



Quarry Mud as Partial Replacement for Fine Combination (Sand) in Concrete

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Abstract

Concrete production has resulted inside the accumulated that has to be compelled to confirm substitute material to sand as inside the assembly of concretes. Quarry mud, a by-product from the crushing methodology throughout production activities is one in each of such materials. Granite fines or rock mud can be a by-product obtained throughout crushing of granite rocks to boot observed as quarry mud. In recent days, there have been additionally several trials to use ash, academic degree industrial by product as partial replacement for cement to possess higher workability, future strength and to make the concrete lots of economically accessible. This gift work could be a trial to use Quarry mud as partial replacement for sand in concrete. Trials are created to review the properties of concrete and to research some properties of Quarry mud, the standard of those properties to alter them to be used partial replacement materials for sand in concrete.

Subject Areas

Civil Engineering

Keywords

Quarry Mud, Red Mud, Compressive Strength

1. Introduction

Concrete is that the foremost well-liked physical object inside the planet. However, the assembly of cement has diminished the stone reserves inside the planet and desires a decent consumption of energy. Watercourse sand has been the foremost trendy choice for the fine combination of a part of concrete within the past, but overuse of the material has semiconductor unit to environmental issues, the depleting of securable watercourse sand deposits and a concomitant

increment inside the fabric. Thus the quarry dirt has been planned as another watercourse sand that provides additional profit to concrete quarry dirt which is believed to increase the strength of concrete over concrete created with equal quantities of rivers sand, but it causes a reduction inside the workability of concrete.

2. Materials Used

2.1. Ordinary Cement

The cement that is used is of OPC fifty 3 grade as per the standard of the country [1] [2] and [3]. The cement in step with the Indian specification ought to satisfy the IS code IS 12269-1987 (reaffirmed 1999). Is commonest kind if cement usually use around the world, used as a basic ingredient of concrete, mortar, stucco, and most non-specialty grout.

It was developed from different sorts of hydraulic lime in European nation at intervals the center nineteenth century and generally originates from stone. In may be a fine power created by heating material terribly} very kitchen appliance to from what is spoken as clinker, grinding the clinker and adding small amounts of other materials. several sorts of cement square measure offered, with the foremost common being spoken as traditional cement (OPC) that's gray in color, but a white cement is in addition offered (Table 1).

2.2. Fine Combination

The natural fine combination are the watercourse sand that's that the foremost commonly used, but the recent social issue that created a shortage of the material created a wonderful disadvantage among the development sector [4] [5]. For the studies the watercourse sand of zone-II is utilized in all the references (Table 2).

2.3. Coarse Combination

The material that is maintained on IS sieve no. 4.75 is termed as a rough combination.

Table 1. Ordinary cement property.

SI. No.	Ordinary Cement Property		
	Property	Initial	Result
1	Normal consistency	NC	33%
2	Initial setting time	IST	30 min
3	Specific gravity	SG	3.15
4	Fines of cement	FC	3200 cm ² /gm

Table 2. Fine combination property.

SI. No.	Fine Combination Property		
	Property	Initial	Result
1	Specific gravity	SG	2.57
2	Fineness modulus	FM	2.28
3	Grading zone	GZ	II

The crushed stone is mostly used as a rough combination. The character of labor decides the most size of the coarse combination. Regionally out there coarse combination having the most size of 20 mm was employed in this work. The combinations were washed to get rid of dirt and dirt and were dried to surface dry condition. The combinations were tested as per IS: 383-1970 (**Table 3**).

3. Quarry Mud/Dust

The Quarry dirt is that the waste product collected from rock mines as are [they're] known as rock waste as these days this dirt was used for darting over recently paved road therefore on create the surface straightforward to usable these are fine sized particles that has identical properties as that compared to sand therefore this may be used for replacement the sand in concrete chosen from the closest supply as raw materials with none process of the dust from the quarry.

3.1. Origin of Quarry Dirt

The quarry dirt is that the waste product from rock mines because the blasting of rock produces smaller particles as waste this waste was utilized in covering the recently paved road. The finer the dirt what's from mines collected from close to by areas.

3.2. Blessings of Quarry Dirt

The specific gravity depends on the character of the rock from that it is processed and therefore the variation is a smaller amount. It's higher fines modulus therefore makes easier bonding between concrete.

