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EFFECT OF STEEL SLAG AND FLAY ASH ON THE PROPERTIES OF CONCRETE MIX FOR PAVEMET

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***Abstract*— The global demand of concrete in the future is more challenging task to find the suitable alternatives of natural aggregates, sand and cement for preparing concrete. Rigid pavement is the one type of pavements which resists more against the external loads and long life period if it is well designed. Rigid pavement structure is composed of a hydraulic cement concrete surface course and underlying base and sub base courses (if used). Concrete is prepared by mixing various constituents like cement, aggregates, water, etc. which are economically available. Concrete plays a critical role in the design and construction of the nation's infrastructure. Almost three quarters volume of concrete is aggregates and the important content of concrete is cement. We have to find the suitable alternatives for both of these materials.**

I. INTRODUCTION

Steel slag is a co-product of the steel making process in which Steel cannot be prepared in the Basic Oxygen Furnace (BOF) or in an Electric Arc furnace (EAF) without making its co-product; steel slag. The use of steel slag aggregates in concrete by replacing natural aggregates is a most promising concept. Steel slag aggregates are already being used as aggregates in concrete paving road mixes due to their mechanical strength, stiffness, porosity, wear resistance and water absorption capacity.

The Fly ash is also by-product material of coal, which uses in furnaces for producing of heat and high temperature. Fly ash is the west material of coal combustion in furnaces. Fly ash is already being used in 15-30 % ratios of cement in concrete as a replacement of Portland cement duo to their physical and mechanical properties and similarity with cement.

Studies and tests are done about use of steel slag as an aggregate and fly ash as cement in concrete by different researchers, but the researches were done separately for each of these materials.

Here we want to do research on uses both of steel slag and fly ash in cement concrete mix, their effects, optimum percentage of suitable replacement, and economic comparison of concrete with and without steel slag and fly ash. There are we conducted experimental tests on conventional and modified concretes.

The problem of fly ash and steel slag utilization is not confined to India alone but is being experienced all over the world. However, this problem is particularly acute in countries like India, where utilization of fly ash and steel slag has not received much attention. The degree of its utilization varies among different countries.

In India, the present rate of utilization of waste material is only about 10 percent, which is below the world average of about 16 percent. Hence in this Study, it is aimed to describe the use of flu ash and steel slag in rigid pavement road works and its improvement of strength with compare to the conventional concrete.

Extensive researches have been conducted for the applications of steel slag in broad areas of construction also fly ash material used in asphalt and Portland cement product. Thus, an important need exists to quantify the benefits of using such cheap materials in concrete technology and concrete asphalt pavement.

In this study, several experiments have been conduct to study the effect of adding steel slag aggregates and fly ash in concrete composite and measuring the effect of these materials on the mechanical behavior of hardened concrete in order to overcome such problem mentioned above. The percentages of replacement in the concrete mix will be in range from 0 to 50%.

Following are objectives of the studies:

- To study the effect of steel slag and fly ash in concrete mix for different proportions.
- To compare various results with conventional concrete and modified concrete.

The Basic scope of this research is to investigate the properties of concrete with steel slag aggregates and fly ash cement, and economical evaluation of suitable sample.

- To carry out physical tests on the aggregates, steel slag as per IS: 383 and fly ash as per IS: 3812 Guidelines.
- To design a concrete mix for M30 as per IS:10262 Guidelines.

- To conducted required tests such as compressive strength, flexural strength as per IS: 516, and split tensile strength as per IS: 5816, of conventional and modified concrete.

II. MATERIALS

(A) Cement

Concrete is composed by different materials such as aggregates, water, cement as termed as binder because it brings the cohesiveness between the all ingredients combined together for producing one material called concrete. There are different types of cement used in construction of structures but ordinary Portland cement is popular binder used widely. According to ASTM, provided the definition of Portland cement as hydraulic cement which form a water-resistance product that produced by pulverizing clinker consisting the hydro calcium silicate and inter-ground addition. This type of cement is made by fusing calcium bearing materials with alumina-bearing materials. The sources of calcium are from limestone, shells, chalks etc.

