

# Exterior Residential Decks and the 2021 IRC

## INTRODUCTION

Exterior wood decks have had a sorted past.

- Many decks have been built with less than adequate attention to structural engineering.
- There have been collapses due to weak connections at the deck-to-house location that were thought to be industry standard.
- There have been accidents due to the failure of guardrails due to a lack of adequately strong enough post-to-deck connections.

The building codes have made improvements to address these problems, but home builders (deck builders) have lagged behind in understanding the issues and following code rules or code prescriptive designs.

This article highlights some of the challenges, and some of the more recent construction regulations that are intended to safeguard the general public.

### 1. A Successful Deck

What are the characteristics of a good residential deck?

Before discussing specific code minimum requirements, it is prudent to step back and simply state what would be the desired goals that must be met to achieve a well-constructed, successful, residential deck project.

A deck should have the following criteria met.

1. A deck should look nice. Owners want an attractive deck.
2. A deck should be a comfortable, appealing place to congregate if the weather is nice.
3. A deck should safely support the anticipated loads of a typical residential gathering. Owners should know the limitations on loading.
4. A deck should support anticipated gravity, snow, earthquakes, and wind loads.
5. A deck should resist decay and protect the house from water intrusion.
6. The potential for accidents must be minimized. All aspects of the deck should protect people from physical harm.

If these goals were achieved, there would be no need for code prescribed minimum requirements or code required design criteria.

Since deck accidents have continued to occur, the code writers have attempted to spell out exact wording to guide the building of decks in order to safeguard the general public.

## 2. DEFINITIONS

**Guard** – A guard of a deck is the railing. A guard must be installed at the perimeter of a deck and along an open stair to prevent people from falling off the deck.

**Handrail** – A handrail is not the guard. The handrail is required on the side of a stair that has more than 4 steps. People use handrails to grasp and support them as they walk up or down a stair (or ramp). IRC defines a handrail as “a horizontal or sloping rail intended for grasping by the hand for guidance or support”.

**Structural Design** – The process of sizing members to resist anticipated loads.

**Deck Design** – A person might say that a deck was designed by an architect or by themselves. This reference to a “design” would involve the layout, the look, and the selection of materials. It would not necessarily include the structural design.

**Construction** – The process of fabricating and erecting building materials to create a structure. It may need specific structural engineering or it may rely on prescriptive design. Prescriptive design information is often presented in tables. Knowing the load and span of a certain element, a table will have the correct member that would be structurally sufficient if used in the confinement of the stated limitations of the design tables.

### 3. The Problem with Guards (Deck Railing)

Deck guards are supposed to protect the people from falling off the deck or stair. Extensive testing was done to determine the required load. It was concluded by scientists that a 200 lbs load was a reasonable.

Therefore, a 200 pound lateral load made its way into regulations such as OSHA and other code publications. Typical guardrails that had been built in the past were tested. Based on testing, it was concluded that many guards that were being placed on decks throughout the country were not able to satisfy the horizontal load requirement. The guardrails were found to be inadequate prior to any aging or weathering of the deck.

For this reason, more and more specific rules were added to codes to make sure guardrails were actually being constructed to provide a safe barrier to falling.

Builders that stated, “this is the way we have been constructing deck railings for years” was no longer acceptable. New construction has improved, but there are numerous insufficient (substandard) guards on residential buildings today.

#### 4. Code Compliance

Each area of the country has regulations and code enforcement that are different. There has been a significant improvement on having a central code that unifies the building industry. The International Residential Code (IRC) has become the model code that is the front runner for other jurisdictions.

Certain loads are different in different parts of the country, but some loads are not different. For example, a residential deck railing should not have different requirements from one location to another.

#### 5. Minnesota Residential Code

There is also a time lag in adopting the modal code. It takes time to update the modal code. It also takes time for a state to adopt (make into law) the latest versions of the modal code.

For example, Minnesota adopted the first addition of the IRC (2000 IRC) on March 31, 2003. This was the start point for the requirement for guards to resist a lateral load of 200 pounds in Minnesota. Prior to this time, residential guards were not very well regulated. They were built based on tradition and the judgement of the builder.

