
Single Family Residence

Draft Report of Cause of Stair Failure

2013

Cause of Stair Failure:

Inadequate connection of the stair stringers to the landing header was the proximate cause of the stair failure. The loading experienced by the stair would not have caused a competent stair to fail. The carpenter did not build stairs that were capable of withstanding the loads required by the building code.

Overview of Stair Location:



Overview Photos of Failed Stairs By Owner



Photo 100_0988



Photo 100_0992 View from deck above stairs

Exhibit 1 at Deposition:

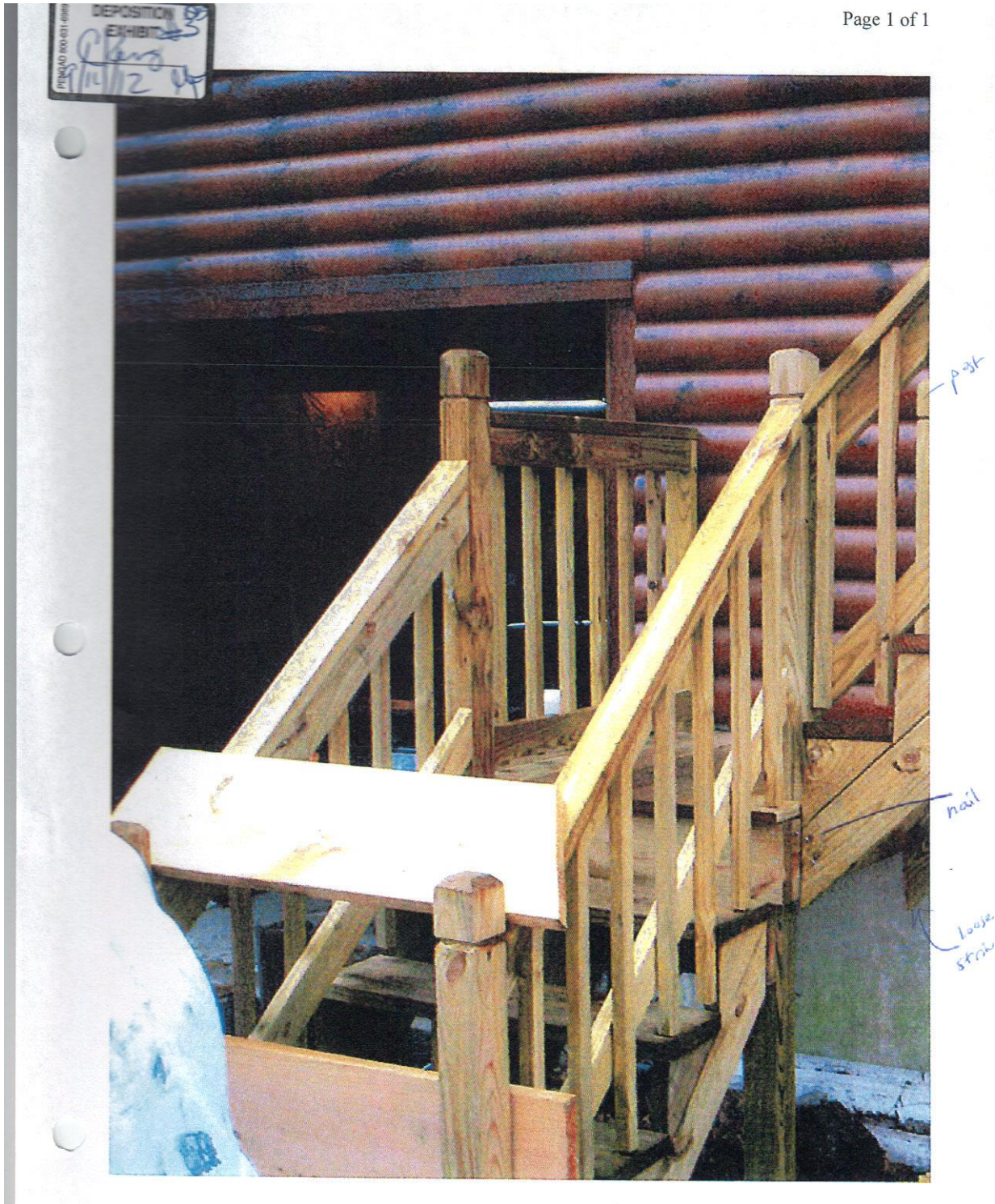
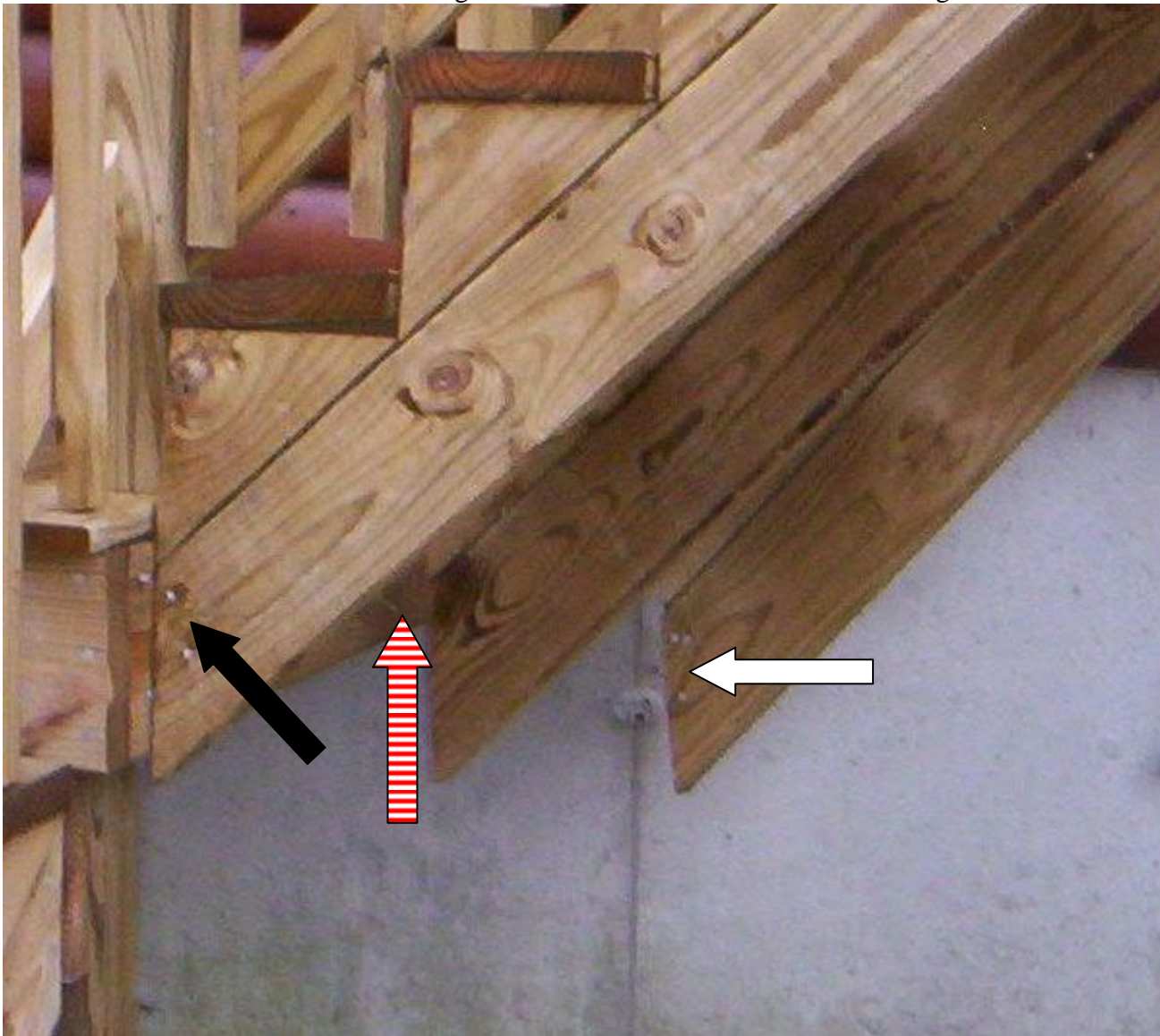


