



Steel Utility Poles vs. Ductile Iron

Understanding Material Behaviors in Overhead
Infrastructure

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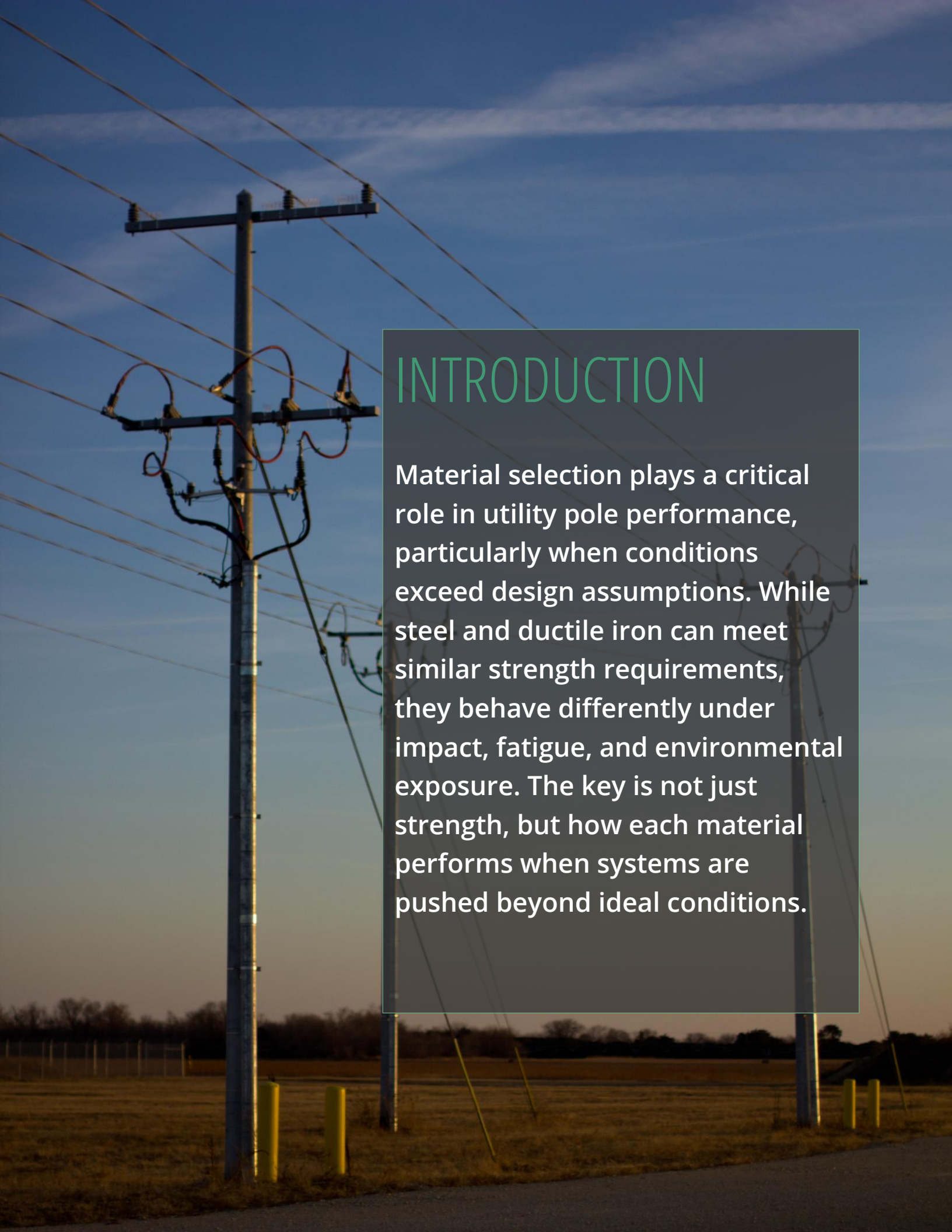
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INTRODUCTION

Material selection plays a critical role in utility pole performance, particularly when conditions exceed design assumptions. While steel and ductile iron can meet similar strength requirements, they behave differently under impact, fatigue, and environmental exposure. The key is not just strength, but how each material performs when systems are pushed beyond ideal conditions.

