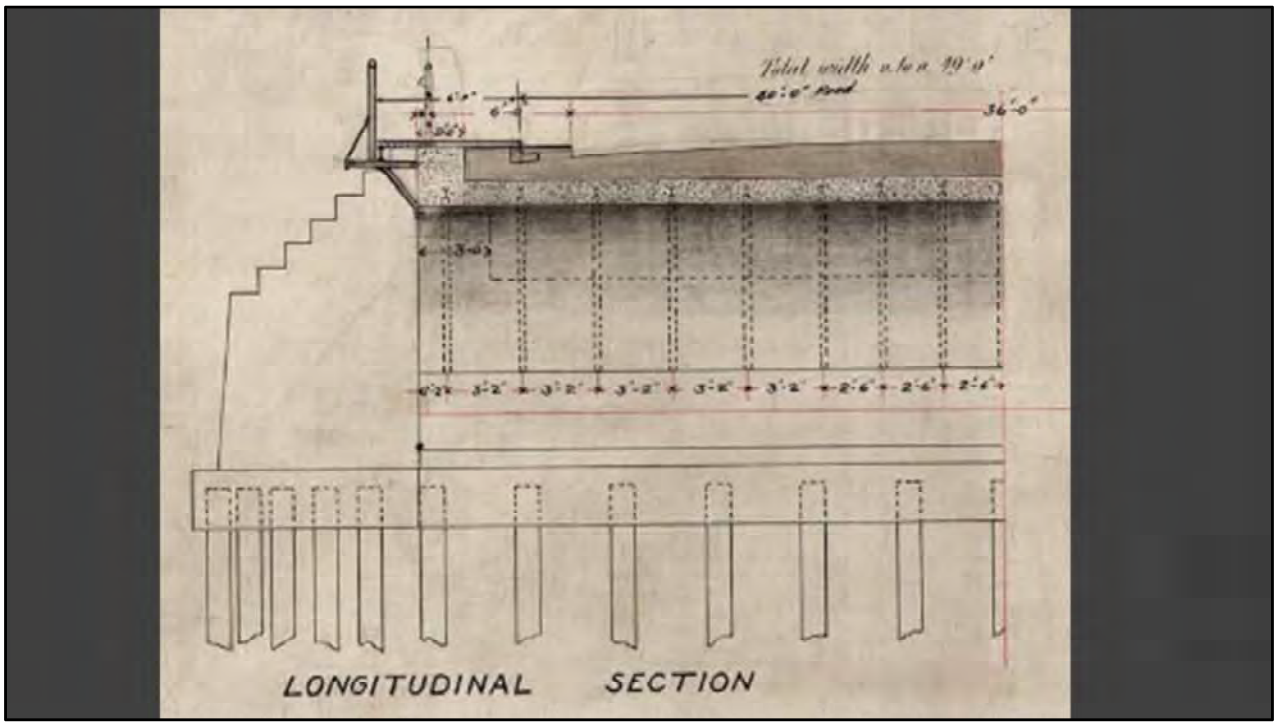
This bridge and many others were reinforced with railroad rails that were bent to conform to the shape of the arch.

The contractor for this bridge in Iowa was from Minneapolis.

There are a few early 1900s melan bridges in the Twin Cities.
A couple of the bridges are still in service in Como Park in St Paul.

This bridge carried 28th Avenue over Minnehaha Creek near Lake Hiawatha.

This photo graced the cover of the 1905 City Engineer's report.



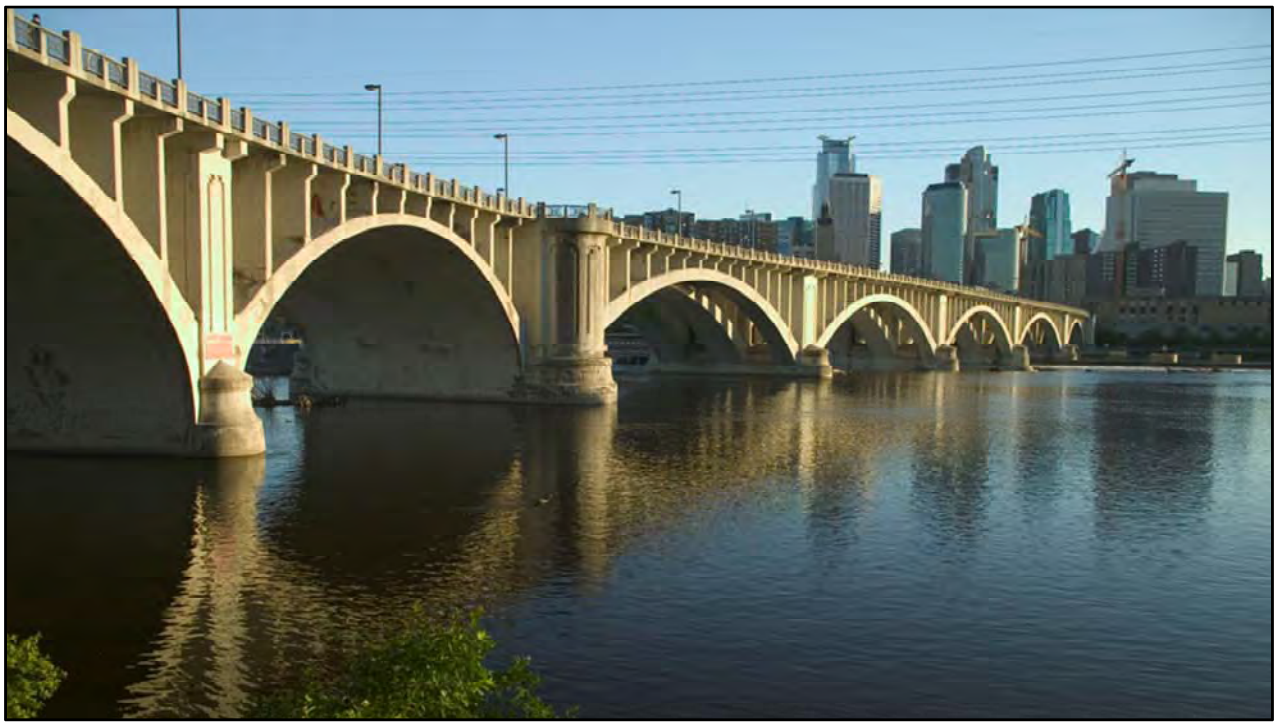
Here’s what the plans look like for the bridge.

It’s a bit difficult to see in the detail but the rails sections are provided at a 3’-2” or 2’-6” spacing.

The tighter spacing in the center was probably provided to accommodate the heavier loads for street cars.

In 2019 the bridge was removed.

During the removal process the “reinforcing” steel sections were documented.
They are shown on the right side of the photo on the right.



Moving on to bigger bridges
Here's the 3rd avenue bridge over the Mississippi River in Minneapolis.
It was constructed between 1914 and 1916.

It has somewhat strange "S" curve alignment.

Looking from the west bank towards the east bank, this is what things looked like in 1913.
The Exposition Center is on the far side of the river.
The Horseshoe dam is clearly visible.

In the foreground one sees many railroad cars.
Today we know that stretch of land as West River Parkway.

