Use of Industrial Waste in Highway Construction

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Abstract. In present time, decomposition of industrial waste is a huge problem in India. A large quantity of waste material is dumped at land filling site, which if investigated properly can be utilized in highway construction and can reduce pollution. Different industrial products generate different waste material which is used for various purposes like fly ash used in concrete admixture, C&D waste used as base/sub-base material in coarse aggregates, silica fume used in PCC, etc. A new technique is being used for partially replacing the aggregates, sand, cement, soil,bitumen, etc. with industrial waste such rubber tyre used as admixture, marble dust as a filler in bituminous mix.

Keyword: *Industrial waste, CBR test, fly ash, silica fume.*

1. INTRODUCTION

India is a developing country where industrialization is growing very fast. With this, many problems also arise such as air pollution, disposal issue, landfilling. Some of the waste materials being a non-biodegradable become hazardous for the environment. India alone generating 4.43 million tons of hazardous wastes every year and it keeps on increasing.Many developing countries are using industrial waste materials to reduce the usage of natural resources and going towards the sustainable development where we can save the resources for our future generation. This is also cutting downthe cost of extraction.

Industrial waste materials are like fly ash, silica fume, marble dust, cement kiln dust, waste tyres, glass waste, chinaclay, etc. We got these waste materials from different industries. Since ages we are using aggregates, soil, sand, cement, bitumen, etc for road construction but as natural resources being inadequate in nature, we are looking for an alternative of these materials. Many researchers are experimenting on different waste materials which can fulfil the properties of aggregates, soil, sand, bitumen, cement, etc. Materials like fly ash from thermal power plant, marble dustfrom marble industry, waste tyre from rubber industry, red mud from alumina industry, silica fume from silicon industry, and construction and demolition waste from construction industry, etc have being proved to be useful and alternative for natural resources in many countries.

As a developing nation, India is seeing vast infrastructural growth like building of expressway, highway, huge skyscrapers, industrial setups, etc. For this, many natural resources are being used and increasing the cost of construction. Although using industrial waste in highway construction cannot be regarded as the most effective way to lower the cost of road construction, it can have a significant economic impact on highway construction in India that are close enough to the supply of industrial waste that the transportation costs to the construction site are not prohibitive.

2. LITERATURE REVIEW

1. ***Anurag K. Gahalod, Vikas Bankar and Payal Nit, Department of civil engineering, Maharashtra, India***
   - Construction and demolition (C&D) waste and tiles waste materials were studied.
   - They worked on how to use C&D waste and tiles waste as an alternative to aggregates.
   - It was found that it is possible to replace 50% of aggregates with C&D waste and tiles waste.

2. ***Sheeraz Ahmad Khan and Saurabh Gupta, Department of Civil Engineering, Kathgarh, India***
   - Waste foundry sand (WFS) and fly ash used, as an industrial waste, which was collected from local industry and then their physical and chemical properties were analysed.
   - They took different proportion of WFS and fly ash together and did some test like CBR (California bearing ratio) test, Split tensile test, and permeability test.
   - They found that 70% of WFS increases the CBR value. by increasing the fly ash percentage, spilt tensile strength of the material also increases the.

3. ***Tara Sen and Umesh Mishra, Department of Civil Engineering, Agartala, India***
   - Different types of industrial waste such as fly ash, blast furnace slag, cement kiln dust, phosphogypsum, waste plastic bags, foundry sand and colliery sand studied.
   - They studied previous research paper and analysed that these materials are enhancing the performance of concrete by being the alternatives of concrete aggregates or alternate binder to cement or as a filler material.

4. ***Rokade S, Department of Civil Engineering, Bhopal, India***
   - He studied the plastic waste and rubber tyres waste. He experimented the semi dense bituminous concrete (SDBC) mix by using Marshall Method of bituminous mix design.
   - The SDBC was prepared with conventional 60/70 grade bitumen added with varying percentage of low-density polyethylene (LDPE) and crumb rubber (CRMB).
   - The result shows that the Marshall Stability value, which is the strength parameter of SDBC, increased by 25% by addition of LDPE and CRMB. the density of the mix also increased in both the cases.

3. MATERIAL

Table 1: Composition of Fly Ash

Chemical Component	Fly ash (%Range)
Silicon Dioxide (SiO_2)	35-60
Aluminium Oxide (Al_2O_3)	15-30
Iron Oxide (Fe_2O_3)	5-20
Calcium Oxide (CaO)	1-5
Magnesium Oxide (MgO)	0.5-10
Potassium Oxide (K_2O)	0.5-5

Fly ash was collected from local industry. Its physical and chemical properties were analysed. The shape of fly ash particles are spherical and it increases the flow ability, which reduces the amount of water required for the mixture. The specific gravity is around 2.2-2.8.

Silica fume contains more than 90 percent of silicon dioxide. It is a dark grey powder. The particles of silica fume are extremely fine.

4. EXPERIMENT

In this experimental study we have taken total of 17 samples. The total amount of industrial waste that is fly ash and silica fume is taken 90 percent with different proportions of fly ash and silica fume which is added with 10 percent of stabilizing material like cement and lime. The proportions of 17 samples are as given infollowing table.

Table 2: Mixture ratio measured for CBR test

S. No.	Waste material		Stabilized Product	
	Fly Ash	Silica Fume	Cement	Lime
1	40	50	05	05
2	45	45	00	10
3	50	40	05	05
4	55	35	10	00
5	60	30	05	05
6	65	25	00	10
7	70	20	05	05
8	75	15	10	00
9	80	10	05	05
10	85	05	00	10

RESULT

California Bearing Ratio Test

This method is used for evaluating the strength of subgrade soil and other pavement materials for the design and construction.

Table 3: CBR Test load per penetration

Penetration (mm)	Standard load (kg)	Unit standard load (kg/cm^2)
2.5	1370	70
5.0	2055	105

The basic principle in CBR test is causing a cylindrical plunger of 50 mm diameter to penetrate the soil or pavement component material to be tested at a rate of 1.25 mm per minute.

The loads needed to cause the plunger to penetrate the measured soil or material by 2.5mm and 5.0mm are recorded.

Table 3: Result of CBR Test

S. No.	Waste material		Stabilized Product		CBR
	Fly Ash	Silica Fume	Cement	Lime	
1	40	50	05	05	21
2	45	45	00	10	30
3	50	40	05	05	39
4	55	35	10	00	44
5	60	30	05	05	51
6	65	25	00	10	57
7	70	20	05	05	62
8	75	15	10	00	55
9	80	10	05	05	49
10	85	05	00	10	41

The CBR (California Bearing Ratio) test indicated that the optimum value was achieved when using a mixture containing 70% fly ash and 20% silica fume. This particular combination resulted in a higher CBR value. Several factors may have contributed to this outcome. Firstly, the inclusion of fly ash in the mixture enhanced the strength and workability of the cement, potentially acting as a coarse aggregate. Additionally, the addition of silica fume helped refine the pore structure, leading to improved mechanical strength in the resulting concrete.

CONCLUSION

After experimenting on these materials with found out that:

- When fly ash was 70%, it found that it has more effective in giving CBR value.
- The value of CBR reduced by 20% when silica fume was used in the mixture.
- The change in CBR values related to the proportion of fly ash used in the mixture is generally not linear.
- Both Fly ash and silica fume are reducing the carbon footprint.

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