Jurnal Kejuruteraan 37(1) 2025: 167-177
https://doi.org/10.17576/jkukm-2025-37(1)-11

Enhancing Shear Strength in RC Beams: A Synergistic Approach with Steel Chips and Wire Mesh

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Received 19 March 2024, Received in revised form 21 August 2024
Accepted 21 September 2024, Available online 30 January 2025

ABSTRACT

This study explores a hybrid approach aimed at enhancing the shear performance of reinforced concrete (RC) beams. The methodology involves the incorporation of industrial steel chips having length 75mm to 100mm in combination with varying widths of wire mesh reinforcement. Comprehensive shear tests were conducted on precisely prepared beam specimens measuring 150mm×150mm×900mm to assess shear strength, crack patterns, and failure modes. The study induces steel chips into the concrete mix at a rate of 0.9% by weight and comprises eight sets of specimens, including a control sample without any mesh reinforcement, along-with specimens reinforced with wire mesh strips ranging from 12.5mm to 87.5mm in width. Notably, the inclusion of steel chips and wire mesh enhances the shear behavior of concrete beams across all samples. As the steel chips and wire mesh acts like small-diameter bars, contributing to the enhancement of shear by improving the interlocking of concrete constituents and eff ectively distributing stresses throughout the beam's cross-section, leading to distinctive diagonal crack patterns on the beam surfaces. The study unveils that with the increasing width of the wire mesh, there is an increase in the number of cracks while the crack widths decreases. The test outcome reveals that percentages increase of 13.66, 22.89, 31.37, 46.50, 55.00, 66.80 and 78.60 respectively, demonstrating the eff ective enhancement of shear strength through the utilization of wire mesh and steel chips.

Keywords: Wire mesh; crack pattern; reinforcing material; steel chips; shear strength

INTRODUCTION

Recent advancements in construction materials and production techniques have seen remarkable growth. Among these innovations, the integration of steel fibers into concrete mixtures for diverse applications has gained prominence. Though the use of fibers in construction has a long history, such as the Romans employing straw fibers in clay to strengthen bricks – the development of steel fiber-reinforced concrete only took place in the early 1960s (Gabule 2009). Subsequently, numerous studies have been conducted to assess its performance and discover additional potential applications.

Incorporating steel chips into the concrete mix can prove to be an efficient means of enhancing the shear characteristics of beams. Shear collaps is particularly concerning as it tends to be catastrophic, occurring suddenly. Therefore, it is preferable for a beam to fail in flexure rather than in shear (Gabule 2009). A prevalent challenge for many existing RC beams is the need for repair due to insufficient shear capacity. The deficiencies in shear strength can be attributed to several factors, including the absence of proper shear reinforcement, reduced steel area from corrosion, higher loads, and construction flaws. The use of steel fibers into concrete shows potential for increasing the shear characteristics of concrete beams. Several researches have been done using industrial waste steel chips or wire mesh separately as shear reinforcement in concrete beams with promising results. Although the combination of steel chips and wire-mesh were not implemented. Researchers give this study information separately and have served as references. The abstract of these studies includes:

Werkina (2021) published a work focusing on the use of waste metal steel scrap to enhance concrete strength. The author experimented with with varying of steel scrap percentages (0, 0.5, 0.75, and 1.5%) in relation to the concrete mix's weight. Following extensive testing, it was determined that an increase of 26.8% occurred at 0.5%, while a 30.7% increase was observed at 0.75%, but there was a 5.3% decrease at 1.5%. Similarly, Gabule (2009) explored the utilization of steel-chips to augment the shearing properties of concrete beams. The research aimed to identify specific percentages at which steel chips significantly improved shear strength. The study involved five varying proportions (0, 0.5, 1, 1.5, and 2%) of steel chips to assess their behavior. The results indicated a -14.19% decrease at 0.5%, and -8.99% decrease at 1.5%, and a -13.15% decrease at 2%, but there was a 9.83% increase at 1% of steel fiber. The author also concluded that a single major crack developed into multiple shorter cracks, indicating a redistribution of stress within the central region of the beam.

