STRENGTHENING OF PAVEMENT USING MUNICIPAL AND C&D WASTE

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***Abstract*— The rapid increase in world population has made sustainable development more important. Challenges in disposal of C&D waste and meeting requirements of natural raw material for pavement industry have led to the need to utilize C&D and municipal waste (fly ash) in pavement construction and strengthening. In general, fly ash can be used as a partial substitute for fine aggregate in rigid pavement mixes. This paper will discuss the use of C&D and fly ash in construction of rigid pavement.**

Keywords—partial replacement of sand, durability, cost-effectiveness.

I. INTRODUCTION

The construction industry generates a substantial amount of waste materials, including fly ash from thermal power plants and construction and demolition (C&D) waste from building and infrastructure projects. The responsible management of these waste materials is essential for sustainable development and environmental preservation. One promising approach is to utilize these waste materials in the construction of pavement, aiming to enhance its strength and durability while reducing the environmental impact associated with waste disposal. The utilization of fly ash and C&D waste in pavement construction has gained significant attention in recent years due to their potential as innovative additives. Fly ash, a byproduct of coal combustion, possesses pozzolanic properties that can contribute to the development of cementitious compounds and improve the performance of concrete. On the other hand, C&D waste, consisting of materials such as concrete, bricks, and asphalt, can be recycled and used as aggregates in pavement construction.

The objective of this research paper is to test the waters for viability and efficiency of incorporating fly ash and C&D waste as additives in the strengthening of pavement infrastructure. By assessing their mechanical properties, durability, and environmental impact, this study aims to provide valuable insights into the sustainable utilization of these waste materials in the road construction industry. Additionally, practical guidelines and recommendations will be developed to promote the implementation of sustainable waste management practices, fostering the adoption of recycled materials and reducing the environmental burden associated with waste disposal.gs, and not as an independent document. Please do not revise any of the current designations. The utilization of fly ash and C&D waste in pavement construction offers numerous potential benefits. By incorporating fly ash, the workability of concrete mixtures can be improved, leading to easier placement and finishing. The inclusion of fly ash can also contribute to reduced heat of hydration, mitigating the risk of thermal cracking. Furthermore, the reactive components in fly ash promote the formation of denser and more durable concrete, enhancing resistance to chemical degradation and increasing the longevity of pavement structures. C&D waste, when recycled and used as aggregates, can reduce the demand for natural resources and contribute to waste reduction. This sustainable approach aligns with the principles of circular economy and environmental stewardship. By diverting C&D waste from landfills and incorporating it into pavement construction, the construction industry can significantly reduce its environmental footprint while achieving cost savings.

However, challenges and considerations exist when utilizing fly ash and C&D waste in pavement strengthening. Factors such as proper characterization of waste materials, optimization of mix designs, and assessment of long-term performance need to be addressed. Furthermore, it is crucial to ensure that the incorporation of these waste materials complies with regulatory requirements and standards to guarantee the safety and structural integrity of the pavement.

By investigating the utilization of fly ash and C&D waste in pavement strengthening, this research paper aims to contribute to sustainable infrastructure development and waste management practices. The findings of this study will provide valuable insights for engineers, researchers, and policymakers, enabling the adoption of recycled materials and promoting the construction of resilient and environmentally friendly pavement structures.

II. EXPERIMENT DETAILS

2.1 Materials

2.1.1 Cement.

Portland Pozzolana cement was utilized, and it met the standards of IS 4031-1988

2.1.2 Fine Aggregates

River sand and class f fly ash were utilized as fine aggregates in this investigation, passing through a 4.75mm IS sieve and being retained at a 150 micron sieve.

2.1.3. Coarse aggregate.

Coarse aggregate used was less than 20mm nominal size as mentioned in IS Code 10262:2009, section 3.2.2

2.2 Mix Design and Testing

Trial mixes were prepared to investigate the effect of water-to-cement (w/c) ratios 0.6. Design mix of, 1.75:1.was considered as control mixes. For each mix, cube specimens measuring 150mm x 150mm x 150mm were casted and tested for compressive strength at 7, 14, 28 and 90 days. Additionally, the mix design involved various replacement levels of fine aggregate with fly ash.

Following the curing period, the trial mix specimens were subjected to compressive strength testing, density determination, and water absorption testing.

2.2.1 Aggregate Crushing value test

The aggregates crushing value test is a vital gauge of an aggregate's durability in the face of a gradually increasing compressive force, reveals invaluable insights into the quality and durability of construction materials. This test involves subjecting a sample of the aggregate to varying levels of compressive force until it fractures, allowing us to assess its strength and suitability for use in concrete and road construction. By quantifying the ability of an aggregate to withstand crushing forces, the aggregate crushing value test plays a vital role in ensuring the structural integrity and longevity of infrastructure projects. The result of the test is given in table 2.

2.2.2 Aggregate Impact Value Test

The aggregate impact value test, an integral assessment of the resistance of an aggregate to sudden impact or shock loads, holds paramount importance in determining the suitability of aggregates for road construction and other high-stress applications. This test involves subjecting a sample of the aggregate to repetitive impacts in a controlled environment, simulating the dynamic forces that occur during transportation and usage. By measuring the

percentage of fines generated after impact, the aggregate impact value test provides valuable insights into the toughness and robustness of the material. It assists engineers and construction professionals in making informed decisions about the selection and design of road surfaces, ensuring they can withstand heavy traffic loads, resist fragmentation, and maintain their integrity over time. The result of the test is given in table 2.