Steel Utility Poles vs. Ductile Iron

Understanding Material Behavior in Overhead Infrastructure.

When a utility pole fails, it is rarely because it did not meet its design strength. Failures occur when conditions exceed assumptions, such as during vehicle impacts, extreme weather events, or decades of corrosion and accumulated loading.

To address these challenges, engineers have developed a range of materials for utility poles, including wood, steel, concrete, fiber-reinforced polymer (FRP), and ductile iron. Each material brings different strengths, but also different risks and performance trade-offs.

This article is the first in a broader series examining these materials as they relate to steel utility poles. In this instalment, the focus is on steel and ductile iron.

Selecting a utility pole material is ultimately a decision about long-term reliability. While steel and ductile iron are both metallic pole materials, they are not interchangeable. Two materials can meet the same design criteria on paper but behave very differently when pushed beyond their limits.

This article focuses on what matters most to utilities: how each material performs when conditions are no longer ideal. It evaluates steel and ductile iron across five key questions:

1. How does it perform in extreme conditions?
2. Can I trust and design around it?
3. Will it last?
4. Can I build and source it?
5. Has it been proven in real-world applications?

Across these areas, steel consistently demonstrates advantages in energy absorption, predictability, durability, constructability, and long-term field validation.

The question is not simply which material meets minimum design requirements. It is how the system performs over decades of service, especially when conditions exceed expectations.

Material Differences and Application History

Steel and ductile iron are both iron-based materials, but they differ significantly in composition, manufacturing, and resulting behavior.

Ductile iron is a type of cast iron, specifically engineered to improve ductility compared to traditional cast iron. It achieves this through the formation of nodular graphite within the metal structure, which allows for some deformation before fracture. While more ductile than traditional cast iron, it still behaves as a cast material with more limited elongation compared to steel [\[1\]](#).

Steel, by contrast, has a lower carbon content and is produced through controlled refining processes that allow it to be formed, shaped, and worked. This results in a material that combines strength with significant ductility, allowing it to deform and absorb energy before failure [\[1\]](#).

The two materials are also manufactured into poles using fundamentally different processes.

Ductile iron poles are produced using centrifugal casting, where molten iron is poured into a spinning mold to create a seamless, tapered structure. This results in thicker wall sections and a seamless geometry.

Steel poles are fabricated from flat plate or coil, which is formed into round or multi-sided shapes and welded. This process allows for precise control over geometry, wall thickness, and structural performance.

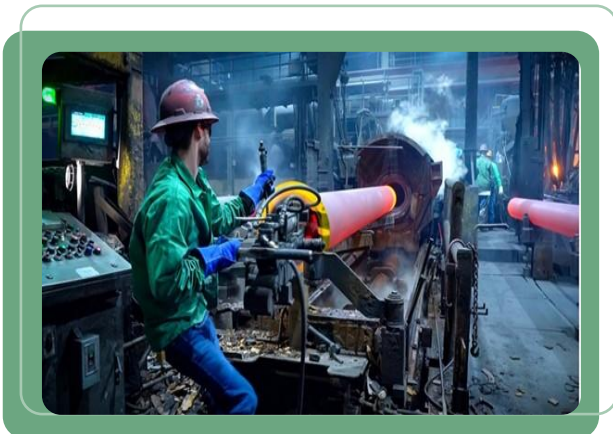


Figure 1. Ductile iron pole being removed from the mold following centrifugal casting

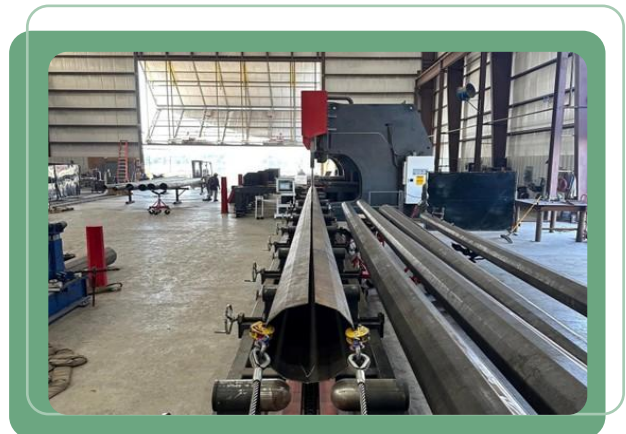


Figure 2. Steel utility pole section formed from flat plate into a multi-sided shape prior to longitudinal seam welding.

