

Study on Enhancement of mechanical properties of cement mortar using Graphene Oxide and use of plastic dust with fine aggregate replacement for light weight concrete production and study of mechanical properties

Dissertation submitted to

JADAVPUR UNIVERSITY, INDIA

In partial fulfilment of the requirement
for the award of the degree of

MASTER OF TECHNOLOGY

In

NANOSCIENCE AND NANOTECHNOLOGY

by

ANUPAM MAITY

Roll number : M4NST19001

Registration Number : 141061 of 2017-2018

Under the guidance of

Dr. Chandan Kumar Ghosh

School of Material Science and Nano Technology

Jadavpur University, India

May,2019

Certificate of Recommendation

This is to certify that the dissertation entitled “Study on Enhancement of mechanical properties of cement mortar using Graphene Oxide and use of plastic dust with fine aggregate replacement for light weight concrete production and study of mechanical properties” has been carried out by Mr AnupamMaity in the “Nanoscience Laboratory”, under our supervision and guidance for partial fulfilment of the requirement for Post Graduate Degree of Master of Technology in Nanoscience and Technology during the academic session 2017-2019.

THESIS ADVISOR

Dr. Chandan Kumar Ghosh
Assistant Professor
School of Material Science and Nanotechnology
Jadavpur University, Kolkata-700032, India

DEAN

ISLM
JADAVPUR UNIVERSITY
KOLKATA-700032, INDIA

DIRECTOR

Dr. Chandan Kumar Ghosh
School of Material Science and Nanotechnology
Jadavpur University, Kolkata-700032, India

Certificate of Approval

This foregoing thesis is hereby approved as a credible study on graphene and plastic dust carried out and presented in a manner satisfactorily to warrant its acceptance as a prerequisite to the Post Graduate Degree of Master of Technology in Nanoscience and Nanotechnology for which it has been submitted. It is understood that by this approval the undersigned do not endorse or approve any statement made or opinion expressed or conclusion drawn therein but approve the thesis only for purpose for which it has been submitted.

Committee of final examination for evaluation of thesis

1. -----
2. -----
3. -----
4. -----

Date : -----

Place: Jadavpur Campus, kolkata-700032, India

(Only in case the thesis is approved.)

Declaration of Originality and Compliance of Academic Ethics

I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of his Post Graduate Degree of Master of Technology in Nanoscience and Nanotechnology during academic session 2017 - 2019.

All information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referred all materials and results that are not original to this work.

Name : Anupam Maity

Roll Number : M4NST19001

Registration Number : 141061 of 2017-2018

Thesis Title : Study on Enhancement of mechanical properties of cement mortar using Graphene Oxide and use of plastic dust with fine aggregate replacement for light weight concrete production and study of mechanical properties

Signature:

Date:

Place: Jadavpur University, Kolkata, India

ACKNOWLEDGEMENT

While bringing out this term paper to its final form, I came across a number of people whose contributions in various ways helped my field of knowledge and research and they deserve special thanks. It is a pleasure to convey my gratitude to all of them.

First of all, I render my gratitude to the almighty who bestowed self-confidence, ability and strength in me to complete this work. Without his grace this would never been a reality.

With deep sense of gratitude I express my sincere thanks to our esteemed and worthy supervisor, Dr. Chandan Kumar Ghosh, Director, School of Material Science and Nanotechnology, Jadavpur University for his support, advice and encouragement and for the opportunity he has given me to work in the research group. The ideas and guidance they have provided me are invaluable.

Their constant motivation has helped me to complete my work in proper shape. I am grateful to Prof. Kalyan Kumar Chattopadhyay, Professor Department of physics, Jadavpur University, and Dr. Mahua Ghosh Chaudhuri, Assistant Professor, Nano science and Nanotechnology Department, Jadavpur University for their constant encouragement that was of great importance in the completion of this thesis.

I extend my heartiest thanks to my seniors for extending their helping hands to me to make my project successful. I am also thankful to all the students members of the department for their full co-operation and much needed help. My greatest thanks are to all who wished us success especially my parents and friends whose support and care make our stay on Earth.

ABSTRACT

My project is basically conducted with the help of one of the well-known unique nanomaterial Graphene Oxide. I investigate the performance of graphene oxide (GO) in improving mechanical properties of cement composites. Graphene Oxide was used to enhance the mechanical properties of cement mortar . Compressive Strength of cement mortar was investigated using graphene oxide with 0.2%, 0.4% ad 0.6%.with water.

The aim of this research is to study the performance of graphene cement mortar, and also compare the compressive strength. We found that GO containing 0.2% gives the highest compressive strength. Ultra high-resolution field emission scanning electron microscopy (FE-SEM) used to observe the fracture surface of samples containing no GO. And the FESEM image of the different percentage of Go cement mortar was observed. ano-GO flakes were well dispersed in the matrix, and no aggregates were observed. FE-SEM observation also revealed good bonding between the GO surfaces and the surrounding cement matrix.

In experiment 2 we discuss about M 25 grade concrete using replacement of fine aggregate with plastic dust. The gainful utilization of waste material speaks to a methods of reducing a portion of the issues of strong waste administration . The reuse of waste is significant from various perspectives. It spares furthermore, support regular assets that are not recharged, it diminishes the contamination of nature and it likewise makes a difference to spare and reuse vitality creation forms. Wastes what's more, mechanical side-effects ought to be considered as possibly significant assets only anticipating suitable treatment also, application. Plastic wastes are among these wastes; their transfer effectsly affects the earth because of their long biodegradation period, and in this way one of the sensible strategies for decrease of their negative impacts is the utilization of these materials in different businesses. Concrete assumes

a significant job in the helpful utilization of these materials in development. A little bit portion of these materials can be helpfully fused in concrete, both as a component of the cementitious cover stage or as totals, it is imperative to understand that not all waste materials are reasonable for such use. Here partial replacement of fine aggregate was introduced with plastic dust and complete the mixture. Then Curing them for 14, 21 and 28 days respectively. Compressive strength was done and data was collected. It is observed that strength was decreased with increase percentage of plastic dust and also saturation of strength in 14 days curing. As plastic dust percentage increases there was hydration issue and hence no effect of curing as on plastic replacement. The compressive strength decreases as plastic increases due to poor bonding of cement sand in the mixture. We can conclude this after observe the surface morphology of the concrete using FESEM.

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CHAPTER 1

INTRODUCTION

Introduction:

Cementitious materials are the most common construction material used worldwide. It is a brittle material, so obviously it has very low tensile strength, though it can be controlled by using reinforcement. In this project I will study the enhancement of strength of mortar using Graphene Oxide(GO). Controlling the growths of cracks using such a wonder material is the main objective of this project. Nano scale cracks are the main reason behind every visible cracks presents in the cementitious materials. If the growth of these nano scale growths can controlled in early ages then visible cracks can be eliminated during the casting. Graphene Oxide, nano material is used to prevent the nano cracks in early ages of casting. As cement and sand used in castings are in micron range, these particles are unable to fill the nano cracks, so a nano material is needed, GO is choosen as the nano material as it's excellent mechanical, chemical, thermal, and electrical properties. [1]

Graphene Oxide (GO), the wonder material is an atomic sheet of graphite decorated by several oxygenated functional groups on its basal planes and at its edges, resulting in a hybrid structure comprising a mixture of sp^2 and sp^3 hybridized carbon atoms.

Graphene Oxide and graphite oxide both have identical structures like stacked layers with chemical functionalities at their basal planes and edges, but there are only one difference between them i.e, Graphene oxide has monolayer or very few layer but graphite oxide has many layers. The formation of oxigeneted functional groups helps graphite oxide to exfoliated into nano sheets. Brodie first demonstrated the synthesis of GO in 1859 by adding a portion of potassium chlorate to a slurry of graphite in fuming nitric acid. Though later many synthesis process is established to produce monolayer GO. They are-

- The Brodie Method
- The Staudenmaier Method

- Modified Hammers Method

Modified Hammers Method is mostly accepted method from researchers as it has an advantage of non toxicity as compare to other two methods. In this paper I used Modified Hammers Method to synthesis of GO. Synthesis method will be discussed later. In this paper we will see how mechanical property(Compressive Strength) will change with dispersion of GO in different percentage level such as 0.2%, 0.4% ad 0.6% respectively.

