MOISTURE CONTENT AND KILN BUILDINGS

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Since moisture content is the theme of this joint seasoning meeting, I would like to bring out one phase of moisture content that is quite different from those generally discussed: that of moisture content in kiln buildings. High moisture content is a very damaging factor in kiln performance and maintenance. Moisture carries destructive agents from kiln vapors to damage mortar joints in kiln buildings. Moisture enters structural concrete to rust the iron reinforcing rods. It both corrodes and erodes metal parts elsewhere in the kilns. It also fills the insulation in the roofs. Most damaging of all are its effects on wooden buildings. In fact, water combined with high kiln temperatures create many serious problems. Water in excess, wherever found, is the number one culprit, and construction methods in general use do little to remedy the situation.

Lumber dry kiln buildings, in general, are constructed about the same now as they have been in the past. Some improvements have been made. Insulation is being used more now as an aid to better economy and performance. As in the modern insulated house, the problems of moisture condensation arise. But in a dry kiln building the situation is more serious.

Source of Moisture

Try to imagine the tropical hurricane that is formed inside of a dry kiln. The weather inside of the building is far more severe most of the time than on the outside. Weather in this case is hot and often humid. In most kiln buildings the best moisture barrier is placed on the outside to keep weather out but oddly enough, the amount of water which falls as rain or snow from without is actually very small compared to that which is

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formed most of the time during the drying of lumber. It would seem logical, then, to keep the water out of the walls and roof, by the best possible inner barrier and to allow that which creeps through to escape freely to the outside. Instead, the inside is generally painted with a standard coating when the kiln is built, and on top of the roof is laid a much better moisture barrier, a 3-layer built-up roof of felt and asphalt to keep out the rain and snow. It does this, all right, but at the same time much of the water that comes through the inner kiln coating in the form of vapor is contained within the roof. The walls which have no built-up outer moisture barrier are not affected, but the roof eventually becomes loaded with water. Tests show the moisture content in the roof may be 150 percent and higher. There may be so much water under this outer roof covering that when punctured the water spurts out like a miniature geyser.

What actually causes this? The answer is simple. Tests using all classes of coatings show that no perfect vapor barrier is available. A small amount of water vapor constantly passing through the inner coating travels through the wall or ceiling until it comes in contact with the cooler zone near the surface. At this point, the vapor condenses into the form of liquid water. If no outer vapor barrier were present, it could pass on out by evaporation at the surface. This happens at most outer walls. But on the roof with its good 3-layer barrier, very little water can escape.

Effect on Kiln Life

As we have said before, the water and the high temperature work together to shorten kiln life. Wooden kiln roofs seldom last more than 6-8 years. The walls may outlast two roofs. They don't have an outer vapor barrier and so are drier. Concrete is thought to be everlasting. This may not be true when water condenses on the reinforcing rods and corrodes them.
The effect of the corrosion is two-fold. First, rust breaks the mechanical bond between the rod and the concrete. This weakens the strength in tension supplied by the rods. Second, the rods actually grow in size as the rust forms on them, because the iron oxide occupies more space than the iron it replaces. This enlargement continues as the coating thickens, eventually exerting force enough to break the surrounding concrete, causing it to spall away. The damage is sometimes great enough to cause complete roof failure. The damage to wooden roofs, although different in nature, may be equally severe.

**Effect on Insulation**

Water also decreases the insulating value of building materials. This is important because heat losses increase drying costs. Concrete roofs are generally insulated because concrete is a poor insulating material. A lightweight concrete aggregate is commonly used. A 6-1 vermiculite to Portland cement is the usual mixture. A 6-inch layer of this is poured over the structural concrete roof, and a standard 3-layer mopped felt and asphalt is placed overall. This insulating concrete is a very effective means of keeping heat losses down when it is dry. But when wet, part of its insulating value is lost. You can test this effect for yourself at home with your wife's pot holder. When dry this pad, made up of several layers of cloth, has many air spaces which retard the passage of heat. But if wet, the protective air spaces are filled. If you use a wet holder on a hot pan, you are likely to get burned before you realize what is happening.

**Suggestions for Improvement**

Several possibilities have been considered in the effort to keep the water out of kiln walls and ceilings. Either a perfect interior coating is needed or some method of allowing the water vapor to pass out of
the structure faster than it enters from within. If it were possible to permit the escape of vapor from within, while excluding the rain and snow from above, so much the better.

The search for more effective inner coatings is going on continually. Many types have been tested, including aluminum foil sealed with mastic. Tests made by the Western Pine Laboratory have shown that none of these have proved to be completely impervious to the passage of moisture. It is necessary to provide for the escape of water from the roof as long as the inner coating allows any water to come through. If this is done, most of the currently available inner coatings are satisfactory when properly applied and maintained.

Several methods of drying out the present insulated roofs have been tried at different plants. In one instance, long narrow sections of the roofing paper have been removed. A continuous ventilator is built along these openings to allow the escape of the moisture. In other instances, the paper has been opened at the seams to permit "breathing" at these points. In still another, ventilation is achieved by means of a raised weather roof. A variation of this raises the weather roof to full head room height to give full ventilation through open sides.

Although these trials have not resulted in an ideal solution of the problem, the benefits shown indicate that they are a step in the right direction. The results have led us to study the problem more extensively.

One method is to omit the outer covering, but with this there is danger of leakage through the roof onto the lumber. A weather roof of 1" shiplap raised above the regular roof by 2x4s or 2x6s on edge spaced on 2½" centers, will provide protection from rain or snow and also make a ventilated air space through which moisture can escape. On a sloped roof
the weather roof can be covered with either corrugated metal or rolled roofing (Fig. 1).

The weather roof should project past the wall to make an air scoop for increased air movement. A flat roof that extends over several dry kilns will need extra ventilation. Continuous ventilators down the center of each kiln will help remove the moisture and also serve as a catwalk (Fig. 2).

The Western Pine Laboratory is testing a more promising method of getting the moisture out of the roof by applying a roof coating that selectively passes vapor from the roof but repels the entry of free water from above. Several products have this property, in a general way, the silicone resins have an exceptional capacity for repelling free water while still allowing the passage of water vapor. They bond chemically to siliceous materials, such as the cement in concrete or in vermiculite insulating concrete. This creates a surface zone rather than a coating. Since it is a good water barrier, it reduces the effect of freezing and thawing. The suggested application is in the form of a solution applied to the insulating concrete after it has become thoroughly dry. Applied at the rate of a gallon per 100 square feet, it costs $3.25 to $4 cents per square foot. The manufacturers consider the effective life to be many years.

Our Laboratory is also testing the possibilities of using this same principle for wooden roofs, using water repellents adapted for wood. In this case, the general weakness of water repellents, that of passing moisture vapor and yet repelling liquid water, makes it useful in this instance. There are a number of these products. The least expensive of these is a paraffin wax solution. This would have to be re-applied every year or so, but the cost is very low. A building paper used between wooden roof layers
Fig. 1 - Ventilated roof design - sloped.

Fig. 2 - Ventilated roof design - flat, showing catwalk vent.
should pass vapor freely, its only purpose being to restrict wind flow. Such types are rosin sized or 15 lb. asphalt paper.

Conclusion

I have told you about some of our research that has been undertaken to solve the problems of increased kiln life by reduction of moisture content within the structure. No single product or method is the answer. The greatest opportunity for a solution lies in improved construction practices.

The developments in our field tests are being carefully evaluated and will be reported to you from time to time. The results, so far, are very encouraging.