International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 11 Issue 4 ǁ April 2023 ǁ PP. 742-761

A Study Based Upon the Effect of Silica Fume, GGBS, Marble Waste and Recycled Concrete Aggregate on the Strength Parameters of Concrete

ABHIMANYU CHOUDHARY
(UID-19MCT1023)
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR AWARD OF DEGREE OF MASTERS OF ENGINEERING
IN Transportation Engineering

Er. JAGDEEP SINGH
(Assistant Professor)
DEPARTMENT OF CIVIL ENGINEERING
CHANDIGARH UNIVERSITY
2019-2021

ACKNOWLEDGEMENT
I would like to put across my deep sense of gratefulness to my Supervisor Er. Jagdeep Singh, Assistant Professor, Department of civil engineering, Chandigarh University for his valuable suggestions, guidance and encouragement throughout the period of my research work. I am very much grateful to my Supervisor for providing me an Enthusiastic Guidance, Useful Suggestions and Constant Inspiration throughout the course of study. Their profound knowledge, always welcoming nature to listen doubts and the foresightedness was a beacon to me and it was a pleasure of lifetime to have work under their supervision. Their pain taking efforts in providing all necessary facilities for the research work and in scrutinizing the manuscript are gratefully acknowledged. I would also like to express gratitude my parents for their consistent support and encouragement during my tenure in Chandigarh University.

ABSTRACT
The demand of utilization of the waste product from the industries is at its peak therefore, several experimental investigations have been carried out to examine their physical and chemical properties when they are used as a replacement material in concrete. This lead to the revolutionary techniques which achieved high strength parameters. The crushed concrete is the most impeccable technique to produce the recycled aggregate. It can also be derived from any kind of concrete debris. The main advantage of recycled concrete aggregate (RCA) is that it resembles the same properties as that of concrete. Silica Fume (SF) is the burnt by product of Silica Industry. It is very fine and it becomes the main advantage of Silica Fume. Another type of replacement material is ground granulated blast furnace slag GGBS and is also replaced with cement. Another type of replacement material is marble waste powder and it is derived by cutting and polishing the marble. In the present experimental study, which was conducted in an attempt to utilize these waste product, design mix of concrete was designed by partially replacing cement with Silica Fume and GGBS, fine aggregate with marble powder and coarse aggregate with recycled concrete aggregate at varying proportions. Different tests were conducted in order to evaluate and determine its strength parameters. The gist, the conclusion which was made for the present study is that the compressive strength and flexuralstrength tends to increase at the beginning and gives maximum value for the design mix containing 20% SF,10% of GGBS, 20% Marble Powder and 25% RCA and after this the strength starts to fall.
The maximum split tensile strength was achieved with the design mix which entails 20% SF, 10% of GGBS, 40% Marble Powder and 25% RCA whereas, other mixes gives satisfactory result.
KEYWORDS: *Silica Fume, Ground Granulated Blast Furnace Slag, Marble Waste Powder, Recycled Concrete Aggregate,*

Date of Submission: 14-04-2023 Date of acceptance: 30-04-2023

I. INTRODUCTION

1.1 INTRODUCTION

In modern world, 80% of the world's energy consumption is obtained by the extraction of fossil fuels, which entails oil, coal and gas. Correspondingly, the fabrication of concrete every single time is the firmament rocketing and the rare substantial is being oppressed in this procedure. In the beginning, the production of concrete was limited but obliviously, man has led to the exploitation of these natural and raw resources as with time, the need for concrete increases with the advancement of infrastructures. Today we are standing at the verge of the modern techniques of construction but the cost of this advancement is degradation of environment.

Figure 1.1 Concrete

https://www.madgetech.com/posts/blogs/maintaining-the-ideal-temperature-during concrete-curing/

1.2 GREEN CONCRETE

More and more research work is being carried out every day so that the tackling to these problems becomes easy. Numerous another course of action or substitutional left-over or by product of numerous substantial to rare and ordinary substantial has been bring together in concrete businesses that reveals equivalent strength and consequences as unique nevertheless with the benefit of low-priced and environmentally friendly. The concrete which is prepared by using waste or by-products is called Green Concrete. With the assistance of green concrete, ecological improvement is being accomplished nowadays. Any structure designed or constructed in such a way that it minimizes the utilization of natural resources for the construction process is called a sustainable development in construction industry. It is an impeccable gift for present and future to the earth when. Green concrete has proved to be a perfect tool through which the environmental impacts have been reduce. Energy saving, reduction in CO2 emission, practice of left-over H2O and constituents are unique chief evidences of consuming green concrete. Constituents like fly-ash, rice husk ash, bottom ash or Silica Fume, marble waste powder, glass waste powder, recycled concrete aggregate are the furthermost common and spine in the idea of substitution of rare substantial in concrete. The practice of the identical in concrete was unique innovatory development that is saving this world. Partial replacement and fully replacement of the raw and natural material with waste or recycle material is done to generate the more strength concrete.

1.2.1 ADVANTAGES OF GREEN CONCRETE

Green concrete, being an impeccable concrete, has many merits over conventional concrete. Following are the Merits of green concrete:

· As concrete is the second most consumed object afterward water and yield 6% of world's over-all CO_2 releases.

· It also prevents the extinction of natural resources by using the replacement technique with waste and recycled material.

· The usage of non-degradable waste material by green concrete solves another big environmental issue. The dumping of such material have been eliminated along with the after effects of dumping.

· Partial replacement or fully replacement is done as per the requirements or research work

with which disposal of industrial waste becomes easy.
· Light-weight concrete reduced the self-weight of Reinforced cement concrete structure which ultimately saves material as the requirement cross-sectional area of various members and footing will be less. Its energy intake is also small in contrast to the normal concrete industrialization.

