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Stage-dependent sensitivity analysis of composite floor systems under Eurocode provisions

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Abstract
Composite floor systems, which combine profiled steel decks and reinforced concrete slabs, are widely used in modern construction owing to their structural efficiency, construction speed, and material economy. However, the relative influence of key design parameters on structural performance remains insufficiently understood. This study investigates the effects of steel deck thickness, slab thickness, and concrete compressive strength to identify the governing parameters that control the composite floor behavior. A representative one-way composite floor system with CF60 profiled steel decking and a reinforced concrete topping was analyzed using a Eurocode-based analytical parametric approach. The analysis considered both the construction stage, in which the steel deck alone resisted the applied loads, and the composite stage, in which the hardened concrete slab and steel deck acted compositely. Parametric combinations were generated by varying deck thickness, slab depth, and concrete compressive strength, and structural performance was evaluated using demand–capacity ratios derived from Eurocode flexural resistance formulations. The results show that the composite floor behavior is primarily governed by construction-stage performance, with the steel deck thickness emerging as the dominant parameter. The slab thickness exhibited a stage-dependent influence, whereas the concrete compressive strength within the normal-strength range had only a minor effect. This study established a quantitative sensitivity hierarchy for geometric and material parameters under Eurocode design conditions. The analysis was limited to a code-based analytical framework without numerical or experimental validation.

Keywords:
Composite floor system;
Compressive strength;
Sustainable design;
Slab thickness;
Steel deck;

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INTRODUCTION

Composite floor systems consisting of profiled steel decks acting compositely with reinforced concrete slabs have become a preferred choice in modern building construction owing to their structural efficiency, speed of construction, and economic advantages [1, 2, 3, 4]. The integration of steel and concrete allows engineers to exploit the tensile strength of steel and the compressive capacity of concrete, resulting in lightweight yet stiff floor systems that can span longer distances than conventional reinforced concrete slabs. In addition, the profiled steel deck serves as permanent formwork during construction, supporting fresh concrete during casting and remaining in place throughout the structure's service life. This eliminates the need for temporary formwork, reduces construction time, lowers material costs, and enhances site safety. Moreover, the profiled geometry of the steel deck enhances the composite action by providing a mechanical interlock with the concrete, thereby increasing shear resistance and overall structural performance [5, 6, 7, 8].

The growing adoption of composite floor systems is driven by their structural efficiency, rapid construction, and economic advantages, which contribute to reduced labor demand, faster project delivery, and lower environmental impact compared with conventional reinforced concrete slabs [9, 10, 11, 12]. Composite floors are most commonly designed as one-way slab systems, where the profiled steel deck spans in the corrugation direction and resists construction-stage loads [13]. More recently, two-way composite slab systems have been developed to improve stiffness, load redistribution, and redundancy, particularly for longer spans and irregular column layouts [14, 15, 16]. While these studies establish the versatility of composite floors at the system level, they primarily focus on global structural behavior and do not explicitly quantify the relative influence of the fundamental design parameters governing slab performance.

Corrugated steel plates (CSP) are widely used in composite slabs. CSP offers high shear strength, low weight, and ease of industrial production, making it a promising substitute for traditional steel trusses in composite slab construction [17], [18]. Experimental and numerical studies have shown that CSP can significantly enhance the load-bearing capacity, ductility, and fatigue resistance of composite slabs [19, 20, 21, 22]. Furthermore, research on seismic performance has demonstrated that CSP–concrete composite slabs exhibit favorable shear capacity and energy dissipation characteristics, making them suitable for applications in seismic-prone regions [23, 24, 25, 26, 27]. Despite these benefits, most existing studies have focused on CSP slabs cast with conventional normal concrete [28], leading to high demand for natural resources, such as sand and aggregates, and raising sustainability concerns.

Several researchers have examined the structural behavior of composite slabs in different contexts. Jeyarajan and Liew [29] examined composite slabs within steel frames subjected to progressive collapse, showing that slabs can significantly enhance global structural robustness. Similarly, Stochino et al. [30] investigated composite slabs incorporating recycled concrete aggregates (RCA), demonstrating improved longitudinal shear strength and supporting sustainability-driven material substitution. While these studies provide valuable insights into extreme loading behavior and material sustainability, respectively, they do not address how geometric and mechanical design parameters influence the flexural demand–capacity relationship of composite floors.

