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State of Art on Steel Composite Slab Systems

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Abstract: This paper presents and reviews the technical literature for past few decades on steel composite slab systems with consideration of vertical loadings. The composite structure in construction runs the method of using binary materials together to use each element for the best advantage that is obtainable by underlining the limitation of the conventional construction system. Over the past few decades, the theoretical, experimental and numerical studies has been conducted to investigated the performance of steel composite slabs with or without infill materials. The literature references of steel composite slab systems were summaries the material composition, interaction type, loading type and parameter studied. Thus, all previous research was remarked on and reported in tabular form.

Keywords: Composite Construction, Steel Composite Slab, Steel Sheet, Dry Board, Infill Material, Shear Connector

1. Introduction

Conventional construction is one of the earliest approaches practiced in the construction industry that have limited skilled labor, lack of heavy machinery, and a shortage of relevant technology [1-4]. The construction industry in Malaysia is experiencing a transformation from conventional methods to a more systematic and mechanized approach known as the Industrialized Building System (IBS) [5-7]. This system has been regulated and varied in a completely different manner compared to the conventional construction system that affected the design, construction method statements and, most importantly the cost implications [8].

Composite structure system is one of the applications related to the Industrialized Building System (IBS) that is high demand to provide optimum design, enhancing structural performance and reducing cost [9] and constructional efficiency. Composite structure system has gain wide acceptance because of their many advantages such as faster to erect, lighter in weight [10], better quality control, reduced time of construction, and better ductility and hence superior lateral load resisting behavior [11]. As stated by Sangeetha *et al.* [12], Siva *et al.* [13] and Tedia and Maru [14] composite construction is widely used as diaphragm strengthening method when two different materials are bound together for the best advantage. Thus, they act strongly together as a single unit from a structural point of view.

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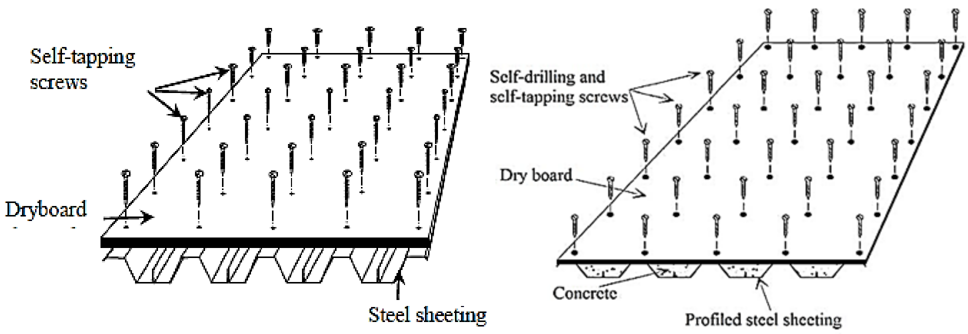
This paper aimed to give an up-to-date literature review that includes experimental, theoretical and numerical studies of composite structure systems in flooring construction. The literature references carefully are chosen and reviewed in this paperwere summaries the material composition, interaction type, loading type and parameter studied. Therefore, the steel composite slab system classifies in to two sections, one section for steel composite slab with infill materials and one section for steel composite slab without infill materials. Each of classification in these section discussed in details. Thus, the benefits, gaps and suggestion of steel composite slab systems from this paper attempt to summaries to give a clear vision for researchers interested in these unique composite slab systems.

2. Steel Composite Slab System

During the 1960s, steel decks act as tensile reinforcement and permanent formwork for supports the concrete [15,16] but nowdays, the composite slabs comprised of profiled steel sheets and top with concrete generally used for the building construction [17,18]. The development of composite slab system with the combination of profiled steel sheet (PSS) and dry board (DB) was conducted in early research by Wright *et al*. [19], Badaruzzaman and Wright [20], Ahmed *et al.* [21,22], and Hamzah and Badaruzzaman [23]. Later than that, the addition of concrete as infill in profiled steel sheet and dry board was introduced in several studies by Badaruzzaman *et al.* [24],Seraji *et al.* [25] and Jaafar *et al.* [26,27].

Compared to other flooring systems, the use of profiled steel composite slab in the construction industry give more benefits [28]. The PSSDB system as an efficient, appropriate, and lightweight system composite composed of a profile steel sheet (PSS) bound to the dry board (DB). This system consists of profiled steel sheeting such as Peva45, Bondek II, Peva50, and others connected to dry boards such as Plywood, Cemboard, Primaflex, and others using mechanical screws such as self-tapping and self-drilling screws [29,30] (see Figure 1).



(a) (b)

Figure 1: Typical PSSDB system (a) without infill [27] (b) with infill materials

2.1 Steel composite slab system withoutinfill materials

The original research was concentrated upon the development system of the steel composite slab without infill materials for use in the construction of flooring and walling units in domestic scale buildings. This results in a strong and efficient structural system which can be exploited for a variety of structural purposes. Not only is the system structurally sound, it has other added advantages such as being lightweight, easily transportable and easily assembled by semi-skilled labour. A complete form of summary of this section is described in Table 1.

Full interaction concept assumes that there no slip between the profiled steel sheeting and dry board, and they act as a single unit. One repetitive section of the PSSDB can be assumed to be a composite beam and transformed- section method will be used by converting the PSSDB section into an equivalent section of steel material (see Figure 2).

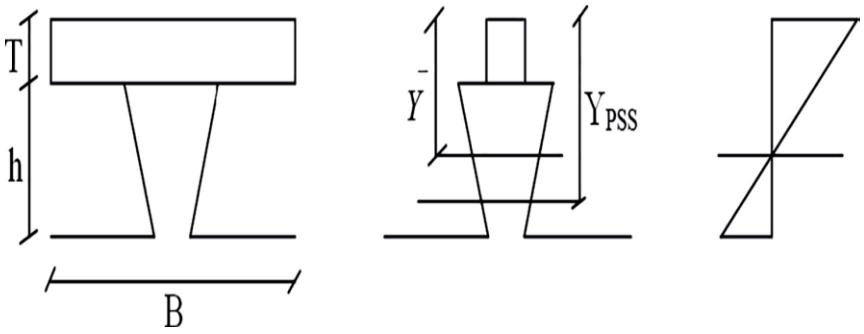


Figure 2: The cross section of the transformed PSSDB system

Eq. (20) which is used to obtain the depth of the neutral axis ($\bar{Y}$) is shown below:

$$\bar{Y} = \frac{(A_{PSS} \cdot Y_{PSS}) + (n \cdot B \cdot T \cdot (T/2))}{A_{PSS} + (B \cdot T)} \quad (1)$$

where:

$$n = E_{DB} / E_{PSS} \quad (2)$$

and the second moment ($I_{Composite}$) of area of the composite section is obtained by:

$$I_{Composite} = I_{PSS} + n \cdot I_{DB} \quad (3)$$

$$I_{Composite} = I_X + A_{PSS} \cdot (Y_s - \bar{Y})^2 + n \cdot B \cdot T \cdot \left(T^2/12 + (\bar{Y} - T/2)^2\right) \quad (4)$$

after that, the maximum bending moment (*M*) can be obtained either from:

$$M = (\sigma_{PSS} \cdot I_{Composite}) / (T + h - \bar{Y}) \quad (5)$$

$$M = (\sigma_{PSS} \cdot I_{Composite}) / \bar{Y} \quad (6)$$

However, since the failure in the two-way PSSDB system occurs in the Dry Board, then Eq. 6 will be used to calculate the ultimate moment. And finally, the ultimate load (*P*) can be obtained from:

$$P = (4 \cdot M) / L \quad (7)$$

Badaruzzaman *et al.*[31] performed a series of out-of plane bending test to investigate the overall structural performance, and the influence of connector modulus and spacing on the performance of the PSSDB panels. The suitability of the component materials for these panels is also investigated. It will be shown that connector modulus and spacing play major roles in influencing the stiffness of composite panels. Suitable choice of connector and spacing is important in determining the stiffness of these panels. Partial interaction approach developed by the authors can safely be used to design composite PSSDB floor panels along the major axis of bending.