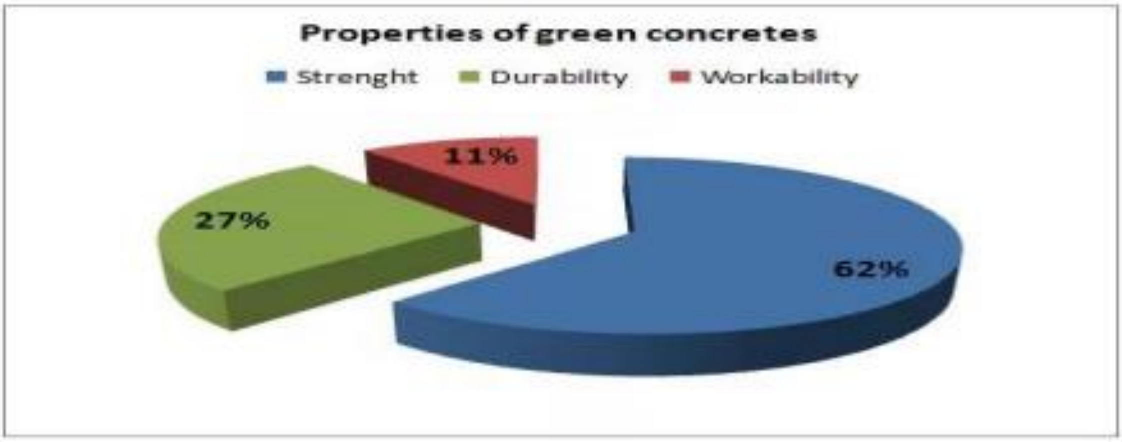

Figure 1.2 Properties of Green Concrete

1.4 RECYCLED CONCRETE AGGREGATE

One of the most impeccable alternative to raw material is concrete aggregate (RCA) which is obtained from production and destruction (C&D) wastes, which results in protecting the natural resources and land; avoid environmental pollution; and reduce the overall charges of construction. The utilization of recycled concrete aggregate in structural construction is practiced in many countries. Numerous methods of handling the trashes, effects on the possessions of concrete are to be discovered. The properties of recycled concrete aggregates are mentioned in table 1.1

Table 1.1 Properties of RCA

Details	Values
Water Absorption	4.11
Specific Gravity	2.39
Size	Between 10 mm to 20mm
Shape	Irregular

Figure 1.3 Concrete Debris

https://www.alamy.com/stock-photo/concrete-debris.html

Figure 1.4 Recycled Concrete Aggregate

https://www.researchgate.net/figure/Concrete-Debris-from-Landfills_fig5_283338603

1.5 SILICA FUME

Silica fume is a by-product from the production of fundamental silicon or alloys comprising silicon in electrical curve kilns. At a temperature of around 2000°C the decrease of great pureness quartz to silicon yields silicon dioxide vapor, which oxidizes and condenses at small temperatures to yield silica fume.

· Silica Fume industry is one of the leading industry as the demand of Silica Fume is huge in the country.

· The culmination creation of mining the Silica Fume from Silica results in silica residue. · The Silica Fume is a precise valuable left-over as it is used in the cisterns in fiery development.

· The Fume which is left behind after the burning is called Silica Fume. · SF has high utilization in concrete as it can be used for replacing cement due to its fineness.

· The properties of SF can vary with its source as it depends on how the Silica Fume is burned. The properties of Silica Fume are mentioned below in the table 1.2.

Figure 1.5 Silica Fume

https://www.indiamart.com/proddetail/silica-fume-7975290730.html

Table 1.2. Physical Properties Of Silica Fume

DETAILS	VALUES
SPECIFIC GRAVITY	2.2
FINENESS PASSING (45µM)	95

MEAN GRAIN SIZE	0.15
COLOR	Light to Dark Grey

Table 1.3. Chemical Properties Of Silica Fume

SILICON DIAOXIDE	85
ALUMINIUM OXIDE	1.12
IRON OXIDE	1.46
CALCIUM OXIDE	0.8
SODIUM OXIDE	1.2

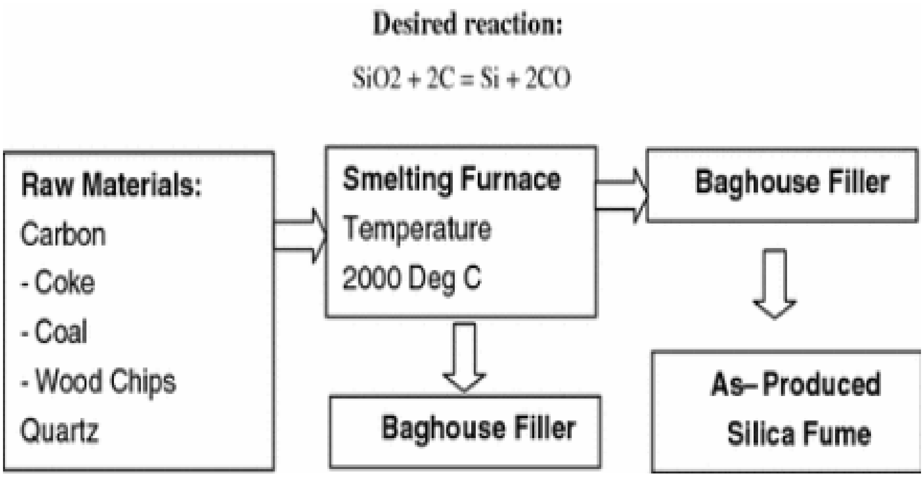

Figure 1.6 Production of Silica Fume

https://link.springer.com/chapter/10.1007/978-3-642-36721-2_4

1.6 MARBLE WASTE POWDER

· Marble remaining powder is nevertheless additional left-over creation of marble business that has been evidenced beneficial in substituting the natural sand in concrete manufacturing.

· Marble waste powder (MWP) is resulting as the consequence of brush up and callous method of marble.

· This by-product is cannot be used further in marble industry and is useless to them. · Therefore, researchers have found a way to utilize this waste product in concrete as an alternative to fine aggregate in order to reduce the cost of concrete and environmental pollution.

· The properties of marble waste powder have been represented in table 1.3.

