

PERFORMANCE EVALUATION OF SELF PURIFYING CEMENT MORTAR INCORPORATED WITH CONSTRUCTION DEBRIS and TiO_2

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering Degree in
Civil Engineering
By

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**DEPARTMENT OF CIVIL ENGINEERING
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC
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APRIL - 2021



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DEPARTMENT OF CIVIL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **R. Arunkumar (37200078)** and **Ra.M. Mukarjee (37200703)** who carried out the project entitled **“PERFORMANCE EVALUATION OF SELF PURIFYING CEMENT MORTAR INCORPORATED WITH CONSTRUCTION DEBRIS and TiO_2 ”** under our supervision from October 2020 to March 2021.

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DECLARATION

We, **R. Arunkumar (37200078)** and **Ra.M. Mukarjee (37200703)** hereby declare that the Project Report entitled “**PERFORMANCE EVALUATION OF SELF PURIFYING CEMENT MORTAR INCORPORATED WITH CONSTRUCTION DEBRIS and TiO_2** ” done by us under the guidance of Dr. S. Packialakshmi is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Civil Engineering.

1.



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**SIGNATURE OF THE
CANDIDATES**

DATE:

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ABSTRACT

In recent years demolished construction waste handling and management is the new primary challenging issue faced by the countries all over the world. In order to minimize the construction waste, the need to find the replacement of fine aggregate with debris. TiO_2 is self-purifying material and acts as a photocatalyst which helps to fill the pores and removes dust in surface. In this research paper, investigation of conventional mortar incorporated with construction debris and titanium dioxide. The cement mortar could be prepared with different mix ratio 1:4. For the above mix ratio the fine aggregate can be replaced by 0%, 25%, 50%, 75%, 100%. In addition of TiO_2 with debris mortar after finding the optimum percentage of debris added. To assess the performance of self-purifying mortar the test such as compressive strength and morphological characteristics where conducted. The optimum percentage of replacing debris is 25% with M-Sand of 75% and TiO_2 of 4% is be found by compression test results. The SEM test used to define the morphology of conventional mortar and self-purifying mortar. The XRD test shows the structure and phase of the sample with spatial arrangements of atoms.

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LIST OF SYMBOLS AND ABBREVIATIONS

The following symbols carrying the meaning noted against them are used in this volume.

Symbols

g	=	gram
N	=	Newton
kN	=	Kilo Newton
kg	=	kilogram
m ³	=	cubic meter
mm, mm ²	=	millimetre, square millimetre

Abbreviations

SEM	=	Scanning Electron Microscopy
XRD	=	X-Ray Diffraction
TiO ₂	=	Titanium dioxide
IS	=	Indian Standards
M ₂₅	=	Grade of concrete
M ₁ – M ₅	=	samples
SiO ₂	=	Silica dioxide
ZnO	=	Zinc oxide
Al ₂ O ₃	=	Aluminium oxide
PCM	=	Phase Change Material
PC	=	Portland Cement
HAC	=	High Alumina Cement
OPC	=	Ordinary Portland Cement
H ₂ SO ₄	=	Sulfuric acid
TGA	=	Thermogravimetry Analysis
DSC	=	Differential Scanning Calorimetry
UTM	=	Universal Testing Machine

CHAPTER I

INTRODUCTION

1.1 GENERAL

Concrete is everywhere, whenever human have inhabited, concrete is there. Home, institutions, hospitals, industry, and footpath all make use of concrete, it's a superb material to create long-lasting and energy efficient building. However, even with good design, human need change and potential waste are going to be generated. This, result's generation of construction debris and debris waste as estimated 900 billion tonnes once a year in India, Europe, US and Japan. The recycling of those waste has several advantages. In India it's estimated that about 10-12 million tonnes of waste annually are generated by industry. These waste materials need an outsized place to dump and hence the disposal of waste how become a several social and environmental problem. On the opposite hand, great thing about natural resources like river sand in another major pollution which end in increasing the depth of river bed. the chance of recycling demolition waste within the industry is thus of accelerating important additionally to the environmental benefit in reducing the demand of land for disposing the waste. The recycling of demolition waste can help to conserve natural material and to scale back the value of waste treatment before disposal. a brand-new approach to avoiding environmental contamination by reducing waste stocks and reducing the employment of natural aggregates is recycling building waste as aggregates it's been established that materials and components recovered from demolished buildings are being reused for brand spanking new construction works likewise as renovation projects, especially by low-income communities in developing countries. Utilizing recycled aggregate in new building concrete components is a technique to alleviate these issues. Recycling wouldn't only conserve the resources but would also promote safe and economic use of such concrete which is that the need of the hour for manging the resources effectively and economically. The waste is crushed and sieve to get the dimensions for replace the fine aggregate. The demolished site is considered as the source for construction debris. The demolished waste was transported, crushed and segregated. Several tests on segregated concretes were conducted in the laboratory like water absorption, sieve analysis, crushing value test, impact value test, and abrasion test, workability and crushing strength of natural & demolished waste by making cubes. The demolished waste was

sieved using a set of IS sieves to get a fineness of fine aggregate which was replaced by construction debris. Mortar is another artifact manufactured from cement, which is mixed with fine sands and water, and lime is applied to extend the product's longevity. Adding water to the current mixture stimulates the cement, causing it to harden or cure within the same way as concrete does. Mortar isn't as strong as concrete and typically isn't used as a sole artefact. Rather, is it the "glue" that holds together bricks, concrete block, stone, and other masonry materials. The present study deals with the replacement of debris with M-Sand in cement mortar. The good quality and required quantity of cement and fine aggregate are used the study to replace the fine aggregate with construction debris. In this both river sand and M-Sand were used as fine aggregate for comparative analysis. To impart self-purifying characteristics for conventional mortar, different percentage of TiO_2 were added.

1.2 OBJECTIVES

By conducting intensive literature survey the following objectives were formulated.

- To study the strength characteristics of mortar added with TiO_2 and construction debris.
- To perform microstructure study using Scanning Electron Microscopy (SEM) and X-Ray Diffraction (XRD) analysis to confirm the self-cleaning process of TiO_2 .

1.3 POINTS TO BE CONSIDERD FOR THE STUDY

- The brick bats should be noticed in the demolition waste and take measures on preventing it.
- The finer particles to be removed from the waste.
- Bonding nature and mortar properties to be observed while casting the test specimen.
- Different proportions of TiO_2 were used for assess the pores coverage in the exterior surface to be noted.
- To compare the surface morphological characterises of conventional mortar with TiO_2 added mortar, SEM analysis and XRD analysis will be conducted.

CHAPTER II

REVIEW OF LITERATURE

2.1 CONVERSION OF DEMOLITION WASTE INTO FINE AGGREGATE

Asif Husain and Masid massaq assas (2013) investigated the feasibility and recycling of demolished waste concrete for brand new construction. the current investigation to be focused on recycling demolished waste materials so as to scale back construction cost and resolving housing problems faced by the low-income communities of the planet. The crushed demolished concrete wastes are segregated by sieving to get required sizes of aggregate, several tests were conducted to work out the combination properties before recycling it into new concrete. The compressive strength test results of partial replacement and full recycled aggregate concrete and are found to be beyond the compressive strength of normal concrete with new aggregate.

Catarina Neno, (2014) concluded the performance of mortars during which recycled concrete aggregates (RCA) was a component. It replaced natural sand but kept the identical particle size distribution. Three mortars were produced with replacement ratios of 20%, 50% and 100% likewise as a reference mortar containing no recycled aggregate. The compressive and flexural strength, water absorption by capillarity, drying capacity and susceptibility to cracking of those mortars were analysed first. Then, supported these results, the foremost satisfactory replacement ratio was chosen and also the following properties were analysed: water retentivity, shrinkage, adhesive strength, modulus of elasticity, and water vapour permeability. Somewhat surprisingly the simplest leads to the primary stage occurred for 20% and 100% replacement ratios, resulting in a cautious choice of the 20% ratio for the second stage. Generally, the mortar with 20% replacement ratio performed better than the reference mortar, apart from adhesive strength and dimensional stability.

Silva, et al., (2014) this reported the factors affecting the physical, chemical, mechanical, permeation and compositional properties of recycled aggregates sourced from construction and demolition waste. the data were collectively subjected to

statistical analysis and a performance-based classification, mainly to be employed in concrete construction, is proposed. The results allowed producing a practical means of measuring the quality of recycled aggregates, which can be accustomed produce concrete with predict Table performance.

Yadhu and Aishwarya Devi (2015) evaluated the effect of partial replacement of cement, fine aggregate and coarse aggregate by different parts of demolished wastes on strength and workability of concrete made. For the study, design mix concrete of grade M₂₅ (Referral concrete) was prepared using IS: 10262-2009. Thereafter, the replacement of varied constituents of concrete, one at a time was allotted by replacing these with the varied sieved fractions of crushed demolition waste. The compressive strength at 28 days, and workability in terms of slump value were measured. The test results show that the behaviour of recycled waste concrete with partial replacement of 10% of cement, fine aggregate and coarse aggregate at 28 days is cherish that of referral code further, the results indicate that also higher replacement of the constituent materials is possible without much compromising the 28 days strength and workability.

Radhika, et al., (2017) concluded the research on the fine aggregate replacement in M₂₀ grade concrete with the development and demolition waste on Different samples like M₁, M₂, M₃, M₄, and M₅. The ratio of sand replaced to recycled fine aggregate are 100-0% as control, 80-20%, 50-50%, 20-80% and 0-100%. The project explains about the properties of materials employed in concrete, mechanical and transport properties of the concrete. within the recycled aggregate the share of fines present is over that of the natural sand. because the fines are over the water absorption also increases. The absorption of RFA is 4%. The RFA does affect the fresh properties of the concrete. The compressive strength is increased some percentage of the replacement.

2.2 JUSTIFICATION OF SELF-PURIFYING MORTAR

Jayapalan et al., (2009) identified the effect of Nano-scale non-reactive anatase titanium dioxide (TiO_2) on early age hydration of cement was experimentally studied. Isothermal calorimetry was performed on cement pastes with two different particle sizes of TiO_2 at replacement levels of 5, 7.5 and 10%. The addition of TiO_2 to cement increased the heat of hydration and accelerated the rate of reaction at early stages of hydration. This increase was found to be proportional to the percentage addition and the fineness of TiO_2 . These results demonstrate that the addition of non-reactive nano-scale fillers could affect the rate of cement hydration by heterogeneous nucleation.

Tao Meng, et al., (2012) reported the test results indicated that when cement was substituted by nano- TiO_2 , the strength of cement mortar at early ages increased lots and therefore the fluidity and strength at evening ages decreased obviously. The change tendency of diffraction intensity of (0 0 1) crystal plane was entirely different thereupon of (1 0 1) crystal plane. It seemed that the most reason for the development of strength is that the decrease and modification of orientation index for the nucleus function, not the increasing amount of hydration products. Results also indicated that it had been useful to change the fluidity and therefore the strength at evening ages of the cement mortar with nano- TiO_2 by adding superplasticizer and slag powder into cement mortar.