Moreover, Gabule's research findings suggested that the optimal shear strength can be achieved by incorporating 0.9% steel chips based on the concrete mix's weight (Gabule 2009). Atlaoui et al. (2020) conducted a study focusing on the mechanical behavior assessed through shear testing, where concrete beams were reinforced with fibres derived from machine waste materials. This study encompassed three different fiber contents: 0%, 0.6%, and 0.8%. A comparison of these results demonstrates a significant enhancement in material ductility following concrete cracking due to the incorporation of chip fibers. Furthermore, these fibers effectively reduce the formation of diagonal shear cracks while simultaneously increasing the material's strength and rigidity.

Ghosh et al. (2020) employed wire mesh and steel stirrups of equal weight across different beams. Following the testing phase, it was disclosed that employing wire mesh for shear reinforcement produces better results compared to using stirrups alone. The author explains that the presence of wire mesh notably influenced the distribution of cracks in the beams. Furthermore, wire mesh offers a greater bonding surface area in concrete samples compared to stirrups, resulting in a more number of cracks that are closer together. Seshu-D et al. (2020) used welded wire mesh (WWM) as reinforcement in the core zone of the beams in his study. He positioned the welded wire mesh at intervals of 160 mm, with the intention of conducting shear failure. The author positioned the welded wire mesh (WWM) at 160 mm intervals (intended for shear failure). The beams designed primarily for flexure experienced failure in shear initially, followed by flexure. The author concluded that a mere 3% increase in shear strength was noted. This improved resistance in the shear and diagonal cracks was due to the presence of core zone transverse reinforcement in the form of WWM.

Elavarasi et al. (2019) used stirrups and wire mesh in various combination. The total weight of wire mesh and steel stirrups was set to equivalent. The author concluded in his research that the use of wire mesh effectively enhances bearing capacity and the shear resistance. Furthermore, the beams having combination of stirrups and wire mesh gives more number of cracks than the stirrups. Sunil et al. (2020) employed wire mesh within the cross-section of T-shaped beams. Following the testing outcomes, the authors recommended for the utilization of steel mesh to enhance the shear capacity of concrete beams. The conclusion drawn by the authors suggests that the incorporation of steel mesh significantly boosts shear strength, demonstrating an increase of 50.54% in ultimate load as compared to the control sample. Yuan et al. (2020) examines the shear strength of high-strength concrete (HSC) beams, which were reinforced with either 0.75% hooked steel fibers per volume of the concrete mix or shear stirrups spaced at varying intervals. Through testing and investigation of thes high strength concrete beams incorporating either steel fibers or stirrups, the crack patterns, failure mode, and shear capacity were analyzed. Substituting the minimum shear reinforcement with 0.75% volume of steel fibers in the high-strength concrete beams resulted in a notable increase of approximately 13.2% in shear strength. Moreover, this improvement in the shear strength results in a reduction in the diagonal crack angle of HSC beams when stirrups were not utilized. Al-Rousan (2021) focused was directed towards improving the shear response of heat-damaged and shear-deficient RC beams. By applying wire mesh wraps on both sides, particularly at the 1/3rd sections, aimed to assess the shear performance of concrete beams. The conclusion drawn indicated variations in the behavior of shear cracks formed in the web, and there was a significant rise in load-carrying capacity with an escalation in the layers of wire mesh. The utilization of internally reinforced welded wire mesh (WWM) effectively enhances both the stiffness and shear performance of concrete beams. Al-Bazoon et al. (2022) employed wire mesh in various configurations, including as vertical strips, inclined strips, and U-jacketing, across two different beam types. Among these configurations, the U-shaped jacketing mesh demonstrated the most substantial influence, elevating shear capacity by 33.4% to 95.9% and augmenting the shear ductile index by 23% in comparison to the reference specimen.

Al-Rousan (2021) determined that beams reinforced internally with wire mesh exhibited enhanced load-bearing capacity compared to the control beam samples. Beams with two layers of wire mesh displayed superior performance, presenting the stiffest load-displacement curve. Comparison of results between specimens reinforced with wire mesh and control beams suggests that the mesh increases beam stiffness, increased ultimate deflection, and improved ultimate strength. These enhancements become more prominent as the number of wire mesh layers increases disproportionately.

