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Flexural Strength Test on Concrete Beam Samples with Polypropylene Fiber (PPF)

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***Abstract:** This review delves into how Flexural Strength affects the behavior of slabs using the Polypropylene Fiber Flexural Strength is crucial, in determining how slabs respond structurally affecting aspects such as deformation and failure mechanisms. Study how slabs behave under varying force conditions. Recent studies are synthesized in this review exploring how it enables examinations of force effects. It discusses the factors that influence Flexural Strength distribution. Acknowledges the challenges associated with this review underscores the importance of considering force in slab design. Highlights FEMs role, in improving comprehension and safety measures.*
***Keywords:** Flexural Strength, Slab behavior, Structural analysis, Deformation, Failure mechanisms.*

I. INTRODUCTION

Flexural strength is a crucial mechanical property that reflects the ability of concrete to resist bending or flexural loads, especially in structural elements such as beams and slabs. In this experimental study, we aim to evaluate the effect of adding Polypropylene Fiber (PPF) to concrete mixes in varying proportions and measure the change in flexural strength. PPF is known to improve crack resistance and durability in cementitious materials. The test is conducted on three concrete beam samples with PPF ratios of 0%, 0.5%, and 1.0% by weight of cement In the field of civil engineering, the structural behavior of slabs under diverse loading scenarios has long been of interest and significance. Shear force is one of the many different kinds of loads that is essential to a slab structure's stability and functionality. It is crucial to comprehend how shear force affects slabs in order to guarantee their stability and safety in real-world applications.

Complex elements including material qualities, shape, boundary conditions, and loading patterns all affect how slabs behave under shear force. The complex behavior of slabs subjected to shear is frequently too complex for traditional analytical approaches to fully capture. As such, numerical methods, and in particular the Finite Element Method , have become increasingly popular due to their capacity to offer comprehensive insights into the behavior of complex structures under a range of loading conditions^(2).

The application of the Finite Element Method to study the impact of shear force on slab behavior has grown in the past several years. With this method, slab structures can be precisely modeled and shear-induced phenomena can be accurately simulated^(5). Researchers can use finite element modeling (FEM) to examine the distribution of shear stresses, crack propagation, deformation patterns, and overall structural response under varying loading scenarios^(3).The objective of this review is to compile and critically evaluate the body of research on the impact of shear force on slab behavior using the Finite Element Method. Through a comprehensive analysis of prior research, this review aims to clarify significant discoveries, pinpoint areas in need of further study, and suggest directions for future research^(1). This paper aims to improve our knowledge

II. LITERATURE REVIEW

Jan C. Jofriet and Gregory M. McNeice , 1971 [6] this study presents a bending analysis of reinforced concrete slabs using the finite element method, focusing on nonlinear behavior resulting from progressive cracking. Post-yield behavior is excluded from the analysis. Two methods, Branson and Beeby, are investigated for estimating the rigidity of cracked concrete regions, with the latter proving more effective. Additionally, techniques for addressing cracking in arbitrary directions are proposed, including the transformation of flexural rigidities matrix and determination of equivalent steel areas aligned with crack orientations. Results demonstrating the efficacy of the proposed approach are presented.

P. M. Lewiński and W. Wojewódzki, 1991 [7] the main goal is to discusses a nonlinear procedure for analyzing the behavior of doubly reinforced concrete slabs. The first step of this procedure involves solving the elasticity problem for the slab, considering ten different cracking patterns. Each cracking pattern assumes a division of the slab thickness into multiple layers, with a maximum of three layers of concrete.

By doing this, the summation of constituent stiffness's over the layers, as seen in the layered method, is replaced by appropriate analytical or simple numerical integration across the total thickness. This method offers advantages such as enabling nonlinear analysis with relatively low numerical effort compared to the layered analysis. It is worth noting that in this approach, the tips of the considered cracks are not required to lie precisely on the interfaces of the layers. The study validates its proposed approach by comparing the results with experimental evidence from tests conducted on deep beams and slabs by other researchers. This comparison serves to assess the accuracy and effectiveness of the proposed method in predicting the behavior of reinforced concrete structures.

Ehab F. El-Salakawy, Maria Anna Polak, and Khaled A. Soudki, 2003 [8] To avoid punch failure due to shear in concrete slabs made of reinforced concrete that are currently in place; this study presents a revolutionary approach. The researchers sought to improve the connections between the slab and column edges by externally adding shear bolts that were bored through the thickness of the slab surrounding the column. Experiments carried out on full-scale slabs, both with and without the novel strengthening method, demonstrated that specimens featuring shear bolts had significantly higher punching capacities and ductility. This demonstrates how well the suggested technique strengthens reinforced concrete slabs to prevent punching shear.