Another work also done in this paper that to obtain M25 strength along with lightweight concrete with the replacement of plastic dust in different percentage with fine aggregate. Plastic is now a global problem and use of plastic in cementitious material is environment friendly too. Plastic waste generation increases 10.43% per year and use of plastic is eco-friendly as well as economical too. Plastic, the non degradable material is not suitable for land filling and also can't burn it because of problem in clogging in drainage and air pollution respectively. So a serious issue with plastic is focused worldwide and recycle of plastic in various fields was searching. Such as plastic may valuable property as construction material. Polymer total is altogether lighter than normal total and along these lines its joining brings down the densities of the coming about cement. This property can be utilized to create lightweight cement. In this manner, use of waste plastic materials in concrete as totals might be thought about a standout amongst the most possible use to conquer some sheltered transfer issues of squander plastic materials. Nonetheless, one of the fundamental objectives of practical strong waste the board is to augment the capacity of its reusing and reusing waste materials. With expanding natural strain to lessen squander contamination, the solid business has begun embracing various strategies to accomplish these objectives. Oneself load of solid which is related with size of the basic individuals can be decreased by the utilization of lightweight materials. Advancement of cement with nonconventional total, for example, polystyrene froth squanders, High Density Polyethylene (HDPE), polyethylene terephthalate

(PET) also, other plastic has been utilized in cement to improve the properties of the solid and decrease cost[2]. Five weight portions 0%, 5%, 10%, 15%, 20%, and 30% of granular plastic waste were utilized to supplant the fine total in the grouping, cast into moulds of 100 mm by 100 mm by 100 mm sizes; cured for 14,21 and 28 days respectively. The compressive strength of the concrete then determinrd. The discoveries likewise uncovered decline in the unit weight of concrete with increment in the rate substitution of plastic waste.

What is Nano Material?

Most definitions rotate around the investigation and control of marvels and materials finally scales beneath 100 nm and regularly they make a correlation with a human hair, which is around 80,000 nm wide.

The term Nanotechnology was authored in 1974 by Norio Taniguchi of Tokyo Science University to portray semiconductor procedures, for example, slim film affidavit that manage control on the request of nanometers. It wasn't until 1981, with the improvement of the checking burrowing magnifying instrument that could "see" singular iotas, with which present day nanotechnology started.

Roused by Feynman's ideas, K. Eric Drexler utilized the expression "nanotechnology" in his 1986 book Engines of Creation: The Coming Era of Nanotechnology, which proposed the possibility of a nanoscale "constructing agent" which would almost certainly fabricate a duplicate of itself and of different things of discretionary multifaceted nature with nuclear control.

2000 years ago Sulphide Nano crystals used by Greeks and Romans to dye hair. Then 1000 years ago Gold nanoparticles of different sizes used to produce different colours in stained glass windows. In 1959 Physicist Richard Feynman gave a radical lecture at an American Physical Society meeting at Caltech titled —"There's plenty of room at the bottom". In 1974 'Nanotechnology' - Professor Norio Taniguchi for the first time uses the term

nanotechnology[3]. In 1981 IBM develops Scanning Tunnelling Microscope[4]. Then in 1985 'Buckyball'- Scientists at Rice University and University of Sussex discover Fullerene (C60)[5]. In 1986: 'Engines of Creation'- First book on nanotechnology by K. Eric Drexler[6]. Atomic Force Microscope invented by Binnig, Quate, and Gerbe. In 1989 IBM logo made with individual atoms. In 1991 Carbon Nanotubes discovered by S. Ijima. Then 1999: 'Nano medicine'- First Nano medicine book by R. Freitas. In 2000: 'National Nanotechnology Initiative' was launched.

While most smaller scale organized materials have comparative properties to the relating mass materials, the properties of materials with nanometre measurements are essentially not the same as those of molecules and mass materials. Among the attributes of nanomaterial that recognize them from mass materials, it is critical to take note of the accompanying:

- Vast division of surface areas.
- High surface vitality.
- Spatial constraintment.
- Decreased quantities of flaws that don't exist in the comparing mass materials.

Advantage of using Nanomaterial are as follows:

- All nanomaterial comprise of extremely little particles. This is the main favorable position of nanomaterial and nanotechnologies, advancing accomplishment of super scaling down. Since they are little, nanostructures can be stuffed all around firmly together. Thus, on a given unit of region one can find increasingly utilitarian nanocracks, which is significant on sample. Their high pressing thickness can possibly convey higher zone and volume ability to increase strength[7].
- In light of their little measurements, nanomaterials have extensive explicit surface zones, quickening collaborations among them and the earth in which they are found.

Nanoparticles have a lot bigger surface region per unit of mass contrasted and bigger particles. Since development and synergist substance responses happen at surfaces, this implies materials in nanoparticle structure will be significantly more receptive than a similar mass of material made up of bigger particles. A solid increment in the investment of surface iotas in the physical and compound properties of nanomaterials is another result of a reduction in molecule measure.

It is realized that the volume of an article diminishes as the third intensity of its direct measurements, however the surface territory diminishes just as its second power. If there should be an occurrence of nanoparticles, the surface territory to-volume proportion (the proportion among surface and mass molecules) increments than that of mass.

It is realized that particles on the outside of nanoparticles have unordinary properties. These surface iotas make nanoparticles altogether different from simply little particles, on the grounds that not all obligations of surface molecules with neighboring particles are empowered. For molecules on uneven surfaces, no immersion of the bonds is much higher. Therefore, corner iotas ordinarily have the most elevated liking to shape bonds to adsorbate particles, trailed by edge and in-plane surface molecules, a reality that is of extraordinary significance for reactant movement. Then again, as a result of their low adjustment because of low coordination, edge and specifically corner molecules are frequently absent on single precious stones, even in thermodynamic harmony . Because of the progressions that happen in particles with a diminishing of molecule measure, nanomaterials can have amazingly high organic and compound reactivity. For instance, chemically dynamic nanomaterials permit quickening either compound or biochemical responses by many thousands, and even a million times. This characteristic clarifies even

1 g of nanomaterial can be more powerful than 1 ton of a comparative yet full scale substance[8].

Another perspective we should consider is that the free surface is a position of aggregation (sink) of crystallographic abandons. At little particles sizes, the surface grouping of such deformities increments significantly. Hardeveld and Hartog in 1969 determined traditionally and demonstrated that the biggest changes of extents between aspects, edges, corners, and small scale surrenders at the surface happen somewhere in the range of 1 and 5 nm . Thus, solid cross section mutilation and even a difference in grid type can occur superficially layer. Truth be told, because of aggregation of auxiliary imperfections and concoction polluting influences superficially, we can watch decontamination of the mass zone of the nanoparticles.

A significant explicit normal for nanomaterial properties (I mean here polycrystalline materials with grain estimate under 40 nm) is an expansion of the job of interfaces with diminishing of the span of grains or crystallites in nanomaterials. Exploratory research has demonstrated that the condition of grain limits has a non-harmony character, molded by the nearness of the high centralization of grain limit surrenders. This non-balance is portrayed by additional vitality of the grain limits and by the nearness of long-go versatile pressure. In the meantime, the grains have requested crystallographic structure, while the grain limit deserts go about as a wellspring of versatile strains. Non-balance of the grain limits starts the event of the grid bending, the difference in interatomic separations, and the presence of adequate dislodging of molecules, straight up to loss of an arranged state.

Another significant factor particular to nanoparticles is their inclination to total. The likelihood of movement (dissemination) of either particles or gatherings of molecules along the surface and the limits, just as the nearness of alluring

powers between them, frequently prompts procedures of self-association into different group structures. This impact has just been utilized for production of requested nanostructures.

One progressively significant part of nanomaterial properties is associated with the way that, amid transport forms (dispersion, electro-and warm conductivity, and so forth.), there are sure powerful lengths of free way of a transporter of this vehicle (L_e , for example, phonon and electron mean free ways, the Debye length, and the exciton dissemination length for specific polymers. While continuing to sizes littler than L_e , transport speed begins to rely upon both the size and the state of the nanomaterial; by and large, the vehicle speed increments strongly.

The foremost qualities of nanomaterials are adapted by their little the size, yet additionally by the presence of new quantum mechanical impacts in a commanding job at the interface. Those quantum estimate impacts happen at a basic size, which is proportionate with the purported correlative sweep of some physical marvels, for instance, with the length of the free way of electrons or photons, the length of lucidness in a superconductor, sizes of attractive spaces, etc. Generally speaking, quantum measure impacts show up in materials with crystallite sizes in the nano go $D < 10$ nm. Accordingly, in nanomaterials with trademark estimate, one can expect the presence of impacts which can't be seen in mass materials.

Categories of Nanomaterials:

Classification	Zero dimension < 100nm	One dimension < 100nm	Two dimensions < 100nm
Examples	Particles, quantum dots, hollow Spheres, etc.	Nanorods, nanowires etc.	Tubes, fibres, platelets, etc.

Synthesis of Nano Material:

So as to investigate the exceptional physical properties and marvels and furthermore to understand the helpful utilizations of nanostructures and nanomaterial, the capacity to create and process nanomaterial and nanostructures is the primary obstacle in nanotechnology. In our work nano material used is Graphene Oxide(GO).

