Overcoming Structural Floor Squeaks in Wood-Framed Construction

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ZIPsystem™ BUILDING ENCLOSURES

AdvanTech™ SUBFLOOR ASSEMBLY

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LEARNING OBJECTIVES

After completing this presentation, you should be able to:

1. Recognize the behavioral characteristics of high-performance wood-framed floor systems with superior strength and stiffness attributes.

2. Investigate the multiple components of a wood-framed floor system and the ways that they all contribute to improved performance and the elimination of movement and floor squeaks.

3. Assess the functional contributions of engineered wood subflooring as it relates to structural strength, fastener retention, water resistance, and overall stiffness.

4. Design and specify wood-framed floor systems that perform as intended and reduce or eliminate squeaks that are indicators of other issues.

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COURSE SUMMARY

Floor squeaks are one of the most common homeowner complaints in single-family homes and can be a costly repair in multifamily or light-commercial buildings. A part of a home or building that actively performs all day, every day, it is one of the most important structural interior components of design. While wood-frame floor systems have maintained fairly consistent design standard for years, there remains a persistent issue with squeaks, pops, and uneven flooring that may be the result of a combination of subpar subflooring products or installation. This course discusses subfloor assembly components and the high-performance standards and product innovations from frame to finish that are helping change the quality feel and sound of flooring systems.

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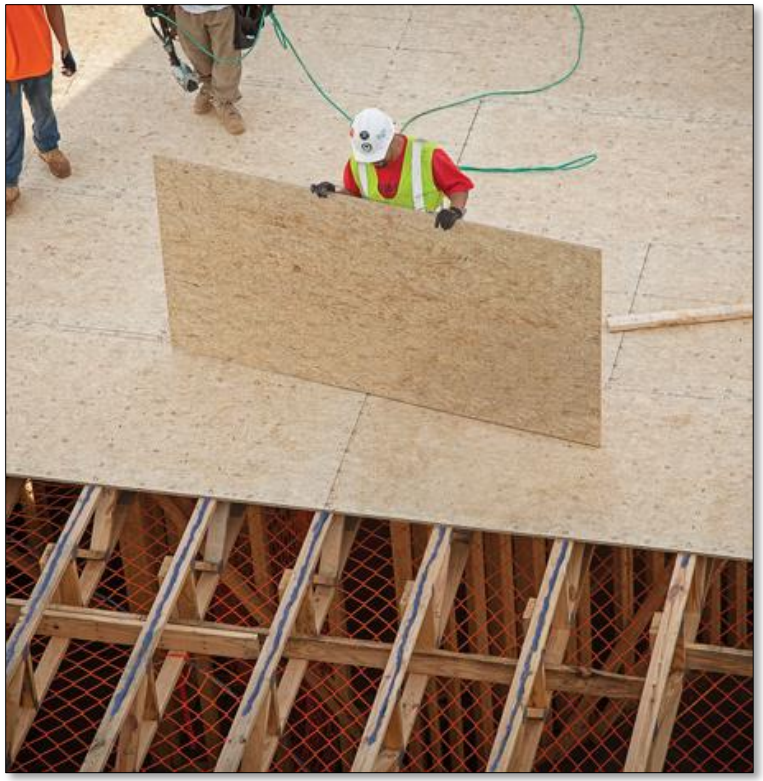
OVERVIEW

Why are there so many squeaky wood floors?

- Longer floor spans?
- Availability of skilled labor?
- Lack of quality control?
- Lower-quality materials?
- Combination of all of these things?
- Regardless, floor squeaks are a sign of construction problems.



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OVERVIEW

Addressing wood-framed floor construction

Look at all aspects of a wood floor system:

- Floor framing
- Subfloor
- Fasteners
- Subfloor adhesive
- Mechanical connections (hangers)
- Any structural steel present?

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AGENDA

- **Section I: Floor Squeaks and Why They Matter**

- **Section II: Floor Framing**
  A. Sizing, choices, and challenges

- **Section III: Subfloor Panels**
  A. High-performance engineered panels during construction
  B. High-performance engineered panels in use

- **Section IV: Installing Subfloor Panels to Framing**
  A. Adhesives
  B. Mechanical fasteners

- **Section V: Finish Flooring**
  A. Choices and impacts

- **Conclusion**

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SECTION I

Floor Squeaks and Why They Matter

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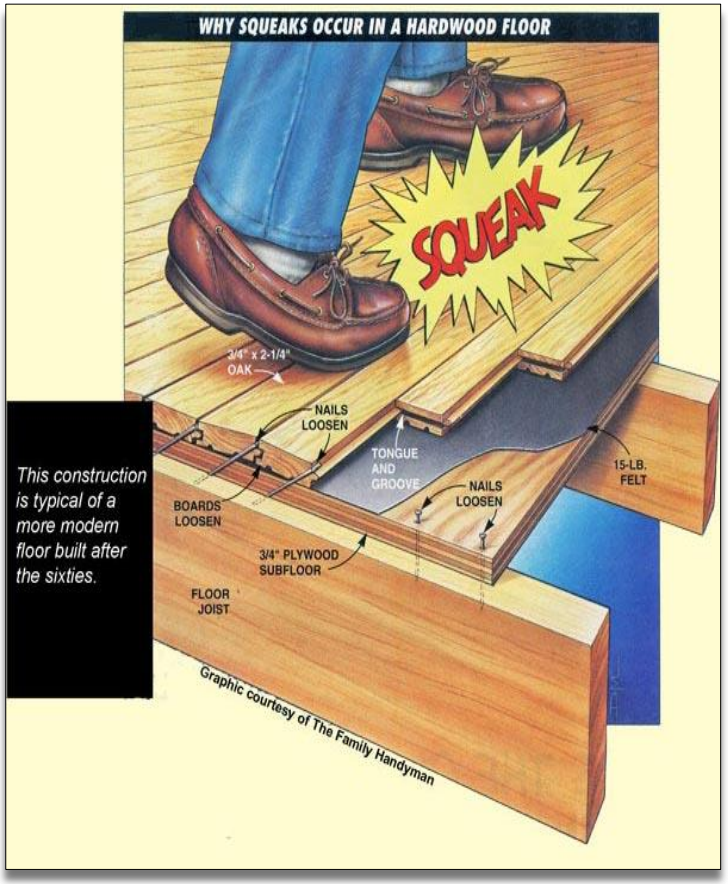
FLOOR SQUEAKS AND WHY THEY MATTER

