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Study of Parameters Affecting Web-Shear Capacity of Multiple Deep Hollow Core Slab System through Finite Element Analysis

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Abstract: Precast industry is gaining popularity in construction industry due to its faster erection and less labour requirement as it manufactured in factories. In this paper, an overview of hollow core, how they are cast, advantages and disadvantages of hollow core slab are described. Generally, it is known that the hollow core slabs are critical in web shear. Parameters which potentially affect the web shear behaviour are explained. This paper reviews the previous research works published on web shear capacity of hollow core slabs studied experimentally, numerically and parametrically.
Keywords: hollow core slabs, web shear behaviour, prestressed tendons, experimental

I. INTRODUCTION

Prefabricated hollow core members are frequently used to construct the floors and ceilings of concrete structures. These systems are affordable and easy to set up. This will ensure that the depth of structural member is kept to a minimum. Longitudinal cores are added, which lowers the dead load and creates a strong structural structure. Typically, structural members need to be renovated due to a variety of problems or for particular circumstances. One of the most frequent issues is the requirement for openings to be created in particular situations when allocating with reinforced concrete slabs; the requirement for openings in slabs is faced in structural engineering. Over the flooring slabs, it is necessary to add new stairs, heat and ventilation ducts, fire protection for the pipelines, additional skylights, plumbing, air conditioning, benefits (electricity, telephones, and wiring ducts), and architectural elements. A hollow core slab, or HCS for short, is a precast or prestressed concrete part with holes spaced out along its length to save weight, cost, and other factors. It can be used in electrical or mechanical controls. HCS are mostly used as surface or roof deck systems, although they can also be used as members, partition sections, or bridge deck components. Without supports, the HCS's span is equal to (18m). Pre-stressed HCS elements are specifically created for diverse applications requiring floor or roof systems. It is best to employ this strategy for residential, commercial, or car garage applications. Precast, prestressed HCS offer significant structural member success through the use of HSC, but require little material overall. The HCS are worthwhile. Dry casting or extrusion moulding technologies, which require very little concrete to be fed through a machine, are used to create slabs. Around the cores created with pipes or roles, the concrete is crushed.The slab with unbroken perforations is being used as electrical wire channels and as heating and cooling ducts. Hollow core slabs eliminate floor squeals and reduce sound and vibration transfer between building floors. A precast concrete slab known as an HCS or voided slab is typically used to construct floors in structural buildings. The slab was especially well-liked in nations where prefabricated concrete homes were the main focus of development. Precast concrete is popular because it can be quickly assembled, has a low self-weight (few materials), and is used in constructions that are more cost-effective.

Fig. 1. Hollow core slabs

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The hollow core slabs are cast using three methods and they are dry casting, wet casting and slip former. The procedure entails pulling prestressed steel wire rope and wet concrete from a moving mould. The continuous slab is then cut with a sizable diamond circle saw to the necessary lengths. Reduced time, labour, and training are clear benefits of factory production. After being transported to the casting machine, the concrete starts to build the hollow core slab.

21Three primary types of casting machines exist:

1) *Extruder:* This device uses a dry, low-cement mix to cast the slab and vibrates it vigorously to compact the concrete. The extruder descends the casting bed as a result of the auger drive and concrete build-up.

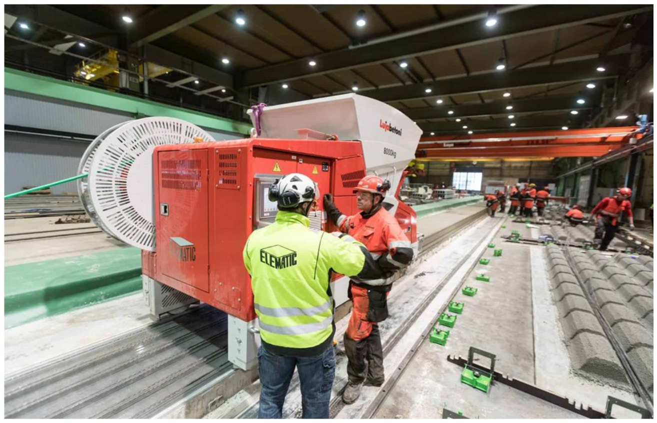

Fig. 2. Dry Extruding of HCS

2) *Slip Former:* With the use of vibration and a drive mechanism, the slip former forms the slab around moving steel cores in two or three phases. They are also adaptable enough to cast additional elements with continuous profiles.