CHAPTER 2

INSTRUMENT AND APPARATUS,

SYNTHESIS OF GO AND IT'S

CHARACTERIZATION

Theory and Instrument Of Apparatus Used

- Synthesis Instrument:
 1. Cold Bath
 2. Magnetic stirrer
 3. Direct Drive stirrer
 4. Centrifuge machine
 5. Hot Air Oven
 6. Probe Sonicator
- Characteristic Instrument:
 1. XRD
 2. Zeta Potential Test
 3. FTIR
 4. Raman Spectroscopy
 5. FESEM
 6. TEM
- Testing Instrument:
 1. Compressive Testing Machine

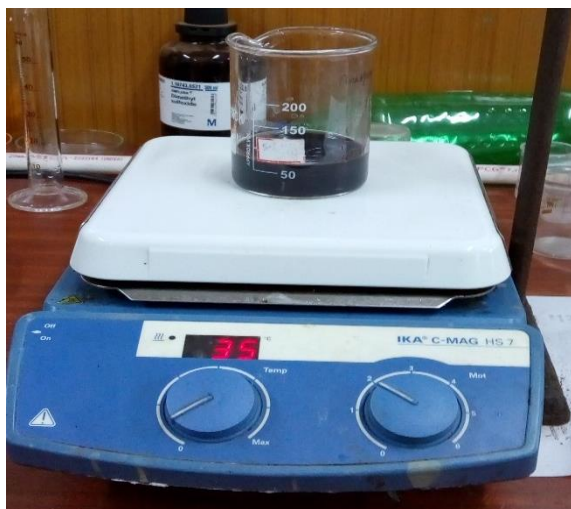
Synthesis Instrument:

1. Cold Bath: A cold bath is laboratory equipment made from a container filled with heated water. It is used to incubate samples in water at a constant temperature over a long period of time. All water baths have a digital or an analogue interface to allow users to set a desired temperature.



Fig. 1: Cold Bath

Magnetic stirrer: A magnetic stirrer or magnetic mixer is a laboratory device that



employs a rotating magnetic field to cause a stir bar immersed in a liquid to spin very quickly, thus stirring it. The rotating field may be created either by a rotating magnet or a Set of stationary electromagnets, placed beneath with the liquid. Because of its small size, a stirring

Fig. 2 Magnetic Stirrer

bar is more easily cleaned and sterilized than

other stirring devices. They do not require lubricants which could contaminate the reaction vessel and the product. Magnetic stirrers may also include a hot plate or some other means for heating the liquid.

2. Direct Drive Stirrer: Direct Drive mechanism is one that takes the power coming from

a motor without any reductions. In Direct Drive Stirrer power is taken from motor and thus rotation takes place.

Main advantage of Direct Drive stirrer is –

- No power wasted due to friction.
- Less noise.
- Lifetime is longer as having fewer moving parts.
- High torque at low r.p.m.

Faster and precise positioning can possible.



Fig. 3: Direct Drive Stirrer

3. Centrifuge Machine: A centrifuge is a piece of equipment that puts an object in rotation around a fixed axis (spins it in a circle), applying a force perpendicular to the axis of spin (outward) that can be very strong. The centrifuge works using the sedimentation principle, where the centrifugal acceleration causes denser substances and particles to move outward in the radial direction. At



Fig. 4: Centrifuge Machine

the same time, objects that are less dense are displaced and move to the center. In a laboratory centrifuge that uses sample tubes, the radial acceleration causes denser particles to settle to the bottom of the tube, while low-density substances rise to the top.

4. Hot Air Oven: Hot air ovens are electrical devices which use dry heat to sterilize. Generally, they can be operated from 50 to 300 °C, using a thermostat to control the temperature. Their double walled insulation keeps the heat in and conserves energy, the inner layer being a poor conductor and outer layer being metallic. There is also an air



Fig. 5: Hot Air Oven

filled space in between to aid insulation. An air circulating fan helps in uniform distribution of the heat. These are fitted with the adjustable wire mesh plated trays or aluminium trays and may have an on/off rocker switch, as well as indicators and controls for temperature and holding time. The capacities of these ovens vary. Power supply needs vary from country to country, depending on the voltage and frequency (hertz) used. Temperature sensitive tapes or biological indicators using bacterial spores can be used as controls, to test for the efficacy of the device during use. Advantage of hot air oven is it do not require water and there is not much pressure build up within the oven, unlike an autoclave, making them safer to work with.

5. Probe Sonicator: Sonication is the act of applying sound energy to agitate particles in a

sample, for various purposes.

Ultrasonic frequencies (>20 kHz) are usually used, leading to the process also being known as ultrasonication or ultra-sonication.

In the laboratory, it is usually applied using an ultrasonic probe, colloquially known as a sonicator. Sonication can be used for the production of nanoparticles, such

as nanoemulsions, nanocrystals .



Fig. 6: Probe Sonicator

CHARACTERISTIC INSTRUMENT:

XRD: X-ray diffraction (XRD) is a powerful nondestructive technique for characterizing crystalline materials. It provides information on structures, phases, preferred crystal orientations (texture), and other structural parameters, such as average grain size, crystallinity, strain, and crystal defects. X-ray diffraction peaks are produced by constructive interference of a monochromatic beam of X-rays scattered at specific angles from each set of lattice planes in a sample. The peak intensities are determined by the distribution of atoms within the lattice. Consequently, the X-ray diffraction pattern is the fingerprint of periodic atomic arrangements in a given material. X-ray diffraction is based on constructive interference of monochromatic X-rays. The interaction of the incident rays with the sample produces constructive interference when conditions satisfy Bragg's law:

$$n\lambda=2d \sin\theta$$

where n is an integer, λ is the wavelength of the X-rays, d is the interplanar spacing generating the diffraction, and θ is the diffraction angle.

Wavelength of electromagnetic radiation to the diffraction angle and the lattice spacing in a crystalline sample relates this law. The diffracted X rays are then detected, processed, and counted. By scanning the sample through a range of 2θ angles, all possible diffraction directions of the lattice should be attained due to the random orientation of the powdered material. Each compound has a unique 'd' spacing. Conversion of the diffraction peak into 'd' spacing allows identification of the compound. Basically compound identification is achieved by comparison of d-spacings with standard reference patterns.

X-ray diffractometers consist of three basic elements:

1. An X-ray tube
2. a sample holder and
3. an X-ray detector

X-rays are generated in a cathode ray tube by heating a filament to produce electrons, accelerating the electrons toward a target by applying a voltage, and bombarding the target material with electrons. Most common target material for single-crystal diffraction is copper, with CuK α radiation = 1.5418 Å. These X-rays are collimated and directed onto the sample. As the sample and detector are rotated, the intensity of the reflected X-rays is recorded. When the geometry of the incident X-rays impinging the sample satisfies Bragg's law, constructive interference occurs and a peak in intensity appears.

A detector records and processes this X-ray signal and converts the signal to a count rate, which is then output to a device such as a printer

or computer monitor. Strengths of X-Ray diffraction technique are-

- Ground-breaking and fast (<20 min) for distinguishing proof of an obscure mineral.
- Gives unambiguous mineral assurance by and large.
- Requires negligible example readiness.
- Wide accessibility of XRD units.
- Generally direct information elucidation.

Some limitations of XRD technique are-

- Homogeneous and single-stage material is best for distinguishing proof of an obscure.
- Access to a standard reference record of inorganic mixes is required.



Fig.7 : XRD Apparatus

- Material, in tenths of a gram amount, must be ground into a powder.
- For unit cell judgments, ordering of examples for nonisometric precious stone frameworks is muddled.
- Pinnacle overlay may happen and declines for high edge "reflections".

Zeta Potential Test: Numerous nanoparticles or colloidal particles have a surface charge when they are suspension. At the point when an electric field is connected, the particles move because of the association between the charged molecule and connected field. The heading and speed of the movement is an element of molecule charge, the suspending medium, and the electric field quality. Molecule speed is then estimated by watching the Doppler move in the dissipated light. The molecule speed is corresponding to the electrical capability of the molecule at the shear plane which is zeta potential. Accordingly, this optical estimation of the molecule movement under a connected field can be utilized to the decide zeta potential.

FTIR: Fourier-change infrared spectroscopy (FTIR) is a system used to acquire an infrared range of retention or outflow of a strong, fluid or gas. A FTIR spectrometer all the while gathers high-otherworldly goals information over a wide phantom range. This gives a critical preferred standpoint over a dispersive spectrometer, which estimates power over a limited scope of wavelengths at once.

When working with noticeable light, for example, you can just utilize a crystal or a diffraction framework to isolate the light from the source in beans of monochromatic light and than make these beans travel trough your example, each one in turn. As it were, you can send light with an offered recurrence to your example and see what ventures trough it. Infrared radiation, however, is more fragile and a source sufficiently able to create

enough light that notwithstanding when separated in numerous beams it would travel through the example would need to be a genuine blaze (maybe truly). In this way, present day machines send all photons created by the source to a Michelson interferometer with a moving mirror and from it to the example. At last, what the machine



Fig. 8: FTIR Apparatus

measures is power of light that achieved the locator X position of the moving mirror yet an estimation utilizing a Fourier change (an essential that can change over a component of a variable in an element of another variable) changes over this to a range: a realistic of force versus recurrence.

Raman Spectroscopy: Raman spectroscopy, a sub-atomic spectroscopy which is seen as inelastically dispersed light, takes into account the cross examination and distinguishing proof of vibrational (phonon) conditions of particles. Accordingly, Raman spectroscopy gives a significant logical instrument to atomic finger printing just as observing changes in sub-atomic bond structure (for example state changes and stresses and strains).

