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# An Experimental Study on Strength Parameters of Concrete with Replacement of Fine Aggregate by Robo Sand

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## ABSTRACT

***Concrete is the most widely used composite construction material. Fine aggregate plays a very important role for imparting better properties to concrete in its fresh and hardened state. Generally, river sand was used as fine aggregate for construction. Due to the continuous mining of sand from riverbed led to the depletion of river sand and it became a scarce material. Also, samining from river bed caused a lot of environmental issues. As a substitute to river sand, Robo sand has been used.***

***In this present experimental study a comparative study has been carried out to check the usability of Robo sand in place of natural sand. This study involves determination of some major properties of concrete like compressive strength, split tensile strength, flexural tensile strength.***

***Based on proposed studies, quality of Robo sand is equivalent to natural sand in many respects, such as cleanliness, grading, strength, angularity, specific gravity. Conclusion have been arrived that Robo sand produced from VSI(vertical shaft impactor) is a suitable and viable substitute to river sand and could be effectively used in making concrete which provides adequate strength and durability for the concrete.***

***In the design of concrete structures, concrete is taken into account by taking its compressive strength, Split tensile strength and flexural strength values. The compressive strength, Split tensile strength and flexural strength value of the concrete made of Robo sand is observed to be very nearer to the strength of the concrete made of natural sand in the present investigation, there by 100% replacement is reasonable.***

*Keywords:* ***Robo sand, crushes dust, vertical shaft impactor, Scarce material***

## INTRODUCTION

### 1.1 GENERAL

This chapter contains the general information about Robo sand, its origin, need of Robo in construction. It also includes the exact meaning of Robo sand, crushed dust, process of manufacturing by various machinery.

Natural sands are weathered and worn out particles of rock and are of various grades or size depending on the accounting of wearing. The main natural and cheapest resource of sand is river. Dams are constructed on every river hence these resources are erasing very fast. Now a day's good sand is not readily available, it should be transported from long distance. Those resources are also exhausting very rapidly [1].

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Sand is the one of main constituents of concrete making which is about 35%of volume of concrete used in construction industry. Natural sand is mainly excavated from river beds and always contain high percentage of in organic materials, chlorides, sulphates, silt and clay that adversely affect the strength, durability of concrete & reinforcing steel there by reducing the life of structure, when concrete is used for buildings in aggressive environments, marine structures, nuclear structures, tunnels, precast units, etc. Fine particles below 600 microns must be at least 30 % to 50% for making concrete will give good results. Normally these particles are not present in river sand up to required quantity. Digging sand, from river bed in excess quantity is hazardous to environment. The deep pits dug in the river bed, affects the ground water level.The sand in the mortar does not add any strength but it is used as an adulterant for economy and with the same it prevents the shrinkag and cracking of mortar in setting. The sand must be of proper gradation (it should have particles from 150µ to 4.75 mm in proper proportion). When fine particles are in proper proportion, the sand will have less voids. The cement required will be less when there will be less void in sand. Such Sand will be more economical. Only sand Robo by V.S.I. Crusher is cubical and angular in shape. Sand made by other types of machines is flaky ,which is troublesome in working.

There is no plasticity in the mortar. Hence the mason are not ready to work with machine made crushed stone sand. For the same reason inferior river sand may be used. Manufacturing sand from jaw crusher, cone crusher, roll crusher often contains high percentage of dust and have flaky particle. Flaky and angular particles may produce harsh concrete, and may result in spongy concrete. There is standard specification for Fine aggregates (Sand). It is divided in four gradations.

Generally known as Zone I, Zone II, Zone III and Zone IV. There is sieve Designation for each grade. Gradation is made as per the use of the sand .V.S.I can produce any zone of sand. But in case of natural sand quality varies from location to location without any control [2].

### 1.2 Robo sand:

“Robo sand is defined as a purpose made crushed fine aggregate produced from a suitable source material. Production generally involves Crushing, Screening and possibly Washing, separation into discrete fractions, recombining and blending.

