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Repair Techniques for Metal Plated Wood Trusses

Part 1: Introduction and Simple Repair Concepts

by

Derek L. Rhodes, P.E.



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Introduction

Metal plated wood trusses are engineered products that are manufactured in a controlled environment and are now used extensively in the wood frame construction industry. Wood trusses provide the architect or building designer greater flexibility in the design of the structure than conventional framed (stick-built) construction. The design is not as limiting with regard to bearing wall locations which enables longer spans and greater ability to shape complicated roof and ceiling profiles. These pre-manufactured wood trusses facilitate a quicker construction schedule and an overall lower cost.

Wood, a renewable resource, has a great deal of manufacturing flexibility. Wood members are easily formed into standard framing sizes, cut into appropriate lengths with odd angles if necessary, and attached to form the wood structure. However, wood is more susceptible than steel or concrete to damage due to internal defects, handling issues, and long term deterioration. Design or manufacturing errors, shipping damage, miscommunication, and change orders are possible causes for the inadequacy of a wood truss for a specific application and therefore a repair or modification of the pre-manufactured wood truss is required. The purpose of this document is to address various repair techniques that could be used to correct damage to the wood members or metal plates, reinforce trusses that do not meet the required specified design loads, or adjust the truss profile or member location to meet other design requirements.

This course is the first part in a three part series which consists of a total of 11 chapters between all three parts. Chapters 1 through 3 provide an introduction to the terms, concepts, and process involved in truss repairs. Chapters 4 through 11 contain actual truss repairs to provide instruction through the use of example. These chapters are broken down as follows

- **Part 1: Introduction and Simple Repair Concepts** – Five Chapters – Current Part
 - Chapter 1 – Definitions
 - Chapter 2 – Repair Design Concepts
 - Chapter 3 – Wood Truss Repair Connections
 - Chapter 4 – Member Damage and Defects
 - Chapter 5 – Plate Damage
- **Part 2: Moderate Truss Repairs** - Four Chapters
 - Chapter 6 – Manufacturing Errors
 - Chapter 7 – Stubs and Extensions
 - Chapter 8 – Minor Modifications
 - Chapter 9 – Major Modifications
- **Part 3: Complex Truss Repairs** - Two Chapters
 - Chapter 10 – Volume Ceiling Changes
 - Chapter 11 – Girders and Truss Loading.



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The dimensions used in this document may be in feet (x'), inches (x"), or feet-inches-sixteenths (f-i-s). The repair examples will usually use feet for larger dimensions such as scab members and inches for the smaller dimensions such as Oriented Strand Board (OSB) gussets. Inches are used for all board and plate sizes (2x4, 2x6, etc.). The f-i-s units will be shown in dimension lines that run along the top and bottom of the trusses as shown on the original truss design drawing. As an example of the f-i-s notation, 10-3-8 equals 10'-3 1/2" (3.14 m) because the last one or two digits in that notation is an unreduced fraction so that 8/16" = 1/2" (13 mm). Throughout the document, a metric equivalent is provided in parenthesis for each dimension of the repair examples. The f-i-s dimensions that run along the top and bottom of the truss are not converted to reduce clutter. Some sample conversions are provided in the chart to the right. When the lumber size is converted to the metric dimensions, it will be the actual board dimensions rather than the rough dimensions. As an example, a 2x4 which has a final cut dimensions of 1 1/2" x 3 1/2" will be shown as 38 x 89 mm instead of the rough cut dimensions of 51 x 102 mm.

meter	f-i-s
1	3-03-06
2	6-06-12
3	9-10-02
4	13-01-08
5	16-04-14
6	19-08-04
7	22-11-09
8	26-02-15
9	29-06-05
10	32-09-11
15	49-02-09
20	65-07-06

When forces are given in this course, tension forces will have a positive value and compressive forces will be negative.



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Chapter 1 - Definitions

The following is a list of terms commonly used in the metal plated wood truss industry:

General Definitions

<p>Truss: An assemblage of structural elements usually shaped into triangles for the purpose of carrying a load over a certain span.</p>
<p>Truss Plate: A galvanized steel plate that has been punched in such a way as to form sharp teeth that can be embedded in wood to connect the structural members and provide rigidity. The most common truss plate thickness is 20 gauge steel (0.91 mm), however 18 (1.21 mm) and 16 (1.52 mm) gauge truss plates are also available.</p>
<p>Metal Plated Wood Truss: An assemblage of wood structural members usually connected in the shape of triangles using steel truss plates and manufactured in a controlled factory setting.</p>
<p>Pitch or Slope: An expression of the angle of the outside members of a truss to define either the roof or ceiling profile. Usually, the pitch is given in terms of the number of inches of vertical rise in a 12" (0.30m) horizontal run.</p>
<p>Gable End: An area of the roof system where a vertical wall projection extends to meet the roof planes defined from adjacent walls.</p>
<p>Hip End: An area of the roof where the roof planes begin at the top of each wall.</p>
<p>Bearing: The structural support for the truss such as a structural wall, beam, or another truss. The truss may be on top of the structural support or connect to the support using a mechanical connection such a steel hanger.</p>
<p>Span: The distance between bearings. When the truss has only two bearing points, the span would be the outside distance between the bearings and often matches or is close to the overall length of the truss.</p>



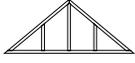
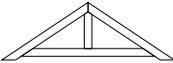
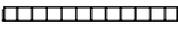
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Truss Types

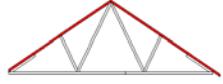
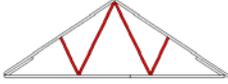
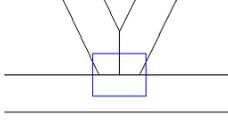
<p>Roof Truss: A wood truss assembled with nominal 2x lumber in the edgewise orientation so that the thickness of the truss is 1 ½” (38 mm).</p>	
<p>Floor Truss: A wood truss assembled with nominal 2x4 lumber in the flatwise orientation so that the thickness of the truss is 3 ½” (89 mm).</p>	
<p>Attic Frame or Attic Truss: An assemblage of wood members that follow the roof and ceiling profile while leaving a large rectangular opening near the middle of the truss for the purposes of framing a room. An attic frame is not technically a truss because it is not triangulated, but because an attic frame is built in the same factory, with the same material, and with the same design considerations as a wood truss, the word truss is commonly associated with an attic frame.</p>	
<p>Common Truss: A symmetric or nearly symmetric triangular shaped wood truss.</p>	
<p>Mono Truss: A roof truss that takes the shape of a right triangle, usually half or less the size of a common truss.</p>	
<p>Girder Truss: A truss that supports other framing members such as other trusses, beams, or conventional framing. A girder truss usually consists of larger lumber sizes and multiple individual trusses or plies connected together to form a single structural unit.</p>	
<p>Hip Truss: A roof truss with a flat region on the top to be used in a hip end.</p>	
<p>Hip Girder Truss: A hip truss that supports other framing members to complete the framing of a hip end.</p>	
<p>Jack Truss: A short mono truss, usually 8’ in length or less and set perpendicular to the hip girder truss.</p>	
<p>Gable Truss: An assemblage of members that is usually placed on top of a wall at the end of a run of trusses and matches the profile of the adjacent truss. Instead of forming triangles, the inside members, called studs, are in a vertical and/or horizontal orientation.</p>	



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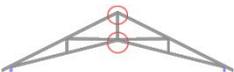
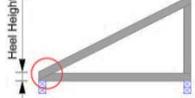
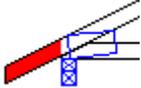
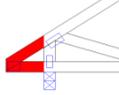
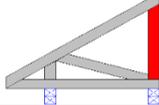
<p>Structural Gable Truss: A truss that is a combination of a roof truss and a gable truss. The structural gable truss is usually partially supported by a parallel wall.</p>	
<p>Valley Truss: A truss similar to a gable truss but that is supported by other trusses or framing members below and is usually set perpendicular to the supporting truss. A valley truss is used to complete over-framing.</p>	
<p>Piggy-Back or Cap Truss: When a roof truss is too tall to ship, the truss is modified to have a flat region on top so it is just like a hip truss, and a shorter truss called a piggy-back is designed to fit on top of the base truss to complete the shape.</p>	
<p>Floor ladder or Knee-wall: A truss similar to a roof gable truss but it is built on the floor table in the flatwise orientation with vertical stud members in the middle.</p>	

Truss Term Definitions

<p>Top Chord: The top most members that define the roof or floor profile. The top chord members are usually continuous from one end of the truss to the other end.</p>	
<p>Bottom Chord: The bottom most members that define the lower or ceiling profile. The bottom chord members are usually continuous from one end of the truss to the other.</p>	
<p>Webs: The interior members of the truss that are used to form triangles and provide intermediate structural support for the top and bottom chords.</p>	
<p>Joint or Panel Point: A location where wood members are joined by a pair of truss plates.</p>	
<p>Panel: The region between two joints.</p>	



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<p>Splice: A joint where two top chord or two bottom chord members are joined. A splice is needed when the length of the truss is longer than available dimensional lumber. The splice may occur at the same locations as web members or out in the panel away from webs.</p>	
<p>Peak: The highest point on either the top chord or bottom chord profile.</p>	
<p>Heel: The joint or joints at the end of the truss.</p>	
<p>Overhang: The region or distance where a top chord member extends beyond the bottom chord at the end of the truss. This region or a portion thereof can be removed from the truss during erection if necessary.</p>	
<p>Cantilever: The region or distance the bottom chord extends beyond the bearing point. The top chord usually extends to the end of the bottom chord.</p>	
<p>End Vertical: The end vertical member used to connect the top chord to the bottom chord on tall heels.</p>	
<p>Chase: A rectangular opening in a floor truss for the purpose of allowing the passage of HVAC duct work or other utility runs.</p>	



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Repair Terms

<p>Scab: A member applied to the side of a wood member.</p>
<p>Clinched Nail: On certain repairs, the nail is intentionally selected longer than the thickness of the combined wood members. The protruding portion of the nail can be bent over or clinched allowing for a Double Shear connection.</p>
<p>Scab Truss: A pre-fabricated truss applied to a side of an existing truss. The scab truss usually does not go the full length of the original truss.</p>
<p>Spider Truss: A spider truss is a truss that is pre-fabricated in at least two sections. Each section is attached to the existing truss similar to a scab truss and the sections are joined together with a field splice. The spider truss effectively replaces the structural function of the original truss.</p>
<p>OSB: Oriented Strand Board is a manufactured wood sheet product similar to plywood.</p>
<p>OSB Gusset: OSB has better structural values than most commonly available plywood and will be specified as the wood sheet product of choice to replace the metal truss plates.</p>



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Chapter 2 – Repair Design Concepts

A key decision for the repair designer is whether to replace the original truss or repair it. The photograph to the right shows a situation where a series of attic trusses fell during erection due to inadequate bracing. It is generally accepted practice within the wood truss industry to replace any trusses involved in a collapse. Beyond the collapse situations, the question of whether to replace the truss or not should be evaluated on a case by case basis with considerations for the structural integrity of the remaining truss, the

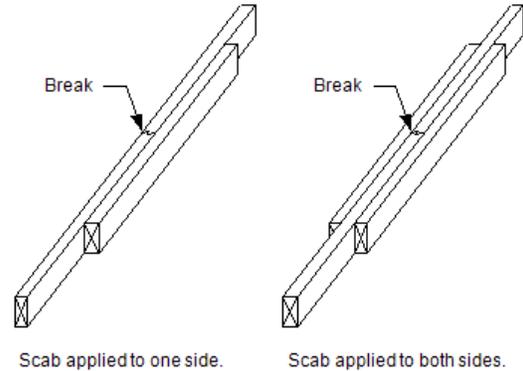


phase of construction, the schedule, and the cost of various options. In many cases the stage of construction makes replacing the truss very impracticable. The open web design of wood trusses allows many different utilities to pass through the trusses. Once the roof or floor sheathing and utilities are installed, it is often more cost effective to repair the existing truss rather than to replace it. However, sometimes the structural requirements of the situation mandate that the truss be replaced even at substantial cost. A spider truss repair can sometimes be an effective way to replace a truss without disrupting the sheathing connection, but usually the utilities still have to be removed prior to installation.

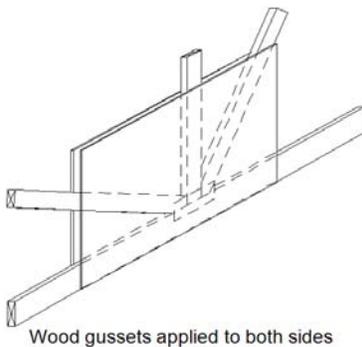
Once the decision to repair the truss is made, an evaluation is then made as to whether the repair is to be applied to one or both faces of the truss. Eccentricity develops when the structural reinforcement is only applied to one side. However, the advantages for a one-sided repair include lower cost and ease of installation. Installation tolerances found in the Building Component Safety Information (BCSI-2013) allow the truss to be set up to $D/80$ out of plumb or a horizontal bow of $L/200$ with neither exceeding 2" (51mm) where D is the vertical depth of the truss at a given location and L is the horizontal length of the truss. The maximum of 2" (51mm) would govern for any truss over 8' (2.4m) tall or approximately 32' (9.8m) long. Therefore, as long as the eccentricity that develops by the application of the repair to one face does not exceed the installation tolerances and the connections are adequately designed, then the one-sided repair would be acceptable. In practice, the application of the repair to one or both faces is determined more by the accessibility of both faces or the preference of the repair designer than by the consideration of eccentricity. This document will use a two-sided repair as the default whenever possible and a one-sided repair when one face is not accessible.

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The scab is a very useful concept in truss repair design and provides the basis for many basic as well as complicated truss repairs. The diagrams to the right show both single and dual scabs applied to a broken truss member where the break is away from the joint. The length of the scab member is usually determined by either a minimum size that the repair designer specifies or the development length of the required connection.