In these studies, ordinary Portland cement of 53 grades has been selected to be used in concrete mix, and its physical requirements are established according to India specification (IS-12269).

(B) Aggregates

Aggregate is an inert, inexpensive material dispersed throughout the cement paste so as to produce a large volume of concrete. Alternative definition, it is considered as inert materials of small sizes obtained either from decomposition or crushing of rocks. Two types of aggregates according to nature formation:

Natural aggregate: they are extracted from the soil but without undergoing any modification in their internal structures.

Artificial aggregate: they also come from the soil but result is a mix of physical or chemical modification operated on them. This process of obtaining artificial aggregate can be done by crushing them into the small sizes needed on the site. Aggregates are classified according to the size, shape, and texture and unit weight.

(C) Fine aggregates

Fine aggregates are the aggregates' passing through 4.75 mm IS sieve. Indian specification classifies the final aggregate into four types based on its gradation as fine aggregate of grading zone-I to zone IV. Zone I is the fine aggregate passing 4.75 which is having the grading of 90 to 100%. Zone IV is the finer aggregate passing 150 Microns IS sieve having grading of 0 to 15%. In these studies, the sand used in concrete is local river sand which is classified in zone II. The analysis is done by using the Indian standard method for checking the size of sand. The results from laboratory are presented in the form of sieve analysis of fine aggregate. The specific gravity of river sand used in these studies is 2.63 with the water absorption of 1.24%.

(D) Flay ash

Fly ash concrete was first used in the U.S. in 1929 for the Hoover Dam, where engineers found that it allowed for less total cement. And the major breakthrough in using fly ash in concrete was the construction of Hungry Horse Dam in 1948, utilizing 120,000 metric tons of fly ash. This decision by the U.S. Bureau of Reclamation paved the way for using fly ash in concrete constructions. It is now used across the country. Consisting mostly of silica, alumina and iron, fly ash is a "pozzolan" which is a substance containing aluminous and siliceous material that forms cement in the presence of water. When mixed with lime and water it forms a compound similar to Portland cement.

Fly ash has also been used as substitute mineral filler in asphalt paving mixtures for many years. In these studies the cement have been replaced by fly ash for different replacing ratios of mixing (0, 05, 10, 15, 20, 25)

(E) Steel slag

Based on the definition of steel slag as by-product of industry steel making which can be produce by oxygen furnace or electric arc furnace. It is produced in the form of rocks which is ground into small particle size as fine or coarse steel slag for construction purpose. It is characterized by different mineral which combined together for producing good construction steel slag material, especially in road pavement. The main composition of steel slag is iron oxide, silicate oxide ferrous metallic, and manganese and aluminate oxide. In order to evaluate the quality of steel slag, the different tests have been conducted with respect the shape and size required to produce good mixture of concrete. The specific gravity of steel slag varies 3.0 to 4.0.

In these studies the natural coarse aggregates of 20 mm have been replaced by coarse steel slag aggregate of 20 mm for different replacement ratio of mixing (0, 10, 20, 30, 40and 50%).

(F) Water

Water is important ingredient of concrete as it actively participates in chemical reaction with cement. The specific

gravity of water as specified by Indian standard code is 1.0. The quality of water is important because impurities in it may interfere with the setting of cement may adversely affect the strength of the concrete. Water cement ratio used in this research was 0.4 as proved after obtaining the required workability as well as strength of concrete.

III. EXPREMINTAL RESULTS

This chapter has been focused on the determination of the quantity of concrete ingredients required to produce the good concrete mixes as well as the required strength. The materials used in these studies are available locally and research materials as fly ash and steel slag has been found in Ahmedabad. It is discussed also the results obtained from different experiments for grading of aggregates, fresh and hardened concrete.

In order to evaluate the strength of concrete, the three specimens are casted and tested for each age according to Indian standards.

