UTILIZATION OF HYPO SLUDGE IN NORMAL CONCRETE

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ABSTRACT

Utilization of industrial waste products as supplementary cementitious materials (SCM) in concrete making is very important aspect in view of economic, environmental and technical reasons. As these supplementary cementitious materials have different chemical and mineralogical composition, there effect on micro structural properties and strength performance vary considerably.

While producing paper various wastes are comes out from the various processes in paper industries. The preliminary waste from paper industry is named as hypo sludge. In this study the material obtained from the paper industry waste (hypo sludge) is admixed with Portland cement at different replacement levels. The properties of concrete to be investigated include workability, setting time, compressive strength, optimum percentage of hypo sludge as supplementary cementations material (SCM).

This report summarizes the various efforts underway to improve the environmental friendliness of concrete to make it suitable as a "Green Building" material. Foremost and most successful in this regard is the use suitable substitutes for Portland cement, especially those that are byproducts of industrial processes, like fly ash, ground granulated blast furnace slag, and silica fume. The combination of different binders and modifiers to produce cheaper and more durable building materials will solve to some extent the environmental and ecological problems.

Introduction

The environmental aspects involved in the production of and use of cement, concrete and other building materials are of growing importance. Producing one tonne of cement results in the emission of approximately one tonne of CO_2. SO_2 emissions is also very high, but is dependent upon the type of fuel used .Energy consumption is also very high at 90-150 KWT/ton of cement produced. It is costly to erect new cement plants. Substitution of waste materials will conserve resources, and will avoid environmental and ecological damages caused by quarrying and exploitation of the raw materials for making cement. While the developed, industrialized countries are called upon to reduce pollution of the environment and their share of the usage of the world's resources, including energy, the developing countries need to avoid the mistakes of the past. This problem is particularly acute, since cement production as well as fly ash generation in China and India are expected to increase significantly in the next few decades. There is an increasing demand for concrete worldwide, estimated to double within the next 30 years. This demand can be met without a corresponding increase in greenhouse gases by using supplementary cementitious materials to replace a maximum amount of the cement in concrete; we can reduce energy and resource consumption, reduce CO_2 emissions, and reduce the negative environmental impact. There is a further environmental benefit in that most commonly used supplementary cementitious materials (such as hypo sludge, fly ash, silica fume) are waste products and would otherwise end up in landfills.

Paper making generally produces a large amount of solid waste. It means that the broken, low- quality paper fibers are separated out to become waste sludge. This paper mill sludge consumes a large percentage of local landfill space every year and also contributes to serious air pollution problems. To reduce disposal and pollution problems emanating from these industrial wastes, it is most essential to develop profitable building materials from them. Partial replacement of cement can be made by hypo sludge, fly ash, silica fumes and natural rock minerals. Partial replacement by natural rock minerals that require little or no processing, saves energy, and decreases emission of gases. The output of waste materials suitable as cement replacement (hypo sludge, fly Ash, silica fumes etc.) is more than double that of cement production. Use of waste products is not only a partial solution to environmental and ecological problems, it significantly improves the microstructure, and consequently the durability properties of concrete, which are difficult to achieve by the use of pure Portland cement. The aim is not only to make the cement and concrete less expensive, but to provide a blend of tailored properties of waste materials and Portland cements suitable for specified purposes. This requires a better understanding of chemistry, and material science. This report concisely explains the technical and environmental benefits of supplementary cementations' materials use, as well as the limitations, applications and specifications.

Constituents of Concrete

Concrete is a construction material composed of cement as well as other cementitious materials such as fly ash, hypo sludge and slag cement, aggregate. Concrete is basically a mixture of two components: aggregates and paste. The paste is usually composed of Portland cement and water, and it binds together the fine and coarse aggregates. Supplementary cementing materials may also be included in the paste. A typical mix is about 10 to 15 percent cement, 60 to 75 percent sand/aggregate, 10 to 20 percent water and 5 to 8 percent air. Concrete solidifies and hardens after mixing with water and placement due to a chemical process known as hydration. The water reacts with the cement, which bonds the other components together, eventually creating a stone-like material. Concrete is used to make pavements, pipe, architectural structures, foundations, motorways/roads, bridges etc.The different constituents of cements are presented in Figure 1.1.