Lucas et al., (2013) concluded the photocatalytic additive (titanium dioxide) was added to cement mortars prepared with aerial lime, cement and gypsum binders. The foremost goal was to seek out the way that microstructural changes affect the photocatalytic efficiency. The photocatalytic activity made up our minds employing a reactor developed to assess the degradation rate with a typical urban pollutant, NO_x . The laboratory results show that each one the compositions tested exhibited high photocatalytic efficiency. it had been demonstrated that photocatalytic mortars are applied in new and old buildings, because the Nano additives don't compromise the mortar hardened state properties

Jintao Liu, et al., (2015) identified the workability, mechanical and microstructure properties of mortar containing four kinds of nanoparticles were Nano- Al_2O_3 , Nano- SiO_2 , Nano- TiO_2 , Nano- ZnO . It can be analyzed by Scanning Electron Microscope and X-ray diffraction. Test results are increasing addition of Nano- SiO_2 and nano- Al_2O_3 led to the increasing water demand while nano- TiO_2 and nano- ZnO had little affect on the mortar fluidity. With 3% nano- SiO_2 particles, the 7 days flexural and compressive strength increased by 17.8% and 9.5%.

Pawel Sikora, et al., (2015) evaluated the self-cleaning properties and strength development characteristics of mortar containing waste glass and nanomaterials (Nano silica and titanium dioxide) are analyzed in terms of waste glass content and also the effectiveness of commercially available nanomaterials. Quartz sand is replaced with brown waste glass at ratios of 25%, 50%, 100% by weight. The photodegradation of the rhodamine B test has been conducted to analyze the effect of titanium oxide, Nano silica and waste glass presence within the cement mortar for its potential application in self-cleaning facades. Studies have shown that waste glass can act as a successful replacement for sand, especially when mixed partially with sand. Additionally, a positive influence of nanomaterials on the mechanical properties and self-cleaning was noted.

Sandra Lucas (2016) examined the growing awareness concerning indoor air quality and energy efficiency, two different solutions became prominent in this research field: latent heat storage capabilities and photocatalytic mortars. The paper discusses the manipulation of cement mortars microstructure, by studying the microstructural modifications with different amounts of PCM (phase change material) and nanoparticles of titanium dioxide. Using the correct combination of both additives, the mechanical strength will not be reduced. The paper demonstrates that it is possible to develop new and advanced cement mortars for building applications, more complex and with multiple functions, opening a new field of opportunities for the construction sector

María Pérez-Nicolás, et al., (2017) investigated the cement mortars with two different binders (Portland cement and high alumina cement) were modified upon the

majority incorporation with Nano-structured photocatalytic additives (bare TiO_2 , and $\text{TiO}_2/\text{TiO}_2$ doped with either iron ($\text{Fe-TiO}_2/\text{TiO}_2$) or vanadium (V-TiO_2)). Water demand was increased, slightly by bare TiO_2 and Fe-TiO_2 , and strongly by V-TiO_2 , in agreement with the reduction of the particle size and therefore the tendency to agglomerate. Changes within the pore size distribution, mainly the filler effect of the Nano-additives, accounted for the rise in compressive strengths measured for HAC mortars. Fe-TiO_2 were found to be homogeneously distributed where the tendency of V-TiO_2 to agglomerate was evidenced by elemental distribution maps. Water absorption capacity wasn't littered with the Nano-additive incorporation in High Alumina Cement mortars, which may be a favourable feature for the applying of those mortars.

Syamsidar, et al., (2017) described Class-C ash and metakaolin were used as raw materials to provide geopolymers pastes (binder). Nano TiO_2 was added into geopolymers paste at different concentration namely 0 wt.%, 5wt%, 10wt% 15wt% ash were immersed in 1 M H_2SO_4 solution for 3 days for acid resistance examination. The self-cleaning properties were observed by immersing the sample into red clays solution. The diffraction (XRD) was performed to look at the structure and phase of the samples before and after acid resistance measurement. Scanning microscopy (SEM) was performed to look at the surface morphology of the resulting composites

Atta-ur-Rahman, et al., (2018) found the effects of titanium dioxide (TiO_2) nanoparticles on the sulphate attack resistance of ordinary Portland cement slag-blended mortars were investigated with a w/c ratio 0.4 and mix ration 1:3. TiO_2 was added as an admixture as 0%, 3%, 6%, 9% and 12% of the binder weight. Mortar specimens were exposed to an accelerated sulphate attack environment. Expansion, changes in surface and mass microhardness were measured. Scanning Electron Microscopy (SEM), Energy Dispersive Spectroscopy (EDS), X-ray Diffraction (XRD), and Differential Scanning Calorimetry (DSC) tests were conducted. The show that the addition of Nano- TiO_2 accelerated expansion, variation in mass, loss of surface microhardness and widened cracks in slag-blended mortars because of Nano- TiO_2

reduced the size of coarse pores, so it increases the crystallization pressure due to the formation of gypsum thus led to more damage under sulphate attack.

Kaszynska, et al., (2018) identified the photocatalytic activity of TiO_2 and its hydraulic properties make it suitable for addition to building materials. The mortar was produced by adding from 1% to 5% of modified TiO_2 . The compressive and tensile strength, initial and final setting time and self-cleansing properties were tested. Performed studies have shown that the addition of TiO_2 influences the flowability of cement paste and significantly increases the rate of setting process. The reduction of the strength of modified mortars compared to ordinary mortars was significant, proving that the TiO_2 has the application in modern architecture.

CHAPTER III

MATERIALS AND METHODS

3.1 CEMENT

Cement is the binding element in both mortar and concrete. It is commonly made of lime stone, shells, clay, and silica sand. These materials are crushed and combined with other ingredients (including iron ore), and then heated to about 2,700 F is ground into a fine powder and packaged to use for mixing various cementitious building materials, including concrete and mortar. The Table 3.1 and 3.2 explains the chemical composition of cement and properties of cement.



Fig. 3.1 Cement

Table 3.1 Chemical composition of cement

Components	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	So ₃	Loss on ignition
PPC %	31	9.5	5.8	43	1.6	2.7	3.1

Table 3.2 Properties of cement

Particulars (IS 1747, IS 1489)	Range	Result
Specific Gravity	2.90	2.85
Consistency	33%-35%	35%
Fineness modulus	10% should be retained	10%
Initial setting time	30 mins	45 mins
Final setting time	600 mins	640 mins

3.2 AGGREGATE

Aggregate in building and construction material used for mixing with cement, lime, gypsum, or other adhesive to form concrete or mortar. The aggregate gives stability and volume, resistance to wear or erosion, and other physical properties to the finished product. Fine aggregate is used in making thin concrete slabs or other structural members and where a smooth surface is obtained; coarse aggregate is used for more massive members.

3.2.1 FINE AGGREGATE

3.2.1.1 River Sand

The amount of fine aggregate usage is very important in cement mortar. The aggregates used are without impurities like clay, shell and organic matters. Fine aggregate includes the particles that retain on 0.075 mm sieve and passes through 4.75 sieve. The Table 3.3 explains the range of sand properties as per standard and the value obtained from test which can be used to compare and check whether the material should be applicable for the preparation of cement mortar.

Table 3.3 Properties of sand

Particulars (IS383)	Range	Result
Specific Gravity	2.65	2.62
Bulk density	1520-1680 kg/m ³	1590
Fineness modulus	2.2-3.2	2.4
Grading	Zone I, Zone II, Zone III, Zone IV.	Zone II, Zone III
Water absorption	Less than or equal to 20% of water should be absorbed	13%

3.2.1.2 M Sand

The amount of fine aggregate usage is very important in cement mortar. The aggregates used are without impurities like clay, shell and organic matters. Fine aggregate includes the particles that retain on 0.075mm sieve and passes through 4.75mm sieve. The following Table 3.4 explains the range of M-Sand properties as per standard and the value obtained from test which can be used for the preparation of cement mortar.

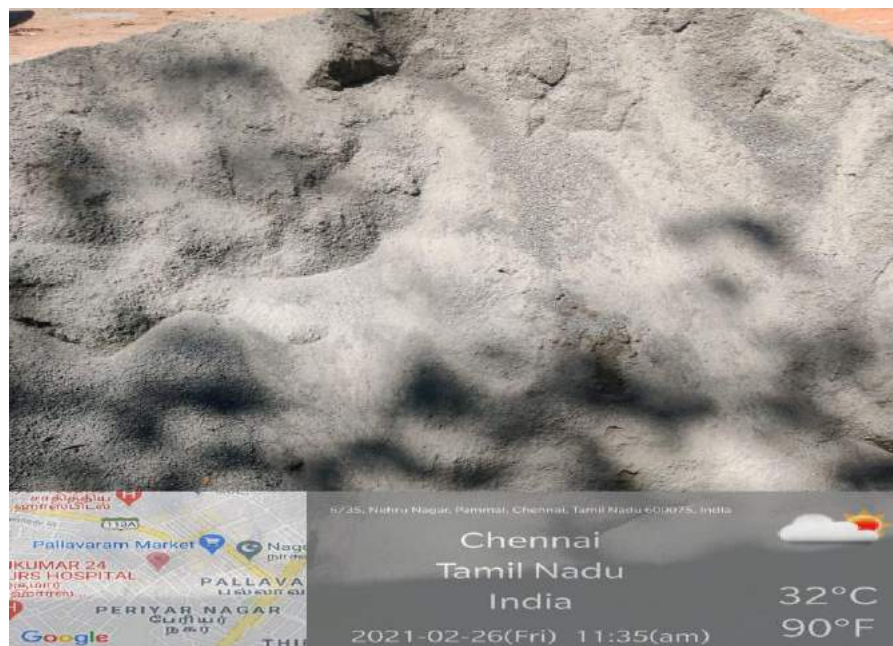


Fig. 3.2 M SAND

Table 3.4 Properties of M-Sand

Particulars (IS383)	Range	Result
Specific Gravity	2.73	2.69
Bulk density	1.75 kg/m ³	1.70
Fineness modulus	4.66	4.62
Grading	Zone I, Zone II, Zone III, Zone IV.	Zone II, Zone III
Water absorption	Less than or equal to 20% of water should be absorbed	15.5%

3.2.1.3 Recycled fine aggregates

The building and demolition waste are taken and crushed to separate fine and coarse materials. Then the aggregates are sent to the batching plant and washed to remove the fines, and then they are separated by sieving. In this project we had been using the recycled fine aggregate. The aggregates passing through 4.75mm sieve and retained on 90 microns are taken. The Figure 3.1 and 3.2 represents the demolition construction waste which is raw construction debris and debris as fine aggregate. The following Table 3.5 explains the range of sand and M-Sand properties as per standard and the value obtained from test which can be used to compare and check whether the material should be applicable for the preparation of cement mortar. Our project mainly deals with the replacement of debris with M-Sand in cement mortar.



