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Effect of Screw Head- and Hook-on Bond Behavior of Flamingo Shear Reinforcing Technique in Concrete

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ABSTRACT

An alternative reinforcing shear technique was proposed during this work in place of the traditional vertical stirrups. Three reinforced concrete beams with dimensions of (200 * 300) mm and a length of 1800 mm were used. A reference control beam with traditional vertical stirrups (RCWS) and two beams reinforced with flamingo with a fixed angle of 45° and free ends (50% and 50%) from effective depth were used, while the main variable was the bonding process with concrete using a screw head (FWS) and hook (FWH). In the flamingo technique, the hook was used and the screw head was used at an equal angle of 130 degrees. A significant improvement was found in the shear capacity of the beam compared to the reference sample. Also, using a screw head made the shear capacity 13.22% higher than using a hook and improved the shear ductility, final deflection, and crushing behavior of beams made with the flamingo technique.

1. Introduction

Bonding is one of the most important processes that might influence the behavior of structural concrete at both the serviceability limit state (when cracking development occurs) and the ultimate limit state (strength, strain localization, and deformation capacity)[1]. It is common for real-world projects to have cracked concrete. Flaws are more prone to appear in designs that involve reinforcement.

Additional considerations include the following two possible outcomes: distinguished: The first corresponds to concrete members where the opening of the crack is controlled, The second relates to concrete members where these cracks develop in an uncontrolled manner[2][3].

Concrete has a high compressive strength but a low tensile strength, so it is necessary to use ductile shear reinforcement to increase the concrete's ability to withstand strain and reduce its brittleness. Traditional steel reinforcement was frequently used. as shear reinforcement (stirrups) in reinforced concrete [4]. The industry views shear failure as an unsafe mode of failure because reinforced concrete beams behave very differently from bent beams when they fail in shear. Flexural cracks, which typically occur abruptly before the beams shear, are much smaller than the diagonal cracks that develop as a result of excessive shear forces. After shear reinforcement became prohibitively expensive and dangerous, reinforced concrete beams were reconsidered. Internal moments and shears support beams. Flexure is typically considered first when designing a reinforced concrete part, which then determines the size and placement of reinforcing bars[5]. Shear

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helical rings on reinforced concrete girders were studied by Boel Veerle and Corte De Wouter (2013) for two types of helical reference beams: one is vertical reference beams and one is continuous helical beam. This technique gave better efficacy than the reference models by 5% of the shear bearing capacity, and reduced the width of the cracks [6].Muhammad et al. (2015) researched shear strengthening in steel swimmers and stirrup bars, and other researchers have studied the technique of swimmers' rods as well. The shape of the swimming rod and ten beams were examined for their ability to withstand concrete pressure. Compared to traditional reinforcement, they did well in terms of shear stress, crack width, spread, and number. [5], [7], [8] Ahmed investigated the flexural and shear shear behavior of CFRP strip-reinforced beams (2018). With the addition of PET fibers, the beam shear behavior was studied (0.25, 0.5, 0.75, 1, 1.25, and 1.5 percent). As a result of the study, there was less corrosion in the stirrups. The conventional steel stirrups were replaced with PET fibers in order to boost the shear strength of a CFRP-stripped beam. Adding more PET fibers boosted the beam's ductility [9] .The use of wire ropes as shear reinforcements was examined in the work of Gerald, Yan, and Yannick (2020). It's a less expensive alternative to standard rectangular concrete stirrups because of its high flexibility, low weight, and robustness. Spiral wire rope-reinforced concrete beams are the subject of this investigation. This was accomplished through the use of six beam samples that were put through four different types of testing. Data Interchange Methodology (DIM)examine the spread of beam cracks. According to tests, Continuous spiral rope has a high shear strength, which makes it ideal for controlling diagonal cracks. The serviceability crack width of spiral wire rope samples was greater than that of stirrup beam samples[10]. Issam and Suhad (2021) studied new methods of shear zone strengthening of structural reinforced concrete members instead of the traditional method, namely carbon fiber and flamingo fabric. Flamingo is a type of technology that is designed to look like the legs of a bird in the shape of the letter Z. The results showed that the beams made a significant difference in the beam shear capacity, shear ductility, final deflection, and their crushing ability[11]. This research aims to determine the best method for the bonding process between concrete and iron used in the manufacture of the flamingo technique for the techniques proposed in the research.