Photo 100_0988 was cropped when shown as Exhibit #1 at 9/14/12 deposition of carpenter. Detached inboard stringer (adjacent to house) was cropped out of the exhibit photo. Detached center stringer is barely visible in exhibit photo.

Close-up of stringer attachment area within Photo 100_0988:

Stairs failed when two of the three stringers detached from header at lower landing as shown:



The inboard stringer (adjacent to the house, but not attached to the house) was toe-nailed to the landing header with three nails on the visible outside. These three nails can be seen in photo above at white horizontal arrow. There were no toe nails on the house side of the inboard stringer. On the back side of the landing header, there is evidence of three nails originally installed through the header into the end of the stringer. These nails are no longer present. Empty holes once containing nails are visible and shown in photos below.

The center stringer also detached from the landing header. There is no evidence of toe-nails in this photo. There is a nail from the backside of the landing header into the end grain of the stringer (red/dashed vertical arrow). This nail is loaded in withdrawal. Loading nails in withdrawal creates a weak connection that cannot be relied upon. During my examination, I found evidence of three nails through the back side of the landing header into the end grain of the center stringer. No evidence of toe nails was found on the center stringer.

Outboard stringer, furthest from house did not detach. It is attached to landing header with two toe-nails (black angled arrow).

Details of Current Attachment of Stringers to Landing Header:

When stairs were repaired, the same three stringers were re-used. The stringers were reattached and metal hangers were installed.

Inboard Stringer 1:

Connection between inboard stringer (adjacent to house) and landing header:

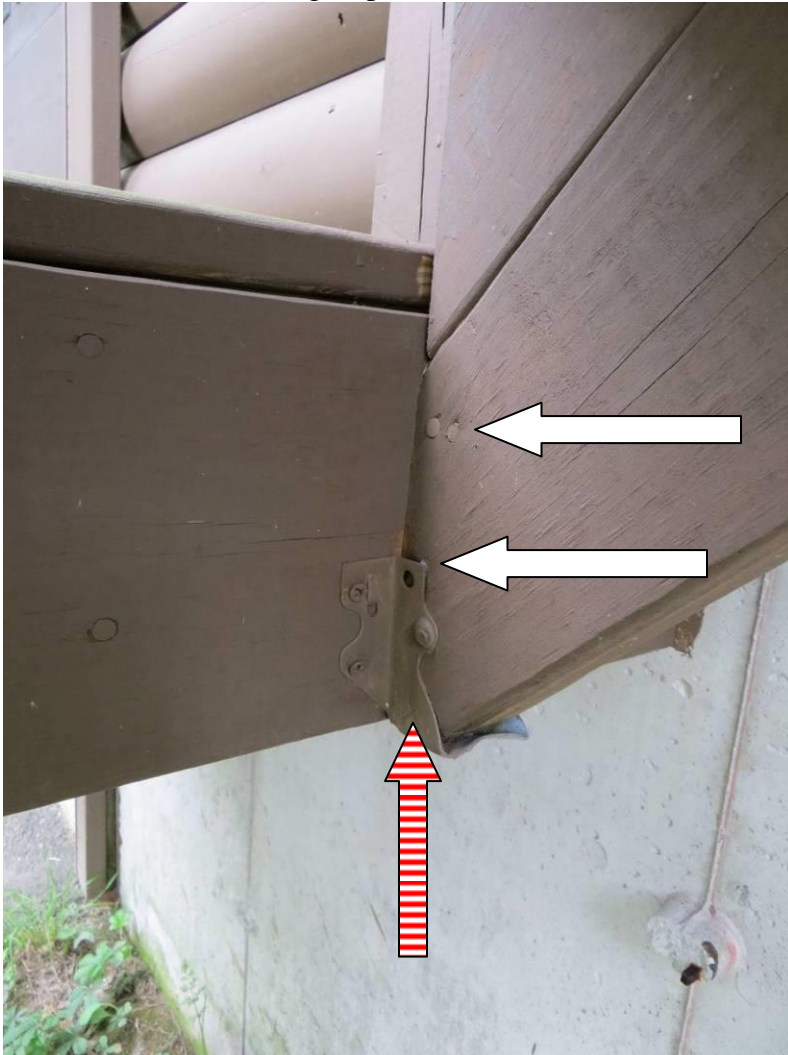
House side of inboard stringer (not painted)



No evidence of toe-nails driven through the house side of the inboard stringer into the landing header. One of the toe-nails driven from the other side of the stringer did not penetrate the landing header, but came through the stringer on the opposite side (white arrow). This nail provided no support. Newly installed metal hanger connects stringer to landing header (red/dashed vertical arrow). Hanger installed is intended for floor joist and not a stringer. Hanger is improperly installed.