Fig. 3.3 Recycled Fine aggregates

Table 3.5 Properties of Recycled Fine aggregates

Particulars	Range	Result
Specific Gravity	2.65-2.73	2.69
Fineness modulus	2.22-4.66	3.2
Bulk density	1520-1750	1590
Grading	Zone I, Zone II, Zone III, Zone IV.	Zone II, Zone III
Water absorption	Less than or equal to 20% of water should be absorbed	20%

3.3 Titanium dioxide

Titanium dioxide nanoparticles, also known as ultrafine titanic oxide, nanocrystalline titanic oxide, or microcrystalline titanium oxide, are titanium oxide particles with diameters less than 100 nano meters. Ultrafine titanium has in anatase structure photocatalytic sterilizing properties, which make it useful as an additive in construction materials, as example in antifogging coatings and self-cleaning windows. The Figure 3.3 and 3.4 represents the microscopic structure of Nano particle and therefore the white colour powder of titanium oxide.

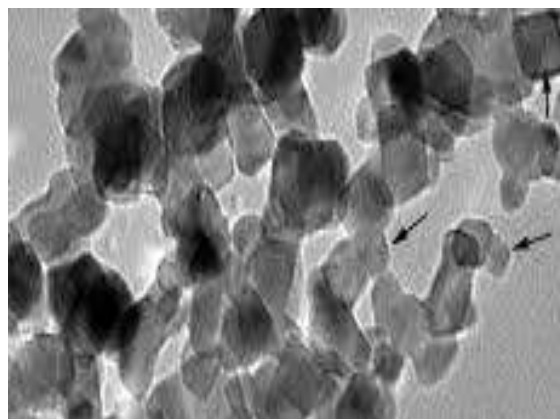


Fig. 3.4 TiO_2 Nano particle



Fig. 3.5 TiO_2 powder

Table 3.6 Mix proportion for normal mortar

Material	1:4
Cement (gm)	700
Sand (gm)	3100
M-Sand (gm)	3080

The Table 3.7, explains the mix proportion for replacement of construction debris with sand and M-Sand to prepare conventional and self-purifying mortar with different ratio 1:4. The replacement of construction debris in different proportions for concrete is reviewed replacement of debris with 20%, 50% and 100%. The replacement of debris with ratio 100:0%, 75:20%, 50:50%, 20:75%, 0:100% for concrete. After reviewing the above-mentioned literature, preparation of cement mortar with the replacement of debris in different proportion of 0:100%, 25:75%, 50:50%, 75:25%, 100:0%. The quantity of materials required for the proportion are mentioned.

Table 3.7 Mix proportion for replacement of mortar ratio1:4

Mix	% of debris	Cement(gm)	Sand(gm)	Debris(gm)
M ₁	0	403	1700	0
M ₂	25	403	1275	425
M ₃	50	403	850	850
M ₄	75	403	425	1275
M ₅	100	403	0	1700
Mix	% of debris	Cement(gm)	M-Sand(gm)	Debris(gm)
M ₆	0	403	1700	0
M ₇	25	403	1275	425
M ₈	50	403	850	850
M ₉	75	403	425	1275

The Table 3.8 and 3.9 represents percentage of titanium dioxide added in self purifying cement mortar to find the optimum percentage needed to make a prototype and total quantity of materials needed for entire project work.

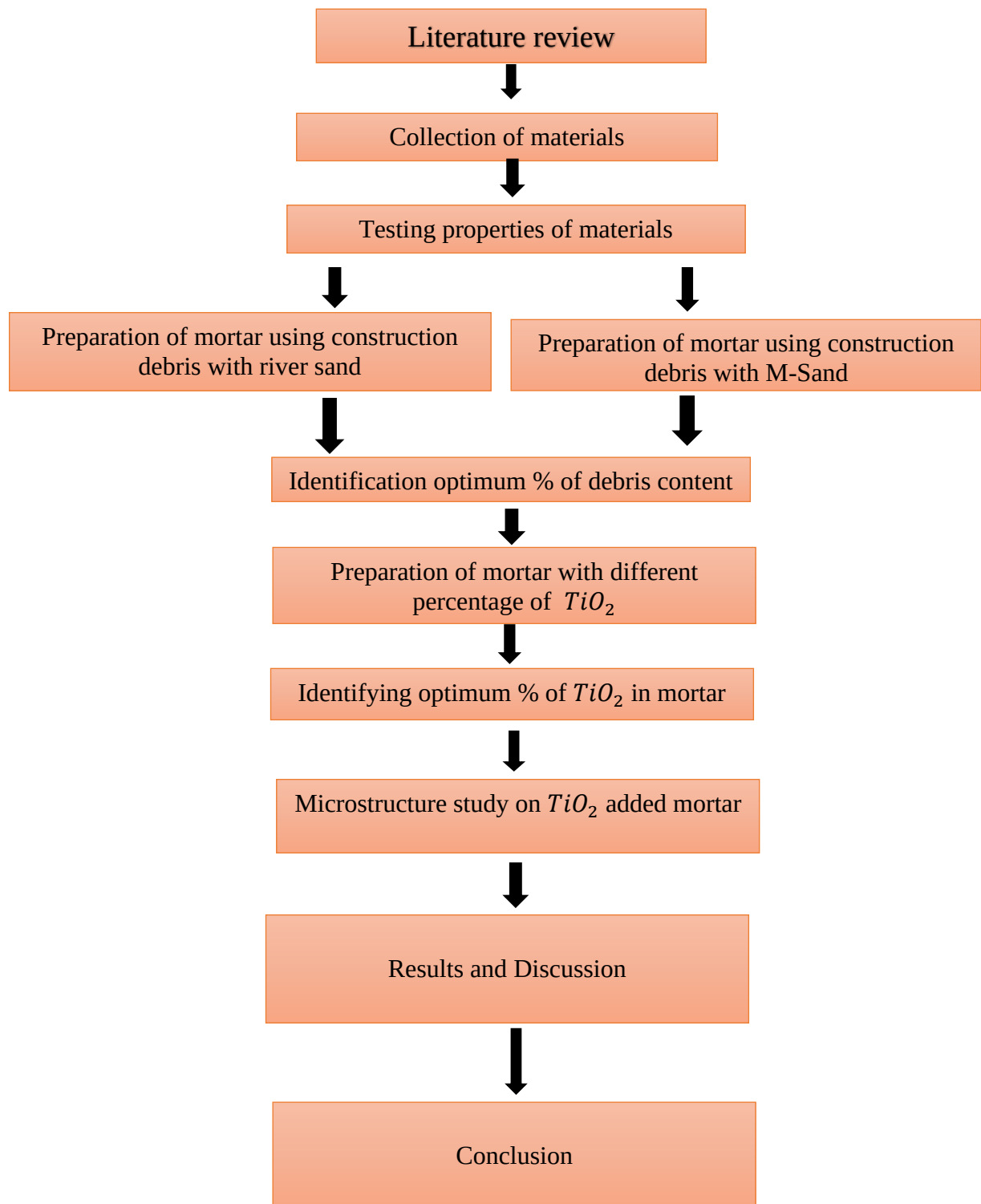
Table 3.8 Percentage of TiO_2 added in cement mortar

% of TiO_2 added	1:4(gm)
2	8
4	16

Table 3.9 Total quantity of materials as per proportion

Materials	Total quantity(gm)
Cement	4800
River Sand	12400
M-Sand	12320
Debris	16550
Titanium dioxide	72

3.5 METHODOLOGY



This shows the methodological framework to conduct the experimental work on modified mortar.

3.6 EXPERIMENTAL PROCEDURE

The test specimen are tested to investigate the compressive strength characteristics, micro structural arrangements and visual interpretation to evaluate the self-purifying characteristics.



Fig. 3.6 Mortar with TiO_2 powder



Fig. 3.7 Preparation of mould



Fig. 3.8 Cube after demolding

3.6.1 Compression Strength

The compressive strength of the mortar was measured on 150mm x 150 mm x 150 mm. All cubes were cast in three layers, and each layer was fully compacted using the mortar cube vibrator. After casting, specimens were kept at room temperature for 24 h. Then they were demoulded and transferred to the curing tank where they were stored until their testing dates. The compressive strength was measured at the age of 28 days using the universal testing machine (UTM) with the capacity of 400 kN. The following Figure 3.7 shows the testing of compressive strength for the test specimen.



Fig. 3.9 UTM Machine under loading

3.6.2 SEM Analysis

Scanning Electron Microscopy scans a focused beam of electrons across the specimen and measures any of several signals resulting from the electron beam interaction with the specimen. The most commonly used imaging modes are secondary electron, backscattered electron, and x-ray. Images are monochrome because they represent the electron or x-ray flux produced by the interaction of the beam and the specimen. Computer-based image processing and analysis make routine quantitative imaging possible.

3.6.3 X-ray Diffraction

A scattering of X-rays by the atoms of a crystal that produces an interference effect so that the diffraction pattern gives information on the structure of the crystal or the identity of a crystalline substance. X-ray powder diffraction (XRD) is a rapid analytical technique primarily used for phase identification of a crystalline material and can provide information on unit cell dimensions. The analysed material is finely ground, homogenized, and average bulk composition is determined.

3.6.4 Visual Interpretation

The visual interpretation was made by observing the colour changes between conventional mortar and modified mortar. The addition of TiO_2 in the preparation of self purifying mortar investigated in this study.

CHAPTER IV

RESULTS AND DISCUSSION

4.1 COMPRESSION TEST

The compression test of mortar cube is carried out in Universal testing machine with the capacity of 400 kN . All cubes were cast in three layers, and each layer was fully compacted using the vibrator. Compressive strength was carried out to investigate the strength characteristics of conventional mortar, debris added mortar with various percentage and TiO_2 added mortar. Comparative analysis was made to assess the performance of construction debris and TiO_2 . Table 4.1 shows the compressive strength of conventional mortar using sand and M-Sand.