Sources of pops or squeaks

- This is an indication that something is moving in floor system.
- Movement can build up internal stress or create friction between components.
- Sudden release of built-up internal stress can result in a “pop” in the floor.
- Friction causes vibration, which emanates sound.
- Eliminate the movement to eliminate squeaks.



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FLOOR SQUEAKS AND WHY THEY MATTER

Finish flooring and subfloor

- Movement in the subfloor can telegraph as movement in the finish flooring.
- Rigid finished floors, like tile and hardwoods, perform best on stiff and solid base.
- **There is no point in putting a high-quality, often costly finish material over an inadequate substrate.**
- A quality flooring material should be installed over a quality subfloor system.

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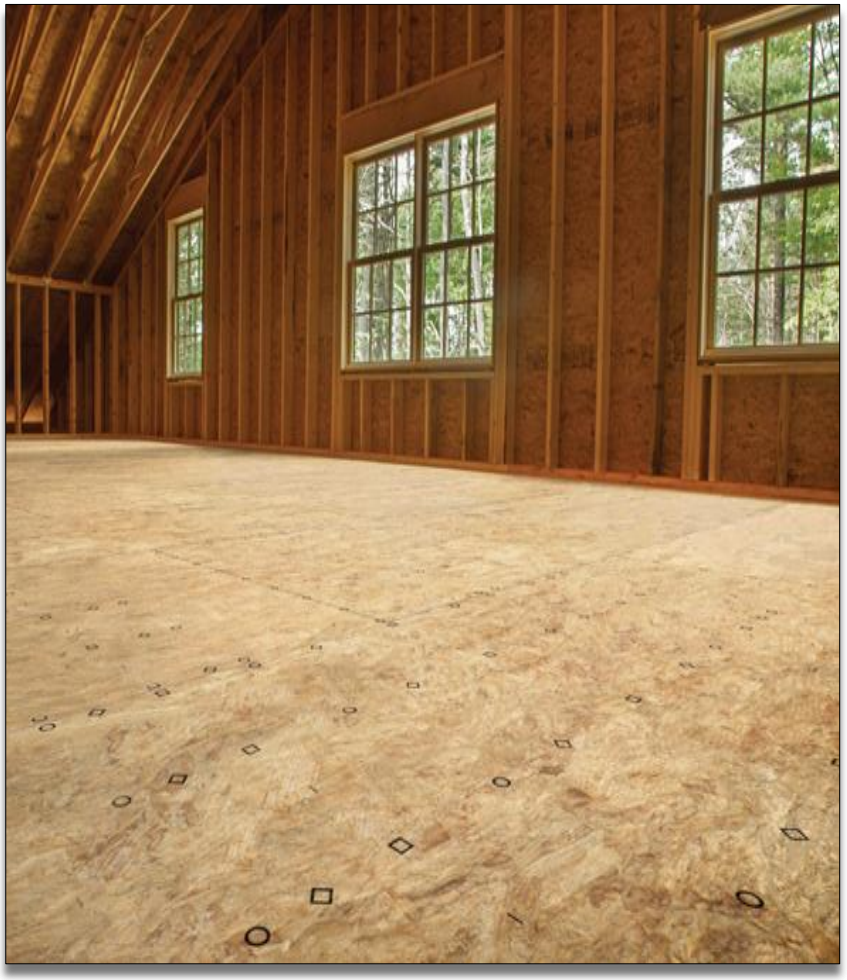
FLOOR SQUEAKS AND WHY THEY MATTER

Why DESIGN to prevent floor squeaks?

- No. 1 reason: Reduce contractor callbacks.[1]
- Achieve long-term durability.
- Promote owner satisfaction.
- Assure that there are not issues with design, construction, or installation.
- Control professional liability/risk management.



[1]2007 J.D. Power New Homebuilder Customer Satisfaction Survey; 2006 ASHI Reporter article; 2017 *Builder* magazine "Common Callbacks"

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FLOOR SQUEAKS AND WHY THEY MATTER

How to DESIGN to prevent floor squeaks?

- Specify finish flooring, subflooring, and framing products that are compatible.
- Specify subflooring that can withstand the anticipated weather exposure during construction.
- Provide good details of how components work together.
- Design the floor system to exceed code minimum deflection requirements.
- Specify an easy-to-use and high-performance subfloor adhesive.

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SECTION II

Floor Framing

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FLOOR FRAMING

Floor system design criteria: dimensional lumber example

Selection is based on multiple criteria to achieve performance.

