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 Contact: Richard Lazarus, 63 Howland Rd, Spencer, NY 14883
607-589-4938ofc, Rick@Lazarus70.com

Recommendations for Appropriate Repairs to Historic Barns and Other agricultural Buildings

Prepared by
Richard Lazarus
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Note:

This paper was prepared as a statement of personal opinion. It is based on hands-on experience working on perhaps two hundred antique barns and timberframed houses since 1974 in and around Tompkins County, New York. This paper has been reviewed by the Technical committee of the NYSBC, and by members of the Traditional Timberframers Research and Advisory Group (Timberframers Guild of NA) and several suggested revisions have been made. However, all reviewers do not agree with all the opinions stated here, so it remains the personal opinion of the author. Many recommendations contained here are the guidelines of the US Secretary of the Interior or the NY State Office of Parks, Recreation and Historic Preservation.

General:

Please see the standards for preservation as outlined by the US Secretary of the Interior. It is important to preserve not only the original fabric of old barns but also the carpentry skills and technologies as well as the layout and framing system used to create a building from trees in the woodlot. My idea of a proper barn repair is one that, except for the glow of green wood, and perhaps a scarf joint in the frame, cannot be recognized as a repair.

Layout system:

A layout system is the method that a builder uses to mark timbers for cutting so that the intent of the building's design can be realized when it is erected.

During the period most of our historic timberframed barns were built there were three layout systems used: scribe rule, square rule, and mill rule. Repairs should be made in whatever layout system was used by the original builder, and that joinery should match the original. Using traditional layout and joinery makes sense economically as well as historically.

The barns with the magnificent heavy timbered frames were built using the scribe rule, square rule, and mill rule layout systems. These layout systems are similar. The very oldest barns in NY were built to the scribe rule. Scribe rule barns are most readily

identified by marriage marks on the layout faces of mated timbers. Marriage marks are usually scratched-in roman numerals with other identifying marks. The scribe rule died out in use pretty much before around 1820 and was replaced by the square rule layout system, which was very much in use by 1810. However TTRAG has found and identified a few frames with marriage marks that are positively square rule. We are calling them "transition frames". The mill rule is an adaptation of the square rule made possible and recognizable by the use of accurately sawn timbers

Understand the layout system and all the mysteries of timberframed barns disappear. Illiterate carpenters with only a pencil or scratch awl, a framing square and the ability to remember 10 principle dimensions of a barn could lay out all the cutting of a frame without plans. Education of modern carpenters is important in acquainting them with old time layout systems. Why ruin an old frame because of modern ignorance?
Barns timber-framed in the square rule should be repaired with replacement members cut in the square rule. Barns timber-framed in the scribe rule should be repaired with replacement members cut in the scribe rule, of course mill rule building repairs should be cut in the mill rule.

For explanation of the square rule and scribe rule, please consult the Timberframers Guild of North America. PO Box 60 Becket, Ma 01223. Phone 888-453-0879. Web site is www.tfguild.org. The guild offers publications that do an excellent job of explaining and teaching the square rule and scribe rule. Look for postings by Rudy Christian and Jack Sobon.

Starting around the turn of the Twentieth Century, barns were beginning to be built from sawn 2" sticks of various widths. (commonly called two by's). Some of these barn frames were built by nailing together two by's to resemble heavy solid timber frames (built up frames). Later, house framing (balloon framing) was adapted for building barns. Balloon framing is still widely practiced and understood by frame carpenters today. Repairing a balloon frame is usually a case of removing a rotten or broken frame member and replacing it with a stick sawn to the same size as the original and nailed into place. Repairing a built up frame is similar.

Timber:

For the most part, the earlier the barn, the more the likelihood that it was built from trees growing close to the site. The later the barn, the more likely the materials were brought in from afar. Hemlock timbers from the Southern Tier of New York were transported by rail all over the state starting with the spread of rail service. In the1890's yellow pine siding was shipped up from the south for the cost of rail transport.

