Studies On Self Compacting Concrete Made With Crushed Rock Dust And Marble Sludge Powder

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ABSTRACT
Self-Compacting Concrete (SCC) has had a remarkable impact on the concrete construction industry, especially the precast concrete industry. Concrete plays important role in the construction industry worldwide. New technologies have helped to develop new types of construction and alternative materials in the concrete area. As society makes determined moves towards sustainability, construction has a very important role to play within this new agenda, not only because of its economic and social contribution, but also because of its impact on the quality of our lives, our comfort and safety. While the building industry provides 5% to 10% of worldwide employment and generates 5% to 15% of GDP (Gross Domestic Product), the built environment accounts for 40% of energy consumption, 40% of CO2 emissions, 30% of the consumption of natural resources, 30% of waste generation and 20% of water consumption. The future global challenge for the construction industry is clearly to meet the world's growing needs while at the same time limiting the impact of its burdens by drastic improvement of its activities. The rapid growth in development of construction industry is leading to an increase in utilization of natural resources like river sand due to which there has been a much scarcity of fine aggregate in availability for construction.

The fast growth in industrialization has resulted in tones and tones of by product or waste materials, which can be Crushed Rock Dust (CRD) and Marble Sludge Powder (MSP) and fly ash, silica fume, and granulated blast furnace slag, steel slag etc. The use of these by- products not only helps to utilize these waste materials but also enhances the properties of concrete in fresh and hydrated states. In the present work a series of tests were carried out to make comparative studies of various mechanical properties of concrete mixes prepared by using Crushed Rock Dust (CRD) and Marble Sludge Powder (MSP).MSP and CRD can be used as filler and helps to reduce the total voids content in concrete. Consequently, this contributes to improve the strength of concrete. An experimental investigation has been carried out specimens were cast and tested for mechanical properties after 7 days and 28 days to study the combined effect of addition of MSP and CRD on the strength and durability of SCC. From the results it is confirmed that compressive strength increases with increase in percentage replacement of MSP up to 20% of CRD in place of FA. It is found that split tensile strength is directly proportional to the compressive strength.

Keywords :- self compacting concrete, marble sludge powder, crushed rock dust, corrosion and filler

1.1. BACK GROUND:
The development of construction industry now-a-days is increasing rapidly because of that it will reduce the amount of natural resources in our country and many of the natural resources will be sacrificed to obtain

source of materials for construction. To save the environment from this loss because of the developmental activities, we need to think of suitable materials that can be used to replace these materials for pavement construction. Environment must be sustained and protected by us for next generation.

Now- a- days, there are so many researches that has been done to improve and upgrade the materials for concrete properties to be enhanced. The utilization of various natural and waste materials as a replacement for producing the concrete can give a lot of benefits to the humans and environment. CRUSHED STONE DUSTAND MARBLE SLUDGE POWDER is some of the alternative that can be used to replace with river sand in the preparation of concrete. As major natural resource CRUSHED STONE DUSTAND MARBLE SLUDGE POWDER can be obtained from the granite and marble industry abundantly at free of cost.

1.2. **PROBLEM STATEMENT**:

Now–a-days, the use of river sand for concrete production has increased rapidly due to increase in number of construction industries. The increase in rate of production of concrete leads to increase in demand for raw materials which in turn leads to price hike of raw materials. Also this demand may be due to scarcity in availability of raw materials mostly the river sand. This problem of importing river sand from other places at a higher price has brought the idea of using the locally available natural material in the place of this river sand. So, by using the CRUSHED STONE DUSTAND MARBLE SLUDGE POWDER which is abundantly available at the granite and marble industry for the low volume road construction, much of the economy of construction could be saved. So, by using CRUSHED STONE DUSTAND MARBLE SLUDGE POWDER from the granite and marble industry as a fine aggregate replacement in preparation of concrete will save our earth for a sustainable environment.

EXPERIMENTAL STUDIES AND DATA ANALYSIS

3.1. TESTS ON CEMENT:

Checking of materials is an essential part of civil engineering as the life of structure is dependent on the quality of material used. Following are the tests to be conducted to judge the quality of cement.

1. Fineness
2. Consistency
3. Initial And Final Setting Time
4. Soundness
5. Specific gravity
6. Compressive Strength

3.1.1. Fineness of Cement by Dry-Sieving Method :(As Per IS-4031 part 1):

Fineness of cement is a measure of size of particle of cement. It is expressed as specific surface of cement (in sq. cm /gm.).
The fineness of cement is an important factor in determining the rate of gain of strength and uniformity of quality. It is measured in terms of specific surface of the cement and can be calculated from the particle size distributions are determined by one of the air permeability.
We have used IS sieve No.9 (90 microns), as per Indian standards(IS :269- 1975), the percentage of residue left after sieving a good Portland cement through IS sieve number 9, should not exceed 10%.

3.1.2. Standard Consistency of Cement:

Normal or standard consistency of any given cement sample is that water content which will produce a cement paste of standard cons instance. Consistence is determined by the Vacate apparatus, which measures the depth of penetration in paste of a 10 mm diameter plunger under its own weight .Normal or standard consistency is expressed as that percentage of water, by mass of dry cement, corresponding to which a specified depth of penetration in paste is achieved. For Portland cements, the normal consistency varies from 26 to 33%.

For finding out initial setting time, final setting time and soundness of cement and strength a parameter known as standard consistency has to be used. The object of conducting this test is to find out the amount of water to be added to the cement to get a paste of normal consistency i.e., the paste of a certain standard solidity, which is used to fix the quality of water to be mixed in cement before performing tests for setting time, soundness and Compressive Strength. The test is required to be conducted in a constant temperature (27^0 c ± 2^0 c) and constant humidity (90%).

3.1.3. Initial Setting and Final Setting:

In order that the concrete may be placed in position conveniently, it is necessary that the initial setting time is not too quick and after it has been laid, hardening should be rapid so that the structure can be made use of as early as possible. The initial set is a stage in the process of hardening after which any crack that may appear will not re-unite. The concrete is said to be finally set when it has obtained sufficient strength and hardness.

The setting time is influenced by temperature, humidity fair and quantity of gypsum in the cement.

3.1.4.Sound ness of Cement (By Le-Chatelier Method):

This test indicates the liability of cement to expand sometimes after setting and causes severe cracking of failure of concrete. The chief test for soundness is the “Le-Chatelier” test.

Scope:

To decide the suitability of given cement sample. The cement is said to be sound when the percentage of free lime and magnesia is within specified limits. These materials expand in the structure and thus the concrete or mortar also expands, causing equal expansion of paste. Disintegration of cement compound is determined by Le-Chatelier apparatus.

3.1.5. Specific gravity of Cement:

Specific gravity is normally defined as the ratio between the mass of a given volume of material and mass of an equal volume of water. One of the methods to determining the specific gravity of cement is by the use of a liquid such as water-free kerosene which does not react with cement. A specific gravity bottle may be employed or a standard Le-Chatelier flask may be used.

Scope:

Specific Gravity is the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water. Water, at a temperature of 73.4°F (23°C).Specific Gravity is important for several reasons. Some deleterious particles are lighter than the “good" aggregates. Tracking specific gravity can sometimes indicate a change of material or possible contamination. Differences in specific gravity may be used to separate the deleterious particles from the good using heavy media liquid .Specific gravity is critical information for the Hot Mix Asphalt Design Engineer. This value issued in calculating air voids, voids in mineral aggregate (VMA), and voids filled by asphalt (VFA). All are critical to a well performing and durable asphalt mix. Water absorption may also be an indicator of asphalt absorption. The absorption is important in determining the net water-cement ratio in the concrete mix. Knowing the specific gravity of aggregates is also critical to the construction of water filtration systems, slope Stabilization projects, railway bedding and many other application.

