Use of cement in road construction

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INTRODUCTION

Urban planning, motor vehicles, or even wheel, first roads that were appeared on landscape thousands of years before. First roads were impulsively formed by humans walking common paths over & over to find water & food like molecules coalesced into cells & cells into more complicated organisms.
The transportation of larger, heavier loads showed many limitations of dirt paths which turned into muddy bogs on the time of raining and followed introduction of wheel 7,000 years ago. The ancient stone paved roads was found about 4,000 B.C. in Indian subcontinent & Mesopotamia.
Recent road-construction techniques might be traced into a process developed by Scottish engineer John McAdam in early 19th century. McAdam excelled multi-layer roadbeds with soil & crushed stone that was then settled down with heavy rollers. Modern day asphalt roads are able to support vehicles that emerged in 20th century. It was built upon McAdams' methods with adding tar as a binder.

Keywords: cement, pavement, compressive strength, workability, Water absorption, abrasion test.

1.5 OBJECTIVE OF RESEARCH

1. To evaluate properties of fly ash & bottom ash mixtures.
2. To identify workability & durability of Highway pavement.
3. To investigate optimal use of bottom ash & fly ash for pavement.
4. To check compressive strength by replacing aggregate with bottom ash & fly ash at different percentage i.e. 0%, 5%, 10%, 15%, 20%.
5. To check suitability of reuse of bottom ash & fly ash in a useful manner.
6. To minimize overall environmental effects of production using these materials as partial replacement.
7. To perform Following tests

A. Water Absorption of Bottom ash/ fly ash
B. Abrasion Test of Bottom ash / Fly ash
C. Impact Test Bottom ash / Fly ash
D. Crushing strength Test Bottom ash / Fly ash
E. Soundness test of Bottom ash / Fly ash
F. Compressive strength after using Bottom ash /fly ash

2 LITERATURE REVIEW

With view to carry out this study in a successful way, literature/reports from national & international journals have been referred to understand present status, identify gap areas & emerging issues to make this study more fruitful. Much research has already been undertaken by research scholars Doughnut world. Abstract of most of related & latest literatures are summarized here. Hence an attempt is made to review literature to know latest development in this study area.

2.1 LITERATURE SURVEY

Li Yijin, Zhou Shiqiong(2002) "The effect of fly ash on the fluidity of Cement paste, mortar, and concrete", International Workshop on Sustainable Development and Concrete Technology[1]

The addition of ultra-fine fly ash to cement paste, mortar and concrete can improve their fluidity, but some coarse fly ash can't reduce water. This paper investigates the effect of fineness and replacement levels of fly ash on the fluidity of cement paste, mortar, and concrete. The fly ash is collected by electro-static precipitators and airflow classing technology. Three different finenesses were chosen, and their replacement levels were 20%, 30%, and 40%, respectively. The experiment results show that particle size distribution, Zeta potential, density and particle morphologies of fly ash are the major factors affecting their fluidity.

Satish Sharma, V.V. Arora, Adarsh Kumar N S (2005) "Study of usage of bottom ash as part replacement of sand for making concrete blocks"[2]

line with the findings of the other authors as outlined in the literature survey carried out in NCB. In the present investigation, laboratory studies have been carried out at NCB laboratory to utilize bottom ash as part replacement of sand in concrete. This study covers manufacturing of concrete blocks without flyash & with bottom ash for making solid blocks as per specification laid down in IS: 2185 using vibro compaction machine available in NCB. Wet density is found to be lower in blocks containing bottom ash & dry shrinkage values are found well within the limits of specifications. Concrete Blocks having bottom ash @ 30% by weight of sand are found suitable for use in the manufacture of concrete blocks.

P. Aggarwal, Y. Aggarwal, S.M. Gupta (2007) "Effect of bottom ash as replacement of fine aggregates in concrete", ASIAN JOURNAL OF CIVIL ENGINEERING (BUILDING AND HOUSING) VOL. 8, NO. 1 (2007)[6]
This paper presents the experimental investigations carried out to study the effect of use of bottom ash the coarser material, which falls into furnace bottom in modern large thermal power plants and constitute about 20% of total ash content of the coal fed in the boilers as a replacement of fine aggregates. The various strength properties studied consist of compressive strength, flexural strength and splitting tensile strength. The strength development for various percentages (0-50%) replacement of fine aggregates with bottom ash can easily be equated to the strength development of normal concrete at various ages.

Shantmurti upadhyaya (2014) "Effects of Fly ash on Compressive Strength of M50 Mix Design Concrete", International Journal of Scientific & Engineering Research, Volume 5, Issue 6, June-2014 [8]
The Ordinary Portland Cement Is One Of The Main Ingredients Used For The Production Of Concrete. Unfortunately Production Of Cement Involves Emission Of Large Amount Of Carbon Dioxide Gas Into Atmosphere, A Major Contributer For Green House Effect And The Global Warming , Hence It Is Invitable Either To Search For Another Material Or Partially Replace It By Some Other Material. The Search Of Any Other Such Material Which Can Be Used As An Altrernative For Cement Should Lead To Global Sustenable Development And Lowest Possible Environmental Impact. Concrete Property Can Be Maintained With Advance Mineral Admixtures Such As Flyash As Partial Replacement Of Cement 0 To 30%. Compressive Strength Of Concrete With Different Dosage Of Fly Ash Was Studied As Partial Replacemnet Of Cement. From The Experimental Investigations, It Has Been Observed That, The Optimum Replacement Of Flyash To Cement Without Changing Much Compressive Strength Is 10%.

Mahdi Rafieizonooz , Jahangir Mirza , Mohd Razman Salim (2014) "Investigation of coal bottom ash and fly ash in concrete as replacement for sand and cement"[7]
The workability of fly ash-bottom ash concrete was reduced due to the utilization of CBA as total or partial substitute of fine aggregate in concrete. The descending values of experimental concrete mix showed a downswing at fixed w/c, with increase in CBA content as substitute of sand in concrete. The CBA particles are found to have rough texture and irregular shape. Use of CBA as fine aggregate actually enhances the concrete's texture with many more irregular and fine-shaped, porous particles that are usually very rough. It, therefore, enhances the inter particle friction which is responsible for obstructing the flow of fresh concrete. The phenomenon of compressive strength development of fly ash-bottom ash concrete with curing period is almost similar to that of control concrete. At curing age of 7 d there was considerable reduction in compressive strength in all fly ash bottom ash concrete mixtures compared with that of control concrete. With progress in curing period, considerable increase in compressive strength of fly ash-bottom ash concrete mixtures was noticed. It can be concluded with some certainty that notable increase in compressive strength of fly ash-bottom ashconcrete mixtures after 28 d curing period, was because of pozzolanic activity of CBA and CFA. At curing period of 91 d, compressive strength of fly ash-bottom ash concrete mixtures was almost the same as the control concrete and after 180 d, it exceeded compare to control concrete.

