Moisture durability for wood products

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This paper provides an overview of the various ways in which moisture (meaning the substance H_2O in any of its phases, including that sorbed within wood) can result in performance problems of wood or wood-based products in building structures. Moisture-induced problems of wood and wood products can be categorized as follows:

- *"Delamination" of adhered products*
- *Dimensional change*
- *Creep deflection*
- *Problems with fastened connections*
- *Finish failures*
- *Biological infestation.*

Members of the Building Moisture and Durability Research Team at the U.S. Forest Products Laboratory (USFPL) conduct research activities in three of these areas. Until 2005, the Team consisted of two research scientists and an engineering technician. The Team currently consists of two research scientists, a materials engineer, a general engineer, and an engineering technician.

Delamination of adhered wood products may make itself readily apparent as visible dis-bonding of members as can occur in plywood or glue-laminated members. This type of failure is believed to be considerably less prevalent than it was in past decades. In the mid-1970's, "boil-proof" adhesives largely replaced less durable adhesives in the production of construction plywood. The most recent (2007) revision of the U.S. Dept. of Commerce Product Standard for

Construction and Industrial Plywood[1] no longer recognizes plywood classes with “Interior” or “Intermediate” bonds[2]. Plywood panels classed Interior were commonplace prior to the 1970’s. Likewise, glue-laminated timbers were, before the mid-1960’s, largely adhered with casein glue. Because of this, moisture control in older buildings that were constructed with plywood or glue-laminated members may be of concern from the perspective of avoiding delamination of structural members. In buildings constructed since the 1970’s plywood, glue-laminated members, and structural composite lumber are assumed to be largely resistant to delamination caused by occasional or accidental wetting. In wood composition materials adhered with durable adhesives, (such as hardboard, oriented strandboard, or parallel strand lumber), some degradation of bonds will occur with product exposure to elevated moisture conditions, but the degradation, even when appreciably advanced, is not made apparent by visible disbonding of wood constituents (fibers or stands). The constituents are inter-leaved within the product. Even when product degradation is appreciably advanced, the constituents largely remain in an inter-leaved configuration. These products undergo irreversible thickness swelling when exposed to elevated moisture conditions. They can be made to show limited (and in some cases appreciably limited) irreversible thickness swelling, but all wood composition materials made from interleaved wood constituents will display some irreversible thickness swelling when exposed to soaking conditions. An increase in water absorptivity accompanies irreversible thickness swelling. In hardboard siding, which will be exposed to wetting at some time during its service life, “edge welting” and “surface deconsolidation” have sometimes been problematic performance attributes; these attributes are associated with irreversible thickness swelling. Members of the Building Moisture and Durability Research Team have performed empirical and experimental research concerning the performance of hardboard siding in environments of appreciable moisture exposure. The Team is performing research concerning the performance of strandboard sheathing in response to cyclic seasonal moisture fluctuations.

The anisotropic dimensional change attributes of wood that are associated with changes in moisture content have been well-characterized for slightly less than a century. Before they were well-characterized, they were nonetheless rec-

[1] This Voluntary Product Standard is designated PS-1.
[2] These classes can be found in the 1995 (and earlier versions) of PS-1.

ognized by woodcrafters. Warp, surface checking, compression-set shrinkage, and buckling of panels are all undesirable performance attributes that are associated with restrained dimensional movement. Irreversible thickness swelling of wood composition materials is associated with moisture-induced dimensional change of their wood constituents, although relaxation of elastic strains induced within the constituents by the pressing operation plays the prominent role. The relaxation of elastic strains within constituents occurs by the phenomenon of mechano-sorption. In recent years, truss arching (in insulated attics) and end-joint opening of wood siding have sometimes become problematic. These result from moisture-induced dimensional change in the longitudinal direction that is not of an insignificant amount. A common assumption is however made that dimensional change in the longitudinal direction is insignificant. When this incorrect assumption is made, the dimensional movement that occurs is not accounted for, and problematic behavior results. In the view of this author, moisture-induced dimensional changes can be effectively dealt with by a combination of component design, building design, and building moisture management. Dimensional movement is not a field in which the Building Moisture and Durability Research Team has conducted experimental research.