3.1.6.Compressive Strength of Cement:

Strength tests generally carried out in tension on samples of heat cement are of doubtful value as an indication of ability of cement to make concrete strong in compression. Therefore these are largely being superseded by the mortars cube crushing tests and concrete compression tests these are conducted on standardized aggregate under carefully controlled conditions and therefore give good indications on strength qualities of cement.

Theory and Scope:

The Compressive Strength of cement mortar is determined in ordered to verify whether the cement conforms to IS specifications (IS: 269-1976) and whether it will be able to develop the required Compressive Strength of concrete.

TABLE: 3.1.1. Physical Test results of cement

	PHYSICAL TESTS	OBTAINED RESULTS	REQUIREMENTS AS PER IS CODES
1	Fineness	3%	Not>10% as per IS 4031 part 1
2	Standard Consistency	32%	IS 4031 part 4
2	Initial Setting time	42min	Not less than 30 minutes as per IS 4031 part 5
3	Final setting time	265 min	Not more than 600 minutes as per IS 4031 part 5
4	Soundness	2 mm	Not>10mm as per IS 4031 part 3
5	Specific gravity	3.10	IS 2720 part 3 (3.15 is generally assumed)

3.2. TESTS ON AGGREGATE:

There are many tests which are conducted to check the quality of aggregates. Aggregates are very important components of concrete, so the quality really matters when it comes to aggregates. Various tests which are done on aggregates are listed below.

1. Sieve analysis for fine aggregate
2. Sieve analysis for Coarse Aggregate
3. Aggregate impact Value
4. Specific gravity and water absorption of Aggregate

3.2.1. Grain Size Distribution of Fine Aggregate:

To study the particle size distribution of given fine aggregate by doing sieve analysis, we need to draw the grading curve and determine the fineness modulus of the given fine aggregate sample. We have used a set of sieves consist the sizes of 4.75 mm, 2.36 mm, 1.18 mm, 600 µ, 300 µ, 150µ and pan. Sample should be taken for which the sample is thoroughly mixed and spread over a clean surface. If any further reduction of quantity is required the process may be repeated. Weight retained on each sieve shall not exceed the limits specifies IS code.

3.2.2. Grain Size Distribution of Coarse Aggregate:

To study the particle size distribution of given coarse aggregate by doing sieve analysis, we need to determine the fineness modulus of the given coarse aggregate sample. We have used a set of sieves consist the sizes of 40 mm, 20 mm,12.5 mm, 4.75 mm,2.36 mm and pan. Sample should be taken for which the sample is thoroughly mixed and spread over a clean surface. If any further reduction of quantity is required the process may be repeated. Weight retained on each sieve shall not exceed the limits specifies IS code.

Scope:

This method of test covers a field procedure for the determination of particle size distribution of fine and coarse aggregates, using sieves with square openings.

Significance and Use: The gradation of fine and coarse aggregate samples must be tested to determine compliance with the specifications for these materials.

3.2.3. Aggregate Abrasion value:

Abrasion testing of aggregate is of more direct application to the testing of stone aggregate for wearing. It has been found that the aggregate which shows a low loss in this test will general be hard, tough, resistant to abrasion and strong which are the desirable and necessary qualities for durability of concrete. The abrasion test on aggregate is found as per IS-2386 Part IV. In no case shall the fragments of the sample be turned or manipulated through the sieve by hand. Use a coarse sieve first in order to minimize wear of 1.7 mm IS sieve.

3.2.4. Aggregate Impact value:

This test may be considered as an alternative to the aggregate crushing test, the special apparatus needed for aggregate impact test is simple and relatively cheap and is portable while the crushing test crushing test requires a 50 tones testing machine, which is expensive. The impact test on an aggregate is a useful guide to its behaviour when subjected and brittleness must also be taken into account. The aggregate impact test is conducted as per IS-2386 part IV.

The sample should be subjected to 15 blows of the hammer at not less than one second interval. The fraction passing and retained on the 2.36 mm IS sieve should be weighed and sum should agree within one gram with the original mass of the sample taken. As the hammer is heavy, be cautions

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to keep away from falling mass, to avoid accidents.

3.2.5. Aggregate crushing value:

This is one of the major Mechanical properties required in a concrete and road stone. This test helps to determine the aggregate crushing value of coarse aggregates as per IS: 2386 (Part IV) – 1963. The apparatus used is cylindrical measure and plunger, Compression testing machine, IS Sieves of sizes – 12.5mm, 10mm and 2.36mm.

Generally this test is made on single sized aggregate passing 12.5 mm and retained on 10 mm IS sieve. The aggregate is placed in a cylindrical mould and a load of 40 ton is applied through a plunger. The material crushed to finer than 2.36 mm is separated and expressed as a percentage of the original weight taken in the mould. This percentage is referred as aggregate crushing value. The crushing value of aggregate is restricted to 30 percent for concrete used for roads and pavements and 45 percent may be permitted to other structures. With the aggregate crushing value 30 % or higher, the result may be anomalous and in such cases the ten percent fines value test should be determined instead.

3.2.6. Specific gravity and water absorption of fine aggregate:

The specific gravity of fine aggregate is generally required for calculations in connection with concrete mix design, for determination of moisture content and for the calculations of volume yield of concrete. The specific gravity also gives information on the quality and properties of aggregate. Departure of specific gravity from its standard value indicted change in shape and grading.

It influences the behaviour of aggregate in concrete in several important aspects. A highly absorptive aggregate, if used in dry condition, will reduce effective water-cement ratio to an appreciable extent and may even make the concrete unworkable unless a suitable allowance is made. Hence determination of absorption of aggregate is necessary to determine net water-cement ratio.

The entire sample should be frequently stirred to secure uniform drying. The air trapped in the aggregate should be brought to surface by rolling the flask in inclined position. All weighing should not be allowed to stick to the sides of the jar or flask. The results of different repetitions should not different more than 0.02 for specific gravity and 0.005 percent for absorption.

TABLE: 3.2.1 Physical Tests of Aggregates which were used in GRANITE DUST used Concrete Mix.

