TIMBER BRIDGE INSPECTION GUIDE

MONTANA
MDT
DEPARTMENT OF TRANSPORTATION

Understanding Timber

Timber can be a difficult element to inspect. It is extremely variable, and often looks like it is in worse condition than it really is. This field guide is intended to help in describing the condition of timber elements.

Consistency in how we describe and code timber elements is extremely important when timber bridges are inspected, load rated, and coded. Historically, the way we describe timber defects has been extremely variable, making it difficult for bridge raters to know how much strength to give timber elements when performing a bridge rating.

In this manual, you will find definitions for the terms check, shake, split, crack, and break. Use these definitions and visual aids when inspecting timber elements and communicating their condition to the Bridge Management Section. Remember that photographs are extremely helpful. Descriptions of crushing and decay are also included, as well as a section on coding repaired timber elements.

Not all conditions that you find in the field will be covered by this manual. There are too many variables out there. If you are unsure how to describe a specific timber defect, take a photo and call the Bridge Management Section for help.

Checks, Shakes, Splits, Cracks, and Breaks

Checks and splits are caused by the natural drying process of timber. Shakes are caused by external forces on standing or harvested raw timber, such as wind, felling of the tree, or handling prior to or during transport of the raw tree. These defects can vary in size and density, but don't significantly affect the load carrying capacity of a timber element. Specifically, checks and shakes will have no effect on the bending capacity of a member. However, for splits, in rare cases the load raters may reduce the capacity of a timber member if they deem a split severe enough. For this reason, any large or excessive splits, checks, and shakes should be documented carefully. What constitutes "large", "excessive", "severe", etc… in terms of timber deficiencies will be discussed in more detail in the following sections of the guide.

Cracks and breaks are usually caused by overloading of a timber member. They can occur along or across the grain of a member and they have a significant impact on the load carrying capacity of a member.

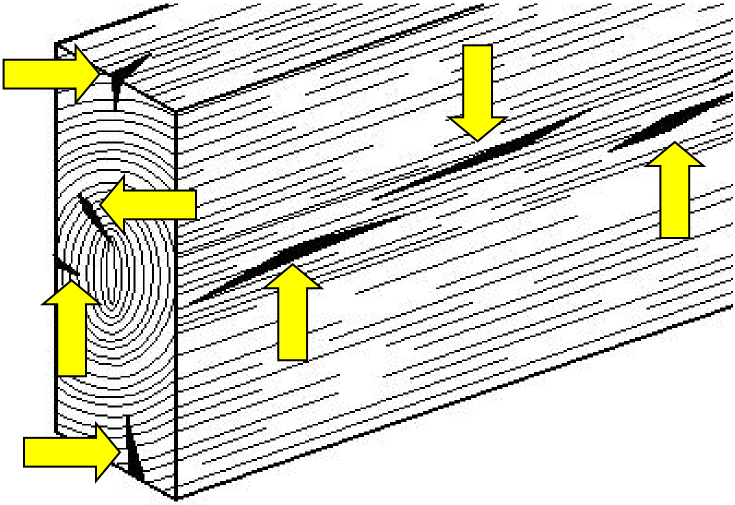
Checks

A check is a separation of wood fibers across or along the growth rings, and typically parallel to the grain, caused by drying of the wood. A check **does not** extend completely through the member.

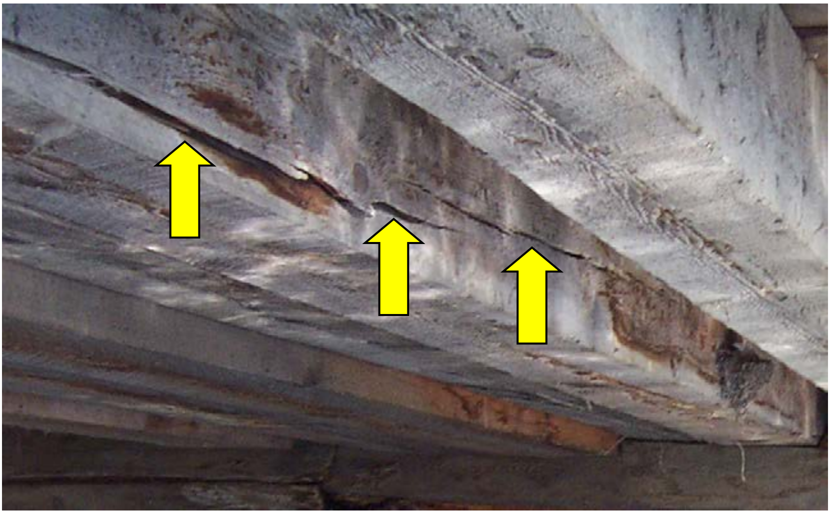
Checks are caused by the drying out or “seasoning” of timber. As timber dries, or seasons, the outer fibers in a member dry faster than the interior fibers. As the wood fibers lose moisture, they shrink. If the interior fibers have more moisture content than the exterior fibers, they shrink at different rates. This differential shrinkage causes stress between these fibers of different moisture contents, resulting in a separation of the fibers that we see as checks. The thicker the member and/or the faster the drying rate, the more likely and pronounced the checks become.

