

# Experimental Investigation on Hypo Sludge Concrete by Using Sikacrete

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**ABSTRACT:** In Existing System, High quantity of waste is contributed by paper industry. To reduce disposal and pollution problems emanating from these industrial wastes, it is most essential to develop profitable building materials from them. Based on this project, to avoid those problems. Hypo sludge is a recent arrival among cementations materials. It was originally introduced as artificial pozzolana while producing paper the various wastes are comes out from the various processes in paper industries. Concrete has attained the status of a major building material in all the branches of modern construction. The Sikacrete molecule also contains two ring groups at its centre which are able to absorb both mechanical and thermal stresses better than linear groups and therefore give the Sikacrete very good stiffness, toughness and heat resistant properties. 1000mm X 150mm X 150mm RCC beams were casting using M<sub>20</sub> grade concrete. Specimens with ordinary Portland cement (OPC) and OPC replaced with hypo sludge at 5%, 10%, 15% and 20% levels and add 50ml sikacrete admixture constants were cast. During casting the RCC beams were mechanically vibrated by using a table vibrator. After 24 hours, the specimens were removed from the mould and subjected to water curing for 28<sup>th</sup> days. After curing, the specimens were tested for flexural strength using a calibrated loading frame testing machine. Flexural strength, also known as modulus of rupture, bend strength, or fracture strength, a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a rod specimen having either a circular or rectangular cross-section is bent until fracture using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress. The Flexural strength increases as the curing period increasing and also decreasing deflection in mm for M20 grade concrete, Flexural strength is increase with 15% replacement finally hypo sludge 15% replaced cement in Phase II.

**KEYWORDS:** Hypo Sludge , Sikacrete, , Cement, OPC, RCC, Fine Aggregate, Coarse Aggregate.

## I. INTRODUCTION

Concrete has attained the status of a major building material in all the branches of modern construction. It is difficult to point out another material of construction which is as variable as concrete. Concrete is the best material of choice where power, robustness, impermeability, fire resistance and absorption resistance are required. The shiny finish on glossy magazine-type paper is produced using a fine kaolin clay coating, which also becomes solid waste during recycling. This hypo sludge consumes a large percentage of local landfill space for each and every year. Worse yet, some of the wastes are land spread on cropland as a disposal technique, raising concerns about trace contaminants building up in soil or running off into area lakes and streams. Some companies burn their sludge in incinerators, contributing to our 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. Keeping this in view, investigations were undertaken to produce low cost concrete by blending various ratios of cement with hypo sludge. Paper making generally produces a large amount of solid waste. Paper fibers' can be recycled only a limited number of times before they become too short or weak to make high quality paper. It means that the broken, low- quality paper

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fibers are separated out to become waste sludge. All the inks, dyes, coatings, pigments, staples and “stickiest” (tape, plastic films, etc.) are also washed off the recycled fibers to join the waste solids.

## 1.2 HYPO SLUDGE

Hypo sludge (paper industry waste) has a tremendous potential in this context and it is well documented that the use of hypo sludge in concrete results in a significant improvement in the rheological properties. Hypo sludge is a recent arrival among cementation materials. It was originally introduced as artificial pozzolana while producing paper. The various wastes that come out from the various processes in paper industries. From the preliminary waste named as hypo sludge due to its low calcium is taken out for our project to replace the cement utilization in concrete. Paper making industries generally produce a large amount of solid waste. Paper fibers can be recycled only a limited number of times before they become too short or weak to make high quality paper. From the paper manufacturing process three types of sludge are obtained namely lime sludge (Hypo sludge and De-Inking sludge). In our project we have utilized lime sludge as a replacement for cement. Lime sludge (Hypo sludge) is a material obtained from the chemical recovery process of paper production. Hypo sludge is available abundantly worldwide, but its usage to date is very limited. Each Indian mill produces an average 40 over-dry tones of sludge per day. Where, this hypo sludge contains, low calcium and maximum calcium chloride and minimum amount of silica. Hypo sludge behaves like cement because of silica and magnesium properties. This silica and magnesium improve the setting of the concrete.

