International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Investigation on Flexural behaviour of Polyvinyl Alcohol Fiber Reinforced Concrete Beam

Saran. S P [1], Selvan. V [2], Enith Kumar.[3]

[1,3] PG Student, Dept. of Civil Engineering, Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India

[2]Assistant professor, Dept. of Civil Engineering, Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India

DOI: https://doi.org/10.55248/gengpi.5.0524.1234

A B S T R A C T

The primary focus of this research is to examine the impact of incorporating polyvinyl alcohol (PVA) fibre into concrete on its workability and compaction. The study suggests that compared to traditional concrete, PVA fibre-reinforced concrete exhibits superior strength. PVA fibre is identified as one of the top polymeric fibre for reinforcing concrete. Previous research suggests that an optimal dosage of 1.5% PVA fibre leads to improved performance across various tests. This paper outlines the experimental setup and results obtained from flexural strength, split tensile strength, and compressive strength tests conducted on cubes, cylinders, and prisms after curing for seven and twenty-eight days. Flexural strength assessments are specifically conducted after a twenty-eight-day curing period. Among the numerous advantages of Fiber Reinforced Polymer (FRP) reinforcements are their high tensile strength, resistance to corrosion, nonmagnetic properties, lightweight nature, and ease of handling. Recent studies highlight various fibre types including polypropylene, steel, glass, and polyvinyl alcohol as suitable options. Earlier investigations recommend a maximum overall fibre content of 3% in concrete. Additionally, the aspect ratio of fibre emerges as a critical characteristic requiring careful consideration. ANSYS software is used to examine the behaviour of normal concrete beams with the findings of polyvinyl alcohol fibre reinforced concrete beams. The study compares these results.

Keywords: PVA FIBRES, FIBRE-reinforced concrete (FRC), High performance FIBRE reinforced concrete, Fiber reinforced concrete beam.

INTRODUCTION

Concrete has a poor tensile strength and is more weak than other building materials like metals and plastics. Crack resistance values indicate that steel is at least 100 times more resistant to crack development than concrete. Concrete hence cracks easily when it is used. This allows harmful substances to enter the concrete and causes early saturation, freeze-thaw damage, scaling, discoloration, and steel corrosion. One of the most adaptable building materials is concrete. Any structural structure, such as a cylindrical water storage tank or a rectangular beam or column in a high-rise building, can be cast to fit it. High compressive strength, superior fire resistance, high water resistance, inexpensive maintenance, and a long service life are among the benefits of using concrete. Improving the concrete's post-cracking response is the main purpose of adding steel FIBREs to the aggregate. Steel FIBRE is an excellent material for internal mechanical interlock because of its tensile strength, stiffness modulus, elasticity modulus, and mechanical deformations. As a result, there is less chance of brittle concrete failure in scenarios involving significant impact and fatigue loading, and the product is more ductile and user-friendly. PVA FIBREs can thereby improve the specimen's splitting tensile property. Since the splitting tensile strength fluctuates with the PVA FIBRE quantity in a manner similar to that of the compressive strength, the two-point loading test must be performed to ascertain the deflection of the concrete beam.

POLYVINYL ALCOHOL FIBRE (PVA)

High-strength concrete is a cutting-edge building material designed to have a higher compressive strength than traditional concrete mixtures. It is achieved by selecting premium raw materials with care, such as cementitious binders and specialty aggregates, and often by adding additives like superplasticizers, fly ash, or silica fume. Consequently, the concrete often has compressive strengths approximately 6,000 psi (41 MPa) higher than normal. High-strength concrete's increased strength makes it perfect for demanding applications in high-rise structures, infrastructure, and projects where structural performance and durability are essential. With its development, construction technology has advanced significantly, paving the way for the construction of stronger, more resilient structures.Tables

All tables should be numbered with Arabic numerals. Every table should have a caption. Headings should be placed above tables, left justified. Only horizontal lines should be used within a table, to distinguish the column headings from the body of the table, and immediately above and below the table. Tables must be embedded into the text and not supplied separately. Below is an example which the authors may find useful.

