As per UGC guidelines an electronic bar code is provided to secure your paper

International Journal for Modern Trends in Science and Technology
Volume 12, Special Issue 01, pages 1267-1273
ISSN: 2455-3778 online
Available online at: http://ijmtst.com/ICRCSET2026.html
DOI: https://doi.org/10.5281/zenodo.20105224

Usage of Flyash in Construction Industry

Sowpati Hari Krishna, Meesala Mery Jyothi, Payyavula Sai Kiran, M Ashok

Department of Civil Engineering, Chalapathi Institute of Technology, Guntur-522016, A.P, India

To Cite this Article
Sowpati Hari Krishna, Meesala Mery Jyothi, Payyavula Sai Kiran & M Ashok (2026). Usage of Flyash in Construction Industry. International Journal for Modern Trends in Science and Technology, 12(SI01), 1267-1273. https://doi.org/10.5281/zenodo.20105224

Article Info
Received: 12 March 2026; Revised: 07 April 2026; Accepted: 10 April 2026.

KEYWORDS

Construction, Concrete, Compressive strength, Split tensile strength, Workability

ABSTRACT

The Indian concrete industry is today consuming about 400 million tonnes of concrete every year, and it is expected that this may reach one billion tonnes in less than a decade. All the materials required to produce such huge quantities of concrete come from the earth's crust, thereby depleting its natural resources every year and creating ecological strain. On the other hand, human activities on earth produce solid wastes in considerable quantities, i.e., over 2500 million tonnes per year, including industrial wastes, agricultural wastes, and other wastes from rural and urban societies. Disposal of such solid wastes involves economic issues as well as ecological and environmental considerations. The major ecological strain in the disposal of solid waste may be due to the presence of waste in it.

Following the normal growth in population, the amount and type of waste materials have increased accordingly. Many of the non-decaying waste materials will remain in the environment for hundreds, perhaps thousands, of years. These non-decaying waste materials cause a waste disposal crisis, thereby contributing to environmental problems. The problem of waste accumulation exists worldwide, specifically in densely populated areas. Most of these materials are left as stockpiles, landfill material, or are illegally dumped in selected areas.

This indicates that 85% of the total solid waste of 1721.8 tons per year falls under the category of building construction waste, of which 90% is being dumped. However, approximately 20% of the building construction waste consists of glass, plastic, and concrete. Therefore, introducing another means of disposal through recycling is nationally required. Large quantities of this waste cannot be eliminated; however, the environmental impact can be reduced by making more sustainable use of this waste. This concept is known as the "Waste Hierarchy." Its aim is to reduce, reuse, or recycle waste, with recycling being the preferred option for waste disposal.

This study is limited to construction waste materials, which can be defined as the unwanted residue resulting from the alteration, construction, demolition, or repair of buildings and other structures. These include, but are not limited to, roofing materials, concrete blocks, plaster, structural steel, plumbing fixtures, electrical wiring, heating and ventilation

equipment, windows and doors, interior finishing materials such as woodwork and cabinets, plastic containers, paving bricks and stones, reinforced and non-reinforced concrete pavement, and glass.

INTRODUCTION

Apart from the mounting problems of waste management, other reasons supporting the adoption of reuse and recycling strategies include reduced extraction of raw materials, reduced transportation cost, improved profits, and reduced environmental impact. Above all, the fast-depleting reserves of conventional natural aggregates have necessitated the use of recycling and reuse technologies in order to conserve natural aggregates for other important construction works.

Waste is generated at different stages of the construction process. Waste generated during construction activities relates to excessive cement mix or concrete left after completion of work, rejection or demolition caused due to changes in design, wrong workmanship, and related factors. The estimated waste generation during construction is about 40 to 60 kg per square meter. Similarly, waste generation during renovation and repair work is estimated to be around 40 to 50 kg per square meter.