Table 4.1 Compression test value for conventional mortar

Cement mortar	1:4	
	sand	M-Sand
strength (N/mm ²)	2.81	3.45

The study conducted by Thivya and Aarthi (2019) shows that the compressive strength using M-Sand shows greater compressive strength than the river sand. The present study is also showing greater value of compressive strength for mortar with M-Sand

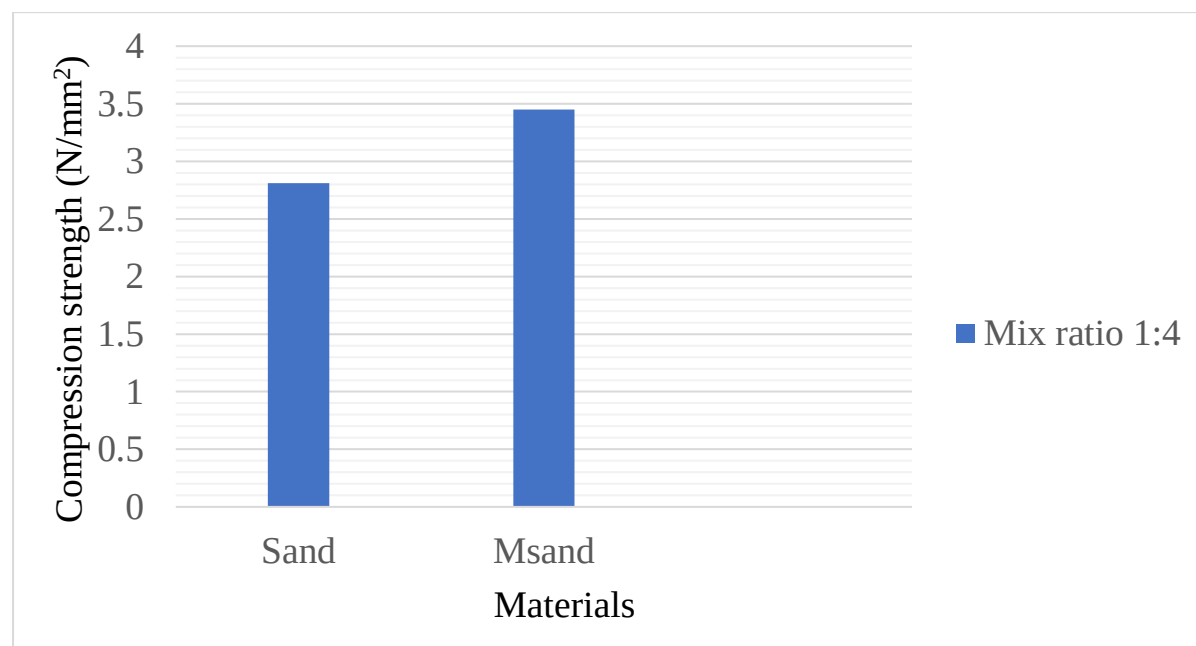


Fig. 4.1 Compression strength for conventional mortar

The Table 4.2, shows compression test value for conventional mortar, with replacement of debris for mix ratio 1:4, respectively.

Table 4.2 Compression test value for debris added mortar for mix ratio 1:4

Cement mortar	25% of debris		50% of debris		75% of debris		100% of debris	
	Sand	M-Sand	Sand	M-Sand	Sand	M-Sand	Sand	M-Sand
strength (N/mm ²)	3	3.98	2.21	2.81	1.87	2.41	2	2.65

Table 4.2 shows the compressive strength of debris added mortar with a replacement proportions of 25,50,75 and 100%.

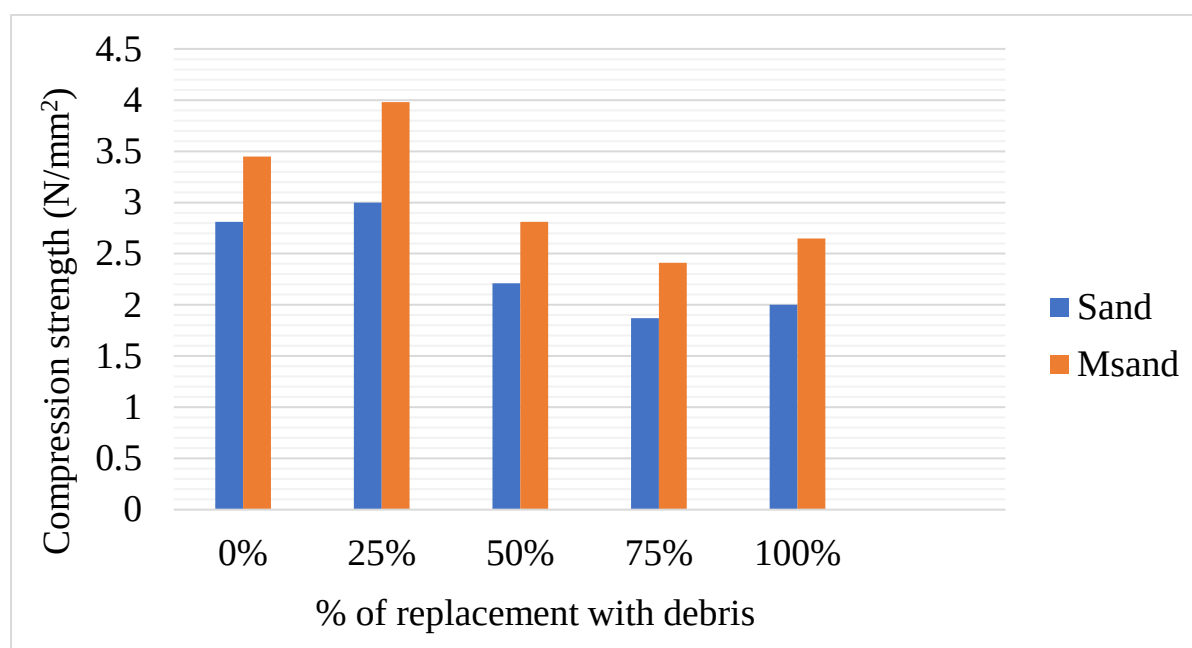


Fig. 4.2 Compression strength debris added mortar for mix ratio 1:4

By referring the Table 4.2 and Figure 4.2, replacement of 25% fine aggregates with construction debris shows the greater compressive strength when compared with 50,75 and 100 % replacement.

Table 4.3 Compression test for self-purifying mortar

Titanium dioxide	Mix ratio	strength (N/mm ²)
2%	1:4	4.51
4%	1:4	6.67

In the Figure 4.3, gives the comparison compression test value for self-purifying mortar with debris for easy observation.

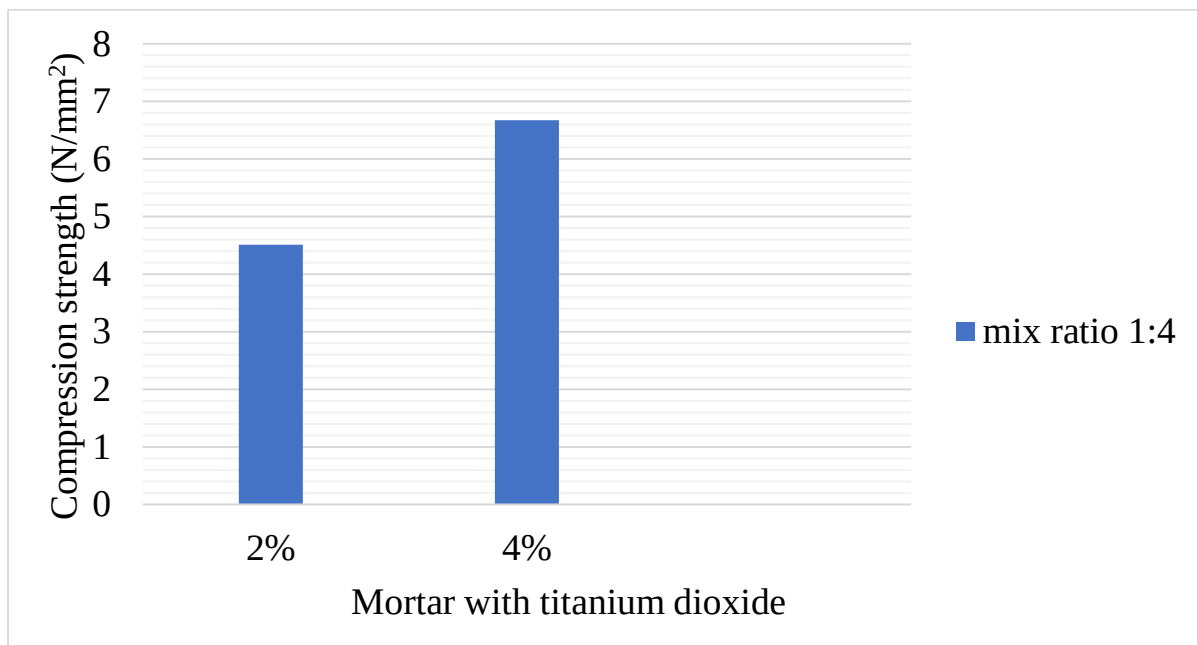


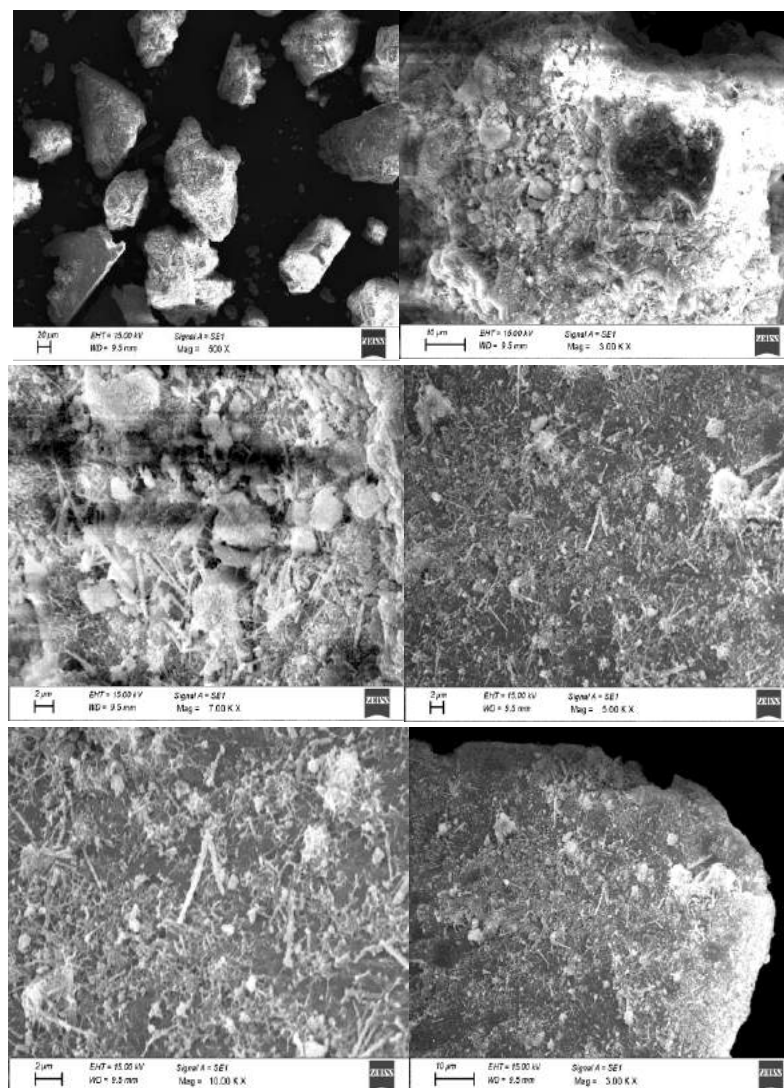
Fig. 4.3 Compression strength for self-purifying mortar

Table 4.3 and Figure 4.3 shows the compressive strength value for TiO_2 added mortar from the results, it is inferred that increase in percentage of TiO_2 improved the strength characterisation. The compressive strength of TiO_2 added mortar 4% is 6.67N/mm² which is greater than 2% added mortar.