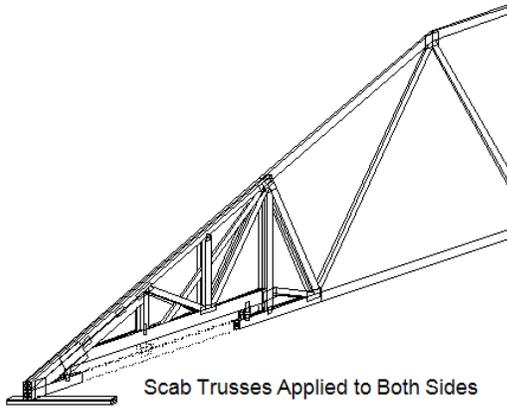


The wood gusset is often useful for truss repairs. A wood gusset is a wood sheet product such as plywood or Oriented Strand Board (OSB) that is cut to the necessary shape and applied to one or both faces of the truss. The diagram to the left shows a roof truss joint with wood gussets applied to both sides. OSB has higher strength values than commonly available plywood and therefore, OSB will be specified in this course whenever a wood gusset is the best option for the truss repair.



OSB is available in various thicknesses. The repair examples in this document will use 7/16" (11 mm) OSB gussets for most roof truss repairs to allow the clinching of the nails. This clinching of the nails will be discussed in greater detail in the next chapter. The floor truss repair examples will use 23/32" (18 mm) OSB gussets to take greater advantage of the extra rigidity found in the larger thickness. Both OSB and plywood are commonly available in 4' x 8' (1.2 m x 2.4 m) sheets. On rare occasions the 4' x 8' (1.2m x 2.4m) sheets are not large enough to develop the required connections in all directions. Larger wood sheets are available or can be special-ordered, but it may be more cost effective to fabricate a scab truss rather than utilize oversize gusset sheets.

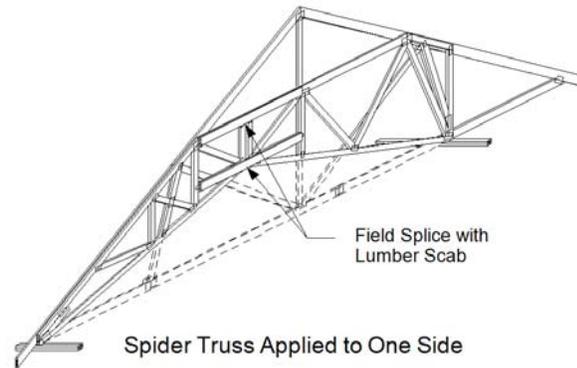
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The scab truss is a useful repair technique when the repair encompasses a larger area than the OSB gusset can cover or the development length for the connection for some of the truss members is too long to be able to specify OSB. The scab truss is designed to work with the remaining part of the original truss to complete the structural functionality of the truss. The scab truss is generally used for volume ceiling changes that affect approximately half or less of the truss span. The figure shows a scab truss attached to both faces of the original truss. Some of the webs of

the scab truss are designed to line up with the webs in the original truss while others do not. The dashed lines represent the part of the original truss that is to be removed to form the box ceiling detail.

The spider truss is similar to the scab truss except that the spider truss is designed to almost completely replace the structural functionality of the original truss and usually needs to span from one bearing to another. The spider truss is usually designed in at least two parts for ease of installation. The parts of the spider truss are erected next to and attached to the original truss. A field splice connection would then be applied to complete the truss installation, sometimes using the remaining portion of the original truss as part of the field splice connection. Examples of truss repairs using scab and spider truss designs will be provided in part 3 of this course series. (The distinction is made in this course between scab and spider truss for instructional purposes. In practice, the term scab truss may apply to both design practices.)



A key step in the preparation of a truss repair is the gathering of appropriate information for the repair designer which would include at a minimum the following:

- A fax or electronic file of the truss design drawing showing the location and extent of the damage or modification with detailed measurements.
- Notes describing the reason/cause for the modification/repair and any limitations to doing the repair such as access to the truss and existing utilities.
- Photographs
- Project information including Builder, Subdivision, and Lot or street address.



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- Contact information for the parties involved including someone near the job site who can actually look at the situation if needed.

Although it would be desirable for the repair designer to visit the job site and gather the information first hand. In most cases that is logistically not practical due to the distance of the job site from the design/fabrication plant. So, the repair designer must rely on information provided by others.

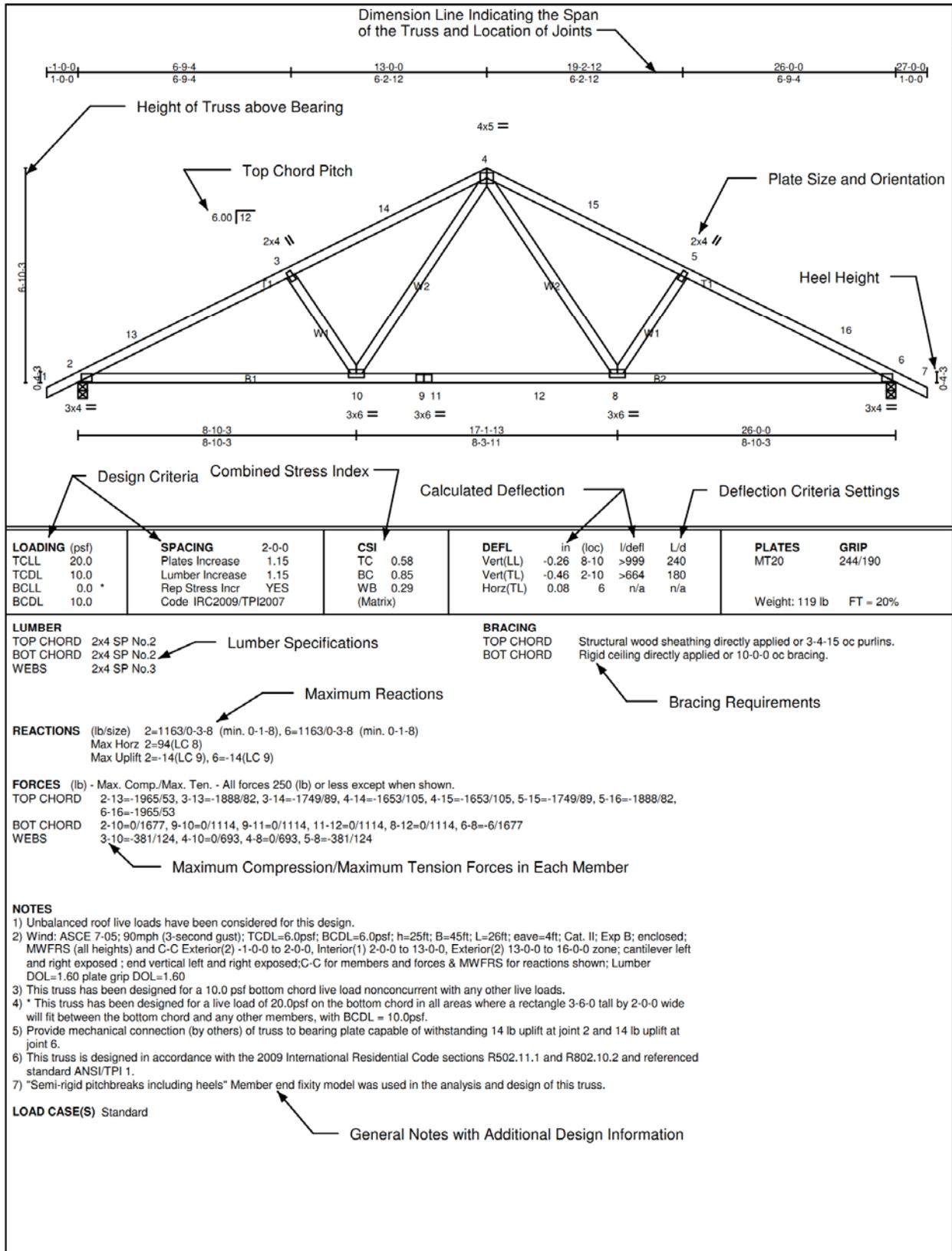
Experience has shown that photographs may be extremely useful if provided in conjunction with a neatly marked-up truss design drawings. It is sometimes difficult to get good photographs due to the proximity of other trusses and framing members or inadequate zooming. Photographs are great as a supplement to the truss design drawing, but should not be relied on as the sole source of repair information.

The TPI 1-2014 requires that all truss design drawings provide certain minimum information such as design criteria, dimensions to joints, lumber size and grade, combined stress index (CSI), deflection criteria, truss plate size/gauge, truss reactions, and maximum compression/tension forces. The CSI number shows the maximum stress index for each category of material and represents a ratio of the calculated to the allowable stress. A CSI over 1.00 would be considered failing. It is often useful to know how much extra stress a member can take when designing the repair. Truss fabricators are required to provide the truss design drawings with each shipment, so, they should be readily accessible at the job site. The figure on the following page shows an example of a truss design drawing with the most critical information highlighted.

If a truss design drawing is not available then the truss can be modeled by inputting the truss into an appropriate truss software package (and there are several such packages available on the internet) or by modeling the truss through hand calculations. Either option would require a significant investigation of the truss to determine the span, member sizes and grades, joint locations, and any special loading conditions that may be present. If using hand calculations, keep in mind that modern software packages have certain capabilities to adjust the rigidity of the joints such that the traditional truss model that would be presented in a Statics course where each joint is pinned and all forces are applied at those pinned joints would be inadequate to properly size members and connectors. In general, that traditional truss model will create higher forces and moments in the members than modern software packages but will not be able to model the moments at the joints. So, caution should be used when determining the forces through hand calculations alone.



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Chapter 3 – Wood Truss Repair Connections

The repair connections are often the limiting factor in repair design. The required development length for the connection will determine the size of the members involved and to some extent the style of the repair. The most common connector used in the industry and this series of courses is the 3” (76 mm) long 10d nail. The 10d comes in different thicknesses including the 10d box nail which has a thickness of 0.128” (3.25 mm), the 10d common nail which has a thickness of 0.148” (3.77 mm), and the standard 10d gun nail with a thickness of 0.131” (3.33 mm). Any of these selections could be used where the 10d nail is specified. There is also a 10d Sinker nail with dimensions of 0.121” x 2 7/8” (3.06 mm x 73 mm), but the 10d Sinker should not be used where a 10d nail is specified because of its reduced dimensions. The following chart shows the shear capacity for various combinations of applications, main member lumber types, side member lumber types and sizes, and Single or Double Shear for the standard 10d gun nail.

Type	Main Member Lumber Type	Side Member Lumber Type					English Units				Metric Units			
			Specific Gravity main - G _m	Specific Gravity side - G _s	Single or Double shear	DOL (Duration of Load)	Diameter D - in.	Length in main - L _m - in.	Length in side - L _s - in.	Connection Capacity (Z) - lbs	Diameter D - mm	Length in main - L _m - mm	Length in side - L _s - mm	Connection Capacity (Z) - N
Roof	SP	SP	0.55	0.55	Single	1.15	0.131	1.50	1.50	122	3.33	38.1	38.1	542
Roof	SP	SPF	0.55	0.42	Single	1.15	0.131	1.50	1.50	106	3.33	38.1	38.1	471
Roof	SPF	SPF	0.42	0.42	Single	1.15	0.131	1.50	1.50	95	3.33	38.1	38.1	423
Roof	SP	7/16" OSB	0.55	0.50	Single	1.15	0.131	1.50	0.44	87	3.33	38.1	11.1	385
Roof	SP	7/16" OSB	0.55	0.50	Double	1.15	0.131	1.50	0.44	173	3.33	38.1	11.1	771
Roof	SP	3/4" OSB	0.55	0.50	Single	1.15	0.131	1.50	0.72	105	3.33	38.1	18.3	465
Floor	SP	SP	0.55	0.55	Single	1.00	0.131	1.50	1.50	106	3.33	38.1	38.1	471
Floor	SP	SPF	0.55	0.42	Single	1.00	0.131	1.50	1.50	92	3.33	38.1	38.1	410
Floor	SP	7/16" OSB	0.55	0.50	Single	1.00	0.131	2.56	0.44	75	3.33	65.1	11.1	335
Floor	SP	3/4" OSB	0.55	0.50	Single	1.00	0.131	2.28	0.72	91	3.33	57.9	18.3	404

Table 3-1 Allowable Shear Capacity for the 10d gun nail.

The above shear values were calculated using the Yield Limit State Equations from the 2015 National Design Specification for Wood Frame Construction (NDS-2015). The NDS-2015 also has tables listing the shear design values for the 10d Box nail, the 10d Common nail, and many other connectors for multiple wood species and thicknesses.

The above table lists only the wood size, species, and DOL combinations that will be used in the repair examples in this document. There are numerous other possible combinations depending on different markets and conditions. The lumber used in the repair examples will be limited to Southern Pine (SP), Spruce-Pine-Fir (SPF), and Oriented Strand Board (OSB). Other markets may have different lumber types readily available, and the repair designer should take that into account in the repair design. It is important to note that a change in materials or change in nail diameter can have a substantial effect on the shear capacity of the nail.



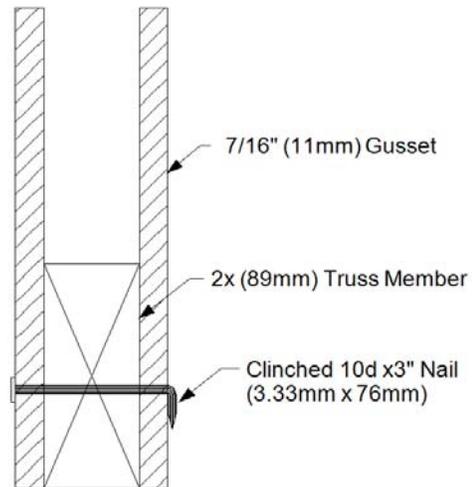
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Another important item to consider is the Duration of Load (DOL). The NDS-2015 allows a DOL increase in the strength considerations of wood connections based on the anticipated time of loading as follows:

- Floors – 1.00
- Snow – 1.15
- Construction – 1.25
- Wind – 1.60

The DOL can have a substantial effect on the allowable shear capacity of a nail. The same nail into the same size and lumber species will have a 60% higher allowable shear capacity if applied to a roof system in a high wind zone than if it were installed in a floor system. This means that the repair designer needs to take into account not only the size and species of the lumber used but also the final application of the repair. The repair examples in this document will only use the 1.00 DOL for floor systems and the 1.15 DOL for roof systems.

