

Effects of Freeze-Thaw Cycling On The Stiffness of Various Composite Decking Products

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Abstract

The purpose of this study was to observe how the flexural stiffness of seventeen commercially available composite decking products changes when exposed to water immersion and freeze-thaw cycling. This work has shown that there is a substantial variability in freeze-thaw performance between different manufacturers. Overall, there were eight products from seven companies which had a 20% or greater reduction in stiffness after 15 freeze-thaw cycles. However, GeoDeck Traditional performed very well, and consistently maintained the highest retained stiffness values of the groups examined. CorrectDeck CX and UltraDeck Fusion also had minimal reduction in stiffness, possibly due to the co-extruded casing covering the material.

Background

The use of composite decking has been increasing in the United States over the last decade, yet the product technology is in a relative infancy when compared to many other building materials. Currently, there are many commercial composite decking products available for purchase. However, the durability of these products when exposed to the environment is not always understood. In regards to the impact of freeze-thaw on the long-term durability of WPCs, the International Code Council Evaluation Service (ICC-ES) simply requires that specimens be submerged in water for 24 hours, frozen for 24 hours, and then thawed for 24 hours. This is repeated two more times, and is considered to encompass the long-term impact of freeze-thaw exposure on WPCs. The limited duration of this testing was most likely chosen for cost, rather than truly understanding the impact of freeze-thaw exposure. This project was conducted to bring clarity to the freeze-thaw performance of many different brands of composite decking.

Methods and Materials

Table 1 lists the composite products evaluated during the experimentation. The products were purchased anonymously at various retail outlets to minimize any potential bias. Test specimens were cut to a length of 20 inches, and conditioned at ambient conditions (@ 70°F) for 24 hours to stabilize the temperature.

Table 1: Composite Specimens Evaluated for Freeze-Thaw Performance

– Azek Deck	– CorrectDeck CX
– Elk CrossTimbers Professional	– TAMKO Evergrain
– Fiberon Tropics	– GeoDeck Traditional
– Gossen Original	– Kodiak Composite Decking
– UFPI Latitudes	– Trex Origins
– Master Mark RhinoDeck	– Trex Transcend
– TimberTech Twin Finish	– Midwest Manufacturing Ultradeck Fusion
– Midwest Manufacturing Ultradeck Natural	– Midwest Manufacturing Ultradeck Rustic
– TimberTech XLM	

Throughout the study, the same mechanical testing technique was used to measure the material flexural bending stiffness using Non-Destructive Evaluation (NDE). The testing configuration was a 3-point bending (shown in Figure 1), with a 16 inch span. The crosshead speed used was 0.2 inches/minute. The specimens were loaded to a maximum load of 400 N (90 lbs). This ensured that the specimens

remained in the elastic region and experienced no detrimental effects due to loading. Specimens were loaded seven times at each test, in order to calculate an average value. In all testing, the first test measurement was not used for calculations due to settling effects.

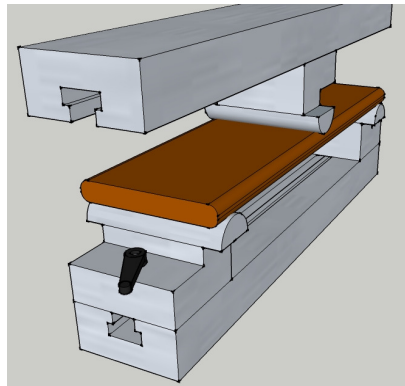


Figure 1: Three-Point Bending Configuration

The individual specimens were exposed to the following conditions:

- Baseline stiffness measurements were collected at ambient (@ 70°F) temperature.
- After testing, specimens were submerged in ambient temperature water for 2 weeks.
- After 2 weeks of immersion, specimens were placed in a 5°F freezer for 24 hours, removed from the freezer, and submerged back into the 70°F water to thaw for 24 hours. This constitutes one “freeze-thaw cycle”.
- When three freeze-thaw cycles were completed, the stiffness was re-tested, and the specimens returned to the freezer for additional cycling.
- After a total of 15 freeze-thaw cycles were completed, a final stiffness measurement was made to see how much the stiffness decreased due to the additional cycling.