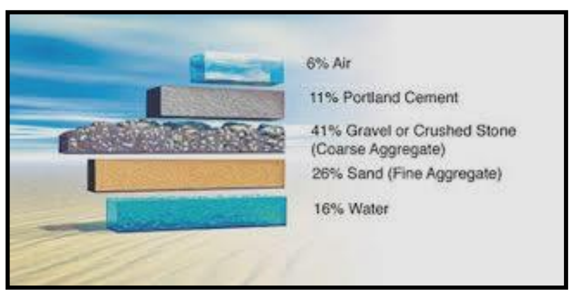


Figure 1.1 Constituents of concrete

Cement

Cement is the most important constituent of concrete. In that, it forms the binding medium for the discrete ingredient. The Chemical composition of cement is presented as follows.

Lime (CaO) 60-67 (SiO2) 17 -25, Alumina (Al2O3) 3-8, Calcium sulphate (CaSO4) 3-4, Iron oxide (Fe2O3) 3-4, Magnesia (MgO) 0.5 - 4,Sulphur trioxide (SO3) 1-2% and Alkalis <1 percent. Portland cement is composed of calcium silicates and aluminates. It is obtained by blending predetermined proportions of limestone, clay and other minerals in small quantities, which is pulverized and heated at high temperatures around 15000 C to produce 'clinker'. The clinker is then ground with small quantities of gypsum to produce fine powder called ordinary Portland cement (OPC). When mixed with water, sand and stone, it combines slowly with the water to form a hard mass called concrete. Cement is a hygroscopic material meaning that it absorbs moisture. In presence of moisture it undergoes chemical reaction termed as hydration. Therefore cement remains in good condition as long as it does not come in contact with moisture. If cement is more than three years old then it should be tested for its strength before being taken it for use.

The Bureau of Indian Standards (BIS) has classified OPC in three different grades .The classification is mainly based on the compressive strength of cement-sand mortar cubes composed of 1part of cement to 3 parts of standard sand by weight with water-cement ratio arrived at by a specified procedure. There are different types of cements are available in the market .The following are the three main grades as presented below.

•33 grade

•43 grade

•53 grade

The grade number indicates the minimum compressive strength of cement sand mortar in N/mm2 at 28 days.

Aggregate

Aggregates which occupy nearly 60 to 75 percent volume of concrete. Fine and coarse aggregates make up the bulk of a concrete mixture. Sand, natural gravel and crushed stone are mainly used for this purpose.

Water

Combining water with a cementitious material forms a cement paste by the process of hydration. Less water in the cement paste will yield a stronger, more durable concrete; more water will give a free-flowing concrete with a higher slump. Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure. The pH value of water should not be less than 6. Hydration involves many different reactions, often occurring at the same time. As the reactions proceed, the products of the cement hydration process gradually bond together the individual sand and gravel particles, and other components of the concrete, to form a solid mass.

Chemical Admixtures

Chemical admixtures are materials in the form of powder or fluids that are added to the concrete to give it certain characteristics not obtainable with plain concrete mixes. In normal use, admixture dosages are less than 5% by mass of cement, and are added to the concrete at the time of batching/mixing. The most common types of admixtures are:

- Accelerators : speed up the hydration (hardening) of the concrete

- Retarders: slow the hydration of concrete, and are used in large or difficult pours where partial setting before the pour is complete is undesirable.

- Plasticizers/super plasticizers (water-reducing admixture) increase the workability of plastic or "fresh" concrete, allowing it is placed more easily, with less consolidating effort. Alternatively, plasticizers can be used to reduce the water content of a concrete (have been called water reducers due to this application) while maintaining workability. This improves its strength and durability.