Even severe or multiple checks will have no effect on the bending capacity of a member. However, if severe checking is noticed, it should be documented in the element description.

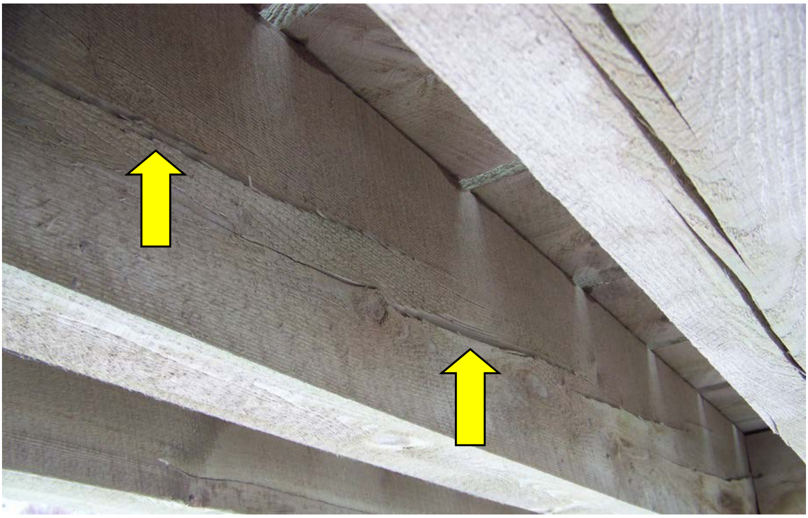
A repair recommendation (Work Item) is never necessary for checks.