Joist Spacing	Species and Grade	Dead Load = 10 psf Maximum Floor Joist Spans			
16 o.c.	Spruce-Pine-Fir #2	2x6	2x8	2x10	2x12
		Ft.-in.	Ft.-in.	Ft.-in.	Ft.-in.
		9–4	12–3	15–5	17–10

Exerpted: IRC Table R502.3.1(2) Floor Joist Spans for Common Lumber
Live load = 40 psf.L/360 deflection

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FLOOR FRAMING: APA I-JOISTS

TABLE 11

ALLOWABLE SPANS FOR **APA EWS** PERFORMANCE-RATED I-JOISTS—SIMPLE SPAN ONLY[a,b,c,d,e]

		Simple Spans			
		On Center Spacing			
Depth	Joist Series	12"	16"	19.2"	24"
9-1/2"	PRI-20	16'-2"	14'-10"	14'-0"	13'-1"
	PRI-30	17'-1"	15'-7"	14'-9"	13'-9"
	PRI-40	17'-9"	16'-3"	15'-4"	14'-4"
	PRI-50	17'-10"	16'-4"	15'-5"	14'-5"
	PRI-60	18'-8"	17'-1"	16'-1"	15'-0"
11-7/8"	PRI-20	19'-3"	17'-8"	16'-8"	15'-7"
	PRI-30	20'-4"	18'-7"	17'-7"	16'-5"
	PRI-40	21'-2"	19'-4"	18'-3"	16'-8"
	PRI-50	21'-2"	19'-5"	18'-4"	17'-1"
	PRI-60	22'-2"	20'-3"	19'-2"	17'-10"
	PRI-70	23'-0"	20'-11"	19'-9"	18'-5"
	PRI-80	24'-6"	22'-4"	21'-0"	19'-7"
16"	PRI-60	27'-11"	25'-6"	24'-0"	22'-5"
	PRI-70	28'-10"	26'-4"	24'-10"	23'-1"
	PRI-80	30'-9"	28'-0"	26'-5"	24'-7"
	PRI-90	31'-7"	28'-9"	27'-1"	25'-3"

, CSA O325, or CSA O437 with a minimum 19/32 Performance Category (40/20 or
· 23/32 Performance Category (48/24 or 24 oc) for a joist spacing of 24 inches. Ad
-01. Spans shall be reduced 12 inches when the floor sheathing is nailed only.
· 1-3/4 inches for the end bearings.

a. Allowable **clear** span applicable to simple-span residential floor construction with a design dead load of 10 psf and live load of 40 psf. The live load deflection is limited to span/480.

b. Spans are based on a composite floor with glued-nailed sheathing meeting the requirements for APA Rated Sheathing or APA Rated STURD-I-FLOOR conforming to PS 1, PS 2, CSA O325, or CSA O437 with a minimum 19/32 Performance Category (40/20 or 20 oc) for a joist spacing of 19.2 inches or less, or 23/32 Performance Category (48/24 or 24 oc) for a joist spacing of 24 inches. Adhesive shall meet ASTM D3498 or APA Specification AFG-01. Spans shall be reduced 12 inches when the floor sheathing is nailed only.

c. Minimum bearing length shall be 1-3/4 inches for the end bearings.

d. Bearing stiffeners are not required when I-joists are used with the spans and spacings given in this table, except as required by hanger manufacturers.

e. This span chart is based on uniform loads. For applications with other than uniformly distributed loads, an engineering analysis may be required based on the use of the design properties in Table 7 of *APA Performance Rated I-Joists*, Form Z725.

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FLOOR FRAMING

Limitations of dimensional 2x framing

- No two pieces of lumber framing are alike.
- Natural defects like wane and knots can occur in lumber framing that do not occur in engineered joists.
- Natural lumber can dry and shrink during construction, especially when the load is perpendicular to the grain like in floor joists.
- Deep lumber joists are prone to a cup in cross section, which can lead to squeaky hangers.

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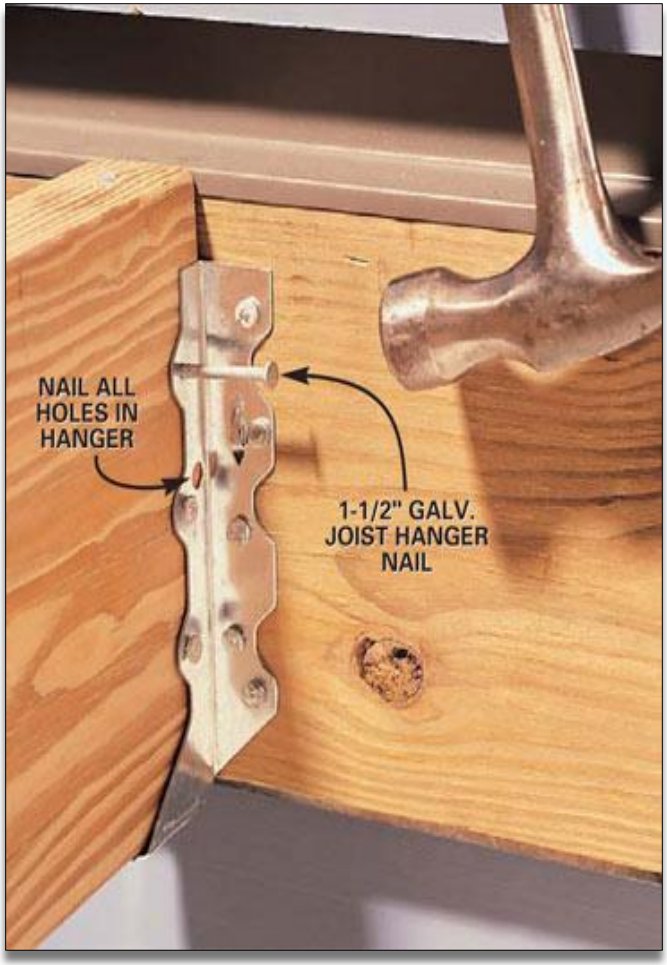
FLOOR FRAMING

