

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 3, March 2018

A Review on Comparative Study on Properties of Concrete using Fly Ash

Ayush Bhandari¹, Gaurav Jaiswal², Achal Agrawal^{3*}, Rahul Vyas⁴

B.Tech Scholar, Department of Civil Engineering, MPSTME NMIMS, Shirpur, India^{1,2}

Assistant Professor, Department of Civil engineering, MPSTME NMIMS, Shirpur, India^{3,4}

*Corresponding Author

ABSTRACT: Fly Ash (FA) is a by-product obtained by the combustion of coal for energy production. Fly Ash is considered as a pollutant because it causes significant economic and environmental problems. Abundant Fly Ash produced in coal power stations is held in dumps which causes waste of land and the long term financial burden of maintenance. Worldwide research has been undertaken to reduce environmental impacts of fly ash, therefore it can help reduce environmental and economic impacts caused by Fly Ash. Cement is the key constituent of concrete, but it generates a significant amount of harmful gas (CO₂), but, as concrete has many advantages, it is mostly used construction material on the planet. Fly Ash can be used as an ingredient of the concrete in place of cement, as FA has pozzolonic properties. With different fineness of fly ash, the OPC cement is replaced by various percentages in different concrete mixture. This paper reviews on the effective use of FA in concrete and its effect on mechanical properties such as compressive strength, flexural strength and split tensile strength of it and to make it economical and reduce environmental effects.

KEYWORDS: Fly Ash (FA), Compressive Strength, Flexural Strength, Split Tensile Strength, Fineness

I. INTRODUCTION

Concrete is a material which is mostly used in the world for the construction purpose due to its properties and availability over other materials [5]. Cement is the main ingredient of concrete, which emits carbon dioxide, and because of this, it has some ill effects on the environment. Efforts have to be put on replacing cement and one of the ways is to replace it partially by the FA, as it consists of aluminous and silicious substance which forms a similar paste as cement, when come in contact with lime and water. FA can be used as a partial replacement of cement as well as of fine aggregates to make concrete more economical, eco-friendly and reliable. FA can be used in varying percentages as a replacement of cement [27] or fine aggregate as per requirement of properties of resulting substrate [25], and it has to be checked and verified by the engineer and consulting an officer. An important application of fly ash is in pavements as it proves to be economical beneficial. Fly ash affect the properties of concrete by its pozzolanic characteristics. Fly is generally divided into two classes Class F and Class C [12]. The difference between these 2 classes are quantities of calcium, silica, alumina and iron content. Researchers have replaced Fly Ash up to 30% wt. of the cement to obtain good results. It also increases the workability of concrete as because of the spherical shape of the particle. To use more amount of fly ash new technologies are being developed so that the use of cement could be lowered and a good example of such technique is in Maharashtra at Ghatghar Dam in which up to 70% of fly ash is been used [2].

II. LITERATURE REVIEW

Ujjwal et al. [10] studied for potential use of Fly Ash in India. Out of the total energy generation in India 65% energy is contributed by coal thermal power plants. The Ash content produced in Indian Coal power plants tends to a higher content (25% - 45%). A huge amount of Fly Ash is generated across India causing disposal related problems, the level of fly ash utilization in the country was estimated to be less than 10% prior to 1996–97. World Wide less

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 3, March 2018

than 25% fly ash of yearly produced fly ash is used. In foreign countries such as Germany, Netherlands etc. more than 95% fly ash is used.

C.D. Atis et al. [14] used FA to build roller compacted concrete (RCC). RCC was produced with different cement quantity and Normal Portland Cement (NPC), FA were replaced with cement in different percentages (0%, 15%, 30%, and 45%), Compressive, flexural, splitting tensile tests were carried out, test result showed that the replacement by 15% - 30% of NPC attained comparable of higher strength form 0% replacement. He concluded that replacement of Fly Ash at 15% - 30% with NPC we can make large floor or road paving with higher strength, more economically, and reducing waste material.

Arun B. et al. [18] studied on Mercury (Hg) flow via coal and coal utilization. Export of coal from a country to another causes relocation of Hg, which was present in coal, during the transportation of coal carried through river, seas, Hg releases from coal which causes environmental and health problems. Technological collaboration should be taken to reduce the release of Hg from coal, Policy makers should allocate fund for renewable energy technology to reduce the effects of Hg.

