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Fly Ash Effects on Fresh Concrete

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Abstract*: Worldwide CO_2 emission has been done by various agencies and reported their roots. The one most emerging and well known contributor of CO_2 emission is the cement manufacturing. Now a days, cement manufacturing work out in practice are 1.7 x 10^9 t/year and it creates 7-8% worldwide greenhouse gas emission. Where the infrastructural growth depends on concrete production and concrete making process needs the binder material as a cement. Cement production has produces 900kg of CO_2 per thousand kilogram of cement consumption and it's definitely doubled in 2050, if other binder material inventions not happened. Therefore as considering a crucial role of binder material, fly ash material can play same or partial role as alternative material to cement. This study mainly introduces fresh fly ash concrete behavior for sustainable adoptability. Fly ash concrete more feasible (cheaper), scale down permeability, boost strength and influence other concrete properties. This paper is useful for assessing workability issues by providing 54 test results of slump cone and compaction factor test.

***Keywords*: CO_2 emisiion, cement, binder material, fly ash, workability.**

I. INTRODUCTION

Cementing materials is promising material to provide pozzalanic properties and it is not produces any CO_2 emissions into the environment. From the news got by Times of India, in edition of Aug 30, 2016 on climatic change directly said that plant will become less thirsty as carbon dioxide in the atmosphere rises. Also reported that the earth can sustain life for 1.8 billion years and after that impossible to live on blue planet. The similar data published by NASA, the 2015 is the warmest year on the record. Figure 1 shows last 140 years global land ocean temperature index and for the year 2020 is between 0.850 – 0.950. Carbon dioxide in the atmosphere rises day to days and the effect of rising temperature seen in the figure 2 to 4. The Time series global surface temperatures [1] of year 1919, 1969 and 2019 respectively shown in figure 2 to 4. The figure 2 indicated blue color of cool nature of temperature, where reddish dark color of fig 4 observed warmer effect on planet. In the last 100 years the surface temperature tremendously increases and the reason behind that is the increasing CO_2 emission in the various types of greenhouse gas emission. It's an evidence of global warming and climate change due to human development with respect to population, mechanical activities, modernization, infrastructural demand, construction material utility, social awareness, energy consumption etc.