If the barn is early it may contain timbers of species that are not replaceable because the species is extinct (American chestnut). Or species may have been used such as walnut, cherry, beech, tulip poplar, maple, or red oak, which have become very expensive (cherry and walnut timbers today cost almost 10 times as much as hemlock) or are inappropriate for use in the location of the original timber (most of the above species as sills, beech as

floor joists etc). If the species cannot be matched because of expense or extinction, replacement timbers may be cut from an alternate species that could or would have also been used at the time of original construction. There are small and large lumber mills all over New York. These mills buy local trees to cut and most will custom saw boards or timbers to your specifications. Lengths, however, are usually limited to less than 24 feet. In general hardwood timbers should be replaced with hardwood, softwood with softwood. Where a timber to be repaired or replaced was originally hewn, I think, in the interest of conservation, (true hewing creates a lot of waste) replacement timbers may be sawn but should be sawn to the original size of the timber to be replaced. There are those who will have a timber sawn to a larger size then hew the timber to give the appearance of hewing. This saves the flitch to be sawn into boards and creates less waste than hewing a timber from a solid log. There is a lot of extra labor involved though.

There is no place for modern dimension lumber and certainly no place for pressure-treated lumber in making repairs on historic barns. These buildings were mostly built with green lumber; they have stood the test of at least a century's time and with adequate maintenance are still standing.

Barns in the best condition had the best maintenance. I don't think that chemical treatment for rot prevention can keep a barn standing where maintenance is poor. And replacing locally sawn or hewn timbers with dimension lumber built up to match what could be a locally sawn timber matched to the original barn frame in size and joinery makes no sense economically or in a preservation sense.

There are those that would argue that using dimension lumber makes the job more affordable but I strongly disagree and am willing to back up this statement with facts and demonstration. Dimension lumber sawn in 1 1/2 " thickness cost twice as much as an equal cross section of rough cut timbers and labor time to install such built up timbers is greater because the carpenter is working and installing many more members. As far as material cost goes, suppose you are replacing a twenty foot section of 8"x10" sill. If you have an 8"x10"x20' milled locally at say $.60 per board foot, the cost of the timber would be $80. If you buy 7 - 2x8x20 at a current price of $22 each to build it up, the cost would be $144 and you end up dealing with a timber with a cross section of 7 1/2 "x10 ½". Where does the carpenter get the 1/2" of additional thickness and how does he get rid of the additional 1/2" in width? More material and more labor. How is the built up timber joined to the remaining true timbers? How does it look?

Concerning timber and board conversion from logs, as mentioned, true hewing creates a lot of waste but one may still obtain timbers of much greater lengths of one can find a suitable tree. Most modern saw mills have a limit of about twenty-four feet to the length of timber that can be sawn. Sash sawing is no longer commonly available but a modern band saw mill creates a similar tooth pattern (possibly confusing later historians). Circular sawing, which started to come into common use about the time of the civil war, is still the most widely used conversion method. Chainsaw mills are inefficient and slow and because of the large kerf cause a lot of waste, but may appropriately supply timbers for repairs. Today's economy is very different than the economy of the time most of our historic barns were built. We can tolerate less the wasting of resources of time and trees.

For this reason, it is desirable that we repair our historic barns with timbers sawn from local trees with whatever type of local sawmill can do the job most inexpensively.

Traditional joinery can make use of shorter lengths available from sawmills instead of hewing longer timbers from logs by using structural scarf joints that have been known and used since Roman times. Modern power hand tools such as saws, drills, and chain morticers can very efficiently duplicate the traditional joinery of our barns built in the nineteenth and early twentieth century and may be used at the discretion of the carpenter instead of hand tools. (The original carpenters had a wide range of tool choices to make and without a doubt chose the tool they were most comfortable with).

Foundation:

Before about 1910 almost all barn foundations were built from local stone. After 1905 portland cement started becoming available and concrete became more widely used for barn and other farmstead foundations.

