SBC ASSOCIATION

Research Report

Truss Repair

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Structural Building Components Association (SBCA)

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Introduction:

Trusses are the major engineered wood component used today, with 63.7% market share for roof trusses and 31.7% market share for floor trusses. The repair and modification of metal plate connected wood trusses can be a very complicated subject, because each situation must be analyzed individually. It is important not only to calculate an adequate repair or modification, but also to ensure that the repair or modification can be performed in the field. The truss designer needs to obtain as much accurate information as possible, by asking questions about what damage occurred and how. In simple scenarios, this may involve a redline Truss Design Drawing or photos of the damaged truss; with more complex damage or modification requirements, this may even involve visiting the site. This research report will give an overview of the fundamental principles behind truss repair that inform the truss designer's approach in all truss scenarios.

One source of confusion within the wood truss industry is the difference between a truss repair and a truss modification. Truss repairs can be summed up as restoring a truss back to its original shape and strength in situations where damage has caused a change or a reduction in either. Truss modifications occur when a truss profile, loading, and/or bearing conditions must be altered to fit a situation for which the original truss was not designed. This report will cover the key concepts involved with a truss repair.

Key Definitions:

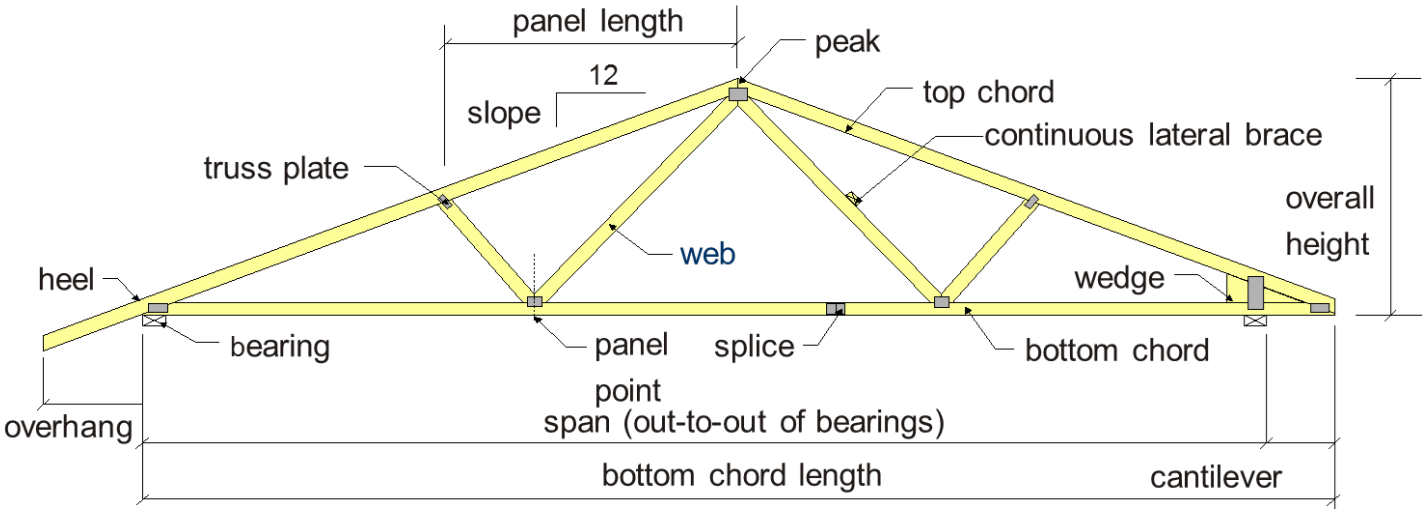

Figure 1: Truss Terminology

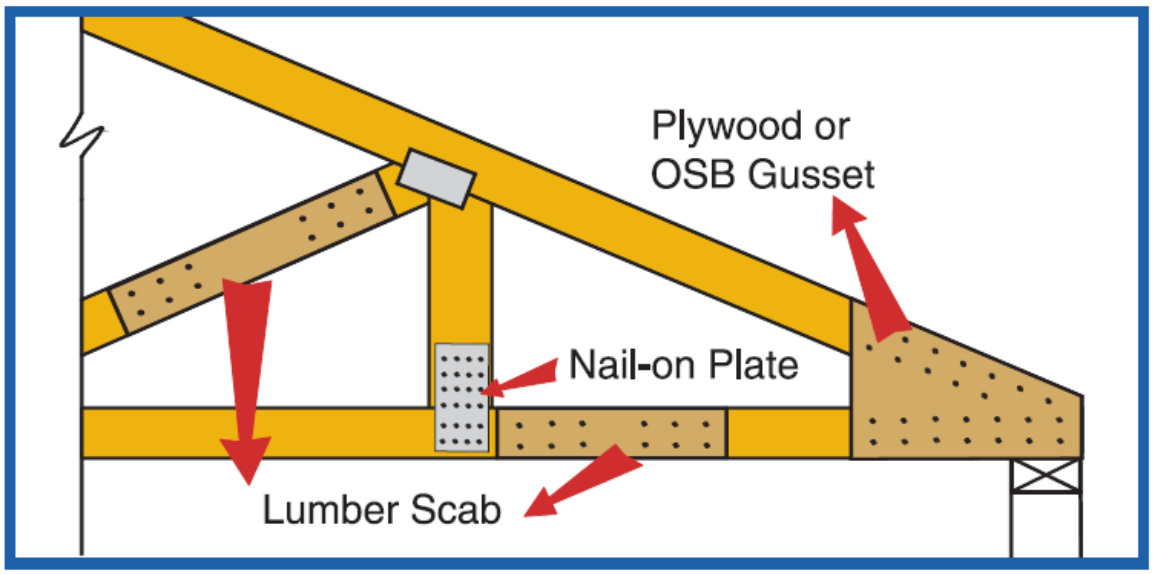

Figure 2: Examples of Repairs

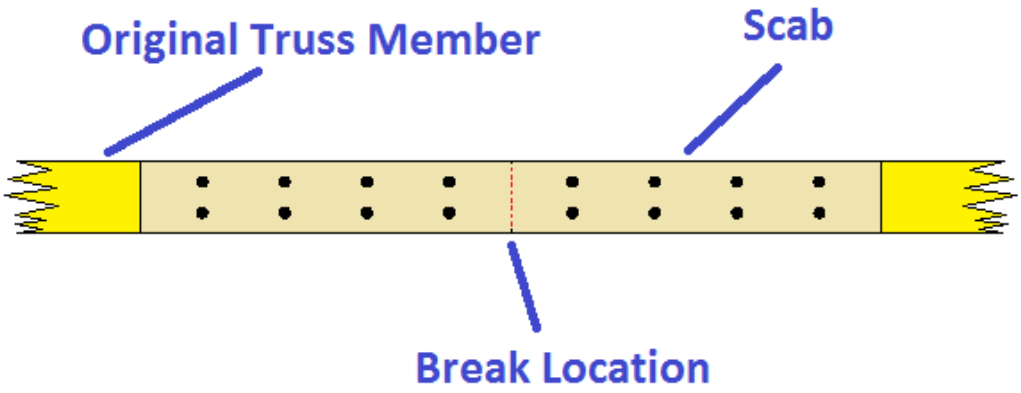

Figure 3: Scab Repair

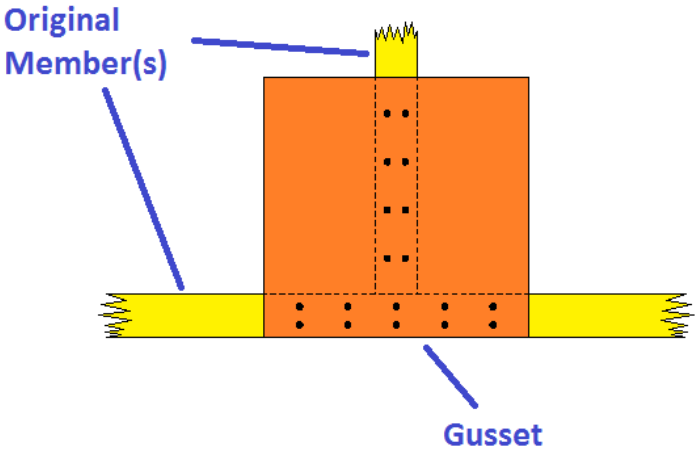

Figure 4: Gusset Repair

Background:

Common situations that require repairs include: damage to the truss from storage and delivery, handling, installation, adverse environments, fire, and manufacturing mistakes. Whatever the reason for a repair, the principles followed by the Truss Designer are similar. The truss repair must result in a truss that is able to carry all loads intended for the truss.