At the beginning Robo sand produced (by Jaw crusher, cone crusher, roll crusher, hammer mill) contains flaky and elongated particles. But now Robo sand produced from V.S.I (vertical shaft impactor) is a suitable and viable substitute to river sand and could be effectively used in making concrete which provides adequate strength and durability for the concrete

Having cubical shape, it effectively provides good bonding in concrete. Grading of Robo sand can be controlled i.e required zone of sand can be obtained. Robo sand can be produced with zero fines. As it doesn’t contain silt and clay, setting properties of cement are not altered. For big projects where large quantity of aggregate is required, Plants are established near the site so that the cost of transportation can be reduced.[3]

### 1.3 Need for Robo sand:

The Civil engineers, Architects , Builders, Contractors agrees that the natural sand, which is available today, is deficient in many respect. It does not contains the fine particles, in proper proportion as required. Presence of other impurities such as coal, bones, shells, mica and silt etc makes it inferior for the use in cement concrete. The decay of these materials, due to weathering effect, shortens the life of the work. Now a days, Government have put ban on dragging sand from river bed.

Due to dragging of the sand,from river bed reduces the water head, so less percolation of rain water in ground, which result in lower ground water level. In some places it may be up to 600 ft deep. The roots of the tree may not be able to get water. The water flowing in the river may be covered with sand so it is less exposed to Sun. In the absence of sand, more water gets evaporated due to direct sunlight. The rain water flowing in the river

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contains more impurities. when it passes through sand bed it gets filtered. ( In water supply schemes the water is filtered in sand bed only) If there is no sand in river-bed, water will not be filtered. Such water may be harmful for drinking purpose. Reduced water level in ground, may result in draught, even scarcity of drinking water, so Government have to supply water by tanker.

Which is more expensive compared to the royalty collected for sand.[4]

## LITERAURE REVIEW

### 2.1 General

Misra(1984) studied the effect of complete replacement of sand with crushed sand (fine sand passing through 75μ). The percentage of water required to produce mortar of same consistency is high for Robo sand as compared to river sand of same grading and same mix proportions. Hudson (1999) reported that Concrete Robo with a high percentage of minus 75 micron material will yield a more cohesive mix than concrete made with typical natural sand. Giridhar (2000) have observed that the concrete prepared using crusher stone dust was found to be relatively less workable than those compared with river sand and for the concrete made with crusher dust, there is an increase of 6% strength split tension and an increase of 20% strength in flexural tensile tension at 28 days for M20 grade design mix.

Ratioet.al (2002) has found that as percentage of stone dust increases the workability decreases in each grade of concrete, to compensate the decrease in workability, some quantity of water and cement were added to get normal workability. The percentage of increase in water is in the range of 5% to7%. [5]

### 2.2 Experimental studies conducted by different researchers along with their study

Bhikshma et.al(2009) conducted tests on 30 concrete cubes and 10reinforced beams. They observed increase in compressive strengths by6.89%, 10.76%, 17.24% and 20.24% for replacements of 25%,50%,75% and100% of Robo sand. Having conducted different tests ULTRA TECH PVT LTD, arrived at increased in compressive strength values.

According to the report given by Venu et.al from BITS PILANI , Hyderabad the flexural strength of high performance concrete increases with increase insilica fume and Robo sand [6].

### 2.3 Literature survey on concrete

### 2.3.1 Concrete

Concrete is the most widely used human-made product in the World. In contrast to its internal complexity, versatility, durability, and economy, it has been the most extensively used construction material with a production over six billion tons every year. Concrete is used to make pavements, building structures, foundations, roads, overpasses, parking structures, brick/block walls and bases for gates, fences and poles. Concrete is primarily a proportionate mixture of aggregate, cement, and water [7].

### 2.4 Ingredients of Concrete

### 2.4.1 Cement

Cements may be defined as adhesive substances capable of uniting fragments or masses of solid mater to a compact whole. Portland cement was invented in 1824 by an English mason, Joseph Aspin, who named his product Portland cement because it produced a concrete that was of the same colour as natural stone on the Isle of Portland in the English Channel.

Raw materials for manufacturing cement consist of basically calcareous and siliceous (generally argillaceous) material. The mixture is heated to a high temperature within a rotating kiln to produce a complex group of chemicals, collectively called cement clinker. Cement is distinct from the ancient cement. It is termed hydraulic cement for its ability to set and harden under water. Briefly, the chemicals present in clinker are nominally the four major potential compounds and several minor compounds. The four major potential compounds are normally termed as Tricalcium silicate ($3CaO.SiO_2$), declaim silicate ($2CaO.SiO_2$), tricalcium aluminates ($3CaO.Al_2O_3$) and tetra calcium aluminoferrite ($4CaO. Al_2O_3.Fe_2O_3$) [8].