Commonly, the footers for stone foundations and even concrete foundations were not placed below frost. Top layers of sod and topsoil were removed to expose hardpan where that subsoil exists or trenches were dug out to remove only sod and grass roots for a depth of a foot or so. A fieldstone footer was laid directly on this base and a foundation wall or plinth stones or concrete was laid on top of the footer.

The most common repair for the foundation of ground barns is to have to straighten the stone foundation wall or the plinths. This can be accomplished by pushing the stonework back to plumb and/or rebuilding the wall or plinth in place with the original stone or local stone after lifting the barn if necessary.

In New York State, bank barns built with fieldstone foundations are very common. And the most common failure of the foundation of these barns is that the stone bank wall is pushed into the cellar by the force of the earth backfill of the earthen bank ramp that allows access to the drive bay of the barn. In some case the stone wall has collapsed partially, in some cases the wall is leaning into the cellar and may also be partially collapsed. Stonework, whether dry laid or laid in a bed of lime mortar, is easily rebuilt where collapsed by the most inexperienced of masons and should be duplicated where rebuilding is required. If the wall is leaning, and the wall is not built from large cobbles or round field stone, the earth backfill can be dug out, the weight of the barn removed from the wall and then the foundation wall can and should be pushed back to plumb before the barn is lowered. In most cases I believe well designed steel-reinforced concrete or stone buttresses tied well to substantial footers should be installed to support the repaired wall, usually under each frame bent. Drainage should be installed on the outside of the wall before backfilling.

If the wall was built from cobbles or round field stone it should be rebuilt with the original or local stone. In some cases the stone wall has already been removed and replaced with a solid concrete or concrete block and the replacement wall is failing. In this case the recommended repair is to excavate and remove the existing wall and replace it with a new solid steel-reinforced concrete retaining wall, or to push the wall back to

plumb and install buttresses. I have successfully and inexpensively replaced old block foundation walls with 12”x16”x48” gravity blocks, which we use our crane to place.

Sills:

The sills of a barn usually fail because they rot. Sills seem to usually rot from the outside of the timber inward. The reason they rot is because they remain wet. Great-door sills are always the first to go. They are always nearer to grade than sills in other locations, and the doors, if left open, through neglect or failure of rollers or hinges, allow rain and snow to saturate them and promote rot.

Sills of a barn are like the keel of a ship. The foundation may rise and fall with the frost or spread under earth load, but the function of the sill is to keep the barn together. The original sills of a barn are usually the full length of the barn or have a scarf if the barn is longer than about fifty feet. As above in the general section, the limit in length of timbers available today without hewing is about twenty-four feet. If the waste and expense of hewing can be tolerated, the recommended way to replace sills is with lengths to match the original. Also acceptable, is to use new timbers sawn to match the hewn size, lengthened with appropriate joinery and in appropriate structural locations. The sill should function structurally as a solid timber. Not acceptable is to laminate new sills from dimension, pressure treated, or rough-cut 2x lumber. The cost of materials is always greater and a carpenter experienced in traditional framing can cut a new timber and install it faster than building it up with kiln dried dimension lumber.

Floor system:

Failure in barn floor systems is found for two reasons. Roof leaks promote rot in the flooring and joists underneath. And when the great-door sills rot, the tenons of the joists that fit into them rot also, leaving the joist ends unsupported. If only the tenon of the joist and a small part of the joist near the tenon is rotted this is an appropriate place for the use of a steel repair piece. Cut away any rotten wood and fabricate and install a structurally appropriate piece of steel fastened to the wood in a structurally appropriate manner to support the remaining joist and tie it to the sill. I usually use a piece of 2”x8”x1/4”x 60”C channel, through bolted to the end of the joist, then tied to the sill with through bolts and resting on the foundation wall. Another way to support rot-shortened joists is to timber frame a beam with posts resting on adequate footers to support a row of joists. Of course replacing the entire or a part of the joist with a timber of appropriate size using traditional joinery is more acceptable, but a bit more expensive because the flooring may have to be removed (but not necessarily). Where roof leaks or other damage cause failure in the middle of a joist, the recommended repair is to replace the joist with a new timber. Floor joists of barns built in the nineteenth century were most often log joists hewn only on one face to provide a flat surface for flooring. If a log joist is to be replaced, it should be hewn to match the original if the species is appropriate and not extinct. Hewing is not difficult to learn and logs are not expensive, so cost should not be a factor in deciding to perform repair or replacement. Many local mills will also saw flat one side of an appropriate log. Rotten or missing floorboards should be replaced using rough sawn 1x or 2x boards to match the original.

