Carbeck, Richard H
The Shearing strength of glued joints of several species of So. American woods made with commercial glues.

Final Report

Forestry 266
and
English 6

THE SHEARING STRENGTH OF GLUED JOINTS OF SEVERAL SPECIES OF SOUTH AMERICAN WOODS MADE WITH COMMERCIAL GLUES

2nd. Sem. '35-'36

Richard H. Carbeck

Table of Contents

Preface

This work was carried out as a special problem in the School of Forestry at the University of Michigan. It is hoped that the results of this work will increase the existing knowledge of our South American woods. As there is no record of similar work ever having been done, this report may be of value to many of the wood using industries interested in the possibility of using species from South America . Although the work did not cover all possible methods of gluing, it is at least a good start. However, much more work will be necessary before definite conclusions can be drawn on the gluing possibilities of these woods.

The author wishes to thank Mr. D. W. Cleverdon for the assistance rendered by him during the testing work. The author is also indebted to Professor William Kynoch for the information and comments supplied by him, also Professor J.E. Thornton for accepting this report in his English 6 course.

May 1936 R.H.C.

The Shearing Strength of Glued Joints of Several Species of South American Woods Made With Commercial Glues

Introduction

With the increased use of wood in plywood and veneer form, a great deal more emphasis has been placed on the gluing properties of wood. At present there exists extensive knowledge on the gluing properties of most of our native woods; however there is still a great deal to be learned about these properties.

This work was undertaken to see how the technique developed for gluing our native woods would apply on several species of wood from South America. The use of these South American woods is rapidly increasing, and as the supply of our more valuable native woods becomes exhausted this demand will increase greatly. Work on the mechanical properties of these woods in solid form has already been completed and will soon be published, but there is no published account available showing results of testing these woods for gluing ability. (2) Thus this work should be accepted as an indication of what can be done, but more tests should be carried out before definitely saying if a particular wood can be glued or not.

Specific Object

The specific object was stated in the "Working Plan" submitted before this work was undertaken.

Procedure

The procedure was also discussed in detail in the "Working Plan;" however as some changes were made a discussion of these changes will now be given. The procedure previously outlined was followed up to the point of cutting the slides. When this part of the work was undertaken, it was found impossible to cut slides from some of the woods and others could only be cut in a longitudinal direction. This was due to one of two things, namely, the wood was too hard to be cut with a microtome knife, or the use of formaline was not a successful method of softening the wood. (Formaline has been the recommended solution for softening glued woods as it does not react with most glues and thus break the glue line.) Cativo and Imbuia, the only two low-density woods tested, were successfully cut in both cross-grain and longitudinal directions. Purpleheart and Pau Roxo, two of the dense woods tested, could not be cut in either direction. When the attempt was made to cut these woods the knife skipped over the surface of the blocks unless such a thick section was cut as to make it valueless for microscopic study. Some of the difficulty may have been due to the tannin in the wood reacting with the formaline as the latter was colored a deep purple from both woods. The other woods were successfully cut in a longitudinal direction in most cases. Some of the sections are quite thick, and thus the photomicrographs appear to be out of focus. This appearance, however, is entirely due to some of the wood structure being in a plane other than the one photographed.

for some other chemical constituent of the wood

Another factor which arose was that most of the glue joints came apart in the formaline. The only reason that can be given for this is that the tannin in the wood mixed with the glue while the latter was in a moist state. As a result most of the photomicrographs show only half of the glue line, or at best all of the glue line but only one of the pieces of wood that was bonded by the glue. Another reason for the lack of success in cutting the slides with both pieces of wood attached to the glue may be due to the hardness of the wood itself. That is, the micratome knife had to be forced through the wood so hard that the thin glue line broke under the strain. In most cases however the photomicrographs illustrate the points desired very well.

Results

Explanation of Tables

Table one is a compilation of the average results obtained from the testing of each wood and glue. The data in the column "Solid Wood" was obtained from Professor Kynoch and is the result of work carried out by him. (2) The other data was obtained from the tests carried out by the author, These average results should not be considered too critically, as some of the individual joint strengths included in the average figures were abnormally low.

Tables 2 to 31 show the results of the individual tests of the glue joints, each table dealing with one species of wood and one glue. The columns of these tables are self-explantory.

The tables are grouped as to species, and the discussion for each species will be found preceding the tables for that species. The 150 pounds pressure stated at the top of these tables is the pressure per square inch applied to the blocks while the glue is drying. The "Assembly and Time" indicated by a 15-C means 15 minutes closed assembly, that is, the glue was spread on the wood and the pieces placed together for 15 minutes before applying the pressure.

Explanation of Plates

Plate one is a graphic description of the figures in table one. Each colored bar representing a certain glue or the solid wood. A key at the bottom of the page tells what each color represents.

Plates 2 to 23 are the photomicrographs taken from the slides, when the latter could be cut. They are intended to illustrate the penetration of the glue into the wood and the thickness of the glue line.

General Conclusions

The discussion for each individual species will be found preceding the tables and plates for that species. It is intended here to summarize those discussions and to point out some of the future work which might be attempted to produce more successful glue joints.

General Comparison of Glues

In considering the value of the glues used for these tests no account is taken of the presence of specific adhesion between the glue and the wood. Little is known about this phenomenon in the case of wooden joints, and there is no way of measuring the value of such adhesion. It is known to exist however, and this existance is well shown by some of the photomicrographs. In many cases the joints gave good strength values, but there was very little penetration of the glue into the wood.

Casein Glue

In general the casein glue gave the best results, and would be recommended to use if only one of the three glues were being selected. This glue, however, tended to be more discolored by the tannins in the woods than the others. The higher percentage of failure in the wood with this glue indicates that the bond between the glue and the wood was also better.

Animal Glue

In most cases this glue also gave favorable results, but the strength of the joints was below that of the casein glue on an average. This glue seemed to penetrate the wood better than the casein glue, but it was noted to be rather granular in some cases after it had become dry. This condition probably resulted from the actions of the tannins in the woods on the glue.

Vegetable Glue

This glue gave very poor results in all cases and could not be used where high joint strength was necessary. However this glue was developed for use in the manufacture of plywood, and for most uses of plywood high strength is not essential. A high penetration of the glue into the wood was usually obtained, and thus plenty of mechanical anchorage was provided to produce good joints if the glue itself had been stronger. The weakness of the glue is also indicated by the fact that there was very little failure in the wood in all of the pieces tested. This glue, due to its high consistency, should be applied by mechanical means. The results would undoubtedly have been better if applied by a mechanical spreader as this means insures a more uniform glue spread.

Suggestions for Future Works

Treatment of Wood

The use of some chemical treatment of the wood, such as the caustic soda treatment recommended by the United States Forests Products Laboratory (1), might well be tried on these woods. This treatment has been applied to many of our native species containing a large amount of tannin, and the resulting glue joint strengths greatly increased thereby. As most of the woods tested contained a great deal of tannin, the same treatment might apply to these woods. The treatment consists of applying a ten percent solution of caustic soda to the

surfaces of the boards to be glued, after about ten minutes the surfaces are wiped with a cloth to remove any excess solution or dissolved material and allowed to dry before being glued. Milk of lime or an ammonia solution might also be tried to see what effect they would have on the joint strength.

Increasing Pressure

As the penetration of the glues into the woods was quite slight in most cases, it might be well to apply higher pressures to these woods to see if more glue could be forced into the wood cells and thus create better mechanical anchorage. A heavier glue spread would then be necessary, however, as more of the glue would be forced from between the blocks at higher pressures and unless care was taken starved joints would result.

Summary

Although the results of this work are not as complete as was anticipated at the start of the work, they form a base around which future work can be built. If more time had been available, the suggestions mentioned above would have been tried. However, it is believed the results of these tests show quite clearly that the common commercial practices in use today in the wood gluing industries will have to be altered before these woods can be glued successfully., However, it should not be said that these woods cannot be successfully glued at all until more study has been done to support these results.

