Influence of Nano Particles, Fly Ash & Fibres on the Performance & Analysis of Concrete Beam Subjected To Loading

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Abstract— Engineered materials using nanotechnology that will allow maximum use of locally available materials and avoid unnecessary transport. It is clear that nanotechnology has changed and will continue to change our vision, expectations and abilities to control the material world. These developments will definitely affect construction and also the field of construction materials. Of late, the major achievements include: the ability to observe the structure at its atomic level and measure the strength and hardness of micro- and nano-scopic phases of composite materials; discovery of a highly ordered crystal nanostructure of “amorphous” C-S-H gel; development of materials with self-cleaning properties based on photocatalyst technology; nanometer-thin coatings protecting carbon steel against corrosion and enhancing thermal insulation of window glass; etc. Among new nano-engineered polymers are highly efficient superplasticizers for concrete and high strength fibres with exceptional energy absorbing capacity. Nanoparticles, such as silicon dioxide, were found to be a very effective additive to polymers and concrete, a development realized in high-performance and self-compacting concrete with improved workability and strength. Here we are showing the comparative results of improvement on the ductility and yield of concrete beams etc. by use of special purpose additives like nano particles fly ash and steel fibres etc. and cast cubes to check compressive strength alongside we are also casting beams to check flexural strength As also to show effect of fibre addition on strength and to show the effect of fly ash and Nano Particles on the concrete strength.

Key words: Nano Particles, Fly Ash, Fibres

I. INTRODUCTION

The next industrial revolution will be nanotechnology. Nanotechnology was first introduced in the famous lecture of Nobel Laureate Richard P.Feynman, “There’s Plenty of Room at the Bottom,” given in 1959 at the California Institute of Technology.1. There have been revolutionary developments in physics, chemistry and biology during the past 25 years. These developments have proved Feynman’s ideas of manipulating and controlling matter at an extremely small scale even to the level of molecules and atoms; i.e., nanoscale. Nanotechnology deals with the production and application of physical, chemical and biological systems at scales ranging from a few nanometers to submicron dimensions. It also deals with the integration of the resulting nanostructures into larger systems. Nanotechnology also involves the investigation of matter to individual atoms.

Drexler gave one of the earlier definitions of nanotechnology as “the control of matter based on molecule-by-molecule control of products and by-products through high-precision systems as well as the products and processes of molecular manufacturing, including molecular machinery.” This definition involves the application of the bottom–up approach of molecular nanotechnology Here, organic and inorganic structures are constructed atom by-atom or molecule-by-molecule. However, contemporary technology continues to rely on the top–down approach. Here bulk materials are broken down into nanoparticles by mechanical attrition and etching techniques

Typical concretes consist of ordinary Portland cement (OPC), fillers such as sand, coarse aggregates, admixtures and water. This combination of materials allows concrete to be produced in a fluid form that can be pumped and moulded. The complex chemistry and physical structure of cement hydrates in concrete however mean that issues of fundamental science still need to be resolved. Research at the nanoscale has the potential to contribute to these debates and questions. Analysis at the nanoscale may provide further insight into the nature of hydrated cement phases and their interaction with admixtures, nanofillers and nanofibers. These interactions offer the possibility of modifying cement reactions, creating new surface chemistries (referred to as nanoscience), developing new products for the concrete industry (referred to as nanotechnology), and allowing a more controlled and ecologically friendly manufacturing route to cement and concrete

A. *Principles and Concept*

Since ancient times humans have started to use nanosized materials in glass. When nanoparticles are created by the “bottom-up” approach, the size, and also the shape, of a particle can be controlled by production conditions. These particles can also be considered as nanocrystals because the atoms within the particle are perfectly ordered, or crystalline. When the dimensions of a material are reduced from macro- to nano-size, while significant changes in electronic conductivity, optical absorption, chemical reactivity and even mechanical properties occur. With reduction in size, more atoms are located on the surface of a particle and, in addition to a remarkable surface area of nanopowders; this imparts a considerable change in surface energies and surface morphologies. As a result, all these factors alter the basic properties and the chemical reactivity of nanomaterials. The shift in properties helps to develop the improved catalytic ability, tunable wavelength sensing ability, as well as enables to design better pigments and paints with self-cleaning and self-healing features. Nanosized particles have been used to enhance the mechanical performance of plastics and rubbers; they help make cutting tools harder and ceramic materials ductile. For example, ductile behaviour was reported for nanophase ceramics such as titania and alumina processed by consolidation of ceramic nanoparticles. New nanomaterials based on metal and oxides of silicon and germanium demonstrate superplastic behaviour, undergoing elongations from 100 to 1000 % before failure.