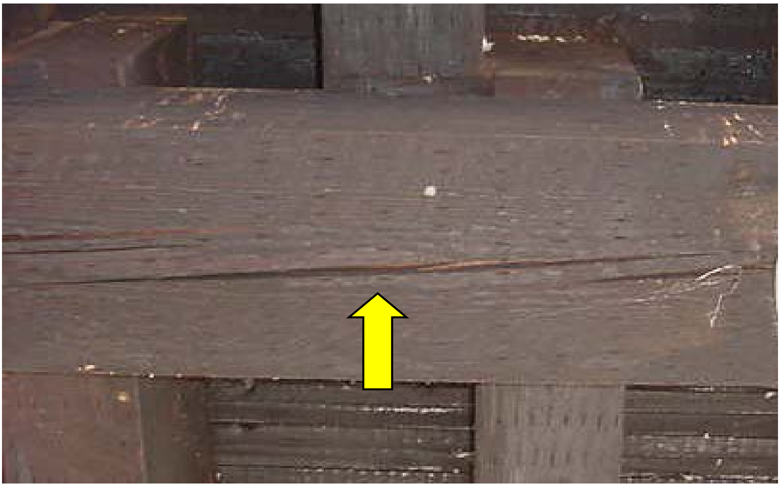
Sketch of Checks



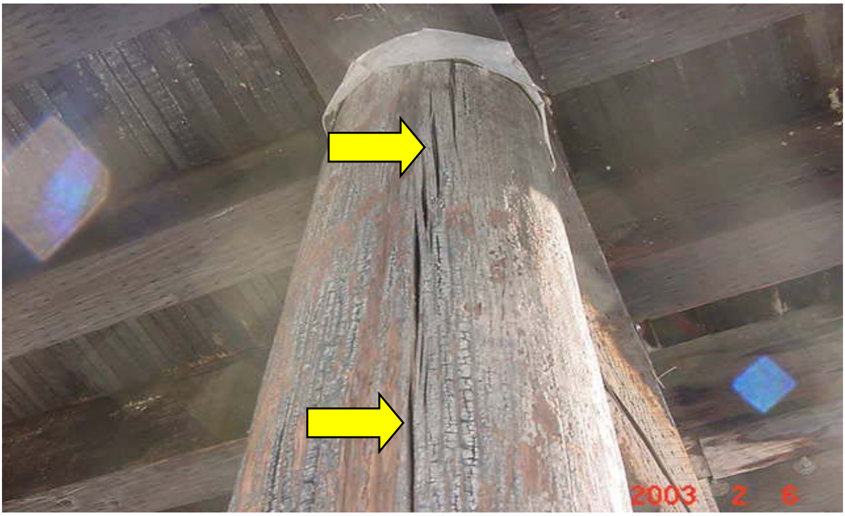
Checks



Checks



Checks



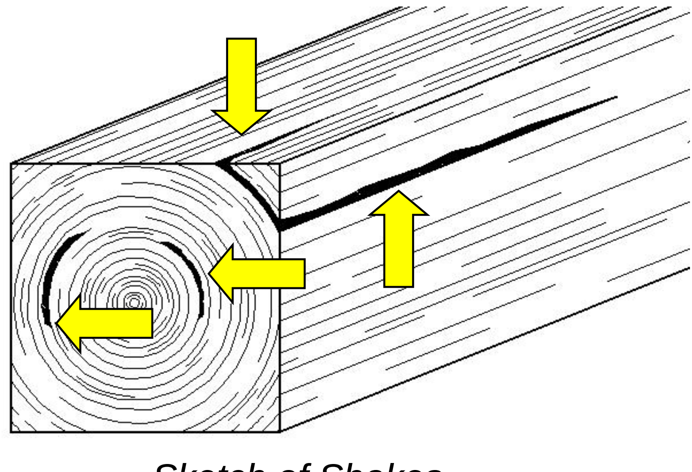
Checks

Shakes

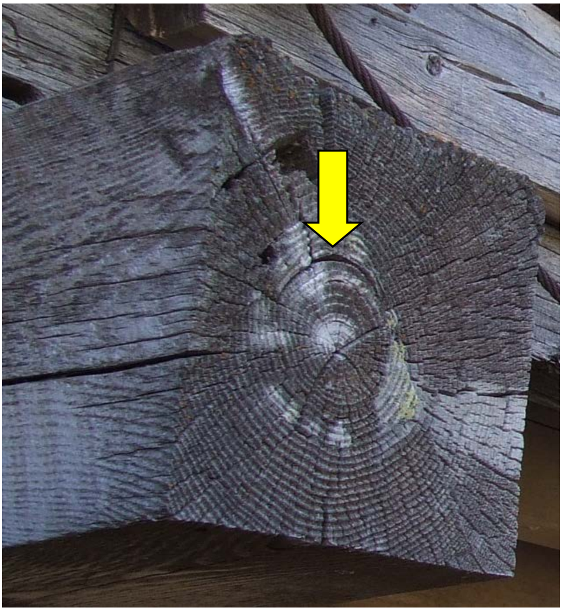
A shake is a separation or plane of weakness between growth rings and can be found throughout a timber member. Shakes are usually caused by external forces acting on the wood before it is milled. This can be caused by wind on a standing tree, during the cutting and felling of the tree, or during the handling and transport of the tree.

As with checks, shakes generally have no effect on the bending capacity of a member. However, severe, deep, or long shakes should be documented and photographed.

A repair recommendation (Work Item) would almost never be necessary.



Sketch of Shakes



Shake

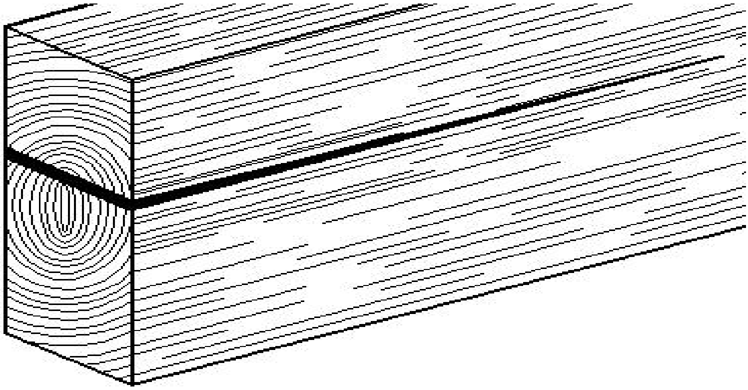
Shake

Splits

A split is essentially a check that extends completely through a member from face to face. It will usually follow the grain of the wood, does not propagate through the top or bottom of the member (i.e. it is more or less parallel to the top and bottom face) and typically starts at the ends of a member. They are usually caused by seasoning of the wood, but can be caused by a notch in a beam acting as a stress riser.