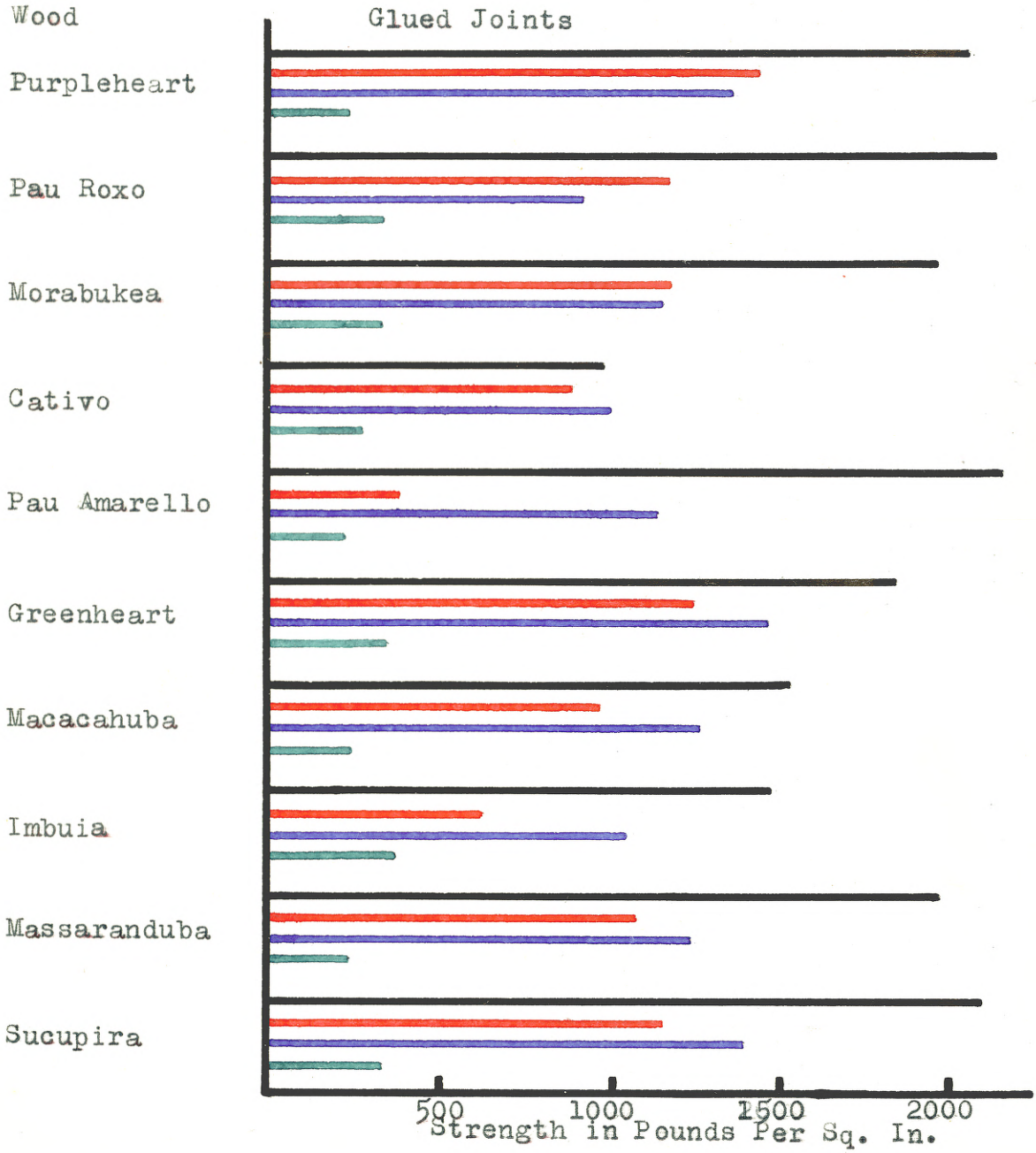
TABLE I

The Average Shear Strengths of Solid Wood and Glued Joints

Species	Solid Wood	Glues		
		Animal	Casein	Vegetable
Purpleheart	2070.0	1437.70	1349.41	227.03
Pau Roxo	2145.5	1167.37	909.98	338.63
Morabukea	1962.0	1174.40	1152.08	325.88
Cativo	985.0	874,49	993.38	251.23
Pau Amarello	2158.0	369.04	1133.87	213.14
Greenheart	1834.5	1243.69	1458.56	346.56
Macacahuba	1547.0	961.77	1260.94	235.40
Imbuia	1480.0	628.53	1034.57	367.94
Massaranduba	2011.5	1067.21	1226.63	222.54
Sucupira	2107.5	1141.73	1371.86	313.54

PLATE 1

A Graphic Comparison of the Average Shear Strengths of Solid Wood and Glued Joints



Discussion (Purpleheart)

The results of the tests on this wood seem to indicate that the casein glue gave the strongest bond between the wood and the glue. The data in table 3 shows that in every case at least some of the failure was in the wood, while for the other two glues the failure was almost entirely in the glue. The average shear strength of the animal glue joints show it to be the strongest, however. The soy bean glue, a vegetable glue, gave by far the poorest joints; however, as this glue is intended for plywood work the demand for strength is not as great. In no case did the glued joints approach the strength of the solid wood as can be seen in table 1. The moisture content of the wood when tested in the solid stste was 13.9%, while at the time of gluing the moisture content of the wood was 6.3%. This difference must be considered and indicates that the solid wood would be even stronger if tested at the moisture content when it was glued.

A caustic soda treatment applied to the wood previous to gluing would perhaps aid in producing stronger joints. This wood contains a large amount of water soluble tannin, and it was readily leached out of the wood by the moist glue. This tannin mixed with the glue undoubtedly changes the properties of the glue and probably reduces its strength. The caustic soda treatment would reduce the leaching action of the tannins considerably.

As it was impossible to cut microscopic sections from this wood, photomicrographs could not be gotten. However an assumption can be made on the penetration of the glue into the

wood. This assumption is based on the density of this wood compared to that of some of the other woods tested. On this basis the penetration was very slight or no penetration at all. A pressure considerably greater than the 150 pounds per square inch used might increase the penetration; however, a much heavier glue spread would also be necessary. and a higher glue consistency.

In conclusion it may be said this wood cannot be successfully glued by the commercial methods used at present.

TABLE 2

SHEAR TEST DATA

SPECIES Purpleheart GLUE Animal PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 6.3% DATE Apr. 13, 1936

BLOCK NO.	DIMENSIONS A IN.	DIMENSIONS B IN.	TOTAL AREA SQ. IN.	SHEAR STRENGTH LBS.	SHEAR STRENGTH LBS./SQ.IN.	PERCENT BREAKAGE WOOD	PERCENT BREAKAGE GLUE
1	1.49	1.56	2.32	5280	2275.86	0	100
2	1.53	1.51	2.31	2160	935.06	0	100
3	1.47	1.55	2.28	3085	1353.07	0	100
4	1.63	1.59	2.59	6570	2536.68	50	50
5	1.59	1.53	2.43	1150	473.25	0	100
6	1.63	1.58	2.58	5180	2007.75	5	95
7	1.60	1.58	2.53	1210	478.26	0	100
8	1.61	1.61	2.59	5895	2276.06	0	100
9	1.66	1.49	2.47	3500	1417.00	0	100
10	1.61	1.53	2.46	1535	623.98	0	100
AVG.					1437.70		

TABLE 3

SHEAR TEST DATA

SPECIES Purpleheart GLUE Casein PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 6.3% DATE Mar. 27, 1936

BLOCK NO.	DIMENSIONS A IN.	DIMENSIONS B IN.	TOTAL AREA SQ. IN.	SHEAR STRENGTH LBS.	SHEAR STRENGTH LBS./SQ.IN.	PERCENT BREAKAGE WOOD	PERCENT BREAKAGE GLUE
1	1.43	1.54	2.20	6095	2770.45	20	80
2	1.45	1.57	2.28	1110	486.84	40	60
3	1.44	1.57	2.26	2740	1212.39	5	95
4	1.43	1.56	2.23	2550	1143.50	10	90
5	1.63	1.59	2.59	2620	1011.58	85	15
6	1.42	1.57	2.23	2080	932.74	60	40
7	1.40	1.56	2.18	5245	2405.96	50	50
8	1.42	1.55	2.20	1260	572.73	5	95
9	1.40	1.58	2.21	3555	1608.60	60	40
10							
AVG.					1349.41		

TABLE 4

SHEAR TEST DATA

SPECIES Purpleheart GLUE Vegetable PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 6.3% DATE Apr. 3, 1936

BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.53	1.50	2.30	455	197.82	0	100
2	1.53	1.54	2.36	960	406.78	0	100
3	1.28	1.48	1.89	875	462.96	0	100
4	1.54	1.53	2.36	540	220.88	0	100
5	1.55	1.45	2.25	460	204.44	0	100
6	1.53	1.51	2.31	290	125.58	0	100
7	1.55	1.45	2.25	235	104.44	0	100
8	1.43	1.58	2.26	210	93.36	0	100
AVG.					227.03		

Discussion (Pau Roxo)

This wood has many properties similar to Purpleheart previously described. The bond between the wood and the glue seemed to be greater, however, as there was a larger percentage of failure in the wood with all glues. The lower strength values of the joints with this wood over Purpleheart was probably due to the higher percentage of water soluble tannins present in the wood. The same coloration of the glues from the wood was present, but to a much higher degree. Thus again the caustic soda treatment may well be recommended as a means of increasing the joint strength. The fact that the vegetable glue gave stronger joints in this case than with Purpleheart, although the joints were still far too weak for most purposes, also supports the belief that the glue is weak.

A comparison of the strength of this wood in the solid form with the glued joints as shown in table one, shows the solid wood to be much stronger. When the moisture content of the wood at the times of testing is considered this difference becomes still greater. The solid wood was tested at a moisture content of 13.1% and the moisture content of the wood at the time of gluing was 6.3%.

It was also found impossible to cut microscopic slides from this wood, and thus the penetration of the glue into the wood could not be studied. It is again felt, however, that a great deal more pressure would be necessary to force the glue into the wood.

In conclusion it may be said that this wood cannot be successfully glued by the present commercial methods.

TABLE 5

SHEAR TEST DATA

SPECIES Pau Roxo GLUE Animal PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 6.3% DATE Apr. 13, 1936

BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.44	1.50	2.16	4725	2187.50	10	90
2	1.49	1.54	2.29	3555	1552.40	10	90
3	1.62	1.49	2.41	1840	763.48	0	100
4	1.60	1.58	2.53	3105	1227.27	25	75
5	1.58	1.47	2.32	2120	913.79	5	95
6	1.61	1.48	2.38	1700	714.28	5	95
7	1.57	1.49	2.34	3450	1474.36	60	40
8	1.58	1.48	2.34	1790	764.96	10	90
9	1.63	1.44	2.35	2300	978.72	80	20
10	1.59	1.46	2.32	2545	1096.98	10	90
AVG.					1167.37		

TABLE 6

SHEAR TEST DATA

SPECIES Pau Roxo GLUE Casein PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 6.3% DATE Mar. 27, 1936

BLOCK NO.	DIMENSIONS A IN.	DIMENSIONS B IN.	TOTAL AREA SQ. IN.	SHEAR STRENGTH LBS.	SHEAR STRENGTH LBS./SQ.IN.	PERCENT BREAKAGE WOOD	PERCENT BREAKAGE GLUE
1	1.45	1.48	2.15	1910	888.37	15	85
2	1.53	1.53	2.34	1170	500.00	10	90
3	1.47	1.48	2.18	2175	997.71	10	90
4	1.43	1.50	2.14	1780	831.78	20	80
5	1.43	1.47	2.10	1270	604.76	5	95
6	1.42	1.49	2.12	1020	481.13	5	95
7	1.41	1.43	2.02	2700	1336.63	75	25
8	1.45	1.49	2.16	3845	1780.09	10	90
9	1.40	1.45	2.03	2365	1165.02	5	95
10	1.44	1.45	2.09	1075	514.35	0	100
AVG.					909.98		

TABLE 7

SHEAR TEST DATA

SPECIES Pau Roxo GLUE Vegetable PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 6.3% DATE Apr. 3, 1936

BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.50	1.47	2.20	170	77.27	0	100
2	1.50	1.44	2.16	700	324.54	5	95
3	1.54	1.57	2.42	1145	473.14	5	95
4	1.50	1.43	2.14	1540	719.63	0	100
5	1.48	1.53	2.26	435	192.48	0	100
6	1.50	1.43	2.14	590	275.70	5	95
7	1.52	1.41	2.14	610	285.05	5	95
8	1.48	1.53	2.26	335	148.23	0	100
9	1.47	1.45	2.13	1175	551.64	5	95
AVG.					338.63		

Discussion (Morabukea)

The results from the tests on this wood indicate that both animal and casein glue work equally well on an average, the animal glue having only a slight edge. The vegetable glue again gave joints that were by far inferior to either of the others. Water soluble tannins were again present but not in such large quantities as to discolor the glue as with the two previous woods.

