



AN EXPERIMENTAL STUDY ON THE IMPACT OF FLY ASH AND PLASTIC WASTE IN THE PAVER BLOCKS

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Abstract: The increasing demand for sustainable construction materials and the growing environmental challenges posed by plastic waste and industrial byproducts such as fly ash have highlighted the need for innovative solutions. This proposed study aims to investigate the feasibility and strength characteristics of paver blocks produced by incorporating fly ash and plastic waste as partial replacements for conventional raw materials. The research will involve designing and testing paver block specimens with fly ash replacing cement at 10%, 15%, 20%, 25% and 30% and shredded plastic waste replacing coarse aggregate at 3%, 6%, 9%, 12% and 15%. The focus will be on evaluating the compressive strength, flexural strength, and water absorption properties of the modified paver blocks in comparison to conventional ones. By utilizing fly ash and plastic waste, the study seeks to reduce the environmental footprint of paver block production. The outcomes of this research help to contribute to sustainable construction practices and waste management strategies. The findings will provide valuable insights into the viability of integrating waste materials into construction applications, paving the way for eco-friendly and cost-effective alternatives.

Keywords: Plastic Waste, Sustainable construction. Flyash, Paver blocks, environmental footprint.

Introduction: The increasing demand for infrastructure development has led to the extensive use of conventional building materials such as cement and concrete. However, their production contributes significantly to environmental degradation due to high carbon emissions and resource depletion. In this context, sustainable alternatives are being explored to reduce the environmental impact of construction materials. One such approach is the incorporation of industrial and plastic waste into construction products, which not only mitigates pollution but also promotes circular economy principles. This project focuses on the sustainable production of paver blocks by utilizing fly ash and plastic waste as partial replacements for conventional raw materials. Fly ash, a byproduct of coal combustion in thermal power plants, possesses pozzolanic properties that enhance the strength and durability of construction materials. Similarly, plastic waste, which poses a significant threat to the environment due to its non-biodegradable nature, can be effectively reused in the manufacturing of paver blocks. The combination of these materials offers an eco-friendly alternative to traditional paver block production. The research aims to investigate the

physical and mechanical properties of the developed paver blocks, including their compressive strength, water absorption, and flexural strength. Various mix proportions of fly ash and plastic waste will be analyzed to determine the optimal composition that meets standard construction requirements. Additionally, the study evaluates the economic feasibility and environmental benefits of the proposed method, highlighting its potential for large-scale implementation. By integrating waste materials into construction applications, this project contributes to sustainable development and environmental conservation. The use of fly ash and plastic waste in paver block production not only reduces landfill burden but also minimizes reliance on conventional raw materials. Through this research, we aim to promote innovative and sustainable practices in the construction industry, paving the way for a greener and more resource-efficient future. Additionally, this approach supports waste management efforts by repurposing non-biodegradable materials effectively. The findings of this study could serve as a foundation for future advancements in eco-friendly construction materials.

Materials

Cement: Ordinary Portland Cement (OPC) is traditionally used in construction due to its excellent binding properties. In this sustainable method, cement usage is minimized by replacing a portion of it with fly ash, reducing the overall carbon emissions associated with cement production. Cement contributes to the early strength and setting properties of the paver blocks, ensuring their structural integrity.



Fig. 1 Cement

Sand: Sand, primarily in the form of crystal structure, is used as a filler material in the production of paver blocks. It plays a vital role in filling voids between coarse aggregates, improving workability, and enhancing the overall strength of the blocks. The use of well-graded fine aggregate ensures better compaction and reduces permeability. The source of sand is Swarnamukhi river, Tirupati.



Fig. 2 Sand

Coarse Aggregate: Coarse aggregate is a key component in the production of paver blocks, providing bulk, strength, and stability to the final product. It improves load-bearing capacity. Traditionally, crushed stones or gravel are used as coarse aggregates. However, in sustainable construction, alternative materials such as recycled concrete aggregate (RCA) or shredded plastic waste can partially replace natural aggregates to minimize environmental impact. The proper grading and selection of coarse aggregates ensure optimal compaction, mechanical performance. We used 6 mm size of aggregate. The source of coarse aggregate is Sree Srinivasa crushers, Chandragiri.



