# DIRECT FASTENING 101: DEVELOPMENTS IN POWER-ACTUATED FASTENING TECHNOLOGY

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**Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.**

AIA Continuing Education Provider

# LEARNING OBJECTIVES

**Upon completing this program, the participant should be able to:**

1. Recognize Power-Actuated Fastener (PAF) attachment methods for construction
2. Understand test methods and model building code evaluations for PAF
3. Communicate a clear understanding of PAF technology including application limits, safety and technical references available for engineering design and specification

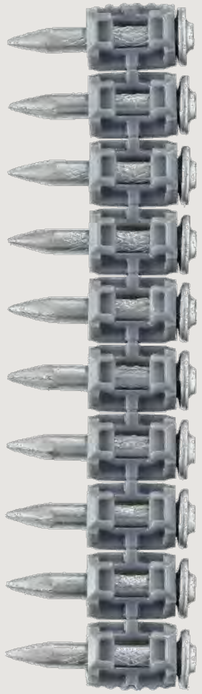
# AGENDA

- **Background Theory**
- Application Overview
- Codes and Standards
- Product Developments
- Conclusion

# POWDER-ACTUATED FASTENING SYSTEMS

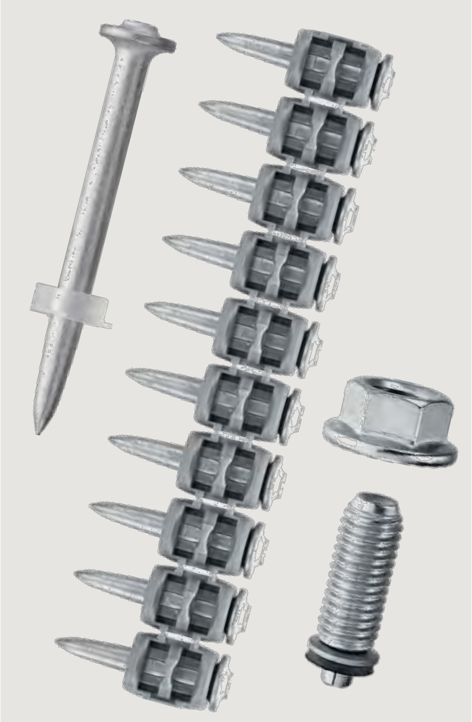
| Powder-Actuated Fastener | Driving Energy | Powder-Actuated Fastening Tool |
| --- | --- | --- |

# GAS-ACTUATED FASTENING SYSTEMS

| Gas-Actuated Fastener | Driving Energy | Gas-Actuated Tool |
| --- | --- | --- |
|  |  |  |

# BATTERY-ACTUATED FASTENING SYSTEMS

| Battery-Actuated Fastener | Driving Energy | Battery-Actuated Fastening Tool |
| --- | --- | --- |




# PAF SYSTEMS INCORPORATE SAFETY FEATURES IN THEIR DESIGN AND SHOULD INCORPORATE OSHA REQUIREMENTS

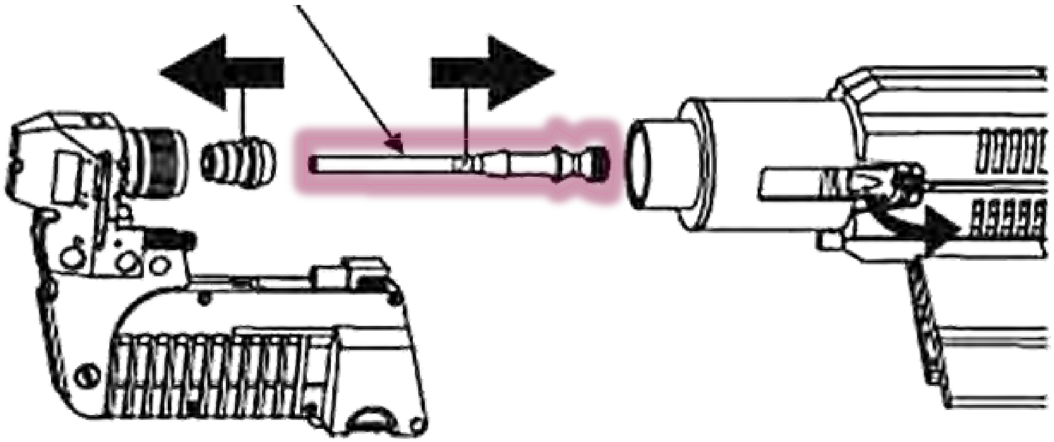
**Tool safety features of low-velocity powder-actuated fastening tools:**

- Captive piston principle
- Drop safety
- Trigger Safety
- Contact pressure Safety
- Unintentional firing

**OSHA & ANSI A10.3 Requirements**

- Safety training
- PPE

**Captive Piston**



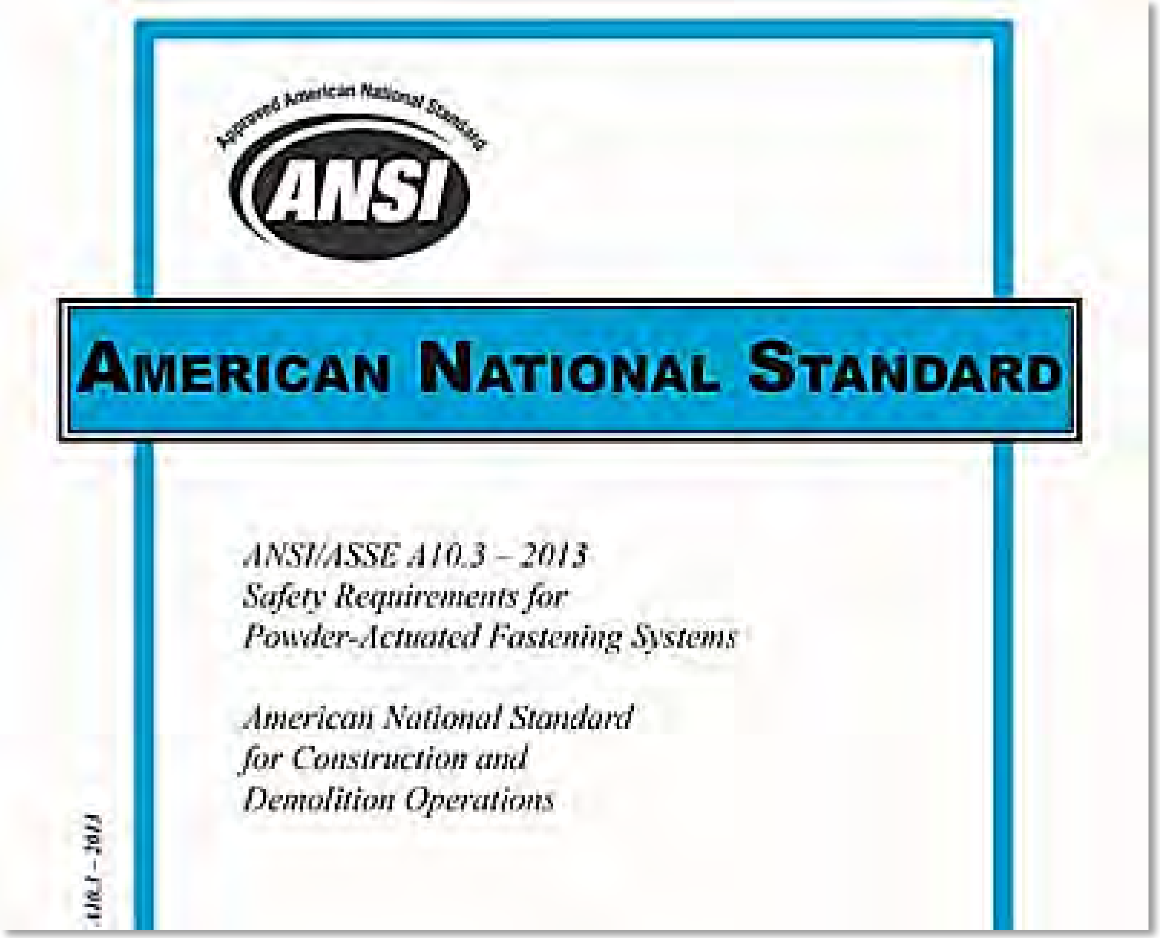
# ANSI STANDARDS PLACE TRAINING REQUIREMENTS ON PAF OPERATORS & SHOULD BE REFERENCED IN NOTES

**ANSI A10.3 – 2013**

**Safety Requirements for Powder-Actuated Fastening Systems**

- Section 12 - Allowance for "alternate" training program (most likely an on-line program, but could be others as well  video, CD, etc.

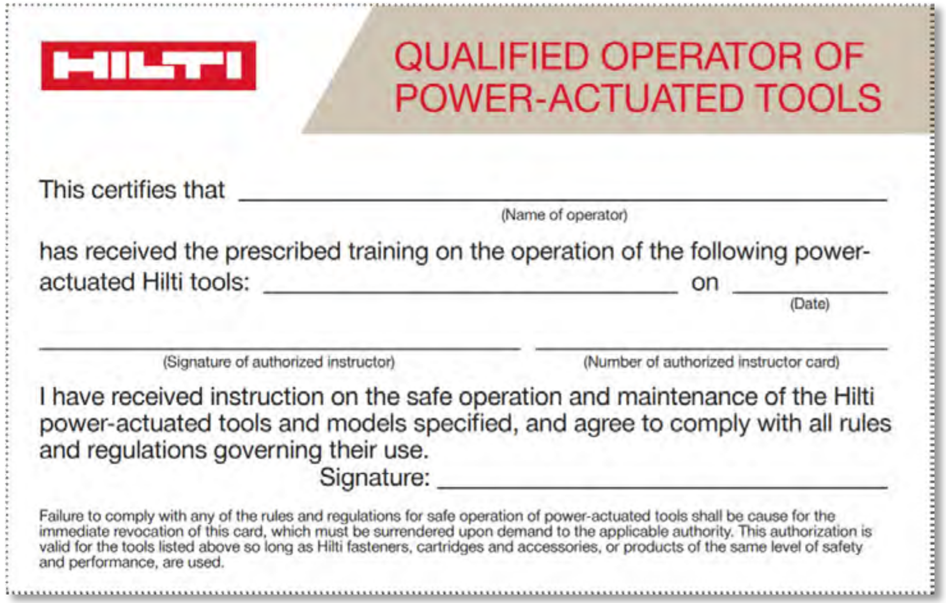
**Standard should be referenced in the Structural General Notes section pertaining to the use of powder-actuated fasteners**



# OPERATOR TRAINING AND CERTIFICATION HELP ENSURE THAT TOOLS ARE USED SAFELY AND AS INTENDED

**Operator Training & Certification**

- Manufacturers offer training and certification programs that cover safe tool operation, maintenance and emergency protocols
- Operators receive a Qualified Operators Card which is valid for the tools they were trained on
- These qualifications do not expire, but additional training might be required as tools and technology changes



QUALIFIED OPERATOR OF POWER-ACTUATED TOOLS

This certifies that ______________________________
(Name of operator)

has received the prescribed training on the operation of the following power-actuated Hilti tools: ______________________ on __________
(Date)

______________________ (Signature of authorized instructor)
______________________ (Number of authorized instructor card)

I have received instruction on the safe operation and maintenance of the Hilti power-actuated tools and models specified, and agree to comply with all rules and regulations governing their use.

Signature: ______________________

Failure to comply with any of the rules and regulations for safe operation of power-actuated tools shall be cause for the immediate revocation of this card, which must be surrendered upon demand to the applicable authority. This authorization is valid for the tools listed above so long as Hilti fasteners, cartridges and accessories, or products of the same level of safety and performance, are used.

# POWER-ACTUATED FASTENING IS USED ON A VARIETY OF APPLICATIONS AND BASE MATERIALS

| Concrete | Masonry | Steel |
|---|---|---|
|  |  |  |

# FACTORS THAT INFLUENCE NAIL CHOICE - BASE SUBSTRATE - CONCRETE

CONCRETE

**We distinguish between three concrete types:**

**Soft (S) -** Example: lightweight concrete

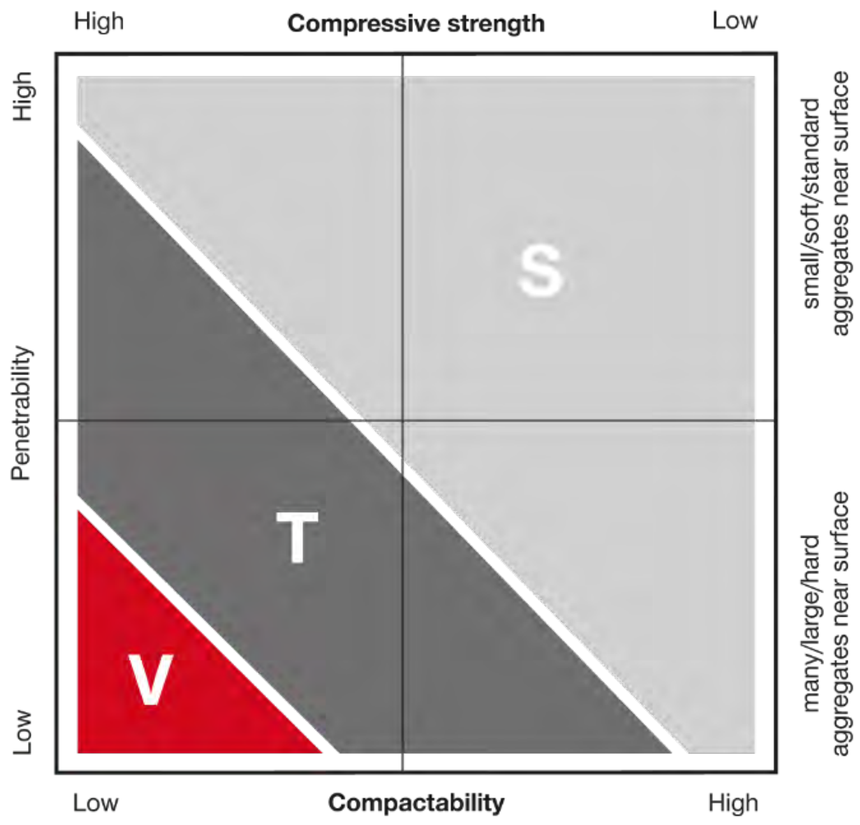
- Low compressive strength (e.g. 2-5 ksi)
- Small to medium-size aggregates; e.g. soft limestone

**Tough (T) -** Example: normal-weight concrete

- Medium to high compressive strength (e.g. 5-7 ksi)
- Medium-size aggregate; e.g. pit gravel

**Very tough (V) -** Example: high-performance concrete

- High compressive strength (e.g. ≤ 7 ksi)
- High proportion of large aggregates, mainly hard; e.g. quartz, granite

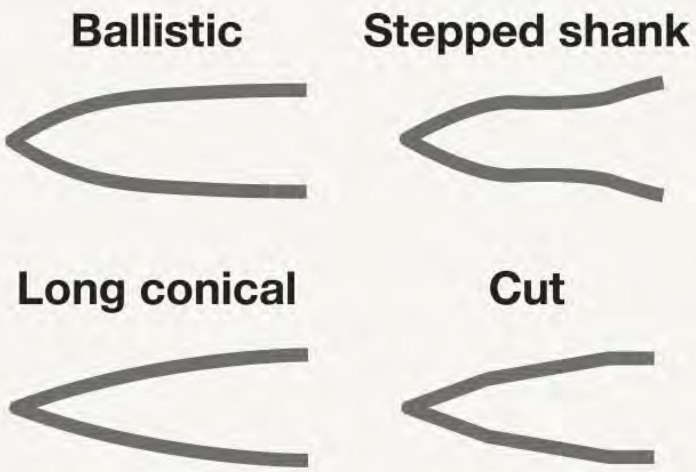


# NAIL DESIGN FEATURES INFLUENCE ABILITY TO PENETRATE AND COMPACT THE CONCRETE

CONCRETE

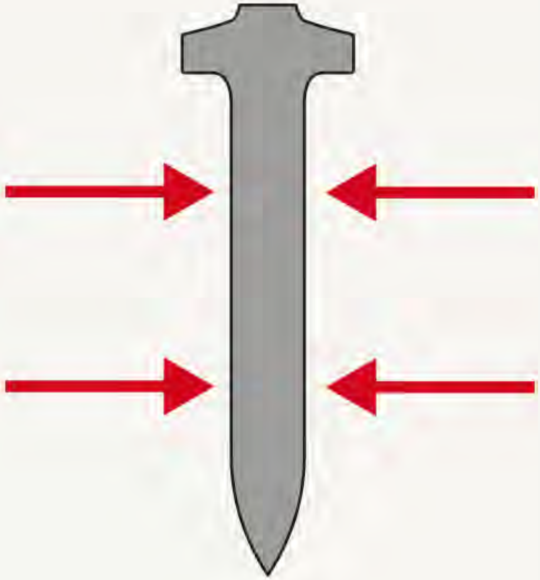
## Tip Shape

- Shape affects penetration
- Four shapes available




## Geometry

- Length and diameter of nail affects the ease of penetration



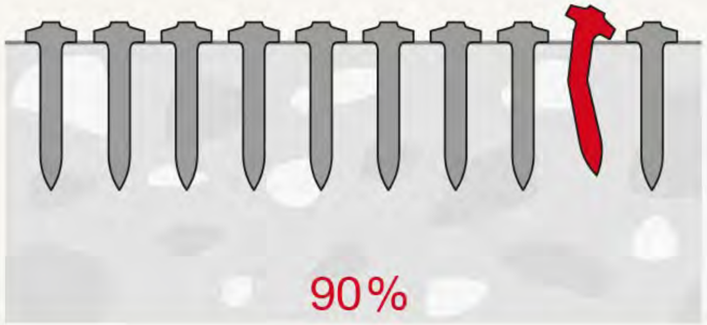
## Hardness

- The nail's hardness influences its drivability
- Harder nails are easier to drive, but more brittle
- Good nails are hard with enough ductility to penetrate without breaking

# THREE FACTORS CAN INFLUENCE THE NAIL CHOICE IN CONCRETE

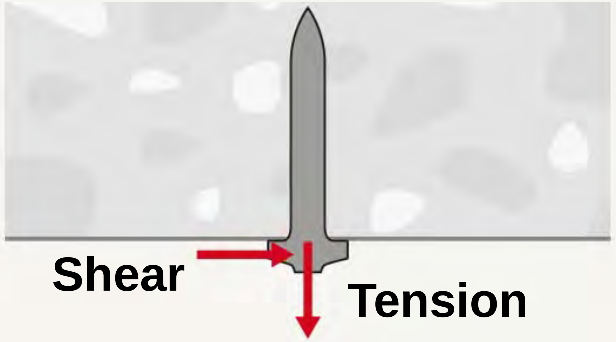

## Stick Rate

- Stick rate indicates the percentage of nails being properly driven, to the correct depth



