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Charles M. Ziegler
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COMPRESSED WOOD FOR EXPANSION JOINT FILLER

B. W. Pocock

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INTRODUCTION

Michigan is one of several States now permitting the use of compressed wood as a filler material for expansion joints in concrete pavement. It was deemed therefore of considerable importance to augment the Department's knowledge of compressed wood behavior, which had been partially confined to knowledge obtained from other sources,* by instituting its own program of study designed to procure certain original and fundamental data.

The laboratory study was set up in order to obtain first-hand information concerning certain specific and fundamental physical properties of different species of wood when compressed before installation in the joint. These properties included (1) the extent to which wood, when compressed to half its original thickness, will expand when the load is released (a) in air and (b) in water; (2) the pressures developed when such precompressed wood is allowed to expand (a) in water and (b) in mortar; and (3) relationships which might be established between the rates of expansion and consequent development of pressure, and the application of certain surface treatments designed to retard the entrance of moisture during shipment and handling.

Species of wood included in this study were California redwood, cypress, Douglas fir and western cedar. Samples were purchased kiln-dried and dressed to seven-quarters thickness. From these, laboratory specimens were cut, measuring four inches square.

* Self-Expanding Joint Filler for Concrete Pavement
W. J. Van London, Houston, Texas Chapter A.S.C.E., February 13, 1945

EXPANSION IN AIR AND IN WATER

In order to study the comparative expansion properties of the four species of wood and the effect of varying moisture contents thereon, laboratory specimens were prepared having different ranges of moisture content. With the exception of moistures in the "as received" condition, the ranges of moisture content were established by soaking in water to constant weight, then allowing to air dry for predetermined intervals. The actual moisture contents were determined by drying specimens prepared simultaneously for this purpose at 105 degrees C. to constant weight.

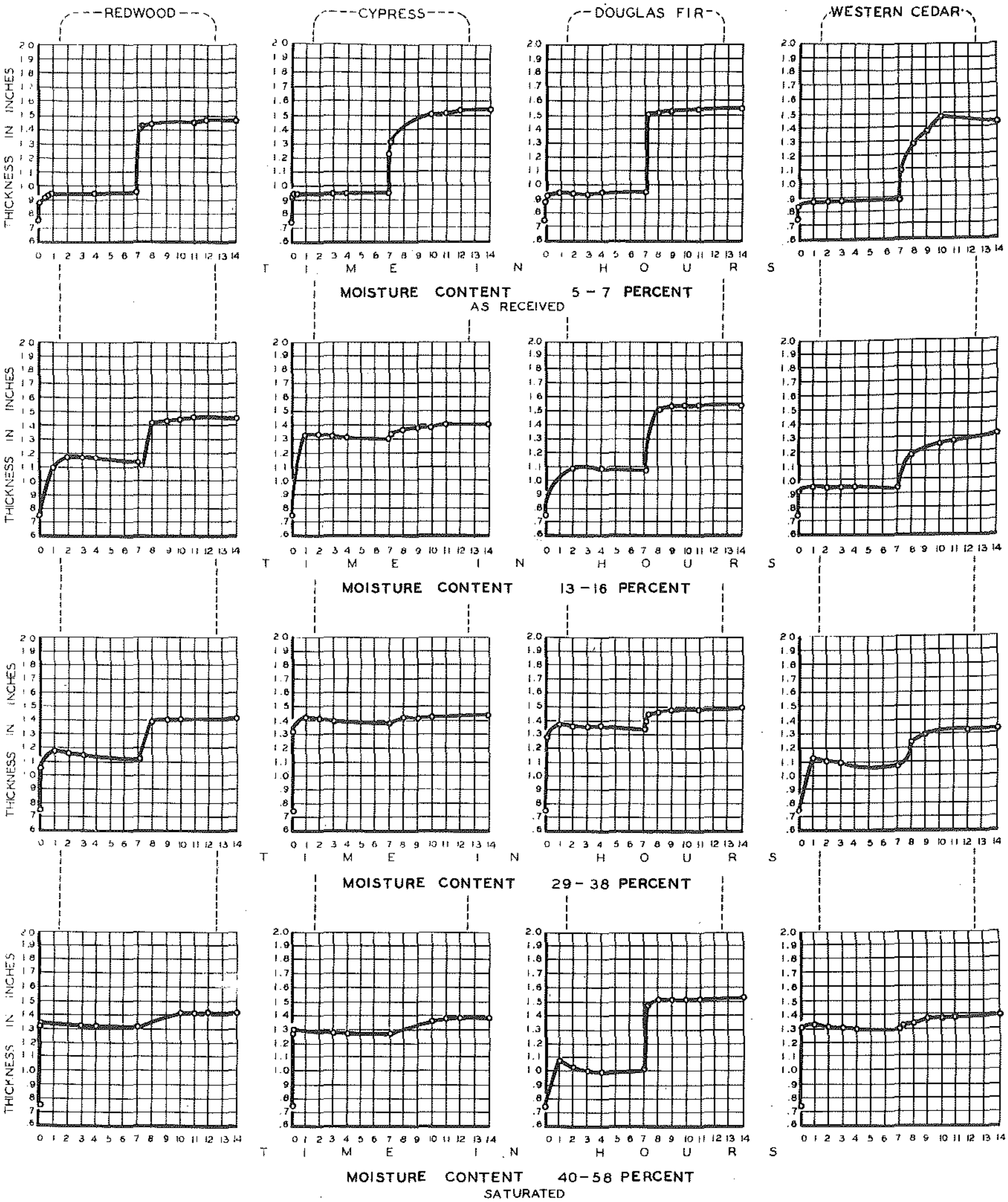
All specimens were compressed to 0.75 inch thickness at the rate of 0.063 inch per minute.