Sl. No	Physical Tests	Obtained results	Requirements as per IS 383
1	Impact Test	19.74%	Not more than 45% (other than wearing surfaces)
2	Los Angeles Abrasion Test	9.89%	Not more than 50% (other than wearing surfaces)
3	Specific gravity		
	a) Coarse Aggregates	2.72	2.6-2.9
	b) Fine Aggregates	2.61	2.6-2.8
4	Water absorption		
a)	Coarse Aggregates	Not>2%	as per IS:2386-Part
b)	Fine aggregate	1%	0.5%

Table 3.2.2 Sieve Analysis of Coarse Aggregate:

S. NO	Sieve Size	Weight retained(kg)	%(Retained)	% Cumulative (Retained)	%Cumulative Passing
1	80	0	0	0	100
2	40	0	0	0	100
3	20	4128	41.28	41.28	58.752
4	10	5546	55.46	96.74	44.54
5	4.75	309	3.09	99.83	96.91
6	Pan	16	0.16	99.99	99.84

Confirming to table 4 of IS 383-1970

3.3. TESTS ON FINE AGGREGATE:

Various lab tests which were done in lab includes

1. Sieve Analysis
2. Specific gravity and Water Absorption

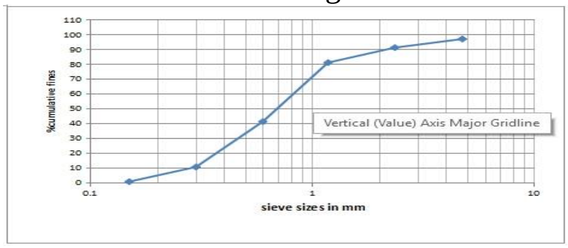
3. **Table 3.3.1 Sieve Analysis of Fine Aggregate (River sand):**

Sieve Size	Weight retained(kg)	%(Retained)	%Cumulative Retained	% Cumulative Passing
4.75 mm	0.032	3.2	3.2	96.8
2.36 mm	0.058	5.8	9	91
1.18 mm	0.101	10.1	19.1	80.9
600 micron	0.398	39.8	58.9	41.1
300 micron	0.306	30.6	89.5	10.5
150 micron	0.099	9.9	99.4	0.6
Pan	0.006	0.6		
Total	1	100		

Fineness modulus = Sum of cumulative percentage retained on standard sieves/100

= 279.1/100
= 2.79

From the sieve analysis of table the river sand is conforming to zone-II.



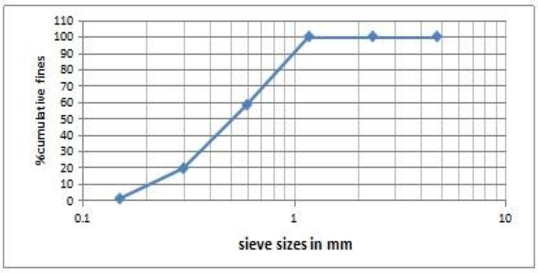
Graph-3.2.1.Shows the gradation curve for River sand

Sieve Size	Weight retained(gm)	%(Retained)	%Cumulative Retained	% Cumulative Passing
4.75 mm	0	0	0	100
2.36 mm	0	0	0	100
1.18 mm	0	0	0	100
600 micron	0.418	41.8	41.8	58.2
300 micron	0.389	38.9	80.7	19.3
150 micron	0.185	18.5	99.2	0.8
Pan	0.008			
Total	1000			

Table 3.3.2 Sieve Analysis of Fine Aggregate (CRUSHED STONE DUST):

Fineness modulus = Sum of cumulative percentage retained on standard sieves/100

= 221.7/100 = 2.22



Graph-3.3.1. shows the gradation curve for CRUSHED STONE DUST

The different physical properties of CRUSHED STONEDUST is given below

3.3.3 Specific Gravity and Water Absorption:

Table 3.4.1 Physical properties of GRANITE DUST:

3.4 MARBLE POWDER:

Waste generated in the stone manufacturing industries during, shaping, cutting and cleaning of marbles stones. Through this process, about 0%, 2.5%,5%,7.5%,10%,12.5%and15% of the procedure marble is turn into the powder variety. India being the third (about 10%) Prime most exporter of marble in the world, every year million tons of marble waste forms processing plants is released. Because of the accessibility of huge amount of waste formed in the marble plant, this assignment has been intended and preceded.

The dumping of Marble Sludge Powder (MSP) us usually a matter of environmental concern. In dry season, the marble powder or dust dangles in the air, flies and deposits on vegetation and crop. Further, fine particles results in poor fertility of the soil due to increase in alkalinity.

3.4.1 Environmental Problems Attributed to Marble Sludge Powder (MSP)

The MSP imposes serious threats to ecosystem, physical, chemical and biological components of environment. Some of the problems encountered are:

- It adversely affects the productivity of land due to decreased porosity, water absorption, water percolation etc.

FIGURE.3.2 DUMPING OF MARBLE DUST

Because of the environmental threats associated with the WMP (waste marble powder), their proper disposal has attracted a lot of attention of the environmentalists in the last years. In order to properly dispose of these hundreds to thousands of tonnes of powder, the use of innovative techniques to recycle them is important. Without the proper disposal of this powder material, the resulting stockpiles would cause major health risks for the public and the environment. Therefore, the objective of this paper is to study the possibility to incorporate marble sawing powder wastes as filler in concrete and also in brick products with no major sacrifice of the properties of the final product and thereby reducing the ill effects of Marble dust.

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3.4.2 CHARACTERISTICS OF MARBLE SLUDGE POWDER

Marble dust is crushed or ground marble particles that can still be formed to make a solid object. Waste marble powder is generated as a by-product during cutting of marble. The waste is approximately in the range of 20% of the total marble handled. The amount of waste marble powder generated at the study site every year is very substantial being in the range of 250-400 tonnes. The dust is used in many more instances than marble itself because of its lower cost and versatility. Marble dust is typically mixed with fine aggregates or resins to make cultured marble, which looks similar to true marble.

The marble cutting plants are dumping the powder in any nearby pit or vacant spaces, near their unit although notified areas have been marked for dumping. This leads to serious environmental and dust pollution and occupation of vast area of land especially after the powder dries up. This also may lead to contamination of the underground water reserves.

3.4.3 Physical Properties

TABLE3. 1

COLOR	WHITE
FORM	POWDER
ODOR	ODORLESS
MOISTURE CONTENT	1.59 (%):

S.no	Properties	Result
1.	Specific gravity	3.03
2.	colour	white
3.	Form	Powder
4.	Odour	Odourless
5.	Fineness	3%

3.4.4 Chemical Properties

TABLE 3.2

Oxide compounds	Marble Dust (Mass %)
SiO2	28.35
Al2O3	0.42
Fe203	9.70
CaO	40.45
MgO	16.25
Density (g/cm3)	2.80

3.4.4 FILLER:

Fillers are particles added to material (plastics, composite material, and concrete) to lower the consumption of more expensive binder material or to better some properties of the mixture material. Fillers have a profound effect on concrete in both the fresh and hardened state. Especially as the development of more effective super-plasticizers has made it possible to increase the amount of fillers which opens new opportunity and fields of application. The particles may be used to reduce the amount of fine aggregate sand give the fresh concrete other properties, example, self-compatibility. The fillers interact with the fine aggregates in several ways. The may be chemically inert but can still indirectly influence the chemical structure of the fine aggregates paste and concrete in a positive way. The large surface of the small particles may foster nucleation, density and homogenize the paste.

3.4.5 APPLICATION OF MARBLE DUST

1. Marble dust as filler

Marble dust can be used either to produce new pro- ducts or as an admixture so that the natural sources are used more efficiently and the environment is saved from dumpsites of marble waste. Many studies have been conducted in literature on the performance of the concrete containing waste marble dust or waste marble aggregate, such as its addition into self-compacting concrete as an admixture or sand, as well as its utilization in the mixture of asphaltic concrete and its utilization as an additive in fine aggregates production, the usage of marble as a coarse aggregate and as a fine aggregate passing through 1 mm sieve.