3.3. Collection of Quarry Dirt

The quarry dirt is waste product from rock mine business close to pudukottai and tanjavur district wherever there square measure an outsized variety of rock mining business gift therefore there'll be enough merchandise out there for production as a reality we have a tendency to square measure assembling the dirt directly from the waste and conducting tests required for decisive the properties of it there'll great amount of dirt out there conjointly for big production. As we have a tendency to square measure assembling the merchandise because it state of nature with none testing's and admixtures square measure to that.

Table 3. Coarse aggregate property.

Sl. No.	Coarse Aggregate Property		
	Property	Initial	Result
1	Size	S	20 mm
2	Total water absorption	TWA	0.705%
3	Specific gravity	SG	2.74
4	Fineness modulus	FM	7.20

4. Would Like for the Replacement of Sand

Large scale efforts square measure needed for reducing the usage of the staple that square measure gift, so giant replacement is finished mistreatment the varied by-product material that square measure out there within the gift day. the opposite material that may be used is quarry dirt that is created whereas within the process of the granite stone into combination, this fashioned as a fine dirt within the crushers that method the aggregates The properties of concrete in contemporary and hardened state square measure the studied within the varied paper that square measure used as a reference for this. a number of the properties square measure workability, compressive strength square measure the most important one that square measure thought of.

4.1. Water

Water is a vital ingredient of concrete because it actively strength giving cement gel, the number and quality of water is needed to be looked into terribly carefully.

4.2. Physical and Chemical Properties

The physical and chemical properties of quarry dirt obtained by testing the sample as per the Indian standards square measure listed within **Table 4** & **Table 5**.

Table 4. Physical properties of quarry dust and natural sand.

Property	Physical properties of quarry dust and natural sand		
	Quarry <i>dust</i>	Natural sand	<i>Test method</i>
Specific gravity	2.54 - 2.60	2.60	IS 2386 (part III)-1963
Bulk density (kg/m ³)	1720 - 1810	1460	IS 2386 (part III)-1963
Absorption (%)	1.20 - 1.50	nil	IS 2386 (part III)-1963
Moisture content (%)	Nil	1.50	IS 2386 (part III)-1963
Fine particles less then 0.075 mm (%)	12 - 15	6	IS 2386 (part III)-1963
Sieve analysis	Zone-II	Zone-II	IS 383-1970

Table 5. Chemical properties of quarry dust and natural sand.

Constituents	Chemical properties of quarry dust and natural sand		
	Quarry <i>dust</i>	Natural sand	<i>Test method</i>
SiO ₂	62.48	80.78	IS 4032-1968
Al ₂ O ₃	18.72	10.52	IS 4032-1968
Fe ₂ O ₃	6.54	1.75	IS 4032-1968
CaO	4.83	3.21	IS 4032-1968
MgO	2.56	0.77	IS 4032-1968
Na ₂ O	Nil	1.37	IS 4032-1968
K ₂ O	3.18	1.23	IS 4032-1968
TiO ₂	1.21	Nil	IS 4032-1968
Loss of ignition	0.48	0.37	IS 4032-1968

4.3. Properties of Material

MATERIAL PROPERTIES

Crushed granite stone Max size: 20 mm;
 Specific gravity: 2.98;
 Fineness modules: 6.36;
 Density: 1.58 gm/cc;
 River sand Specific gravity: 2.53;
 Fineness modules: 3.08;
 Density: 1.63 gm/cc;
 Void ratio: 0.55;
 Quarry dust Specific gravity: 2.57;
 Fineness modules: 2.41;
 Density: 1.85 gm/cc;
 Void ratio: 0.42;
 Ordinary Portland cement Specific gravity: 3.05;
 Initial setting time: 30 min;
 Final setting time: 220 min;
 Fineness: 8% residue on IS 90 micro sieve.

5. Design Procedure

5.1. Mixing

Mixing of concrete desires careful condition to avoid segregation and therefore the problem of blending the materials uniformly. Increase within the ratio, volume proportion, size and amount of coarse combination intensity difficulties and balling tendencies.

The object of blending is that the concrete mass becomes homogenized and uniform in color and consistency. All the mixture particles ought to have a price of cement past and every one the ingredients of the concrete ought to mix into a regular mass.

Mixing of concrete could also be done by one in every of the traditional strategies of hand combination (or) machine combination. But it's necessary to own a regular dispersion and combination constituents to forestall segregation or balling throughout combination.