The material and design for a repair serves to restore the ability of broken or damaged truss members to carry the forces specified in the original Truss Design Drawing. For example, in the case of missing plates at a joint with multiple webs, Nail-on Plates, OSB or Plywood gussets are attached in place of the missing plates. To be sized appropriately, the gusset must overlap each intersecting member enough to allow for fastening that equals or exceeds the forces (axial, moment and/or shear) each member places on the joint. The number of fasteners required into each member is calculated based on the amount of force each fastener can resist in each member. Fasteners must be spaced to meet all end, edge, and row distance requirements as required by the NDS. Finally, the truss designer must check whether the gusset itself is able to resist all forces at the joint.

Things to consider before repairing a truss:
If a truss is damaged in the field, the truss should be laid flat on a solid, level surface and the repair completed before installing the truss. If the truss is already installed, it is important to temporarily brace or support the truss to prevent further damage to the truss and potential danger to workers before conducting the repair.

A repair should not be attempted without a Truss Repair Design Drawing. Repairing a truss prior to receiving a Truss Repair Design Drawing could result in additional work and possibly removing material, if the repair detail differs from the field repair. It is important to use a repair detail that is specific to the truss and field condition being repaired, because even slight variations in truss loading or damage condition can significantly affect the repair required. If the designed repair cannot be accomplished, inform the building designer, truss designer, or truss manufacturer.

Forces acting within a truss that affect repairs:
Axial Forces
Axial forces in relation to truss designs are forces that act on the truss parallel the truss member. Axial forces acting on truss members are either tension or compression. Tension forces pull on each truss member, whereas compression forces push on each truss member. These forces are developed through the resistance of the truss members to gravity, wind, and other design loads and, in many cases, the forces can be substantial.

Shear Forces
Shear force in a member is the force acting perpendicular to its longitudinal direction. Shear force is highest at joints, concentrated load locations, and bearing locations.

Moment Forces
Moment forces in relation to truss design are forces that cause rotation. Depending on the fixities of the joints, moment forces occur in chords and sometimes in the webs. Joints in trusses are usually subject to moment forces, and the highest joint moments usually include the heels, peak, pitch-breaks, and chord joints where large axial forces come together either at different angles and/or in opposing directions (tension versus compression). In some cases, the moment force around a joint will be greater than any of the axial forces acting upon it and not necessarily show up on the design drawing, it but will be accounted for in the design of the gusset plate. For this reason, the truss designer must always take into account all of the forces acting on a joint.

Common materials used in repairs:
Materials commonly found in the geographical location and ideally already at the jobsite should be used, if possible. Notify the truss designer or truss manufacturer about preferred materials for the repair, availability of special order materials, if there is a plate press on site, or additional considerations.

- OSB/plywood gusset
- Lumber scab
- Metal nail-on plates
- Truss plates applied with a portable plate press
- Scab truss
- Steel angles

- Steel side plates
- LVL or other engineered wood
- Nails
- Screws
- Bolts
- Adhesives

Some adhesives create an excellent bond with the wood, providing greater strength than the wood itself. Application conditions must be considered including: temperature, moisture, surface condition of the wood member, quality and supervision of labor, and cure time.

Nails

Nails are used in most field repairs to connect the repair material to the existing truss members. However, nails are not as efficient in connecting wood members as metal gusset plates, For example, a splice in a 2x4 SPF No. 2 member with 1000 lbs. of axial force and a load duration factor of 1.15 would take approximately 11 nails on each side of the splice to make the connections but only 5.5 sq. in. of a gusset plate. One of the main differences is the 11 nails would need to be spaced per *NDS* Table C11.1.6.6, which would equate to about 16" on each side of the splice using the maximum nails per row and the minimum spacing between rows. To put this in simpler terms, (1) – 3" x 0.131" gun nail is good for 94 lbs. of force transfer compared to 1 sq. in. of a metal gusset plate that can transfer about 150 lbs. or 300 lbs., when considering plates on both sides. These numbers will vary depending on load duration, lumber species, plate orientation, plate type, nail diameter, and nail length.

Nail design values are specified in *NDS* Chapter 11. Truss designers use these values and their factors, along with the forces in the truss design that were described earlier, to determine the quantity of nails required for the repair.

Nail Clinching

NDS 11.1.6.5 allows nails to be clinched in order to double the shear value of the fasteners installed in the gusset. To do this, gussets must be installed on both sides of the repair, and fasteners must be installed of sufficient length to pass through both gussets and the main truss member while retaining enough length to be clinched (minimum of $^{3}/_{8}$") (see Figure 5). The use of clinched nails allows a gusset repair to be significantly smaller than one without, allowing easier installation and more space available inside the truss following the repair. The person performing the repair should take care to make sure that, if clinched nails are specified on the truss repair drawing, they are installed. Clinching the nails affects the withdrawal value of the nail allowing more force to be transferred directly to the adjoining members. If the nails are not clinched, the force transfer is greatly reduced. Most repairs that specify clinched nails will not be sufficiently sized for fasteners without clinching.

