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Recent Improvements in the Longitudinal Shear Resistance in Composite Slabs: A Review

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ABSTRACT

Composite slabs made of profiled steel sheets and concrete topping are considered the most frequent floor solution in composite building construction. The key benefits of this structural system are thought to be the increased speed of construction, traditional replaceable shuttering removal, and reduction in the number of props needed. According to Eurocode 4, bending, longitudinal shear, and vertical shear resistances are considered the main parameters to define the composite slab capacity. In general, longitudinal shear resistance is considered the most conditioning parameter for composite slabs. Composite slabs are considered to have a substantial bending capacity due to the profiled steel sheet contribution. Therefore, longitudinal shear resistance must be improved to provide a high degree of connection, allowing the composite slabs to attain their full bending capacity. Over the past decades, many researchers have attempted to propose new methods to improve the longitudinal shear capacity. These improvements can be categorized into three categories. Improvements by proposing new types of concrete to increase the bending capacity of the concrete topping, improvements by proposing new types of end-anchorage, and enhancements by proposing shear connectors placed along the span of the composite slabs. In this paper, technical literature for the past few years for previous researchers who attempted to improve the longitudinal shear capacity will be presented and reviewed.

Index Terms— Composite slab, longitudinal shear failure, shear connector, end-slip.

I. INTRODUCTION

Composite is a term used to describe two or more materials connected and act monolithically. In civil engineering, the materials used to act monolithically are concrete, steel, FRP, etc. Composite construction combines the structural properties of the materials to produce structural members that are lighter, stronger, and stiffer which can be done by creating a connection between the materials to transfer the shear forces and make them act as one unit [1]. (R. P. Johnson and D. Anderson , 2004) [2] defined the composite slab as a slab system consisting of profiled metal sheet that acts as permanent formwork in the construction stage and tensile reinforcement in the composite stage, and hardened concrete. The steel deck and concrete slab are the main components of the composite slab, which are frequently accompanied by steel mesh on the upper side of the concrete slab part. Profiled steel decking offers numerous advantages such as providing a safe platform to support workers and equipment and protect workers below it from falling objects, increasing the speed of construction as the corrugated profiles act as permanent formwork for the cast in situ concrete, the geometry of the profiled steel sheet can be used to reduce the volume of concrete and thus the overall dead loads and allowing the services to be fitted and distributed inside the depth of the composite slab.

Flexural, vertical shear, bond, or longitudinal slip failure are the three main reasons for a simply supported composite deck to fail. A bond failure causes slippage between the concrete and the metal deck, which might result in the composite action at the interface being canceled. Because of the slip at the steel-concrete interface, the composite slab's behavior is complicated, and the exact nature of the bond between the profiled steel sheet and concrete topping is still unknown. The longitudinal steel-concrete bond varies over the span due to the partial interaction between the profiled steel sheet and concrete caused by the slip [3]. The three basic failure modes for composite deck design are flexure, vertical shear at the support, and longitudinal shear between the steel and concrete [4].

Longitudinal shear failure is considered the most common type of failure that occurs in composite slabs. It occurs when the applied loads exceed the longitudinal shear resistance at the interface between the corrugated steel sheet and concrete. It is controlled by the shear bond capacity and the type of shear connection at the steel-concrete interface. This type of failure can be recognized by a diagonal crack that develops near or under the concentrated load and is followed by an end slip between the corrugated steel sheet and concrete within the shear span. In a composite slab system, it's essential to provide enough bond between the profiled metal sheet and hardened concrete to act as one unit. even though there is a friction bond between the two parts, this bond will be degraded due to high loads., it's important to use shear connectors to overcome the bond loss and make the two parts acts as one unit. The embossment shear connectors are widely used in the profiled metal deck to provide friction and mechanical interlock between concrete and profiled metal sheet.

