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Review Paper on Use of Waste and Fly Ash on Road Pavement

Vishal Rohilla
Assistant Professor, Gateway Institute of Engineering & Technology, Sonipat(Haryana)
Rohit Prabhakar, Sandeep Sanwa
B.Tech scholar, Gateway Institute of Engineering & Technology, Sonipat(Haryana)

Abstract

With the evolution of the road industry and growing traffic on roads, construction materials have also been evolved and more unconventional ingredients have been incorporated. The rationales was the scarcity of conventional natural materials and the jeopardized environment which have underpinned the tendency towards evaluation other materials resources to be incorporated in the road industry. The inclusion of such materials entails several secondary and tertiary materials. Several waste by-products and materials have been investigated, assessed, evaluated for utilizations and practiced in the field. Depending on the attributes of the characteristics of the recycled material, the inclusion varies. Some recycled material have been proven to possess preferable properties over the other and have performed satisfactorily in the field. However, there are numerous concerns regarding such incorporation based on both laboratory experimental, and field observations which have turned out to be of the essence for further in-depth studies. Reclaimed asphalt pavement, recycled concrete aggregates, plastic wastes, scrap tires, mine wastes, recycled crushed glass, foundry sand, coal combustion products as fly ash, bottom ash, and pond ash, steel slag, oil sand, oil shale sand, lateritic soil, are amidst the long list. It is believed that magnificent preservation of natural and precious resources would be attained from the inclusion of secondary and tertiary materials in road construction. Nonetheless, without rigorous cooperation between the academia and the industry and educating people who are in routinely interact with paving activities, several performance-related issues would not be resolved and would remain in existence. This paper present a literature review report on the most viable recycled materials currently in practice by the industry and it aims towards developing a noble idea on better inclusion of a recycled material in the road industry.

Keywords: Asphalt pavements - Aggregates – Asphalt binder - Recycling - Waste by-products

Introduction

The pivotal thrust of utilizing waste materials into road construction field is diminishing the detrimental repercussions of processing natural materials on the environment, to alleviate the burden on authorities in both developing and developed countries in providing landfills and setting provisions for such wastes, and to reaffirm the commitment of the industry towards better road services and riding quality. Besides, the scarcity of the natural resources is also an intuitive rationale that underpins utilizations. Several experimental and research studies have been dedicated to investigating potential incorporating of waste materials in road construction field. Many pieces of research have proven a success in reusing and recycling of some compositions of these waste materials in pavement structures and others are still undergoing comprehensive research studies to further shed the light on what can be gained from their recycling into pavement constructions. Due to some stringent knowledge and shortage of funding for in-depth analysis of utilizing the some waste materials in the utmost beneficial way, the waste material is a core problematic issue to governmental institutions and transportation legislation authorities in several parts of the world. International cooperation is a key factor in protecting the environment through diminishing the greenhouse gasses emission and preserving natural resource via exploiting viable recycled materials into the construction field and giving focus on assessing approaches in employing such materials.

The Non-conventional material is defined as the material that does not possess the required properties as per the traditional specifications [17]. With the unending demand for aggregates material in road construction, the scarcity of accepted quality material as well as the urge in preserving natural resources, there has become

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urgent necessity for inclusion secondary material and waste by-products in road construction field. Several waste recyclable materials have been incorporated in various projects all over the globe and displayed the opportunity in not only budgetary saving but also in protecting the environment. Road responses and long-term performance rely exhaustively on serious of attributes of the incorporated material in the compositions of the structure, it is an overarching issue to thoroughly comprehend the behaviour and pattern of these materials and their transmutation effects when used on its own or assorted with other materials and used in road pavement structure. It is believed that the responses to the increasingly huge demand on providing substitutions for natural materials in road construction has been efficiently responsive and reflected mounds of researches have been dedicated to executing feasibility studies on using these surrogate material with the consideration of sustainability perspective for both the environment and the economic.

