Strength Properties of Full-Size Oriented Strand Board Panels Following Submergence in Potable and Salt Water

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Abstract

One of the largest contributors to the economic loss from floods is the complete or partial destruction of residential buildings, and finding ways to eliminate or minimize this loss is important. Oriented strand board (OSB) is a wood product commonly used in home construction, so a better understanding of how flood water affects its mechanical properties is warranted. In this study, the moduli of elasticity and rupture (MOE and MOR, respectively) of representative samples removed from full-size (4 by 8-ft [1.2 by 2.4 m]) OSB panels were examined following the submergence of the panels in potable and salt water (surrogates for flood water) for increasing periods of time (i.e., 8, 24, 48, 72, 168, and 336 h). The results of our study show that after 8 hours of panel submersion in potable water, MOR and MOE is reduced by 15 percent and 16 percent, respectively; no significant change was observed in MOR and MOE for panels soaked in salt water. After 168 hours, the MOR loss was 43 percent for panels soaked in potable water and 38 percent for panels soaked in salt water. For MOE, there was a 35 percent loss regardless of water type. Submersion of panels in either water type for an additional 168 hours resulted in no significant change in MOR or MOE. The MOR and MOE of samples removed from the edges of the submerged panels, for both water types, were lower than those of the interior samples. Finally, the decreases in average MOR and MOE following submergence in either water type were approximately independent of brand.

Floods are the number one natural disaster in the United States and annually account for billions of dollars in damages (Armal et al. 2020). One of the largest contributors to flooding losses is the complete or partial destruction of residential buildings (i.e., homes). Flood water negatively affects the durability of these structures in a variety of ways and depends upon the type of event (Leichti et al. 2002, Marvi 2019). Without doubt, finding ways to build flood-resistant homes in risk-prone areas is important if losses are to be minimized or prevented.

One option in minimizing flood damage to homes is employing materials in their construction that have robust performance when submerged in water and then dried. Most homes across the United States are built with wood materials because they are inexpensive and have excellent strength properties. Among the various solid and engineered wood products utilized in home construction, oriented strand board (OSB) is common (Howard 2000). OSB is a structural panel fabricated from aligned wood pieces (known as strands), adhesives, and additives under heat and pressure. OSB has similar mechanical properties as structural plywood but is lower in cost to manufacture (Brochmann et al. 2004).

Research in our laboratory has been focusing on the flood resilience of wood building materials, and the study presented here examines the mechanical properties of full-size (4 by 8-ft [1.2 by 2.4 m]) OSB panels submerged for prolonged periods of time in potable and salt water. Full-size OSB panels were specifically studied in this work—as opposed to small samples—in order to evaluate the panels as functional units (i.e., as they would be used in home

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construction). Interestingly, there have been no significant studies on the structural performance of OSB following lengthy exposure to water under flood-like conditions, especially on full-size panels. Most research on OSB materials with regard to water penetration has focused on areas such as moisture absorption from humidity, water transport in the material, environmental weathering, and thickness swelling (Gu et al. 2005, Kojima et al. 2011, Li et al. 2016, Cheng et al. 2018). Additionally, two studies have been conducted examining the flexural response of small samples when subjected to hot water soaking as well as fatigue deflection at room temperature (Norita et al. 2008, Li et al. 2019).

In this research, synthetic flood water surrogates were prepared in the laboratory and utilized in order to circumvent problems arising from the reproducibility, storage, and transport of large amounts of natural water. These surrogates included potable water, which was used to represent fresh water that might be found in river flooding, and a synthetic salt water mixture, available commercially, to represent salt water that might be encountered along coastal regions. It is recognized, however, that actual flood water may contain substances that may affect the strength properties of OSB panels. In general, factors affecting the composition of flood water include its geographic location, types of nearby industrial and agricultural activities, the nature of the water itself, etc. (Carey et al. 2011). Future communications from this laboratory will report on how the presence of foreign chemical substances in water, commonly arising from floods, affects the strength properties of full-size OSB panels.

Materials and Methods

No standard method exists for measuring the flood resilience of full-size panels. However, methods for evaluating the physical properties of small specimens have been developed by different organizations. In North America, the American Society for Testing and Materials (ASTM) has published methods for evaluating water-related thickness swelling (D1037; ASTM 2006a) as well as the strength properties of dry samples (D3043, ASTM 2006b). These methods have been adapted for use in this work. Specifically, the physical properties of flexural strength (modulus of rupture and modulus of elasticity) were evaluated on small specimens extracted from the large panels after the large panels had been submerged in water (two different types, potable and salt) for increasing periods of time and then dried.

