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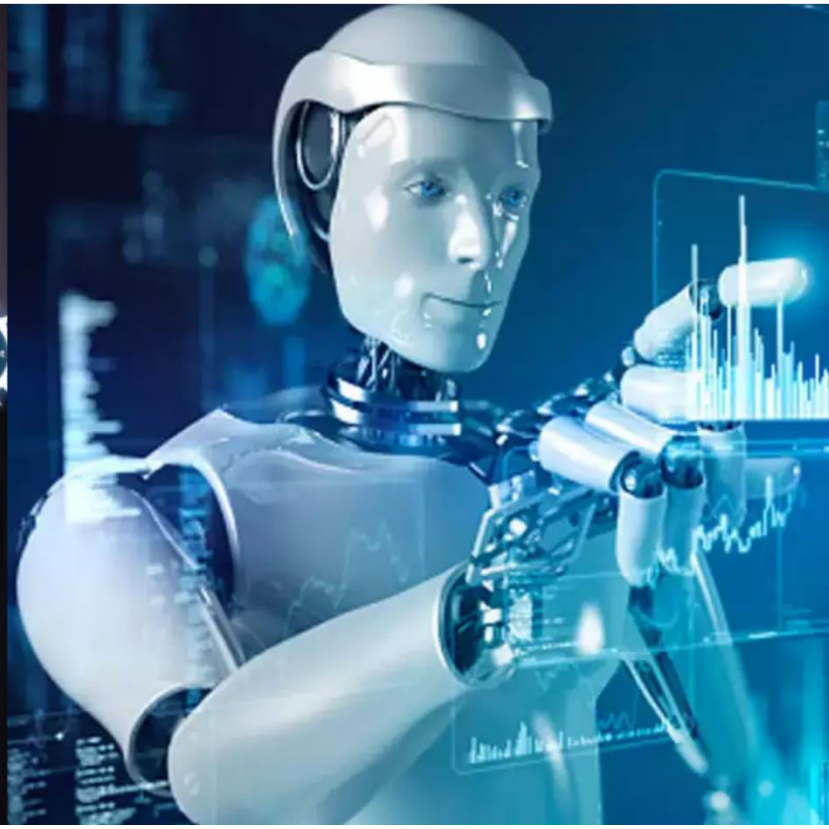

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# Mechanical and Fresh Properties of Polypropylene Fiber-Reinforced Self-Compacting Geopolymer Concrete

**Koppala Veera Sivudu[1], I.V. Ramana Reddy[2]**

PG Student, Department of Civil Engineering, Sri Venkateswara University College of Engineering, Tirupati, Andhra Pradesh, India[1]

Professor, Department of Civil Engineering, Sri Venkateswara University College of Engineering, Tirupati, Andhra Pradesh, India[2]

**ABSTRACT**: This experimental work explores the fresh and hardened behavior of self-compacting geopolymer concrete (SCGC) reinforced with polypropylene fibers. The study aims to evaluate how different fiber contents influence flow behavior, compressive strength, and flexural performance. Fly ash and GGBS were activated with sodium hydroxide and sodium silicate solutions to form the geopolymer matrix. The inclusion of polypropylene fibers enhanced the fracture resistance and reduced brittleness, though a moderate decline in workability was observed. The optimum fiber dosage yielded improvements in tensile and flexural strength without significantly compromising self-compacting ability. These findings highlight the potential of PPF-SCGC as a durable, sustainable, and high-performance concrete for modern infrastructure

**KEYWORDS**: Blast Furnace Slag (GGBS), Fly Ash, Ground Granulated Silica Fume, Mechanical Properties Polypropylene Fibers, Self-Compacting Geopolymer Concrete (SCGPC).

## I. INTRODUCTION

Self-compacting geopolymer concrete (SCGC) is an advanced, eco-friendly construction material that offers an alternative to traditional Portland cement concrete with significantly reduced carbon emissions. SCGC combines the benefits of geopolymer technology using industrial byproducts like fly ash and ground granulated blast furnace slag (GGBS) activated with alkaline solutions with the ease of placement and compaction inherent to self-compacting concretes. Incorporating polypropylene fibers into SCGC has attracted attention due to the fibers ability to enhance mechanical properties, including fracture resistance, tensile strength, and durability, while reducing brittleness. Although fiber addition may moderately reduce fresh concrete flowability, optimal polypropylene fiber dosages can maintain the self- compacting characteristics necessary for practical applications. This modification aims to improve the long-term performance, toughness, and sustainability of concrete for modern infrastructure, making polypropylene fiber-reinforced SCGC a promising material for structural and civil engineering uses. Understanding the fresh and hardened behavior of fiber- reinforced geopolymer concrete is vital for promoting its wider use in sustainable construction.