Review of Literature

The efficiency of reusing waste plastic in production of concrete and concluded that reusing waste plastic as a sand-substitution aggregate in concrete gives a good approach to reduce the cost of materials and solve some of the solid waste problems posed by plastics. Frigione [2010] investigated and found that the WPET concretes display similar workability, characteristics, compressive strength and splitting tensile strength slightly lower that the reference concrete and a moderately higher ductility. Sultana et al. [2012] investigated the potential use of waste plastic as a modifier for asphalt concrete and cement concrete pavement. The results showed the better values for asphalt concrete .This is eco-friendly process. Harison et al. [2013] investigated PPC cement replacement by fly ash in the range of 0 to 60 % by weight of PPC at water cement ratio 0.48 for M-25 mix. Concrete mixtures were produced, tested and compared in terms of compressive strength and reported that compressive strength comparable upto 20% replacement .level at 28 days. Kumar et al. [2014] reported that the workability is reduced with increase in dose of polythene and the compressive strength is increased on inclusion of waste polythene in concrete at all edges up to 0.75% and thereafter it starts decreasing. Harison et al. [2014] reported that up to 30% replacement of PPC by fly ash strength is almost equal to referral concrete after 56 day. PPC gained strength after the 56 day curing because of slow hydration process. Chaudhary et al. [2014] reported a study on the use of waste without plasticizer. Compressive strength and split tensile strength of concrete with plastic waste as aggregate and observed a good strength gain. Singh et al. [2015] investigated that PPC can be replaced up to 20%by fly ash without compromising compressive strength of concrete. Ariyamuthu et.al [2015] concluded that adding of shredded waste plastics with 0.25% of weight of cement leads to improvement in both compressive and split tensile strength. Soni et al. [2015] reported that by addition of fly ash and ponded as partial replacement of PPC and fine aggregate respectively, improved compressive strength can be achieved as compared to referral conventional concrete both in tap water as well as in chloride environment at all the ages. Srivastava et al. [2015] reported that the workability was considerably decreased with increase in dose of waste polythene, however, both compressive and flexural strength considerably increased with addition of waste polythene. Guendouz et al. [2016] concluded that reusing waste plastic in sand concrete gives a positive approach to reduce the cost of materials and solve some environmental problems. construction material in order to come with a suitable and viable utilization with regards to type of material and the employed dosage.

The deficiencies and drawbacks in the quality of produced asphalt binder from native crude-oil producers have its repercussions on the performance of asphalt pavement under oscillating traffic loads. The quality and price of asphalt cement use in the road industry has been another pile of advocating the quest for anther replacement. A supporting evidence for the bitumen-related issue is the concern in Ontario over the usage of refined motor oil with the asphalt cement. It was stated that about 50% of used asphalt cement is the road construction contains traces of remaining substance from the refining process of engine motor oil. This is a disastrous course of action which transmute the rheological properties of the asphalt cement and lead to unfavourable HMA performance. Shortfalls and scarcity of natural quality aggregates, heavy imposed traffic loads, and extreme environmental conditions have taken tolls on road paving industry. Researches on existing recycling material was to valorise the utilization of recycled materials in road constructions and improve the long-term performance of asphalt pavement. any successful applications of recycled materials in road construction works oriented towards the efforts of achieving a sustainable pavement construction. According to the ministry of national resources on the status of aggregates in Ontario, the industry still reluctant in utilizing currently suggested materials and the rationale was ascribed to the shortage of supportive practical and field experience and to some deficiencies- in the performance of implemented materials. Only 18% to 19 % of the total annual required aggregates for road construction was surrogated by recycled aggregates that represented in total a 130 Million tons according to the state of aggregates report issued by ministry of the national resource of Ontario in 2009.

Materials & Methodology

1. Materials

1.1. Cement

In the present study, Portland pozzolana cement (PPC) of Reliance brand obtained from single batch throughout the investigation was used. The properties of cement used is as under

• Fineness - 3.34%

• Normal consistency - 30%

• Initial setting times - 90 minutes

• Final setting times - 200 minutes

1.2. Fine Aggregate

Natural river sand 'Jamuna' was used in this work. Sieve analysis was carried out to determine fineness modulus, specific gravity and water absorption of the fine aggregate were 2.8, 2.73 and 1.4% respectively.

1.3. Coarse Aggregate

Crushed stone obtained from Bharatpur of 20mm and 12.5mm nominal size were used in this investigation.

The fineness modulus, specific gravity and water absorption for 20mm size coarse aggregate were 7.43, 2.64 and 0.61% respectively and 6.76, 2.71 and 0.51% respectively for 12.5mm size coarse aggregate.