In contrast with other vibrational spectroscopy strategies, for example, FT-IR and NIR, Raman has a few noteworthy points of interest. These points of interest come from the way that the Raman impact shows itself in the light dispersed off of an example instead of the light consumed by an example. Therefore, Raman spectroscopy expects almost no example planning and is uncaring toward watery assimilation groups. This property of Raman

encourages the estimation of solids, fluids, and gases straightforwardly, yet in addition through straightforward compartments, for example, glass, quartz, and plastic.

FESEM: FESEM stands for Field Emission Scanning Electron Microscope. A FESEM is magnifying instrument that works with electrons (particles with a negative charge) rather than light. These electrons are freed by a field discharge source. The item is filtered by electrons as per a crisscross example. A FESEM is utilized to picture little topographic subtleties superficially or whole or on the other hand fractioned objects.

Scientists in science, science and material science apply this system to watch structures that might be as little as 1 nanometer.

Electrons are freed from a field discharge source and quickened in a high electrical field angle. Inside the high vacuum segment these supposed essential electrons are focussed and avoided by electronic focal points to deliver a thin output pillar that assaults the article. Therefore auxiliary electrons are radiated from each spot on the article. The point and speed of these auxiliary electrons identifies with the surface structure of the article. A locator gets the auxiliary



Fig. 9: FESEM Apparatus

electrons and produces an electronic sign. This sign is intensified and changed to a video filter picture that can be seen on a screen or to an advanced picture that can be spared and prepared further.

TEM: TEM stands for Transmission Electron Microscope. In TEM we quicken electron to increase enough active vitality to enter slender foil (our example - 100-10 nm thick). We are gathering electrons that gone through the example into CCD camera. The manner in which electron have figured out how to pass (infiltrate) through the example and the electron/test association are deciding the differentiation of our picture. The majority of this event in vacuum - so as to build the mean freeway (Mean free way) of the electron.

TEM is a stage - you can add extra locators to acquire diagnostically data. One of the precedents is EDS locators (Energy-dispersive X-beam spectroscopy) - that enables you to know your example substance creation.

TEM can task is various modes - so as to gather various sorts of data. For instance so as to get auxiliary information of the example you can perform Electron Diffraction (Electron diffraction) in TEM - just by changing the optical way of the electrons in the framework.

Electron shaft in TEM is high vitality, exceptionally cognizant electrons - generally quickened at 200 kV with vitality spread of 1 V. The state of the shaft constrained by set of focal points (condenser framework - 2 or 3 electromagnetic focal points) and set by an ideal method of activity. In TEM imaging the bar will be spread and the entire example will be lit up in the meantime.

TESTING INSTRUMENT:

Compressive Testing Machine: Compressive Test machines are widespread trying machines uniquely arranged to assess static compressive quality attributes of materials, items, and parts. Our pressure test machines measure attributes, for example, ultimate compression quality, yield quality, redirection and modulus.

The objective of a pressure test is to decide the conduct or reaction of a material while it encounters a compressive burden by estimating essential factors, for example, strain, stress, and misshapening.

The deliberate compressive quality of the example will be determined by

partitioning the greatest burden connected to the example amid the test by the cross sectional Area, determined from the mean components of the segment and will be communicated to the closest newton per mm².



Fig. 10: Compressive Testing Machine

Synthesis of Graphene Oxide(GO):

Material Used:

- Graphite fine powder (3991D00500) purchased from Loba Chemie.
- Sodium Nitrate purchased from Merck
- Potassium Permanganate purchased from Merck
- Sulfuric acid (H₂SO₄) about 98% concentrated purchased from Merck
- Hydrogen Peroxide (H₂O₂) purchased from Merck

Synthesis Procedure:

1 gm. Graphite powder is added with 0.5 gm. NaNO₃ and then filled with 45 ml. sulphuric acid and then put it into the ice bath maintaining below 5⁰ c temperature. NaNO₃ is used to enhance the oxidation on the basal plane of the graphitic sheets and also sodium nitrate decrease the absorbance value. Then stirred the solution for 2 hours at 400 r.p.m. with Direct Drive Stirrer. Then 3 gm., 4 gm., and 5 gm. KmnO₄ is weighing in the weighing balance and pour them very slowly in 3 different solution for preparing 3 different GO samples with different quantity of KmnO₄. Maintain the stirring with Direct Drive Stirrer for another 3 hours after pouring KmnO₄ with less than 5⁰ c temperature. Role of KmnO₄ is to achieve oxidation. After that ice bath was removed the mixture was stirred in a 35⁰ c water bath with magnetic stirrer for 2.5 hours to form thick Dark Brown colour paste. Then 110 ml. distilled water was slowly added to cause an increase in temperature to 90⁰ c and then stirred the mixture for another 30 minutes. Distilled water has also same function to increase the oxidation rate. After the procedure was completed put the sample into probe sonicator for 25 minutes. Probe Sonication condition: Amplitude- 50%, Frequency- 20 hz, Power- 500 watt, Titanium Alloy Probe width 13 millimeter constant applied energy 1900 joule/ minute. After the completion of sonication put the sample on the magnetic stirrer again and another 100 ml. distilled water put into it followed by the slow addition of 3 ml. Hydrogen Peroxide(H₂O₂). Hydrogen Peroxide stops the

oxidation process and it is the final step of GO synthesis. During H_2O_2 mixing with the solution the dark brown colour will change to bright yellow colour and violent bubbles formed at the same time. This GO has acidic PH value and unable to use for any application. So the resulted mixture was washed for several times with 3% HCL solution and then distilled water until the PH value of GO was about 7. The neutral GO was taken into the petri dish and put them into the hot air oven for an overnight. Collect the sample as a powder form and now GO is ready for use.



Fig. 11: Graphene Oxide after synthesis

Characterization:

Following characterizations are done on the prepared Go sample to detect area, size, and morphology, crystallinity etc.

1. XRD
2. Zeta Potential Test
3. FTIR
4. Raman Spectroscopy
5. FESEM
6. TEM

1. XRD:

XRD investigation was utilized to decide the normal crystalline properties of the GO sheet. The XRD example of the graphite demonstrates a diffraction crest at $2\theta = 26.3^\circ$. The XRD pattern of all the samples are shown in the figure below and it is clearly shown that $2\theta = 26.3^\circ$ peak starts decreasing and finally disappears at higher oxidation level i.e at using 4 gm. of KmnO_4 using. The XRD example of the integrated examples indicates critical changes in the crystallinity of GO at each phase of oxidation.

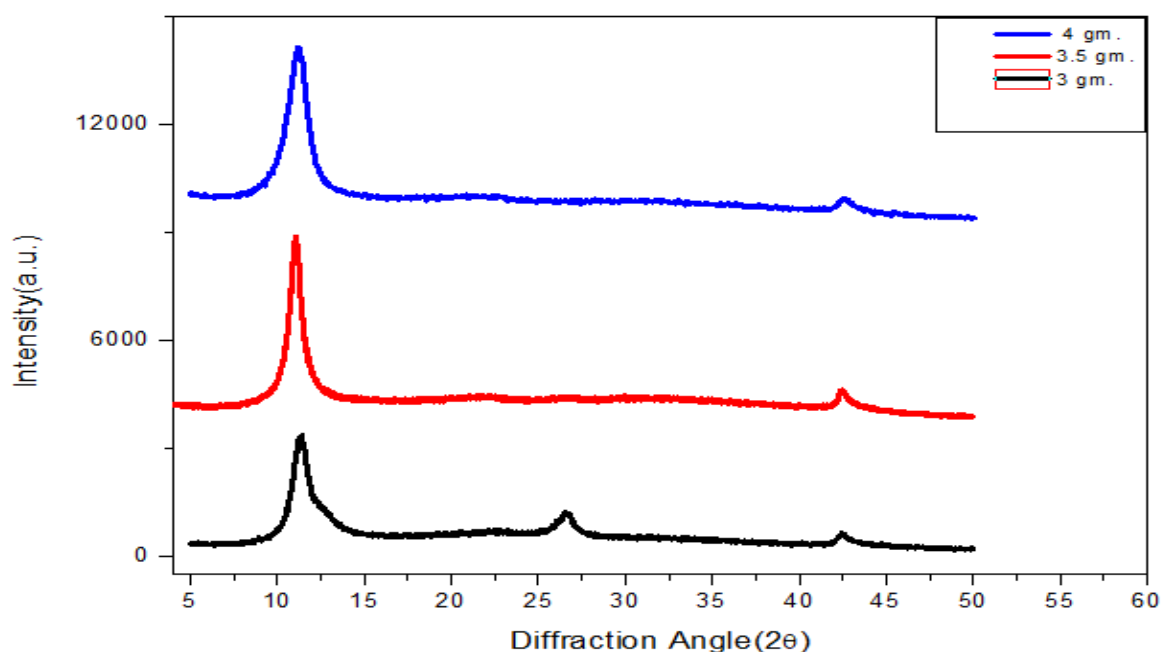


Fig. 12: X Ray diffraction pattern of GO with different degree of oxidation

Increaseing oxidation rate results in the following:

- The graphitic peak vanishes at higher oxidation level.
- When the concentration of KmnO_4 was increased from 3 gm to 3.5 gm and 4 gm the intensity of the peak shifts from $2\theta = 11.48^\circ$, 11.16° and 11.05° respectively.