It was possible to cut microscopic slides of this wood, and thus obtain photomicrographs. These are shown in plates 2to 4. A study of these pictures shows that the penetration of the glues into the wood was very slight. In the case of animal glue, plate two, there was no penetration at all. The casein glue, plate three, has a wide glue line, but the openings in it indicate that the pressure was not great enough. A slight penetration is visible along the glue line of the vegetable glue joint (plate 4). The lack of penetration in all cases seems to indicate a much higher pressure is necessary.

A comparison of the strength of the solid wood and the glued joints shows that the glued wood could not be substituted for the solid wood if high strength were necessary. This difference in strength would be still greater if both tests had been made at the same moisture content; however the solid wood was tested at 14.6% moisture and the glued wood at 6.5%. This difference in moisture effects the strength of the wood considerably.

TABLE 8

SHEAR TEST DATA

SPECIES Morabukea GLUE Animal PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 6.5% DATE Apr. 13, 1936

BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.63	1.55	2.53	1645	650.20	5	95
2	1.47	1.56	2.29	2125	927.95	20	80
3	1.49	1.60	2.38	4445	1867.65	0	100
4	1.52	1.52	2.31	4260	1844.16	0	100
5	1.61	1.53	2.46	4305	1750.00	25	75
6	1.59	1.55	2.46	1020	414.63	5	95
7	1.58	1.54	2.43	945	388.89	5	95
8	1.62	1.55	2.51	4365	1739.04	15	85
9	1.61	1.54	2.48	3480	1403.22	30	70
10	1.58	1.53	2.42	1835	758.26	25	75
AVG.					1174.40		

PLATE 2

Photomicrograph of Morabukea Wood Glued With Animal Glue

Longitudinal Section

TABLE 9

SHEAR TEST DATA

SPECIES Morabukea GLUE Casein PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 6.5% DATE Mar. 27, 1936

BLOCK NO.	DIMENSIONS A IN.	DIMENSIONS B IN.	TOTAL AREA SQ. IN.	SHEAR STRENGTH LBS.	SHEAR STRENGTH LBS./SQ.IN.	PERCENT BREAKAGE WOOD	PERCENT BREAKAGE GLUE
1	1.50	1.51	2.26	4350	1924.78	5	95
2	1.46	1.58	2.31	3580	1549.78	45	55
3	1.48	1.56	2.31	3820	1653.67	15	85
4	1.39	1.57	2.18	1410	646.79	5	95
5	1.40	1.56	2.18	1230	564.22	5	95
6	1.49	1.52	2.26	1145	506.64	25	75
7	1.45	1.53	2.22	3745	1686.94	5	95
8	1.38	1.57	2.17	2340	1078.34	10	90
9	1.48	1.56	2.31	1750	757.58	25	75
AVG.					1152.08		

PLATE 3

Photomicrograph of Morabukea Wood With

Casein Glue

Longitudinal Section

TABLE 10

SHEAR TEST DATA

SPECIES Morabukea GLUE Vegetable PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 6.5% DATE Apr. 3, 1936

BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.50	1.58	2.37	615	259.49	0	100
2	1.48	1.56	2.31	760	329.00	0	100
3	1.49	1.56	2.32	375	161.64	0	100
4	1.52	1.51	2.30	315	136.96	0	100
5	1.52	1.60	2.43	335	137.86	0	100
6	1.53	1.57	2.40	655	272.92	0	100
7	1.52	1.48	2.25	2285	1015.56	0	100
8	1.49	1.51	2.25	735	326.67	0	100
9	1.47	1.55	2.28	770	337.72	0	100
10	1.38	1.52	2.10	590	280.95	0	100
AVG.					325.88		

PLATE 4

Photomicrograph of Morabukea Wood With Vegetable Glue

Longitudinal Section

Discussion (Cativo)

The results of the glue joint strength tests on this wood were quite satisfactory. The animal glue, table 11, and casein glue, table 12, gave joints comparable in strength to that of the solid wood. One of the reasons for these favorable results is due to its lower density; thus the wood could be more easily penetrated by the glue. The photomicrographs of sections of this wood show that the glue did penetrate the wood quite deeply, see plates 5, 6, and 7.

The wood does not contain any water soluble tannins, but it does have gum producing properties. As the wood was dry, however, the gum did not interfere with the gluing.

Although this wood can be easily glued, its softness does not make it especially valuable as a wood for finished work. However it may find use as a core wood , another material for which there will be a demand after our supply of chestnut is exhausted.

TABLE 11

SHEAR TEST DATA

SPECIES Cativo GLUE Animal PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 5.8% DATE Apr. 13, 1936

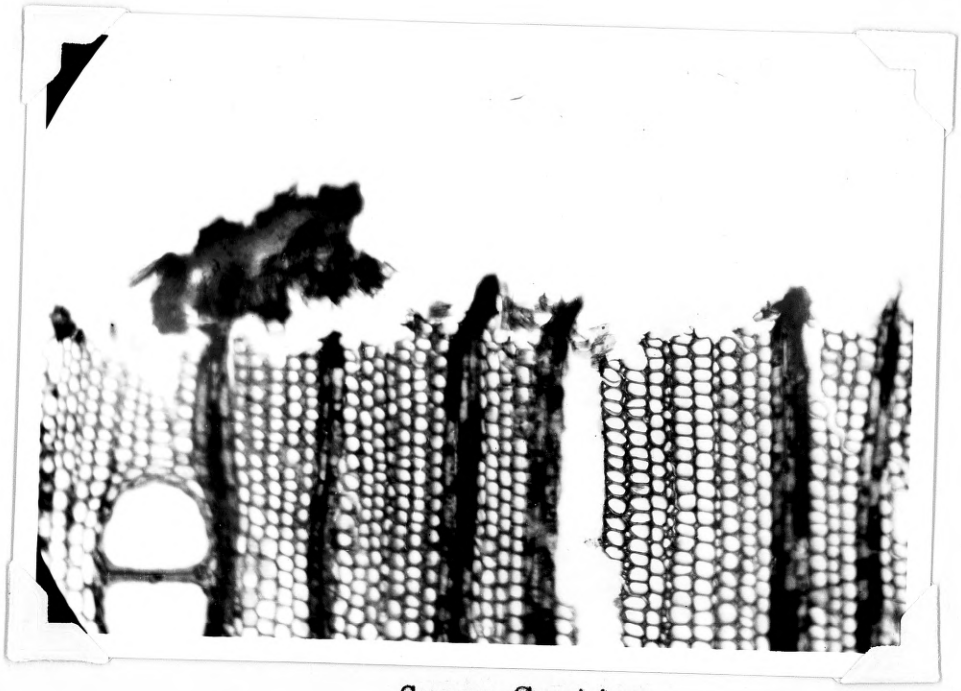
BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.51	1.56	2.36	2095	887.71	100	0
2	1.52	1.63	2.48	2700	1088.71	20	80
3	1.62	1.62	2.62	2640	1007.63	50	50
4	1.60	1.56	2.50	2840	1136.00	80	20
5	1.65	1.63	2.69	2830	1052.04	40	60
6	1.63	1.52	2.48	1210	487.90	30	70
7	1.65	1.63	2.69	2035	756.50	50	50
8	1.58	1.59	2.51	1800	717.13	40	60
9	1.63	1.57	2.56	1075	419.92	5	95
10	1.67	1.57	2.62	3120	1190.84	100	0
AVG.					874.44		

PLATE 5

Photomicrographs of Cativo With

Animal Glue

Longitudinal Section



Cross Section

TABLE 12

SHEAR TEST DATA

SPECIES Cativo GLUE Casein PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 5.8% DATE Mar. 27, 1936

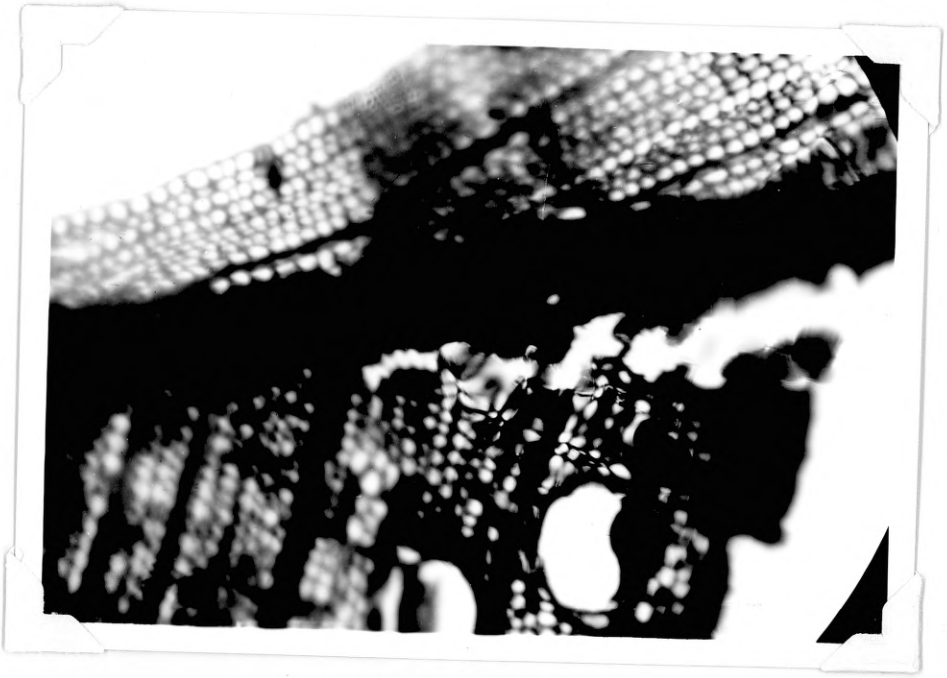
BLOCK NO.	DIMENSIONS A IN.	DIMENSIONS B IN.	TOTAL AREA SQ. IN.	SHEAR STRENGTH LBS.	SHEAR STRENGTH LBS./SQ.IN.	PERCENT BREAKAGE WOOD	PERCENT BREAKAGE GLUE
1	1.48	1.59	2.35	2470	1051.06	25	75
2	1.42	1.61	2.29	2555	1115.72	50	50
3	1.53	1.63	2.49	1500	602.41	30	70
4	1.54	1.65	2.54	2525	994.09	5	95
5	1.39	1.52	2.11	2490	1180.09	50	50
6	1.42	1.57	2.23	2340	1049.33	60	40
7	1.41	1.56	2.20	2020	918.18	5	95
8	1.46	1.55	2.26	2470	1092.92	75	25
9	1.45	1.63	2.36	2435	1031.78	50	50
10	1.51	1.53	2.31	2075	898.27	15	85
AVG.					993.38		