2. Experimental program

2.1Material

- Cement

  This study employs standard Portland cement (type I) supplied by the Tasluja factory in Iraq. The chemical makeup and physical attributes adhere to the Iraqi Standard Specification (I.Q.S. No.5, 1984) (I.Q.S. No.5, 1984)[12].

- Finer Aggregates

  The natural sand used for this project's fine aggregate was found in the Al-Sidor area. It has a 2.38 fineness modulus. Conformity of the fine aggregate's grading and physical characteristics to the Iraqi Specification's limitations (I.Q.S. No.45, 1984.)[13].

- Coarse aggregate

  In this investigation, coarse aggregates consist of natural gravel with a maximum particle size of (12.5mm). The natural gravel came from the Al-Sidor area. After being cleaned, the gravel was dried by air. The physical properties and grading of the aggregates met the requirements (Iraqi standard No. 45, 1984)[13].

- Steel Reinforcement

  Deformed steel bars are used to reinforce beams in shear and bending, as shown in Table (1) 6mm,8mm and 10 mm stirrups were used in the Flamingo technique, as well as 2 ⍉12 in the compression zone to stabilize steel and 4 ⍉ 16 for flexural reinforcement whereas ⍉8 @130mm were used as traditional vertical stirrups.

Table 1: Properties of reinforcing steel bar

Type	Diameter (mm)	Yield Stress fy MPa	Ultimate Strength fu MPa	Elongation (%)
Main reinforcement	16	580	683	10.24
	12	635	728	9.04
Shear reinforcement	10	495.5	597.7	11.25
	8	330	528.1	21.52
	6	336.6	696.5	19.72

- Weld the head stud to the free ends (doublly head).

Figure 1. Screw head

2.2 Concrete Mix

Concrete with a strength of 39 MPa and the mixing components listed in Table (2) were used. The compressive strength of concrete was measured using cylinders with a height of 300 mm and a diameter of 150 mm. The samples were processed in water tanks for 28 days after dismantling [14][15].

Table 2: Concrete mix constituents

Cement (kg/m^3)	450
Sand (kg/m^3)	860
Gravel (kg/m^3)	860
Water (kg/m^3)	207
S. P	0.46%
w/c	46%
Slump (mm)	140mm

3. Experimental setupe

The beam samples in this study were cast using molds with dimensions of 200 * 300 * 1800 mm. The first control beam (Reference Concrete Beam with Stirrups, RCWS) (see Fig. 2) was reinforced with steel bars in bending and conventionally with vertical steel stirrups in the shear zone. The reference beam was tested in order to determine the shear capacity of the reinforced beam using a conventional stirrup. On the other hand, it was used as a sample compared to the shear beams reinforced with flamingo technology, with a diameter of 8 mm and a fixed angle of inclination of 45°, and the free ends were 50% of the effective depth value of both ends. And he used the concrete bonding method as the main alternative, using the hook or using the screw head, two needles welded to the head of the free end of the technique to form a part resembling a screw head. Figure 3 shows the details of the flamingo patterns (see Fig. 3a, b, c).