Inboard Stringer 1:

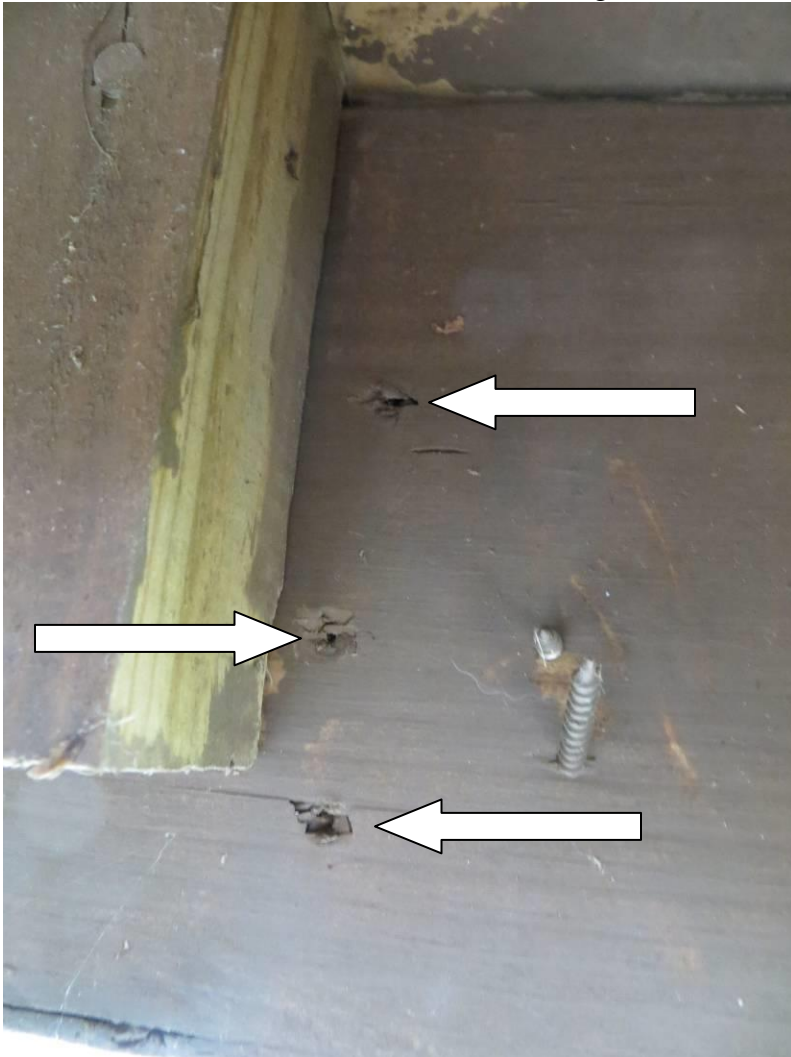
Outside of inboard stringer (painted):



Three toe-nails were driven from the outside of the stringer into the landing header (white arrows). Newly installed metal hanger connects stringer to landing header (red/dashed vertical arrow). Hanger installed is intended for floor joist and not a stringer. Hanger is improperly installed.

Inboard Stringer 1:

Inside of header at attachment of inboard stringer:



Evidence of three nails driven through landing header into the end grain of the inboard stringer (adjacent to the house) is shown by white arrows. Nails were not reinserted after hanger was installed. Note screws from new hanger protrude through single layer 2" x 8" header.

Center **Stringer 2:**

Connection between center stringer and landing header:

House side center stringer:



No evidence of toe-nails driven through the house side of the center stringer into the landing header. Newly installed metal hanger connects stringer to landing header. Hanger installed is intended for floor joist and not a stringer. Hanger is improperly installed.

Center **Stringer 2:**

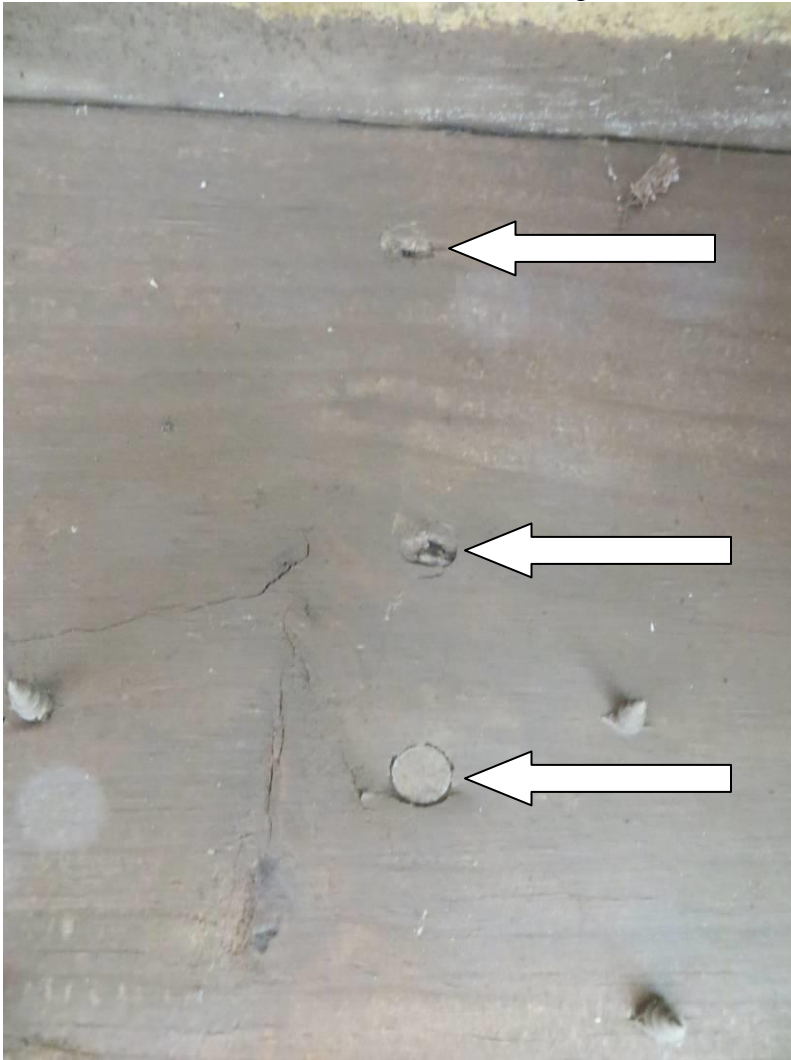
Outside center stringer:



