DRYING PRESERVATIVE TREATED WOOD

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The subjects to be discussed in this paper are related to the kiln drying of wood products which have been treated with water-borne salts. The main reason for proposing this topic is the increasing interest which is being shown in the concept of preserved wood foundations. Materials for this end use presently comprise the bulk of treated products requiring kiln drying. A second example would be interior plywood paneling which is treated with water-borne fire retardant salts. The kiln operator obviously should play an important role in the production of an acceptable end product, and there are some interesting problems involved which he should be fully aware of.

The preserved wood foundation system is an extension of the familiar wood-frame house with the frame walls carried below ground to serve as the foundation. All of the wood exposed to the decay hazard is pressure treated with chemical preservatives. The chemicals permanently impregnate the wood cells to penetration and concentration levels that make the wood resistant to attack by decay organisms and termites. The treated material is then dried to the normal 19 percent moisture content limit. Construction can take place in most weather conditions and can be completed faster than with traditional foundations, resulting in reduced construction time and lower labour costs.

In the complete production of treated lumber, the kiln operator should see the lumber pass through his hands twice. First, the green lumber which is to be treated must be dried to a moisture content of 25-30 percent or less. This can be referred to as the initial drying process. The purpose of the initial drying is to remove at least all of the free water in the wood which is to be treated, so that more preservative can be forced in under pressure. There is very little difference in the initial drying of this lumber from the usual drying of green lumber which is to be sold simply as kiln dried. The only real difference is that the target moisture content is higher than in the case of kiln dried lumber, where at least 95 percent of a shipment should have a moisture content not exceeding 19 percent. This is not to say that any less care should be taken in the drying of lumber which is going to be treated, since any degrade which is introduced into the lumber at this stage, for example, warp and splits due to poor piling, will probably be made worse in the later stages of the process.

The most effective treating method is to force preservative solution into the wood in a large pressure vessel or retort at pressures up to 150 psi. A preliminary vacuum may be applied to remove air from the wood cell cavities so that the preservative can saturate the wood, this is called a 'full-cell' treatment. Alternatively an 'empty-cell' process may be used where the air is left in the wood, so that it is compressed during treatment and 'kicks-back' most of the solution when the pressure is taken off. The process which is used is related to the amount of preservative that is required in the wood, and this in turn is controlled by the intended end use of the wood and the severity of the decay hazard likely to be encountered.

The treating solutions which are used are composed of a number of salts dissolved in water. The two most common water-borne preservatives used in pressure applications are chromated copper arsenate, CCA (of which there are three different formulations) and ammoniacal copper arsenite, ACA.

The moisture content of the lumber or plywood after treatment will vary according to a number of factors. First, the type of treatment; 'full-cell' treatment leaves cell lumens essentially full of preservative, 'empty-cell' treatment leaves cell lumens essentially empty. Second, the duration of the treatment and the amount of salts required to be deposited in the wood; to obtain high salt levels more solution may have to be forced in. Third, the wood itself; if in the initial drying any free water if left in the wood, then preservative solution cannot fill that space. This may be brought about deliberately, for example, a particular situation may require that only the outer layer of the wood be treated, therefore initial drying would proceed only long enough to remove free water from these areas. Some wood types are virtually untreatable, interior Douglas-fir for example, where the moisture content after attempted treatment may not be much higher than after initial drying.

Following 'full-cell' treatment to high salt retention levels it is usual for treatable lumber to have a moisture content higher than the original green moisture content. Coastal western hemlock will be found to have a moisture content between 90 and 120 percent after being treated to the loadings required for wood foundations. Similarly, treated permeable pine lumber in other areas has moisture contents in the 140 to 150 percent range. Eastern white pine treated with water-borne fire retardant salts to very high retentions can have moisture contents exceeding 200 percent.

The drying of treated lumber takes longer than the drying of green lumber, even taking into account that the target moisture content before treating is 25-30 percent, and less than 19 percent after treatment. The most obvious reason for the longer time is the higher moisture content after treatment but this is only a small part of the cause. The condition of the wood itself is changed in the initial drying so that the free water can no longer move so freely.

The pathways for free water flow in the drying of softwoods are the bordered pits in the cell walls. The principal feature of a bordered pit is the membranous material which appears to divide the two adjacent cells, and particularly the thickened central area of this pit membrane which is called the torus. The membrane surrounding the torus is called the margo and it consists of strands of microfibrils radiating from the torus to the periphery of the pit chamber. The openings between the microfibrils permit the passage of fluids through the pit membrane. However, the torus may move from its central position to one side of the pit chamber and it can then act as a valve to prevent the flow of liquid. A bordered pit in this condition is said to be aspirated.