Parametric investigations have largely focused on connector behavior and reinforcement detailing. Tavares et al. [31] studied the effects of connector height, reinforcement configuration, concrete cover thickness, and concrete strength on composite slabs with channel connectors, showing that stiffness-related parameters significantly affect load capacity and ductility. Nevertheless, their work primarily addresses connector performance, leaving largely unexplored the influence of steel deck thickness and slab depth, which directly govern flexural resistance during the construction and composite stages.

Overall, the existing literature demonstrates that material properties, connector behavior, and the global system response influence the performance of composite floors. Many recent studies have employed finite element (FE) methods to investigate the detailed structural behavior, including bond–slip interaction, local buckling, and nonlinear material response. Although these approaches provide valuable insights into local mechanisms, they are often computationally intensive and highly dependent on modeling assumptions and calibration parameters; therefore, they typically focus on specific structural configurations. Consequently, previous studies have primarily examined individual components or isolated mechanisms, such as connector detailing, material substitution, and extreme loading scenarios, rather than systematically evaluating the relative importance of fundamental design parameters. Consequently, a comparative assessment of the influence of key geometric and material parameters, specifically steel deck thickness, concrete slab thickness, and concrete compressive strength, across both the construction and composite stages remains limited. This lack of a unified evaluation prevents the identification of governing mechanisms and sensitivity hierarchies, which are essential for rational, efficient, and safety-critical composite-floor designs.

Accordingly, this study investigates the structural performance of composite floor systems by systematically varying the steel deck thickness, slab thickness, and concrete compressive strength within a Eurocode-based analytical framework to identify the parameters that most critically influence the structural behavior. Addressing this gap enables composite floors to be designed with balanced consideration of construction-stage safety, structural efficiency, and material economy, thereby supporting more reliable and sustainable design practices. Beyond practical implications, this study contributes to the scientific literature by establishing a comparative analytical framework that quantifies parameter sensitivity and clarifies the dominance of geometric characteristics in governing composite floor behavior.

METHOD

This study investigates the structural performance of one-way composite floor systems consisting of profiled steel decks and reinforced concrete slabs using a comparative code-based analytical parametric approach. The analysis was conducted using the design-by-formula procedures prescribed in Eurocode, focusing on the relative influence of the steel deck thickness, concrete slab thickness, and concrete compressive strength on the load-carrying capacity of composite floors. The overall research framework adopted in this study is illustrated in Figure 1, which summarises the system definition, Eurocode-based analytical procedure, parametric evaluation, and sensitivity analysis used to identify the governing parameters of the composite floor behavior.

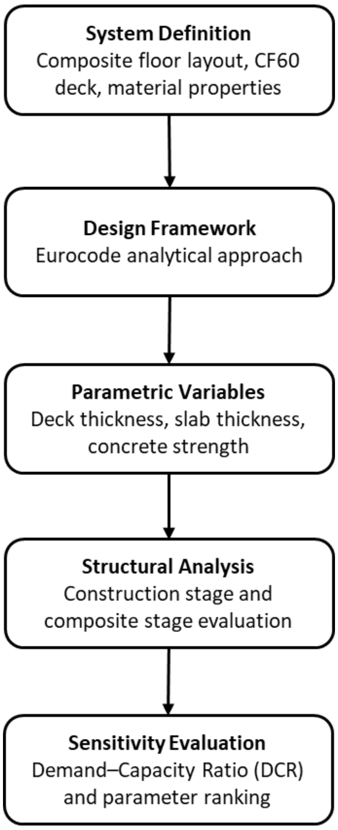

Figure 1. Research methodology flowchart

To achieve this objective, a representative composite floor system was modeled and analyzed, as shown in Figure 2. The system comprised a primary beam–secondary beam arrangement within a square floor bay of 9 m × 9 m, with secondary beams spaced at 3 m intervals to create a one-way slab span of 3 m. This configuration represents a typical one-way composite floor system in which the flexure between secondary beams governs the slab action.

The slab was constructed using a CF60 profiled steel deck topped with reinforced concrete. The geometric profile of the CF60 steel deck, shown in Figure 3, governs the flexural stiffness and resistance of the slab during the construction stage, as the steel deck alone resists the applied loads before concrete hardening. The steel deck had a thickness of 1.0 mm and served as permanent formwork during construction and as tensile reinforcement in the composite stage. The overall slab depth was 130 mm, comprising a 60 mm deck profile and a 70 mm concrete topping above the crest. The concrete slab had a compressive strength of 25 MPa, representing normal-strength concrete commonly used in building floor systems.