OSB panels classified as exposure 1 were obtained from three separate manufacturers in order to obtain representative samples from North American producers. Two of the three products carried the Engineered Wood Association's American Plywood Association (APA) stamp while the third carried the Teco stamp. Two of the manufacturer's products were 19/32 inch in nominal thickness while the third was 23/32 inch, as dictated by availability.

Each of the full-sized panels was submerged in two types of water for increasing amounts of time. Fresh, potable water was obtained directly from the tap (City of Raleigh) and the salt water was prepared using a synthetic mixture from Instant Ocean brand aquarium dry salt mix per manufacturer guidelines (138 g of brine mix per 1 US gal [3.8 L] of tap water). According to the literature (Pilson 1998), the composition of this synthetic salt water solution is similar to that of ocean water. The specific gravity of this salt solution was checked and maintained between 1.02 and 1.03. Both types of water had pH ranges of 8.1–8.5.

Three panels from each manufacturer were weighed and placed in separate stainless steel containers 52 inches wide by 100 inches long by 4 inches tall (132 cm by 254 cm by 10 cm). Using ASTM D1037 as a guide, each panel was submerged under 30–31 gallons of water so that it was 1 inch (2.54 cm) beneath the surface. The panels were restrained to hold them at the correct depth and prevent them from floating to the surface. Additionally, spacers were placed under the panels to prevent them from resting on the bottom of the tank during submersion. Water levels were checked daily to assure constant depth within 1/8 inch (0.32 cm) of a 1-inch (2.54-cm) depth mark.

Separate panels were submerged for 8, 24, 48, 72, 168, and 336 hours and the results obtained from these experiments compared with those from panels that were not submerged. These unsubmerged panels served as controls (0 h). Submersion times were chosen in order to encompass a wide spectrum of potential flood durations.

Following submersion, the panels were removed from the stainless steel containers, stood on edge, and allowed to drip for 10–15 minutes to remove any free water. The panels were then weighed, and their thickness measured. Samples were stacked horizontally on bolsters in the lab (at approximately 9% equilibrium moisture content), stickered with 1.5-inch (3.8-cm) spacers and then air-dried using a fan. Air-drying continued until the panels returned to within 10 percent of their original mass (samples were dry to touch at this point).

Sixteen bending samples from each panel were harvested in a prescribed pattern as shown in Figure 1. This pattern allowed the samples to be grouped into four different types: edge samples with orientation parallel to strength axis, interior samples with orientation parallel to strength axis, edge samples with orientation perpendicular to strength axis, and interior samples with orientation perpendicular to strength axis. All samples were cut in a manner such that they were compliant with ASTM D3043 two-point load test bending protocol. Specifically, parallel samples had a width of 2 inches (5.1 cm) and a length of 28 inches (71.1 cm) plus a 2-inch overhang, and perpendicular samples had a width of 2 inches and a length of 14 inches (35.6 cm) plus a 2-inch overhang.

The mass of each sample was determined and then all samples were placed in an equalization chamber held at 23°C at 50 percent relative humidity. These environmental conditions were chosen to ensure that the equilibrium moisture content of the samples would be approximately 9 percent. Samples were weighed daily over a period of approximately 2 weeks and were considered to have reached equilibrium when the mass changed no more than 0.2 g in a 24-hour period per ASTM D4442 (ASTM 2007). In order to assure minimal changes to moisture content, the samples were placed into plastic bags as they were taken from the equalizing chamber prior to the static bending tests.

Each OSB sample was tested in static bending according to ASTM D3043 Method B – two-point loading. The testing speed was 0.342 inches/minute for parallel samples and 0.086 inches/minute for perpendicular samples (per ASTM D3043). Data were collected on cross-head movement, loading, and deflection at a rate of 10 samples/second (5 Hz)

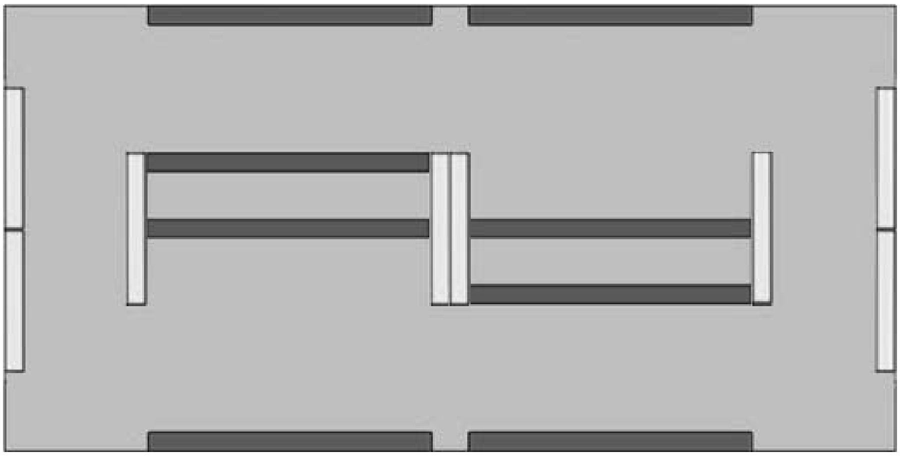

Figure 1.—Schematic diagram illustrating location of four types of samples removed from each panel (i.e., from the edge, the interior, parallel to the strength axis and perpendicular to the strength axis). A total of 16 samples were removed from each panel.

in order to calculate modulus of rupture (MOR) and modulus of elasticity (MOE).