Table 1 - An example of a table.

An example of a column heading	Column A (*t*)	Column B (*t*)
And an entry	1	2
And another entry	3	4
And another entry	5	6

SIGNIFICANCE OF RESEARCH

Ensuring the structural safety of buildings and structures is essential in protecting them against natural disasters like earthquakes, landslides, and more. Therefore, developing up with a way to lessen the impact of these kinds of attacks is essential. Using FIBREs in concrete is one way to safely resist the construction against static and dynamic loads. With its great ductility, strength, and energy-absorbing capacity, it can withstand impact loads and serve as a crack arrester. FIBREs can therefore be used to prevent the abrupt spalling of buildings during rapid attacks.Many investigations are conducted to increase the performance of concrete by using steel FIBREs. Research has demonstrated that the addition of FIBREs to concrete enhances its strength, flexural behavior, impact resistance, and post-cracking behavior. Therefore, it is required to use readily available brands of steel FIBREs in order to build enhanced future construction processes in an affordable and easy manner. It's critical to educate people about new technologies in order to promote society's advancement and safety. Section headings Section headings should be left justified, bold, with the first letter capitalized and numbered consecutively, starting with the Introduction. Sub-section headings should be in capital and lower-case italic letters, numbered 1.1, 1.2, etc, and left justified, with second and subsequent lines indented. All headings should have a minimum of three text lines after them before a page or column break. Ensure the text area is not blank except for the last page.

SCOPE OF PROJECT

The important to study the properties of the construction material for the safety of the structure by using the FIBREs. The creation of "FIBRE REINFORCED CONCRETE," or concrete with high strength, ductility, and energy absorption capacity, is needed. By using FIBRE in concrete will ensure the safety against cracking at the time of natural disasters or sudden impact loading. This study aims at determining the performance of concrete reinforced with the certain percentage of the polyvinyl alcohol FIBRE to the plain concrete. hyphenation at the end of a line. Symbols denoting vectors and matrices should be indicated in bold type. Scalar variable names should normally be expressed using italics. Weights and measures should be expressed in SI units. All non-standard abbreviations or symbols must be defined when first mentioned, or a glossary provided.

OBJECTIVE

- To determine the physical and mechanical properties of the aggregates and concrete.
- To determine the ideal result value for the fibre content in concrete by comparing the test results of various PVA fibre combinations.
- To cast and test the flexural behaviour of the conventional and the PVA fibre reinforced concrete beam using M30 Grade.
- To compare the analytical and experimental test results of the conventional and the PVA fibre reinforced concrete beam using Ansys 13.0 software.

LITERATURE REVIEW

1. **Sadaqat Ullah Khan, Tehmina Ayub (2016)**

In this study, PVA fiber-reinforced concrete demonstrates the ability to precisely depict the tensile stress-strain behavior up to a fiber volume of 3%, showing close correspondence with experimental outcomes of High-Performance Fiber-Reinforced Concrete (HPFRC). PVA fiber-reinforced concrete showcases a strain-hardening reaction with remarkable ductility and a strain capacity of 2%, surpassing that of Steel Fiber-Reinforced Concrete (SFRC). The utilization of a maximum 3% PVA fiber volume is dictated by the constraint of maintaining a constant binder content (Ordinary Portland Cement (OPC) + silica fume or metakaolin) in this investigation.

2. **Mingke Deng, Zhifang Dong , Cong Zhang (2020)**

Elevating the PVA fiber content and reinforcement ratio resulted in the formation of multiple cracks and a decrease in crack spacing, primarily due to the bridging effect exerted by short PVA fibers. This study examined the tensile characteristics of carbon Textile Reinforced Mortar (TRM) incorporating short PVA fibers. The ultimate stress and peak strain exhibited an increase with higher PVA fiber content, notably, a 2.0% content augmentation enhancing ultimate stress in M20 concrete mix design.