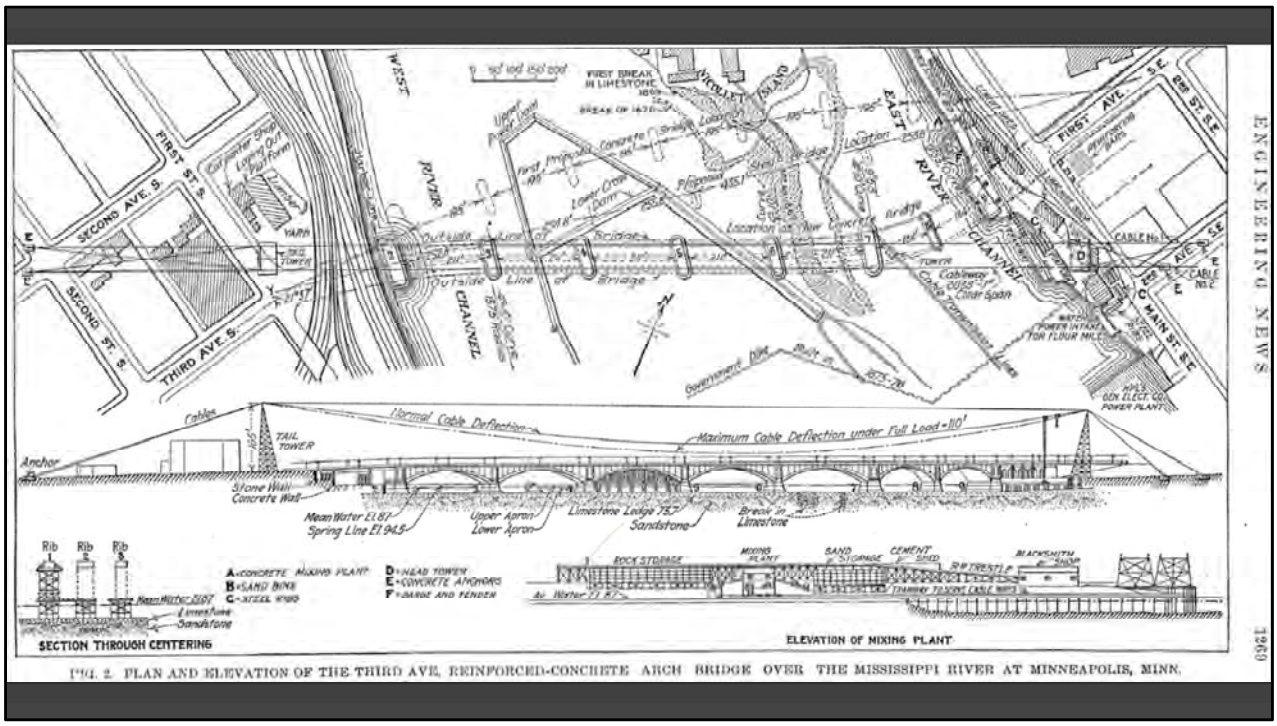


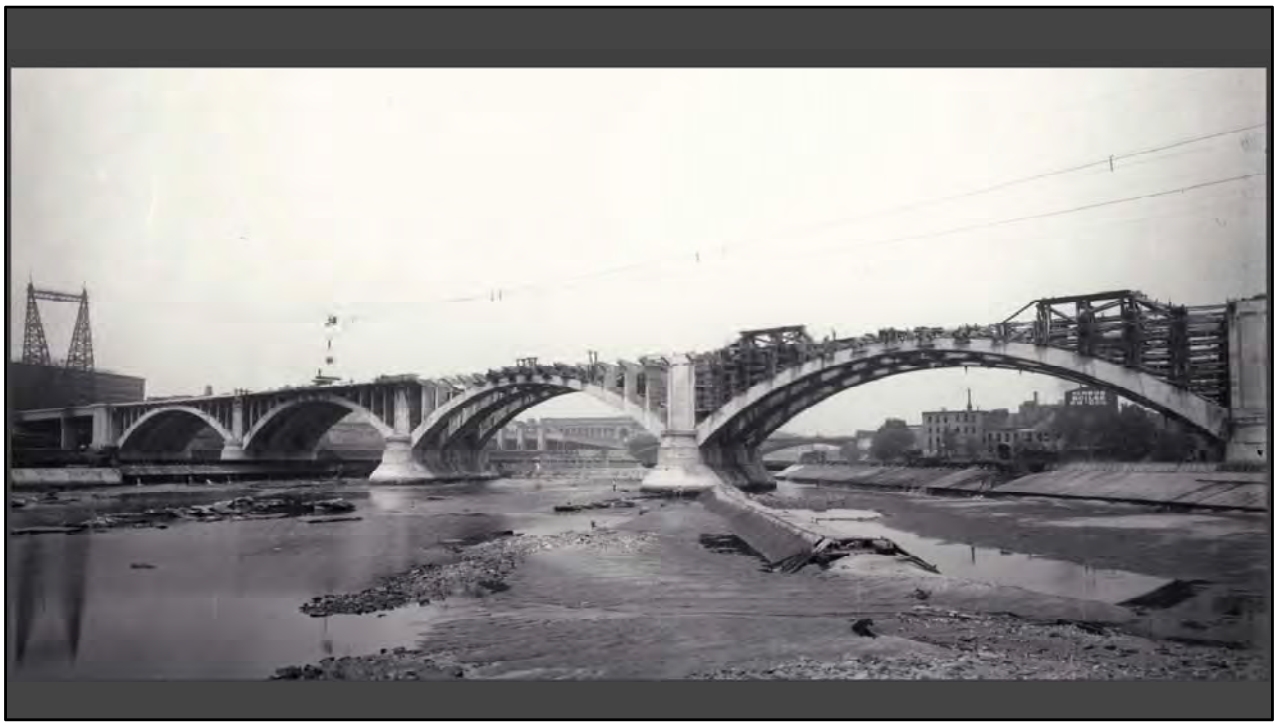
FIG. 2. PLAN AND ELEVATION OF THE THIRD AVE. REINFORCED-CONCRETE ARCH BRIDGE OVER THE MISSISSIPPI RIVER AT MINNEAPOLIS, MINN.

Here's an image from the Engineering News magazine story on the bridge during construction.

One could spend half an hour unpacking this image.

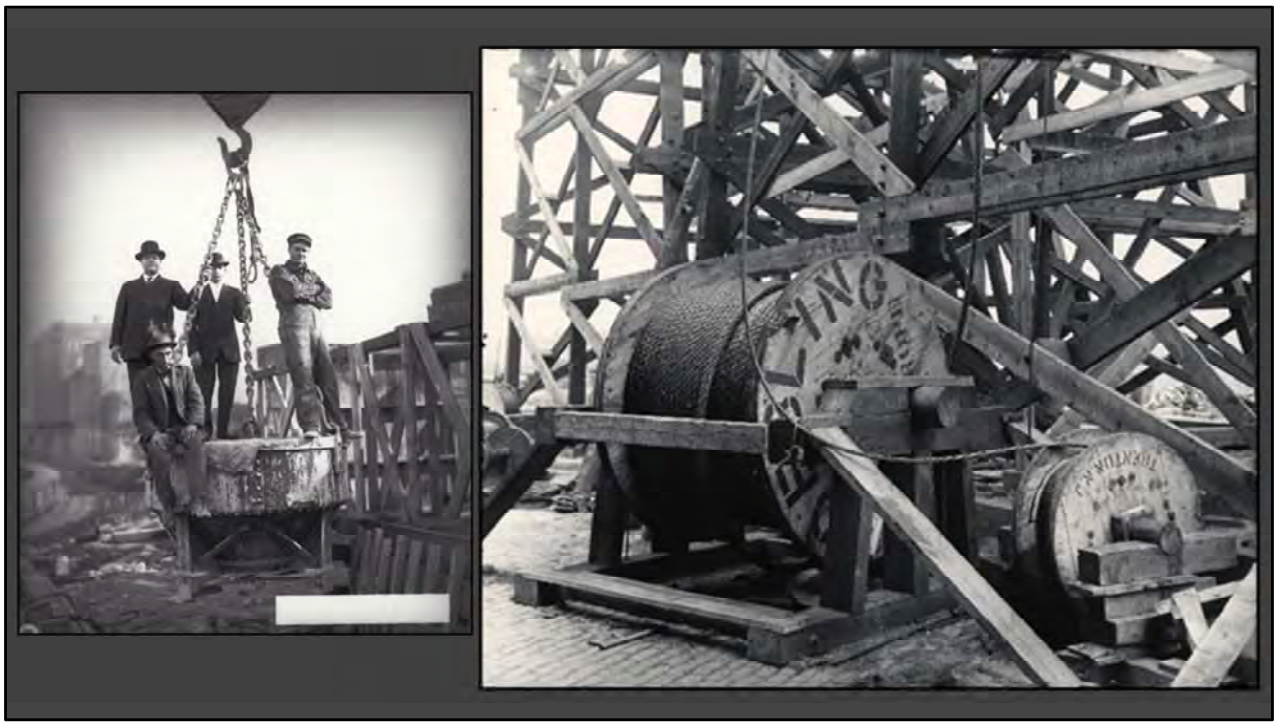
Due to the difficult conditions at the site the bridge was constructed with a high line system.
Wooden towers were built on both banks and cables strung between the towers and anchored beyond the towers..

