EFFECTS OF PRESERVATIVE TREATMENTS ON THE AXIAL LOAD CHARACTERISTICS OF NAILED WOOD JOINTS

by

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INTRODUCTION

Nailed joints, fabricated from various combinations of nails and timbers provide the most common type of mechanical fastening for farm structures. Resistance to loading is affected by such nail characteristics as diameter, length, surface finish or coating and point design. Strength is also affected by wood properties such as density, direction of grain, whether hardwood or softwood, presence of defects and variations in moisture content.

Many of these properties have been investigated by research organizations and results have been incorporated into various Timber Design Manuals and Handbooks (1, 2, 4, 5). Recommendations in these publications apply to lumber which has not been subjected to any type of preservative treatment prior to construction. Modern structures, and particularly farm buildings, frequently employ preservative treated lumber in the design to prevent or impede the ravages of wood decay and thus extend the life of structures. The nature of treatment is such that fibres of wood members are penetrated by preservative chemical which could affect joint strength characteristics. The objective of this paper is to report on the axial load characteristics of nailed joints in one species of wood (Ponderosa Pine) subjected to: (a) pressure treated pentachlorophenol, (b) pressure treated creosote, (c) vacuum treated pentachlorophenol.

PROCEDURE

Ponderosa Pine lumber was chosen for the investigation since this species of wood displays minor diferences between heartwood and sapwood. This lumber accepts preservative chemical readily, both in heartwood and sapwood and has high capacity for retention of preservative chemical.

One 2" x 16" x 16' plank and three 1" x 12" x 14' boards, typical of the species and free from knots were selected. Material for the main specimen joint members were cut from the plank into strips having dimensions approximately 1⅝" x 2" x 14' to be used for splice plates. Lengths of 42 inches, each sufficient for five specimen joints (each joint component was 8 inches long, were selected at random from the cut pieces. Four bundles were assembled from the selected pieces and each bundle contained adequate material for fifteen specimen joints. Preservative chemical treatment was applied to three of the bundles as required and components for the joints were cut from this material after treatment. One bundle received no treatment and was used to fabricate the control joints.

Each bundle of material contained four 42 inch pieces selected at random from the main plank and nine 42 inch pieces selected at random from the three boards. It was found that variations in retention of preservative chemical occurred within single planks and between similar boards which can be observed in Table I. Retention differences found within the plank material were not as great as those found in the splice plate material. It is of interest to note this variation as they occurred in the selected Ponderosa Pine plank and boards.

Smooth box, galvanized box and annular ring shank nails, all 8d (2½ inch), were selected for the study in order to obtain comparisons between nail types and preservative treatments. Five joints were fabricated from each of the three selected treatments and also from control lumber (no treatment). Each of the three nail types were used on all sets of five joints to make a total of 60 specimen joints. Individual pieces from all bundles (treated and non-treated) had at least one joint made up with each of the three selected nail types and two of some types. In no instance was a strip of material from any bundle

TABLE I

PRESERVATIVE CHEMICAL RETENTION IN EACH BUNDLE OF RANDOM SELECTED MATERIAL IN POUNDS PER CUBIC FOOT

Plank Material	Vacuum Pentachlorophenol	Pressure Creosote	Pressure Pentachlorophenol
1	5.6	10.33	13.76
2	6.0	14.33	12.77
3	3.6	11.43	15.08
4	4.17	14.65	12.41
1	1.04	7.09	2.75
2	1.56	6.19	3.21
3	9.26	12.88	5.07
4	3.20	35.38	16.29
5	5.00	20.79	18.08
6	4.78	39.26	16.33
7	7.23	25.41	15.55
8	7.82	24.65	16.40
9	6.32	14.83	11.27

used to fabricate five specimen joints with the same nail type. A jig was employed to fabricate all joints, as shown in figure 1. Ten nails were

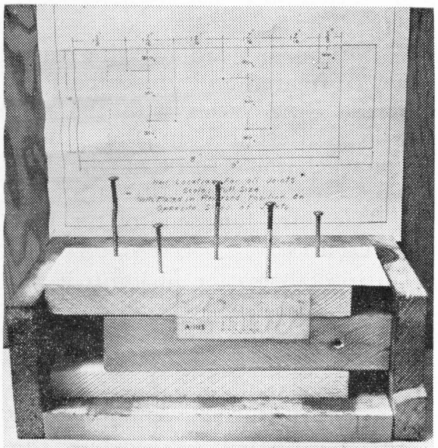


Figure 1. Fabrication jig and template for nail location. Note vernier on face of joint for measurement of slip under load.

placed in each joint, five in each splice plate. A template was used to insure that nail locations would be similar on all joints. It was expected that ten nails would result in axial loads of such magnitude that good comparisons could be made.