It is mutually understood that further research in nanotechnology promises breakthroughs in such areas as materials and manufacturing, nanoelectronics, medicine and healthcare, energy, biotechnology, information technology, and national security. It is also expected that construction and especially the construction materials field can substantially progress utilizing the developments

Study of the structure of C-S-H in Portland cement systems using X-ray diffraction is limited due to its poorly crystalline nature. Early research investigations were conducted using mainly surface area and density measurements, and, weight and length change isotherms in order to characterize this material . In the last few decades, many new aspects of the C-S-H have been revealed with the advancements in the analytical techniques and application of new methods such as nuclear magnetic resonance (NMR) spectroscopy. The nanostructure of C-S-H has been the subject of much research, yet is still not clearly understood with suggested models ranging from colloidal to "layer-like". One of the first physical models was proposed by Powers and Brownyard. It describes C-S-H as a colloidal material. In this model the gel particles are held together mainly by van der Waals' forces and the space between them is called "gel porosity" which is accessible only by water molecules. A more comprehensive model was developed later by Feldman and Sereda based on extensive experimental studies of hydrated cement systems. The role of water in this model is explained in more detail and the changes in the mechanical properties of C-S-H related to water content can be easily described. The main feature of their model is concerned with the layered nature of the C-S-H. Structural roles that are assigned to the interlayer water of the C-S-H, exhibit irreversible behavior during the adsorption and desorption processes.

II. CHARACTERIZATION OF MATERIALS

The Characterization of Material was designed to enlist the physical and chemical properties of HSC

The conduct of the research in view of the set aim and objectives calls for detailed laboratory testing of specimens followed by a thorough analysis This was fundamentally carried out at the Civil Engineering Department at concrete testing laboratory at the Kavi Kulguru Institute of technology and Science, Ramtek

A. Concrete

It is composed of Cement and Water combined with Fine aggregates and coarse aggregates. The concrete is plastic and can be moulded into any form or trowelled to produce a smooth surface. Hardening starts immediately after mixing but precautions are taken usually by covering, to avoid rapid loss of moisture since the presence of water is necessary to continue the chemical reaction and increase the strength. Excess of water however produces a concrete that is more porous and weaker. The quality of paste formed by the cement and water largely determines the character of concrete. proportioning of ingredients is referred to as designing the mixture. Normally the full hardening of concrete is at least 28 days. Concrete is stronger in compression than in tension

The ingredients of concrete include: tap water, Cement (Ordinary Portland cement) , coarse aggregates with diameters in the range of 10-20 mm medium graded with aggregate size Within 4-10mm ,Fine sand and polypropylene micro fibre fly-ash and Nano particles .The details of all the materials are discussed as follows

B. Cement

Cement Used in all mixes was Ordinary Portland Cement Physical Properties and Mechanical properties characteristics of cement are provided in Table

Sr. No.	Properties	Average values Considered	Standard Requirements as per IS 4031 (Part 2) :1988
1	Fineness	4% (370)	Not more than 10% Not less than 300 m²/kg
2	Consistency	30 %	N.A.
3	Specific Gravity	3.15	N.A.
4	Initial Setting time	40	Not less than 30 mins
5	Final Setting time	590	Not greater than 600 mins
6	Soundness by Le'Chattelier Expansion mm	8	Not more than 10
7	28 Days Compressive strength	54	Not less than 33

Table 1: Physical and Mechanical Properties of Cement

C. Coarse Aggregates

20 mm Maximum size of crushed aggregates from Panchgoan Nagpur were used as coarse Aggregates. The coarse aggregates are crushed angular Shape and free from dust

D. Testing of coarse Aggregates

1) Sieve Analysis the Results of Sieve analysis is furnished in fig 3.1 and Table 3.2
2) Specific Gravity : 2.84
3) Absorbtion Value : 1.0%

Sieve Size mm	Wt. Retained gm	Cumulative Wt. Retained	% Cumulative Wt. Retained	% Cumulative Passing
40	0	0	0	100
31.5	0	0	0	100
25	756	756	14.12	85.88
20	2234	2990	59.8	40.2
16	770	3760	75.2	24.8
12	570	4330	86.6	13.4
10	310	4640	92.8	7.2
6.3	320	4960	99.2	0.8
4.75	25	4985	99.7	0.3
Pan	15	5000	100	0