- Pigments: can be used to change the color of concrete, for aesthetics.

- Corrosion inhibitors: are used to minimize the corrosion of steel bars in concrete. Bonding agents are used to create a bond between old and new concrete.

PROPERTIES OF CONCRETE

Concrete is a mixture of cement, sand, stone aggregates and water. Concrete has two main stages. Among first one is Fresh concrete and secondly hardened concrete

Fresh Concrete

It should be stable and should not segregate or bleed during transportation and placing when it is subjected to forces during handling operations. The mix should be cohesive enough to be placed in the form around the reinforcement and should be able to cast into the required shape without losing homogeneity under the available techniques of placing the concrete at a particular job.

Hardened Concrete

It is one of the most important properties of the hardened concrete is its strength which represents the ability if it resist forces. The compressive strength of hardened concrete is generally considered to be the most important property and is often taken as the index of the overall quality of concrete.

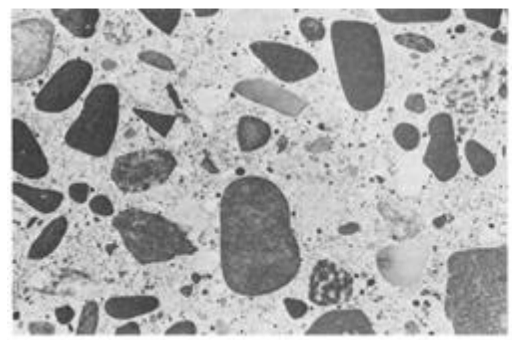


Figure 1.2 Hardened Concrete Structures

Workability

It is defined as the ease with which the concrete is handled, transported and placed so that concrete remains homogenous. Workability depends on water content, aggregate (shape and size distribution), cementitious content and age and can be modified by adding chemical admixtures. Raising the water content or adding chemical admixtures will increase concrete workability. Excessive water will lead to increased bleeding (surface water) and/or segregation of aggregates with the resulting concrete having reduced quality. Workability of concrete may be determined by slump test, compaction factor test.

Compactability

It is the ease with which concrete can be compacted. In other words, it is the amount of internal work required to produce complete compaction. The addition of admixtures greatly increases compactability.

Stability

The ability of concrete to remain a stable, homogeneous mass without segregation both during handling and during vibrations is termed as stability.

Segregation

It can be defined as separating out of the ingredients of a concrete mix, so that the mix is no longer in a homogeneous condition. Only the stable homogeneous mix can be fully compacted. It can be minimized by adding small quantity of water which improves the cohesion of the mix.

Bleeding

It is due to the rise of water in the mix to the surface because of the inability of the solid particles in the mix to hold all the particles under the effect of compaction. The bleeding causes formation of a porous, weak and non durable concrete layer at the top of placed concrete.

Curing

Curing means maintaining a satisfactory moisture content and temperature in concrete in order to achieve the desired strength and hardness. Drying removes the water needed for hydration. Without adequate water and due to insufficient hydration, concrete tends to be weak. Temperature is an important parameter to consider for proper curing.

History and importance of Sludge

Paper making generally produces a large amount of solid waste. Paper fibres can be recycled only a limited number of times before they become weak to make high quality paper. This paper mill sludge consumes a large percentage of local landfill space for each and every year. To reduce disposal and pollution problems from these industrial wastes, it is most essential to develop profitable building materials from them. The amount of sludge generated by a recycled paper mill is greatly dependent on the type of furnish being used and end product being manufactured

Need for the present study:

This study includes different concrete mixtures were produced to determine the influence of hypo sludge. It is very essential to dispose these wastes safely without affecting health of human being, environment, fertile land, sources of water bodies, etc. These wastes have number of impurities which adversely affect the strength, durability, and other properties of building materials based on them. Paper producing industries produce a large amount of solid waste. For achieving high quality paper, the fibers which are used a limited number of times till they reach their weak stage. Many companies burn their sludge in incinerators which leads towards air pollution. So the paper presents the management of the wastes coming from paper industries.