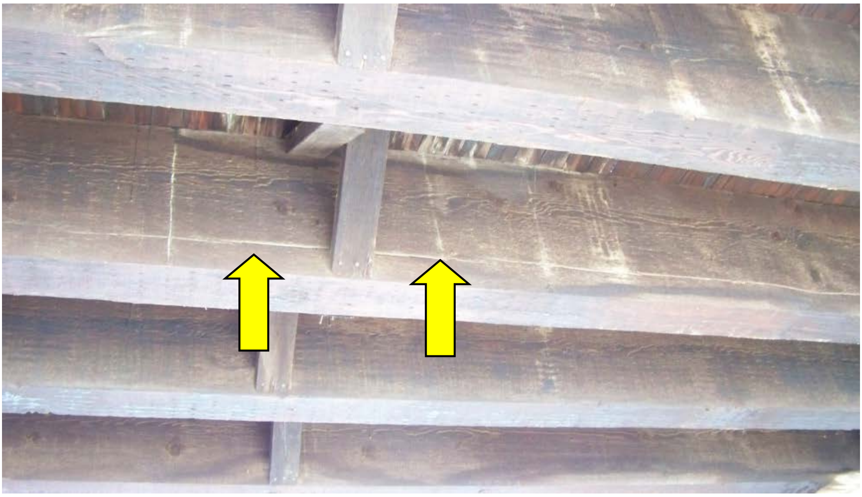
Generally, splits will have no effect on the bending capacity of a member. However, in rare cases the load raters may reduce the capacity of a timber member if they deem a split to be severe enough. Severe may be defined as a split longer than 25% of the member length, the faces of the split are offset, or multiple splits. For this reason, moderate or severe splits should be noted and documented.

A repair recommendation (Work Item) is generally not necessary.



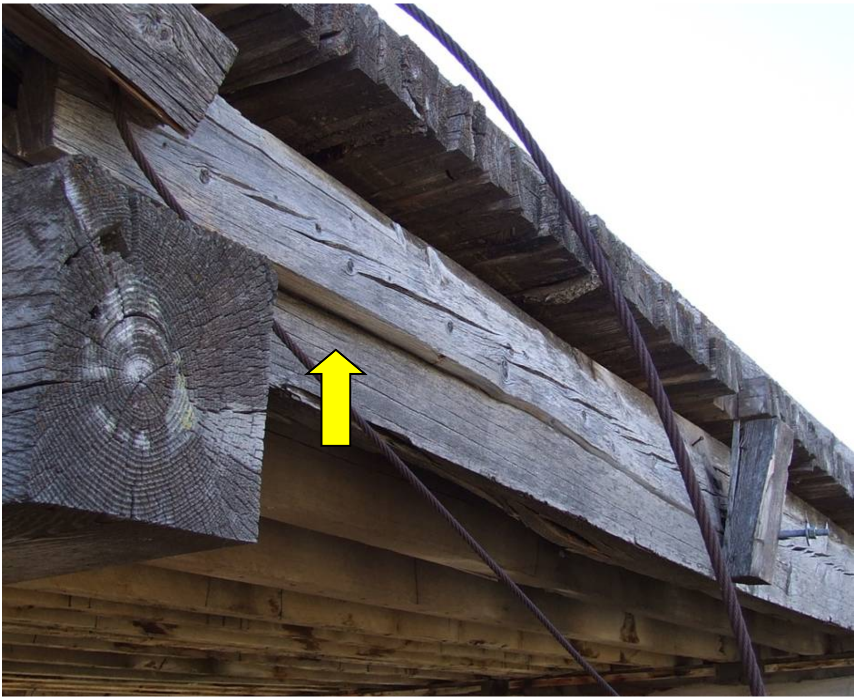
Sketch of a Split

Split



Split

Split propagating from a notch



Split with lateral displacement between sections

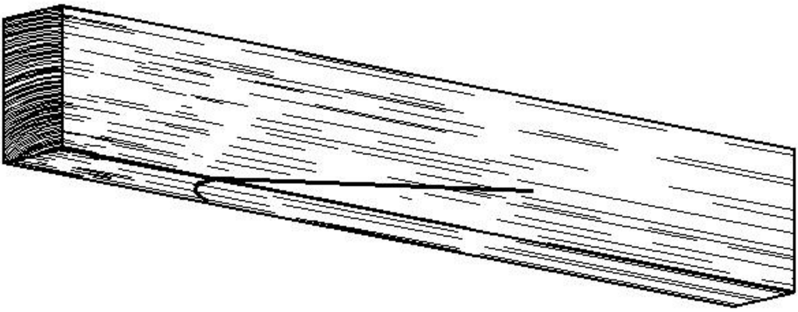
Cracks

Cracks are used in the description of timber girders more often than in any other element description. They are basically breaks that are not yet complete. Cracks will extend completely through a member, to the opposite or adjacent face, generally starting on the tension face (the bottom) of a member (usually a girder) extending up into the member at an angle.

They will many times begin near the mid-span of a beam in the area of highest stress. Stress risers such as a knot, impact or handling damage, or where a check follows the wood grain down to the bottom surface can also initiate crack propagation in any location along the beam.