In the composite stage, full shear interaction between the profiled steel deck and concrete slab is assumed, in accordance with Eurocode provisions for composite slabs with adequate mechanical interlock provided by the deck geometry and embossments. Under this assumption, the partial shear connection and interface slip were not explicitly modeled, and no separate pull-out or bond–slip equations were employed. Longitudinal shear transfer is therefore implicitly accounted for through the composite section resistance formulation prescribed in Eurocode EN 1994-1-1 [32], which is appropriate for evaluating the global flexural capacity of composite slabs.

The flexural resistance of the composite slab was evaluated using a plastic stress-resultant model, in which the steel deck was assumed to reach yield in tension. In contrast, the concrete was idealized by a rectangular compressive stress block. Force equilibrium between the tensile and compressive resultants is enforced to determine the position of the plastic neutral axis, from which the corresponding plastic bending resistance is obtained. It should be noted that the profiled steel decking systems in this study are predominantly used in building floor applications and are not commonly adopted in bridge decks, where different structural systems and performance requirements govern the design.

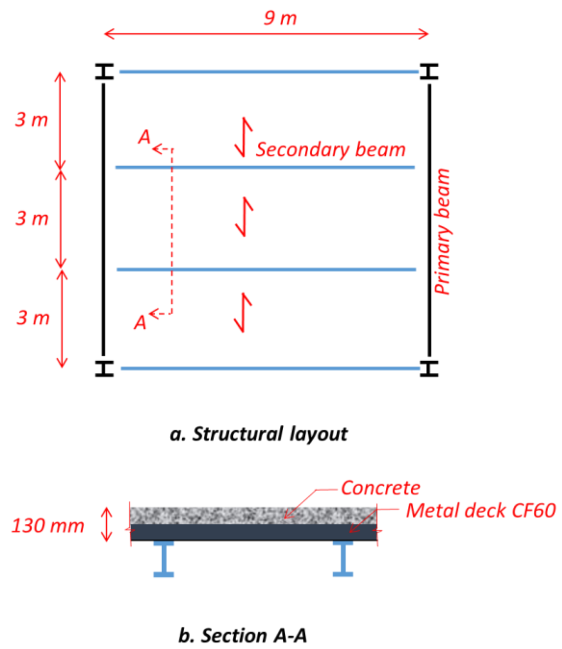

Figure 2. (a) Structural layout and slab span (b) Composite slab cross-section and slab depth

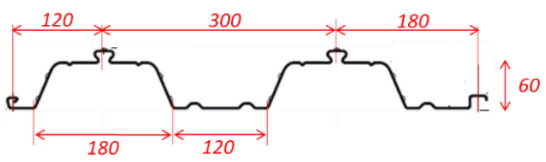

Figure 3. Cross-section of CF60 profiled steel deck with geometric dimensions used in analysis (unit in mm)

The composite floor models were subjected to load combinations in accordance with the building code requirements. The applied loads were as follows.

- Dead load: including the self-weight of the composite slab and the steel deck.
- Superimposed dead load: 0.2 kN/m^2, representing the floor finishes and ceilings.
- Live load: 3.0 kN/m^2, representing typical office occupancy

These loads were applied as uniformly distributed loads across the slab surface using load factors and their combinations. For the boundary conditions, the composite slab panels were modeled as supported along the secondary beams, simulating a one-way slab action over a 3 m span. The primary beams provided continuity in the transverse direction but did not directly contribute to the flexural behavior of the one-way slab system. This approach is consistent with common construction practices, in which profiled steel deck slabs primarily span between the secondary beams.

Based on this baseline configuration, parametric variations were introduced to the deck thickness, slab depth, and concrete compressive strength to evaluate their effects on structural performance systematically. The design and analysis of the composite floor system, based on Eurocode [32, 33, 34], were conducted with two distinct stages of behavior in mind.