Objectives of the present study:

To reduce disposal and pollution problems emanating from these industrial wastes, it is most essential to develop profitable building materials from them. Keeping this in view, investigations were undertaken to produce low cost concrete by blending various ratios of cement with hypo sludge. This project is concerned with experimental investigation on strength of concrete and optimum percentage of the partial replacement by replacing cement via 10%, 20%, 30%, and 40% of Hypo Sludge.

Literature Review

General

In the previous chapter the history and developments of its subsequent technologies were presented. In addition to the above the main use of hyper sludge and its use, properties and role in the civil engineering materials was discussed thoroughly .In the present chapter the review of literature survey on the hyper sludge and previous works in India and elsewhere were presented.

Earlier Studies on Hyper Sludge

Malhotra et.al (1998) pointed out that the worldwide production of cement accounts for almost 7percent of the total world CO2 production" based on the following figures: 1995 cement production at 1.4 billion tons, CO2 emissions at 1 ton per ton of cement; and 1995 global CO2 emissions at 21.6 billion tons.

Wilson and Alex (1993) Reported that cement production now accounts for more than 1.6 billion tons of CO2-over 8 percent of total CO2 emissions from all human activities." This was based on the following figures: cement production at 1.25 billion tons, CO2 emissions at 1.25 tons per ton of cement, and global CO2 emissions of 20 billion tons. This article takes a look at how these materials are made, and then reviews a number of environmental considerations relating to their production, use, and eventual disposal.

Ganesan et. al (2005) revealed that Over 330 million tons of industrial wastes are being produced per annum by chemical and agricultural process in India. Paper making generally produces a large amount of solid waste. It means that the broken, low- quality paper fibers are separated out to become waste sludge. This paper mill sludge consumes a large percentage of local landfill space every year and also contributes to serious air pollution problems. To reduce disposal and pollution problems emanating from these industrial wastes, it is most essential to develop profitable building materials from them.

Mehta et.al (2001) said that environmental impact of concrete; it is helpful to have a general understanding of how current environmental problems relate to technology choices. Let us assume that environmental damage (D) is a function of three interlinked factors that are expressed mathematically as follows:

$$D = f(P \times I \times W)$$

Where P stands for population, I is an index of industrial and urban growth, and W an indicator of the degree to which a culture promotes wasteful consumption of natural resources. The exponential and unsustainable forecast of CO2 emissions during the 21st century is based on an estimate of population increase from 6 to 9 billion, a corresponding growth in industrial development and urbanization that would result in three-fourths of the earth's inhabitants living in urban communities, and assuming little or no change in today's wasteful consumption pattern of natural resources. As (W) has a multiplier effect on the environmentaldamage, we can control the degree of damage by controlling this factor.

Meyer et.al (1999) conducted a study on concrete is by far the most widely used construction material worldwide. Its huge popularity is the result of a number of well-known advantages, such as low cost, general availability, and wide applicability. But this popularity of concrete also carries with it a great environmental cost. The billions of tons of natural materials mined and processed each year, by their sheer volume, are bound to leave a substantial mark on the environment. Most damaging are the enormous amounts of energy required to produce Portland cement as well as the large quantities of CO2 released into the atmosphere in the process. This paper summarizes the various efforts underway to improve the environmental friendliness of concrete to make it suitable as a "Green Building" material. Foremost and most successful in this regard is the use suitable substitutes for Portland cement, especially those that are byproducts of industrial processes, like fly ash, ground granulated blast furnace slag, and silica fume. Also efforts to use suitable recycled materials as substitutes for concrete aggregate are gaining in importance, such as recycled concrete aggregate, post-consumer glass, tires, etc.