## II. LITERATURE SURVEY

**[1] Abu Dhabi University et a (2024)** broad review including PP fibers. Discusses how PP fibre influences fresh properties (reducing flow & spread, increasing viscosity), hardened strength, durability (resistance to chemical attack, permeability etc.), comparing conventional vs geopolymer matrices.**[2] Yamuna Bhagwat, Gopinatha Nayak, Poornachandra Pandit, Aishwarya Lakshmi (2023)** M-sand SCC with PP fibers at 0.1%, 0.15%, 0.2%. Fresh properties decline with fibers; durability improved: reduced drying shrinkage (~40%), water absorption (~30%), water penetration, acid resistance, improved corrosion crack initiation time. Strengths: compressive (~6.97%), split tensile (~8.68%), flexure (~3%) improvements at about 0.15%.**[3] Prabu Baskar, Shalini Annadurai, Kaviya Sekar, Mayakrishnan Prabakaran (2023)** This is a survey of multiple studies. It includes

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effects of various fiber types (including PP), discussing fresh workability losses, hardened properties (compressive, tensile, flexural), microstructure (crack bridging, pore refinement), optimum fibre contents, etc. **[4] Diddi, P.K., Sharma, P.K., Srivastava, A. et al. (2022)** Blends of PP and alkali resistant fibres: fresh properties like flow, hardened strength for early strength SCC. PP fibres reduce flow, increase viscosity etc.; strength improvements depending on blended fiber proportions.

## III. METHODOLOGY

The experimental study on *Self-Compacting Geopolymer Concrete (SCGPC)* reinforced with *polypropylene fibers* involved the use of fly ash, Ground Granulated Blast Furnace Slag (GGBS), and silica fume as binder materials, activated with a 12M alkaline solution composed of sodium hydroxide and sodium silicate in a 1:2 ratio. Natural river sand and crushed granite were used as fine and coarse aggregates, respectively, with a polycarboxylate-based superplasticizer added to enhance workability. Ten concrete mixes were prepared by varying silica fume (0–15%) and polypropylene fiber (0–2%) content, maintaining an alkaline liquid-to-binder ratio of 0.45. The concrete was mixed in a pan mixer, cast into cubes, cylinders, and beams, and cured at ambient temperature (27 ± 2°C) for 7, 28, and 90 days. Fresh properties were tested as per EFNARC guidelines (slump flow, T50, V-funnel, L-box, and U-box tests), while hardened properties were evaluated through compressive, split tensile, and flexural strength tests. The results identified the mix containing 40% GGBS, 50% fly ash, 10% silica fume, and 1% polypropylene fiber as the optimum combination, showing superior strength and workability performance under ambient curing conditions.

***Mix Designations***

M1-60 %Fly ash +40% GGBS
M2-60%Fly ash +30% GGBS +10% Silica fume
M3-60%Fly ash+ 20% GGBS +20% Silica fume
M4-55%Fly ash+ 40% GGBS +5% Silica fume
M5-50%Fly ash +40% GGBS +10% Silica fume
M6-45%Fly ash+ 40% GGBS +15% Silica fume
M7-50%Fly ash+ 40% GGBS +10% Silica fume +0.5 Polypropylene Fibers
M8-50%Fly ash+ 40% GGBS +10% Silica fume +1.0 Polypropylene Fibers
M9-50%Fly ash +40% GGBS+ 10% Silica fume +1.5 Polypropylene Fibers
M10-50%Fly ash+ 40% GGBS+ 10% Silica fume +2.0 Polypropylene Fibers