Pits in this condition are frequently found in the heartwood and much less in the sapwood. This is one of the reasons why liquid flow is more easily obtained in the sapwood. Pit aspiration is a natural consequence in the ageing and maturing of a tree as sapwood changes to heartwood. It can also occur as sapwood dries, the capillary forces developed when free water leaves the sapwood cell lumens cause the torus to move to one of the pit aperatures effectively closing that passage. It has been found that as the green sapwood of softwoods dries, the proportion of aspirated pits gradually increases until fibre saturation point is reached, by which time most but not all of the pits have become aspirated.

The main feature about pit aspiration is that it is not reversible. While the initial drying may take place from very permeable wood, the amount of pit aspiration that accompanies this drying makes the wood much less permeable during the redrying. Because many of the passageways for flow are irreversibly closed in the first drying, the redrying is therefore much slower. Note that not all pits become aspirated otherwise penetration would be nearly impossible. The small number left unaspirated are sufficient for full penetration, but are incapable of allowing the drying of free water at the previous rate.

Another important consequence of the relative impermeability of the treated wood is that in redrying there is a much greater tendency for degrade to develop. A number of studies have shown that moisture content gradients are very much steeper during the drying of treated wood than drying of comparable green wood. Therefore there is a very much greater shrinkage difference between the dry shell and the wet core and this can be accompanied by severe surface checking. Referring back to the initial drying, if the wood was dried to only 25 percent moisture content then very little shrinkage would have developed and degrade would likely be slight. In redrying to a lower target moisture content after treatment, much more shrinkage will develop and therefore much more degrade can be expected.

This can cause serious problems in lumber and poles that are only partially dried before treatment. Surface checks which begin during initial drying to 25 percent moisture content close up during preservative treatment as the wood is wetted and swells, but they reopen and deepen during redrying. How much they deepen depends on how much redrying is done and the moisture content they finally attain in service. In this way untreated wood may be exposed by the deepening surface checks and a decay hazard may develop. Ideally this problem should be avoided by specifying that the wood be seasoned initially to the expected in-service moisture content before treating. Unfortunately this is seldom practical especially for large timbers.

In addition to reduced permeability caused by pit aspiration, there can be further reduced permeability due to deposition of salts on cell walls and pit membranes.

The kiln operator is therefore faced with the same lumber showing very different drying characteristics before and after treatment. If checks and splits must be limited, then extra care must be taken in the redrying. In practice, the treated lumber is often allowed to air-dry for a time before being placed in the kiln. This allows a portion of the free water to evaporate at low temperatures and the danger of degrade is reduced. In any event the drying schedule used in the kiln should not be more severe than that used in the drying of green lumber if degrade due to shrinkage differences is to be avoided. If an appreciable amount of surface checking has already developed during the initial drying, then a less severe schedule should be used in the redrying.

The problem of drying degrade is less likely to occur with fire-retardant treated lumber. Very high loadings of salts must be retained in the wood and the presence of these salts greatly reduces the tendency of the wood to check. This is a situation where the slow drying of the wood following pressure treatment can be overcome by using more severe and faster schedules. Some restrictions have been introduced however to limit the temperatures which can be used in drying fire-retardant treated lumber, since it has been found that redrying at high temperatures causes appreciable strength reductions.

Another serious problem facing the kiln operator is how to measure the moisture content of treated lumber. The most accurate method for moisture content determination at any time is to take small specimens for oven-drying. This is usually impractical in industrial kiln drying operations, so for convenience, electric moisture meters are used. The readings of these meters are based on the relationship between moisture content and the electrical properties of wood. These electrical properties, however, depend to some extent on factors other than moisture content. Some of these factors can be determined readily and the meter readings can be corrected for their effect. Examples are species, temperature, and to a limited extent, wood density. Some factors cannot readily be determined, so these factors introduce some degree of uncertainty into the meter readings. Examples are uneven moisture distribution, abnormal wood structure and the presence of chemicals in the wood. Wood preservatives fall into the latter category.

Attempts have been made to obtain correction factors for the resistance type moisture meter when it is used on CCA treated wood. Tables have been published for a few species showing that the presence of CCA increases the electrical conductivity of the wood so that the wood is actually drier than the meter indicates. Much more reliability can be placed on the correction tables when the wood moisture content is around 12 percent than when it is 18-21 percent. Ideally, tables for this purpose should take into account the amount and distribution of the particular preservative formulation for each species tested. Even then some reliable authorities on moisture meters caution that corrected readings are subject to considerable uncertainty.

If close control of moisture content is desired then the sample board method should be used whereby a number of prepared boards can be withdrawn from the kiln charge and weighted periodically to gauge the progress of drying. If, over a period of time, the same lumber species and sizes are treated to the same loading of preservative and dried in the same kiln by the same schedule, then the sample board method need be used only a few times to give the required drying times and then dispensed with.