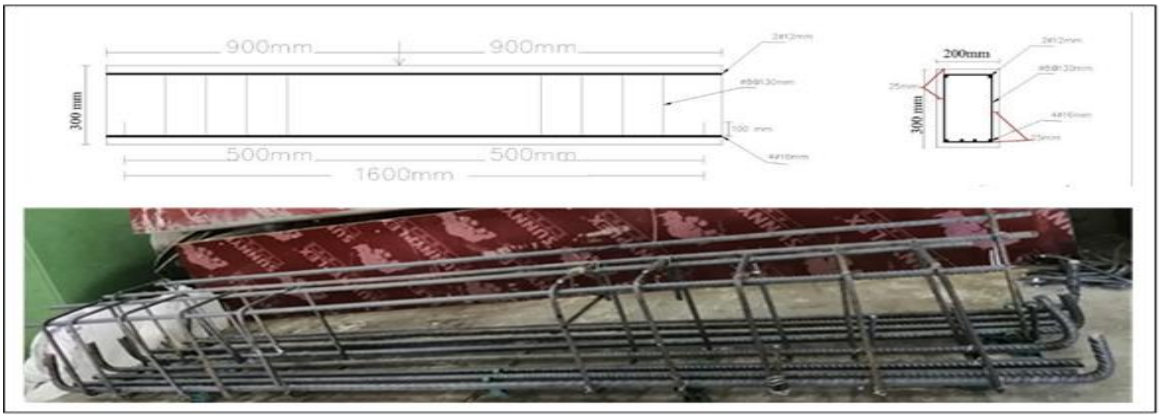
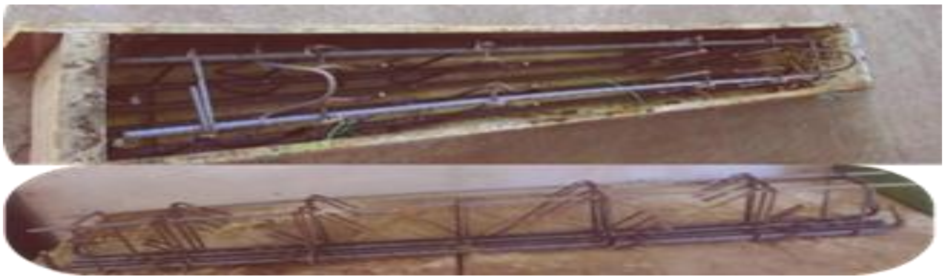
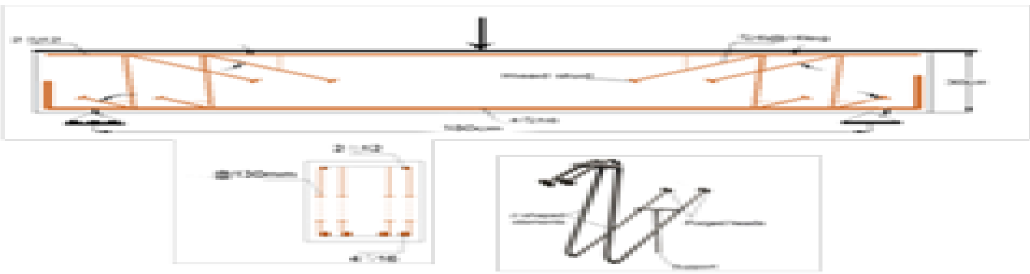


Figure 2. Strengthening the shear with vertical stirrup (Reference beam)

(a)



(b)



(c)

Figure 3. Flamingo reinforcing technique

4. Result and disccussion

This section compares the flamingo and control beams' load-bearing capacity, load deflection, and shear ductility index. Steel stirrups are compared to show which technique makes the most efficient use of them, which is the control beam and the flamingo. Rather than relying on traditional steel stirrups for shear zone reinforcement.

4.1 Load carrying capacity

The results of the beam test can be summarized in Figure 4 using the terminal load (the load at which shear failure occurs) and the mid-range deflection at this load. Flamingo reinforcement increased the load-bearing capacity of FWS and FWH beams by 52.2% and 34.4 %, respectively, when shear reinforcement was used. Strengthen the flamingo with screw head at the end(FWS) andStrengthen the flamingo with hook at the end (FWH) have nearly identical amounts of reinforcement in the shear region compared to the control beam. Flamingo-shaped steel reinforcement is ideal for creating shear junctions at points where the legs of the system intersect. Lower and higher slopes on the free ends help to limit crack spread, and results show that the use of a screw head provides a better bonding strength than the use of a hook for the free ends.