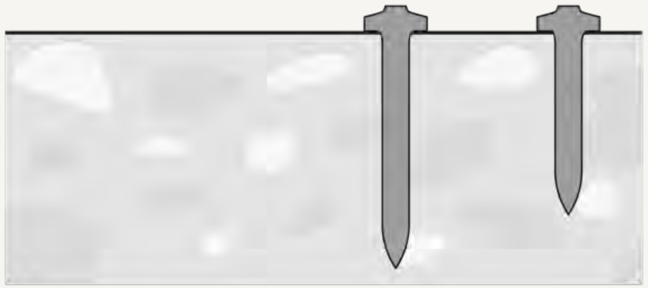

## Holding Value

- Holding values provide a measure of a nail's load-bearing capability
- Loads are split into
  - Shear
  - Tension




## Embedment

- The depth of embedment influences nail performance
- The deeper the embedment, the higher the setting energy required, which in turn affects the stick rate

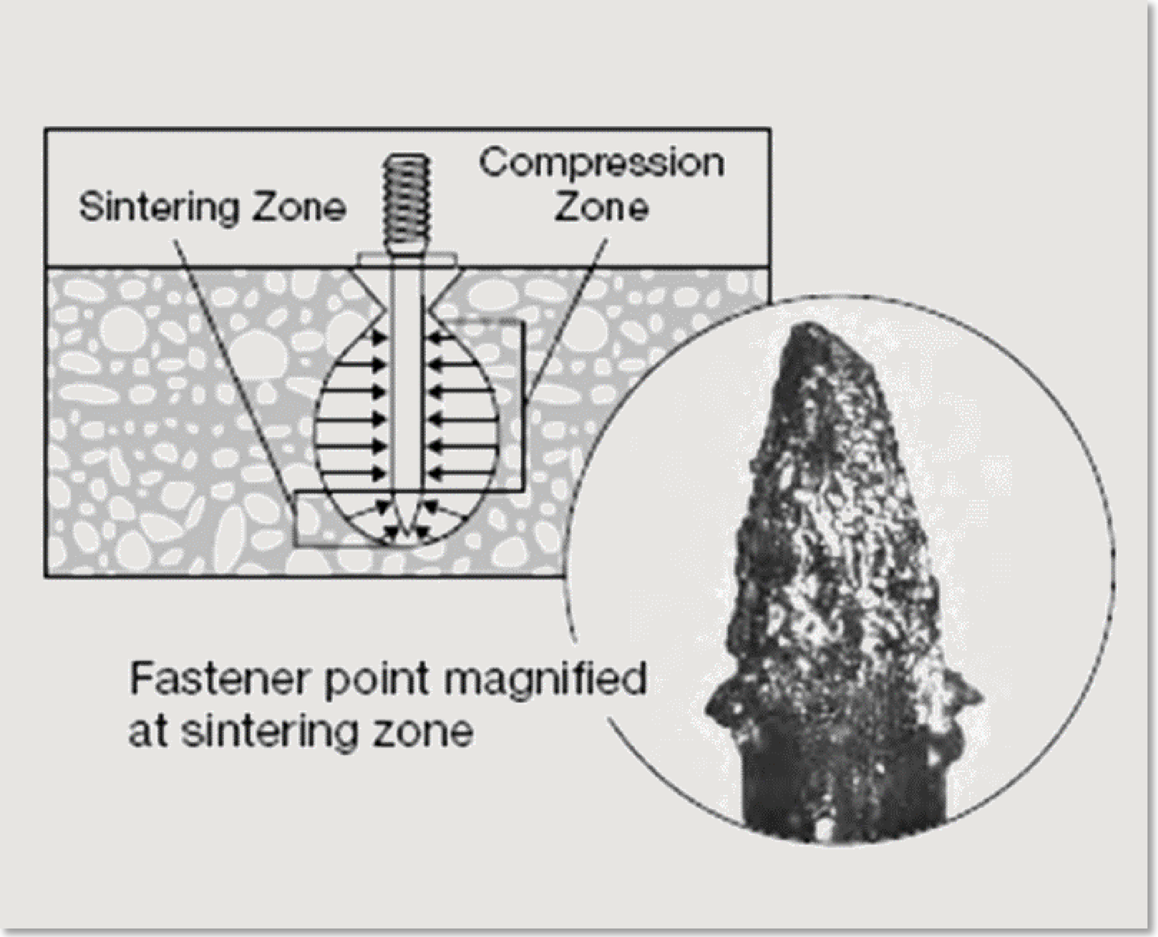


# POWER-ACTUATED FASTENING HOLDING MECHANISMS TO CONCRETE

CONCRETE

**Holding mechanism to concrete**

- Bonding / Sintering – friction generated between concrete & fastener during driving process
- Micro-interlock – mechanical hold between ridges of fastener and concrete
- Keying – created between knurling on fastener shank and concrete

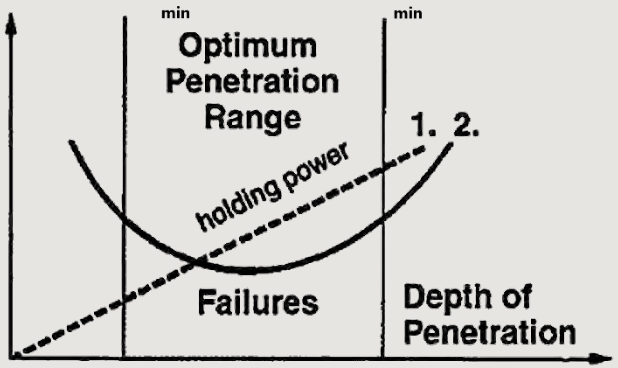


# FACTORS AFFECTING POWER-ACTUATED FASTENING TO CONCRETE

CONCRETE

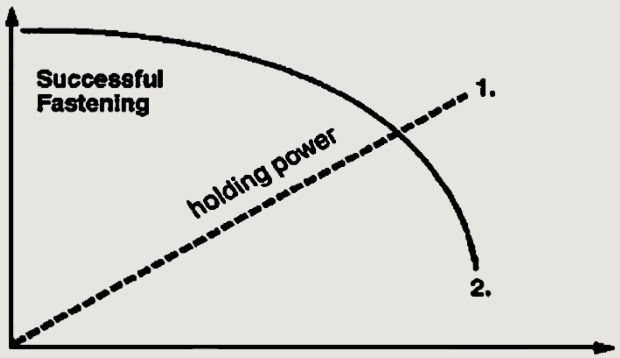
## Depth of Penetration into Concrete

- Fastener penetration is related to load capacity (1)
- When penetration depth is too shallow or too deep it may cause increased failures (2)



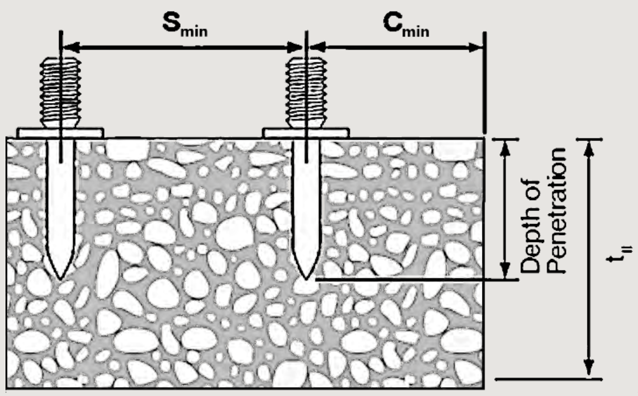

## Compressive Strength of Concrete

- Compressive strength is related to the fasteners load capacity (1)
- High compressive strength and aggregate hardness decrease the possibility of making a  successful fastening (2)




## Spacing, Edge Distance and Base Material Thickness Requirements for Concrete

- Hardness and tip geometry of the fastener
- Fastener spacing, edge distance and concrete thickness

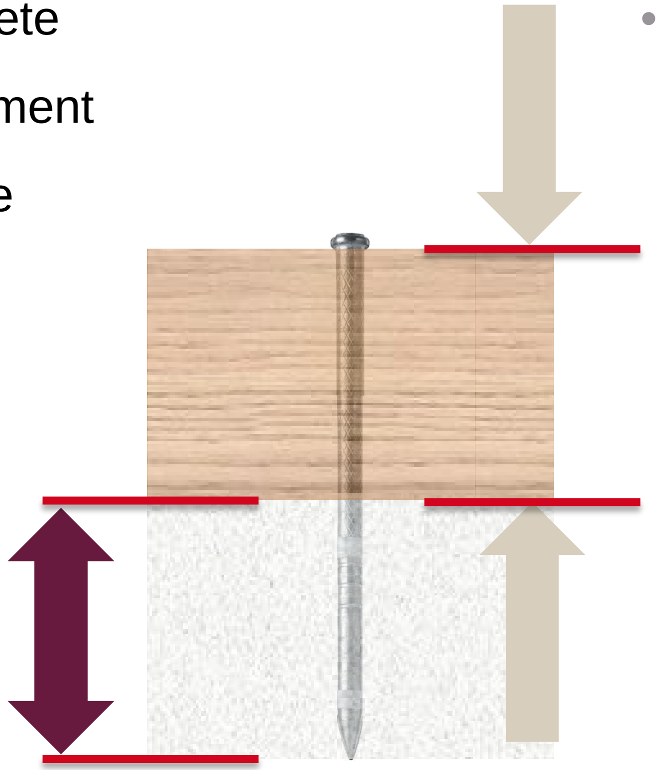


# PROPER INSTALLATION INTO CONCRETE DEPENDS ON THE EMBEDMENT AND CLAMPING

CONCRETE

| Embedment | Clamping |
| --- | --- |

- Driven required distance into concrete
- Holding Capacity related to embedment
- Depends on Fastener type/concrete strength



- There should be clamping between underside of head and material being attached to the concrete base

# SUCCESS DEPENDS ON SELECTING THE RIGHT NAIL FOR YOUR CONCRETE APPLICATIONS

CONCRETE

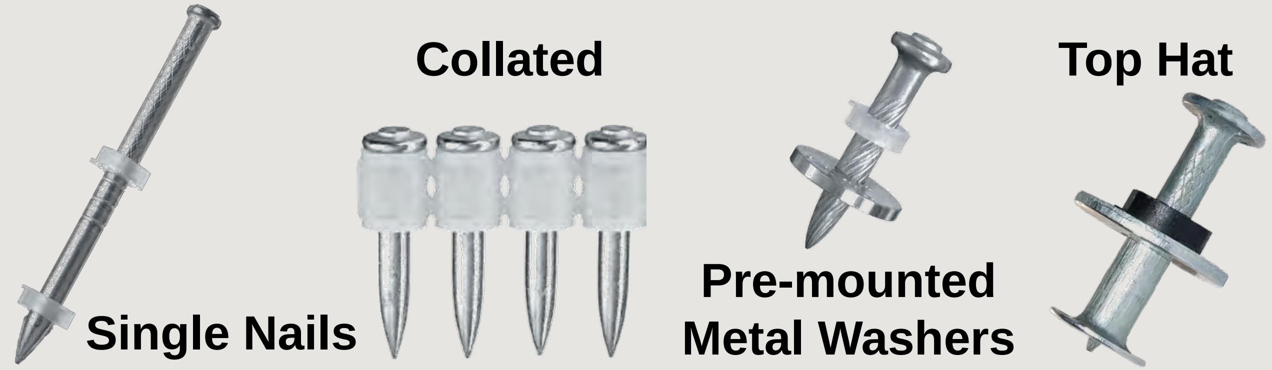
**Select the nail based on your application**

- Understand the application
- Determine what requirements are important
- Choose the nail based on your application and project requirements, which includes the tool and driving energy

**Following these steps will help:**

- Maximize the stick rate
- Achieve the required holding values
- Select the most cost-efficient nail
- Achieve optimum embedment depth based on selecting the appropriate cartridge and adjusting the power setting

**Nails offer flexible solutions to many project needs**



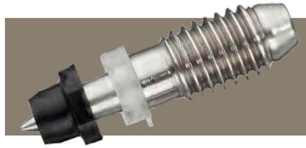
# FACTORS THAT INFLUENCE CHOICE WHEN CONNECTING TO STEEL

STEEL

**Advantages over traditional methods**

- Fasten to base material with minimal preparation, compared to welding or through-bolting
- No skilled welder is required
- One sided assembly increases worker productivity
- Offers application flexibility
- Attachment in almost any weather conditions
  - Multiple driving technologies, powder, gas and battery
  - Eliminating the need for an external power source

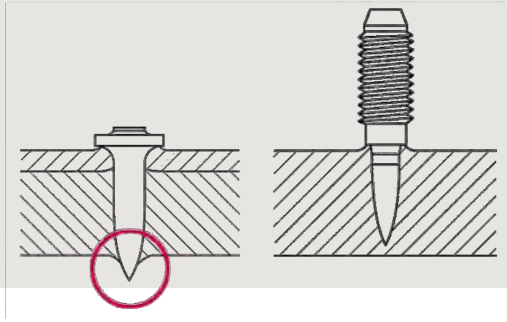
# FASTENER OPTIONS CONNECTING TO STEEL

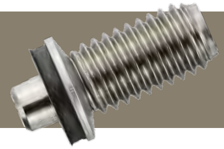



## Sharp Tip Fastening

**Sharp tip fastener is driven by a powder-actuated tool into the base material, creating a high-quality connection**

- Suitable for high-frequency applications where each fastening can be completed in a few seconds
- Stainless steel fasteners for mildly corrosive environments where penetration through base material is acceptable

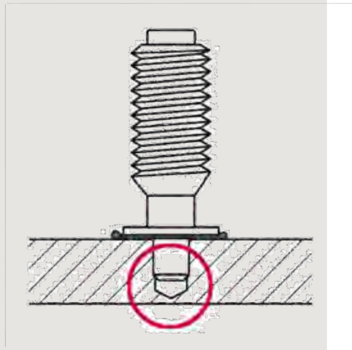




## Blunt Tip Fastening

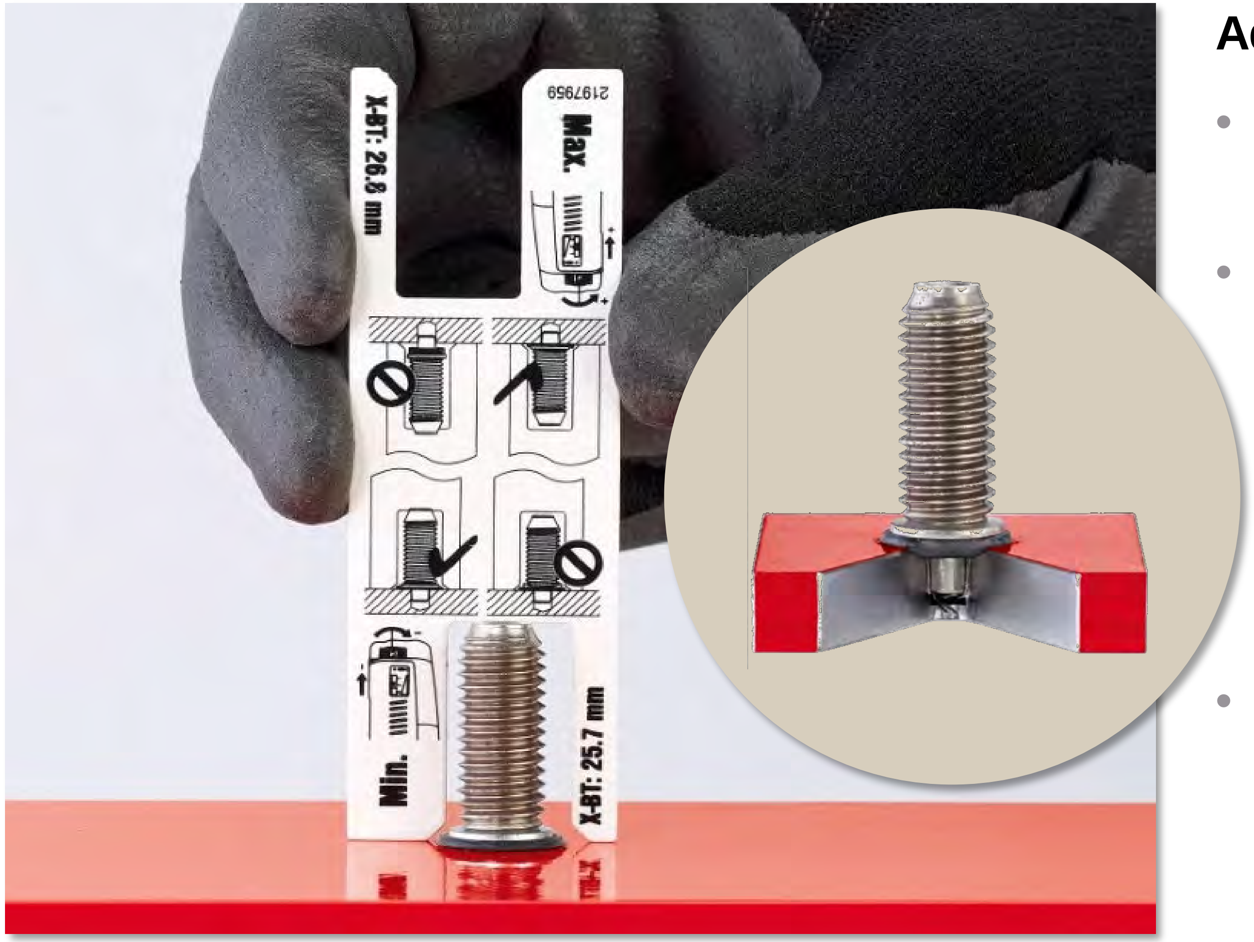
**Blunt-tip fastener, smooth shank, driven by a powder-actuated tool into a pre-drilled hole, creates a high-quality connection**

- Little to no damage to base material corrosion protection in non-through penetration applications
- Options for highly-corrosive environments or mildly-corrosive environments