### 2.4.2 Coarse and Fine Aggregates

- All aggregates shall comply with the requirements of IS: 383-1970
- The nominal maximum size of coarse aggregate shall be as large as possible subject to the following
- In no case greater than one-fourth the minimum thickness of the member, provided that
- The concrete can be placed without difficulty so as to surround all prestressing tendons and reinforcements and fill the corners of the for m.
- It shall be 5 mm less than the spacing between the cables, strands or sheathings where provided
- Not more than 40 mm; aggregates having a maximum nominal size of 20 mm or smaller are generally considered satisfactory
- Coarse and fine aggregates shall be batched separately
- Specification for coarse and fine aggregates from natural sources for concrete second revision

### 2.4.3 Robo Sand

It is being called in the market with different names like Artificial sand(as it is artificially produced ), Robo sand(as it produced first by the company named Robo silicon ,pvt, limited) ,crushed sand (as it is produced from crushing),Rock sand ( as the origin is rock) [9].

### 2.4.4 Water

The requirements of water used for mixing and curing shall conform to the requirements given in IS: 456-2000. However use of sea water is prohibited.

## METHODOLOGIES

### 3.1 General

An experimental study is conducted to find 7 and 28 day Compressive, Split tensile and Flexural tests in M 40 grade concrete made of both Natural sand and Robo sand and the results were compared for drawing a conclusion.

Methodology and experimental work involves the tests required to ascertain the quality of materials for making concrete, designing the concrete mix, preparation of specimens and different standard methods for testing the concrete

### 3. 2 Materials

The materials used in this study were cement, fine aggregates (both natural sand and Robo sand) ,Coarse aggregates and water. The description of each of the material is described in the following sections.

### 3.3 Tests on Materials

### 3.3.1 Cement

Ordinary Portland cement of 53 grade available in local market is used in the investigation. The cement used has been tested for various properties as per IS:4031-1988 and found to be confirming to various specifications as per IS:12269-1987. [10]

### 3.3.1.1 Initial and Final setting time

We need to calculate the initial and final setting time as per IS: 4031 (Part 5) – 1988. To do so we need Vicar apparatus conforming to IS: 5513 – 1976, Balance, Gauging trowel conforming to IS: 10086 – 1982.

### Procedure to determine initial and final setting time of cement

- Take 500gms of Cement sample and gauging it with 0.85 times the water required to produce a Cement paste of standard consistency.
- Start a stop-watch, the moment water is added to the cement.
- Fill the Vicar mould completely with the cement paste gauged as above, the mould resting on a non-porous plate and smooth off the surface of the paste making it level with the top of the mould. The cement block thus prepared in the mould is the test block.
- The temperature of water and that of the test room, at the time of gauging shall be within 27ºC ± 2ºC. [11]

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### Initial setting time

Place the test block under the rod bearing the needle. Lower the needle gently in order to make contact with the surface of the cement paste and release quickly, allowing it to penetrate the test block. Repeat the procedure till the needle fails to pierce the test block to a point 5.0 ± 0.5mm measured from the bottom of the mould. The time period elapsing between the time, water is added to the cement and the time, the needle fails to pierce the test block by 5.0 ± 0.5mm measured from the bottom of the mould, is the initial setting time. [12]

### Final setting time

Replace the above needle by the one with by a circular attachment. The cement should be considered as finally set when, upon applying the needle gently to the surface of the test block, the needle makes an impression therein, while the attachment fails to do so. The period elapsing between the time, water is added to the cement and the time, the needle makes an impression on the surface of the test block, while the attachment fails to do so, is the final setting time. In other words the paste has attained such hardness that the centre needle does not pierce through the paste more than 0.5 mm. [13]

### 3.3.1.2 Consistency Test

The basic aim is to find out the water content required to produce a cement paste of standard consistency as specified by the IS: 4031 (Part 4) – 1988. The principle is that standard consistency of cement is that consistency at which the Vicar plunger penetrates to a point 5-7mm from the bottom of Vicar mould. [14]

