WisDOT Structure Inspection Series - Timber

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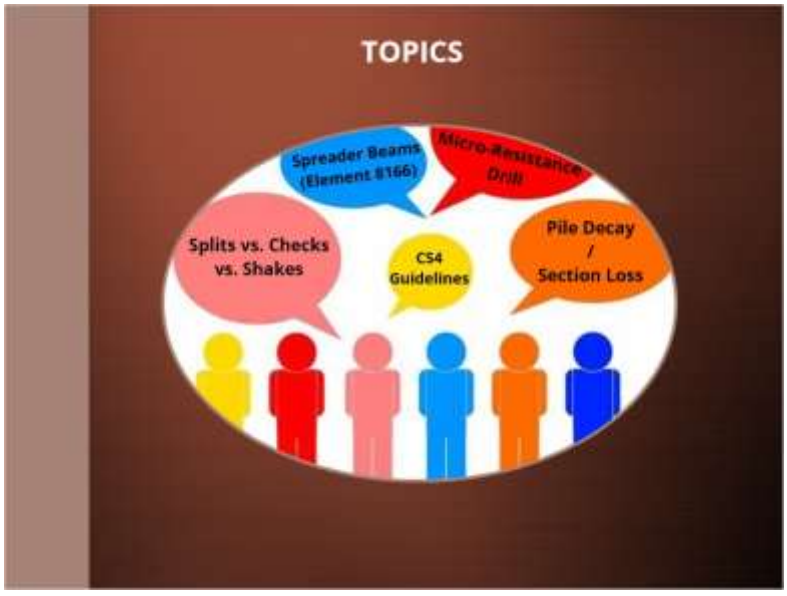

In this session, you will review:

-The difference between splits, checks, and shakes
-Spreader Beam Element 8166 – what to inspect, and why it's important
-How to use a Micro-Resistance Drill
-How to calculate and document pile decay and section loss, and
-CS4 Guidelines for timber.

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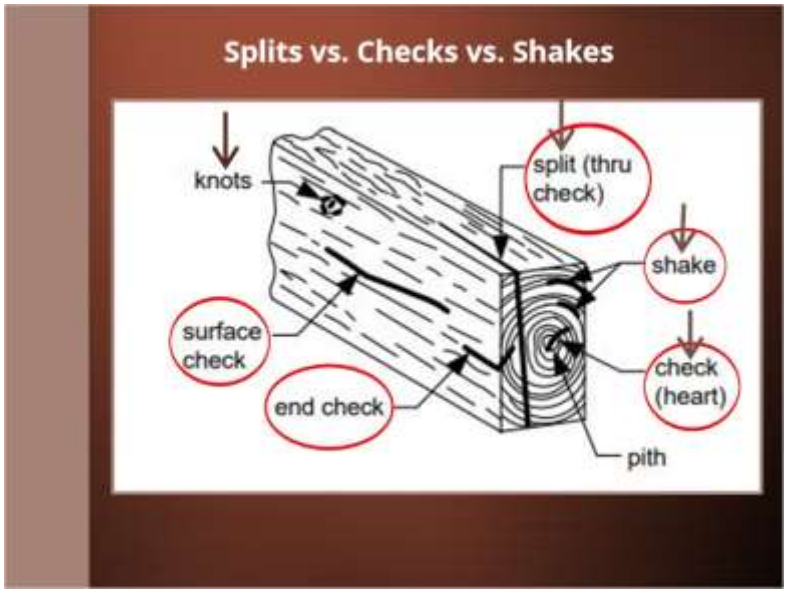

First, let's review some terminology for timber defects. This image shows the common defects associated with wood: knots, checks, shakes, and splits.

Two of the most common defects observed and noted for timber bridges inspections are Splits and Checks. However, the difference between them is often confused.

Both are separations of the wood fibers that generally occur parallel to the grain, and across the growth rings. And actually, a "split" [ANIMATION] is a type of check, sometimes called a "through check." It extends completely through the member. "Surface checks" [ANIMATION], "end checks" and "heart checks" should not be referred to as "splits," since they do not extend all the way through the member thickness.

Another type of defect, a "shake," [ANIMATION] is a separation that is also parallel to the grain, but occurring between the growth rings instead of across them.

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The defects shown here on bridge rail posts, from left to right, are a split, [PAUSE] checks, [PAUSE] and shakes.