The highest contribution to waste generation is due to the demolition of buildings. Demolition of Pucca and Semi-Pucca buildings generates, on average, 500 kg/sq.m and 300 kg/sq.m of waste, respectively. Concrete appears in two forms in construction waste. Structural elements of buildings contain reinforced concrete, while foundations contain mass non-reinforced concrete. Excavation activities produce topsoil, clay, sand, and gravel, which may either be reused as filler material at the same site after excavation work or transported to another site for reuse.

Large quantities of bricks and masonry arise as waste during demolition activities. These are generally mixed with cement mortar or lime. Stone waste is generated during excavation activities or from the demolition of old buildings. Metal waste is generated during demolition in the form of pipes, conduits, light sheet materials used in ventilation systems, wires, sanitary fittings, and reinforcement in concrete. Metals are generally recovered and recycled through re-melting processes.

Timber recovered in good condition from beams, window frames, doors, partitions, and other fittings can be reused. However, wood used in construction is often treated with chemicals to prevent termite infestation, which requires special care during disposal. Other problems associated with wood waste include the presence of joints, nails, screws, and other fixings.

Bituminous materials arise from road planning activities, waterproofing compounds, and from breaking and digging roads for services and utility installations. Other miscellaneous materials generated as waste include glass, plastic materials, paper, and similar substances.

The total quantum of waste generated from the construction industry is estimated to be about 12 to 14.7 million tons per annum. The quantities of different constituents of waste arising from the construction industry in India are estimated as follows:

2. GOVERNMENT OF TELANGANA TOWARDS OPTIMAL USAGE OF WASTE AND RECYCLED MATERIALS

Telangana Deputy Chief Minister Mohd. Mahmood Ali and his team visited Nagpur to study the Solid Waste Management (SWM) processing system. The Telangana Government plans to adopt the Nagpur model for solid waste management in Hyderabad city in order to make the city cleaner and more environmentally sustainable. This announcement was made by Deputy Chief Minister Mohd. Mahmood Ali after studying the SWM processing and house-to-house garbage collection system in Nagpur on Tuesday.

The delegation expressed satisfaction over the garbage lifting and transportation system operated by Kanak Resources Management Limited (KRML), which transports waste from Budhwari to the Bhandewadi Dumping Yard. A high-level delegation from Telangana State visited Nagpur specifically to examine the SWM processing methods and door-to-door garbage collection system implemented in the city.

The delegation included Transport Minister P. Mahendar Reddy, Members of Parliament K. Keshava Rao, K. Vishweshwar Reddy, Ch. Malla Reddy, and K. Prabhakar Reddy, along with eleven legislators. Senior officials including Somesh Kumar, Commissioner G. Kishan, Zonal Commissioner R. Dhan Singh, Engineer-in-Chief, and other government representatives were also present during the visit. The team visited Rajiv Nagar, Pratap Nagar, and Ramkrishna Nagar to observe the door-to-door garbage collection system managed by KRML. The delegation also visited the Budhwari Bazar garbage collection center.

The Telangana Government is planning to utilize the nearly 4,000 metric tonnes of waste generated every day in Hyderabad city to produce electrical power. In this regard, the Swachh Hyderabad team visited the RDF (Refuse Derived Fuel) power plant located in Bibinagar Mandal of Nalgonda district and discussed measures for generating electricity using municipal solid waste.

The Bibinagar plant is capable of producing approximately 12 MW of power by utilizing municipal garbage. The government team is considering either upgrading the existing Bibinagar plant or constructing four new waste-to-energy plants around Hyderabad city for efficient utilization of garbage.

The proposal will be further discussed in an all-party meeting. During their recent study visit, the team had also visited a similar waste-to-energy plant in New Delhi, where electricity is successfully generated from municipal solid waste.

3. INTRODUCTION-FLYASH

Fly ash is a waste material generated from the combustion of coal in power generation plants. Due to its pozzolanic properties, it is widely utilized in the construction industry. Fly ash, also known as flue ash, is one of the residues generated during combustion and consists of fine particles that rise with the flue gases. The ash that does not rise with the gases is known as bottom ash. In an industrial context, fly ash generally refers to the ash produced during the combustion of coal.