Expansion in Air

After compression to 0.75 inch, specimens were placed on a drying rack and thicknesses were recorded at intervals for seven days. Reference to Figure 1 shows the relative expansion properties of the four species of wood when allowed to expand to constant thickness in air at room temperature. In general, the greater the original moisture content, the greater was the ultimate expansion in air. Drying rack and associate equipment are shown in Figure 2.

Expansion in Water

After seven days' expansion in air, specimens had come to constant thickness in all cases. They were then stood upon end, grain vertical, in 1/4 inch depth of water, each specimen being sandwiched individually between



NOTE: ALL SAMPLES ORIGINALLY 13/4 INCHES THICK AND COMPRESSED TO 3/4 INCHES
0 TO 7 HOURS EXPANSION IN AIR —— 7 TO 14 HOURS EXPANSION IN WATER

EFFECT *of* MOISTURE *at* TIME *of* COMPRESSION *on* SUBSEQUENT EXPANSION

Figure 1

Figure 2. Center shows drying rack used for conditioning wood blocks at different stages of investigation. At left can be seen water bath for immersion of blocks. At right is one of a series of identical instruments incorporating dynamometer ring and dial indicator for measuring pressures developed in wood in contact with water or mortar.

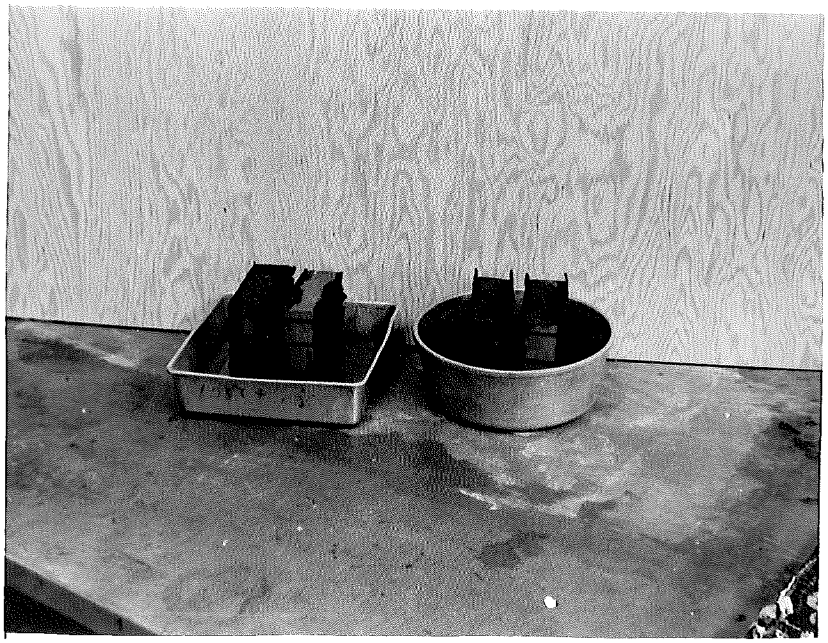


Figure 3. Wood blocks after compression to half thickness shown standing in 1/4 inch depth of water with grain vertical. Blocks held in contact with blotting paper by rubber bands.

two sheets of blotting paper held in intimate contact with the wood by rubber bands. This was to simulate position in an actual expansion joint in concrete pavement. (See Figure 3)

Swelling of all specimens began immediately after contact with water. Thicknesses were averaged and recorded, at first at fifteen minute intervals, then at hourly, then daily intervals for seven days. The 1/4 inch depth of water was maintained by additions. Here again, constant thickness was reached at the end of seven days.

Figure 1 shows these results as well as those relating to expansion in air. It would appear that wood in the "as received" condition, containing about five to seven per cent moisture, displays the greatest ability to expand when immersed in water after being compressed; wood containing higher percentages exhibits the lowest ability. The effect of immersion in water after a preliminary expansion in air is greatly diminished with increasing original moisture content. A study of Figure 1 discloses interesting comparisons among the four species investigated.

PRESSURE OF EXPANSION IN WATER AND IN MORTAR

In order to obtain as complete information as possible with respect to relative expansion properties of the four types of wood, it was considered advisable to investigate the magnitude of forces set up when compressed wood is restrained from expanding after immersion in water or fresh concrete. Accordingly, a battery of instruments was set up for this purpose, constructed as shown in Figure 4. Standard C-clamps were arranged to

Figure 4. View of apparatus used in measuring pressures exerted by both normal and compressed wood when surrounded by water or mortar. A series of three such instruments was used in this investigation. Instrument consists essentially of a large C-clamp with suitable steel plates for sandwiching specimens, a dynamometer ring and a dial indicator registering in ten-thousandths of an inch.

hold a compressed wood block between suitable steel plates, with a dynamometer ring and dial indicator for recording total force produced. Pressures were calculated in the conventional manner in pounds per square inch.