- Metal joist hangers are common for dimensional lumber, I-joists, and floor trusses.
- Proper hanger specification is essential.
- cannot skip fasteners – missing fasteners means reduced strength and stability.
- Insufficient fastening could allow joist bearing end to rotate inside the hanger causing squeaks.



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FLOOR FRAMING

Mechanical/electrical/plumbing

- M/E/P trades often cut framing to perform their work.
- Floor framing can be drastically weakened if cut in the wrong location.
- Open-web floor trusses offer openings many openings for M/E/P.

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SECTION III

Subfloor Panels

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SUBFLOOR PANELS

Material choices for subfloor

- Historically, lumber boards were installed on an angle across floor framing.
- In the mid-1900s, engineered plywood became prevalent.
- In the late 1970s, oriented strand board was developed as a wood structural panel with performance equivalent to plywood.
- In 1997, high-performance wood structural panels were introduced as subflooring options with performance greater than plywood or OSB.

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HIGH PERFORMANCE SUBFLOOR PANELS IN USE

Categories of panel thickness: DOC PS-2

Panel Thickness Requirements*		
PERFORMANCE CATEGORY	MINIMUM THICKNESS, in. (mm)	MAXIMUM THICKNESS, in. (mm)
7/16 PERF CAT	.406 (10.32)	.469 (11.91)
1/2 PERF CAT	.469 (11.91)	.531 (13.49)
5/8 PERF CAT	.594 (15.08)	.656 (16.67)
19/32 PERF CAT	.563 (14.29)	.625 (15.88)
23/32 PERF CAT	.688 (17.46)	.75 (19.05)
7/8 PERF CAT	.831 (21.11)	.919 (23.34)
1 PERF CAT	.950 (24.13)	1.05 (26.67)
1-1/8" PERF CAT	1.069 (27.15)	1.181 (30.00)

*PS2-10, Table 1

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SUBFLOOR PANELS

Plywood subfloor systems

- Plywood subfloor systems have their limitations.
- Moisture absorption is high on this type of panel.

NWFC Source: National Wood Floor Consultants

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SUBFLOOR PANELS

Plywood subflooring

- Water absorption is high.
- Prone to delamination but more resistant to edge swell than OSB.
- Not all plywood is equal. Species used in the construction plays a important role in performance.

NWFC Source: National Wood Floor Consultants, Inc.

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SUBFLOOR PANELS

OSB subfloor systems

Oriented strand board (OSB)

- Commodity grade
- Average grade
- High-performance grade

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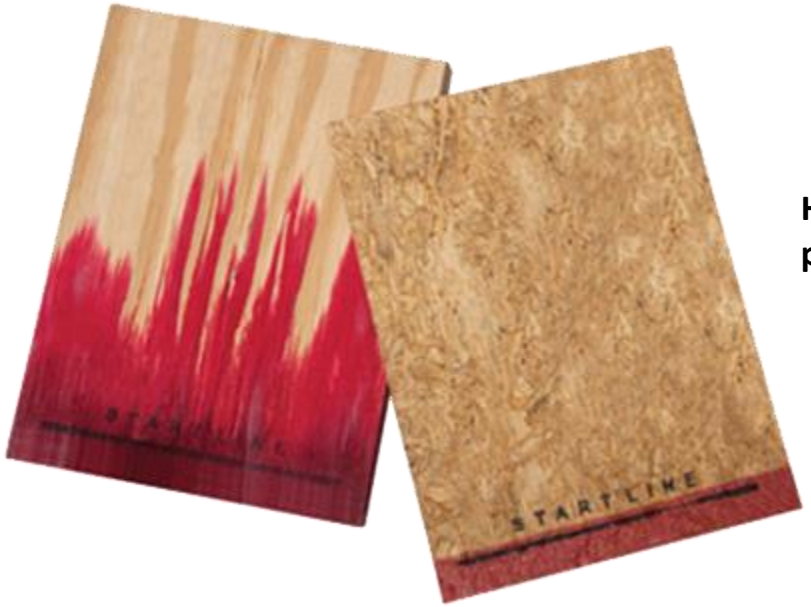
HIGH-PERFORMANCE SUBFLOOR PANELS DURING CONSTRUCTION

Water resistance testing

- Subfloor panel soak test.

- Results show progress of water penetration through the 3-hour test.