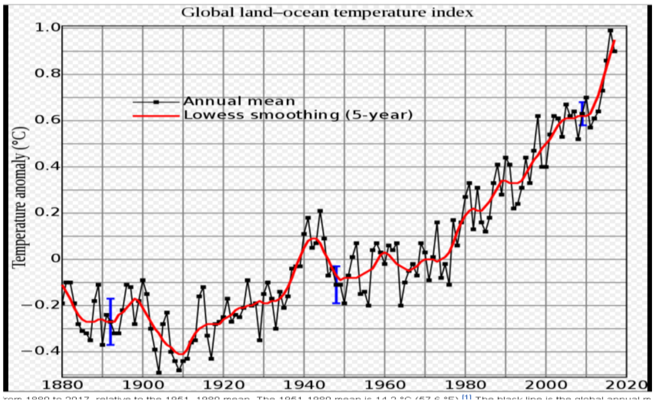

Fig. 1 Global land- ocean temperature Index, 1980-2020

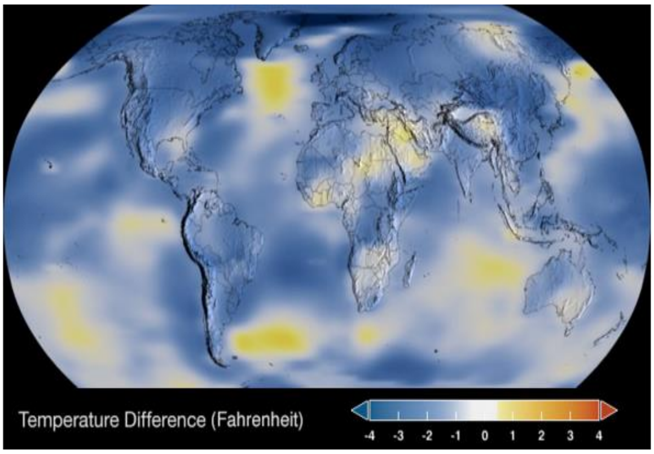

Fig.2 Global Earth Surface Temperature, Year 1919

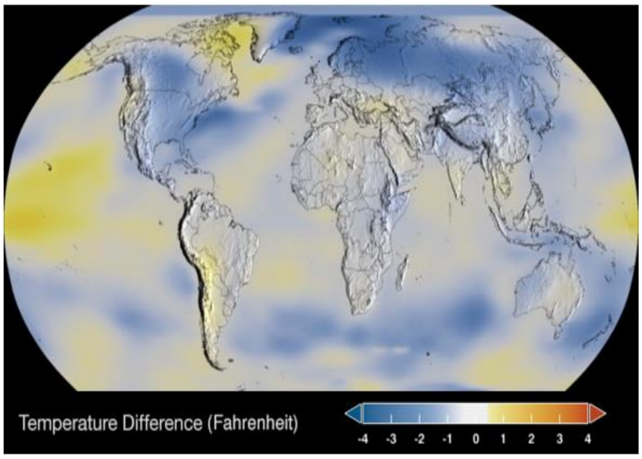

Fig.3 Global Earth Surface Temperature, Year 1969

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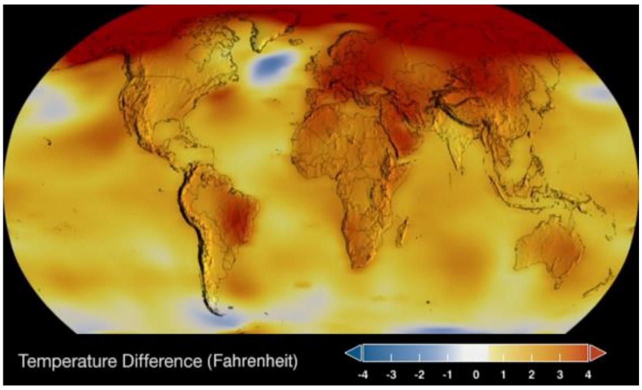

Fig.4 Global Earth Surface Temperature, Year 2019

The demand of materials has increases in similar manner as world populations increases. The unavoidable population growth consumes concrete resources for construct their living houses. The construction of living things is proportionally occupy the volume of concrete. Concrete is versatile and largest used material in the field of construction [2]. Cement is chiefly and unethically used in construction activities, which emits the CO_2 into atmosphere [3]. Following figure 5 indicates the faster production scenario of cement at global level.

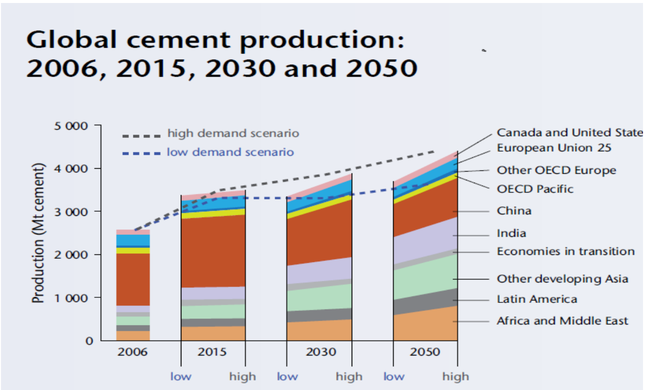

Fig. 5 Global cement production:2006, 2015, 2030 and 2050[4]

The fig. 5 consist the marking of estimated cement production over the year 2006 to 2050. The Asian, Africa and Middle East countries cement projection drawn. The cement production is projected to propagate by 0.8/ Year to 1.2% / year, reaching between 3,700 MT and 4,400 MT in 2050.