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These embossments are in a pattern that is unique to each profile. As a result, each pattern has a different shear bond property. Therefore, it could be considered a disadvantage as every pattern needs tests to examine which leads to an increase in the cost, being not economical and making the analysis complex. As a result, several studies are focusing on improving longitudinal shear resistance at the interface of profiled steel sheets and concrete topping. In this paper, technical literature for previous researchers who attempted to enhance longitudinal shear capacity during the last few years will be presented and reviewed. The literature will be categorized into three categories. Improvements by proposing new types of end-anchorage, enhancements by proposing shear connectors placed along the span of the composite slabs, and improvements by proposing new types of concrete to increase the bending capacity of the concrete topping.

II. END-ANCHORAGE SHEAR CONNECTORS

To investigate the influence of end anchorage on ultimate load capacities and failure modes, [5] conducted a series of experiments on both solid and profiled composite slabs. According to the test results, end anchorage has a significant effect on the ultimate capacity of both solid and composite slabs, regardless of long-term loading conditions. The use of shear connections to link the steel beam and the concrete slab makes advantage of each component's best attributes. End anchorages, in combination with other shear transfer mechanisms, influence the strength, stiffness, and ductility of composite slabs. Although the slip between the two materials was reduced, the composite slab only had a partial connection and failed before reaching its maximum bending capacity.
(A. Fonseca, B. Marques, and R. Simões, 2015) [6] conducted an experimental program on composite slabs to increase the longitudinal shear resistance by using bars as an end-anchorage placed in the transverse direction crossing the corrugated steel sheet through the middle height of its webs at the supports as shown in Fig.1. According to the authors, this system can behave the same as an end-anchorage device made from welded studs. The experimental program consisted of two parts, one is small-scale specimens used to develop the equation required to determine the resistance of the new system, and full-scale simply supported specimens used to evaluate the new system's influence on the composite slabs. In the second part, eight composite slabs with or without transversal bars in the support cross-sections and longitudinal bars on the concrete ribs were tested with a four-point bending test. The bearing of the steel sheeting was found to be the controlled condition of the failure mode of the specimens equipped with the end anchorage system, as illustrated in Fig.2. The proposed alternative end anchorage system enhanced the slab's capacity and ductility. However, this system is hard to apply on-site which makes it the main disadvantage of the proposed system.

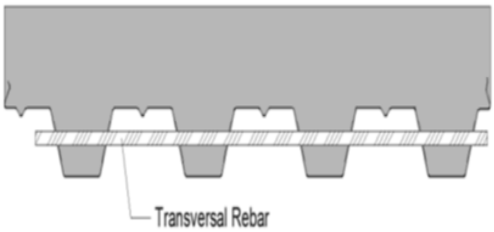

Fig.1 The proposed end-anchorage system

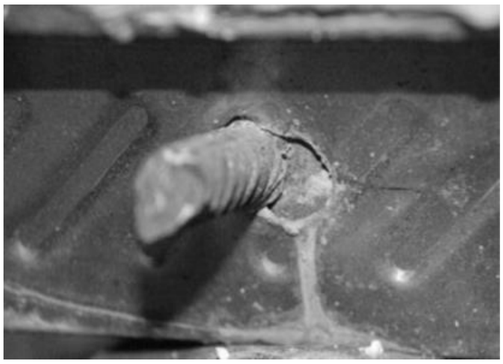

Fig.2 Bearing of the profiled steel sheet

(H. H. Eltobgy, K. M. M. Abdelkareem, and M. M. Bakhoum , 2021) [7] presented an experimental investigation to improve the shear bond capacity by inserting shear connectors between the composite deck slab and the supporting steel beam. A total of 24 specimens of composite slabs in full scale were prepared. The specimens were then tested with a four-point bending test. All specimens were grouped into two categories, with or without shear connectors. In each group, different configurations were considered, such as profiled steel sheet type and shear spans. The shear connector used as shown in Fig.3 was a channel shear connector named UPN100 and used to connect the profiled steel sheet,

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concrete topping, and the supporting steel beam. The results of the test revealed that all specimens were failed with shear bond failure. Composite slabs with shear connectors, on the other hand, exhibited ductile behavior and higher concrete and steel strains, which might be attributed to the increased composite action in these specimens.

