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GUIDELINES TO MINIMIZE MOISTURE ENTRAPMENT IN PANELIZED WOOD ROOF SYSTEMS

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INTRODUCTION

One of the most common uses of engineered wood products is in panelized roof systems. Panelized wood roof construction is a type of construction that is typically used in flat or low slope roofs for industrial and light manufacturing facilities in the Western U.S. These roof systems incorporate a wide variety of structural wood components including solid sawn lumber, glued laminated timber, wood I-joists, pre-engineered metal gusset plate wood trusses, structural panels and other proprietary wood products. It is estimated that approximately 200 million square feet of these panelized wood roofs are constructed annually.

Until the mid 1970's, virtually all of these buildings were constructed without roof insulation with the wood elements exposed on the underside. However, as the emphasis on building more energy efficient facilities increased, insulation materials applied directly to the underside of the wood roof framing members began to be used. Today the majority of panelized wood roof systems employ this type of insulation. The most commonly used insulation materials are single or multiple layer reflective foil systems or batt insulation with or without vapor retarders.

The panelized system, by the nature of its construction, consists of a number of cells or cavities which when insulated from below can create a series of dead air spaces. Since venting these cavities would appear to reduce the effectiveness of the insulation, i.e. reduce the R-value most of these facilities have been constructed with sealed or unvented air spaces between the insulation and the underside of the structural wood deck panels.

These unvented air spaces can then become a natural space for entrapment of moisture. It is well established that if roof- ceiling cavities have relatively high moisture contents, moisture can condense on cold surfaces such as metal fasteners or hangers or on the wood members during the daily thermal cycling. Moisture from outside sources (such as rain) can also be trapped in these unvented spaces. Such occurrences of condensation or moisture entrapment can lead to short and long term degradation of both the wood and steel components.

MOISTURE SOURCES

It is not the intent of this publication to provide a complete discussion on the subject of designing roofs to avoid moisture related problems and the reader is referred to one of the references listed at the end of this document for more information on this subject. However, it is important to highlight some of the possible moisture sources, which may introduce moisture into these insulated roof cavities. These possible sources of moisture can be classified into two general groupings; (a) those which occur during and immediately following the construction phase and (b) those which are generated during the use or occupancy of the facility.

The most common sources of moisture during the construction phase are:

1. The use of unseasoned or 'green" solid sawn lumber.
2. Exposing the structure to rain or snow during construction or by installing products which have been exposed to these moisture sources prior to installation, thus permitting them to absorb excess moisture.
3. Moisture that migrates to or condenses in the roof system due to the release of moisture from the curing of concrete slabs, walls and gypsum wallboard plaster.
4. Moisture from wet concrete foundations or wet soil due to poor drainage.

Moisture sources that may introduce water into the roof cavity during use or occupancy include:

1. Vapor permeability of the roof membrane.
2. Roof leaks.
3. Natural condensation due to higher internal vapor pressure which forces warm air into the cavities above the insulation. This may be particularly prevalent in relatively high humidity areas such as coastal regions.
4. Human occupancy, which can introduce up to 0.4 lbs. Of moisture per person per hour into the environment making this particularly critical in high occupancy uses such as offices and auditoriums or in building areas such as lavatories, kitchens and similar facilities.
5. Migration of moisture through concrete foundation slabs or from wet soil without adequate vapor retarders.
6. Occupancy generated moisture from operating equipment and materials handling equipment such as a wet process manufacturing operation or process clean-up procedures.
7. Moisture accumulations within the structure due to improperly designed, installed or maintained HVAC and mechanical systems.

The following Guidelines are presented to provide the building designer, contractor and owner with a series of design and construction considerations which can be utilized to minimize the potential for moisture entrapment in concealed wood roof cavities and lessen potential moisture condensation problems. It must be emphasized that the use of these Guidelines is not a guarantee that moisture problems will not occur. Proper maintenance with periodic inspections of these roof systems is strongly recommended to detect any moisture problems at an early stage when they can be more easily remedied.

MOISTURE CONTROL GUIDELINES

1. Provide positive roof slope (½:12 minimum or 1:12 preferably) to facilitate moisture movement and roof drainage.
2. Provide ventilation to outside atmosphere at high ends of roof slopes.
3. Insure proper job-site storage of materials to minimize exposure to moisture during the construction cycle.
4. Install roofing materials as soon after installation of wood roof decks as possible to minimize exposure of the wood deck to moisture sources—use temporary coverings if roofing materials cannot be installed.
5. Use dry wood, (grade stamped S-DRY), with a moisture content less than or equal to 19% <u>or</u> do not install below roof insulation materials or vapor retarders until all wood framing elements have dried to a moisture content of 19% or less at the time of installation of these insulation materials.
6. Avoid dead air spaces between the insulation or vapor retarders and the roof deck—provide ventilation of the air space above the insulation or vapor retarders to the outside atmosphere when possible.
7. Keep the airspace between the underside of the roof decking and the top of the insulation to a depth, which will avoid the need to introduce a sprinkler system above the insulation while maintaining sufficient space to allow moisture movement by natural convection currents.
8. When using any vapor retarder type of insulation, such as reflective foil insulation, cut back the reflective foil at each end of each roof cell and around metal connectors which extend below the insulation to provide a ¼" – ½" wide space to allow water vapor movement through the cavity.