Fig. 3. Slip former

3) *Flow Former:* casts the concrete without mechanisms or drive units. The concrete flows by gravity and vibration. The process uses plastic quality concrete for the versatility of cross-section profile options with a smooth, rough or indented surface finish.

A. *Advantages*

Due to the slabs' superior fire resistance, great durability, and decreased self-weight, they can exceed earthquake resistant norms. Additionally, their excellent thermal qualities aid in lowering the energy needed to heat and cool buildings. No additional formwork or any special construction machinery is required for reinforcing the hollow block masonry. These slabs have extra-long spans. The surface is neat and flat so that the bottom surface can immediately become a ceiling for the floor below. The usage of hollow core slabs minimizes the risk of earthquake hazards.

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B. Disadvantages

The hollow core ribbed slab units could sustain damage during shipping if they are not handled carefully. Making satisfactory linkages between the precast parts becomes challenging. To lift and move the precast units, specific equipment needs to be arranged. Not cost-effective for short durations. These hollow core slabs are difficult to strengthen and restore.

II. REVIEW

Keith D. Palmer and Arturo E. Schultz (2011) experimentally investigated the web-shear strength of deep hollow core units and observed that the shear capacities predicted by the tests conducted revealed values lesser than those obtained by the web shear equations given in ACI 318-08. The goal of this study was to identify the causes of these thicker units' failure at shear stresses that are lower than those indicated by the ACI 318-05 requirements. Two distinct manufacturers of precast concrete, identified as suppliers A and B, provided the hollow-core modules tested in this programme. For a total of 24 tests in the main series, 12 hollow-core components were sheared to failure on both ends. To test potential shear strength improvement strategies, two more units were used. Shear enhancement techniques utilized in this research programme were core filling technique and fiber reinforced specimen.

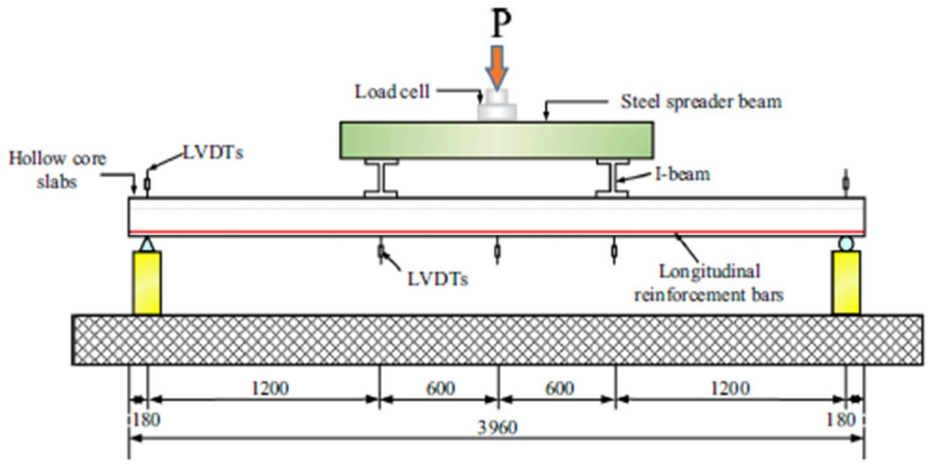

Fig. 4 Experimental set up

Because the stress in the steel bars was transferred to the slabs with the aid of cement mortar that was cast into the cores, the steel bars mounted in the cores were able to increase the flexural capacity of the hollow core slabs. Compared to the control slab, the specimen (S40) strengthened with mounted steel bars had enhanced ductility. The overall outcomes of the finite element model and the test findings are in good accord. The perfect bond assumption in the FE model is what causes the increased stiffness, overstated strain concentration, and variations in crack patterns. The bond-slip relationship should be properly taken into account in order to improve the FE model, which requires more research.