It should be noted there is one entry in the table that shows a Double Shear connection. This entry is the 1.5" (38 mm) SP main member with 7/16" (11 mm) OSB side members. In this case, if the 7/16" (11 mm) OSB is applied to both sides of a roof truss then the total thickness would be approximately 2 1/2" (63 mm). The 10d nail is 3" (76 mm) long, so the nail would extend approximately 1/2" (13 mm) beyond the wood members allowing the nail to be bent over, or clinched, producing a double shear connection and greatly increasing the allowable shear capacity of the nail.



The spacing of the nails is the next issue requiring consideration. The NDS-2015 has various requirements for minimum edge and end distances and a minimum spacing of connectors between rows and within rows. These minimum distances are in the range of 4D to 7D where D is the diameter of the connectors. For the thickest of the 10d nails, the 10d Common, 7D is 1.036" (26.3 mm). Even though that is the smallest allowable spacing according to the NDS-2015, practically the limits are significantly greater due to the tendency for the wood to split with nails that are too close together or to the edge or end of the board. The recommended minimum specified nail spacing for roof truss repairs is 3" (76 mm) on-center (o.c). The repair examples to follow will usually specify the 10d nails to be spaced at 3" (76 mm) o.c. for roof truss repairs. The roof truss examples shown will specify 1 row of nails in a 2x4 (38 x 89 mm) member, 2 rows in a 2x6 (38 x 140 mm) member, 3 rows in a 2x8 (38 x 184 mm) member, and 4 rows in 2x10 (38 x 235 mm) and larger members. However, for floor truss repairs, the examples will usually specify one row of 10d nails at 4" (107 mm) o.c into each member covered. The larger spacing is to reduce the probability of splitting since the nail is going into the narrow face of the floor truss member.



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When the allowable shear capacity of a nailed connection is not sufficient to meet the required loads, larger nails or screws may be specified. Various hangers and special connectors will also be specified.



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Chapter 4 – Member Damage and Defects

Truss repairs that fall into the category of Member Damage and Defects are usually the easiest to deal with, but these repairs build a strong foundation for the more complicated repairs. These trusses require repairs because the wood members have either a natural defect such as a knot, wane, or a split or are damaged during the manufacture, transportation, or erection of the trusses. There are several standard repair details available in the industry for this type of repair which are usually shown in a table listing various lumber species/sizes and the capacity of the connection for various length scabs

To calculate the capacity of a given scab, a repair designer would calculate the number of nails that would be applied between the break or damaged area and the end of the scab with an appropriate end distance. The NDS requires a minimum of 4 diameters end distance for connectors. For a 10d nail, that is a little over ½” (13 mm). In practice, the minimum end distance should be greater. The examples in this course will add one space to the number of required nails to account for the end distance and allows for a little uncertainty in the extent of the damage. As an example, a 4’ (1.22 m) long SPF scab applied to one side of a roof truss member with 1 row of nails 3” (76 mm) o.c. would have 8 spaces and 7 nails between the break or damaged area and the end of the scab. This assumes that the scab is centered on the break, and the break is nearly perpendicular to the long dimension of the wood member. Referring back to Table 3-1, each nail would have a capacity of 106 lbs (0.47 kN) for a total allowable connection capacity of 742 lbs (3.30 kN). If the scabs are placed on both sides, the allowable capacity would double to 1,484 lbs (6.60 kN).

The remainder of this chapter and the chapters that follow will show some example truss repairs. Each example will have a statement of the problem, a drawing showing the repair, and a discussion of the solution. The circled number on each drawing corresponds to the repair notes and the sequence generally reflects the order the repair steps are to be accomplished. The maximum compression (-) and tension (+) forces for the affected members are shown for the purpose of instruction, but are not usually shown on final repair drawings.



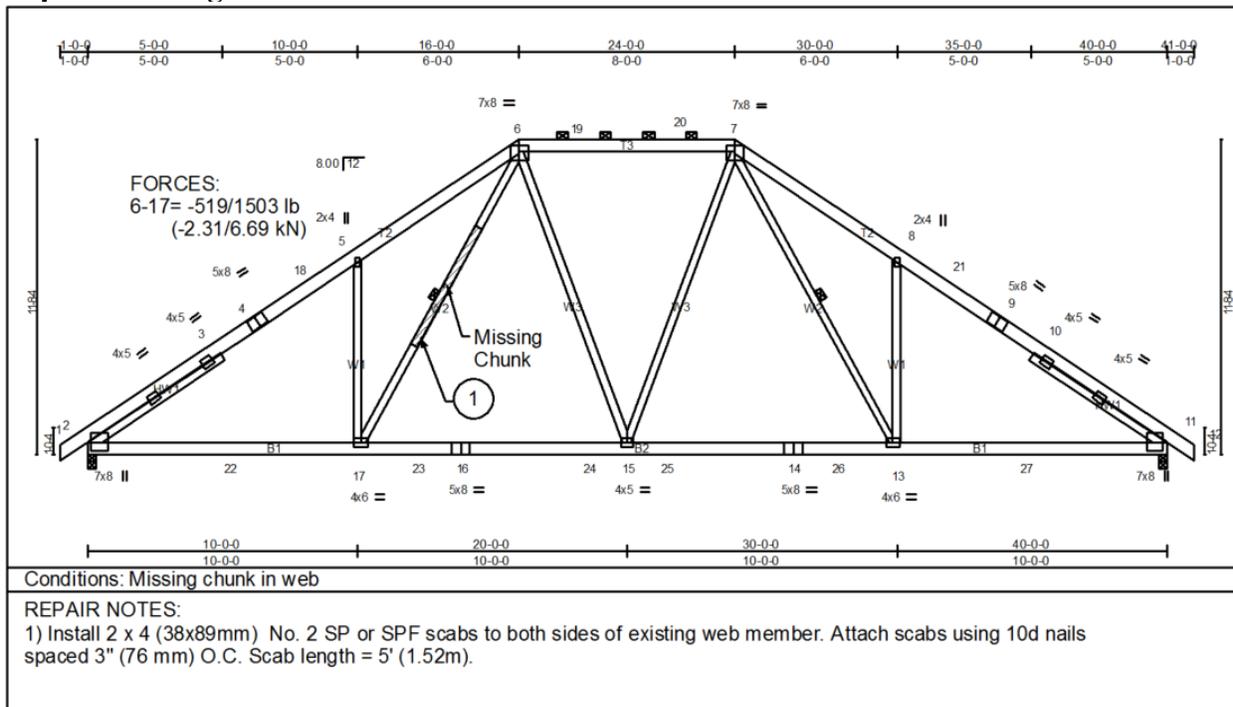
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Example 4-1 Simple Web Break/Damage

Problem

The web, W2, between joints 6 and 17 is damaged near the middle of the member.

Repair Drawing



Discussion

In the market where this truss was fabricated, SP (Southern Pine), lumber is used for the trusses, but SPF (Spruce-Pine-Fur) is more readily available at the jobsites in the geographic region, and so even though nails in SPF lumber have a slightly less shear capacity, SP or SPF are specified whenever possible. The maximum compression force in the damaged web member is 519 lbs (2.31 kN) and the maximum tension force is 1503 lbs (6.69 kN). From Table 3-1, the shear capacity of each 10d nail in SPF lumber for a roof application is 106 lbs (0.47 kN). Therefore 15 nails with 16 spaces would be required on each end of the break. With the nails spaced at 3" (76 mm) o.c. the total required scab length would be 8' (2.44 m) for a one sided repair or 4' (1.22 m) for a two sided repair. To allow for some tolerance in the application of the repair and to account for the possibility that the length of the damaged region may be as much as 12" (0.30 m), 5' (1.52 m) scabs were applied to both sides of the web member. Experience has shown that it is good to allow for some tolerance or rounding up of the member lengths due to the inherent uncertainty in wood construction.



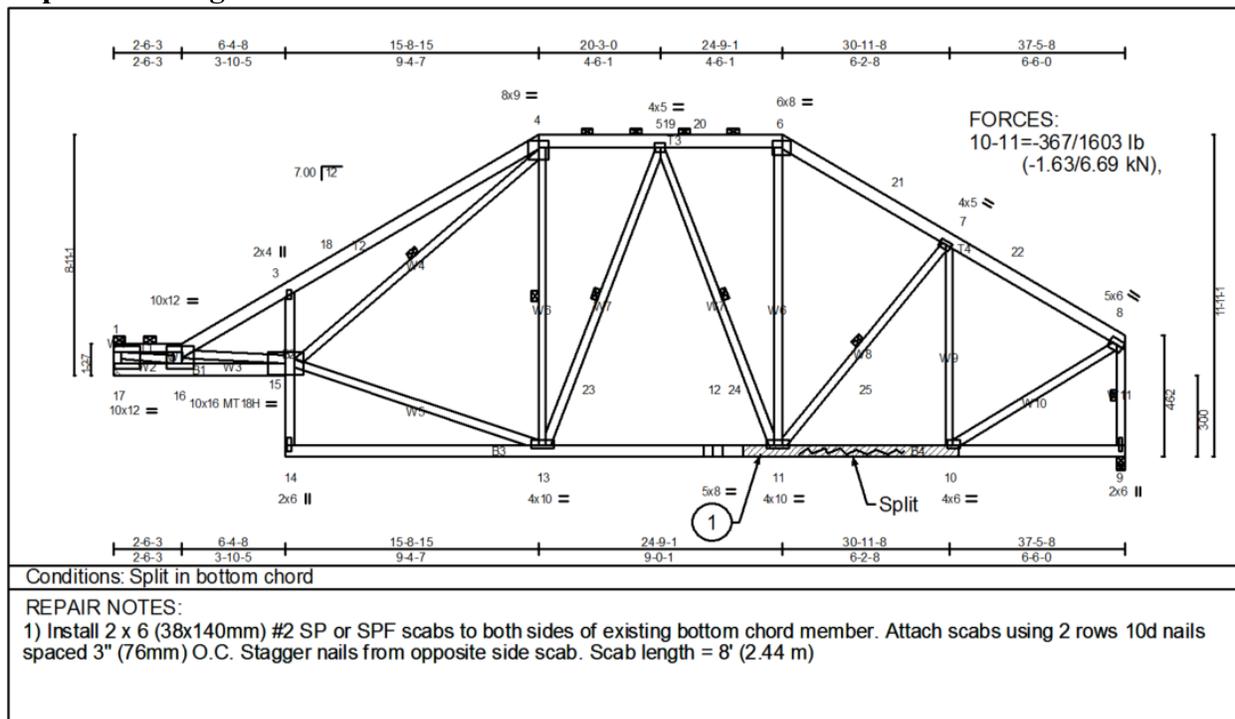
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Example 4-2 Long Split in the Bottom Chord

Problem

The bottom chord member between joints 10 and 11 has a horizontal split that is approximately 4' (1.22 m) long.

Repair Drawing



Discussion

This repair is very similar to example 4-1 except for the length of the damage and the member size. The controlling force in the affected member is the maximum tension force of 1603 lbs (7.13 kN). From Table 3-1, the shear capacity of each 10d nail is 106 lbs (0.47 kN). Therefore 16 nails would be required beyond the extent of the split at both ends. Two rows of nails were used for the 2x6 (38x140 mm) bottom chord member. With the nails spaced at 3" (76 mm) o.c. in each row, 8 nails with 9 spaces or 27" (686 mm) of development length would be required beyond the split for a one sided scab repair yielding a minimum scab length of 8.5' (2.59 m). For a two sided repair, 4 nails with 5 spaces or 15" (381 mm) would be required beyond the split, yielding a total length of 6.5' (1.92 m). An 8' (2.44 m) long two sided 2x6 (38x140 mm) scab was chosen for this example due to potential uncertainty as to the actual length of the split.



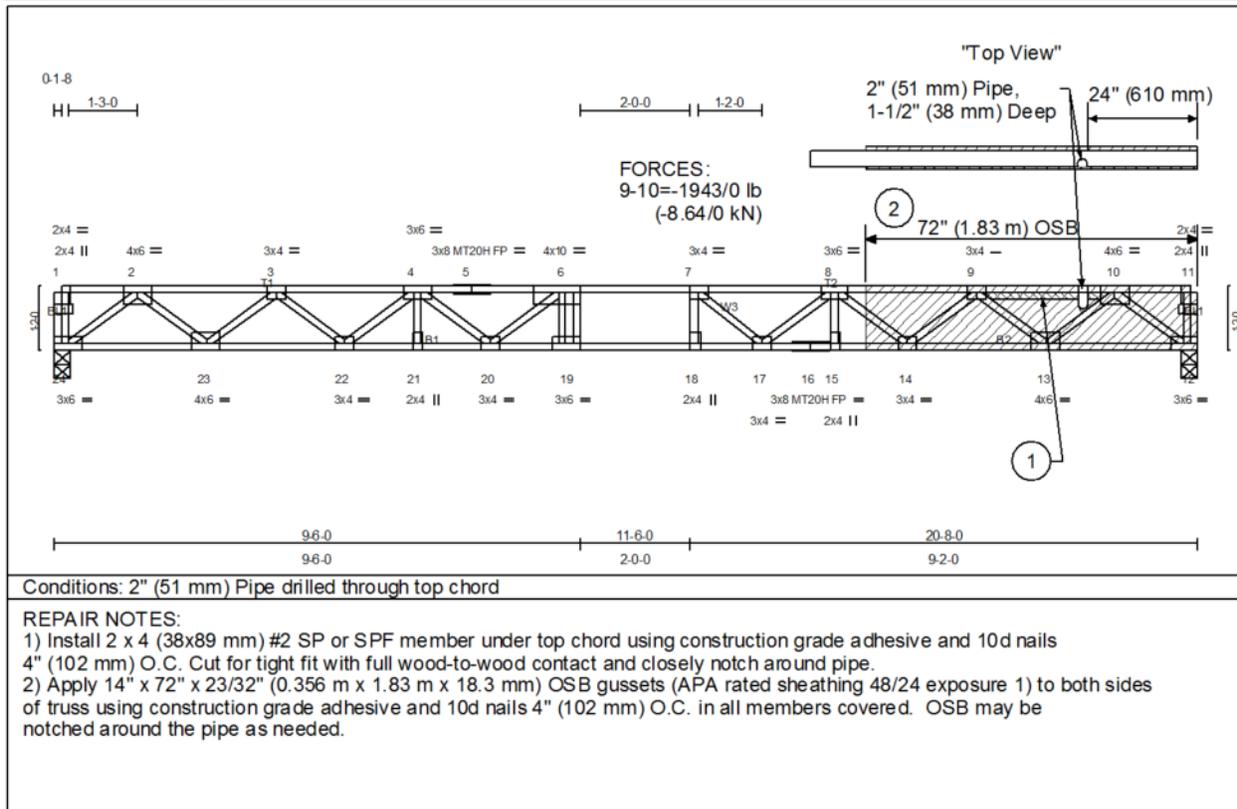
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Example 4-3 Damaged Top Chord of a Floor Truss

Problem

A notch for a pipe was cut into the top chord member between joints 9 and 10.