Fly ash is usually captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal-fired power plants. Together with the bottom ash removed from the bottom of the furnace, it forms coal ash. In the past, fly ash was commonly released into the atmosphere; however, pollution control regulations introduced in recent decades now require that it be collected before release.

Fly ash is generally stored at coal power plants or disposed of in landfills. Approximately 43% of the fly ash generated is recycled and often used as a pozzolanic material in the production of hydraulic cement or hydraulic plaster, or as a partial replacement for Portland cement in concrete. The use of fly ash in concrete improves the setting properties and provides greater resistance against moisture and chemical attack. However, certain health concerns have also been expressed regarding its usage and disposal.

In some cases, such as the burning of solid waste for electricity generation, fly ash may contain higher levels of contaminants than bottom ash. Mixing fly ash with bottom ash helps reduce the proportional concentration of contaminants to levels that may qualify as non-hazardous waste under certain regulations. Otherwise, unmixed fly ash may sometimes be classified as hazardous waste. In such cases, the combined material is generally referred to as coal ash.

Different types of mineral admixtures used in construction are as follows:

Bentonite
Fly Ash
Vermiculite
Silica Fume
Ground Granulated Blast-Furnace Slag (GGBS)

3.1 BUILDING CONSTRUCTION WASTE MANAGEMENT:

Waste materials must be kept clean and stored in separate batches in order to be reused or recycled efficiently. Although separation can also be carried out after mixed waste is removed from the construction site, segregation at the source significantly improves the efficiency of recycling and reuse processes. The flowchart shown in Fig. 1 presents recommendations for an effective construction waste management plan.

The reduction of construction waste materials can be achieved by carefully studying the design details of the building to ensure the efficient utilization of materials. In addition, accurate cutting and measuring practices should be adopted to minimize unnecessary wastage. The use of materials manufactured from recycled products, as well as materials that can themselves be recycled, should be considered during the initial design stage of the structure.

Proper storage methods should also be implemented to prevent damage caused by mishandling and adverse weather conditions. Furthermore, construction materials should be ordered only when required, preferably just before the commencement of work, to avoid excess storage and material deterioration.

To complete the waste management plan, there should be proper monitoring, collection, segregation, transportation, recycling, and disposal strategies for all waste materials generated during construction activities.

3. 2Definitions: Bentonite

Bentonite is a colloidal clay material that is highly hydrophilic in nature. It assists in the absorption of water and stabilizes the concrete mix by preventing the settlement of cement particles. Bentonite also improves the workability of concrete by enhancing its pumpability and flowability.

It is commonly used in grout mixes in proportions ranging from 1% to 4% of the cement weight. Bentonite helps in reducing the strength of backfill and contact grout while improving the handling characteristics of the mix.

4. FLY ASH

Fly ash is a waste material generated from the combustion of coal in power generation plants and, due to its pozzolanic properties, is widely utilized in the construction industry. The particle size of fly ash ranges from 0.5 µm to 100 µm (micrometers). It mainly contains silica, alumina, iron, and calcium in the form of silicate glass.

Fly ash can also be used in grout mixes or as a partial replacement for cement in backfill materials, which helps in reducing the heat of hydration. It is also considered important in tunnel and shaft backfilling applications due to its improved workability and stability characteristics.

5. VERMICULITE

Vermiculite is a foliated mineral admixture that is added to mixes used in backfilling works. It is formed through the alteration of biotite and mica minerals and helps in producing low-density and highly compressible filling material.

In areas experiencing seismic activity and high in-situ rock stresses, vermiculite is incorporated into the mix because the compressibility of the backfill material becomes an important requirement. Its use helps in improving flexibility and reducing stress concentrations within the filled areas.