Creep deflection will occur in structural members that are heavily loaded. It is well-recognized that changes in moisture content while members are under load exacerbates creep deflection. The term “mechano-sorption” reflects the recognized influence that moisture content changes have on mechanical behavior of members under load. Creep deflection can be noticeable in buildings constructed before the adoption of building codes, and tends to be more prevalent in buildings constructed for persons of modest financial means. These buildings may be framed with under-sized members. An appreciable number of these buildings still exist in the housing stock of the United States (Figure 1). The phenomenon of creep deflection is largely ignored in new construction. The reason for this is not entirely clear, but a plausible explanation is that new buildings are typically framed with members of such size that they are lightly loaded and thus unlikely to undergo noticeable creep deflection. Consideration of creep by the National Design Specification is confined to a deflection allowance for members in bending; it specifies that a higher amount of anticipated creep deflection be calculated for wood beam members installed in a green condition and maintained in a dry environment. The existence of this caution in the National Design Specification (NDS) most likely reflects that in the state of California, residential buildings are typically constructed with green (unseasoned) lumber. The NDS does

not address creep deflection under seasonal moisture cycling; it thus apparently assumes that seasonal moisture fluctuations will be modest. Control of creep deflection is not a field in which the Building Moisture and Durability Research Team has conducted experimental research.

Figure 1. Noticeable sag of rafters on a single-story home of modest size, constructed in 1940. At the time of construction, regional building codes had not been developed.

Fastened connections are subject to weakening by three moisture-induced phenomena: loosening of connections with moisture cycling, iron-catalysed degradation of wood substance in the proximity of fasteners, and fastener corrosion. The National Design Specification specifies load adjustment factors for mechanical connections based on wood moisture content at time of joint fabrication and on in-service moisture content. The NDS does not address the effect of repetitive moisture cycling on the load carrying capacity of fastened joints, apparently assuming that significant moisture fluctuations do not occur in service. Likewise, the NDS does not address the effect of fastener corrosion on load capacity of joints. A current member of the Building Moisture and Durability Research Team has expertise in characterizing corrosion parameters of a variety of ferrous metal fasteners. This is an area of research focus for the Team.

The failure of exterior paint on insulated buildings in the 1930's and 1940's led to the development of moisture control theory for buildings. Exterior paint

failures can still be observed in cold climates in the United States. They are most prevalent on older buildings, which tend to lack interior vapor retarders and have fairly vapor-permeable sheathings. In contemporary construction, exterior paint failure caused by cold weather moisture accumulation is relatively rare. In contemporary construction seasonal moisture accumulation in strandboard sheathing is typically of greater concern than is failure of exterior finishes. The Building Moisture and Durability Research Team is involved in the issue of limiting seasonal moisture accumulation in exterior building walls in cold climates, but primarily for reasons other than failure of exterior finishes.

The role of moisture in biological infestation is usually considered as more significant than any other role with regard to the performance of wood and wood products. In the case of mold, biological infestation can render the substrate unserviceable without physically destroying it. In the case of carpenter ants, biological infestation will physically damage the substrate, even though the infesting agent does not consume the substrate for nutritional sustenance. In contrast, wood decay fungi and termites destroy wood substrates while consuming them for nutritional sustenance. The Building Moisture and Durability Research Team has expertise in this field, with an emphasis on decay infestation. This is a field of ongoing emphasis within the Team.

Conclusion

The Building Moisture and Durability Research Team at USFPL maintains active research in three of the six general problem areas relating to performance for wood and wood-based products. The number of researchers on the Team has increased over the last five years, as the importance of the Team to the mission of USFPL has gained recognition.

Reference

American Forest and Paper Association. National Design Specification for Wood Construction: ANSI/AF&PA NDS-2001.

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VTT SYMPOSIUM 263

Keywords: biomaterial, wood, fiber, composite, packaging, passive building

2009 Wood and Fiber Product Seminar

VTT and USDA Joint Activity

September 22–23, 2009

Edited by

Ali Harlin & Minna Vikman

Organised by

VTT

ISBN 978-951-38-7589-3 (soft back ed.)
ISSN 0357–9387 (soft back ed.)

ISBN 978-951-38-7590-9 (URL: http://www.vtt.fi/publications/index.jsp)
ISSN 1455–0873 (URL: http://www.vtt.fi/publications/index.jsp)

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puh. vaihde 020 722 111, faksi 020 722 4374

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Edita Prima Oy, Helsinki 2010