Repair Drawing



Discussion

The repair must be designed around the pipe that needs to remain in place. The controlling force in the damaged member is the compressive force of -1943 lb (-8.64 kN). According to Table 3-1, the shear capacity of a 10d nail in a floor application using an OSB gusset is 91 lb (0.40 kN). With the nails spaced at 4" (102 mm) o.c. and the OSB gussets applied to both sides, the required development length beyond the damage is 44" (1.12 m). Since the damaged area is only 24" (0.61 m) from the end of the truss, the required development length can only be achieved to the left of the pipe notch. A block was added under the top chord member to augment the development length. It is standard practice to make gussets the full depth when applying OSB gussets to floor trusses because the perimeter nailing makes the combination of the truss and OSB into a box beam with increased stiffness and improved performance. The 24" development length on the right side was deemed sufficient considering the increased stiffness of the box beam, the reinforcing block, the web nailing, and the fact that less than half of the width of the top chord was damaged.



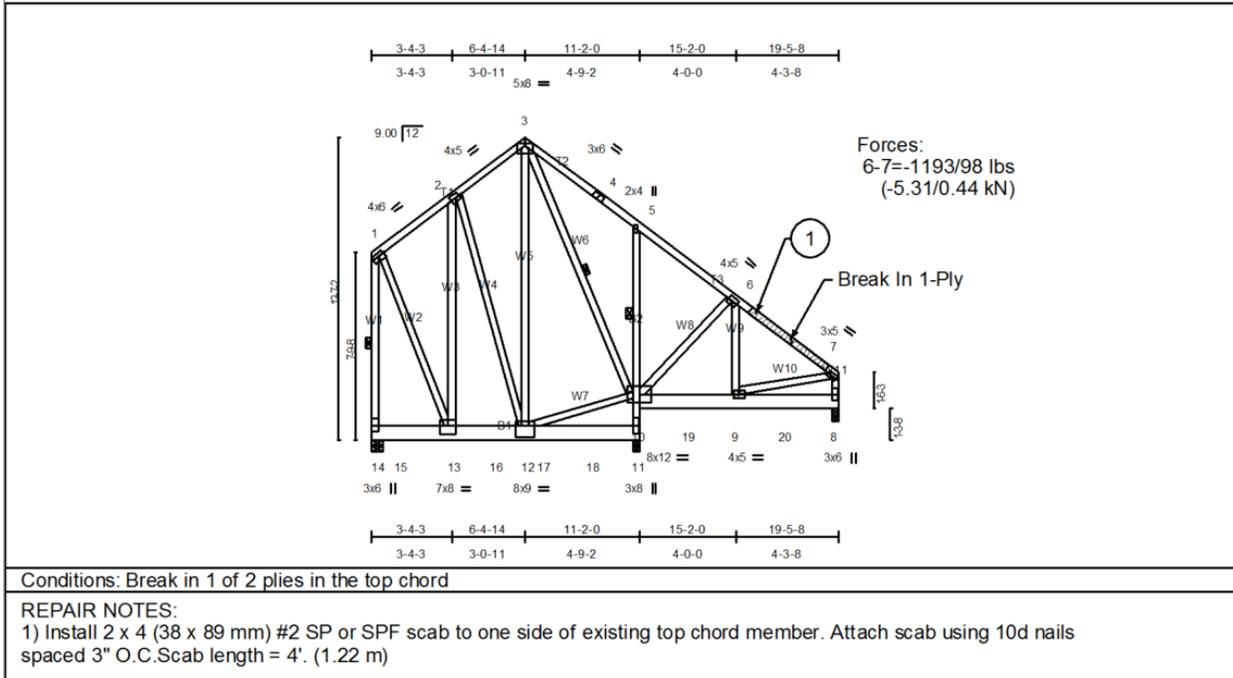
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Example 4-4 Break in a Multi-ply Truss

Problem

One ply of a 2-ply girder truss has a break in the top chord member.

Repair Drawing



Discussion

The presence of an interior bearing in the truss causes the forces in the damaged member to be relatively small for a girder truss. A one ply member would be sufficient to carry the load for that one panel, so technically no repair would be needed. However, a broken member, especially on a girder, is easily noticeable and would cause concern to most people. Therefore, the appropriate course of action is to apply a minimal repair to the member to remove future concerns, and a one sided lumber scab was chosen.



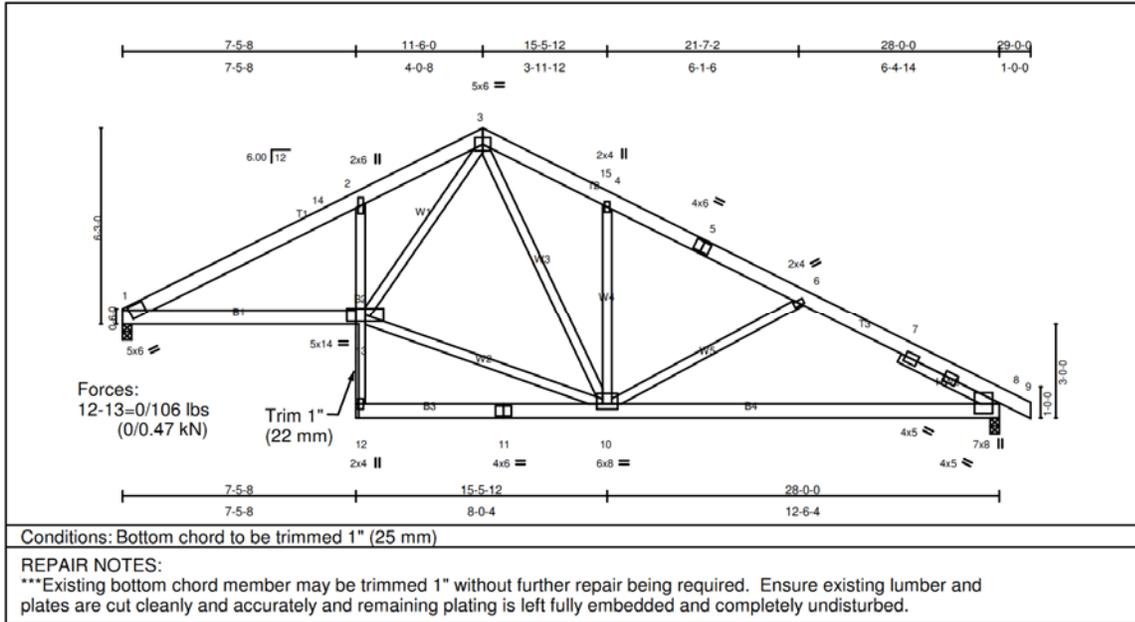
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Example 4-5 Shift Step-up for Raised Ceiling

Problem

Truss member at step-up does not line up with the wall below.

Repair Drawing



Discussion

This type of repair is common when different ceiling heights are present due to the nature of wood construction. Fortunately, the vertical bottom chord member below the raised ceiling has a tension force of only 106 lbs (0.47 kN). The repair is simply to trim the member because in this situation and other similar repairs, the vertical piece can usually be completely removed without adversely affecting the truss. If the raised ceiling step-up needed to shift to the point where the W2 web needed cutting, a much more substantial repair would be required because that member usually has a high tension force.



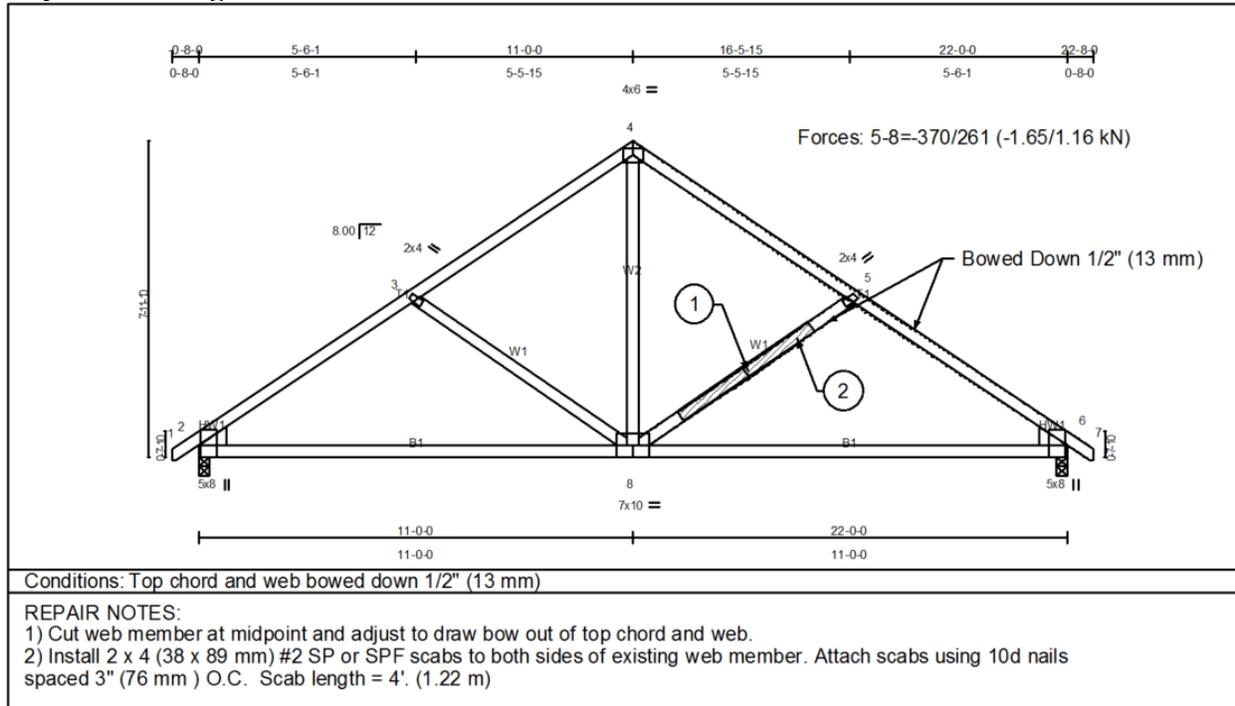
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Example 4-6 Bowed Down Top Chord

Problem

Top chord of truss bowed and the roof sheathing is already attached.

Repair Drawing



Discussion

The first thought for a situation like this would be to scab a new member on the side of the top chord member, but with the sheathing already attached, that connection would need to be severed in order to apply a scab to correct the bow. A better solution is actually to cut the web, push the top chord to the desired position, and repair the web. Before the cut is to be made, consideration should be given to see if temporary support is needed for the truss and what method should be used to push the top chord out to the desired position. This is a fairly small truss and so a temporary support would be useful to provide something firm to push against, but it would not be required. Since the bow is relatively small, the pushing force could be accomplished by applying shims at the cut in the web member. Also, the location of the cut is important. The easiest repair technique is the application of lumber scabs. In order for the scabs to work, the cut has to be far enough away from the joint to develop the connection, and so the midpoint of the web was chosen as the location for the cut.

This repair concept can be used to correct a bowed bottom chord as well. In the truss shown, if joint 8 was bowed down, all three webs would need to be cut in order to shift the joint. So, a prime consideration for this type of repair is the number of webs coming into a joint.



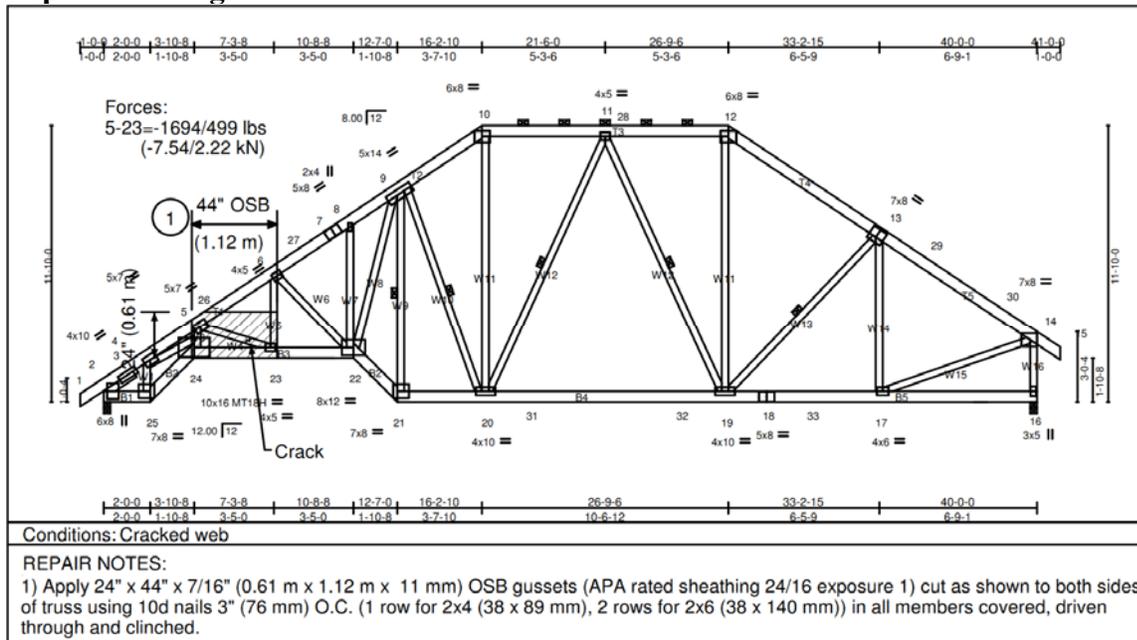
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Example 4-7 Break in a Relatively Short Web

Problem

A web is broken, but the length of the member is too short to develop the connection for a lumber scab.