The quantity of ingredients for the preparation of cubs is little thence during this project hand combination is adopted.

5.2. Casting

The check cube specimens are created once combination and such away on manufacture full compaction of the concrete with neither segregation nor excessive laitance. The concrete is crammed into the cube mould. In putting every scoop jam-packed with concrete, the highest fringe of the mould because the concrete slide from it, so as to every by hand or by vibration. Once the highest layer has been compacted the surface is delivered to the finished level with the highest of the cube mould employing a trowel.

The standard tamper is employed and therefore the strokes of the bar distributed during a uniform manner over the cross section of mould. The stroke penetrate into the underneath lying layer and therefore the bottom layer is required.

5.3. Concrete Cube Made by Using Quarry Dust

The concrete cubes are prepared by using replacement of 10%, 20%, and 30% of quarry dust. These cubes are tested for compressive strength at 3, 7 and 14 days. Three cube specimens were tested at 3, 7, and 14 days in each percentage and obtained the compressive strength.

6. Testing of Material

6.1. Specific Gravity for Quarry Dust Material

Procedure:

Dry the pycnometer/density bolte and weight with its cap tightly screwed on. Let it be w1. Unscrewed the cap and put in the quarry dust material. Let it be w2.

Add sufficient amount of water to cover the quarry dust material about half full and screw on top. Shake the pycnometer well and remove entrapped air if any.

Repeat the procedure for their sample and obtain the average values of specific gravity (Table 6, Figure 1).

Table 6. Specific gravity for quarry dust material.

SI. No.	Specific gravity for quarry dust material		
	Specification	TRIAL-1	TRIAL-2
1	Empty weight of pycnometer (W1)	0.612 kg	0.610 kg
2	Empty weight of pycnometer + quarry dust (W2)	1.316 kg	1.310 kg
3	Empty weight of pycnometer + quarry dust + water (W3)	1.900 kg	1.897 kg
4	Empty weight of pycnometer + water (W4)	1.486 kg	1.480 kg



Figure 1. Pycnometer.

Observation:

- W1 = Empty weight of pycnometer;
- W2 = Empty weight of pycnometer + quarry dust;
- W3 = Empty weight of pycnometer + quarry dust + water;
- W4 = Empty weight of pycnometer + water.

Calculation:

$$\begin{aligned}\text{Specific gravity} &= (W2 - W1) / ((W2 - W1) - (W3 - W4)) \\ &= (1.316 - 0.612) / ((1.316 - 0.612) - (1.900 - 1.486)) \\ &= 2.42\%\end{aligned}$$

Result:

Specific gravity of quarry dust material = 2.42%.

6.2. Fineness for Quarry Dust Material**Procedure:**

The about 100 gms of quarry dust material in the sieve 90 micron. Then place the sieve in the sieve shaker and switch on the sieve shaker. After 15 min we have to switch off the sieve shaker. Then we have to switch note the material retained in the sieve. Then using the below formula we have to find out the percentage of the quarry dust material (**Table 7**).

Result:

Fineness of quarry dust material = 2.67%.

6.3. Bulk Modulus of Quarry Dust**Procedure:**

Bulking is a major problem while mixing the concrete. A measuring jar is taken and sand is filled up-to a mark in the measuring jar.

Then water is added up to the highest mark in the vessel and left it for settling and the settled height is measured and the percentage bulking is calculated (**Table 8**).

Result:

The bulk modulus of given material = 238 g.

6.4. Workability of Quarry Dust Material**Procedure:**

- The workability is one of the physical parameter of concrete which affect the strength and durability and the appearance of the finished surface. If the water absorption capacity if the aggregates.
- In our case we have used slump cone test for measuring the workability of concrete.
- We have measured the height of the fall of the cone of concrete for various water cement ratio and recorded the value for ordinary concrete (**Table 9**). Then the same procedure is done with the concrete having the partial

Table 7. Fineness for quarry dust material.

Sl. No.	Fineness for Quarry Dust Material		
	Weight of sample in gm	Weight of residue %	Fineness in gm
1	100	4	4
2	100	3	3
3	100	3	3

Table 8. Bulk modulus of quarry dust.

Sl. No.	Bulk modulus of quarry dust		
	Volume of quarry dust	Water absorption of quarry dust	Time taken of absorption
1	200 g	238 g	10 min

Table 9. Workability of quarry dust material.