Statistical analysis of MOR and MOE was performed using SAS Version 9.4 software. This study examined five factors that could possibly affect the MOR and MOE of OSB exposed to simulated flood water. The five factors examined were (1) water type, (2) submersion time, (3) OSB brand, (4) sample location, and (5) strength axis orientation. The five factors and levels for each factor are presented in Table 1. The statistical tests used the SAS General Linear Model (GLM) procedure to determine significance of factors at the $\alpha = 0.05$ level and used the Student-Newman-Keuls (SNK) multiple mean comparison to establish significant differences between factor levels.

Results and Discussion

Control group properties

There were 32 control samples from each of the 3 brands (a total of 96 control samples) that were not submerged in either potable or salt water. Table 2 presents the MOR and MOE results from the bending tests on these samples. As expected, the overall results obtained in this study (the average values in Table 2) are similar to those found in the literature (Wang et al. 2004) and are in approximate agreement with the typical reference values supplied by the APA—The Engineered Wood Association (APA 2016). These results were taken into account in subsequent statistical analyses that focused on the time-dependent losses of strength and stiffness when samples were submerged in either type of water.

Table 1.—The five factors and associated levels for each factor that were examined in this study. OSB is oriented strand board.

Water type	Submersion time (hours)	OSB brand	Sample location	Strength axis orientation
Potable water	0	Brand 1	Edge	Parallel
Salt water	8	Brand 2	Interior	Perpendicular
	24	Brand 3		
	48			
	72			
	168			
	336			

Overview of statistical analysis

The first statistical analysis that was undertaken in this study was examining the effects of the five major factors listed in Table 1. The analysis employed a factorial statistical design consisting of two water types, six submersion or treatment times, three OSB brands, two sample locations, two strength axis orientations, and four samples from each combination of factors. Control samples were not included in this analysis because their inclusion would duplicate identical data sets for potable and salt water data, hence suggesting similarities between water treatments that did not exist.

The 2 by 6 by 3 by 2 by 2 factorial design resulted in a total of 144 combinations, or 576 possible samples (2 water types by 6 submersion times by 3 brands by 2 locations by 2 orientations by 4 samples = 576 possible treated samples). However, some samples were damaged and not testable, which resulted in a slightly lower number: 570 MOR and MOE values. The missing sample values resulted in an unbalanced factorial design. Therefore, the statistical analysis was conducted using a general linear models procedure (SAS Proc GLM). The results of the statistical analysis on the main factors are shown in Table 3.

As can be seen in Table 3, all major factors were highly significant at the $\alpha = 0.05$ level for both MOR and MOE, with the exception of the factor of water type for MOE. Significant interactions between two factors at the $\alpha = 0.05$ level were indicated between strength axis orientation and submersion time, OSB brand and location of bending sample (i.e., edge or interior), OSB brand and strength axis orientation, and location of bending sample and strength axis orientation. These interactions are not surprising and are likely related to the differences in the orientations of the strands in the two panel axes (e.g., with regard to strength axis orientation and submersion time) as well as material and processing differences among the manufacturers (e.g., with regard to OSB brand and location of the bending sample). It should be borne in mind, however, that a study of the underlying reasons for these interactions was not a goal of this work. Rather, what was of interest was the loss of

Table 2.—Parallel and perpendicular moduli of rupture and elasticity (MOR) and (MOE) and ratios for all control samples.

Sample location	MOR (psi) Parallel	MOR (psi) Perpendicular	MOR (psi) Average	MOR (psi) Para/Perp ratio	MOE (10^6 psi) Parallel	MOE (10^6 psi) Perpendicular	MOE (10^6 psi) Average	MOE (10^6 psi) Para/Perp ratio
Edge	3,530 [a]	1,840	2,685	1.94	0.949	0.311	0.630	3.06
CV (%)	15.5	20.9	36.3		20.7	20.4	56.0	
N	24	24	48		24	24	48	
Interior	3,166 [a]	1,861	2,513	1.70	0.856	0.320	0.588	2.71
CV (%)	21.8	18.5	33.9		21.6	18.0	51.5	
N	24	24	48		24	24	48	
Average	3,348	1,850	2,599	1.81	0.903	0.316	0.609	2.86
CV (%)	19.2	19.5	35.2		21.5	19.0	53.8	
N	48	48	96		48	48	96	

[a] Paired edge and interior means are significantly different from each other at the alpha = 0.05 level.