From an application standpoint, steel poles began to be introduced in the early 1900s as utilities expanded beyond the capabilities of wood construction. As electrical systems grew in voltage, span length, and loading requirements, steel provided a solution for taller, stronger, and more durable structures [\[2\]](#).

By the early to mid-20th century, steel had become an established material in transmission systems, with decades of continued use across a wide range of environmental and loading conditions.

Ductile iron, while well established in water and municipal infrastructure, is a much more recent entrant into the utility pole market. Ductile iron poles were introduced into overhead utility applications in the mid-2010s, with manufacturers such as McWane Poles bringing the material into distribution systems. This relatively recent adoption contrasts with the more than century-long use of steel in overhead transmission and distribution infrastructure.

Understanding how these materials are made and where they have been used provides important context, but the most critical differences emerge in how they behave under real-world conditions.

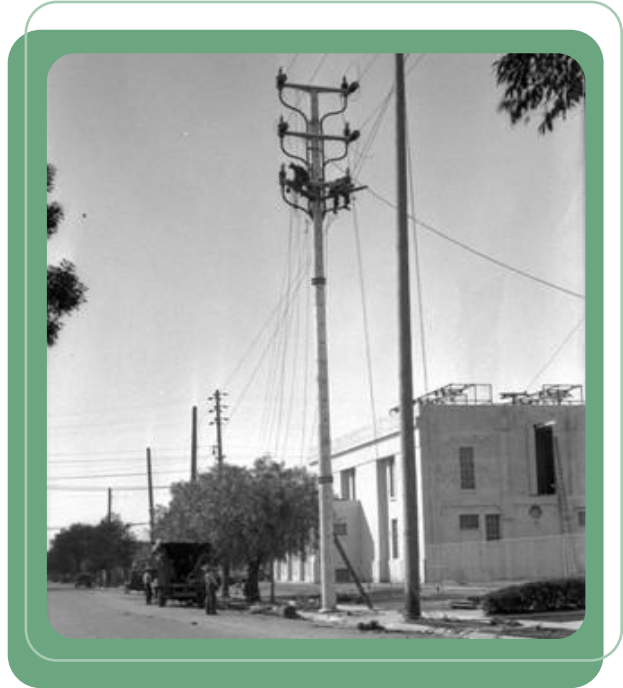


Figure 3. Early steel utility pole installation (1930s)
– View of one of the first steel poles installed on a Bureau of Power and Light system [\[2\]](#).



Five Key Questions

1. How does it perform in extreme conditions?
2. Can I trust and design around it?
3. Will it last?
4. Can I build and source it?
5. Has it been proven in real?

1. How It Performs in Extreme Conditions

Structural Performance Under Real-World Loading

Utility poles are routinely exposed to conditions that exceed normal design assumptions, including extreme wind, ice loading, vehicle impact, and dynamic conductor forces. Under these conditions, how a material behaves after it reaches its strength limit becomes critical.

Yield strength marks the point at which a material begins to permanently deform, meaning it will not return to its original shape once the load is removed. However, it does not describe what happens next. Some materials can continue to deform and absorb energy, while others fail shortly after reaching that point.

One way to visualize this is through a stress-strain curve.