Questions have been asked regarding the health hazard to kiln operators who handle and dry CCA and ACA treated wood. When wet lumber is being handled after treatment one must wear gloves to keep the solution off the hands, and particular care should be taken in washing hands before handling food. During the drying of CCA treated lumber, there is no danger at all, the arsenic in the wood does not go into a gaseous form and therefore cannot be inhaled. The ammonia in ACA treated wood could be dangerous if one entered the kiln during drying, but other than that there is no danger. Any free ammonia gas will be vented from the roof-top vents in the kiln during the course of drying.

While discussing hazards, the subject of possible kiln corrosion arises. No corrosion problems due directly to CCA are likely to arise in a kiln drying CCA treated lumber, therefore no special precautions are required. The ammonia in ACA treated wood will attack copper, so any fittings made of copper, or alloys containing copper, must be avoided. No short-term damage to aluminum by ammonia has been found but for long term protection it may be wise to coat the inside of an aluminum kiln with a suitable paint or lacquer. Concrete block kilns with mortar joints must be protected with an internal vapor barrier. Particular attention must be paid to keep dissimilar metals out of contact with one another.

The drying of treated plywood raises more questions for the kiln operator particularly since there are almost no published schedules to guide him. Plywood for preserved wood foundations is treated to the same salt retention as lumber, namely 0.6 pounds per cubic foot. Moisture contents after treatment usually range from 90 to 120 percent.

Several plants in the Vancouver area have developed their own drying schedules for 1/2 inch and 5/8 inch treated plywood but their drying times are very variable. In some plants the drying times used are twice as long as in others. Due to this diversity of approaches, the WFPL has undertaken a study program which involves testing a wide range of schedules to identify those which provide shortest drying times with an acceptable end product. While our testing is not yet complete, it seems that higher dry bulb temperatures can be used safely, than those being used locally.

A comment that is often made by the kiln operators is that they do not use high temperatures because the plywood becomes too brittle. Our results suggest that the drying temperature is not the factor causing brittleness and excessive surface checking, but that the schedule has been continued too long. Again, moisture meters should not be relied on to monitor the progress of drying, but the sample board method should be used for a number of kiln runs to ensure that the average moisture content of the plywood charge does not fall below 15 percent.

Sticker spacing for plywood can be dealt with in a number of ways. Some plants place stickers between every two sheets of plywood so that with 1/2 inch sheets the moisture is being withdrawn from 1 inch of wood. This practice originated with drying interior fire retardant treated panels, where sticker markings were a problem for applying a clear finish. By doubling up the sheets, one face of each sheet remained free of sticker marks. This consideration is not needed for preserved wood foundation plywood, but nevertheless the practice is being used. More plywood can be put in the kiln using this method, but laboratory tests have indicated that overall kiln throughput is not increased since with 1/2 inch sheets the increased kiln capacity is exactly offset by the longer time required to dry the 1 inch thickness. It is interesting to note that the drying from only one side of each sheet does not cause warp despite the large difference in moisture content between inner and outer faces.

Five 1 by 3 inch stickers are sufficient for 8 ft. plywood sheets so that there is a 2 ft. spacing between them. This assumes that the air is directed across the width of the sheets but if it is directed along the length then 3, 8 ft. 1 x 3 inch stickers will likewise give a 2 ft. spacing.

The degrade that can develop during drying of plywood is surface checking and delamination. We use a sonic detector to delineate the areas where delaminations or blisters have developed between inner plies. This non destructive test is done first on the dry plywood as it is supplied by the mill, and then on the treated plywood after redrying. In general there is always an increase in blister area after redrying, and this increase is greater with higher redrying temperatures.

Our laboratory trials with CCA treated plywood will be completed in a few months, at which time we intend running confirmatory tests with ACA and fire-retardant treated panels to check whether the conclusions and recommendations are the same.

QUESTIONS AND ANSWERS

Q. It was interesting to hear of the unreliability of the moisture meter readings, especially when it's cold.

A. I wouldn't say necessarily when it's cold. The resistance moisture meter is unreliable at high moisture contents, 19 - 22% range, with any treated product. The correction factors will vary.

Q. Would you be a source to talk to on this if we had a question about it?

A. Yes.

Q. Are you going to produce kiln schedules on CCA and ACA treated lumber and plywood?

A. Our research is only on treated plywood, and upon completion of the tests, we will make public the best schedules.

Q. This is more of a comment than a question. Wood does not normally decay when its moisture content is below about 19 percent. We are dealing with wood foundations where the moisture content in the surface would usually be above 19%. Possibly, we might expect some review of the standards whereby the second drying does not require a 19% limit or a higher moisture content might be acceptable.

A. I might add that currently in Canada and the United States surveys are being conducted on existing wood foundations in service to establish what the equilibrium moisture content is for various times of the year. This information should provide the basis for final moisture content requirements.