PLATE 6

Photomicrographs of Cativo

With Casein Glue

Longitudinal Section



Cross Section

TABLE 13

SHEAR TEST DATA

SPECIES Cativo GLUE Vegetable PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 5.8% DATE Apr. 3, 1936

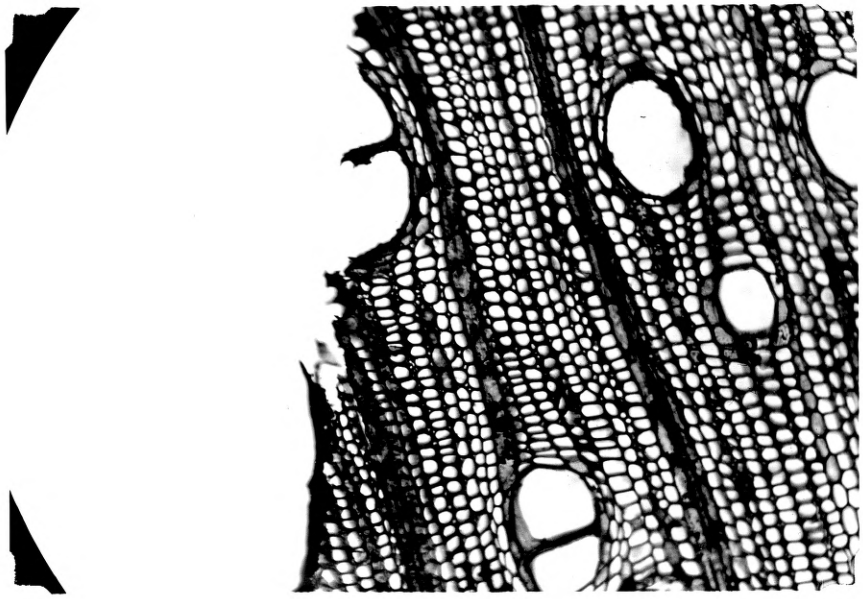
BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.48	1.52	2.25	235	104.44	0	100
2	1.47	1.53	2.25	895	397.78	50	50
3	1.49	1.51	2.25	470	208.89	0	100
4	1.50	1.58	2.37	995	419.83	0	100
5	1.49	1.53	2.23	410	183.86	0	100
6	1.49	1.56	2.32	760	327.59	0	100
7	1.47	1.49	2.19	435	198.63	0	100
8	1.48	1.59	2.28	520	228.07	5	95
9	1.48	1.54	2.28	390	171.05	0	100
10	1.50	1.58	2.37	645	272.15	5	95
AVG.					251.23		

PLATE 7

Photomicrographs of Cativo With

Vegetable Glue

Longitudinal Section



Cross Section

Discussion (Paul Amarello)

The results obtained from the gluing of this wood with casein glue, table 15, were quite satisfactory. Although the joints were considerably weaker than the shear strength of the solid wood, they were the highest for all of the glues tested. It should also be stated in this connection, that the moisture content of the solid wood was 12.8% at the time of testing, while the moisture content of the wood when glued was 5.9%. This difference in moisture indicates that the glued joints were evem weaker than the data shows. The photomicrographs of this wood and glue, plate 9, shows very little glue penetration, and thus an increase in pressure might produce even more favorable results.

The animal glue joints, table 14, were unusually low, and it is believed this may be due to an interaction between the tannins in the wood and the glue. The photomicrograph for this wood and glue, plate 8, shows that the glue line broke away from the wood, and no penetration of the glue into the wood is visible. Thus a caustic soda treatment and a higher pressure might both be attempted to produce better results.

The results for the vegetable glue joints, table 16, seem to be pretty well in line with the results generally obtained with this glue. A satisfactory microscopic section could not be cut, and thus no comparison can be made between the penetration and the strength obtained.

TABLE 14

SHEAR TEST DATA

SPECIES Pau Amarello GLUE Animal PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 5.9% DATE Apr. 13, 1936

BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.48	1.50	2.22	265	119.37	0	100
2	1.47	1.42	2.09	495	236.84	0	100
3	1.52	1.49	2.26	545	241.150	0	100
4	1.65	1.47	2.42	2015	832.64	0	100
5	1.57	1.50	2.36	1310	555.08	0	100
6	1.68	1.43	2.40	550	229.17	0	100
AVG.					369.04		

PLATE 8

Photomicrograph of Pau Amarello With

Animal Glue

Longitudinal Section

TABLE 15

SHEAR TEST DATA

SPECIES Pau Amarello GLUE Casein PRESSURE 150#

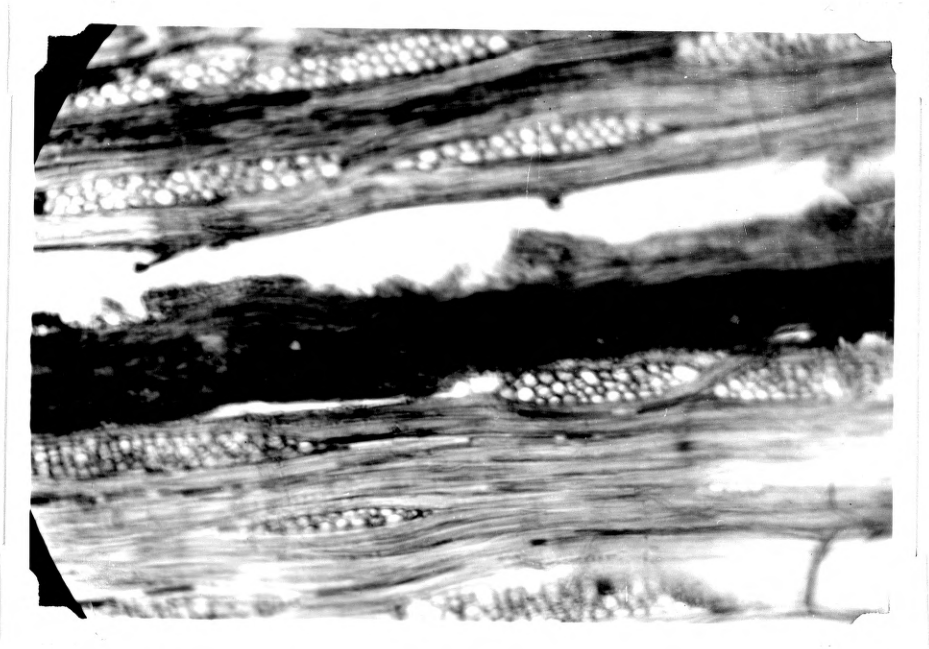
ASSEMBLY & TIME 15-C MOIST. CONT. 5.9% DATE Mar. 27, 1936

BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.42	1.45	2.06	1110	538.83	0	100
2	1.47	1.51	2.22	2185	984.23	0	100
3	1.46	1.48	2.16	2490	1152.78	20	80
4	1.43	1.37	1.96	2265	1155.61	0	100
5	1.40	1.45	2.03	2605	1283.25	100	0
6	1.52	1.44	2.19	5070	2315.07	10	90
7	1.52	1.53	2.32	1670	719.83	20	80
8	1.47	1.43	2.10	1905	907.14	0	100
9	1.42	1.49	2.12	2520	1188.68	0	100
10	1.43	1.46	2.09	2285	1093.30	0	100
AVG.					1133.87		

PLATE 9

Photomicrograph of Pau Amarello

With Casein Glue



Longitudinal Section

TABLE 16

SHEAR TEST DATA

SPECIES Pau Amarello GLUE Vegetable PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 5.9% DATE Apr. 3, 1936

BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.48	1.44	2.13	315	147.89	0	100
2	1.48	1.44	2.13	875	410.80	0	100
3	1.48	1.53	2.26	345	152.65	0	100
4	1.52	1.44	2.19	210	95.86	0	100
5	1.50	1.45	2.18	245	112.38	0	100
6	1.48	1.59	2.35	395	168.08	0	100
7	1.47	1.47	2.16	610	282.41	0	100
8	1.50	1.55	2.32	335	144.40	0	100
9	1.47	1.54	2.26	785	347.34	0	100
10	1.50	1.53	2.30	620	268.56	0	100
AVG.					213.14		

Discussion (Greenheart)

The results obtained with both animal glue and casein glue were quite satisfactory with this wood. The photomicrographs show that the glue did penetrate the wood to some extent, and thus provided mechanical anchorage. It is believed however that a caustic soda treatment would increase this joint strength still more. The casein glue formed the best bond between the wood and the glue as the higher percentage of failure in the wood for this glue indicates.

The strength of the vegetable glue joints again was low, although the penetration of the glue into the wood was reasonably good.