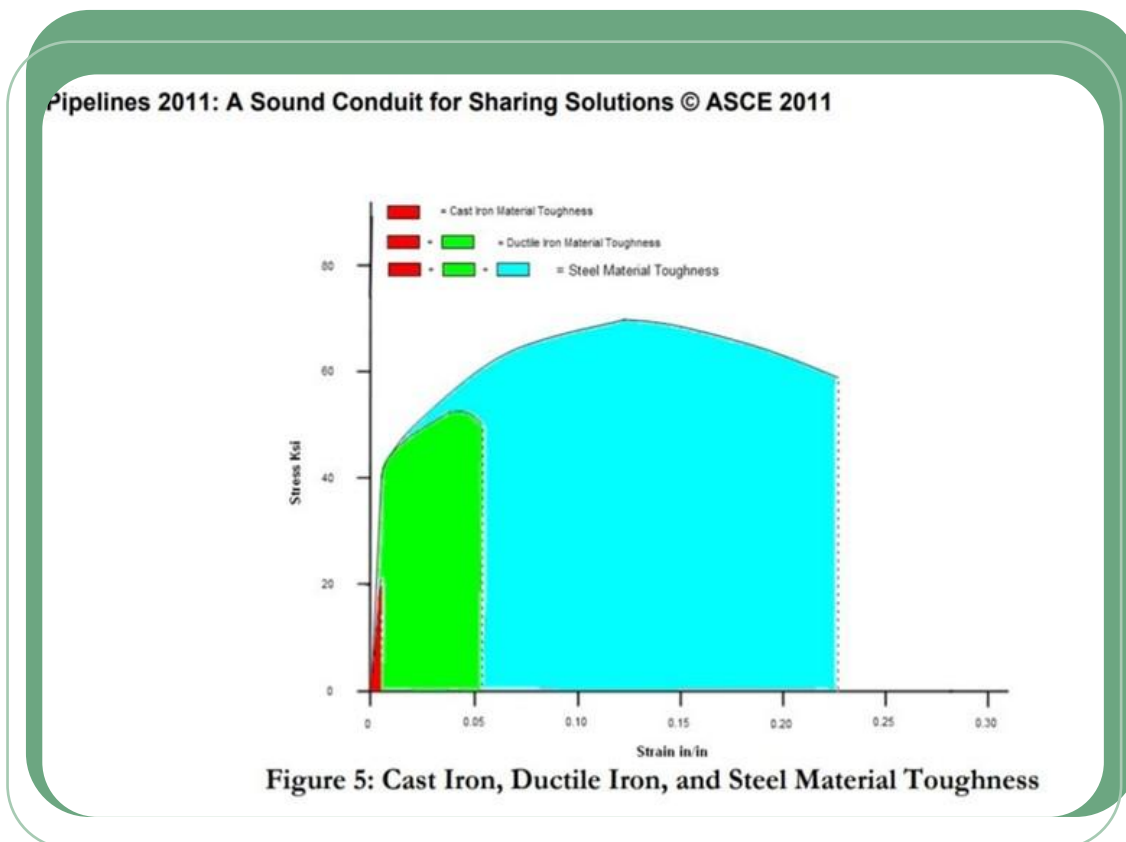


Figure 4. Stress-strain curve for cast iron, ductile iron, and steel [\[1\]](#)

On this curve:

- The vertical axis represents stress
- The horizontal axis represents strain

The area under the curve represents the total energy a material can absorb before failure and is a measure of material toughness. Steel has a much larger area under its curve, both before and after it reaches yield strength. Steel poles typically yield at higher stress levels, around 50 to 75 ksi, compared to about 42 ksi for ductile iron. More importantly, after yielding, steel continues to deform and absorb energy, redistributing stresses under overload. Ductile iron, by comparison, has limited deformation capacity beyond yield and is more prone to fracture once that limit is reached. As a result, steel can absorb significantly more energy before failure and provides greater tolerance during extreme loading events [\[1\]\[3\]](#).

This difference becomes especially important under impact and extreme loading conditions. Impact resistance is commonly evaluated using the Charpy V-notch test, which measures the energy a material can absorb during a sudden impact and characterizes both its baseline toughness and the temperature at which it transitions from ductile behavior to brittle fracture, providing critical insight into real-world performance.

In comparative testing conducted by Keil and Devletian, both steel and ductile iron were evaluated under similar conditions, providing a direct comparison of material behavior [\[1\]](#).