As the oxidation rate increases different levels of oxygen containing groups were attached to the graphite lattice. There were no significant changes occurred in the XRD pattern of GO samples. It is self-evident that all the tests have a sheet like morphology with unique transparencies. This is presumably because of the quantity of layers present in the stacked structure of GO. The example with 3 gm kmno_4 contains less oxygenated utilitarian gatherings which confines them regarding peeling into monolayers or few layers after the shedding procedure. Additionally the straightforwardness of these examples is not exactly the others due to the presence of more layers. Be that as it may, with increments in the oxidation level, GO tests with 3.5 gm and 4 gm KmnO_4 become very straightforward, since these examples have high measures of oxygenated practical gatherings, which makes reasonable for peeling into monolayers or only a couple of layers of GO after ultrasonication. A general investigation of the XRD perceptions demonstrates that the crystal structure and transparency are exceedingly subject to the dimension of oxidation and the peeling methodology[9].

2. Zeta Potential Test:

The zeta-potential is frequently utilized as a file of the greatness of electrostatic connection between colloidal particles and is subsequently a proportion of the colloidal soundness of the arrangement. Particles with a zeta-potential not exactly - 15 mV or in excess of 15 mV are expected to be steady from electrostatic considerations. However particles with zeta-

possibilities between - 15 and 15 mV can in any case be steady on the off chance that they are settled sterically[10].

Figure shows the zeta-potential curve for Graphene Oxide with different oxidation level i.e. with 3 gm KMnO_4 , 3.5 gm KMnO_4 and 4 gm KMnO_4 . As the KMnO_4 increases, rate of oxidation increases.

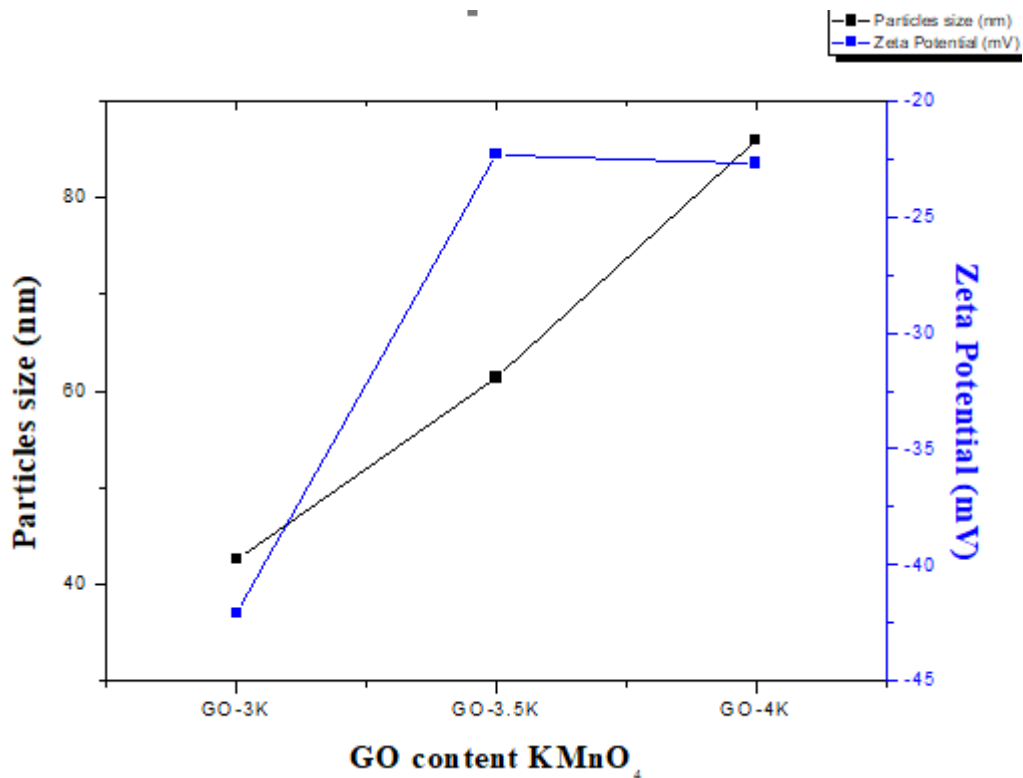


Fig: 13: Particle size with Zeta potential with different degree of oxidation

All the particles are mutually repulsive, and since the zeta potential is measured based on the electrophoretic mobility of the particles, the sensor translates the frequency shift in the light scattering components into zeta potential value for individual element which results in a much broader distribution. In this context GO with 3 gm KMnO_4 showing the highest repulsion and GO with 4 gm KMnO_4 shows lowest repulsive force. As the oxidation increases repulsive force decreases which leads to broader particle size. How particle size changes with change of oxidation rate is listed below:

GO content KMnO ₄ (gm)	Particles Size (nm)	Zeta Potential (mV)
3K	42.52	-42.1
3.5K	61.33	-22.3
4K	85.98	-22.7

Table 1: Variation of particle size with different oxidation level

It is evident that the change in zeta potential value strongly signifies the existence of a unique interaction between the particles. As the oxidation rate increases, repulsive force decreases and particle size increases.

3. FTIR:

FTIR spectra analysis was performed to investigate the structure and functional groups of the materials. Here for 3 different variation of Kmno₄ 3 different results are shown in the figure below:

Kmno₄ variations are 3 gm., 3.5 gm. and 4 gm. respectively. The GO sheet demonstrated clear absorption groups for the carboxyl C=O (1723 cm⁻¹), aromatic C=C (1621 cm⁻¹), epoxy C– O (1220 cm⁻¹), alkoxy C– O (1043 cm⁻¹), and hydroxy – OH (3391 cm⁻¹) gatherings[11]. The introduction of oxygen-containing useful gatherings, for example, C=O and C– O, further affirmed that the graphite undoubtedly was oxidized into GO and was predictable with the writings. The introduction of C=C bunches demonstrated that even graphite had been oxidized into GO; the fundamental structure of layer graphite was still held. The FTIR result shows synthesis of GO was successful.

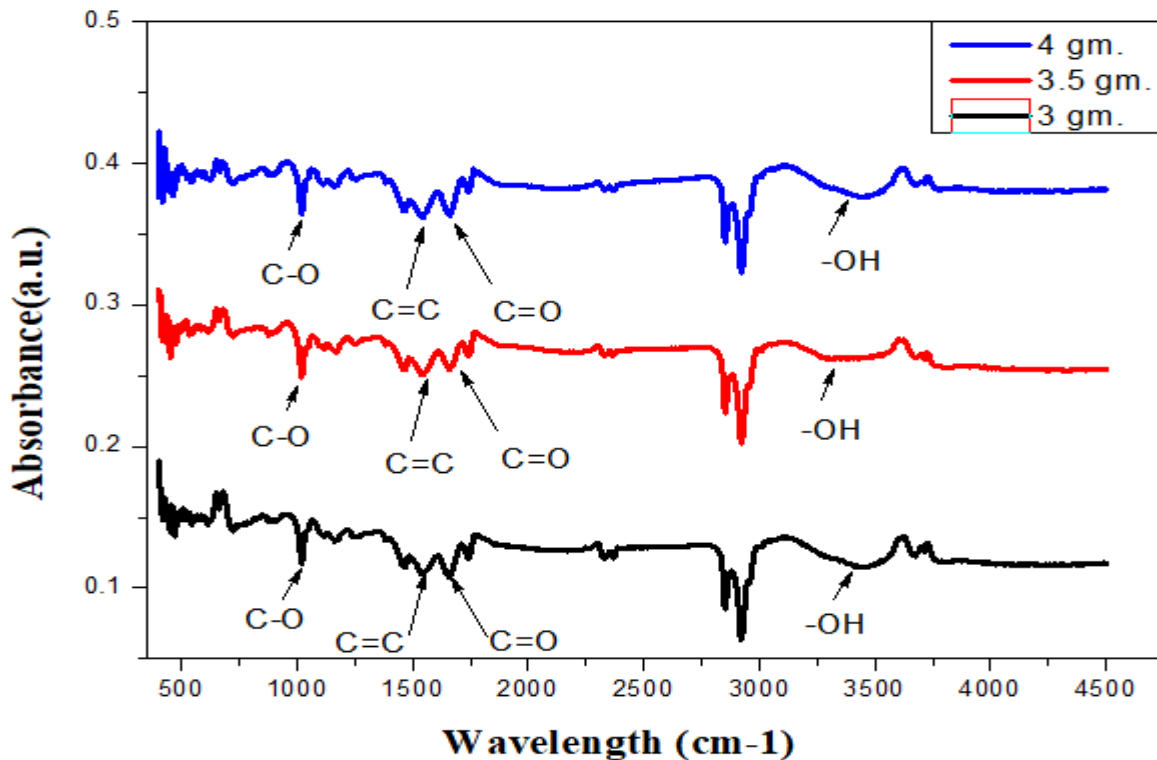


Fig.: 14: FTIR of GO with different degree of oxidation

4. Raman Spectroscopy:

Raman spectroscopy is a non-damaging strategy which is a generally utilized device to acquire basic data of carbon-based materials. The fundamental highlights in the Raman spectra of graphitic carbon-based materials are the G and D peaks and their overtones.