### 1.2.1 Need for Hypo Sludge Utilization

While producing paper the various wastes that come out from the various processes in paper industries. From the preliminary waste named as hypo sludge, due to its low calcium is taken out for our project to replace the cement utilization in concrete. Due to the cement production green house gases are emitted in the atmosphere. For producing 4 million t of cement, 1 million t green house gases are emitted. Also, to reduce the environmental degradation, this sludge has been avoided in mass level disposal in land. To eliminate the ozone layer depletion, production of cement becomes reduced. For this, the hypo sludge is used as partial replacement in the concrete as high performance concrete. By utilizing this waste the strength will be increased and also cost reduction in the concrete is achieved.

## 1.3 CEMENT

The products of hydration form of viscous cement paste, which coats the aggregate surfaces and fills some of the void spaces between the aggregate pieces. The cement paste loses consistency (‘stiffens’) on account of gradual loss of free water, through adsorption and evaporation, and subsequently ‘sets’, transforming the mixture into a solid mass. If the consistency of the cement paste is either excessively ‘harsh’ or excessively ‘wet’, there is a danger of segregation, the aggregate tends to separate out of the mix.

The most common type of hydraulic cement used in the manufacture of concrete is known as Portland cement, which is available in various forms. Portland cement is made by burning together, to about 1400 degree Celsius, intimate mixture (in the form of slurry) of lime stone with alumina-, silica and iron oxide-bearing. The type of cement that could be made only by varying the relative proportion of the oxide compositions, were not found to be sufficient. Resources have been taken to add one or two more new materials, known as additives, to the clinkers at the time of grinding, or to the use of entirely different basic raw materials in the manufacture of cement.

## 1.4 FINE AGGREGATE

Specifications for sand to be suitable for the concrete are that it should be free from all these injurious materials. Further the percentage of the clay and silt content are restricted to maximum 5% and it should be free from organic impurities such as tannin acid derived surface vegetation. Sand are classified according to the source such as river sand, pit sand, sea sand etc.

## 1.5 COARSE AGGREGATE

These igneous rocks are fine grained, strong and dense formed by the cooling of parts of the bodies molten material which is called general Basalt are more common igneous rocks. Aggregate developed by crushing of

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these rocks are black in color and very common used for concrete work also known as black trap. Sedimentary rocks also called derivative rocks were deposited in some geological age mechanically through the agency of water, wind or ice action chemically or organically. These rocks cover about three quarters of the earth's land surface, sandstone is one of its types used in concrete production being hard and durable. Sandstone in the forms of strips is also used in slab construction. Metamorphic rocks are formed from igneous or sedimentary rocks. The igneous crust where they are upon by great heat and pressure because of these agencies rock are also partly or wholly changed and new is formed.

## 1.7 SIKACRETE

Sikacrete are formed from a long chain molecular structure similar to Sikacrete with reactive sites at either end. In the epoxy resin, however, these reactive sites are formed by Sikacrete groups instead of ester groups. The absence of ester groups means that the Sikacrete has particularly good water resistance. The Sikacrete molecule also contains two ring groups at its centre which are able to absorb both mechanical and thermal stresses better than linear groups and therefore give the Sikacrete very good stiffness, toughness and heat resistant properties. The concrete industry is the largest consumer of virgin materials such as sand, gravel, crushed rock, and fresh water. It is consuming Portland and modified Portland cements at an annual rate of about 1.6 billion metric tons. The cement production consumes vast amounts of limestone and clay besides being energy-intensive. Obviously, large amounts of energy and materials, in addition to financial resources, are wasted when structures deteriorate or fail prematurely which, in fact, has been the case with many recently built reinforced concrete bridge decks, parking garages, and marine structures throughout the world.

## II. PROPERTIES OF MATERIALS

### 2.3.1 SPECIFIC GRAVITY OF CEMENT

Specific gravity is defined as the ratio of the weight of a given volume of a substance to the weight of an equal volume of some reference substance, or, equivalently, the ratio of the masses of equal volumes of the two substances. Specific bottle is used determining the specific gravity of cement. The empty specific gravity bottle is weighed as  $W_1$  gram. The bottle is filled is filled one third quantity of cement and weighed as  $W_2$  grams. And then the bottle is filled with kerosene and stirred well to remove the air voids and then weighed as  $W_3$  grams. Clean the bottle and filled kerosene up to the neck portion of the bottle and weighed as  $W_4$  grams. Specific gravity of the cement was calculated from the following formula.

$$\text{Specific gravity of cement} = \frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)}$$