Fig. 3 Coarse Aggregate

Flyash: Fly ash is a fine, powdery material obtained from coal combustion in thermal power plants. It is rich in silica, alumina, and calcium oxide, which contribute to the binding properties required in construction materials. In paver block production, fly ash serves as a partial replacement for cement, reducing the demand for conventional cement, which has a high carbon footprint. Fly ash improves workability, enhances long-term strength, reduces permeability, and makes the blocks more resistant to chemical attacks. Its pozzolanic properties allow it to react with calcium hydroxide to form additional cementitious compounds, improving durability. The source of fly ash is Rayalaseema Thermal Power Plant, Kadapa.



Fig. 4 Fly Ash

Plastic Waste: Plastic waste, particularly Low-Density Polyethylene (LDPE), is incorporated into paver block production as a sustainable alternative to conventional materials. Shredded or processed LDPE plastic waste is used as a replacement for coarse aggregates or as a reinforcing material, enhancing the mechanical properties of the paver blocks while addressing waste management challenges. The inclusion of plastic waste in the mix improves impact resistance, flexibility, and durability, making the paver blocks more resistant to cracking and weathering. Additionally, utilizing plastic waste helps reduce landfill accumulation and mitigates environmental pollution, contributing to a circular economy.



Fig. 5 Plastic Waste

Results & Discussion: Mix design refers to the process of selecting and proportioning the ingredients of concrete, such as cement, aggregates (fine and coarse), water, and admixtures, to achieve desired properties like strength, durability, workability, and economy. It involves determining the right ratio of these materials based on factors such as the type of project, environmental conditions, and specific performance requirements. The objective is to create a concrete mix that meets both structural and non-structural requirements while minimizing waste and cost. Standard methods like the IS (Indian Standards) mix

design method or the ACI (American Concrete Institute) method are often used to calculate the ideal mix proportions.

Compressive Strength: The bar graph illustrates the relationship between the percentage of plastic waste and the compressive strength of the material over 7 and 28 days. Initially, at 3% plastic waste, both strengths are at their highest, with a 7-day strength of 31.44 N/mm² and a 28-day strength of 40.00 N/mm². As the plastic waste content increases to 6%, a significant drop in strength is observed. However, at 9% and 12%, the strength values rise again, though they do not reach the initial peak. This increase in strength at 9% and 12% plastic waste can be attributed to the improved bonding between plastic particles and the cementitious matrix, which enhances the internal structure and reduces porosity. Additionally, at moderate plastic content, the material achieves better load distribution and impact resistance, contributing to improved compressive strength. At 15% plastic waste, both strengths decline slightly compared to 12%, likely due to excessive plastic content reducing the material's overall cohesiveness and leading to weaker interparticle bonding.

Table 1 Compressive Strength (N/mm²) of Paver Blocks with Different Plastic Waste Content

Plastic Waste (%)	Compressive Strength at 7 Days (N/mm ²)	Compressive Strength at 28 Days (N/mm ²)
0	32	42.31
3	31.44	40
6	11.4	18
9	22.17	24.05
12	23.4	27.38
15	20	25.35

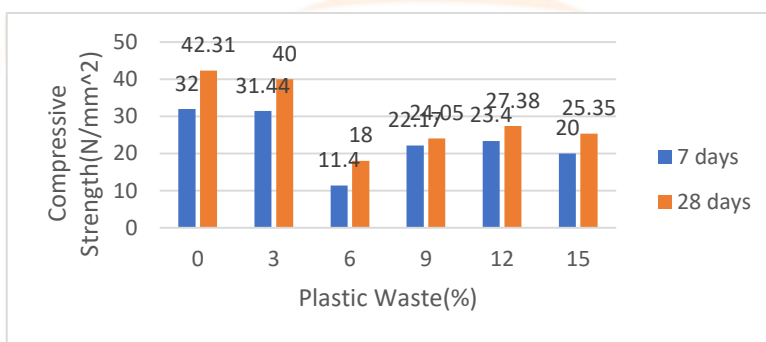


Fig. 5 Compressive Strength of Paver Blocks with Plastic Waste at 7 and 28 Days

Table 2 Compressive Strength (N/mm²) of Paver Blocks with Different Fly Ash Content

Fly Ash (%)	Compressive Strength at 7 Days (N/mm ²)	Compressive Strength at 28 Days (N/mm ²)
0	32	42.31
10	40	46
15	41	46.2
20	34.78	43
25	37.39	43.47
30	29	33.04