# FACTORS THAT INFLUENCE CHOICE WHEN CONNECTING TO STEEL

STEEL




**Advantages over traditional attachment to steel**

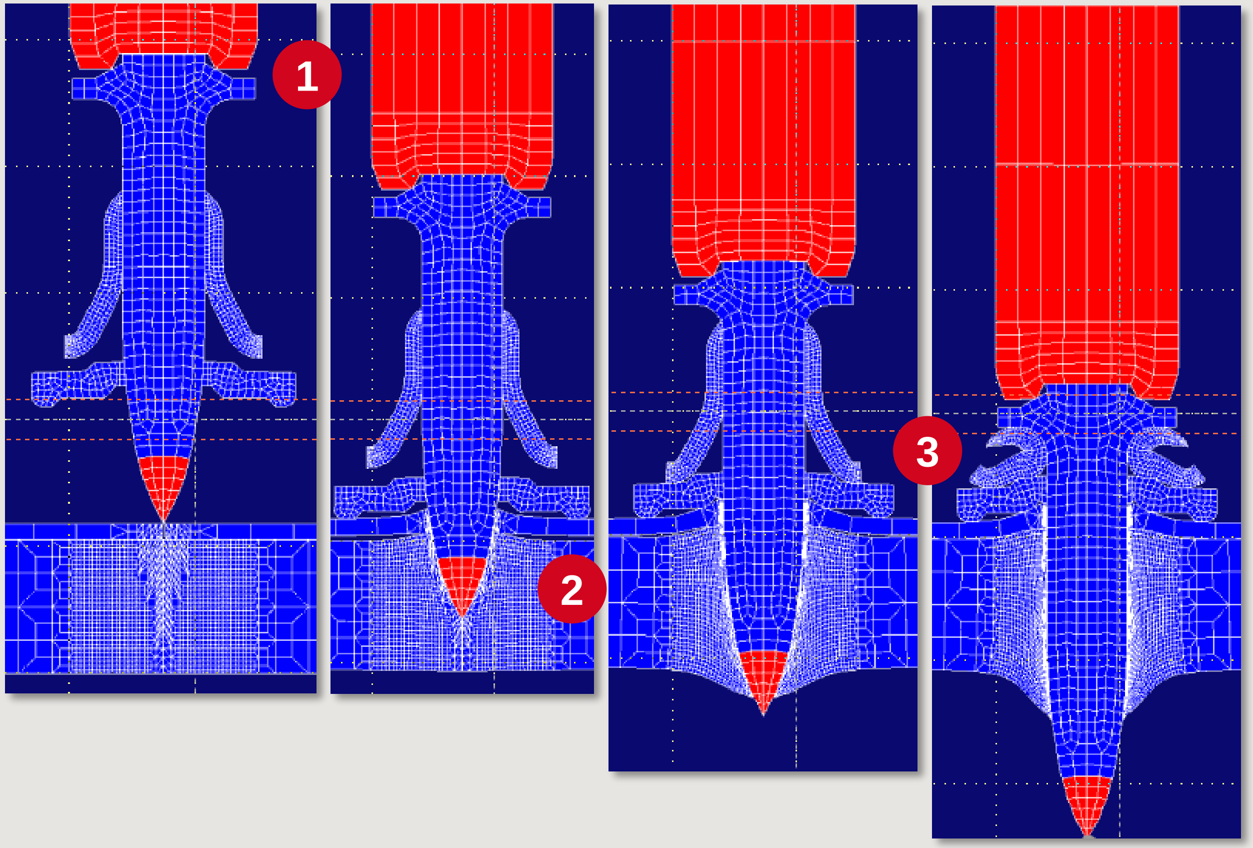
- Reliable products backed by extensive testing and industry approvals
- Procedures and checks for repeatable, quality installations
  - Visual aids help installers evaluate proper installation
  - Visual depth gauges also help inspectors check for proper installation
- Little to no through penetration or damage to back of steel
  - Could be ideal for corrosive environments

# FINITE ELEMENT MODEL OF FASTENER INSTALLATION INTO STEEL

STEEL

**Finite Element Model Animation of Fastener Action**

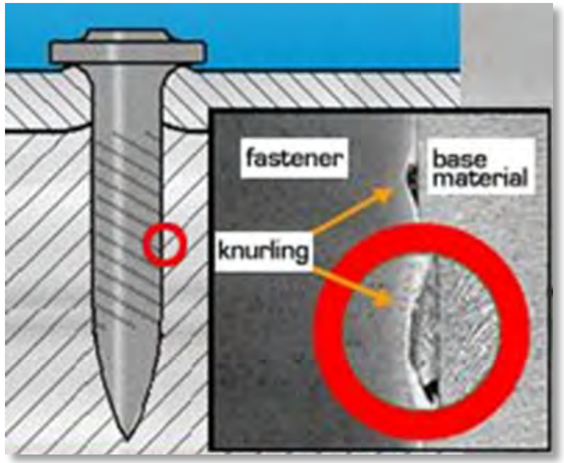
1. Captive piston in contact with nail head throughout action
2. Point penetration - Displacement of the base steel elastic and plastic
3. Compression of top hat washer aids in clamping the attached element to the base steel for transfer of shear loads and resisting tension pullover.

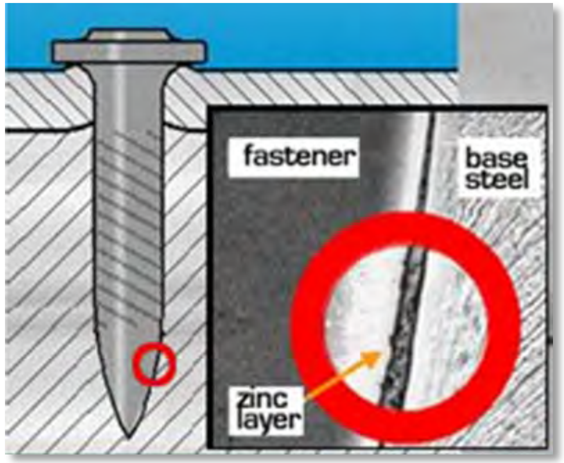


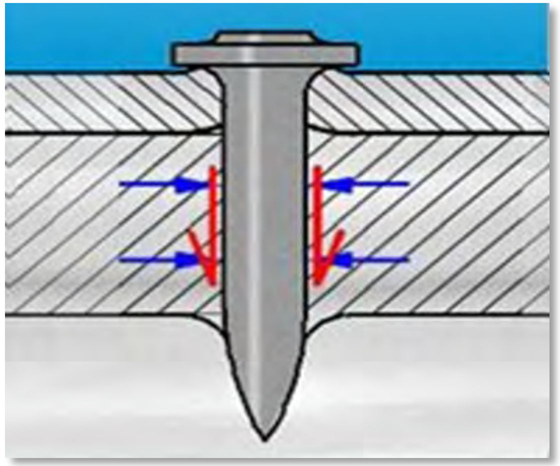
# HOLDING MECHANISMS OF POWER-ACTUATED FASTENING TO STEEL

STEEL

| Keying Hold | Soldering / Fusion | Friction Hold |
|---|---|---|
| • Mechanical interlock with knurling on fastener shank | • Zinc electroplated coating partially fuses with base material providing additional bond with the base material | • Clamping action as the base steel rebounds around the fastener shank<br>• Aids in transfer of shear loads and resists pullover effects |



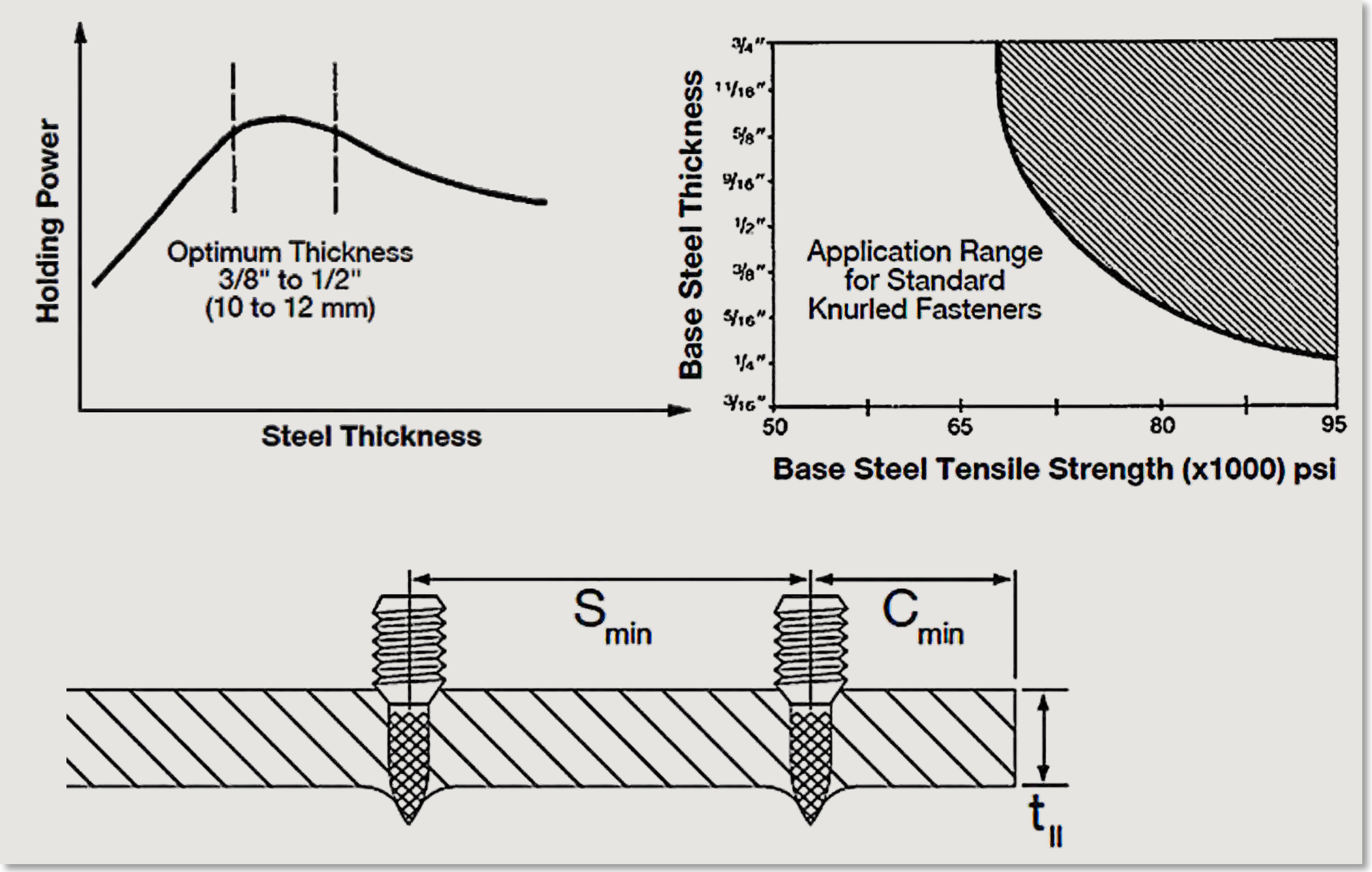



# OTHER FACTORS AFFECTING PERFORMANCE OF POWER-ACTUATED FASTENERS TO STEEL

STEEL

### Factors Affecting Power-Actuated Fastening to Steel

- Base material thickness
- Tensile strength of base material
- Fastener spacing and edge distance
- Fastener shank diameter
- Penetration of point through backside of base material



# AGENDA

- Background Theory
- **Application Overview**
- Codes and Standards
- Product Developments
- Conclusion

# PAF IS USED ON A VARIETY OF APPLICATIONS – **FASTENING TO CONCRETE**

CONCRETE

### General Fastening

### Electrical Applications

### Drywall

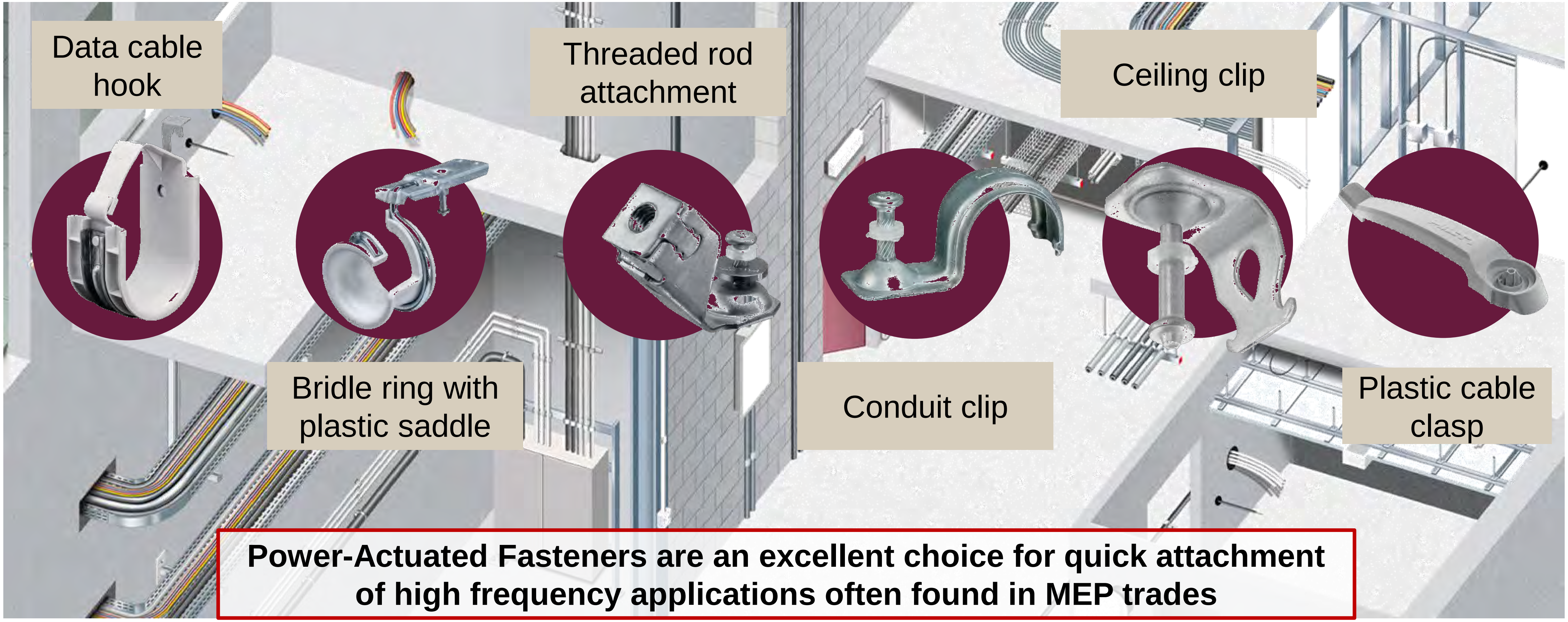
### Insulation

### Low Voltage hangers

### Overhead Cabling

# POWER-ACTUATED FASTENING OFFER FLEXIBLE ATTACHMENTS TO MANY MEP APPLICATIONS

CONCRETE




**Power-Actuated Fasteners are an excellent choice for quick attachment of high frequency applications often found in MEP trades**

# GENERAL FASTENING APPLICATIONS FOR TEMPORARY APPLICATIONS LIKE FORMWORK

CONCRETE

**Nails for temporary applications like attaching formwork feature distinct benefits for this purpose**

- Predefined shear points on the fastener for controlled fastener removal
- Fast removal – no crowbar needed
- Remove wood virtually undamaged so it can be reused
- Collated fasteners for the temporary fastening of wood to concrete

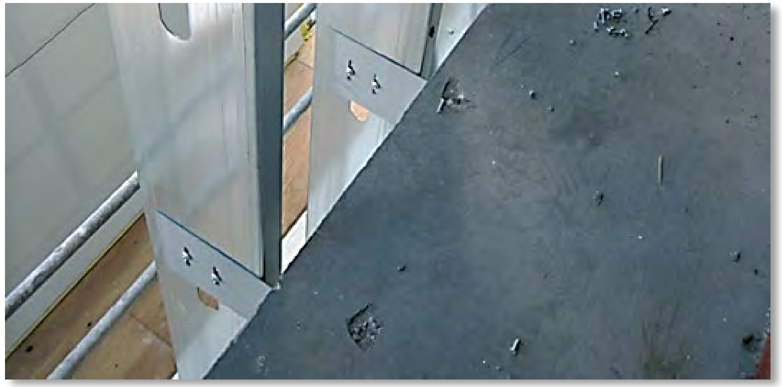
# POWER-ACTUATED FASTENING IS USED ON A VARIETY OF APPLICATIONS ATTACHING TO STEEL


**Decking**

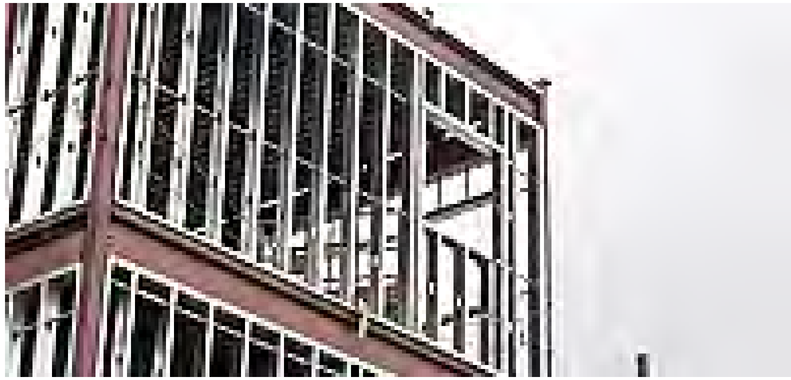
**Grating**

**Strut Supports**

**Vertical Movement**



**Shear Assemblies**

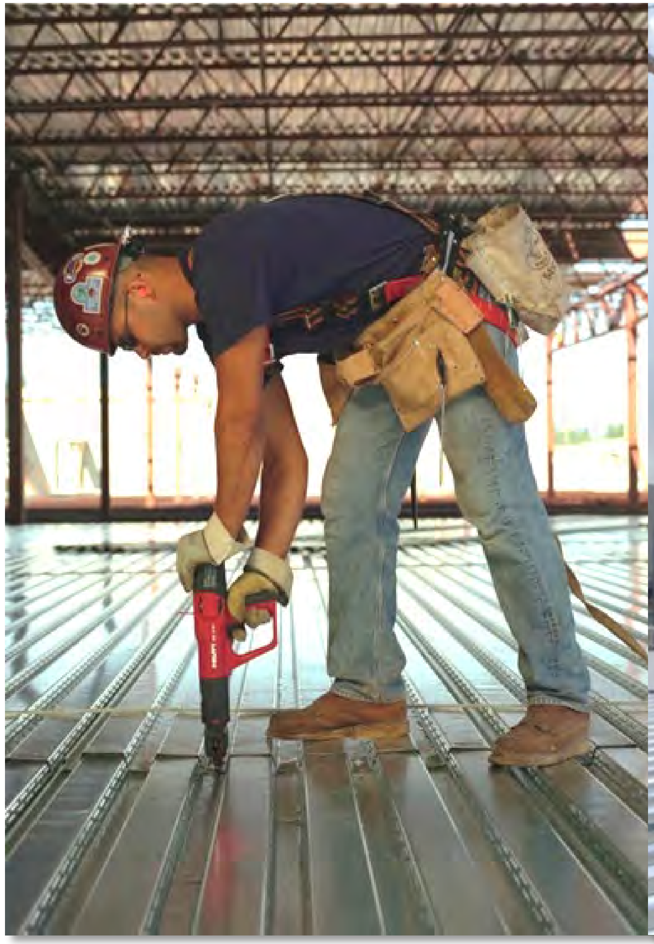


**Grounding/Bonding**

# COLD-FORMED STEEL ROOF OR FLOOR DECK FASTENING TO STEEL IS A VERY COMMON APPLICATION

**The deck and it's fastening system are generally designed as a diaphragm. Base materials can be either structural steel or bar joist**

- Fixing of composite deck-in-floor construction can be performed with a handheld DX tools or stand-up version to reduce operator fatigue
- For narrow beams such as bar joist, a Punch Through Resistance (PTR) feature is built into select tools to minimize the potential of nail free-flight when the supporting beam is missed.