a. Construction stage

During the construction stage, the CF60 profiled steel deck alone resists the applied actions because the freshly cast concrete does not contribute to structural resistance prior to hardening. An unpropped construction condition was assumed. The applied actions included the self-weight of the steel deck, the weight of wet concrete based on the slab thickness, and a uniformly distributed construction live load representing temporary construction activities; temporary shoring was not considered. Load combinations are defined in accordance with Eurocode EN 1990 [34] for construction situations, with permanent and variable actions combined using the relevant partial safety factors. Structurally, the steel deck behaves as a thin-walled cold-formed steel section, for which local plate buckling influences the effective stiffness and strength. Local buckling is not checked through a separate buckling analysis; instead, its effects are implicitly accounted for by adopting effective section properties derived using the effective width method, in accordance with Eurocode provisions. These effective properties are then used to determine the bending resistance of the deck during construction. Accordingly, the effective width method is used to determine section properties, and the design bending resistance of the deck is given by

$$M_{Rd,deck} = \frac{W_{eff} f_y}{\gamma_M} \quad (1)$$

where W_{eff} is the effective section modulus, f_y is the yield strength of the steel deck, and γ_M is the partial safety factor for the material resistance. This expression provides the design moment resistance of the profiled deck under construction-stage loading conditions.

b. Composite stage

Once the concrete hardened, the system transitioned to the composite stage, in which the concrete flange carried the compression and the profiled CF60 steel deck resisted the tension. The two materials act together through a mechanical interlock, ensuring longitudinal shear transfer at the interface. The plastic bending resistance of the composite section can be determined by enforcing axial force equilibrium between the steel tension and the concrete compression.

- Tension force in steel deck

$$T_{Rd} = A_p f_{yd} \quad (2)$$

- Compression force in concrete

$$C_{Rd} = b_{eff} x_{pl} f_{cd} \quad (3)$$

- Force equilibrium

$$x_{pl} = \frac{A_p f_y}{b f_{cd}} \quad (4)$$

- Plastic resistance moment

$$M_{pl,Rd} = A_p f_{yd} \left(d_p - \frac{x_{pl}}{2} \right) \quad (5)$$

where A_p is the effective tensile area of the steel deck (per rib strip or unit width) and *where* $f_{yd} = f_y/\gamma_M$ is the design yield strength of the deck, and b_{eff} is the effective concrete flange width for one-way action. *where* $f_{cd} = \alpha_{cc} f_{ck}/\gamma_c$ is the design compressive strength of concrete, x_{pl} is the concrete compression depth (≤ concrete thickness above the deck crest). D_p is the distance from the tensile resultants of the deck to the resultant of the concrete compression block (for the deck in tension, i.e., the distance from the deck centroid in tension to the centroid of the compression block at $x_{pl}/2$ above the slab soffit). This sequence of equations reflects the logical development of the composite bending resistance, beginning from the individual material actions (Equations 2 and 3), applying the equilibrium conditions (Equation 4), and finally obtaining the overall composite capacity (Equation 5).

The study considered three key parameters: (i) steel deck thickness (0.9–1.2 mm), (ii) concrete slab thickness (120–150 mm), and (iii) concrete compressive strength (20 MPa to 35 MPa). A total of 12 parametric combinations were evaluated by varying one parameter at a time while keeping the others constant to isolate their individual influences on the structural performance. For each configuration, both the construction and composite stages were analyzed to determine the corresponding demand–capacity ratios in accordance with the Eurocode provisions. This methodological framework enables a systematic evaluation of parameter sensitivity under realistic design conditions, providing a consistent basis for comparing the influence of geometric and material variables on the structural performance of composite floor systems. Notably, long-term effects, such as concrete creep, shrinkage, and differential deflection, were not explicitly considered in the composite-stage analysis.

RESULTS AND DISCUSSION

Influence of steel deck thickness

Figure 4 presents the demand–capacity ratio (M_{Ed}/M_{Rd}) of the composite floor system for steel deck thicknesses of 0.9 mm and 1.2 mm. Two conditions were evaluated: the construction stage, in which the steel deck alone resisted the applied loads, and the composite stage, in which the hardened concrete and steel deck acted together.

The results indicate that the construction stage governs the design for all deck thicknesses. For a steel deck thickness of 0.9 mm, the demand–capacity ratio reached approximately 0.75, indicating that the steel deck was close to its resistance limit under the weight of the fresh concrete and imposed loads. As the thickness increased, the demand–capacity ratio decreased substantially, decreasing to approximately 0.45 at 1.2 mm. This pronounced reduction reflects a mechanism-driven response, as the construction-stage behavior is governed entirely by the flexural resistance of the steel deck acting alone. In this stage, the bending capacity scales directly with the steel area and effective section modulus, both of which increase proportionally with the deck thickness. In contrast, the applied bending demand remains largely unchanged.