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The next topic to highlight is spreader beams – Element 8166. This element label should be used instead of Timber Floorbeam.

Spreader beams, also called transverse stiffener beams, should be tight to the bottom of the slab, so that nearly all of the slab laminations are in contact with it. A recommended maintenance action and/or a structural review may need to occur if the bolts are loose, or if there are a lot of gaps between the bottom of the slab and the top of the spreader beam.

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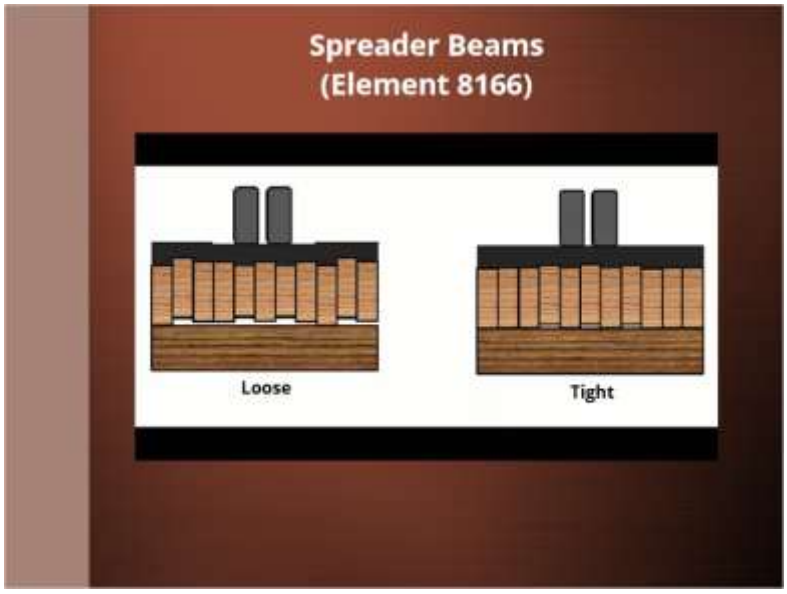

As timber expands and contracts and bolts become loose, spreader beams need to be regularly tightened and shimmed to maintain tight contact across the bottom of the slab.

A loose spreader beam allows slippage between laminations. [ANIMATION] As a wheel travels over the bridge, the load distributes to fewer laminations, causing more deflection and stress in the slab, as well as accelerated deterioration of the asphalt wearing surface.

There are no well-defined rules on size or quantity of gaps to know whether a spreader beam is considered loose or tight. This requires a judgment by the inspector. Photos to monitor changes from one inspection to the next may help. Consider the condition of the wearing surface, as well, to judge spreader beam tightness. An asphalt wearing surface with longitudinal reflective cracking may have been partially caused by a loose spreader beam.

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In general, if the inspector feels a spreader beam can or should be tightened and shimmed to improve bridge performance, it should be a recommended maintenance item and the spreader beam should be placed in Condition State 4.

This is a relatively inexpensive and simple repair. If this does not occur, the bridge's capacity is compromised, and a load posting may be necessary.

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The next topic is a review of one of the most useful NDE instruments for timber bridge inspections, especially for timber piles with decay: A micro-resistance drill, also called a “resistance microdrill” or a “Resistograph.” It uses a needle smaller than 1/8-inch in diameter to identify locations of decay in timber elements. The needle travels through the member at a defined movement rate and rotational speed, and measures the relative resistance of the wood to penetration. Hard wood in good condition will have a lot of resistance. Decayed wood, splits and voids will have very little or no resistance.

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Here it is in action, showing the model WisDOT owns. It has a display screen in which the relative resistance can be observed while drilling.

The spikes up and down on the graph are the growth rings. This is the pattern you will see in good healthy timber. Then it flattens out in the middle, where decay has initiated and the wood is not as healthy, but average resistance is still not a huge drop off. Then after a couple inches the growth ring pattern picks up again. At 11.5 inches, the resistance drops to zero, where the drill has gone through the other side of the pile.