Total	5000			

Table 2: Results of Sieve Analysis for Coarse Aggregates

Fineness of Aggregates = (% Cumulative Wt. Retained)/100

FM = 6.27

Bulk Density = ((Wt. Of container + Loss of agg) – (Wt of empty Container)) / (Volume of Container) $(\rho)b$ = 1500 Kg/m³

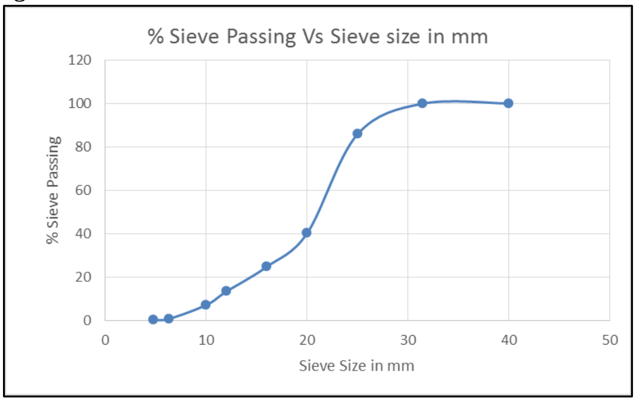

Fig. 1: Chart of sieve analysis of coarse aggregates

E. Fine Aggregates

4.75 maximum size of fine aggregates from Pench Kanhan River were used. Which is free from organic impurities. This sand is yellowish brown and proves to be good for concrete The silt was checked and found to be well below 5%

F. Testing of Fine Aggregates

Sieve Analysis

The results of sieve analysis of fine aggregates are furnished in Fig 3.2 and Table 3.4

1) Specific Gravity 2.72
2) Water Absorption 1.1%

Sieve Size mm	Wt. Retained Gm.	Cumulative Wt. Retained	% Cumulative Wt. Retained	% Cumulative Passing
4.75	15	15	1.5	98.5
2.36	58	73	7.3	92.7
1.18	156	229	22.9	77.1
0.6	215	444	44.4	55.6
0.3	296	740	74.0	26
0.15	168	908	90.8	9.2

Table 3: Results of sieve analysis for fine aggregate

Note Based on Test Results Sand conforms to grading Zone II

Fineness of Aggregate = (% Cumulative Wt. Retained)/100

FM = 2.409

Bulk Density =

$$\frac{(\text{Wt of Container + Loss of Agg}) - (\text{Wt.of empty Container})}{\text{Volume of Container}}$$

(ρ)=1460 Kg/m³

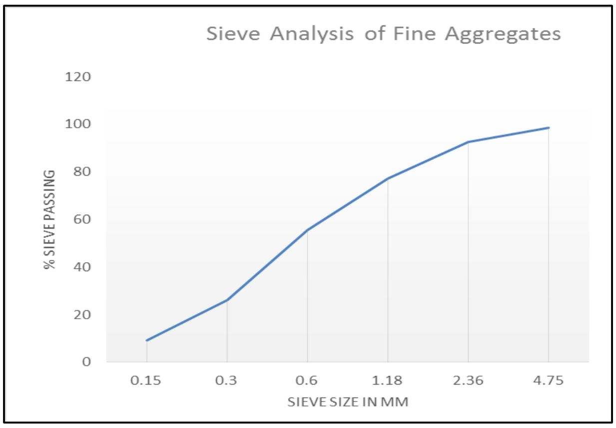

Fig. 2: Chart of Sieve Analysis of Fine Aggregate

Figure 3.1 and Figure 3.2 shows the graphs of sieve size in mm vs % of sieve passing for coarse aggregate . The fineness modulus for coarse and fine aggregates is found to be 6.27 and 2.409respectively . The aggregates are chemically inert materials which when bonded with cement paste to form concrete constitute the bulk of total volume of concrete . Depending upon their size the material are classified as coarse aggregates and fine aggregates .The material retained through 4.75mm is termed as fine aggregates where as the material passing 4.75 mm sieve is termed as fine aggregates

G. Polypropylene Micro Fibre

Polypropylene Micro Fibre was procured from Bajaj Reinforcement Nagpur and was used in the present study. These fibres have been specifically engineered and manufactured in ISO 9001 2000 certified facility for use as concrete reinforcement at the recommended dosage rate of 1 kg per cubic meter for effective performance The table below shows Chemical and physical properties of polypropylene macro fibres in experimental Investigation.