Nitin S. Naik, B.M.Bahadure, C.L.Jejurkar (2014) " Strength and Durability of Fly Ash, Cement and Gypsum Bricks" [10]
Unique possibility exists for the bulk utilization of fly ash in producing bricks in the proximity of thermal power plants, phosphoric acid and fertilizer industries. The test cubes are having sufficient strength and have potential as a replacement for conventional burnt clay bricks. Cementitious binder with fly ash and phosphogypsum content equal to 90% gives better compressive strength and 28.22 % water absorption and thus suitable for use in construction industry. Being lighter in weight, it will reduce the dead weight and material handling cost in multi storied constructions.

Soman, Divya Sasi (2014) "Strength properties of concrete with partial replacement of sand by bottom ash", [11]
The concrete is the need of the present. Bottom ash is an abundant waste from furnace of thermal power plants and other industries. Studies so far done have revealed that bottom ash will increase the durability in several cases. Based on this experimental study, the following conclusions are drawn. The study shows that 30% replacement of M Sand with bottom ash has given a 28 day compressive strength of 38.43 MPa The result shows that bottom ash can be used to substitute M sand and the optimum replacement level is 30%. The use of bottom ash in concrete will reduce the environmental problems arising from filling it in land. As a result of reduced sand consumption the problems in sand mining can also be reduced. The reduction of landfill costs and ill effects of land filling along with reduction in sand mining finally leads to sustainable development.

Syed Afzal Basha, P.Pavithra, B.Sudharshan Reddy "Compressive Strength of Fly Ash Based Cement Concrete" [2014][12]
In this paper an attempt is made for assessment of compressive strength of Fly ash based cement concrete. Concrete mixes M25, M30, are designed as per the Indian standard code (IS-10262-82) by adding, 0%, 10%, 20%, 30% and 40% of fly ash. Concrete cubes of size 150mm X 150mm X 150 mm are casted and tested for compressive strength at 7 days, 14 days, 21 days and 28 days curing for all mixes and the results are compared with that of conventional concrete.
The compressive strength of all mixes is tabulated. Concrete is a vital ingredient in infrastructure development with its versatile and extensive applications. It is the most widely used construction material because of its mouldability into any required structural form and shape due to its fluid behavior at early ages. However, there is a limit to the fluid behavior of normal fresh concrete. Thorough compaction, using vibration, is normally essential for achieving workability, the required strength and durability of concrete. Inadequate compaction of concrete results in large number of voids, affecting performance and long-term durability of structures. Since due to the vast construction in the urban development programs there is a high demand of concrete in bulk and for achieving the requirement of concrete in bulk, fly ash is being used as a mineral admixture in concrete.

S. Sivakumar1 and B. Kameshwari (2014) "Influence of Fly Ash, Bottom Ash, and Light Expanded Clay Aggregate on Concrete",[14]

The paper attains the highest possible strength for LECA concrete while noting the advanced technology in producing light weight concrete. The results show that 5% replacement of cement with fly ash, fine aggregate with bottom ash, and coarse aggregate with light expanded clay aggregate (LECA) was found to be good performance in compressive strength, split tensile strength, and flexural strength of beamin 56 days when compared with 28 days strength. At the same time 28 days strength also approximately equals normal conventional concrete; that is, 0% replacement and dry weight of specimen have been reduced. In future, soft computing techniques will lead with core areas us to attain better performance in short interval of time as the time is the major factor involved in this research work.

A. Sumathi*1, K. Saravana Raja Mohan (2015) " Compressive Strength of Fly Ash Brick with Addition of Lime, Gypsum and Quarry Dust", International Journal of ChemTech Research, Vol.7, No.01, pp 28-36,[13]

Based on the experimental study, following conclusions can be drawn regarding the strength behavior of flyash brick; The study was conducted to find the optimum mix percentage of flyash brick. However the brick specimen of size 230mm x 110mm x 90mm were cast for different mix percentage of Flyash (15 to 50%), Gypsum (2%), Lime (5 to 30%) and Quarry dust (45 to 55%). However the specimens have been tested for seven mix proportions. The mechanical properties such as compressive strength were studied for different mix proportions, at different curing ages. From the results it was inferred that, among the seven proportions the maximum optimized compressive strength is obtained for optimal mix percentage of Flyash-15% Lime-30% Gypsum-2% Quarry dust-53% as 7.91 N/mm^2.

Vikas R Nadig, Sanjith J , Ranjith A (2015) "Bottom Ash as Partial Sand Replacement in Concrete- A Review",[15]

This study reviews the characteristics of Concrete incorporated with Bottom Ash as partial replacement for fine aggregates, with a main focus on the mechanical properties such as Compressive strength, splitting tensile strength, flexural strength etc. Ten different research papers are reviewed. The practical use of Bottom ash shows a great contribution to waste minimization as well as resources conservation.

K. SathyaPrabha1, J. Rajasekar (2015) "Experimental Study on Properties of Concrete Using Bottom Ash with Addition of Polypropylene Fibre",[16]

Bottom ash is a hazardous by-product from coal based thermal power plants. In this study fine aggregate in concrete mix has been replaced with bottom ash and Polypropylene fibre is additionally used to enhance the strength characteristics of concrete. The concrete mix design is done for M25 grade concrete. The mix is prepared for different combinations of 0%, 10%, 20% and 30% of replacement of sand by bottom ash with 0.5% of polypropylene fibre by total weight of the Cube. The mechanical properties were compared with control mix and it was found that the optimal combination as 30% bottom ash and 1.0% polypropylene fibre. Flexural strength was compared by testing beams of size 1.5 x 0.25 x 0.15m under two point loading. Results showed that there was no degradation of strength for beams with bottom ash as replacement for fine aggregates.