In contrast, the composite stage exhibited much lower demand–capacity ratios, with values ranging between 0.25 and 0.18 over the thickness range considered. The reduction with increasing thickness was marginal compared to that during the construction stage. This behavior arises because, in the composite condition, the flexural strength is primarily governed by the concrete slab's contribution in compression, whereas the steel deck serves mainly as tensile reinforcement. Consequently, further increases in deck thickness beyond 1.0 mm provide only limited gains in the overall composite capacity.

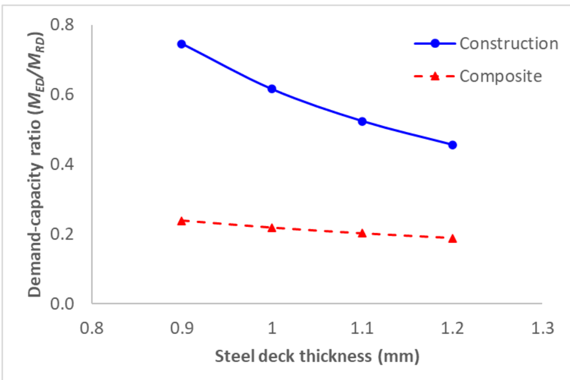

Figure 4. Demand–capacity ratio for varying steel deck thickness

Overall, these results demonstrate that the dominance of steel deck thickness originates from fundamental construction-stage mechanics rather than code formulation. During concreting, the profiled steel deck acts as the sole flexural member, and its thickness directly governs the tensile stress capacity and effective section modulus, thereby controlling the bending resistance and stiffness. Once composite action develops, the concrete slab primarily carries compressive stresses, and the lever arm between compression and tension is governed mainly by the slab geometry rather than deck thickness. Consequently, the influence of deck thickness diminished in the composite stage. This mechanistic interpretation explains why deck thickness emerges as the governing parameter in the sensitivity ranking and highlights the critical importance of construction-stage design checks in composite floor systems.

Influence of concrete slab thickness

Figure 5 illustrates the variation in the demand–capacity ratio (M_{Ed}/M_{Rd}) for slab thicknesses ranging from 120 to 150 mm. The results again confirm that the construction stage governs the design, as the demand capacity ratios are consistently higher than those in the composite stage.

During the construction stage, the demand–capacity ratio increased with increasing slab thickness. At a slab thickness of 120 mm, the ratio was approximately 0.60, which increased to approximately 0.68 at 150 mm. This trend is expected because during construction, the steel deck alone must resist the applied loads, and thicker slabs directly increase the weight of fresh concrete. Therefore, a higher imposed load leads to a greater demand relative to the deck's resistance, emphasizing that construction safety is sensitive to the slab thickness.

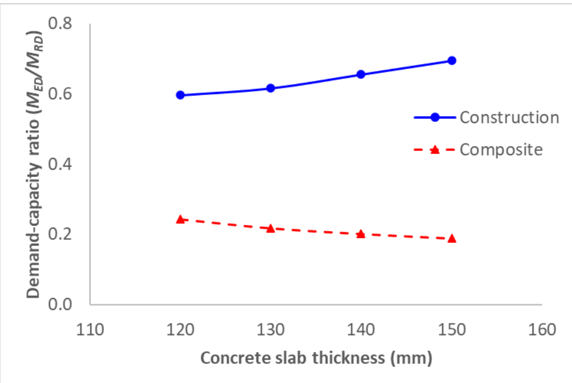

Figure 5. Demand–capacity ratio for varying concrete slab thickness

In contrast, during the composite stage, the demand–capacity ratio decreased slightly as the slab thickness increased. Values reduced from 0.24 at 120 mm to 0.18 at 150 mm. This behavior can be attributed to the thicker slab providing greater depth of concrete in compression, thereby enhancing the flexural capacity of the composite section. The increase in resistance outweighed the additional self-weight, resulting in improved performance during the composite stage.

These opposing trends demonstrate that the slab thickness plays a dual stage-dependent role governed by flexural mechanics. During construction, an increase in the slab thickness amplifies the bending demand by increasing the weight of the fresh concrete, which must be resisted solely by the steel deck. Conversely, once composite action is established, a thicker slab enhances flexural resistance by increasing the depth of the compression block and the internal-force lever arm between the concrete compression and the steel tension. This mechanistic interpretation explains why the slab thickness exhibits moderate sensitivity during the composite stage but can be detrimental during construction if not properly controlled.