Sl.No.	Description	Trial 1	Trial 2	Trial 3
1	Weight of empty bottle $W_1$ (g)	49	49	49
2	Weight of bottle + Cement $W_2$ (g)	76.5	77	77.5
3	Weight of bottle + Cement + Kerosene $W_3$ (g)	146	146	146
4	Weight of bottle + Kerosene $W_4$ (g)	127	126.5	126
5	Specific Gravity	3.23	3.19	3.29

**Table 4.1 Specific Gravity of Cement**

Average Specific gravity of cement = 3.21

### 2.3.2 FINENESS OF CEMENT

Fineness of cement indicates the amount of grindings done on the cement. It has an important bearing on the rate of hydration. 100 grams of cement is taken in a standard IS Sieve No 90 $\mu$ . The air which get lump is broken down and the material is sieved continuously for 15 minutes using sieve shaker. The residue left on the sieve is weighed.

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Percentage of residue left on the sieve = (Weight retained / Weight taken) × 100

Sl.No:	Observation	Sample 1	Sample 2	Sample 3
1	Weight of sample taken	100	100	100
2	Weight of material retained after sieving	2	2.5	2.3
3	% of residue left on the Sieve No 90 $\mu$	2	2.5	2.3

**Table 4.2 Fineness of Cement**

Fineness of Cement = 2.6%

### 2.3.3 STANDARD CONSISTENCY OF CEMENT

Using Vicat apparatus the standard consistency of cement was found. Consistency is a general term to indicate the degree of fluidity or the degree of mobility. 400gms of cement is taken and a paste with a weight quantity of water (say 24%) is prepared. The paste is filled in the mould within 3 to 5 minutes. The mould is shook well to exit air. A standard plunger of 10mm diameter and 50mm long is attached to the Vicat Apparatus and brought down to touch the surface of the paste in the test block and is quickly released to sink into the paste by its own weight. The depth of penetration of the plunger is noted. The second trail is conducted by adding 25% of water and the depth of penetration is noted. Similarly, numbers of trails were conducted, till the plunger penetrates to a depth of 33mm to 35mm. The particular percentage of water which allows the plunger to penetrate to a depth of 33mm to 35mm is the percentage of water required to produce the cement paste of standard consistency (P). Needle used: Plunger size 10mm diameter and 50mm length.

Trial No	Weight of cement (grams)	% of water added	Amount of water (ml)	Pointer reading from bottom(mm)
1	400	24	96	38
2	400	25	100	36
3	400	26	104	33
4	400	28	112	13
5	400	29	116	11
6	400	30	120	4

**Table 4.3 Standard Consistency of cement**

Standard consistency of cement paste = 30%

### 2.3.4 COMPARISON OF CEMENT AND HYPO SLUDGE

Sl. No	Constituent	Cement (In %)	Hypo Sludge (In %)
1.	Lime(CaO)	62	49.2
2.	Silica(SiO <sub>2</sub> )	22	18
3.	Alumina	5	3.6
4.	Magnesium	1	0.63
5.	Calcium sulphate	3	3.03
6.	Other	1	1.02

**Table 4.4 comparison of cement and Hypo Sludge**

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### 2.3.5 SPECIFIC GRAVITY OF FINE AGGREGATE

Sl.No.	Description	Trial 1	Trial 2	Trial 3
1	Weight of empty bottle $W_1$ (kg)	0.468	0.468	0.468
2	Weight of bottle + sand $W_2$ (kg)	0.838	0.854	0.835
3	Weight of bottle + sand + Water $W_3$ (kg)	1.460	1.480	1.475
4	Weight of bottle + Water $W_4$ (kg)	1.240	1.240	1.240
5	Specific Gravity	2.47	2.84	2.68

**Table 4.5 Specific Gravity of sand**

Average Specific gravity of sand = 2.58

### 2.3.6 FINENESS MODULUS OF FINE AGGREGATE

The sample be brought to an air-dry condition before weighing and sieving this may be achieved either by drying at room temperature or heating at a temperature of 100°C to 110°

The air-dry sample shall be weighed and sieved successively on the appropriate sieves starting with the largest size sieve. If sieving is carried out with rest of sieves on a machine not less than 10 minutes sieving will be required for each test.