Recycled steel wires (Aksoylu et al. 2022) were incorporated into reinforced-concrete beams at proportions ranging from 1% to 3% by weight of the concrete mix, with an increment of 1%. The addition of recycled steel wires to the concrete samples at 1%, 2%, and 3% resulted in an increase in compressive strength of the cylinder by 17.2%, 30.8%, and 46.4%, respectively, compared to the control concrete specimen. Similarly, an increment of 14.4%, 25.1%, and 36.7% was observed in tensile strength, respectively. This demonstrates that the rise in fiber content led to an enhancement in both the compressive and tensile strength of concrete. Furthermore, although the presence of fibers in samples with wide stirrup spacing (27 cm) provides significant advantages in improving the shear behavior of beams. Slater et al. (2012) compared equations and concluded that the linear regression equations that was developed from the research for shear force reinforced concrete beams databased could accurately be predicted the shear strength comparing to the other. Özkılıç et al. (2023) conducted research on Aluminium waste using 0%, 1%, 2% and 3%, instead of steel chips and found a decreased in the load taking capacity was observed. Furthermore, he suggests that a reduction in load-bearing capacity by 1% due to the presence of aluminum waste is acceptable. Based on this, it can be concluded that the inclusion of aluminum waste in reinforced concrete beams can enhance beam shear by as much as 1%. Yuan et al. (2021) used engineering cementitious technique and the test results show that the ultimate displacement and shear strength has significant improvement using shear strengthen techniques. Numerous small shear cracks emerged on the surface prior to the beams' failure. The load-bearing capacity decreased as these shear cracks appeared, underscoring their significant role in resisting shear within concrete beams relative to the overall shear capacity.

Megarsa et al. (2022) used mesh wrapping as a transverse reinforcement. The main parameters considered was spacing, no. of mesh layers, dia. and combination with the steel stirrups. The results concluded in his research was as the wire mesh layers and dia increased, the shear capacity, ultimate failure load, and stiffness of the control specimen likewise experience augmentation. Furthermore, with the augmentation of mesh layers beyond three, there were no discernible alterations noted in the enhancement of the shear capacity of concrete beams. Moreover, by increasing the spacing between the wire mesh the failure load, stiffness and shear capacity decreased. This study confirmed that when employing an equal weight of wire mesh and stirrups, reinforced concrete beams with a combination of wire mesh and stirrups as shear reinforcement exhibit superior shear performance compared to beams utilizing only stirrups.

Seshu et al. (2023) aimed at assessing the effects of substituting traditional stirrups with welded wire mesh (WWM) as transverse reinforcement in the core zone of reinforced concrete (RC) beams across different shear span-to-depth ratios, while also varying the size and spacing of WWM. The experimental investigation reveals that when the shear span-to-depth ratio exceeds 2.5, welded wire mesh (WWM) proves to be more efficient in reinforced concrete beams, displaying superior shear resistance compared to conventional stirrups. El-Syed et al. (2018) used wire mesh as equivalent to the weight of stirrups. He reached the conclusion that beams reinforced with welded wire mesh show a significant enhancement in shear capacity in contrast to beams reinforced with conventional reference wire mesh and expanded (diamond-shaped) wire mesh. This determination stemmed from a thorough nonlinear finite element analysis conducted using Ansys 14.5, with the analysis findings aligning excellently with the experimental outcomes. Additionally, it was observed that beams reinforced with wire mesh displayed a reduced occurrence of crack patterns when compared to those without wire mesh reinforcement.

Numerous studies and methods have performed with the aim of increasing the shear strength of RC beams, either by using steel chips exclusively or by utilizing wire mesh. Existing literature indicates that both approaches have proven to enhance the shear strength of reinforced concrete beams. However, there is a gap in the research regarding the potential outcomes when combining wire mesh strips and steel chips as a combined shear enhancement strategy for concrete beams.