Figure 1.7 Marble Waste

https://www.marmomac.com/en/marble-and-sustainability-the-stonethica-case/

Table 1.4. Properties of Marble Powder

Details	Values
SPECIFIC GRAVITY	2.51
HARDNESS	3
BRIGHTNESS	92
FINENESS	3
MOISTURE	0.12%

ACID INSOLUBLE	2%

Figure 1.8 Marble Waste Powder
https://www.researchgate.net/publication/287994273_A_STUDY_ON_WASTE_UTILIZATION_OF_MARBLE_DUST_IN_HIGH_STRENGTH_CONCRETE_MIX

1.7 GROUND GRANULATED BLAST FURNACE SLAG

Glass granulated blast furnace slag is a globally obtainable formation and well-informed as a residue from the steel and iron processing industry. It is a great superiority, small CO2 substantial. For the reason that GGBS has small exemplified CO2, it permits designing concrete mixes for ecological erection. The manufacturing of GGBS necessitates a smaller amount than 20% of the energy and harvests a smaller amount than 10% of the CO2 releases as equated to Portland cement manufacture.

Table 1.5. Properties of Ground Granulated Blast Furnace Slag

SPECIFIC GRAVITY	2.88
COLOR	WHITE
SURFACE AREA	400
SILICON DIOXIDE	32.50
CALCIUM OXIDE	37.05
MAGNESIUM OXIDE	7.81

FIGURE 1.9 GROUND GRANULATED BLAST FURNACE SLAG
https://www.indiamart.com/proddetail/ggbs-powder-16968319397.html

CHAPTER 2
REVIEW OF LITERATURE
2.1 REVIEW OF LITERATURE

In order to study the closely and sparsely related studies in the field replacing raw material with waste and recycled materials, many literature was reviewed through different approaches and methods.

YFumewanth M K. et al.; (2016) investigated the effect of utilizing Silica Fume and fly Fume in concrete. In this learning, Silica Fume & fly Fume were bodily and chemically considered and moderately substituted in the ratio of 0%, 5%, 10%, 15% and 20% by heaviness of cement to produce concrete. Synergic effect of Silica Fume & fly Fume up to 15% is bring into being to be improved standby for cement for refining workability of insubstantial. From the compressive strength consequences of cubes, it is establish that on 15% of Fumes auxiliary with cement will harvest better compressive strength as compared to precise concrete. Therefore, we can accomplish that accumulation of it up to 15% of Silica Fume and fly Fume as supernumerary for cement to harvest concrete which can be recycled for practical structural solicitations.

Puneet Jain et al.; (2017) examined the probability of substitution of natural Fine aggregate by marble waste or leftover powder, mended from marble slurry of marble treating components from 0 **percent -** 20 percent varieties, in fabrication of concrete used in housing developments. Results shows that in concrete construction, substituting of sand up to 20% by marble left-over powder gives almost comparable strength as of concrete mixes with 100% sand together at early and concluding ages. It can be used as sand replacement material used in construction of residential Apartments and Flats, which is economical with compare to normal concrete.

Ragu.R et al.; (2017) the series of test are directed to study the effect of 15% 20% 25% 30% and 35% Marble Dust powder, creates the ecological difficulties. Due to ecological glitches it has a countless impact on human well-being as well as on environment. To resistor its effect, we have to practice this left-over in concrete mix and also equate the compressive, flexural and split

tensile strength, workability and toughness of concrete mix. The M sand example was originate to be well graded and the concrete mix had factual slumps with lessening steadiness as the quality M sand. The sequences of examination are accompanied to study the consequence of 50 **percent** of M-Sand. The Granite left-over largely contaminate the surroundings. Therefore this Project Aim is to utilize the granite waste in the effective way. The different Percentage of replacement of materials is increased a strength. This Waste material used to economy, and cost reduces in concrete works. The series of test are directed to revision the effect of 35% of granite waste. This material use in concrete is reduced an environmental pollution in the earth.

Er. Gokul Prasadsharma et al.; (2017) studied the different types of wastes can be used in different types of works such as in building works, road works, in different ceramic works, Ready mix concrete, and cement industries. The wastes are dumped on land and the dust is airborne by the wind and makes air pollution in environment. Marble slurry affects the soil fertility and reduces them. Here in this paper author has suggested to use in concrete works. It will solve double purpose; it will reduce the cost of construction and will save the environment. Addition of marble wastes does not affect the strengths of structures also. Results show that the compressive strength of concrete confirming to IS: 456-2000 has increased 38 N/mm2 by adding marble dust in 28 days and has further also increased 40.5% by adding marble dust.

Nidhi Agrawal1 et al.; (2017) investigated the use of industrial and household waste as construction material will not only decrease the demand of construction material and environmental problems but also give positive effect to the economy in construction. Crushed tiles are an industrial waste that causes environmental pollution. There is huge usage of ceramic tiles in construction purpose and its demand is increasing with time. Thus there is also increase in accumulation of waste tiles. Similarly, marble is a very popularly used material and its processing produces waste such as marble dust. This study has two parts, 1st use of crushed tiles as coarse aggregate and 2nd use of marble dust as fine aggregate in concrete mix of design ratio 1:1:2. Then compressive strength at 7, 14 and 28 days are checked and compared.

Kishan N. Davara1 et al.; (2017) studied the use of waste marble precipitate as a partial replacement of cement can be reduce the cost of cement and may be switch the release of damaging gases into atmosphere and showed ecological to atmosphere. Such that, Waste glass is too a major constituent of solid left-over stream in many countries. It is originate in many systems, ampule glass, flat glass as opening, bulb glass. At current, a minor proportion of post consumer glass has been cast-off with great presentations and unique appealing properties which make it appropriate for wide feast uses. The learning is meant at employing leftover marble powder building industry itself as cement and waste glass smithereens as coarse aggregates in concrete. The numerous literature related to this have been premeditated. Compressive Strength of concrete is amplified with accumulation of waste marble powder up to 50% by weight in dwelling of sand and further addition, compressive strength decrease. As the partial replacement level of waste marble powder with cement in concrete intensifies, workability decreases.

2.2 INFERENCES DRAWN FROM LITERATURE REVIEW

· The premeditated target mean strength of 32.56 N/mm2 was not attained. This may be as an outcome of approximate influences like manner of mixing (hand mixing), compaction and the reactivity of the Silica Fume.

· For mechanism, the compressive strength was 27.8N/mm2. This can be recycled for plain and reinforced concrete with frivolous aggregate and reinforced concrete with standard aggregate.

· 10% addition of cement with Silica Fume produced compressive strength of 23.3N/mm2 and 84.2% of PAI; 21% addition yielded 21.1N/mm2 and 75% of PAI, and 30% addition yielded the compressive strength of 18.3N/mm2 and 64.5% of PAI. 10% and 20% addition can be cast-off for reinforced concrete with regular aggregates and 30% for reinforced concrete with inconsequential aggregates.