Plywood panel edge test



High-performance panel edge test

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SUBFLOOR PANELS

High-performance engineered wood panels

- More dimensionally stable than typical OSB or plywood
- Higher strength and stiffness properties
- Better moisture resistance
- Greater fastener-holding power

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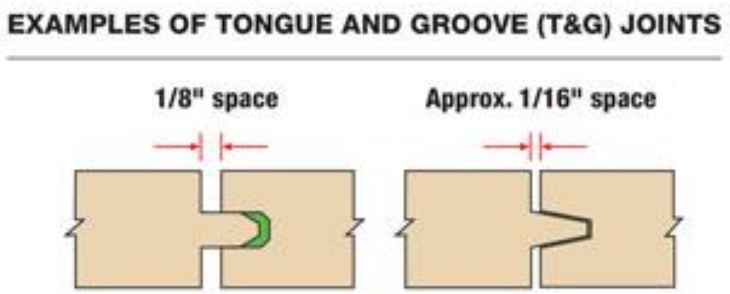
HIGH-PERFORMANCE SUBFLOOR PANELS DURING CONSTRUCTION

Tongue and groove profile

- Typical OSB and plywood rely on “wedge” style profiles.
  - Wedge T&G profiles can create a friction fit, which allows for accumulation of stresses between the panels.
  - Stress build up can result in noise between panels.
- T&G profiles should fit snug but not tight.
- Gaps between panels should be maintained by the T&G.



Regular OSB/plywood

High-performance panels with integral spacer

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HIGH-PERFORMANCE SUBFLOOR PANELS DURING CONSTRUCTION

Water resistance

- Typical OSB and plywood are susceptible to water, which can cause swollen edges or delamination.
- A common fix for swollen edges is to sand the panel surface.
- High-performance panels are engineered to resist the negative effects of water during construction.

High Performance Panels unaffected by water and wet/dry cycles

Plywood after wet/dry cycles

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HIGH-PERFORMANCE SUBFLOOR PANELS IN USE

Strength and stiffness

- High-performance engineered wood subfloor panels are engineered to be stronger and more stiff.
- It is less likely to sag, which creates a higher perception of quality.
- There is less “bounce” when people walk on floor.
- There is less deflection for finished floors.
- There is less chance of squeaks at non-load-bearing walls.

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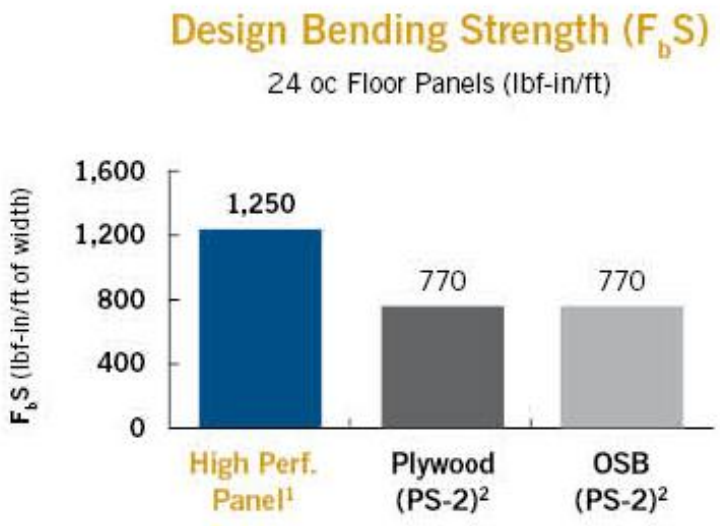
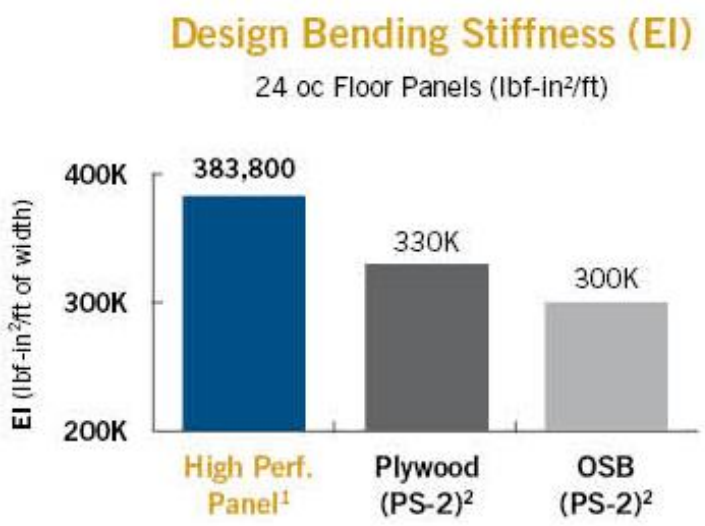
HIGH-PERFORMANCE SUBFLOOR PANELS IN USE

Verifying performance

- Typical high-performance panel vs. OSB and plywood
  - 62 percent stronger than OSB and plywood
  - 16 percent more stiff than plywood
  - 28 percent more stiff than OSB

ICC EVALUATION SERVICE





1. Based on the design values published in ICC-ES Evaluation Service Report, ESR-1785 and the 2012 APA Panel Design Specification, Form No. D510C.
2. 2012 APA Panel Design Specification, Form No. D510C.