A. K. M. Jahangir Alam ,Khan Mahmud Amanat, and Salek M. Seraj, 2009 [9] This experiment examines the punching shear capacity of flat slabs, focusing on factors often overlooked in current design codes: boundary restraint against rotation and the influence of flexural reinforcement. Through testing 15 model slabs, it assesses how these factors, along with slab thickness, impact structural behavior and punching load-carrying capacity. Findings highlight the significant effect of edge restraint and flexural reinforcement on punching failure load. By comparing results with various design codes, the study identifies discrepancies and emphasizes the need for incorporating its findings to enhance the accuracy of punching shear estimation in structural design.

Josef Hegger, Dominik Kueres, and Philipp Schmidt, 2010 [10] this research aims to examine how flat slabs with different levels of shear reinforcement punch shear. To this end, three systematic test series—two with and without stirrups—were carried out. Eight tests with low and medium levels of shear reinforcement were included in the experimental program, in addition to three reference tests conducted without it. The stirrup diameter was the only variable used in the testing to alter the amount of shear reinforcement. The shear span- depth ratio and the effective depth were further studied impacts. Discussion and comparison of the test series.

III. OBJECTIVES

Evaluate the flexural strength of concrete beams with and without PPF.
Observe crack resistance improvement with different PPF ratios.
Simulate realistic experimental procedure and collect virtual readings.

A. *Main Applications:*

- Crack control in ready-mix concrete, precast concrete, shotcrete, screeds, rendering mortars, and micro-silica concrete.
- Concrete slabs, pavements, driveways, and imprinted/stamped concrete.
- Water-retaining structures, marine concrete, patch repairs, and thin wall sections.

B. *Key Advantages:*

- Cost-effective alternative to anti-crack wire mesh (secondary reinforcement).
- Easy to use; reduces construction time and labor.
- Rust-proof, uniformly disperses in mix, enhances finishing and durability.
- Does not affect air entrainment significantly and is chloride-free.

1) *Technical Specifications:*

- Form: 100% Virgin Polypropylene fiber
- Specific Gravity: 0.91 g/cm³
- Tensile Strength: 350 N/mm²
- Modulus of Elasticity: 3500 – 4800 MPa
- Melting Point: 160 – 170°C
- Ignition Point: 590°C
- Alkali, Sulphate & Chloride Content: Nil

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- Cement Compatibility: Excellent

Mix Design Specifications

Material	Quantity per m³
Ordinary Portland Cement (OPC)	400 kg
Natural Sand (0–4 mm)	650 kg
Coarse Aggregate (5–20 mm)	1200 kg
Water	180 L
PPF (0%, 0.5%, 1%)	0 / 2 / 4 kg
Water/Cement Ratio	

Determining the Required PPF Amount Based on Cement Weight per SampleFor this experiment, all concrete beams were designed with identical mix proportions, using 2.0 kg of cement per sample. The PPF (Polypropylene Fiber) was added based on a percentage of the cement weight:

Sample A 0 % PPF serves as the reference (control).

Sample B includes 0.5 % PPF, equal to 10 grams.

Sample C includes 1% PPF, equal to 20 grams.

Sample ID	PPF Dosage (% of Cement Weight)	Cement Weight per Sample (kg)	PPF Amount (grams)
Sample A	0%	2	0 g
Sample B	0.5%	2	10 g
Sample C	1 %	2	20 g

Assuming each beam specimen is cast with dimensions of **100 × 100 × 500** mm, which is a standard size for flexural testing.

- V=0.1×0.1×0.5=0.005m3

Cement weight per sample=0.005×400=2kg

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2) Samples Preparation:

Three beam specimens (100 x 100 x 500 mm) were cast for this experiment. Mixes were prepared manually, with PPF added evenly during the dry mixing stage. The samples were cast into plastic molds and compacted with a vibrating table. All specimens were water cured for 28 days.

3) Flexural Strength Test Procedure:

The test follows ASTM C78 (Third-Point Loading method). A hydraulic flexural testing was used. Loading rate was set to 0.1 mm/min until failure. Load values and crack formation were recorded.

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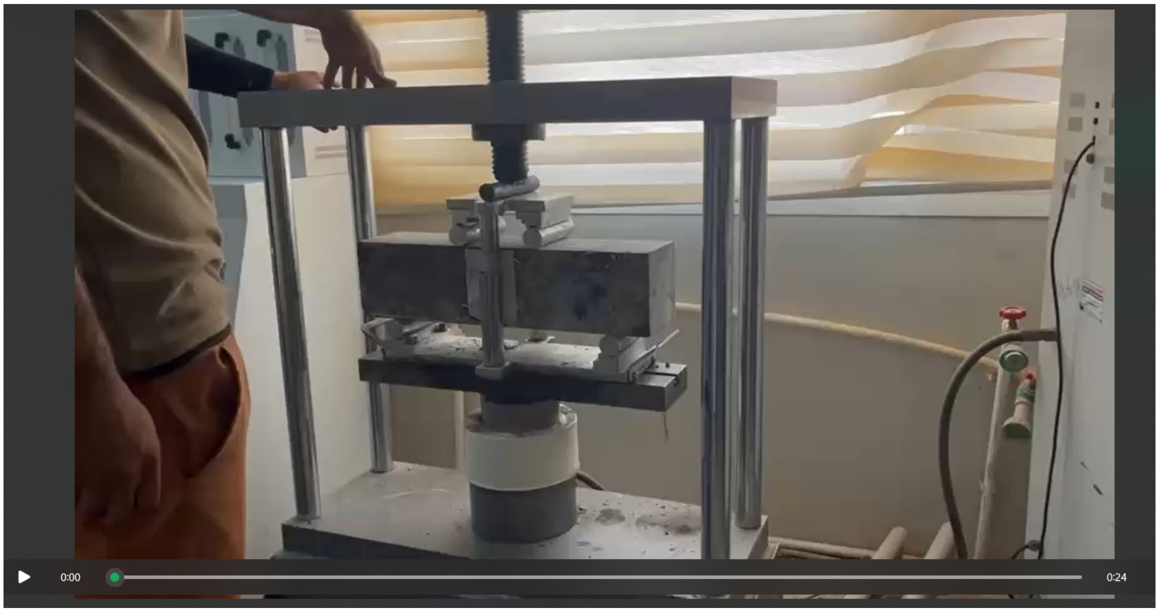