Cracks have a direct effect on the load carrying capacity of a beam. Any crack that has extended up more than 10% of the depth of the girder would be considered moderate to severe and would need a rating analysis. Because of this and their potential to quickly propagate, all cracks that are found should be documented in detail and photographed, especially any moderate or severe cracks.

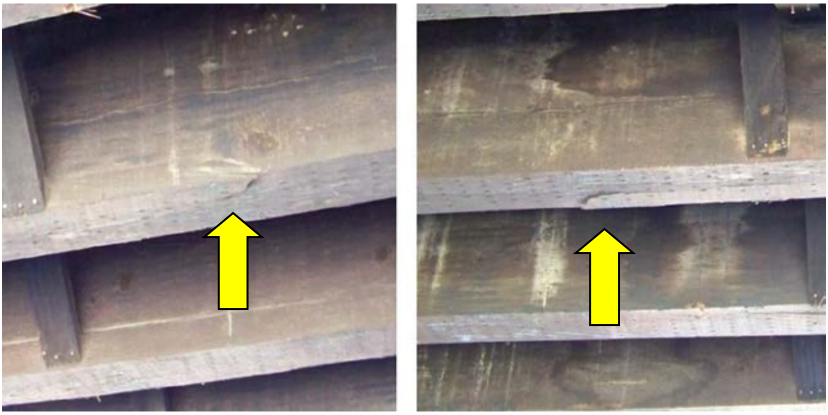
A repair recommendation (work item) is usually necessary. A hanger repair may be appropriate if the crack is not severe, but when severe, replacement (or a helper girder) is the best option.



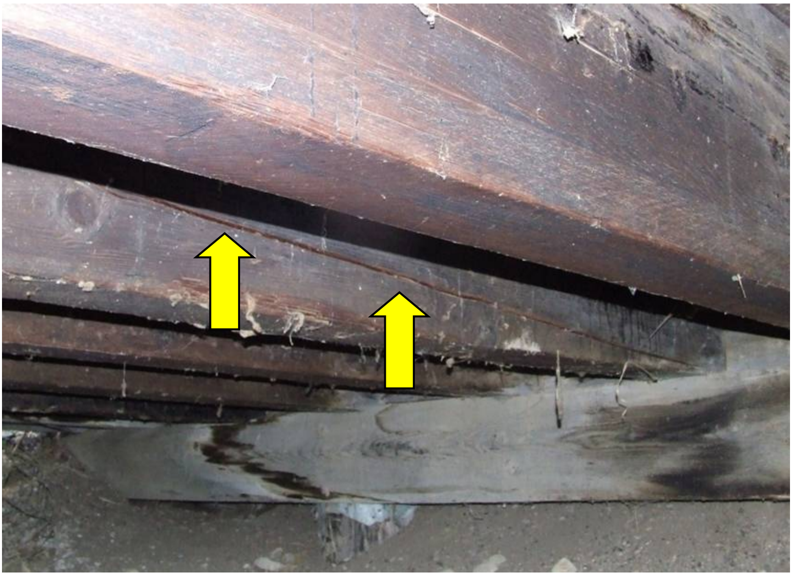
Sketch of a Crack

Moderate Crack

Moderate Crack



Minor Crack (both photos are of same crack)



Severe Crack

Breaks

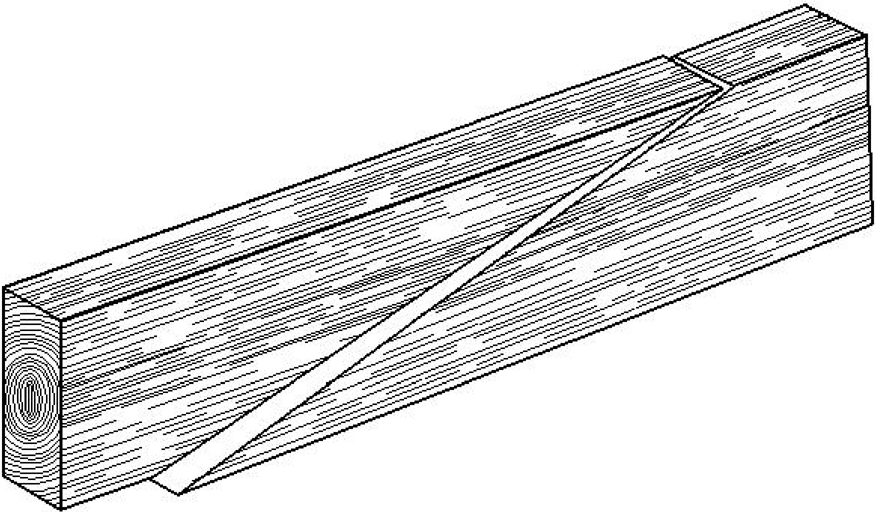
There are two types of breaks – partial breaks and complete breaks.