This image also explains the funny "S" shaped alignment. To the right of the horseshoe dam one can see the "flaws" in the limestone cap protecting the falls. The "S" shape alignment allows the bridge to "leap frog" over the flawed areas.



Here’s an image of the bridge during construction.
One can see the wooden tower on the downtown side.
One can see the high line in place
Why the interior of the horse shoe dam is dry in this picture is a bit of a mystery to me.

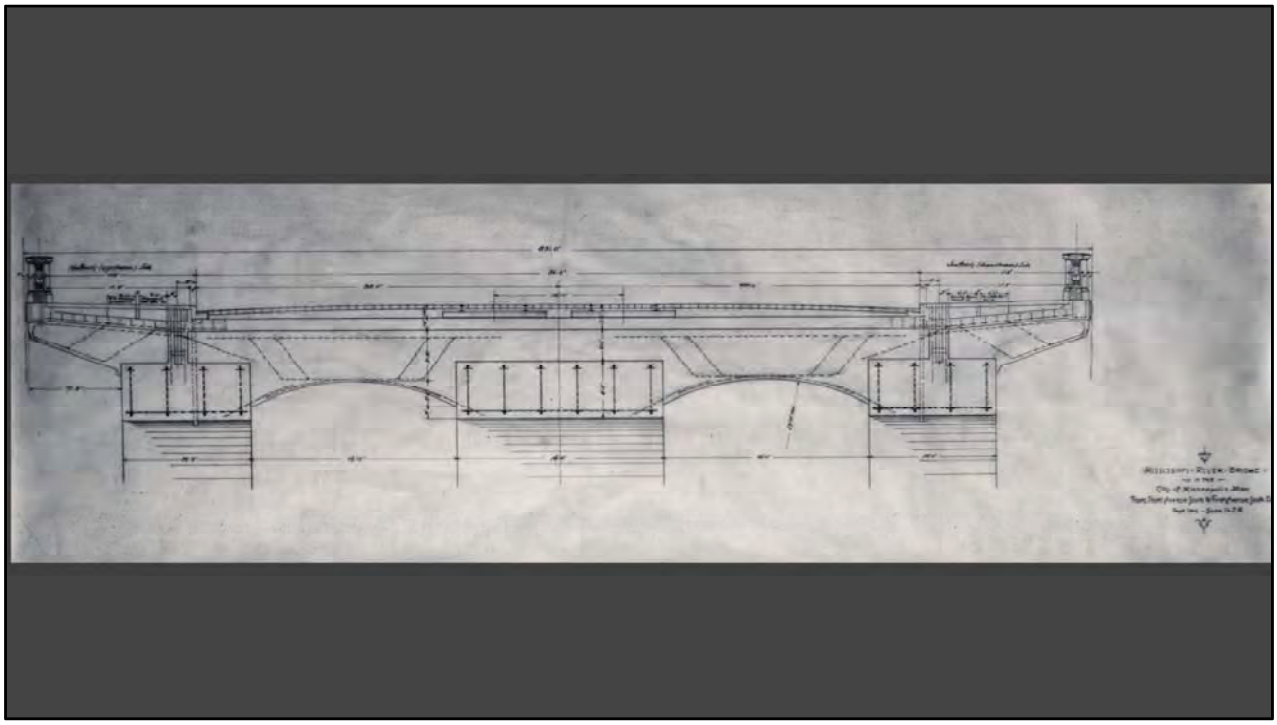
If you look really close you can see people next to the base of Pier 4.



Here are a few travelers on a concrete bucket traveling over the river.

I was fascinated to learn that the steel cable for the high line came from Trenton, NJ and the Roebling wire rope works.

The same plant that made the cables for the Brooklyn Bridge made the wire rope for the high line.

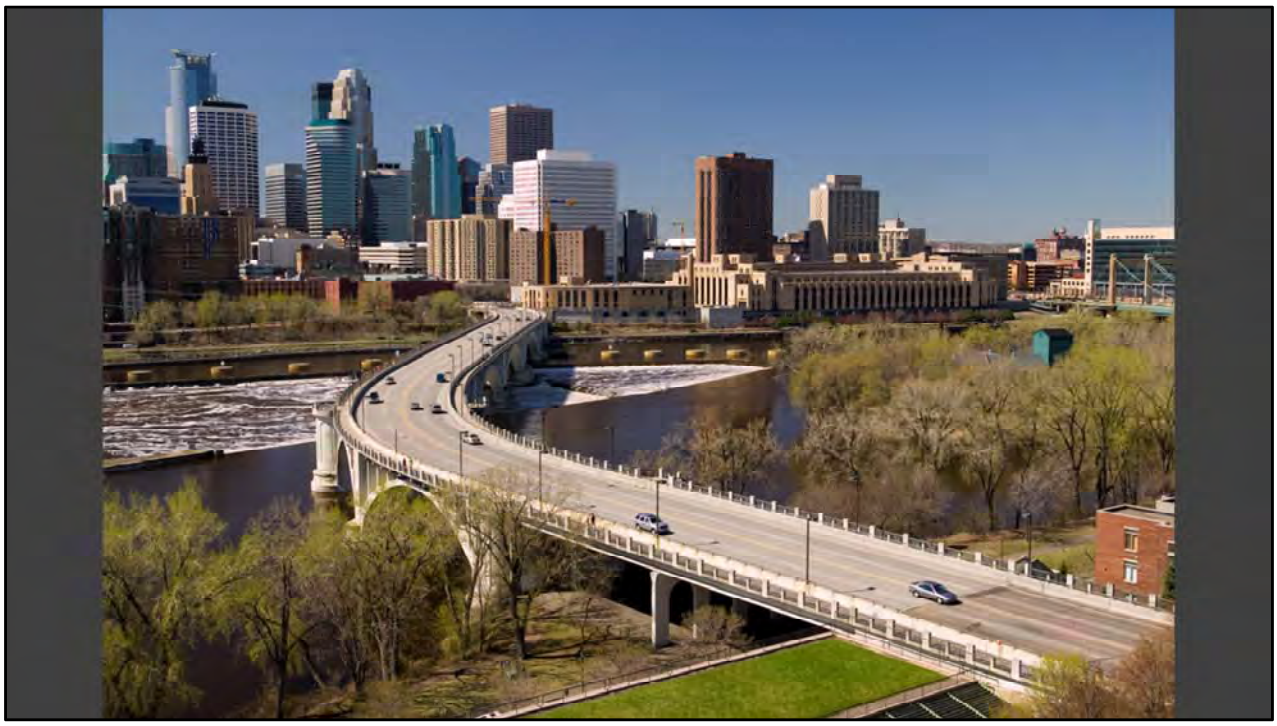


Here’s what a cross section of the original bridge looked like.
One can see the three arch ribs
One can see that each of the arch ribs is reinforced with “trusses”

Here’s what the reinforcing trusses looked like at one of the piers.