Frame above floor:

Barn roofs leak if not maintained. Tops of posts, plates, purlins, queens, and rafters rot from roof leaks. Bottoms of posts rot with sills. Tie beam tenons fail from rot and structural failure. Sometimes a roof system fails where an original gable roof system was replaced by a gambrel roof and the gambrel was poorly designed. Rafter plates always rot from the inside out and a perfectly good-looking plate may be hollowed out by rot and rodent infestation. Always check rafter plates for rotted insides by tapping them or looking down at them from the top. Often discoloration or mold signify interior rot.

Rotted sections of timbers should be replaced using new timbers of appropriate size and species joined to neighboring timbers with joinery appropriate to the age of the barn as above. Where tenons of tie beams have failed, slip tenons bound with 1/8" x 2" steel may be appropriate. Where the top or bottom of a post has rotted, it should be repaired with a new piece of like sized timber scarfed onto the remaining post and tied into the repair piece using traditional joinery. A lightning scarf or a bladed scarf tied with pegs, or a bladed and cogged scarf joint will provide adequate strength. In some cases, frequently on plates and posts, the timber is rotted in only a small surface area. In this case a dutchman may be bolted or pegged into place after removing the rotted material. Excellent discussion and drawings of this type of joinery was published by the Timber Framers Guild in a publication titled Historic American Timber Joinery by Jack Sobon (2002)

Sisters may be used under weakened plates or beside broken or failing rafters if appearance is of little concern but they must be properly supported.

Siding:

Siding repairs and replacement should be of the same species (if not extinct) and same size as the original. Even if the siding is tongue and groove or horizontal clapboards or novelty siding, local sawmills can duplicate the material.

Doors and windows:

Installing new overhead doors is not acceptable. They ruin the historic appearance of a barn. New sliding or hinged doors can usually provide the same or better accessibility, at no greater cost. Windows to be replaced should be replaced with sash to match the existing. Care should be taken to provide proper flashing where none exists. Wood head flashing is adequate and will last longer if hidden wood is painted. New great doors should match the originals and if the original door was hinged, care should be taken to reuse the original frame and hinges. Hand forged hinges can usually be reused and are not difficult to install; they are easily and inexpensively repaired by a local welding shop if broken. The outer surface of all great doors should be flat with no outside cross bucks or other bracing. New roller track and trolleys may be used if the existing hardware cannot be repaired. Man doors must present a flat surface on the outside of the barn too. In a barn that is not heated man doors may not be house doors, they should be simple board doors.

Roofing:

Since the roof of a barn protects the barn, any roofing material may be installed which will keep a barn dry. But in no case should plywood or OSB be installed over, or replace existing roof boards. It adds significant weight to the roof and destroys the historic appearance of the inside of the roof. For the most part this requirement prohibits the use of asphalt shingles except for T Tabs or Diamond tabs. Asphalt roll roofing may be installed but life expectancy is less than 15 years depending on the surface on which it is installed. Most desirable would be to install roofing to match the original. Slate, white pine, hemlock, cedar, and oak shingles and shakes are still available, and if the barn is more than ninety years old they are the most likely original roofing. A painted or galvanized steel roofing system can provide a lifetime roof for a barn when it is maintained, and it is a very desirable and inexpensive replacement roof for a barn. The use of aluminum should be avoided because it has poor longevity for the expense. Aluminum oxidizes and becomes brittle after thirty or so years of exposure

Hardware:

Modern nails and other fasteners may be used for siding and roofing. And modern door handles and other door hardware may be used outside the barn. I feel that modern hardware and nails can help date repairs for future owners if the original is missing, and do not detract from the appearance of an antique barn.