Darzi Musaib A.,Bhumre Shivkumar, Kamble Ashok, Giri Sunil C., Kamble Rupesh, Seham Khaleel (2016) "Effective Partial Replacement Of Cement And Sand With Fly-Ash And Marble Powder To Make Green Concrete" [18]

This research paper is finding ways to reuse these products for making new products or as admixture in some products. Marble industry is the most thriving industry in our country. About 20 % of the final product is marble dust generated from marble processing industry. This waste is dumped in the natural soils which reduces the fertility of the soil. Fly ash is the waste generated from the coal combustion. Marble has properties like durability and also has good aesthetics whereas flyash has good binding properties. Cement upto a certain extent causes degradation of the environment as it releases major green house gas i.e. carbon dioxide. Also the prices of cement are rising day-by-day. The resources of natural sand are decreasing and its price is increasing tremendously. In this experimental investigation we are partially replacing cement with flyash in percentages of 5,10 and 15 % and partially replacing sand with marble powder in percentages of 20, 40 and 60 %. We are going to assess its impact on compressive and split tensile strength and find the optimum percentage of replacement to gain the maximum strength and compare it with the strength of ordinary M20 concrete.

Mohammad Abushad[1], Misbah Danish Sabri[2],(2017) " Comparative Study of Compressive Strength of Concrete with Fly Ash Replacement by Cement", International Research Journal of Engineering and Technology Volume: 04 Issue: 07 | July -2017

The above state results go towards the conclusion that to compare the strength of concrete with conventional waste materials is fruitful. Fly ash and stone dust in concrete mix proved to be very useful to solve environmental problems and up to some extent one can minimize the requirement of cement in large quantity.

Hence it is safe and environmentally consistent method of disposal of fly ash. And it can be find that the power plant are uses the fly ash as replacement of cement .Based on the studies of different literatures from book, journals on application of fly-ash cement concrete .It is being concluded that most of the experiment were based on different material such as, silica flumes ,marble dust ,stone waste, pond ash , sugarcane bagasse in the fly-ash cement It is difficult the find actual proportion and types of fly ash in concrete cubes concrete.

RESULTS AND DISCUSSION

The various aspects studied include (i) effect of bottom ash on workability (Compaction Factor) of fresh concrete; (ii) effect on compressive, flexural & splitting tensile strength using bottom ash in varying percentages as a partial replacement of fine aggregates.

Mixture no.	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5
Cement (Kg/m^3)	426.7	426.7	426.7	426.7	426.7
Bottom ash(%)	0%	20%	30%	40%	50%
Bottom ash (Kg/m^3)	**0.0**	**107**	**162**	**210**	**267.35**
Water (lts)	185	185	185	185	185
Sand Kg/m^3)	532.7	425.7	370.7	322.7	265.3
Coarse aggregate Kg/m^3)	1225	1225	1225	1225	1225
Air temperature(^{0}C)	34	32	33	35	34
Concrete density Kg/m^3)	2482	2469	2428	2413	2416

Table 4.4 Chart of mixture of cement, Bottom ash, water, sand and coarse aggregate in 5 batches

4.1.8 WORKABILITY

The workability measured in terms of compaction factor, decreases with increase of replacement level of fine aggregates with bottom ash. It could be due to extra fineness of bottom ash as replacement level of fine aggregates is increased. Thus, increase in specific surface due to increased fineness & a greater amount of water needed for mix ingredients to get closer packing, results in decrease in workability of mix.

Mix type	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5
C.F	0.91	0.88	0.84	0.83	0.81

Table 4.5 Workability in term of compaction factor

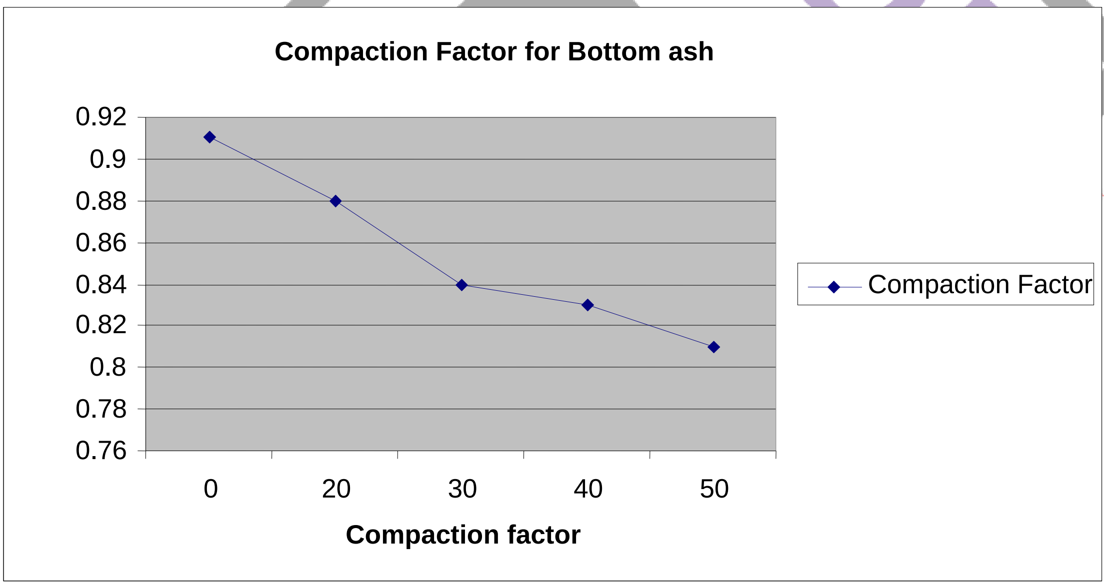

Fig 4.2 Compaction Factor in case of bottom ash

4.1.9 COMPRESSIVE STRENGTH

Compressive strength of concrete mixes made with & without bottom ash was determined at 7, 28, 56, 90 days. The test results are given in Table 6,7 & Figures 3,4. The gain of compressive strength by different types of bottom ash concrete with respect to their compressive strength at age of 90 days varies from 56-65% at 7 days 75-85% at 28 days & varies between 86-90% at 56 days. The bottom ash concrete gains strength at a slower rate in initial period & acquires strength at faster rate beyond 28 days, due to pozzolanic action of bottom ash. Also, at early age bottom ash reacts slowly with calcium hydroxide liberated during hydration of cement & does not contribute significantly to densification of concrete matrix at early ages.