The results show a clear separation in performance. Steel absorbs significantly more energy than ductile iron, with Charpy impact values approximately 3 to 30 times higher under comparable conditions. In addition, steel maintains ductile behavior across a wide temperature range, with transition to brittle behavior occurring between approximately -40°F and 0°F. This performance aligns with established industry expectations, including ASCE 48 requirements specifying a minimum of 15 ft-lb (20 J) at -20°F.

Ductile iron, by comparison, exhibits significantly lower impact resistance in the same testing, with Charpy values remaining around approximately 7 ft-lb even at room temperature, indicating relatively brittle behavior across temperatures relevant to utility applications. This lower toughness is reflected in ASTM A1133 (2025), a recently developed standard specific to ductile iron utility poles, which requires a minimum of 7 ft-lb (9.49 J) at 70 ± 10°F. This threshold is significantly lower than established steel requirements and does not align with the lower temperature performance criteria commonly used in steel design. The lower acceptance criteria reflect the material's inherent impact performance rather than a harmonized standard across materials.

This difference is further reinforced through bend testing. In the same testing conducted by Keil and Devletian, steel samples have been shown to withstand 180-degree bends without cracking or fracture, demonstrating substantial ductility and deformation capacity. Ductile iron samples, by comparison, fractured at relatively low levels of deformation, with most samples failing at approximately 30 degrees of bending [\[1\]](#).

Impact and Overload Behavior

When a vehicle strikes a pole, or when wind and ice loads exceed design assumptions:

- Steel poles tend to bend and deform, absorbing energy and redistributing loads. In many cases, the structure may remain standing long enough to keep lines in service or allow for controlled response.
- Ductile iron poles are more likely to fracture once their strain limit is reached, resulting in a sudden break and potential line drop.

This difference directly affects outage risk and safety. A structure that deforms provides warning and residual capacity. A structure that fractures provides little warning and can result in immediate system disruption.

Post-Event Inspection and Damage Assessment

Another important difference between materials is how damage can be evaluated in the field following an impact event.

Steel poles provide visible and measurable indicators of overstress. If a steel pole has experienced an impact but shows no permanent deformation, there is typically little concern regarding its structural adequacy.

When deformation does occur, it can be quantified and evaluated. In many cases, a certain amount of deformation is acceptable and does not compromise the structural adequacy of the pole. Because steel can deform without fracturing, utilities are able to assess the extent of damage and determine whether the pole can remain in service or requires further review or repair. More significant deformation, particularly from high-energy impacts such as vehicle collisions at highway speeds, will typically warrant additional inspection and engineering evaluation.

This ability to observe and assess damage provides a practical framework for post-event decision making and reduces uncertainty in field operations.

2. Can I Trust and Design Around It?

Predictability and Design Confidence

A key question for utilities is whether a material can be designed, specified, and evaluated with confidence. That confidence comes from established industry standards and design frameworks. Steel utility poles are supported by well-developed standards such as ASCE 48 for transmission structures, along with broader reliability-based approaches such as ASCE 111.

This difference is further reflected in the overall code landscape supporting each material.

Steel's predictability is further reinforced by a mature and well-developed industry ecosystem. Steel utility poles are supported by a mature, multi-layered code framework developed over decades through collaboration between utilities, manufacturers, engineers, and standards organizations. These standards

and methodologies are written with steel structures in mind and are directly aligned with how utilities design, analyze, and evaluate overhead systems.

In addition to structural design standards, steel is supported by a wide range of related codes and specifications. Material specifications are well established through ASTM standards. Structural design is governed by ASCE 48, which provides a dedicated, reliability-based methodology. Fabrication and welding are covered by AWS D1.1, while corrosion protection is supported by ASTM standards for galvanizing and coatings. Electrical performance is addressed through IEEE standards, and system loading is defined by the National Electrical Safety Code (NESC), with steel design methodologies fully aligned with these requirements.

This creates a fully integrated design ecosystem with clear guidance across material selection, structural design, fabrication, and long-term performance.

Because steel has been used extensively in overhead infrastructure, engineers have a high degree of confidence in how it behaves under normal loading, overload conditions, fatigue, and environmental exposure. This allows steel to be directly incorporated into design calculations, safety factors, and reliability models with a high level of consistency.