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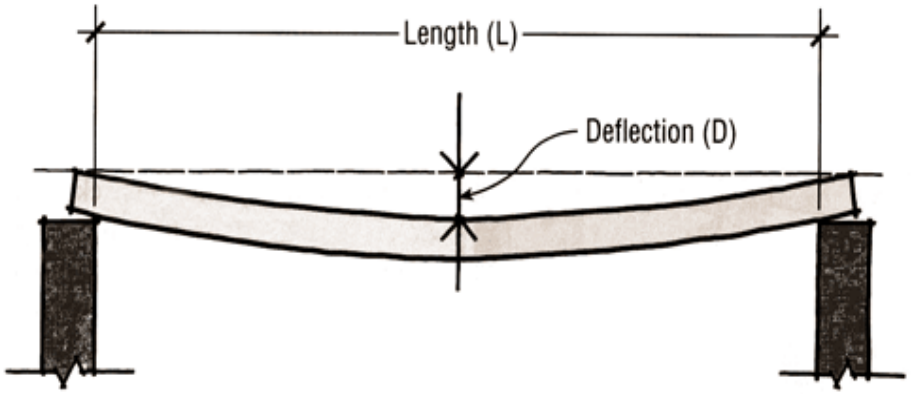
HIGH-PERFORMANCE SUBFLOOR PANELS IN USE

Subfloor panel deflection/calculating deflection



Maximum allowable deflection (D) for joists is equal to L/360

For example, if L = 20'-0":

$$\text{Deflection (D)} = \frac{L}{360} = \frac{20' \times 12"}{360} = \frac{240"}{360} = .666" \cong 5/8"$$

NWFC Source: National Wood Floor Consultants

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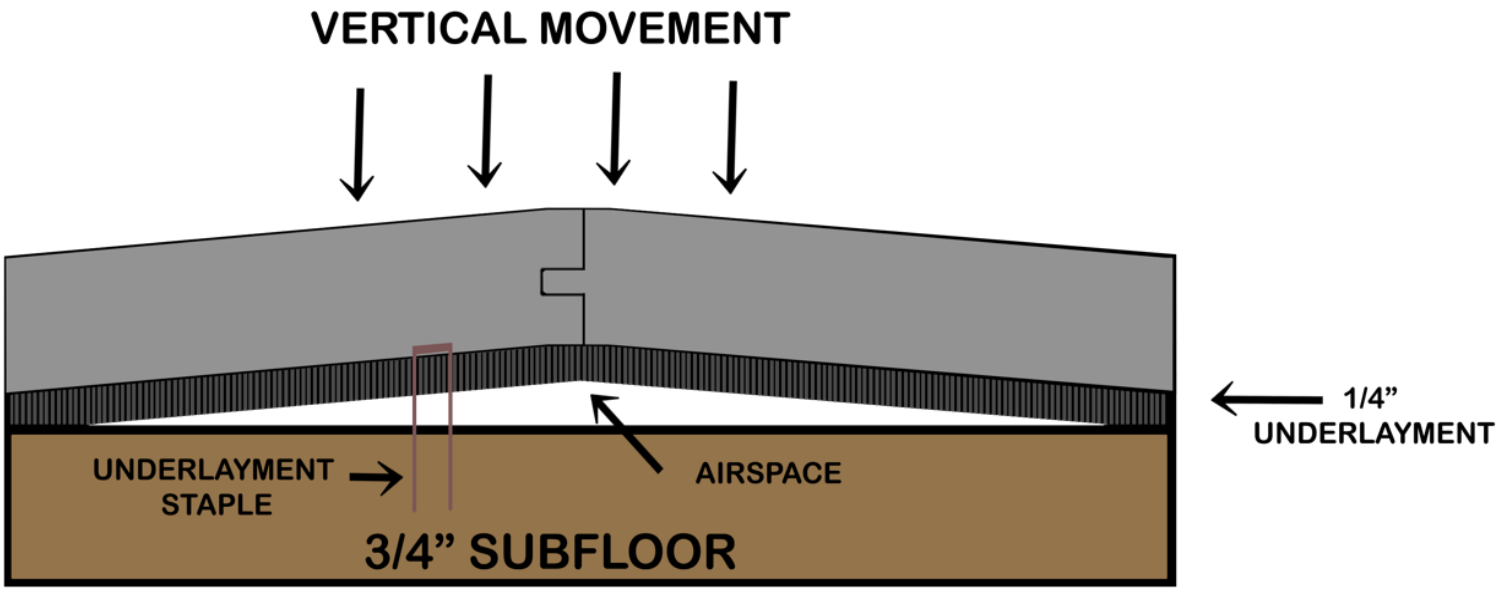
HIGH-PERFORMANCE SUBFLOOR PANELS IN USE

Non-flat underlayments



NWFC Source: National Wood Floor Consultants

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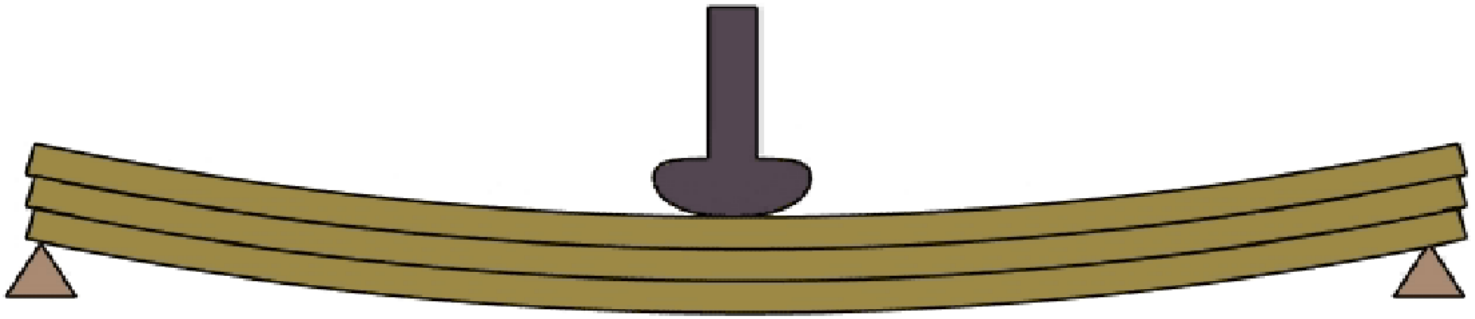
HIGH-PERFORMANCE SUBFLOOR PANELS IN USE

Loose subfloors

Q: Why is the industry standard to glue panels to floor joists?