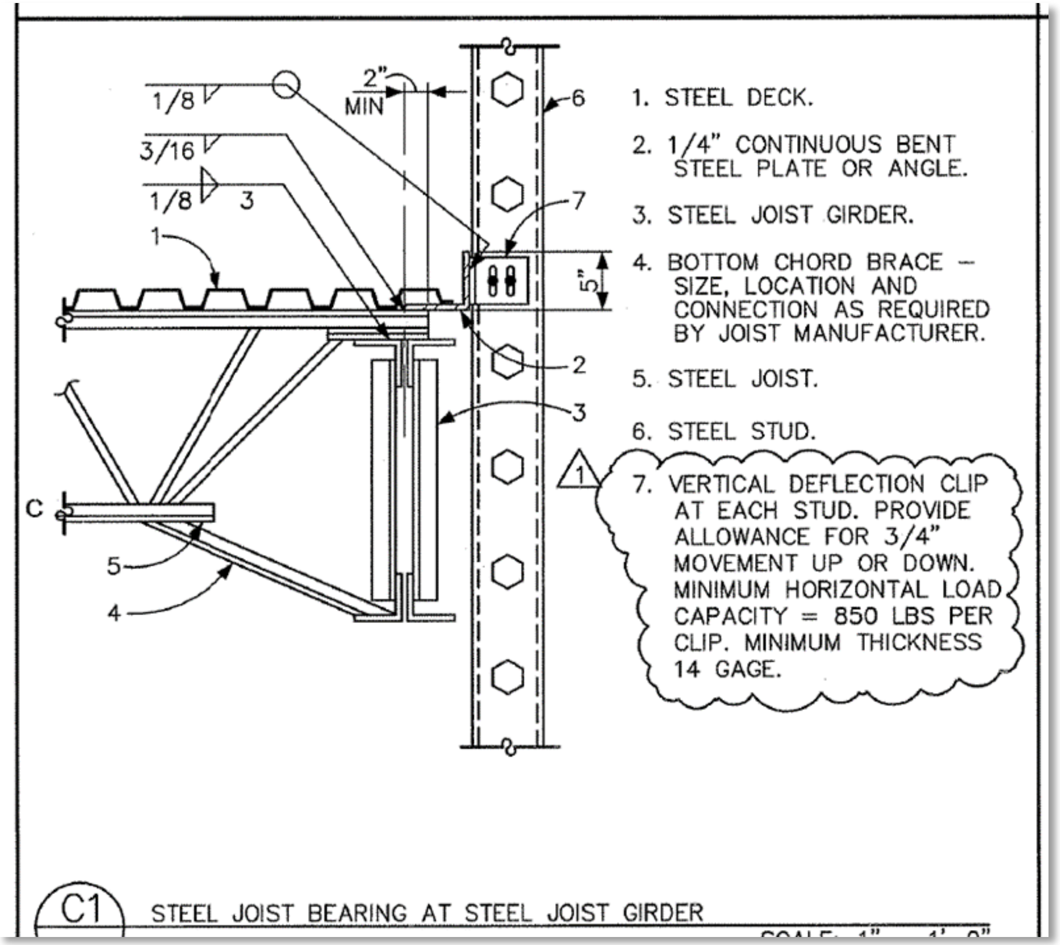
# ATTACHING COLD-FORMED STEEL TO VARIOUS BASE MATERIALS IS A COMMON APPLICATION

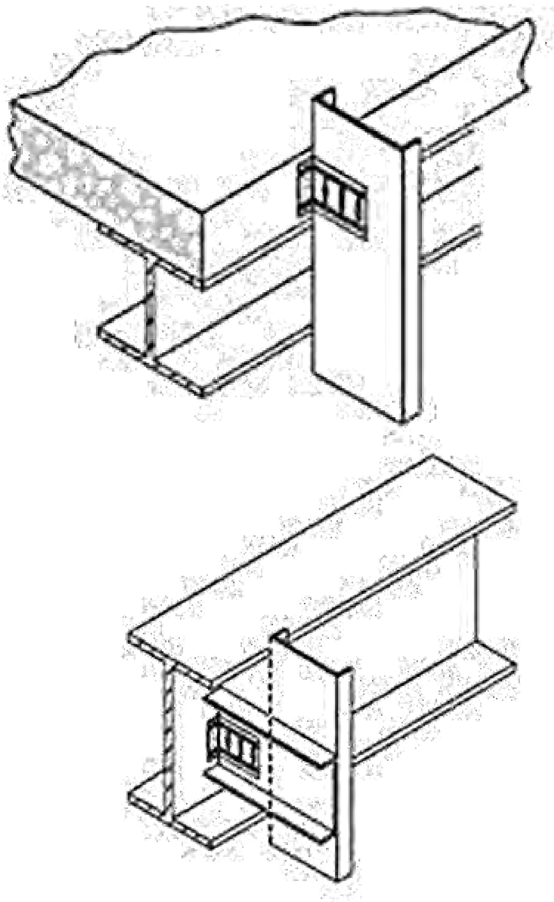
**Steel framing provides efficient load bearing for your structure**

- In most applications you will need to fasten your steel frame to either a thicker steel support or into a concrete slab
- Knurled shanks and tips are a particularly useful advancement as it greatly improves fastener performance in concrete and steel

**Knurled shank**

# DEFLECTION SLIP CLIPS ARE USED FOR LOAD TRANSFER AND SUPPORT AND SUBSTITUTES WELDED CONNECTIONS

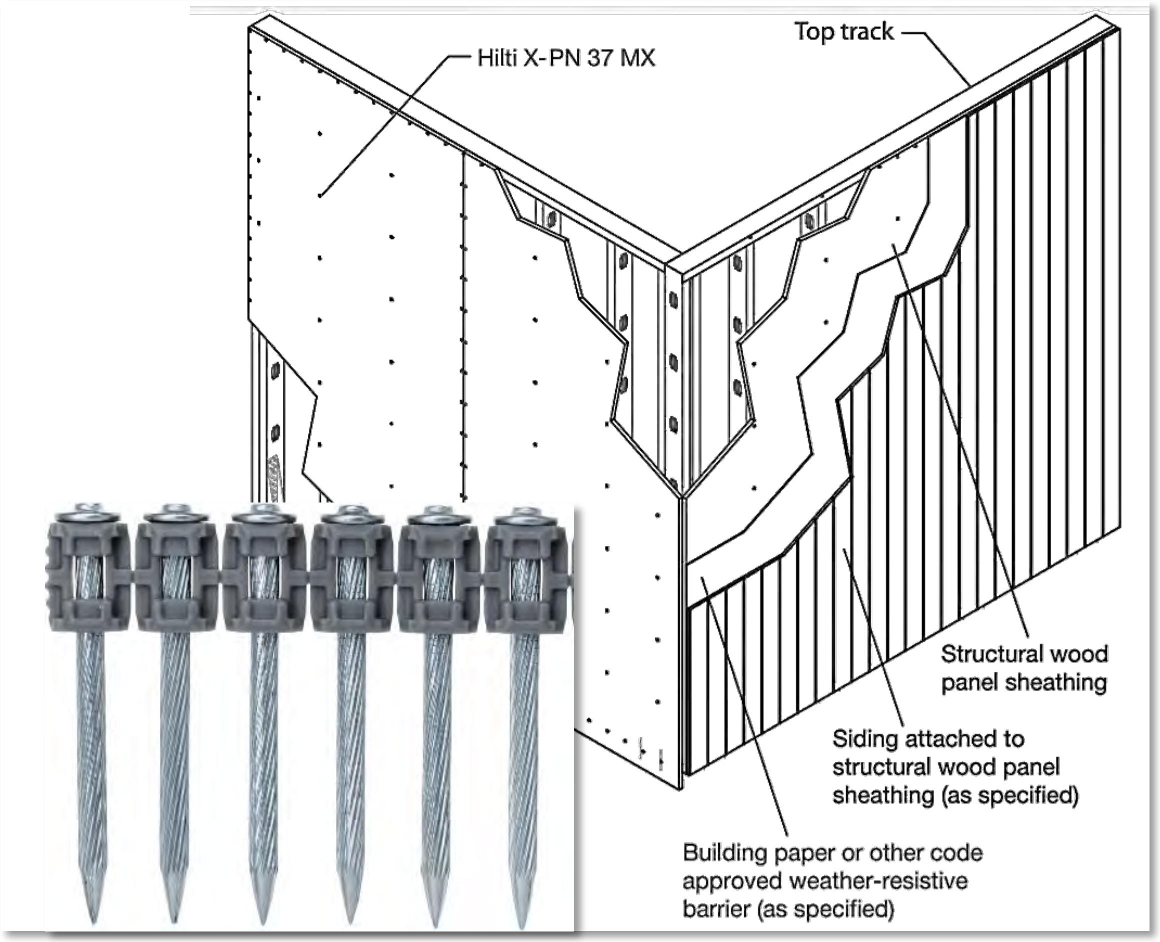


# SHEAR WALL ASSEMBLIES CAN TRANSFER LATERAL LOADS FROM WIND OR SEISMIC THROUGHOUT THE STRUCTURE

**Shear wall is a lateral force resisting structural system that provides resistance to wind, seismic, and other lateral forces and provides stability to the overall structure.**

- Lighter shear walls may be assembled by using – Cold-Formed Steel (CFS), framing members typically covered by wood structural sheathing panels
- Power-actuated fasteners replace screws and anchors, increasing contractor productivity



# FASTENING IN CORROSIVE ENVIRONMENTS PRESENTS ADDITIONAL CONSIDERATIONS BEYOND MATERIAL CHOICE

**According to ASTM G15, corrosion is the chemical or electrochemical reaction between a material, usually metal, and its environment that produces a deterioration of the material and its properties**

- Common types of corrosion for anchor or power-actuated fasteners include direct chemical attack and electrochemical contact
- An additional issue for standard direct (hardened-steel) fasteners is HASCC – Hydrogen Assisted Stress Corrosion Cracking (i.e., embrittlement failure)

**Blunt tip technology was developed to address corrosive environments – it doesn’t penetrate the backside and doesn’t damage the surface**

# DESIGNERS SHOULD TAKE CORROSION REQUIREMENTS INTO ACCOUNT WHEN PLANNING GRATING ATTACHMENT

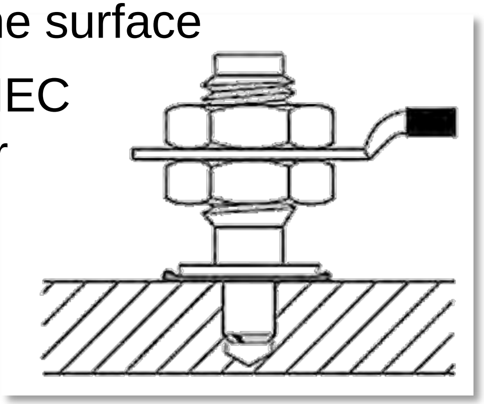
**Power-actuated fastening offers several options for attaching grating on your projects**

- The level of corrosion resistance required for the project and application should be a prominent consideration during project planning
- For highly corrosive applications or environments designers should select an appropriate systems to ensure proper corrosion protection
- In milder environments gratings may be attached directly to the base material

# GROUNDING AND BONDING OF ELECTRICAL SYSTEMS ARE IMPERATIVE TO SAFETY AND SYSTEM OPERATION

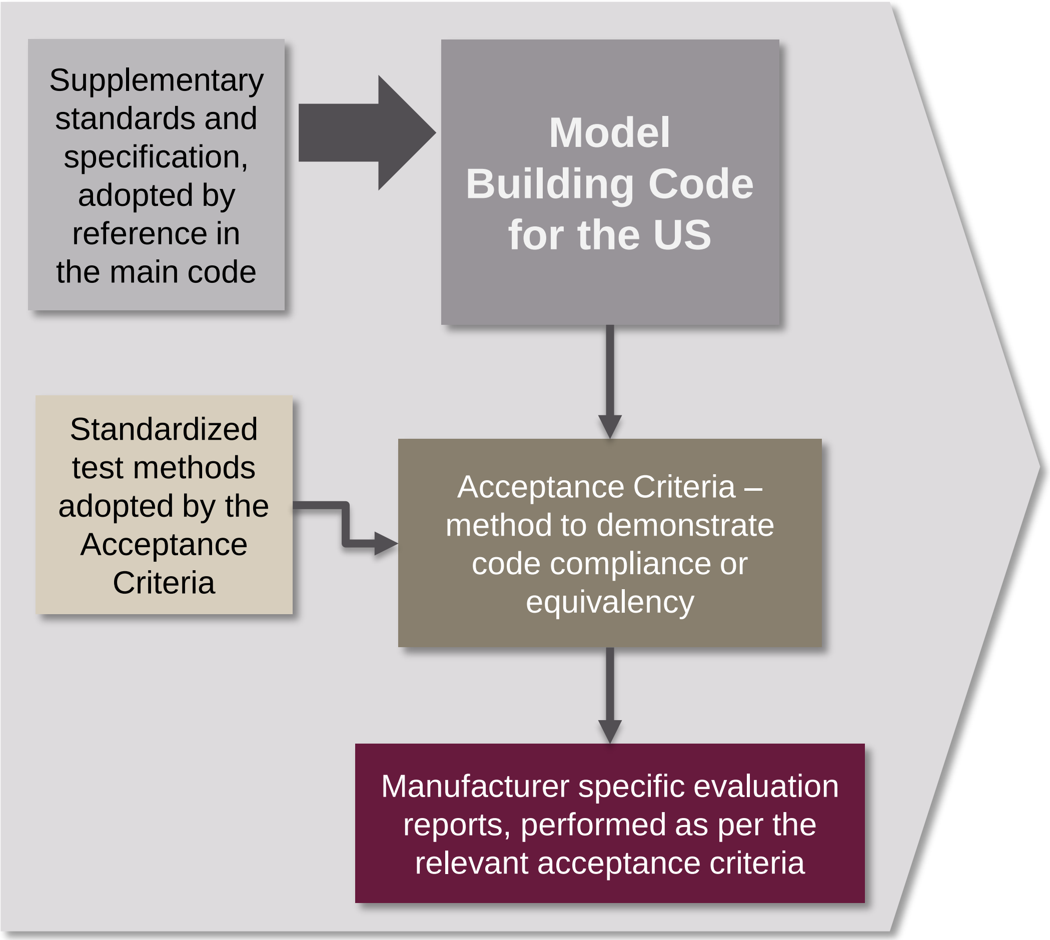
**Bonding and grounding are important considerations for all project types**

- Equipment requires grounded circuits for operation and even non-current carrying metallic components should be electrically connected to eliminate carrying a voltage potential between them
- PAF provides functional bonding in corrosive environments, without damaging the surface
- Products should follow NFPA 70/ NEC compliant solutions and have UL or other relative approvals

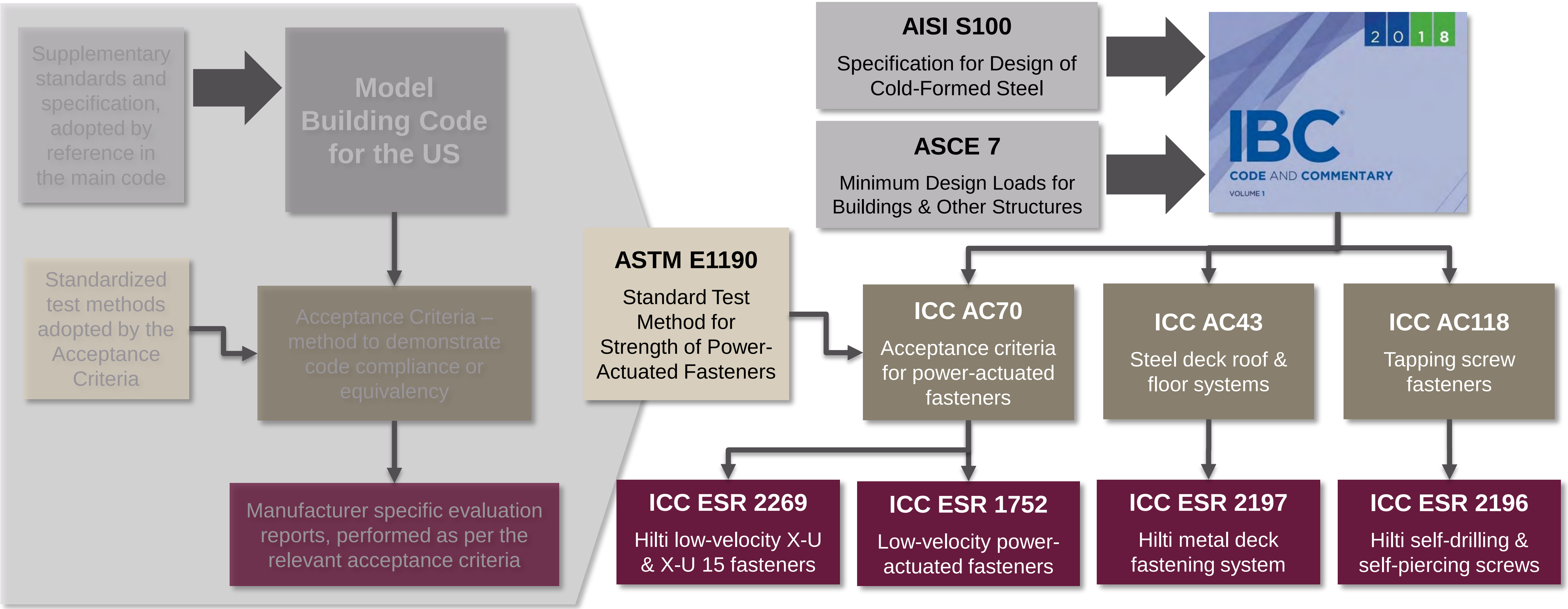


# AGENDA

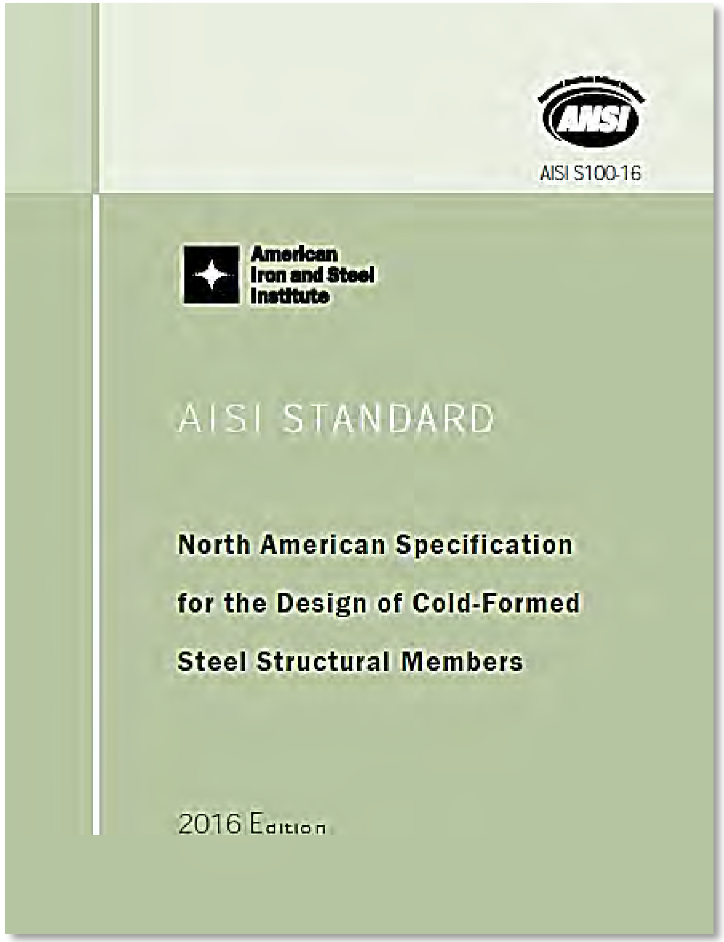
# WHAT ARE THE RELEVANT MODEL CODES AND STANDARDS?