TABLE 17

SHEAR TEST DATA

SPECIES Greenheart GLUE Animal PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 6.2% DATE Apr. 13, 1936

BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.44	1.62	2.33	1610	690.99	0	100
2	1.46	1.54	2.25	5160	2293.33	5	95
3	1.50	1.55	2.32	1225	528.02	0	100
4	1.64	1.58	2.59	6215	2399.61	0	100
5	1.63	1.57	2.56	1480	578.12	0	100
6	1.68	1.55	2.60	3105	1194.23	75	25
7	1.59	1.54	2.45	1870	763.26	0	100
8	1.61	1.54	2.48	3135	1264.11	5	95
9	1.59	1.58	2.51	2675	1065.74	0	100
10	1.63	1.56	2.54	4215	1659.45	0	100
AVG.					1243.69		

PLATE 10

Photomicrograph of Greenheart

With Animal Glue

Longitudinal Section

TABLE 18

SHEAR TEST DATA

SPECIES Greenheart GLUE Casein PRESSURE 150#

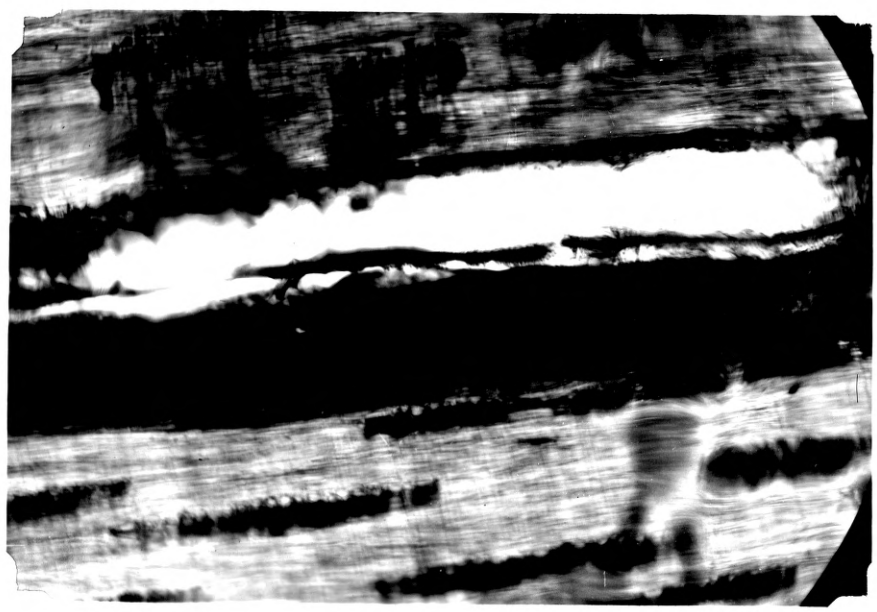
ASSEMBLY & TIME 15-C MOIST. CONT. 6.2% DATE Mar. 27, 1936

BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.47	1.59	2.34	3670	1568.38	40	60
2	1.53	1.52	2.33	3740	1605.15	75	25
3	1.41	1.53	2.16	2245	1039.35	30	70
4	1.52	1.53	2.33	2270	974.25	25	75
5	1.37	1.53	2.10	2685	1278.57	50	50
6	1.52	1.60	2.43	4455	1833.33	90	10
7	1.42	1.65	2.34	3100	1324.79	30	70
8	1.45	1.54	2.23	5075	2275.78	15	85
9	1.46	1.52	2.22	2725	1227.48	40	60
AVG.					1458.56		

PLATE 11

Photomicrograph of Greenheart

With Casein Glue



Longitudinal Section

TABLE 19

SHEAR TEST DATA

SPECIES Greenheart GLUE Vegetable PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 6.2% DATE Apr. 3, 1936

BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.43	1.51	2.16	750	347.22	0	100
2	1.34	1.50	2.01	390	194.03	0	100
3	1.36	1.50	2.04	340	166.67	0	100
4	1.48	1.51	2.23	280	125.56	0	100
5	1.43	1.52	2.17	2100	967.74	10	90
6	1.54	1.47	2.26	655	289.82	0	100
7	1.48	1.45	2.15	720	334.88	0	100
AVG.					346.56		

PLATE 12

Photomicrograph of Greenheart With

Vegetable Glue

Longitudinal Section

Discussion(Macacahuba)

The casein glue gave very favorable results with this wood, giving an average shear strength nearly equal to that of the solid wood. However this statement is based on the solid wood being tested at a moisture content of 10.7% and the moisture content at the time of gluing was 6.0%. Some of the individual joints were very weak however. This is believed to be due to starved joints, a fault of the operator rather than the wood or glue. The glue penetrated into the wood slightly, and thus provided some mechanical anchorage.

The animal glue joints were considerably weaker than those for the casein glue on an average, and the smaller amount of failure in the wood indicates the bond between the wood and the glue was not as good as with the casein glue. The photomicrograph indicates a deeper penetration of this glue into the wood than was true with the casein glue, especially along the rays.

The vegetable glue joimts were true to character and did not show any real joint strength. There was a good penetration of the glue into the wood however.

The caustic soda treatment might well be applied to this wood also. Although there were no signs of a coloration of the glue from the wood, the wood contains a great deal of tannin which migh easily react with the glue.

TABLE 20

SHEAR TEST DATA

SPECIES Macacahuba GLUE Animal PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 6.0% DATE Apr. 13, 1936

BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.52	1.57	2.39	3220	1347.28	5	95
2	1.51	1.48	2.23	1035	464.12	0	100
3	1.68	1.47	2.47	790	319.84	25	75
4	1.61	1.45	2.33	2980	1278.99	5	95
5	1.59	1.48	2.35	3130	1331.91	15	85
6	1.59	1.47	2.34	610	260.68	0	100
7	1.60	1.43	2.29	3795	1657.20	10	90
8	1.58	1.50	2.37	2920	1232.07	15	85
9	1.62	1.45	2.35	2030	863.83	0	100
AVG.					961.77		

PLATE 13

Photomicrograph of Macacahuba

With Animal Glue

Longitudinal Section

TABLE 21

SHEAR TEST DATA

SPECIES Macacahuba GLUE Casein PRESSURE 150#

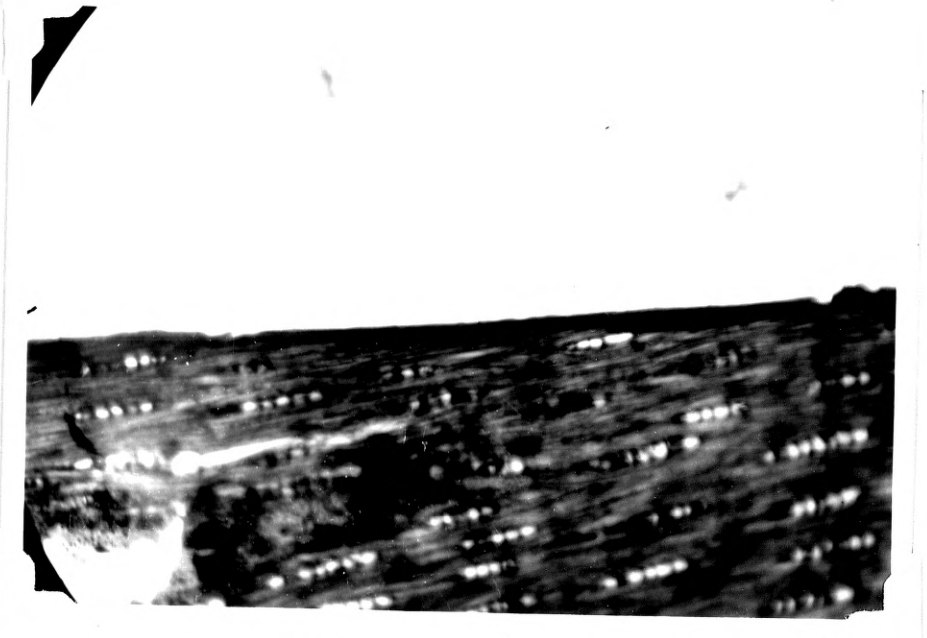
ASSEMBLY & TIME 15-C MOIST. CONT. 6.0% DATE Mar. 27, 1936

BLOCK NO.	DIMENSIONS A IN.	DIMENSIONS B IN.	TOTAL AREA SQ. IN.	SHEAR STRENGTH LBS.	SHEAR STRENGTH LBS./SQ.IN.	PERCENT BREAKAGE WOOD	PERCENT BREAKAGE GLUE
1	1.43	1.56	2.23	3600	1614.35	75	25
2	1.45	1.50	2.18	2465	1130.73	10	90
3	1.44	1.43	2.06	2470	1199.03	20	80
4	1.54	1.53	2.36	3545	1502.12	10	90
5	1.45	1.53	2.22	2125	957.21	15	85
6	1.47	1.49	2.19	2545	1162.10	25	75
AVG.					1260.92		

PLATE 14

Photomicrograph of Macacahuba

With Casein Glue



Longitudinal Section

TABLE 22

SHEAR TEST DATA

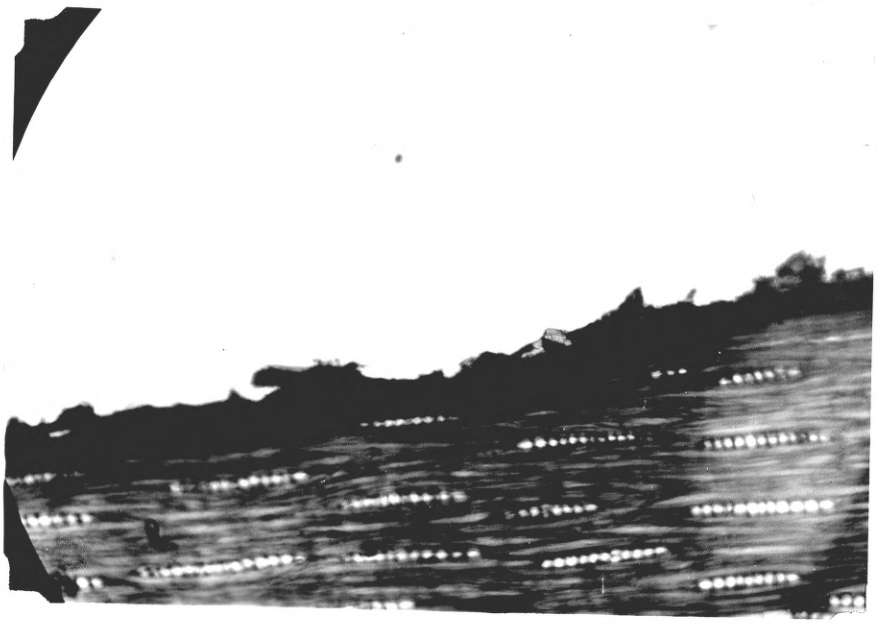
SPECIES Macacahuba GLUE Vegetable PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 6.0% DATE Apr. 3, 1936

BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.50	1.45	2.18	310	142.20	0	100
2	1.53	1.46	2.23	285	127.80	0	100
3	1.50	1.47	2.20	175	79.54	0	100
4	1.50	1.47	2.20	820	372.73	0	100
5	1.48	1.42	2.10	405	192.86	0	100
6	1.52	1.41	2.14	325	151.87	0	100
7	1.49	1.43	2.13	360	169.01	0	100
8	1.54	1.43	2.20	245	111.36	0	100
9	1.54	1.43	2.20	270	122.73	0	100
10	1.53	1.38	2.11	1865	883.89	0	100
AVG.					235.40		

PLATE 15

Photomicrograph of Macacahuba With Vegetable Glue



Longitudinal Section

Discussion (Imbuia)

The casein glue joints gave by far the best results with this wood. It is hard to account for this superior strength with the data available. The photomicrographs for this wood and glue showed practically no penetration of the glue into the wood. The wood however contained a large amount of tannin and it is possible that this glue was not affected by it.