Fig.3 Channel shear connector

(I. Abbas, A. M. Ibrahim, and T. A. Jassim , 2021) [8] performed an experimental study to see how introducing shear connectors to composite deck slabs with different types of profiled steel sheets affected the results. The behavior and resistance of composite slabs are determined by the development of longitudinal shear resistance. To evaluate the behavior and longitudinal shear resistance of composite slabs, six specimens of composite deck slabs with different types of profiled steel sheets such as triangle, T-shapes, and trapezoidal with dimensions 1850mm x 500mm x 110mm were prepared and tested with a four-point bending test in the presence and absence of shear connectors. Head stud shear connectors were used in this study as end anchorage and longitudinal reinforcements along the span. From the results, it was concluded that the ultimate load capacity of composite slabs with triangle and T shapes was more than composite slabs with trapezoidal shapes because triangle and T shapes increased the interlock between concrete and profile steel sheet. In addition, shear studs connectors increased the composite action between the profiled steel sheet and concrete, and that lead to an increase in horizontal shear resistance but the effect of adding shear connectors to composite slabs with T-shape was negligible due to the shape of ribs act as a shear connector. It can be indicated that adding shear connectors to the composite deck slabs does not influence the failure mode. where all specimens with rectangular and triangle profile shapes failed with longitudinal shear failure.

III. SHEAR CONNECTORS ALONG WITH THE PROFILED SHEET

(K. N. Lakshmikandhan, P. Sivakumar, R. Ravichandran, and S. A. Jayachandran, 2013) [9] investigated the longitudinal shear transfer mechanism at the interface between steel and concrete. The author proposed three schemes of mechanical shear connectors. Shear connector 1 consisted of 8mm diameter and 100mm length bolts staggered perpendicular to the web in opposite webs with 300mm center to center spacing, bolts fastened to profiled steel sheet with nuts. Shear connector 2 consisted of bolts that were inserted at the top flange of the steel sheet, and rebars with an 8mm diameter were placed in the transverse direction via holes in the steel sheet web's middle height. shear connector 3 consisted of rebars with 10mm diameter placed in the transverse direction through holes at the middle height of the steel sheet web, all scheme configurations are shown in Fig.4 (a), (b), and (c). Twelve full-scale composite slabs were constructed, three specimens for control and 3 specimens for each of the shear connectors. All specimens were in simply supported condition and tested with a four-point bending test. The composite deck without shear connectors slipped and failed at the earlier load level because the concrete deck and supporting steel section are not perfectly connected. On the other hand, all proposed schemes developed full interaction with negligible slip. However, the disadvantage of these schemes is that it's hard to apply on-site and the exposed parts of the shear connectors 1 and 2 will suffer from corrosion.

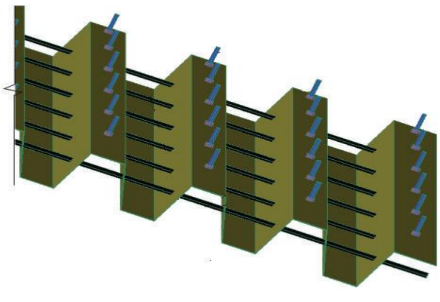

Fig.4 (a) Shear connector scheme 1

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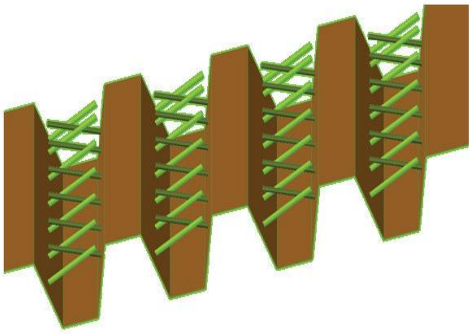