No evidence of toe-nails driven through the outside of the center stringer into the landing header. Newly installed metal hanger connects center stringer to landing header. Hanger installed is intended for floor joist and not a stringer. Hanger is improperly installed.

Center **Stringer 2:**

Inside of header at attachment of center stringer:

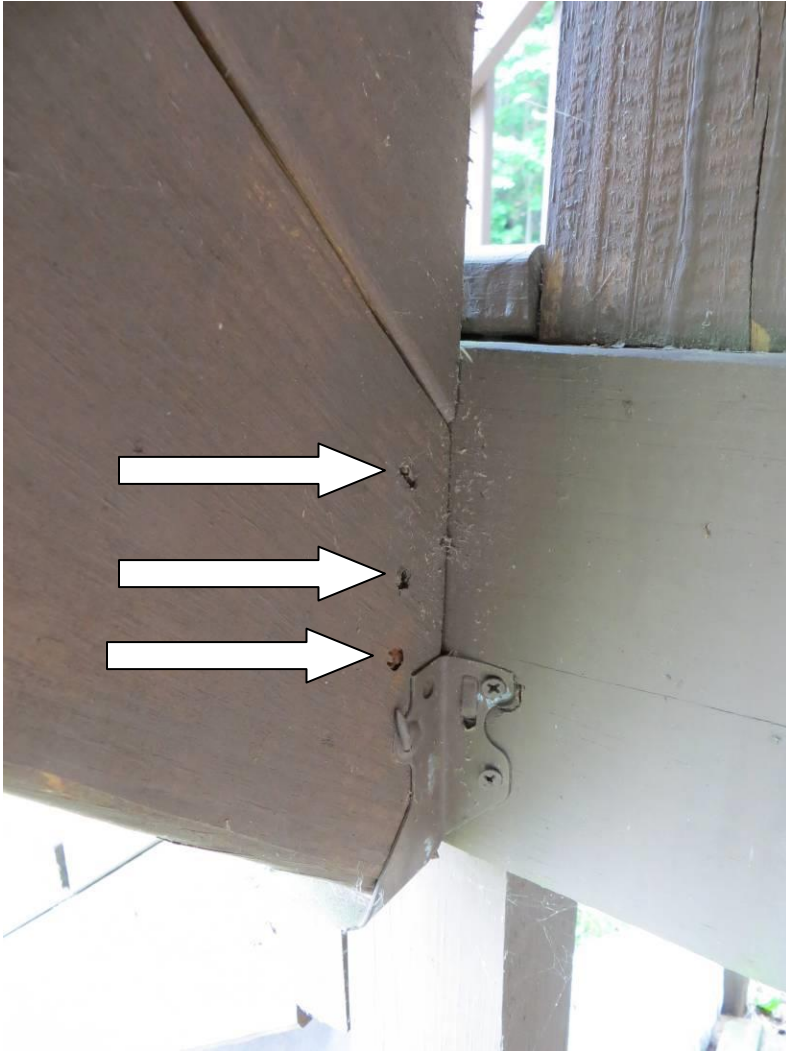


Evidence of three nails driven through landing header into the end grain of the stringer adjacent to the house is shown by white arrows. Top two nails were not reinserted after hanger was installed. Note screws from new hanger protrude through single layer 2" x 8" header.