Table 3.—Degrees of freedom (df), F *value, and associated Pr level of significance for the main study factors and their two-way interactions for moduli of rupture and elasticity (MOR) and (MOE). OSB is oriented strand board.*

Factor	df	*F* value for MOR	Pr > *F*	*F* value for MOE	Pr > *F*
Water type	1	46.65 [a]	<0.0001	3.04[b]	0.0816
Submersion time	5	81.07 [a]	<0.0001	42.37 [a]	<0.0001
OSB brand	2	61.11 [a]	<0.0001	86.89 [a]	<0.0001
Sample location	1	89.74 [a]	<0.0001	36.10 [a]	<0.0001
Strength axis orientation	1	1425.54 [a]	<0.0001	3910.52 [a]	<0.0001
Water type × Submersion time	5	1.91	0.0909	1.85	0.1017
Water type × OSB brand	2	0.82	0.4425	0.69	0.5043
Water type × Sample location	1	0.35	0.5566	1.84	0.1750
Water type × Strength axis orientation	1	1.04	0.3076	0.20	0.6567
Submersion time × OSB brand	10	1.63	0.0958	0.91	0.5235
Submersion time × Sample location	5	1.54	0.1742	1.62	0.1537
Submersion time × Strength axis orientation	5	8.52 [a]	<0.0001	6.71 [a]	<0.0001
OSB brand × Sample location	2	3.30 [a]	0.0376	0.07	0.9289
OSB brand × Strength axis orientation	2	46.66 [a]	<0.0001	69.39 [a]	<0.0001
Sample location × Strength axis orientation	1	7.12 [a]	0.0078	0.21	0.6431

[a] *F* value indicates significance of the factor at the $\alpha = 0.05$ level.

[b] Probability > *F* = 0.0816, indicating that water type trended toward significance for MOE but was not significant at the $\alpha = 0.05$ level.

MOE and MOR as a function of water submersion time for realistic conditions commonly found in the application of full-size panels.

Further analysis to find significant differences between the means of the different levels for each main factor were conducted using the SNK multiple mean comparison method and the results are reported in the following sections.

MOE and MOR in potable and salt water

As shown in Table 4, the results of the statistical analyses on the entire batch of bending samples for each water type show that there was a significantly greater loss in average MOR for panels submerged in potable water compared with panels submerged in salt water. In contrast, there was no significant difference in the average MOE between the two water types.

Parsing the cumulative results of the bending tests into separate submersion times for the two water types yields the results shown in Tables 5 and 6 and Figures 2 and 3. As shown in Table 5, the samples removed from the OSB panels that had been submerged in potable water for 8 hours and then air-dried resulted in a reduction in MOR of approximately 15 percent. The reductions were 25 percent after 24 hours and 43 percent after 168 hours of potable water submersion. Doubling the submersion time to 336 hours did not significantly increase the loss in MOR from 168 hours.

Significant MOE reductions due to submerging in potable water occurred and were similar in magnitude to the

Table 4.—Average moduli of elasticity and rupture (MOE) and (MOR) values for all treated samples. Results of Student-Newman-Keuls (SNK) multiple mean comparisons for samples submerged in either potable or salt water. Means include both orientations, both locations, and all brands and submersion times. No control samples (0 h of submerging) were used in this analysis.[a]

Property	Water type: Potable water	Water type: Salt water
MOR		
Mean (psi)	1,773 B	1,984 A
CV [b] (%)	44.5	42.0
n [c]	283	287
MOE		
Mean (10^6 psi)	0.443 A	0.456 A
CV (%)	59.6	59.2
n	283	287

[a] Means followed by the same letter are not significantly different at the $\alpha = 0.05$ level using the SNK multiple mean comparison.

[b] CV = Coefficient of Variation.

[c] *n* = Number of samples.

Table 5.—Results of Student-Newman-Keuls (SNK) multiple mean comparison for samples removed from panels that were submerged in potable water for increasing periods of times.[a] Means include both orientations, both locations, and all brands.

	Submersion time						
Property	0 h	8 h	24 h	48 h	72 h	168 h	336 h
MOR							
Mean (psi)	2,599 A	2,205 B	1,948 C	1,857 CD	1,755 D	1,474 E	1,394 E
CV[b] (%)	35.2	37.7	40.8	40.9	47.4	40.3	44.4
n[c]	96	47	48	46	48	48	46
MOE							
Mean (10^6 psi)	0.609 A	0.512 B	0.471 BC	0.468 BC	0.427 CD	0.398 D	0.381 D
CV (%)	53.8	54.4	61.4	60.4	57.3	58.7	63.1
n	96	47	48	46	48	48	46

[a] Means followed by the same letter are not significantly different at the $\alpha = 0.05$ level using the SNK multiple mean comparison.
[b] CV = Coefficient of Variation.
[c] *n* = Number of samples.