**Table 1: Mix Proportions of Different Mixes (kg/m$^3$)**

| Mix | Fly ash | GGBS | Silica fume | Fine Agg. | Coarse Agg. | NaOH | $Na_2SiO_3$ | Super plasticizer | Additional Waters |
|---|---|---|---|---|---|---|---|---|---|
| M1 | 297.93 | 198.62 | - | 496.55 | 924 | 74.88 | 148.96 | 7.443 | 49.65 |
| M2 | 297.93 | 148.96 | 49.655 | 496.55 | 924 | 74.88 | 148.96 | 7.443 | 49.65 |
| M3 | 297.93 | 99.31 | 99.31 | 496.55 | 924 | 74.88 | 148.96 | 7.443 | 49.65 |
| M4 | 273.1 | 198.62 | 24.828 | 496.55 | 924 | 74.88 | 148.96 | 7.443 | 49.65 |
| M5 | 248.27 | 198.62 | 49.655 | 496.55 | 924 | 74.88 | 148.96 | 7.443 | 49.65 |
| M6 | 223.44 | 198.62 | 74.483 | 496.55 | 924 | 74.88 | 148.96 | 7.443 | 49.65 |
| M7 | 248.27 | 198.62 | 49.655 | 496.55 | 924 | 74.88 | 148.96 | 7.443 | 49.65 |
| M8 | 248.27 | 198.62 | 49.655 | 496.55 | 924 | 74.88 | 148.96 | 7.443 | 49.65 |
| M9 | 248.27 | 198.62 | 49.655 | 496.55 | 924 | 74.88 | 148.96 | 7.443 | 49.65 |
| M10 | 248.27 | 198.62 | 49.655 | 496.55 | 924 | 74.88 | 148.96 | 7.443 | 49.65 |

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## IV. EXPERIMENTAL RESULTS

**Fresh Properties:**
All mixes satisfied EFNARC ranges (Slump Flow: 650–800 mm, $T_{50}$: 2–5 s). PP fiber up to 1% marginally reduced flowability but maintained satisfactory self-compaction. Beyond 1.5%, workability declined significantly due to fiber balling and increased viscosity.

**Table 2: Fresh Properties of SCGPC Result**

| Mix Designations | Slump Flow Test (mm) | $T_{50}$ Slump (sec) | V Funnel Test (sec) | L -Box Test | U-Box Test(mm) |
|---|---|---|---|---|---|
| M1 | 700 | 3.7 | 6.2 | 0.84 | 17.5 |
| M2 | 670 | 3.2 | 7.1 | 0.89 | 19.9 |
| M3 | 655 | 4 | 7.9 | 0.92 | 21.5 |
| M4 | 680 | 3.6 | 6.8 | 0.86 | 18.1 |
| **M5** | **670** | **4.2** | **7.3** | **0.9** | **19.6** |
| M6 | 660 | 3.5 | 7.6 | 0.94 | 20.6 |
| M7 | 725 | 4.5 | 6.9 | 0.95 | 28 |
| **M8** | **690** | **3** | **7.5** | **0.93** | **27** |
| M9 | 685 | 3.5 | 8.5 | 0.91 | 24 |
| M10 | 655 | 4 | 9 | 0.86 | 22 |

**Mechanical Properties:**
**1. Compressive Strength:** Highest at 38.55 MPa (28 days, M5 + 0.5% PP), compared to 38.06 MPa in control mix.

**Table 3: Compressive Strength Results**

| Mix Designations | Compressive strength test ($N/mm^2$) | | |
|---|---|---|---|
| | **7days** | **28 days** | **90 days** |
| M1 | 26.86 | 34.85 | 35.1 |
| M2 | 17.81 | 30.76 | 31.2 |
| M3 | 13.97 | 23.31 | 23.4 |
| M4 | 18.92 | 21.34 | 28.16 |
| **M5** | **27.44** | **38.06** | **38.17** |
| M6 | 17.12 | 17.01 | 19.29 |
| M7 | 26.54 | 36.26 | 37.12 |
| **M8** | **28.68** | **38.55** | **39.16** |
| M9 | 20.84 | 33.98 | 35 |
| M10 | 16.14 | 28.09 | 27.19 |

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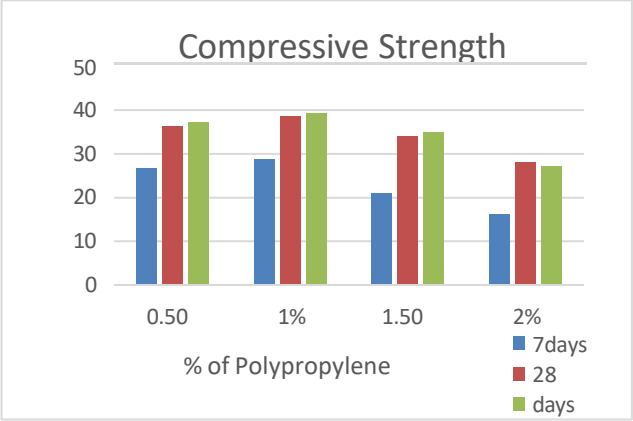