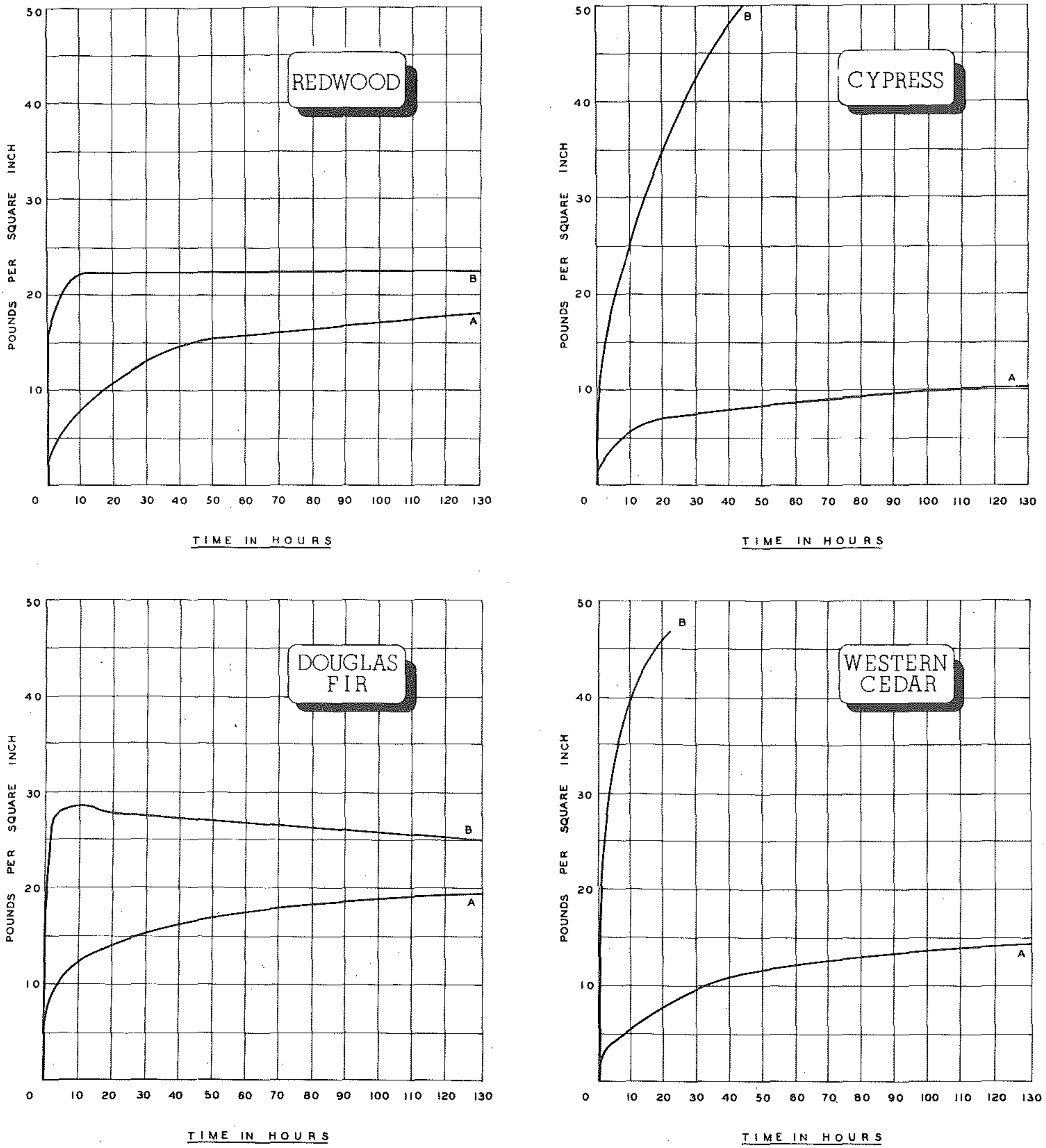
Pressure of Expansion in Water

Reference to Figure 5 discloses that in all cases the pressures produced by total immersion in water of wood compressed to half its original thickness were far greater than the pressures developed by specimens which were not compressed. These differences were enormously greater in the case of cypress and western cedar, although the pressures developed by these two species in the uncompressed state were less than those produced by redwood and fir in the uncompressed state.

Pressure of Expansion in Mortar

Although the pressures developed tending to produce expansion of wood when immersed in water are of fundamental significance, it was felt necessary to obtain data concerning such pressures resulting from immersion in fresh mortar. This, it was believed, would more nearly simulate the actual case of using compressed wood as a filler material for expansion or contraction joints in concrete pavement.

Therefore, employing the same apparatus which was used in studying the pressures developed in water, records were secured of pressures induced when wood specimens were surrounded by a standard 1:2 Portland cement-natural sand mortar. After pressures had become stabilized at approximately ninety-five hours after each experiment was started, water was poured over the specimen to simulate rainfall, its depth being maintained at 1/4 inch.