Weight of cement	Workability of quarry dust material		
	Water cement ratio	Volume of water	Slump in (mm)
1	2000 g	0.50	900 ml
2	2000 g	0.55	1100 ml
3	2000 g	0.60	1300 ml

replacement of sand with raw quarry dust at various percentages.

Result:

The slump value of concrete is = 120 mm. Therefore, the slump is true slump.

6.5. Fineness for Sand**Procedure:**

The about 100 gms of quarry dust material in the sieve 90 micron.

Then place the sieve in the sieve shaker and switch on the sieve shaker. After 15 min we have to switch off the sieve shaker. Then we have to switch note the material retained in the sieve. Then using the below formula we have to find out the percentage of the quarry dust material (**Table 10**).

Result:

Fineness of sand = 2.67%.

6.6. Fineness of Cement**Procedure:**

- Weight accurately 100 gm of cement in a china dish.
- Place it on a standard IS 90 micron sieve.
- The sieve in both the hand.
- Breakout any air set lumps ion cement sample with figure (**Figures 2-7**).
- Weight the residue of sieving accurately.
- Repeat the procedure three such samples (**Table 11**).

Calculation:

$$\begin{aligned}
 \text{Fineness value} &= (\text{weight of residue}/\text{weight of cement}) \times 100 \\
 &= 3/100 \times 100 \\
 &= 3\% \\
 &= (3 + 2 + 2)/3 \\
 &= 2.33\%
 \end{aligned}$$

Table 10. Fineness for sand.

SL. No.	Workability of quarry dust material		
	Weight of sample in gm	Weight of residue in %	Fineness in gm
1	100	4	4
2	100	3	3
3	100	3	3

Table 11. Fineness of cement.

SL. No.	Fineness of cement		
	Weight of cement in gm	Weight of residue in %	Fineness in cement
1	100	3	3
2	100	2	2
3	100	2	2

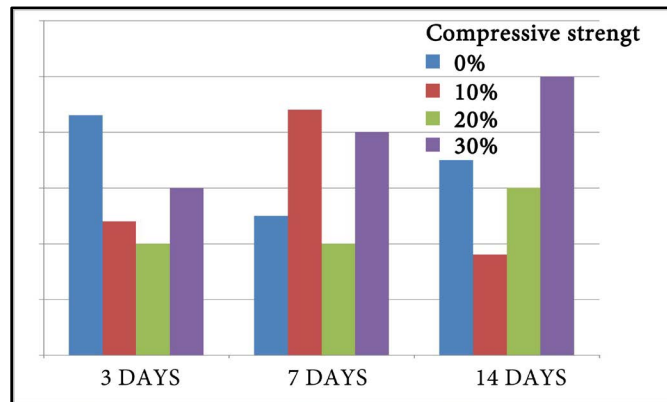


Figure 2. Compressive strength chart.

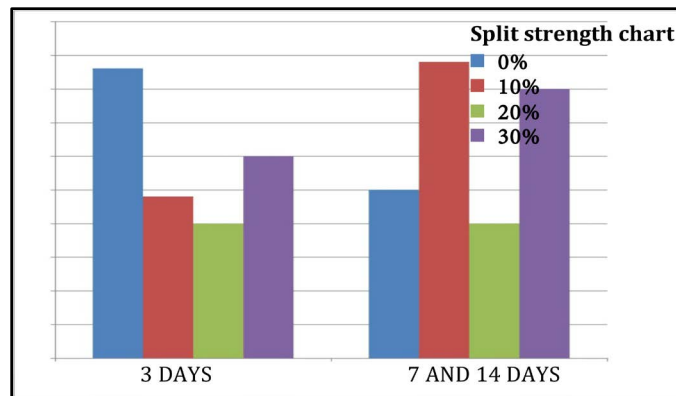


Figure 3. Split strength chart.



Figure 4. Compressive strength test for 3 days curing.



Figure 5. Compressive strength test for 14 days curing.



Figure 6. Compressive strength test for 21 days curing.



Figure 7. Quarry mud.

Result:

Fineness of cement = 2.33%.

6.7. Specific Gravity of Cement

Observation (Table 12):

- W1 = Empty weight of pycnometer;

- W2 = Empty weight of pycnometer + cement;
- W3 = Empty weight of pycnometer + cement + water;
- W4 = Empty weight of pycnometer + water.