Scott A. Asperheim and Benjamin Z. Dymond (2021) studied the factors affecting the web shear capacity of hollow core slabs with filled cores. The first goal of this experimental programme was to determine how much additional shear capacity might be gained by filling one or more hollow-core slab voids with core-fill grout, core-fill concrete, or by omitting a void altogether during the extruded (dry-cast) hollow-core slab production. The second goal of this programme was to compare and contrast the methodology and outcomes used to determine the shear capacity of hollow-core slabs with both circular and noncircular voids according to ACI 318-149 and EN 11685.Twenty extruded dry cast hollow core slabs were used in the test; eight were heavy duty slabs that were 48 inches wide, 12 inches deep, and 20 feet long, and twelve were 48 inches wide, 12 inches deep, and 23 feet long. Asperheim and Dymond came to the conclusion that where core-fill material is expected to boost the web-shear capacity, composite action between the core-fill material (concrete or grout) and the hollow core slab is required. The shear prediction methods used in this experiment were ACI 318-14 and EN 1168. The web-shear capacity of hollow-core slabs with noncircular voids loaded similarly to those in this study programme is influenced by moment demand from applied load and self-weight. Potentially higher web-shear capacity will result from decreased moment demand. When compared to their respective capacities, slabs with noncircular gaps and thick webs showed significant shear and high moment demands at failure. Compared to slabs with circular voids, narrow webs, and moment demands that were around half of the projected capacity, these slabs failed at shear demand-to-capacity ratios that were lower.

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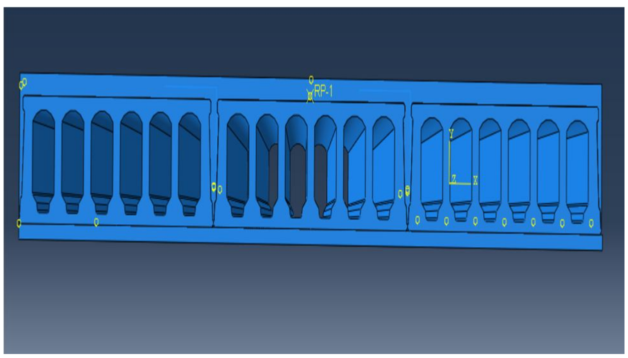
Matthew R. McDermott, Benjamin Z. Dymond (2020) studied the Shear capacity of hollow-core slabs with concrete-filled cores. The experimental program for this project included manufacturing and testing both ends of eight hollow-core slab specimens. Of the eight specimens, one served as a control specimen, or baseline, for the testing program, and the cores remained unfilled. The remaining seven specimens were modified by adding concrete filling to the center void using various methods. These methods included cold joint core fill, typical immediate fill, typical immediate fill aged 209 days before testing, fiber-reinforced fill, core wall surface roughening, headed steel bar in core fill, and WWR in core fill.

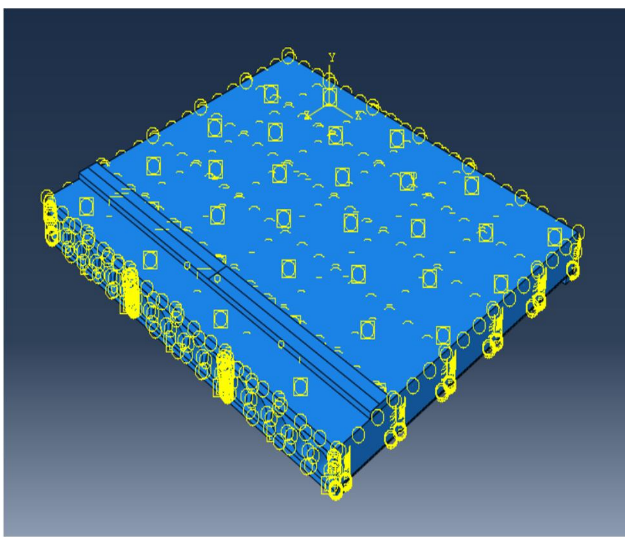
None of the core-fill enhancement strategies definitively demonstrated an improvement in web-shear capacity beyond the typical core-filled specimen. Rather, bond between the core-fill concrete and hollow-core-slab concrete appeared to be the most important factor for core-fill web-shear strength. Axial precompression of the core-fill concrete, which enhanced the shear capacity of the core-fill concrete, was made possible by an adequate bond between the hollow-core-slab concrete and core-fill concrete. The observed crack angles in the core-fill concrete provided evidence in favour of this finding. In particular, the three core-filled specimens with the highest shear capacity (typical immediate fill, core wall surface roughening, and WWR) had shallow core-fill concrete crack angles with respect to the horizontal plane and remained connected to at least one of the adjacent hollow-core-slab webs, which suggested axial precompression in the core-fill concrete and a strong bond with the slab concrete.