3.hen Gao , Peng Zhang , Juan Wang , Kexun Wang , Tianhang Zhang (2022)

The Fiber Factor (FF) emerged as a crucial parameter for evaluating the effectiveness of polyvinyl alcohol (PVA) fiber-reinforced mortar. The optimal value was achieved when the geopolymer mortar was combined with 0.8% and 2.0% PVA fibers. Incorporating PVA fibers improved the residual load-bearing capacity of both the geopolymer mortar and the concrete substrate. In the geopolymer mortar, the alkali activator solution comprised NaOH, Na2SiO3 solution, and water.

INVESTIGATION OF SPECIMEN

COMPRESSION STRENGTH TEST

The compressive strength of cube specimen according to the IS standard is tested for 3 days, 7 days and steam curing and it is given below.

Note:

A - Nominal Concrete

B – 0.5% of Polyvinyl alcohol FIBRE

C - 1% of Polyvinyl alcohol FIBRE

D - 1.5% of Polyvinyl alcohol FIBRE

E – 2% of Polyvinyl alcohol FIBRE

Table 2 - Concrete compressive strength after 7 days curing

MIX	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4
A	31.2	30.8	31.6	31.2
B	30	32.6	30.5	31.69
C	35.7	32.5	34.4	32.86
D	32.1	35.4	31	33.23
E	33.6	33.2	32	32.9

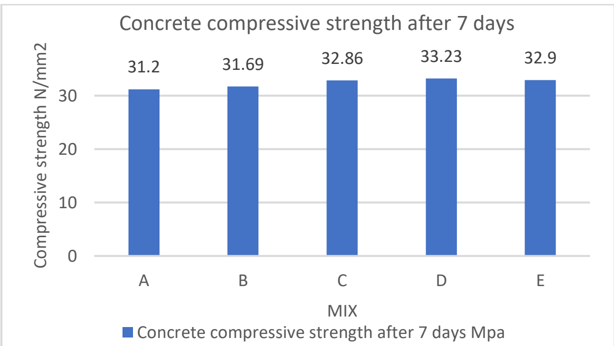

Fig. 1 - Concrete compressive strength after 7 days graph

Table 3 - Concrete compressive strength after 28 days curing

MIX	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4
A	34.8	36.7	36.2	35.9
B	34.55	35.7	37.7	35.65
C	35.3	40.1	38.1	38.83
D	42.13	40.56	43.78	40.12
E	39.5	37.9	36.6	38

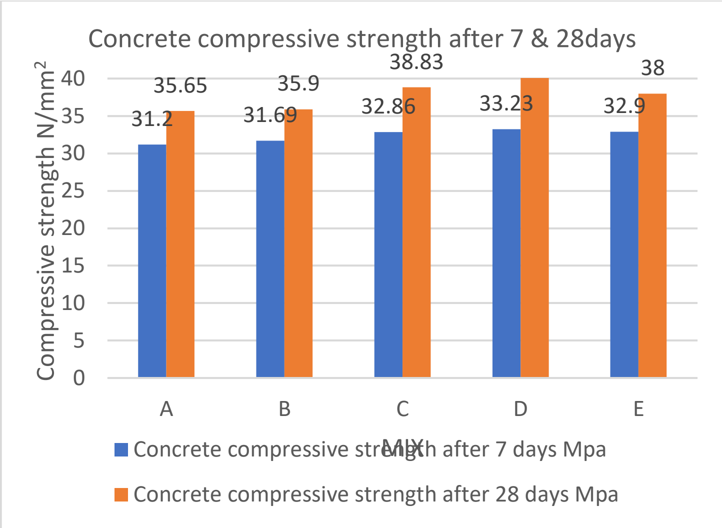

Fig. 2 - Concrete compressive strength after 28 days graph.

SPLIT TENSILE STRENGTH TEST

The split tensile strength of cylinder specimen according to the IS standard is tested for 7days, 28 days and steam curing and it is given below.