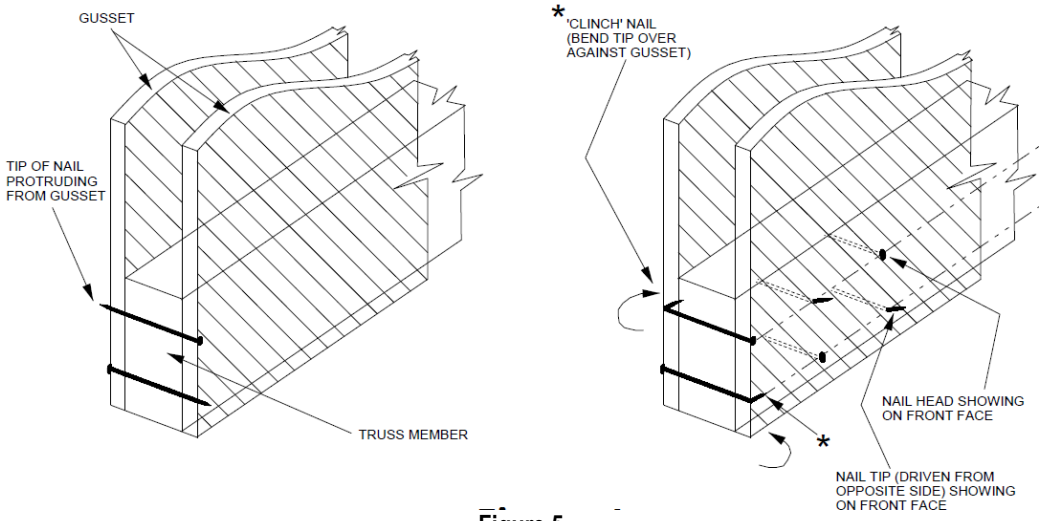

Figure 5

Truss Repairs:

Repair Considerations

When designing a truss repair, there are several items that the responsible truss designer must take into consideration in order to create an accurate and feasible solution. Items the truss designer must consider when creating a repair drawing include:

- Type of truss involved
- Stage of construction for the building
- Location of the truss in the building
- Tools and materials available to complete the repair at the jobsite
- Materials used in the truss construction
- Interferences (HVAC, plumbing, electrical, other trusses, etc.) that may affect the size and type of repair
- Location and type of damage on the truss
- Load types and locations that are supported by the repaired truss
- Number of plies in the damaged truss and how many are damaged
- Any weather resistant or fire treatment applied to the truss

Types of Common Truss Repairs

Break/Damage in Members

In situations where a member is broken or damaged not at a joint, with the exception of splice joints, the primary method of repair is to apply scabs to the truss centered on the damage/break to transfer the load carried by the original member. The responsible truss designer, based on the existing shape, materials, and loads, must determine the forces carried by the damaged/broken member. The truss designer must then calculate the scab member size and material. In most cases, the scab material may be the same size, wood species, and grade of the original member. However, the truss designer may allow alternative lumbers, based on lumber calculations for the damaged/broken member and analysis of the truss. Once the scab material is selected, the truss designer must determine the fastener to use for the repair. A typical scab repair uses nail fasteners, but depending on certain factors, alternative fasteners may be used such as screws or bolts. Following *NDS* guidelines, the truss designer will determine, based on the types of materials involved and the loads that need to be supported by the scab, the number and spacing of fasteners required for the repair. The scab will then be sized based on the size of the damage and the amount of fasteners required on each side of the damage. The preferred method of designing a scab repair is to have scabs on both sides of the truss to avoid creating eccentricity in load transfer in the scabs. However, the truss designer may determine a scab on one side of the truss is sufficient, based on several factors including truss location, loads carried by the damaged member, and truss bracing.

If a break or damage to a truss member occurs in a location that will not allow the amount of fasteners required to transfer the load before the member terminates at a joint, a different approach is required. In these instances, a plywood or OSB gusset repair may be required, similar to the methods of a missing member repair with the difference that the fasteners determined necessary to complete the transfer of load from the damaged member must be accounted for in the gusset size past the location of the damaged section.