EFFECT *of* PRECOMPRESSION *on* EXPANSIVE FORCE *of* VARIOUS WOODS *in* WATER

CURVES B: COMPRESSED CURVES A: NOT COMPRESSED

Figure 5

Reference to Figure 6, in which pressures of expansion in mortar are plotted against time, shows ultimate pressures ranging from fifteen to approximately fifty-five p.s.i., depending on the species of wood. At the extreme left in each graph can be seen the curve of compressive strength of normal concrete. At first glance it would appear that all the pressure curves for wood lie well under the curve of compressive strength of concrete. The magnified portions of the curves, however, show that this is not the case during the first few hours. For a period of from three to four hours depending upon the species, the pressure developed by compressed wood is considerably greater than the compressive strength of concrete.

It was therefore considered advisable to investigate the possibility of treating compressed wood in some manner which would delay the entrance of water without sacrificing ultimate pressure, in this way postponing the development of pressure until the concrete is strong enough to withstand it.

EFFECT OF SURFACE TREATMENT

Treatment employed consisted of (a) one dip and (b) two dips in a good grade of commercial (proprietary) membrane-curing compound. In case (b) (two dips) samples were allowed to dry to touch before application of the second dip. In all cases, as shown in Figure 6, two dips imparted the desired postponement of pressure. In three out of four species, one dip proved insufficient, and in the fourth case (fir) it was barely sufficient. In no case did treatment seriously retard the development of pressure with corresponding tendency to follow a receding concrete face.

Stacking Treated Samples

Inasmuch as any of the four species of wood studied appeared to have definite merit as a joint filler material, the question naturally arose whether commercially fabricated joint filler material prepared in the manner above could be stacked and handled without sticking together. It was found that no sticking occurs provided the pieces are dusted with powdered chalk as soon as dry to touch after the second dip.

FIELD INSTALLATIONS

Because of the promising results of the laboratory investigations, it was decided to make certain field installations of expansion and contraction joints using compressed wood. The Grand Ledge-Mulliken paving project F-23-6 was available as a site for a limited number of experimental joints at this particular time (October, 1946). Plans were therefore made to incorporate two expansion joints and two contraction joints of one inch and 1/2 inch thickness respectively, using California redwood, compressed and treated with two dips of membrane-curing compound.

Material for the contraction joints was supplied by Texas Foundries, Inc., in the form of blocks of redwood measuring 6 x 9 inches. These pieces, originally 1/2 inch thick, had been compressed by the vendor to 3/8 inch, then allowed to expand freely in dry air.

Material for the expansion joints was purchased in the form of redwood planks 7/4 inch thick, dressed. These planks were cut into blocks about 5-1/2 inches wide, in some cases wider, and exactly 7-3/4 inches long. Blocks for two complete joints were compressed in the laboratory to 0.75

inch and allowed to expand in dry air. They were then trimmed, fitted into the steel supporting baskets, dowel holes were drilled, and the blocks individually dipped twice in membrane curing compound.

In the case of all four joints, the blocks were placed with the grain vertical. Each block was fastened to the adjacent blocks by corrugated fasteners. Figures 7 through 10 show the method used in setting up and installing the contraction and expansion joint assemblies.

Location and Installation

The experimental joints were placed at the following locations on October 23, 1946:

Station	Type of Joint	Paper Under Joint
780+68	Expansion	Yes
779+68	Contraction	Yes
778+68	Contraction	No
777+68	Expansion	No

Figures 11 through 14 illustrate the various steps involved in installing the joint assemblies. In all four cases, the joints were made to set flush with the surface of the pavement and were left unsealed in order to facilitate observation of subsequent behavior.

Behavior of Wood Joints After Installation

Periodic examination of the wood joint installations over a period of several months disclosed that the thin compressed wood filler assemblies used in the contraction joints were unsatisfactory in that they did not appear to follow the increase in joint opening which was observed. Considerable space developed on each side of the wood filler, between the wood and the concrete joint face. See Figure 15.