Fig.4 (b) Shear connector scheme 2

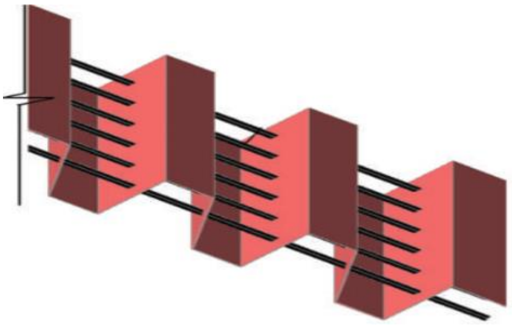

Fig.4 (c) Shear connector scheme 3

(R. P. Johnson and A. J. Shepherd, 2013) [10] tested composite slabs with the addition of reinforcing bars in the longitudinal direction placed above the trough which was utilized to increase the shear bond capacity at the interface of the composite slabs as shown in Fig 5. Nine composite slabs were constructed, 3 specimens without any additional reinforcements, and considered as control specimens. Four of the specimens had one longitudinal bar on each rib supported by transverse bars that rested on the top flange. The last two specimens were similar to the previous specimens but without the transverse bars. All specimens were in simply supported condition and tested with a four-point bending test. Different sizes of rebars were used (10mm,16mm) in diameter. According to the results, using longitudinal rebars increased the bending capacity of composite slabs but without any improvements to the bond capacity between the profiled steel sheet and concrete topping where the failure mode for all specimens was a shear bond failure. The longitudinal bars only improve the bending capacity of the concrete slab but without any improvements to the connection between the profiled steel sheet and concrete slab at the interface.

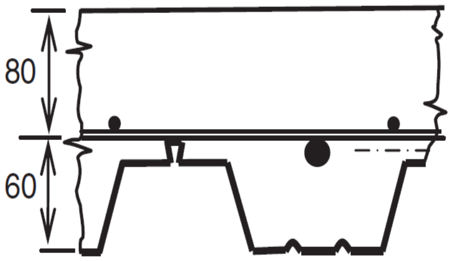

Fig.5 Composite slab cross-section

Shear connectors such as drilling screws and cold-formed members with different shapes (U and C) were proposed by [11] to improve the longitudinal shear interaction at the concrete-profiled steel sheeting interface of the composite slab as shown in Fig.6 (a) and (b). The same shear connection details are used for the push-out test and four-point bending test. Fourteen push-out specimens with varying steel deck thicknesses and shear connector types. In addition, eleven full-scale specimens were created in various configurations. The results of the tests showed that the composite slab's failure mode may be upgraded to ductile, and the inclusion of shear connectors can increase load-carrying capacity, but the longitudinal shear failure is still the failure mode that controlled the behavior of all specimens. Changing the profiled steel sheeting thickness has an impact on the slab's load performance where the ultimate load increased significantly for higher thickness specimens.

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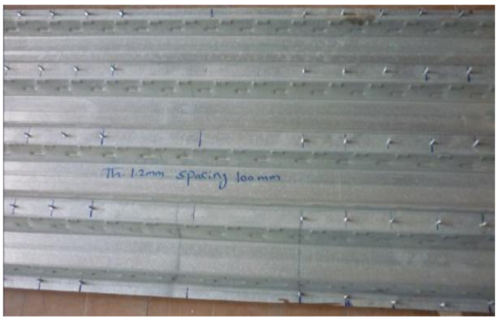

Fig.6 (a) Drilling screws shear connector

Fig.6 (b) Cold-formed members as shear connectors

(H. S. Abbas, 2016) [12] presented a new method for strengthening composite slabs using U-bolt shear connectors and standard headed stud shear connections (HSSC) as shown in Fig.7. Eight Specimens were prepared and tested with a four-point bending test. All specimens have the same dimension with different arrangements of the shear connectors. Control specimens without shear connector, specimens with U-bolt shear connector, specimens with shear studs, and specimens with U-bolts and (one and two) lines of shear studs. The results showed that all specimens failed with longitudinal shear failure except for the samples with U-bolts and two lines of shear studs that showed flexural failure. When compared to composite slabs without shear connectors, the experimental results demonstrated that shear connectors were more efficient at enhancing the stiffness and strength of the composite slab. The U-bolt shear connectors were also found to be strong and ductile enough to increase composite action between the profile steel sheet and the concrete topping.