The study conducted by Kaszynska, and Olczyk, (2018), addition of TiO_2 is accelerating the rate of hydration significantly. When the level of nanoparticle dosages exceeded the optimum dosage of 3 % by the weight of cement, Nano TiO_2 showed a gradual decrease in the workability of the fresh mortar

4.2 SCANNING ELECTRON MICROSCOPY TEST

Scanning Electron Microscopy analysis test is done by using an instrument called scanning electron microscope which the electrons are generated by heating by the electron gun, which acts like a cathode. These electrons are propelled towards the anode, in the same direction as the sample, due to strong electric field. The condensed electron beam then reaches the objective lens, which the consumer calibrates to a fixed location on the sample.



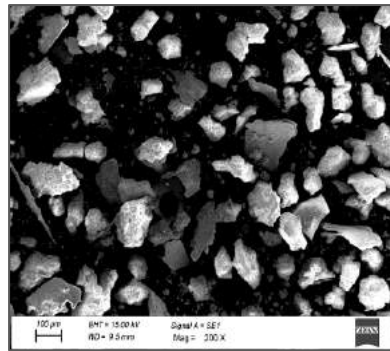
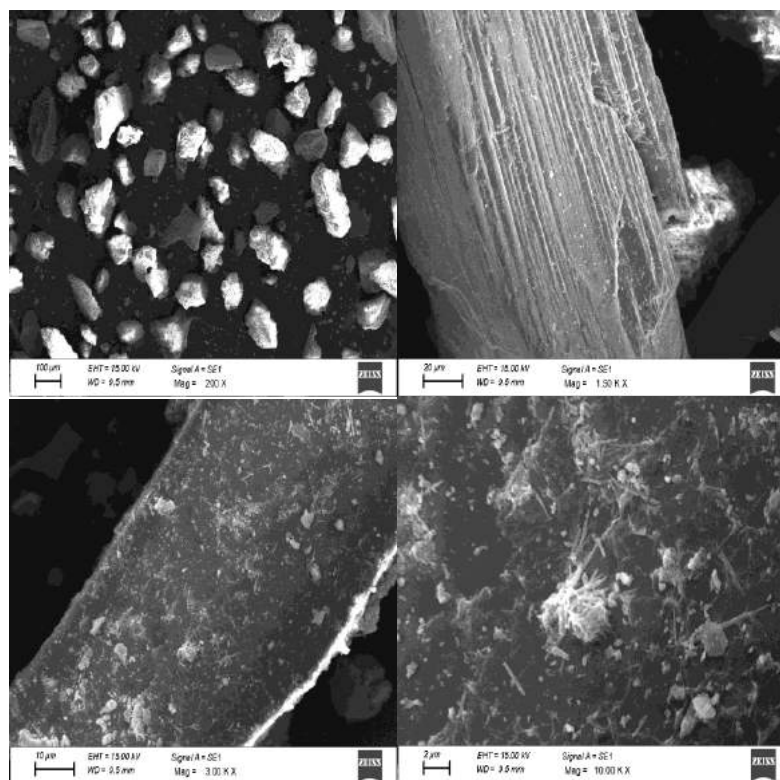


Fig. 4.4 SEM image of conventional mortar cube



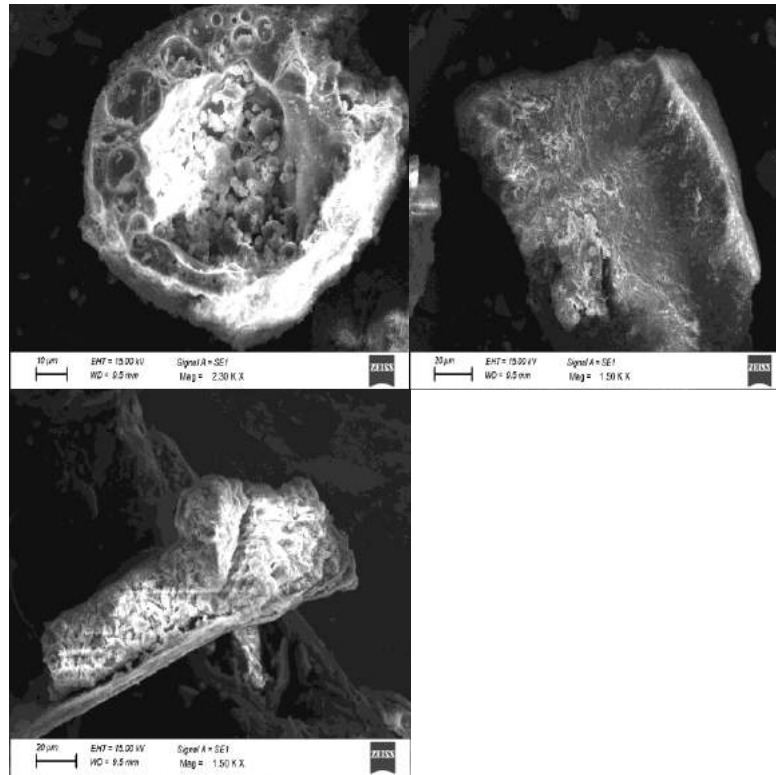


Fig. 4.5 SEM image of self-purifying mortar cube

To find the dissimilarity between conventional mortar and self-purifying mortar by comparing Figure 4.4 and 4.5 bondage development is more in self-purifying mortar than the conventional mortar due to the restricted process of elutriation especially in the self-purifying mortar. Further, the morphological, qualitative and semiquantitative analysis, particle size of the conventional mortar and self-purifying mortar were investigated with scanning electron microscopy coupled with Energy Dispersive X-Ray process. The samples collected from the self-purifying mortar cube show the filling pores compared to the conventional mortar and in self purifying mortar titanium dioxide are react to form a major difference in the morphology and texture of the mortar compared to conventional mortar. It leads to increase the strength of the mortar and increase the self-purifying property of the mortar.

The following graph 4.6 and 4.7 represents the energy dispersive X-ray system for conventional mortar and self-purifying mortar. In fig 4.6 it shows the oxides and silicates ranges of 790 to 890 and 490 to 590 res where as in fig 4.7 for self-purifying mortar the ranges oxide sand silicates 390 to 440 and 440 to 490 respectively. It shows accelerated hydration and silicate formation than conventional mortar.

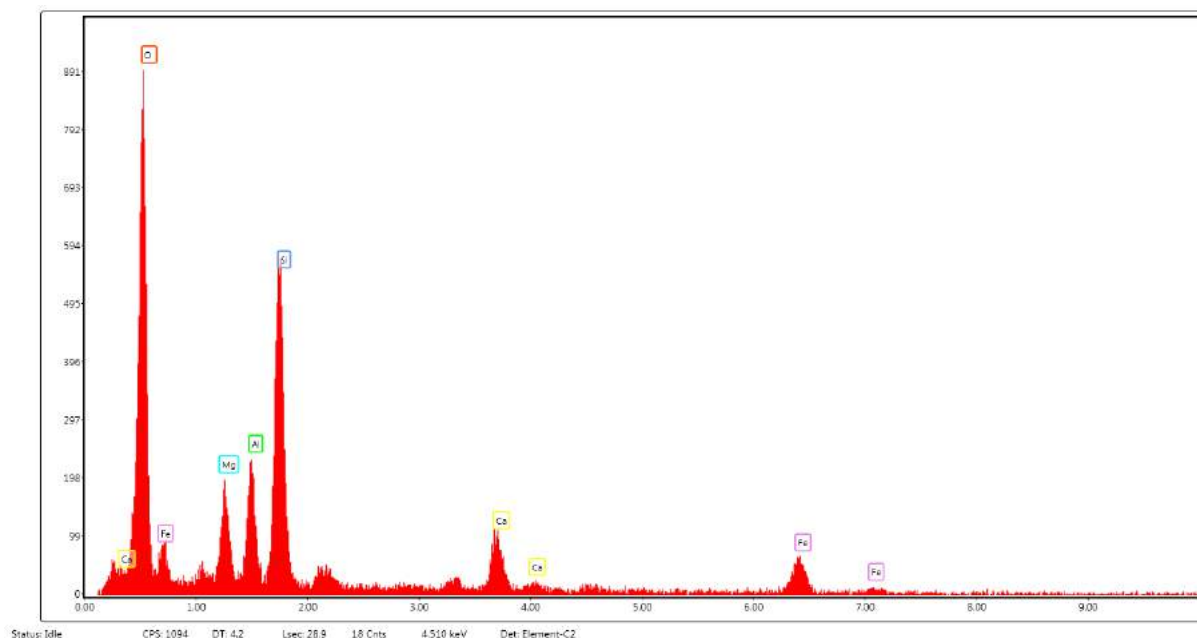


Fig. 4.6 Energy Dispersive X-Ray System for conventional mortar

Table 4.4 Elemental composition of conventional mortar

Element	Weight %	Atomic %	Error %
O	43.45	59.7	9.15
Fe L	1.63	0.64	67.63
Mg	4.1	3.71	11.59
Al	6.8	5.54	9.06
Si	26.75	20.94	5.36
Ca	17.27	9.47	12.08

From the above Table 4.4 shows the absence of TiO_2 content where as the table 4.5 shows the elemental composition of TiO_2 in self-purifying mortar.