Mix type	Compressive strength (f_c) N/mm^2			
	7 days	28 days	56 days	90 days
Batch 1	25.74	32.33	34.40	36.18
Batch 2	22.26	31.43	31.15	35.07
Batch 3	23.48	30.55	32.78	37.74

Batch 4	22.70	29.00	30.60	34.26
Batch 5	19.15	25.37	31.44	34.18

Table 4.6 Compression behaviour of bottom ash concrete with age

Mix type	$\text{Strength gain}=\dfrac{\text{Strength of Bottom Ash}}{\text{Strength of Plain Concrete}}\times 100$			
	7 days	28 days	56 days	90 days
Batch 2	59.8709	84.5347	83.7816	94.32491
Batch 3	63.15223	82.16783	88.16568	101.5062
Batch 4	61.05433	77.99892	82.30231	92.14632
Batch 5	51.50619	68.23561	84.56159	91.93115

Table 4.7 Compression behaviour of bottom ash v/s plain concrete

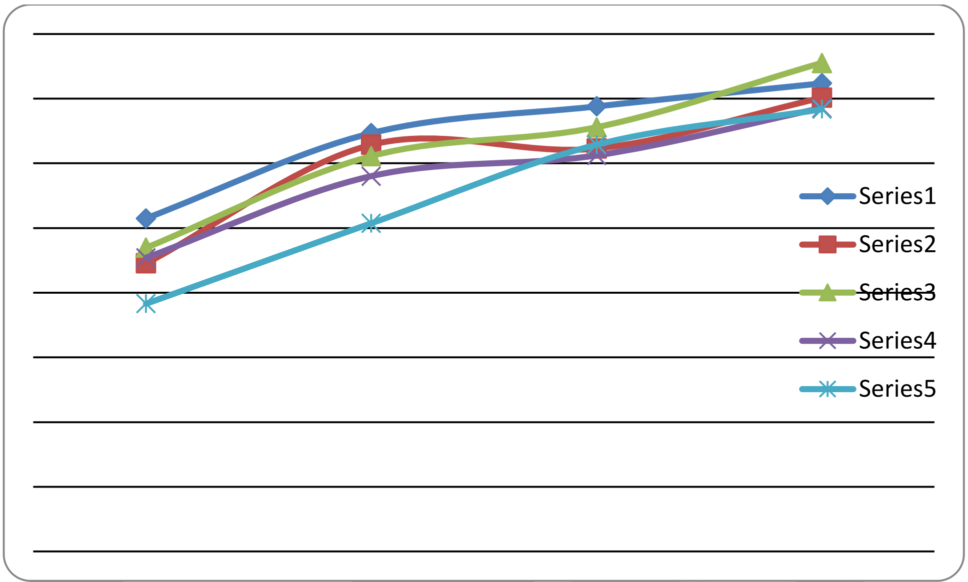

Fig 4.3 Chart for Compression behaviour of bottom ash concrete with age

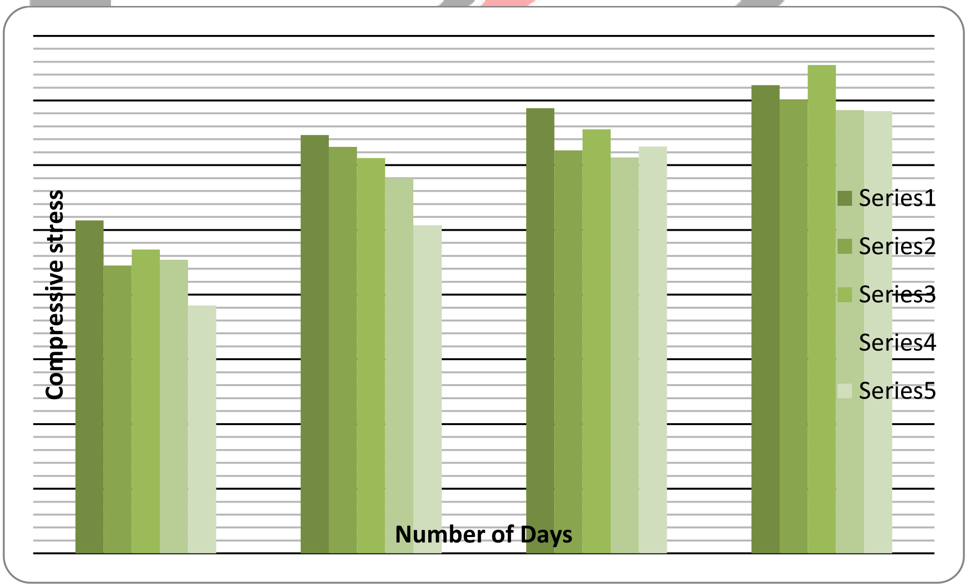

Fig 4.4 Compressive stress chart

4.1.10 FLEXURAL STRENGTH

The results of flexural strength test of bottom ash concrete are given in Table 8 & shown in Figures 5 & 6, respectively. Figure 5 shows flexural strength development with age, & Figure 6 shows variation of flexural strength for various percentages of bottom ash. It is found that 'Batch 4' mix type gives comparable flexural strength at age of 90 days which could be used for application of pavement. The flexural strength is affected to more extent with increase in bottom ash concrete. The bottom ash concrete gains flexural strength with age that is comparable but less than that of plain concrete. It is believed to be due to poor interlocking between aggregates, as bottom ash particles nature is are spherical.