# HOW ARE THE RELEVANT MODEL CODES AND STANDARDS TIED TOGETHER?



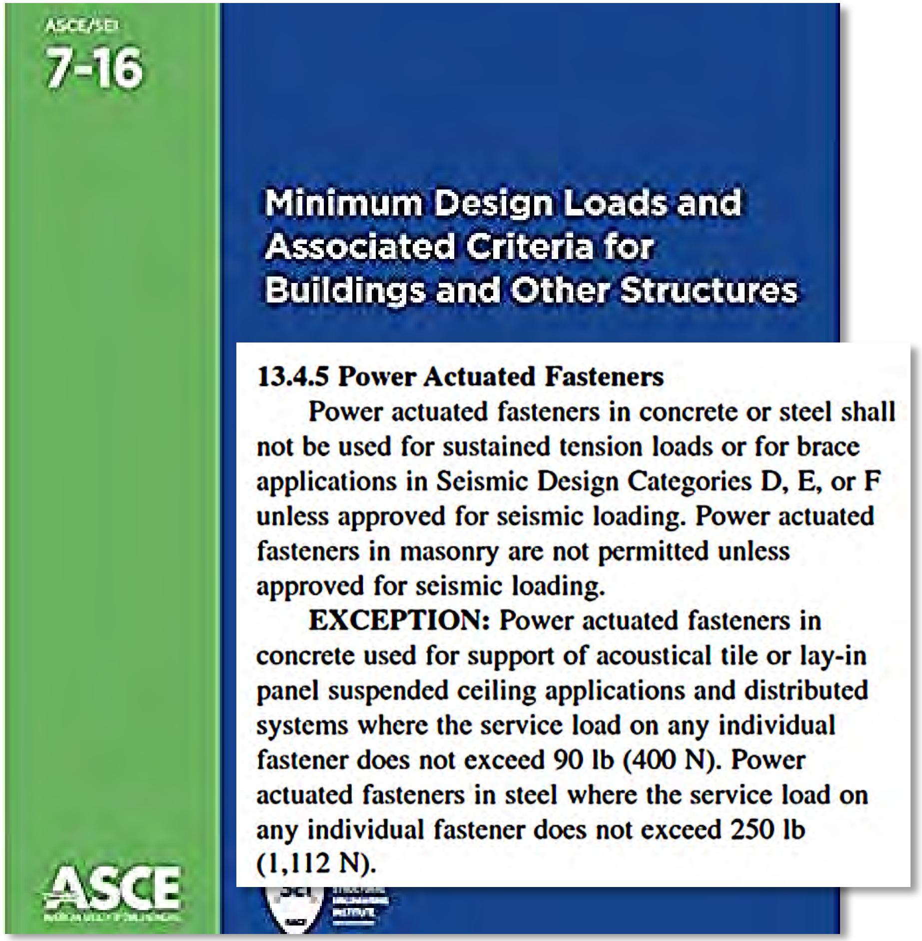
# AISI S100-16 FOR COLD-FORMED STEEL APPLICATIONS IS ADOPTED BY REFERENCE IN THE 2018 IBC MODEL CODE




**AISI S100-16 is the standard for design of cold formed members and adopted as reference for 2018 IBC code.**

- Section I2 addresses metal deck used as a diaphragm
  - AISI S310-16 provides additional design standards for profiled steel diaphragm panels
- Section J5 specifically addresses "Power-Actuated Fasteners installed in steel substrates"
  - Calculation methods provided for all failure modes except PAF pullout
  - PAF pullout to be determined by testing
- Section J7 addresses connections to other materials (i.e. concrete.)
  - Some limit states can be calculated per section J5; others must be determined by test or some other method.

# ASCE 7-16 IS ADOPTED BY REFERENCE IN THE 2018 IBC MODEL CODE




**13.4.5 Power Actuated Fasteners**

Power actuated fasteners in concrete or steel shall not be used for sustained tension loads or for brace applications in Seismic Design Categories D, E, or F unless approved for seismic loading. Power actuated fasteners in masonry are not permitted unless approved for seismic loading.

**EXCEPTION:** Power actuated fasteners in concrete used for support of acoustical tile or lay-in panel suspended ceiling applications and distributed systems where the service load on any individual fastener does not exceed 90 lb (400 N). Power actuated fasteners in steel where the service load on any individual fastener does not exceed 250 lb (1,112 N).

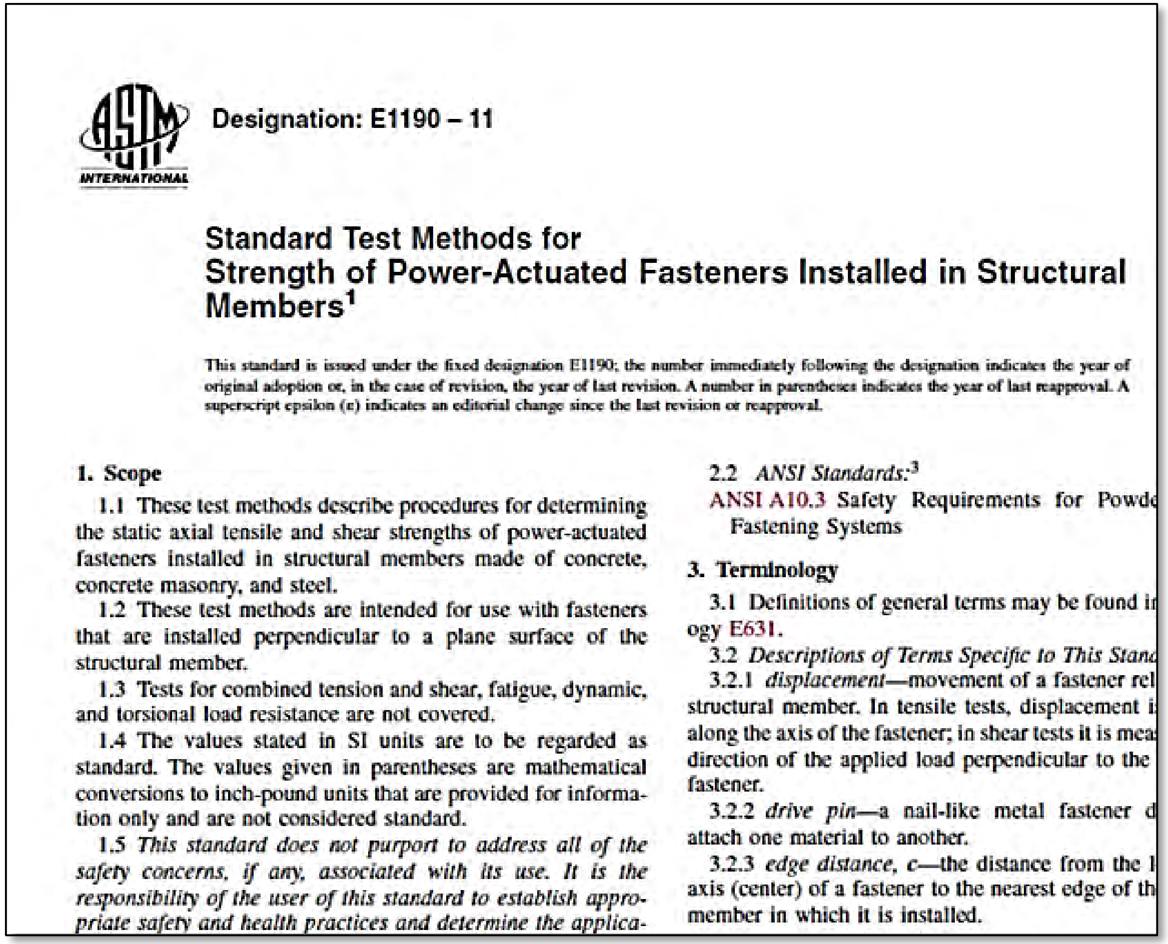
**Chapter 13, Seismic Design Requirements for Nonstructural Components**

- Section 13.4.5, Power-Actuated Fasteners
  - Limits use of PAF for some applications in SDC D,E and F.
  - “Unless approved for seismic loading.”
- ICC-ES AC70 provides method for testing and approval of seismic loading in steel
- Some manufacturer ICC-ES ESRs specifically state seismic recognition in steel
- Also included are exceptions for some applications in concrete, with service loading limited to 90 lb.
  - Exceptions include suspended ceilings, distributed systems and distribution systems

# STANDARD TEST METHODS ARE PRESCRIBED IN ASTM E1190: STRENGTH OF POWER–ACTUATED FASTENERS

**Fasteners may be tested according to *ASTM E1190 Strength of Power-Actuated Fasteners Installed in Structural Members***

- ASTM provides the testing procedure
- Manufacturers should follow the method for strength of power-actuated fasteners installed in structural members
- To have a third-party evaluation report published, manufacturers must submit independently performed or witnessed test reports
- These tests are described in the ASTM E1190



INTERNATIONAL

Designation: E1190 – 11

Standard Test Methods for
Strength of Power-Actuated Fasteners Installed in Structural Members[1]

This standard is issued under the fixed designation E1190; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

**1. Scope**

1.1 These test methods describe procedures for determining the static axial tensile and shear strengths of power-actuated fasteners installed in structural members made of concrete, concrete masonry, and steel.

1.2 These test methods are intended for use with fasteners that are installed perpendicular to a plane surface of the structural member.

1.3 Tests for combined tension and shear, fatigue, dynamic, and torsional load resistance are not covered.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applica-*

2.2 *ANSI Standards:*[3]

ANSI A10.3 Safety Requirements for Powde
Fastening Systems

**3. Terminology**

3.1 Definitions of general terms may be found i
ogy E631.

3.2 *Descriptions of Terms Specific to This Stand*

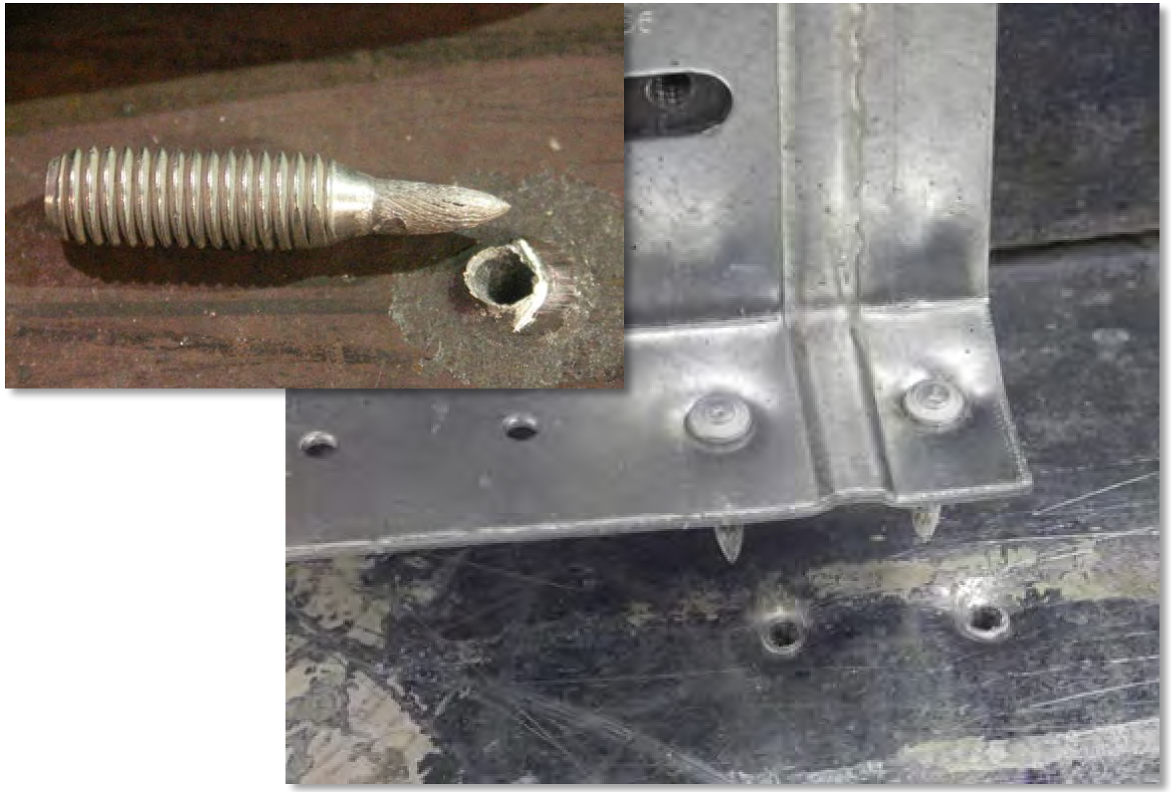
3.2.1 *displacement*—movement of a fastener rel
structural member. In tensile tests, displacement i
along the axis of the fastener; in shear tests it is mea
direction of the applied load perpendicular to the
fastener.

3.2.2 *drive pin*—a nail-like metal fastener d
attach one material to another.

3.2.3 *edge distance, c*—the distance from the l
axis (center) of a fastener to the nearest edge of th
member in which it is installed.