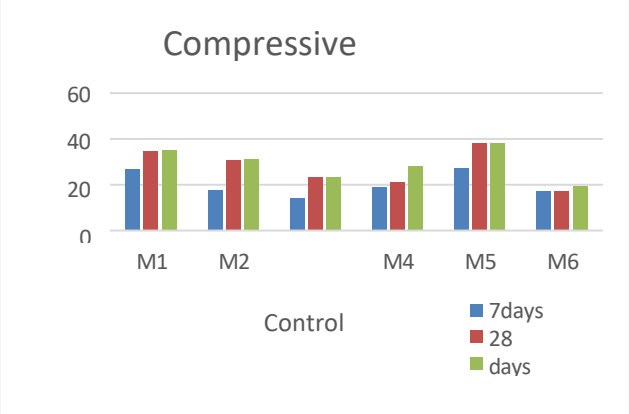
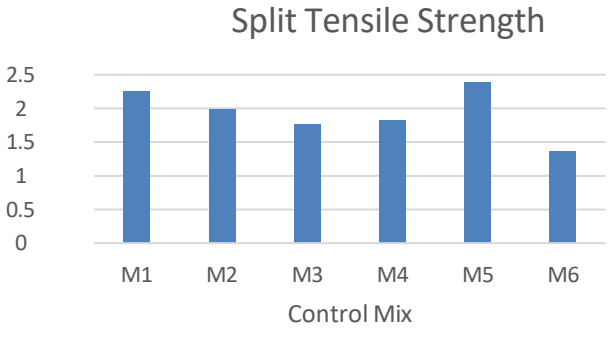




**Fig 1: Compressive Strength**

**2. Split Tensile Strength:**
Improved from 2.38 MPa (control) to 2.83 MPa with 1% Polypropylene fiber.

**Table 4: Split Tensile Strength Results**

| Mix Designations | Split Tensile Strength -28 days(N/mm$^2$) |
|---|---|
| M1 | 2.25 |
| M2 | 1.99 |
| M3 | 1.76 |
| M4 | 1.83 |
| **M5** | **2.38** |
| M6 | 1.37 |
| M7 | 2.63 |
| **M8** | **2.83** |
| M9 | 2.35 |
| M10 | 2.06 |



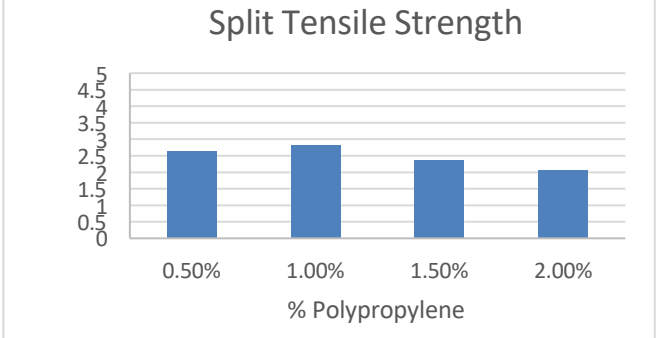




**Fig 2: Split Tensile Strength**

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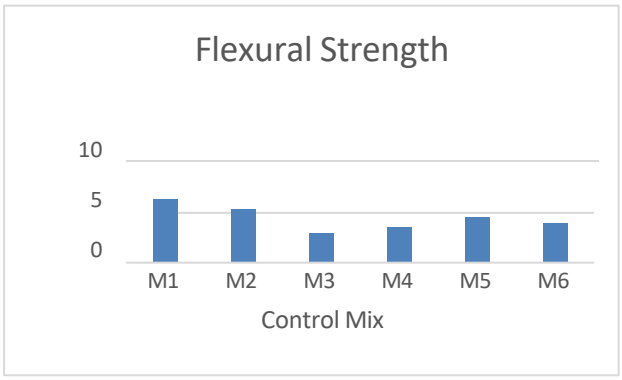
**3. Flexural Strength:**
Increased from 5.59 MPa to 6.70 MPa at 1% Polypropylene fiber addition.