Mix type	Flexural strength (f_t) N/mm^2			
	7 days	28 days	56 days	90 days
Batch 1	2.58	3.22	3.54	4.50
Batch 2	2.60	3.10	3.62	3.82
Batch 3	2.18	2.82	3.46	3.66
Batch 4	2.10	2.42	3.34	3.70
Batch 5	2.24	2.30	3.34	3.66

Table 4.8 Flexural behaviour of bottom ash concrete with age

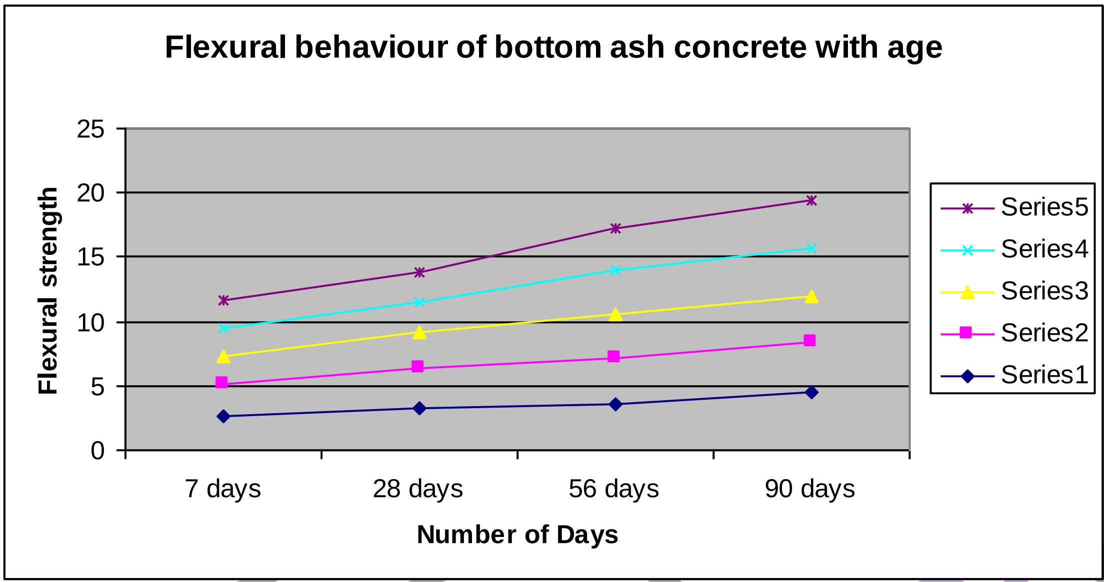

Fig 4.5 Flexural behaviour of bottom ash concrete with age

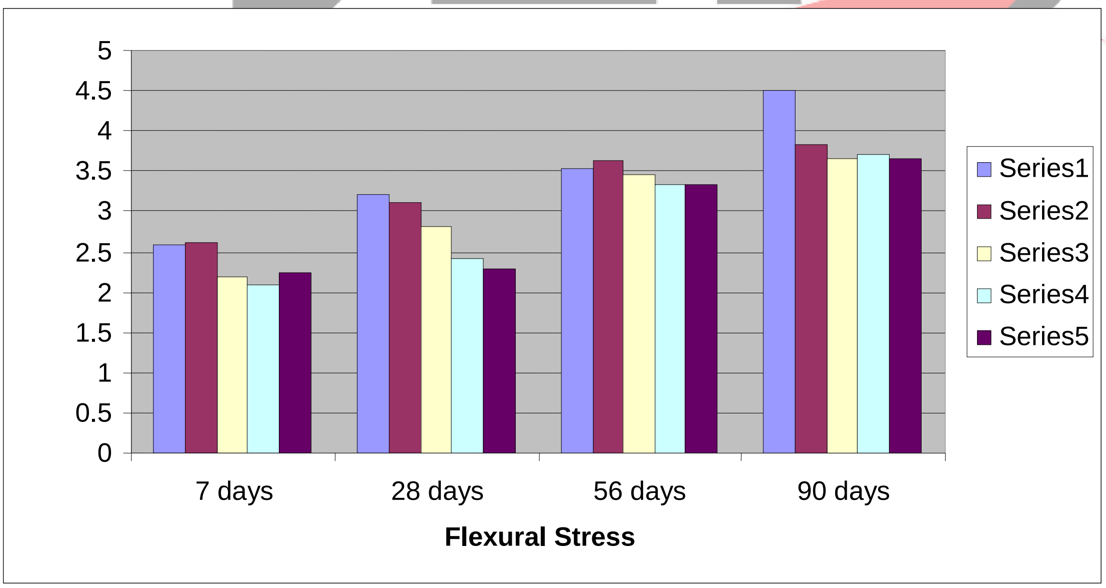

Fig 4.6 Chart for flexural stress

4.1.10 Slump Test

All mixes have a moderate workability level but at least this should be consistent. Average slump values are shown in Table 4.11. The slump was measured twice, once for each batch. Although IS (Standards India 1959) states that for high slumps exceeding 110 mm a tolerance of ± 30 mm is permitted., these high slumps value are too high for practical use in comparison with commercial concrete & is not acceptable in industry.

With such a high workability, special care was taken not to over tamping concrete by rod to avoid segregation of concrete. Figure 4.5 shows average, upper & lower slump values of mixes.

Table 4.9 Workability Experienced of Concrete Mixes

Replacement %	**0%**	**20%**	**30%**	**40%**	**50%**
Average slump	76	71	64	61	56