Sl.No.	IS Sieve Size	Weight retained(g)	%of Weight retained	% of Weight passing	Cumulative % of Weight retained
1	4.75mm	28	2.8	97.20	2.56
2	2.36mm	0	0	100	2.80
3	1.18mm	312	31.2	68.80	34
4	600 $\mu$	84	8.4	91.60	42.40
5	300	228	22.8	77.20	65.20
6	150	206	20.6	79.40	85.80
7	Pan	136	13.6	86.40	100

Weight of sample taken = 1Kg

**Table 4.6 Fineness Modulus for sand**

Fineness modulus for sand = 2.56

### 2.3.7 AGGREGATE IMPACT TEST

It consists of aggregate size 10mm to 12.5mm. The aggregate should be dried by heating from 100 °C to 110 °C for a period of 4 hours and then cooled. The material is sieved through 12.5mm and 10mm IS sieves. The one which is retained on 10mm IS sieve comprises of the test materials the aggregate are filled to one-third depth of the cylindrical cup. The materials are compacted by giving 25 gentle blows with the round end of the tamping rod. Two more layers are added and the cylindrical cup is made full in the same manner. Surplus aggregates are struck off. The net weight of the aggregate is found out to the nearest grain. The sample is then transferred to the cup of the after impact testing machine and tapped 25 times with the rod. The impact machine is brought to test by weighing or placing upon the level plate block so that rigid hammer and the grid columns are vertical.

The cup is fixed firmly in position on the machine and the whole of the test sample is placed in it and compacted by giving 25 numbers of gentle blow with the tamping rod. The hammer is raised until the lower face is 380mm above the surface of the aggregate sample. Fifteen such blows are given at an interval not less than 1 second between falls. The crushed aggregate is removed from the cup and it is sieved through 2.36mm IS sieve until no further significant amount passes in 1 minute. The fraction passing through the sieve is weighed to an accuracy of 1 gm ( $W_2$ ).

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Trial	Weight of Aggregate		Aggregate impact value %
	Taken ( W <sub>1</sub> )gms	Passing through 2.36 mm in IS Sieve ( W <sub>2</sub> )gms	
1.	366	50	13.66
2.	357	53	14.84
3.	369	49	13.27

**Table 4.7 Aggregate impact value**

$$\text{Aggregate Impact Value} = \frac{100 * (W_2)}{W_1}$$

Aggregate impact value of Recycled coarse aggregate = 13.92%

### II.3.8 SIZE AND SHAPE OF COURSE AGGREGATE FLAKINESS INDEX

The flakiness index of aggregate is the percentage by weight of particles in it whose greatest dimension (Thickness) is less than 0.6 times of their mean dimension. The test is not applicable to sizes smaller than 6.3mm.

1. Take sufficient quantity of aggregates such that a minimum number of 280 pieces of any fraction can be tested.
2. Sieve the aggregate first in IS Sieve 63mm and collect the aggregates, which are passing throughout. Sieve these aggregates once again in IS Sieve 63mm.
3. Weigh the aggregates which are retained in the IS Sieve 63mm. Let it be W<sub>1</sub> gms.
4. Sieve the aggregates in IS Sieve 50mm. Gauge the aggregates which are retained in the IS sieve 50mm for thickness on the metal gauge (thickness gauge) in 33.90mm slot.
5. Collect the aggregates, which are passing in the gauge in a separate tray.
6. Repeat the same procedure (Steps 4 & 5) for the remaining aggregates according to the table given.
7. Weigh the aggregates, which are passed in the gauge, let it be W<sub>2</sub> gms.

Flakiness index of aggregates = 11%

### ELONGATION INDEX

The elongation index of aggregate is the percentage by weight of particles in it whose greatest dimension (Length) is less than 1.8 times of their mean dimension. The test is not applicable to sizes smaller than 6.3mm.

1. Take sufficient quantity of aggregates such that a minimum number of 200 pieces of any fraction can be tested.
2. Sieve the aggregate first in IS Sieve 50mm and collect the aggregates, which are passing throughout. Sieve these aggregates once again in IS Sieve 50mm.
3. Weigh the aggregates which are retained in the IS Sieve 50mm. Let it be W<sub>1</sub> gms.
4. Sieve the aggregates in IS Sieve 40mm. Gauge the aggregates which are retained in the IS sieve 40mm for thickness on the metal gauge (thickness gauge) in 81.00mm slot.
5. Collect the aggregates, which are passing in the gauge in a separate tray.
6. Repeat the same procedure (Steps 4 & 5) for the remaining aggregates according to the table given.
7. Weigh the aggregates, which are passed in the gauge, let it be W<sub>2</sub> gms.
8. Calculate the elongation index, which is taken as the total weight of material retained on the various length gauge expressed as a percentage of the total weight of sample gauged. Elongation index of aggregates = 13%