Approximately, 43% to 72% cement production growth rate will happened in 2050 as compared to 2006. In recent years, only single country china consumes more than half share of total cement production, It's expect to peak on 2030. After 2030 global cement production will be suffers by strong demand due to developing nature countries like India, Asian countries, Africa, Middle East etc. Nearly, 7% (1.35 billion tons/ annum) greenhouse gas emission is caused due to cement production [5].

In the fig. 6, Worldwide CO2 emission per Capita for various countries are mention and fig. 7, illustrates rate of CO_2 emission per Capita- Log. North America has been 8-10 times greater rate of CO_2 emission per Capita than Asian countries but apart from it, all countries per capita CO_2 emission growth are upwards. Developing countries has possesses high CO_2 exertion due to unavoidable modernization but rate of it reduces if supplementary material replace by traditional material.

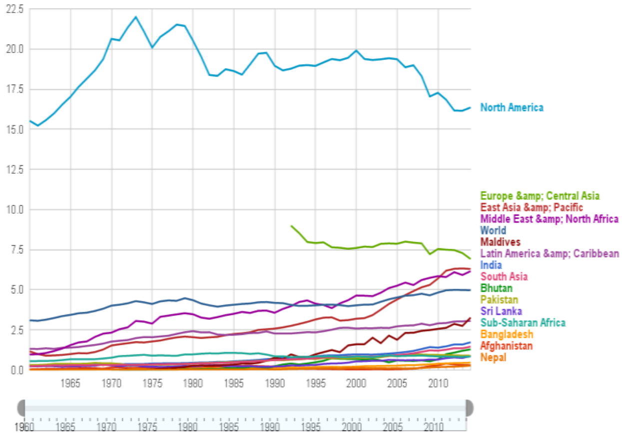

Fig. 6 Worldwide CO_2 emission per Capita

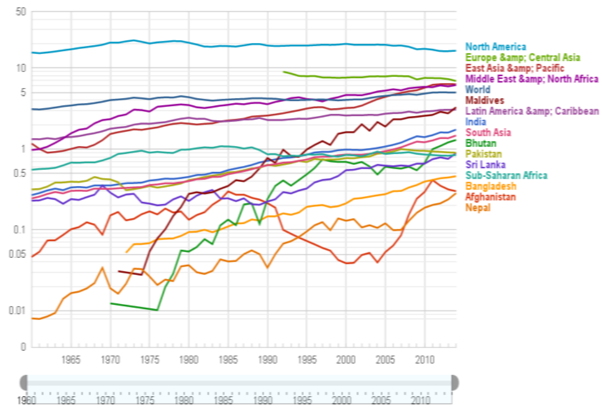

Fig. 7 Worldwide CO_2 emission per Capita- Log

The alternative material can easily introduce into concrete elements due to heterogeneous behavior. Now a days, Concrete volume is four fold more than 1990's concrete used demand, therefore incorporation of supplementary constituents occupied in large volume. The concrete volume is also chief source of carbon dioxide emission, 5% of worldwide man made emission. Concrete has great potential to reduce bad effect on environment by capturing industrial by-products as supplementary ingredients. Concrete is mix formation of fine (FA) aggregates, coarse (CA) aggregate and binding materials. If other materials seen into concrete then it should be needed similar properties of materials i.e. cement, sand and aggregates. Existing researchers introducing few substituents to all these material at few to potential amount. Fly ash is one of the promising alternative material to cement for partial replacement. That possess the characteristics of hardened concrete by fulfil the pozzolanic reaction [6] and it can be replaced to cement or binder[7]. It is economical by product of industrial material used to scale down permeability of concrete as well as for improve the strength of concrete[8]. Workability of fresh concrete is the initial phase to check feasibility of material, therefore fly ash incorporation and workability tests are taken into consideration.