Beyond codes, steel benefits from broad industry adoption. Multiple companies design, manufacture, evaluate, inspect, and maintain steel utility poles. This creates a deep and consistent body of knowledge, along with established best practices across the full lifecycle of the asset, from initial design through long-term maintenance and life extension.

Established inspection methods, condition assessment practices, and life-extension strategies exist for steel poles, allowing utilities to confidently evaluate condition, plan maintenance, and extend service life using well-understood approaches.

Ductile iron, while supported by general material standards, has more limited application-specific guidance for utility pole design. Ductile iron utility poles, by comparison, are supported by a more limited and recently developed framework. ASTM A1133 serves as the primary material and product standard, but it was developed within ASTM Committee A04 on Iron Castings, which has a narrower scope compared to the broader, multi-organization framework supporting steel design.

There is no equivalent to ASCE 48 providing a dedicated structural design methodology for ductile iron poles. While NESC loading applies, ductile iron behavior has not been historically incorporated into utility-specific design approaches. Corrosion and durability guidance is more general in nature, and there is no widely adopted, pole-specific framework comparable to galvanized steel systems.

As a result, engineers have fewer established references, less standardized design methodology, and more limited long-term field data to rely on when incorporating it into overhead system designs. As a result, engineers have fewer integrated references and less standardized guidance when designing with ductile iron in overhead utility applications.

For utilities, this predictability is critical. Materials that are supported by established standards, consistent design methodologies, and broad industry experience allow for more reliable design, better alignment with codes, and greater confidence in long-term system performance.

3. Will It Last

Corrosion Protection and Long-Term Durability

Long-term durability is a primary consideration for utility poles expected to remain in service for 50 to 75 years or more. While initial strength is important, long-term performance is often governed by how well the material resists corrosion over time.

Both steel and ductile iron require corrosion protection, but the systems used and the available performance data differ in important ways.

Corrosion Protection Systems

Steel poles are commonly protected using hot-dip galvanizing or weathering steel.

Hot-dip galvanizing creates a metallurgically bonded zinc coating. During the galvanizing process, the zinc reacts with the steel surface to form a series of zinc-iron alloy layers that are integral to the base metal. This bond provides durable, sacrificial protection, meaning the zinc will preferentially corrode to protect the underlying steel.

These zinc-iron intermetallic layers are harder than the underlying steel, providing increased resistance to abrasion and mechanical damage. The outer eta layer consists of pure zinc and remains relatively soft, but the underlying alloy layers contribute significantly to the overall durability of the coating system.

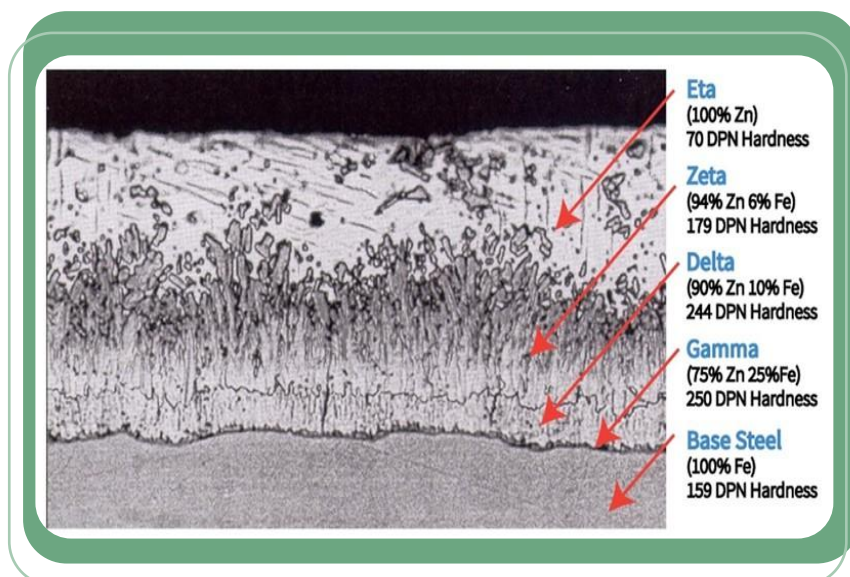


Figure 5. Cross-section of hot-dip galvanized coating showing zinc-iron intermetallic layers metallurgically bonded to the steel substrate [\[4\]](#).