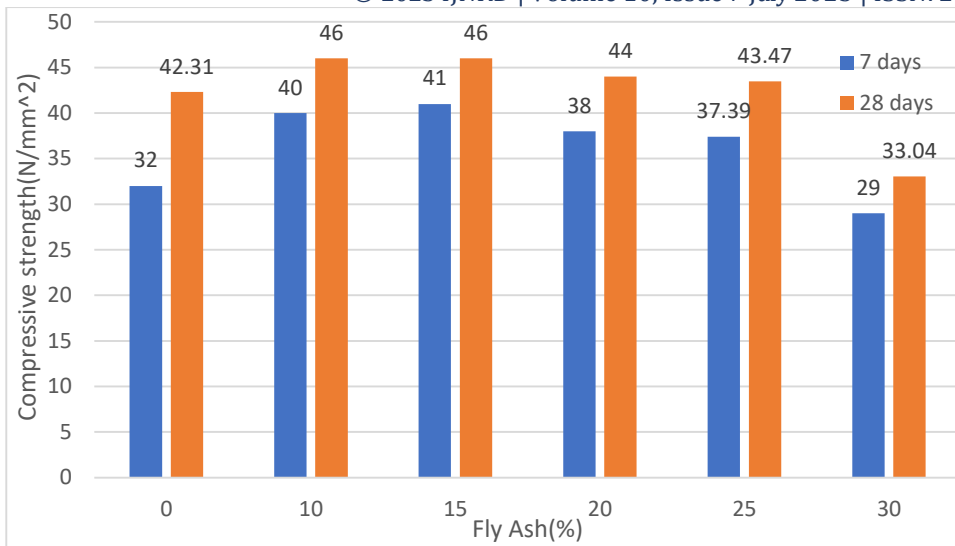


Fig .6 Compressive Strength of Paver Blocks with Fly Ash at 7 and 28 Days

The bar graph depicts the variation in compressive strength with different percentages of fly ash over 7 and 28 days. At 10% and 15% fly ash content, the compressive strength remains high, with both reaching a 28-day strength of 46.00 N/mm². This increase in strength can be attributed to the pozzolanic reaction of fly ash, which enhances the microstructure by refining pore distribution and improving the density of the concrete matrix. Additionally, at moderate fly ash content, the filler effect contributes to better particle packing, reducing voids and increasing overall strength. As the fly ash percentage increases to 20% and 25%, there is a gradual decline in both 7-day and 28-day strengths. The most significant drop occurs at 30%, where the 7-day strength falls to 29.00 N/mm², and the 28-day strength decreases to 33.04 N/mm². This reduction in strength at higher fly ash content is likely due to the dilution effect, where excessive fly ash replaces a significant portion of cement, leading to lower early-age strength development and weaker overall binding properties.

Table 3 Compressive Strength (N/mm²) of Paver Blocks with Plastic Waste and Fly Ash

Plastic Waste (%)	Fly Ash (%)	Compressive Strength at 3 Days N/mm ²	Compressive Strength at 7 Days N/mm ²	Compressive Strength at 28 days N/mm ²
15	30	14.05	19.42	28

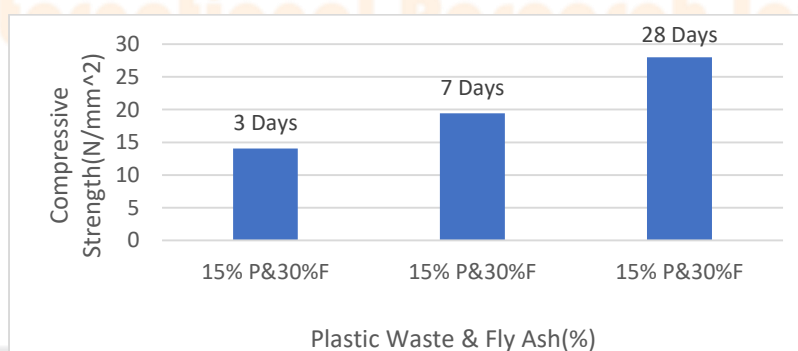


Fig .7 Compressive Strength of Paver Blocks with Plastic Waste and Fly Ash at 3, 7, and 28 Days

The graph presents the compressive strength of paver blocks made with 15% plastic waste and 30% fly ash over three curing periods 3 days, 7 days, and 28 days. The results show a clear increase in strength over time: approximately 14 N/mm² at 3 days, 20 N/mm² at 7 days, and 28 N/mm² at 28 days. This steady rise indicates the ongoing hydration and effective bonding of materials as curing progresses.