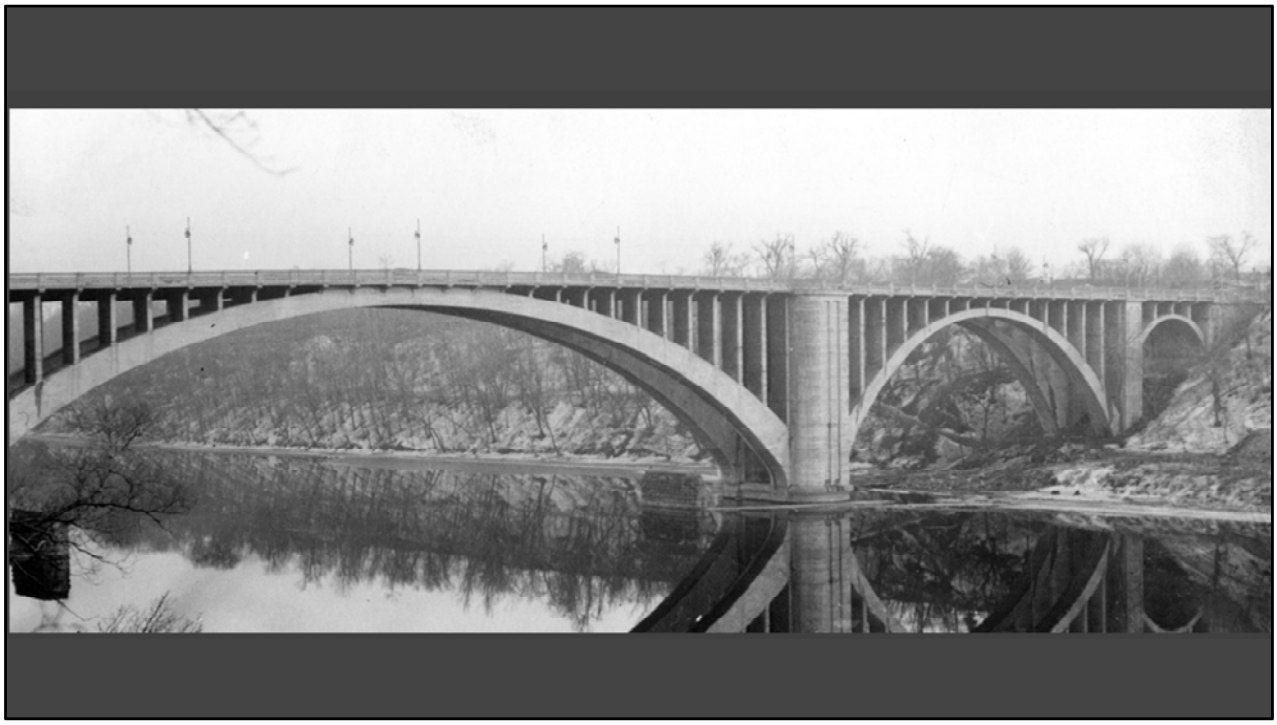
Here’s what a pier looks like with some concrete encasing the trusses.

In the background you can see the stone arch bridge



Here's the bridge in 2006 with the "S" curve alignment.

The bridge is scheduled to be rehabilitated shortly.
Full road closures are expected to begin early next year.

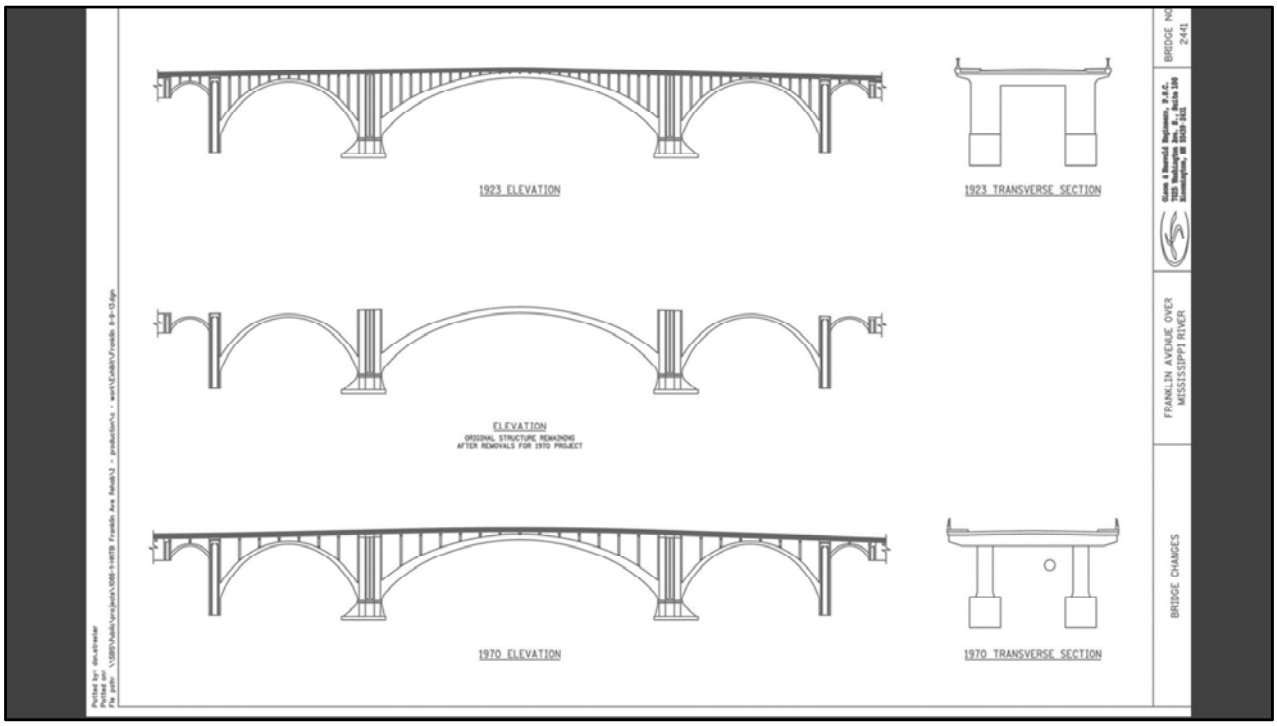


Does anyone know what bridge this is?

It’s the Franklin Avenue Bridge before 1970.

It’s before the parkway was added to the west side of the river.