Because the coating is metallurgically bonded, it is highly resistant to damage from handling, installation, and long-term environmental exposure. The performance of galvanized steel has been extensively

documented across a wide range of environments, including atmospheric, soil, and coastal conditions [\[4\]](#).

Steel can also be specified as weathering steel, a specialized alloy designed to form a stable, protective oxide layer when exposed to appropriate environmental conditions. This oxide layer acts as a barrier to further corrosion, allowing the material to perform without additional coatings in suitable environments. Weathering steel also develops a natural, rust-colored surface with a matte texture, which can provide an appearance more similar to wood and may be desirable in certain settings.

Similarly, ductile iron poles offer two corrosion protection options: an arc-applied zinc coating and a natural, uncoated finish that relies on the inherent corrosion resistance of ductile iron. Unlike steel, ductile iron cannot be hot-dip galvanized due to its chemical composition, including its silicon content, which prevents the formation of a consistent metallurgical zinc coating.

Arc-applied zinc provides sacrificial protection similar in concept to galvanizing, but the coating is mechanically bonded to the surface rather than metallurgically integrated. As a result, the bond strength is lower than that of hot-dip galvanizing, which forms a metallurgical bond with the steel.

Unlike hot-dip galvanizing, arc-applied zinc consists primarily of a layer of pure zinc applied to the surface and does not form the same zinc-iron intermetallic alloy layers. Because of this, the coating is generally softer and more susceptible to mechanical damage compared to galvanized coatings.

This makes long-term performance more dependent on surface preparation, application quality, and coating integrity over time. In addition, arc-applied zinc systems are typically more complex to apply and often more costly compared to hot-dip galvanizing.

Interpreting Corrosion Data

Another key difference is the available data. Steel, particularly galvanized steel, has extensive corrosion performance data in overhead utility applications, including atmospheric exposure, wet-dry cycling, and groundline conditions [\[4\]](#).

Ductile iron corrosion data is often based on buried or continuously wetted environments, which differ from the exposure conditions experienced by utility poles.

For utilities, durability is not just about corrosion resistance, but about confidence in how that protection system will perform over decades in real-world conditions.

4. Can I Build and Source It

Constructability and Supply Chain

Material selection also affects how infrastructure is manufactured, transported, installed, and sourced.

Steel poles are produced by multiple manufacturers, providing supply flexibility and reducing dependence on a single supplier. This improves lead times and allows utilities to respond more effectively during large projects or storm recovery.

Ductile iron poles are currently produced by a limited number of suppliers, with only one domestic manufacturer actively serving the utility market today. As a result, utilities may face increased supply concentration risk compared to steel, particularly when considering long-term procurement, replacement needs, and system expansion.

Steel fabrication allows for a high degree of design flexibility. Dimensions and details can be adjusted without requiring new tooling, allowing engineers to optimize designs for specific conditions.

Ductile iron poles are produced through casting, which can limit customization and require additional lead time for design changes.

Steel's high strength-to-weight ratio also results in more efficient structures. Ductile iron poles often require thicker sections to achieve similar capacity, increasing weight and impacting handling and installation.

Steel poles are also more tolerant during handling and installation. Because steel is more ductile and can deform more without fracturing, minor handling or installation impacts are less likely to result in immediate structural failure. This provides additional robustness during construction and reduces the risk of damage during transport and installation.

Hot-dip galvanizing further enhances this durability. Its metallurgical bond and hard zinc-iron alloy layers provide increased resistance to abrasion and handling damage, reducing the likelihood of coating damage and subsequent corrosion during transportation and installation.

Steel poles are commonly designed using standardized geometries, connection details, and hardware interfaces, allowing for greater interchangeability across projects and utilities. This standardization simplifies procurement, design integration, and long-term asset management.