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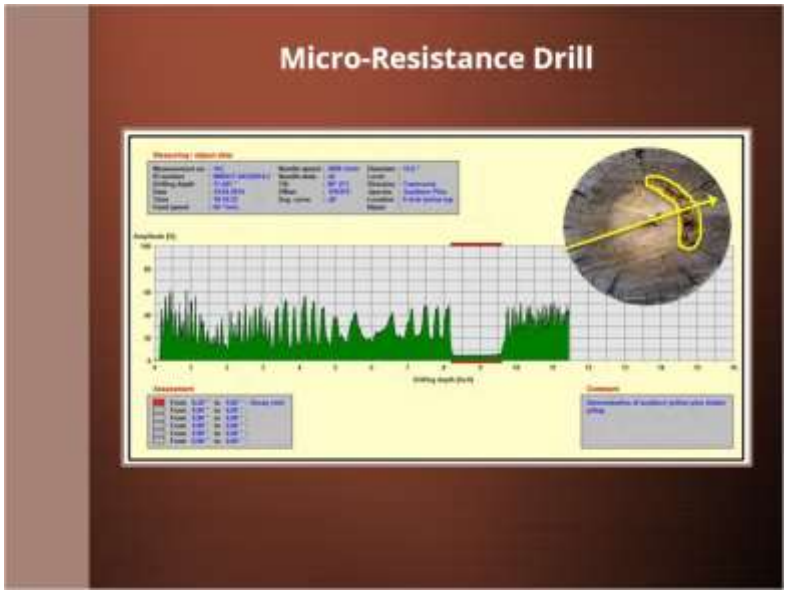

Here is a look at the computer software where readings from the Resistograph are saved. A cross section of the timber sample used for this measurement is provided as well. In this example, you can see how the graph picked up the area with a decay void that otherwise would not have been observed with visual inspection.

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The Resistograph model owned by WisDOT, the IML PD400, has been used reliably for several years now. Here are a few tips to consider when using it.

1) Broken or worn needles will need to be replaced occasionally, and removing broken ones and replacing takes a little practice. They cost about $200 for 10, but each should last hundreds of measurements if it does not break.

2) Sometimes a message will appear that says “overload feed motor!” If this happens, you should lower the needle rotational speed and feed speed or risk breaking the needle.

3) The memory on the instrument will store about 75 readings. At this point they will need to be downloaded to a computer using PD-Tools Pro and cleared from the instrument. If the Resistograph will be taken into the field for several days of use, it is advised to bring a laptop containing the software.

4) Every couple years, the Resistograph should be sent in to IML for calibration and general maintenance. Additionally, users should routinely lubricate and clean the instrument for optimal performance.

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Here are some additional resources that may be helpful. Search YouTube for the video “Timber Bridge Inspection: Resistance Microdrilling Demonstration” for a more detailed demonstration produced by Minnesota DOT.

To request use of the Resistograph, you can contact the BOS Maintenance Section or WisDOT Regional Maintenance Engineer. At this time the device is only available to WisDOT Bridge Inspectors, but they can deploy the device and inspectors to perform the measurements upon request, as resources allow.

WisDOT has also developed its own set of detailed supplemental instructions for using this device for bridge inspections, available upon request. WisDOT-owned computers can have PD-Tools Pro installed upon request, and measurement templates for logging measurements can be provided.

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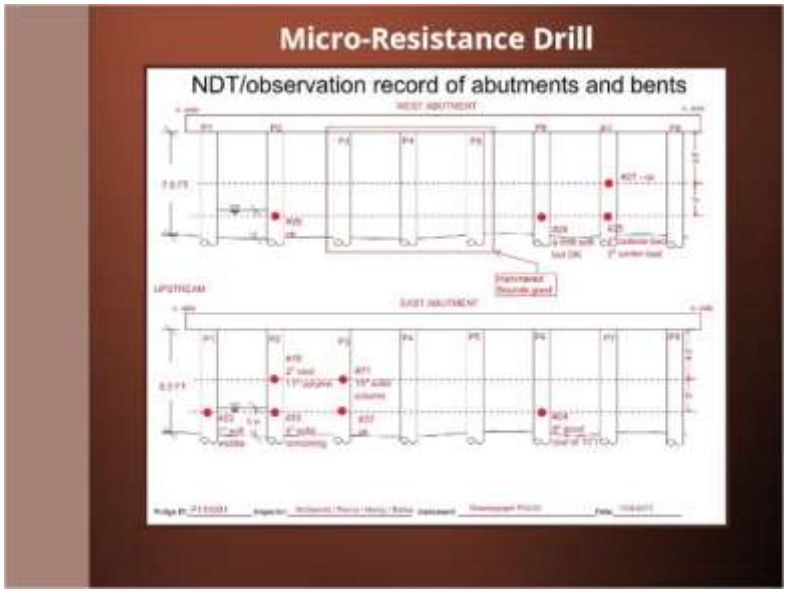

Here's an example of a measurement log.