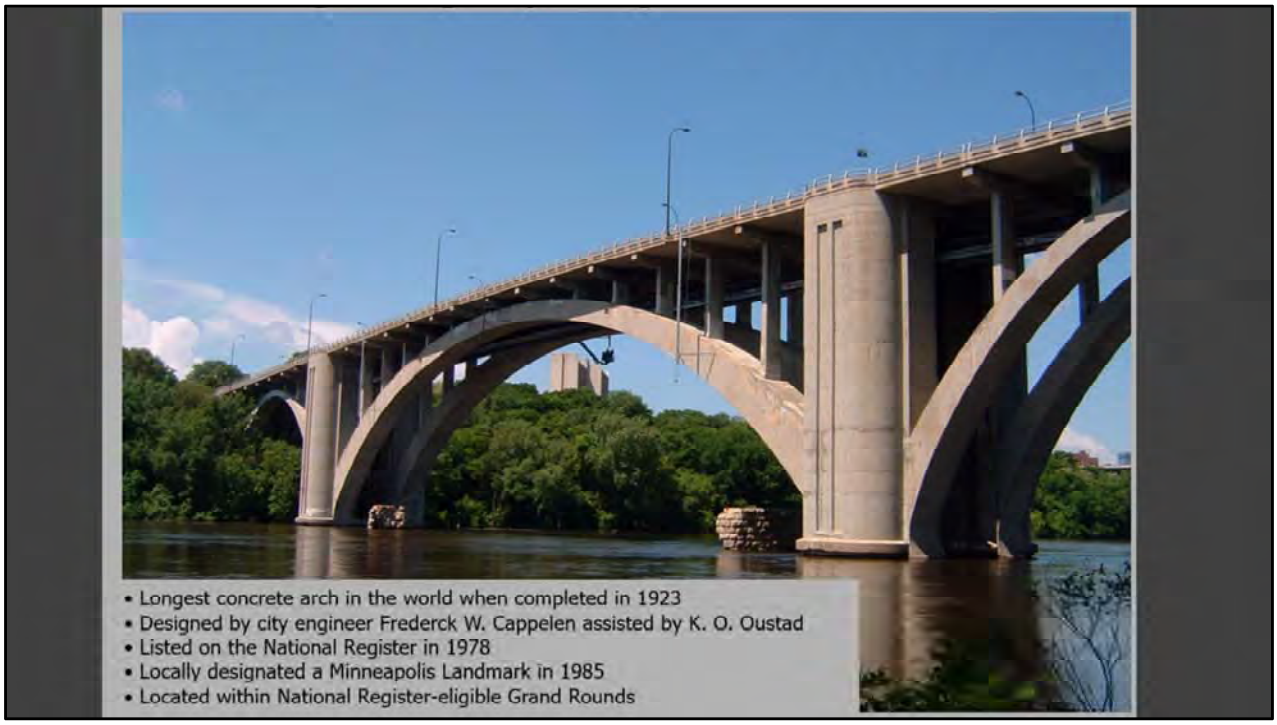
One can see the old light standards and the remnants of the old piers from the old truss bridge that predated this bridge at this site.



Originally the bridge had a tight spandrel column spacing.

During an extensive rehab in the 1970s the bridge had half of the spandrel columns removed.

On the right you can see how the spandrel columns were altered and the addition of a 48” diameter water main.



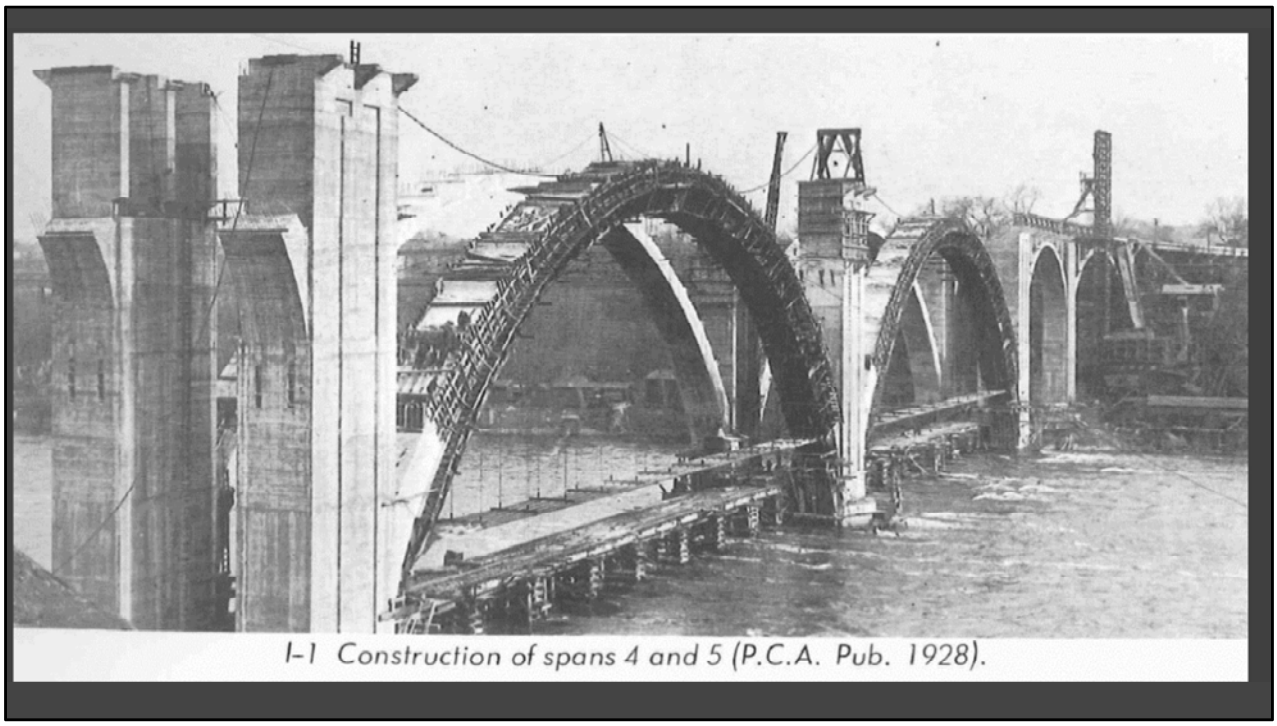
Here's a picture of the bridge prior to its most recent rehab.

At one point in time it was the longest concrete arch span in the world.
400 foot span is pretty impressive for 1923 or so.

Engineers from Europe came to visit the bridge and learn about it.

Cappelen was instrumental in the design of the 3rd Avenue Bridge and this bridge.

He would die of an appendicitis attack during construction of the Franklin Avenue Bridge.



I-1 Construction of spans 4 and 5 (P.C.A. Pub. 1928).

Moving up river here is the 10th Avenue Bridge under construction in the 1920s.

Cappelen's understudy Oustad would be the designer of this bridge for the City of Minneapolis.

Nonconventional Arch Reinforcing

This is the transition of “Melan” reinforcing to rebar in the bridge world in Minnesota.
It’s the late 1920s.
The smaller arch ribs are reinforced with square bars. The bigger river spans are reinforced with Melan Trusses.

The structural engineers in the audience will notice something peculiar about the detail on the left.

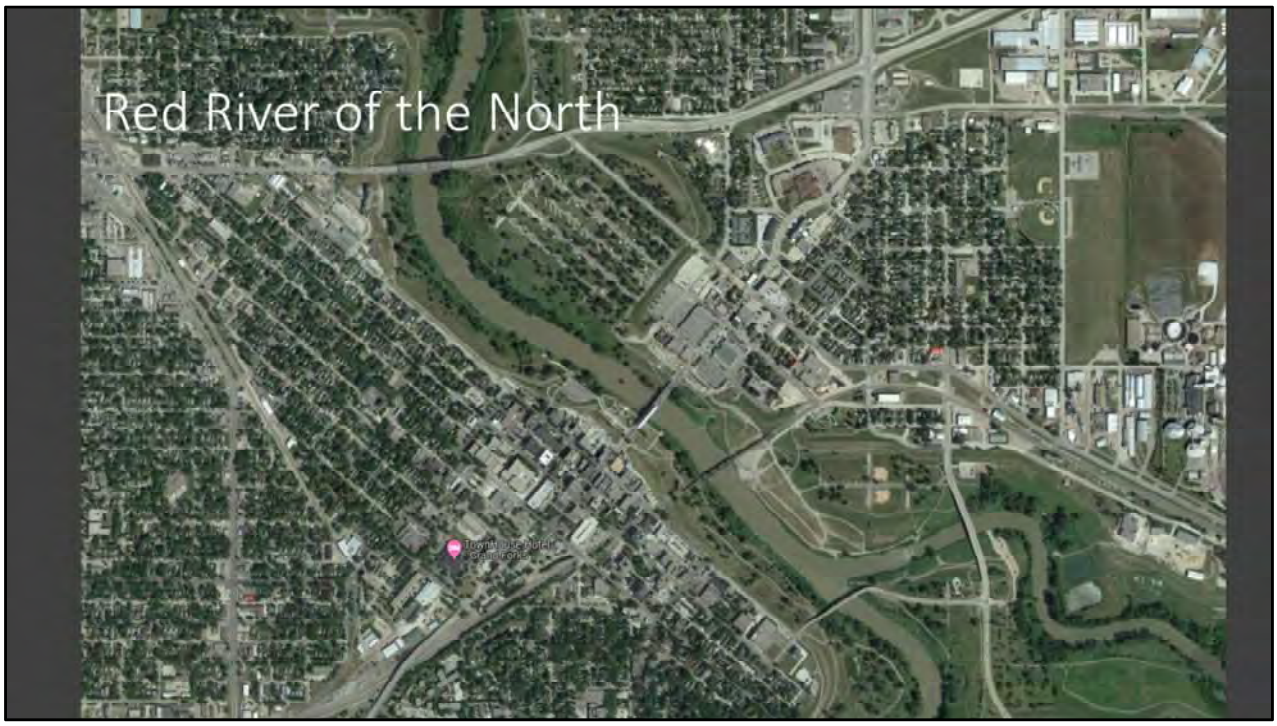
Today we always have our longitudinal rebars encased in stirrups to give them better load capacity.