Hypo sludge

HYPO SLUDGE

Energy plays a crucial role in the growth of developing countries like India. In the context of low availability of non-renewable energy resources coupled with the requirements of large quantities of energy for building materials like cement, the importance of using industrial waste is very important. While producing paper various wastes are comes out from the various processes in paper industries. The preliminary waste from paper industry is named as hypo sludge. The hypo sludge contains, low calcium, maximum calcium chloride and minimum amount of silica. Hypo sludge behaves like cement because of silica and magnesium properties. This silica improves the setting of the concrete.

For this, the hypo sludge is used as supplementary cementitious material for partial replacement in the concrete as high performance. By utilizing this waste the strength will be increased and also cost reduction in the concrete is achieved.

Figure 3.1Raw hypo sludge disposal

Properties of Hypo Sludge:

The following tables shows the hypo sludge chemical properties and the comparison between cement and hypo sludge.

EXPRIEMENTAL ANALYASIS

EXPERIMENTAL ANALYSIS ON CONSTITUENTS OF CONCRETE

It includes the various tests on constituents of concrete i.e., on

(1)Aggregate

(i)Sieve analysis

(ii)Specific gravity of aggregate

(iii)Mechanical properties of aggregate

(2)Cement

(i)Specific gravity of cement

(ii)Fineness of cement

(iii)Normal consistency of cement

(iv)Initial final setting time of cement

(v)Compressive strength of cement

(vi)Slump test

TESTS ON AGGREGATE

SIEVE ANALYSIS

Significance: Sieve analysis allows the determination of the distribution of particles sizes in granular materials. Since many separation processes and reactions depend on the amount of surface area relative to mass and that ratio increases as particle size decreases, knowing the distribution of sizes can be very important. Particle size distribution can also be important when using slurries to move particulates from one place to another.

For coarse aggregate IS sieves of 12mm and 20mm are used. The Arrangement of set of sieves are in such a way that each sieve is finer than the one above and coarse than the one below and placing the collecting pan under the finest sieve and a lid over the top sieve.

Figure 3.1Raw hypo sludge disposal

Sl .No	Constituents	% Present of Hypo Sludge
1	Moisture	56.8
2	Magnesium oxide (MgO)	03.3
3	Calcium oxide (CaO)	46.2
4	Acid insoluble	11.1
5	Silica (SiO_2)	09.0

Table 3.1 Properties of Raw Hypo Sludge

COMPRESSIVE STRENGTH OF CEMENT

In the study of strength of materials, the compressive strength is the capacity of a material or structure to withstand loads tending to reduce size. It can be measured by plotting applied force against deformation in a testing machine. Some material fracture at their compressive strength limit; others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load. Compressive strength is a key value for design of structures. Compressive strength is often measured on a universal testing machine. The ultimate compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compressive strength is usually obtained experimentally by means of a compressive test

Observation and Calculation:

Weight of cement = 200gms

Weight of sand = 600gms

Amount of water to be added is (P/4 + 3) % of wt of cement + wt of sand = 84ml.

Compressive strength of cement = load/ Area

Result: Therefore the compressive strength of cement after 7 days on an average of 3 cubes is 39N/mm2.

SLUMP TEST

The concrete slump test is an empirical test that measures the workability of fresh concrete. More specifically, it measures the consistency of the concrete in that specific batch. This test is performed to check the consistency of freshly made concrete. Consistency is a term very closely related to workability. It is a term which describes the state of fresh concrete. It refers to the ease with which the concrete flows. It is used to indicate the degree of wetness. Workability of concrete is mainly affected by consistency i.e. wetter mixes will be more workable than drier mixes, but concrete of the same consistency may vary in workability. It is also used to determine consistency between individual batches.

•Principle: The slump test result is a measure of the behavior of a compacted inverted cone of concrete under the action of gravity. It measures the consistency or the wetness of concrete.