The animal glue joints were very weak compared to those of the casein glue, being about half as great. The glue penetrated the wood well however, and it is again believed the tannin is responsible for the poor strength. Thus caustic soda should be tried on this wood.

The vegetable glue joints remained low, although the glue penetrated the wood somewhat. The joints were strong enough however to be used for plywood, the purpose for which the glue is intended.

TABLE 23

SHEAR TEST DATA

SPECIES Imbuia GLUE Animal PRESSURE 150#

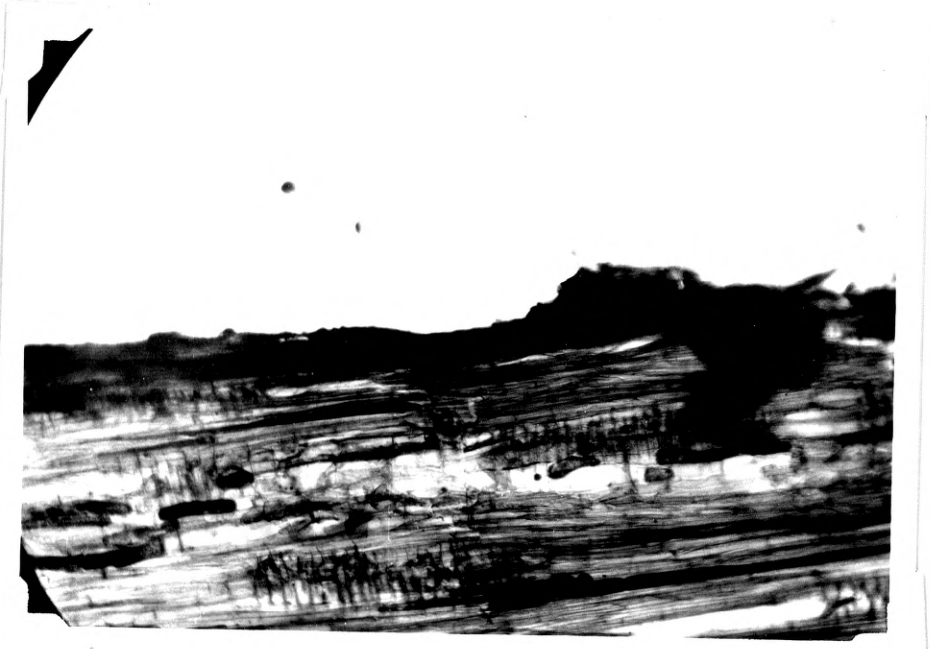
ASSEMBLY & TIME 15-C MOIST. CONT. 5.8% DATE Apr. 13, 1936

BLOCK NO.	DIMENSIONS A IN.	DIMENSIONS B IN.	TOTAL AREA SQ. IN.	SHEAR STRENGTH LBS.	SHEAR STRENGTH LBS./SQ.IN.	PERCENT BREAKAGE WOOD	PERCENT BREAKAGE GLUE
1	1.53	1.50	2.30	795	345.65	5	95
2	1.53	1.50	2.30	1320	573.91	0	100
3	1.54	1.49	2.29	1615	705.24	5	95
4	1.52	1.55	2.36	1200	508.46	0	100
5	1.70	1.50	2.55	770	301.96	0	100
6	1.62	1.49	2.41	300	124.48	0	100
7	1.62	1.48	2.40	400	166.67	0	100
8	1.57	1.47	2.31	2740	1186.15	20	80
9	1.63	1.50	2.44	2820	1155.74	10	90
10	1.60	1.47	2.35	2860	1217.03	25	75
AVG.					628.53		

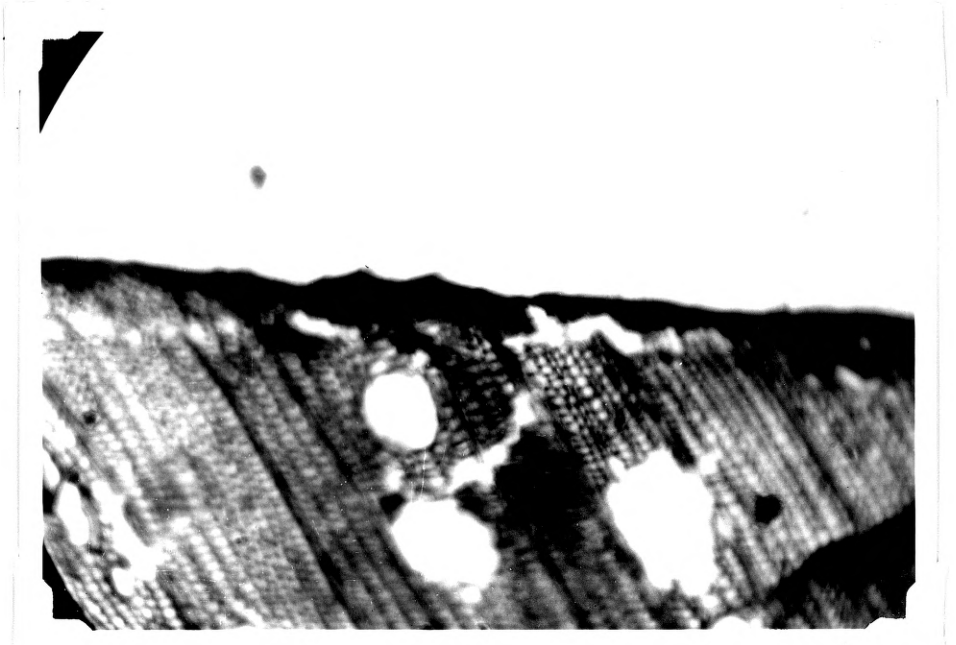
PLATE 16

Photomicrographs of Imbuia With

Animal Glue



Longitudinal Section



Cross Section

TABLE 24

SHEAR TEST DATA

SPECIES Imbuia GLUE Casein PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 5.8% DATE Mar. 27, 1936

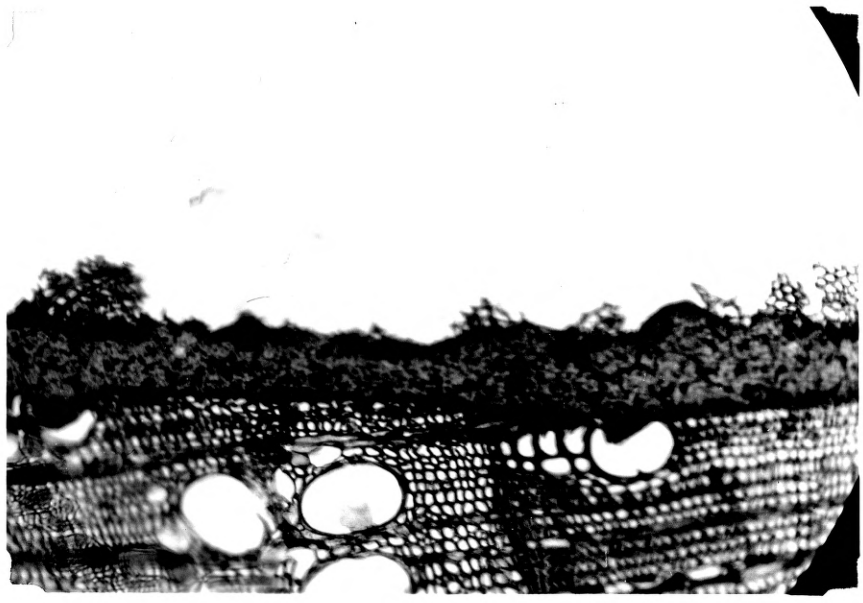
BLOCK NO.	DIMENSIONS A IN.	DIMENSIONS B IN.	TOTAL AREA SQ. IN.	SHEAR STRENGTH LBS.	SHEAR STRENGTH LBS./SQ.IN.	PERCENT BREAKAGE WOOD	PERCENT BREAKAGE GLUE
1	1.50	1.41	2.12	1390	650.42	0	100
2	1.45	1.54	2.23	2820	1264.57	15	85
3	1.43	1.42	2.03	2190	1078.82	5	95
4	1.44	1.48	2.13	3430	1610.33	5	95
5	1.45	1.46	2.12	2430	1146.23	10	90
6	1.49	1.53	2.28	3805	1668.86	10	90
7	1.43	1.49	2.13	2165	1016.43	0	100
8	1.35	1.47	1.98	1450	732.32	0	100
9	1.43	1.50	2.14	1200	560.75	0	100
10	1.38	1.24	1.71	1055	616.96	0	100
AVG.					1034.57		