M. Ahmaruzzaman et al. [21] studied on the utilization of fly ash in concrete, as an adsorbent for removal of organic compounds, flue gas, road sub base. By converting fly Ash into zeolites will not only reduce the problem of waste disposal but converts a waste material into a marketable commodity. To maximize the utilization of Fly Ash new technologies should be used. The improve adsorption capacities of chemicals Fly Ash can be used, Unburned Carbon in Fly Ash plays an important role for adsorption. For long term economic and environmental benefit Fly Ash generated products should be used.

Pitroda et al. [22] has studied on the use of fly ash to replace cement in the concrete mixtures. The replacement of the cement was done by 0% to 40% by the weight of cement in M25 and M40 mix.

Semsi Yazici et al. [23] experimented on CEM I 42.5 R type cement and type C Fly Ash which is collected from Soma thermal power plant. Blaine fineness of Fly Ash was 2351 cm²/g. The mixture of aggregate consists of 45% fines, 55% coarse by weight. He studied on the mechanical properties of the concrete such as slump test, compressive and splitting tension test in concrete. It was observed that the highest degree of fineness has highest compressive strength. He also found that as fly ash ratio increases as the compressive strength decreases. At 5% replacement rates of fly ash the value of splitting tensile strength and compressive strength was observed decreasing.

Blissett et al. [24] studied about the application of coal fly ash in various field such as in manufacturing of glass, zeolite production, as an improving agent in soil. He concluded that there is most important use of fly ash as a raw material and in refined state. He suggest that by refining the coal fly ash will create and enhance the new industrial interaction with fly ash.

Yamei Zhang et al. [4] used a calcium Fly Ash with High SO₃ content to prepare high performance concrete, he used 50% and 60% Fly Ash in all mixes. Cement paste showed a certain instability and poor pore structure but the 3days and 28days compressive strength of mortars was found to be 25.2 Mpa to 42.2 Mpa, 90d strength of mortar was 67.3 to 85.5 Mpa. His study shows that fly ash which contains high SO₃ showed instability, but a good compressive strength and flexural strength.

Prinya et al. [17] investigated on class F Fly Ash of two different fineness, taken from Mae Moh Power plant in north of Thailand and replaced the Portland cement at 0%, 20%, and 40% by weight. It was observed that the compressive strength of classified fly ash (CFA) is higher than original fly ash (OFA) cement paste. It was also found replacement of OPC (ordinary Portland cement) with OFA increases the porosity and decreases the average pore size of the paste. In order to achieve higher strength it is therefore necessary to reduce porosity of cement paste. The blain

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 3, March 2018

fineness of OFA and CFA was taken as 300 and 510 m²/kg, and the specific gravities of these two were 2.33, 2.54 respectively. It was found that compressive strength decreases as the total porosity of blended cement paste increases.

Halit Yazici et al. [19] studied on the Reactive Powder Concrete (RPC) which is an ultra-high strength material, his paper aims to reduce the use of Silica Fumes (SF) of RPC with use of Fly Ash and ground granulated blast furnace slag (GGBFS). The results shows that the RPC containing high volume of (SF-FA, SF-GGBFS, and SF-FA-GGBFS) have a good strengths, the replacement of SF by FA and GGBFS is very effective, the compressive strength of RPC containing FA and GGBFS was found up to 281-324 Mpa.

Berndt et al. [20] studied properties of concrete which were made by using partial replacement of fly ash, slag and recycled concrete aggregate. He made different mix by the use of fly ash and blast furnace slag. The results indicates that the concrete having 50% replacement as blast furnace slag provided improvement in mechanical properties and durability.

Achal Agrawal et al. [25] studies on properties of concrete by partial replacing various constituents such as fly ash, glass powder etc. He replaced cement by FA and Glass powder (GP) in varying proportions from 0% to 25% and formed cubes and beams of standard size specified in Indian Standards. He computed compressive and flexural strength of concrete for all the mixes. Thereafter he carried the optimum proportion for the next stage of work and replaced Natural Coarse Aggregates (NCA) by Recycled Concrete Aggregates (RCA) from 0% to 40% and computed the same. He found, when cement is partially replaced with 0% GP and 25% FA & NCA is replaced with RCA, maximum strengths of concrete is obtained. On further replacing NCA by RCA, strength is significantly decreased.