· The compressive strength of the concrete cubes for all the mix ratios upsurges with curing stage and diminutions as the Silica Fume content upsurges. The fraction lessening of compressive strength for 15%, 25% and 35% addition of cement with Silica Fume compared with control are 17.8%, 26% and 36.5% correspondingly.

· Commencing the density consequence, the Silica Fume concrete can be confidential as normal weightiness concrete. The proportional reduction in density for 10%, 20% and 30% replacement of cement with Silica Fume are 3.7%, 7.7% and 9.47% correspondingly.

· In concrete construction, substituting of sand up to 30% by marble unwanted powder gives practically parallel strength as of concrete mixtures with 100% sand together at premature and concluding ages. It can be used as sand addition substantial cast-off in manufacturing of inhabited Bedsitting room and Penthouses, which is inexpensive with equated to standard concrete.

2.3 IDENTIFICATION OF GAP

After reviewing the previously carried works of different researchers, it was observed that many research program has been carried out on concrete by replacing cement sand and aggregate with various material separately. The gaps are mentioned below:

· Very less work has been done previously by replacing cement with Silica Fume (SF)- Ground Granulated Blast Furnace Slag(GGBS) and aggregates with marble leftover powder (MWP) and recycled concrete aggregate (RCA).

· The combined effect of these replacement material on concrete has to be explored in various forms as the behavior of concrete was evaluated after using these materials at different proportions only.

· NDT Tests like rebound hammer test and ultraviolet pulse velocity also need to be performed in order to comprehend the performance of replacement material on concrete.

· The optimum dosage of above-mentioned replacement materials needs to be discovered for better and enhanced results of concrete.

CHAPTER 3:
EXPERIMENTAL PROGRAM
3.1 INTRODUCTION

This unit describes the aims of the program which was carried out along with the research methodology that has been used in achieving the desired objectives as below: · The properties of several of waste and recycled materials used.

· Different test procedures which were carried as per the requirements of the present experimental study.

· The various methods employed for preparing the different test specimens including casting, curing and conditioning were also mentioned.

3.2 OBJECTIVES

The present experimental study has been conducted in order to produce green concrete by partially replacement of raw material with waste and recycled materials**.** The main objectives are mentioned below**:**

· To prepare the reference concrete mix of grade M30 for the purpose of comparison**.**

· To partially replace the cement with Silica Fume and GGBS, fine aggregate with marble waste powder and coarse aggregate with recycled concrete aggregate at varying proportions and prepare the concrete mix**.**

· To determine split tensile strength, flexural strength and compressive strength using split tensile strength test, flexural strength test and compressive strength test respectively.

· To compare the obtained results and suggest the optimum proportion of various material used for replacement**.**

3.3 RESEARCH METHODOLOGY

After analyzing the gaps from literature review so far, a systematic approach was developed to carry out the present experimental program.

The following steps were involved during the entire process.

· The Coarse Aggregates, Fine Aggregates and other material were collected from local sources and were tested as per the relevant Indian Standard Codes in order to get their properties.

· The reference design mix M-30 of concrete was prepared as per IS: 10262-1982 with conventional ingredients and various samples were casted.

· Various samples of mix were prepared with replacement of cement with Silica Fume, and GGBS, fine aggregate with marble waste powder and coarse aggregate with recycled concrete aggregate at varying proportions.

· The prepared mix was then cured for 7 days and 28 days and were verified for compressive strength, flexural strength, split tensile strength test, UPV and rebound hammer value.

· In the end, final outcome of the study was concluded i.e. the optimum proportion of various replacement materials.

3.4 MATERIALS USED

The various materials were obtained from locally available sources and were tested for their properties as per the guidelines of significant standard codes. The ingredients utilized in current study were Ordinary Portland Cement, locally available fine aggregates, Silica Fume, GGBS, marble waste powder, recycled concrete aggregate and admixture. The narratives of all the materials used in experiments are given below.

3.4.1 CEMENT

The cement was Ordinary Portland cement of grade 43. Cement is normally manufactured under controlled and supervised conditions. The cement is tested for Consistency test, Setting time test and Specific gravity test. The characteristics of the cement used in this experimental work are represented with the Table 3.1

Table: **3.1 Properties of Cement Used**

PARAMETERS	VALUES
PRIMARY SETTING TIME	131 min
SECONDARY SETTING TIME	301 min
SPECIFIC GRAVITY	3.09
NORMAL CONSISTENCY	28

Figure 3.1 Cement

3.4.2 AGGREGATES

Natural Coarse aggregates and natural fine aggregates are unruffled from local most nearly available source. Next to collection, these natural fine and coarse aggregates were examined in the test site to predict the properties on numerous factors.

3.4.3 FINE AGGREGATE

Creased sand was utilized as natural fine aggregate. Sieve examination was ended to define the region of sand as per the rules of Indian Standard Code: 383-1970. All the physical possessions as well as consequences of sieve examination are presented in Table underneath.

Table: 3.2. Physical Properties of Fine Aggregates

PARAMETER	VALUE
SILT	4.6 %
FINENESS MODULUS	2.79
SPECIFIC GRAVITY	2.41

Table: 3.3. Sieve Analysis of Fine Aggregates

IS SIEVE SIZE	WEIGHT RETAINED (GM)	% WEIGHT RETAINED	CUMULATIVE PERCENT WEIGHT RETAINED	PERCENT PASSING
10 MM	0	0	0	100
4.75 MM	30	3.1	3.1	95.8
2.36 MM	173	17.3	20.5	77.6
1.18 MM	241	23	43.4	54.6
600 MICRON	153	16.4	60.8	41.2
300 MICRON	202	20.0	79.8	21.1
150 MICRON	185	18.7	98.7	2.5
75 MICRON	11	1	99.4	0.5
PAN	4	0.4	100	0

NOTE: WEIGHT OF SAMPLE = 1000GM

3.4.4 COARSE AGGREGATE

Grading of natural coarse aggregate was executed out conferring to Indian standard code: 383- 1970. Crushed aggregates utilized were pointed in form. Specific gravity and water absorption of coarse aggregate were determined conferring to Indian standard code 2386 (PART –3)-1963. Thorough sieve examination test of coarse aggregates was prepared for novel collective graded aggregate and consequences have been presented in Table below along with its physical properties**.**