Table 4 - Concrete compressive strength after 7 days curing

MIX	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4
A	2.01	1.98	1.87	1.98
B	2.48	2.30	2.35	2.37
C	2.30	2.05	2.01	2.12
D	2.48	2.73	2.58	2.59
E	2.25	2.4	2.1	2.25

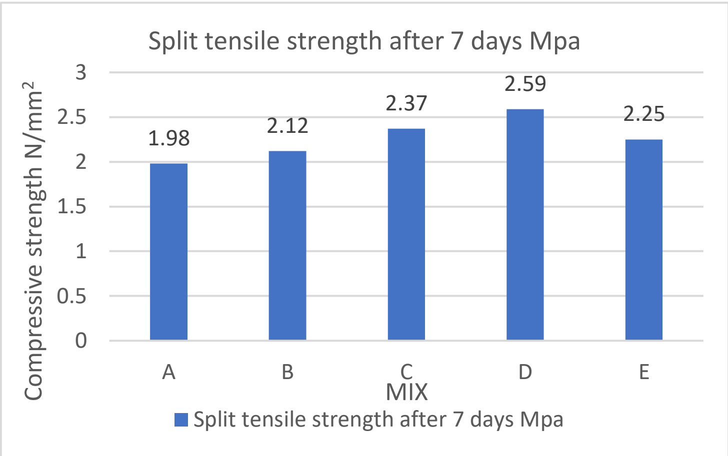

Fig. 3 - Concrete split tensile strength after 7 days graph.

Table 5 - Concrete compressive strength after 28 days curing

MIX	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4
A	7.6	7.03	7.14	2.5
B	8.05	8.15	8.25	3.45
C	8.45	8.56	8.45	3.89

D	9.10	8.95	8.9	4.52
E	8.70	8.35	8.13	4.19

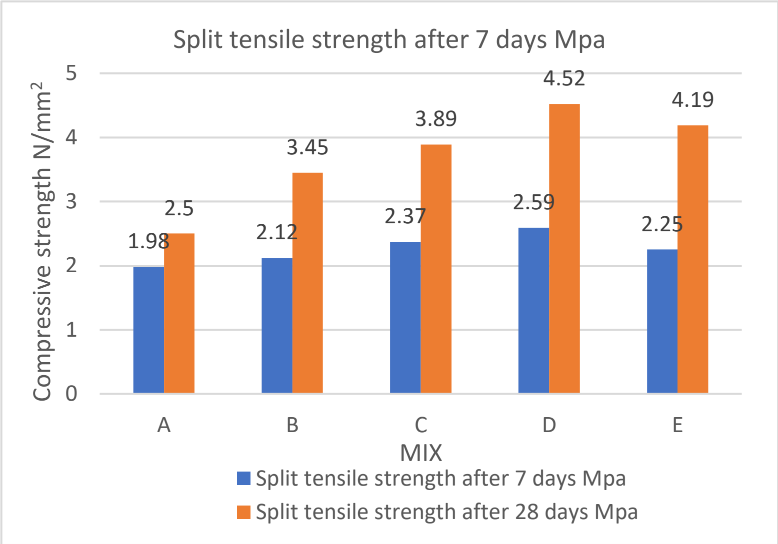

Fig. 4 - Concrete split tensile strength after 28 days graph.

SPLIT TENSILE STRENGTH TEST

The split tensile strength of cylinder specimen according to the IS standard is tested for 7days, 28 days and steam curing and it is given below.

Table 6 - Flexural strength after 28 days curing

MIX	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4
A	7.6	7.03	7.14	7.25
B	7.97	8.23	8.5	8.23
C	9.57	8.54	9.32	9.14
D	13.87	13.05	13.42	13.44
E	14.70	15.20	14.45	14.78