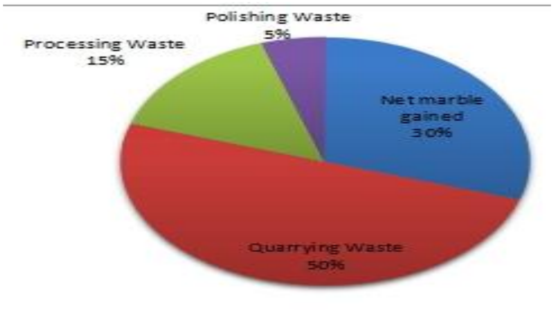

FIGURE 3. 4 MARBLE PRODUCT AND WASTE (% OF MINED OUT)

Generally, in literature waste marble dust has been replaced with either all of the fine aggregate (0 - 4 mm) or passing 1 mm sieve. However, not a single study on the performance of the concrete prepared by replacing very fine sand (passing 0.25 mm sieve) with WMD. The studies concerning the utilization of marble dust, which is obtained as a by-product of marble sawing and shaping processes in the factories those operating in our region as a fine sand aggregate into the normal strength concrete have not reached a convincing conclusion; in other words, additional studies and investigations are necessary to fully evaluate the potential usages of this waste material. Therefore, the aim of this current study is to avoid the environmental pollution.

CONCRETE MIX DESIGN

4.1. INTRODUCTION:

4.1.1. Mix Design:

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative propositions with the object of producing concrete of certain minimum strength and durability as economically as possible.

4.1.2. Concept of mix design:

It will be worthwhile to recall at this stage the relationships between aggregate and paste, which are the two essential ingredients of concrete. Workability of the mass is provided by the lubricating effect of paste and influenced by the amount of dilution of paste. Further, predominate contribution to drying shrinkage of concrete is that of paste. Since the properties of concrete are governed to a considerable extent by the paste, it is helpful to consider more closely the structure of the paste. The fresh paste is a suspension, not a solution of cement in water.

The more dilute the paste, the greater the spacing between cement particles, and thus the weaker will be the ultimate paste structure. The other conditions being equal, for workable mixes, the strength of concrete varies as an inverse function of the water by cement ratio. Since the quantity of water that is as little paste as possible should be used and hence important for grading.

4.2. CONCRETE MIX DESIGN AS PER INDIAN STANDARD CODE (IS: 10262-2009):

4.2.1. Introduction:

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in 2 states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance.

5. The Compressive Strength of hardened concrete which is generally considered to be an index of its other properties, depends upon many factors, e.g. quality and quantity of cement, water and aggregates; batching and mixing; placing, compaction and curing. The cost of concrete is made up of the cost of materials, plant and labour. The variations in the cost of materials arise from the fact that the cement is several times costly than the aggregate, thus the aim is to produce as lean a mix as possible. From technical point of view the rich mixes may lead to high shrinkage and cracking in the structural concrete, and to evolution of high heat of hydration in mass concrete which may cause cracking.

6. The actual cost of concrete is related to the cost of materials required for producing a minimum mean strength called characteristic strength that is specified by the designer of the structure.

TYPES OF MIXES

Nominal Mixes

In the past the specifications for concrete prescribed the proportions of cement, fine and coarse aggregates. These mixes of fixed cement-aggregate ratio which ensures adequate strength are termed nominal mixes. These offer simplicity and under normal circumstances, have a margin of strength above that specified. However, due to the variability of mix ingredients the nominal concrete for a given workability varies widely in strength.

Standard Mixes

The nominal mixes of fixed cement-aggregate ratio (by volume) vary widely in strength and may result in under- or over-rich mixes. For this reason, the minimum Compressive Strength has been included in many specifications. These mixes are termed standard mixes.

IS 456-2000 has designated the concrete mixes into a number of grades as M10, M15, M20, M25, M30, M35 and M40. In this designation the letter M refers to the mix and the number to the specified 28 day cube strength of mix in N/mm2.

4.3.3. Designed Mixes

In these mixes the performance of the concrete is specified by the designer but the mix proportions are determined by the producer of concrete, except that the minimum cement content can be laid down. This is most rational approach to the selection of mix proportions with specific materials in mind possessing more or less unique characteristics. The approach results in the production of concrete with the appropriate properties most economically. For the concrete with undemanding performance nominal or standard mixes (prescribed in the codes by quantities of dry ingredients per cubic meter and by slump) may be used only for very small jobs, when the 28-day strength of concrete does not exceed 30 N/mm2. N

FACTORS AFFECTING THE CHOICE OF MIX PROPORTIONS

The various factors affecting the mix design are:

4.4.1. Compressive Strength

It is one of the most important properties of concrete and influences many other describable properties of the hardened concrete. The mean Compressive Strength required at a specific age, usually 28 days, determines the nominal water-cement ratio of the mix. The other factor affecting the strength of concrete at a given age and cured at a prescribed temperature is the degree of compaction. According to Abraham's law the strength of fully compacted concrete is inversely proportional to the water-cement ratio.

4.4.2. Workability

The degree of workability required depends on three factors. These are the size of the section to be concreted, the amount of reinforcement, and the method of compaction to be used. For the narrow and complicated section with numerous corners or inaccessible parts, the concrete must have a high workability so that full compaction can be achieved with a reasonable amount of effort. This also applies to the embedded steel sections.

4.4.3. Durability

The durability of concrete is its resistance to the aggressive environmental conditions. High strength concrete is generally more durable than low strength concrete. In the situations when the high strength is not necessary but the conditions of exposure are such that high durability is vital, the durability requirement will determine the water-cement ratio to be used.

4.4.4. Maximum Nominal size of Aggregate

In general, larger the maximum size of aggregate, smaller is the cement requirement for a particular water-cement ratio, because the workability of concrete increases with increase in maximum size of the aggregate. However, the Compressive Strength tends to increase with the decrease in size of aggregate.

IS 456:2000 and IS 1343:1980 recommend that the nominal size of the aggregate should be as large as possible.

4.4.5. Grading and Type of Aggregate

The grading of aggregate influences the mix proportions for a specified workability and water-cement ratio. Coarser the grading leaner will be mix which can be used. Very lean mix is not desirable since it does not contain enough finer material to make the concrete cohesive. The type of aggregate influences strongly the aggregate-cement ratio for the desired workability and

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stipulated water cement ratio. An important feature of a satisfactory aggregate is the uniformity of the grading which can be achieved by mixing different size fractions.

Mix Proportion Designations

The common method of expressing the proportions of ingredients of a concrete mix is in the terms of parts or ratios of cement, fine and coarse aggregates. For e.g., a concrete mix of proportions 1:2:4 means that cement, fine and coarse aggregate are in the ratio 1:2:4 or the mix contains one part of cement, two parts of fine aggregate and four parts of coarse aggregate.

FACTORS TO BE CONSIDERED FOR MIX DESIGN

1. The grade designation giving the characteristic strength requirement of concrete.
2. The type of cement influences the rate of development of Compressive Strength of concrete.
3. Maximum nominal size of aggregates to be used in concrete may be as large as possible within the limits prescribed by IS 456:2000.
4. The cement content is to be limited from shrinkage, cracking and creep.
5. The workability of concrete for satisfactory placing and compaction is related to the size and shape of section, quantity and spacing of reinforcement and technique used for transportation, placing and compaction.