PLATE 17

Photomicrographs of Imbuia With

Casein Glue

Longitudinal Section



Cross Section

TABLE 25

SHEAR TEST DATA

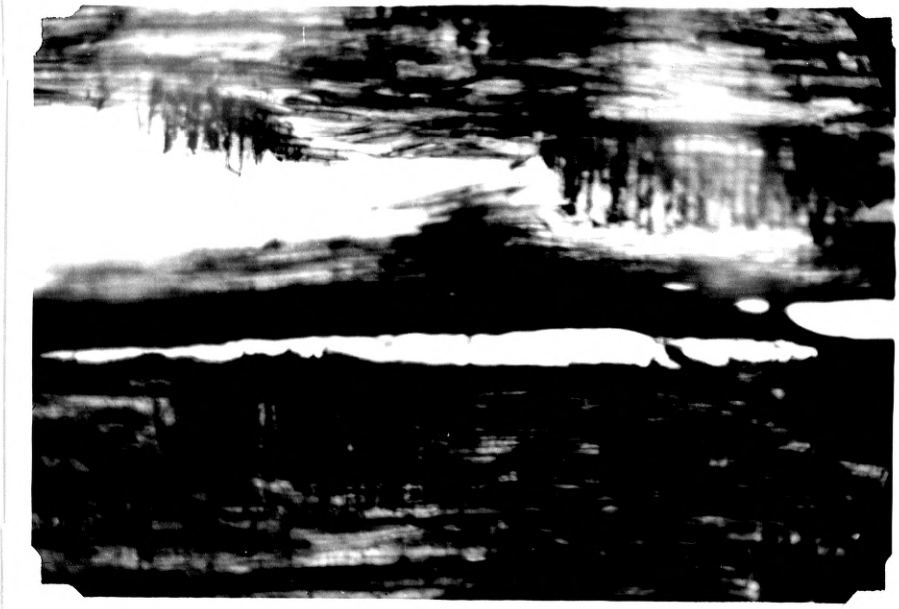
SPECIES Imbuia GLUE Vegetable PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 5.8% DATE Apr. 3, 1936

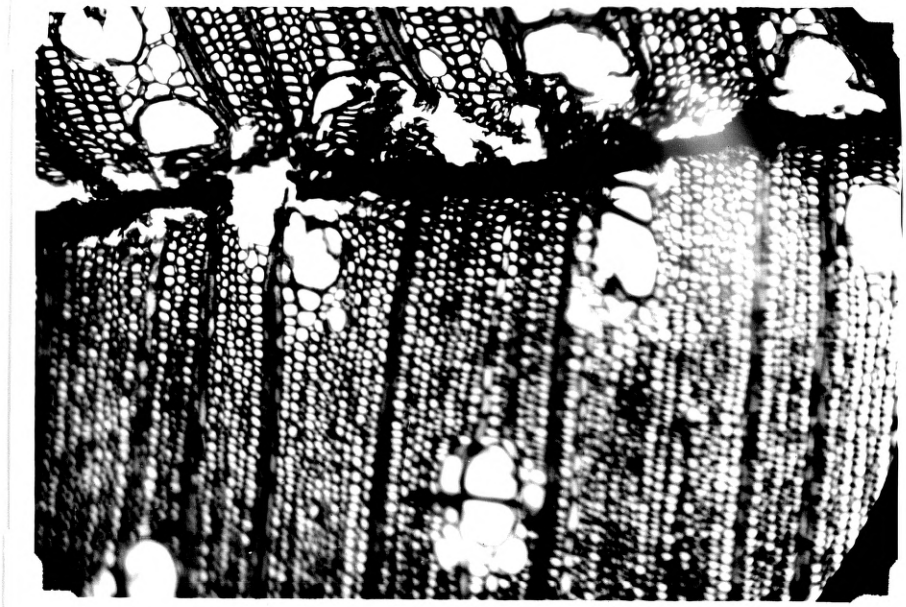
BLOCK NO.	DIMENSIONS A IN.	DIMENSIONS B IN.	TOTAL AREA SQ. IN.	SHEAR STRENGTH LBS.	SHEAR STRENGTH LBS./SQ.IN.	PERCENT BREAKAGE WOOD	PERCENT BREAKAGE GLUE
1	1.49	1.49	2.22	720	324.32	0	100
2	1.48	1.41	2.09	1155	552.63	0	100
3	1.49	1.42	2.12	650	306.60	0	100
4	1.48	1.40	2.07	535	258.45	0	100
5	1.52	1.44	2.19	410	187.21	0	100
6	1.49	1.46	2.18	1435	658.26	0	100
7	1.47	1.50	2.20	785	356.82	0	100
8	1.48	1.41	2.09	1030	492.82	0	100
9	1.52	1.50	2.28	625	274.12	0	100
10	1.49	1.48	2.20	590	268.18	0	100
AVG.					367.94		

PLATE 18

Photomicrographs of Imbuia With Vegetable Glue



Longitudinal Section



Cross Section

Discussion (Massaranduba)

The casein glue again gave the best results with this wood. Its strength however was considerably below that of the solid wood. The moisture content of the wood must also be considered with its strength. The solid wood at the time of testing was at 13.3% moisture, and the glued wood had a moisture content of 6.2%. The casein glue also exhibited the best bond with the wood. The photomicrographs indicates that there was some penetration of the glue into the wood.

The animal glue also gave favorable results, and there was considerable failure in the wood indicating a good bond between the glue and the wood. The photomicrograph shows only a slight penetration of the glue into the wood.

The vegetable glue remained in its class and gave joint strengths comparable to that obtained with the other woods tested. The photomicrograph indicates a good penetration of the glue into the wood.

The caustic soda treatment and also an increased pressure might well be tried on this wood in an attempt to obtain greater strength from the glue joints.

TABLE 26

SHEAR TEST DATA

SPECIES Massaranduba GLUE Animal PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 6.2% DATE Apr. 13, 1936

BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.52	1.45	2.20	2450	1113.64	20	80
2	1.62	1.37	2.22	2405	1083.33	0	100
3	1.68	1.34	2.25	1380	613.33	40	60
4	1.57	1.44	2.26	1585	701.33	5	95
5	1.60	1.35	2.16	720	333.33	15	85
6	1.57	1.34	2.10	4365	2078.57	10	90
7	1.62	1.43	2.32	3805	1640.09	5	95
8	1.63	1.41	2.30	3115	1354.35	5	95
9	1.60	1.39	2.22	1525	686.94	5	95
AVG.					1067.21		

PLATE 19

Photomicrograph of Massaranduba

With Animal Glue

Longitudinal Section

TABLE 27

SHEAR TEST DATA

SPECIES Massaranduba GLUE Casein PRESSURE 150#

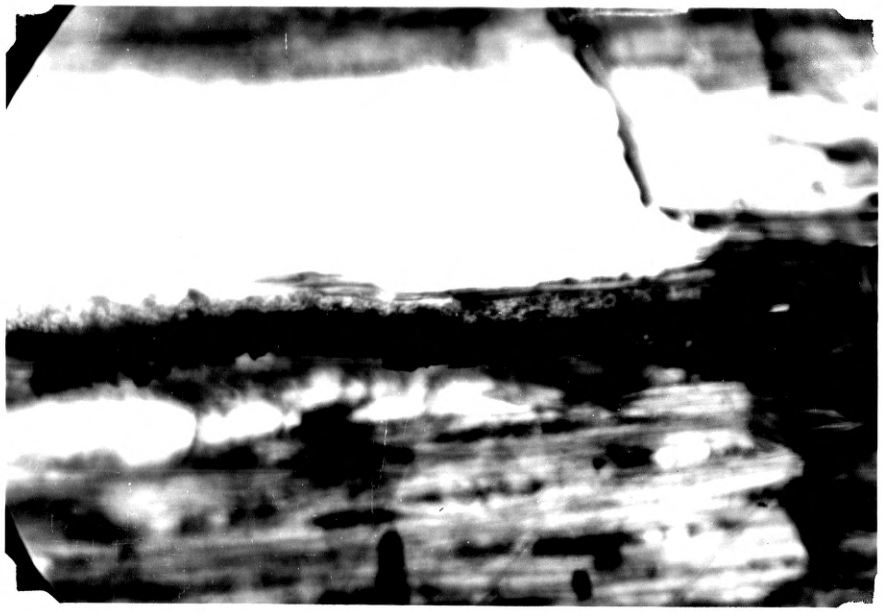
ASSEMBLY & TIME 15-C MOIST. CONT. 6.2% DATE Mar. 27, 1936

BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.49	1.37	2.04	1890	926.47	40	60
2	1.47	1.37	2.01	2995	1490.05	30	70
3	1.58	1.40	2.21	3375	1527.15	5	95
4	1.53	1.44	2.20	2135	970.45	10	90
5	1.47	1.45	2.13	2760	1295.77	0	100
6	1.47	1.43	2.10	1740	828.57	5	95
7	1.47	1.43	2.10	3290	1566.67	25	75
8	1.50	1.36	2.04	2745	1345.58	50	50
9	1.51	1.42	2.14	2380	1112.15	20	80
10	1.46	1.40	2.04	2455	1203.43	5	95
AVG.					1226.63		

PLATE 20

Photomicrograph of Massaranduba

With Casein Glue



Longitudinal Section.