Repair Drawing



Discussion

From Table 3-1, the shear capacity of a 10d nail in a roof application with OSB gussets on both sides with clinched nails is 173 lbs (0.77 kN). The controlling force is the compressive force of -1694 lbs (-7.54 kN) and therefore 10 nails are needed beyond the break. The OSB gussets allow the connection to spread into the other members at joint 23. The height of OSB gussets allow 5 nails to be installed in the vertical web member (W5) leaving 5 nails for the bottom chord member which can easily be installed in the 2x6 (38 x 140 mm) member using 2 rows of nails.

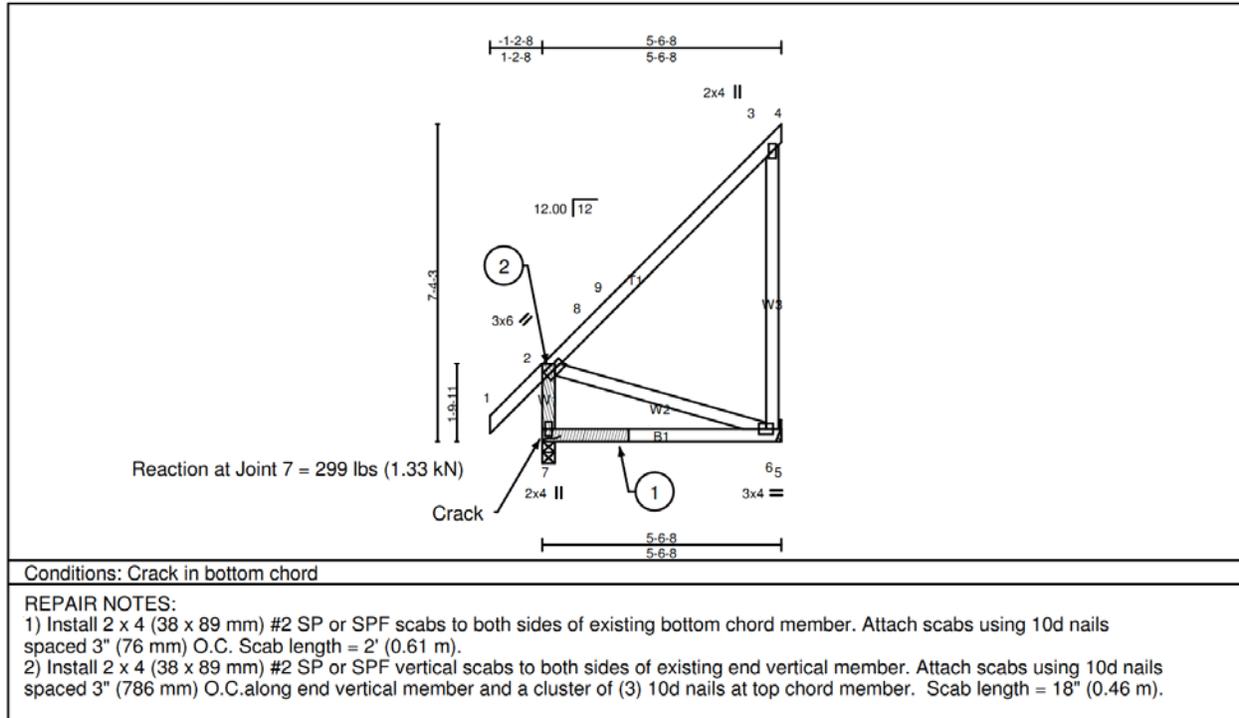
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Example 4-8 Crack at the bearing

Problem

The bottom chord of a small mono truss is cracked just above the left bearing.

Repair Drawing



Discussion

Having a split at a truss bearing is a common issue. The split is often caused by the nails from the hurricane clip. The photograph to the right was supplied by the builder and it shows the crack in the bottom chord adjacent to the hurricane clip. As is often the case in these situations, the truss plate that connects the end vertical to the bottom chord was undamaged and remains fully embedded. Therefore the connection between those members did not need to be addressed, but the repair did need to address transferring the forces into the wall. The combination of the horizontal and vertical scabs provide good vertical force transfer from the roof and shear force transfer from the bottom chord, and they are applied to both sides to prevent any eccentricity at the bearing surface. The hurricane clip is rendered ineffective due to the location of the split and will need to be removed. For this small truss, the hurricane clip can be reinstalled and connected to the scab members after the repair is complete.





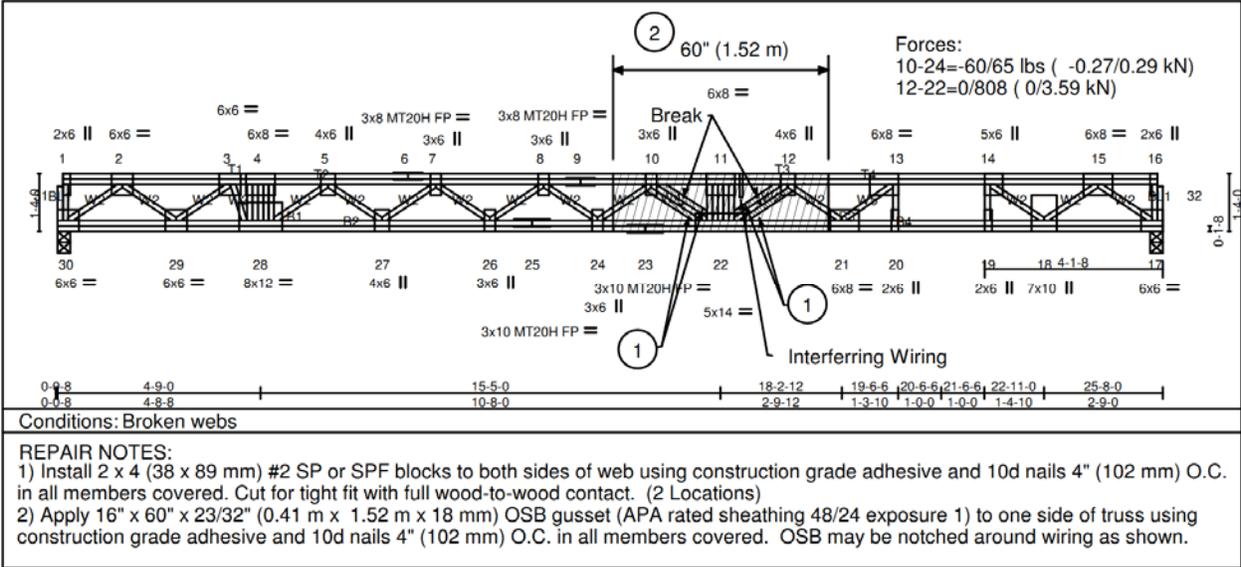
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Example 4-9 Break in a Floor Truss Web

Problem

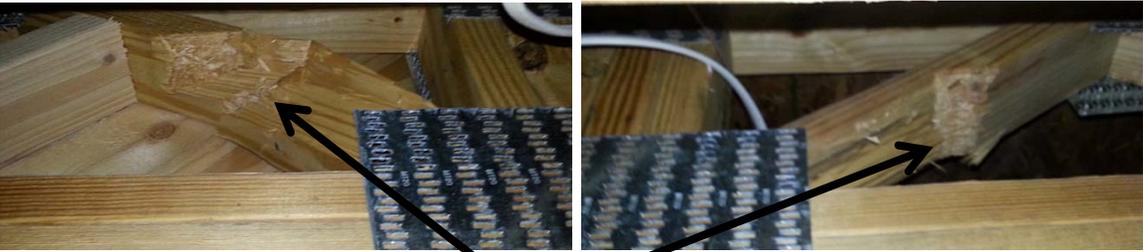
Two webs of a floor truss girder are broken.

Repair Drawing



Discussion

The builder provided the two photographs shown below to aid in the preparation of the repair documents. The floor girder truss supports a beam and is up against a stairwell on the opposite side of the truss from what is shown, so only one side of the truss is accessible. From Table 3-1, the nails connecting the 23/32" (18 mm) OSB gusset to the truss would have a shear capacity of 91 lbs (0.40 kN). To achieve the full nailing with the OSB gusset, nine 10d nails would be needed above and below the break in the web from joint 12 to joint 22. Nails in the top and bottom chord members in the area near the web can be included in the count because the web is too short to develop the connection. The blocks were added to both sides of the broken webs to secure the damaged members and to augment the connection with the OSB gusset, but by themselves, they could not achieve the required nailing because of the close proximity of the other truss members. The OSB gusset was sized to symmetrically cover both breaks and was also notched for the wire shown in the photograph.



Broken Webs



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Example 4-10 Floor Truss with Interfering Pipes

Problem

The top chord, bottom chord, and web members were all cut to allow plumbing to pass.

Repair Drawing

Forces:
 12-13=-5711/0 (-25.4/0 kN)
 19-20=0/6807 (0/30.3 kN)
 18-19=0/6807 (0/30.3 kN)
 12-18=-1827/0 (-8.13/0 kN)

8x14 MT18H =
 2x6 ||
 1.5x3 =
 6x8 ||
 6x6 =
 3x8 MT20H FP =
 2x6 ||
 3x6 ||
 3x6 ||
 3x8 MT20H FP =
 6x6 =
 6x8 ||
 2x6 ||
 6x10 MT18H ||
 2x6 ||

1 2 3 T1 4 T2 5 6 3x6 || 7 8 9 10 11 T2 12 T1 13 14 6x10 MT18H || 15

32 2.0.0

31 30 29 28 27 26 25 24 23 22 21 19 18 17 16

6x8 = 7x8 || 6x8 || 2x6 || 3x10 MT20H FP = 2x6 || 3x6 || 4x6 || 2x6 || 6x8 || 7x8 || 6x8 =

0.1.8 2.0.0

TOP VIEW

7/16" (11 mm) OSB Installed By Others On Back Side

Back Side

Front Side

1-1/2" (38 mm)

12' (3.66 m) Scabs

5'-8" (1.73 m) Scab

4" (102 mm) Diameter Holes Drilled Through Truss Edge

BOTTOM VIEW

7/16" (11 mm) OSB Installed By Others On Back Side

Front Side

Back Side

1-1/2" (38 mm)

4'-10" (1.47 m) Scab

23/32" (18 mm) OSB

4" (102 mm) Diameter Holes Drilled Through Truss Edge

23/32" (18 mm) OSB

12' (3.66 m) Scabs

5'-8" (1.73 m) Scab

~6' (1.83 m)

~5'-8" (1.73 m)

25-3-1
25-3-1

Conditions: (2) 4" Diameter holes drilled through truss for pipes

REPAIR NOTES:

- 1) Install 2 x 4 (38 x 89 mm) #2 SP blocks on each side of 4" (102 mm) pipe, 1 block above and 1 block below existing diagonal web. Cut for tight fit with full wood-to-wood contact. DO NOT CUT existing web. 4 Blocks Total.
- 2) Apply 2' x ~6' x 23/32" (0.61 m x 1.83 m x 18 mm) OSB gusset (APA rated sheathing 48/24 exposure 1) to front side of truss using construction grade adhesive and 10d nails 4" (102 mm) O.C. in all web members covered. Tack in place along top and bottom chord in areas where scabs are to be applied at Step 4. Gussets may be closely notched around interfering plumbing as required.
- 3) Apply 2' x ~5'-8" x 23/32" (0.61 m x 1.73 m x 18 mm) OSB gusset (APA rated sheathing 48/24 exposure 1) to front side of truss using construction grade adhesive and 10d nails 4" (102 mm) O.C. in all web members covered. Tack in place along top and bottom chord in areas where scabs are to be applied at Step 4.
- 4) Install 2 x 4 (38 x 89 mm) #2 SP scabs to front face of truss top chord overtop previously installed OSB in step 2 as shown. Tack in place along top chord in areas where scabs are to be applied at Step 7. Scab Length = ~6' (1.83 m).
- 5) Install 2 x 4 (38 x 89 mm) #2 SP scabs to front face of truss top and bottom chord overtop previously installed OSB in step 3 as shown. Tack in place along top and bottom chord in areas where scabs are to be applied at Step 7. Scab Length = ~5'-8" (1.73 m).
- 6) Install 2 x 4 (38 x 89 mm) #2 SP scabs to front face of truss bottom chord overtop previously installed OSB in step 2 as shown. Tack in place along bottom chord in areas where scabs are to be applied at Step 7. Scab Length = ~4'-10" (1.47 m).
- 7) Install 2 x 4 (38 x 89 mm) SP M31 or SS scab to both sides of truss using construction grade adhesive and Simpson SDS 1/4" (6.4 mm) Wood Screws spaced 6" (152 mm) O.C. (4-1/2" (114 mm) Screws on back side and 6" (152 mm) Screws on front side) in all members covered. Alternate screws from front and back side scabs. Scab Length = 12' (3.66 m). (2 Locations) Scabs to be installed overtop of previously installed OSB and 2x4 (38 x 89 mm) scabs in steps 2-6 on front side and overtop of previously installed 7/16" (11 mm) OSB by others on back side.



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Discussion

This repair is similar to Example 4-3 in that for both repairs, the pipes had to remain in place and the repair had to be designed around them. In both cases, the repair would have been avoided altogether had the trusses been shifted slightly to avoid the location of the pipes. The difference is that for the current example, the bottom chord which has a controlling tension force is cut in addition to the top chord which has a controlling compression force and that the forces involved are approximately three times greater than the other example. The forces are so much higher for this example because it supports a corridor in a multi-family dwelling and according to the IBC2015 table 1607.1, corridors should be designed for 100 psf (4.79 kN/m²) whereas the individual residential units need only to be designed with 40 psf (1.92 kN/m²).

The fact that a pipe needs to pass through the entire truss suggests that there would be a wall above and below the truss at least at the spot where the pipe would pass through the truss. For the case at hand, the wall was considered non-bearing and so from a structural perspective, the truss had to be designed as if the wall was not there at all. Had the wall been considered bearing, then the required repair would have been substantially less. Also, the fact that there was a wall at a truss with corridor loading, probably means while the area on one side of the wall would have to have the corridor loading, the area beyond the wall could be designed with the reduced residential unit loading. Another mitigating factor might be that the net section area of each of the truss members was only reduced by about 42% leaving more than half of the original member dimensions to transfer the forces. However, experience has shown that it is usually better to assume more severe damage than is actually reported because the experience level of the person reporting the damage along with the accuracy of the description is not always known. So, the repair was designed as if the entire force needed to be transferred across the damaged area.