III. MODELLING

In Abaqus CAE, simplified CDP model was adopted to model plasticity in concrete. Young's modulus and Poisson's ratio of steel was used to model elastic behaviour of steel rebars and tendons. Prestressing achieved through tendons is simulated by applying it as temperature load to the tendons.

The structural topping or screed concrete was also modeled. The reinforcement provided in screed included 8 mm bars at 200 mm c/c in both directions. Alternate hook reinforcement was provided at 600 mm spacing. C3D8R element was used to model concrete, supporting and loading plate and T3D2 elements were used to model steel rebars and tendons.





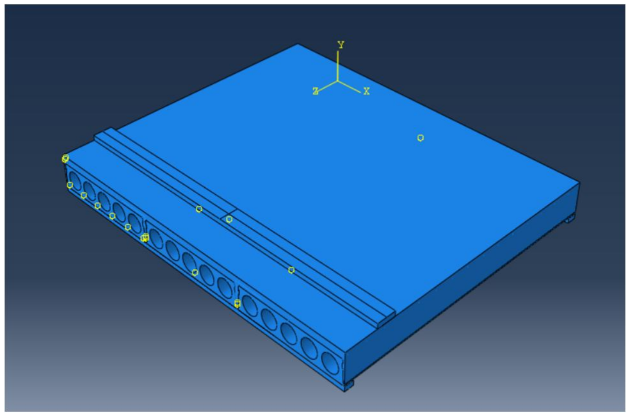


Fig. 5 Numerical Model of MHCSS

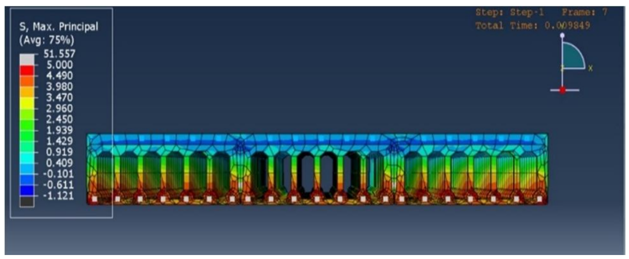


Fig. 6 Web Shear Distribution

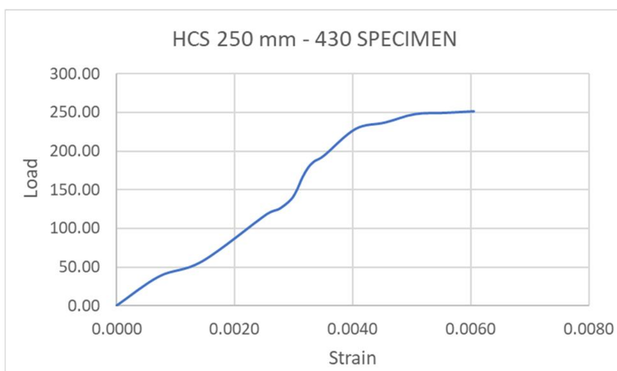


Fig. 7 Load Strain Curve of 250 mm HCS

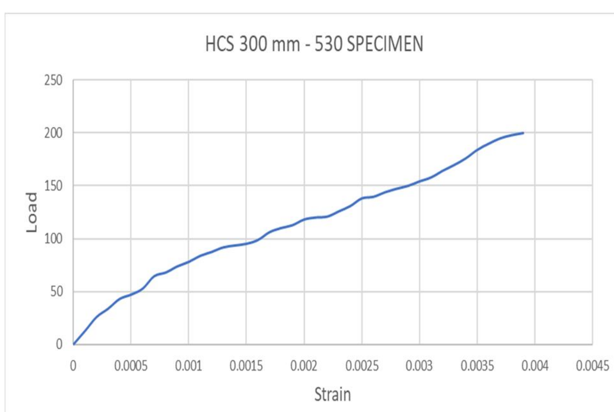


Fig. 8 Load Strain Curve of 300 mm HCS

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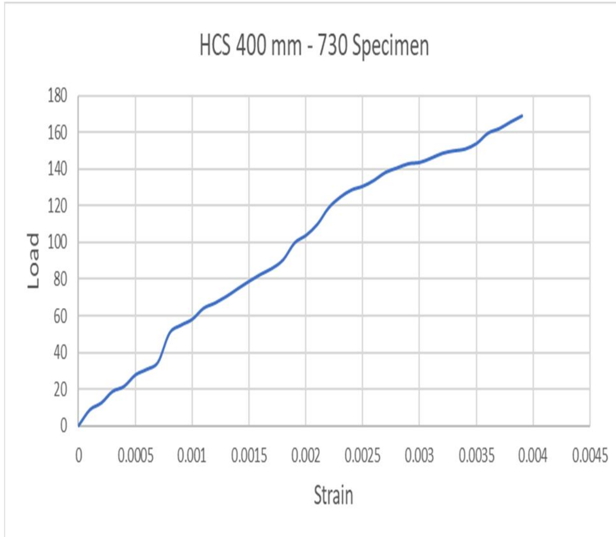