Characteristic	Material Properties	Characteristic	Material Properties
Fibre length	12 mm	Type /Shape	Monofilament Fibre
Absorption	Nil	Diameter	30 microns
Specific Gravity	0.90	Thermal conductivity	Low
Tensile strength	4.5 Kgf	Melt Point	162° C(324° F)
Acid and salt Resistance	High	Electrical Conductivity	Low

Table 4: Chemical and physical properties of polypropylene Micro Fibres (Bajaj Reinforcement Nagpur)

H. Nano Particle Gel

This is sourced from the medical field basically Dentistry the product is used to stop sensitivity of teeth it contains 5% Calcium phosphosilicate and 35% Titanium dioxide nano particles Gel is used to carry nano particles as nano powder being very small it gets air bourne and is found to enter lungs and gets deposited therein. What we have done here is to source the nano particle material from these gels and premixed this with water before adding this to concrete as a source of Nano particle

Material Properties	Nano Particle gel	Material Properties	Nano Particle Gel
Type	Gel Paste	Calcium Phospho	5%

		silicate Nano Particle	
Colour	White	Titanium Dioxide Nano particle	35%
Sodium Lauryl Sulphate	5%	Silica	5%
Potassium Acesulfame	2%	Thermal Conductivity	Low

Table 4: Showing Material Properties of Nano Particle Gel

Fly Ash This is sourced from the power plant and is a waste product for the Power plant Studies have been carried out towards mamagement of FA disposal and utilisation Of the total power generated in India 70% is produced by thermal power plants which genetrate an enormous quantity of fly ash FA .FA contains trace amounts of toxic metals (U,Th,Cr, Pb,Hg, Cd etc. Which may have negative effect on Human health and on Plants .Several studies have been carried out to acess hazards caused by FA on enviroment and plants. Hence there is a need to effectively address the need to utilise FA In Concrete

Texture	Very Fine	Diameter	1-150µ
Weight	Light weight	Nature	Refractory
Density	1.97-2.89 g/cc	Ability	puzzolanic
Specific Surface Area	4000-10000 cm²/g	Colour	Grey
SiO_2	59.38%	Fe_2O_3	6.11%
Al_2O_3	23.59%	CaO	1.94%
MgO	0.97%	SO_3	0.76%
Alkalies	1.41%	Unburnt S & Moisture	3.74%

Table 5:

III. Mix Design

A. Mix Design of M 30 Grade Concrete

1) Design Stipulation

1) Charecterstic strength = 30 N/mm²
2) Degree of Quality Control = Good
3) Degree of Exposure =Moderate
4) Workability = 100 mm Slump value

2) Material Suppplied

1) Cement : Ordinary Portland Cement
2) Coarse Aggregates :20 mm
3) Fine Aggregates : Sand Conforming to grading zone II

B. Design Mix Proportions (I.S.10262:2009)

Mix Design is the process of selection of suitable ingredients of concrete and determining their proportions with the object of producing concrete of certain maximum strength and duribility as economically as possible . The concrete mix is designed as per I.S. 10262-2009, I.S. 456-2000 . The table gives the materials required for M 30 Grade concrete Water Cement Ratio is 0.45 and mix proportions are (1:1.95:2.61)

Sr. No.	Material	Quantity in Kg/m³
1	Cement	395
2	Fine Aggregates	770
3	Coarse Aggregates	1033
4	Water	178
5	Ad Mixture	7

Table 6: Containing concrete mix proportions in Kg per Meter cube Conventional Concrete

C. Methodology of Mix Ratios

1) Methodology of Concrete Preperation

Initially we start with C-0 M-30 Grade concrete wherein OPC is mixed with Fine and Coarse aggregates and water to produce the base concrete version This is initially mixed in dry state and water is added till concrete becomes hydrated and turns into a thick paste this is base concrete .

In C-1 Concrete M-30 Grade of concrete with 30 % fly ash is made Here use of fly ash helps in cement replacement this also affects strength

In C-2 Concrete M-30 Grade of concrete with 30% Fly-ash and 0.25 % Fibres is prepared Fibres helps in arresting of shrinkage cracks and increasing strength of concrete

In C-3 Concrete M-30 Grade of concrete with 30 % Fly ash and 0,25% Fibres and 0.5 % nano particles is prepared here nano particles help in exponential increase of strength

Table Showing Cube results at 7 and 28 Days after casting

Type of Concrete	% of Fly-ash	% of Fibers	% of Nano particles
C-0	0	0	0
C-1	30	0	0
C-2	30	0.25	0
C-3	30	0.25	0.5