•Limitations: The slump test is suitable for slumps of medium to high workability, slump in the range of 25 – 125 mm; the test fails to determine the difference in workability in stiff mixes which have zero slumps, or for wet mixes that give a collapse slump. It is limited to concrete formed of aggregates of less than 38 mm (1.5 inch).

Observation and Calculation:

Proportions of concrete mix = M20

Cement = 10kgs

Fine Aggregate = 15kgs

Fine Aggregate = 30kgs

Water = 0.5% of cement

Height of concrete before subsidence = 300mm

Height of concrete after subsidence = 170mm Slump value of concrete = 130mm

Result: The slump value of concrete is 130mm

APPARATUS USED FOR EXPERIMENTAL ANALYSIS

Fig - 4.1 slump test apparatus

Fig - 4.2 vicat apparatus

The slump test apparatus are used for determination of slump of fresh concrete mix as a measure of its consistency. The apparatus comprises the following:

•Slump cone 100 mm diameter at the top, 200 mm diameter at the bottom and 300 mm high with two cleats and lifting handles.

•Base plate with clamping arrangement for the slump cone and a swivel handle which also serves as the datum for measuring the slump.

•Tamping rod 1.6 cm diameter and 60 cm long with one end rounded and graduated from 0 to 15 cm in 0.5 cm spacing to measure the slump.

The Vicat apparatus is used for determination of normal consistency of hydraulic cement, gypsum plaster and lime and setting time of cement, gypsum plaster and gypsum concrete. These consist of the following:

•A frame with a vertically moving bearing rod.

•Mould in the form of frustum of a cone 70 mm bottom diameter, 60 mm top diameter and 40 m high with base plate.

•Needle 1 mm diameter x 50 mm long.

•Plunger 10 mm diameter x 50 mm long.

•Plunger 19 mm diameter x 44.4 mm long.

Fig - 4.3 sieve analysis apparatus

Fig - 4.4 Impact testing machine

A sieve analysis test is a practice or procedure used to assess the particle size distribution of a granular material. It consists of a sieve set of size 4.75mm, 2.36mm, 1.18mm, 0.6mm, 0.425mm, 0.3mm, 0.15mm, 0.075mm, lid and collecting pan

The impact testing machine is used to measure the resistance of aggregate to impact or sudden shock.

Fig - 4.5 cube mould 70.6mm

Fig - 4.6 cube mould 150mm

The cube mould 70.6mm X 70.6mm is used for casting the cement moulds.

The cube mould 150mm X 150mm is used for casting the concrete moulds.

The vibrating machine is used for compacting the concrete and cement cube moulds.

The compression testing machine is used for determination of compressive strength of cement and concrete.

Fig - 4.7 vibrating machine

Fig - 4.8 weighing balance

Fig - 4.9 compression testing machine

•Capacity : 2000 kN

RESULTS AND ANALYSIS

RESULTS AND ANALYSIS

It includes analysis on

(i)Results

(ii)Graphical interpretation

(iii)Mix design

(iv)Cost Analysis

TEST RESULTS

Compressive strength of 15cm X 15cm concrete cubes

Table - 6.1 Compressive strength of cubes at 14 days

Compressive strength of cubes at 14 days				
Partial replacement of hypo sludge in %	No of Cubes	Initial Crack Load(kN)	Ultimate crushing Load(kN)	Ultimate Compressive Strength (N/mm²)
0	3	163	392	17.20
10	3	184	401	17.80
20	3	192	423	18.87
30	3	224	453	20.07
40	3	145	345	15.33
50	3	135	295	13.11