PROCEDURE FOR MIX DESIGN:

1. Determine the mean target strength ft from the specified characteristic Compressive Strength at 28-day fck and the level of quality control.ft = fck+1.65 S
2. Where S is the standard deviation obtained from the Table of approximate contents given after the design mix. Obtain the water cement ratio for the desired mean target using the empirical relationship between Compressive Strength and water cement ratio so chosen is checked against the limiting water cement ratio. The water cement ratio so chosen is checked against the limiting water cement ratio for the requirements of durability given in table and adopts the lower of the two values.
3. Estimate the amount of entrapped air for maximum nominal size of the aggregate from the table.
4. Select the water content, for the required workability and maximum size of aggregates (for aggregates in saturated surface dry condition) from table.
5. Determine the percentage of fine aggregate in total aggregate by absolute volume from table for the concrete using crushed coarse aggregate.
6. Adjust the values of water content and percentage of sand as provided in the table for any difference in workability, water cement ratio, grading of fine aggregate and for rounded aggregate the values are given in table.
7. Calculate the cement content from the water-cement ratio and the final water content as arrived after adjustment. Check the cement against the minimum cement content from the requirements of the durability, and greater of the two values is adopted.
8. From the quantities of water and cement per unit volume of concrete and the percentage of sand already determined in steps 6 and 7 above, calculate the content of coarse and fine aggregates per unit volume of concrete from the following relations:

V =[W+ + +]x

V =[W+ + +]x

Where,

V = Absolute volume of concrete

= Gross volume (1m3) minus the volume of entrapped air

Sc= Specific gravity of cement

W = Mass of water per cubic meter of concrete, kg

C = Mass of cement per cubic meter of concrete, kg

p = Ratio of fine aggregate to total aggregate by absolute volume

fa, Ca = Total masses of fine and coarse aggregates, per cubic meter of concrete, respectively, kg, and

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Sfa,Sca = Specific gravities of saturated surface dry fine and coarse Aggregates, respectively

Determine the concrete mix proportions for the first trial mix

ANNEXURE-II

IS Requirement for fine and coarse aggregates (based on IS 383)

Table 1: Grading limits for fine aggregates:

10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50

Source: Refer Table No. 4 (Clause 4.3) Page no. 11 of IS 383 -1970

Table 2: Grading limits for single size coarse aggregates

IS Sieve

Designation PERCENTAGE PASSING FOR SINGLE – SIZED AGGREGATE OF NOMINAL SIZE

	63 mm	40 mm	20 mm	16 mm	12.5 mm	10mm
80 mm	100	-	-	-	-	-
63 mm	85 to100	100	-	-	-	-
40 mm	0 to 30	85 to100	100	-	-	-
20 mm	0 to 5	0 to 20	85 to100	100	-	-
16 mm	-	-	-	85 to100	100	-
12.5 mm	-	-	-	-	85 to100	100
10 mm	0 to 5	0 to 5	0 to20	0 to30	0 to45	85 to100
4.75 mm	-	-	0 to 5	0 to 5	0 to10	0 to20
2.36 mm	-	-	-	-	-	0 to 5

Source: TABLE 2 page no 9 (Clauses 4.1 and 4.2) IS 383 – 1970

Table 3: Grading limits for graded coarse aggregate:

IS Sieve

Designation PERCENTAGE PASSING FOR GRADED AGGREGATE OF NOMINAL SIZE

	40 mm	20 mm	16 mm	12.5 mm
80 mm	100	-	-	-
63 mm	-	-	-	-
40 mm	95 to 100	100	-	-
20 mm	30 to 70	95 to 100	100	100
16 mm	-	-	90 to 100	-
12.5 mm	-	-	-	90 to 100
10 mm	10 to 35	25 to 55	30 to 70	40 to 85
4.75 mm	0 to 5	0 to 10	0 to 10	0 to 10
2.36 mm	-	-	-	-

Source: TABLE 2 page no 9 (Clauses 4.1 and 4.2) IS383 – 1970

Table 4 Grading limits for combined aggregates:

IS Sieve

DESIGNATION	PERCENTAGE PASSING FOR ALL-IN AGGREGATE GRADING	
	40 mm Nominal Size	20 mm Nominal Size
80 mm	100	
40 mm	95 to 100	100
20 mm	45 to 75	95 to 100
4.75 mm	25 to 45	30 to 50
600 micron	8 to 30	10 to 35
150 micron	0 to 6	0 to 6

Quality of aggregates:

Aggregates Crushing Value – The aggregate crushing value, when determined in accordance with IS: 2386 (Part IV) –1963 shall not exceed 45 percent for aggregate used for concrete other than for wearing surfaces, and 30 percent for concrete for wearing surfaces, such as runways, roads, and pavements.

- Aggregates Impact Value – As an alternative to 3.3 the aggregate impact value may be determined in accordance with the method specified in IS: 2386 (Part IV)-1963. The aggregate impact value shall not exceed 45 percent by weight for aggregates used for concrete other than for wearing surfaces and 30 percent by weight for concrete for wearing surfaces, such as runways, roads and pavements.
- Aggregates Abrasion Value – Unless otherwise agreed to between the purchaser and the supplier, the abrasion value of aggregates when tested in accordance with the method specified in IS: 2386 (Part IV) – 1963 using Los Angeles machine, shall not exceed the following values: -

- For aggregates to be used in concrete for wearing surfaces 30 percent
- For aggregates to be used in other concrete

ANNEXURE-III

References from IS 10262-2009

Table 1 - Approximate water content per m^3 of concrete

Nominal maximum size of aggregate, mm	Water content per m3 of concrete Kg
	For Grades up to M 35
10	208
20	186
40	165
	For Grades above M 35
10	200
20	180

Source: Table 4 and 5 page no 9 IS 10262-2009

Table 2 Assumed Standard Deviation (clauses 3.2.1.2, A-3 and B-3):

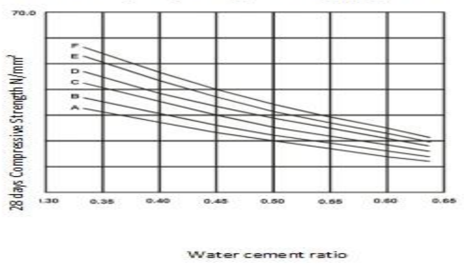
Source: Table 1 pg.no.2-IS 10262-2009

Table 3: Minimum Cement Content, Maximum water/cement ratio and Minimum grade of Concrete for different exposures with Normal Weight Aggregates of 20 mm Nominal Maximum Size

SL No	Plain concrete Reinforced concrete Min cement content Kg/m3	Max free w/c ratio	Min grade of concrete	Min cement content Kg/m3	Max free w/c ratio	Min grade of concrete
1	220	0.60	-	300	0.55	M 20
2	240	0.60	M 20	300	0.50	M 25
3	250	0.50	M 20	320	0.45	M 30
4	260	0.45	M 25	340	0.45	M 35
5	280	0.40	M 25	360	0.40	M 40

Source: IS-456-2000

Selection of W/C ratio corresponding to strength from the graph given below:



3 days	16
7 days	22
28 days	33

IS Requirements for Cement and Water:

IS: 1489-1991 Requirements for ORDINARY PORTLAND CEMENT Compressive Strength, in Mpa

3 days	16
7 days	22
28 days	33

IS Requirements for Cement

	33 Grade	43 Grade	53 Grade
3 days (N/mm²)	62	32	7
7 days (N/mm²)	23	33	7
28 days (N/mm²)	34	35	3

Fineness: By Dry Sieve Analysis

For OPC and Portland Slag	Minimum 2250 cm2/gm.
For PPC Fly ash based	Minimum 3000 cm2/gm.