The key step in the repair process is step 7 where the four 2x4 (38 x 89 mm) scabs, two on the top chord and two on the bottom chord, were applied and attached with the Simpson SDS screws. Had the pipes been moved away from the truss or the truss moved away from the pipes, then the step 7 scabs would have been all that was required to accomplish this repair. According to the Simpson C-2015 catalogue, the SDS 4 1/2" (114 mm) x 6" (152 mm) screws with a 1 1/2" (38 mm) wood side plate would have a shear capacity of 350 lbs (1.56 kN) per screw and since this a floor application, the Duration of Load (DOL) would be 1.00. So, there would be no adjustment available for the shear capacity of the screw. With a controlling tension force of 6807 lbs (30.3 kN) in the bottom chord, eleven screws would be required on either side of the damaged section. The builder had already applied an unknown amount of OSB on the opposite face of the truss from the damage. It was decided to keep the OSB in place on that side rather than risk damaging the truss further by removing it. The steps 1-6 consist of vertical blocks adjacent to the damage within the plane of the truss, OSB gussets, and horizontal 2x4 (38 x 89 mm) scabs. These are all in place to pad out the side of the truss so that the scabs on the front side of the truss in step 7 would clear the pipes. Therefore, once the items in steps 1-6 were



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complete, the thickness of materials dictated that the length of screw from the back side should be 4 1/2" (114 mm) while the length of screw from the front side would need to be 6" (152 mm).



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Chapter 5 – Plate Damage

Plate damage usually occurs when the trusses are not handled properly. While trusses are strong to resist forces in the plane of the truss, they are very weak out of the plane. If the trusses are subjected to bending out of the plane of the truss, the truss plates can be overstressed or pull out of the wood. Examples of situations where out plane bending can occur include the pack of trusses being delivered on ground that is rough and uneven, long trusses being picked up by a small forklift so that the ends of the pack droop, or the use of inappropriate crane equipment and methods that can cause the truss to fold over as it is being lifted. Other causes of plate damages can include sliding the truss along rough ground, having the plate snag another object as the truss moves past the object or the object moves past the truss, misplacing the plate during the fabrication, or not having sufficient plate embedment. The current version of the Building Component Safety Information also known as the BCSI series of documents provide good practices for handling and bracing the trusses to avoid injuries to the workers and damage to trusses.



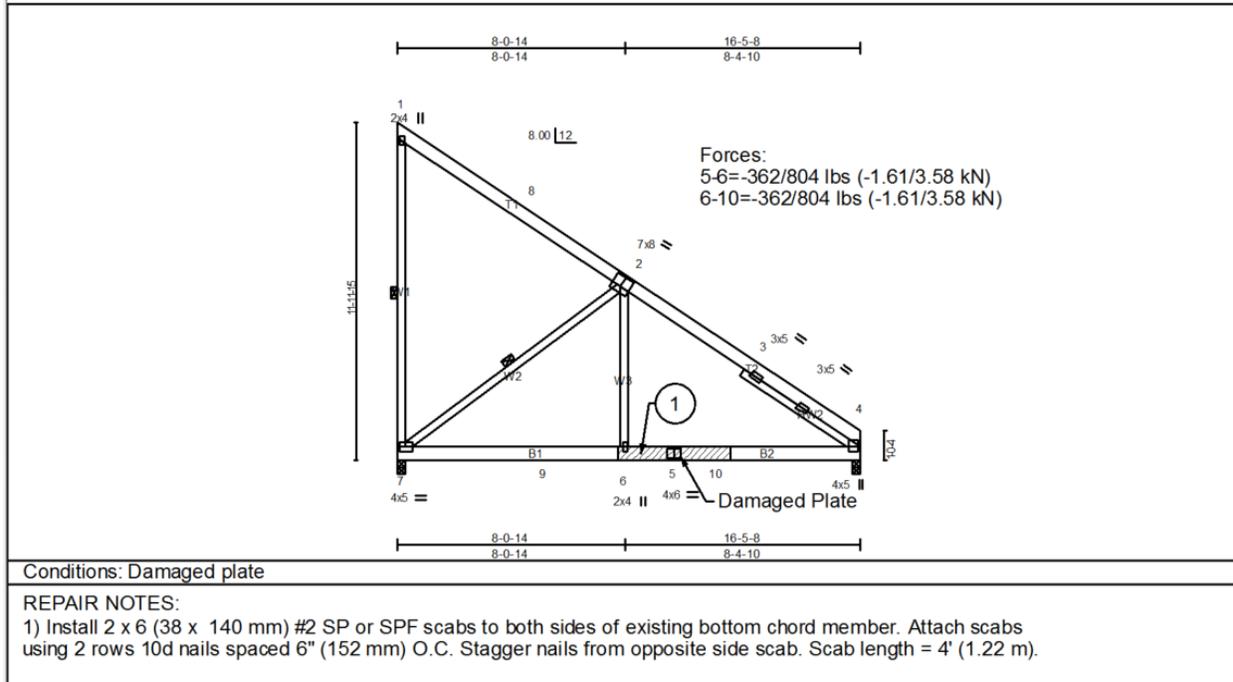
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Example 5-1 Damaged Bottom Chord Splice Plate

Problem

The plate on the bottom chord splice has been damaged.

Repair Drawing



Discussion

A damaged splice plate can be treated just like a broken member when it is out in the panel away from web members, and a lumber scab can be used as the repair. For a roof truss with a lumber scab, the shear capacity of the 10d nail from Table 3-1 is 106 lbs (0.47 kN) and therefore, 8 nails would be needed beyond the splice on both ends. In theory, a single 4' (1.22 m) long 2x6 (38 x 140 mm) scab would be sufficient. However, the repair designer prefers to use a two-sided repair whenever possible and therefore, specified the double scab solution.



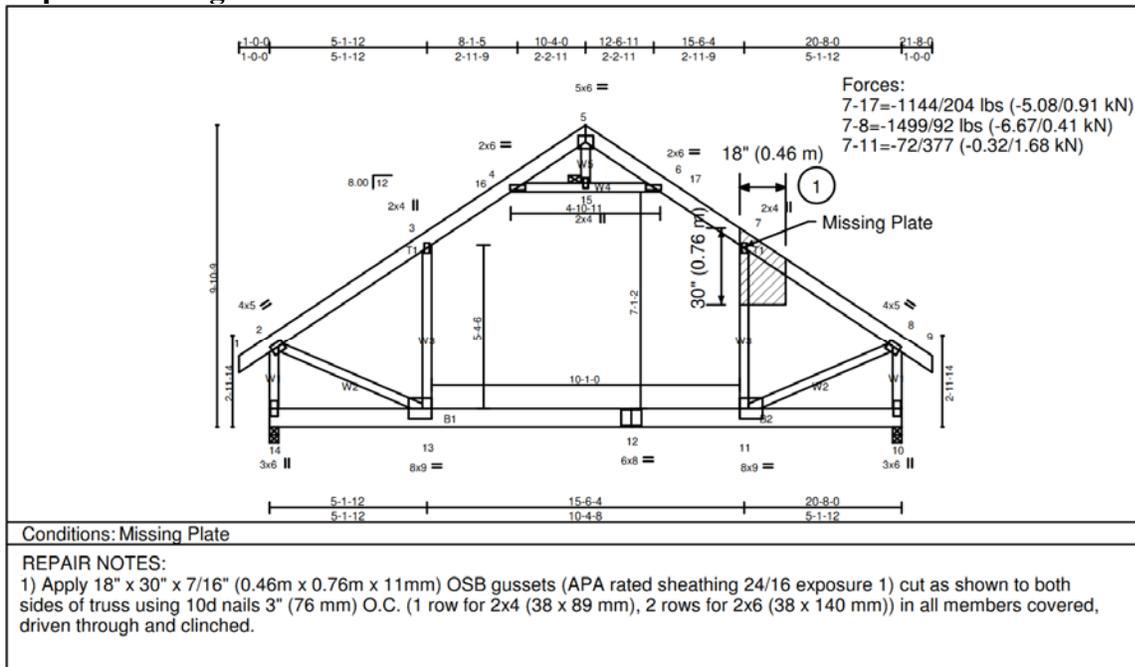
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Example 5-2 Missing Plate

Problem

The plate at a top chord joint adjacent to an attic room is missing.

Repair Drawing



Discussion

Having only a two member joint with a missing plate makes this a good example to continue the discussion regarding damaged plates. Since the top chord member is continuous through the joint and is not broken, the full axial force of the top chord does not need to be developed with the connection. Therefore, the critical design force is the tension force of 377 lbs (1.68 kN) in the vertical web member from joint 7 to joint 11. With the controlling force for the connection being relatively small, there are several possibilities for repairing this joint with the missing plate. In this case, OSB gussets with a thickness of 7/16" (11 mm) were chosen to provide the required reinforcement. From Table 3-1, for a roof truss repair with 7/16" (11 mm) OSB gussets, the 10d nail would be subjected to double shear and have a capacity of 173 lbs (0.77 kN). The connection requires a minimum of three 10d nails in each member. The OSB gussets are sized a little larger than required because of the repair designer's preference to provide a minimum gusset size for this type of joint. Normally, the gussets would have been centered on the vertical web member. However, in this application, the gussets were shifted to avoid the attic room.



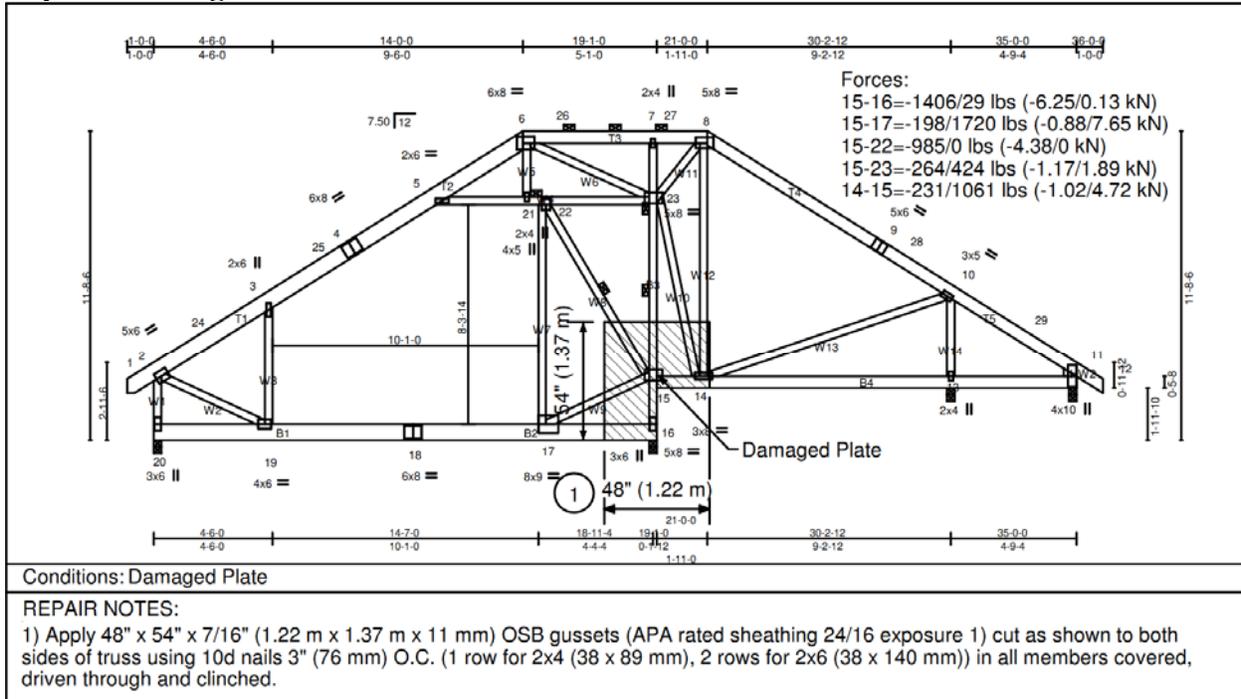
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Example 5-3 Damaged Plate

Problem

The plate at the bottom chord step-up has been damaged.

Repair Drawing



Discussion

When a damaged plate connects several members, it is useful to start with the assumption that OSB gussets are a good option for the repair and then to assemble the required forces and gusset development lengths in a table. This compilation of forces and gusset development lengths assists in determining the best placement of the gussets and also to confirm that OSB gussets can be used. According to Table 3-1, the double shear capacity of the 10d nails is 173 lbs (0.77 kN). The table below presents the required development lengths in a clockwise manner:

Member	Size	Controlling Force	No. Nails	No. Rows	Required Length
15-16	2x4 (38x89 mm)	-1406 lbs (-6.25 kN)	9	1	30" (0.76 m)
15-17	2x4 (38x89 mm)	1720 lbs (7.65 kN)	10	1	33" (0.84 m)
15-22	2x4 (38x89 mm)	-985 lbs (-4.38 kN)	7	1	24" (0.61 m)
15-23	2x4 (38x89 mm)	424 lbs (1.89 kN)	3	1	12" (0.30 m)
14-15	2x6 (38x140 mm)	1061 lbs (4.72 kN)	7	2	15" (0.38 m)

Comparing the graphic to the table, the OSB gussets appear to not provide enough development length to cover members from joints 15 to 16 and 15 to 17. The vertical member



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from 15 to 16 is not really a concern because it is continuous through joint 15, and the full tension force can developed above joint 15 as well as below. The web member from joint 15 to 17 has a tension force as the controlling force and the OSB coverage and the nailing pattern for this member does not allow enough nails to develop the full connection by itself. However, the nails in the horizontal bottom chord member from joint 16 to 17 can also be counted in the tension web total.