Papadakis et al. [6] used a fly ash having low content of calcium as a replacement of aggregate and cement. He concluded that the strengths (compressive and tensile) was found higher when these fly ash was replacement with aggregate than cement. He also said that the water bound ratio was found to be higher in aggregate replacement and total porosity of the specimen was decreased.

Guijian et al. [13] studied on petrological and mineralogical characteristics and chemical composition of fly ash from power plant in Yanzhou China. He concentrated on trace elements such as Zn, Th, As etc. in coal fly ash. The motto of this paper was to provide a scientific utilization and reduction of environmental pollution in future he concluded that the ash is remain obtained from inorganic and organic matter during combustion of coal. He concluded that the combustion and incarceration of coal is dependent on type of coal. The major composition of fly ash is: Al₂O₃ and SiO₂, few amounts of Fe₂O₃ and SO₃, P₂O₅, Na₂O, CaO, K₂O, and TiO₂.

Rafat Siddique et al. [12] studied on mechanical properties of concrete by replacing sand with class F fly ash and found that the sand replacement by 50% gives good compressive, splitting tensile and flexural strength which was 40, 3.5 and 4.3 Mpa respectively, higher than normal plain concrete. He concluded that class F fly ash can be easily used in structural concrete.

John P. et al. [9] studied on the absorption of air allowing admixtures in cement. Air –entraining admixture used in Class F Fly Ash samples. Class F fly ash was found to have low capacity for adsorption as compared to Portland cement. His study shows that how air-entraining admixture affects the concrete if the concrete contains significant levels of unburnt carbon, his study shows that adsorption by unburnt carbon requires longer time. Poor adsorption by unburnt carbon in Fly Ash can lead to less air entrainment.

Dan Ravina et al. [1] has studied the effect on workability, water requirement, setting times of fly ash (high amount) containing concrete and found that workability of fly ash concrete was better than the non-fly ash concrete at any content ratio of fly ash. The water requirement was also reduced in fly ash concrete by 5% to 10% but the setting time was increased or delayed in fly ash concrete.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 3, March 2018

M.N. Haque et al. [5] used fly ash of low fineness in high strength concrete. 10% replacement of cement will reduce water content and early strength can easily be gain than non-fly ash concrete which was 20% more than non-fly ash concrete. He also concluded that at 15% replacement there was reduction in workability. The water penetration characteristic was also been reduced to 28% than the plain concretes.

Poon et al. [7] performed laboratory experiment to develop high strength concrete with using large volumes of low calcium fly ash (Class F). Paper study includes compressive strength, heat of hydration, and degree of hydration and pore structure of fly ash. The results were obtained that the compressive strength after 28 days of around 80MPa could be obtained by water to binder ratio of 0.24 with 45% fly ash. Such a concrete has low heat of hydration. He also concluded that the concrete prepared with low water binder ratios give the strength contribution from fly ash better than in concrete prepared with high water binder ratio.

Vinod Goud et al. [26] had replaced cement with fly ash and studied the effect on concrete. He concluded that workability of concrete decreases as the increment in fly ash is done. About 10% to 20% replacement of fly ash provides the good characteristic strength but at 30% replacement the ultimate strength gets reduced.

Tarun R Naik et al. [2] examined the abrasion resistance on high volume concrete and concluded that at 50% and 70% cement replacement by fly ash the compressive strength were lower than the normal concrete containing no fly ash though at 50% replacement gives enough strength for structural applications. He also concluded that the abrasion resistance in concrete containing no fly ash is relatively higher than the fly ash concrete containing high amount of fly ash.

J. Pay~I et al. [3] studied the effect of different fly ash sized fraction on compressive and flexural strength of cement paste he has done so by replacing 15-60% of Portland cement. He has experimented only on the cement paste. He also studied the influence of curing temperature on the paste. His study reveals this the size of the finest particle less than 10 μm is a basic parameter for yielding a good compressive strength. He concluded that the partial substitution of fly ash requires lesser water requirement.

Kraiwood et al. [8] studied the various properties of coarse fly ash which were collected from five different sources in Thailand. He found that using fly ash as replacement to cement in concrete led to slow development of early compressive strength to overcome this disadvantage he used fine fly ash. The compressive strength was found higher in grinded fly ash than in coarse fly ash. The strength in finer fly ash concrete is met earlier than the coarse one.