Fig. 9 Load Strain Curve of 400 mm HCS

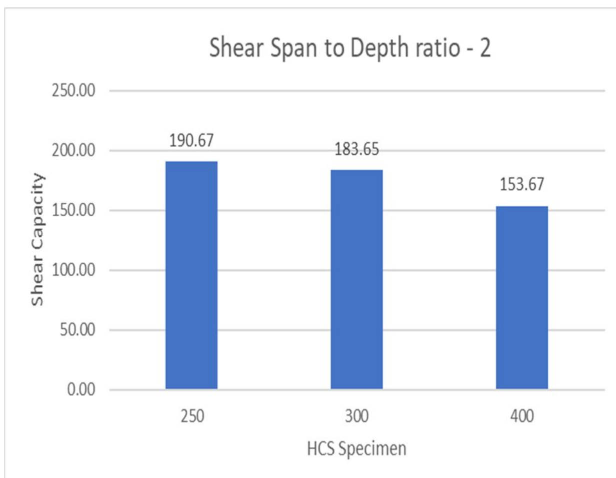

Fig. 10 Shear Capacities Shear Span to Depth ratio -2

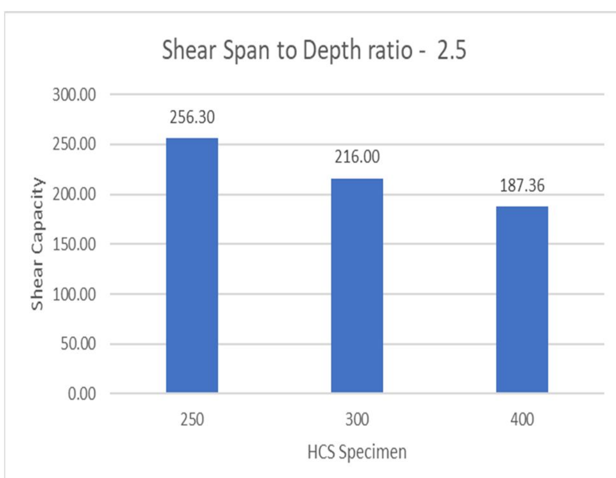

Fig. 11 Shear Capacities Shear Span to Depth ratio -2.5

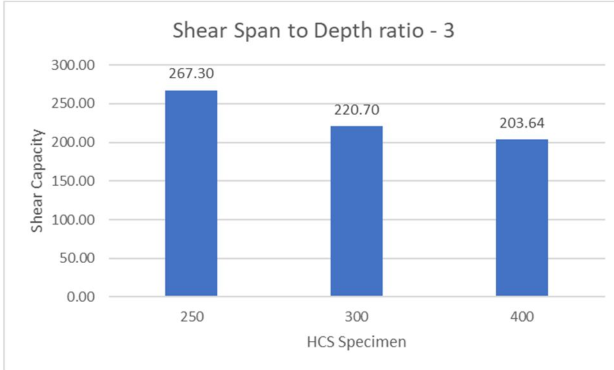

Fig.12 Shear Capacities Shear Span to Depth ratio -3

The numerical investigation revealed that the shear capacities of slab specimens reduces as the shear span to ratio decreases.

IV. CONCLUSION