6. SILICA FUME

Silica fume, also known as micro silica, is a byproduct obtained during the reduction of high-purity quartz with coal in electric furnaces used for the production of silicon and ferrosilicon alloys. Silica fume is also collected as a byproduct during the manufacture of other silicon alloys such as ferrochromium, ferromanganese, ferromagnesium, and calcium silicon.

Before the mid-1970s, nearly all silica fume produced was discharged into the atmosphere. However, due to increasing environmental concerns, the collection and landfilling of silica fume became necessary. Subsequently, it became economically viable and technically beneficial to utilize silica fume in various construction applications because of its excellent pozzolanic properties and ability to improve concrete performance.

Ground Granulated Blast-Furnace Slag (GGBS)

Although Portland blast-furnace slag cement, produced by intergrinding granulated slag with Portland cement clinker, has been used for more than 60 years, the use of separately ground slag combined with Portland cement as a mineral admixture at the mixer began only in the late 1970s. Ground Granulated Blast-Furnace Slag (GGBS) is a granular material formed when molten iron blast-furnace slag is rapidly chilled or quenched by immersion in water. It is a granular product with very limited crystal formation and possesses highly cementitious properties. When ground to cement fineness, it hydrates similarly to Portland cement.

What is Fly Ash?

Fly ash closely resembles the volcanic ash that was used in the production of some of the earliest known hydraulic cements nearly 2,300 years ago. These cements were produced near the Italian town of Pozzuoli, from which the term "pozzolan" originated. A pozzolan is a siliceous or aluminous material that, when mixed with lime and water, forms a cementitious compound.

Fly ash is one of the most commonly used pozzolanic materials in the world. Unlike natural volcanic ash, modern fly ash is mainly produced from coal-fired electricity-generating power plants. In these plants, coal is ground into a fine powder before combustion. The mineral residue generated during combustion is collected from the exhaust gases and used as fly ash.

The difference between fly ash and Portland cement becomes apparent under microscopic examination. Fly ash particles are almost completely spherical in shape, allowing them to flow and blend freely in concrete mixtures. This property makes fly ash a highly desirable admixture for concrete applications.

Why Use Fly Ash in Concrete?

The spherical shape of fly ash particles creates a ball-bearing effect in concrete mixtures, thereby improving workability without increasing water demand. Fly ash also enhances the pumpability of concrete by making the mix more cohesive and less susceptible to segregation. The reduction in friction between concrete and pump lines further improves pumping efficiency.

Additionally, some fly ashes significantly reduce heat generation during the hardening and strengthening process of concrete. Like other pozzolanic materials, fly ash contributes to long-term strength development in concrete to a greater extent than Portland cement alone.

One of the primary reasons for using fly ash in concrete is the improvement in durability and life-cycle performance. During hydration, fly ash chemically reacts with calcium hydroxide to form additional calcium silicate hydrate and calcium aluminates. This reaction reduces the permeability of concrete and minimizes the leaching of calcium hydroxide. Fly ash also lowers the water-to-cement ratio, thereby reducing the volume of capillary pores in concrete. The improved consolidation resulting from the spherical particle shape further decreases permeability.

Other benefits of fly ash in concrete include improved resistance to:

- Corrosion of reinforcing steel
- Alkali-silica reaction
- Sulfate attack
- Acid attack
- Salt attack

How Much Fly Ash Should Be Used in Concrete?

Typically, fly ash is used as a partial replacement for Portland cement at levels up to 30% of the total cementitious material. The use of high-volume fly ash concrete has been extensively studied over the past several years, and its advantages have been well documented. Properly designed concrete containing 40%, 50%, or even 60% fly ash replacement exhibits significantly reduced permeability and excellent resistance to premature deterioration.

The selection of constituent materials in concrete should be based on exposure conditions, structural type, and intended application. High-volume fly ash concrete can be effectively used in structural components such as footings, columns, walls, and beams where surface exposure is relatively limited. For mass concrete applications such as mat or raft foundations, the use of even higher quantities of fly ash is often recommended.