Chai et al. [15] studied on improving the method of coarse fly ash in order to replace condense silica fumes to improve concretes quality. The coarse fly ash was grinded till the average particle size was 3.8 μm . He has done so by replacing coarse fly ash between 15%-50% to produce higher strength concrete and he concluded that at 25% cement replacement of cement provides highest compressive strength.

Atis et al. [11] studied on heat evolution of high volume fly ash concrete. It was found that heat characteristic is highly dependent on fly ash replacement. The temperature was found to be reduced much more when cement is replaced by fly ash, superplasticizer was also used to delay the peak time of concrete. He concluded that temperature is inversely dependent on fly ash replacement. As fly ash content increases temperature gets reduced. Such concrete can be used in dams construction, large foundation etc.

Rafat Siddique et al. [16] experimented on characteristics of high volume class F fly ash and found that up to 50% of cement replacement can be done in fly ash concrete. He also concluded that the compressive, tensile strength and abrasion resistance of concrete get decreased at the age of 28 days and significant increment was found at the age of 91 and 365 days due to pozzolanic reaction of fly ash.

R.D. Padhye et al. [27] replaced cement by fly ash up to 40% and found that there was steep increment as the fly ash content increases but the early strength characteristic of concrete get reduced as soon as the content of fly ash

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 3, March 2018

increases. The optimum level of fly ash was found to be 40% and above this level the strength was found to be reduced. Hence, adverse effect of fly ash was seen in early strength character of concrete.

III.CONCLUSION

This Paper has provided an overview that there is a large scale potential and application of Fly Ash which can benefit society economy and environment. In India a yearly production of Fly Ash is more than 184 million as per 2012 which will cross 600 million in 2031-32 and only 30-32% is utilized.

Studies show that the concrete mix with partial replacement of cement with FA having a low water binder ratio results in better compressive strength than the mix without Fly Ash.

Replacement of cement with blast furnace slag reduces the consumption of cement up-to 50% and gave the enhanced results in term of mechanical properties and durability. Furthermore, replacement of fine aggregate with Fly Ash gave enhanced results rather than replacing the cement with FA.

It was found in the studies the use of Fly Ash make the concrete, lightweight, the main drawback of fly ash was found that the high content of fly ash will reduce the mechanical properties of the concrete.