Therefore, this research was carried out to address this knowledge gap and investigate the failure behavior of beams under shear loading, as well as to quantify the potential increase or decrease in shear strength that could be achieved through the combined use of steel chips and wire mesh.

MATERIAL PROPERTIES

STEEL CHIPS

The waste steel scrap as shown in (Figure 1: (a) Steel Chips) was collected from the Machine Building and Manufacturing Industry of Hitech, a specialized manufacturer of military spare parts and machinery. There was two shapes i.e. coil spiral and straight, were chosen for mixing purposes. The effectiveness of these fibers depends on their performance within the concrete matrix and the simplicity of their production, both of which significantly impact their cost (Werkina 2021). The collected steel chips and scrap from this industry were transported to the laboratory.

Subsequently, The strands were maintained at a length ranging from 75mm to 100mm. Based on ACI specification (ACI, 544) for steel fibers, the aspect ratio (length to diameter ratio, l/d) of the steel fibers was established between 50 and 60, utilizing waste steel scrap in concrete. When working with straight steel scrap, its thickness was regarded as the diameter (d), whereas for coil spiral steel scrap, the coil's diameter was utilized as (D) to determine the aspect ratio. This waste steel scrap inherits the material properties of the primary structural steel. Its worth nothing that, for this study, we did not consider the corrosion effects after mixing, and it should be emphasized that the steel chips we employed were not corroded during the storage period.

WIRE MESH

The wire mesh as shown in (Figure 1: (b) Wire Mesh) produced from steel wire or metallic-coated steel wire(i.e. welded wire mesh). The metallic-coated fabric may be polymer coated after fabrication. The wire mesh sheets of 12.5mm × 12.5mm square panels were bought from the market and cut into the desired width and into the desired length. The choice of these panels were determined by the accessibility of wire-mesh. The material properties used in this research was same as reported by Taha A. et al. are given in [Table 1] (El-Syed et al. 2018).

TABLE 1. Mechanical characteristics of wire mesh

No	Wire mesh properties	
1	Dimension Size	12.5×12.5 mm
2	Wire Diameter	0.7 mm
3	Weight	600 gm/m^2
4	Youngs Modulus	17000 N/ mm^2
5	Yield Strain	600 N/ mm^2
6	Yield Stress	400 N/ mm^2
7	Ultimate Strain	58.8 × 10^{-3}

(a) Steel Chips (b) Wire Mesh

FIGURE 1. (a) Steel Chips , (b) Wire Mesh

METHODOLOGY

Typical beam's cross-section is shown in (Figure 2). These dimensions were selected as per the size of testing platform of universal testing machine. Furthermore, the span to cross section ratio of specimen was also selected to study the actual behaviour of beam.