2.2.3 Los Angeles Abrasion Test

The Los Angeles abrasion test is a widely recognized and standardized method for assessing the hardness, toughness, and durability of coarse aggregates used in road construction. This test simulates the abrasive forces experienced by aggregates in real-world scenarios, such as the repetitive impact and grinding caused by traffic loads. The test involves subjecting a sample of the aggregate to a rotating steel drum, along with a specific quantity of steel balls. The drum rotates at a fixed speed and duration, causing the aggregate to undergo significant abrasion and impact forces. The resulting fine material and the aggregate's weight loss are measured, providing valuable insights into its resistance to abrasion and ability to maintain its physical integrity. The Los Angeles abrasion test aids engineers and construction professionals in selecting aggregates that can withstand the harsh conditions of road surfaces, ensuring longer lasting and more durable infrastructure. The result of the test is given in table 2.

2.2.4 Compressive Strength Test

A compressive strength examination was carried out according to the specifications provided in IS 2185 Part-I 1979, using a universal testing machine. The specimens, which had been stored in water during the designated curing periods, were tested promptly after being removed from the water and drying the surface. Precise measurements were taken to determine the dimensions of the specimens, and their weights were recorded prior to testing. The specimens were tested at both 28 and 90 days of age. The load was incrementally increased without any sudden shocks until the specimen fractured and could no longer sustain a higher load. The result is given in table 3

2.2.5 Flexural Strength Test

The flexural strength test on pavement concrete is a critical examination conducted to evaluate the ability of concrete to resist bending or flexural stresses. This test is particularly significant in assessing the performance and durability of concrete used in pavement and road construction. The test involves subjecting a beam or specimen of pavement concrete to a gradually increasing load at its midpoint, causing it to bend until it fractures. The result for the given test is shown in table 4 of the given test.

Nominal M30 Concrete Readings.

Table 1.

SAMPLE	FLY ASH PERCENTAGE	C&D WASTE PERCENTAGE
SAMPLE 1	15%	15%
SAMPLE 2	20%	20%
SAMPLE 3	25%	25%

Table 2.

Test Conducted	Result Obtained
Aggregate Impact Value	28.6%
Crushing Value of Aggregate	29%
Los Angeles Abrasion Test	23.2%

Table 3. (Compressive Test Results)

Sample	7 days		14 days		28 days	
	Peak Load	Peak Stress	Peak Load	Peak Stress	Peak Load	Peak Stress
Sample 1	497 kN	22 MPa	393.2 kN	17.4 MPa	397.6 kN	17.6 MPa
Sample 2	642.3 kN	28.5 MPa	639.9 kN	28.4 MPa	589.4 kN	26.1 MPa
Sample 3	760.2 kN	33.7MPa	867.9 kN	38.5 MPa	880 kN	39.1 MPa

SAMPLE	7 DAYS	14 DAYS	28 DAYS
Sample	34.68 MPa	36.3 MPa	35.83 MPa

Table 4. (Flexural Test Results)

SAMPLE	7 days	28 days
Sample 1	18 kN	27.5 kN
Sample 2	12.5 kN	20 kN
Sample 3	14 kN	25.5 kN

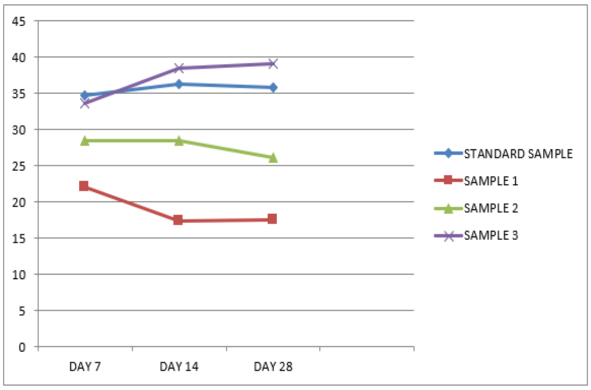

Fig 1 (Compressive strength comparison)

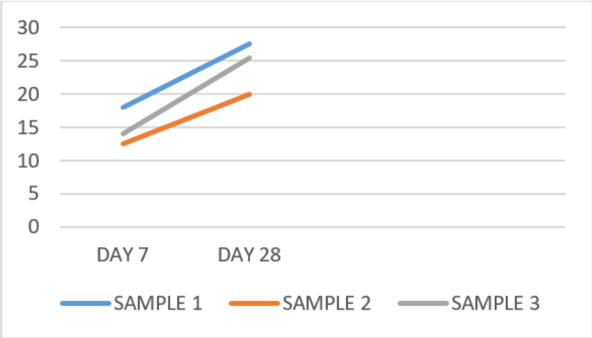

Fig 2 (Flexural strength comparison)

III Result and conclusions

3.1 Compressive Strength

An evaluation of compressive strength was performed on mixed samples, comparing them to a normal test sample. The results indicated that the mixed samples had lower early strength at 7 and 14 days compared to the normal sample. However, Sample-3, which consisted of 25% fly ash and 25% C&D waste, showed slightly higher strength at 28 days compared to the normal sample. As the percentages of fly ash and C&D waste increased, the early strength of the samples decreased. However, the late strength, measured at 28 days, increased significantly. This suggests that while the mixed samples may exhibit lower early strength, they have the potential to develop higher strength over time.

3.2 Aggregates

The aggregates were tested for 3 different properties which were:

1) *Impact value for sudden load capacity*
2) *Crushing value for Strength of the aggregates.*
3) *Abrasion for durability of the aggregates*

In table 5 is given various range acceptable for the results of the above-mentioned tests:

Table 5.

S.N.	Name of Test	CWD	Conventional Aggregate	Range	
1.	Aggregate Crushing Value Test	12.3%	29%	<45% (Wearing course) <30% (Concrete pavement)	Remark Hence the values are in optimum range.
2.	Aggregate Impact Test	12.26%	28.6%	<30%	
3.	Los Ange Test	28%	23.2%	<40%	

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