Table 6.—Results of Student-Newman-Keuls (SNK) multiple mean comparison for samples removed from panels that were submerged in salt water for increasing periods of times.[a] Means include both orientations, both locations, and all brands.

	Submersion time						
Property	0 h	8 h	24 h	48 h	72 h	168 h	336 h
MOR							
Mean (psi)	2,599 A	2,650 A	2,085 B	2,035 B	1,906 B	1,600 C	1,639 C
CV[b] (%)	35.2	36.8	37.8	36.9	34.2	37.9	46.5
n[c]	96	47	48	48	48	48	48
MOE							
Mean (10^6 psi)	0.609 A	0.584 A	0.470 B	0.455 B	0.440 B	0.394 C	0.395 C
CV (%)	53.8	52.6	57.9	58.1	55.6	60.2	65.3
n	96	47	48	48	48	48	48

[a] Means followed by the same letter are not significantly different at the $\alpha = 0.05$ level using the SNK multiple mean comparison.
[b] CV = Coefficient of Variation.
[c] *n* = Number of samples.

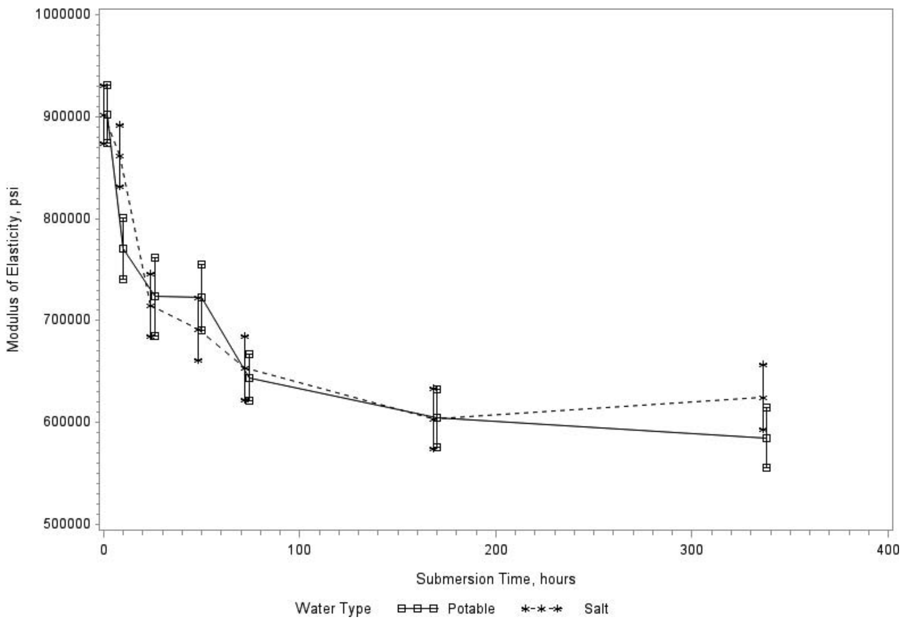

Figure 2.—Loss in modulus of elasticity (MOE) of samples removed from full-size oriented strand board (OSB) panels as a function of submersion time in either potable or salt water. Each mean represents approximately 24 (parallel to strength axis) samples and consists of 3 brands and both interior and edge samples. Bars are offset slightly to allow better visibility.