Outboard Stringer 3:

Connection between outboard stringer (furthest from house) and landing header:

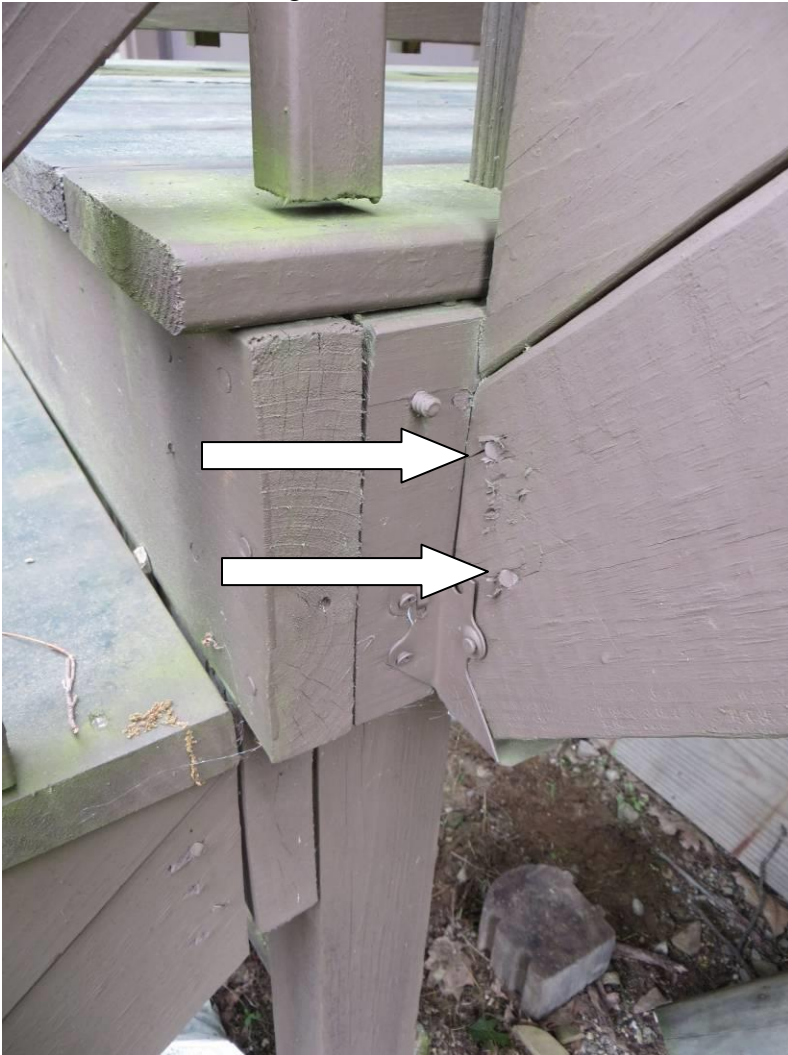
House side outboard stringer:



Evidence of three toe-nails driven through the house side of the outboard stringer into the landing header is shown by white arrows. Newly installed metal hanger connects stringer to landing header. Hanger installed is intended for floor joist and not a stringer. Hanger is improperly installed.

Outboard Stringer 3:

Outside outboard stringer:



Evidence of two toe-nails driven through the outside of the outboard stringer into the landing header is shown by white arrows. These two toenails are also visible in the photo taken by owner just after the stair failure (see above). Newly installed metal hanger connects outboard stringer to landing header. Hanger installed is intended for floor joist and not a stringer. Hanger is improperly installed.

Outboard Stringer 3:

Inside of header at attachment of outboard stringer:



No evidence of nails driven through landing header into the end grain of the outboard stringer is visible due to railing posts.

Building Code Requirements:

6th Edition of Massachusetts Building Code was applicable during construction of stairs.

Code does not explicitly state how many fasteners are required or method for the stringer to header connection.