Cost of Fly Ash

Fly ash generally costs approximately one-half to two-thirds the cost of Portland cement, provided that suitable batching facilities are available. Typically, 10% to 30% of Portland cement clinker can be replaced by fly ash in concrete production.

Pulverized Fuel Ash

Pulverized Fuel Ash (PFA) is a very fine powdery material recovered from the flue gases of coal-fired power stations through the use of electrostatic precipitators.

Source of Fly Ash

Fly ash particles are generally collected from the exhaust systems of thermal power plants before they escape into the atmosphere. Hence, the material derives its name “Fly Ash.” The particle size of fly ash typically ranges from 0.5 μm to 100 μm.

Composition of Fly Ash

Fly ash is primarily a siliceous or siliceous-aluminous material. Its typical chemical composition is as follows:

- Silica (SiO_2): 40% – 70%
- Alumina (Al_2O_3): 20% – 35%
- Ferric Oxide (Fe_2O_3): 5% – 15%
- Calcium Oxide (CaO): 1% – 5%
- Magnesium Oxide (MgO): 0.1% – 0.7%
- Sodium Oxide (Na_2O): 1.6% – 2.0%
- Sulphur Trioxide (SO_3): 0.1% – 0.30%
- Phosphorous Pentoxide (P_2O_5): 0.1% – 0.12%
- Strontium Oxide: 0.06% – 0.12%
- Barium Oxide: 0.0% – 0.12%
- Chromium Oxide: 106 – 180 mg/kg
- Arsenic: 1% – 2%

CHEMICAL COMPOSITION AND CLASSIFICATION

Component	Bituminous	Subbituminous	Lignite
SiO_2(%)	20-60	40-60	15-45
Al_2O_3(%)	5-35	20-30	20-25
Fe_2O_3(%)	10-40	4-10	4-15
CaO(%)	1-12	5-30	15-40
LOI (%)	0-15	0-3	0-5

Structure of Fly Ash

Fly ash particles are generally spherical in shape and possess a smooth surface texture. These spherical particles improve the flowability and workability of concrete mixes by creating a ball-bearing effect. The structure of fly ash mainly consists of silica, alumina, iron oxides, and calcium compounds in amorphous glassy form, which contribute to its pozzolanic behavior. Due to its fine particle size and cementitious properties, fly ash is widely used as a supplementary cementitious material in concrete production.

Experimental Program

A total of 18 cubes and 18 cylinders were cast to determine the effectiveness of the strengthening process through the optimization of fly ash, a waste material obtained from thermal power plants.

Another set of 18 cubes and 18 cylinders was prepared to evaluate the strength parameters of concrete containing demolished concrete recycled coarse aggregates (RCA) as waste materials. The recycled aggregates were incorporated into the concrete mix at various replacement percentages, as presented in the results section.

In addition, a total of 18 cubes and 4 beams were cast using partially replaced aggregates with coconut shells and wood sawdust. The sawdust was used as a partial replacement for fine aggregate. This experimental study was carried out to analyze the deformation characteristics under loading conditions and to identify the crack-prone areas in the structural elements.

Furthermore, a total of 12 cubes and 12 tiles were prepared using optimum percentages of plastic waste materials. In this investigation, ordinary cement was replaced with white cement of the same grade to enhance the visibility and appearance of the plastic waste particles within the specimens.

RESULTS AND DISCUSSIONS

Compression strength tests were conducted to evaluate the strength development of concrete containing various percentages of e-waste materials at curing ages of 7, 14, and 28 days.

Table : Compressive Strength Test Results in N/mm²

Mix Specification	Control mix -1	Control mix -2	Control mix -3
Proportion of E-waste	0%	2%	4%
7days	22.33	21.02	20.23
14days	32.67	30.28	29.84
28days	55.23	55.36	54.25

DISCUSSIONS

An analysis was carried out on the strength characteristics of e-waste mortar cubes containing ground e-waste and plastic bottle waste materials. Graph 1 illustrates the reduction in compressive strength of the mortar cubes. This reduction in strength is mainly attributed to the fact that the ground e-waste material does not possess cementitious properties. Since it does not bond effectively with cement paste, the overall strength of the concrete decreases.