The 2020 Minnesota Residential Code (MRC) is based on the 2018 IRC and specifies the 200 pound horizontal load.

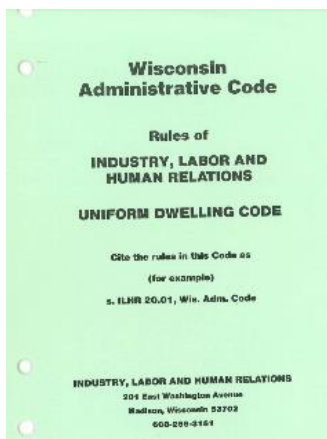
Section R301.5 of the MRC specifies 200 pound horizontal live load that must be applied in both directions to the top of a guard rail. The load is not actually placed on the railing. It is intended that the guard be designed (constructed) to resist that load. However, there is no prescriptive design for a wood railing in the 2018 IRC.

#### 6. Wisconsin - Uniform Dwelling Code (UDC)

The Uniform Dwelling Code (UDC) was the statewide building code for one- and two-family dwellings built since June 1, 1980.

The 1985 addition of the UDC was the first code to show the required 200 pound horizontal load for guards.

The current UDC code has a very extensive section devoted to decks (SPS 321.225). This section shows the 200 pound horizontal load and many other requirements. The Wisconsin code has a prescriptive design for a wood guard.



#### 7. The International Residential Code (IRC)

In general, the IRC is the modal code that drives the adoption of state residential codes. States adopt the modal code mostly in full but will delete items or add items that they feel are necessary for that particular state.

Therefore, while the model code has the most up-to-date wording on an issue, it may not be codified (adopted) by a state immediately. The following discussion of deck issues is based on the 2021 IRC.

Depending on the adoption process of an individual state, the IRC will eventually become the standard that must be followed for new construction or for repairs if damage takes place.

#### 8. 2021 IRC Residential Deck Review.

This paper is not intended to cover all code requirements of a deck in each state. It highlights the “big ticket” items that must be followed to make a deck safe.

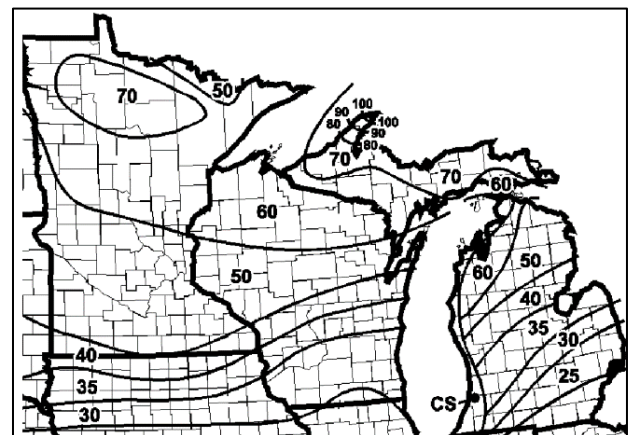
IRC Section R507 is the section of the IRC that is dedicated to exterior decks. There was no specific section R507 dedicated to exterior decks until the release of 2012 IRC. Prior to 2012, deck requirements were listed in wood flooring section R502 in the 2009 IRC.

The deck section has continued to grow in size with each new release of the IRC. The following is a summary of code items. The items in **Red are new to the 2021 IRC.**

**507.1** Decks must be designed for the live load or the specified **ground snow load**.

This is a new requirement. Previous versions of the IRC did not specify that decks needed to be designed for snow load. Prior to this change, decks have been designed for a live load of 40 psf live load.

The new wording in the IRC indicates that decks may have to be designed for 50, 60, or even 70 psf per the IRC ground snow load map shown below. This would be a substantial increase in load for some states.



**507.2.1** Wood shall be preservative-treated or naturally durable such as cedar.

Unfortunately, untreated wood is still found on existing decks. The image below shows an untreated glue lam member that was adequately sized but was rotting due to not being treated. The untreated beam should not have been used for exterior construction.