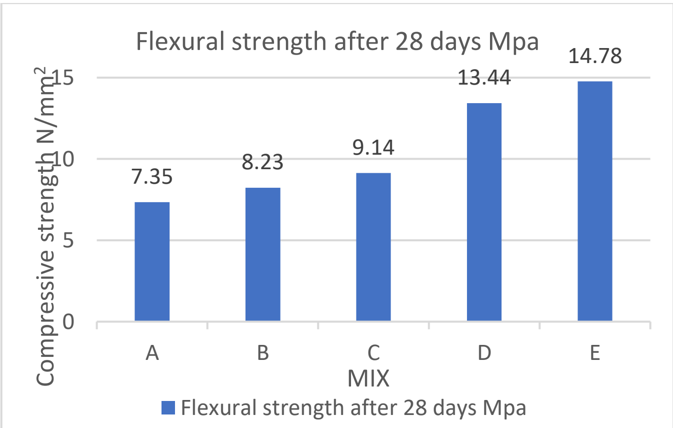

Fig. 5 - Concrete flexural strength after 28 days graph

4. DESIGN OF BEAM

A beam's dimensions and structural characteristics must be determined during design in order to make sure that it can securely handle the loads it will encounter during its intended use.

4.1 PRELIMINARY DATA

Grade of Concrete :M 30

Grade of Steel :Fe 500

Length of Beam :1500 mm

Effective Span Length:1300 mm

Breadth of Beam :150 mm

Depth of Beam :180 mm

Cover :25mm

Loading Type :Two-point Loading at Equal Distance (L/3)

End Condition :Simply Supported Beam

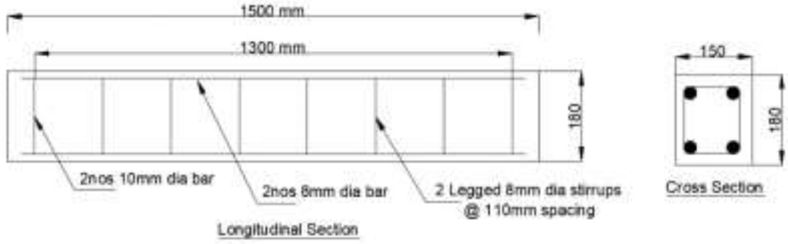

Fig. 6 - Longitudinal and cross section of concrete beam

5. FLEXURAL BEHAVIOUR OF CONCRETE BEAM

The two-point loading test is to evaluate the flexural behavior of the beams The setup, which was only supported, was where the beam was placed. On both sides of the beam, a 100mm support distance marking was placed. The load cell was adjusted and set up after a steel I section was positioned on the beam. In order to uniformly distribute the load on the beam, a three-point loading configuration was created. Using an LVDT (Linear Variable differential transformer), the deflection at the beam center, or L/2 distance, from the supports was measured. The deflection values were measured at a distance of L/3 from one of the supports using a dial gauge the experimental setup is shown.

Fig. 7 - Experimental Setup of Beam in Loading Frame

Table 7 - Final Observation for Conventional Beam

PARAMETERS	RESULTS	
1st Crack	39.22 KN (4 T)	
Deflection at 1st crack Load	L/2 = 1.51 mm	L/3 = 1.25 mm

Ultimate Load	142.19 KN (14.5 T)	
Ultimate Deflection	L/2 = 9.1 mm	L/3 = 8 mm

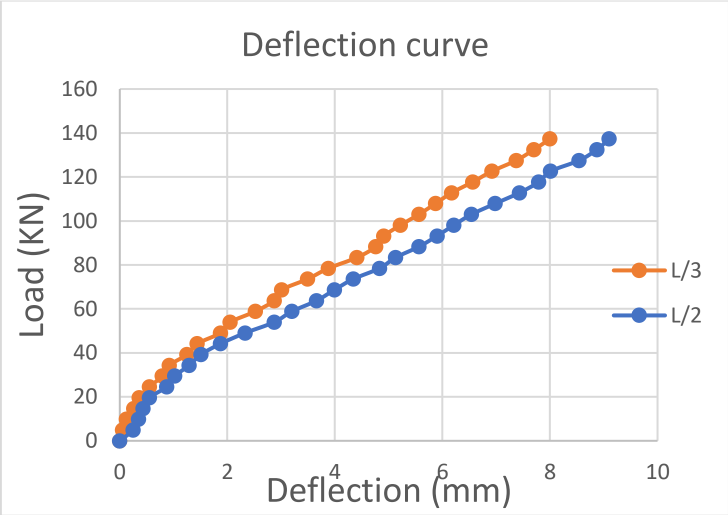

Fig. 8 - Load Deflection Curve (Conventional Reinforced Concrete Beam)