Missing/Damaged Connector Plates:

In situations where truss connector plates are missing or have become loose or damaged, the forces that carried through the plate must be restored through a repair. If available, a portable plate press can allow the installation of a new plate to carry the necessary forces. If this option is available, it should be noted that, since the area of the original plate connector has been damaged, the new plate must be sized greater than the original to allow the plate to connect into good lumber because the tooth holding value in lumber that has had a gusset plate removed and where the wood is otherwise undamaged has been reduced by 50%. This decrease does not mean that the plate has to be 50% bigger, but that the truss designer needs to recalculate the capacity of the gusset plate with the decreased capacity. When a portable plate press is unavailable, the primary method of repair is OSB or plywood gussets to transfer the forces originally transferred through the truss connector plate.

Metal connector plates used in the construction of trusses are very strong and able to transfer large amounts of force into the wood truss members, due to the material they are made of and the number of teeth that engage each member. Gusset repairs will always be significantly larger by comparison to the metal connector plate that they are replacing. To determine the proper gusset repair, the truss designer must first determine the forces originally carried by the connector plate from all intersecting truss members. Since metal plates are stronger than OSB and plywood, the truss designer must verify that the material used for the gusset is capable of withstanding the forces it will carry when installed. The truss designer must determine the thickness and type of material used for the gusset, along with material of the members being connected in order to use *NDS* guidelines to determine the number of fasteners that will be required on each member. When sizing the gusset, the Truss designer will make sure that all members being connected can achieve the required amount of fasteners. It is imperative for the person performing the repair to verify that the repair gusset being installed is cut and positioned as called out in the Truss Repair Drawing (larger gussets may be used).

Missing Members

In situations where a member is missing from a truss, the primary method of repair is to replace the missing member with a new member the same size, grade, and species as specified on the Truss Design Drawing. The responsible truss designer may allow the use of another grade or species of wood based on their analysis of the truss. The new member must be cut to fit tightly into the location as was specified on the original Truss Design Drawing. This is especially important in members/joints that have compression forces in them because design values can change due to direct wood-to-wood contact. Since the forces being transmitted from the missing member into the joint are shared by all other members at the joint, the repair from this point is treated the same as a missing or damaged connector plate. All members in the joint must be reconnected for all of the forces that are transmitted through the joint.

Information that Should be Provided to the Truss Designer

- If available, the original Truss Design Drawing as the truss was built. If the original truss design drawing is not available, a sketch should be provided of the existing truss, showing geometry and materials (size, species, and grades) along with size and type of connector plates.
- Is the truss installed or not?
    - If installed, the stage of construction that the truss is currently in
- Is there any interference that might affect the repair (HVAC, electrical, plumbing, etc.)?
- Is the lumber damaged? If so provide:
    - Exact location of damage from a known location such as a panel point or bearing
    - Description of damage
    - Dimensions of the damaged area
    - Note any treatments applied to the truss
- Is the plate or joint damaged? If so provide:
    - Location or the Truss Design Drawing joint number of the damaged plate or joint
    - Size of the damaged plate
    - Description of plate or joint damage
    - Indicate if there is damage to one or both faces of the plate/joint
- Digital photos can save time explaining the site situation or circumstances.
- Drawings of the damage on the TDD can also help provide additional information for the truss designer.
- Available materials and or tools to complete the repair
- Any other pertinent information

Conclusion:

Though truss repair can be a complex topic, following the guidelines in this research report will ensure that the repair is completed in the safest and most economical way. When a damage condition is noticed, the truss manufacturer should be notified and provided with complete information and photos of the damage condition. Temporary bracing should be applied to the truss until a repair detail is obtained. The instructions in the repair detail should be followed completely, to prevent additional damage or rework. The repair detail should be kept and provided to the building inspector if requested.

Resources:

NDS National Design Specifications for Wood Construction with Commentary, *ANSI/AWC NDS-2012*; American Wood Council; Approval Date: Aug. 15, 2011.

American National Standard: National Design Standard for Metal Plate Connected Wood Truss Construction, *ANSI/TPI 1 – 2014*; Truss Plate Institute; Revision of *ANSI/TPI 1 – 2007*.

Additional Resources

BCSI Building Component Safety Information: Guide to Good Practice for Handling, Installing, Restraining & Bracing of Metal Plate Connected Wood Trusses 2013 Edition, Chapter *BCSI-B5: Truss Damage, Jobsite Modifications & Installation Errors*; Jointly Produced by the Structural Building Components Association and Truss Plate Institute; Updated March 2015.