**507.2.3** Fasteners shall be galvanized or stainless.

**507.2.4** Flashing shall be corrosion-resistant metal.

Not only should flashing be corrosion-resistant, it should be present. Unfortunately, there are decks that have no flashing. Without flashing, water can enter the house leading to rot and water damage. The image below shows a deck attached over the siding with no flashing.



**507.3.1** Minimum footing sizes are given for different load and soil bearing values (including snow).

**507.3.2** Deck footing shall be not less than 12 inches below the undisturbed ground surface.

This requirement is not really a new requirement. It was previously required in an early section of the code but not in this section.

Residential construction does not require significant backfilling and compaction. This requirement would help eliminate settlement issues if a footing was only placed to below frost but on uncompacted soil.

This should have been good construction practice and followed without having it written. But, having it written in the deck section takes out any question as to what good minimum construction practice is and is not.

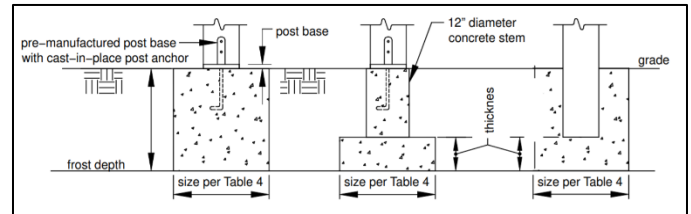
**507.3.3** Frost Protection - Deck footing shall be protected against frost by extending below the frost depth or on rock.

This is not really a new requirement but is now stated in the deck section to remove any doubt that it is required for decks.

The table note states that the jurisdiction shall determine the frost depth.

**507.4** Deck post sizes are given for different load and height (including snow)

**507.4.1** Lateral restraint shall be provided to post to foundation connections.

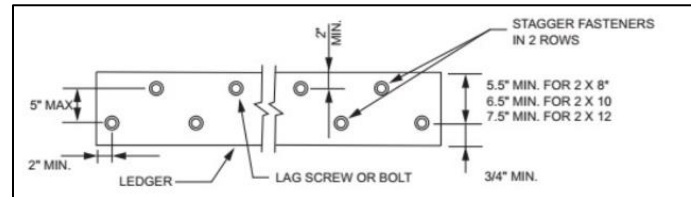


**507.5** Beam sizes are given for span and loads. (including snow)

**507.6** Joist sizes are given for span and loads. (including snow)

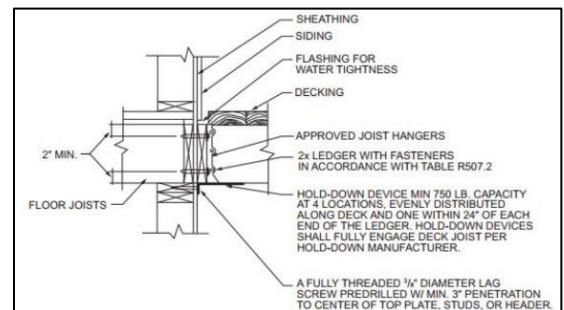
**507.7** Decking spans are given per thickness and span condition.

**507.9** The connection of the ledger to the house now includes snow loads.

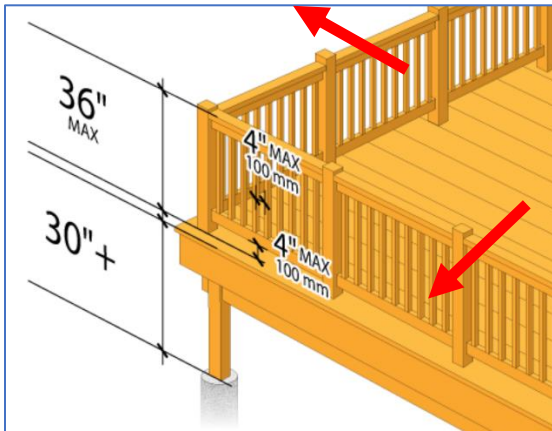


**507.9.1** Decks must have lateral attachment to the house or be laterally braced.

Inadequate connections of ledgers to a house where a main driving force that sparked the addition of a designated deck section to the code. The image below is an example of a prescriptive design that can be used to satisfy code.