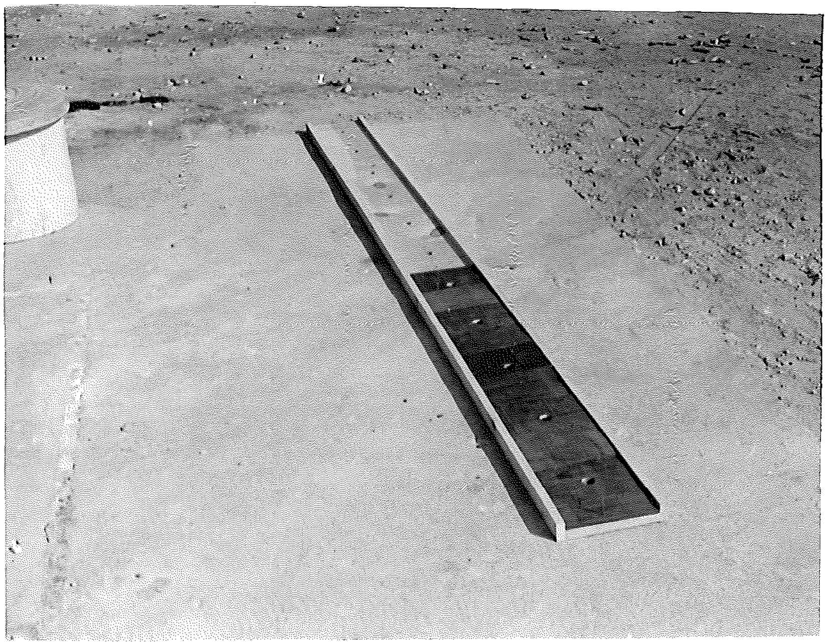


Figure 7. Wooden form used in constructing precompressed expansion and contraction joints. Form made to conform to crown of pavement. Length of form equals width of one lane.

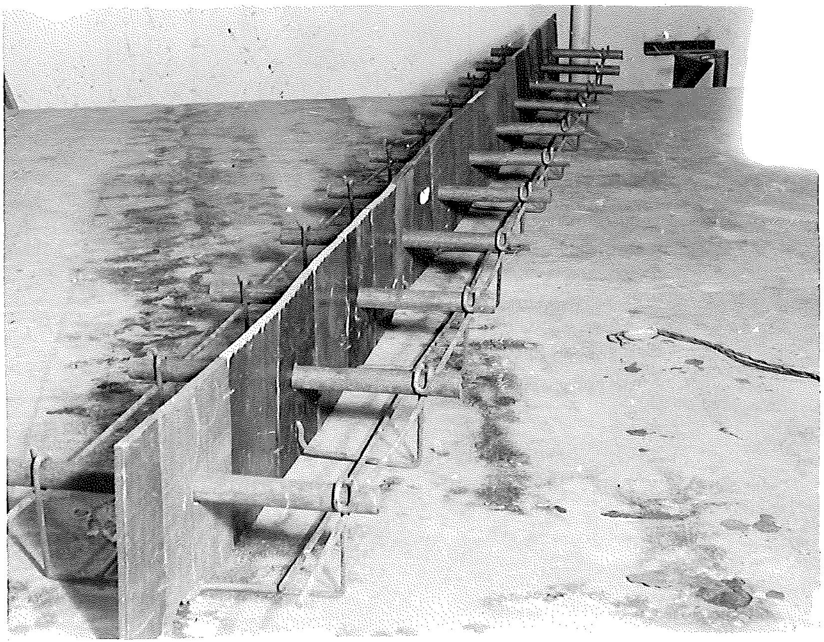


Figure 8. Contraction joint made of 3/8 inch commercially compressed redwood, constructed in Laboratory, surface treated, and installed in Grand Ledge-Mulliken pavement.

