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Property Care White Papers

Timber Frame Repair Assessment and Planning

Assessing and Planning a Timber Frame Repair

Water infiltration over time is the leading cause of deterioration in a timber frame structure. The general causes of this deterioration are from a leaky roof, failing gutters and downspouts, splash back from buildings with no gutters, improperly applied cladding, and a soil grade that pitches towards the building or is even in close contact to the sill. These conditions will expose the frame to moisture that can cause rot, invite insect infestation and eventually compromise the building's structural integrity. In other cases, modern technology added to historic buildings can weaken the framing system. The addition of heating, plumbing and electrical systems can stress a building frame when boring through posts and beams, as well as removing bracing, is required during the installation process of said systems. There may also be inherent structural issues with the building if it were poorly designed or implemented to begin with.

It is an important part of the planning process to assess the building for signs of deterioration and the possible causes. If deterioration or failure is suspected more invasive investigation, although potentially damaging to historic fabric, is the only manner in which to truly ascertain the true condition and is helpful in determining a thoughtful and comprehensive treatment plan.

Assessing and Planning a Timber Frame Repair

- Prior to the removal of any siding or exterior finish it is essential to understand and document all existing conditions and failure mechanisms. An understanding of those conditions which led to the deterioration of the existing material will help inform the treatment plan and potentially the selection and installation of new materials.
- Research and document the history and prior repairs to the building. Photographs, measured drawings, framing plans or floor plans of the building can help to understand the frame before opening the building envelope.
- If deterioration is suspected start with non-destructive investigative techniques to explore the condition of the structure. Visually inspect the building and look for signs of structural distress.
- Careful deconstruction of the focus area may be necessary in order to fully plan out the repair. Conditions may merit opening up sections of the exterior or even the interior to review the true conditions of the framing.
- Following the conditions assessment a basic Scope of Work should be identified outlining the steps of the project followed by a detailed Treatment Plan. This plan will outline the repair methodology, whether a comprehensive replacement or selective removal and replacement.
- Documentation of the work throughout the project and at its completion is critical for academic and logistical purposes in the future.

Technical Guidelines for the Assessment and Planning of a Timber Frame Repair

Prior to the removal of any siding or exterior finish it is essential to understand and document all existing conditions and failure mechanisms. An understanding of those conditions which led to the deterioration of the existing material will help inform the treatment plan and potentially the selection and installation of new materials.

- This information should be documented in the conditions assessment and Project Review Form.

Research and document the history and prior repairs to the building. Photographs, measured drawings, framing plans or floor plans of the building can help to understand the frame before opening the building envelope.

- Re-occurrence of the same damage is a clear indication that one is treating the manifestation of an issue but not the underlying cause.
- This information should be documented in the conditions assessment and Project Review Form.

If deterioration is suspected start with non-destructive investigative techniques to explore the condition of the structure. Visually inspect the building and look for signs of structural distress. Typically building features were installed level and in plumb. So if the general lines of the building are no longer level then more review is required to determine if an issue is present.

- Typical visual inspection would look for the following issues:
 - Significant cracking or bulging of interior plaster or masonry walls.
 - Visible bowing, heaving, leaning and misalignment of walls and/or floors.
 - Sagging or binding doors or windows.
 - Separation of cladding from structural frame or trim elements.
 - Dropping of siding
 - Trusses pulling away from seating points at support walls.
 - Sagging joists and rafters.
 - Noticeable dips in the roof between rafters.
- There are other techniques categorized as non-destructive techniques that a structural engineer might employ in this type of evaluation. The Structural Engineering White Papers should be consulted for additional guidance.



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Careful deconstruction of the focus area may be necessary in order to fully plan out the repair. Conditions may merit opening up sections of the exterior or even the interior to review the true conditions of the framing. Although not feasible or reasonable in all occasions, this is the manner in which one can most thoroughly assess the conditions of the framing and develop a clear and thoughtful treatment plan.