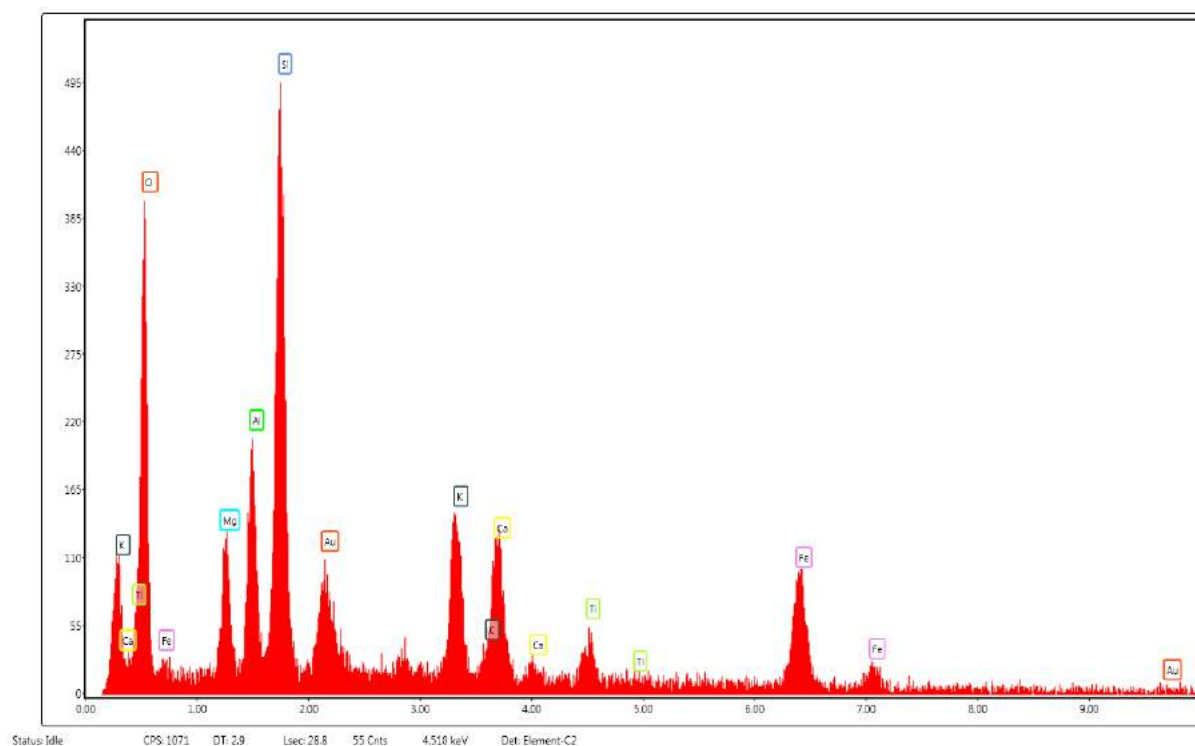


Fig. 4.7 Energy Dispersive X-Ray System for self-purifying mortar

Table 4.5 Elemental composition of Titanium Oxide in self-purifying mortar

Element	Weight %	Atomic %	Error %
O	22.19	39.45	13.3
Fe L	0	0	99.99
Mg	2.9	1.28	63.95
Al	4.67	4.93	13.84
Si	22.35	22.63	6.25
Au M	5.78	0.83	25.39
K	17.34	12.61	11.51
Ca	21.39	15.18	10.36
Ti	3.38	3.08	63.18

The Energy Dispersive X-Ray System test is similar to the x-ray diffraction test. This shows the chemical composition of the mortar in the form of graph which has the highest peak of silicon in the conventional mortar whereas oxygen peak is higher in the self-purifying mortar. It leads to increase the strength of the mortar and increase the self-purifying property of the mortar.

The Table 4.4 conforms that the conventional mortar has no TiO_2 content in it where as the Table 4.5 shows that the presence of TiO_2 at the weight of 3.38 percentage. Nanoparticles can improve the hardened mortar's microstructure by promoting the formation of C-S-H gel through an accelerated hydration mechanism.

In the Figure 4.4 $Ca(OH)_2$ are present in large quantity due to which the micropores is seen in the image where as in Figure 4.5 after the addition TiO_2 with the dosage of 4 % the microstructure of the sample appears much denser than the conventional mortar this due the development of C-S-H gel in the specimen by the process of hydration. So, the porosity can be reduced with increase in the nanoparticles. The addition of TiO_2 which induces the microchemical properties of the cement pastes and the addition of TiO_2 can increase the flexural and compressive strength but if it exceeds the optimum percent it reduces the mechanical properties of mortar due to agglomeration of nanoparticles.

4.3 X-RAY DIFFRACTION TEST

X-ray diffraction test will be done by using an instrument Bruker's X-ray diffraction D8-Discover instrument. X-ray diffractometers include three basic elements: An thermionic valve, a sample holder, and an X-ray detector. In an extremely beam tube, X-rays are generated by heating a filament to supply electrons, applying a voltage to accelerate the electrons toward a target, and bombarding the target material with electrons. Characteristic X-ray spectra are formed when electrons have enough energy to dislodge inner shell electrons of the target material it absolutely was performed to look at the structure and phase of the samples before and after acid resistance measurement. The Figure 4.8 and 4.9 represents the X-ray diffraction pattern for conventional mortar cube and self-purifying mortar cube.

From the specimens used for compressive strength testing small amount of sample was selected from the core of the cube and sieved through 100 μ IS sieve and was tested by XRD. The result obtained was analysed using X Pert High Score Software and the result was plotted using Origin Pro Software. From fig.4.8 Sodium Calcium Aluminium Silicate peaks are higher in conventional mortar. From fig.4.9 silicon dioxide peaks are higher in self purifying mortar and less in conventional mortar. The increases in number of peaks signifies the presence of silicon oxide is more in self purifying mortar which leads to increase the strength, durability, water resistance and reduction of water absorption and decreases of shrinkage deformation while hardening.

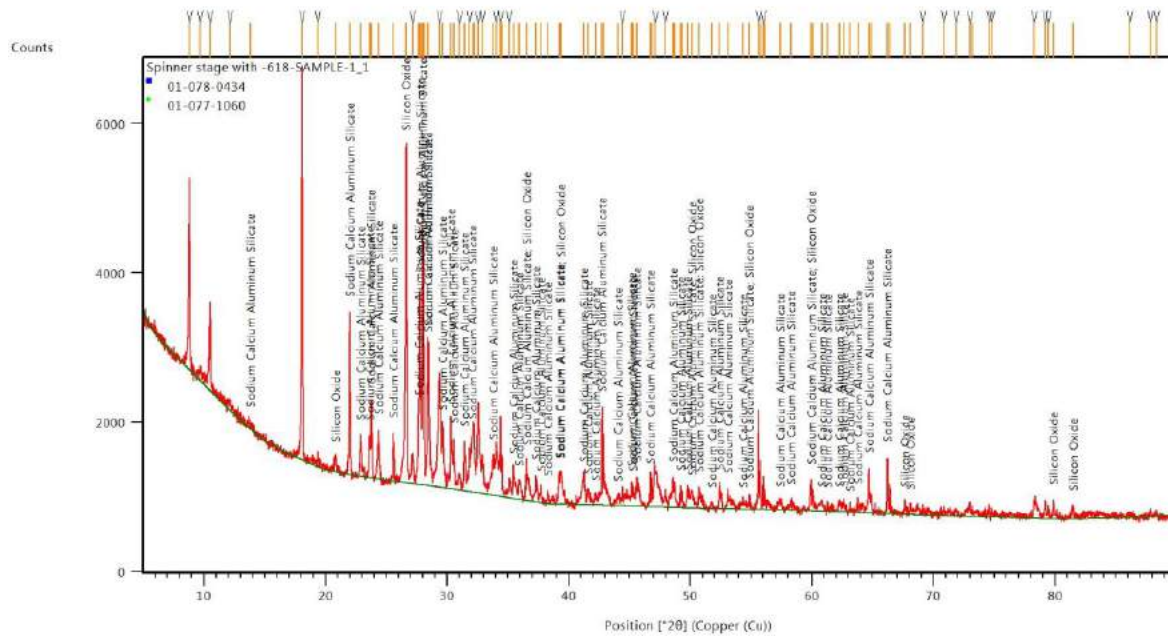


Fig. 4.8 X-ray diffraction pattern for conventional mortar cube

Table 4.6 Peak values obtained for conventional mortar

Pos. [°2θ]	Height [cts]	FWHM Left [°2θ]	d-spacing [Å]	Rel. Int. [%]
8.8177	2636.70	0.0512	10.02871	48.95
9.6963	148.05	0.3070	9.12184	2.75
10.5118	1218.46	0.0640	8.41593	22.62
12.1348	121.19	0.3070	7.29376	2.25
13.8320	84.15	0.3070	6.40239	1.56
18.0714	5386.00	0.0640	4.90887	100.00
19.3699	195.81	0.0768	4.58262	3.64
20.8483	197.68	0.1535	4.26088	3.67
21.9936	2223.34	0.0384	4.04152	41.28
22.8843	562.42	0.0512	3.88619	10.44
23.6307	578.83	0.0512	3.76510	10.75
23.7828	1086.20	0.0512	3.74137	20.17

24.3650	674.21	0.0512	3.65328	12.52
25.5938	662.45	0.0384	3.48059	12.30
26.6430	4698.96	0.0384	3.34587	87.24
27.1838	409.18	0.0768	3.28051	7.60
27.6719	1013.80	0.0468	3.22109	18.82
27.7748	2695.90	0.0468	3.20938	50.05
27.8555	1560.06	0.0312	3.20822	28.96
28.0051	3543.05	0.0624	3.18352	65.78
28.0863	1721.45	0.0468	3.18238	31.96
28.3984	1889.42	0.0468	3.14031	35.08
28.4837	1975.88	0.0468	3.13110	36.69
29.4075	1507.21	0.1872	3.03481	27.98
29.6497	855.98	0.0468	3.01056	15.89
30.3135	979.74	0.0468	2.94614	18.19
30.5490	698.68	0.0468	2.92396	12.97
31.0310	211.95	0.1248	2.87963	3.94
31.4214	677.14	0.0624	2.84474	12.57
31.8348	616.81	0.0468	2.80873	11.45
32.0759	793.57	0.2496	2.78817	14.73
32.2290	925.60	0.0468	2.78217	17.19
32.5778	1244.15	0.0624	2.74635	23.10
32.9121	503.44	0.1560	2.71922	9.35
33.7905	554.25	0.0936	2.65051	10.29
34.0532	745.80	0.0780	2.63066	13.85
34.4185	1123.65	0.0468	2.60357	20.86
34.5075	576.54	0.0468	2.60351	10.70
35.1208	260.19	0.1560	2.55310	4.83
35.4510	408.36	0.0624	2.53007	7.58
35.9191	244.32	0.0936	2.49817	4.54
36.5241	546.88	0.0468	2.45816	10.15
37.3124	370.77	0.0468	2.40802	6.88
37.7345	225.96	0.0936	2.38205	4.20
38.2823	177.03	0.0936	2.34921	3.29
39.2362	420.13	0.0468	2.29427	7.80
39.3785	421.20	0.1872	2.28630	7.82
41.2632	382.05	0.1248	2.18613	7.09
41.5957	218.79	0.1248	2.16942	4.06
42.2171	126.13	0.1872	2.13891	2.34
42.7553	1345.13	0.0468	2.11323	24.97
42.8652	986.90	0.0468	2.11330	18.32
44.0766	121.68	0.1872	2.05289	2.26
44.4407	256.40	0.0468	2.03692	4.76
45.2006	332.64	0.0468	2.00442	6.18
45.3046	267.75	0.0624	2.00006	4.97
45.6186	403.05	0.0468	1.98702	7.48
46.7258	381.20	0.0936	1.94248	7.08
46.8622	396.72	0.0468	1.94196	7.37
47.1092	562.86	0.0780	1.92757	10.45
47.9696	200.68	0.1248	1.89498	3.73
48.5945	416.97	0.0624	1.87206	7.74
48.7329	333.36	0.0468	1.87171	6.19
49.2167	295.01	0.0624	1.84984	5.48
49.3514	235.08	0.0468	1.84969	4.36
49.7812	313.02	0.0780	1.83018	5.81
50.1306	241.75	0.1248	1.81824	4.49
50.7142	288.37	0.0624	1.79868	5.35
51.7705	74.62	0.2496	1.76443	1.39
52.4217	319.74	0.0780	1.74404	5.94
53.1048	281.36	0.0624	1.72320	5.22
54.3451	86.98	0.3744	1.68677	1.61
54.8675	203.57	0.0624	1.67194	3.78
55.6074	1368.84	0.0624	1.65143	25.41
55.7582	679.74	0.0624	1.65141	12.62
56.0096	464.42	0.0468	1.64052	8.62
56.1657	277.96	0.0468	1.64040	5.16
57.4157	106.40	0.2496	1.60364	1.98
58.2993	146.00	0.0936	1.58142	2.71
59.9431	431.57	0.0780	1.54193	8.01