The choice of 8d (2½ inch) nails allowed for close approximation of the Wood Handbook recommendations (4) for depth of penetration into joint members.

Two vernier cards were placed on each joint in order that slip could be observed as loads were applied to the joints.

Following fabrication all specimen joints were loaded to their ultimate strength in a compression testing machine which had a rate of travel of approximately 0.05 inches per minute. Typical specimen joints, after loading to ultimate strength, are shown in Figure 2.

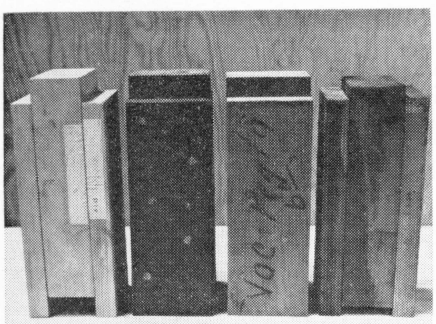
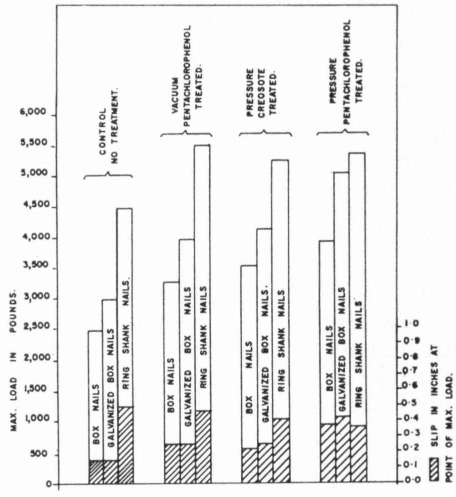


Figure 2. Typical specimen joints after loading to ultimate strength — using galvanized box nails. (left to right) Control, pressure creosote, vacuum pentachlorophenol, pressure pentachlorophenol.

RESULTS AND DISCUSSION

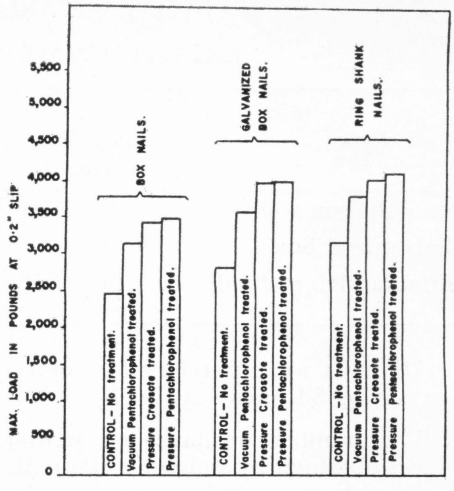
Results for each set of 5 joints were averaged and plotted to obtain graphs 1 and 2. Graph 1 compares axial load characteristics of the three selected nail types, while graph 2 compares axial load variations due to preservative treatment at 0.2 inches slip. A slip of 0.2 inches was selected for graph 2 since this amount of slip occurred prior to the yield point on all joints tested. The load values at this magnitude of slip are representative of the load values obtained over the entire range of loading.



Graph 1.

Load comparison of three types of 8d 2½") nails in joints fabricated from selected preservative treated ponderosa pine lumber. (Each bar represents data from 5 specimen joints.)

An examination of graph 1 reveals that the order of increasing strength was common to all treatments with the smooth box nail displaying lowest values and the annular ring nail the highest. Allowable loads, computed



Graph 2.

Load comparison of joints fabricated from selected preservative treated ponderosa pine lumber and 8d (2½") nails (Each bar represents data from 5 specimen joints.)

from ultimate strength values and based on a factor of safety of 6, are recorded in table II for all groups of joints.

The smooth box nail in non-treated material has the lowest load carrying capacity of all joints tested. Other nails and treatments can therefore be referred to this specimen to obtain relative strength as shown by table III.