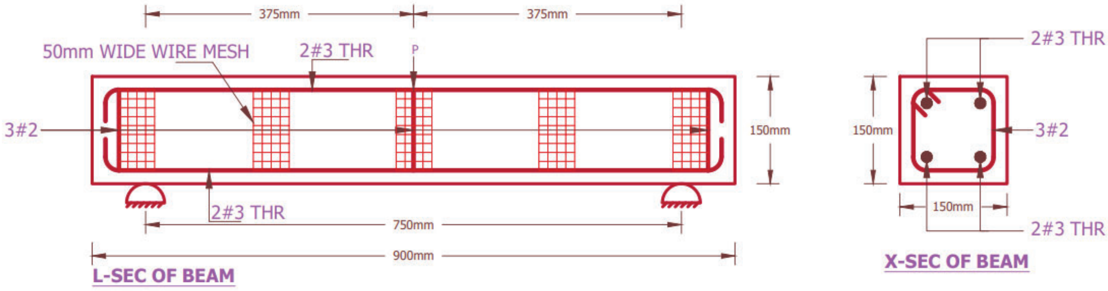

FIGURE 2. Typical cross section of beam

Eight groups of specimens, designated as sets A, B, C, D, E, F, G and H, were prepared, each set considered of three samples. Set A served as the control sample without wire mesh, while sets B through H included strips of wire mesh measuring 12.5mm, 25mm, 37.5mm, 50mm, 62.5mm, 75mm, and 87.5mm in width, respectively. 4#3 longitudinal bars as shown in (Figure 2), of Grade 60 were used and only three stirrups of #2 bars (one at the centre and two at the edges of longitudinal bars) in each beam were used. These stirrups served only the purpose of securing and positioning the longitudinal bars accurately. All twenty-four beam samples were casted using identical steel chips at a constant ratio of 0.9%, while the mesh widths varied. As the wire mesh is substituting the traditional stirrups, it was positioned with a 150mm spacing from edge to edge. In order to ensure an even dispersion of steel chips throughout the beam, the concrete mix for each set of three samples was prepared individually, followed by the addition of the specified ratio of steel chips as mentioned-earlier.

FIGURE 3. Sample preparation process

The sample preparation process is demonstrated in (Figure 3). All the RC beams are casted with Class A mix i.e. 1:2:4 (Genevieve Gabule, 2009). Class A mix has a compressive strength around 20.68 N/mm². Concrete with this strength will show the explicit difference in the results. After twenty-four hours, the beam samples was removed from the molds, the beam samples were placed in a curing tank for a duration of twenty-eight days. Following the completion of the curing period, the beam samples were extracted from the tank and moved to the laboratory. The beam samples were subjected to a point load test using the Universal Testing Machine and the cylinder samples for compression test. The beam specimens were loaded at a one point using a Universal Testing Machine having a maximum capacity of 500 tons, an effective span length of 750mm, a shear span length of 375mm from loading as illustrated in (Figure 2).

Crack width were measured using the standard crack width procedure. Locations of cracks were identified on the concrete structure where crack widths need to be measured. Selected locations represent critical areas susceptible to cracking, such as corners, mid-spans of beams, or regions with high stress concentrations. Surface around the crack was cleaned to remove any debris, dirt, or loose particles that may interfere with accurate measurements. A crack width gauge was utilized for measuring the width of cracks by positioning and ensuring perpendicular spaning to the full width of the crack. Measurement was taken by reading the width indicated on the measurement tool. Measurement process was repeated multiple times at each selected location to ensure consistency and reliability of data. Measured crack widths were recorded at each selected location. Relevant information such as the location of the crack, and any observations related to crack characteristics (e.g. width, direction) were documented. Collected data was analyzed to identify the trends, variations, and correlations in crack widths across different locations and over time.

RESULTS AND DISCUSSION

All beams specimens performed good in shear. Table 2 presents the mean crack width of beams at the failure of beam specimens. Trial 01, Trial 02 and Trial 03 representing the number of samples of each set. The control specimen, which only utilized flexural reinforcement, experienced failure characterized by a large shear crack around 3.0 mm inwidth.

TABLE 2. Mean crack width of beam samples

No	Description	Crack Width (mm)			
		Trial 01	Trial 02	Trial 03	Mean
1	Set A	2.7	3.1	2.9	2.9
2	Set B	2.7	2.5	2.8	2.7
3	Set C	2.1	2.5	2.5	2.3
4	Set D	2.2	1.7	2.1	2.0
5	Set E	1.3	2.0	1.7	1.6
6	Set F	1.8	1.3	1.1	1.4
7	Set G	1.3	1.1	1.0	1.1
8	Set H	1.0	0.5	0.8	0.7

Furthermore, from the observation made during the test mean crack width of set A is 2.9 mm having constant steel chips ratio and no wire mesh in it. Table data reveals that Set A exhibits the widest crack among all specimen sets, while as wire mesh is introduced in Set B, a reduction in crack width becomes apparent. Set B contains 2.6 mm crack width with the addition of 12.5mm wide strips of wire mesh. Set C contains 25mm wide mesh strip and a major crack of 2.3mm wide and only a minor hairline crack was seen. Similarly the crack width of set G and H is 1.1 mm and 0.7 mm, which is the result of 75mm and 87.5mm wide-strips of mesh. It is clear from above that the Crack widths consistently decreased as the mesh width increased from set A to set H.