# TEST FAILURE MODES - FASTENER PULLOUT OF BASE MATERIAL

**Base material Pullout - Steel**



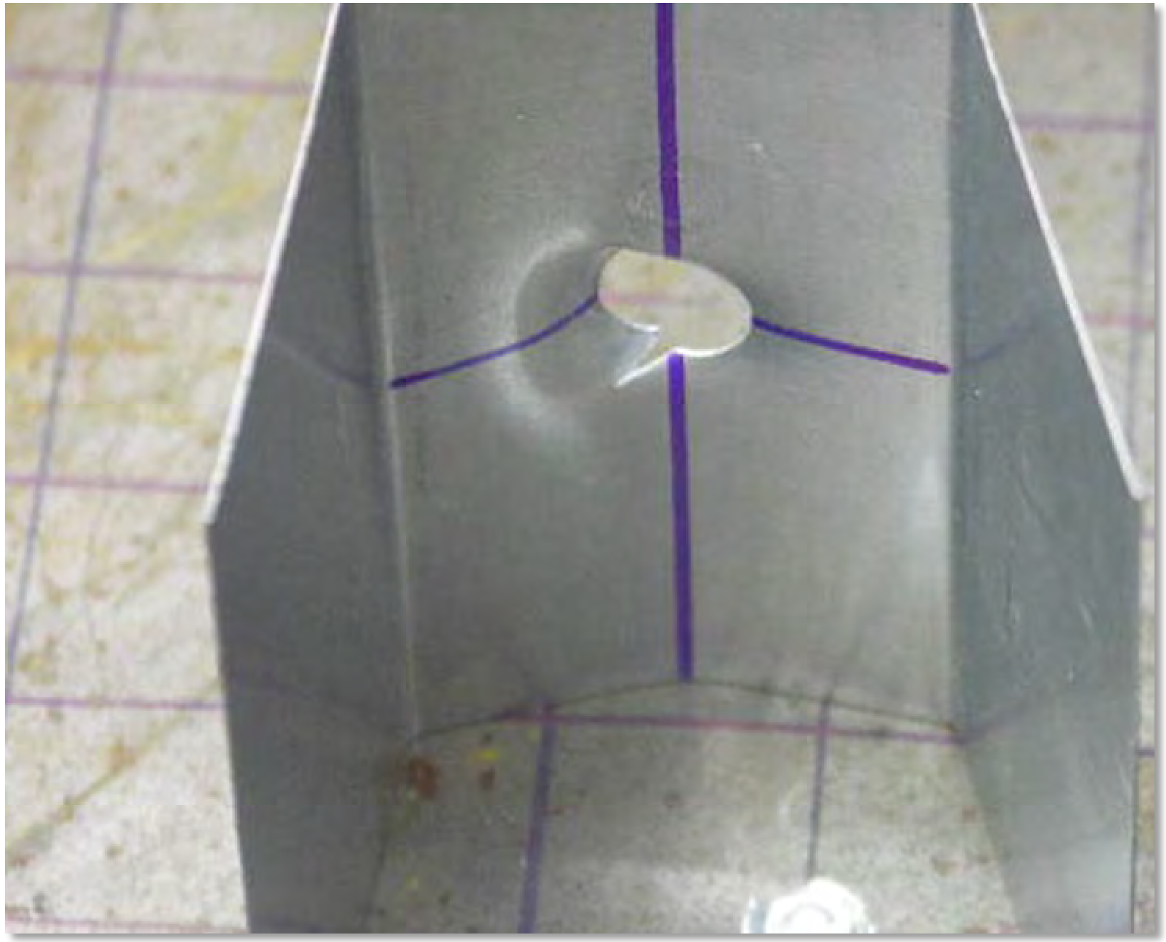
**Base material Pullout - Concrete**

# TEST FAILURE MODES – SHEET STEEL PULLOVER

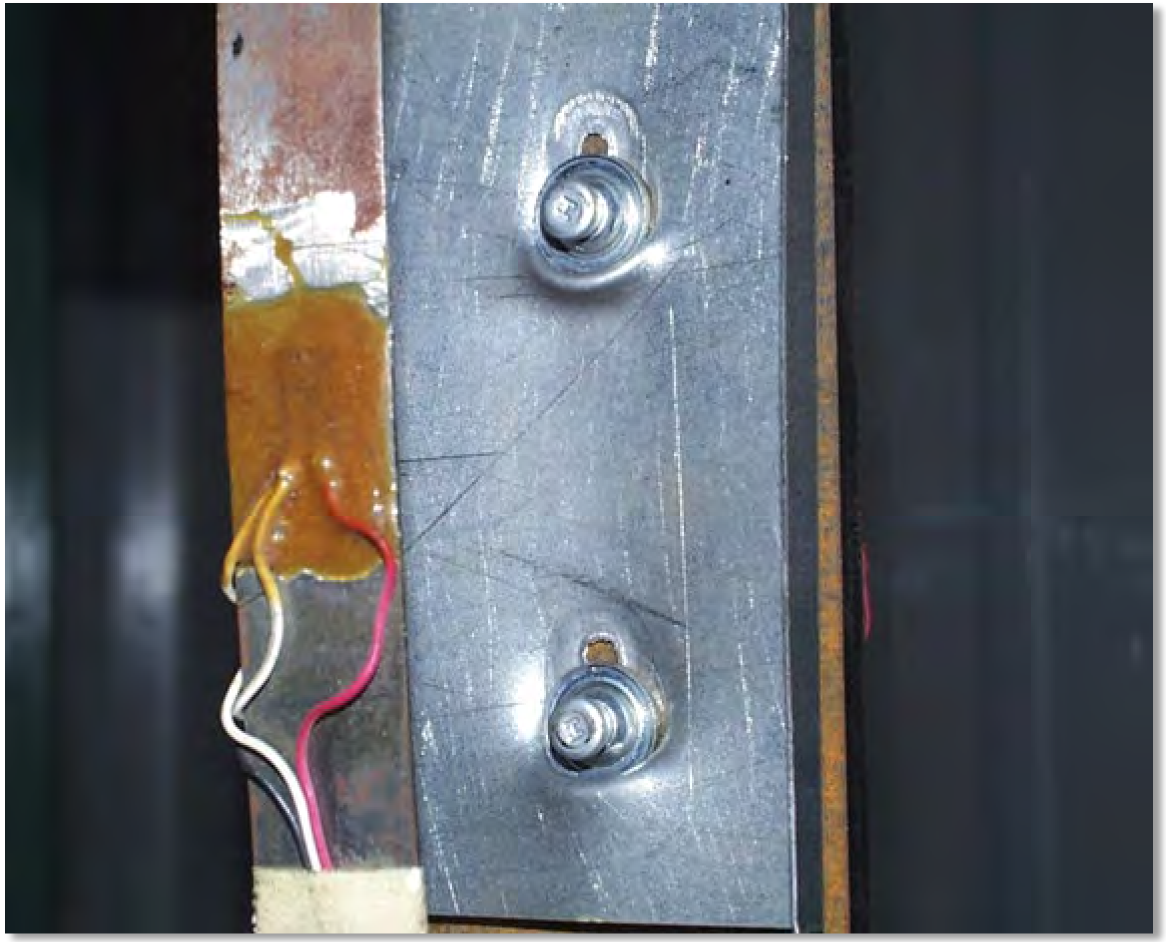
**Sheet Steel Pullover**

**A failure mode can also occur while the base connection remains intact**

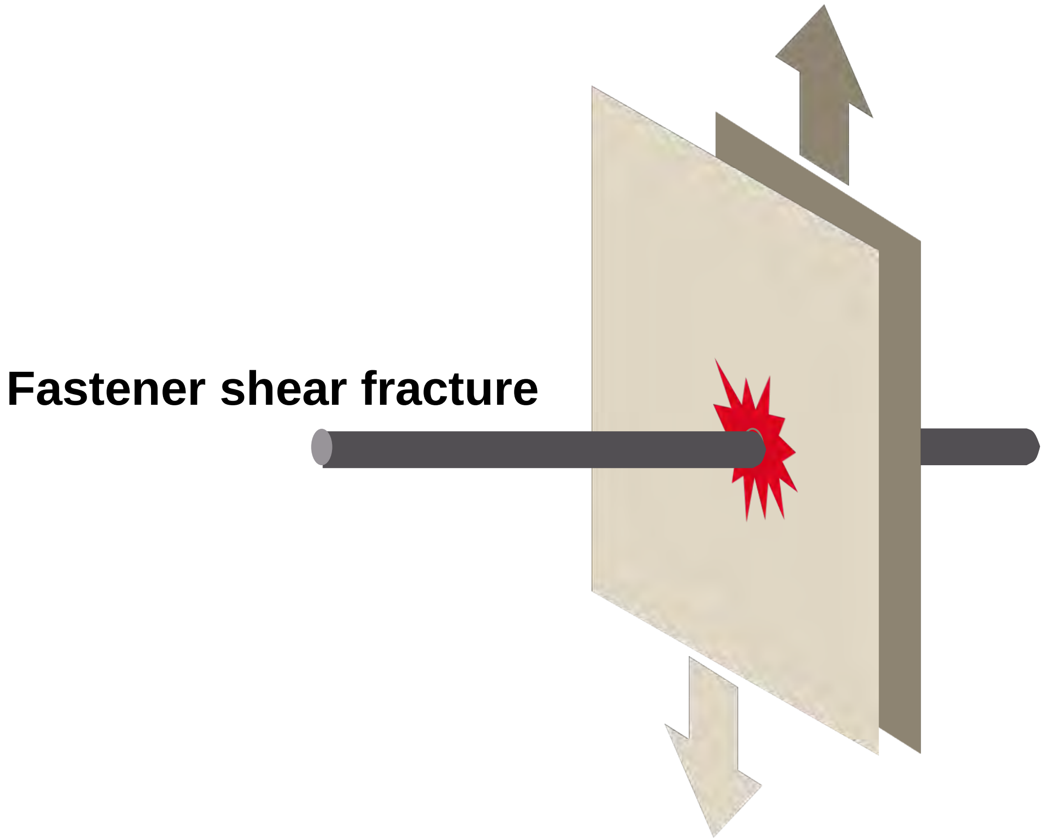
- Thinner CFS steel can pull over the fastener head or washer
- This failure mode can be determined by testing or calculation

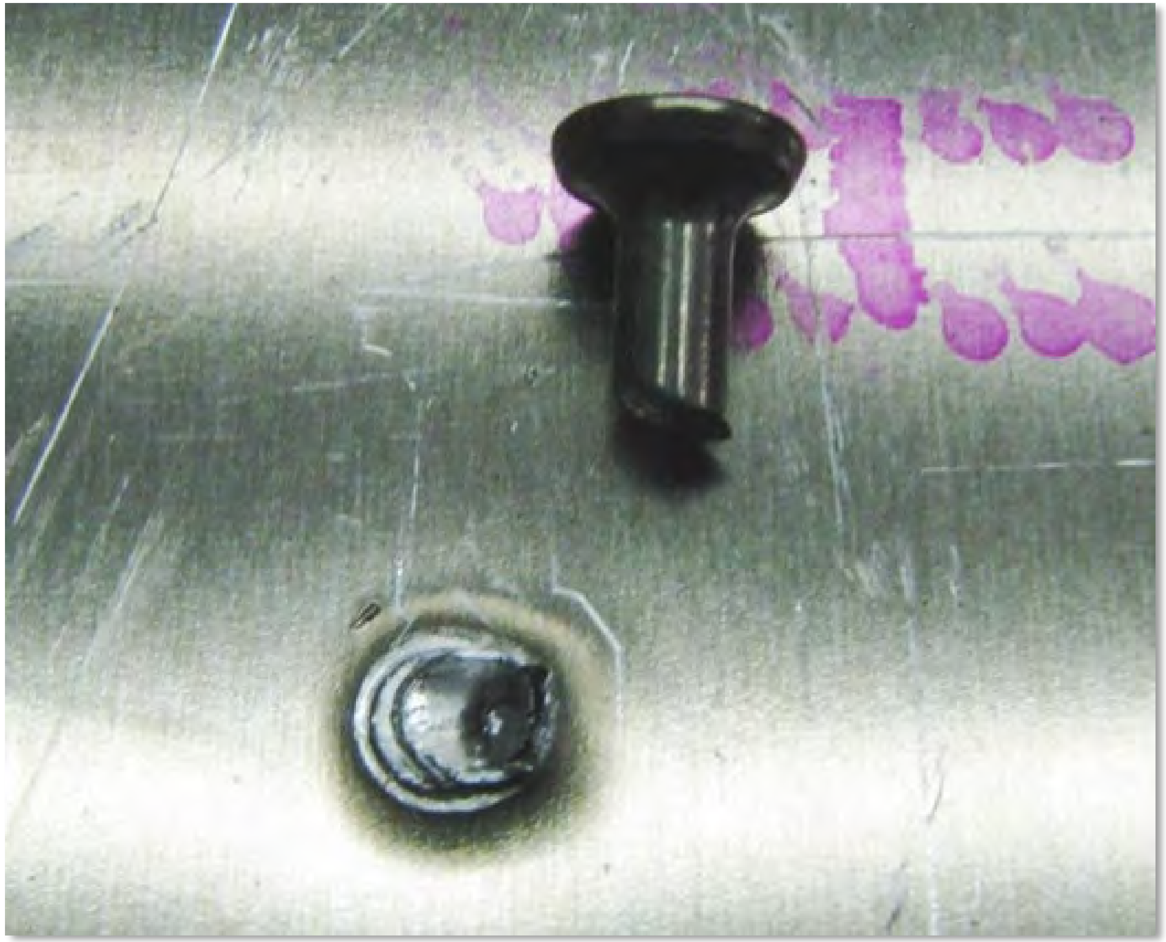


# TEST FAILURE MODES – SHEAR FAILURE MODE: BEARING, TEARING & PILING UP



# TEST FAILURE MODES – SHEAR FAILURE MODE: FASTENER SHEAR FRACTURE

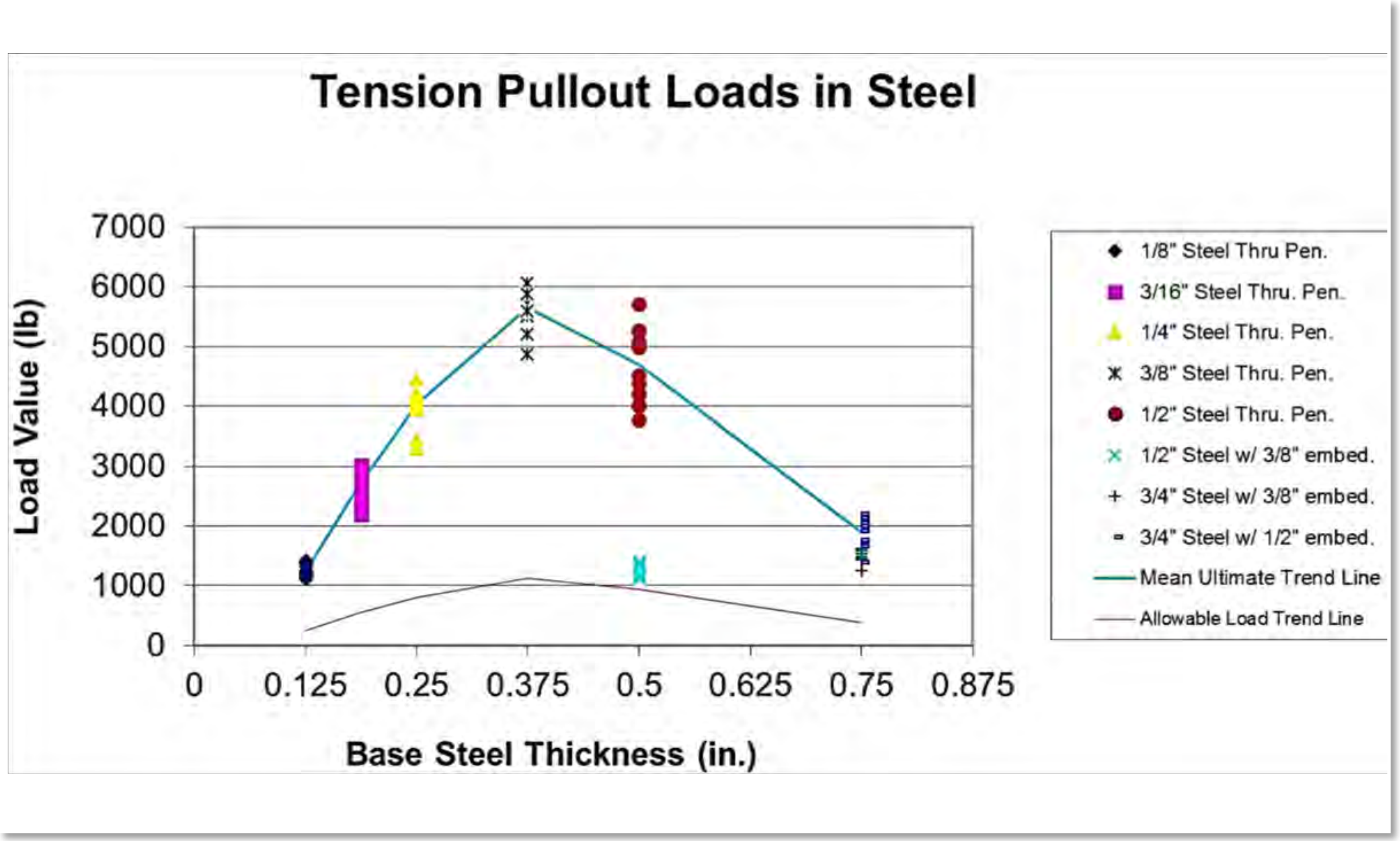


# TYPICAL REPRESENTATIVE TEST DATA FOR TENSION PULLOUT LOADS IN STEEL

**This test data graph shows the performance of a universal power-actuated fastener with fully knurled tip in steel base materials**

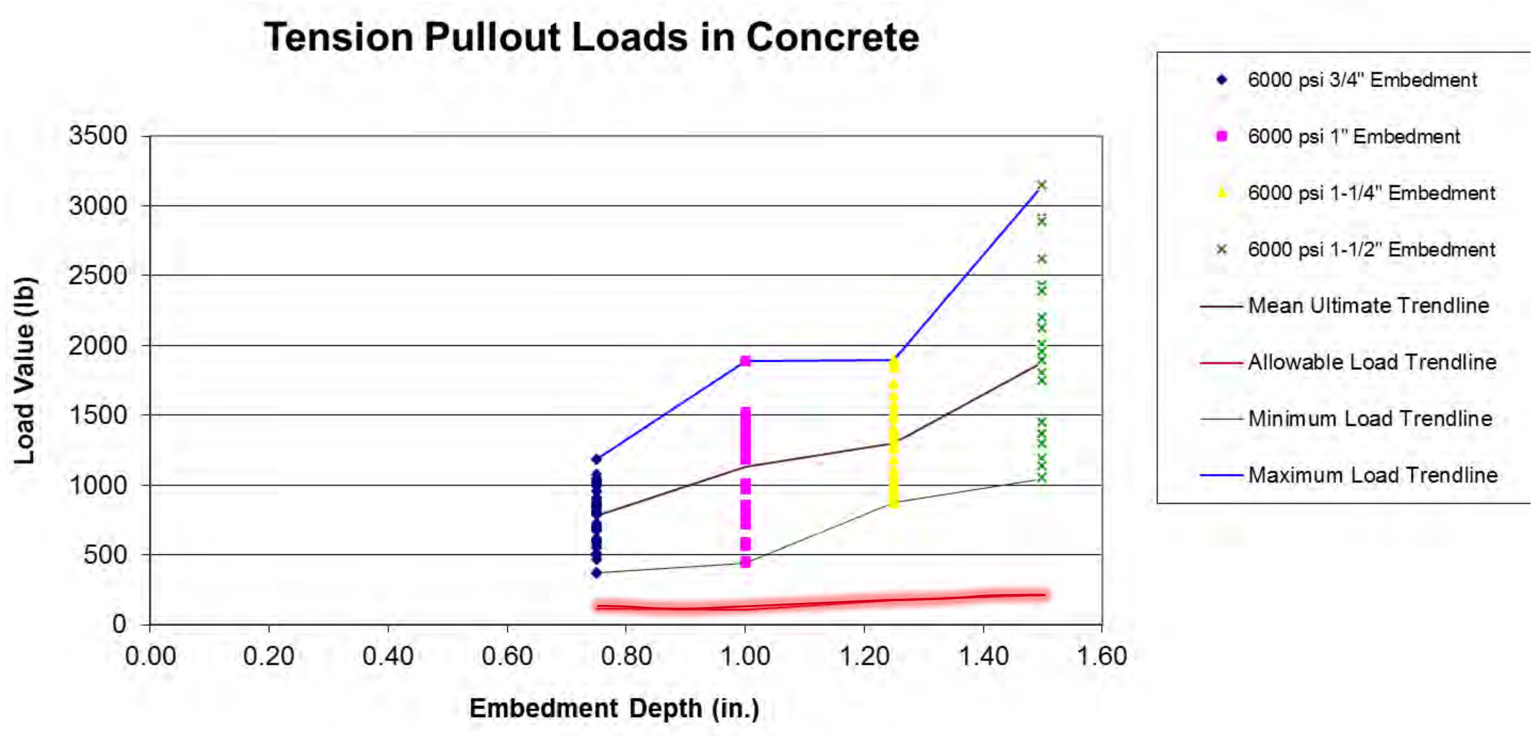
- The graph shows the mean ultimate tension pullout loads versus the base steel thickness
- The red curve that shows the ICC-ES AC70 calculated allowable load value under the data clusters for mean ultimate loads in various plate thicknesses



# TYPICAL REPRESENTATIVE TEST DATA FOR TENSION PULLOUT LOADS IN CONCRETE

**This test data graph shows the performance of a universal power-actuated fastener with fully knurled tip in concrete base material**

- The graph shows the mean ultimate tension pullout loads versus the embedment depth of the fastener in 6000 psi normal weight concrete
- The red curve shows the ICC-ES AC70 calculated allowable load value under the data clusters for mean ultimate loads at tested embedment depths

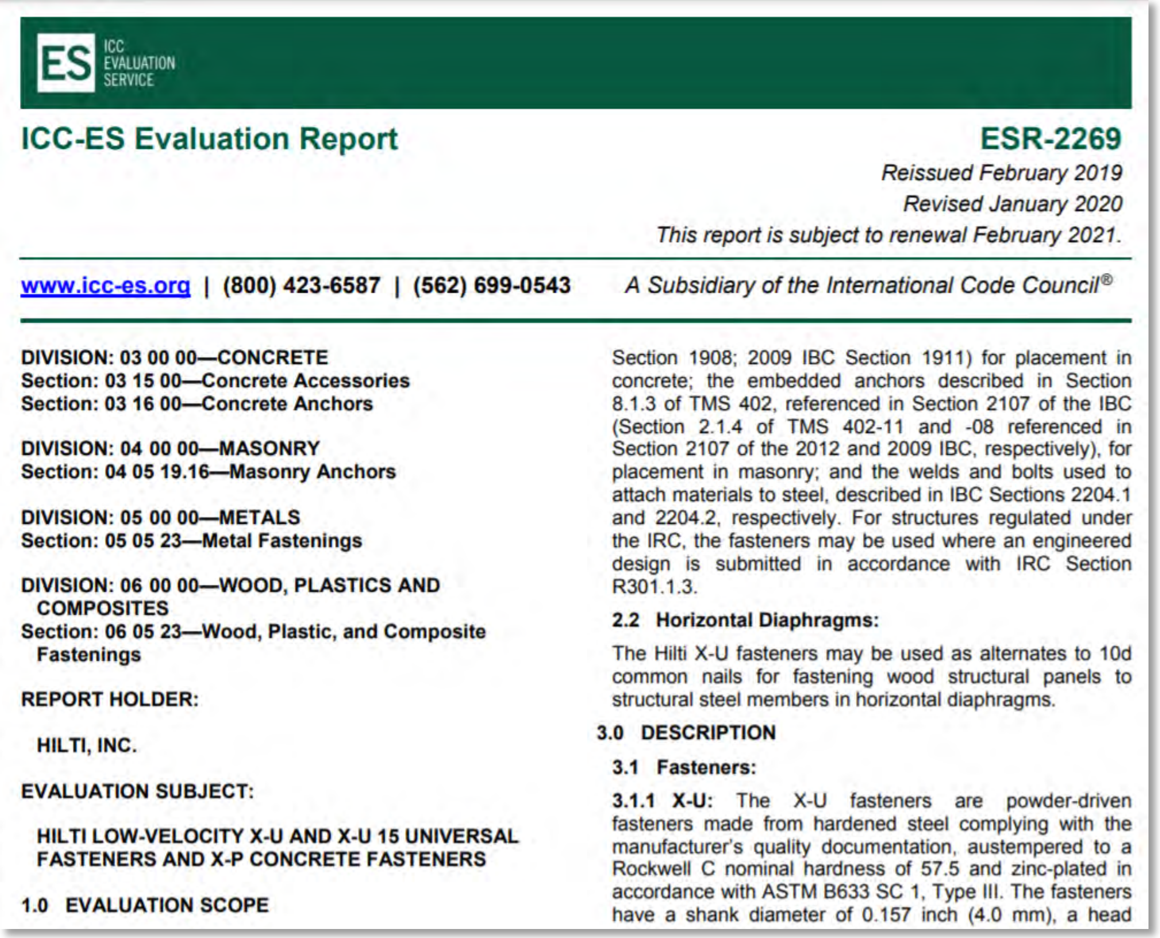



**Deeper embedment does not suggest better performance, beyond 1-1/4 in, results produce substantial variance**

# INTERNATIONAL CODE COUNCIL EVALUATION SERVICE (ICC-ES) – EVALUATION SERVICE REPORT (ESR)

**Manufacturers may obtain Evaluation Service Reports from ICC-ES, IAPMO or other independent organizations**

- The Evaluation Reports generally use ASTM E1190 as a basis
- ESR's enable engineers and building officials to determine code compliance or code equivalency



ES ICC EVALUATION SERVICE

**ICC-ES Evaluation Report** **ESR-2269**

*Reissued February 2019*
*Revised January 2020*
*This report is subject to renewal February 2021.*

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**DIVISION: 03 00 00—CONCRETE**
**Section: 03 15 00—Concrete Accessories**
**Section: 03 16 00—Concrete Anchors**

**DIVISION: 04 00 00—MASONRY**
**Section: 04 05 19.16—Masonry Anchors**

**DIVISION: 05 00 00—METALS**
**Section: 05 05 23—Metal Fastenings**

**DIVISION: 06 00 00—WOOD, PLASTICS AND COMPOSITES**
**Section: 06 05 23—Wood, Plastic, and Composite Fastenings**

**REPORT HOLDER:**

**HILTI, INC.**

**EVALUATION SUBJECT:**

**HILTI LOW-VELOCITY X-U AND X-U 15 UNIVERSAL FASTENERS AND X-P CONCRETE FASTENERS**

**1.0 EVALUATION SCOPE**

Section 1908; 2009 IBC Section 1911) for placement in concrete; the embedded anchors described in Section 8.1.3 of TMS 402, referenced in Section 2107 of the IBC (Section 2.1.4 of TMS 402-11 and -08 referenced in Section 2107 of the 2012 and 2009 IBC, respectively), for placement in masonry; and the welds and bolts used to attach materials to steel, described in IBC Sections 2204.1 and 2204.2, respectively. For structures regulated under the IRC, the fasteners may be used where an engineered design is submitted in accordance with IRC Section R301.1.3.