Influence of concrete compressive strength

Figure 6 shows the variation in the demand–capacity ratio (M_{Ed}/M_{Rd}) as a function of concrete compressive strength, ranging from 20 MPa to 35 MPa. As with the previous parameters, the construction stage remained critical, with demand–capacity ratios significantly higher than those in the composite stage.

In the construction stage, the results revealed that the demand–capacity ratio was unaffected by variations in the concrete compressive strength.

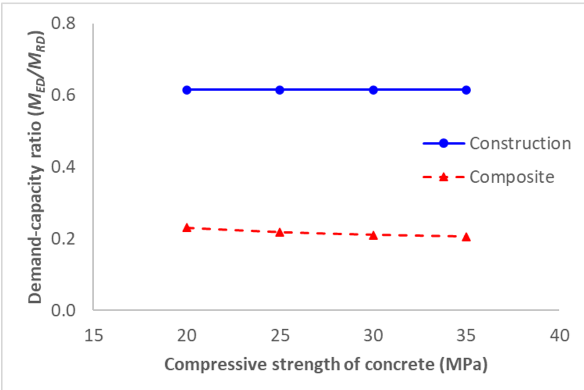

Figure 6. Demand–capacity ratio for varying compressive strength of concrete

This outcome is expected because, during construction, the concrete is still fresh and does not contribute to the structural resistance; the steel deck alone resists the applied loads. Consequently, changes in concrete strength have no impact on construction-stage performance.

At the composite stage, a slight reduction in the demand–capacity ratio was observed as compressive strength increased, from approximately 0.23 at 20 MPa to 0.20 at 35 MPa. This limited sensitivity can be explained by the stress–strain distribution within the composite sections. Under positive bending, the concrete contributes through a rectangular compressive stress block, whereas the steel deck governs the tensile resistance by yielding. Increasing the concrete strength primarily increased the peak compressive stress but did not significantly alter the depth of the compression block or the internal force lever arm. Consequently, once the tensile yielding of the steel deck governs the flexural resistance, further increases in concrete strength yield only marginal improvements in overall capacity. This behavior confirms that the flexural performance of the composite within the normal-strength range is governed predominantly by the section geometry and tensile force equilibrium rather than by concrete strength enhancement.

Comparative synthesis and design implications

The comparative evaluation of the parametric study highlighted the distinct roles of the steel deck thickness, slab thickness, and concrete compressive strength in influencing the behavior of composite floor systems. Among these parameters, steel deck thickness emerged as the most critical factor, particularly during construction. Increasing the thickness from 0.9 to 1.2 mm markedly reduced the demand–capacity ratio, confirming that a stiffer deck provides greater flexural resistance to the weight of fresh concrete and temporary loads. This observation is consistent with the findings of Tavares et al. [31], who reported that increasing stiffness-related parameters, such as connector height and reinforcement configuration, enhances load-bearing capacity and ductility in composite slabs. The present study extends this understanding by demonstrating that deck thickness plays a dominant role in governing construction-stage performance. In contrast, the composite stage was relatively less sensitive to changes in deck thickness because the compressive contribution of the concrete slabs dominated the overall flexural resistance.

The influence of the slab thickness was more nuanced, producing opposite effects in the two stages. During the construction stage, larger slab thicknesses increased the demand–capacity ratio because the additional weight of the fresh concrete imposed higher stresses on the steel deck, which alone resisted the loads. However, once composite action was developed, thicker slabs enhanced the flexural capacity of the system by providing a deeper compression zone, thereby reducing the demand–capacity ratio. A similar improvement in flexural resistance with increased concrete volume was observed by Jeyarajan and Liew [29], who highlighted the contribution of composite slabs to overall frame stiffness and reduced deflection. However, unlike studies that focus on the global frame response, the present study isolates the local parametric effects of slab thickness, emphasizing its dual role in short-term loading and long-term performance. This dual effect underscores the importance of carefully balancing constructability during casting and long-term strength requirements.

In comparison, variations in the concrete compressive strength had a negligible influence on the structural performance. The demand–capacity ratios remained virtually unchanged in the construction stage and showed only marginal reductions in the composite stage as the strength increased from 20 to 35 MPa. This trend is consistent with the results reported by Stochino et al. [30], who found that material substitution and concrete quality had limited influence on flexural capacity compared with geometric parameters. The present findings confirm that, within the normal strength ranges, concrete strength contributes little to flexural resistance compared with the mechanical action of the steel deck. This finding indicates that within the normal-strength range, concrete strength does not govern the flexural behavior of the composite slabs; rather, it is controlled by the tensile resistance of the steel deck and the slab geometry.