TABLE 28

SHEAR TEST DATA

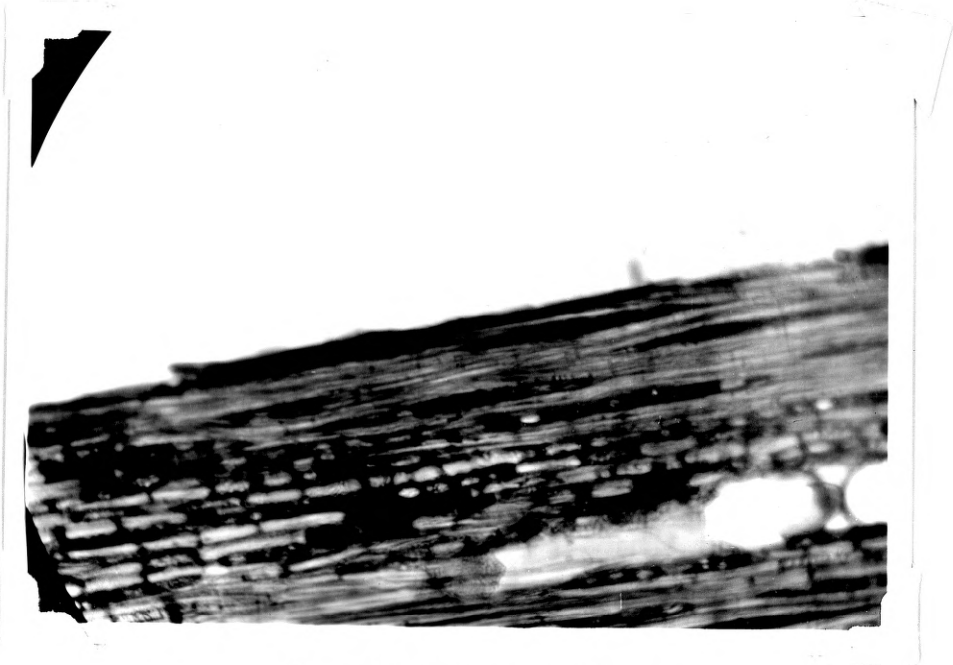
SPECIES Massaranduba GLUE Vegetable PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 6.2% DATE Apr. 3, 1936

BLOCK NO.	DIMENSIONS A IN.	DIMENSIONS B IN.	TOTAL AREA SQ. IN.	SHEAR STRENGTH LBS.	SHEAR STRENGTH LBS./SQ.IN.	PERCENT BREAKAGE WOOD	PERCENT BREAKAGE GLUE
1	1.50	1.51	2.26	190	84.07	0	100
2	1.47	1.44	2.12	590	278.30	0	100
3	1.50	1.38	2.07	280	135.26	0	100
4	1.50	1.52	2.28	595	260.96	0	100
5	1.50	1.47	2.20	825	375.00	0	100
6	1.53	1.40	2.14	460	214.95	0	100
7	1.53	1.44	2.20	410	186.36	0	100
8	1.47	1.48	2.18	535	245.41	0	100
AVG.					222.54		

PLATE 21

Photomicrograph of Massaranduba With Vegetable Glue



Longitudinal Section

Discussion (Sucupira)

The casein glue again gave superior joints with this wood, although the strength did not come up to that of the solid wood. The strength for the solid wood in this case was determined at a moisture content of 12.2%, and that of the wood at the time of gluing was 6.3%. This makes the difference in strength between the solid wood and the glued wood even greater, as the shear strength of wood increases with a decrease in moisture content. A favorable penetration of the glue into the wood rays can be seen in the photomicrograph; however the vessels adjacent to the glue line contain no glue at all.

The animal glue joints, although lower in strength than the casein glue joints, were also quite satisfactory. A fair penetration of the glue into the wood can besseen in the photomicrograph.

The vegetable glue exhibited slightly higher strength with this wood than it did in most of the other woods tested. The photomicrograph also indicates a deeper penetration of the glue into the wood than has existed with most of the other woods.

This wood also contains a water soluble tannin material which undoubtedly affected the strength of the joints. Thus the caustic soda treatment would be well worth trying, and higher pressure might also increase the strength of the joints.

TABLE 29

SHEAR TEST DATA

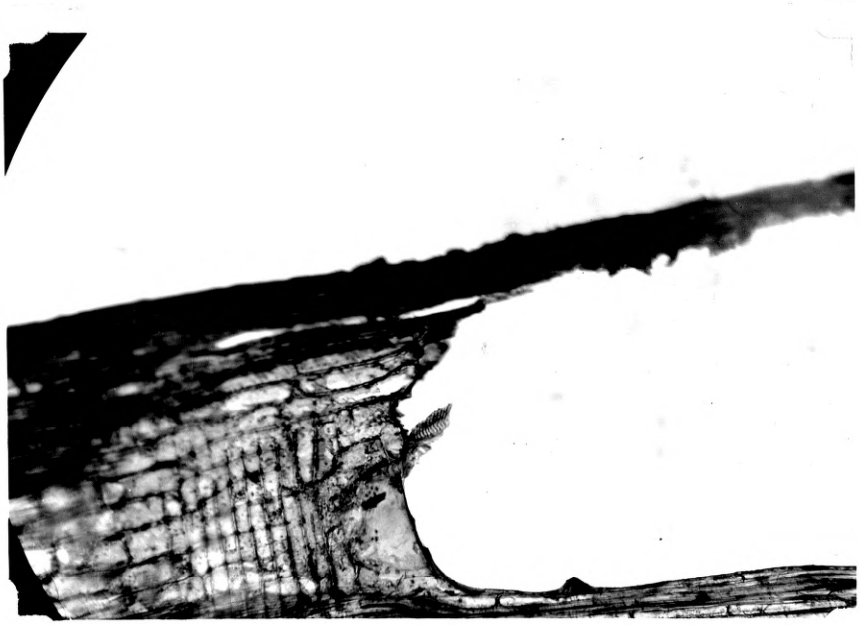
SPECIES Sucupira GLUE Animal PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 6.3% DATE Apr. 13, 1936

BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.59	1.64	2.61	695	266.28	0	100
2	1.52	1.53	2.33	3650	1566.52	0	100
3	1.49	1.75	2.61	2780	1065.13	0	100
4	1.68	1.47	2.47	1865	755.06	0	100
5	1.61	1.48	2.38	1785	750.00	0	100
6	1.64	1.43	2.34	3325	1420.94	5	95
7	1.62	1.52	2.46	4525	1839.43	5	95
8	1.60	1.43	2.29	2755	1203.06	0	100
9	1.64	1.51	2.48	2760	1112.90	0	100
10	1.65	1.47	2.42	3480	1438.02	5	95
AVG.					1141.73		

PLATE 22

Photomicrograph of Sucupira With Animal Glue



Longitudinal Section

TABLE 30

SHEAR TEST DATA

SPECIES Sucupira GLUE Casein PRESSURE 150#

ASSEMBLY & TIME 15-C MOIST. CONT. 6.3% DATE Mar. 27, 1936

BLOCK NO.	DIMENSIONS A IN.	DIMENSIONS B IN.	TOTAL AREA SQ. IN.	SHEAR STRENGTH LBS.	SHEAR STRENGTH LBS./SQ.IN.	PERCENT BREAKAGE WOOD	PERCENT BREAKAGE GLUE
1	1.37	1.41	1.93	1820	943.00	30	70
2	1.44	1.56	2.25	3880	1724.44	25	75
3	1.47	1.53	2.25	4705	2091.11	10	90
4	1.45	1.57	2.28	1760	771.93	0	100
5	1.43	1.48	2.12	2505	1181.60	5	95
6	1.41	1.52	2.14	2295	1072.43	10	90
7	1.48	1.51	2.23	2510	1125.56	10	90
8	1.48	1.50	2.22	2545	1146.39	20	80
9	1.39	1.50	2.08	4235	2036.06	25	75
10	1.47	1.51	2.22	3610	1626.13	15	85
AVG.					1371.86		

PLATE 23

Photomicrograph of Sucupira With

Casein Glue

Longitudinal Section

TABLE 31

SHEAR TEST DATA

SPECIES Sucupira GLUE Vegetable PRESSURE 150#

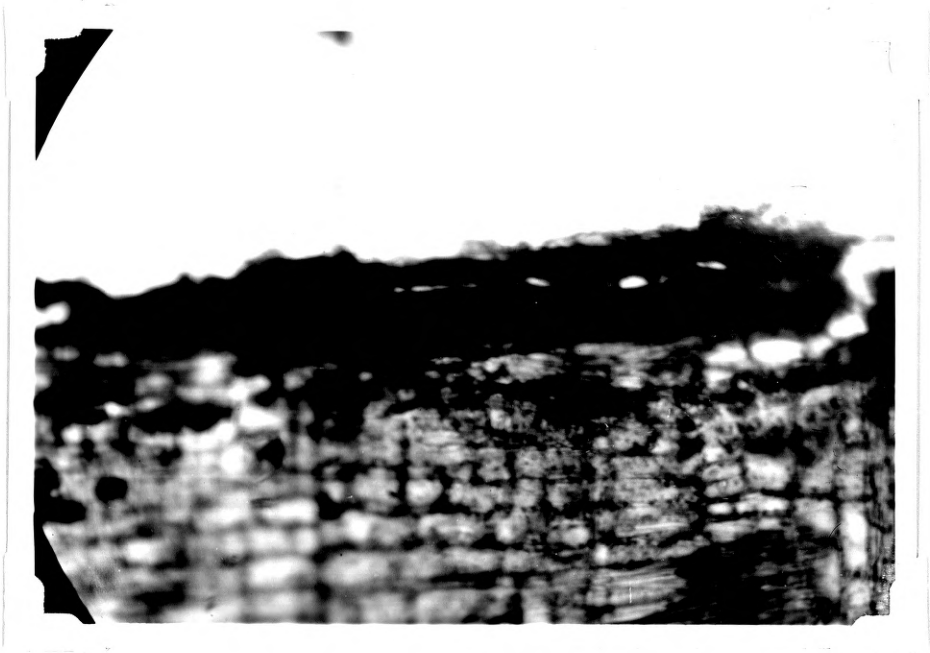
ASSEMBLY & TIME 15-C MOIST. CONT. 6.3% DATE Apr. 3, 1936

BLOCK NO.	DIMENSIONS		TOTAL AREA	SHEAR STRENGTH	SHEAR STRENGTH	PERCENT BREAKAGE	
	A IN.	B IN.	SQ. IN.	LBS.	LBS./SQ.IN.	WOOD	GLUE
1	1.51	1.45	2.19	1205	550.23	0	100
2	1.52	1.46	2.22	420	189.19	0	100
3	1.47	1.50	2.20	515	234.09	0	100
4	1.52	1.52	2.31	380	164.50	0	100
5	1.50	1.42	2.13	605	284.04	0	100
6	1.50	1.49	2.24	1010	450.86	0	100
7	1.48	1.43	2.12	535	252.35	0	100
8	1.46	1.42	2.07	700	338.16	0	100
9	1.48	1.38	2.04	680	333.33	0	100
10	1.50	1.47	2.20	745	338.64	0	100
AVG.					313.54		

PLATE 24

Photomicrograph of Sucupira With

Vegetable Glue



Longitudinal Section

Bibliography

(1) The Gluing of Wood, United States Dept. of Agr. Bul. 1500, June, 1929

(2) Private Discussion With Prof. W. Kynoch.