Ahmed *et al.* [21] described the structural behavior, analysis, and testing of a structural PSSDB system when applied as two-way floor panels subjected to out-of-plane loading. This involved two types of modeling: first, the isotropic model, and secondly, the orthotropic equivalent model representing the geometrically orthotropic profiled steel sheeting. However, comparison of theoretical to experimental results shows that the isotropic model is more accurate, within reasonable agreement with discrepancies ranging from 2.8% to 12.8%. This indicates that there is a need for improving further the orthotropic model. However, for practical design purposes, the orthotropic model is acceptable since it is more conservative in predicting deflection values of the two-way PSSDB panel. The orthotropic model is preferred over the isotropic model because it is less tedious, requiring less computer memory and computational time, and is more practical for design purposes.

Badaruzzaman *et al.* [23] presented the application of various type of dry boards that is known as the Bondek II/ Cemboard Composite Flooring Panel (BCCFP) system. The role of dry boards in the BCCFP system and the performance of the system using various type and thickness of dry boards are investigated. In addition, the effect of varying the spacing of screws on the panel performance is also studied. From test results, it was found that the application of dry boards in the BCCFP system could increase the flexural stiffness of the composite panel by between 12.8% to as high as 26.3%. The introduction of a layer of dry board to the bare steel sheeting alone has the potential to increase by 12.2% the moment capacity value of 12.2 kNm/m. It can be concluded that the dry boards, which are normally used in non-load bearing applications, are having great potential to be used as components in load bearing structural system.

Nordinet al. [32] generated PSSDB system with six 3.0m span of semi-continuous and continuous samples that were tested under a uniformly distributed load. The semi-continuous panels showed a two-phase behavior whilst the continuous panels showed a three-phase behavior under loading. Results showed that the stiffness of the semi-continuous panels were half of the continuous panels. The 25 screws used in the 0.6m middle connecting panel had shown to be quite insufficient to hold the whole semi continuous panel together. Therefore, the addition of screws with closer spacing is recommended to increase the panel stiffness.

Liet al. [33] examined the potential of the lightweight bamboo-steel composite slab as a structural member. Six slab specimens were tested to study the flexural behavior of the composite slabs, which were composed of cold-formed thin-walled steel channel and bamboo plywood sheathings. Three types of connections to fabricate the composite slabs were investigated, which are simple adhesive connection, self-tapping screw enhanced connection, and stability improved connection with bamboo laths glued on the both sides of cold-formed steel channel. Results indicated that the specimens fabricated using the stability improved connection showed a remarkable increase in stiffness, capacity and stability, compared with the other two connections. The bamboo-steel composite slabs have the potential to replace concrete or wood slabs in low buildings.

Rahmadi *et al.* [34] investigated the deflection behavior of the profiled steel sheet medium density fiberboard (PSSMDF) system. A theoretical model has yielded deflection result within 12% accuracy compared to experimental value obtained in the laboratory. Through theoretical model, the behavior of the PSSMDF floor on the composite partial interaction problem can be predicted. The result of this research is useful for the success of applying the PSSMDF floor system as product diversification in industrial building construction.

Al-Shaikhli *et al*. [35] investigates the effect of presence of steel plates on the two-way behavior of the PSSDB floor panels subjected to a point load using finite element modelling (FEA) (see Figure 3). The results have shown that changing the plate thickness can enhance the PSSDB stiffness. However, increasing the number of plates or changing the plate width doesn’t greatly affect the performance. Therefore, steel plates can be considered an economic solution to enhance the structural behavior of the system.

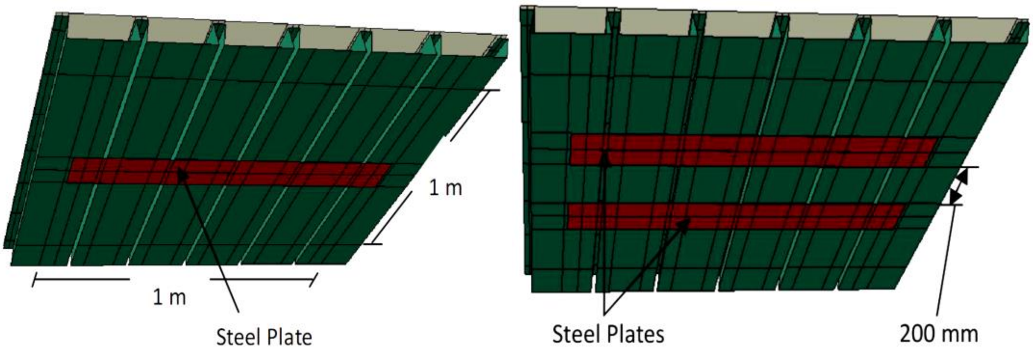


Figure 3: PSSDB model with a steel plate at the bottom [35]

Al-Shaikhli *et al.* [36] examined the two-way flexural behavior of the PSSDB floor system. The study employs both theoretical and non-linear finite element (FE) analysis. The theoretical one was conducted using an elastic full interaction analysis while the FE approach has been done using ABAQUS software. In addition to an elastic full interaction analysis, the FE modeling, has been conducted on the PSSDB two-way panel. The obtained results were verified against experimental tests and it was shown that both the theoretical and FE solutions are adequate enough to predict the behavior of PSSDB system. It was found that the changing the dry board depth can enhance the behavior up to 23%. However changing the type of board has a minor effect on the elastic stage and it starts increasing in the plastic period up to 14%. Also, it was shown that changing the thickness of steel sheeting can affect the performance by approximately 18%. Screw spacing has an impact on the strength of the syste up to 9.6%. Finally, applying line load has demonstrated a better two-way action than point load.

Table 1: Previous study on composite slab system without infill material

Ref.	Materials composition		Interaction type	Loading type	Parameters studied	Remarks
	Steel sheet	Dry board				
[31]	Bondek II	Plywood, cemboard, chipboard	Self-tapping screws	Static	Board type, connectors spacing	Stiffness of slab influenced by screws connector spacing, partial interaction approach was developed.
[21]	Bondek II	Cemboard	Self-tapping, self-drilling screws	Static	Direction corrugation steel sheeting	Compare with the numerical study.
[23]	Bondek II	Plywood, chipboard, cemboard	Self-drilling, self-tapping screws	Static	Type and thickness board, screw spacing	Dry boards have great potential to be used as components in load-bearing structural systems.
[32]	Peva 45	Cemboard	Self-tapping screws	Static	Slab span, spacing screw	The stiffness of the semi-continuous panels is half of the continuous panels.

[33]	Cold-formed thin-walled channel	Bamboo plywood	Self-tapping screw, adhesive, bamboo laths glued	Static	Connections type	Bamboo-steel composite slabs have the potential to replace concrete or wood slabs in low buildings
[34]	NC900	Medium-density fiberboard (MDF-Board)	Self-drilling screw	Static	Steel sheet thickness	Compare with the numerical study.
[35]	Bondek II	Cemboard	Self-tapping, self-drilling screws	Static	Plate distance, thickness plate	Steel plates can enhance the structural behavior of the system.
[36]	Bondek II	Cemboard	Self-taping, self-drilling screws	Static	Type and thickness board, steel sheeting thickness, screw spacing, loading location	Both theoretical and FE solutions are adequate to predict the behavior of the PSSDB system.