Results and Discussion

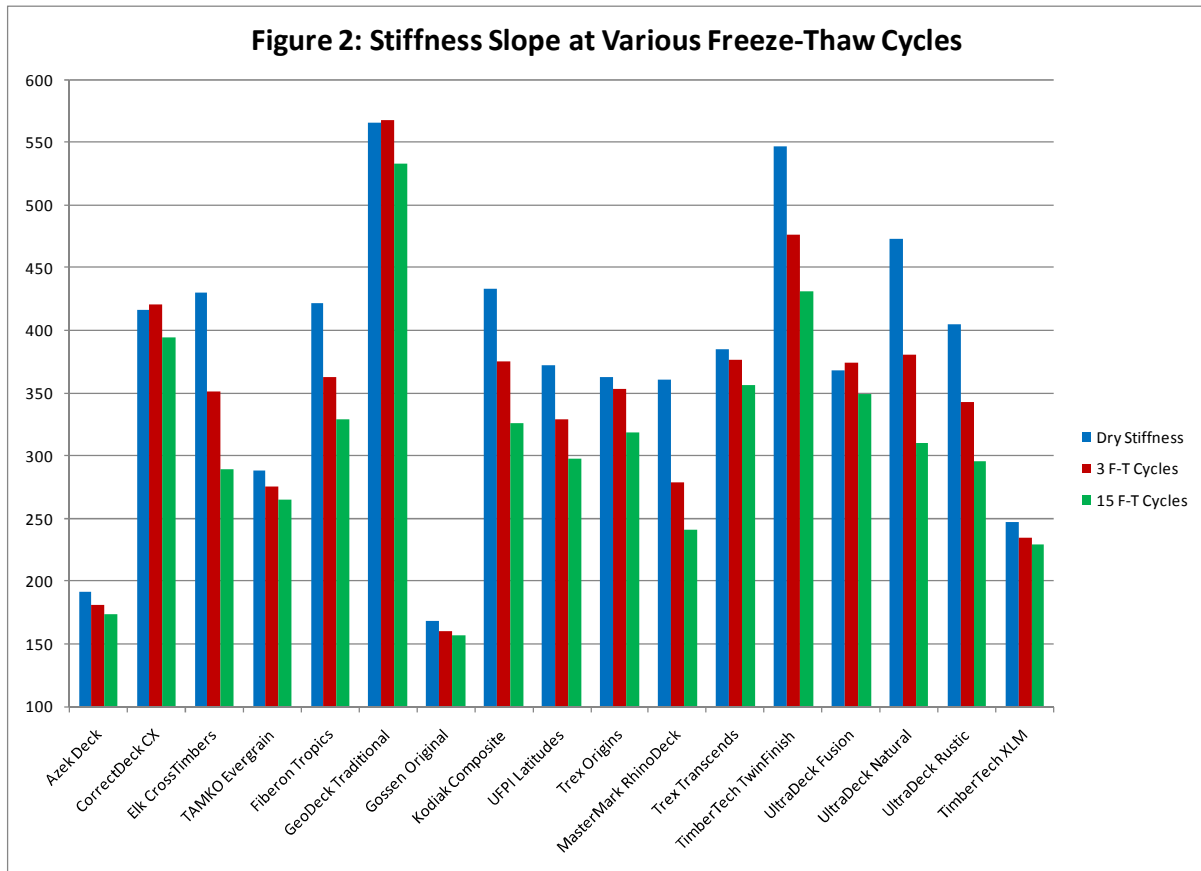
Table 2 outlines the compiled changes in the average stiffness due to specimen exposure after three and fifteen freeze-thaw cycles. In the table, the different composite products are sorted based on the stiffest materials first and lowest stiffness last. From this data, the tested product can be categorized as:

- There is a very large range of stiffness losses through the different products tested, from as low as ~ 5% to as high as ~ 33% stiffness lost due to freeze-thaw cycling.
- After 3 freeze-thaw cycles, GeoDeck Traditional, CorrectDeck CX, Trex Transcends, UltraDeck Fusion, Trex Origins, TAMKO Evergrain, and Azek Deck showed minimal stiffness impact (~ ≤5% stiffness loss)
- After 15 freeze-thaw cycles, GeoDeck Traditional, CorrectDeck CX, and UltraDeck Fusion showed a minimal stiffness impact (~ ≤5% stiffness loss)
- After 15 freeze-thaw cycles, Azek Deck, TAMKO Evergrain, TimberTech XLM, Trex Transcends, and Gossen Original showed a moderate impact on stiffness (~ 5-10% stiffness loss).
- After 15 freeze-thaw cycles, Trex Origins, UFPI Latitudes, TimberTech TwinFinish, Fiberon Tropics, Kodiak Composite Decking, Elk CrossTimbers, MasterMark RhinoDeck, and UltraDeck (Natural and Rustic) showed a severe impact on stiffness (~ ≥10% stiffness loss).

Table 2: Results of Freeze-Thaw Testing, Ranked Stiffest Highest

Product ID	Initial	3 Freeze-Thaw Cycles		15 Freeze-Thaw Cycles	
	Stiffness Slope	Stiffness Slope	% Loss	Stiffness Slope	% Loss
GeoDeck Traditional	565.9	567.5	0.3%	532.9	-5.8%
TimberTech TwinFinish	546.5	476.3	-12.8%	431.4	-21.1%
UltraDeck Natural	473.1	380.6	-19.5%	310.0	-34.5%
Kodiak Composite	433.1	375.0	-13.4%	325.9	-24.7%
Elk CrossTimbers	429.6	351.6	-18.1%	289.7	-32.6%
Fiberon Tropics	421.3	362.4	-14.0%	329.2	-21.9%
CorrectDeck CX	416.2	420.5	1.0%	394.0	-5.3%
UltraDeck Rustic	404.6	342.6	-15.3%	295.5	-27.0%
Trex Transcends	385.2	375.9	-2.4%	356.7	-7.4%
UFPI Latitudes	372.1	328.9	-11.6%	298.1	-19.9%
UltraDeck Fusion	368.5	374.6	1.7%	349.5	-5.1%
Trex Origins	362.3	352.8	-2.6%	318.1	-12.2%
MasterMark RhinoDeck	361.1	278.8	-22.8%	240.5	-33.4%
TAMKO Evergrain	287.9	275.6	-4.3%	264.7	-8.0%
TimberTech XLM	247.3	234.5	-5.2%	228.9	-7.5%
Azek Deck	191.0	181.4	-5.0%	173.3	-9.3%
Gossen Original	168.7	159.5	-5.4%	156.4	-7.3%

In Figure 2, data shown in Table 2 is presented graphically, showing the overall high stiffness and minimal reduction of stiffness with GeoDeck Traditional in comparison to the other tested products.



Conclusions

In this study, eighteen commercially available composite deckboards were tested and compared to GeoDeck Traditional and Tongue & Groove. The testing examined the loss in stiffness and weight change of 20" long specimens exposed to 15 freeze-thaw cycles.

This work has shown that there is a substantial variability in freeze-thaw performance between different manufacturers. Overall, there were eight products from seven companies which had a 20% or greater reduction in stiffness after 15 freeze-thaw cycles. GeoDeck Traditional performed well, and consistently maintained the highest retained stiffness values of the groups examined. CorrectDeck CX and UltraDeck Fusion also had minimal reduction in stiffness, possibly due to the co-extruded casing covering the material. The testing also showed that the ICC-ES testing protocol of 3 freeze-thaw cycles does not properly compensate for long-term freeze-thaw stiffness reduction. In some of the tested products, there was a substantial decrease in stiffness after the application of the 12 additional cycles.