- In certain structures, such as a barn, the framing is generally accessible from the inside minimizing the need for removal of historic fabric.
- On a finished structure, the assessment will require that the building envelope be opened so that the frame can be exposed for a visual inspection.
- Plan the assessment in a similar manner to an actual repair. Be conscious of weather, site usage, and the anticipated time required to complete the assessment and secure the envelope.
- The least amount of material to be removed for assessment is ideal however it typically is necessary to remove trim, exterior cladding, the underlayment and then sheathing to access the necessary elements.
- Check the framing for deteriorated wood.
 - As a start, use a sharp tool to identify the areas with soft or punky wood. Continue checking until solid wood is reached thereby identifying the overall extent of expected repair.
 - The use of a quarter inch drill bit can expand this analysis deeper into the timber. Drill into the timber and review material that comes out with the drill bit.
 - If the bit has a clean accumulation of sound wood that section of timber is sound.
 - Compromised wood is crumbly and clearly deteriorated.
 - Check the condition of all adjoining framing members in the general location of the deterioration.
 - A small diameter bit can be used to determine overall resistance throughout timber.
- Document the existing conditions, joints and features for replication as part of the repair;
 - Photographs from all angles including shots that establish context and detail shots are the baseline level of documentation.
 - If practical, a drawing with notations should be developed to provide visual documentation of all existing conditions.
 - In lieu of a drawing annotated photographs detailing all existing conditions should be produced. This information will serve as the template to accurately reproduce the existing details in the new work.
 - In general it is essential to document the following details:
 - Existing finishing. Note tool marks, scribe marks and other identifiable markings, empty pockets.
 - Specie of the framing members. If necessary samples should be removed from inconspicuous places in order to determine the exact specie.
 - Evidence of previous use
 - Dimensions of the framing members affected

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- Extent of deterioration
 - Extant joints and connections to other timbers
 - The existence of previous repairs
 - Types of nails, trunnels and other fasteners
 - Patterning of fasteners
 - What is in the building cavity (nogging, pipes, insulation, etc)
 - The surrounding materials including foundation, seemingly unaffected framing members and interior finishes.
 - Anything that could aid dating the building, evolution of structure, differences between members.
- Secure the exterior envelope in a manner that is appropriate for the site and the length of time until the expected repair. As part of the planning of the project these details must be communicated to the site staff to make sure it will be understood.
 - Weatherproofing is a requirement but level of finish detail is determined case by case. Different methodologies include:
 - The replacement of all exterior cladding in a high sensitivity site;
 - The use of tarping and cleats if monitoring of the frame is necessary and the materials will need to be removed repeatedly;

Following the conditions assessment a basic Scope of Work should be identified outlining the steps of the project followed by a detailed Treatment Plan. This plan will outline the repair methodology, whether a comprehensive replacement or selective removal and replacement. The treatment and execution plans should consider the following as part of the work:

- The impact of the repair on the surrounding finishes – both exterior and interior.
- Removal of the exterior trim, cladding, underlayment and sheathing boards as required to provide access for full evaluation and execution of the repair. Upon completion of the required structural repair work all removed materials shall be reinstalled in their original location and orientation;
- Removal of the interior floor and subflooring to access joists and their connections to the sill or girt;
- Removal of floor joists as necessary to expose the top of the structural members;
- Identification of repair methodology including type of joints, fasteners, and whether the use of epoxies is merited;
 - Design the repair piece and all joints. A post may be connected to more than a dozen other frame members. Even a partial repair may have 5 or 6 joints.
 - Replacement joints should match the original joint
 - Repair joints merging a new section of framing to the original should take into account all of the forces on that joint including tension, compression and shear.
 - Think carefully about the installation sequence.
 - Which piece will be installed first?
 - How will the post be connected to the other frame members?