Table 7: Showing different type of mixes

IV. Experimental Study

A. Introduction

In this chapter the experemental results of all the cubes and beams with conventional concrete compared with HSC High Strength Concrete are intepreted Their behavour throughout the test is described using recorded data on workability test compressive test and flexural test Three cubes and two beams were tested for 7 days of curing and three cubes and two beams were tested for 28 days curing the results compared between conventional concrete fly ash concrete fibre plus fly ash concrete and Fibre fly ash and nano particle concrete

B. Workability Test

Slump Test was conducted for finding the workability of concrete The slump test conducted before casting concrete cube and beam , the test is in term of slump value The result of this test is shown in Table

Type of Concrete	% of Fly-ash	% of Fibers	% of Nano particles	Slump (mm)
C-0	0	0	0	98
C-1	30	0	0	100
C-2	30	0.25	0	96
C-3	30	0.25	0.5	92

Table 8: Slump of Different concrete Mix

Fig shows the bar chart of workability of concrete by use of slump cone method the workability of flyash mix C-1 is 100 mm according to the other mix good workability is found to be in conventional concrete According to the result use of Nano particle gives lower workability

C. Concrete Strength

Here the strength of cube and beams at different Mixes were analysed Compressive strength and Flexural sterngth of each cube and beams were compared with conventional concrete and Fly ash Fiber and Nano particle mixed in that order For calculation of compressive strength and flexural sterngth of concrete the compressive testing machine was used . For flexural strength the two point loading attachment was used

D. Compressive Strength Of Concrete

Compressive strength of concrete, out of the many test applied to concrete this is the utmost important which gives an idea about all the characterstics . By this single test one can judge weather concreting is done properly or not For testing of concrete cubical moulds of size 150 mm x150 mm x150mm are commonly used.

Concrete Mix	Cube Nos.	7 Days Cube Strength N/mm²	Average	28 Day Cube Strength N/mm²	Average
	1	25.5		36.6	
C-0	2	25.1	24.7	37.5	37.26
	3	23.5		37.7	
	1	23.0		34.5	
C-1	2	22.5	22.96	33.4	33.9
	3	23.4		33.8	
	1	26.5		38.5	
C-2	2	26.0	26.5	39.0	38.56
	3	27.0		38.2	
	1	28.5		43.0	
C-3	2	29.0	29.0	44.5	44.4
	3	29.5		45.7	

Table 8: Values of 7 and 28 Day Compressive strength of Cubes

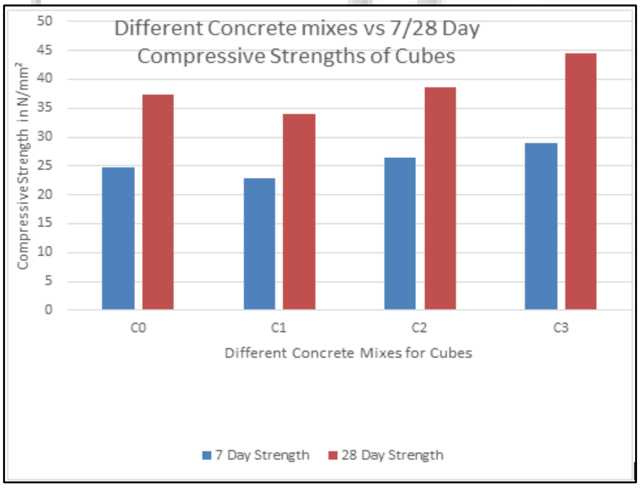

Fig. 3: Bar Chart showing comparative compressive strengths

E. Flexural strength of concrete

Flexural test is one measure of the tensile strength of concrete It is the measure of a reinforced concrete beam to resist failure in bending It is measured by loading concrete beam with span lengths at least three times the depth. The flexural strength is expressed as Modulus of rupture in Mpa and is determined by two-point loading. Table 5.3 and figure 5.2 shows the average results of the flexural strength test that determined at the age of 7 days and 28 days. The flexural strengths for different mix proportion is varying. It can be seen that the flexural strength is a maximum for C-3 mix at 7 and 28 days

Concrete Mix	7 Day Flexural strength of Beam N/mm²	Deflection mm.	28 Day Flexural Strength of Beam N/mm²	Deflection mm.
C-0	4.47	3.5	5.88	2.6
C-1	4.16	4.7	5.62	3.8
C-2	4.52	3.7	6.82	2.5
C-3	5.17	2.8	7.93	1,7