Fig.7 U-bolts shear connector

(M. Ferrer, F. Marimon, and M. Casafont , 2018) [13] recently unveiled the UPC-System, a unique full-connection bonding mechanism comprising small crown-shaped cutting bands created in the webs of profiled steel sheeting as a replacement for embossments as shown in Fig.8. The authors conducted a four-point bending test on eleven specimens of composite slabs with varied parameters such as profiled steel sheet type and thickness, concrete topping thickness, and slab width. Three distinct commercial trapezoidal profiles, ranging in height from 60 to 80 mm and featuring the UPC-System or embossments on the profile's webs were used. The authors also considered three punching densities in the proposed system (low, medium, and high). The results demonstrated that slabs using the UPC-System were able to maintain a complete connection between the steel sheeting and concrete until the final failure without substantial slippage. The UPC-System also enabled the ultimate load to be increased. However, despite all the advantages that this system could provide, it is considered a noneconomic solution.

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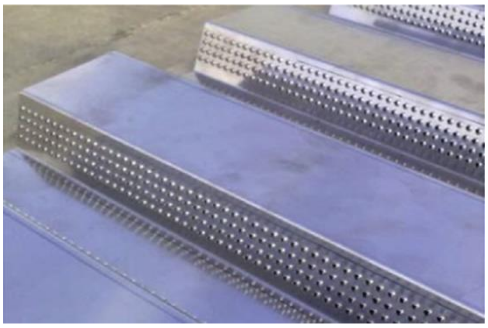

Fig.8 New bond Technology

(R. Simões and M. Pereira, 2020) [14] developed a new reinforcing system for composite slabs that increased the longitudinal shear resistance. A set of reinforcing bars in the transversal direction crosses the stiffeners of the upper flange of the corrugated steel sheet as shown in Fig.9. According to the authors, this type of reinforcement takes advantage of the composite slabs' strong bending resistance and improves the slab's ductility. A small-scale test program was conducted to study the resistance provided by the reinforcing system in detail, and a full-scale test program was conducted to test simply supported and continuous composite slabs to determine the efficiency of the proposed reinforcing system on the slabs' overall behavior. An equation was developed based on the results of the small-scale tests to predict the resistance produced by the proposed reinforcing system. The authors concluded that, by considering the bearing failure at the points where the steel sheet and reinforcing bars are contacted, the proposed system will be more effective when a greater thickness of the steel sheet is used. In addition, utilizing the proposed reinforcing system, the resistance and ductility of composite slabs are greatly increased.