Table 8 - Final Observation for PVA fibre Reinforced Beam

PARAMETERS	RESULTS	
1st Crack	49.03 KN (5 T)	
Deflection at 1st crack Load	L/2 = 1.69 mm	L/3 = 1.48 mm
Ultimate Load	164.74 KN (16.8 T)	
Ultimate Deflection	L/2 = 9.08 mm	L/3 = 7.5mm

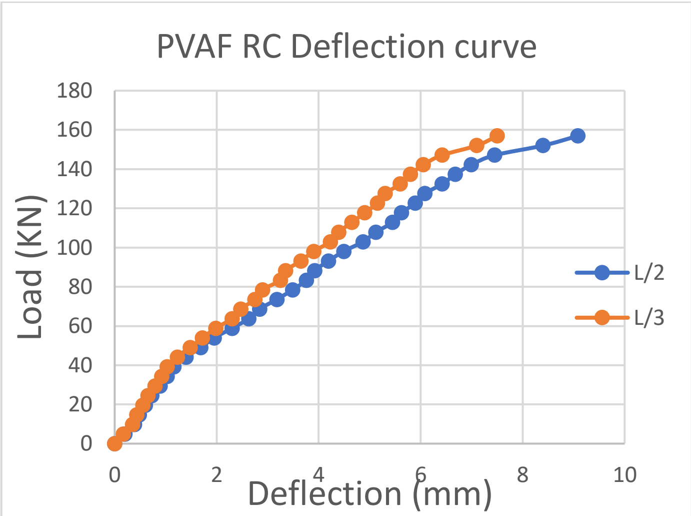

Fig. 9 - Load Deflection Curve (PVA Reinforced Concrete Beam)

6. ANSYS SOFTWARE

ANSYS is a key software solution in the field of structural engineering, where reliability and accuracy are key. It enables engineers to design, model, and analyze structures with unequalled effectiveness and precision. The massive simulation software package ANSYS is well-known for its adaptability to a wide range of engineering specialties, including electromagnetics, fluid dynamics, structural analysis, and more. It provides engineers with a stable platform to model and simulate the behavior of intricate structures under a range of loading scenarios. It was developed by ANSYS, Inc.

6.1 ANSYS SOFTWARE RESULTS

Table 9 - FLEXURAL BEHAVIOUR – RESULTS

SPECIMEN	**MAXIMUM DEFLECTION**	
	EXPLERIMENTAL RESULTS	**ANSYS RESULTS**
CONVENTIONAL BEAM	9.1	6.75
PVA FIBRE BEAM	9.08	7.56

This table shows the experimental and ANSYS results of flexural behavior of Conventional beams and Polyvinyl alcohol fibre concrete. By comparing with conventional beams, results shows that the Polyvinyl alcohol fibre reinforced beams have shown higher deflection in both experimental and analytical results in ANSYS software.

6. RESULTS

- In M30 Grade concrete, the addition of 1.5% PVA FIBRE improves the workability of the concrete.
- Numerous mechanical tests, such as flexural, split tensile, and compression strength tests, are performed on the concrete specimen.
- The results of these tests are compared to conventional concrete to determine the ideal amount of fibre content for maximum strength.
- Bond strength between polymer FIBREs and concrete is high from the results.
- To evaluate the flexural strength of the fibre-reinforced concrete beam, 1.5% of Polyvinyl Alcohol Fibre content the ideal percentage is applied.
- PVAF concrete beam performs better when comparing the load capacities of the two types of beams before to their cracking. Compared to a normal concrete beam, which can hold a weight of 14.5 tonnes, it can support 16.8 tonnes before cracking. It's important to keep in mind that when exposed to excessive strains, both types of beams eventually fracture.
- This implies that even with a higher load capacity, the PVAF concrete beam is still susceptible to failure in extreme circumstances. To evaluate the resistivity and long-term performance of both kinds of beams under various loads, more investigation could be necessary.
- Using Ansys software, the experimental and analytical methods are used to compare the results of the study of the standard concrete beam and the Polyvinyl Alcohol Fibre concrete beam