The location of measurement locations, along with other general observations and field measurements, are recorded. Which brings us to our next topic…

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How to document pile decay and section loss.

Many bridges with timber piles do not have as-built plans available, so thorough information should be provided whenever the pile is in poor condition. Helpful documentation includes:

- Diameter of the pile

- Height from the ground line to top of the pile
- Spacing between piles

- Locations of the deterioration – is it at the top, at the water line, or throughout its height?

- An estimate of percent decay or section loss, if more exact measurements from a Resistograph are not provided. And is the decay on the inside or outside of the pile?

- If the pile has any tipping or rotation out of plumb, this should be documented and measured. This can cause an eccentric load, which increases stresses on the pile.

- If the pile is relatively tall, does it have any deadman tiebacks or bracing to help resist lateral earth pressure at the abutment?

- And finally, [ANIMATION] photos and sketches are always helpful.

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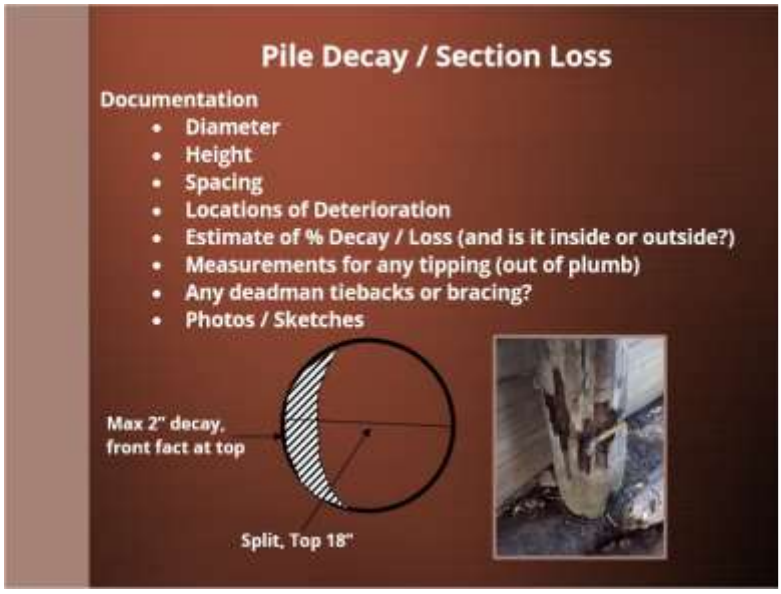

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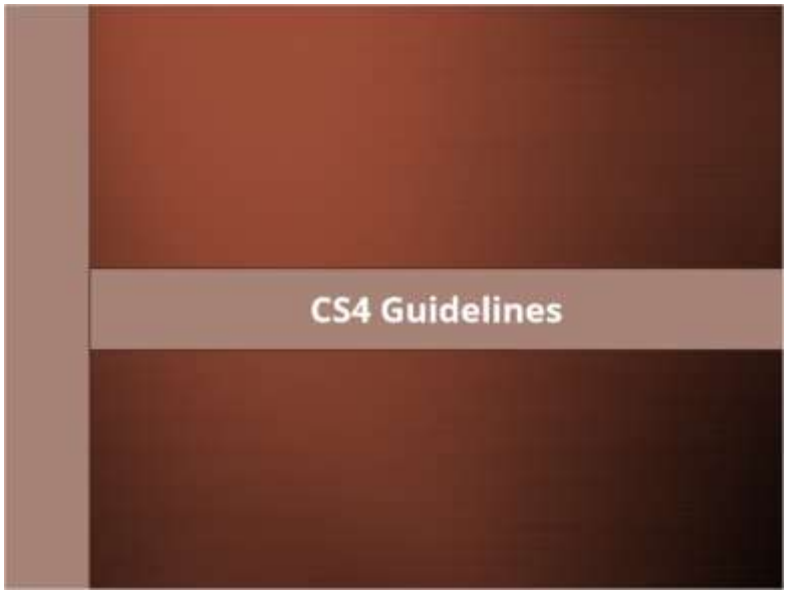

For structural review purposes, notes need to clear about the location, if the percent loss is relative to length or cross sectional area, and whether the decay is in the interior or exterior of the pile. Here are some examples of notes commonly included with timber piles. Some of these are good and some could be better.