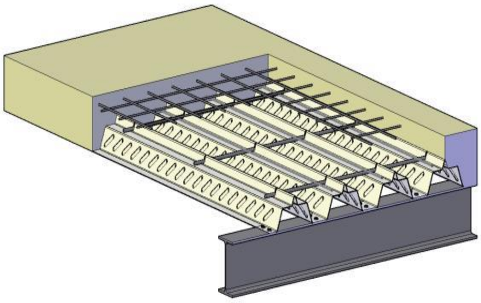

Fig.9 Reinforcing system as a shear connector

IV. BY USING DIFFERENT TYPES OF CONCRETE

(N. Holmes, K. Dunne, and J. O'Donnell, 2014) [15] investigated the longitudinal shear capacity of a new system of composite slabs with profiled steel sheets using recycled shredded car tires in the form of crumb rubber in the concrete mix. The concrete mixes were designed with 0% and 7.5% replacement of fine aggregate for control and crumb rubber specimens respectively. The crumb rubber utilized in this investigation was made from discarded tires that had been shredded into smaller particles ranging in size from 0.425 to 4.75 mm. In this study, two sets of full-scale composite slabs were used with a 130 mm concrete thickness, one with crumb rubber and the other without, each set with two shear spans. The composite slabs had a clear span of 2500 mm and were simply supported. A reduction in the density and compressive strength were found in crumb rubber concrete which is due to the lower density of crumb rubber aggregate. According to the author, CRC slabs have higher mid-span deflections than control slabs due to the high value of modulus of elasticity, higher ductility, and reduced rigidity. Furthermore, when rubber particles were used in concrete, it was found that the particles moved to the upper surface of the specimens following vibration, resulting in non-uniform distribution and early failure at lower stress. Given the hydrophobic nature of crumb rubber particles, one may expect them to congeal and flock together along the top surface following vibration. The longitudinal shear capacity of the crumb rubber composite slabs is comparable to the control specimens and no major improvements in the shear resistance occurred as all specimens had a longitudinal shear failure. This system has the benefits of reducing the environmental impacts of the tire rubber but the shear resistance still needs improvements.

(F. P. A. Rabanal, J. Guerrero-Muñoz, M. Alonso-Martinez, and J. Emartinez-Martinez , 2016) [16] presented an experimental study to better understand composite slab structural behavior. Profiled steel sheets and various types of concrete are used to create these composite slabs. Four different types of concrete were utilized in this research to investigate their structural capacities in composite slabs. Three types of lightweight concrete and normal concrete were utilized. All the lightweight concretes were constructed with a type of expanded clay aggregate called "Arlite," which came in three different densities. Furthermore, 16 composite slab specimens were investigated with two lengths (2610 1120 160 mm and 20301120160 mm) to evaluate structural characteristics between long and short composite slabs. According to the author, when the failure load was achieved, the longitudinal displacement between the profiled steel sheet and the concrete was less than 0.1mm for composite slabs of lightweight concrete. According to Eurocode 4, the shear behavior is considered brittle behavior in this case. Normal concrete composite slabs, on the other hand, behaved differently where the recorded longitudinal displacement at the failure load was greater than 0.1mm, indicating ductile failure. According to the results of the experiments, the failure load of composite slabs comprised of fiber-reinforced lightweight concrete is lowered by 11 to 25% when compared to normal concrete composite slabs. Furthermore, longitudinal shear failure is the primary failure mode of composite slabs made of lightweight concrete and normal weight concrete.

(K. M. A. Hossain, S. Alam, M. S. Anwar, and K. M. Y. Julkarnine, 2016) [3] presented an experimental study to develop and evaluate the performance of new high-performance composite slabs comprised of a new type of green Engineered Cementitious Composites (ECCs). Experiments were conducted to evaluate the proposed system's structural performance during the construction and service phases. Thirty full-scale composite slabs were constructed and tested using a four-point bending test under simply supported conditions. The experiment included two different types of concrete, green (ECC) and self-consolidating concrete (SCC), two different types of profiled steel sheets, with or without shear studs, and five shear spans. PVA fibers with a length of 8 mm and a diameter of 39 m, local mortar sand, fly ash (which substituted cement by 55 percent), cement, and admixtures were used to make ECC. The water-cement ratio used for the mix was 0.27. In addition, SCC was made from cement, silica fume, aggregate with a maximum size of 10 mm, and other selected admixtures. According to the author, the results showed that all specimens failed with longitudinal shear failure without any significant difference in the failure mode between SCC and ECC specimens. Which is accompanied by a slip at the interface between the profiled steel sheet and concrete slab. The failure occurred without reaching the profiled steel sheet yielding point. In addition, when comparing ECC to SCC specimens, the strength gain in terms of moment and shear capacities was larger for ECC specimens. This can be caused by the high capacity ECC to provide better steel-concrete composite action through shear studs and embossments. All composite slabs were ductile based on end slip criteria, and all slabs satisfied Eurocode 4 ductility requirements before the longitudinal shear failure, according to Eurocode 4. ECC composite slabs are more energy-based ductile than SCC composite slabs in general.