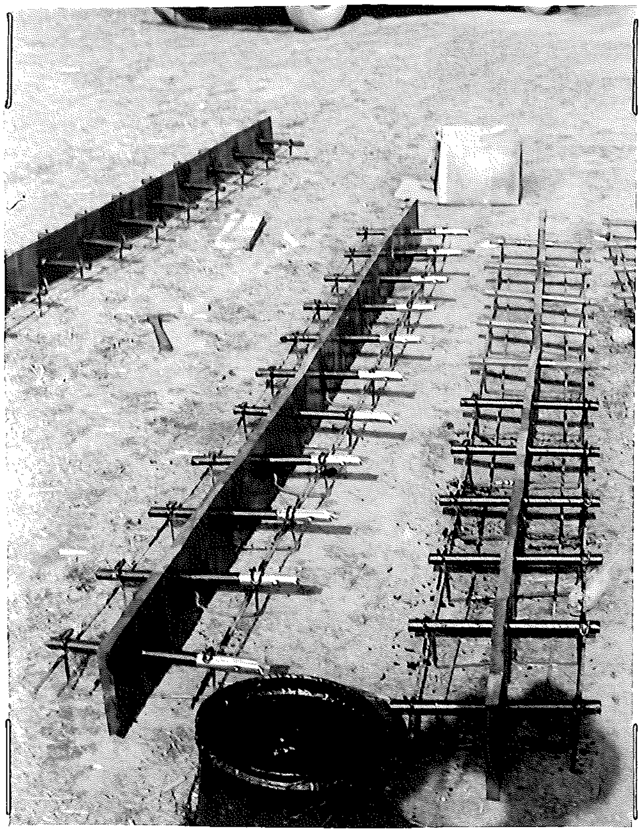


Figure 9. View of compressed and treated redwood expansion and contraction joint assemblies set up for dowel lubrication and sleeve installation.

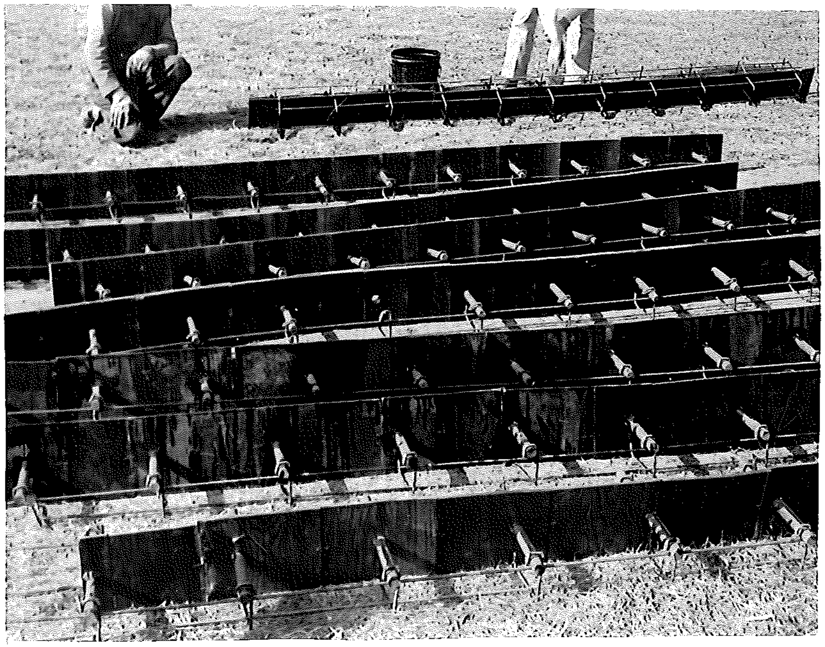


Figure 10. Another view of assemblies in same stage as in Figure 9.

Figure 11. Stage during installation of experimental precompressed and treated redwood expansion joint assembly at Station 780 + 68. Assembly is being trued to form.