Table - 6.2 Compressive strength of cubes at 28 days

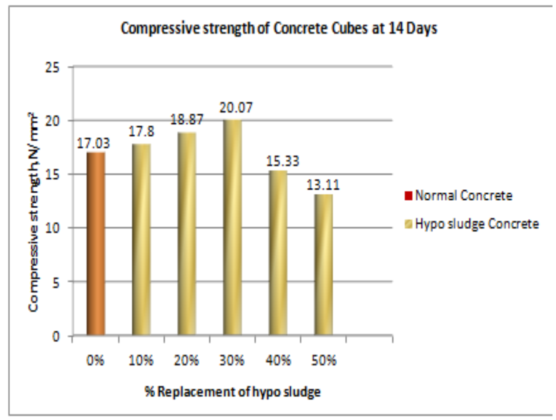
Compressive strength of cubes at 28 days				
Partial replacement of hypo sludge in %	No of Cubes	Initial Crack Load(kN)	Ultimate crushing Load(kN)	Ultimate Compressive Strength (N/mm²)
0	3	181	498	22.14
10	3	199	522	23.18
20	3	230	537	23.85
30	3	255	567	25.18
40	3	160	420	18.70
50	3	145	379	16.81

1) It is observed that hypo sludge concrete with (90% + 10%) proportion of (HS+C) shows higher compressive strength compared to the conventional concrete. The percentage increase in strength as compared to conventional concrete is 4.7%

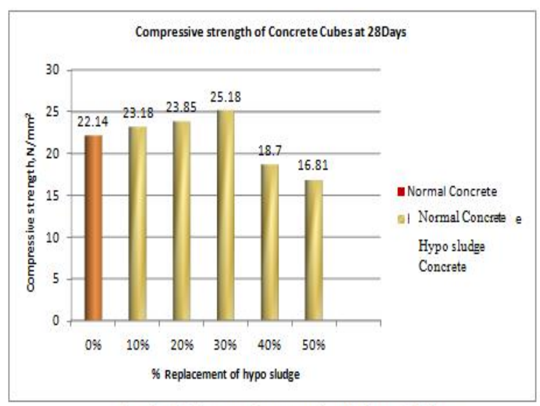
2) It is observed that hypo sludge concrete with (80% + 20%) proportion of (HS+C) shows higher compressive strength compared to the conventional concrete. The percentage increase in strength as compared to conventional concrete is 7.7 %

3) It is observed that hypo sludge concrete with (70% + 30%) proportion of (HS+C) shows higher compressive strength compared to the conventional concrete. The percentage increase in strength as compared to conventional concrete is 13.7 %

4) It is observed that hypo sludge concrete with (60% + 40%) proportion of (HS+C) shows higher compressive strength compared to the conventional concrete. The percentage decrease in strength as compared to conventional concrete is 15.5%



Graph - 6.1 Compressive strength of cubes at 14 days



Graph - 6.2 Compressive strength of cubes at 28 days

CONCLUSIONS

Based on experimental investigation on the "compressive strength of concrete" and considering the "environmental aspects" the following observations are made regarding the resistance of partially replaced hypo sludge.

- From the observation of graphs of compressive strength of concrete, replacement of cement with the hypo sludge material provides maximum compressive strength at 30% replacement.
- Environmental effects can be minimized and the usage of cement can be minimized through this project
- It is observed that the density of hypo sludge concrete is less compared to that of normal concrete. Therefore hypo sludge concrete can be used as lightweight concrete
- This material can be used for construction of temporary shelters during natural calamities.
- But in economy point of view, the cost of concrete can be reduced by replacing cement with hypo sludge. As per IS 456-2000 the cost of normal concrete can be reduced up to 445/m3 for M20 mix by replacement of cement with 30% hypo sludge.
- More important, that the concept of Green Building and sustainable development principles, which will modify the whole picture in favor of the environment. Advances in concrete research have demonstrated that it is possible to coordinate these two developments, thereby minimizing the need for vast additional cement production capacity and creating that balancing act of sustainable development on a global scale.
- The concrete industry, which uses vast amounts of energy and natural resources and contributes to generation of CO_2, can improve its record with an increased reliance on recycled materials and in particular by replacing larges percentages of Portland cement by byproducts of industrial processes. Substitution of waste materials will conserve resources, and will avoid environmental and ecological damages. But let us now all work together to keep our planet livable.

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