2.2 Steel composite slab system with infill materials

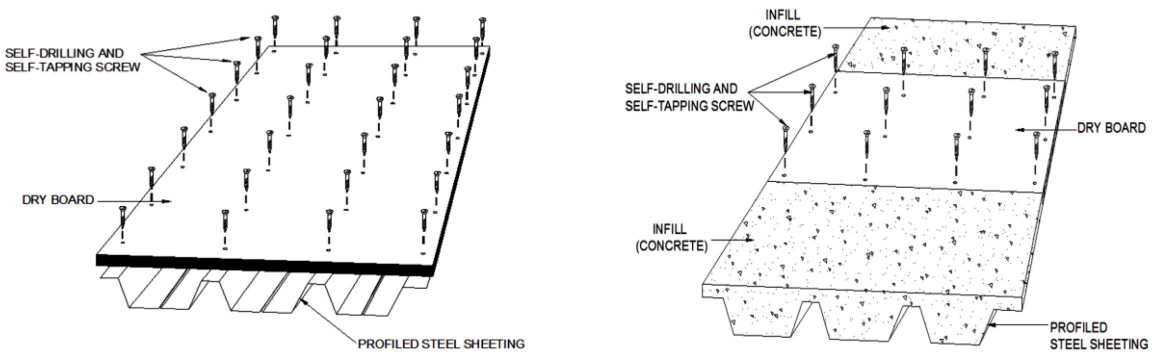
The steel deck provides a formwork for concrete in relatively large spans supporting the self-weight of the concrete as well as the construction loads without temporary propping between the beams [36]. Given the various type of studies conducted to these type of steel composite when subjected under vertical loading to provide a deep understanding and clear presentations. A complete summary of this section is present in Table 2.

Zou *et al.* [37] investigates the static mechanical property of a new type of lightweight composite slabs. The test results show that the composite slab has a better entirety and higher bearing capacity, and the restraint at the two ends of the composite slabs has a greater effect on bearing capacity of the slabs. It shows that the failure modes of the composite slab include cracking of concrete and local buckling of the thin-walled steel beams. The results also show that the composite slab works elastically as if the equivalent uniform load applied to the upper surface of the slab is less than $5kN/m^2$.

Siddh *et al.* [38] examined the mid-span deflection and end slip of the composite slabs. A total of four specimens were cast and tested to interpret the actual behavior of the composite slab. Experiments were performed on composite slabs with a trapezoidal type of profiled sheeting of 0.8mm and 1.2mm thickness. In the results of these investigations, load versus displacement and load versus slip behavior was observed. A comparison of experimental values of deflections and end slip revealed that agreement between these values was sufficiently good at all stages of the slab behavior.

El-sayed *et al.* [39] studied the flexural behavior of steel-concrete-steel sandwich slabs. Tens steel-concrete-steel slabs full-scale specimens were prepared and experimentally tested taking into account the variables of this study. The experimental results included ultimate load, vertical deflection at three points, slip between steel plate and concrete core and mode of failure. Test results show that steel-concrete-steel slabs have excellent flexural characteristics. The failure modes observed during experiments occurred due to shear studs rupture, concrete cracking and yielding of steel plates. The shear studs was found to be effective not only in ultimate load capacity but also in the vertical deflection.

Jaffar *et al.* [40, 27] focused on PSSDB that uses 12M geopolymer concrete infill with a modified PSSHDB panel using a half-sized dry board (see Figure 4). This study aims to analyze the relationship between stiffness and deflection at the mid-span of PSSDB systems using different parameters. Results show that the panel with 12M GPCHB has 107% and 40% increase in rigidity compared with those of the control (without infill) and full board normal concrete panels, respectively. Mid-span deflection is also reduced to 52%. In conclusion, stiffness increases and deflection decreases when 12M GPCHB is used in the panel.



(a) (b)

Figure 4: (a) PSSDB basic structural (b) PSSHDB with concrete infill

Jaffar *et al.* [41] presented the behavior of infill materials of profiled steel sheeting dry board (PSSDB) floor system. Two tests were conducted, namely, push-out test to know the connection stiffness and bending test on the PSSDB panel under the influence of different infill materials. The result of the push-out test shows that the connection stiffness of the geopolymer concrete-filled PSSDB is 331% higher than that of PSSDB that is filled with normal concrete. This connection stiffness contributed to the reduction of the deflection value of 21% in the middle of the mid-span for full-board geopolymer concrete infill panel bending test. This phenomenon triggered the increase of interaction within the composite system, making the panel that is filled with the geopolymer concrete 25% stronger than the normal concrete-filled panel.

Abas *et al.* [42] determined the behavior of short-term static load tests on two-span composite slabs. In total, eight two-span composite slab specimens were cast and moist cured for 14 days and then loaded monotonically to failure at the age of at least 28 days. Compared to the plain concrete composite slab and the slab containing SL62 welded wire mesh in the negative moment region over the interior support, the slabs containing steel fibers over 20 kg/m^3 provided significant improvements in the slip load and the peak load. Besides, at service load levels, the fibers provided crack control that was of similar effectiveness to that provided by the SL62 mesh.

Tian *et al.* [43] generated the flexural performance of a new lightweight composite floor constructed of cold-formed steel trusses and a composite mortar slab (see Figure 5). The average floor bearing capacity was approximately 15 kN/m^2 at the mid-span deflection serviceability limit, and 22.5 kN/m^2 at the ultimate load. The ratio between the shear force applied to both the cement mortar and upper chord of the steel trusses, and the total shear force applied to the composite floor obtained using a finite element model. Then, the theoretical method for determining the composite floor deflection and bearing capacity was proposed, which agreed with the previous results.

Figure 5:The assembled CFS trusses

Al-Shaikhli *et al.* [44] investigated the flexural performance of the two-way PSSDB floor panel with the presence of the infill material. An experiment (EXP) and finite element (FE) approaches were employed. For the EXP tests, it was found that applying a steel plate (SP) can enhance the stiffness and strength of the PSSDB system by approximately 31% and 15%. The results were used to compare with the ones of a previous study, and it was shown that applying infill material can improve the strength by 13.2%. Applying both Steel Plate (SP) and infill material instead of SP alone can enhance it by 13.6%. As for the FE approach, it was demonstrated that changing the thickness of the DB and SP has a minor effect by no more than 5%, while changing the PSS thickness can affect the performance by up to 18.3%. And finally, the effect of changing the type of infill material is less than 1%.

Hossain *et al.* [45] presented the development and performance evaluation of a new high-performance composite flooring system incorporating emerging green, cost-effective Engineered Cementitious Composites (ECCs). Thirty full-scale composite slabs were fabricated and tested under simply supported four-point loading conditions. The structural performance of ECC based composite slabs was compared with their SCC counterparts based on the load-displacement response, shear load resistance, failure modes, strain development in concrete/ steel, load-slip behavior, ductility, energy-absorbing capacity and steel-concrete shear bond resistance. ECC composite slabs have shown superior performance compared with their SCC counterparts in terms of strength, ductility, energy-absorbing capacity and shear bond resistance.

Hossain *et al.* [46] generated the nonlinear finite element (FE) modeling of composite slab system comprising of profile steel deck and high performance Engineered Cementitious Composite (ECC) and Self-Consolidating (SCC) concrete. FE models were developed, and their performance validated based on experimental results of composite slabs subjected to monotonic loading to failure. Parametric studies were conducted to investigate the influence of numerical, material and geometric parameters on FE model performance. Developed FE models were used to determine the behavior of twenty-two experimental composite slabs invalidation and further validation with performance evaluation stages. The simulated load-deflection response, strength and shear bond capacity of FE model slabs were found to be in good agreement with those obtained from their experimental counterparts.

Jaffar *et al.* [26] introduced geopolymer concrete, an eco-friendly material without cement content as an infill material in the PSSDB floor system to highlight its effect on the PSSDB (with full and half-size dry boards) floor system stiffness and strength. Experimental tests on various full-scale PSSDB floor specimens were conducted under uniformly distributed transverse loads. Results illustrate that the rigidity of the panel with a geopolymer concrete infill with the half-size dry board (HBGPC) increases by 43% relative to that of the panel with normal concrete infill with the full-size dry board (FBNC). The developed finite-element modeling (FEM) successfully predicts the behavior of the FBGPC model with 94.8% accuracy. Geopolymer concrete infill and dry board size influence the strength panel, infill contact stiffness, and mid-span deflection of the profiled steel sheeting or dry board (PSSDB) flooring system.