II. EXPERIMENTAL EVALUATION

In order to discover the effect of fly ash immersion on concrete materials, primarily strength and workability, a wide range of water cemented material ratios and cemented material contents have been studied extensively. Binder content 300kg/m3 (B1), 375kg/m3 (B2), 450kg/m3 (B3) and various water-cm combinations like W1(0.5), W2(0.55), W3(0.6), W4(0.45), W5(0.4) are considered for experimental testing. The Fly ash replacement were taken as 0% (F00), 10% (F10), 20% (F20), 30% (F30), 40% (F40), and 50% (F50).

In order to find a good assessment of consistency experimental work, both slump and compacting factor (CF) tests were executed as per IS: 1199:1959[9]. Slump Cone apparatus conforming to IS 7320:1974[10] was used for slump testing and for the compacting factor test purpose, Compacting Factor Apparatus was used.

Slump checking is the most commonly employed method of measuring fresh concrete consistency that can be used either in the laboratory or at the workplace. The slump values were measured in mm and its category was also noted by visual observations. The C. F. values have been calculated according to the following formula. The fresh concrete density was also recorded for all experimental mixes.

$$\text{C. F.} = \frac{\text{Weightofpartiallycompactedconcrete}}{\text{Weight of fully compacted concrete}}$$

The graphical representation drawn into Fig. 1 to Fig, 7 as below

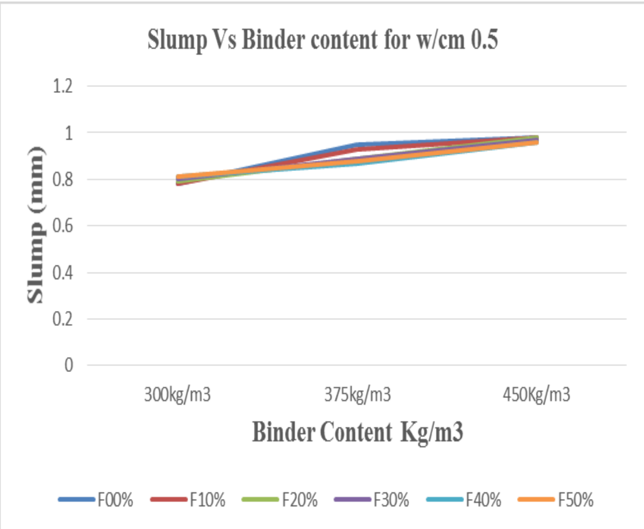

Fig. 1. C.F. Vs Binder content for w/cm=0.5

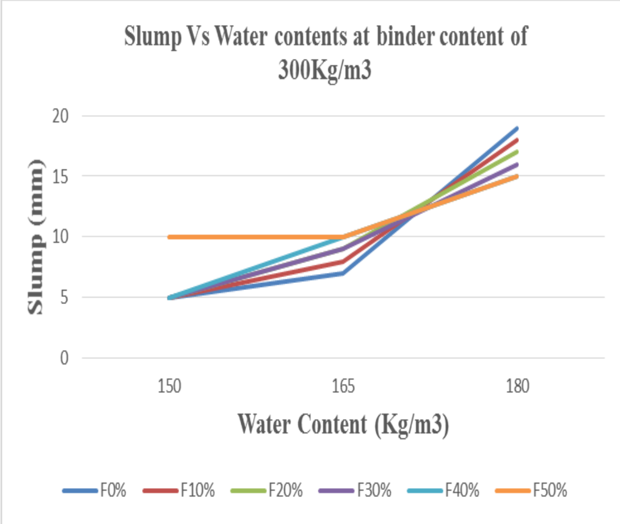

Fig. 2. Slump and Water contents at binder content of 300Kg/m^3

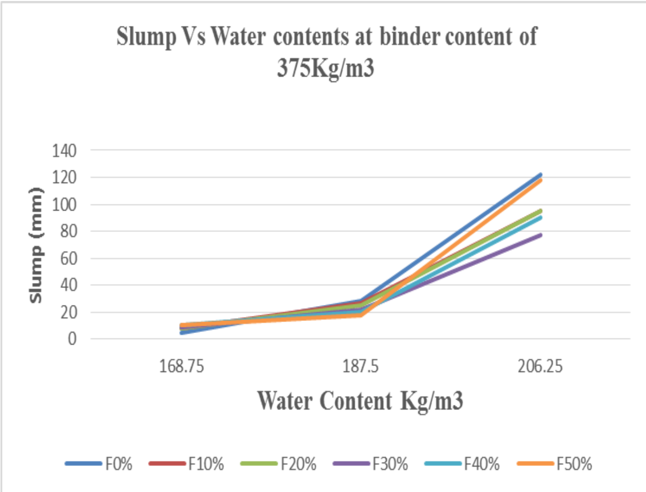

Fig. 3. Slump and Water contents at binder content of 375Kg/m^3

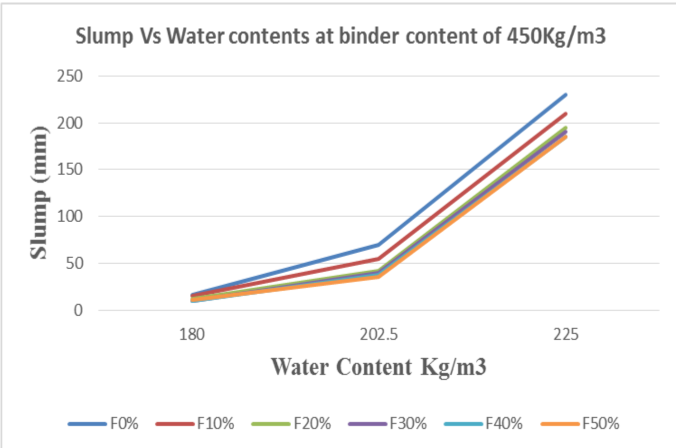

Fig . 4. Slump and Water contents at binder content of 450Kg/m^3

Various combinations of 54 different concrete mixes were examined and the all results stated in the following Table I.

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Table- I: Fresh Concrete Properties of Fly ash + (cement) based concrete