The data collected from laboratory are summarized in the form of tables and charts in order to simplify the understanding of results obtained.

2.2 Grading of aggregates

The materials used in these studies are found locally, the coarse aggregates of 10 and 20 mm are used and replaced by the steel slag of 10 and 20 mm size and Portland cement replaced by fly ash C respectively.

The fine aggregates used in these studies are also found locally as river sand.

The specific gravity water absorption Bulk density aberration value of aggregates and steel slag are shown chart:

S/N	Type of properties	Crushed coarse aggregates (20 mm)	steel slag aggregates (20 mm)
1	Specific gravity	2.74	3.20
2	Water absorption%	0.48	0.25
3	Bulk density g/ccm	16.85	17.70
4	Aggregates abrasion value%	10.00	11.70

Fineness modulus of sand, coarse aggregates and coarse steel slag as per IS: 2386 are 2.58, 8.10, and 8.41 respectively.

2.3 Mix proportion of concrete

According to bureau of Indian standard guideline described in literature review, the mix design is required to select the suitability of materials as well as determination of quantity required in mix for producing the good concrete.

The materials used in these studies are aggregate, sand, cement and water.

The following information is considered in determination of mix proportion:

- Grade of concrete: M30 and Grade of cement: 53 OPC
- Maximum nominal size of aggregates: 20 mm
- Workability of required: 50 to 70 mm and Maximum water cement ratio: 0.45
- Type of aggregate: crushed angular aggregate and sand
- Minimum and maximum cement content: 360 to 540 kg/m3 thereafter the all required quantities were determined according to IS: 10262-2009.

Summary of all data calculated in the form of tables as shown below:

Description	Mix proportion in kg/ m^3				
Ingredients	Water	Cement	Sand	Course Agg.	U. weight kg /m^3
Weight (kg)	186	443	664.5	1143	2436
Per bag of cement	20.09	1 (50 kg)	75	129	
Per W/C ratio	0.42	1	1.5	2.58	

Numbers of specimens and quantity of mix materials for each trail of mix proportion in these studies:

6 Cubes (15x15x15) cm for 7 and 28 days curing

6 Cylinders (15ØX30) cm for 7 and 28 days curing

3 Beams (15X75) cm for 28 days curing

Quantity of Mix materials for each proportion of these studies are in kg/cc.

S/N	% of Fly ash	% of slag	water	cement	Fly ash	sand	C. Agg 20 mm	S. slag 20 mm	No of specimens
1	0	0	20.09	50	-	75	129	-	15
2	05	10	20.09	47.5	2.5	75	116.1	12.9	15
3	10	20	20.09	45	05	75	103.2	25.8	15
4	15	30	20.09	42.5	7.5	75	90.3	38.7	15
5	20	40	20.09	40	10	75	77.4	51.6	15
6	25	50	20.09	37.5	12.5	75	64.5	64.5	15

2.4 Experimental results

The concrete mix proportion used in these studies is 1:1.5:2.58 with the water cement ratio of 0.42.

The concrete mix of M30 is selected in these studies as per rigid pavement requirement. According to Indian standard referred for performing different laboratory experiments, the two types of concrete properties are evaluated.

2.4.1 Fresh concrete

Fresh concrete is the property of concrete which is evaluated in term of workability by slump and compaction factor test. The bulk density (unit weight) is also tested; the following table and pictures show the results and work of fresh concrete's tests of four trails of conventional and modified concrete:

S/N	Trial Mix	% of fly ash	% of slag	Slump (mm)	C .factor (ratio)	U. weight kg/cc
1	M1	0	0	60	0.80	2436.5
2	M2	05	10	65	0.82	2439.4
3	M3	10	20	65	0.85	2443.0
4	M4	15	30	70	0.87	2447.5
5	M5	20	40	75	0.89	2457
6	M6	25	50	75	0.90	2463

2.4.2 Hardened concrete

The important property of hardened concrete is the strength which is evaluated in term of compressive, flexural, split tensile strength in these studies. The different specimens are casted for each trial of mix.