Seraji *et al.* [25] examined the effect of membrane action in improving the flexural capacities of the PSSDB system. Experimental tests were conducted along with developing a nonlinear finite element model to explore the effect of membrane action in the PSSDB floor. Experimental results of the PSSDB panel with simply end support was exploited to verify the nonlinear finite element results. The developed finite element model was then modified by restraining the horizontal movement of the slab at the supports. The obtained results disclosed that the developed compressive membrane action enhanced the stiffness of the slab at serviceability load by about 240%.

Holomek and Bajer [47] studied on composite action using a different type of shear connection and its behavior under different types of loading. Four-point bending tests were performed on the whole span slab. Additional tested on small-scale to understand the shear behavior of thin-walled steel sheet in the ultimate limit state. The data from the tests make it possible to set up and calibrate numerical models. These models can then facilitate pointing out the main factors which influence the load-bearing capacity of slab structure.

Lee *et al.* [48] proposed a new type of one-way composite voided slab system (TUBEDECK), as shown in Figure 6 below. In this study, shear tests on a total of 12 specimens were conducted with slab thickness, the presence or absence of voids and/or steel decks, and tension reinforcement ratio as variables. The results show that combined flexure and shear dominated the behavior of both voided (V) slabs and TUBEDECK (TD) slabs, and web-shear cracking did not affect strength. Predicted shear strength based on the minimum web width was too conservative. Conversely, the shear strength prediction equations, which were proposed based on the real cross-sectional area of concrete, predicted the capacity of both V slabs and TD slabs from a reasonably conservative perspective. A discussion on the influence of moment-shear interaction is also included and an interaction design model is proposed in a further investigation.

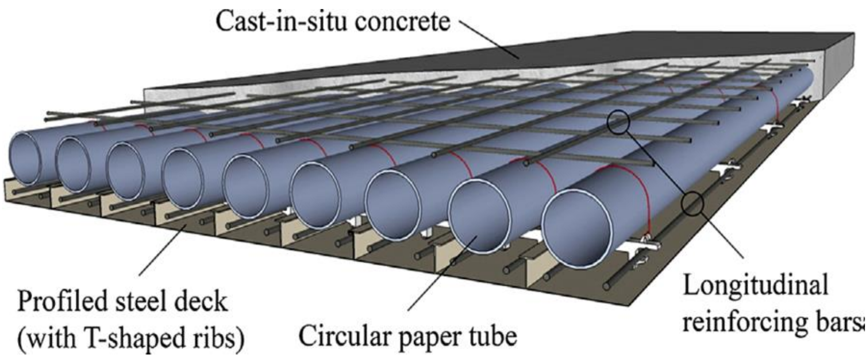


Figure 6: Schematic of the TUBEDECK slab system [52]

Aarthi *et al.* [49] analyzed the longitudinal shear resistance of lightweight concrete composite slabs with profiled sheets. In this research, the lightweight expanded clay aggregates and fly ash aggregates have been used to study the effect of lightweight concrete on the shear bond resistance of composite slabs with cold-formed profiled deck sheets. It is found that the longitudinal shear resistance of clay aggregates concrete is less than the normal concrete. But the same for the fly ash aggregates is 69% of that of normal concrete.

Waldmann *et al.* [50] focused on the applicability of dense lightweight woodchip concrete in constructive engineering. The total scale of the study comprises of 22 plate elements with varied of the shear spans, profile sheet types and sheet thickness. Each examined sheet has an undercut profile with additional embossment. Based on experimental results, the influences of the varied parameters and profile forms on the load-bearing and composite behavior are discussed. This study provides important key findings which show that dense lightweight woodchip concrete can transfer sufficient longitudinal shear forces to the composite joint.

El-Sayed *et al.* [51] presented the enhancement of the longitudinal shear interaction at the concrete-profiled steel sheeting interface of the composite slab by using shear connectors. The push-out and flexural tests are carried out with the same shear connection details — fourteen of push-out specimens with different steel deck thickness and various types of shear connectors. Eleven large scale specimens with different configurations were prepared. The test results show that the failure mode of the composite slab can be improved to ductile type and the presence of the shear connectors can increase the load-carrying capacity. The load performance of the slab is also affected by changing the profiled steel sheeting thickness.

Abbas *et al.* [52] performed experimentally on the corrugated steel-concrete composite slab to develop a new scale test method by using two lines of shear connectors welded onto the corrugated plate and lateral beam, to increase the shear bond resistance of a composite slab. The expected result was achieved maximum capacity and slippage capacity amounted to 120 kN and 3.5 mm, respectively. Experimental results show that the composite slab has high ductility and that the end slip is minimal compared to the composite slab without shear connection.

Seraji *et al.* [53] determined the capability of the profiled steel sheet dry board (PSSDB) system to develop the compressive membrane action (CMA) in the floor. The development of the CMA inside the floor is strictly associated with the horizontal movement of the slab end under the vertical loading. Therefore, the simply supported PSSDB floor was tested under vertical uniformly distributed load. The study of results revealed that the recorded horizontal movement at the roller support of the slab is 0.81 mm in the pin-roller supported case. These prove that the PSSDB floor has the potential to develop the CMA under the pin-pin support condition.

Based on m-k method, the total longitudinal shear resistance capacity for a composite slab (V_t) consisting of the shear resistance for concrete core (V_{ts}) and shear resistance due to bending (V_{tb}) as follows:

$$V_t = V_{tb} + V_{ts} \tag{8}$$

Shear resistance for the concrete core is assumed to be equal to:

$$V_{ts} = \tau_c \cdot b \cdot d_p \tag{9}$$

Concrete shear strength is typically estimated as a function of $\sqrt{f_c'}$, so Eq. (9) can be rewritten as:

$$V_{ts} = k\sqrt{f_c'}b \cdot d_p \tag{10}$$

where k is the concrete shear constant, and d_p is effective depth. The shear resistant V_{tb} is calculated depending on the flexural moment capacity of the profile sheet as follows:

$$+M_u = V_{tb} \cdot l_s \tag{11}$$

After yielding of the composite deck slab, the failure is dominated by plastic theory:

$$+M_u = [As_{sheet} \cdot f_{ys}]z \tag{12}$$

whereAs_{sheet} and f_{ys} are the total cross-section area and the yield strength of profiled steel sheet respectively, while z is the internal moment arm. Substituting Eq. 12 into Eq. 11 and yields V_{tb}:

$$V_{tb} = m\frac{As_{sheet}}{l_s}d_p$$

OR

$$\frac{V_{tb}}{b \times d_p} = m \frac{As_{sheet}}{l_s \times b} \tag{13}$$

Where *m* is the contributing factor for both yielding profile steel sheet f_{ys} and internal moment arm coefficient α. Substituting Eqs. 13 and 10 into Eq. 1 leads to:

$$V_t = m \frac{As_{sheet}}{l_s} d_p + k\sqrt{f'_c} b \cdot d_p \tag{14}$$

$$\frac{\varphi V_{tb}}{b \cdot d_p} \le m \frac{As_{sheet}}{l_s \times b} + k\sqrt{f'_c} \tag{15}$$

Eq. 15 summarizes the total longitudinal shear resistance capacity for a composite slab. The value of f_{ys} is kept constant for the entire series of test, and it does not have any influence on longitudinal shear failure. 'ϕ' is resisting factor for shear. Ahmed *et al.* [54] investigated the steel-concrete composite slabs that subjected to symmetrical double line loads and the prediction of longitudinal shear resistance capacity that evaluated using the shear bond mechanism or m-k procedure. Based on the experimental measurements, a new simplification from m-k curves to yields the equation 'y= λ x+q' and prove this equation combinatorial to assess the λ -q (modified m-k) effectiveness for longitudinal shear strength using effective depth-shear span ratio (d_p/ls).