Shear tests conducted on hollow core slabs by various researchers were studied. The parameters like geometrical properties such as moment of inertia, second moment of area, shear span to depth ratio were discussed. It was found that as the depth of the member increases, shear capacity of the member decreases due to the size effect. Shear strengthening techniques like core filling methods, fibre reinforced concrete can be employed.

V. ACKNOWLEDGMENT

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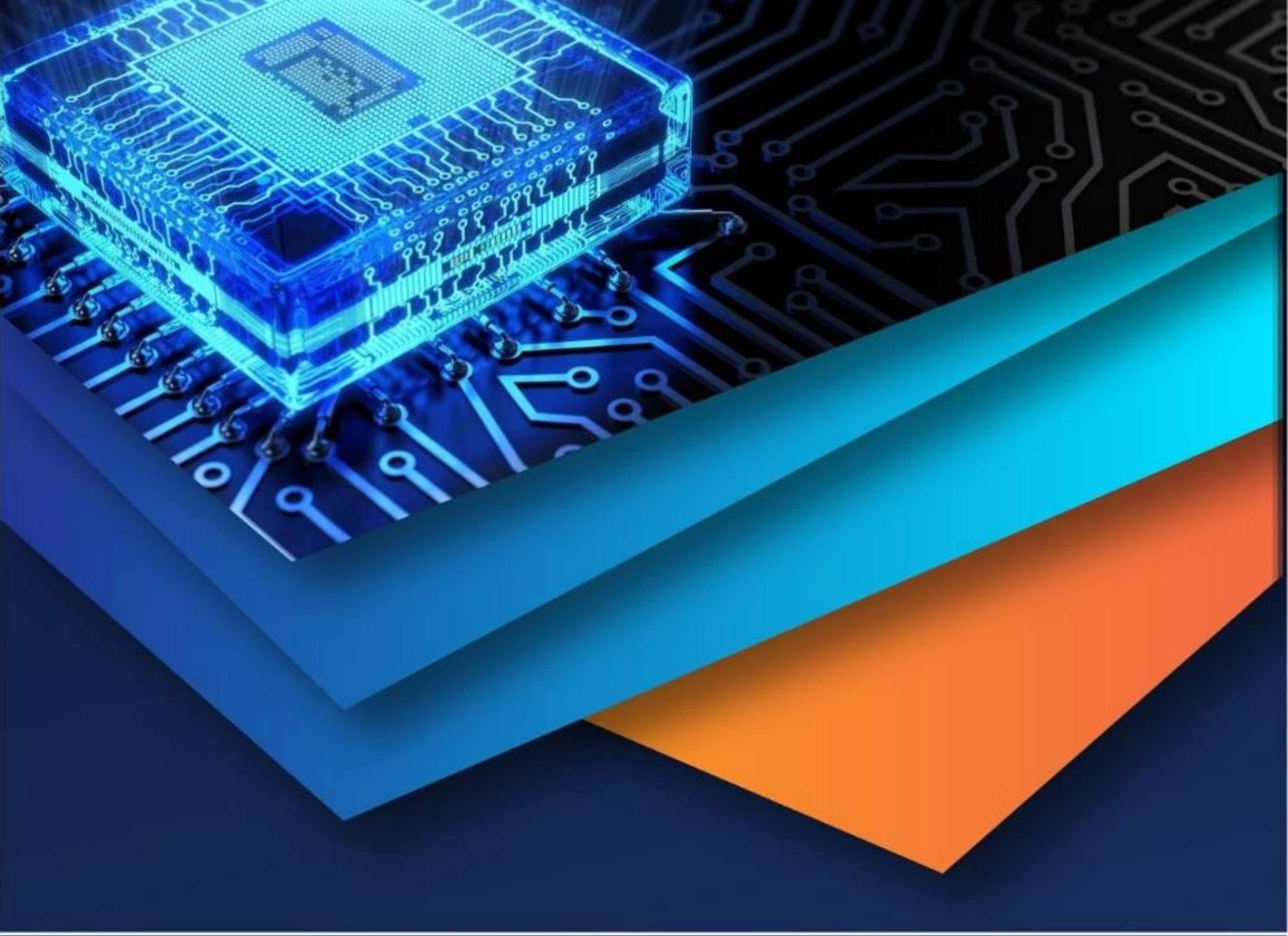
REFERENCES