Table: 3.4. Sieve Analysis of Graded Aggregates

IS SIEVE SIZE	WEIGHT RETAINED (GM)	% WEIGHT RETAINED	CUMULATIVE PERCENT WEIGHT RETAINED	PERCENTAGE PASSING

20 MM	35	3.5	3.5	96.2
10 MM	757	75.7	80	22
4.75 MM	113	11.3	91.2	9.7

Table: 3.5. Physical Properties of Graded Coarse Aggregates

TEST	RESULTS
SPECIFIC GRAVITY	2.81
WATER ABSORPTION	0.49 %
GRADING RATIO OF 20 MM TO 10 MM	2:1

Figure 3.2 Natural Fine Aggregate

Figure 3.3 Natural Coarse Aggregate

3.4.5 WATER

Drinkable water obtainable in the research laboratory for mixing and curing was utilized for this development requirement compliant to Indian Standard Code: 456- 2000.

3.4.6 RECYCLED CONCRETE AGGREGATE

One of the most impeccable alternative to raw material is concrete aggregate (RCA) which is obtained from construction and demolition (C&D) wastes, which results in protecting the natural resources and land; avoid environmental pollution; and reduce the overall charges of construction. The utilization of recycled concrete aggregate in structural construction is practiced in many countries. Various techniques of processing the wastes, effects on the properties of concrete are to be explored. The properties of recycled concrete aggregates are mentioned in table 1.1

Table 3.6. Properties of RCA

Details	Values
Water Absorption	4.11
Specific Gravity	2.39
Size	Between 10 mm to 20mm
Shape	Irregular

Figure 3.4 Recycled Concrete Aggregate at Chandigarh Highway

3.4.7 SILICA FUME

Silica fume is a by-product from the production of fundamental silicon or alloys comprising silicon in electrical curve kilns. At a temperature of around 2000°C the decrease of great pureness quartz to silicon yields silicon dioxide vapor, which oxidizes and condenses at small temperatures to yield silica fume. Silica Fume industry is one of the leading industry as the demand of Silica Fume is huge in the country. The culmination creation of mining the Silica Fume from Silica results in silica residue. The Silica Fume is a precise valuable left-over as it is used in the cisterns in fiery development.The properties of Silica Fume are mentioned below in the table 3.7

Table 3.7. PHYSICAL Properties Of Silica Fume

DETAILS	VALUES
SPECIFIC GRAVITY	2.2
FINENESS PASSING (45µM)	95

MEAN GRAIN SIZE	0.15
COLOR	Light to Dark Grey
SILICON DIAOXIDE	85
ALUMINIUM OXIDE	1.12
IRON OXIDE	1.46
CALCIUM OXIDE	0.8
SODIUM OXIDE	1.2

Figure 3.5 Silica Fume

1.7 GROUND GRANULATED BLAST FURNACE SLAG

Glass granulated blast furnace slag is a globally obtainable formation and well-informed as a residue from the steel and iron processing industry. It is a great superiority, small CO2 substantial. For the reason that GGBS has small exemplified CO2, it permits designing concrete mixes for ecological erection. The manufacturing of GGBS necessitates a smaller amount than 20% of the energy and harvests a smaller amount than 10% of the CO2 releases as equated to Portland cement manufacture.

Table 3.8. Properties of Ground Granulated Blast Furnace Slag

SPECIFIC GRAVITY	2.88
COLOR	WHITE
SURFACE AREA	400
SILICON DIOXIDE	32.50
CALCIUM OXIDE	37.05
MAGNESIUM OXIDE	7.81

Figure 3.6 Ground Granulated Blast Furnace Slag

3.4.8 MARBLE WASTE POWDER

Marble remaining powder is nevertheless additional left-over creation of marble business that has been evidenced beneficial in substituting the natural sand in concrete manufacturing. Marble waste powder (MWP) is resulting as the consequence of brush up and callous method of marble. This by-product is cannot be used further in marble industry and is useless to them. Therefore, researchers have found a way to utilize this waste product in concrete as an alternative to fine aggregate in order to reduce the cost of concrete and environmental pollution.The properties of marble waste powder have been represented in table 3.8

Table 3.9 Properties of Marble Powder

Details	Values
SPECIFIC GRAVITY	2.51
HARDNESS	3
BRIGHTNESS	92
FINENESS	3

MOISTURE	0.12%
ACID INSOLUBLE	2%

Figure 3.7 Marble Waste Powder.

3.4.9 ADMIXTURE

Super plasticizer type retarding admixture confirming Indian standard code 9103-1999 was accepted for creating the concrete examples at 1 percent in all mixes. The properties of admixture that was used in the present study is mentioned in table 3.9.

Table: 3.10 Properties of Admixture

DETAILS	**VALUE**
COLOR	Golden
RELATIVE DENSITY	1.11
PH	6.61
DRY MATERIAL CONTENT (%)	29.69

3.5 CONCRETE MIX SPECIMEN PREPARATION

· On the basis of literature which was reviewed for the present study, following are the replacement proportions of Silica Fume, marble waste powder and recycled concrete aggregate which were used for the study.

· Total calculated design mix as per Indian Standard was organized with variable percentage of Silica Fume, marble left-over powder and recycled concrete aggregate end to end with the control mix, in order to observe their consequence on concrete.

· The partly substitution of cement with Silica Fume is done from 10 percent to 30 percent with the augmentation of 10 percent. Marble left-over powder was utilized in a proportion of 20 percent and 40 percent.