(Note: tests conducted by the Reflective Insulation Manufacturers Association (RIMA) have shown that cutback reflective foil insulation will result in virtually no loss in R value if there is no forced air flow through the cavity, i.e. only natural convection exists to move air through the cavity).

9. When using batt insulation, fasten ends back ¼” – ½” from purlins to allow air movement above the batts.
10. Apply moisture retardant wood sealers at edges and mating surfaces of wood products to retard moisture absorption when transient moisture conditions are unavoidable.
11. Minimize irregularities and local discontinuities in structural wood panel surfaces to minimize roof leaks. These irregularities can be caused by metal hanger flanges or disproportionate shrinkage of connecting wood elements resulting in possible breaks in the roof covering. Avoid nails, screws, or other mechanical fasteners protruding above the surface of the roof deck.
12. Minimize interior humidity conditions through conditioning of the air in the interior environment by the use of HVAC systems, dehumidifiers, air-to-air heat exchangers, or other similar systems. Owners are encouraged to seek the guidance of a mechanical engineer to assure the proper design of these systems.
13. Insure that mechanical ventilation systems are operations, operated and not “turned off” as a cost savings measure.
14. Maintain an effective maintenance and building inspection program to detect potential problems such as roof leaks or unusual moisture conditions at an early stage so that remedial measures can be taken to avoid more costly repairs at a later date.
15. Consider the use of above roof insulation systems when costs permit.

SUGGESTED FIELD INSPECTION PROCEDURES TO DETECT POSSIBLE MOISTURE PROBLEMS IN WOOD ROOF STRUCTURES

The following recommendations are presented to provide a systematic procedure for detecting possible roof moisture problems:

1. Measure temperature and relative humidity.

    - In vacant spaces below insulation.
    - Above vapor retarder and insulation adjacent to the roof sheathing.

   Relative humidity (RH) readings in the 70% plus range can signify problems if the ambient RH of the space below is much lower.

2. Take moisture content readings in the wood members both above and below the insulation in the areas where RH and temperature readings are taken.

    - Moisture content readings in a dry use structure that read above 13% or 14% can signal potential problems.
    - Moisture content readings in the 20% and higher range will support the growth of decay fungi.

   NOTE: Moisture content readings can be higher in the winter than the summer.

3. Look for signs of condensation above the vapor retarder, particularly on steel fittings that would have to have been installed after the roof was closed in and not subject to direct rain exposure during the construction process, such as:

    - Rusting staples used to attach insulation to the roof structure,
    - Oxidation of galvanized stiffener hangers.

- Corrosion of hanger nails, exposed nail shanks, which have not penetrated framing members, and other, unprotected steel fasteners and hardware above the insulation.
- Corrosion of aluminum vapor retarder where it is in contact with ungalvanized steel hardware and fasteners.
- Free water standing on top of vapor retarder or on top of reflective insulation.
- Batt insulation sagging down or torn loose due to the weight of condensed moisture in the insulation.
- Water streaks on hangers.
- Water streaks and staining of beams and purlins at steel hardware attachment points.
- Water stain lines on beams and purlins at the level of the vapor retarder attachment.
- Mold growth on wood members particularly near joints, such as at the mating line of the roof sheathing at stiffeners, purlins, and beams.
- Decay damage or presence of decay fruiting bodies at connection locations at the mating line of the roof sheathing and stiffeners, purlins, and beams.

4. Check for moisture migrating through the floor slab and condensing under floor mats or other impervious fixtures lying on the floor.

SUMMARY

While panelized wood roof systems are relatively simple in concept, the proper design of these systems to avoid potential moisture entrapment/condensation problems can be complex. The designer must have a thorough knowledge and understanding of (a) engineered wood products and their structural capabilities, (b) the performance of these wood products when exposed to moisture, (c) roofing materials and their application to wood roof systems, (d) the design of HVAC and ventilation systems and (e) the inter-relationship between each of these design considerations in a panelized wood roof system. By applying the general construction Guidelines presented in this publication, the potential for moisture entrapment and condensation in insulated wood roofs can be minimized.

REFERENCES

The following are several of the many references available that address the problem of moisture control in roof design.

1. *Condensation Control in Timber Frame Construction*, Timber Research and Development Association (TRADA) - Stocking Lane, Hughenden Valley, High Wycombe, Buckinghamshire HP14 4ND, United Kingdom.

2. *Condensation Control in Low-Slope Roofs*, Cold Regions Research and Engineering Laboratory (CRREL) - U.S. Army Corps of Engineers, 72 Lyme Road, Hanover, NH 03755

GENERAL REFERENCES

1. *ASHRAE Handbook of Fundamentals*, American Society of Heating, Refrigeration and Air-Conditioning Engineers, Atlanta, GA

2. *Structural Uses of Wood in Adverse Environments*, Edited by Robert W. Meyer and Robert M. Kellogg, 1982, Van Nostrand Reinhold Company Inc., New York, NY.