**Apparatus –** Vicat apparatus conforming to IS: 5513 – 1976, Balance, Gauging trowel conforming to IS: 10086 – 1982.

### Procedure to determine consistency of cement

- Weigh approximately 400g of cement and mix it with a weighed quantity of water. The time of gauging should be between 3 to 5 minutes.
- Fill the Vicar mould with paste and level it with a trowel.
- Lower the plunger gently till it touches the cement surface.
- Release the plunger allowing it to sink into the paste.
- Note the reading on the gauge.
- Repeat the above procedure taking fresh samples of cement and different quantities of water until the reading on the gauge is 5 to 7mm

**Specific gravity:** It is the ratio between the weight of a given volume of material and weight of an equal volume of water. To determine the specific gravity of Cement, kerosene which does not react with cement is used.

**Apparatus:** Density bottle (or) Specific gravity bottle, Cement, weighing balance capable of weighing accurately up to 0.1gm, kerosene (free from water).

### Procedure to determine Specific gravity of cement:

- Weigh a clean and dry Specific gravity bottle with its stopper ($W_1$).
- Place a sample of cement up to two-third of the flask and weigh with its stopper ($W_2$).
- Add kerosene to the cement in the flask till it fills and weigh it ($W_3$).
- Mix thoroughly with glass rod to remove entrapped air.
- Empty the flask, clean it refill with clean kerosene and weigh ($W_4$). [15]

### Calculation:

$$\textit{Specific Gravity} = \frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)}$$

Where,

W1 = Weight of empty flask = 23gm
W2 = Weight of flask + Cement = 53 gm
W3 = Weight of flask + Cement + Kerosene = 82.5 gm
W4 = Weight of flask + Kerosene = 61 gm

### EXPERIMENTAL STUDIES

In this chapter, we focus on the procedures utilized for creating and testing concrete. To draw reasonable

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conclusions in regards to choosing appropriate mixture ratios for concrete, testing and experimentation must be conducted. Different strengths are determined by creating specimens of concrete and subjecting it to loadings until failure.

### 4.1 Lab Tests on Fresh Concrete

Each batch of concrete shall be tested for consistency immediately after mixing, by one of the methods described in IS: 1199-1959. The Methods are:

1. Slump Test- Workability
2. Compaction Factor

Provided that care is taken to ensure that no water or other material is lost, the concrete used for the consistency tests may be remixed with the remainder of batch before making the test specimens. The period of re-mixing shall be as short as possible yet sufficient to produce a homogeneous mass.

### 4.1.1 Slump Test – Workability

Slump test is used to determine the workability of fresh concrete. Slump test as per IS: 1199 – 1959 is followed. The apparatus used for doing slump test are Slump cone and tamping rod.

**Procedure to determine workability of fresh concrete by slump test:**

- The internal surface of the mould is thoroughly cleaned and applied with a light coat of oil.
- The mould is placed on a smooth, horizontal, rigid and non-absorbent surface.
- The mould is then filled in four layers with freshly mixed concrete, each approximately to one-fourth of the height of the mould.
- Each layer is tamped 25 times by the rounded end of the tamping rod (strokes are distributed evenly over the cross section).
- After the top layer is ridded, the concrete is struck off the level with a trowel.
- The mould is removed from the concrete immediately by raising it slowly in the vertical direction.
- The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured.
- This difference in height in mm is the slump of the concrete.

Fig 4.1.1 Slump Test

**Reporting of Results:**

The slump measured should be recorded in mm of subsidence of the specimen during the test. Any slump specimen, which collapses or shears off laterally, gives incorrect result and if this occurs, the test should be repeated with another sample. If in the repeat test also, the specimen shears, the slump should be measured and the fact that the specimen sheared, should be recorded.

### 4.1.2 Compaction Factor – Workability

Compacting factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test as per IS: 1199 – 1959. The apparatus used is Compacting factor apparatus.

**Procedure to determine workability of fresh concrete by compacting factor test:**

- Sample of concrete is placed in the upper hopper up to the brim.
- The trap-door is opened so that the concrete falls into the lower hopper.
- The trap-door of the lower hopper is opened and the concrete is allowed to fall into the cylinder.
- The excess concrete remaining above the top level of the cylinder is then cut off with the help of plane blades.