Based on the PSC method, the partial shear connection diagram is determined by varying the degree of shear connection (ŋ). Where 0 (no longitudinal shear forces are transmitted by any means) and 1 (a full connection between steel and concrete forming a composite slab acting as one entity). For each degree of shear connecting, a compressive normal force in the concrete flange $N_c = \eta N_{c,f}$ is calculated. For a full shear connection, the compressive normal force in the concrete flange $N_{c,f}$ is equal to the plastic resistance of the profiled steel sheeting N_p and can be determined using Eq. 16.

$$N_{cf} = N_p = A_{pe} f_{yp} \tag{16}$$

where A_{pe} is the effective cross-sectional area of the profiled steel sheeting, f_{yp} is the yield strength of the profiled steel sheeting. For each N_c, a corresponding reduced plastic resistance moment of the profiled steel sheeting M_{pr}, Eq. 17, and a distance between the neutral axis and the extreme fiber of the concrete slab in compression x, Eq. 18, can be calculated. The matching lever arm z between N_c and N_p is given by Eq. 19.

$$M_{pr} = 1.25 M_{pa}\left(1 - \frac{N_c}{N_{c,f}}\right) < M_{pa} \tag{17}$$

where M_{pa} is the design value of the plastic resistance moment of the effective cross-section of the profiled steel sheeting.

$$x = \frac{N_c}{f_{cm} b} \tag{18}$$

where f_{cm} is the mean value of the measured cylindrical compressive strength of concrete, b is the width of the slab.

$$z = h_t - 0.5x - e_p + (e_p - e)\eta \tag{19}$$

where h_t is the overall thickness of the test specimen, *e* is the distance from the centroid axis of profiled steel sheeting to the extreme fiber of the composite slab in tension, e_p is the distance from the plastic neutral axis of profiled steel sheeting to the excessive fiber of the composite slab in tension.

Subsequently, M_{test}, the maximum experimental bending moment, and $M_{pl,Rm}$, the plastic resistance moment of the composite section with full shear connection, can be calculated using Eqs. 21 and 22, respectively, in which the contribution of the mesh is neglected. The distance between the plastic neutral axis and the extreme fiber of the concrete slab in compression x_{pl}can be determined using Eq. 23.

$$M_{pl,Rm} = N_{c,f}\left(h - e - 0.5x_{pl}\right) \tag{20}$$

$$x_{pl} = \frac{N_{c,f}}{f_{cm}b} \tag{21}$$

$$M_{test} = M_{pr} + N_c z \tag{22}$$

Using Eqs. 21 and 22, the ratio $M_{tes\ t}/M_{pl,Rm}$ can be calculated for each degree of shear connection g, and subsequently be plotted against it. After calculating the ratio $M_{test}/M_{pl,Rm}$ for each test, with $M_{test} = F_{max}L_s/2$ and $M_{pl,Rm}$ determined by Eq. 22. The corresponding longitudinal shear resistance is calculated using Eq. 24 when excluding the effect of friction at the supports or Eq. 25 when the effect of friction at the supports is considered. The friction coefficient l should be taken as 0.5 as recommended in Eurocode 4, Annex B.3 [55].

$$\tau_u = \frac{\eta N_{c,f}}{b\left(L_s + L_0\right)} \tag{23}$$

$$\tau_u = \frac{\eta N_{c,f} - \mu V_t}{b\left(L_s + L_0\right)} \tag{24}$$

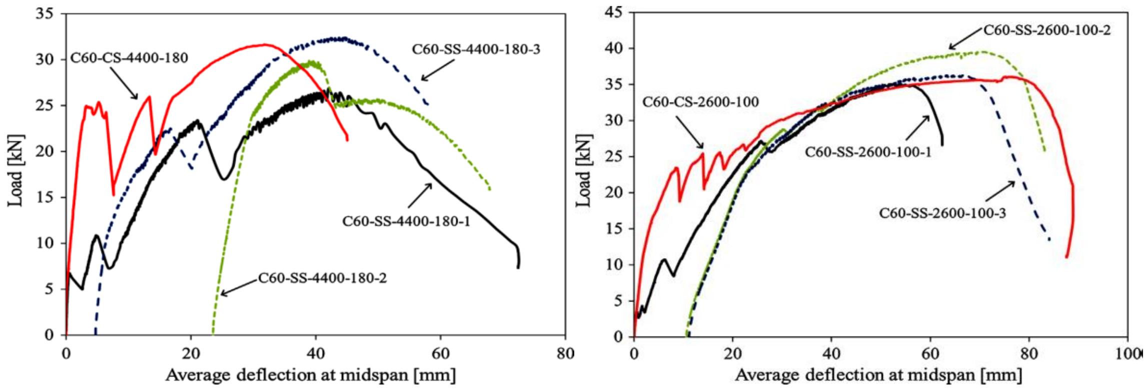
Where V_t is the support reaction at the ultimate test load, equal to $F_{max}/2$, L_s is the length of the shear span, L_o is the length of the overhang (100mm for all slabs).

Li *et al.* [56] examined a new type of composite slab produced using both lightweight aggregate concrete and polymer fiber reinforced lightweight aggregate concrete with a closed-type (non-embossed dovetailed) steel sheeting profile (LFRCS). A total of 12 simply supported specimens were tested to investigate the structural behavior of the new composite slab with special emphasis on the lamination thickness. It was observed that plane cross-sections remain plane in LFRCSs, but the longitudinal shear bond strength dominates the failure mode regardless of lamination thicknesses. Besides, rational modifications and relevant formulas of linear regression methods and PSC based methods have been proposed. Results predicted using the proposed analytical techniques were compared to those obtained experimentally, and the comparison showed good agreement.

Lauwens *et al.* [57, 58] examined the longitudinal shear resistance of stainless steel composite slabs through an experimental study. One short and three long-span slabs, made using a Cofraplus 60 ferritic EN1.4003 stainless steel corrugated deck. The Partial Shear Connection (PSC) method is used to assess the longitudinal shear resistance.

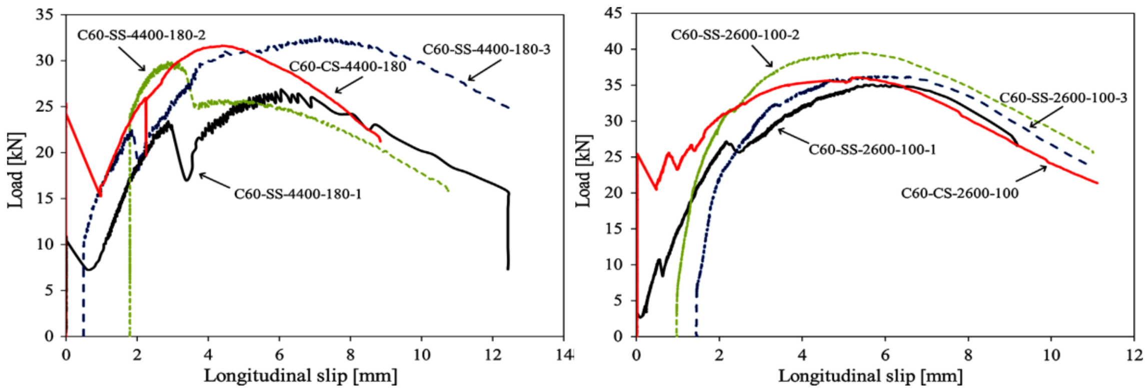
Ferrer *et al.* [59] developed an innovative of full-connection bonding technology consisting of producing bands of many small crown-shaped cuttings in the profile webs as a replacement for the embossments. Three specimens of the same type have been tested according to the static and cyclic loading procedure as stated in standards [55, 60]. The cyclic loading of specimens consists of 5000 cycles between 20% and 60% of the strength of specimen that tested under monotonic loading. The results of the investigation show that full connection is achieved with the new system, such as yielding both materials that occurs without any slip, in contrast to the partial connection of traditional embossments. The longitudinal shear strengths are 1.4-7 times higher. The specimens tested include the use of conventional galvanized steel and concrete, as well as ferritic stainless steel and lightweight aggregate concrete.