FIGURE 4. Crack pattern at failure of set A

As shown in (Figure 4) above, the beams sample shows the diagonal cracks appear on the test specimen. This is the result of 0.9% steel chips having no shear reinforcement. The crack initiated from supports and propagated toward the loading point. It is clear from the figure that the cracks appear were large sized and only a major cracks appear on the test specimen were observed. Similary the cracks pattern appear in set B with 12.5mm wide strips of mesh was diagonal and comparatively small and less cracks width were appear on the test specimen.

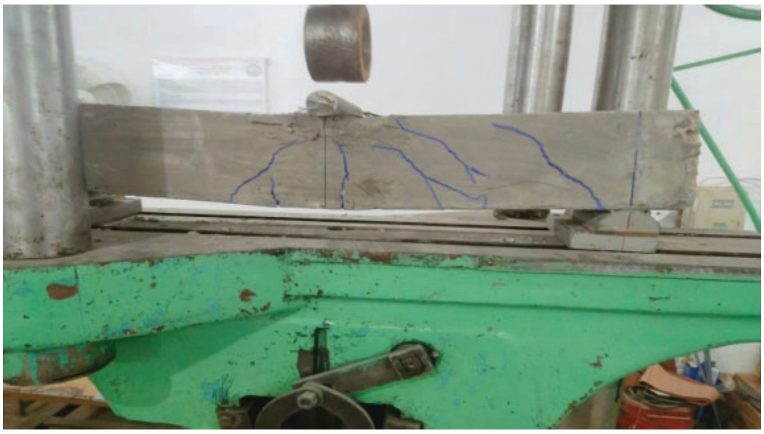

FIGURE 5. Crack pattern at failure of set H

(Figure 5) represent the Set H with constant steel chips ratio and the width of mesh was 87.5mm. From figure, it could be seen that the crack appeared on the test specimen are small in size representing less cracks width as compared to the previous one. From above it can be seen that as the mesh width increases, the cracks developed were more in numbers with minimal thickness as seen on the test specimen.

The irregular shape and distribution of steel chips and wire mesh within concrete create discontinuities in the material. As the cracks propagate through the concrete, these fibers act as bridges across these cracks, effectively distributing the applied load and preventing further crack propagation. This crack-bridging mechanism helps maintain the integrity of the structure and enhances its resistance to shear forces.

This indicates that when steel chips and wire mesh are added to the test material, they prevent the formation of a single large crack. Instead, they lead to the formation of several shorter cracks when the material fails. The presence of these many short cracks suggests that the steel chips and wire mesh function like small diameter bars, closely spaced and randomly distributed, which stop the growth of one large crack and cause the formation of multiple shorter cracks. Furthermore, the steel chips and wire mesh have the additional effect of redistributing stresses across the beam's effective span, similar to dowel bars. This redistribution enables stress to transfer from one side of the crack to the other.

TABLE 3. Actual shear strengths of concrte beams

No	Description	Shear force (KN)				Variation from set A	Percentage difference
		Sample 01	Sample 02	Sample 03	Mean		
1	Set A	45.5	46.0	44.0	45.16	0.00	0.00
2	Set B	52.0	50.5	51.5	51.33	6.17	13.66
3	Set C	56.5	53.5	56.5	55.50	10.34	22.89
4	Set D	60.5	59.0	58.5	59.33	14.17	31.37
5	Set E	68.5	64.5	65.5	66.16	21.00	46.50
6	Set F	72.0	69.0	69.0	70.00	24.84	55.00
7	Set G	75.5	76.5	74.0	75.33	30.17	66.80
8	Set H	81.5	81.0	79.5	80.66	35.50	78.60

As shown in (Table 3), average shear strength of SetA is 45.16KN, indicating that 0.9% of steel chips without wire mesh contributed to this result, which aligns with findings from Gabule (2009). Set B demonstrates a shear strength of 51.33 KN, reflecting an increase compared to Set A, with a percentage difference of 13.66% higher. Set C exhibits a shear strength of 55.50 KN, representing a 22.89% increase over Set A.