In this early rebar section, the lower and side longitudinal bars are inside the stirrups. However, the top longitudinal bars are simply laying on the stirrup.

Here's a relatively recent picture of the bridge. We'll talk more about this one later.

Just behind the bridge you can see the 35W bridge.

Before the original 35W bridge was in place, the 10th Avenue Bridge was owned by MnDOT and was part of Trunk Highway 36.

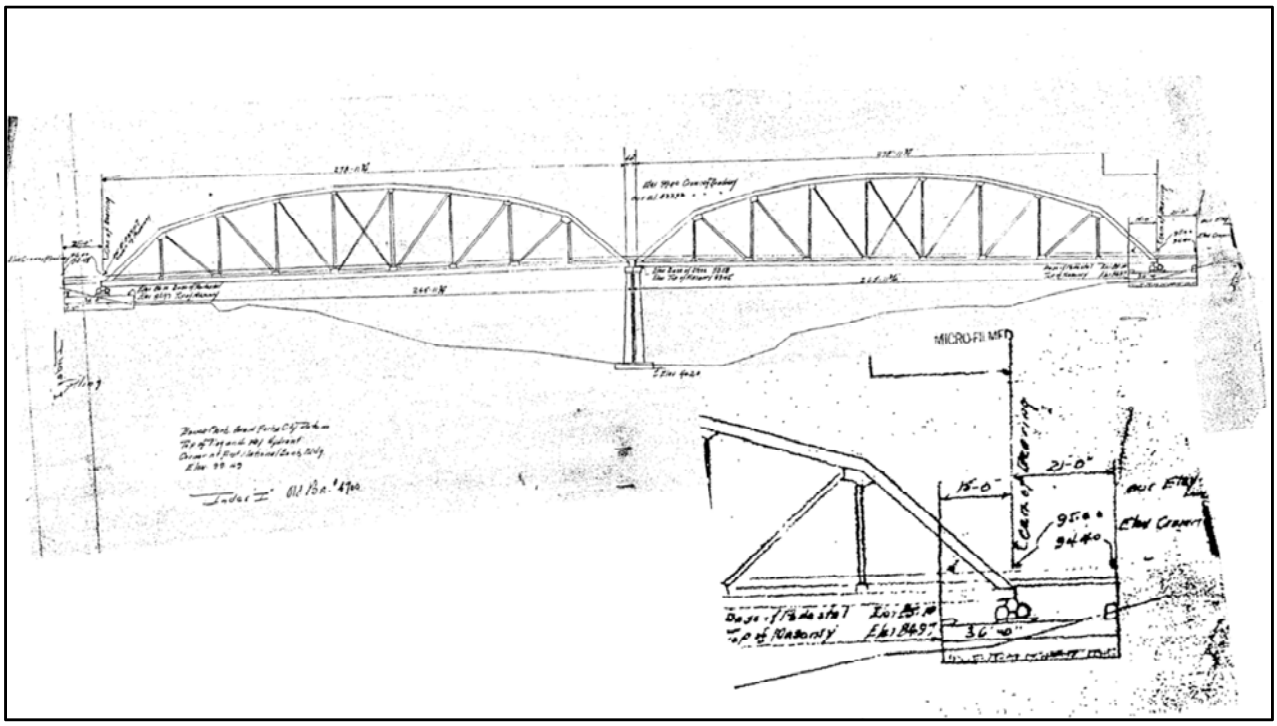


Now let’s shift gears to steel bridges and the Red River of the North

This is a picture of the Red River winding through the Grand Forks/East Grand Forks area.

The Kennedy Bridge with US 2 is the bridge at the top of the photo

The next bridge down is the Sorlie Bridge.



Here’s a detail from the plans for the Sorlie Bridge.

It has a couple unique features.

Often times bridge engineers try to avoid anchoring bridges to substructure units in a waterway. Here the designer did just the opposite, the fixed pier is smack dab in the middle of the river.

The embankments have short side or jump spans and then the truss spans are put on wheels. A closer look at the detail shows these jump spans are about 21 feet long.

The Red River Valley soils are very very soft. There is about 80-90 of goop next to the surface.
Placing load or surcharge on the embankment leads to is moving towards the river channel. This also happens during flood events.

Instead of trying to “fight” the soil mass from moving, the old engineer tried to “accommodate” it. The wheels under the truss would allow the abutment to move towards the river. As the abutment would move the rails could be repositioned under the wheels and the “jump” spans trimmed.

Roughly 20 feet of movement could be accommodated at this bridge.

Standing on the bank of the river looking at ND this is what one sees.
On the far bank one sees a little monument.
The monument has rings identifying the elevation of the river at different flood events.

The river looks pretty calm in this picture.

Here’s a picture of what the bridge looks like from the roadway.

On the end post on the right one can see the memorial plaque for Mr. Sorlie who was a strong advocate for transportation in North Dakota.

Here’s a picture of the river when it is less calm.

The plaque on the end post is barely above the water in this photo.