According to Indian standard, the minimum 3 specimens are casted for each age of curing (7&28 days) and tested.

A. Compressive strength

The compressive strength of hardened concrete is tested according to Indian standard (IS-14858:2000). The 3 specimens of cubes (15*15*15 cm) were casted and tested for age of 7 and 28 days. The plane area of specimen (cubes) is calculated (150*150) mm and obtained 22500 mm2. The following pictures and figures show the research work in the laboratory for different experiments:

Compressive strength in Mpa					
Trail mix	% of replacement		Period of curing		No. of specimens
	Flay ash	Steel slag	7 days	28 day	
M1	0	0	24.4	36.7	6
M2	05	10	24.8	37.1	6
M3	10	20	25.5	37.8	6
M4	15	30	25.6	37.8	6
M5	20	40	23.3	35.3	6

B. Split tensile strength

The tensile strength of hardened concrete is tested according to Indian standard (IS: 5816-1970). The 3 specimens of cylinder are casted and tested for each 7 and 28 days of curing. In these studies, the 7 and 28 days of curing are presented for conventional and modified concrete.

The maximum load applied on the cylinder specimens was 250 and 500 KN respectively. The specimens are tested horizontal with the area equal 141372 mm2.

The split tensile strength of concrete should be between 8 to 12% of compressive strength results.

In this experimental testing procedure and result is shown in the form of figures and table. The split tensile strength is found between 9 and 12% of compressive strength results as shown in the figure and table below:

Split tensile strength in Mpa					
Trail mix	% of replacement		Period of curing		No. of specimens
	Flay ash	Steel slag	7 days	28 day	
M1	0	0	2.45	3.50	6
M2	05	10	2.60	3.73	6
M3	10	20	2.71	3.90	6
M4	15	30	2.90	4.15	6
M5	20	40	2.85	4.05	6

C. Flexural strength

Flexural strength of hardened concrete is evaluated according to Indian standard (IS: 516 - 1959).

The 3 specimens of beams (15*15*75 cm) are casted and tested for 28 days of curing.

The flexural strength test of both conventional and modified concrete is also carried out for checking the modulus of rupture. In the below table shows the average results in which modified concrete performed better with compare to conventional concrete.

Trail mix	% of replacement		Period of curing	No. of specimens
	Flay ash	Steel slag	28 day	
M1	0	0	3.85	3
M2	05	10	3.98	3
M3	10	20	4.12	3
M4	15	30	4.20	3
M5	20	40	3.9	3

2.5 Summary

The experimental results described in this chapter have presented for both conventional and modified concrete. The different tests performed for fresh concrete proved that fly ash and steel slag are the best waste materials to be used in road construction.

The results obtained from 7&28 days of compressive strength test have demonstrated the required targeted strength (36 Mpa) is achieved except the last trail.

Split tensile strength result is found as 10% of compressive strength as specified by bureau of Indian standard code.

Flexural strength results also show that the increasing the waste materials %, the strength increased considerably. The both fly ash and steel slag could be used as the mix materials in place of natural aggregates and cement if locally and economically available

IV. CONCLUSION

The effect of steel slag and fly ash on the properties of concrete mix for rigid pavement in the main research work have carried out in these studies, thereafter the comparison between the both conventional and modified concrete have considered in order to cheek the suitability of optimum quantity of waste materials and concrete mix and their effects

on it. The following conclusions are written based on the context of this paper:

- Steel slag is a by-product of the steel making process, which is already being used as aggregates in concrete paving road mixes due to their mechanical strength, stiffness, wear resistance and water absorption capacity.
- The Fly ash is also by-product and waste material of coal combustion in thermal power houses. Fly ash is already being used in 15-30 % ratios of cement in concrete as a replacement of Portland cement duo to their similar physical and mechanical properties.
- In these studies, the replacement on aggregates and cement by steel slag and fly ash percentage such as 0, 10, 20, 30, 40, 50% and 0, 5, 10, 15, 20, 25% respectively.
- Fly Ash & Steel slag could be used in concrete mix because of its suitable Physical and Mechanical properties.
- The fresh modified concrete results show that fly ash & steel slag could be used as alternative concrete materials.
- The compressive, Split tensile and flexural strength of conventional concrete is less than modified concrete up to Trail Mix No 4, but in Trail no 5, it is not achieved the required strength.
- As per excremental results we can select trail no 4 (replacing of 15 % of flay ash and 30 % of steel slag) as optimum replacement of aggregates in cement for 30 Mpa concrete.
- As per cost comparison of conventional and modified concrete, if the fly ash and steel slag as co product materials could be locally available, are cheaper than cement and aggregates.

RETEERENCES

1. ARVO Tinni "*Introduction to concrete pavement" , Concrete Association of Estonia, pp.6-7, February, 2013*
2. Dr.Kadyali , Dr.N.B.Lal, *"Principles and practices of highway engineering ", sixth editions, Khanna Publishers Delhi, pp.339-344, 2013*
3. P. Kumar Mehta, *"Advancements in Concrete Technology", Concrete International, june 1999*
4. Irem Zeynep Yildirim and Monica Prezzi, *"Chemical, mineralogical and morphological properties of steel slag", Hindawi Publishing Corporatio Advances in Civil Engineering, Article ID 463638, July 2011*
5. Praveen Mathew, Leni Stephen and J. George, "*steel slag ingredients for concrete pavement", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 3, March 2013*
6. EUROSLAG, *"Chemical, mechanical and physical properties of steel slag", September, 2014*
7. M.Maslehudin, Alfarabi M.Sharif, M.Shameem, M.Ibrahim and M.S.Barry, *"comparison of properties of steel slag and crashed lime stone aggregate concrete", 2003*
8. S.C.Maiti, Raj K.Agarwal and Rajeeb Kumar, *"Concrete mix proportioning", Indian Concrete Journal, December 2006*
9. Dr. M.C.Nataraja, *"Concrete mix design", Second National seminar on Advances in Materials and Structure, IIT, Chennai, India, pp. 22-25, 2011*
10. T. U. Ganiron Jr, *"Author of "Scrap Waste Tire as an Additive in Asphalt Pavement for Road Construction", International Journal of Advanced Science and Technology, pp.21-30, 2012*
11. M. Ramesh ,K.S.Karthic, T. Karthikeyan, *"Construction Materials From Industrial Wastes-A Review of Current Practices", International Journal of Environmental Research and Development, ISSN 2249-3131 Volume 4, 2014*
12. Shetty M S, *"Concrete Technology Theory and Practice", S.Chand Publishers, NewDelhi, 2009*
13. P. R. Wankhede1, V. A. Fulari, *"Effect of Fly ash on Properties of Concrete" International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, Volume 4, Issue 7, July 2014*
14. IS: 10262-2009, *"Indian standard Concrete mix proportioning – guidelines", First revision Bureau of India Standard, New Delhi, India*
15. IS: 3812-2003, *"Indian standard for use as us fly ash in cement– guidelines", Second revision Bureau of India Standard, New Delhi, India*
16. IS: 515-1959, *"Indian Standard for Methods of tests for strength of concrete" Bureau of India Standard, New Delhi, India*
17. IS: 383-1970, "Indian Standard *for Physical Tests of aggregates" Second revision Bureau of India Standard, New Delhi, India*
18. http://www.google.pavement design.org/article/ factors
19. http://www.engineering /civil.com/concrete mix design as per Indian standard codes
20. http://www.google. Steel slag manufacturing images

21. http://www.indian road congress.org.in
22. http://www.en.wikipedia.org/wiki/rigid pavement
23. http://en.wikipedia.org/wiki/Fly_ash.org
24. http://euroslag.com/