1.4. Plastic waste

In the present investigation plastic waste used were PVC shredded pipes. Fineness modulus, specific gravity and water absorption of the same were 2.0, 1.54 and 0.28% respectively.

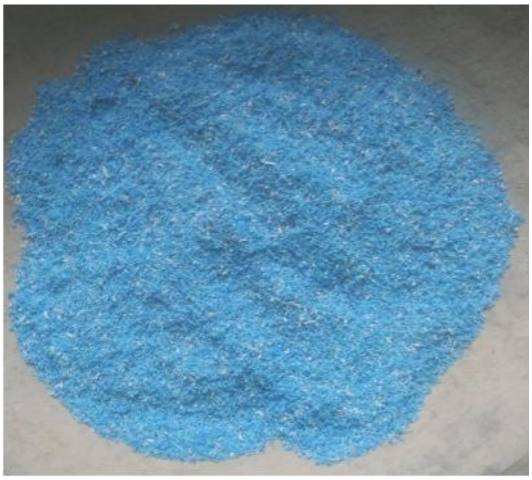

Figure-1.1 Plastic waste

1.5. Fly ash

Fly ash used in the present investigation was obtained from NTPC Bara Shankargadh thermal power plant, Allahabad U.P.

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Figure-1.2 Fly Ash

1.6. Superplasticizer

Superplasticizer of Sicca company is used at a constant dose of 0.4% (by weight of cement) enhancing the workability.

1.2. Methods

In the present investigation M25 grade of concrete was used. The mix proportion concrete was 1:1.8:3.2 at water cement ratio of 0.44. The specimen concrete was tested for density and workability green concrete and compressive & flexural in hardened state after 7 days and 28 days of moist curing.

Laboratory Test Conducted

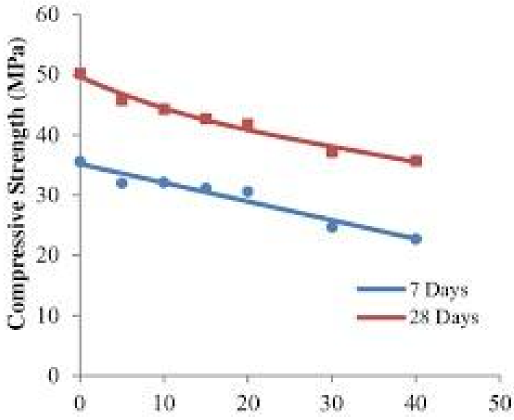
2.1. Compressive Strength

Compressive strength of concrete is the most common test for judging the ability of the concrete to withstand the load as well as the quality of the hardened concrete.

The compressive strength of concrete made with plastic waste and fly ash is given in table. Same results are shown in graphical form for observation of various pattern.

Table 2.1 Compressive strength of concrete

S.NO.	W/c	Cube Designation	Replacement of Plastic Waste	Replacement of Fly Ash	Compressive strength (N/mm^2)	
					7 days	28 days
1	0.44	A1	0	0	23.2	35.0667
2	0.44	A2	2	0	21.2	34.8667
3	0.44	A3	4	0	19.667	32.4667
4	0.44	A4	6	0	15.333	29.8
5	0.44	A5	8	0	13	22.733
6	0.44	A6	10	0	12.2	17.33
7	0.44	AF1	0	10	22.667	35.933
8	0.44	AF2	2	10	20.53	34.93
9	0.44	AF3	4	10	19.533	32.667
10	0.44	AF4	6	10	14.133	30.133
11	0.44	AF5	8	10	12.733	23.4
12	0.44	AF6	10	10	11.666	18.13



Variation of Compressive strength at different replacement level

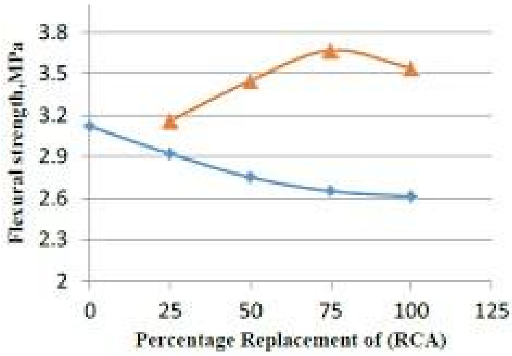
28 days curing, it is evident from table that compressive strength was decreased with increase in replacement level of fine aggregate. The decrease in compressive strength is the range of 2.29 -51.52% for replacement level of 2 to 10%.