(D. K. Aarthi, E. Jeyshankaran, and N. Aranganathan, 2019) [17] conducted an experimental study on using lightweight expanded clay (LECA) and fly ash (FA) aggregates to produce a lightweight composite slab system. The study covers the influence of using lightweight aggregate concrete on the shear bond resistance of the composite slabs system. Four specimens of composite slabs were produced and tested. All specimens were tested with a four-point bending test under simply supported conditions. Two specimens were produced using LECA aggregates and a type 1 profiled steel sheet. The other two specimens were produced using PA aggregates and a type 2 profiled steel sheet. According to the results, all specimens were failed by longitudinal shear failure. Furthermore, the longitudinal shear capacity of the specimens with LECA aggregate and specimens with FA aggregates is shown to be lower than specimens with normal concrete. In Addition, it was found that the new lightweight systems produce less chemical bond with the profiled steel sheet compared to the normal system. Also, the ultimate load-carrying capacity of both systems was found to be reduced.

(J. Lv *et al.*, 2020) [18] conducted an experimental investigation on the flexural behavior of composite slabs consisting of self-compacting rubber lightweight aggregate concrete (SCRLC) and profiled steel sheet. SCRLC mix proportions are designed, with six substitution ratios of rubber particles ranging from 0 to 50%. The author stated that the apparent density, elastic modulus, compressive strength, and splitting tensile strength of SCRLC decreased as the rubber particles replacement ratio in SCRLC increased. When the rubber particle substitution ratio was increased from 0% to 50%, compressive strength, splitting tensile strength, elastic modulus, and apparent density were all reduced by roughly 54.4 %, 46.7 %, 42.2 %, and 14.2 %, respectively, when compared to the control mix (SCLC). As a result, two typical SCRLC mix proportions with rubber particle substitution ratios, (0% and 30%) were chosen to prepare composite slabs for the experimental investigation. Four specimens of composite slabs with different shear spans of 450mm and 800mm and (0% and 30%) substitution ratios of rubber particles are prepared. Four-point bending tests were used to study flexural parameters such as failure modes, deflection at mid-span, profiled steel sheeting, concrete surface stain at mid-span, and end slippage. When compared to composite slabs made of self-compacting lightweight aggregate concrete, the results showed that using SCRLC with 30 percent rubber particle substitution ratios in composite slabs improves anti-cracking performance (SCLC). However, the flexural properties of SCRLC composite slabs revealed that when the rubber particles concentration in SCRLC increases, the yield load, ultimate load, and deflection corresponding to the yield load and ultimate load of composite slabs decrease. The flexural bearing capacity of corresponding composite slabs is less affected by variations in SCRLC strength.

(L. Bai, Y. Li, C. Hou, T. Zhou, and M. Cao, 2021) [19] examined the longitudinal shear behavior of composite slabs made by engineered cementitious composites (ECC) and profiled steel sheets. Eleven specimens of composite slabs comprised of profiled steel sheet and ECC were developed and tested under a four-point bending test to assess the failure modes and longitudinal shear behavior. The main parameters included in this study were the depth of the composite slab, the thickness of the steel sheeting, the shear span ratio, and the arrangement of the shear studs and shear reinforcement.

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The ECC was created using PVA fibers with a diameter of 40 m and a length of 12 mm. The PVA fiber's density, Young's modulus, nominal strength, and elongation were 11.3 g/cm3, 40 GPA, 1600 MPA, and 6%, respectively. As reported by the results, Specimens that included shear reinforcement and end anchorage were reported to have a bending failure. When the load reached (14 % -16 %) of the ultimate load, cracks occurred in the shear span and bending areas and were observed for the first time. No end slips were measured for these specimens when reaching the ultimate load. Ductile shear failure was reported for the specimens that include end anchorage only. The first fine fractures occurred near the loading points when the load reached roughly 10%–38% of the ultimate load, followed by further cracks at the bending area. When the load reached (45 % –80 %) of the ultimate load, end slippages began to develop. The end slippage was extremely significant when the ultimate load was reached, with one of the samples reaching an end slip results of 8.52 mm. Brittle shear failure was reported in specimens without end anchorage or shear reinforcement. The first fine crack formed around the loading point when the load reached 30–55 % of the ultimate load, followed by the formation of subsequent cracks. The end slip of the samples was less than 1mm when the ultimate load was reached. Based on the results, it can be stated that including ECC into a composite slab system has no significant impact on longitudinal shear capacity. In addition, due to the small size of the aggregates, the drying shrinkage of ECC can be critical. It only improves ductility by using PVA fibers.