Sr. No	Mixes	Workability		Fresh concrete Density (Kg/m3)	Visual Observation
		Slump	C.F.		
1	B1W1F00	5	0.78	2546	Non Cohesive
2	B1W1F10	5	0.78	2540	stiff
3	B1W1F20	5	0.79	2503	Poor cohesion
4	B1W1F30	5	0.80	2488	Stiff and dry
5	B1W1F40	5	0.81	2448	Dry mix
6	B1W1F50	10	0.81	2424	Dry
7	B1W2F00	7	0.81	2570	Cohesive, True slump
8	B1W2F10	8	0.82	2509	Cohesive, moderate bleeding
9	B1W2F20	9	0.83	2486	Cohesive
10	B1W2F30	9	0.84	2453	More cohesive, true slump
11	B1W2F40	10	0.85	2441	More cohesive
12	B1W2F50	10	0.85	2423	Cohesive, true slump
13	B1W3F00	19	0.91	2516	More cohesive, true slump
14	B1W3F10	18	0.91	2544	Easy to compact, cohesive
15	B1W3F20	17	0.89	2499	True slump
16	B1W3F30	16	0.88	2468	Moderate bleeding, cohesive
17	B1W3F40	15	0.88	2411	Highly cohesive
18	B1W3F50	15	0.88	2401	Moderate cohesive
19	B2W4F00	5	0.85	2535	Cohesive, true slump
20	B2W4F10	8	0.85	2515	True slump, highly cohesive
21	B2W4F20	8	0.84	2499	Stable mix
22	B2W4F30	9	0.85	2436	Moderate bleeding, true slump
23	B2W4F40	10	0.85	2417	Cohesive
24	B2W4F50	10	0.85	2390	Cohesive
25	B2W1F00	28	0.95	2503	Good and stable
26	B2W1F10	27	0.93	2501	Easy to compact, cohesive
27	B2W1F20	25	0.89	2496	Easy to compact, bleeding
28	B2W1F30	22	0.89	2489	Stable, highly cohesive
29	B2W1F40	20	0.87	2477	Highly cohesive
30	B2W1F50	18	0.88	2458	Cohesive, plain nature
31	B2W2F00	122	0.99	2501	Bulging of slump, cohesive
32	B2W2F10	95	0.98	2489	Bulging of slump, cohesive
33	B2W2F20	95	0.97	2478	Bleeding but no segregation
34	B2W2F30	77	0.97	2456	Highly cohesive
35	B2W2F40	90	0.95	2423	Collapse slump, high bleeding
36	B2W2F50	118	0.96	2401	Collapse slump
37	B3W5F00	16	0.90	2519	Highly cohesive, true slump
38	B3W5F10	15	0.89	2498	More cohesive
39	B3W5F20	12	0.87	2480	Easy to compact, cohesive
40	B3W5F30	10	0.85	2455	Uniform color
41	B3W5F40	10	0.83	2423	Uniform and stable mix
42	B3W5F50	11	0.83	2401	Cohesive
43	B3W4F00	70	0.98	2495	Medium bleeding
44	B3W4F10	55	0.97	2469	Moderate bleeding
45	B3W4F20	42	0.96	2458	More cohesive and stable
46	B3W4F30	40	0.94	2429	True slump
47	B3W4F40	38	0.93	2403	Uniform and cohesive
48	B3W4F50	36	0.93	2394	Stable and uniform mix
49	B3W1F00	230	0.98	2475	Flowing, collapsible slump
50	B3W1F10	210	0.98	2467	Bleeding, collapse slump
51	B3W1F20	195	0.98	2409	Collapse slump
52	B3W1F30	190	0.97	2397	Less cohesive
53	B3W1F40	185	0.97	2367	More bleeding
54	B3W1F50	185	0.96	2347	flowing

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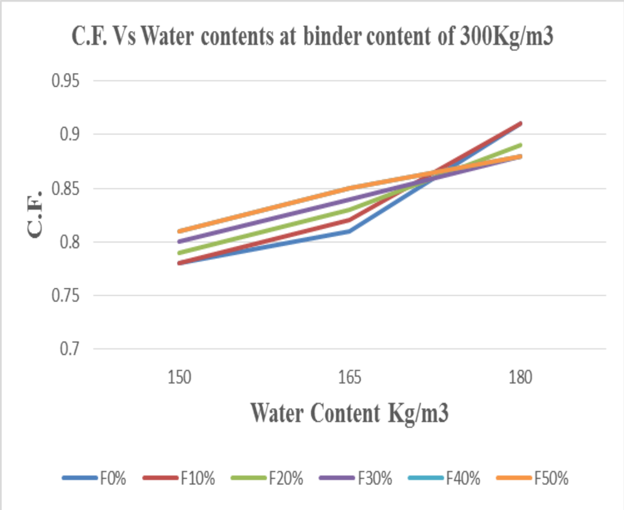