In the same way, the shear strength of Set D is 59.33 KN, indicating a 31.37% rise compared to the control specimen. Set E yields shaer resut of 66.16 KN, Representing a significant improvement of 46.50% compared to set A. Likewise, Sets F, G, and H demonstrate shear strengths of 70.00, 75.33, and 80.66 KN, respectively, with percentage differences in strength of 55%, 66.80%, and 78.60%, respectively.

Figure 6 evaluates both the shear strength in practice and the percentage variance. Set E gives a shear strength percentage difference of 15.13, the most significant among all sets. As the mesh width increases, there is a gradual increase or enhancement in shear strength, accompanied by a corresponding increase in the percentage difference.

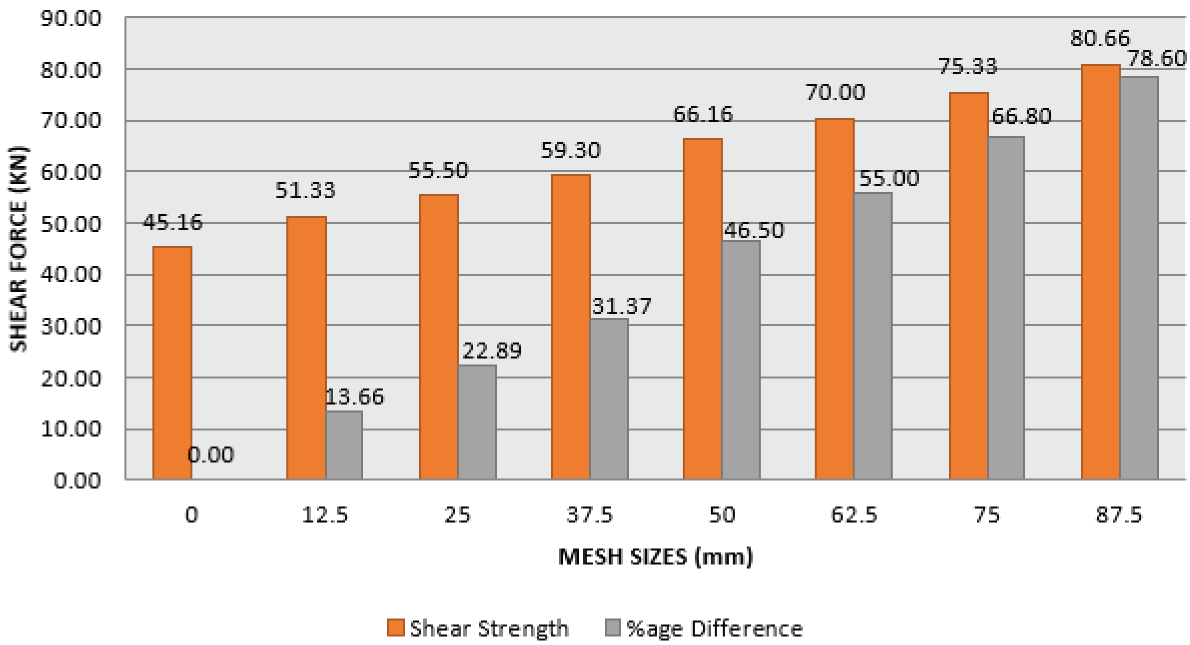

FIGURE 6. Comparison of Shear Strength and Percentage Difference

From observation during testing no significant change was observed in the failure behaviour of set A, B and set C. From set D as the wire mesh was increasing hairline cracks along with major cracks was seen. Similarly as the width of wire mesh inceasing, the large cracks was divided into smaller cracks and more number of cracks was appeared. During testing, the observed increase in the slope of vertical shear cracks in the RC beams, equipped with wire mesh as shear reinforcement, signified the improved efficacy of the wire mesh. These combinations of wire mesh and steel chips offers a greater bonded area compared to traditional stirrups, leading to the dispersion of significant stresses across the section.