Graph 2 presents the relationship between compressive strength and the percentage of ground plastic bottle waste used in the mix. Due to the flaky and irregular nature of the ground plastic bottle waste, the strength gradually decreases with an increase in the proportion of waste material in the concrete mixture.

From the investigation, it is concluded that the utilization of fly ash in the construction industry significantly reduces environmental problems caused by the accumulation of unutilized fly ash generated in large quantities near thermal power plants. Partial replacement of cement with fly ash in concrete also provides material economy and promotes sustainable construction practices.

The experimental results further indicate that the use of fly ash in concrete improves the compressive strength compared to conventional concrete mixes without admixtures. In addition, fly ash enhances the workability of concrete and reduces segregation within the mixture, leading to improved overall performance.

As a continuation of the present investigation, future research may be conducted on the following aspects for a better understanding of the role of admixtures and marginal materials in concrete:

1. Use of different types of fibers in concrete to study their influence on strength and durability performance.
2. Investigation of the exact chemical reactions occurring when various marginal and waste materials are incorporated into concrete mixes.
3. Study of long-term durability characteristics of concrete containing industrial and construction waste materials.
4. Evaluation of the environmental and economic benefits of using recycled materials in large-scale construction applications.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] Zhu, X. et al. 2017. Structural Health Monitoring Using Wireless Sensor Networks. European Workshop on Structural Health Monitoring. In Lecture Notes in Civil Engineering (Vol. 253). Springer. https://doi.org/10.1007/978-3-031-07254-3_41

[2] Li, Y. et al. 2019. Machine Learning Algorithms in Civil Structural Health Monitoring: A Systematic Review. Archives of Computational Methods in Engineering. Springer. Available at: https://link.springer.com

[3] Kim, J. et al. 2020. Structural Health Monitoring Using Machine Learning Techniques and Domain Knowledge-Based Features. 8th European Workshop on Structural Health Monitoring. Springer. Available at: https://link.springer.com

[4] Karan, E., Safa, M., & Suh, M. J. 2020. Use of Artificial Intelligence in a Regulated Design Environment – A Beam Design Example. Proceedings of the 18th International Conference on Computing in Civil and Building Engineering, 3–15. DOI: 10.1007/978-3-030-51295-1_1

[5] Yashiro, Y. et al. 2020. An Interview-Based Method for Extracting Knowledge of Skilled Workers at Construction Sites Using Photographs and Deep Learning. Proceedings of the 18th International Conference on Computing in Civil and Building Engineering, 16–25. DOI: 10.1007/978-3-030-51295-1_2

[6] Zima, K., Leśniak, A., & Andújar-Montoya, M. D. 2021. Big Data in Construction Engineering and Management. Applied Sciences, 11(6), 12–34. DOI: 10.3390/app11062150

[7] Schönbeck, P., Löfsjögård, M., & Ansell, A. 2021. Collaboration and Knowledge Exchange Possibilities between Industry and Construction 4.0 Research. Procedia Computer Science, 192, 129–137. DOI: 10.1016/j.procs.2021.08.014

[8] Palmitessa, R. et al. 2021. Soft Sensing of Water Depth in Combined Sewers Using LSTM Neural Networks with Missing Observations. Journal of Hydroenvironment Research, 38, 106–116. DOI: 10.1016/j.jher.2021.01.006

[9] Mishra, M. 2021. Machine Learning Techniques for Structural Health Monitoring of Heritage Buildings: A State-of-the-Art Review and Case Studies. Journal of Cultural Heritage, 47, 227–245. DOI: 10.1016/j.culher.2020.09.005

[10] Noymanee, J. & Theeramunkong, T. 2019. Flood Forecasting with Machine Learning Technique on Hydrological Modeling. Procedia Computer Science, 156, 377–386. DOI: 10.1016/j.procs.2019.08.214