Calculation:

$$\begin{aligned}\text{Specific gravity} &= (W2 - W1) / ((W2 - W1) - (W3 - W4)) \\ &= (258 - 131) / ((258 - 131) - (454 - 366)) \\ &= 3.15\end{aligned}$$

Result:

Specific gravity of cement material = 3.15.

6.8. Specific Gravity of Sand**Procedure:**

- Dry the pycnometer/density bolte and weight with its cap tightly screwed on. Let it be w1. Unscrewed the cap and put in the quarry dust material. Let it be w2.
- Add sufficiend amount of water to cover the sand material about halfull and screw on top. Shake the pycnometer well and remove entrapped air if any.
- Repeat the procedure for there sample and obtain the average values of specific gravity.

Observation (Table 13):

- W1 = Empty weight of pycnometer;
- W2 = Empty weight of pycnometer + sand;
- W3 = Empty weight of pycnometer + sand + water;
- W4 = Empty weight of pycnometer + water.

Table 12. Specific gravity of cement.

SI. No.	Specific gravity for quarry dust material		
	Specification	Weight	TRIAL-1
1	Empty weight of pycnometer	(W1)	131
2	Empty weight of pycnometer + cement	(W2)	258
3	Empty weight of pycnometer + cement + water	(W3)	454
4	Empty weight of pycnometer + water	(W4)	366

Table 13. Specific gravity of sand.

SI. No.	Specific gravity for quarry dust material		
	Specification	Weight	TRIAL-1
1	Empty weight of pycnometer	(W1)	670
2	Empty weight of pycnometer + sand	(W2)	1221
3	Empty weight of pycnometer + sand + water	(W3)	1869
4	Empty weight of pycnometer + water	(W4)	1544

Calculation:

$$\begin{aligned}\text{Specific gravity} &= (W_2 - W_1) / ((W_2 - W_1) - (W_3 - W_4)) \\ &= (1221 - 670) / ((1221 - 670) - (1860 - 1544)) \\ &= 2.59\end{aligned}$$

Result:

Specific gravity of sand material = 2.59.

6.9. Specific Gravity of Coarse Aggregate**Procedure:**

Dry the pycnometer/density bolte and weight with its cap tightly screwed on. Let it be w1. Unscrewed the cap and put in the quarry dust material. Let it be w2.

Add sufficient amount of water to cover the coarse aggregate material about Hal full and screw on top. Shake the pycnometer well and remove entrapped air if any.

Repeat the procedure for there sample and obtain the average values of specific gravity (**Table 14**).

Observation:

- W1 = Empty weight of pycnometer;
- W2 = Empty weight of pycnometer + coarse aggregate;
- W3 = Empty weight of pycnometer + coarse aggregate + water;
- W4 = Empty weight of pycnometer + water.

Calculation:

$$\begin{aligned}\text{Specific gravity} &= (W_2 - W_1) / ((W_2 - W_1) - (W_3 - W_4)) \\ &= (817 - 484) / ((817 - 484) - (1342 - 1123)) \\ &= 2.75\end{aligned}$$

Result:

Specific gravity of coarse aggregate material = 2.75.

7. Concrete Mix Design (Table 15)

(M 20 GRADE)

Test data for materials:

- 1) Specific gravity of cement = 3.24;
- 2) Specific gravity of coarse aggregate = 2.75;
- 3) Specific gravity of sand = 2.6;
- 4) Water absorption = 8%;
- 5) Coarse aggregate = 0.50%;
- 6) Sand = 1.00.

Target mean strength:

The target mean strength for specified characteristic cube strength is

$$F_{ck1} = F_{ck} + 1.68s;$$

$$S = 4.0 \text{ (is 106262; Table 1).}$$

$$\begin{aligned}F_{ck1} &= 20 + (1.65 \times 4) \\ &= 26.6 \text{ N/mm}^2.\end{aligned}$$

Table 14. Specific gravity of coarse aggregate.

SI. No.	Specific gravity for quarry dust material		
	Specification	Weight	TRIAL-1
1	Empty weight of pycnometer	(W1)	484
2	Empty weight of pycnometer + CA	(W2)	817
3	Empty weight of pycnometer + CA + water	(W3)	1342
4	Empty weight of pycnometer + water	(W4)	1123

Table 15. Mix proportion.