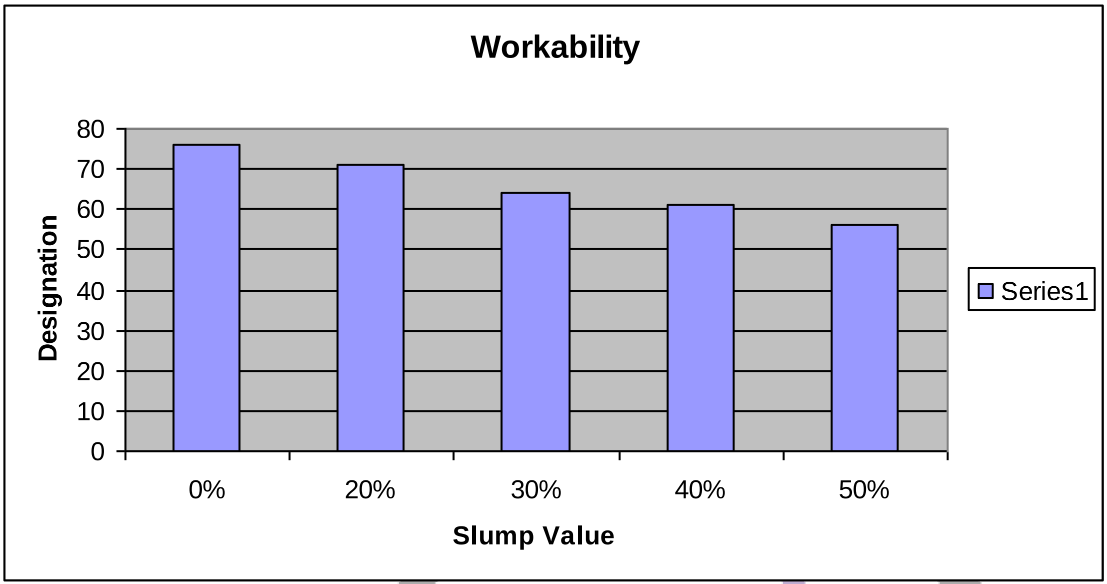

Figure 4.7 Workability of various mix

4.2 EXPERIMENT RELATED TO FLY ASH

Mixture no.	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5
Cement (Kg/m^3)	426.7	426.7	426.7	426.7	426.7
Fly ash(%)	0%	20%	30%	40%	50%
Fly ash (Kg/m^3)	**0.0**	**110**	**165**	**205**	**264.35**
Water (lts)	185	185	185	185	185
Sand Kg/m^3)	532.7	422.7	367.7	327.7	268.3
Coarse aggregate Kg/m^3)	1225	1225	1225	1225	1225
Air temperature(^{0}C)	34	32	33	35	34
Concrete density Kg/m^3)	2482	2469	2428	2413	2416

Table 4.10 Chart of mixture of cement, Fly ash, water, sand and coarse aggregate in 5 batches

RESULTS AND DISCUSSION

The different aspects studied include (i) effect of bottom ash on workability (Compaction Factor) of fresh concrete; (ii) effect on compressive, flexural & splitting tensile strength using bottom ash in varying percentages as a partial replacement of fine aggregates.

4.2.1 Workability

With increase of replacement level of fine aggregates with bottom ash the workability measured in terms of compaction factor decreases as given in Table 5

2. Replacement level of fine aggregates is increased due to extra fineness of bottom ash So increase in specific surface due to increased fineness & a greater amount of water needed for mix ingredients to get closer packing, results in decrease in workability of mix.

Mix type	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5
C.F	0.95	0.91	0.88	0.84	0.83

Table 4.11 Workability in term of compaction factor

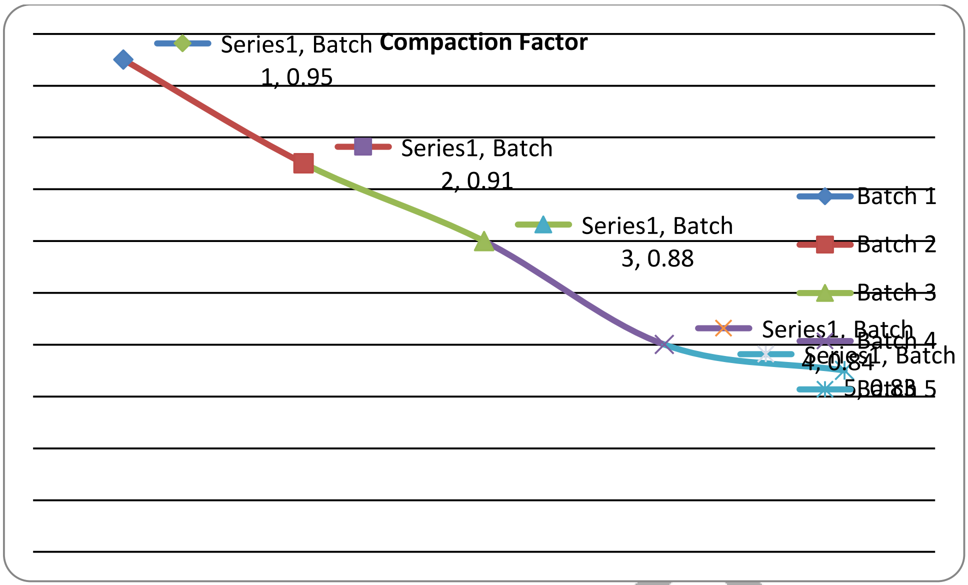

Fig 4.8 Compaction Factor in case of fly ash

4.2.2 Compressive Strength

Compressive strength of concrete mixes made with & without Fly ash was determined at 7, 28, 56, 90 days. The test results are given in following table & Figures. The gain of compressive strength of different types of fly ash concrete with respect to their compressive strength at time of 90 days varies from 56-65% at 7 days 75-85% at 28 days & varies between 86-90% at 56 days. At initial time fly ash concrete gains strength at a slower rate & the rate gets faster acquires strength beyond 28 days, due to pozzolanic action of Fly ash. Also, at early age fly ash reacts slowly with calcium hydroxide liberated during hydration of cement & does not contribute significantly to densification of concrete matrix in the beginning.

Mix type	Compressive strength (f_c) N/mm^2			
	7 days	28 days	56 days	90 days
Batch 1	26.98	33.33	36.34	37.18
Batch 2	24.37	32.43	34.15	35.65
Batch 3	24.30	31.55	33.78	38.47
Batch 4	23.60	30.00	31.60	35.62
Batch 5	20.15	26.37	30.44	35.24

Table 4.12 Compression behaviour of Fly ash concrete with age

Mix type	Strength gain= $\frac{\text{Strength of Fly Ash}}{\text{Strength of Plain Concrete}} \times 100$			
	7 days	28 days	56 days	90 days
Batch 2	65.54599	87.22431	91.85046	95.88488
Batch 3	65.35772	84.85745	90.8553	103.4696
Batch 4	63.47499	80.68854	84.99193	95.8042
Batch 5	54.1958	70.92523	81.87197	94.78214