Setting time

Initial setting time	Minimum 30 minute
Final setting time	Maximum 600 minute

Soundness

By Le-Chatlier's method	Maximum 10 mm

Table 5 relates the results of the compaction factor test to slump and the sample's

Degree of workability:

Degree of Workability Slump, Mm Compaction Factor Applications

Very Low	0-25	0.78	0.80	Vibrated concrete in roads or other large Sections
Low	25-50	0.85	0.87	Mass concrete foundations without vibration. Simple reinforced sections with Vibration
Medium	50-100	0.92	0.935	Normal reinforced work without vibration and heavily reinforced sections with vibration
High	100-180	0.95	0.96	Sections with congested reinforcement

Slump test sample calculation

Observations:

Weight of aggregate taken = 29 kg
Weight of cement 10.775kg
Weight of sand = 16.84kg
Required water content = 4725ml

RESULT:

Slump value observed = 90 mm

COMPACTION FACTOR TEST SAMPLE CALCULATIONS

water cement ratio 0.42

Empty weight of cylinder (w1) kg	7.19
Mass of partially compacted concrete (w2) kg	16.60
Mass of fully compacted concrete (w3) kg	18.28

Mass of partially compacted concrete (w2-w1) kg = 9.41

Mass of fully compacted concrete (w3-w1) kg = 11.09

Compaction factor (C.F) = $W_2-W_1/W_3-W_1=$ =0.848

TESTS ON CONCRETE

5.1. INTRODUCTION:

The tests methods should be simple, direct and convenient to apply. One of the purposes of testing hardened concrete is to confirm that the concrete used at site has developed the required strength.

The basic tests to be conducted in the field as well as in the lab based on its state of concrete are given below.

1. Tests on Fresh concrete
2. Tests on Hardened concrete

5.2Tests on Fresh Concrete:

Fresh concrete or plastic concrete is a freshly mixed material which can be mould into any shape. Strength of concrete primarily depends upon the strength of cement paste. In other words, the strength of paste increases with cement content and decreases air and water content. Abrams water/cement ratio law states that the strength of concrete is only dependent upon water/cement ratio provided the mix is workable. Hence it can be clearly understood that the water/cement ratio required from the point of view of workability.

5.3 Tests Conducted To Check Quality of Concrete:

The grading and shape of aggregates even from the same source vary widely. Considerable variations occur partly due to quality of plant available and partly due to efficiency of operation. There are no unique attributes to define the quality of concrete in its entirety. Under such a situation the concrete is generally referred to as being of good, fair or poor quality. This interpretation is subjective. It is therefore necessary to define the quality in terms of desired performance characteristics, economics, aesthetics, safety and other factors. Due to large number of variables influencing the performance of concrete, the quality control is an involved task. However, it should be appreciated that the concrete has mainly to serve the dual needs of safety (under ultimate loads) and serviceability (under working loads) including durability. These needs vary from one situation and one type of construction to another. Therefore, uniform standards valid for general application to all the works may not be practical. It should be noted that the usual 28 day cube tests are not the quality control measures in the strict sense; they are in fact the acceptance tests.

The aim of the quality control is to reduce the above variations and to produce uniform material which provides the characteristics desirable for the job envisaged.

5.4 Tests to be conducted on site as well as lab for quality control are

1. **Slump Test**
2. **Compaction Factor Test**

5.4.1 Slump test:

The slump test is the most well-known and widely used test method to characterize the workability of fresh concrete. The inexpensive test, which measures consistency, is used on job sites to determine rapidly whether a concrete batch should be accepted or rejected. The test method is widely standardized throughout the world .Four types of slumps are commonly encountered, as shown in Figure 5.1.3.1(a). The only type of slump permissible under ASTM C143 is frequently referred to as the "true" slump, where the concrete remains intact and retains a symmetric shape. A zero slump and a collapsed slump are both outside the range of workability that can be measured with the slump test. Specifically, ASTM C143 advises caution in interpreting test results less than ½ inch and greater than 9 inches. If part of the concrete shears from the mass, the test must be repeated with a different sample of concrete. A concrete that exhibits a shear slump in a second test is not sufficiently cohesive and should be rejected.

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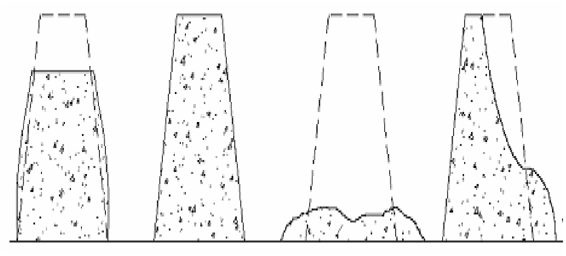


Figure -5.1.3.1(a): Four Types of Slump

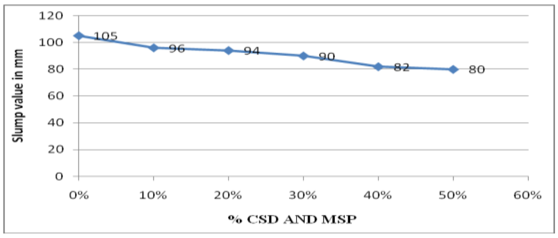
The slump test is not considered applicable for concretes with a maximum coarse aggregate size greater than 1.5 inches. For concrete with aggregate greater than 1.5 inches in size, such larger particles can be removed by wet sieving. Additional qualitative information on the mobility of fresh concrete can be obtained after reading the slump measurement. Concretes with the same slump can exhibit different behaviour when tapped with a tamping rod. A harsh concrete with few fines will tend to fall apart when tapped and be appropriate only for applications such as pavements or mass concrete. Alternatively, the concrete may be very cohesive when tapped, and thus be suitable for difficult placement conditions. This is a site test to determine the workability of the ready mixed concrete just before it's placing to final position inside the formwork, and is always conducted by the supervisor on site. However in mid of concreting process , should the site supervisor visually finds that the green concrete becomes dry or the placement of concrete has been interrupted , a re-test on the remaining concrete should be conducted in particular of the pour for congested reinforcement area . The procedure of test in brief is as follows: -

1. Ensure the standard Slump Cone and associated equipment's are clean before test and free from hardened concrete.
2. Wet the Slump Cone and drain away the superfluous water.
3. Request the mixer or concrete truck to well mix the concrete for additional 5 minutes.
4. Place the Slump Cone on one side (i.e. not in middle) of the base plate on leveled ground and stand with feet on the foot-pieces of cone
5. Using a scoop and fill the cone with sampled concrete in 3 equal layers, each of about 100mm thick.
6. Compact each layer of concrete in turn exactly 25 times with a Slump Rod, allowing the rod just passes into the underlying layer.
7. While tamping the top layer, top up the cone with a slight surcharge of concrete after the tamping operation.
8. Level the top by a "sawing and rolling" motion of the Slump Rod across the cone.
9. With feet are still firmly on the foot-pieces, wipe the cone and base plate clean and remove any leaked concrete from bottom edge of the Slump Cone.
10. Leave the foot-pieces and lift the cone carefully in a vertical up motion in a few seconds time.
11. Invert the cone on other side and next to the mound of concrete.
12. Lay the Slump Rod across the inverted cone such that it passes above the slumped concrete at its highest point.
13. Measure the distance between the underside of rod and the highest point of concrete to the nearest 5mm.

Table-5.1.3.1. Slump Values of CRUSHED STONE DUST AND MARBLE SLUDGE POWDER mix

SL NO	Percentage addition of CSD AND MSP to concrete	Slump Values in mm.
1	0%	105
2	20%	96
3	40%	94
4	60%	90
5	80%	82
6	100%	80

As per IS requirements the slump value for medium workability of concrete should be 50-100.