Table 9: showing Beam Flexural Strength Results along with Deflection

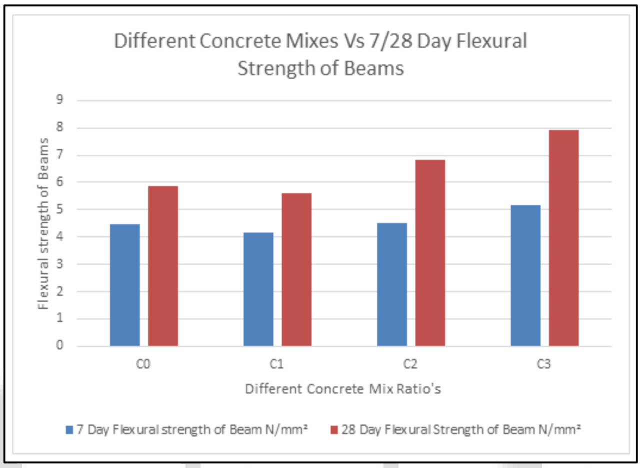

Fig. 4: Showing Flexural Results of 7 and 28 days for Beams

Table Changes in flexural strengths as a percentage

Type of Concrete	% of Fly-ash	% of Fibers	% of Nano particles	Percentage at 7 days	Percentage at 28 Days
C-0	0	0	0	0	0
C-1	30	0	0	(-) 6.9	(-) 4.4
C-2	30	0.25	0	1.1	15.98
C-3	30	0.25	0.5	15.65	34.86

Table 10: Percentages of flexural strength changes at 7 and 28 Days

The percentage variation at 7 days average flexural strength for mix proportion C1 C2 C3 is -6.9% 1.1% and 15.65 % .It is observed that flexural strength is a maximum for mix C3 as compared to the conventional and other mix proportions as shown in Table 5.4

The percentage variation of 28 days average flexural strengths for mix proportion C1, C2 & C3 are (-) 4.4 15.98 & 34.86 It is observed that flexural strength is a maximum for mix C3 as compared to conventional and other mixes as shown in Table 5.4

PHOTOS Shown Subsequently are some photos taken during concrete casting and testing of cube and beam they are mainly shown for the purpose of record and review There is shown Compression testing machine UTM And viberating table among other things

Fig. 5: Cube Testing Machine

Fig. 6: Viberating Table

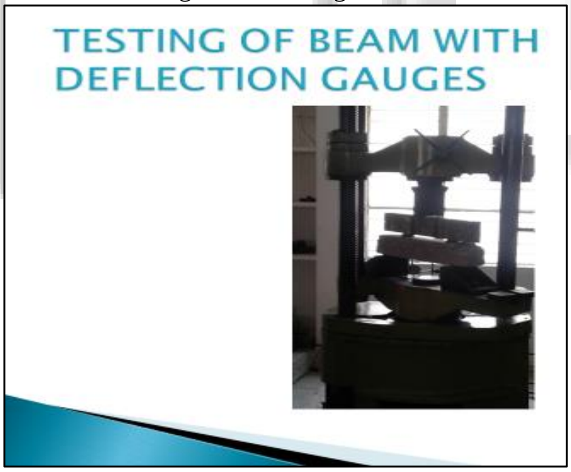

Fig. 7: Testing of Beam with Deslection Gauges

Fig. 8: Checking and Aligning

V. CONCLUSIONS

Following conclusions are drawn on the basis of experimental investigation carried out in these studies

1) Based on result and analysis it is concluded that addition of fly ash to concrete gives the concrete a high degree of workability
2) Addition of 0.25% Polypropylene micro fibres increases the workability of the resultant concrete even further
3) Addition of Nano particles decreases the workability of the concrete leading to a stiffer concrete mix
4) Although addition of fly ash to concrete helps in increase in workability, it leads to decrease in strength up to 8.5%
5) Addition of microfibers to concrete leads to increase in strengths of the concrete
6) Addition of Nano Particles to concrete leads to greater increase in strengths of resultant concrete
7) Synergistic reinforce effects of low modulus polypropylene fibres and Highly reactive Nano particle in improving the flexural toughness and fracture properties of concrete
8) Fly ash was useful in economising the construction since its replacement directly reduces consumption of cement which is highly costly product to use as compared with fly ash
9) Any shortfall in the strength due to use of fly ash is made up by using fibre which also provides the necessary durability to concrete hence enhances economic criteria addition of Nano particles also gives back the strength advantage, but its use is not as economical as fibres

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