Figure is the Raman spectra of as-got Graphene Oxide test. The two generally extraordinary peaks are the G band at 1580 cm^{-1} and the 2D band at 2200 cm^{-1} . The G peak is because of the bond extending of all sets of sp_2 molecules in both the rings and chains. It is the aftereffect of in-plane optical vibrations and compares to the optical E_{2g} phonons at the Brillouin zone focus coming about because of the bond extending of sp_2 carbon combines in both, rings and chains. The 2D band, otherwise called the G' band, is the second generally unmistakable band in the Raman spectra and is constantly seen in graphite tests. The pinnacle at 1350 cm^{-1} is

likewise called the D crest and uncovers abandons in the example. The D crest is because of first request reverberation. The D peak speaks to the breathing method of aromatic rings emerging because of the deformities in the example. The D-crest power is in this way frequently utilized as a proportion of the level of turmoil. The Raman spectra of GO in Figure demonstrates the nearness of a solid D crest at $\sim 1350\text{ cm}^{-1}$ with a force tantamount to that of the G crest at $\sim 1580\text{ cm}^{-1}$. The extraordinary D crest alongside an enormous data transmission propose the critical basic issue in GO. The 2D crest at around 2650 cm^{-1} is credited to twofold reverberation advances bringing about the creation of two phonons with inverse force. Unlike the D peak, which is Raman active only in the presence of defects, the 2D peak is active even in the absence of any defects[12].

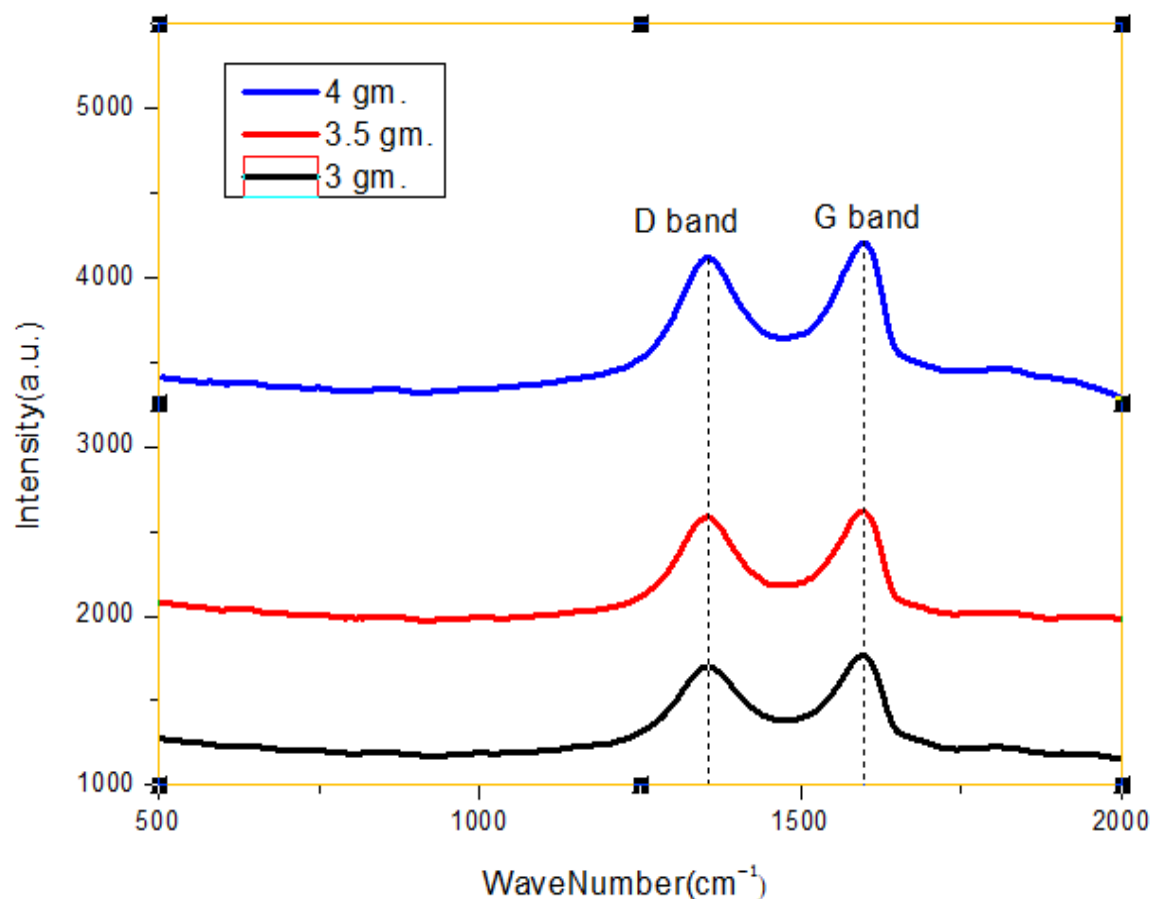


Fig.: 15 Ramon Spectroscopy of GO with different degree of oxidation

5. FESEM:

The grain size and surface morphology were seen by the field emission examining electron magnifying instrument (FESEM). FESEM pictures of the Graphene Oxide (GO) have all around characterized and interlinked three-dimensional Graphene sheets, framing a permeable system that looks like a free wipe like structure as appeared in Figure below. One can likewise see that the GO is shaped by a layered structure. This is because of the oxidation of the material, since the more noteworthy the level of oxidation, the higher are the spaces between the functionalized layers. From the observations it is clear that with the higher degree of oxidation level it leads to exfoliation into single or few layered GO.

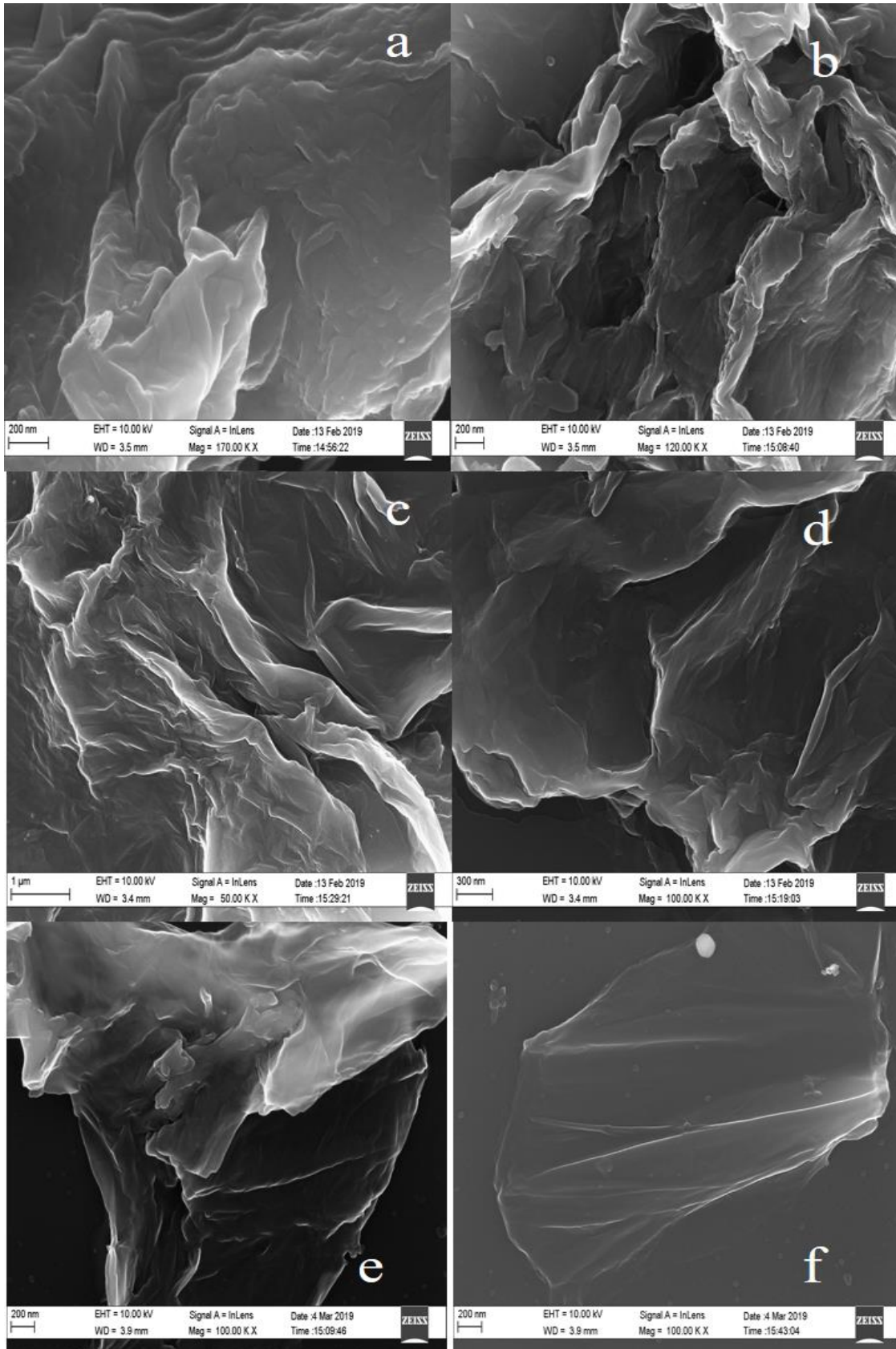


Fig. 16 :FESEM image of Graphene Oxide with different degree of oxidation: (a),(b)-3 gm KMnO_4 , (c),(d)-3.5 gm KMnO_4 , (e),(f)- 4 gm KMnO_4

The distinction in the quantity of layers can be effectively recognized utilizing the difference of the sheets. The monolayers of GO have a light in colour though the few layered GO are splendid in shading in Fig (e),(f). The nearness of a couple of layers in the example is because of the accumulation or on the other hand self get together of a few layers of GO amid the drying process in the example arrangement. We likewise analyzed the idea of monolayer GO. Thus, Fig (e),(f) demonstrates the nearness of monolayer and few layered GO portraying the nearness of wrinkles in the sheets.