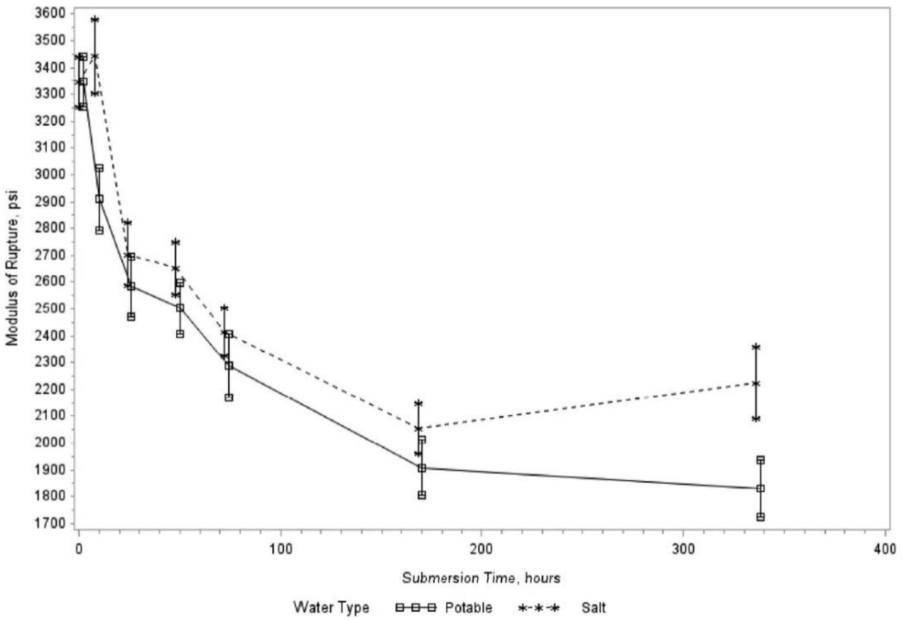

Figure 3.—Loss in modulus of rupture (MOR) of samples removed from full-size oriented strand board (OSB) panels as a function of submersion time in either potable or salt water. Each mean represents approximately 24 (parallel to strength axis) samples and consists of 3 brands and both interior and edge samples. Bars are offset slightly to allow better visibility.

reductions in MOR. Eight hours of submerging in potable water followed by air-drying reduced the mean sample MOE by 16 percent compared with the control samples. Similar MOE reductions for submerging in potable water for 24 and 168 hours were 23 and 35 percent, respectively. There was no further significant loss in MOE when the submersion time was doubled to 336 hours.

The average MOR and MOE values of the samples obtained from the full-size panels submerged in salt water are shown in Table 6. After 8 hours of submersion there was no significant change in MOR of panels submerged in salt water and then air-dried compared with the control samples. After 24 hours of submerging, there was a significant MOR reduction of 20 percent; and after 168 hours of submerging, MOR was reduced by 38 percent. Additional submerging did not significantly reduce MOR within the limits of the study.

The mean MOE of panels submerged in salt water for 8 hours and then air-dried was not significantly different from panels that were not submerged (the control group). The MOE of panels submerged for 24 hours was significantly reduced by 23 percent. The reduction in MOE of panels submerged for 168 hours in salt water was 35 percent. Submerging for a total of 336 hours did not significantly increase MOE loss compared with submerging half as long.

Figure 2 shows the loss in MOE as a function of soak time in potable and salt water for the samples that were oriented parallel to the strength axis. There was no significant difference in MOE between water types. Additionally, there was no significant loss in MOE after 168 hours of submersion in water, with most of the loss in stiffness occurring during the initial 72 hours of submergence.

MOR loss as a function of submersion time in potable compared with salt water is shown in Figure 3 for samples that were parallel to the major strength axis. Much of the loss in MOR occurs in the first 168 hours (7 days) of submersion in either water.

Effect of sample location and submersion time on MOE and MOR

This study found that there were significant differences in the average MOR and MOE for panel samples removed from the edge versus the interior after being submerged in the potable and salt water. Comparing the results in Table 7 with those from control values found in Table 2, it was found that the MOR of the edge samples submerged in potable water decreased by 39 percent compared with only 24 percent for the interior samples. Similarly, the MOE of the edge samples decreased by 32 percent compared with 22 percent of interior samples. For the salt water experiment, the MOR of the edge samples decreased by 32 percent versus by 15 percent for the interior samples. The MOE for the edge samples decreased by 32 percent and the interior samples decreased by 18 percent.

The cumulative loss of average MOR and MOE as a function of submersion time, shown in Figures 4 and 5, respectively, reveals that the samples located in the interior of the panel do not lose their strength as fast as those on the edges. This is very likely due to the faster diffusion of water into the edges of the panels as opposed to their faces.

Variation of MOE and MOR due to manufacturer

The differences of the MOR and MOE values following the submergence of the full-size panels in potable and salt water, as a function of brand, were evaluated by comparing the control sample values with those obtained following submergence. Table 8 shows the results of the control samples and Table 9 shows the results following submergence. The MOR loss averaged 25 to 30 percent and MOE loss averaged 25 to 27 percent when compared with their respective control values, regardless of brand.

Table 7.—Results of Student-Newman-Keuls (SNK) multiple mean comparisons for edge versus interior samples submerged in either potable water or salt water. No control samples (0 h of submersion) were used in this analysis.[a]

	Sample location	
Property	Interior	Edge
Submerged in potable water		
MOR		
Mean (psi)	1,905 A	1,637 B
CV (%) [b]	38.7	49.9
n [c]	143	140
MOE		
Mean (10^6 psi)	0.458 A	0.427 B
CV (%)	56.9	62.6
n	143	140
Submerged in salt water		
MOR		
Mean (psi)	2,138 A	1,828 B
CV (%)	37.6	45.8
n	144	143
MOE		
Mean (10^6 psi)	0.483 A	0.429 B
CV (%)	55.8	62.7
n	144	143

[a] Means followed by the same letter are not significantly different at the $\alpha = 0.05$ level using the SNK multiple mean comparison.