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- The concrete in the cylinder is weighed. This is known as weight of partially compacted concrete.
- The cylinder is filled with a fresh sample of concrete and vibrated to obtain full compaction. The concrete in the cylinder is weighed again. This weight is known as the weight of fully compacted concrete

**Compacting factor = (Weight of partially compacted concrete) / (Weight of fully compacted concrete)**

When maximum size of aggregate is large as compare with mean particle size the drop into bottom container will produce segregation and give unreliable comparison with other mixes of smaller maximum aggregate sizes.

The method of introducing concrete into mould bears no relationship to any of the more common methods of placing and compacting high concrete. Compaction factor test establishes the fact that with increase in the size of coarse aggregate the workability will decrease.

## Result Analyses

## Introduction

In this chapter, all the strength performance of various mixes containing two different types of fine aggregate (natural sand and robo sand) will be discussed. All the tests conducted were in accordance with the methods described in this chapter

The discussion will be divided into three sections according to objectives stated in the earlier parts. The results are to be discussed and analyzed accordingly to draw out the conclusion later. The three sections mentioned are:

I) Effect of robo sand concrete to Compression Strength, Tensile strength and Flexural strength.

ii) The optimum replacement level of natural sand with robo sand

iii) Comparison between Ordinary Concrete and robo sand concrete

### 5.2.1 COMPRESSIVE STRENGTH

In this section, the main concern is to study the compressive strength of concrete containing two different types of fine aggregate (natural sand and robo sand ) Control specimens are concrete with 100% replacement of fine aggregate (natural sand with robo sand)

Cubes with the size of 150 x 150 x 150 mm were tested at the ages of 7 and 28 days. The results of the compressive strength test are shown in Table No.- 4.4.1 .

From the graph shown in the Fig.5.2.1., 100 % replacement of fine aggregate (natural sand with robo sand)has been observed as an optimal strength than other proportions at 7and 28 days.

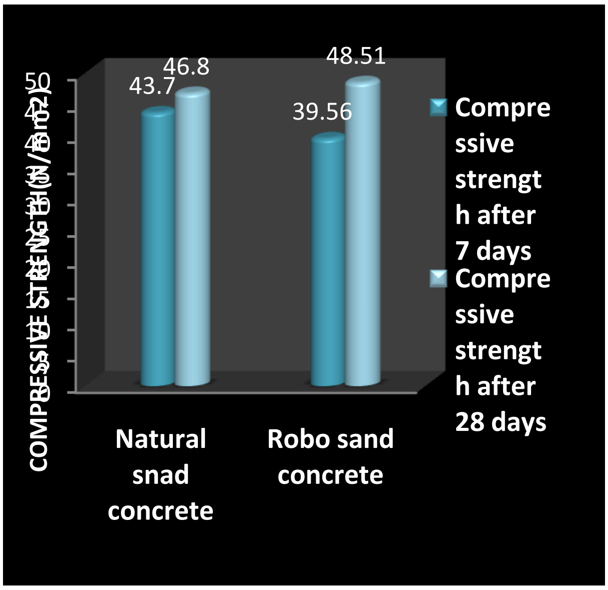


Fig 5.2.1. Graph showing Compression Strength of two types of concrete

### 5.2.2 Split Tensile Strength Test

In this section, the main concern is to study the spilt tensile strength of concrete containing two different types of fine aggregate (natural sand and robo sand ) Control specimens are concrete with 100% replacement of fine aggregate (natural sand with robo sand)

The Cylinder consist of 150 mm diameter and 300mm Long were tested at the ages of 7, and 28 days. The

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results of the Split tensile strength test are shown in Table No.- 4.4.2

From the graph shown in the Fig.5.2.2. 100 % replacement of fine aggregate (natural sand with robo sand) has been observed as an optimal strength than other proportions at 7and 28 days.