A complete break is the loss of all strength in a member. Complete breaks extend across the entire member, usually diagonally, and propagate from the bottom of the member completely to the top. Complete breaks will open significantly under live load, and will sometimes hang open under dead load.

A partial break is the loss of all strength in a portion of the member's cross-section. Partial breaks typically occur where a split meets a knot near the bottom of a girder. Partial breaks are likely to hang open under dead load, but will sometimes only open under live load. When describing a partial break, it is important to note how much of the member's cross-section is intact.

If a girder is completely broken, it will have essentially no capacity to carry load. A recommendation to replace the member should always be made. This should not only be in the form of a Work Item, but should also be made verbally to the entity responsible for maintenance of the structure.

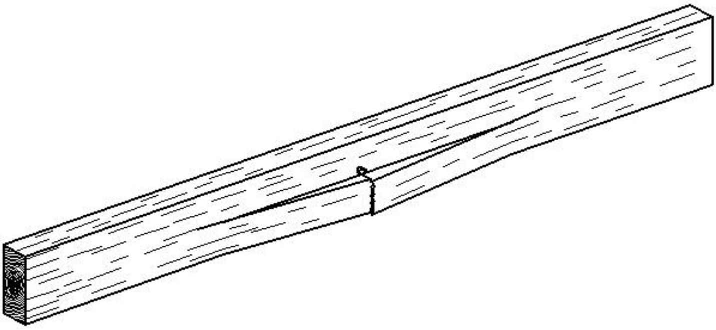
A partially broken girder will have a significantly reduced load carrying capacity and a recommendation to replace it should also be made using the Work Item feature, and in most cases, also verbally.



Sketch of a Complete Break

Complete Break

Complete Break



Sketch of a Partial Break

Partial Break

Partial Break

Decay and Crushing

The main agent of decay deterioration in Montana is fungus. Other, very minor agents would be mold, bacteria, and sunlight, but the rate of deterioration due to those agents is so slow, it is not an issue in the life span of a bridge. Other agents such as decay due to insects are rare in Montana, and marine borers do not exist here at all.

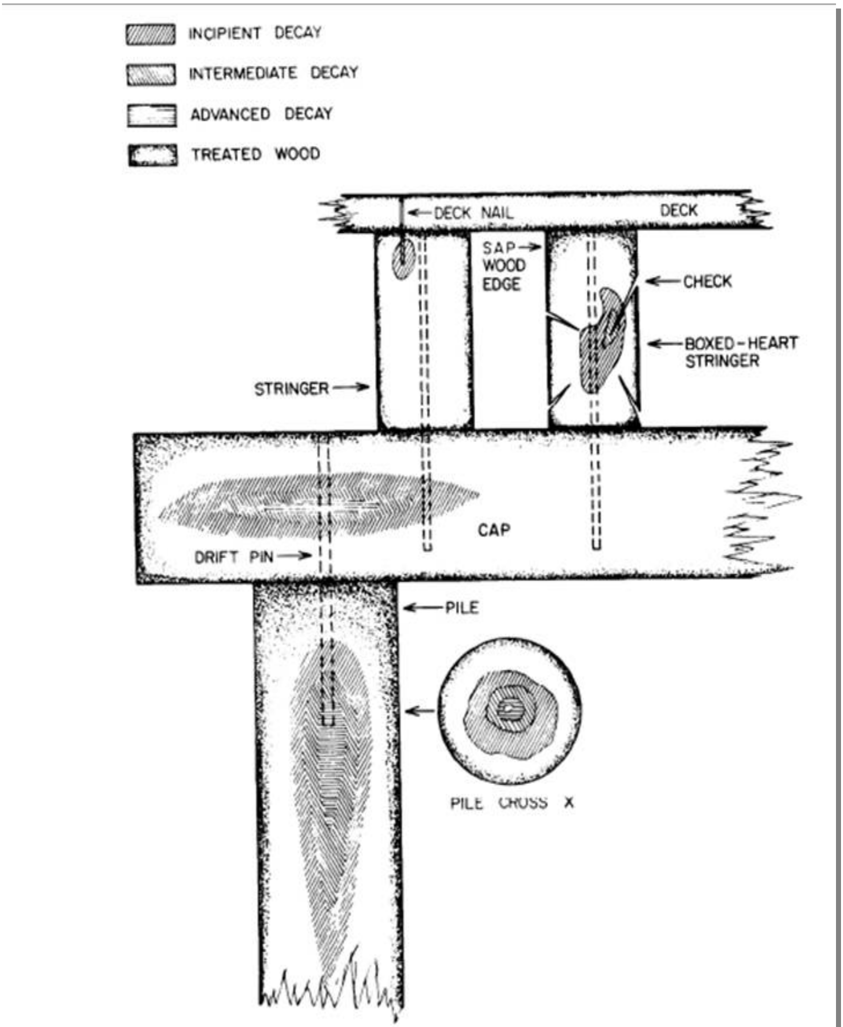
Deterioration due to decay results in a loss of strength of the member, and when enough of the cross section has deteriorated, failure of the member occurs. Crushing is the most obvious sign of severe rot.