Figure 12. Stage during installation of experimental precompressed and treated redwood expansion joint assembly at Station 780 + 68. Steel reinforcing mesh being placed over first layer of concrete west of joint. Note care being taken to avoid displacement of joint assembly.

Figure 13. Early stage during installation of precompressed and treated redwood contraction joint assembly at Station 779 + 68. Joint assembly being trued to form and crown.

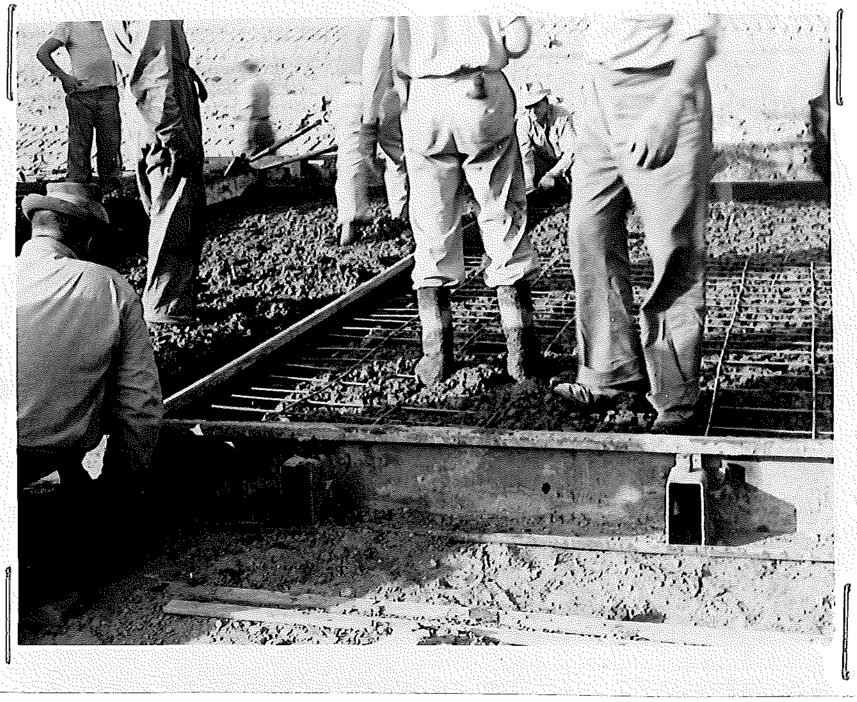


Figure 14. Slightly later stage than that shown in Figure 13. Note steel reinforcing mesh being covered.

Figure 15. Shows condition of redwood contraction joint at Station 778 + 68 three weeks after installation.

The one inch expansion joints, however, still were in fairly satisfactory condition at this writing (May, 1947). See Figure 16.

CONCLUSIONS

1. Certain species of wood when compressed to half its original thickness in a dry state will expand, in the presence of moisture, to approximately 85% of the original thickness. Thus a board 7/4 inches thick when compressed and installed to form a one inch expansion joint would always exert a pressure against the abutting slab faces to form a tight joint.
2. California redwood seems to be ideal for this purpose although certain other woods may be used successfully.
3. All compressed woods must be treated with a water repellent material after compression in order to delay expansion in storage and handling and when placed in the pavement to postpone the development of pressure until the concrete is strong enough to withstand it. Laboratory studies indicate that this may be easily accomplished by various methods, and therefore constitutes a minor manufacturing problem.
4. It is believed that compressed wood would not be successful for joint widths less than 3/4 inch in width because the thin boards would produce joint fabrication difficulties and the lesser wood section will not provide the desired pressure at all times to keep the joints sealed.
5. Although compressed wood as a joint filler material is unquestionably superior to other materials now in common use, it is not economically available at the present time to contractors in Michigan.

Figure 16. Shows condition of redwood expansion joint at Station 780 + 68 three weeks after installation.