Graph: 5.1.3.1. Shows the variations in slump

5.4.2Compaction factor test:

The compaction factor test measures the degree of compaction resulting from the application of a standard amount of work. Compaction factor test is adopted to determine the workability of concrete, where nominal size of aggregate does not exceed 20 mm. It is based upon the definition, that workability is that property of the concrete which determines the amount of work required to produce full compaction. The test consists essentially of applying a standard amount of work to standard quantity of concrete and measuring the resulting compaction. To find the workability of freshly prepared concrete, the test is carried out as per specifications of IS: 1199-1959. Workability gives an idea of the capacity of being worked, i.e., idea to control the quantity of water in cement concrete mix to get uniform strength. The test should be carried out on a level ground.

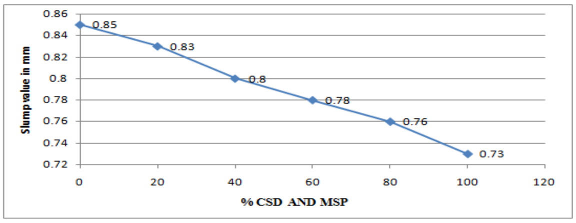
The compaction factor is defined as the ratio of the mass of the concrete compacted in the compaction factor apparatus to the mass of the fully compacted concrete. The standard test apparatus, described above, is appropriate for maximum aggregate sizes of up to 20 mm. A larger apparatus is available for concretes with maximum aggregate sizes of up to 40 mm.

The results of the compaction factor test can be correlated to slump, although the relationship is not linear. Table 5 relates the results of the compaction factor test to slump and the sample's degree of workability.

The test has typically been used in precast operations and at large construction sites. Compared to the slump test, the apparatus is bulky and a balance is required to perform measurements. In addition to these practical drawbacks, the test has several flaws that reduce the accuracy of the results. The magnitude of this friction varies between different concrete mixtures and may not reflect field conditions. Further, the compaction factor test does not utilize vibration, the main compaction method used in the field.

Table: 5.1.3.3. COMPACTION FACTOR VALUES OF GRANITE DUST:

S.NO	% Addition of CSD AND MSP to concrete	Compaction Factor Value
1	0%	0.85
2	20%	0.83
3	40%	0.80
4	60%	0.78
5	80%	0.76
6	100%	0.73



Graph: 5.1.3.3. Shows the variations in compaction factor

5.5 PREPARATION OF TEST SPECIMENS:

The preparation of test specimen including sampling of materials, preparation of materials, proportioning, weighing, mixing, testing for workability, choice of the size of test specimens, compacting, and capping of specimen shall be in accordance with IS: 516-1959*, if tests are intended to draw correlation curve between the results from Compressive Strength tests on specimens cured by normal curing method and accelerated curing method. If the tests are intended for control purposes, sampling shall be done in Accordance with IS: 1199-1959t and choice of the size of test specimens, compacting, and capping of specimen shall be in accordance with IS: 516-1959*. Immediately after moulding, each specimen shall be covered with a steel plate thinly coated with mould oil to prevent adhesion of concrete. Threat and extent of hydration of cement under a particular curing regime depend mainly upon the

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chemical composition of cement, water-cement ratio and mix proportions, which are considered to be important parameters in the correlation of results from Compressive Strength tests on specimens cured by normal curing method.

5.6 CURING METHOD FOLLOWED:

Traditional curing:

All specimens will be moist cured for one day and after moist curing the specimens will be water cured for required days. Testing will be done after required days. In the Traditional curing the cubes moulded with the cement concrete is subjected to curing in the water Tank and then check the strengths achieved by the cubes and beams for every 7 days and 28 days from this we can get the Compressive Strength from cubes and Compressive strength from Beams, split tensile strength for cylinders.

Figure-5.1.5: Shows Curing

5.7 TESTS ON HARDENED CONCRETE:

For testing concrete in hardened state, it is required to cast the various moulds like cubes and beams. It is cured for the required period after 24 hours of casting.

5.7.1.1 Introduction:

Compressive strength of hardened concrete is the most important parameter and representative of almost overall quality of concrete. It mainly depends on the water/cement ratio of the mix and curing and age after it is cast. Compressive strength of concrete is determined by testing the cylindrical or cubical specimens of concrete using a compression testing machine, at various ages such as: 7 days, and 28 days. Compressive strength test is conducted during mix proportioning for assessing the quality of concrete cast at site.

Tensile strength of concrete is found to be proportional to its Compressive Strength. It is determined by flexure test on beam specimens. Although the tensile strength of concrete is of no practical relevance, it is determined to show how a brittle material like concrete has very low strength as compared to its very high Compressive Strength of concrete is determined by testing the concrete beam specimens using a universal testing machine at various ages such as: 7 days, and 28 days.

Table 5.1.6.Dimensions of the Specimens Used for Compressive Strength and Compressive strength:

Serial No	Specimens	Dimensions in mm
1	Cube	150 X 150 X 150

Table 5.1.7.Number of specimens required for the 7, 28 days strength tests

% of GRANITE DUST replaced	No. of cubes for Compression test
0	6
20	6
40	6
60	6
80	6
100	6
Total	54

Total number of specimens= 54

5.7.1.2 Test for Compressive Strength of Concrete:

This deals with the procedure for determining the Compressive Strength of concrete specimens. Tests shall be made at recognized ages of the test specimens, the most usual being 7 and 28 days. Ages of 13 weeks and one year are recommended if tests at greater ages are required. Where it may be necessary to obtain the early strengths, tests may be made at the ages of 24 hours ± ½ hour and 72 hours ± 2 hours. The ages shall be calculated from the time of the addition of water to the dry ingredients .Specimens stored in water shall be tested immediately on removal from the water and while they are still in the wet condition. Surface water and grit shall be wiped off the specimens and any projecting

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fins removed. Specimens when received dry shall be kept in water for 24 hours before they are taken for testing. The dimensions of the specimens to the nearest 0.2 mm and their weight shall be noted before testing.

As the spherically seated block is brought to bear on the specimen, the movable portion shall be rotated gently by hand so that uniform seating may be obtained. The load shall be applied without shock and increased continuously at a rate of approximately 140 kg/sq. cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted.