6. TEM:

The morphological structure of GO was described by transmission electron magnifying lens (TEM) and appeared in Figure 17. Plainly GO is fundamentally transparent. Be that as it may, the versatile layerings and the looked over or collapsed edges regularly result in various splendor on the outside of the GO. Dim territories demonstrate the thick stacking nanostructure of a few graphene oxide or potentially graphene layers with some measure of oxygen utilitarian gatherings. The higher darkness regions show a lot more slender movies of a barely any layers graphene oxide as well as decreased graphene oxide coming about because of stacking nanostructure peeling. . Significantly larger surface area of high transparency of delaminated graphene layers (of about one to few layer thickness) in shown by high oxidised Go sample than the lesser oxidised GO sample[13].

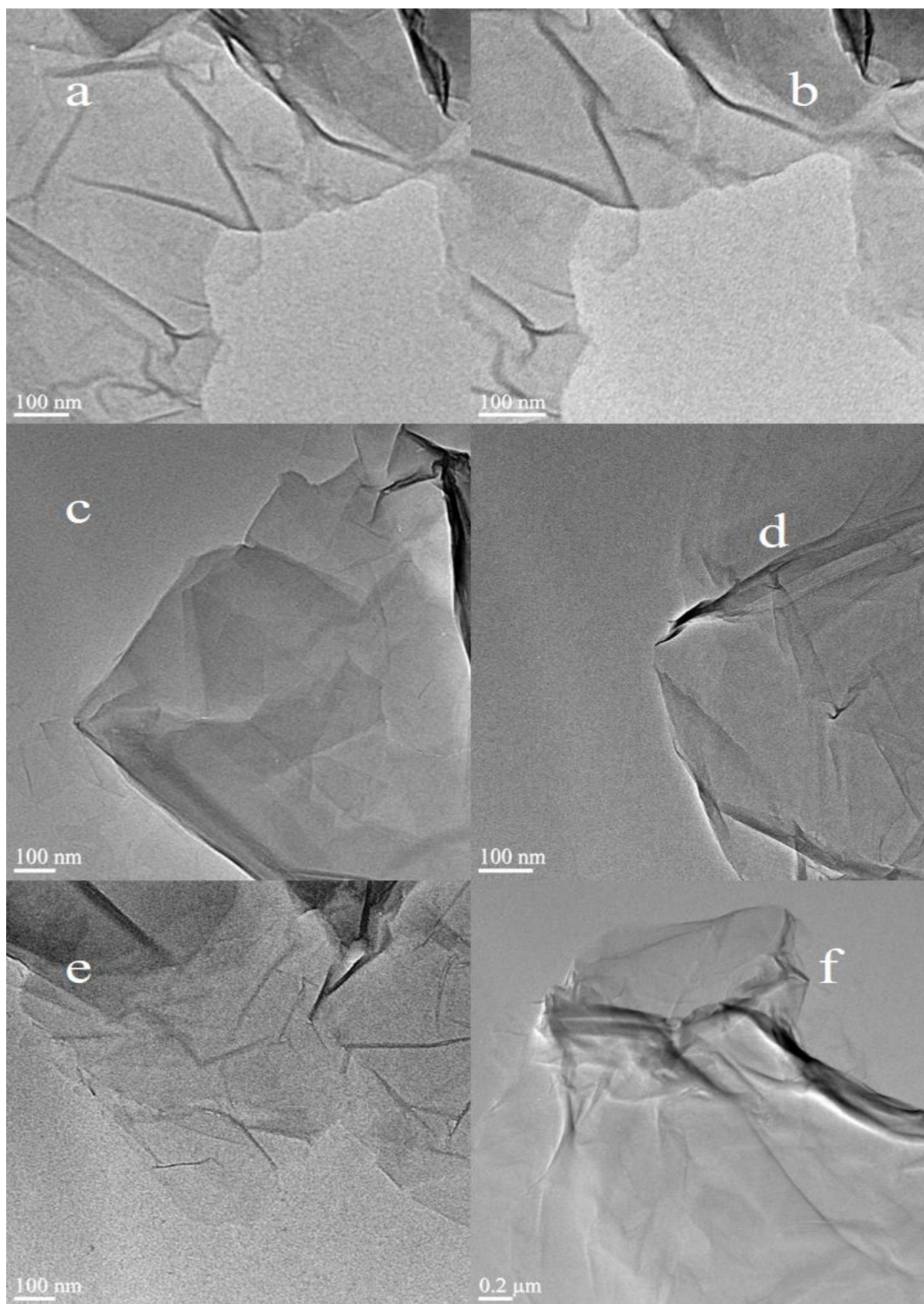


FIG. 17 : TEM image of Graphene Oxide at different oxidation level –(a),(b)-4 gm KmnO₄, (c),(d)- 3.5 gm KmnO₄ (e),(f)- 3 gm KmnO₄

CHAPTER 3

MECHANICAL PROPERTY

ENHANCEMENT

Experiment 1: Enhancement of mechanical properties using GO

To deliver cement mortar containing various rates of GO and a control test containing no GO, one section cement and 2.5 sections Ottawa standard sand (by weight) were blended to set up the mortar tests. Four examples were created from the same group for use in compressive tests.

Table 2 demonstrates the blend extents for the examples, which had diverse GO substance of 0.2 %, 0.4 %, 0.6 % with respect to water. Specimens are moulded in a 50 mm cube mould as shown in figure.



Fig.: 18 Prepared GO Cement Mortar

Water cement ratio was taken 1:2.76. At first required sand, cement was weighing on the weigh machine and then mix them using hands. Then pour

the GO dispersed water with appropriate ratio which was sonicated for around 150 mins in probe sonicator. Then mixes them well and pour them into the 50 mm cube and leave them for overnight for dried. After drying, in ver next day break the mould and put them into the water for curing for 28 days.

% OF GO DISPERSION IN 100 ML WATER	WATER RATIO	CEMENT IN GM	WATER IN ML	SAND IN GM
0.2% GO	1:2.76	360	130	900
0.4% GO	1.:2.76	360	130	900
0.6% GO	1:2.76	360	130	900

Table 2: Mixture proportions for the samples

Dispersion of Carbon Nanostructures within Cement Matrix.:

As referenced before, for carbon nanostructures to be completely used inside a material, they should initially be appropriately scattered. In the present case, scattering is the procedure of isolating the groups of GO into individual drops inside a lattice. To scatter the carbon nanostructures inside the bond lattice, the GO was added slowly to water and the mixture was sonicated for almost 150 min. The sonication conditions were as per the following: the amplitude was set to 50%, frequency 20Hz, power 500W, titanium alloy probe width 13mm, and a constant applied energy of 1900 J/min..

Mechanical property Test:

The compressive test was measured by compressive testing machine by the following procedure:

- Bring the cubes after 28 days curing and weighing them one by one on the weighing machine.
- After checking the weight note down the weight of ever specimen and bring them to compression testing machine.

- Put them one by one into the jaws of the machine and fit them properly that they never slips from their position when load is applied on them.
- After that safety measures and turn on the machine and load is applied gradually.
- Note down the maximum that the cube can withstand during testing.
- Follow the same procedure for next specimens.
- Take the average of load of all the specimens and a new observation table was obtained that is given below.

	SAMPLE NUMBER	WEIGHT IN GM.	LOAD IN 28 DAYS IN KN
NORMAL MORTAR	1.	280	80
	2.	279	90
	3.	275	85
	4.	285	87
.2% GO	1.	285	120
	2.	290	130
	3.	285	120
	4.	280	123
.4% GO	1.	290	100
	2.	285	110
	3.	287	110
	4.	288	105
.6% GO	1.	280	90
	2.	279	92
	3.	279	85
	4.	281	88

Table 3: Load variation of mortar for different percentage of GO dispersion

Result and Discussion:

Result of the compressive test was shown in figure.