· Coarse aggregate was partly substituted with the static quantity of 25 percent with reprocessed concrete aggregate. Different proportion of various material is shown in table 3.10

Table 3.11 Different Proportions of Materials for Concrete Mix

Design Mix	**Silica Fume** (%)	**GGBS (%)**	**Marble powder** (%)	**RCA** (%)
Control Mix	0	0	0	0
M1	10	10	20	25
M2	10	10	40	25

M3	20	10	20	25
M4	20	10	40	25
M5	30	10	20	25
M6	30	10	40	25

· For compressive strength, a molding cubes of 150mm x 150mm x150mm were prepared and then tested for the compressive strength test as per Indian standard code. · For split tensile strength, samples of dimensions 150 mm dia. and 300 mm altitude were prepared and examination was accomplished as per Indian standard code: 5816-1999. · And for testing the flexural strength, the specimen of beam (size 100mm x 100mm x 500mm) were prepared under the provisions of Indian standard code: 516- 1959. · These concrete samples were tested at 7 days and 28 days for their respective strength parameters.
· Along with these tests, ultrasonic pulse velocity test as per IS: 13311.1-1992 and rebound hammer test were executed at 28 days.

3.6 MIXING

· All the raw ingredients along with the water were weighted first with a weighing balance.
· Then these ingredients are mixed thoroughly by adding water in small increment along with the admixture to prepare the reference mix.
· Similarly, the weight of partial replacements is noted as per the obtained proportions and mixed together with raw ingredients to prepare the replacement mixes.

Figure 3.8 Mixing Of Concrete Mix

3.7 CASTING AND CURING OF CUBES

The empty molds of all the samples were lubricated in advance so that the obtained mixture of ingredients can be poured into the molds as soon as possible. The quantities for all the cubes, cylinder and beams were calculated. After mixing the desired concrete mix, the pouring process was carried out in three layers and with a tamping rod, the compaction of the mold is done. A trowel was used to smoothen the top surface of the molds. The filled molds were covered with wet jute bags in order to ensure no loss of moisture content. After 24 hours the samples were removed from the confinements of the molds, they were put inside a curing tank for curing of concrete. The models were engrossed in curing container for 7 and 28 days beneath an idyllic temperature.

Figure 3.9 Curing Of Specimens

3.8 TESTING OF CONCRETE

The following test procedures were conducted as per the IS 516 to carry out the strength test of the specimens.

COMPRESSIVE STRENGTH TEST

Three samples of each mix was tested and an average of these were recorded and used to represent the results of present study. Cubes of 150mm×150mm×150 mm were prepared for testing at 7 and 28 days of curing correspondingly. Maximum load at which sample fails and any non-usual behavior in the type of failure were recorded. Entirely the examples were substantiated below the compression testing machine as per Indian standard code: 516-1959. Attained significance of Load at the catastrophe is divided by area of cross-section of model cubes and contributes the assessment of compressive strength of concrete cube.

Figure 3.10 Compression Testing Machine

SPLIT TENSILE STRENGTH TEST

This test is mainly performed to determine the split tensile strength of the concrete sample. For performing this test several cylinders were casted. Again 3 samples of cylindrical shape was prepared for each mix, and then tested for split tensile strength as per IS: 5816-1999.
Split tensile strength of concrete =

Figure 3.11 Split Tensile Strength Testing

FLEXURAL STRENGTH TEST

A long beam sample of size 100mm×100mm×500 mm was casted in order to perform the flexure strength test. The casting of the beams is done as per the provisions of IS: 516-1959, 3 beam samples were prepared for each mix group. The beam was tested in the apparatus having two points and three loading mechanism.
The modulus of rupture is calculated using the formula:

Figure 3.12 Flexure Strength Test

ULTRASONIC PULSE VELOCITY TEST

· UPV test is an in-situ, non-destructive test that is utilized to predict the excellence of concrete at a quantified assumed period.
· With the help of this test, the strength and excellence constraint of concrete is considered by assessing the speed of a pulse of ultrasonic that is moved from side to side of a concrete specimen and period taken from preliminary point to termination point is measured.
· If the velocity is higher, then the quality of structure is good.
· And it indicates that the material has good continuity which means no crack or less crack are present in structure and sample.
· But if the velocity has lower value, then the structure has many cracks and voids. Cube samples of all the concrete mixes were tested under this test.

Figure 3.13 UPV Testing

REBOUND HAMMER TEST

· Rebound Hammer test is a technique of Non-destructive test of concrete that measure a convenient and quick suggestion of the compressive strength of concrete structures or example at a quantified time.
· The hammer that is utilized in this test is named as Schmidt hammer that involves a spring well-ordered mechanism that slips on a plunger surrounded in a tube-shaped shell. · The amount of bouncing back characterizes the surface hardness and is measured on advanced scale.
· This chronicled assessment is known as the Rebound Number or the rebound index. Lower value of rebound hammer test tells about the concrete with low strength and low stiffness as it absorbs more energy.

Figure 3.14 Schmidt Hammer for Rebound Hammer Test

CHAPTER 4
RESULTS AND DISCUSSION
4.1 GENERAL

In present chapter, the findings and results of experimental investigation are represented. The numerous examinations which were conducted to evaluate the effect of partial replacement of cement FA and CA on compressive, splitting tensile and flexural strength test, ultrasonic pulse velocity and rebound hammer value. The partly substitution of OPC with Silica Fume is done from 10 percent to 30 percent with the augmentation of 10 percent. Marble left-over powder was utilized in an amount of 20 percent and 40 percent. Coarse aggregate was partly substituted with the static percentage of 25 percent with recycled concrete aggregate.

Table 4.1 Different Proportions of materials For Concrete Mix

DESIGN MIX	**SILICA FUME** (%)	**GGBS (%)**	**MARBLE POWDER** (%)	**RCA** (%)
CONTROL MIX	0	0	0	0
M1	10	10	20	25
M2	10	10	40	25
M3	20	10	20	25
M4	20	10	40	25
M5	30	10	20	25
M6	30	10	40	25

4.2 RESULTS

The consequences that were chronicled throughout the research work entitled "**A STUDY BASED UPON THE EFFECT OF SILICA FUME, GGBS, MARBLE WASTE AND RECYCLED CONCRETE AGGREGATE ON THE STRENGTH PARAMETERS OF CONCRETE**" are point out as under:

4.3 COMPRESSIVE STRENGTH

Reference concrete mix and substitution concrete mix cube were examined under Compression analysis machine. The samples were organized as per the Indian Standard Code provisions and verified for its compressive strength at 2 different curing periods that is seven days and twenty eight days. The consequences attained from the examinations are signified as under in tabular and graphical form.