Arrayago *et al.* [61] carried out cyclic testing on composite slabs made from EN1.4003 ferritic stainless steel and ordinary C25/30 concrete in two series of span lengths to determine the different parameters defining their ultimate longitudinal shear response. Cyclic loading was applied for 5000 cycles following a sinusoidal signal (0.5 Hz). The average deflections of the mid-span section for long and short span are plotted in Figure 7, whereas Figure 8 shows the load-longitudinal slip curves for the same specimens. In both figures, cyclic residual deflections and slips have been included.



(a) (b)

Figure 7: Load mid-span deflection curves for (a) long span (b) short span slab tests (cycling residual deflections included)



(a) (b)

Figure 8: Load-slip curves for (a) long span (b) short span slab tests (cycling residual deflections included)

Li *et al.* [62] studied on a new type of composite slab produced from lightweight aggregate concrete and closed profiled steel sheeting (LCCS). A total of 11 simply supported specimens were tested to investigate the structural behavior of this new type of composite slab with special emphasis on their failure modes. The ultimate carrying capacity and the shear bond stress predicted using the slenderness method and force equilibrium method showed very good agreement with test results. PSC composite beam method may underestimate the longitudinal shear bond strength, but still can be used as an optional method.

Mohammed *et al.* [63] analyzed the longitudinal shear resistance of PVA-ECC composite slabs. Two groups of full-scale composite slabs were prepared, cast, and tested until they attained the failure point. Test results have been analyzed and the longitudinal shear bond strength has been computed.

Besides, comparison with other types of composite slabs using the same profiled steel sheeting was also carried out. The longitudinal shear bond strength was found to be 0.46 MPa and 0.387 MPa using m–k and PSC, respectively, with a difference of 15.87%. The results showed that the failure modes of the PVA-ECC composite slabs are ductile with enhanced load carrying capacity. Therefore, the use of PVA-ECC composite slabs in the construction industry would consider a better economic solution.

Cifuentes and Medina [64] generated experiment to investigate the shear-bond behavior of composite slabs and to analyze the longitudinal shear strength of composite slabs. The m-k and partial shear connection methods were analyzed. This involved testing 30 composite slabs with two different types of profiled steel sheeting with up to three different thicknesses were considered. The study assessed the influence of the previous cyclic load and the placement of crack inducers on the longitudinal shear strength.

Hedaoo *et al.* [65] focused on the structural behavior of composite concrete slabs by experimental and analytical studies. A full-size experimental test has been carried out to investigate the shear bond strength under the bending test. Eighteen specimens are split into six sets of three samples each in which all sets are tested for different shear span lengths under static and cyclic loadings on simply supported slabs. The longitudinal shear bond strength between the concrete and steel deck is evaluated and compared. The experimental results are verified and compared with the results of both m-k and PSC methods. A comparison of experimental and analytical results of the load-carrying capacity of composite slabs revealed that agreements between these values are sufficiently good. As a result, the m-k method proved to be more conservative than the PSC method.

Mohammed *et al.* [66] performed an analytical and experimental study on composite slabs utilizing palm oil clinker concrete. A total of eight full-scale composite slabs, six palm oil clinker concrete (POCC) slabs and two conventional concrete slabs were constructed and tested in accordance to Eurocode 4: Part 1.1 [55] and BS 5950: Part 4: 1994 [67]. The structural behavior of the slabs was investigated and compared. Test results show that the structural behavior and the horizontal shear-bond strength of the POCC slabs are nearly similar to the conventional concrete slabs. The mechanical interlock (m) and the friction (k) between the steel and the concrete are 117.67 N/mm^2 and 0.0973N/mm^2, respectively, and the design horizontal shear-bond strength using m-k and PSC methods is 0.248 N/mm^2 and 0.215 N/mm^2, respectively. The difference between the two methods is 13.3%. POCC is, therefore, suitable to be used for structural applications with a reduction in weight of 18.3% compared to conventional concrete composite slabs.

Petkevicius andValivonis [68] determined the strength of composite steel-concrete slabs. For two slabs the layer of concrete was reinforced with steel fiber whereas the rest of them were not. Slabs were tested under static short-time load. The method for the strength analysis of the horizontal section in composite slabs is based on the built-up bars theory. Experimental investigations were performed for the determination of the shear characteristic for the bond between the steel sheeting and the concrete layer. Therefore, the specimens were made of the same concrete mixture as that of the slabs. Theoretical analysis of the horizontal section for the composite slabs was made. Quite a good agreement between theoretical and experimental results is obtained.

Jeong [69] deals with a simplified model to predict the partial-interactive behavior of steel-concrete composite slabs. A series of nonlinear partial-interaction analyses with various degrees of interaction and shear span ratios are conducted to formulate the partial-interactive problem. Through the statistical analysis of these data, a simplified model for the partial-interactive structural performance is proposed. The test program verifies the proposed model. A simplified model based on a partial-interaction analysis is a powerful tool to predict the partial-interactive structural behavior of composite members.

Marimuthu *et al.* [70] investigated the shear bond behavior of the embossed composite deck slab under simulated imposed loads and to evaluate the m–k values. Totally 18 composite slab specimens were cast using M20 grade concrete. The 18 numbers of samples were split into six sets of three samples each in which three sets were tested for shorter shear span loading and the other three sets for longer shear span loading. Vainiunas *et al.* [71] examined the strength of the horizontal section in 6 fragments of the composite slab with 'Holorib' type profiled steel sheeting. Theoretical calculations for the strength of a horizontal section of experimental slabs were made in this investigation. Experimental and theoretical results of the strength of horizontal section in composite slabs were compared. A comparison of the results revealed that their agreement was sufficiently good.

Marciukaitis *et al.* [72] studied the deflections of composite slabs. Experimental investigations were performed on deflections of composite slabs with a Holorib type of profiled sheeting. Variations in experimental deflections of slabs were explored from the beginning of loading up to the ultimate moment. Theoretical calculations of deflections for the experimental slabs were made. Calculations were performed according to the theory of built-up bars. A comparison of experimental and theoretical values of deflections revealed that agreement between these values was sufficiently good at all stages of the slab's behavior.

Chen [73] carried out experiments to identify the shear-bond action in composite slabs. Seven simply supported one-span composite slabs and two continuous composite slabs were tested. The slabs with end anchorage of steel shear connectors were found to bear a higher shear-bond strength than that of slabs without end anchorage. The shear-bond strength was calibrated based on a linear regression of the test results of the one-span composite slabs with end anchorage. The prediction of the shear-bond resistance was also found in close agreement with the vertical shear force at the onset of the initial shear-bond slip in the two-span continuous composite slabs.

Lee *et al.* [74] studied the behavior of cold-formed steel deck and concrete composite slab under a hogging moment. An experimental programmed was performed using ten specimens of different thicknesses and reinforcement ratios. The negative moment capacity of each slab predicted using a simple analytical model was compared with that obtained from the experiment. The experimental results indicate that the steel deck contributes to the hogging moment capacity and this region exhibited a fair amount of ductility, which can be utilized for moment redistribution.

Rios *et al.* [75] analyzed the numerical model by comparison with the available experimental results of two different types of composite slabs previously tested to the m-k. To extend the validity of the numerical model for the usual design case of uniform loads with a non-constant longitudinal shear force acting on the slabs, a new set of composite slab specimens were subjected to six-point bending tests. The results confirm the validity of the model and its simplicity concerning other available models since only two values of the interface τ-s law are necessary to describe the whole behavior of the slab. Additionally, an interpolation method was applied to obtain the τ-s values in the steel-concrete interface for composite slabs with the same steel deck but different geometry and unknown shear-bond behavior.

Gholamhoseini *et al.* [76] presented the results of the short term testing up to the failure of four types of profiled decking that are widely used in Australia. Full-scale, simply-supported slab specimens were tested in four-point bending with shear spans of either span/4 or span/6. The bond-slip relationship of each slab was determined during the testing and the values of maximum longitudinal shear stress calculated using different methods are described and compared. A finite element model is proposed and verified by experimental data using an interface element to model the bond properties between steel decking and concrete slab and investigate the ultimate strength of composite slabs.