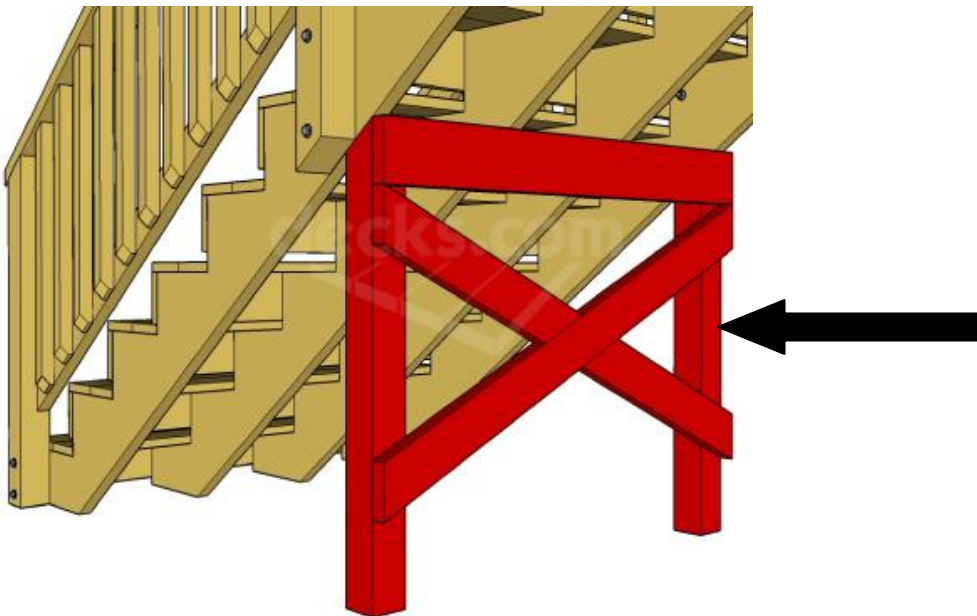
Applicable code provisions:

- Table 1606.1:
 - Design live load for stairs is 100 psf (pounds per square foot).
- 2303.1 Structural Design:
 - “All structural wood members and connections shall be of sufficient size or capacity to carry all design loads as required by 780 CMR 16”
- The closest code paragraph that would apply to this connection
 - 2305.6.2 Support and anchorage on walls or beams
 - “Joists shall bear on walls of beams of wood or steel not less than 1-1/2” or shall be supported by metal stirrups, hangers, or a nominal 2” wood ledger strip.”
 - Paragraph describes requirement for joists, I think this would be considered the minimum for stringers
 - Using proper hanger would meet these requirements

Details of Other Issues

Header under Stair Stringers:

In his deposition, carpenter mentioned that he installed a header under the stair stringers for support. There is no evidence that a header was ever installed under stair stringers. The diagram below shows a typical header configuration in red as indicated by black arrow.



There are no nail holes or other indications anything was installed near the mid-span of the stair stringers. If such a header were installed, there is no interference with a door to the garage under the stair stringers.

Current Metal Hangers Used to Support Stair Stringers:

The hangers installed are intended for floor joists. The joist hangers are not installed with the proper fasteners. Not all nail holes in the hangers are used properly. The joist hangers can work but are probably not best for this connection.

I spoke with hanger manufacturer. They do not make a specific hanger for this connection because stringers usually terminate on top of intermediate landing.

This hanger could work.

<http://www.strongtie.com/ftp/catalogs/c-2013/C-2013-p085.pdf>

Solid Saw Joist Hangers
LSU/LSSU Adjustable Light Slopes/Slovable U Hangers

This product is preferable to similar connectors because of its easier installation, its higher loads, or its lower installed cost, or a combination of these features.

The LSU and LSSU series of hangers may be sloped and skewed in the field, offering a versatile solution for attaching joists and rafters. These hangers may be sloped up or down and skewed left or right, up to 45°.

MATERIAL: See table.
FINISH: Galvanized. Some products available in ZMAX® coating; see Corrosion Information, page 14-15.

INSTALLATION:

- Use all specified fasteners. See General Notes.
- Attach the sloped joint at both ends so that the horizontal force developed by the slope is fully supported by the supporting members.
- To see an installation video on this product, visit www.strongtie.com.

CODES: See page 13 for Code Reference Key Chart.

LSU and LSSU INSTALLATION SEQUENCE (For Skewed or Sloped/Slovable Applications)

STEP 1: Nail hanger to slope-out carried member, installing nail and first hole. No fasteners necessary for skewed installation. Install first nails at 45° angle.

STEP 2: Slide hanger from 0-45°.