Table: 4.2. Compressive Strength Test Results

Type of Mix	Compressive Strength after curing of 7days N/mm^2	Compressive Strength after curing period of 28days N/mm^2
Control Mix	22.35	33.26
M1	22.6	33.87
M2	23.20	34.63
M3	25.08	37.44
M4	24.81	37.05
M5	23.64	35.32
M6	22.1	33.14

· With the accumulation of left-over and reprocessed substantial, an enhancement is seen in compressive strength.

· In the commencement, the strength upsurges as the % of substitution of Silica Fume, marble leftover powder and Recycled concrete aggregate till mix M3 and as M3 achieves the compressive strength. But afterwards mix M4, the compressive strength tends to diminution till mix M6.

· Least strength was originate out for mix M6 at twenty eight days.

· All the combinations displays diminutive dissimilarity with respect to each other. · But discrepancy in M3 w.r.t reference mix is extraordinary as there was a huge intensification in its strength.

· The bar chart specified underneath is displaying the difference in the consequence of compressive strength of the test specimen at seven and twenty eight days.

COMPRESSIVE STRENGTH TEST RESULTS

45
40
37.44 37.05
35 30 25 20 15 10 5
23.64

Control Mix M1 M2 M3 M4 M5 M6 Compressive Strength (7days)N/mm2 Compressive Strength (28days)N/mm2

Figure 4.1. Compressive Strength Result Bar Chart

4.3 SPLIT TENSILE STRENGTH

· The split tensile strength was mainly performed to determine the split tensile strength of concrete, split tensile strength is the resistance of a concrete sample against the tensile forces.

· Experimental results of split tensile strength test at the curing period of 7 days, 28 days are given in the Table below.

· These values are also represented graphically in Fig below which is used to represent the variation of strength values and comparison purpose between the various concrete mixes.

Table: 4.3 Results of Split Tensile Strength Test of Specimen

Design Mix	Split tensile strength (7days) N/mm^2	Split tensile strength (28days) N/mm^2
Control Mix	2.83	3.98
M1	2.94	4.12
M2	3.12	4.14
M3	3.21	4.18
M4	3.23	4.57
M5	3.17	4.43
M6	2.91	4.23

· It is decided that the regular tensile strength of the specified sample differs with the dissimilar amount of substitution.
· The difference in consequences of split tensile strength at seven days and twenty eight days is characterized in fig below.
· Supreme split tensile strength at seven days and at twenty eight Days can be understood for mix M-4.
· While, the control mix demonstrates the least strength at both the curing period. · For a second time the difference amongst these standards is not enormous and the outline of upsurge and reduction in strength look like twist and turn pattern.

SPLIT.23
3.984.12 4.14 4.18
4
3.5
3.12 3.21 3.23
3.17
2.832.94
2.91
3
2.5
2
1.5
1
0.5
0

Control
Mix M1 M2
M3 M4 M5 M6 Split tensile strength (7days) N/mm2 Split tensile strength (28days) N/mm2

Figure 4.2 Split Tensile Strength Result

4.4 FLEXURE STRENGTH TEST

· Flexural strength test is a technique that describes degree of flexural strength of concrete.
· It describes degree of the strength of an unreinforced concrete beam in contradiction of the failure in bending. Test consequences of Flexural strength test at the age of seven days, twenty eight days are specified in the Table underneath.
· Concrete mix M3 exhibited supreme flexure strength amongst all former concrete specimen.

Table: 4.4 Flexural Strength Result

Design Mix	Flexural Strength (7days) N/mm^2	Flexural Strength (28days) N/mm^2
Control Mix	4.70	5.38
M1	4.82	5.42
M2	4.89	5.49
M3	4.97	5.72
M4	4.94	5.63
M5	4.75	5.53
M6	4.71	5.42

· The examination consequences replicate that the regular flexure strength of the specimen upsurge till concrete Mix M3 and formerly it tends to reduction with the upsurge in the ratio of substitution.
· It was determined from fig beneath that the M-3 mix displays advanced flexural strength at twenty eight days than extra design mixes and M-6 mix has smallest flexural strength at twenty eight days.
· The difference in flexural strength is small for all the mixes at both the curing period i.e. seven days and twenty eight days.

FLEXURAL STRENGTH TEST RESULTS

72 5.63 5.53 5.42

Control Mix M1 M2 M3 M4 M5 M6 Flexural Strength (7days) N/mm2 Flexural Strength (28days) N/mm2

Figure 4.3. Flexure Strength Test Results

4.5 ULTRASONIC PULSE VELOCITY TEST

UPV test is an in-situ, non-destructive test that is utilized to check the excellence of concrete at a quantified assumed period. With this test, the strength and superiority consideration of concrete is designed by calculating the velocity of a pulse of ultrasonic that is sent through a concrete structure or specimen and time taken from preliminary point to termination point is measured. If the velocity is greater, then the quality of structure is worthy.

Table: 4.5. Ultrasonic Pulse Velocity Test Results

DESIGN MIX	ULTRASONIC PULSE VELOCITY TEST AT 28DAYS(KM/SEC)
CONTROL MIX	4.13
M1	4.23

M2	4.37
M3	4.71
M4	4.67
M5	4.47
M6	4.21

5
4.8 4.6 4.4 4.2 4
3.8 3.6
Ultrasonic Pulse velocity Test at 28days(Km/sec)

Figure 4.4. Ultrasonic Pulse Velocity Outcomes

4.6 REBOUND HAMMER TEST

· Rebound Hammer test is a technique of Non-destructive test of concrete that measures a suitable and rapid suggestion of the compressive strength of concrete structures or sample at a quantified time.

· the test results of the rebound hammer test showed that the maximum value of the compressive stregth of the concrete sampole using several maerials was obtained at M3 mix.

Table: 4.6. Rebound Hammer Test Results

DESIGN MIX	REBOUND HAMMER TEST AT (28DAYS) N/MM^2
Control Mix	36.62
M1	37.32
M2	38.39
M3	42.32
M4	41.74
M5	39.36
M6	36.25

· Figure 4.4 and 4.5 show the discrepancy in the consequences of ultrasonic pulse velocity and rebound hammer test correspondingly.

· In both the tests, concrete mix M-3 shows greater values and M-6 shows the least values. · Therefore, the optimum concrete mix is M3 according to these tests.