Cement	Specific gravity for quarry dust material		
	Fine Aggregate	Course Aggregate	W/C ratio
0.156 cum	0.304 cum	0.496 cum	0.55
1	1.95	3.18	0.55

Water-cement ratio:

W/C ratio for M20 concrete = 0.55 (Table 5: is 456).

Water content:

Water content for 20 mm for 25 - 50 slump = 186 liters.

Cement content:

W/C ratio = 0.55.

Mass of cement needed = water cement/5.5
 = 372 kg of cement
 = 7.5 bags of cement.

Water cement ratio:

Water cement ratio for M20 concrete = 0.55 (Table 5; is 456).

Water content for 20 mm for 25 - 50 mm slump = 186 litres (Table 2; is 10262)

$$\begin{aligned} w/c &= 0.55 \\ &= 0.55 \times 0.95 \\ &= 0.470 \text{ lit} \end{aligned}$$

Material calculation:

Mix ratio M20 = 1:1.9:3.1

$$\begin{aligned} \text{volume of cube} &= 0.15 \times 0.15 \times 0.15 \\ &= 3.375 \times 10^{-3} \text{ m}^3 \end{aligned}$$

Density of unit weight of cement = 1440 kg/m³

$$\begin{aligned} \text{volume} &= 1/mc \times \text{volume} \times \text{density} \\ &= 1/5.10 \times (3.375 \times 10^{-3}) \times 1440 \\ &= 0.95 \end{aligned}$$

$$\text{cement} = 1 \times 0.95 = 0.95 \text{ kg}$$

$$\text{sand} = 1.9 \times 0.95 = 1.80 \text{ kg}$$

$$\text{coarse agg} = 3.1 \times 0.95 = 2.94 \text{ kg}$$

Coarse aggregate proportion:

M20 grade, zone ii from Table 5.

Proportion for 0.5 w/c ratio.

Coarse aggregate proportion = 0.62 (**Table 3** is 10262).

Coarse aggregate content:

$$\begin{aligned}
 \text{total aggregate} &= 1 - \text{volume of cement} - \text{volume of water} \\
 &= 1 - (\text{mc}/1000\text{sc}) - (\text{mw}/1000\text{sw}) \\
 &= 1 - (372/1000 \times 3.15) - (186/1000 \times 1) \\
 &= 1 - 0.1181 - 0.186 \\
 &= 0.6959 \text{ cu.m} \\
 &= 0.62 \times 0.6959 \times 2.74 \times 1000 \\
 &= 1182 \text{ kg of coarse aggregate} \\
 &= 0.38 \times 0.6959 \times 2.74 \times 1000 \\
 &= 725 \text{ kg of fine aggregate}
 \end{aligned}$$

GRADE M20 ratio.

Replacement of fine aggregate

- FOR 10% OF REPLACEMENT = $(10/100) \times (1800) = 180 \text{ gm};$
- FOR 20% OF REPLACEMENT = $(20/100) \times (1800) = 360 \text{ gm};$
- FOR 30% OF REPLACEMENT = $(30/100) \times (1800) = 540 \text{ gm}.$

Compressive strength and split tensile strength (**Table 16**).

8. Conclusions

- Organization of favor and making of concrete cubes for testing are that the key for the success of this project.
- Protection of natural resources sand from extinction is that the foremost important wish of the implementation of this project.
- It is important that every natural resource got to be saved for future so as that we've an inclination to take sand.
- Completion of this project can result in a simply out there replacement and a main quality concrete.
- This project was done on the sphere by making concrete cubes and curing

Table 16. Compressive strength and split tensile strength.

% of quarry added in	Compressive Strength Curing days		
	7	14	21
30	30	30	30
10.2	10.2	10.2	10.2
21.1	21.1	21.1	21.1
26.5	26.5	26.5	26.5
% of quarry added in	Split tensile strength		
	Curing days	14	21
30	30	2.6	2.6
10.2	10.2	2.9	2.9
21.1	21.1	2.8	2.8
26.5	26.5	3	3

them within the traditional water as we have a tendency to waste traditional concrete thus on not modification the essential nature and easily out there one.

- The project offers an excellent result as that quarry dirt could be another by product that could be rock dirt naturally accrued which can assist in place of sand and have analogous properties as of sand.
- As a result, we've an inclination to successfully find a replacement material for sand in concrete as per Indian standards.

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