Flexural Strength Test: The use of fly ash and plastic waste in paving blocks has been shown to enhance the flexural strength over time, as demonstrated in a study with the following results: at 3 days, the flexural strength was 3 MPa, at 7 days it increased to 5 MPa, and at 28 days, it reached 6 MPa. The addition of 15% plastic waste and 30% fly ash contributed to this improvement. This increase in strength can be attributed to the pozzolanic reaction of fly ash, which reacts with calcium hydroxide to form additional cementitious compounds, thereby improving the material's strength over time. Moreover, the inclusion of plastic waste helps in enhancing the workability and durability of the blocks, making them more resilient under various environmental conditions. The gradual increase in flexural strength with age

is indicative of the continued hydration and bonding reactions between these materials, leading to enhanced durability and structural integrity over time.

Table 4 Flexural Strength of Paver Blocks with Plastic Waste and Fly Ash

Plastic Waste (%)	Fly ash (%)	Flexural Strength at 3 Days	Flexural Strength at 7 Days	Flexural Strength at 28 days	Units
15	30	3	5	6	Mpa

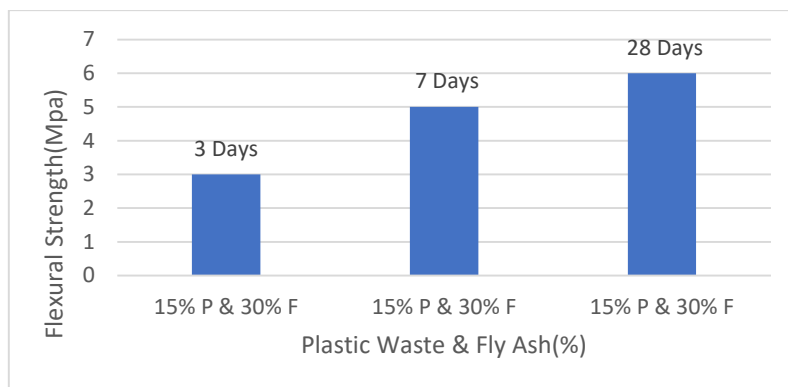


Fig.8 Flexural Strength of Paver Blocks with Plastic Waste at 3, 7 and 28 Days

The use of fly ash and plastic waste in paving blocks has been shown to enhance the flexural strength over time, as demonstrated in a study with the following results: at 3 days, the flexural strength was 3 MPa, at 7 days it increased to 5 MPa, and at 28 days, it reached 6 MPa. The addition of 15% plastic waste and 30% fly ash contributed to this improvement. This increase in strength can be attributed to the pozzolanic reaction of fly ash, which reacts with calcium hydroxide to form additional cementitious compounds, thereby improving the material's strength over time. Moreover, the inclusion of plastic waste helps in enhancing the workability and durability of the blocks, making them more resilient under various environmental conditions. The gradual increase in flexural strength with age is indicative of the continued hydration and bonding reactions between these materials, leading to enhanced durability and structural integrity over time.

Water Absorption Test: The bar chart illustrates the effect of plastic waste content on water absorption at 7 and 28 days. Initially, as plastic waste increases up to 6%, water absorption slightly decreases, indicating a potential reduction in porosity. This reduction in water absorption can be attributed to the hydrophobic nature of plastic, which repels water and reduces capillary pores within the mix, thereby enhancing the compactness and durability of the material. Additionally, plastic waste acts as a filler, improving the particle packing and lowering the overall permeability. However, beyond 6%, water absorption starts to rise, particularly at 9% and higher, suggesting increased permeability and a possible loss of compactness. This increase in absorption occurs because excessive plastic disrupts the cementitious matrix, creating micro voids that allow more water penetration. The trend remains consistent for both 7-day and 28-day absorption values, with slightly higher absorption observed at 28 days, likely due to prolonged exposure to moisture and the gradual development of pores over time.