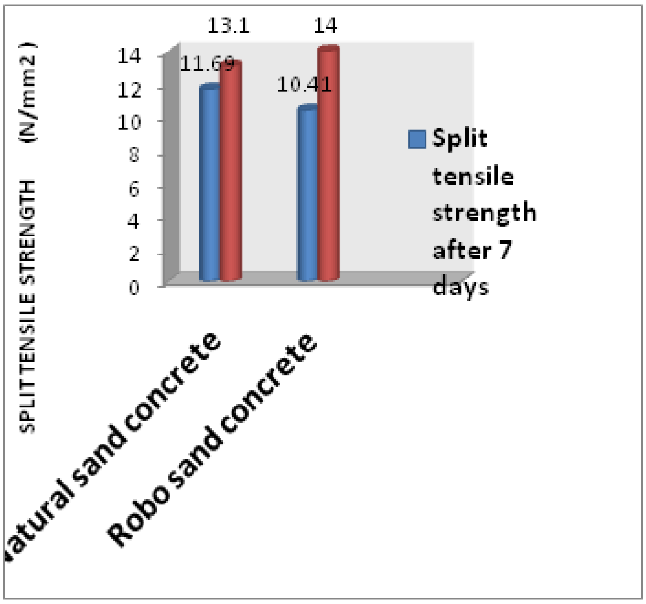


Fig 5.2.2 Graph showing Tensile Strength of two types of concrete

### 5.2.3 FLEXURAL STRENGTH TEST

In this section, the main concern is to study the flexural strength strength of concrete containing two different types of fine aggregate (natural sand and robo sand ) Control specimens are concrete with 100% replacement of fine aggregate (natural sand with robo sand).

The size of specimen shall be 10 × 10 × 50 cm. were tested at the ages of 7and 28 days. The results of the flexural strength test are shown in Table No.- 4.4.3 Where each value is averaged from the results of three cubes.

From the graph shown in the Fig.5.2.3., 100 % replacement of fine aggregate (natural sand with robo sand) has been observed as an optimal strength than other proportions at 7and 28 days.

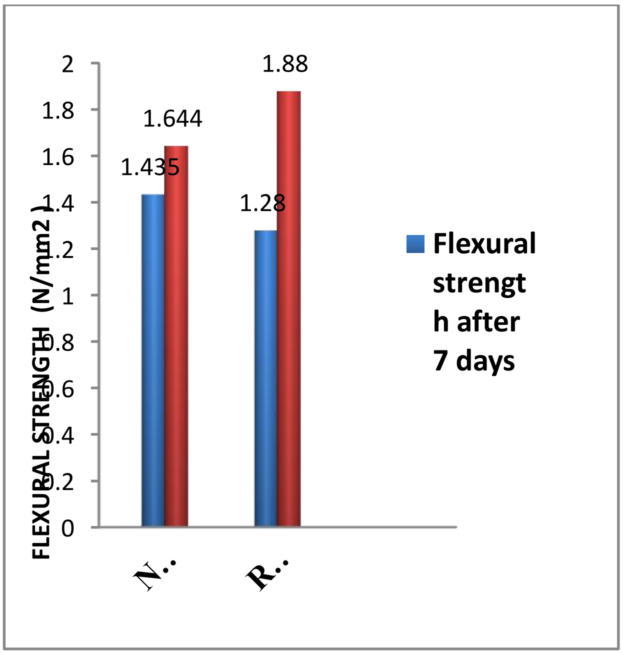


Fig 5.2.3 Graph showing Flexural Strength of two types of concrete

### CONCLUSIONS:

- 100% replacement is reasonable where there is low workability requirement. And where there is high workability requirement, partial replacement can bemade keeping in view the strength and economy.
- Strength criteria can be fully ascertained with 100% replacement of naturalsand with Robo sand.
- **MAY 2016** The Andhra Pradesh Government is seeking to encourage use of Robo sand, a natural sand substitute for use in the construction sector.
- For big projects like highways, establishing a plant leads to economy as theyrequire large amount of fine aggregate.
- River beds can be safeguarded by reducing the excavions for atnatural sand

### ENVIRONMENTAL CLEARANCE

Referring to the difficulties faced in providing new sites for quarrying, she said that the Government has applied for environmental clearance for 15 locations and expects to apply for clearances for 49 other sites.

## FUTURE SCOPE

- Replacing natural sand with different % of Robo sand so that clear variation of strength can be plotted as well as optimum amount can also be determined.
- Conducting investigation for M40, M50and also for high strength concrete.
- Conducting chloride penetration test and water absorption tests on concrete to ensure adequate durability.
- Suitability of Robo sand must be ascertained for plastering

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