Tzaros *et al.* [77] constructed a numerical model based on nonconvex–nonsmooth optimization for the simulation of bending tests on composite slabs. For the modeling of the shear bonding, a nonmonotone law involving vertical and softening branches is used. However, this complex shape of the shear bonding law leads to a hemivariational inequality mathematical formulation. For its numerical treatment, a numerical procedure is presented that uses tools from the theory of nonconvex–nonsmooth energy optimization. The results obtained by the proposed methodology are compared with those obtained by experimental testing. It is found that the numerical results are in good agreement with the corresponding experimental ones.

Pereira and Simoes[78] determined the contribution of steel sheeting to the vertical shear capacity of composite slabs. The results of an experimental programmed, comprising four experimental tests on short-span steel-concrete composite slabs. To induce a failure by vertical shear, the composite slabs tested were provided with a longitudinal shear reinforcement system composed of transversal bars crossing longitudinal stiffeners placed along the upper flange of the steel sheets. The experimental and numerical results showed quite conservative as it underestimates the relevant contribution of the resistance of the profiled steel sheeting to the slabs vertical shear capacity (see Figure 9).

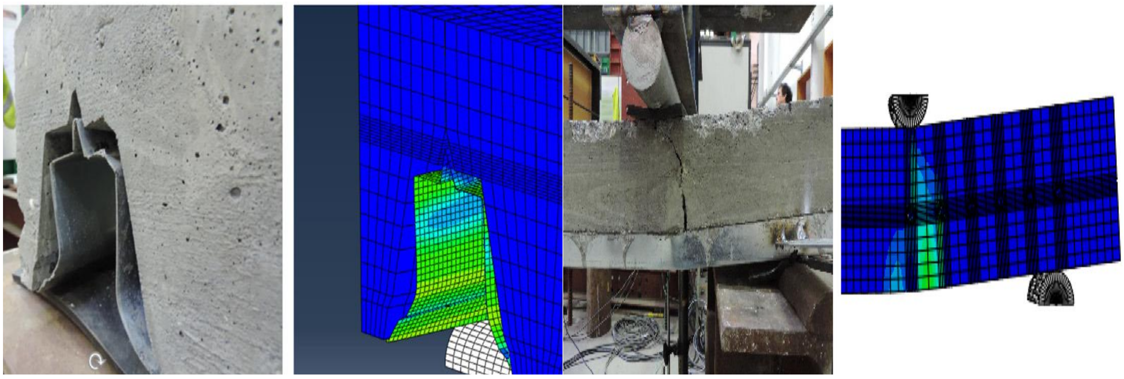


Figure 9: Comparison between numerical and experimental results of end slip and crack pattern

Husain *et al.* [79] developed the finite element modeling of the ultimate load behavior of double skin composite (DSC) slabs. In a DSC slab, shear connectors in the form of nut bolt technique studs are used to transfer shear between the outer skin made of steel plates and the concrete core. The current study is based on finite element analysis using ANSYS Version 11 APDL release computer program. The close agreement has been observed between the finite element and experimental results for ultimate loads and load-deflection responses. The finite element model was thus found to be capable of predicting the behavior of DSC slabs accurately.

Table 2: Previous study on composite slab system with infill material.

Ref.	**Materials composition**			**Interaction type**	**Loading type**	**Parameter studied**	**Remarks**
	Steel sheet	**Dry board**	**Infill**				
[37]	Thin-walled steel skeleton	-	Post-pouring concrete	-	Static	Constraint conditions.	The composite slab has a better entirety and higher bearing capacity.
[38]	Trapezoidal	-	Normal weight concrete	-	Static	Type and thickness of the steel	Deflections and end slip were sufficiently

						sheet.	good at all stages of the behavior of the slab.
[39]	Hot rolled Grade 37A	-	Normal weight concrete	Bar, plate, and bolts	Static	Steel sheet thickness and shear connector type.	Steel-concrete-steel slabs have excellent flexural characteristics.
[40,27]	Peva 50	Prima*flex*	Normal weight and geopolymer concrete	Self-drilling and self-tapping	Static	Board size and infill type.	Stiffness increases, and deflection decreased when 12M GPCHB was used in the panel.
[41]	Peva 50	Prima*flex*	Normal weight and geopolymer concrete	Self-drilling and self-tapping	Static	Infill type.	The panel that filled with the geopolymer concrete is 25% stronger than the normal concrete-filled panel.
[42]	W-deck trapezoidal	-	Commercially pre-mixed concrete	Shear studs	Static	Fiber type.	Slab containing SL62 welded wire mesh provided significant improvements in the slip, peak, and service load.
[43]	Cold-formed	EPS board	Composite cement mortar	Self-drilling screws	Static	Presence or absence of the dry board.	Compare with the theoretical and numerical study.
[44]	Peva 50	Prima*flex*	Lightweight Expanded Polystyrene (EPS) concrete	Self-tapping and self-drilling screws	Static	Steel sheet thickness, dry board thickness, and steel plate thickness.	Steel plate (SP) can enhance the stiffness and strength of the PSSDB system.
[45]	P3623 and P2432 with embossment	-	Engineered Cementitious Composite (ECC) and Self-Consolidating (SCC)	Stud	Static	Steel sheet type, infill type, shear span length, and presence or absence of stud connectors.	ECC composite slabs have superior performance in terms of strength, ductility, energy-absorbing capacity and

			concrete				shear bond resistance.
[46]	P3623 and P2432 with embossment	-	Engineered Cementitious Composite (ECC) and Self-Consolidating (SCC) concrete	-	Static	Steel sheet type, infill types, and shear span length.	FE model slabs were found to be in good agreement with those obtained from experimental counterparts.
[27]	Peva 50	Prima*flex*	Normal weight and geopolymer concrete	Self-drilling and self-tapping screws	Static	Infill type and board size.	FE model successfully predicts the behavior of the FBGPC model with 94.8% accuracy.
[25]	Peva 45	Prima*flex*	Normal weight concrete	Self-drilling and self-tapping screws	Static	Steel sheet type.	The compressive membrane action enhanced the stiffness of the slab at the serviceability load by about 240%.
[47]	Cofraplus 60	-	Normal weight concrete	-	Static	Type and arrangement of loading.	Compare with the numerical study.
[48]	T-shaped ribs	-	Reinforced concrete	-	Static	Slab thickness, presence or absence of voids, and tension reinforcement ratio.	A combination of flexure and shear dominated the behavior of both voided and TUBEDECK slabs.
[49]	Cold-formed	-	Normal dense and lightweight concrete	-	Static	Steel sheet type and infill type.	Longitudinal shear resistance of lightweight concrete is less than normal dense concrete.
[50]	Undercut profile with additional embossment	-	Lightweight concrete	-	Static and cyclic	Shear spans, type, and thickness of the steel sheet.	Dense lightweight woodchip concrete can transfer sufficient longitudinal shear forces to

							the composite joint.
[51]	Trapezoidal with embossment	-	Normal weight concrete	Self-drilling screws and cold-formed members	Static	Steel sheet thickness and type, length, and spacing of shear connector.	Load carrying capacity increased by changing the profiled steel sheeting thickness and the presence of shear connectors.
[52]	Corrugated	-	Ready-mix concrete	Bolts	Static	Two lines of connectors.	The composite slab has high ductility, and that the end slip is very small.
[53]	Peva 45	Prima*flex*	Normal weight concrete	Self-tapping and self-drilling screws	Static	Support condition.	PSSDB floor has the potential to develop the CMA under the pin-pin support condition.
[54]	Corrugated	-	Reinforced concrete	Bolts	Static	Shear span length.	Compare with theoretical study.
[56]	Closed-type (non-embossed dovetailed)	-	Lightweight aggregate and polymer fiber reinforced lightweight aggregate concrete	-	Static	Steel sheet thickness, infill type, thickness, and length of lamination and end connection conditions.	Compare with theoretical study.
[57,58]	Cofraplus 60	-	Normal weight concrete	-	Static	Shear span length.	Stainless steel corrugated sheet and the concrete behave as a single structural component.
[59]	A80, C60, and W60	-	Normal weight and lightweight concrete	-	Static and cyclic	Steel sheet type, span length, bonding type, and loading type.	Longitudinal shear strengths are 1.4-7 times higher.
[61]	Trapezoidal Cofraplus 60	-	Normal weight concrete	-	Static and cyclic	Span length and loading type.	Compare with theoretical study.