Table 5: Flexural Strength Results

| Mix Designations | Flexural Strength Test 28 days ($N/mm^2$) |
|---|---|
| M1 | 6.43 |
| M2 | 5.38 |
| M3 | 2.97 |
| M4 | 3.60 |
| **M5** | **5.59** |
| M6 | 3.98 |
| M7 | 5.35 |
| **M8** | **6.70** |
| M9 | 5.98 |
| M10 | 4.36 |



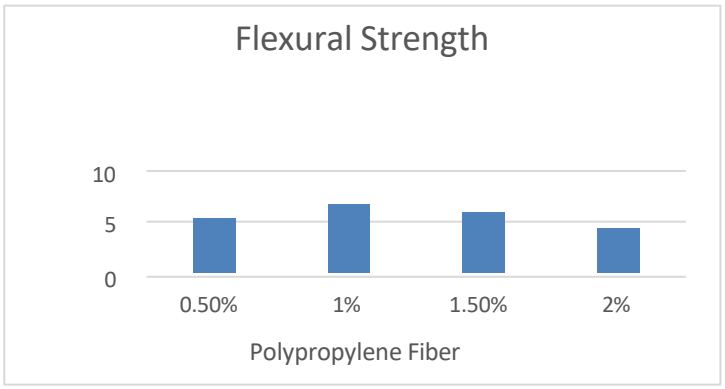




**Fig 3: Flexural Strength**

**Beam Behavior:** Fiber addition (1%) combined with stirrups increased flexural capacity by 28.5% and energy absorption, reducing crack width and propagation rate.

**Table 6: Flexural Strength Results**

| Beam Type | Flexural Strength Test 28 days($N/mm^2$) |
|---|---|
| Beam without stirrups Control Mix (M5) | 12.836 |
| Beam without stirrups M8 (1% Polypropylene Fibers) | 14.08 |
| Beam with stirrups Control Mix (M5) | 13.893 |
| Beam with stirrups M8 (1%Polypropylene Fibers) | 17.85 |

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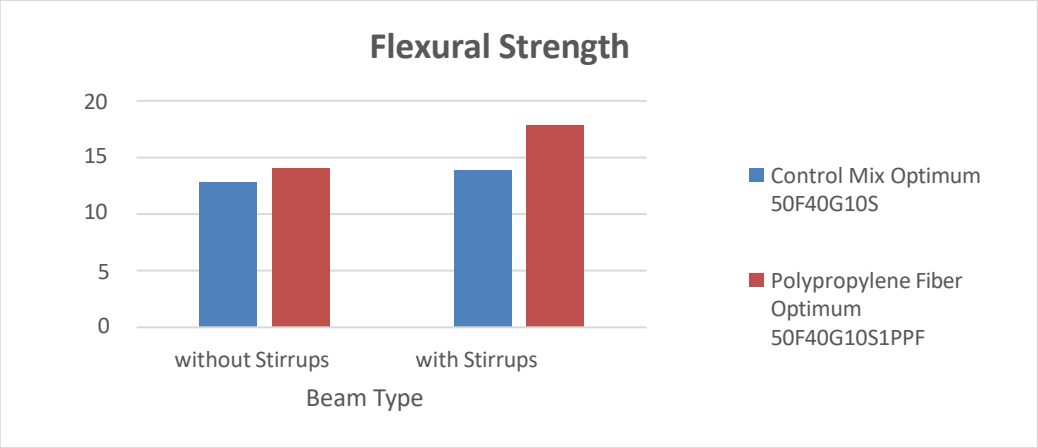


**Fig 4: Comparasion of With and Without Stirrups**

Improvement in strength and deformation capacity at 1% fiber content demonstrates effective crack bridging and load redistribution. Higher fiber amounts caused reduced compaction and strength loss, aligning with previous findings on fiber optimum dosage. Replacement of fly ash with GGBS improved ambient curing performance due to calcium-rich gel formation.

## V. CONCLUSION

1. SCGPC incorporating 40% GGBS and 10% silica fume achieved optimum mechanical strength under ambient curing.
2. Addition of 1% polypropylene fiber improved compressive, tensile, and flexural strengths by 12–20% while maintaining acceptable workability.
3. Excessive fiber content (>1.5%) reduced self-compaction and strength.
4. Beams with 1% PP fiber and conventional stirrups displayed maximum ductility and energy absorption.
5. SCGPC reinforced with PP fibers provides an eco-efficient, ductile alternative for structural applications, promoting carbon-neutral construction.