Steel, rods, and cable:

The use of steel cable is not acceptable inside a barn to tie structural elements together if the cable is wrapped around a timber. The compressive strength of wood cannot stand up to tensions that may be applied by cable wrapped around a timber.

Where the barn requires wind bracing, the existing knee braces should be tightened with shims after the barn is straightened.

Cross bracing with steel rod or cable is not acceptable in my opinion because they create obstructions within the barn and limit movement through the barn. They also destroy the beauty of the structure of a barn. And they are usually not necessary if existing knee braces are tightened as above or if they are replaced if missing.

In the case of spreading rafter plates causing a saddle in the roof, a steel rod of sufficient cross section may be installed between opposite plates secured on the outside of the rafter plate with a steel plate sized at least 12 square inches. The roof peak may be jacked as the rod is drawn in tight to get rid of the saddle. The cause of roof saddle is usually failure of the joint between the tie beam and the post. Repairing the cause of the failure frequently requires scarfing a new section onto the post and installing a slip tenon on the tie beam, or a hidden steel strap to connect it to the post.

In numerous cases it is appropriate to fabricate and install steel gussets, angles or other plates to connect sound timbers with rotted tenons. The steel repair should be designed to

be as small and unobtrusive as possible and fastenings should be well designed. Steel should be used only for the sake of economy and to save the original fabric of the barn frame.

Epoxy, fiberglass:

This is an expensive and messy repair material. The cost of the material at around $120 per cubic foot or the equivalent of approximately $10 per board foot, unreliable bonding to remaining wood, unequal thermal expansion coefficient, all point away from the use of this material for barn repairs except perhaps for window sash repair.

Bad design, pieces parts barns:

Many of our oldest barns had their gable roofs removed for the installation of gambrel roofs, which allowed greater hay storage with the use of hay tracks. In many cases these roofs were stick framed and inadequately braced. The only wind bracing provided in some of these roofs is the roof boards themselves. In barns where the wind has pushed the roof, the proper repair is to pull the rafters back to plumb and install diagonal bracing on the underneath side of the rafters using either steel strapping or boards. If a new roof is to be installed and the old roof material is stripped, diagonal strapping can be installed on the top of the roof boards and thus be hidden.

A significant number of barns were built of pieces and parts of older buildings. In many cases existing joinery of the older timbers was adapted to the new building and in many cases new joinery was cut and timbers were reused willy-nilly. In these barns I have no appropriate repair recommendations for the frame, and make structural repairs in whatever way that will keep the barn standing. Often these are extremely dangerous buildings to work on, and I usually turn down these jobs because there is no recognizable pattern or framing system to work from. However the exterior of these barns may be repaired or replaced to match the original if the structure seems sound.

Decorative elements:

No new decorative or trim elements should be applied to the outside of barns that did not exist when the barn was built; these include fancy widow and door casings, soffits, fascia, cupolas etc.

Paint:
Barns may be painted at the discretion of the owner.

Chemical preservatives:

Chemical preservatives may be harmful to livestock and to carpenters repairing barns again in the future. There is no substitute for careful craftsmanship, proper selection of materials, and maintenance, which will keep wood parts of a barn dry. However the use of boric acid solution may be appropriate in treating timbers that may still contain some rot but that are otherwise structurally sound. Boric acid is the least toxic wood preservative available and is also the least expensive.

Conclusion:

Please consider what you are doing to the history of an antique building before you or your contractor rush to a local lumber yard or hardware store for modern materials for repairs.

Richard Lazarus
63 Howland Rd.
Spencer, NY 14883
607-589-4938ofc
607-351-2394 cell
Rick@Lazarus70.com