[62]	YX66	-	Shale ceramisite lightweight aggregate concrete	-	Static	Steel sheet thickness, span length, and slab thickness.	Compare with theoretical study.
[63]	Profiled	-	Normal weight and Engineered cementitious composite (ECC)	-	Static	Infill type and shear span length,	PVA-ECC composite slabs are ductile with enhanced load carrying capacity.
[64]	MT60 and MT100	-	Ready-mix concrete	-	Cyclic	Type and thickness of steel sheet and shear span length.	Compare with theoretical study.
[65]	Trapezoidal	-	Normal weight concrete	-	Static and cyclic	Shear span length.	The load-carrying capacity of composite slabs revealed sufficiently good agreements.
[66]	Bondek II	-	Palm oil clinker (POCC) and conventional concrete	-	Static	Infill type and shear span length.	Structural behavior and horizontal shear-bond strength are nearly similar to conventional concrete slabs.
[68]	Holorib	-	Normal weight concrete	-	Static	Presence or absence of reinforcement.	Compare with theoretical study.
[69]	Profiled		Normal weight concrete	Stud	Static	Degrees of interaction and shear span length.	A simplified model based on a partial-interaction analysis is a powerful tool to predict the partial-interactive structural behavior.
[70]	Embossed	-	Normal weight concrete	-	Static	Shear span length.	Compare with theoretical study.

[71,72]	Holorib	-	Normal weight concrete	-	Static	Concrete layer thickness and concrete strength.	Compare with theoretical study.
[73]	3W-deck	-	Normal weight concrete	-	Static	Steel sheet thickness, span slab, and different end restraints.	Slabs with end anchorage of steel shear connectors were bear a higher shear-bond strength.
[74]	Bondek II	-	Normal weight concrete	-	Static	Steel sheet thickness and reinforcement ratio.	Compare with theoretical study.
[75]	MT-60 and MT-100	-	Normal weight concrete	-	Static	Type and thickness of steel sheet, span, and shear span length.	Compare with the theoretical and numerical study.
[76]	Re-entrant and trapezoidal	-	Normal weight concrete	-	Static	Steel sheet type and shear span length.	Compare with the theoretical and numerical study.
[77]	Symdeck 73	-	Normal weight concrete	-	Static	Shear span length.	Compare with the theoretical and numerical study.
[78]	LAMI 60+ and LAMI 120+	-	Normal weight concrete	-	Static	Steel sheet type.	FE model underestimates the resistance of the profiled steel sheeting to the vertical shear capacity.
[79]	Flat	-	Normal weight concrete	Nut bolt	Static	Slab element.	FE model was capable to predict the behavior of DSC slabs accurately.

3. Conclusion

A review of each previous research work was presented and summarized in paragraph form, and data collected in the past years were classified and summaries in Table 1 and 2. The studies were classified based on the variation in material composition, interaction type, loading type and parameter study. Out of the 53 reviews, eight investigated the performance of steel composite slab systems without infill materials when subjected to vertical loading and the rest was investigated the performance of steel composite slab systems with infill material. A stacked column chart generated to provide a clear presentation about the number of studies for each kind of steel composite slab system classified in the study as presented in Figure 10.

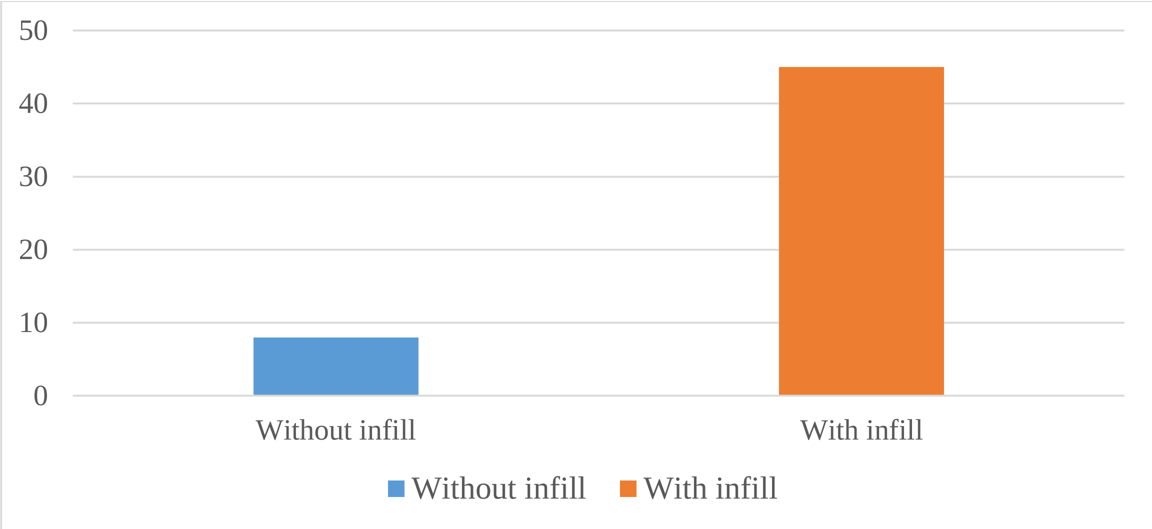


Figure 10: The number of research studies for each type of composite slabs subjected to vertical loading

Based on early research studies, steel composite slab without infill tested when subjected to vertical loading with the total number of eight. The theoretical, experimental and numerical solutions have conducted and proposed by authors to understand the real performance of steel composite slab. The steel composite slab systems without infill materials were comprise of steel sheet and dry board at the top. There are type of steel sheet used such as Bondek II, Peva 45 and cold-formed steel. There are also have type of dry board that used to develop these steel composite slab such as plywood, cemboard, chipboard, bamboo and MDF board. The interaction of this steel composite slab were invstigated used self-drilling and self-tapping screws, adhensive and glue. Mostly, these steel composite slab were tested under static vertical loading. From all these previous research studies of steel composite slab systems without infill material, there are gaps in the type of interaction and type of loading. The self-drilling and self-tapping were provide result of partial interaction and there are limited number were investigated for full interaction. The cyclic loading applied were also has limited number of research compared to static vertical loading.

The steel composite slab with infill tested when subjected to vertical loading with the total number of 45. The theoretical, experimental and numerical solutions have conducted and proposed by authors to understand the real performance of these steel composite slab. The steel composite slab systems with infill materials were comprise of steel sheet, dry board at the top and concrete as infill or steel sheet and concrete as infill and topping. It can see that the gaps in the previous research of steel composite slab system without infill material has been counter back and has been investigated on steel composite slab with infill materials. Some infill materials can act as a structural element in these steel composite slab that can gives more strength to resist the bending or vertical load. But there are some disadvantage for these steel composite slab when fill the slab with concrete. The selfweight has been increase and some of infill can act as non-structural only such as sound proofing, heat resistance and so on. There still has limited number of research to investigated these steel composite slab with cyclic loadings.

The performance of steel composite slab system is well understood. These review revealed that the increment number of the study investigated the performance of engineered cementitious composite as an infill. However, a limited number of studies focused on the strengthening of steel composite slab with embedded materials such as steel or fiber. As a suggestion, more research study about steel composite slab infill using engineered cementitious concrete to provide comprehensive information about this new and a very ductile material that can effectively resist vertical loading compared with normal concrete. Thus, to increase the ultimate load resistance of the steel composite slab system, these study proposes to strengthen the system by embedding it with high-ductility materials.

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