The availability of multiple manufacturers and standardized designs also improves storm response. Utilities can source replacement structures more quickly and from multiple suppliers, reducing restoration timelines following major events.

Field Modification and Repair

Steel is readily weldable and compatible with standard field practices, allowing utilities to make modifications or repairs as needed.

Ductile iron is more difficult to weld and typically requires specialized procedures, limiting field adaptability.

5. Has It Been Proven

Application Maturity and Field Validation

Steel utility poles have been used in overhead systems for more than a century across a wide range of environments. This provides a substantial body of real-world performance data under both normal and extreme conditions.

Design standards such as ASCE 48 have been developed around this experience, allowing engineers to design with confidence using established methodologies.

Steel also benefits from application-specific corrosion data and well-developed inspection and maintenance practices. Utilities have decades of experience evaluating performance, managing assets, and extending service life through established methods.

In addition, steel is supported by a mature and well-developed maintenance and service ecosystem. Multiple vendors provide inspection, assessment, repair, and life-extension solutions, allowing utilities to confidently manage steel pole assets over their full lifecycle.

Steel poles have also demonstrated performance in real-world extreme events, including high-wind, ice, and storm conditions. This provides utilities with validated performance under the same types of loading scenarios that drive system risk.

Just as important as performance is failure predictability. Steel pole behavior and failure modes are well understood, allowing utilities and engineers to anticipate how structures will respond under overload conditions and incorporate that understanding into system design and risk planning.

Decades of field use have also created a feedback loop between design, performance, inspection, and standards development, continually improving how steel poles are designed and applied in utility systems.

Ductile iron poles, while well established in other industries, were introduced into overhead utility applications in the 2010s and have more limited field history in this specific use case. As a result, there is

less long-term performance data available under the range of environmental and loading conditions experienced in utility systems.

This more recent adoption also means that the supporting ecosystem for inspection, maintenance, remediation, and life extension is less developed. Utilities may face greater uncertainty when planning for long-term service strategies, repair methods, and lifecycle management.

For utilities, proven performance reduces uncertainty. Materials with extensive field history provide greater confidence in long-term reliability.

Conclusion

Steel and ductile iron are both metallic materials, but they are not interchangeable in how they perform in utility pole applications.

While both materials can meet structural design requirements, the differences in material behavior, predictability, corrosion protection, constructability, and field validation become increasingly important when systems are subjected to real-world conditions beyond those assumptions.

Steel's ability to bend, deform and absorb energy, its well-defined and standardized design framework, its proven and durable corrosion protection systems, and its extensive history in overhead applications all contribute to a more predictable and lower-risk solution for utilities.

In addition, steel benefits from a mature supply chain, standardized design approaches, and a well-established inspection, maintenance, and life-extension ecosystem. These factors provide utilities with greater confidence not only in initial design, but in long-term asset management and system resilience.

For utilities, the decision is not simply about meeting minimum design requirements. It is about selecting a material that can be designed, constructed, inspected, and maintained with confidence over decades of service, under a wide range of conditions, including those that were not originally anticipated.

In that context, material behavior, design confidence, supply chain reliability, and proven field performance are the factors that ultimately define long-term system reliability.

This article is part of a broader series examining material selection for utility poles. Future articles will explore comparisons with other commonly used materials, with a continued focus on performance, durability, and long-term reliability.

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About Us

Clean Energy Steel Construction Center

The **Clean Energy Steel Construction Center (CES)** is an industry-led initiative focused on advancing the use of durable, cost-effective, and sustainable steel solutions in clean energy and electric utility infrastructure. CES works across transmission, distribution, solar, wind, and emerging energy markets through education, research, and collaboration to support long-life infrastructure solutions and informed design decisions.

Steel Utility Pole Coalition (SUPC)

The **Steel Utility Pole Coalition (SUPC)** operates as a technical and industry-focused program within CES, dedicated specifically to the use of steel poles in electric utility applications. SUPC brings together utilities, manufacturers, engineers, and industry partners to provide education, technical resources, and real-world performance data that support reliable, resilient overhead power systems.

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Steel Utility Pole Coalition

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