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## 2.4 MIX DESIGN

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative quantities with the object of producing as economically as possible concrete of certain minimum properties notably consistent strength and durability.<sup>2</sup>

### III. FACTORS IN THE CHOICE OF MIX PROPORTIONS

It may be convenient at this stage to restate the basic problem. We are to determine the proportion of cheapest concrete mix that will be satisfactory both in fresh and in hardened state. Using limits state method and followed by IS 456-2000. The design of an engineering structure must ensure that (1) under the worst loadings, the structure is safe, and (2) during normal working conditions the deformation of the member does not detract from the appearance, Durability or performance of the structure. The limit state method involves applying partial factors or safety, both to the loads and to the material strengths. The magnitude of the factors may be varied so that they may be used either with the plastic conditions in the ultimate state or with the more elastic stress range in the working loads.

#### REINFORCEMENT DETAILS OF BEAM:

- Provide Beam as 150 mm Width and 150 mm Overall Depth.
- Provide 2 nos of 10 mm dia Fe 415 bars as Tension Reinforcement.
- Provide 2 nos of 8 mm dia Fe 415 bars as Hanger Bars.
- Provide 6 mm dia bar of Fe 415 bars at 20 mm Centre to Centre as Two Legged Stirrups.
- 

#### DETAILS OF MIX PROPORTION

S.NO	CEMENT %	HYPO SLUDGE %	SIKACRETE (for 1cu.m)	FINE AGGREGATE %	COURSE AGGREGATE %
1	100	0	50ml	100	100
2	95	05	50ml	100	100
3	90	10	50ml	100	100
4	85	15	50ml	100	100
5	80	20	50ml	100	100

Table 4.8 Details of Mix Proportion

#### 4.5.1 Details of specimens

Test specimens used for the investigation are RCC beams specimens.

1. The dimension of the RCC Beams used is 1000 X 150 X150mm.
2. All the specimens used for investigation are of uniform size.

### IV. RESULTS AND DISCUSSIONS

#### 5.1 FLEXURAL STRENGTH TEST:

1000mm X 150mm X 150mm RCC beams were casting using M<sub>20</sub> grade concrete. Specimens with ordinary Portland cement (OPC) and OPC replaced with hypo sludge at 5%, 10%, 15% and 20% levels and add 50ml sikacrete admixture constants were cast. During casting the RCC beams were mechanically vibrated by using a table vibrator. After 24 hours, the specimens were removed from the mould and subjected to water curing for 28<sup>th</sup> days. After curing, the specimens were tested for flexural strength using a calibrated loading frame testing machine.

Flexural strength, also known as modulus of rupture, bend strength, or fracture strength, a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending

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test is most frequently employed, in which a rod specimen having either a circular or rectangular cross-section is bent until fracture using a [three point flexural test](#) technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress.

