

Mixed Steel Deck Systems and Their Applications in Civil Construction: A Comprehensive Review

Larissa Tatiane Gonçalves de Paula

Faculdade Presidente Antônio Carlos, Brazil

Corresponding author: ltg_paula@gmail.com

Abstract

Composite steel–concrete systems have significantly transformed structural engineering practices over the last decades. Among these systems, the steel deck slab—also known as composite slab or collaborative slab—has become one of the most efficient solutions for multi-story buildings and industrial structures. This review article presents a comprehensive analysis of the historical development, structural behavior, design principles, execution methods, advantages, limitations, economic impact, sustainability aspects, fire resistance considerations, and maintenance requirements of steel deck systems. The study consolidates technical literature, Brazilian standards (NBR 8800 and NBR 6118), and international research to evaluate the structural efficiency and practical applications of composite slabs. Results demonstrate that steel deck systems provide substantial improvements in construction speed, reduction of material waste, enhanced productivity, and optimized structural performance when compared to conventional reinforced concrete slabs. Despite certain limitations in corrosive environments and fire exposure conditions, the steel deck system represents a rational, economical, and sustainable solution for modern construction demands.

Keywords: Composite slab; Steel deck; Mixed structures; Steel–concrete systems; Construction productivity; Structural efficiency.

1. Introduction

Since ancient times, humanity has developed construction techniques using locally available materials. With technological progress, structural systems have evolved significantly, particularly with the widespread use of reinforced concrete and structural steel

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The combination of steel and concrete in structural systems led to the development of composite structures, where both materials act together to resist loads efficiently. Among these innovations, the steel deck slab system stands out as a highly efficient structural solution for floors in multi-story buildings.

The steel deck system—also referred to as composite slab or slab with collaborative formwork—consists of galvanized steel sheets acting as permanent formwork and tensile reinforcement, combined with a concrete topping layer.

The objective of this review is to analyze the technical, economic, and constructive efficiency of the steel deck system in civil construction, highlighting its advantages, limitations, and future prospects.

2. Historical Development of Steel Deck Systems

The concept of composite slabs originated in the United States in the 1920s, with early patents filed in 1926 by Loucks & Giller

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. Initially, steel decks functioned primarily as working platforms. Soon after, concrete was added to provide structural strength and fire resistance.

Key historical milestones include:

- 1920s: Early development of composite slab concepts
- 1950s: Commercial production by Granco Steel Products Company
- 1967–1991: Research development at Iowa State University under Professor Carl Ekberg
- 1991: First official Steel Deck Institute (SDI) design manual
- 2006–2011: Updates reflecting technological advancements

In Brazil, the system began spreading in the 1970s through Robtek, a partnership between Robertson (USA) and Tekno (Brazil)

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3. Definition and Structural Concept

According to Queiroz, Pimenta, and Martins (2012), composite steel–concrete systems are those in which steel profiles work together with reinforced concrete to form composite beams, columns, slabs, or connections

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In steel deck slabs:

- The steel sheet works as permanent formwork during casting
- It acts as positive reinforcement after concrete curing
- The concrete resists compressive stresses
- Shear connectors ensure composite action

According to NBR 8800 (2008), before the concrete reaches 75% of its specified compressive strength, the steel deck must support construction loads independently

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Bond between steel and concrete is not considered sufficient alone; mechanical interlocking and shear connectors (stud bolts) are required.

4. Components of the Steel Deck System

The system consists of:

1. Galvanized trapezoidal steel sheet (0.80 mm, 0.95 mm, or 1.25 mm thickness)
2. Concrete topping layer
3. Welded wire mesh (anti-cracking reinforcement)
4. Shear connectors (stud bolts) in composite beams

Deck sheets can reach lengths up to 12 meters, limited by transportation constraints

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5. Applications in Civil Construction

Steel deck systems are widely used in:

- Industrial buildings
- Schools
- Hospitals
- Shopping centers
- Airports

- Office buildings
- Bridges and walkways

They can be applied in:

- Steel structures
- Reinforced concrete structures
- Masonry structures
- Timber structures (with specific design considerations)

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6. Structural Performance and Load Capacity

Steel deck slabs may support overloads up to 2 t/m² under standard configurations

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Advantages include:

- Elimination of positive reinforcement
- Reduced need for shoring (for spans between 2 m and 4 m)
- Improved distribution of tensile stresses

For large openings:

- Openings < 20 cm: No reinforcement required
- 20–60 cm: Reinforcement required
- 60 cm: Supporting beams required

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7. Construction Speed and Productivity

One of the main advantages of the steel deck system is execution speed.

Key productivity benefits:

- Reduced formwork installation time
- Elimination of form removal
- Minimal shoring
- Immediate working platform
- Simplified logistics

It is possible to execute approximately 2,000 m² in three days, reducing labor costs by up to 40%

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8. Economic Considerations

Although initial material costs may be slightly higher than conventional slabs, overall savings are achieved through:

- Reduced labor
- Shorter construction time
- Lower equipment usage
- Elimination of temporary formwork

Fakury et al. (2016) emphasize that composite systems optimize steel consumption while maintaining structural performance

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9. Fire Resistance

Steel deck slabs require fire protection measures.

Since steel loses strength at high temperatures, protective solutions include:

- Cementitious sprayed coatings
- Suspended ceilings
- Additional reinforcement layers

Cichinelli (2011) highlights the need for specific fire resistance solutions in composite slabs

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10. Corrosion and Maintenance

Under normal conditions, galvanized steel decks require minimal maintenance.

However, corrosion risks increase in:

- Coastal environments
- Industrial atmospheres
- Moisture-exposed areas

Maintenance measures include:

- Removal of oxidation
- Cold galvanizing coatings
- Source-of-moisture correction

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Salomão et al. (2019) emphasize corrosion protection as essential for long-term durability.

11. Sustainability and Waste Reduction

Steel deck systems promote sustainable construction through:

- Elimination of disposable formwork
- Reduced construction waste
- Recyclable steel components
- Lower material consumption

da Silva Barbosa et al. (2018) highlight the importance of steel recycling in sustainable construction

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12. Safety Considerations

Reduced shoring and fewer workers lower accident risks.

Steel decks also provide:

- Stable working platforms
- Organized installation processes
- Reduced on-site clutter

13. Limitations

Despite advantages, limitations include:

- Not recommended for highly corrosive environments without protection
- Fire resistance concerns
- Design complexity for large openings
- Need for skilled supervision

14. Future Perspectives

Future research directions include:

- Improved corrosion-resistant coatings
- Advanced fire-resistant composite systems
- Integration with Building Information Modeling (BIM)
- Performance optimization under dynamic loading

Steel deck systems represent a mature yet evolving technology in structural engineering.

15. Conclusion

The steel deck composite slab system represents a rational and efficient structural solution aligned with modern construction demands. Its advantages in speed,

productivity, material optimization, sustainability, and cost-effectiveness make it particularly suitable for multi-story and industrial buildings.

While limitations exist regarding corrosion and fire resistance, appropriate design and protective measures mitigate these concerns.

Continuous technological development is expected to further enhance performance and expand its applications in civil engineering.

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