[b] CV = Coefficient of Variation.

[c] n = Number of samples.

Table 8.—Moduli of rupture and elasticity (MOR) and (MOE) of control samples (not soaked in potable or salt water) with the results of Student-Newman-Keuls (SNK) multiple mean comparison[a]

Property	Brand 0	Brand 1	Brand 2
MOR			
Mean (psi)	2,770 A	2,363 B	2,665 A
CV [b] (%)	39.3	35.2	28.8
n [c]	32	32	32
MOE			
Mean (10^6 psi)	0.687 A	0.583 B	0.558 B
CV (%)	58.2	48.8	50.3
n	32	32	32

[a] Means followed by the same letter are not significantly different at the $\alpha = 0.05$ level using the SNK multiple mean comparison.

[b] CV = Coefficient of Variation.

[c] n = Number of samples.

Table 9.—Results of Student-Newman-Keuls (SNK) multiple mean comparisons for all treated samples submerged in either potable or salt water. No control samples (0 h of submersion) were used in this analysis.[a]

	OSB brand		
Property	Brand 0	Brand 1	Brand 2
MOR			
Mean (psi)	2,073 A	1,654 C	1,911 B
CV [b] (%)	46.9	42.4	36.4
n [c]	190	191	189
MOE			
Mean (10^6 psi)	0.517 A	0.424 B	0.407 B
CV (%)	62.6	53.3	55.8
n	190	191	189

[a] Means followed by the same letter are not significantly different at the $\alpha = 0.05$ level using the SNK multiple mean comparison.

[b] CV = Coefficient of Variation.

[c] n = Number of samples.

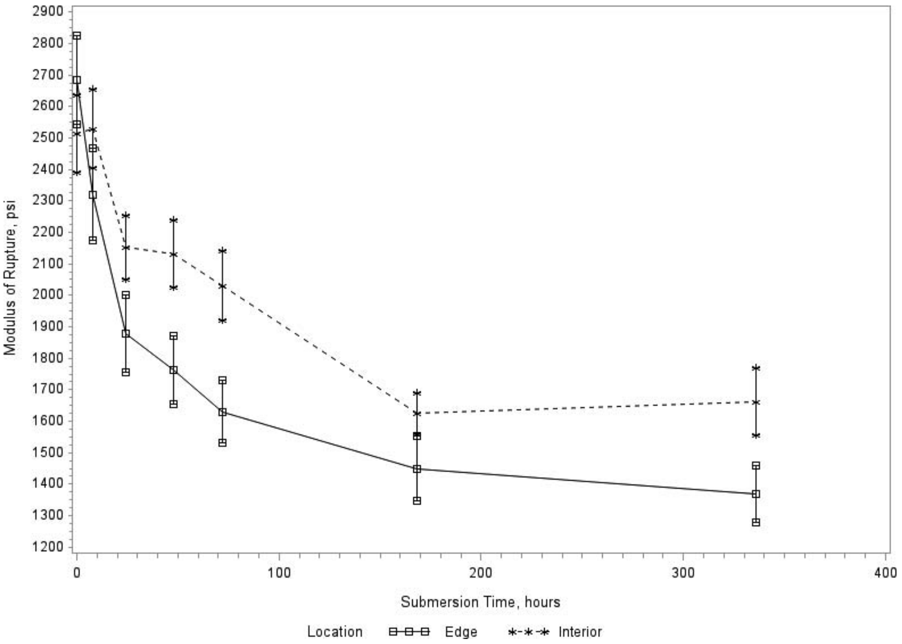

Figure 4.—Loss in modulus of rupture (MOR) of samples removed from full-size oriented strand board (OSB) panels as a function of submersion time in potable and salt water for the two sample locations (panel interior or panel edge). Each mean represents approximately 48 samples.