References

1 A. Saradar, P. Nemati, A.S. Paskiabi, M.M. Moein, H. Moez, E.H. Vishki, Prediction of mechanical properties of lightweight basalt FIBRE reinforced concrete containing silica fume and fly ash: experimental and numerical assessment, J. Build. Eng. 32 (2020) 101732

2. B. Li, H. Xiong, J. Jiang, X. Dou, Tensile behavior of basalt textile grid reinforced engineering cementitious composite, Compos. Part B 156 (2019)

3. F.O. Falope, L. Lanzoni, A.M. Tarantino, Double lap shear test on steel fabric reinforced cementitious matrix (SFRCM), Compos. Struct. 201 (2018) 503–513

4. hang, R.; Jin, L.; Tian, Y.; Dou, G.; Du, X. Static and dynamic mechanical properties of eco-friendly polyvinyl alcohol FIBREreinforced ultra-high-strength concrete. Struct. Concr. 2019, 1051–1063.

5. J. Shi, B. Liu, J. Qin, J. Jiang, X. Wu, J. Tan, Experimental study of performance of repair mortar: evaluation of in-situ tests and correlation analysis, J. Build. Eng. 31 (2020) 101325

6. Jiang, F.-X.; Wittmann, F.; Zhao, T.-J. Influence of Mechanically Induced Damage on Durability and Service Life of Reinforced Concrete Structures. Restor. Build. Monum. 2011, 17, 25–32

7. Liu, Y.; Shi, C.; Zhang, Z.; Li, N.; Shi, D. Mechanical and fracture properties of ultra-high performance geopolymer concrete: Effects of steel FIBRE and silica fume. Cem. Concr. Compos. 2020, 112,

8. M. Deng, H. Sun, X. Liang, W. Jing, Experimental study of flexural behavior of ductile FIBRE reinforced concrete, Industrial Construction 5(11) (2014) 84–93.

9. M. Deng, Y. Zhang, Seismic performance of high-ductile FIBRE-reinforced concrete short columns, Adv. Civ. Eng. 3542496 (2018),

10. M. Leone, M.A. Aiello, A. Balsamo, F.G. Carozzi, F. Ceroni, et al., Glass fabric reinforced cementitious matrix: tensile properties and bond performance on masonry substrate, Compos. Part B 127 (2017) 196–214

11. Malik, M.A.; Sarkar, M.; Xu, S.; Li, Q. Effect of PVA/SiO2 NPs Additive on the Structural, Durability, and Fire Resistance Properties of Geopolymers. Appl. Sci. 2019,

12. Nam, J.; Kim, G.; Lee, B.; Hasegawa, R.; Hama, Y. Frost resistance of polyvinyl alcohol FIBRE and polypropylene FIBRE reinforced cementitious composites under freeze thaw cycling. Compos. Part B Eng. 2016, 9

13. Pakravan, H.R.; Jamshidi, M. Tensile properties of strain-hardening cementitious composites containing polyvinyl-alcohol FIBREs hybridized with polypropylene FIBREs. J. Cent. South Univ. 2018

14. R. Barhum, V. Mechtcherine, Effect of short, dispersed glass and carbon fibres on the behaviour of textile-reinforced concrete under tensile loading, Eng. Fract. Mech. 92 (2012) 56–71. D

15. S. Yin, Y. Yang, T. Ye, Y. Li, Experimental research on seismic behavior of reinforced concrete columns strengthened with TRC under corrosion environment, J. Struct. Eng. 143 (5) (2017) 04016231