Many of the timber bridges in Montana are constructed with pressure treated timber. However, treatment can only penetrate to a depth of ½ to 1 inch. This creates a protective, treated shell surrounding the interior, untreated portion of the member. If fungus spores get past this treated shell into the interior, rot will begin if moisture conditions are favorable.

Extent of pressure treatment penetration

Concentrate efforts to locate rot in likely areas such as where the protective shell has been penetrated by nails or bolts, or where the member has been cut, or where deep (greater than 1”) checks exist.

If timber is completely saturated or submerged, decay fungus cannot grow. So the most favorable moisture conditions are areas that hold moisture for a considerable time but are not too wet. These areas include the piles and backwalls just above the waterline and just above the ground line, areas that have material buildups such as the tops of caps and ends of girders, and timber decks that are covered with asphalt.



Likely areas to find decay

Decay can be detected by sounding the timber member with a hammer or by boring. Sounding of timber is done by tapping the timber in different locations and listening for the different tapping tone made when the timber is rotten ("hollow" or "punky" sounding tap) vs. the tone made when tapping solid timber. Boring is typically used to determine the extent of deterioration when decay is noted with sounding. Be sure to use plugs after boring a member in order to minimize new rot occurring in the borehole.

When rot is detected, it is important to find out how much of the member's cross-section is still sound so the element can be re-rated. This gives us the option to reduce the load posting before the member begins to fail.

Even after crushing is noted, it is still important to find out how much of the member's cross-section is sound. The Bridge Management Section can then re-rate the bridge or recommend replacement of the member. Eventually, almost complete failure can occur, a condition in which there is not enough cross-section remaining in the member for it to have any significant strength, such as in the following photographs on pages 26-28.

Severe crushing due to decay

Severe crushing due to decay

Failed timber pile due to decay

Failed timber pile

Severe decay in a girder

In the case of the following photos (page 29) however, the member has only partially or locally failed, and could have some strength left in the cross-section.

The extent of decay in all members should be documented and **photographed thoroughly** so that it can be properly evaluated and analyzed by the Bridge Management Section. A repair recommendation will depend on the extent of the deterioration, but if the decay is moderate, or crushing and/or bulging is moderate to severe, a recommendation to replace is usually appropriate. The Bridge Management Section can then do an evaluation and analysis to determine if the recommendation is appropriate.

Crushing due to decay

Bulging due to decay

Fire Damage

In some cases, timber can perform well in a fire. This statement is true if the duration of the fire is limited, it is not fueled by an external source, and the members are “thick” – which is typical of bridge members. Also, as timber burns, a char layer forms which insulates the inner layers of the member from the fire.

If the duration of the fire is limited, many timber bridges will survive the fire with only a small amount of section loss. After a timber bridge has been through a fire, the inspector needs to give it a thorough inspection. The char layer should be scraped off in random locations and in areas of likely maximum section loss, then the measurements of the intact cross-section of all members should be recorded. The Bridge Management Section can then re-rate the bridge with these measurements.

Burned timber members with the char layer scraped off

Timber bridge after a fire

Considerable section is left on members under the char layer

Timber Repairs

There are many types of timber member repairs out there. The most common type is the hanger clamp on timber girders along with the occasional steel splice plate girder repair. Unfortunately, these types of timber girder repairs do not restore the member to its full capacity. Most of the time, they can arrest any additional crack propagation and may even add back some of the lost capacity. However, quantifying any additional capacity that a specific hanger clamp repair will add is not practically possible because of all the different types of hanger repairs that are done throughout the state.

Because of the uncertain additional capacity that the hanger or splice plate repair adds, girders repaired with these types of repairs should be in condition state 4 if the hanger was to repair a moderate or severely cracked or broken girder. The girder can be in condition state 3 only if the hanger is to repair a minor crack or was used as a preventative repair on a split girder. It can only be in a condition state 1 or 2 if it is a preventative or unnecessary hanger repair *and* it was in condition state 1 or 2 before the repair.

The location of timber member repairs should be documented thoroughly – member location, length of repair if applicable, location of repair along member, and type of repair. Because of the many different types of hanger repairs, and to assist in evaluation and analysis for load rating, photos should be taken.

The other type of “repair” that is commonly seen is the replacement of a broken girder with a new steel or timber girder or just adding a new girder directly adjacent to the damaged one. When this situation is encountered, the old, damaged girder (if still in place) is ignored and not counted in the element quantity. The new girder should then be evaluated and placed into the appropriate condition state (hopefully condition state 1 or 2).