Table 4.13 Compression behaviour of Fly ash v/s plain concrete

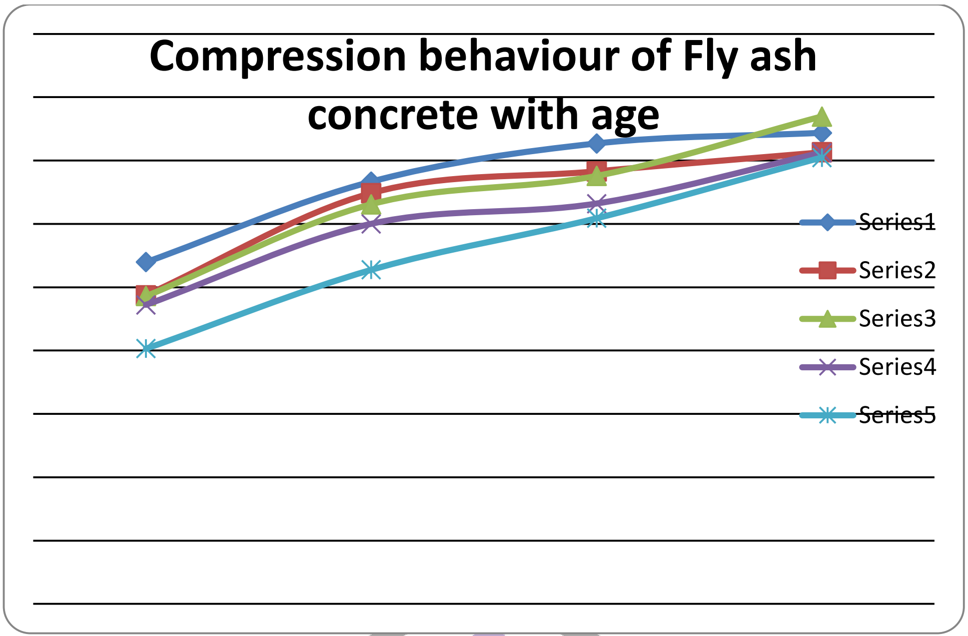

Fig 4.9 Chart for Compression behaviour of Fly ash concrete with age

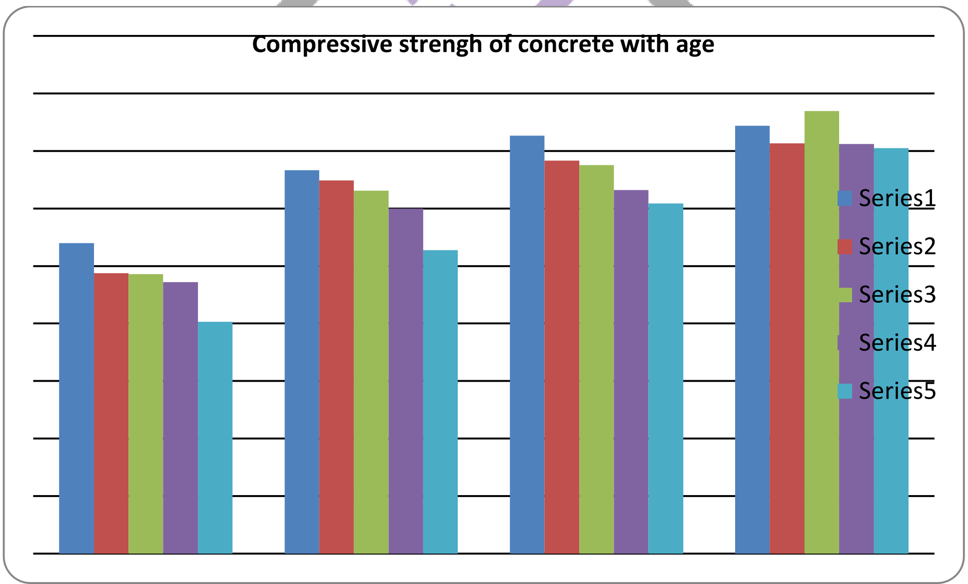

Fig 4.10 Compressive strength of concrete with age

4.2.3 Flexural Strength

The flexural strength test results of bottom ash concrete are given in following table & shown in following Figures. Following Figures shows flexural strength development with age, & variation of flexural strength for various percentages of bottom ash. It is observed that 'Batch 4' mix type gives comparable flexural strength at age of 90 days which can be used for pavement application .With the increase in bottom ash concrete, flexural strength is affected. The bottom ash concrete gains flexural strength but less than plain concrete with age which is comparable. It may be due to poor interlocking between aggregates, as Fly ash particles are spherical in nature.

Mix type	Flexural strength (f_t) N/mm^2			
	7 days	28 days	56 days	90 days
Batch 1	3.67	4.21	4.45	5.50
Batch 2	3.40	4.10	4.42	4.82
Batch 3	3.36	3.76	4.36	4.64
Batch 4	3.23	3.21	4.34	4.54
Batch 5	3.18	3.80	4.31	4.50