TABLE II

ALLOWABLE LOAD IN POUNDS FOR SPECIMEN JOINTS CONTAINING 10 NAILS

(Factor of safety of 6 used to obtain allowable loads)

	No Treatment	Vacuum Penta	Pressure Creosote	Pressure Penta
	Allowable Load (lbs.)	Allowable Load (lbs.)	Allowable Load (lbs.)	Allowable Load (lbs.)
Smooth Box	405	542	574	663
Galvanized box	472	650	680	850
Annular Ring Shank	746	883	863	873

TABLE III

RELATIVE STRENGTH OF JOINTS FROM TREATED SPECIMENS USING SELECTED NAIL TYPES

	No Treatment	Vacuum Penta	Pressure Creosote	Pressure Penta
Smooth box	1	1.34	1.42	1.64
Galvanized box	1.16	1.60	1.68	2.1
Annular Ring shank	1.84	2.18	2.13	2.16

It cannot be concluded that all differences in strength are due to the surface finish of the nails since differences were found in the physical dimensions of the nail types chosen as illustrated by table IV.

TABLE IV

SELECTED NAIL SPECIFICATIONS

Nail Type	Length (inches)†	Diameter Average of 5 Nails	Number of Nails per Pound*
Smooth box	2½	0.116 ins.	130
Galvanized box	2½	0.124 ins.	116
Annular Ring shank	2½	0.132 ins.§	88

† All nails were purchased commercially as 8d nails (2½ inch)

* The number of nails per pound was obtained by weighing 100 nails of each type and computing the number of each per pound. Diameter values recorded are the average of micrometer measurements of 5 nails.

§ Diameter value in table for annual ring shank is that of the smooth portion of the nail. The ring groove portion varied in diameter from .133 to .146, the average of 10 nails being 0.139.

The order of increasing diameter is also the order of increasing joint strength. It was noted, however, during loading that ring shank nails held tenaciously to the main joint member and the nail heads were measurably depressed in splice plates before ultimate strength was reached.

Slip values in the working load ranges for all nails was observed to be in close proximity. Initial slip was slightly greater in the case of ring shank nails which was most probably due to injury of wood fibres resulting from driving the ring grooved nail. The footnote to table IV shows the diameter of the ring grooved portion of the ring shank nail (average of 10 nails) to be .007 inches larger than the smooth portion. This larger diameter had the effect of pre-drilling to a diameter larger than the smooth portion of the nail during driving. The side plates were then allowed to slip during the application of the load before the nails came into bearing with the side plates. These properties and observations justify the greater initial slip when load was applied to all joints fabricated with the ring shank nail.

The moisture content o fthe 2" x 3" material averaged 7.58 percent while the 1" x 3" material was slightly lower. This is well below the moisture content for wood normally used in construction. Nail holding (3) is affected more by changes in moisture content than by any specific percentage present. Variations in moisture content of specimens used in these tests was not likely to have influenced joint strength to any appreciable degree.

Graph 2 shows variations in load characteristics due to preservative treatments. It is significant to note that joints fabricated from selected preservative treated Ponderosa Pine lumber displayed greater load carrying capacity than non-treated joints. It is also significant that the order of increasing load carrying capacity was no treatment, vacuum pentachlorophenol, pressure creosote, and pressure pentachlorophenol for all nails used. Ratios of increased strength due to treatment can be read horizontally in table III. Greater increases were obtained in joints fabricated with smooth box and galvanized nails than in specimens using ring shank nails, but the highest ultimate load was obtained with ring shank nails.

It is of interest to note on graph 1 that pressure pentachlorophenol joint specimens carried greater loads up to ultimate strength than did vacuum pentachlorophenol except in the joints employing ring shank nails. In this case the vacuum pentachlorophenol specimens only exceeded the pressure pentachlorophenol after 95 percent of the ultimate load value was reached.

CONCLUSIONS

1. Joints fabricated from preservative treated Ponderosa Pine lumber display greater load carrying capacity than joints made from untreated material. These findings are very significant since structural connections fabricated from treated lumber can be designed from standard specifications and tables without allowances for reductions in strength, due to preservative treatments.
2. Strength increases due to various preservative treatments, as observed in this study, were surprising and contrary to expectation. The findings merit further investigations with similar or other preservative treatments on other species of lumber and with additional nail types.
3. Variations in load carrying capacity of treated and untreated Ponderosa Pine varies with the nail type. Differences in the dimensional characteristics of the nail types, as commercially available will account for some of the load differences.
4. During fabrication of joints it was found that an edge distance of one-quarter the length of the nail was inadequate to prevent splitting. The nailing pattern for any future investigation should therefore be revised to increase this distance.

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