- "50% decay/rot" is not clear about location, and it is not clear if this refers to a guess on interior decay based on hammer sounding, or if it was observed and measured with more precise methods.
- "50% section loss" – similarly, the location is not given.
- "1 inch rot around exterior" is a helpful note that allows the load rating engineer to analyze the remaining section more accurately.
- "3 inches decay in center" is another good example
- Estimates of section loss can be provided, if it's clear that the amount noted is an estimate and location is given.
- "Two piles getting soft at water line" leaves too many questions – how soft? Is it getting worse? Which piles?
- A better note might be "Piles 1 and 8 with estimated 50% area loss from exterior decay at water line"

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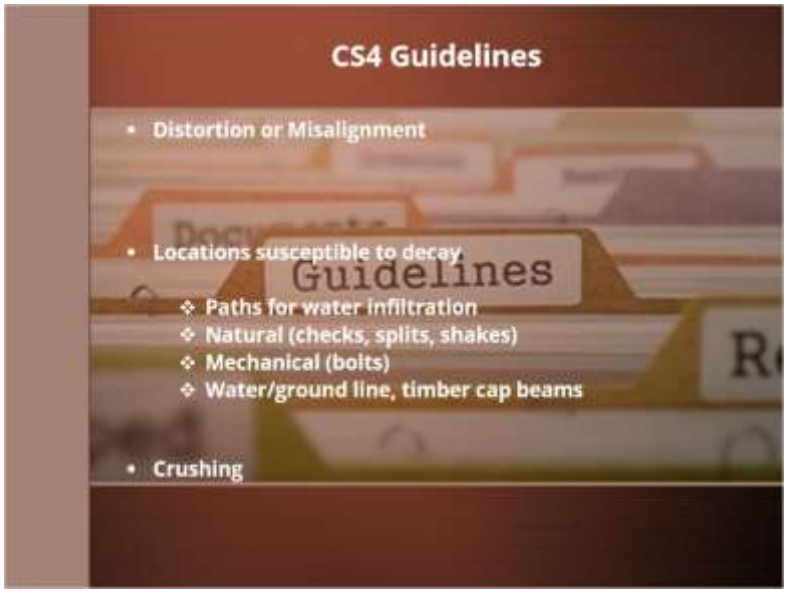

For the last section of this training, we will go over some guidelines for timber elements in condition state 4. Aside from obvious issues related to decay or local failure, a few things to look for include:

- Distortion or misalignment

- Locations susceptible to decay, which include any location where water infiltration into the timber member's interior can occur. These can be natural occurring pathways for water, such as checks, splits, and shakes, or mechanical ones such as bolt penetrations. Areas requiring special attention are at the water or ground line, and timber cap beams.

- Finally, minor crushing is a commonly observed defect in timber. But when does it become a concern?

Let's take a look at some examples.

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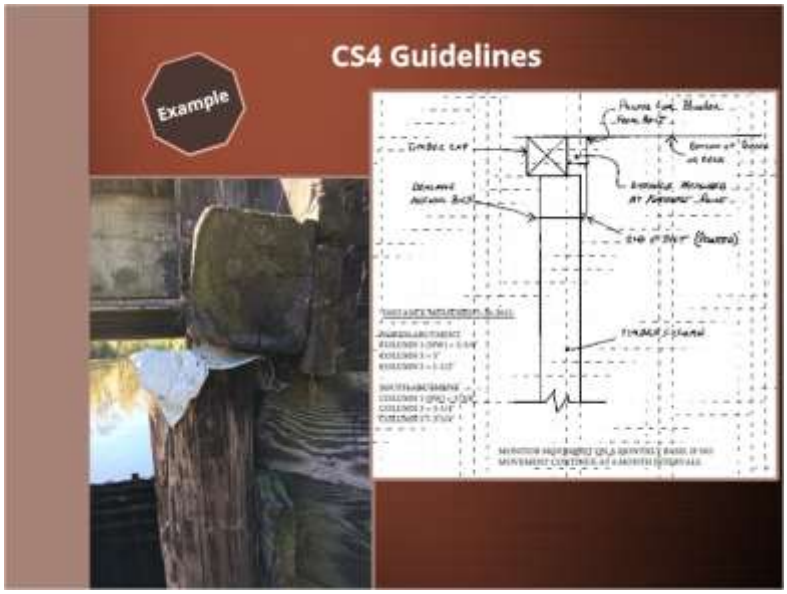

Here is a good example of documentation provided for tipping timber abutment piles. In this example, the inspector has noted measurements and provided a template for taking future measurements to monitor movement.