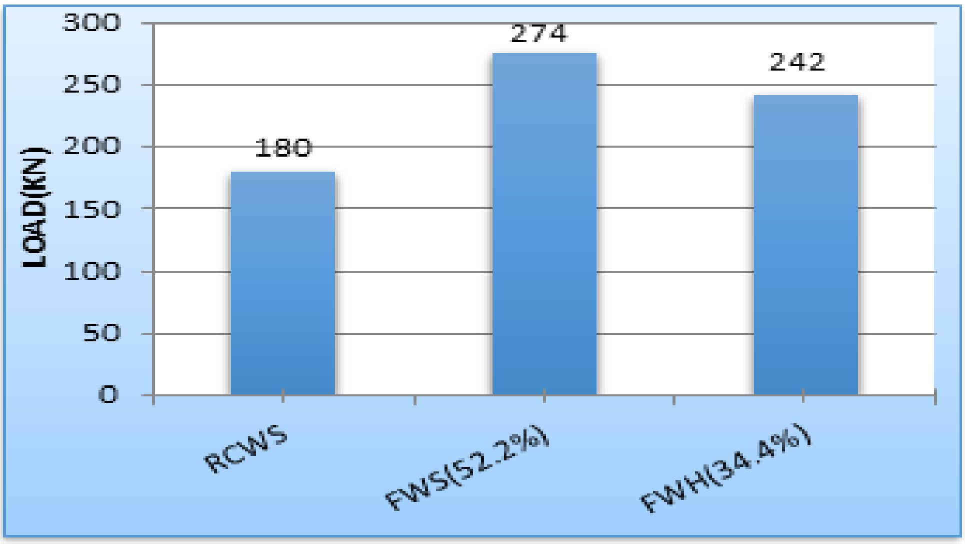


Figure 4. Test results of the beams

The final deflection of the beams is shown in Table 3. According to the control beam, the beams (FWS and FWH) show a 21.7 % and 10.7 % decrease in deviation, respectively (RCWS). Because of the flamingo technology's increased crushing hardness, this is the case.

Table 3: Test results of the beams

Specimen	Ultimate load kN	Δ_u mm
RCWS	180	13
FWS	274	11.61
FWH	242	10.18

4.2 Load deflection behaviour

The skew relationship between the load in the middle band and the skeletal member typically shows the skew behavior. The beam structure in this investigation is shown by the load and skew curve. The load and skew curve allow us to distinguish between three distinct phases: the linear elastic phase, which lasts until the notch appears; the non-linear phase, in which the reinforcement regulates the beam's behavior; and the non-linear phase, which lasts until the notch appears again. Depending on the reinforcing material, the final stage is either completed through production of steel rebar or rupture of brittle reinforcing materials. During this early stage, the concrete limits the behavior, which is why the beam's bending stiffness is linked to its linear elastic phase slope. Each of the samples shown in Figures (5) corresponds to each other when the applied load is set to 100 kN. With the use of flamingo technology, beam bearing capacity is increased as well as the amount of distortion that occurs to samples is reduced. The screw head technique has a greater contact area with the concrete than the hook, which may be a weak point in this technique. However, using the screw head to interlock with the concrete gave a higher bearing capacity in another sample.