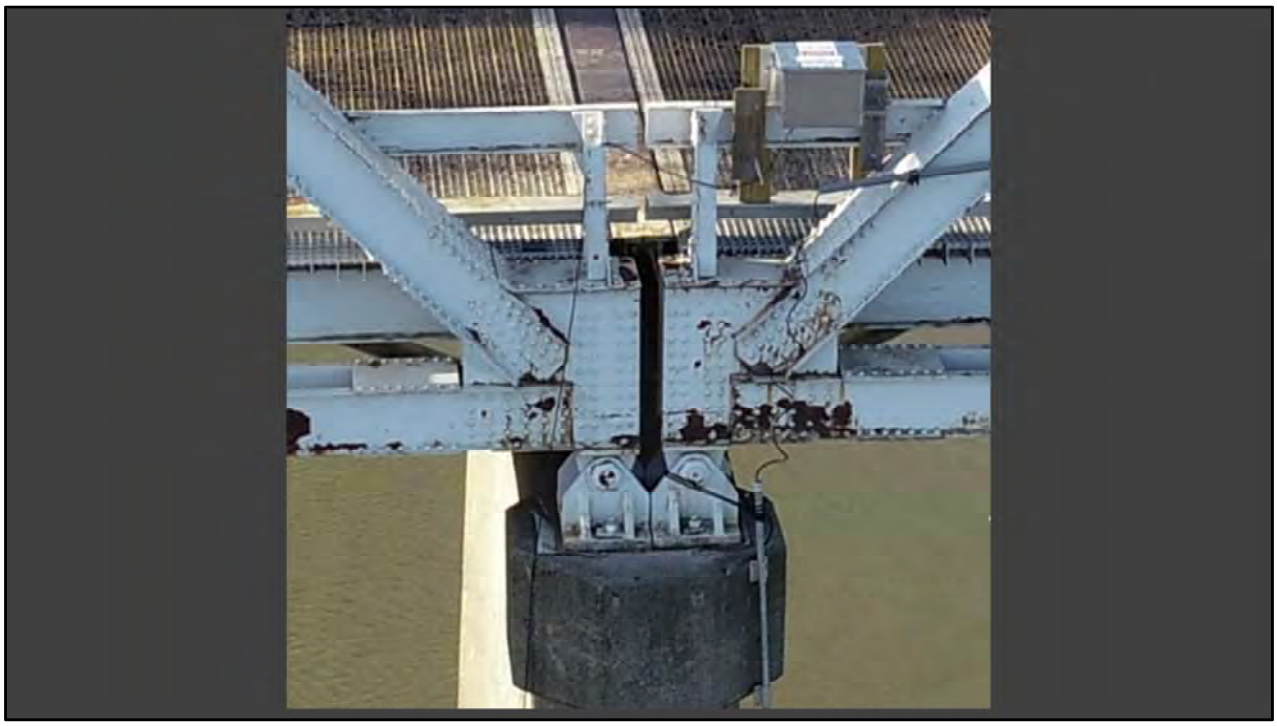
Moving north and down river. Here are some substructure units on the Oslo Bridge over the Red River of the North.
Steel Frames with hinges top and bottom allow the soil to move relative to the bridge.

This is the Center Avenue Bridge in the Moorhead Fargo area.

Once again we have the pinned piers at top and bottom.

This bridge also has beam hinges and pin and hanger details.

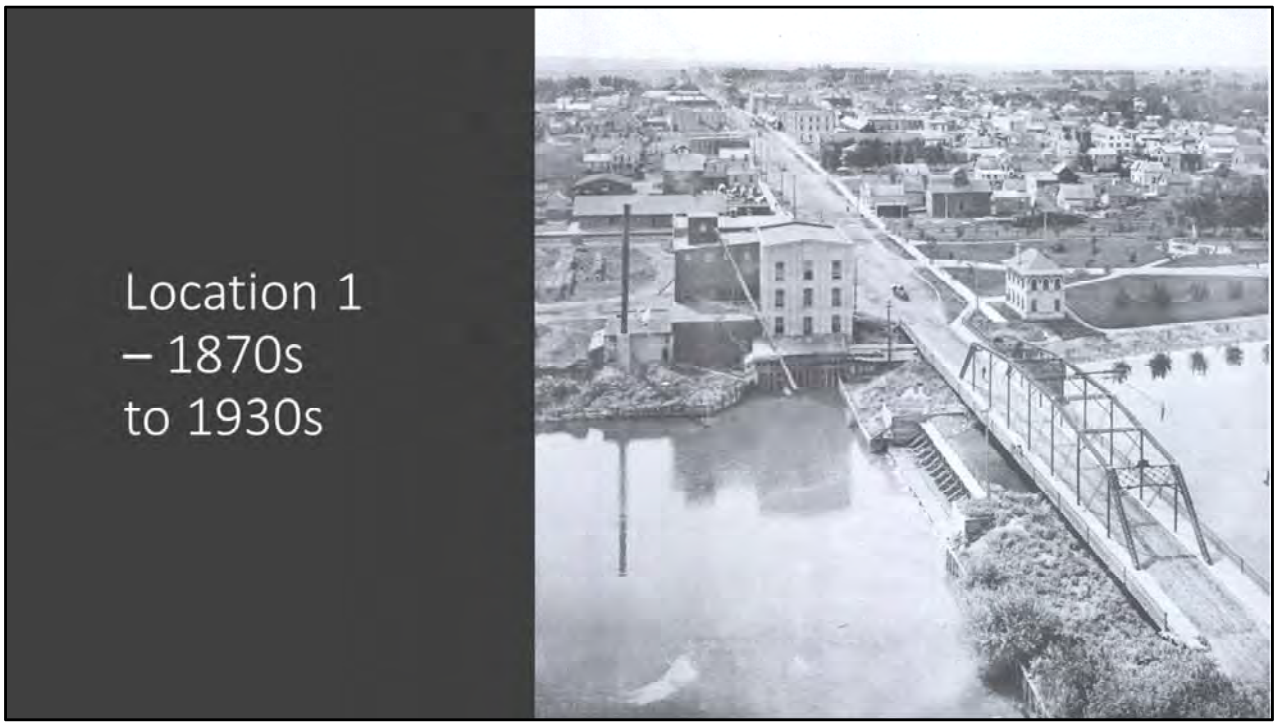
About 20 miles north of Moorhead is this County Bridge.
Once again we see a “fixed” pier in the middle of the river.



A closer view shows both of the truss spans have their “fixed” bearing at the middle river pier.

If we look to the Minnesota bank. We see an awfully odd looking pier.
The pier shaft or stem doesn't look too weird.
It's the Pier cap that looks extremely strange.

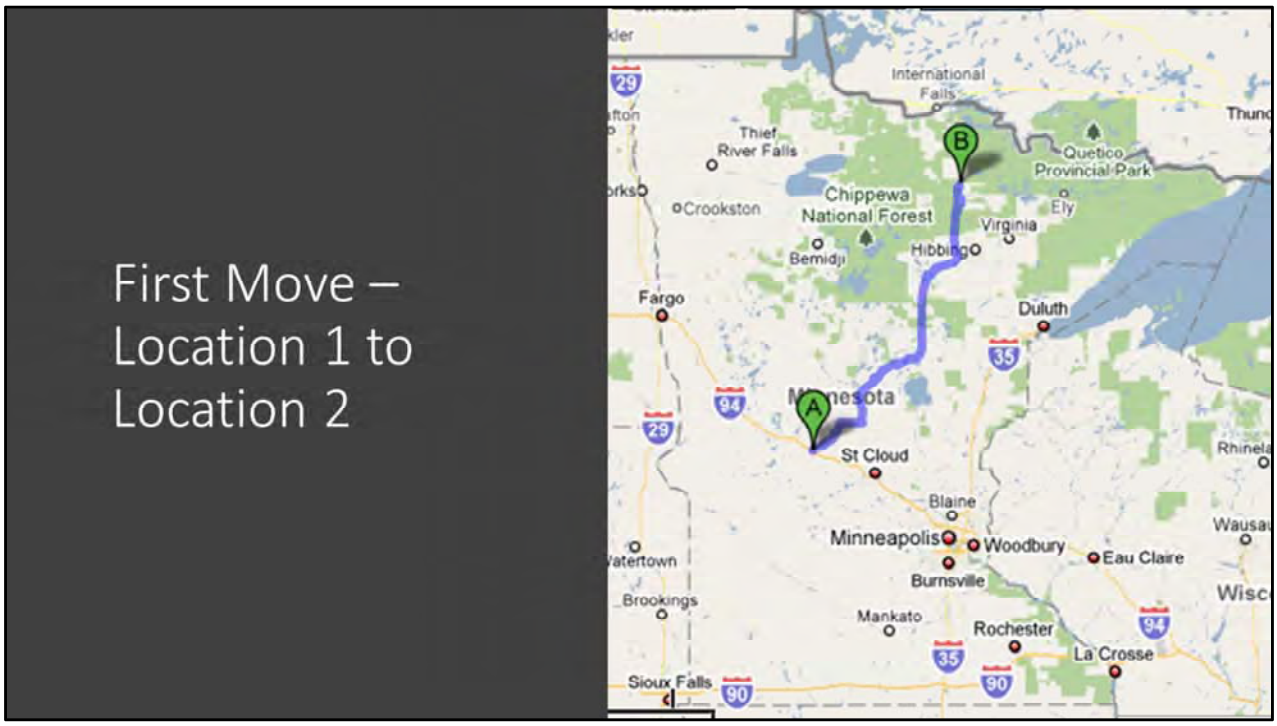
Looking over the side of the barrier and down on the truss bearing, one can see a large bearing plate that would allow the pier to shift towards the river a couple feet without compromising the performance of the bridge.