Fig. 5. C.F. Vs Water contents at binder content of 300 Kg/m³

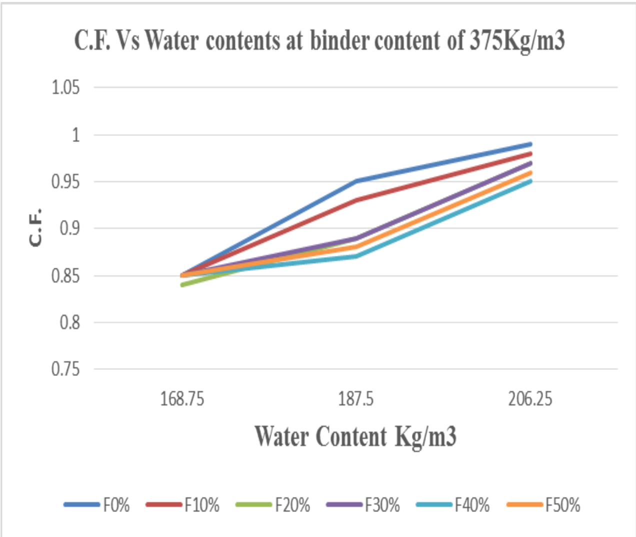

Fig. 6. C.F. Vs Water contents at binder content of 375 Kg/m³

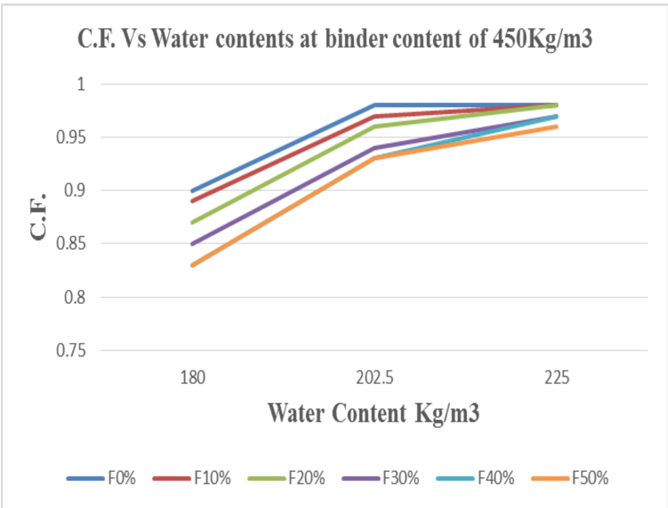

Fig. 7. C.F. Vs Water contents at binder content of 450Kg/m³

It was found that fly ash in higher replacement levels concrete in the fresh state gives viscous, cohesive and dark in colour than lean concrete. Fly ash concrete seen more workable than without fly ash concrete at equivalent slump.

In lean mixes, or where aggregates are minimum, a changes increase in the volume plastic paste and a betterment in consistency will be additional advantageous to gaining workability. Reduction of water content observed in all binder content 300kg/m³, 3750kg/m³, and 450kg/m³. The effects on fresh concrete density seen minor change in all 54 mixes due to homogeneity of ingredients.

III. CONCLUSION

- The fly ash can be used as cementitious material as alternative material to cement because in all mixes they mostly observed cohesive slump (below 100 mm) and the compaction factor found in same range of 0.78-0.98. The most of the results of CF test has seen above 0.9 and these value is accepted for good workability.
- Fly ash material possesses binding and workability properties due to their similar oxide compositions. Due to fly ash less bleeding observed than control concretes.
- In many cases moderate bleeding, true slump was obtained upto replacement of 30-40%, also highly cohesive nature seen. As the water content and binder content increases the CF and Slump was observed rise in nature.
- For w/c ratio 0.5, 0.55 and 0.6 the slump having range below 20 are seen lower CF values than mix contains w/c ratio 0.4 and 0.45.
- A higher fineness benefited in a higher workability. The workability concrete has improves due to incorporation of fly ash. Fresh concrete initially seen workable nature according to slump and CF test characteristics, so no doubt to adopt these three binder contents and variation in w/c range for making fly ash concrete.

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Lomesh S. Mahajan, has appeared PhD from DBATU lonere in civil engineering and working as Assistant professor at R. C. Patel Institute of Technology Shirpur, India. Till date publishes more than 8 books in International level and more than 30 papers presented in various conferences. The Research interest are in the field of fly ash, cementitious materials, and sustainable materials. Got Research excellence and Academic Award-2018, for spectacular performance given by combined society for research and development, Dehradun, Uttarakhand. Also acting a reviewer and team member for reputed Journal named JETIR. Life time Membership of the Indian Society for Technical Education and IAENG.

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