STEP 3: Attach hanger to the carrying member, along slope side first. (See footnote 4.) Install nails at an angle.

| Joist Width | Model No. | Ea | Dimensions | | | | Fasteners | DF/SP Allowable Loads | | | SPFH Allowable Loads | | | Code Ref. |
|-------------|-----------|------|------------|--------|--------|--------|-----------|-----------------------|-------------|------------|----------------------|-------------|------------|--------------|
| | | | W | H | A | Face | | Joist | Floor (100) | Roof (125) | Roof (150) | Floor (100) | Roof (115) | |
| 1 1/2" | LSU206 | 1/2" | 1 1/2" | 1 1/2" | 1 1/2" | 1 1/2" | 3 1/2" | 3 | 3 | 3 | 210 | 280 | 330 | I14, F13 |
| 2" | LSU410 | 1/2" | 2" | 2" | 2" | 2" | 3 1/2" | 3 | 3 | 3 | 210 | 280 | 330 | I14, LS, F13 |
| 2 1/2" | LSSU28 | 1/2" | 2 1/2" | 2 1/2" | 2 1/2" | 2 1/2" | 3 1/2" | 3 | 3 | 3 | 210 | 280 | 330 | I14, LS, F13 |

This clip could work also:

<http://www.strongtie.com/ftp/catalogs/c-2013/C-2013-p192.pdf>

L/LS/GA Reinforcing and Skewable Angles

L-Staggered nail pattern reduces the possibility of splitting.
 LS-Field-adjustable 0° to 135° angles.
 The GA Gasket Angles' embossed bend section provides added strength.

MATERIAL: L-16 gauge; GA and LS-18 gauge.
FINISH: Galvanized. Some products available in stainless steel or ZMAX® coating; see Corrosion Information, page 14-15.

INSTALLATION:

- Use all specified fasteners; see General Notes.
- LS-field skewable; bend one time only.
- Joint must be constrained against rotation (for example, with solid blocking) when using a single LS per connection.
- Nail the L angle's wider leg into the joist to ensure table loads and allow correct nailing.

CODES: See page 13 for Code Reference Key Chart.

These products are available with additional corrosion protection. Additional products on this page may also be available with this option, check with Simpson Strong-Tie for details.

These products are approved for installation with the Strong-Drive S3 Structural-Connector screw. See page 27 for more information.

| Model No. | L | Fasteners | DF/SP Allowable Loads ^{1,2,3} | | | | SPFH Allowable Loads | | | | Code Ref. |
|-----------|--------|-----------|--|------------|------------|------------|----------------------|------------|------------|------------|--------------|
| | | | Floor (100) | Roof (115) | Roof (125) | Roof (160) | Floor (100) | Roof (115) | Roof (125) | Roof (160) | |
| GA1 | 2 1/2" | 4-10d | 185 | 185 | 185 | 185 | 160 | 160 | 160 | 160 | I14, F13 |
| GA2 | 3 1/2" | 6-10d | 335 | 385 | 415 | 450 | 290 | 335 | 335 | 335 | I14, LS, F13 |
| LS0 | 3 | 4-10d | 220 | 240 | 240 | 240 | 190 | 205 | 205 | 205 | I14, LS, F13 |
| LS0 | 5 | 6-10d | 335 | 385 | 420 | 445 | 290 | 335 | 360 | 385 | I14, LS, F13 |
| LS0 | 7 | 8-10d | 445 | 510 | 555 | 565 | 380 | 435 | 475 | 485 | I14, LS, F13 |
| LS0 | 9 | 10-10d | 555 | 640 | 695 | 740 | 480 | 550 | 600 | 640 | I14, LS, F13 |
| LS30 | 3 1/2" | 6-10d | 355 | 395 | 395 | 395 | 305 | 335 | 335 | 335 | I14, LS, F13 |
| LS50 | 4 1/2" | 8-10d | 475 | 540 | 585 | 730 | 410 | 465 | 505 | 630 | I14, LS, F13 |
| LS70 | 6 1/2" | 10-10d | 595 | 675 | 730 | 915 | 510 | 580 | 630 | 785 | I14, LS, F13 |
| LS90 | 7 1/2" | 12-10d | 715 | 810 | 875 | 1040 | 615 | 695 | 755 | 895 | I14, LS, F13 |

1. L angles-loads are for condition F1 or F2.
 2. GA1 and GA2 angles table loads are F1 - loads for F2 are 220 lbs. and 335 lbs. (100) and 280 lbs. and 415 lbs. (125), respectively.
 3. Roof loads are 125% of floor loads unless limited by other criteria.
 4. Connectors are required on both sides to achieve F2 loads in both directions.
 5. L angles may be installed with 10d x 1 1/2" nails and achieve full load.
 6. L5 angles may be installed with 10d x 1 1/2" nails at 0.11 x table load.
 7. NAILS: 16d = 0.162" dia. x 3 1/2" long, 10d = 0.148" dia. x 3" long, 10d19 = 0.148" dia. x 1 1/2" long. See page 22-23 for other nail sizes and information.

Paul Huijing, P.E.