Table 5 Water absorption of Paver Blocks with Different Plastic Waste Content

Plastic Waste (%)	Water Absorption at 7 days (%)	Water Absorption at 28 days (%)
0	0.57	0.573
3	0.51	0.515
6	0.50	0.513
9	0.69	0.72
12	0.692	0.73
15	0.68	0.70

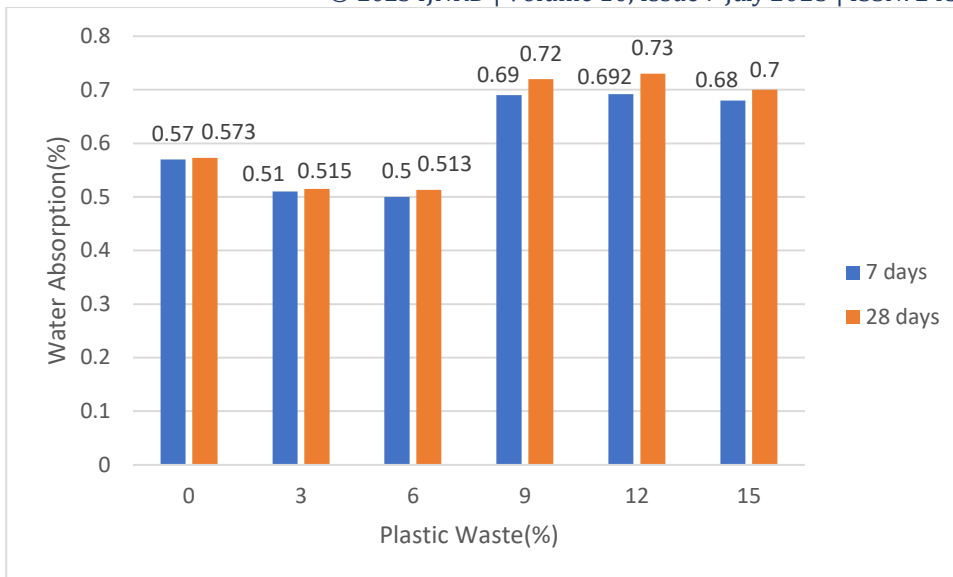


Fig. 9 Water Absorption of Paver Blocks with Plastic Waste at 7 and 28 Days

The bar chart illustrates the effect of plastic waste content on water absorption at 7 and 28 days. Initially, as plastic waste increases up to 6%, water absorption slightly decreases, indicating a potential reduction in porosity. This reduction in water absorption can be attributed to the hydrophobic nature of plastic, which repels water and reduces capillary pores within the mix, thereby enhancing the compactness and durability of the material. Additionally, plastic waste acts as a filler, improving the particle packing and lowering the overall permeability. However, beyond 6%, water absorption starts to rise, particularly at 9% and higher, suggesting increased permeability and a possible loss of compactness. This increase in absorption occurs because excessive plastic disrupts the cementitious matrix, creating micro voids that allow more water penetration. The trend remains consistent for both 7-day and 28-day absorption values, with slightly higher absorption observed at 28 days, likely due to prolonged exposure to moisture and the gradual development of pores over time.

Table 6 Water absorption of Paver Blocks with Different Fly Ash Content

Fly Ash (%)	Water Absorption at 7 days (%)	Water Absorption at 28 days (%)
0	0.57	0.573
10	0.593	0.596
15	0.619	0.628
20	0.646	0.66
25	0.593	0.608
30	0.54	0.556

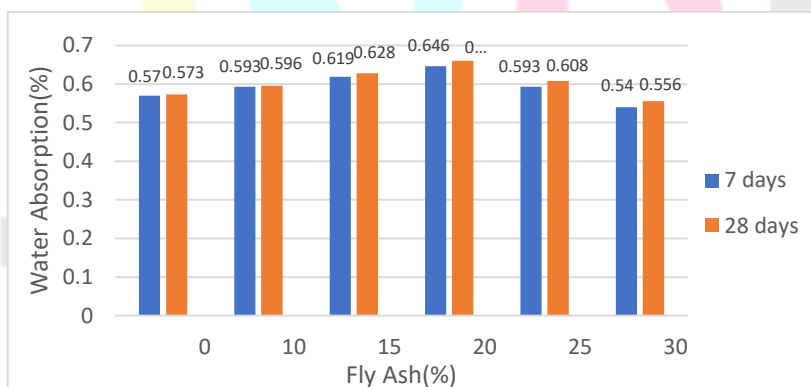


Fig.10 Water Absorption of Paver Blocks with Fly Ash at 7 and 28 Days

The water absorption graph shows the effect of fly ash replacement (0% to 30%) in concrete over 7 and 28 days. Initially, water absorption increases with fly ash content, peaking at 15% fly ash (0.646% at 7 days, 0.66% at 28 days), likely due to increased porosity. This occurs because fly ash particles, being finer than cement, delay early hydration, leading to a more porous microstructure at lower replacement levels.