60.1183	296.46	0.0624	1.54167	5.50
60.8287	125.23	0.2496	1.52158	2.33
61.3045	118.76	0.0936	1.51091	2.21
62.2675	133.02	0.1872	1.48983	2.47
62.6156	143.66	0.1872	1.48238	2.67
63.1341	77.86	0.1872	1.47145	1.45
63.7806	183.97	0.0780	1.45809	3.42
64.7009	611.75	0.0624	1.43955	11.36
64.8969	231.80	0.0936	1.43924	4.30
66.2268	772.44	0.0624	1.41004	14.34
66.4182	412.62	0.0624	1.40993	7.66
67.6594	168.08	0.0624	1.38362	3.12
68.1141	129.66	0.0936	1.37549	2.41
69.1039	116.94	0.1248	1.35818	2.17
70.8822	117.24	0.0936	1.32841	2.18
71.8704	71.72	0.2496	1.31255	1.33
72.9955	197.18	0.0780	1.29507	3.66
73.2097	114.75	0.0936	1.29502	2.13
74.5776	115.57	0.1248	1.27147	2.15
74.7761	126.50	0.0936	1.26859	2.35
78.2746	251.83	0.0468	1.22041	4.68
79.2151	243.73	0.0624	1.20826	4.53
79.4600	146.22	0.0936	1.20515	2.71
79.8779	258.98	0.0624	1.19990	4.81
81.4793	173.25	0.1248	1.18031	3.22
86.1740	38.72	0.6240	1.12764	0.72
87.8273	111.25	0.0936	1.11062	2.07
88.3513	51.64	0.1872	1.10539	0.96

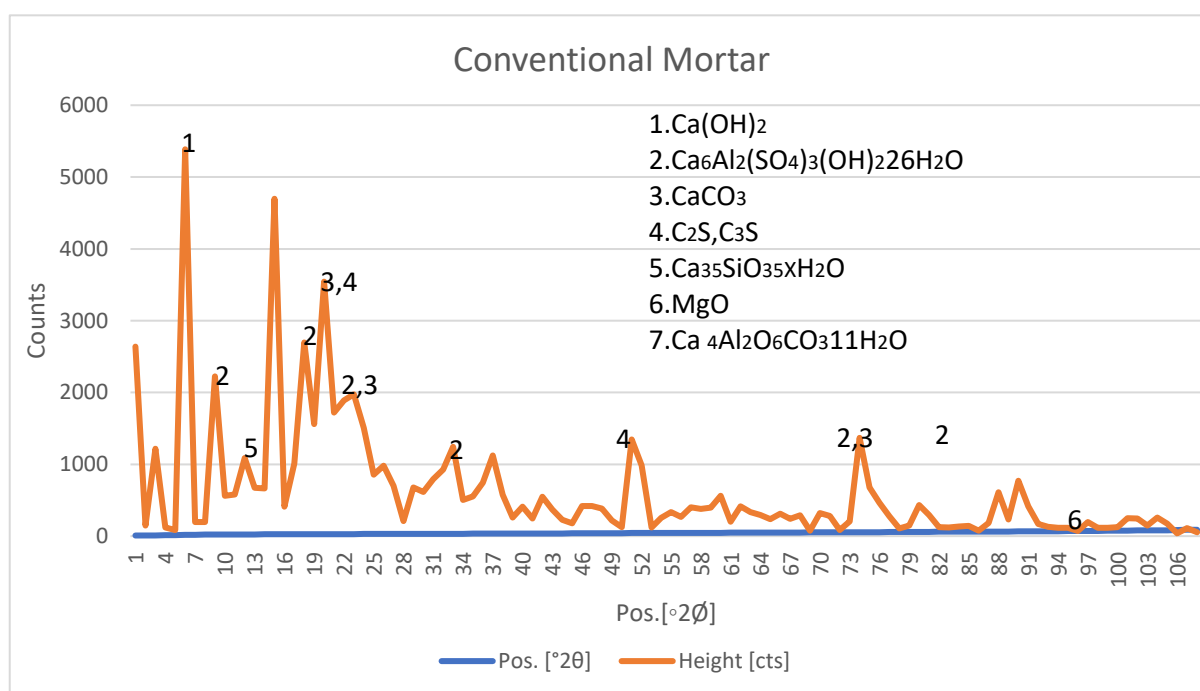


Fig 4.9 Graph values for conventional mortar

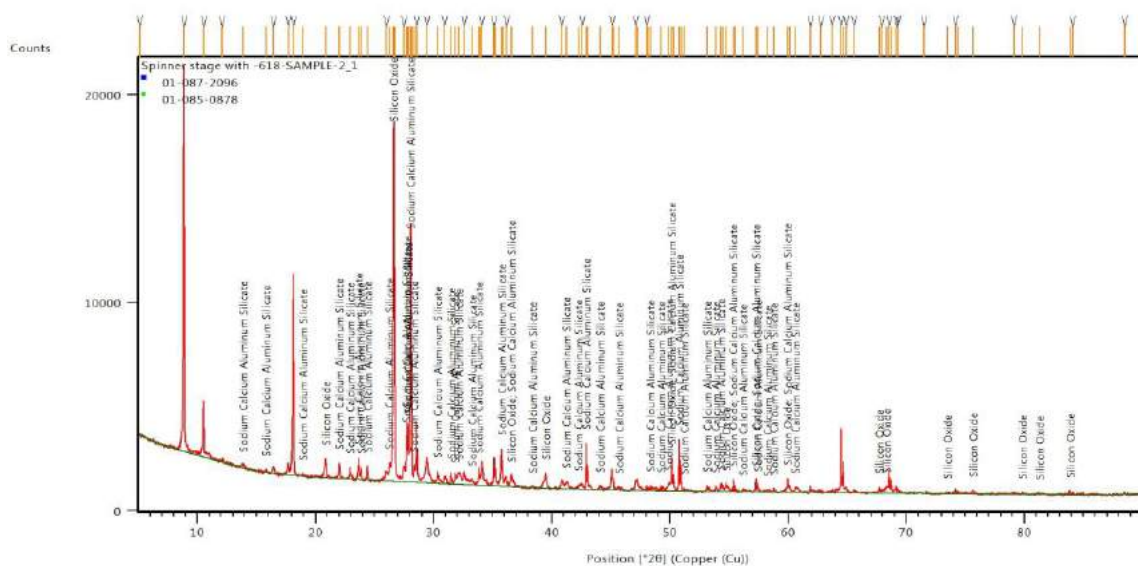


Fig. 4.10 X-ray diffraction pattern for self-purifying mortar cube

Table 4.7 Peak values obtained for self-purifying mortar

Pos. [°2θ]	Height [cts]	FWHM Left [°2θ]	d-spacing [Å]	Rel. Int. [%]
5.1401	34.10	0.6140	17.19283	0.18
8.8671	19023.99	0.0640	9.97297	100.00
10.5540	2783.55	0.0640	8.38242	14.63
12.0834	112.19	0.3070	7.32468	0.59
13.8851	127.61	0.2558	6.37804	0.67
15.8229	130.63	0.1535	5.60100	0.69
16.4539	305.96	0.1279	5.38762	1.61
17.7029	612.69	0.0640	5.01021	3.22
18.1086	9861.49	0.0768	4.89886	51.84
18.9495	130.25	0.1535	4.68332	0.68
20.8952	933.47	0.0512	4.25142	4.91
22.0259	759.07	0.0384	4.03566	3.99
22.9316	596.89	0.0384	3.87829	3.14
23.6542	1079.86	0.0384	3.76142	5.68
23.8610	611.37	0.0768	3.72929	3.21
24.4019	732.08	0.0512	3.64783	3.85
25.9852	473.18	0.1023	3.42905	2.49
26.2877	898.43	0.0768	3.39028	4.72
26.6440	17722.01	0.0624	3.34297	93.16
26.7219	8203.83	0.0468	3.34169	43.12
27.4974	772.47	0.1092	3.24113	4.06
27.6905	2265.43	0.0312	3.21896	11.91
27.7637	3003.16	0.0312	3.21064	15.79
27.8390	2719.60	0.0468	3.20213	14.30
28.0628	12660.25	0.0468	3.17709	66.55
28.1428	6052.97	0.0312	3.17612	31.82
28.3809	819.39	0.0936	3.14220	4.31
28.5628	3024.21	0.0312	3.12261	15.90
28.6405	1626.91	0.0312	3.12205	8.55