The axial, compressive, and shear capacities of the panel should also be determined to confirm that the strength of panel will transfer the forces across the joint. The Manual for Engineered Wood Construction reports the following strength characteristics for the OSB gussets used in this course:

Span Rating	Thickness	Allowable Stress
Panel Tension $F_t A$ with units of lbs/ft of panel width (kN/m of panel width)		
24/16	7/16" (11 mm)	1,300 (19.0)
48/24	23/32" (18 mm)	2,550 (27.3)
Panel Compression $F_c A$ with units of lbs/ft of panel width (kN/m of panel width)		
24/16	7/16" (11 mm)	2,500 (36.5)
48/24	23/32" (18 mm)	4,300 (62.8)
Panel Shear Through-The-Thickness $F_v t_v$ with units of lbs/ft of shear-resisting panel length (kN/m of shear-resisting panel length)*		
24/16	7/16" (11 mm)	1,980 (28.9)
48/16	23/32" (18 mm)	2,640 (38.5)

*The original table used units of lbs/in for the Panel Shear Through-The-Thickness table but these values were converted to lbs/ft for consistency.

Table 5-1 Strength Characteristics for OSB Gussets.

In general, the sizing of the OSB gussets to meet the forces in each member at a joint will produce a gusset of sufficient size to meet the required strength characteristics for that panel when applied to one ply trusses. However, for multi-ply girders or unusual situations with high forces the strength of the gusset may be a controlling criteria. For the current example the bottom chord member from joints 14 to 16 has a force of 1061 lbs (4.72 kN). The tension force would be resisted by the vertical 1.5' (0.76 m) dimension in the raised region of the gussets on both sides providing a tension capacity of 3,900 lbs (17.3 kN). The shear force would be controlled by the horizontal dimension of 2' (0.61 m) on the left side of the stepped-up region giving a shear capacity of 3,960 lbs (17.6 kN).

The most readily available size of OSB is 48" (1.22 m) x 96" (2.44 m). Since the required height is greater than 48" (1.22 m) the horizontal limit of the OSB gusset was set at the 48" (1.22 m) sheet width. If the shear value of the bottom chord nails were not counted for the



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tension web from joint 15 to 17, then some other repair technique such as a scab truss would be required instead of the OSB gusset because of the 48" (1.22 m) limiting sheet width.

Consideration should be given to the following when designing a truss repair using OSB gussets:

- In the example given, the full dimensions of the OSB gussets were used to develop the allowable shear and tension values. However, engineering judgement may be required to estimate effective dimensions of the gusset at various truss members or determine if the gusset is likely to buckle between the members. To resolve these issues, thicker gussets could be chosen, the gussets could be doubled, or perimeter blocking could be added. Each of these options could affect the final size of the gussets and/or the shear capacity of the connectors.
- The maximum available width is 48" (1.22 m) and the max available length is 96" (2.44 m). It may be advantageous to shift and rotate the gusset to achieve the acceptable development length. (Larger OSB sheet sizes may be available in certain markets or can be special ordered, but generally it is good practice to limit the specified size as discussed.)
- If the geometry of the joint and the forces in the members do not push the limit of the 48" (1.22 m) width or 96" (2.44 m) length, then it is recommended that the gusset be centered over the joint and aligned with the dominant member.
- Whenever possible, the gusset should be sized so that the corners fall on or near the truss members. If there is a corner of the gusset that is not near any truss member, then the repair designer may consider specifying a diagonal cut to eliminate the free corner. If perimeter members are close to the repair area, then it is advantageous to place the OSB gusset to maximize the perimeter nailing potential.
- When a truss plate is missing or damaged on one side of the truss, it is appropriately conservative to assume that the plates are missing or damaged on both sides of truss and therefore, the full axial forces need to be developed by the repair connection.
- A good rule of thumb for most floor truss repairs is that the length of the gusset should be at least twice the depth of the floor truss and the gusset should be the full depth of the floor truss.



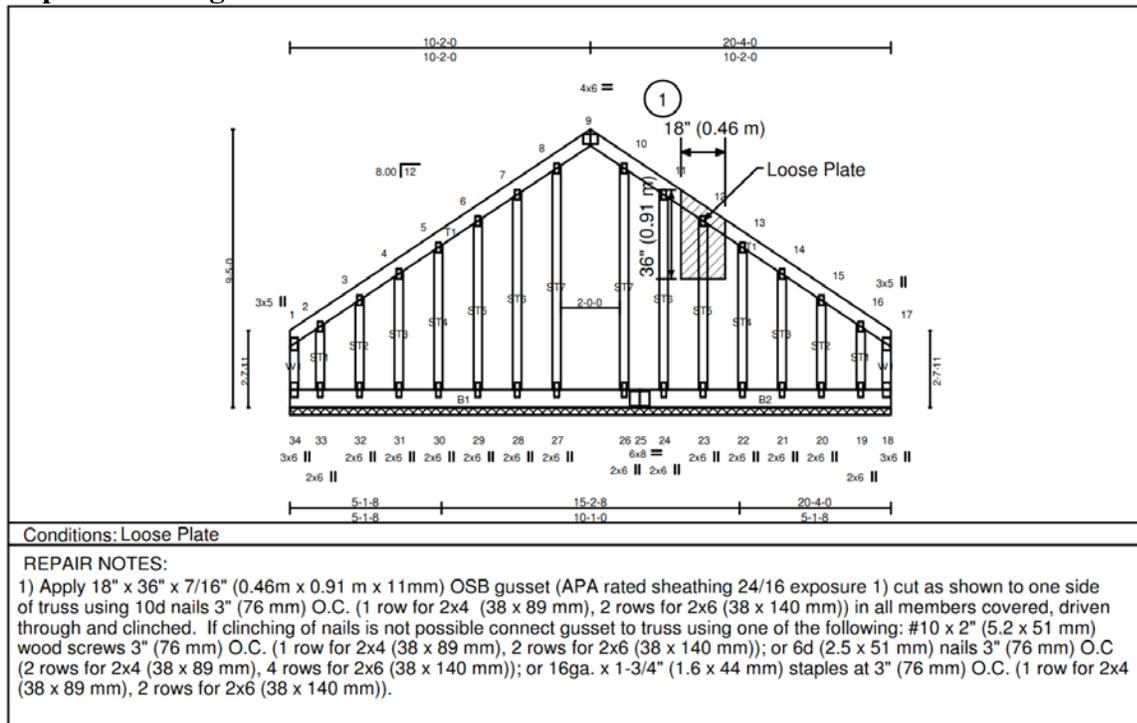
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Example 5-4 Loose Plate on a Gable Truss

Problem

The plate at a top chord joint in a gable truss is damaged.

Repair Drawing



Discussion

Gable truss repairs require unique solutions to stay within the confines of the building exterior. The size of the OSB gusset for gable truss repair members is usually based on the geometry of the truss rather than the forces in the members. The thickness of the gable truss and exterior sheathing limits the length of the connector. The connector must either be clinched if installed prior to the exterior sheathing or be no more than the thickness of the exterior sheathing plus 2" (51 mm) long so that it does not protrude to the outside of the structure.

The comprehensive list of connectors was developed over a period of time based on feedback from the repair installers. According to Table 3-1, a 10d nail provides a shear capacity of 87 lbs (0.39kN) for a roof truss with an OSB gusset applied to one side. Each connector was specified to roughly equal the capacity of the 10d nail even though the size of the OSB gussets for a gable truss repair is usually governed by the geometry of the joints rather than the actual force of the member.



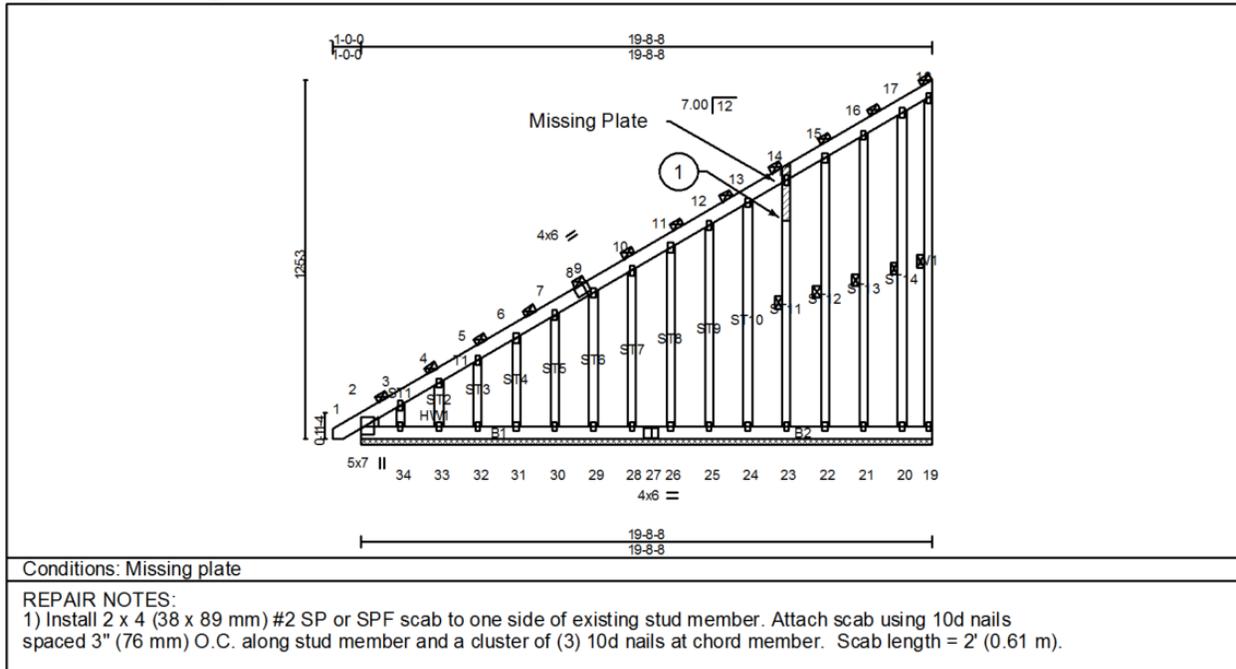
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Example 5-5 Alternate Gable Truss Joint Repair

Problem

The plate at a top chord joint in a gable truss is missing.

Repair Drawing



Discussion

This example is presented as an alternate approach to repairing gable truss joints to the previous example. The main advantage of using a lumber scab repair for a missing or damaged plate on a gable truss instead of the OSB gusset repair presented in the previous repair is that the thickness of the assembly is now 3" (76 mm), and therefore the standard 10d gun nail can be used to attach the scab without the nail penetrating the exterior of the structure.



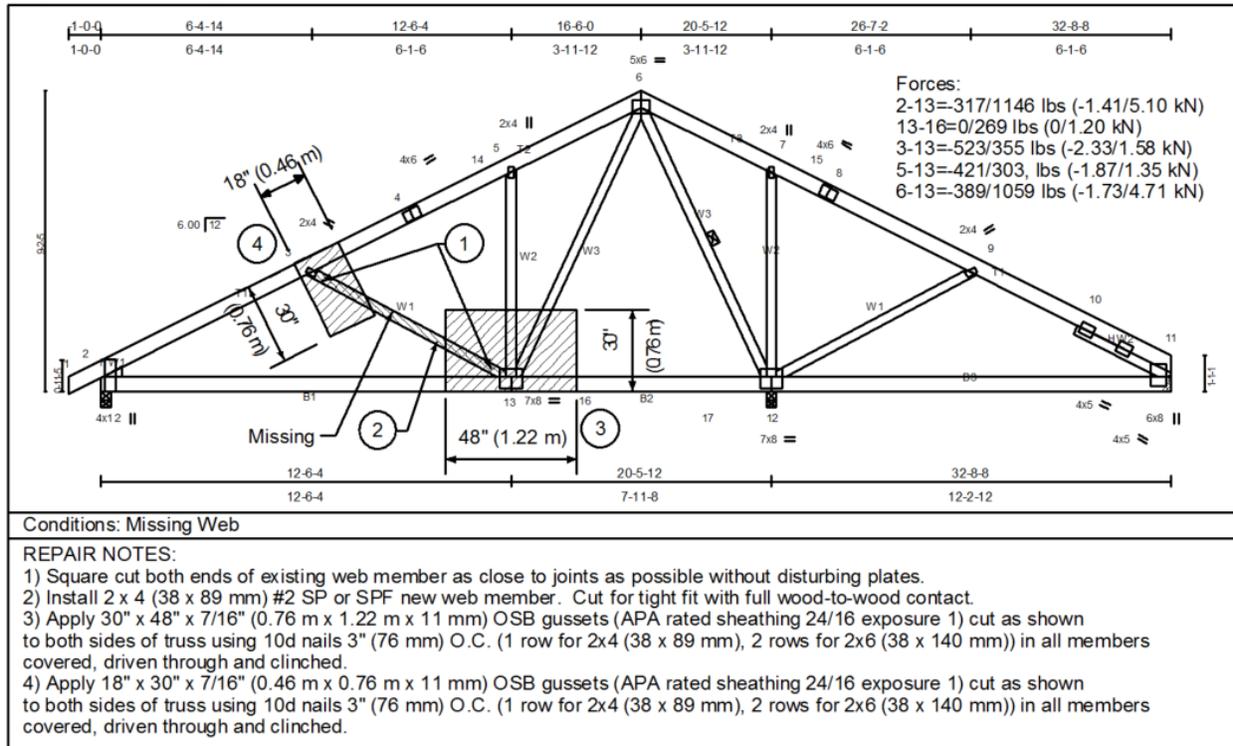
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Example 5-6 Missing Member

Problem

A web is broken and missing from the truss.

Repair Drawing



Discussion

When a member has been broken out of a truss, the pieces that are left behind are often jagged. The first step in replacing a member that left jagged edges would be to square cut the pieces to allow for a clean splice joint. Also, in order to reduce the size of the OSB, this cut should be made as close as possible to the joint.

When a member is missing, it is advisable to consider what else may have been damaged. This web being torn from the truss would likely also damage the plate at the critical bottom chord splice joint 13. So, in addition to considering the forces in the missing member, the forces in the other members at joint 13 should also be considered when sizing the OSB gusset. Since this is a roof truss with OSB gussets, the double shear capacity for the 10d nail of 173 lbs (0.77 kN) applies. Proceeding clockwise around the joint, member B1 would require 7 nails in two rows for a development length of 15" (0.38 m), W1 – 4 nails requiring 15" (0.38 m), W2 – 3 nails for 12" (0.30 m), W3 – 7 nails needing 24" (0.61 m), and B2 – 2 nails using 6" (0.15 m). The controlling dimensions for OSB gussets at joint 13 would be the W1 web beyond the square cut splice and the W3 web. The OSB gussets at joint 3 only have to develop the force in the web member because the top chord member is undamaged and is continuous through the joint.