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- A timber frame is erected in a particular order, but a repair must be enacted without full disassembly of the frame.
 - In some repairs, it may be necessary to introduce new elements into the frame for structural reasons.
 - An undersized original building component may need to be reinforced by an appropriately sized member directly fastened to the original (a “sister”) or installing an additional member spaced in between framing elements.
 - A welded steel angle may be added to a post/plate connection or steel straps may be needed to properly support a joint in what was originally a full length timber.
 - Other examples could include the addition of flitch plates, or mending plates.
 - In general the use of epoxies is limited in a timber frame repair due to concerns about its performance and the affect epoxies might have on structural integrity and moisture movement.
 - Typically the repair will entail the removal of deteriorated wood until sound material is reached.
 - In certain instances where the timber is an integral part of the aesthetic or interpretation of the site epoxies and consolidants should be considered as a means in which to retain historic fabric – and specifically retain visible historic fabric.
 - The use of adhesives should also be limited so as to not introduce rigid stresses within the timber.
 - Consult with a structural engineer if the deterioration is severe or it appears that the structure was under-designed and the overall integrity of the structure is in question.
- Installation of bracing and structural support as required for the execution of the structural repair;
 - Plan jacks and bracing as needed. Jacking and bracing should be secured to the frame and redundantly backed up.
 - A failure can threaten the building, workers and visitors. Imagine the worst case scenario and design the system accordingly
 - Jacking and bracing are by their nature less stable than the structures they are temporarily replacing or supporting. They should be employed for the shortest time possible.
- Removal of the deteriorated portions of the framing members and their associated elements dependent on the type of repair;
 - Following the preservation philosophy as much material as possible should be retained. Material requiring replacement must meet the following criteria:
 - There is active biological or environmental decay that has resulted in the loss of material.
 - The material is physically damaged beyond repair. Cracks or splits should be carefully analyzed to ensure that the material cannot be repaired rather

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- than replaced. Cracks or splits can often be repaired with an adhesive and clamped in place.
 - The material is missing.
 - There is an ongoing failure mechanism in place that unless removed will continue to degrade the resource.
 - The use of epoxy consolidant and fillers might be appropriate if deterioration is limited.
 - Some framing might be connected to other materials and therefore the removal of that the framing might damage those materials.
 - An example is the connection of plaster and lath to studs – and therefore the repair of those studs will involve potential interaction with the plaster and lath.
- Fabrication and installation of in-kind replacement material and repairs to adjoining features;
 - Timbers and other materials will be replaced in kind.
 - Replacement timbers shall be fabricated to match the thickness, width and other conditions of the existing timbers to which they will join. All dimensions will be field verified by the contractor.
 - Any existing joinery or evidence thereof, including but not limited to notches or mortises, whether in use or not, shall be documented prior to removal and reproduced in the new work.
 - Replication of tooling marks is generally not necessary for most repairs but the context of the repair and the overall appearance of the feature should be taken into account.
- Specification on the use of preservatives or flashing to protect the framing from ongoing moisture damage;
 - To protect the sill from moisture or the damage caused from moisture the following might be considered:
 - Borate rods should be installed as per manufacturers specifications as a preservative.
 - A flashing detail between the sill and the foundation stones might be installed to protect the sill from moisture rising from below.
 - A flashing detail can also be used to protect the sill from moisture from adjacent sources – like high grade.
 - The use of self-adhesive flashing membrane also might be used to create a barrier between a sill and a particularly moist foundation or direct contact to grade.
 - All new wood and existing wood material that is accessible should be sprayed with a wood preservative, usually a borate product that can also serve as an insecticide.
- Labeling of all new material added;
 - Please refer to the White Paper on Labeling New Material