**507.10** Section 507.10 is entirely new. The section is devoted to exterior guards.

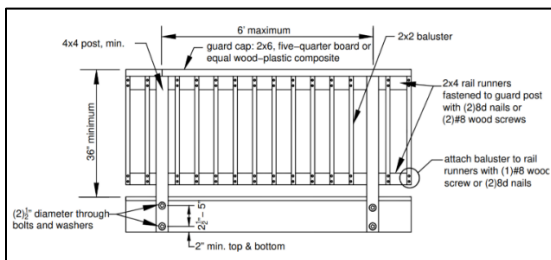


The first sentence makes it clear that decks guards must be constructed to resist a 200 pound horizontal live load. This is not new; however, Table R301.5 shows the 200 pound horizontal load is now directional. The table note reads as follow:

“Where the top of a guard system is not required to serve as a handrail, the single concentrated load shall be applied at any point along the top, in the vertical downward direction and in the horizontal direction away from the walking surface.

Where the top of the top of the guard is also serving as the handrail, a single concentrated load shall be applied in any direction at any point along the top. Concentrated loads shall not be applied concurrently”

The first addition of the IRC was released in 2000 and it had the 200 pound horizontal guard load. The following image was taken from Appendix B of the Wisconsin Uniform Dwelling Code. It shows a prescriptive design that can be used to satisfy the code.

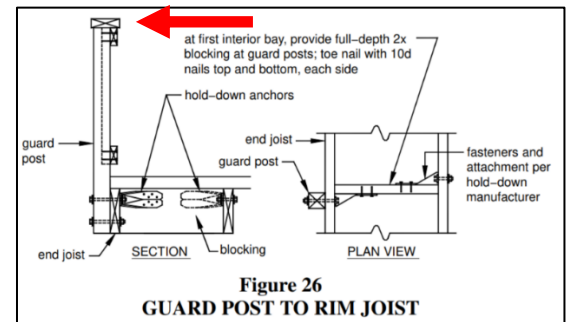


As previously stated, the requirement for guards to safely resist a 200 pound lateral load at the top of the rail has been in the codes for quite some time. Typical detailing prior to guard testing has shown that the industry has typically made weak (less than adequate) wood connections.

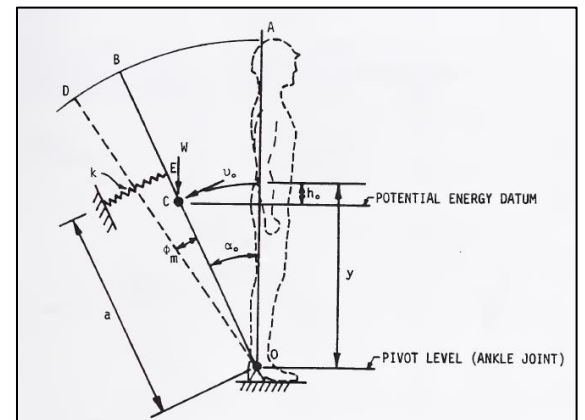
**507.10** The residential building codes have tried to provide prescriptive designs. As of the 2021 IRC, there is no prescriptive detail given in the code that accomplishes a guard attachment that is capable to resist an inward or outward load of 200 pounds.

The following image was taken from Appendix B of the Wisconsin Uniform Dwelling Code. This detail has been tested and found to be sufficiently strong enough to resist the 200 pound load in the outward direction as shown.

This detail would likely be found to be lacking if the force was applied in the inward direction.



Center for Building Technology Institute for Applied Technology National Bureau of Standards conducted extensive research to understand accidental loads on guardrails in the 1970's. The work was presented in a report that was prepared for the Occupational Safety and Health Administration Department of Labor (OSHA). That report has extensive information on what an anticipated load would be from an accidental outward fall of an adult construction worker. The actual load is dynamic meaning there is an impact force.