**2.2 Horizontal Diaphragms:**

The Hilti X-U fasteners may be used as alternates to 10d common nails for fastening wood structural panels to structural steel members in horizontal diaphragms.

**3.0 DESCRIPTION**

**3.1 Fasteners:**

**3.1.1 X-U:** The X-U fasteners are powder-driven fasteners made from hardened steel complying with the manufacturer's quality documentation, austempered to a Rockwell C nominal hardness of 57.5 and zinc-plated in accordance with ASTM B633 SC 1, Type III. The fasteners have a shank diameter of 0.157 inch (4.0 mm), a head

# PAF ALLOWABLE LOAD TABLES ARE PUBLISHED BY MANF., BUT MAY REQUIRE ADDITIONAL CONSIDERATION

**Example of load tables you can find in the ICC-ES Report (ICC-ES REPORT ESR-2269)**

- These tables indicate the ICC ES reviewed values for the design of Hilti X-U knurled fasteners into both steel and concrete
- In critical applications, the numbers published in load tables in a catalog or evaluation report may not be the only consideration

TABLE 2—ALLOWABLE LOADS FOR FASTENERS DRIVEN INTO STEEL[1,2,6] (lbf)

| FASTENER DESCRIPTION | FASTENER | SHANK DIAMETER (in.) | STEEL THICKNESS (in.) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 3/16 | | 1/4 | | 3/8 | | 1/2 | | ≥ 3/4 | |
| | | | Tension | Shear | Tension | Shear | Tension | Shear | Tension | Shear | Tension | Shear |
| Universal Knurled Shank | X-U | 0.157 | 500 | 720 | 775 | 720 | 935 | 720 | 900 | 720 | 350[4] / 275[3] | 375[4] / 350[3] |
| Universal Knurled Shank | X-U 15 | 0.145 | 155 | 400 | 230 | 395 | 420 | 450 | 365[5] | 500[5] | 365[5] | 400[5] |

**For SI:** 1 inch = 25.4 mm, 1 lbf = 4.4 N; 1 ksi = 6.9 MPa.

[1]Allowable load capacities are based on base steel with minimum yield strength ($F_y$) of 36 ksi and minimum tensile strength ($F_u$) of 58 ksi.
[2]The fasteners must be driven to where the point of the fastener penetrates through the steel base material, unless otherwise noted.
[3]Based upon minimum point penetration of 3/8 inch.
[4]Based upon minimum point penetration of ½ inch.
[5]Based upon minimum point penetration of 15/32 inch.
[6]Allowable loads are applicable to static and seismic loads in accordance with Section 4.1.

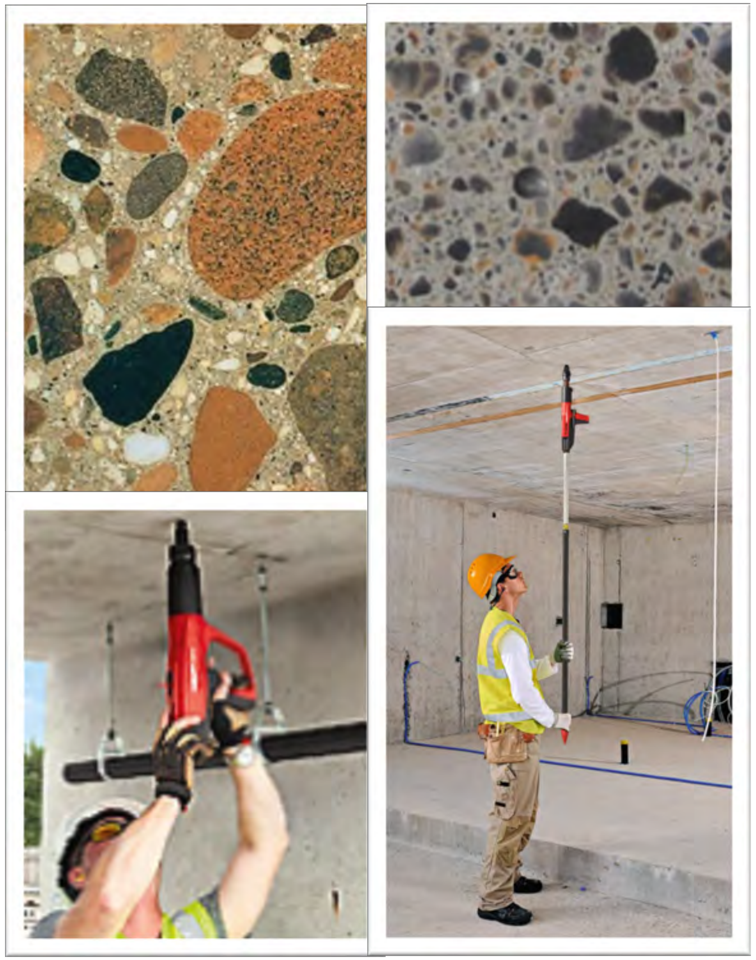
TABLE 3—ALLOWABLE LOADS FOR FASTENERS DRIVEN INTO NORMAL-WEIGHT CONCRETE[1,2] (lbf)

| FASTENER DESCRIPTION | FASTENER | SHANK DIAMETER (in.) | MINIMUM EMBEDMENT (in.) | CONCRETE COMPRESSIVE STRENGTH | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 2000 psi | | 4000 psi | | 6000 psi | |
| | | | | Tension | Shear | Tension | Shear | Tension | Shear |
| Universal Knurled Shank | X-U | 0.157 | 3/4 | 100 | 125 | 100 | 125 | 105 | 205 |
| | | | 1 | 165 | 190 | 170 | 225 | 110[3] | 280[3] |
| | | | 1 1/4 | 240 | 310 | 280 | 310 | 180 | 425 |
| | | | 1 1/2 | 275 | 420 | 325 | 420 | – | – |

**For SI:** 1 inch = 25.4 mm, 1 lbf = 4.4 N, 1 psi = 6895 Pa.

[1]Unless otherwise noted, values apply to normal weight cast-in-place concrete. Fasteners must not be driven until the concrete has reached the designated minimum compressive strength.
[2]Unless otherwise noted, concrete thickness must be a minimum of 3 times the embedment depth of the fastener.
[3]This allowable load value also applies to normal weight hollow core concrete slabs with $f'_c$ of 6600 psi and minimum dimensions shown in Figure 6, when installed in accordance with Section 4.2.4.

# DESIGN FOR FASTENING TO CONCRETE SHOULD ALWAYS ALLOW FOR REDUNDANCY



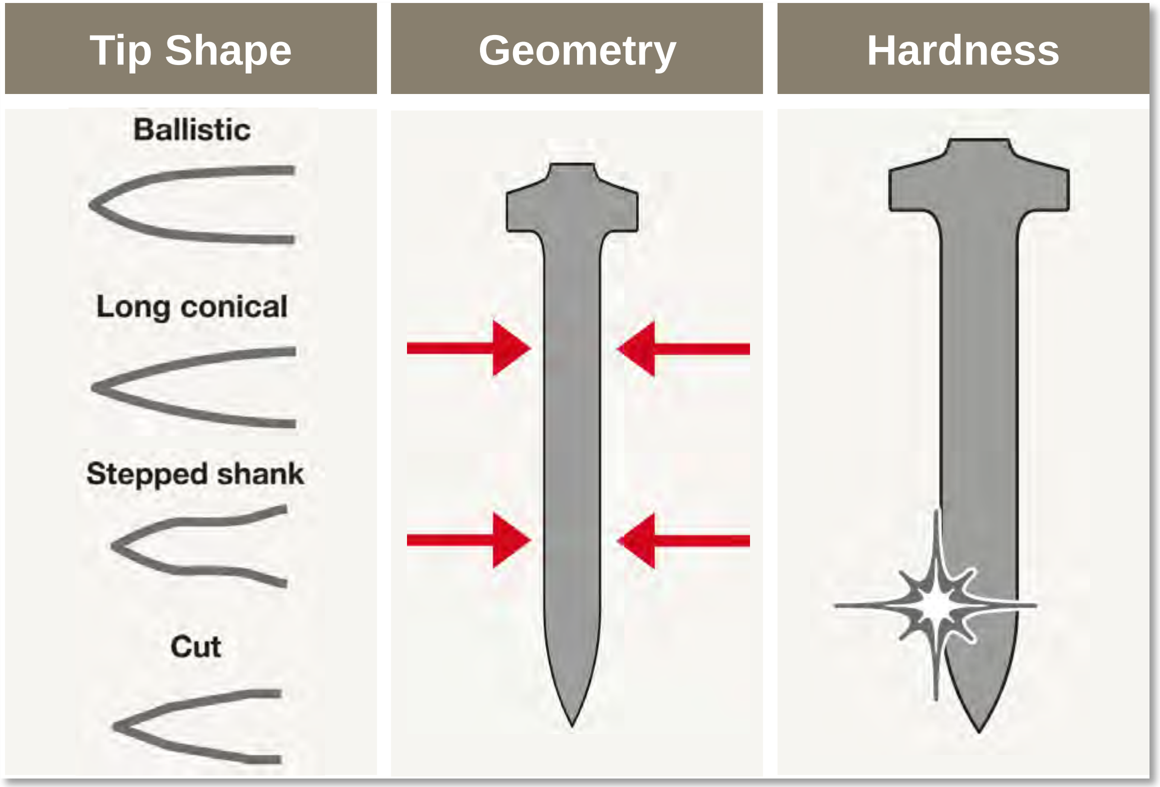
**The composition of the concrete, especially the aggregate, can impact fastener performance. In a typical tech data sheet or evaluation report, the only given information on the concrete is its compressive strength.**

- Not all concrete is the same. Larger, harder aggregate is tougher for a nail to penetrate.
- Concrete toughness may lead to inconsistent results and occasional "No-holds".
- Not all applications are the same. Some applications consistently include multiple fasteners with the ability to "load share." Examples: Acoustic hung ceilings, Metal Deck Diaphragm fastening, etc.
- Other applications don't necessarily allow for this redundancy and should be designed to add redundancy or be avoided. Examples: Pipe hung from concrete overhead, HVAC hangers, etc.

# ADDITIONAL ITEMS TO CONSIDER WHEN ASSESSING LOAD VALUES

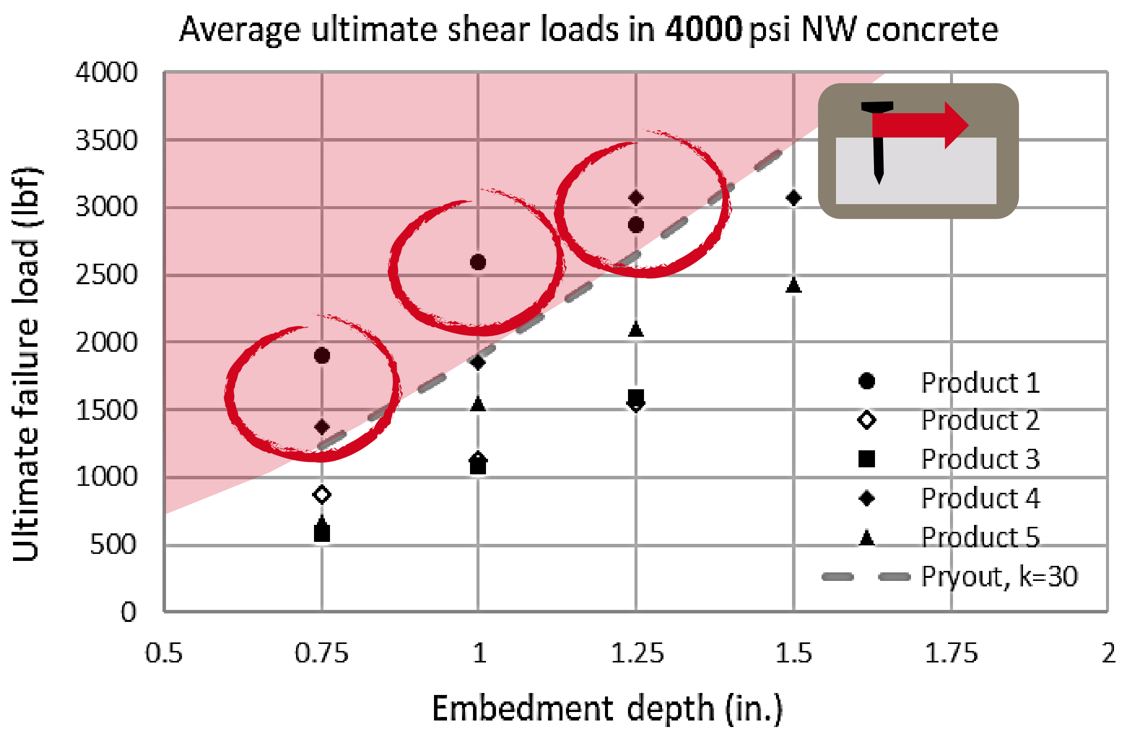
**Concrete used in testing may not be representative of field conditions**

- Not all PAF's are created equal
  - PAF diameters range from 0.1" to 0.2"
  - Steel hardness of finished product ranges from Rc 52 to Rc 60
  - Tip geometry varies widely – advanced tip design helps the fastener to penetrate concrete more easily
- Published loads should be checked to see if they make sense relative to other anchor types




**For critical applications multiple sources of published loads should be considered and/or add additional safety factor should be considered (allow for redundancy)**

# ULTIMATE LOADS FOR PAF IN CONCRETE SHOULD NOT EXCEED THE CALCULATED PRYOUT CAPACITY PER ACI 318



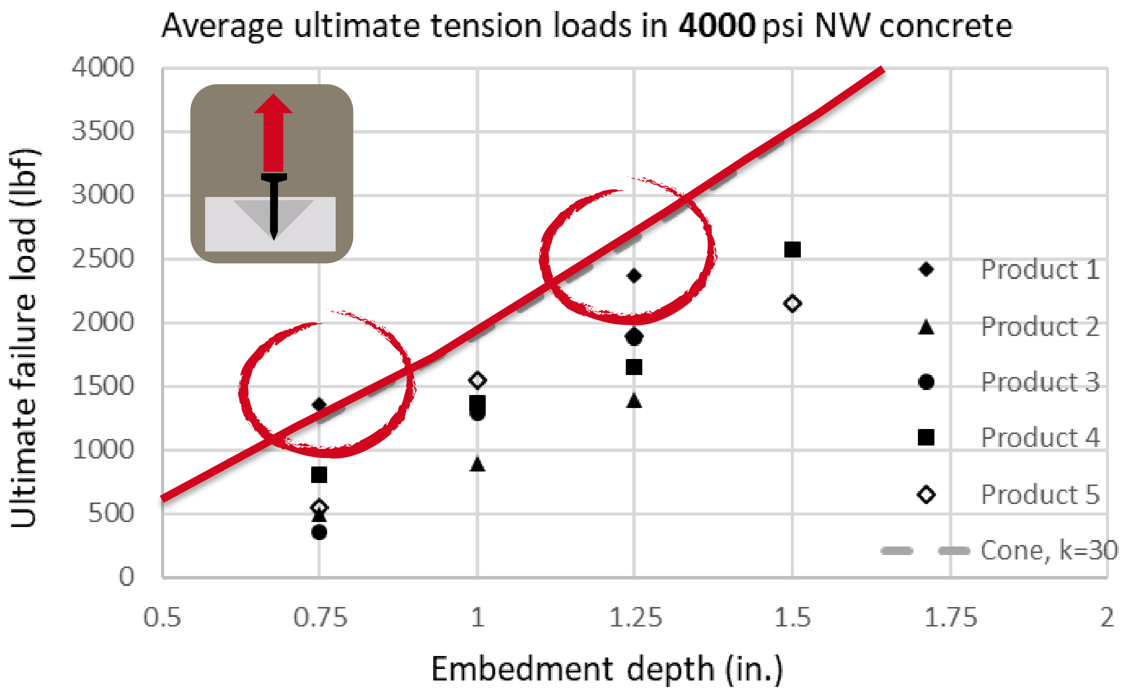

* All shown products are similar 0.157 in. Pins from various manufacturers

**The chart shows published shear loads for 5 different products. All products shown are 0.157" hardened fasteners. The published loads for each embedment vary widely.**

- One check is to compare those values to the anchor pryout capacity per ACI
- PAF ultimate loads are generally at least 5 x the published allowable
- Basic pryout strength Nb x kcp = 1 per ACI 318 for single anchor away from edges, embedment < 2.5 in. (ACI pryout capacity is represented by the dotted line)