Table 4.14 Flexural behaviour of Fly ash concrete with age

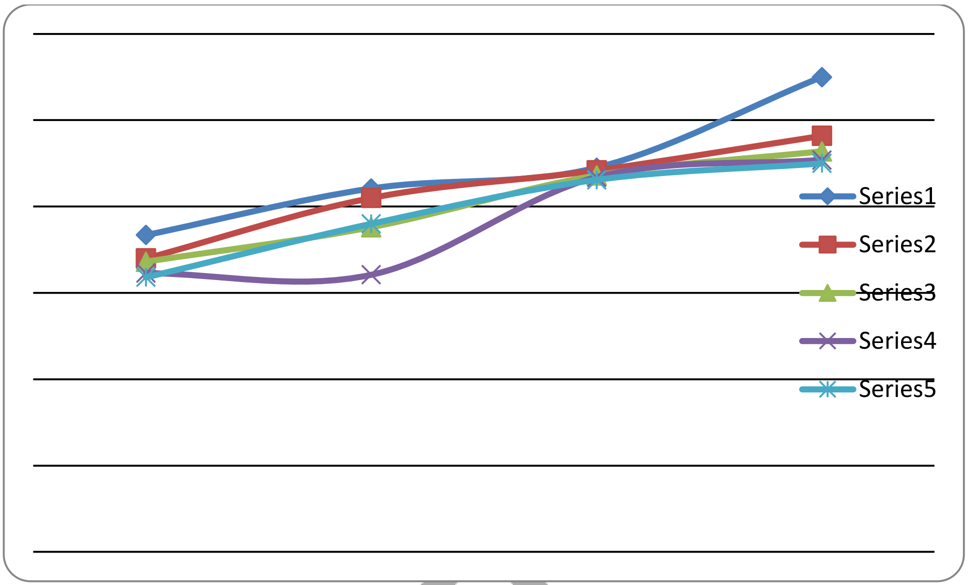

Fig 4.11 Age wise comparison of Flexural behaviour of Fly ash

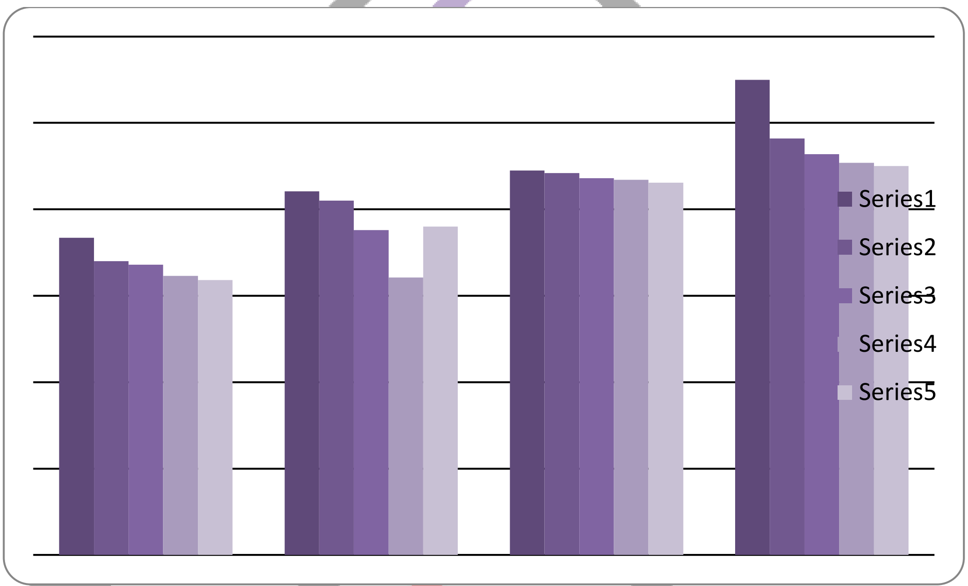

Fig 4.12 Chart of Flexural behaviour of Fly ash

4.2.4 Slump Test

A moderate workability level is persisting by all mixes but at least this was consistent throughout. Average slump values are shown in following. The slump is measured twice, once for each batch. Although IS (Standards India 1959) states that for high slumps exceeding 110 mm a tolerance of ± 30 mm is permitted. Value of these high slumps is little high for practical use in comparison with commercial concrete & would not be accepted in industry.

Special care was taken with such a high workability not to over tamping concrete by rod to avoid segregation of concrete. Following figure shows average, upper & lower slump values of mixes.

Table 4.15 Workability Experienced of Concrete Mixes

Replacement %	**0%**	**20%**	**30%**	**40%**	**50%**
Average slump	78	68	66	63	57

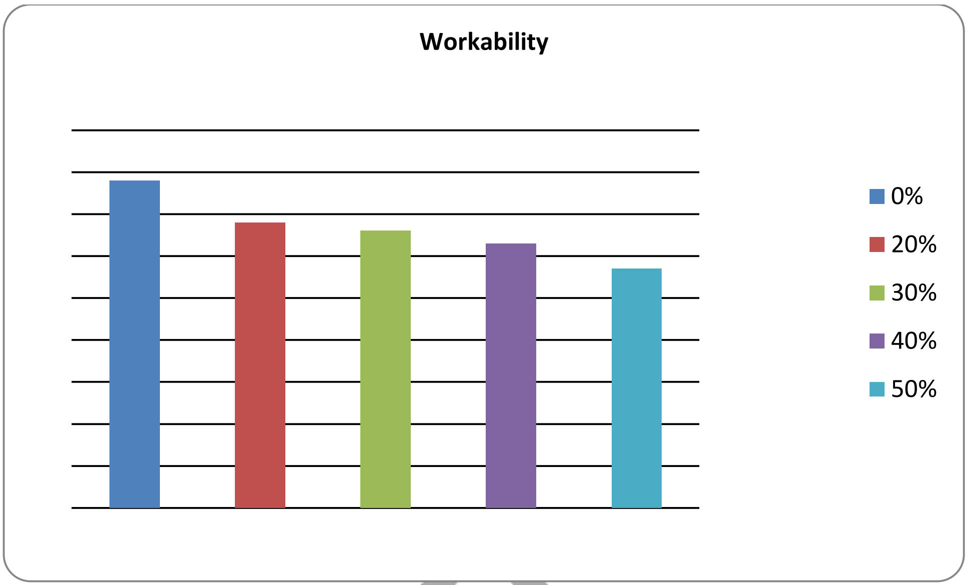

Fig 4.13 Workability of various mix

1. FUTURE SCOPE AND CONCLUSION

5.1 CONCLUSION

Research has focused on reduction of cost using fly ash and bottom ash in road pavement. Workability of concrete has been reduced with the increase in bottom ash content due to increase in water demand.

- Density of concrete has been reduced with the increased bottom ash content because of low gravity of bottom ash in comparison of fine aggregates.
- Compressive strength, Flexural strength and Splitting tensile strength of fine aggregates has been replaced with bottom ash concrete specimens were lower than control concrete specimens at all the ages.
- Strength difference between bottom ash concrete specimens and control concrete specimens turn to less distinct after 28 days.

In same way workability of sand has been reduced with the increase in fly ash content.

- The gain of compressive strength of different types of fly ash with respect to their compressive strength at time of 90 days varies from 56-65% at 7 days 75-85% at 28 days & varies between 86-90% at 56 days.
- Flexural strength test results of both bottom ash and fly ash are have been discussed in this research. Research shows flexural strength development with age, & variation of flexural strength for various percentages of bottom ash.

5.2 FUTURE SCOPE

The fly ash & bottom ash are performing significant role in road pavement. Such material is cost saving as well as compressive strength & durability is provided using such material. In construction of rural roads in low lying or flood prone areas, fly ash should have to be considered as normal choice in near future. This research would play a significant role in future Taxiways, Parking grounds for heavy weight vehicles, and Heavy Industrial floors such as military tanks.

Industrial floors which have high requirements in terms of flatness & durability & surface exposure to aggressive attacks could use this technology. Long tunnels road pavements may get benefit from this research.

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