From a design perspective, these findings emphasize that construction-stage checks are critical and often govern system adequacy. Therefore, the steel deck thickness should be prioritized in the design to ensure safe performance during concreting. In contrast, the slab thickness should be carefully controlled to avoid overloading the deck during the temporary stage. However, specifying a higher concrete strength provides minimal structural benefits and is unnecessary unless durability, fire resistance, or crack control considerations dictate otherwise. These results collectively align with the broader conclusions in the prior literature that the structural efficiency in composite systems is primarily governed by stiffness-related geometric characteristics rather than material strength alone.

Collectively, the synthesis suggests that optimizing geometric parameters, particularly deck thickness and slab depth, while ensuring construction-stage safety, offers the most effective strategy for achieving efficient, economical, and sustainable composite floor designs.

Beyond structural performance, the findings of this study also contribute to sustainable design practices by promoting material and energy efficiency. Increasing the deck stiffness while avoiding unnecessary slab thickness directly reduces material consumption and structural self-weight, thereby lowering the embodied carbon and construction costs. Similarly, the limited influence of concrete strength indicates that normal-strength concrete is sufficient for most applications, thereby reducing cement use and associated CO_2 emissions. Consequently, the proposed design approach not only enhances safety and efficiency but also supports environmental sustainability through rational material utilization and an optimized construction design.

CONCLUSION

This study investigated the structural performance of one-way composite floor systems by systematically varying three key parameters: steel deck thickness, concrete slab thickness, and concrete compressive strength. A representative composite floor with CF60 profiled steel decking and reinforced concrete topping was analyzed for both the construction and composite stages in accordance with Eurocode provisions. The structural performance was evaluated using demand–capacity ratios (DCR), enabling a quantitative comparison of the parameter sensitivity.

The results demonstrate that steel deck thickness is the dominant parameter, particularly during the construction stage. Increasing the deck thickness from 0.9 mm to 1.2 mm reduced the construction-stage DCR by approximately 40%, indicating that the construction-stage safety is highly dependent on the deck stiffness and flexural resistance. In contrast, the composite stage exhibited limited sensitivity to deck thickness, as the flexural resistance was primarily governed by the compressive action of the concrete slab rather than by the tensile capacity of the steel deck.

Concrete slab thickness exhibited a dual and stage-dependent influence. During the construction stage, increasing the slab thickness from 120 to 150 mm increased the DCR by approximately 15% owing to the higher self-weight of the fresh concrete acting on the steel deck. Conversely, during the composite stage, the same increase reduced the DCR by approximately 25%, reflecting the enhanced flexural capacity provided by a deeper compression zone and a larger internal lever arm.

In comparison, the concrete compressive strength showed the least influence on the structural performance. Increasing the strength from 20 MPa to 35 MPa altered the DCR by less than 5%, with no effect during the construction stage and only a marginal improvement in the composite stage. This confirms that, within the normal strength range, the flexural behavior is governed primarily by the geometric parameters and the steel deck response rather than by the material strength.

Based on the magnitude of the DCR variation, a clear sensitivity hierarchy can be established: steel deck thickness (strong influence), concrete slab thickness (moderate influence), and concrete compressive strength (low influence). These findings confirm that the construction stage governs composite floor design, highlighting the importance of controlling deck stiffness and slab geometry to ensure safe and efficient performance during construction.

Although the present study provides a deterministic sensitivity assessment based on Eurocode analytical formulations, future research may extend this framework by incorporating advanced statistical sensitivity methods, such as global sensitivity indices or regression-based modeling, to quantify parameter interactions and uncertainty effects. In addition, finite element simulations and experimental investigations may further validate the analytical predictions and provide deeper insights into the stress–strain behavior and interaction mechanisms within the composite floor systems.

Overall, the findings provide practical guidance for engineers to prioritize critical geometric parameters when designing composite floor systems, thereby improving safety during construction, enhancing structural efficiency, and promoting more sustainable material utilization.

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methodology, analysis, and conclusions remain entirely the authors' work.

AUTHOR CONTRIBUTION

RS prepared the manuscript, MK performed the analyses, MS reviewed the manuscript, and MA reviewed the manuscript.

DATA AVAILABILITY

Analysis https://zenodo.org/records/17018658

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