(K. M. A. Sohel, J. Y. R. Liew, and A. I. Fares, 2021) [20] studied the structural behavior and shear bond capacity of composite slabs made of ultra-lightweight (ULCC) concrete and profiled steel sheets. The density of ULCC was designed to be roughly 1440 kg/m3. Ultra-lightweight fiber reinforced concrete, or ULCC, is a form of ultra-lightweight fiber reinforced concrete. Water, cement, polyvinyl alcohol (PVA), chemical admixtures, cenospheres, and undensified silica fume are the main components of the ULCC's mix. An experimental investigation was conducted to determine the shear bond characteristics of the composite slabs. Eight specimens of composite slabs with different shear spans (short and long) were constructed and tested according to Eurocode 4. Where six specimens were made with ULCC and Two specimens with normal concrete as control specimens for comparison. Composite slabs with ULCC exhibited superior ductility and load-carrying capacity than composite slabs with NWC, according to the results. The shear bond characteristics of ULCC specimens were determined using two Eurocode 4 methods (m-k) and (PSC). The shear bond characteristics of composite slabs with NWC were determined for comparison. When compared to ULCC specimens and NWC specimens, ULCC specimens were found to have an equivalent strength of the shear bond with the profiled steel sheet however the failure mode for all specimens was a longitudinal shear failure. As a result, ULCC can be used effectively in composite slabs with a large self-weight reduction, although the interface bond still has to be improved.

(O. Yi, J. E. Mills, Y. Zhuge, X. Ma, R. J. Gravina, and O. Youssf, 2021) [21] investigated composite slabs made of profiled steel sheet and concrete where the sand was Partially replaced with crumbed rubber particles derived from used tires to form crumb rubber concrete (CRC) and normal concrete composite slabs, both types have the same compressive strength of 25 Mpa. All specimens were tested under a four-point bending test according to Eurocode 4. Different loading schemes and shear spans were applied and tested in this investigation. According to the results, crumbed rubber particles can have a negative impact on the mechanical properties of concrete. However, the absorption of the plastic energy and ductility of CRC have been shown to improve. The thickness of all slabs was 130 mm, with long slabs having a full span of 3400 mm (800 mm shear span) and short slabs having a full span of 1800 mm (400 mm shear span). From the results, it was found that load carrying capacity, end-slippage, interaction with steel, and Overall performance of the CRC composite slabs were comparable to or even better than those of the corresponding normal concrete composite slabs, indicating that CRC might be used as a viable substitute in composite slabs. In addition, it was found that CRC slabs have better longitudinal shear resistance and higher failure loads compared to normal concrete slabs even though the compressive strength of CRC slabs was lower than normal concrete slabs which indicates that the longitudinal shear resistance of the composite slabs, and thus their flexural behavior, is not directly related to the concrete compressive strength.

V. CONCLUSION

For the past few years, many researchers had attempted to improve the bond between the profiled steel sheet and concrete by different proposed methods to make the composite slab attain its full bending capacity. These methods are categorized in this paper into three categories. Improvements by End-anchorage shear connectors, shear connectors along the span, and by proposing new types of concrete.

Most of the previously proposed methods in end-anchorage and shear along with the span categories only improved the partial interaction behavior from brittle to ductile. A limited number of previous researches attained full interaction. However, these methods Either it is uneconomical or impractical.

For concrete type methods, it was found that improving the ductility of the concrete will only improve its bending capacity but without attaining full interaction. For future studies, it is recommended to investigate new types of composite slabs that contain concrete with high bending capacity such as engineered cementitious composites along with a proper shear connector that is considered economic and practical to apply on-site.

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