By keeping on increasing the mesh width upto 87.5mm, the shear strength nearly doubles compared to the initial strength. Increasing strip widths, the shear strength will continue to increase showing the significant difference. As the wire mesh is considered as the bars with small diameter, the stresses distribution were observed as uniform. Because of uniformly distributed steel chips and wire mesh throughout the beam cross section, the shear strength increases in the beam.

In concrete reinforced with steel chips and wire mesh, the fibers help redistribute stresses applied to the material. When shear forces act on the concrete, the irregularly shaped steel chips provide alternate load paths, allowing the stresses to be redistributed more uniformly throughout the

structure. This redistribution of stress helps to mitigate localized stress concentrations and prevents premature failure due to shear.

The bond strength between the fibers and the surrounding concrete matrix is essential for enhancing shear strength. Steel chips and wire mesh provide additional surface area within the concrete, promoting mechanical interlocking and chemical adhesion between the fibers and the surrounding cementitious matrix. These strong bonds ensures effective load transfer between the added fibers and the concrete, thereby enhancing shear strength.

In brief, the combined effects of crack bridging, stress redistribution, and bond strength play crucial roles in enhancing shear strength when using steel chips and wire mesh as reinforcements in concrete construction. These mechanisms helps in alleviating the impact of shear forces, thus enhancing the overall performance and durability of reinforced concrete structures.

CONCLUSION

This study aimed to enhance the shear strength of reinforced concrete beams through the combined utilization of industrial waste steel chips and wire mesh. Based on these findings, the following conclusions are drawn:

1. The test results indicate that the shear strength increases progressively from Set A to Set H, with values of 45.16, 51.33, 55.50, 59.33, 66.16, 70.00, 75.33, and 80.66 KN, accompanied by percentage increments of 0, 13.66, 22.89, 31.37, 46.50, 55.00, 66.80, and 78.60%, respectively. This illustrates the effectiveness of wire mesh in improving shear resistance.
2. The greater the width of wire mesh in combination with steel chips used results in increasing the shear strength. The presence of these fibers acts like reinforcing bars which in results arrest the formation of large crack into multiple short cracks
3. These results demonstrate the efficacy of a single wrap of wire mesh. Increasing the number of wraps may lead to higher shear strength percentages.
4. This increment in the shear strengths is due to addition in the shear reinforcement**.** Using a single wrap of 87.5mm wide mesh strip led to a nearly doubled shear strength increase (78.60%) compared to the control.
5. Increasing the width of the wire mesh strips results in a greater number of cracks, while concurrently reducing the width of individual cracks.
6. An increase in the slope of vertical shear cracks in RC beams, reinforced with wire mesh for shear reinforcement, signifies the effectiveness of the wire mesh.
7. Incorporating steel chips and wire mesh into the concrete mixture arrests the formation of single large crack into numerous shorter cracks suggest the redistribution of stress with in the effective phase of beam.

The wire mesh is easily accessible and can be conveniently cut into desired shapes and sizes. Briefly, utilizing wire mesh yields superior results compared to traditional stirrups.

This discussion concluded that the utilization of wire mesh and steel chips effectively improves shear performance and may yield better results through consistent application of U-shape wrapping across the shear-zone.

FUTURE RECOMMENDATION

1. Based on the research conclusions, the following suggestions are proposed;
2. Future investigations should explore the effects of increasing width of strips and the nos of mesh layers rather than utilizing a single wrap.
3. An investigation should be made to compare the

outcomes of wire mesh wrapping with traditional steel shear reinforcement for better outcomes.

4. Further studies should examine the incorporation of wire mesh and steel chips at different proportions and within concrete mixes other than the Class A mix 1:2:4.
5. An additional study should conduct to assess and compares the outcomes of wire-mesh against commercially available steel shear reinforcement.

The investigation should also include a cost comparison between wire mesh and steel chips versus conventional steel.

ACKNOWLEDGEMENTS

The authors extend their appreciation to the Department of Civil Engineering at the University of Engineering and Technology, Taxila for their provision of technical assistance and laboratory support during the research's experimental period.

DECLARATION OF COMPETING INTEREST

None.

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