Rebound Hammer Test at (28days) N/mm2 50
45
42.32 41.74
40 35 30 25 20 15 10 5
0

36.62 37.32 38.39
39.36

36.25
Control Mix M1 M2 M3 M4 M5 M6 Rebound Hammer Test at (28days) N/mm2

Figure 4.5. Rebound Hammer Test Outcomes

CHAPTER-5:
CONCLUSIONS AND FUTURE SCOPE
5.1 CONCLUSIONS

The current investigational study was executed by preparing the design mix (reference mix and substitution mix) of grade M-30. The partly substitution of cement with Silica Fume is prepared from 10 percent to 30 percent with the augmentation of 10 percent. Marble leftover powder was utilized in a percentage of 20 percent and 40 percent. Coarse aggregate was partly substituted with the static percentage of 25 percent with reprocessed concrete aggregate.

AFTER PERFORMING THIS STUDY AND COMPARISON OF THE RESULTS, THE CONCLUSIONS THAT WERE DRAWN FOR THE PRESENT STUDY ARE DISCUSSED BELOW:

· The compressive strength and flexural strength progressively rises till the concrete mix M-3 and then it tends to reduction till concrete mix M-6.

· The compressive strength and flexural strength of concrete was found out to be extreme for the concrete mix containing 20 percent Silica Fume, 20 percent marble leftover powder and 25 percent Recycled concrete respectively. And smallest strength is displayed by the concrete mix M-6 (30 percent Silica Fume, 40 percent marble left-over powder and 25 percent Recycled concrete aggregate). Therefore, it can be established that all the substitution mixes presented improved consequences than control mix excluding for the concrete mix M-6.

· While, the split tensile strength of concrete upsurges till the concrete mix M-4 and then it starts to reduce till the last concrete mix i.e. M-6. It was established out that the supreme split tensile strength was observed for concrete mix M-4 which entails 20 percent Silica Fume, 40 percent marble left-over powder and 25 percent Recycled concrete aggregate. Moreover, the least split tensile strength was detected for control concrete mix. Therefore, it can be established that all the substitution mixes indicated improved results than control mix.

· Experiment consequences of ultrasonic pulse velocity and rebound hammer specified that concrete mix M-3 displays the advanced standards than any other concrete mix.

· In the mix, the optimal percentage of numerous substitution substantial is 20 percent Silica Fume, 20 percent marble left-over powder and 25 percent Recycled concrete aggregate as it gives advanced values for the current learning.

5.2 LIMITATIONS

· Results of present study may vary if proportions or percentage of different replacement ingredients vary.

· The source of replacement material may not be the same and it might be difficult to obtain the same at certain locations.

· Different admixtures behave differently and hence extra precaution should be taken. · Method used for mixing also results in variation in the results of the study.

5.3 FUTURE SCOPE

· The same study shall be performed for other concrete grades except for M30.

· The strength parameters of same study can be determined at elevated temperature so as to check the resistance of concrete at high temperature.

· The study can be extended to determination with regard to permeability and abrasion resistance.

· Different admixtures as per the requirements can be used to extent the scope of this study.

REFERNCES

· A REVIEW." Abdulkadir, T. S., D. O. Oyejobi, and A. A. Lawal. "Evaluation of Silica Fume as a replacement for cement in concrete works." ACTA Technica Corviniensis Bulletin of Engineering 7.3 (2014): 71.

· Aliabdo, Ali A., Abd Elmoaty M. Abd Elmoaty, and Esraa M. Auda. "Re-use of waste marble dust in the production of cement and concrete." Construction and building materials 50 (2014): 28-41.

· Awargand, Vinod, and Abhijit Warudkar. "international journal of engineering sciences & research technology compressed cement earth block using Silica Fume:

· Biruk Hailu et al, "Application of Silica Fume as a partial cement replacement material"

· Chusilp, Nuntachai, Chai Jaturapitakkul, and Kraiwood Kiattikomol. "Utilization of Silica Fume as a pozzolanic material in concrete." Construction and Building Materials23.11 (2009): 3352-3358.

· Dilbas, Hasan, Mesut Şimşek, and Ö. Çakır. "An investigation on mechanical and physical properties of recycled aggregate concrete (RAC) with and without silica fume." Construction and Building materials 61 (2014): 50-59.

· Gar, Parisa Setayesh, Narayana Suresh, and Vivek Bindiganavile. "Silica Fume as a pozzolanic admixture in concrete for resistance to sustained elevated temperatures." Construction and Building Materials 153 (2017): 929-936.

· Gupta, Raghubansh Bahadur, Kirti Chandraul, and Manindra Kumar Singh. "EXPERIMENTAL STUDY ON STRENGTH OF CONCRETE USING SUGGAR CANE SILICA FUME." (2011).

· Hebhoub, H., et al. "Use of waste marble aggregates in concrete." Construction and Building Materials 25.3 (2011): 1167-1171.

· Kawade et al., "Effect of use of Silica Fume on Strength of Concrete" ISSN: 2319-8753 Vol. 2, Issue 7, July 2013.

· Kou, Shi-Cong, Chi-Sun Poon, and Miren Etxeberria. "Influence of recycled aggregates on long term mechanical properties and pore size distribution of concrete." Cement and Concrete Composites 33.2 (2011): 286-291.

· Kubissa, Wojciech, et al. "Properties of concretes with natural aggregate improved by RCA addition." Procedia Engineering108 (2015): 30-38.

· Marcos oliveira de paula."Silica Fume as a partial Portland cement replacement material," Medellin, September, 2010. ISSN 00127353.

· MK, YFumewanth, and P. Nagarjuna. "An Experimental Study on Synergic Effect of Silica Fume Cane Silica Fume a Patel, Jayminkumar A., and Dr DB Raijiwala.

· Nuntachai Chusilp et al, "Utilization of Silica Fume as a pozzolanic material in concrete" Journal of Materials in Civil Engineering, Construction and Building Materials 23 (2009) 3352–3358.

· Piyanu, "Effect of fine Silica Fume on workability and compressive strength of mortar", Chaing Mai J.sci 2013; 40(1):126-134

· Poon, C. S., et al. "Influence of moisture states of natural and recycled aggregates on the slump and compressive strength of concrete." Cement and concrete research 34.1 (2004): 31-36.