At higher fly ash percentages (25%-30%), water absorption decreases, indicating improved densification and reduced permeability over time. This improvement is attributed to the pozzolanic reaction of fly ash, which enhances the formation of additional calcium silicate hydrate (C-S-H) gel, thereby refining the pore structure and increasing overall

compactness. Additionally, fly ash contributes to better particle packing, reducing voids and improving durability. The 28-day values are slightly higher than the 7-day values, suggesting continued hydration and gradual strength gain due to the long-term reactivity of fly ash.

Table 5.7 Water absorption of Paver Blocks with Different Plastic Waste and Fly Ash

Plastic Waste (%)	Fly ash (%)	Water Absorption at 3 days (%)	Water Absorption at 7 days (%)	Water Absorption at 28 days (%)
15	25	0.562	0.57	0.64

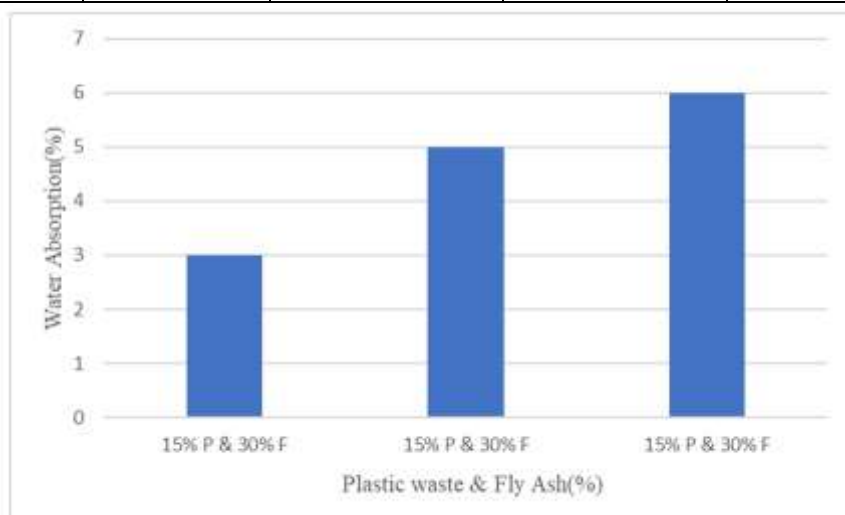


Fig.11 Water Absorption of Paver Blocks with Plastic Waste Content and Fly Ash at 3, 7 and 28 Days

The graph illustrates the water absorption percentages of paver blocks made with 15% plastic waste and 30% fly ash, showing noticeable variation among the three samples approximately 3%, 5%, and 6%. Despite having identical material proportions, the differences suggest inconsistencies in mixing, curing conditions, or raw material quality, which may have influenced the porosity and bonding within the blocks. This variation highlights the need for better process control and standardization to ensure consistent performance and lower water absorption in sustainable paver block production.

Conclusion: This study focused on sustainable production of paver block using plastic waste and fly ash. The experimental investigations included the assessment of compressive strength, flexural strength and water absorption characteristics at varying replacement levels.

The following conclusions were drawn based on the experimental results:

- Paver blocks made from fly ash and plastic waste offer a sustainable and durable alternative to conventional materials.
- 15% plastic waste achieved a compressive strength of 20 N/mm² at 7 days and 25.35 N/mm² at 28 days.
- Strength decreased beyond 15% plastic waste due to reduced bonding efficiency.
- 25% fly ash increased compressive strength to 37.39 N/mm² at 7 days and 43.47 N/mm² at 28 days.

- Water absorption for 15% plastic waste blocks was 0.68% at 7 days and 0.70% at 28 days.
- Water absorption for 25% fly ash blocks was 0.593% at 7 days and 0.6085% at 28 days.

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