29.4576	1277.71	0.1092	3.02976	6.72
30.3502	604.14	0.0468	2.94266	3.18
30.9136	270.70	0.1560	2.89030	1.42
31.4738	588.38	0.0468	2.84013	3.09
31.8535	396.65	0.1248	2.80713	2.09
32.1340	565.09	0.3120	2.78326	2.97
32.6003	638.45	0.0624	2.74451	3.36
33.2624	277.35	0.1248	2.69138	1.46
33.8358	923.80	0.0468	2.64706	4.86
33.9216	565.57	0.0468	2.64713	2.97
34.1110	1172.27	0.0780	2.62634	6.16
35.1335	1439.65	0.0468	2.55221	7.57
35.2228	899.46	0.0468	2.55226	4.73
35.7606	1842.06	0.0624	2.50888	9.68
35.8573	852.59	0.0468	2.50855	4.48
36.1662	468.31	0.1092	2.48167	2.46
36.5689	563.66	0.1560	2.45526	2.96
38.3760	54.26	0.3744	2.34369	0.29
39.5177	741.17	0.0780	2.27857	3.90
40.8425	402.79	0.1560	2.20767	2.12
41.2725	338.93	0.1248	2.18566	1.78
42.2576	222.86	0.0780	2.13695	1.17
42.5959	281.64	0.0936	2.12076	1.48
42.9301	2276.82	0.0624	2.10502	11.97
43.0421	1137.62	0.0468	2.10502	5.98
44.1226	173.01	0.1560	2.05086	0.91
45.1198	1030.75	0.1092	2.00782	5.42
45.2190	571.56	0.0624	2.00863	3.00
45.6856	157.34	0.2496	1.98426	0.83
47.1244	499.10	0.1248	1.92698	2.62
47.2825	584.05	0.0468	1.92568	3.07
48.0443	267.62	0.0624	1.89221	1.41
48.1767	149.77	0.0780	1.89201	0.79
48.3460	275.85	0.0468	1.88110	1.45
49.2536	225.04	0.0468	1.84854	1.18
49.8859	356.31	0.1248	1.82658	1.87
50.1704	1653.81	0.0624	1.81689	8.69
50.3000	810.15	0.0468	1.81702	4.26
50.8074	2546.27	0.0624	1.79560	13.38
50.9420	1317.04	0.0468	1.79562	6.92
51.2113	163.42	0.0468	1.78238	0.86
53.1738	281.83	0.0468	1.72113	1.48
53.8816	271.64	0.0624	1.70018	1.43
54.3442	402.73	0.0936	1.68679	2.12
54.5181	296.33	0.0936	1.68600	1.56
54.8065	357.92	0.0624	1.67365	1.88
55.3663	603.73	0.0624	1.65805	3.17
55.5162	302.64	0.0468	1.65803	1.59
56.1783	144.05	0.0936	1.63599	0.76
57.2970	616.70	0.0468	1.60668	3.24
57.4500	353.72	0.0624	1.60277	1.86
58.2716	111.11	0.0936	1.58211	0.58
58.8149	222.72	0.0468	1.56878	1.17
59.9894	672.96	0.0780	1.54084	3.54
60.1505	339.94	0.0624	1.54092	1.79
60.6495	247.53	0.1560	1.52565	1.30
61.9057	304.05	0.0624	1.49767	1.60
62.8032	104.78	0.1248	1.47841	0.55
63.7607	137.58	0.0936	1.45849	0.72
64.4868	3242.02	0.0468	1.44381	17.04
64.6676	1550.16	0.0624	1.44379	8.15
64.9229	249.07	0.0936	1.43516	1.31
65.5931	152.10	0.0936	1.42211	0.80
67.7460	297.16	0.0624	1.38206	1.56
67.9348	209.44	0.0936	1.37868	1.10
68.3386	339.69	0.0936	1.37152	1.79
68.5511	1209.65	0.0624	1.36778	6.36
68.7431	659.48	0.0780	1.36782	3.47

69.1553	333.53	0.0936	1.35730	1.75
69.3515	211.10	0.1248	1.35394	1.11
71.5422	34.62	0.7488	1.31777	0.18
73.5158	69.74	0.3744	1.28719	0.37
74.1834	269.34	0.0624	1.27725	1.42
74.3766	118.89	0.0936	1.27757	0.62
75.6518	184.20	0.1248	1.25606	0.97
79.1694	71.01	0.3744	1.20885	0.37
79.8757	125.12	0.1248	1.19992	0.66
81.3121	58.06	0.6240	1.18232	0.31
83.8780	183.31	0.0780	1.15256	0.96
84.1046	128.13	0.0936	1.15003	0.67
88.4855	105.09	0.0936	1.10406	0.55

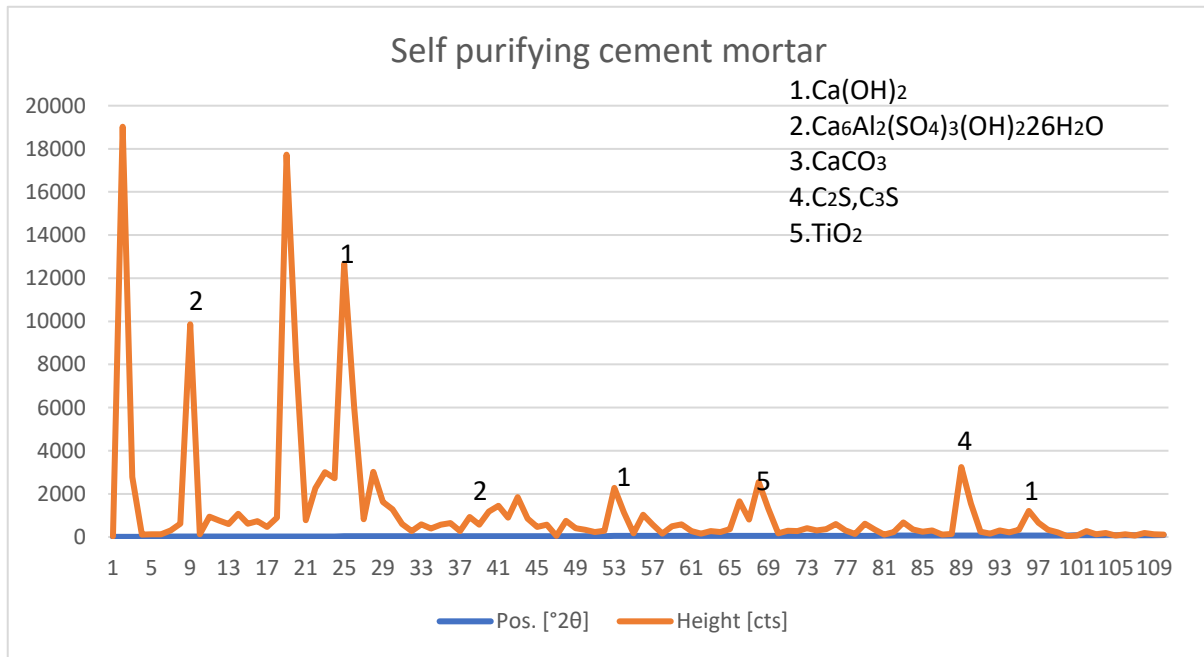


Fig 4.11 Graph values for self-purifying cement mortar

In comparison to the conventional mortar (Figure 4.10) and self-purifying mortar (Figure 4.11), the number of large $\text{Ca}(\text{OH})_2$ crystals has greatly decreased. This can be explained by the controlled crystallisation process by nanoparticles. Where the required dose of nanoparticles is applied, the formation of $\text{Ca}(\text{OH})_2$ crystals can be prevented.

4.4 VISUAL INTERPRETATION

Here the addition of TiO_2 nanoparticles in the mortar with debris results in functional composites which have a self-cleaning ability. It is well known that TiO_2 nanoparticles are an excellent photocatalyst material when it sizes below 100 nm. the

self-cleaning ability of the composite made of cement, M-Sand, and debris were examined. The sample was found that the surface of the composite remains clean, no dirt and it can improve the life and protect the environment. The Figure 4.10 shows the difference of conventional and self-purifying mortar.



Fig. 4.12 Prototype of conventional and self-purifying mortar.

CHAPTER V

SUMMARY AND CONCLUSIONS

5.1 SUMMARY

The objective of the present study is to define the self-purifying properties of cement mortar using TiO_2 . There several chemicals reported in literature which can improve the strength and other chemical properties of cement mortar. The properties of materials such as river sand, M-Sand, construction debris, and cement were tested and compared with IS considerations which should be satisfied. Then the cement mortar for 1:4, were allowed to investigate the self-purifying of modified mortar. The hardened specimen was tested after 28 days of curing. As compared to conventional cement mortar the self-purifying mortar have gradual increase in its compressive strength. To study the variation of compressive strength, and apparent density of cement mortar, cubes with mix ratio 1:4, were considered for investigation. The hardened specimen was tested after 28 days of curing to find out the optimum replacement percentage of fine aggregate needed for the preparation of the cement mortar.

The present experimental investigation deals with the self-purifying cement mortar incorporated with TiO_2 and construction debris. For that different proportions (25%, 50%, 75%, 100%) of river sand and debris as well as M-Sand and debris where tested. The partial replacement of sand with debris reduces the dumping of demolition construction waste and protection of natural resources by minimum usage which ensure the environmental protection also. In this comparison, the optimum percentage of debris are identified for the preparation of cement mortar as 25% of debris and 75% of M-Sand.

After that, the different percentage of TiO_2 is added with conventional mortar using the river sand to investigate self-purifying capacity of TiO_2 in cement mortar. Titanium dioxide increases self-purifying process and helps to diminish the air polluting effect by exhaust gases. Titanium dioxide acts as a photocatalyst. The principle of photocatalysis and the application in combination of cement, especially towards purifying action which replies to the social demand of safe and environmentally friendly infrastructure. The specimens were allowed to curing for 28 days and the hardened

specimens were tested to find out the optimum percentage of self-purifying mortar based on the comparison of the compressive strength.

Another objective of this present study is to determine the mechanical and chemical properties of self-purifying and conventional cement mortar which can be analysed using by Scanning Electron Microscopy and X-ray Diffraction test. In Scanning Electron Microscopy, the variations in pores of conventional and self-purifying mortar are shown in the form of images in which the dissimilarities among the images are observed. From the Energy Dispersive X-Ray (EDX) analysis the chemical composition and diffraction pattern were analysed for both conventional mortar and self-purifying mortar.

5.2 Conclusions

Different mortars with Nano- TiO_2 photocatalysts in bulk were prepared and their plastic and hardened performances were studied. The incorporation of the Nano-additives showed a tendency to increase the water demand of the mortars, which was especially true for the addition of TiO_2 . This fact, which was further confirmed by particle size measurements, was due to its high specific surface area and its tendency to agglomerate, thus reducing the fluidity of the plastic paste.

The optimum percentage of replacement of fine aggregate with debris is 25% which could be observed by the compression strength after 28 days curing. The compressive strength test was taken for conventional mortar, conventional mortar with replacement of debris in different proportions and self-purifying mortar. The obtained test values were compared with conventional mortar and self-purifying mortar. The results show the compressive strength (after 28 days curing) of self-purifying mortar (added with TiO_2) each greater than the conventional mortar.

The optimum percentage of titanium dioxide in debris added mortar is 4% which could be observed by the compression strength after 28 days curing. It acts as a photocatalyst. Presence of titanium dioxide in self purifying mortar may decreases the setting time while compared with conventional mortar. The bonding between the atoms are made more stronger in conventional mortar. An additive TiO_2 generates free radicals which destroy the cell walls of bacteria, algae and reduces the permeability of structure would immensely improves its life.

The morphology of the conventional and self-purifying mortar was found out by Scanning Electron Microscopy (SEM) analysis. It shows the direct involvement of

titanium dioxide reaction in the self -purifying mortar. The morphology image shows the rod-shaped impressions which is consistent with the rigid dimensions of the titanium dioxide on self-purifying mortar cube.

The conducted XRD analysis shows the variation of elemental composition between conventional mortar and self-purifying mortar.

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