A: To prevent squeaks by eliminating “shear slip” between panel and joist, making the joist more stiff than with just fasteners alone.



NWFC Source: National Wood Floor Consultants

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SUBFLOOR PANELS

Composite action

- Composite construction occurs when two separate materials are bound together so strongly that they act as though they are one homogenous component.

- Composite action makes two components greater than the sum of their parts.

Source: www.steelconstruction.info/Shear_connection_in_composite_bridge_beams

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SECTION IV

Fastening Subfloor Panels to Framing

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FASTENING SUBFLOOR PANELS TO FRAMING: ADHESIVES

Connection is critical

- Fasteners plus adhesive creates composite action.
- This reduces movement and squeaks.

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FASTENING SUBFLOOR PANELS TO FRAMING: ADHESIVES

Conventional adhesives

- Assures continuous bond
- Different types of adhesives available
- Mechanically squeezed cartridges have some limitations.
  - Difficult to control: uneven bonding
  - Temperature sensitive: compromised bonding
  - Difficult to install can lead to poor coverage

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PROJECT EXAMPLE: ADHESIVES

Southern Cottage Homes, Charlotte, North Carolina

- Used polyurethane foam subfloor adhesive on his personal home that was rocked with rain during construction

“That [polyurethane foam subfloor adhesive] is bulletproof! It doesn’t squeak, and there is NO movement. High-performance engineered subfloor is all we have used for 11 years and [the subfloor adhesive by the same manufacturer] is a no brainer.”

—Kevin Milbredt, Southern Cottage Homes

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FASTENING SUBFLOOR PANELS TO FRAMING: MECHANICAL

Purpose

- Mechanical fasteners used in conjunction with adhesives while bonding takes place.
- Combination helps assure immediate and long-term bond for strength, stiffness, and squeak resistance.
- Proper fastening and fully gluing subfloor to framing can eliminate squeak at the panel to joist connection.

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FASTENING SUBFLOOR PANELS TO FRAMING: MECHANICAL

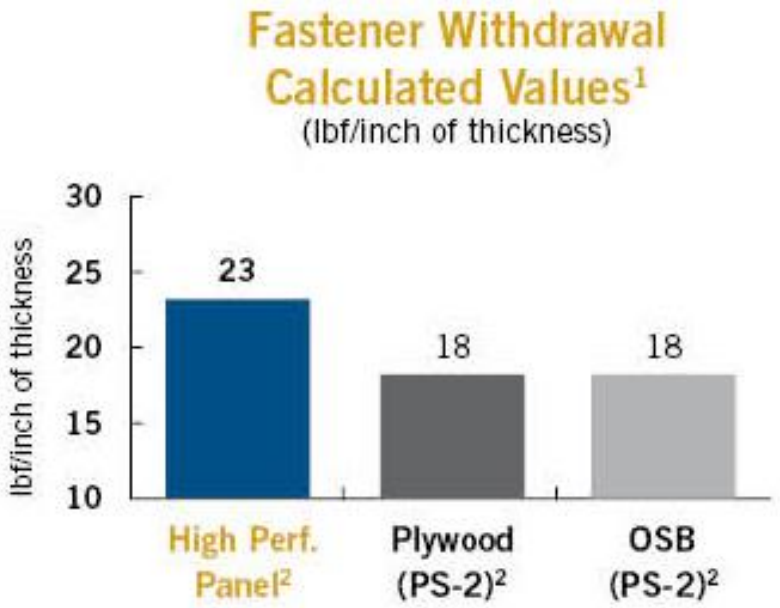
Types

- Screws have greatest holding power.
- Smooth-shanked nails can back out as wood dries.
- Ring-shank or screw-shank nails provide more friction to resist pullout.

FASTENING SUBFLOOR PANELS TO FRAMING: MECHANICAL

How tight is your grip?

Some high-performance engineered wood subfloor panels have been tested to demonstrate greater equivalent specific gravity, or fastener holding power, for mechanical fasteners compared to plywood or conventional OSB.



1. Allowable nail withdrawal values were calculated in accordance with the 2015 National Design Specification for Wood Construction using a 0.131 inch diameter nail for flooring and 0.148 inch diameter nail for roof and wall sheathing calculations. American Wood Council ASD/LRFD.
2. Based on the design values published in ICC-ES Evaluation Service Report, ESR-1785 and the 2012 APA Panel Design Specification, Form No. D510C.

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FASTENING SUBFLOOR PANELS TO FRAMING: MECHANICAL

Fastener spacing

- Too few fasteners can lead to reduced floor shear (diaphragm) capacity and squeaks.
- Code minimum is 6-inch spacing along edges and 12 inches at intermediate supports.
- Pre-printed panels help assure proper spacing for structural strength and bonding.

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FASTENING SUBFLOOR PANELS TO FRAMING: MECHANICAL

Fastener spacing

- Pre-printed panels can help fasteners align with floor joists.
- Fasteners need to properly penetrate into the framing beneath the subfloor.
- Near misses or exposed fasteners below can rub on framing and cause squeaks.