Flexural strength for RCC Beams =  $(3FL/2bd^2)$

F - Load force at the fracture point

L - Length of the Support Span

b - Width

d - Thickness

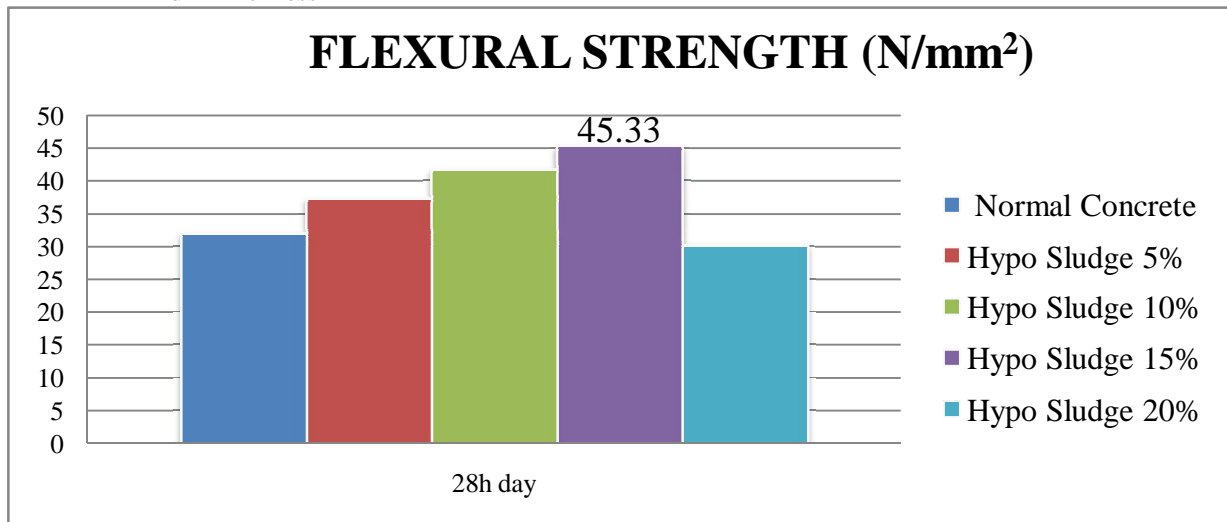


Figure 5.1 Flexural Strength (N/mm<sup>2</sup>) Bar Chart

### LINE CHART BETWEEN LOAD VS DEFLECTION:

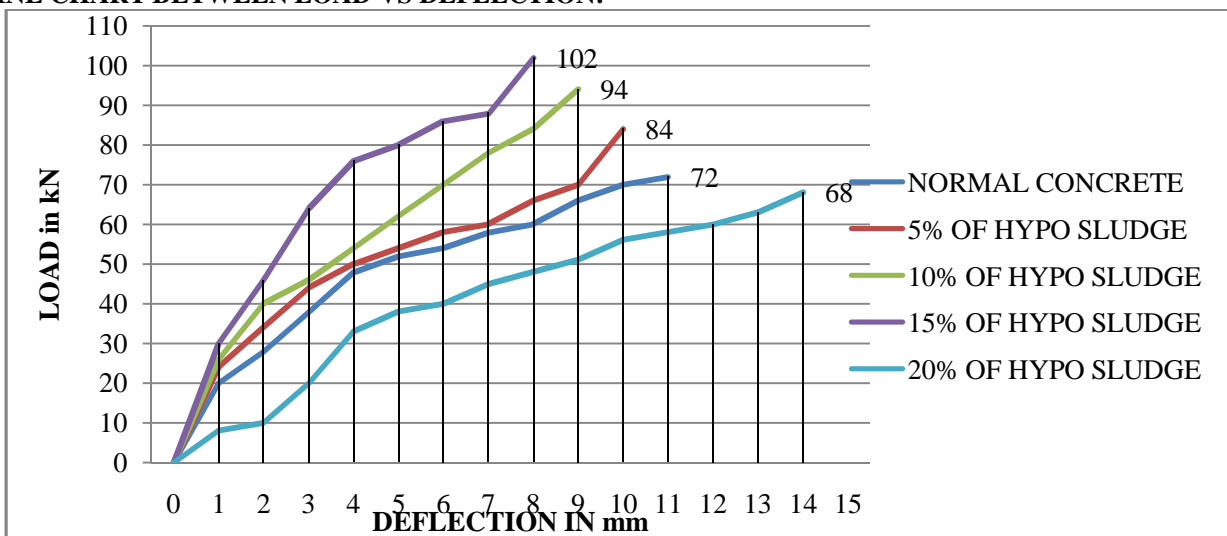


Figure 5.2 Deflection mm VS Load kN Line Chart



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## V. CONCLUSION

Casting of conventional RCC Beams has been done Casting of concrete beams added with paper industrial waste (HYPO SLUDGE ) has also been done Comparison of results has been done Testing of RCC beams with various methods like loading frame test has been done for both RCC beams Up to 15% of hypo sludge concrete, the Flexural strength has been increased, so up to 15% cement has been replaced by hypo sludge compression test of concrete with various mixes with different curing periods which are 28 days by partial replacement of cement with hypo sludge that is 0%, 5%, 10%, 15% ,20% and 50ml sikacrete added which are noted. The Flexural strength increases as the curing period increasing and also decreasing deflection in mm for M20 grade concrete, Flexural strength is increase with 15% replacement finally hypo sludge 15% replaced cement in Phase II.

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