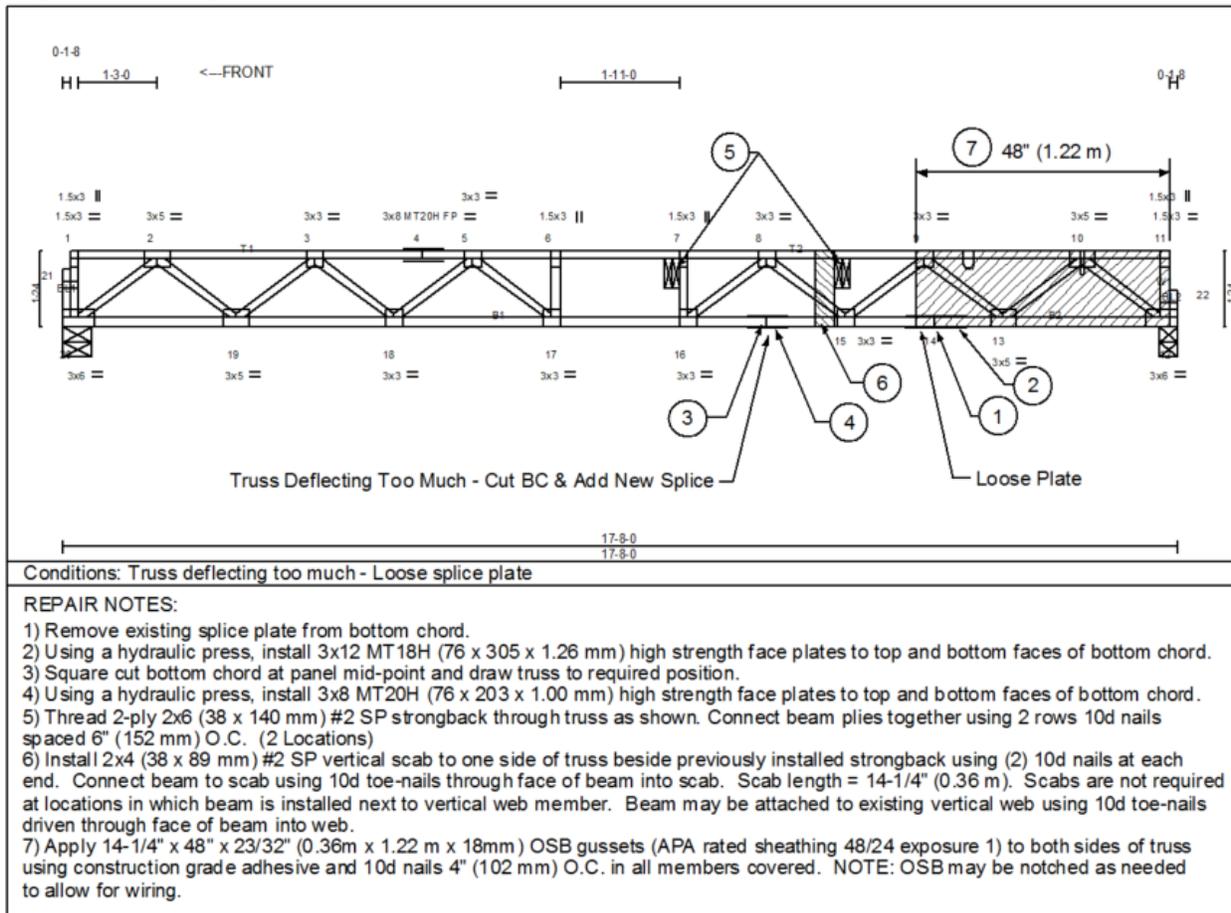
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Example 5-7 Deflecting Floor Truss Caused by a Damaged Splice Plate.

Problem

Unacceptable deflection was noticed in a few floor trusses in a residential structure after the home owner moved some furniture several years after the house was built. Upon inspection, the primary cause of the deflection was a bottom chord splice plate that had pulled out.

Repair Drawing



Discussion



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The photograph to the right shows the truss as it was found once the gypsum ceiling was removed. The damaged plate and the resulting deflection can be seen in the lower left corner of the photograph. Three adjacent trusses also displayed excessive deflection and required similar repairs. The four repairs were accomplished in concert by using the two 2-ply 2x6 (38 x 140 mm) beams with posts and jacks to raise the truss to its correct position. This truss repair example highlights several educational points as described below.



While the structure is under construction, building materials are unloaded through doors or windows, and this stockpiled material can overload the supporting structure. The deflected portion of these trusses fit this profile because of the proximity of a sliding glass door on the floor above. There are documents available in the industry addressing the placement of material temporarily around the structure without overloading a particular component. The Structural Building Components Association website (www.sbcindustry.com) contains more information on this subject.

The first step in this repair is to remove the existing damaged bottom chord splice plate and install a new larger plate using a portable hydraulic press. ANSI/TPI 1-2014 Section 3.9.3 states that when a new plate is pressed into wood where there are tooth holes from a previously installed plate, then the plate grip value of the teeth in that area must be reduced by 50%. The original splice plate was a 3x8 (76 x 203 mm) high strength plate with each plate covering an area of 12 in² (7 742 mm²) for each bottom chord member. A new 3x12 (76 x 305 mm) high strength plate was chosen because it would provide a total of 18 in² (11 612 mm²) which takes into account the 50% penalty in the area of the existing tooth holes.

The strong-back term referred to in Note 5 is common in the wood truss industry and would be defined as a structural member that passes through multiple trusses to create a load-sharing system. The strong-back acts as a beam that distributes concentrated loads to the adjacent trusses, so that no truss is overloaded and deflects more than the adjacent trusses. Normally, the strong-back is a single 2x6 (38 x 140 mm) member placed perpendicular to floor truss at 10' (3.05 m) o.c. In this case, the 2-ply members were first used to act as a lifting beam and then they were left in place to act as strong-backs. Before the trusses were cut, the 2-ply members were threaded into the truss 1-ply at a time, connected together in place, and supported using four columns with each column sitting on a jack.

Cutting undamaged structural members may seem counterintuitive. However, once wood has taken a deflected state for a period of time, it does not easily return to the desired position

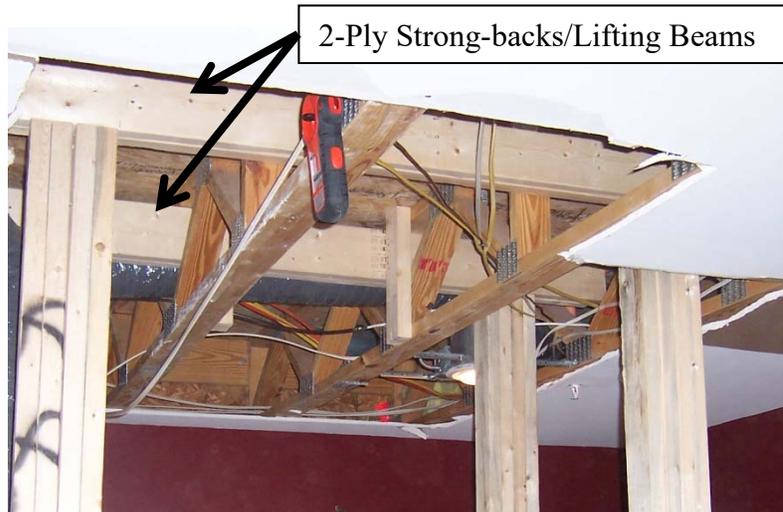


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and the members must be cut, raised, and spliced back together. The location of the cut was chosen based on several factors including the location of the lowest spot of the deflected shape, an area away from other truss joints, and the location where the 2-ply strong-back members could physically be installed. The size of the cut is also important because as the truss is lifted back in place, the gap left by the saw cut closes up. In this case, the actual gap needed to be greater than the width of the saw blade, requiring multiple cuts on each truss. The actual gap for this repair needed to be between 1/4" (6 mm) and 3/8" (9 mm) depending on the particular truss.

Once the 2-ply strong-back members with the supporting columns were in place, and the trusses were cut, the jacks were used to slowly and carefully lift the trusses back to the intended position. The jacks were placed on load distributing blocks to prevent cracking of the concrete slab in the basement. If there is a wood floor under the jacks, temporary supports should be provided to prevent damage to that lower floor system from the jacking force.

The photograph to the right shows the 2-ply strong-backs in place with the supporting columns before the trusses were cut. The laser tool was used to determine when the trusses were at the desired position.

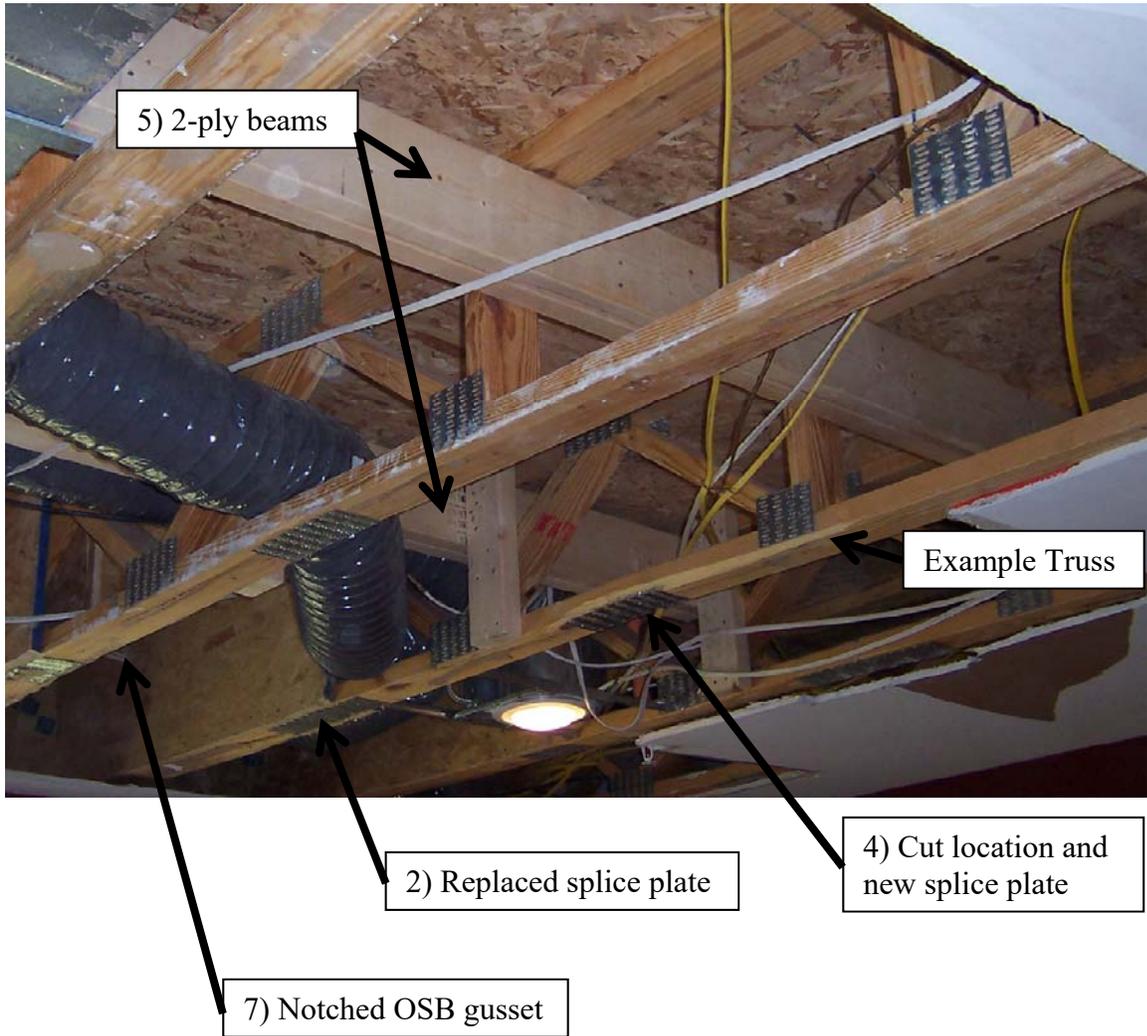


Notching of the OSB gussets for existing utilities must also be considered. The ideal structural situation would be to rerun the utilities around the gussets or drill holes and rerun the wires through the new OSB gussets. However, the practical solution is usually to leave the wires or pipes in place and design the repair around the interfering object. If the truss chord is undamaged in the area of the notch, then the truss chord will work in conjunction with the OSB gusset to carry the force around the notch. If the truss chord is damaged in this region, then additional scab material may be required over the notched OSB gusset to properly transfer the load. Another solution would be to use two OSB gussets on each side: one piece with the notch pointing up and the other with the notch pointing down. Also, it is recommended that any notching should have a rounded end as shown in the repair drawing to reduce possible stress concentrations that occur in a V shaped cut.

The following photograph shows the finished repair.



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Conclusion

The purpose of this course series has been to examine various techniques and approaches to repairing, reinforcing, or modifying metal plated wood trusses. While most repairs are fairly straight forward and can use standard repair methods such as lumber scabs and OSB gussets, a small portion of the repairs and modifications are more complex. This course series provides a broad spectrum of the possible situations and suggested solutions for truss alterations.

This document is the first part in the three part series and has focused on repair concepts and relatively simple repairs. The discussion began with some definitions, followed by truss repair concepts, connections, some examples of member damage and defect, and concluded with some plate damage examples. Part two of this course series will look at moderately complex repairs. The final part will include a more detailed description of a limited number of very complex repairs.

References and Notes:

- I first want to thank Mr. Mike Fuss PE of Builders FirstSource for being a mentor and friend. There have been many hours spent discussing truss repairs, and I have learned a lot from him. Thanks Mike!
- The repair sketches in this document were originally prepared by Ms. Christine Cavanaugh or Mr. Bryon DeGraw and have all been modified from the original truss repairs for this document.
- The truss designs presented in this document were all produced using the Engineering software and all repair sketches were made in the accompanying CAD software both developed by Mitek Industries Incorporated of Chesterfield, MO.
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