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- The replacement of flooring, sheathing, underlayment, cladding, and any exterior trim affected;
- Treatment and finishes for exterior materials if necessary
- Identification of the materials required for implementing the repair.
 - Replacement Timbers
 - All replacement material used shall match the existing in kind. New material shall match the specie, grain characteristics and dimensions of the existing.
 - Situations in which changes in species might be merited are documented in the White Paper on the In Kind Replacement of Wood.
 - The new material should be clear and free from all defects including twists or bows. Knots and checks should be evaluated for their affect on the structural integrity and should not be utilized if the stability is suspect.
 - Ideally the wood species has been determined during the assessment stage of the project. If that is the case then the timber can be ordered. If the identification has to wait until the project is process then lead time needs to be allowed to facilitate custom sawmill work. Certain species, such as white oak, may take several weeks to obtain, especially in larger dimensions.
 - A wide variety of different wood species were used in American timber framed buildings. White oak and white pine are the most common choices for posts, but are by no means universal. Even in the earliest records there is evidence of frames being constructed from chestnut, beech, ash (rare), fir, larch, walnut and even douglas fir in late nineteenth-century buildings.
 - While the frame is exposed the specie of all visible frame members should be positively identified and recorded in the maintenance files.
 - Large dimension timbers will usually need to be custom sawn. White pine is currently widely available and may even be stocked in some common sizes. White oak is less common, a sawmill may need several weeks to arrange with a logger or tree service to obtain suitable timber.
 - If there is a desire to obtain dendrochronological samples, the opportunity should be planned for at this time as well.
 - Trunnels
 - Typically historic joints are joined by wood trunnels and when replacing a historic joint the detailing should be replaced in kind.
 - Wood trunnels for the connection of the replacement timber joints typically should be as dense or denser that the material in which it is installed. Generally white oak unless we are matching an existing material in kind.
 - Preservatives
 - Preservatives, such as borates, provide additional protection to both new and old material and should be on all exposed material.

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- Sills close to grade should consider the installation of borate rods as per manufacturers recommendations.
- Flashing
 - Flashing between the sill and foundation to prevent excess exposure to moisture is another preventative method.
- Hardware
 - Lag bolts are typically used to connect repair joints together.
 - Hardware should be of galvanized or stainless steel
- Develop the logistical details of the treatment plan thinking about scheduling of the repair, weather protection, and ordering materials.
 - Understand and follow all applicable building codes and restrictions.
 - Determine if any of these requirements will have a negative impact upon the historic integrity of the building.
 - If so consult with your local building official to determine what steps can be taken to alleviate the requirements of the regulations.
 - Obtain the required permits both state and local.
 - Turn the Treatment Plan into detailed specifications for the project.
 - Materials, such as timber, staging, fasteners, and weather protection, require lead time and should be ordered well in advance of the start date.
 - Choose the type of weather protection.
 - Even the best temporary weather protection is more vulnerable to extreme weather events than the intact weather envelope and should not be relied upon to protect the building for long periods of time.
 - Tarps and plastic sheeting should be secured with battens and made redundant.
 - If it is necessary to stop work for any length of time, the weather protection should be inspected regularly to insure that the building is protected.
 - Staging and supports should be erected according to OSHA regulations and in a manner that allows access for all stages of the work.
 - Eg: If you need to install a 16 foot post, make sure you provide a pathway through the staging
 - Schedule the repair, taking into account weather, site usage, availability of repair materials, anticipated time required to complete the work and the schedule of any other trades that may need to be involved.
 - While repair projects are a vital part of our mission, they can be disruptive to regular site activities and visitation. Because they are often very visible to the general public as well as the visitor they need to be well managed, neat and efficient.

Documentation of the work throughout the project and at its completion is critical for academic and logistical purposes in the future.

- During the project each step should be documented through photographs, daily work logs and weekly reports. Together this documentation should illustrate the work and be thorough enough that future scholars and caregivers will be able to understand the intervention.
- If an unusual or unknown feature is uncovered work should temporarily be halted to document the feature.
 - Documentation will primarily be photographs and drawings
 - The project managers should advise the team leader if they feel the feature is academically significant and work should be postponed while the feature is properly documented by scholars.
- At the conclusion of the project the work should be summarized and differences between the original plan and the implemented work highlighted. The completion report should also include copies of all pertinent project documentation.