**It is not credible that PAF generate higher strengths than cast-in or post-installed anchors**

# ….OR ARE NOT EXPECTED TO BE CLOSE TO CALCULATED CONCRETE BREAKOUT STRENGTH PER ACI 318*



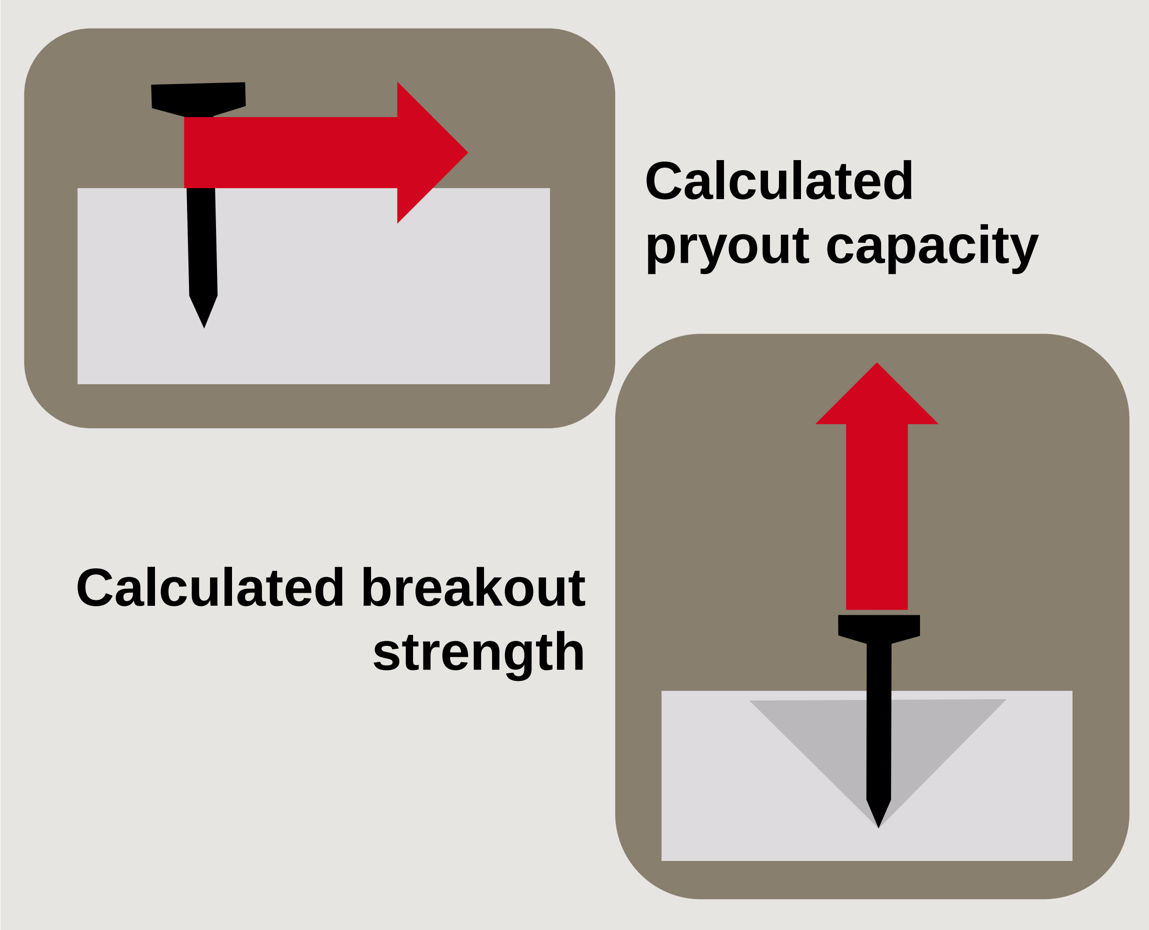

* All shown products are similar 0.157 in. Pins from various manufacturers

**The chart shows published tension loads for 5 different products. The values can be compared with the ACI calculated concrete breakout strengths.**

- PAF ultimate loads generally at least 5 x the published allowable
- Basic concrete cone breakout $N_b$ per ACI 318 for single anchor away from edges (ACI breakout strength is represented by the red line)
- Expectation is that PAF should be well below concrete breakout strength

**It is not credible that PAF generate strengths similar to cast-in or post-installed anchors**

# ULTIMATE LOADS FOR PAF IN CONCRETE SHOULD NOT EXCEED THE CALCULATED PRYOUT / BREAKOUT CAPACITY




**When assessing PAF performance:**

- Published load values in a report are not the only criteria to consider
- Redundancy should be allowed for, even if not specifically called out in the ICC-ESR
- All the footnotes and scope statements should be read and understood
- The intended application should be considered
  - Does the published data reflect the intended use?
  - Do the values shown make sense relative to the application and compared with other fastening methods?

# THERE ARE ADDITIONAL APPROVALS AND LISTINGS AVAILABLE FOR PAF DEPENDING ON APPLICATION

**Power-Actuated Fasteners are recognized alternatives to welding, bolting and anchoring in specific applications.**

- ICC-ES, Factory Mutual, UL and other industry associations provide product evaluation reports, approvals and listings for fasteners individually and as part of larger structural systems (roof decks diaphragms, etc.)
- Mechanical Fasteners for roof deck are recognized in ICC Evaluation Service Reports (ESR)
- Fastener and deck manufacturer ICC-ESR, FM RoofNav, UL Fire Resistance directory and SDI Diaphragm Design Manual Listings include proprietary and generic PAF's.
- Local and regional authorities, including the State of Florida and the City of Los Angeles, also grant approvals for PAFs

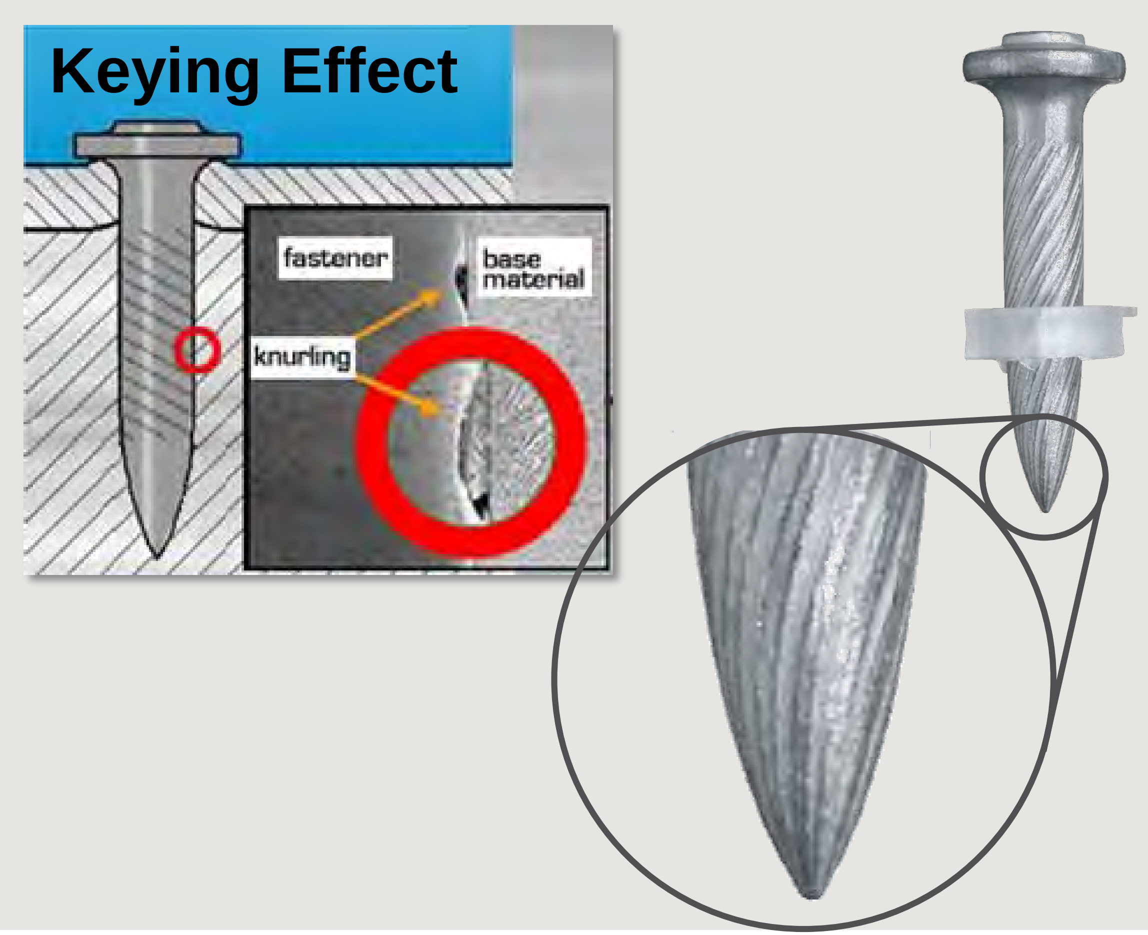
# AGENDA

- Background Theory
- Application Overview
- Codes and Standards
- **Product Developments**
- Conclusion

# FULL TIP KNURLING IMPROVES RELIABILITY OF THE FASTENING IN HARDER STEEL AND CONCRETE BASES

**Recent developments in power-actuated fastener design include full-tip knurling, which greatly improves reliability of the fastening in harder steel and concrete base materials**

- Ballistic point for optimum driving
- Fully-knurled point for higher application limits on steel and increased fastening consistency in harder concrete
- Resists bending when penetrating even the hardest base material
- Knurling aids in the **Keying Effect** for a secure hold and high loading capacity on steel

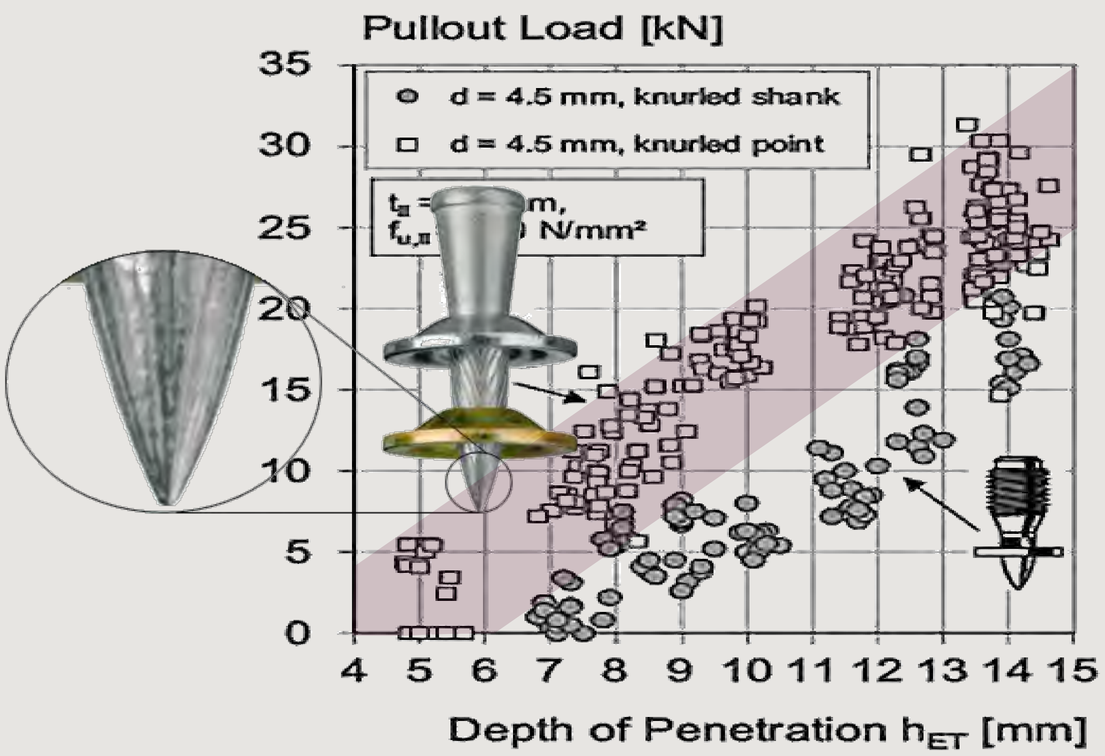


# FULL TIP KNURLING IMPROVES RELIABILITY OF THE FASTENING IN HARDER STEEL AND CONCRETE BASES

**The Graph shows testing done between two fasteners; the knurled tip fastener outperformed the knurled shaft fastener on pullout loads. Tip knurling therefore:**

- Reduces required embedment
- Increases application range
- Decreases required driving energy
- Reduces potential for excessive stand-off

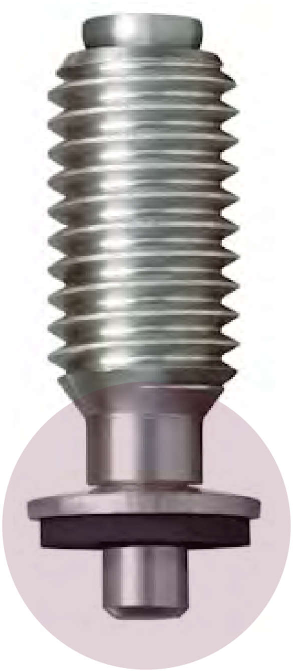
**Influence of Tip Knurling on the Required Fastener Driving Depth**



# BLUNT TIP TECHNOLOGY WAS DEVELOPED FOR CORROSION PROTECTION FOR EXPOSED APPLICATIONS

**Eliminate damage to base metal coatings such as Stainless Steel, etc.**

- Minimum base steel thickness 5/16 in (8 mm)
- No through penetration
- No rework on coated steel
- No application limit
- Portable system
- Fast & easy installation
- No welder



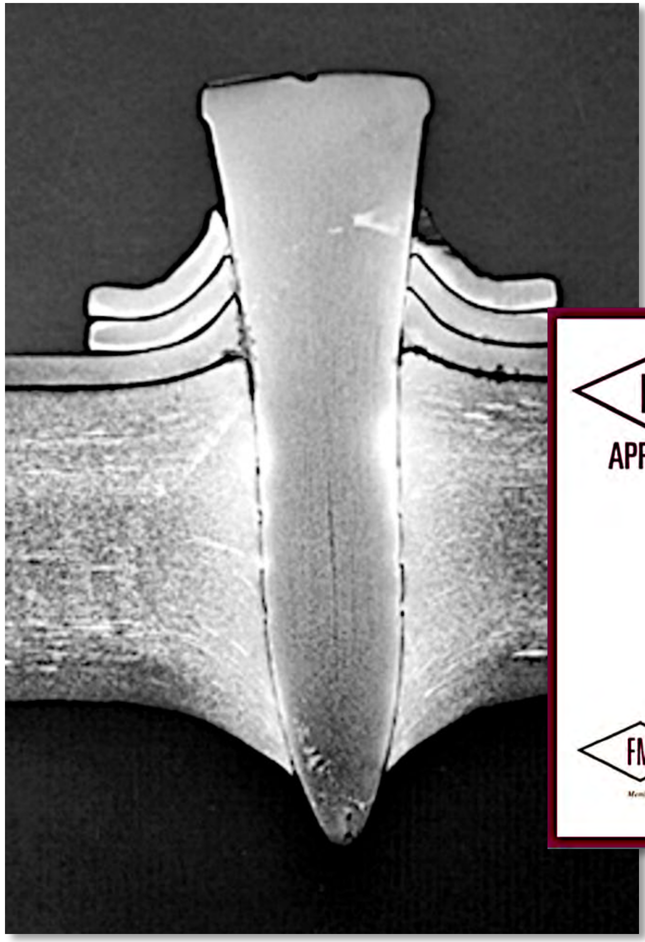
# AGENDA

- Background Theory
- Application Overview
- Codes and Standards
- Product Developments
- **Conclusion**

# ADVANTAGES OF POWER-ACTUATED FASTENING SYSTEMS

**Reliability - PAF is a reliable and secure fixation system:**

- Model Code compliance including testing to the latest code requirements for IBC Model Code
- Some manufacturers' fasteners also receive a Factory Mutual approval for high wind uplift forces, with rating up to 330psf based on a full scale conducted in the FM lab
- Some manufacturers' fasteners are also recognized for High Velocity Hurricane Zones (HVHZ)



FM APPROVED

Certificate of Compliance

This certificate is issued for the following:

X-ENP-19 L15, X-ENP-19 L15MX, X-ENP-19 L15MXR
X-HSN 24, X-EDN19 THQ12, X-EDN19 THQ12M
X-EDNK22 THQ12, X-EDNK22 THQ12M
S-MD 12-24 x 1-5/8 M HWH5
S-SLC 01 HWH, S-SLC 01 M HWH
S-SLC 02 HWH, S-SLC 02 M HWH
S-MS 01 Z4,8 X 20M, S-MS 01 Z4,8 X 20
S-MD 12-14 X 1 HHWH Stitch
S-MD 10-16 x 7/8 HHWH Pilot Point

Prepared for:

Hilti Inc
7250 Dallas Parkway,
Suite 1000
Plano, TX 75024
United States

FM Approvals Class: 4451

Approval Identification: 3054498 Approval Granted: 11/3/2015

To verify the availability of the Approved product, please refer to www.roofnav.com

Said Approval is subject to satisfactory field performance, continuing Surveillance Audits, and strict conformity to the constructions as shown in RoofNav, an online resource of FM Approvals.

Cynthia Frank
AVP - Manager of Materials
FM Approvals
1151 Boston-Providence Turnpike
Norwood, MA 02062

FM Approvals

# ADVANTAGES OF POWER-ACTUATED FASTENING SYSTEMS

**Productivity – in multiple applications and uses:**

- Ergonomic design of power-actuated tools increase fastening speeds significantly
- Faster than other means (welding, screwing, bolting)
- Quick set-up time for loading, re-loading and troubleshooting
- Less time spent on training
- Faster completion of projects

# ADVANTAGES OF POWER-ACTUATED FASTENING SYSTEMS

**Health and safety:**

- Self-contained fastening system
- No associated health hazards from welder-generated respiratory sickness or toxic fumes
- No electrical power cords or tripping and fall hazards
- Reduced worker fatigue with ergonomic fastening tools
- Quicker installation time = less time on jobsite and decreased accident potential

**This concludes The American Institute of Architects Continuing Education Systems Course**

AIA Continuing Education Provider

# PROVIDING BEST-IN-CLASS TECHNICAL SUPPORT WHETHER ON THE JOBSITE OR IN DESIGN AND SPECIFICATION

**Technical Support and Training**

- Field engineers are available to assist with training and guidance on design and specification
- Ask Hilti is a dedicated platform to support the design and specification community with moderated discussions, technical articles and education opportunities. **Visit Ask.Hilti.com**
- Design software and modeling elements for engineers and designers
- Professional product submittals for contractors
- Product technical literature, design load tables, guideline specifications, details and approvals
- Qualified operator training and certification

# LEARNING OBJECTIVES

**Upon completing this program, the participant should be able to:**

1. Recognize Power-Actuated Fastener (PAF) attachment methods for construction
2. Understand qualification test methods and building code evaluations for PAF
3. Communicate a clear understanding of PAF technology including application limits, safety and technical references available for engineering design and specification

# QUESTIONS?

**Hilti North America**
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