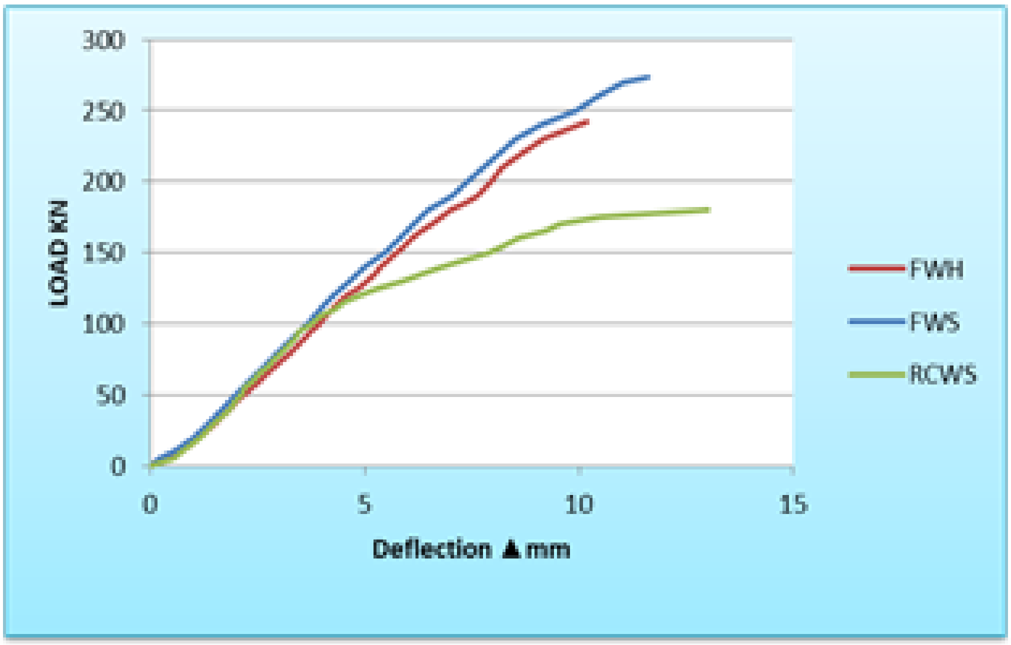


Figure 5. Load deflection curves for the flamingo specimens

4.3 Shear ductility

If the material can deform without significantly reducing the bending strength, it is considered to have good ductility. Shear ductility is calculated from the yield point and maximum deformation point of the model. Table 4 displays the shear ductility values for the sample beam. The shear ductility index for FWS and FWH increased by 12.66% and 3.8% when using flamingo reinforcement, while the shear ductility index for RCWS decreased when the initial decrease in the load deflection curve occurred. In particular, the load slope curve showed a gradual decrease.

Table 4: displays the beams' shear ductility index

Specimen	Ultimate load kN	Deflection Δu mm	Shear ductility Index (μ1)
RCWS	180	13	1.58
FWS	274	11.61	1.78
FWH	242	10.18	1.64

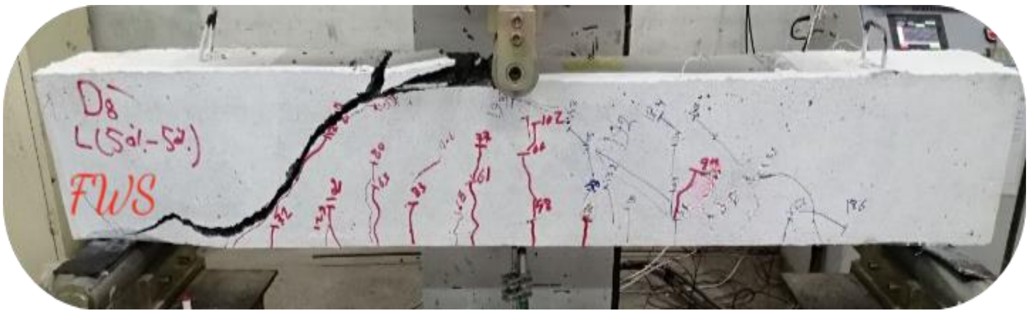
5. Cracking behavior

Each sample's crushing data can be found in Table 5. The first slit appears at 27.3%, 38.3%, 31.3% final loading of (RCWS, FWS, FWH) when load is applied to these beam samples. Percentages based on the total weight of the shipment are shown. Crushing load can be significantly increased by using Flamingo Strengthening technology instead of regular stirrups in beams (RCWS). Because of the interconnected process between concrete and user technology, the behavior of the slit pattern varies from bundle to bundle. In comparison, using a screw head reduces the width of the slit when compared to using a hook. Slit widths of 0.02 mm and 0.04 mm were found in the FWS and FWH models at a load of 170 kN, respectively.

Table 5: Details about all of the cracks

Specimen	Crack load Pcr (kN)	Ultimate load Pu (kN)	Pcr/Pu (%)
RCWS	50	180	27.3%
FWS	72	274	38 %
FWH	78	242	31%

a)



b)

C)

Figure 6. Crack pattern for all beams a) Pattern of cracks Reference beam (RCWS), b) Pattern of cracks for Flamingo with screw head (FWS), C) Pattern of cracks for Flamingo with hook (FWH)

6. Conclusions

During a study, according to the results, it was found that:

- The payload deflection, stiffness and cracking behavior of the Flamingo Technology stirrups were better than those of conventional steel stirrups.
- Flamingo's use of a screw-head technology to bond to concrete has yielded good results to increase the final shear strength, making it an ideal application of this technology.

- The failure pattern of the screw head sample was a shear beam failure, and the sample in which the hook was used had a concrete crush with a shear failure condition.
- In the case of flamingo techniques, it was found that the crack width decreases at a given load and this decrease is related to the use of the screw head method for interlocking with concrete.

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