2.2. Flexural Strength

Flexural strength is defined as a materials ability to resist deformation under load. It is also known as modulus of rupture, bend strength, or fracture strength.

Observed data of specimens after 28 days for flexure strength is given below in table and figure.

S. NO.	W/C	Cube Designation	Replacement of Plastic Waste	Replacement of Fly Ash	Flexural Strength (N/mm^2) 28 days
1	0.44	C1	0	0	7
2	0.44	C2	2	0	7.2
3	0.44	C3	4	0	7
4	0.44	C4	6	0	5.6
5	0.44	CF1	0	10	7.4
6	0.44	CF2	2	10	7.6
7	0.44	CF3	4	10	7.2
8	0.44	CF4	6	10	5.2



Variation of flexural strength at different replacement level

Flexural strength of non-conventional concrete is better then fresh concrete. We observed that replacement of 2% fine aggregate flexural strength increased 2.71% with respect to fresh concrete.

Results & Discussions

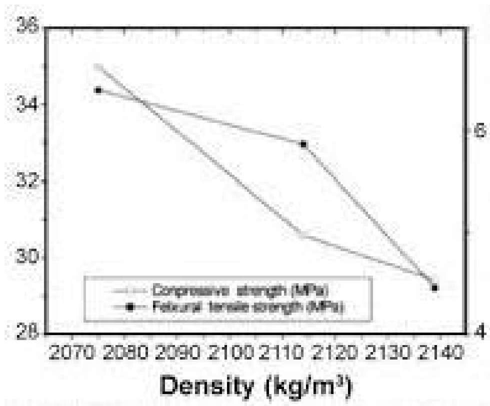
3.1. Properties of Fresh Concrete

3.1.1. Density

Density is a measurement that compares the amount, ratio of matter an object has to its volume. An object with a little matter in the same amount of volume has a low density. Results of density of fresh concrete at different replacement levels are given in table .The same results are shown graphical form in figure

Slump values and Density of concrete

S.NO.	W/C	Replacement of Plastic Waste (%)	Replacement of Fly Ash (%)	Slump Value (mm)	Density (kg/m^3)
1	0.44	0	0	132	2498.667
2	0.44	2	0	126	2458.667
3	0.44	4	0	102	2418.667
4	0.44	6	0	80	2341.333
5	0.44	8	0	52	2265.239
6	0.44	10	0	14	2174.629
7	0.44	0	10	128	2500
8	0.44	2	10	120	2478.5
9	0.44	4	10	98	2462
10	0.44	6	10	68	2412.27
11	0.44	8	10	45	2333.855
12	0.44	10	10	11	2240.49

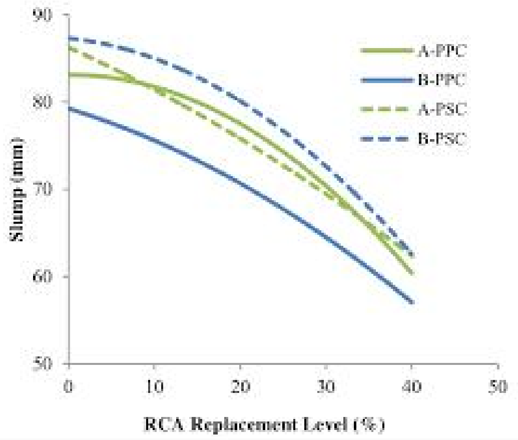


Variation of density at different replacement level

3.1.2. Workability

Workability is defined as the property of freshly mixed concrete or mortar which determines the ease and homogeneity with it can be mixed, place, compacted and finished.

The results of workability in terms of slump are shown in table. The same results are shown in figure in graphical form for observation of various pattern.



Variation of slump at different replacement level

Conclusion

- Density in green state of concrete observed to be decreased (1.62-13 %) with increase in replacement level.
- Workability of concrete made using waste plastic observed to be decreasing with increase in replacement level.
- Compressive strength of concrete made using waste plastic found to be decreased with increase in replacement level.
- Decrease in compressive strength while using.

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