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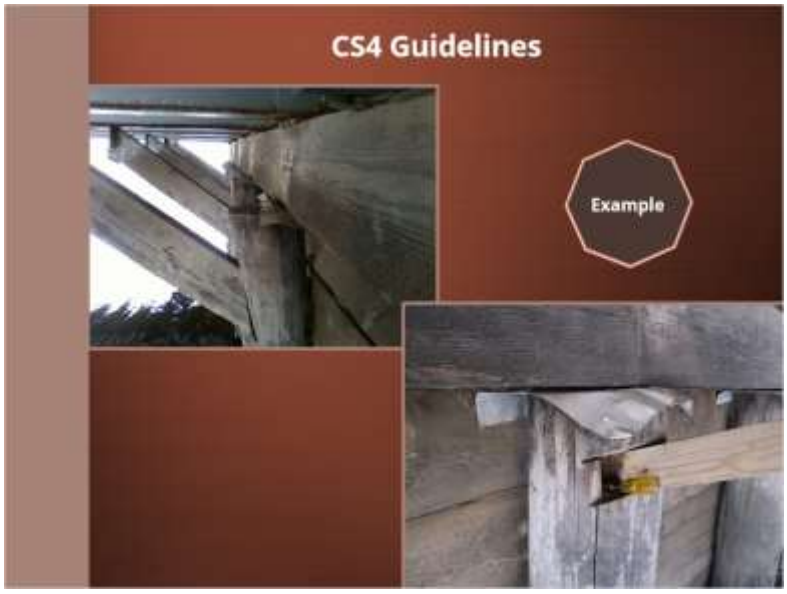

Sometimes this tipping is mitigated by providing braces up to the superstructure. However, this repair introduces other problems. Specifically, a pathway for water infiltration into the interior of the pile has been created. This should be identified as a location susceptible to decay and should be closely inspected.

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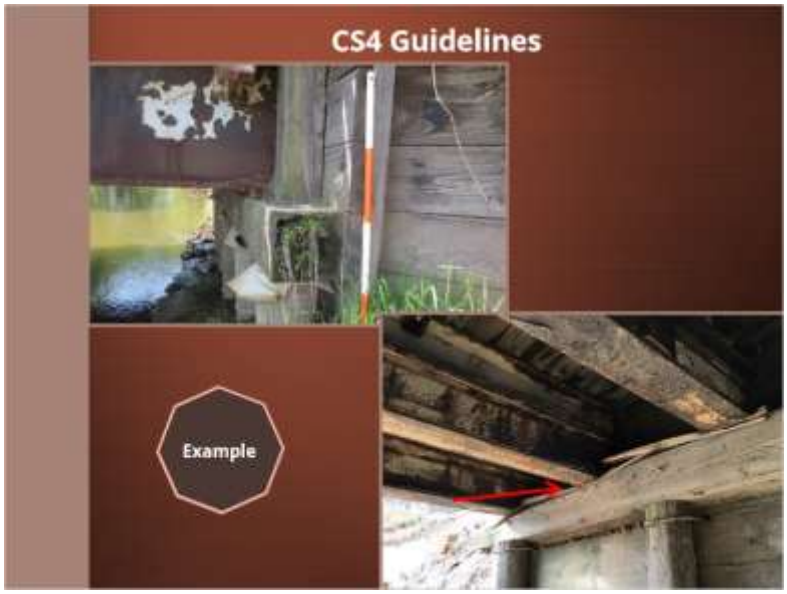

Here are a couple examples of timber pile caps that have crushed.
The one on the left has severe decay at the end of the cap, but the crushing is relatively minor. Additionally, the steel girder is directly above the pile, so further crushing is considered more of a serviceability issue – the pile cap will likely just continue to compress between the bottom of the girder and top of the pile cap.
On the photo on the right, however, pile cap crushing has occurred where the girder bears on it between two piles. This is much more of a concern, because pile cap failure here could lead to complete loss of support for that girder.

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