It is determined from the expression given below

∴ Compressive Strength = P/A, in Mpa
Where,P = Maximum applied load in KN
A = Area of mould


Fig No: 5.1.6.2 (a)


Fig No: 5.1.6.2 (b)

CUBE UNDER COMPRESSION IN CTMCUBE AFTER CRUSHING

SPLIT TENSILE TEST

The size of cylinders 300 mm length and 150 mm diameter are placed in the machine such that load is applied on the opposite side of the cubes are casted. Align carefully and load is applied, till the specimen breaks. The formula used for calculation.(Figure.4.2)

FIGURE 4.2 SPLIT TENSILE TEST

FLEXURAL STRENGTH TEST

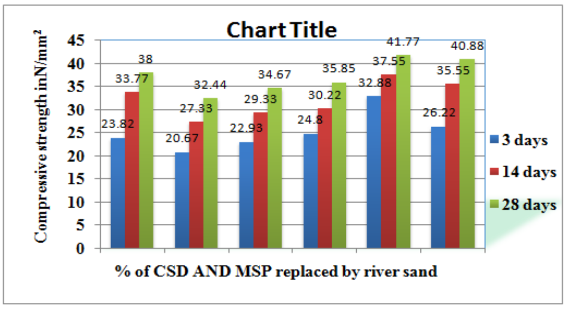
During the testing, the beam specimens of size 700mmx150mmx150mm were used. Specimens were dried in open air after 7 days of curing and subjected to flexural strength test under flexural testing assembly. Apply the load at a rate that constantly increases the maximum stress until rupture occurs. The fracture indicates in the tension surface within the middle third of span length. (Figure.5.3)

FIGURE4.3 FLEXURAL STRENGTH TEST

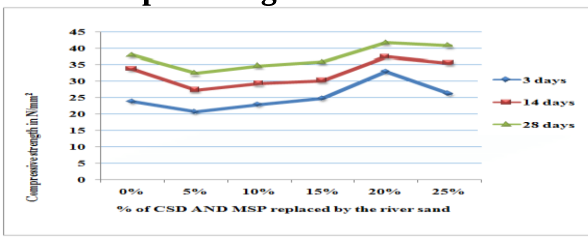
RESULTS AND DISCUSSIONS

TABLE: 6.1: Shows the characteristic Compressive and Compressive Strength of the cubes and beams for different percentages of CSD AND MSP

Percentage of CSD AND MSP added in concrete mix	Age in days	Compressive strength in Mpa	Compressive Strength in Mpa
0 %	7		
	28		
20 %	7		
	28		
40 %	7		
	28		
60 %	7		
	28		
80 %	7		
	28		
25 %	7		
	28		



Graph-6.1(a) Compressive Strength v/s Different percentages of CSD AND MSP



Graph-6.1(b) Compressive Strength v/s Different percentages of CRUSHED STONEDUST

In the present study, the CSD AND MSP has been replaced with river sand in concrete mix. The compressive strength and Compressive strength for different percentages of CSD AND MSP is shown in table. For 5% replacement the compressive strength has decreased for 14.6% and gradually increased with increased in percentage of CSD AND MSP. The optimum strength achieved is 9% more than the normal strength at 20% of CSD AND MSP replaced. The Compressive strength behaviour is also similar in this case since the strength has decreased for about 15.5% by 5% replacement and increased to 6.4% more than the normal concrete mix strength.

SPLIT-TENSILE STRENGTH RESULTS:

TABLE.5.3: SPLIT-TENSILE STRENGTH RESULTS

Replacement of CSD and MSP %	Split tensile strength	
	7 days	28 days
0%	2.12	2.88
2.5%	2.17	2.97
5%	2.07	3.02
7.5%	2.30	3.11
10%	2.40	3.34
12.5%	2.12	3.06
15%	2.07	2.68

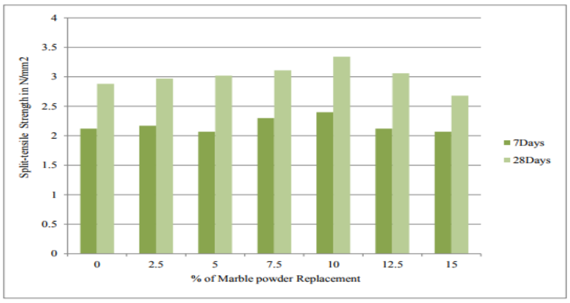


FIGURE.5.2: SPLIT-TENSILE RESULTS FOR 7&28DAY

6.2 FLEXURE STRENGTH RESULTS

TABLE.5.4: FLEXURE STRENGTH RESULTS FOR 28 DAYS

Replacement of CSD and MSP % 28 days result

Maximum load (kn)	Maximum deflection in(mm)	Flexural strength in (n/mm2)	
0%	18.5	5.20	5.92
5%	19.47	4.80	6.84
10%	20.93	4.90	7.44
15%	16.74	5.00	5.65

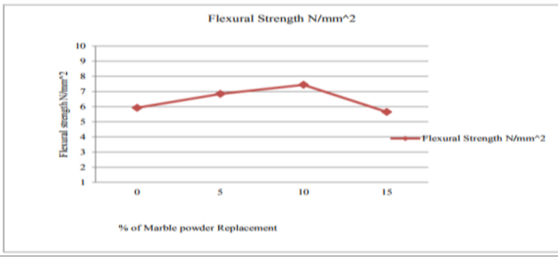


FIGURE.5.3: FLEXURAL STRENGTH RESULTS FOR 28DAYS

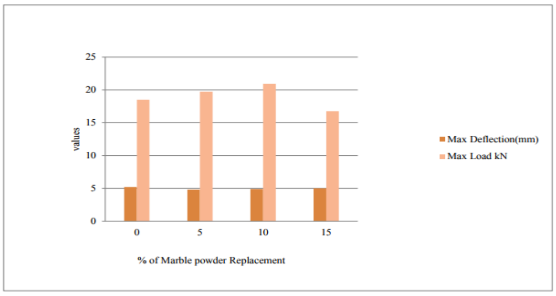


FIGURE5.4: MAX LOAD & DEFLECTION OF BEAMS

CONCLUSIONS AND SUGGESTIONS

Conclusions:

1. The replacement of CRUSHED STONE DUST AND MARBLE SLUDGE POWDER to concrete slightly increases the compressive and Compressive strength.
2. By replacing20%CRUSHED STONE DUST AND MARBLE SLUDGE POWDER the compressive strength has increased by 9%
3. By replacing 40% CRUSHED STONE DUST AND MARBLE SLUDGE POWDER the Compressive strength has increased by 6.4%.
4. Adoption of waste materials, cost of construction can be reduced to some extent.

Suggestions for future work:

1. The CRUSHED STONE DUSTAND MARBLE SLUDGE POWDER from different location can be collected and their properties could be studied.

2. The crusher dust from different quarries is to be added in different percentages instead of Fine aggregate and the strength is checked
3. Stress-strain curve can be plotted and their behaviour can be studied.
4. The crack pattern can be studied using fracture mechanics.
5. The usages of different percentages of other materials instead of river sand and check the variations in the strengths.
6. Some of waste products are fly ash, rice husk, saw dust, and discarded tires, plastic, glass rock, steel slugs and ceramic, can be used in different percentages instead of fine aggregate.
7. Admixture can be added and the properties can be studied.

In this experimental investigation, a comparative study on conventional concrete with green concrete quarry dust as fine aggregate replacement of 20% and replacement of marble powder 0%, 2.5%, 5%, 7.5%, 10%, 12.5% and 15% by cement have been studied and the results were presented and analysed in the previous chapter

Natural river sand, if replaced by twenty five percent Crushed stone Dust from quarries, better result than the concrete made with Natural Sand, in terms of compressive and flexural strength studies marble sludge powder is a by-product that can be used in concrete to obtain durability, cost, and environmental benefits. The concurrent use of the above two by products, gives an excellent results in strength aspect and quality aspect. The compressive strength of concrete is increased with addition of crushed stone dust and waste marble sludge powder up to 12.5%. Also the split-tensile strength of concrete is increased with addition of crushed stone dust and marble sludge powder up to 12.5%.Increase the marble powder content by more than 12.5% improves the workability but affects the compressive and split tensile strength of concrete

Empirical equations have been developed to predict the compressive as well as split tensile strength of cement mortar for different cement-to-sand ratio in terms of w/c. These results will be helpful in design of cement mortar mix for masonry structures.

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