The study did not look at inward loads to handrails. The requirement for 200 pounds inward load on a handrail might be overkill. An average person using a handrail to support themselves by holding onto a handrail can not hold 200 pounds with one or both hands.

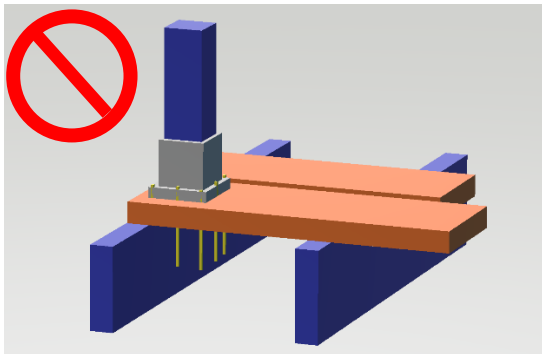
**507.10** Guards must be constructed to meet all requirements of guards in section R312.

While this should have been understood that stair requirements should have been required. This new statement within this new section of the code makes it clear that R312 guard requirements are required on exterior stairs.

- required for anything over 30 inches
- guard height must be 36 minimum
- guard height on stairs must be 34 minimum
- 4 in sphere must not pass through the step
- 6 inch sphere at stair triangular opening
- 4 3/8 sphere at stair

**507.10.1** The guard connection to the structure must transfer load to the framing members by a continuous load path. (not just to the deck)

A railing cannot be attached to a deck board and have that deck board transfer the load to the framing. The connection must be made to the framing or to blocking. The fasteners can go through the deck but must not rely on the deck to transfer the load to the framing.



**507.10.1** The adjacent joist must be connected to prevent rotation.

Connecting a guard post to the perimeter joist without engaging the first interior joist is no longer acceptable.

The image below shows a typical bolted guard to a perimeter joist. This would not be acceptable due to the lack of blocking to the next joist

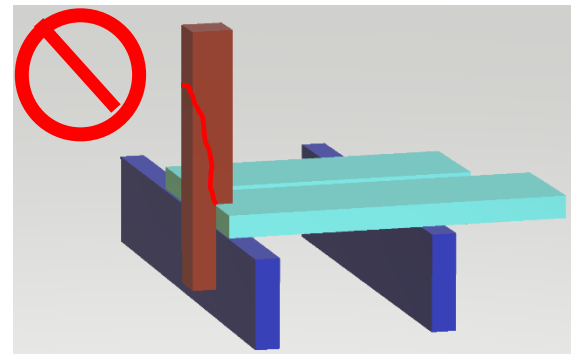


**507.10.1** Connections with end grain withdraws are not permitted.

When connecting a guard there may be all sorts of materials that come together. Decks are primarily made out of wood. Relying on end grain withdraw is no longer acceptable.

**507.10.2** A 4x4 post must not be notched.

There are many existing decks that have notched posts. Unfortunately, weathering of a notched post can cause cracking. The crack can propagate and create a very weak post



**507.10.4** Other guards shall be in accordance with either manufacturer's instructions or accepted engineering principles.

This allows builders to install guards that are designed by manufactures. The manufacture is required to design their materials to resist the 200 pound horizontal load and provide installation instructions.

**311.7** Section R311.7 clearly states that exterior deck stairways must comply with Section R311.7

- must be 36 clear above handrail
- 31 ½ clear below single handrail
- 27 clear below stairs with handrails on both sides.
- head room of 6-8 from tread line.
- 12-7 maximum rise between floors or landings
- 7 ¾ riser maximum
- 3/8 maximum difference in riser height
- 4 inch sphere passage above 30 inches at openings between treads.
- 10 inch minimum tread depth
- 3/8 maximum difference in tread depth
- Handrails for stairs with 4 or more risers
- Handrail height max is 38
- Handrail height minimum is 34
- Handrail must not project more than 4 ½ inch
- Graspable handrails are required

By Richard T. Abbott, PE, SE  
Abbott Consulting Forensics and Design  
www.abbottforensics.com