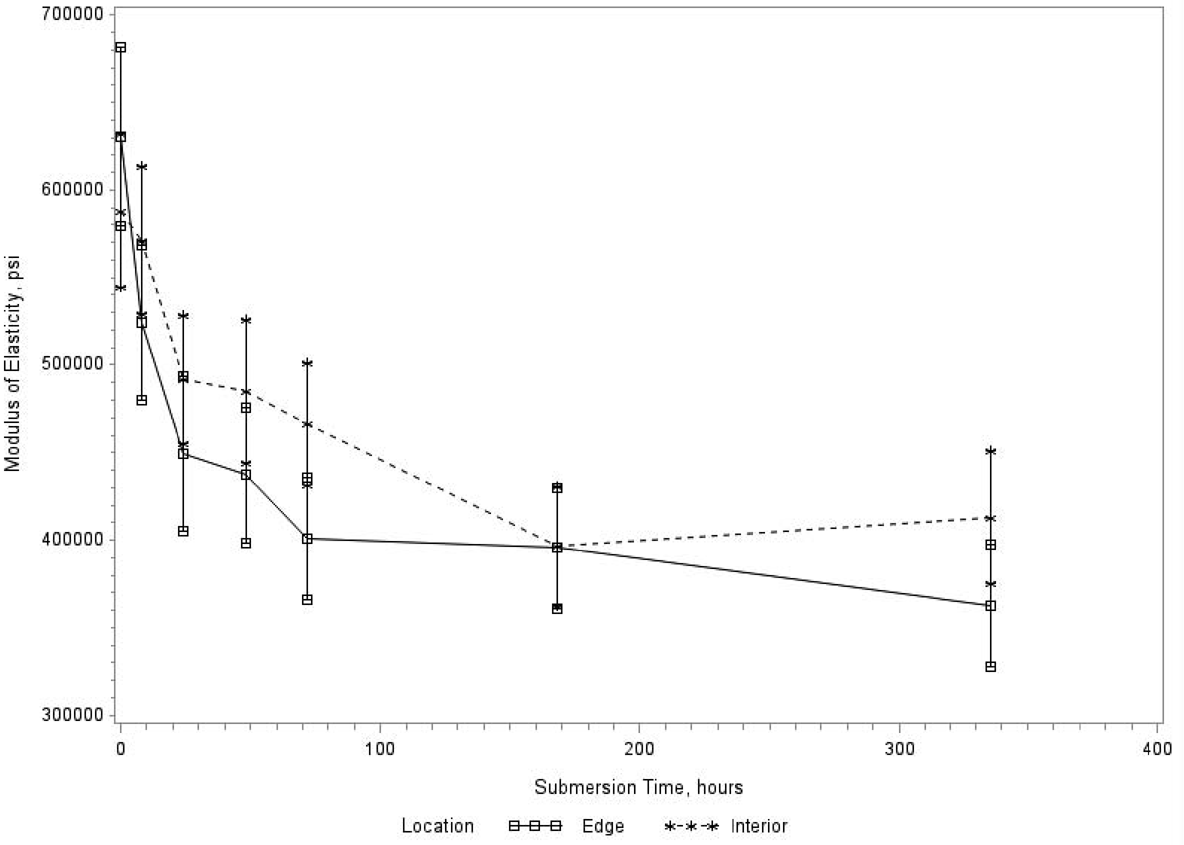

Figure 5.—Loss in modulus of elasticity (MOE) of samples removed from full-size oriented strand board (OSB) panels as a function of a submersion time in potable and salt water from the two sample locations (panel interior or panel edge). Each mean represents approximately 48 samples.

Conclusions

The results from this investigation are as follows:

1. Significant statistical interactions were indicated between the strength axis orientation and submersion time, the OSB brand and the location of bending sample (i.e., edge or interior), the OSB brand and the strength axis orientation, and the location of the bending sample and the strength axis orientation.
2. On average, there was significantly greater loss in MOR for the samples submerged in potable water compared with submersion in salt water when all the samples were included. There was no significant difference in MOE between the types of water in which the panels were submerged.
3. Taking into account all sample types submerged in either potable water or salt water, a significant reduction in MOR and MOE occurred for some samples. After 8 hours of submersion in potable water there was a reduction in MOR and MOE of 15 percent and 16 percent, respectively. After the same period of time submerging in salt water, there was no significant change in MOR or MOE. After 168 hours (7 days) of submersion there was a 43 percent loss in MOR (potable water) and 38 percent loss in MOR (salt water). For MOE there was a 35 percent loss regardless of water type. Submersion in either water type for an additional 168 hours resulted in no significant change in MOR or MOE.
4. On average, the mean MOR of samples removed from the edge of the potable water submerged panels was lower than interior samples (39% vs. 24% in comparison with the controls). Similarly, the mean MOE of edge samples was significantly lower than interior samples (32% vs. 22% in comparison with the controls). For the samples submerged in salt water, the mean MOR for the edge samples was significantly lower than that of the interior samples (32% vs. 15% in comparison with the controls). Finally, the MOE for the edge samples submerged in salt water was significantly reduced in comparison to the interior samples (32% vs. 18% in comparison with the controls).
5. The decrease in mean MOR and mean MOE as a function of brand following submergence in both water types was 25 to 30 percent and 25 to 27 percent, respectively. Thus, all three brands studied in this work exhibited similar average loss behavior.

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