REFERENCES

- [1] Ravina, D., and Mehta, P. K. "Properties of fresh concrete containing large amounts of fly ash." *Cement and Concrete Research*, 16(2), (1986): 227-238.
- [2] Naik, T. R., Singh, S. S., and Hossain, M. M. "Abrasion resistance of concrete as influenced by inclusion of fly ash." *Cement and Concrete Research*, 24(2), (1994): 303-312.
- [3] Paya, J. "Early-strength development of Portland cement mortars containing air classified fly ashes." *Cement and concrete research*, 25.2, (1995): 449-456.
- [4] Yamei, Zhang, Sun Wei, and Shang Lianfei, "Mechanical properties of high performance concrete made with high calcium high sulfate fly ash." *Cement and Concrete Research*, 27.7, (1997): 1093-1098.
- [5] Haque, M. N., and Kayali, O. "Properties of high-strength concrete using a fine fly ash." *Cement and Concrete Research*, 28(10), (1998): 1445-1452.
- [6] Papadakis, V. G. "Effect of fly ash on Portland cement systems: Part I. Low-calcium fly ash." *Cement and Concrete Research*, 29(11), (1999): 1727-1736.
- [7] Poon, C. S., L. Lam, and Y. L. Wong. "A study on high strength concrete prepared with large volumes of low calcium fly ash." *Cement and Concrete Research*, 30.3 (2000): 447-455.
- [8] Kiattikomol, Kraiwood, "A study of ground coarse fly ashes with different finenesses from various sources as pozzolanic materials." *Cement and Concrete Composites*, 23.4, (2001): 335-343.
- [9] Baltrus, John P., and Robert B. LaCount, "Measurement of adsorption of air-entraining admixture on fly ash in concrete and cement." *Cement and Concrete Research*, 31.5, (2001): 819-824.
- [10] Bhattacharjee, Ujjwal, and Tara Chandra Kandpal, "Potential of fly ash utilisation in India." *Energy*, 27.2, (2002): 151-166.
- [11] Atiş, C. D. "Heat evolution of high-volume fly ash concrete." *Cement and Concrete Research*, 32(5), (2002): 751-756.
- [12] Siddique, R. "Effect of fine aggregate replacement with Class F fly ash on the mechanical properties of concrete." *Cement and Concrete research*, 33(4), (2003): 539-547.
- [13] Liu, Guijian, "Petrological and mineralogical characterizations and chemical composition of coal ashes from power plants in Yanzhou mining district, China." *Fuel processing technology*, 85.15, (2004): 1635-1646.
- [14] Atiş, C. D., "Strength properties of roller compacted concrete containing a non-standard high calcium fly ash." *Materials Letters* 58.9 (2004): 1446-1450.
- [15] Jaturapitakkul, Chai, "Use of ground coarse fly ash as a replacement of condensed silica fume in producing high-strength concrete." *Cement and Concrete Research*, 34.4, (2004): 549-555.
- [16] Siddique, R. "Performance characteristics of high-volume Class F fly ash concrete." *Cement and Concrete Research*, 34(3), (2004): 487-493.
- [17] Chindaprasirt, Prinya, Chai Jaturapitakkul, and Theerawat Sinsiri, "Effect of fly ash fineness on compressive strength and pore size of blended cement paste." *Cement and Concrete Composites*, 27.4, (2005): 425-428.
- [18] Mukherjee, Arun B., "Mercury flow via coal and coal utilization by-products: a global perspective." *Resources, Conservation and Recycling*, 52.4, (2008): 571-591.
- [19] Yazıcı, Halit, "Utilization of fly ash and ground granulated blast furnace slag as an alternative silica source in reactive powder concrete." *Fuel*, 87.12, (2008): 2401-2407.
- [20] Berndt, M. L. "Properties of sustainable concrete containing fly ash, slag and recycled concrete aggregate." *Construction and building materials*, 23.7, (2009): 2606-2613.
- [21] Ahmaruzzaman, M. "A review on the utilization of fly ash." *Progress in energy and combustion science*, 36.3, (2010): 327-363.
- [22] Pitroda, Jayeshkumar, L. B. Zala, and F. S. Umrigar, "Experimental Investigations on Partial Replacement of Cement with Fly ash in design mix concrete." *International Journal of Advanced Engineering Technology, IJAET* 3.4, (2012): 126-129.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 3, March 2018

- [23] Yazici, Şemsi, and Hasan Şahan Arel, "Effects of fly ash fineness on the mechanical properties of concrete." *Sadhana*, 37.3, (2012): 389-403.
- [24] Blissett, R. S., and N. A. Rowson, "A review of the multi-component utilisation of coal fly ash." *Fuel*, 97, (2012): 1-23.
- [25] Achal Agrawal, Lovish Pamecha, "Assessment of properties of concrete with partial replacement of various constituents." *International Journal of Latest Trends in Engineering and technology*, Vol.7, Issue 1(2016): 444-451.
- [26] VinodGoud, NirajSoni, "Partial Replacement of Cement with Fly Ash in Concrete and Its Effect" *IOSR Journal of Engineering*, Vol. 06, (2016): 69-75.
- [27] Padhye, R. D., and Deo, N. S. "Cement Replacement by Fly Ash in Concrete." *International Journal of Engineering Research*, 5, (2016): 60-62.
- [28] Toniolo, Nicoletta, and Aldo R. Boccaccini. "Fly ash-based geopolymers containing added silicate waste. A review." *Ceramics International* (2017).
- [29] Gołaszewska, Małgorzata, and Tomasz Ponikiewski. "Influence of low pressure steam curing on development of strength of mortars based on cement with high-calcium fly ash." *Procedia engineering* 192 (2017): 249-254.
- [30] Nadesan, Manu S., and P. Dinakar. "Mix design and Properties of fly ash waste light weight aggregates in structural light weight concrete." *Case Studies in Construction Materials* (2017).
- [31] Cerny, Vit, Magdalena Kocianova, and RostislavDrochytka. "Possibilities of lightweight high strength concrete production from sintered fly ash aggregate." *Procedia Engineering* 195 (2017): 9-16.
- [32] Chen, J. J., et al. "Production of high-performance concrete by addition of fly ash microsphere and condensed silica fume." *Procedia Engineering* 172 (2017): 165-171.
- [33] Horszczaruk, Elżbieta, and PiotrBrzozowski. "Properties of Underwater Concretes Containing Large Amount of Fly Ashes." *Procedia Engineering* 196 (2017): 97-104.