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SECTION V

Finish Flooring

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FINISH FLOORING

Relationship to subfloor

- Finished floor is directly influenced by subfloor performance.
- Proper subfloor installation is critical before finished floor installation.
- Isolate or minimize subfloor movement.

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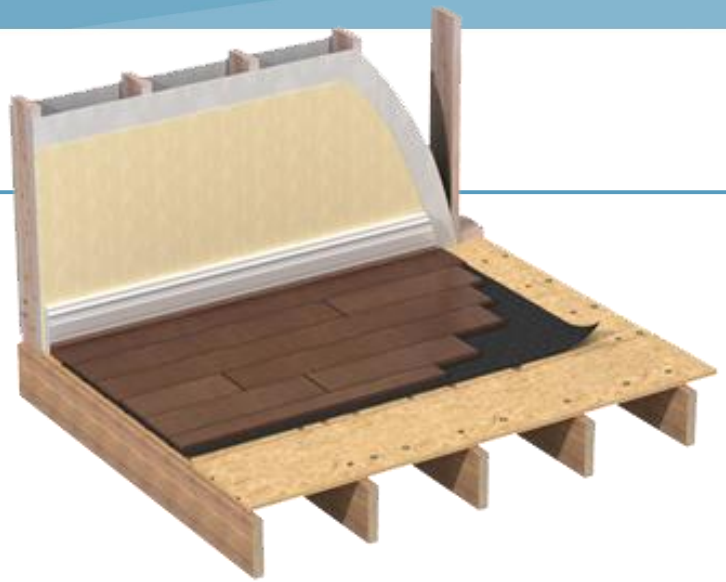
FINISH FLOORING

Wood flooring



- Full spread direct glue down application for hardwood flooring ($1/square foot upcharge to cover materials).
- Sell thicker hardwood flooring materials with longer lengths (approximately $1–$2/square foot).
- Blocking between joists/truss every 24 inches o.c. (approx. $1/square foot to cover labor and blocking materials).
- Upgrade subfloor panel quality or thickness for better fastener retention and less deflection (approximate upcharge between $0.38 to $0.50 per square foot).
- **One of these choices may be required to minimize flooring noise.**

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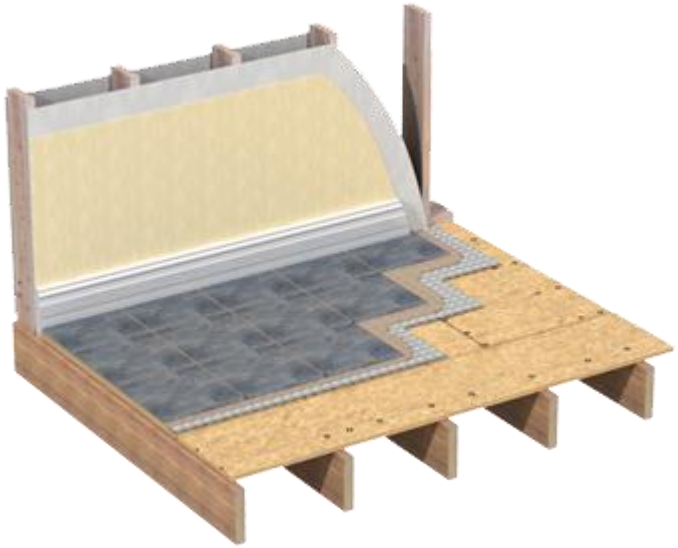
FINISH FLOORING

Tile flooring (ceramic or porcelain)

- Underlayment are usually required.
- Underlayment need to be fastened securely and permanently.
- Subfloor stiffness is important to avoid tile cracks.
- Many tile underlayment options are available. Imperative to follow manufacturer instructions.



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FINISH FLOORING

Matching subfloor to finish floor

- OSB and plywood are sufficient for carpet.
- OSB and plywood are sufficient for sheet vinyl but proper underlayment must be used.
- Brittle or hard finishes, like tile and hardwood, require minimum deflection which can be achieved by using:
  - Thicker subfloor panels.
  - High-performance subfloor panels with elevated stiffness design values.
  - Tighter joist spacing.
  - Shorter joist spans.
  - Full composite action between panel and joist. Specify a high-strength and easy to use adhesive.

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PROJECT EXAMPLE: SINGLE FAMILY

Classica Homes in Charlotte, North Carolina

- Key is providing quality for their customers
- Had project with multiple homes in construction during heavy rains and a mix of subfloor types

“The high-density panels held up unbelievably well while we had all kinds of issues with the other panel, such as nail retention problems, hardwood issues, moisture problems, and floor squeaks.”

—Brian Hall, Classica Homes, Charlotte, North Carolina

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SECTION VI

Conclusions

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CONCLUSIONS

1. Create high-performing floor systems

To meet high quality expectations for a solid, quiet flooring base, use a combination of:

- Appropriately selected floor framing.
- High-performance engineered wood subfloor panels.
- Installed with polyurethane spray-foam adhesive and screws or deformed nails.

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CONCLUSIONS

2. Enhanced capabilities

This system can demonstrate:

- Extreme moisture resistance.
- Increased strength and stiffness.

These are characteristics that help subfloor panels stay flat with no sanding required, even after exposure to harsh job-site conditions.

The ultimate result is a quality project that will hold up over time for designers, owners, and users.

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THANK YOU!

This concludes the Huber Engineered Woods LLC
AIA/CES Continuing Education System Course

Thank you for participating.

For more information, contact:

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