## REFERENCES

**1.** Davidovits, J. (1991). *Geopolymers: Inorganic polymeric new materials*. Journal of Thermal Analysis and Calorimetry, 37(8), 1633–1656.
**2.** Van Deventer, J. S. J., Provis, J. L., & Duxson, P. (2012). *Technical and commercial progress in the adoption of geopolymer cement*. Minerals Engineering, 29, 89–104.
**3.** Hardjito, D., & Rangan, B. V. (2005). *Development and properties of low-calcium fly ash-based geopolymer concrete*. Research Report GC 1, Curtin University of Technology, Australia.
**4.** Memon, F. A., Nuruddin, M. F., & Shafiq, N. (2013). *Effect of curing conditions on strength of fly ash- based self-compacting geopolymer concrete*. International Journal of Civil and Environmental Engineering, 7(2), 106–112.
**5.** Madheswaran, C. K., Gnanasundar, G., & Gopalakrishnan, N. (2014). *Effect of molarity in geopolymer concrete with GGBS*. International Journal of Civil and Structural Engineering, 4(2), 106–115.
**6.** Nath, P., & Sarker, P. K. (2015). *Flexural strength and elastic modulus of ambient-cured blended low- calcium fly ash geopolymer concrete*. Construction and Building Materials, 101, 1–8.
**7.** Sivakumar, A., & Santhanam, M. (2007). *Mechanical properties of high strength concrete reinforced with metallic and non-metallic fibres*. Cement and Concrete Composites, 29(8), 603–608.
**8.** Sangi, R., Bollapragada, S. S., & Shanker, K. (2024). *Effect of Polypropylene Fiber on the Strength Properties of Geopolymer Concrete Activated with Water Glass.* **Slovak Journal of Civil Engineering, 32**(3), 13–20. https://doi.org/10.2478/sjce-2024-0015 Paradigm+1

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**9.** Mohamed, Z. A., Al-Jaberi, L. A., & Shubber, A. N. (2021). *Effect of Polypropylene Fiber on Properties of Geopolymer Concrete Based on Metakaolin.* **Journal of Engineering and Sustainable Development, 25**(2), 58–67. https://doi.org/10.31272/jeasd.25.2.7 jeasd.uomustansiriyah.edu.iq

**10.** Mohamed, O., Zuaiter, H. (2024). *Fresh Properties, Strength, and Durability of Fiber-Reinforced Geopolymer and Conventional Concrete: A Review.* **Polymers, 16**(1), 141. https://doi.org/10.3390/polym16010141 MDPI+1

**11.** Görhan, G., & Danishyar, F. (2022). *The Effect of Silicate Modulus on the Properties of Polypropylene Fiber-reinforced Geopolymer Composite Material.* **Periodica Polytechnica Civil Engineering, 66**(3), 891–899. https://doi.org/10.3311/PPci.19417 pp.bme.hu+1

**12.** Bhagwat, Y., Nayak, G., Pandit, P., & Lakshmi, A. (2023). *Effect of Polypropylene Fibres on Strength and Durability Performance of M-sand Self-Compacting Concrete.* **Cogent Engineering, 10**(1). https://doi.org/10.1080/23311916.2023.2233783 impressions.manipal.edu+1

**13.** Lakshmi, A., Pandit, P., Bhagwat, Y., & Nayak, G. (2021). *A Review on Efficiency of Polypropylene Fiber-Reinforced Concrete.* In Lecture Notes in Civil Engineering: **Sustainability Trends and Challenges in Civil Engineering** (pp. 799–812). Springer Singapore. https://doi.org/10.1007/978-981-16-2826-9_50

**14.** Prayuda, H., Monika, F., Saleh, F., & Cahyati, M. D. (2020). *Fresh and mechanical characteristics of self-compacting polypropylene fibre concrete incorporated with kaolin.* SINERGI: Journal of Engineering & Science, 6(3). DOI: 10.22441/sinergi.2020.3.007. publikasi.mercubuana.ac.id

**15.** Govindasami, S., Sakthivel, P., & Harish, R. (2018). *Strength assessment of polypropylene fibre reinforced concrete (PPFRC).* International Journal of Engineering and Technology, 7(3.34), 436-438. DOI:10.14419/ijet.v7i3.34.19345. sciencepubco.com

**16.** Rajak Manoj et al. (2019). *Effect of micro polypropylene fibre on the performance of fly-ash-based geopolymer concrete.* Journal of Applied Engineering Sciences, 9(1), 97-108. DOI:10.2478/jaes-2019-0013. Paradigm

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