[1] "A State Of The Art Review On Hollow Core Slabs", Ihsan A. Al-Shaarbaf, Adel A. Al- Azzawi and Radhwan Abdulsattar.
[2] "Experimental Investigation of the Web-Shear Strength of Deep Hollow-Core Units", Palmer, K. D., and A. E. Schultz, (2011), PCI Journal Vol.56, No. 4, pp. 83–104.
[3] "Experimental and numerical study of hollow core slabs strengthened with mounted steel bars and prestressed steel wire ropes",Xinghua Li , Gang Wua, Mohammed Shafiq Popal ,Jianbiao Jiang .
[4] "Factors affecting web-shear capacity of hollow-slabs with filled cores", Asperheim S.A., and B. Z. Dymond (2021) PCI Journal Vol.66, No.4, pp.43–65.
[5] "Shear Capacity of Hollow core Slabs with Concrete-Filled Cores" McDermott, M. R., and B. Z. Dymond (2020), PCI Journal Vol.65, No.2, pp.59–74.
[6] "Experimental study on the shear behaviour of precast concrete hollow core slabs with concrete topping" ,I.S. Ibrahim , K.S. Elliott , R. Abdullah , A.B.H. Kueh , N.N. Sarbini.
[7] ACI (American Concrete Institute) Committee 318-2014, *Building Code Requirements for Structural Concrete* (ACI 318-14) *and Commentary* (318R-14). Farmington Hills, MI: ACI
[8] Becker R.J. and Buettner D.R. (1985), 'Shear Tests of Extruded Hollow Core Slabs', PCI Journal Vol.55, No.5, pp.40–54.
[9] Cheng, S., and X. Wang. 2010, 'Impact of Interaction between Adjacent Webs on the Shear Strength of Pre- stressed Concrete Hollow core Units', PCI Journal Vol.55, No.3, pp. 46–63.
[10] Hawkins, N. M, and S. K. Ghosh (2006), 'Shear Strength of Hollow core Slabs', PCI Journal Vol.51, No.1, pp.110–114.
[11] Lee, D., M. Park, H. Joo, S. Han, and K. S. Kim. (2020), 'Strengths of Thick Prestressed Precast Hollow Core Slab Members Strengthened in Shear', ACI Structural Journal Vol.117, No.2, pp.129–140.
[12] Simasathien, S., and S.-H.Chao., (2015), 'Shear Strength of Steel-Fiber-Reinforced Deep Hollow core Slabs', PCI Journal Vol.60, No.4, pp. 85–101.
[13] Truderung K.A., Amr EI-Ragaby, Mady M. and Ehab EI-Salakawy (2019), 'Shear capacity of dry-cast extruded precast, prestressed concrete hollow core slabs', PCI Journal Vol.64, No.4, pp.71–83.



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