Steel hanger girder repair – through deck hangers with bottom plates

Steel hanger girder repair with multiple bolts

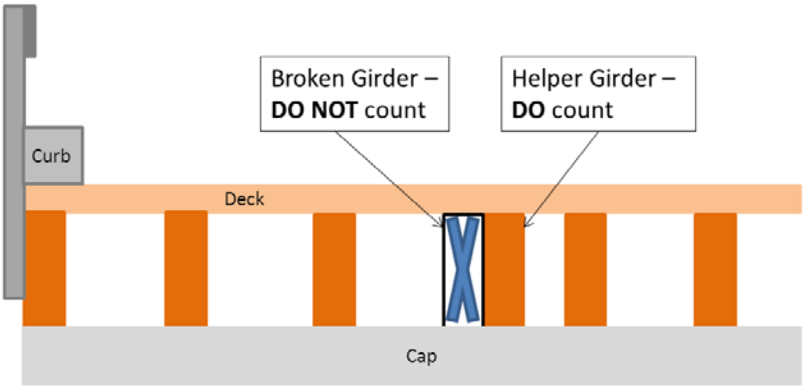
Steel hanger girder repair - single bolt and no bottom plate

Steel plate girder repair

Inspection Report Specifics

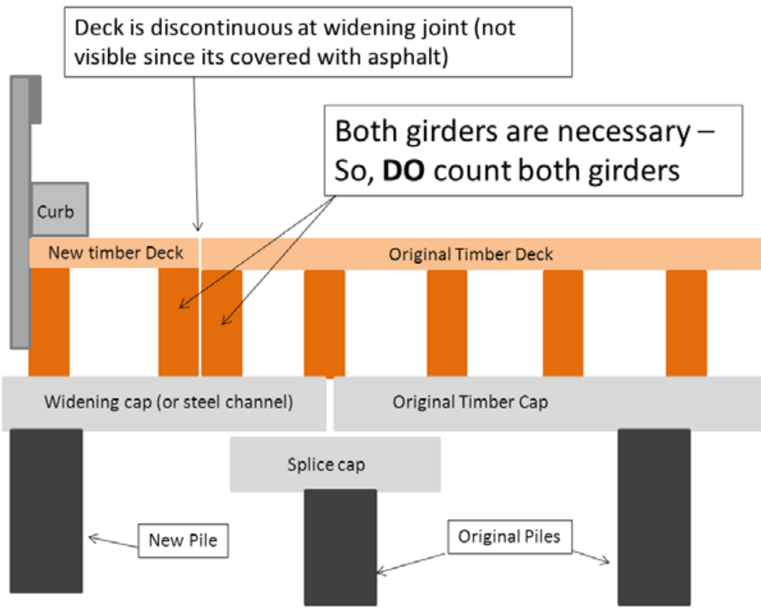
- When reporting timber deficiencies in the element comments, accurately specify (i.e. span number and beam number, bent number, pile number, etc…) which member you are describing. This information is necessary for load rating purposes.
- Take photos of all deficiencies that are noted in the element descriptions.
- For county owned timber structures, a good clear photo of the beams and caps, regardless of their condition, is very helpful to us in determining the grade of timber to use for load ratings.
- When to count and not to count doubled up girders:
    - When a broken girder has been "replaced" by a new "helper" girder, **DO NOT** count the broken girder quantity, but **DO** count the new helper girder quantity. In other words, the new helper girder replaces the broken girder in the report.
    - If the helper girder is made of steel, be sure adjust the timber quantities down and to add a steel element and quantity to the inspection report
    - Note in the element comments which beam has been "replaced", and

measure and record the new timber or steel beam dimensions and spacing on the appropriate bridge measurement form.



Broken Girder “replaced” with a “helper” girder.

- **DO** count girders that are adjacent to one another because of a widening or similar condition, where both (or more) girders are necessary to support the deck or otherwise make the structure stable.



Typical widening cross section with adjacent girders at the widening joint.

Conclusion

Because of the natural variability of timber as a material and the infinite number of conditions that can be encountered, accurately and consistently assessing the condition of timber bridge elements is difficult. Understanding the factors that affect the conditions and capacities of timber will allow you to be more accurate and consistent in your assessment. This guide is meant to help with that, but as stated in the introduction, not everything you will encounter can be covered in this guide. Using this guide while taking detailed notes, accurate measurements, and lots of photos when documenting decay and defects of timber members should enable you to give more accurate and consistent descriptions. If you are still unsure of how to describe or rate a specific timber condition, contact the Bridge Management Section.

Notes

Notes

Notes