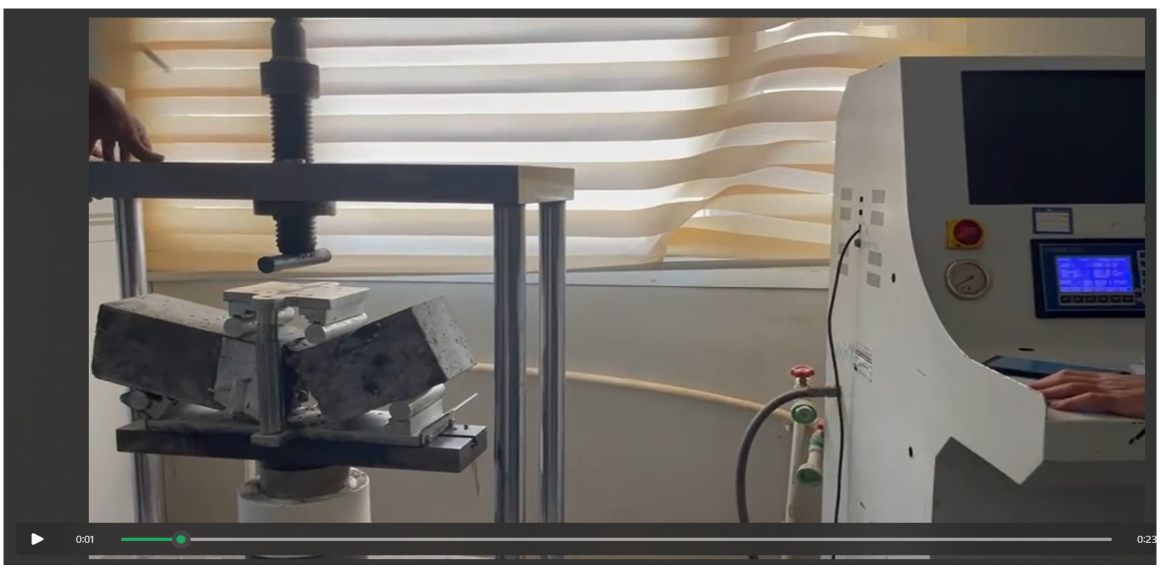

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IV. CALCULATION METHOD

Flexural strength (R) was calculated using the formula:

$R = (P \times L) / (b \times d^2)$

Where:

- R: Flexural strength (MPa)
- P: Maximum load (N)
- L: Span length = 400 mm
- b: Width = 100 mm
- d: Depth = 100 mm

Sample **A** calculation as an example:

$R = (P \times L) / (b \times d^2)$

$P=16.8\times1000=16800$ N

$$R = \frac{16800 * 400}{100 * 100^2} = 6.72\ MPa$$

But since the loading is at one-third, a correction factor is applied according to ASTM C78 (approximately 0.625 for Three-Point Loading).

$R=6.72\times0.625=4.20$ MPa

V. READINGS AND RESULTS

Sample	PPF Ratio (%)	Maximum Load (kN)	Flexural Strength (MPa)
A	0	16.8	4.2
B	0.5	20.4	5.1
C	1	22.8	5.7

VI. DISCUSSION

The experimental results show a significant improvement in flexural strength with the inclusion of PPF. Sample B (0.5% PPF) showed a 21.4% increase in strength compared to the reference sample A, while Sample C (1.0% PPF) achieved a 35.7% increase. Crack resistance and post-crack performance improved with increasing fiber content. The fibers helped in bridging micro-cracks and delaying failure. However, it is noted that higher fiber content may reduce workability, which can be compensated by using plasticizers.

VII. CONCLUSION

1) The use of PPF fibers significantly improves the flexural resistance of concrete.
2) The optimum ratio is between 0.5% and 1.0%, depending on the application.
3) It is recommended for use in elements subject to flexure, such as lintels and slabs.

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