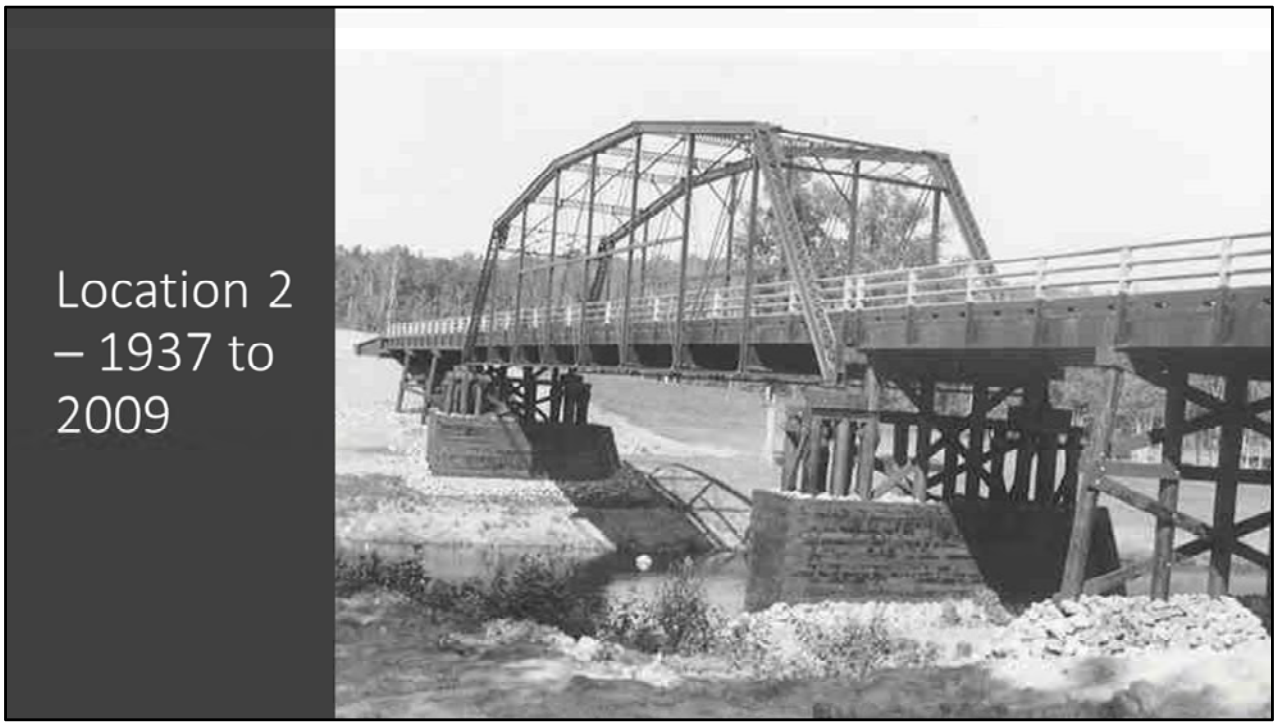
Now we move on to our rehab examples.

Who has heard of Sinclair Lewis?
This bridge was first put in service in Sauk Centre around 1873. It is an iron bridge.
It had deep portals at this site.
It had sidewalks on both sides.

It was just fine here until the 1930s.



In the 1930s the bridge was moved north to Koochiching County on Trunk Highway 65.



Here's what it looked like while it was in service over the Little Fork River.

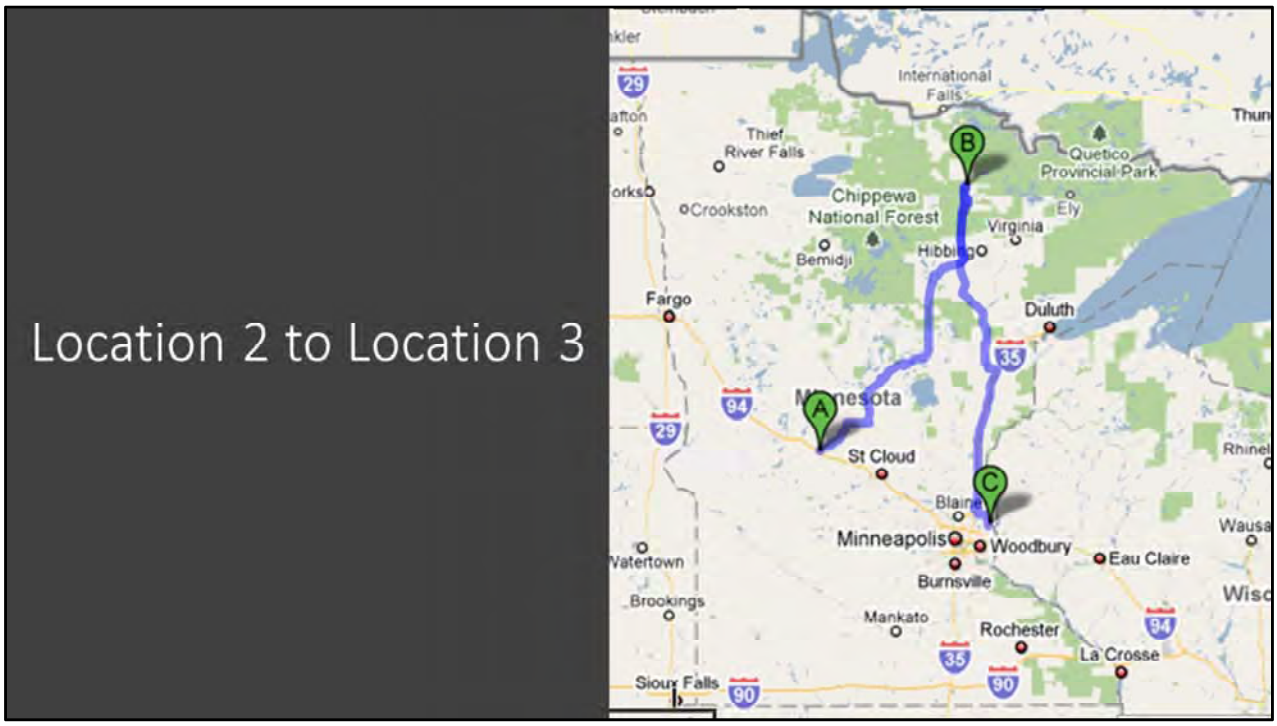
The wooden piers next to the river are "ice breakers". Just large boxes of rocks with an armored edge on the upstream face.

By 2009 everyone agreed that this bridge could not remain in service at this site.
19.5' is not nearly wide enough for a two lane trunk highway.

The bridge was known as the "load leveler" up north. The timber logging vehicles would hit the portals on the bridge and their load would be leveled for them.

Eventually MnDOT would improve the bridge clearance by shortening the height of the portals.

It was decided that this bridge would be moved to a DNR trail for preservation going forward.



The DNR found a home for the bridge on the Gateway Trail over Manning Avenue in Washington County.