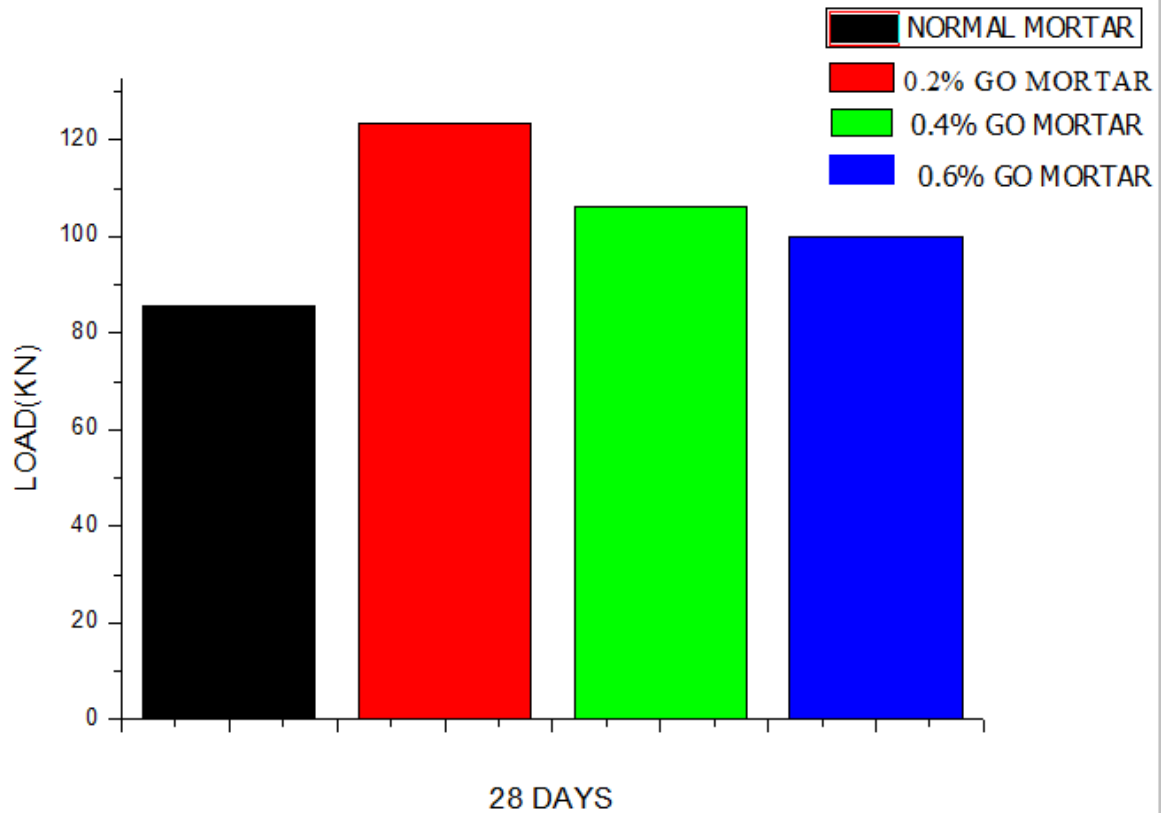


Fig. 19: Variation in Load taking capacity of GO CEMENT mortar with different percentage of GO dispersion

Take the average load of 4 specimens for all percentage of GO dispersion and take the result.

- Average load of normal mortar was 85.5 KN.
- Average load of 0.2% GO dispersed mortar was 123.25 KN.
- Average load of 0.4% GO dispersed mortar was 106.25 KN.
- Average load of 0.6% GO dispersed mortar was 88.75 KN.
- Strength of normal mortar after 28 days: 34.2 N/ mm²
- Strength of .2% GO mortar after 28 days: 49.3 N/ mm²
- Strength of .4% GO mortar after 28 days: 42.5 N/ mm²
- Strength of .6% GO mortar after 28 days: 35.5N/ mm²

- % increase of .2% GO mortar is 44.15%
- % increase of .4% GO mortar is 24.26%
- % increase of .6% GO mortar is 3.8%

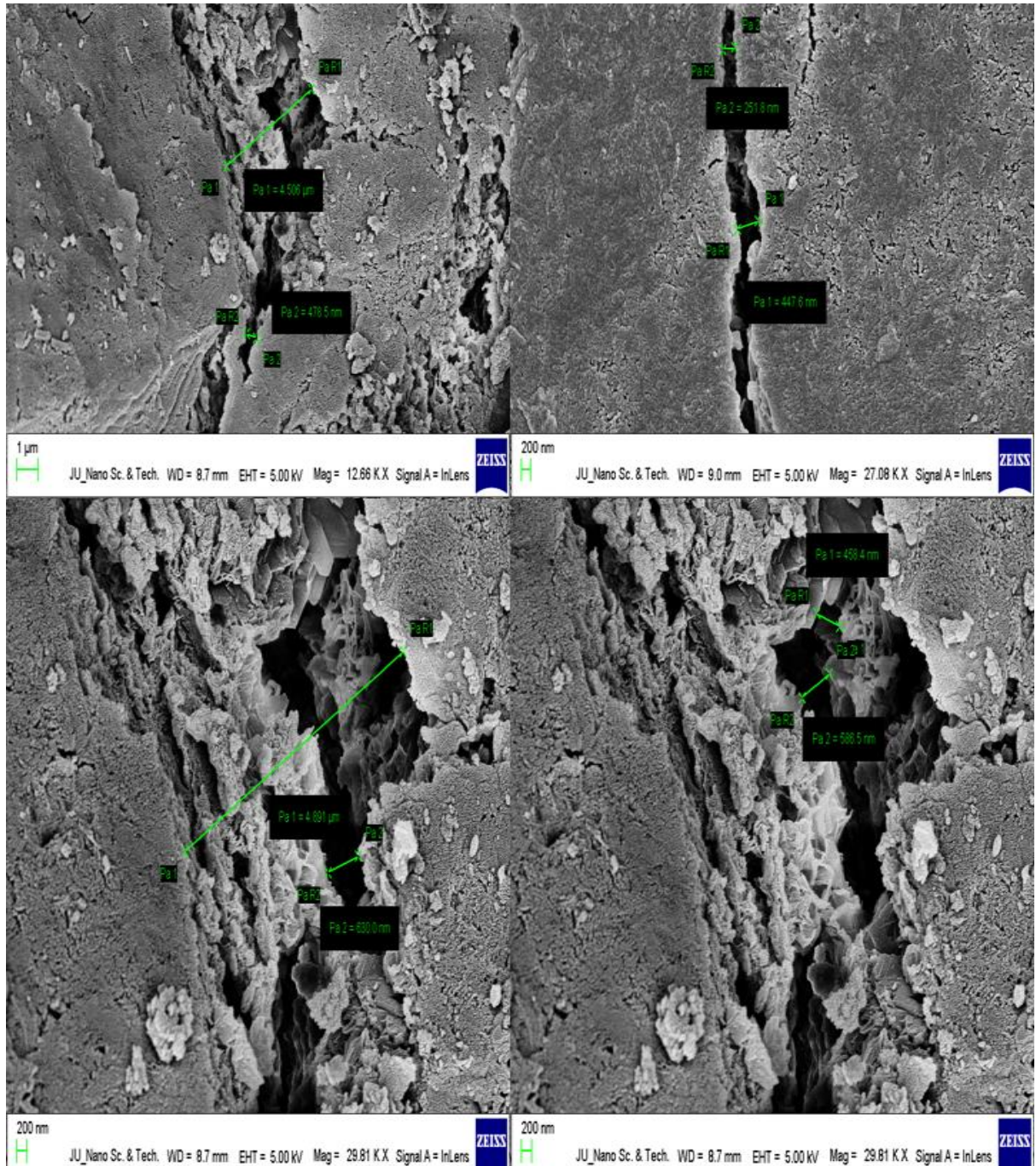


Fig. 20: FESEM image of normal cement mortar without using GO

From the experimental result it is observed that strength increases when GO is dispersed, but upto a certain amount. The main reason behind the strength variation is the Inner Transition Zone(ITZ). ITZ is the region in the mortar between the cement and sand after casting. Generally minimum size of sand is 60-80 micron and minimum cement size is 10-20 micron we can found, so there are nanospace between them during the casting which can not be filled by these elements and also there are lots of nano cracks into the specimen after curing 28 days which can not visible by naked eye. When load applied crack starts propagate from these regions and when load increases gradually these cracks are bigger and tends to break the sample. These cracks can be visible by doing FESEM of the sample. The Fesem image of normal mortar without GO is given in figure 20. In the given figure cracks are visible which are in nano dimension range which can not be filled by construction elements and crack propagate starts from here. GO is a nano material which has wonderful mechanical properties as well as it has nano dimension which can easily deposit on these cracks and makes a defectless structure so that the crack can not propagate so easily with applying the load[14]. Deposited GO withstand some load upto certain value and increase the load carrying capacity. Dispersion of Go on the nano cracks are shown in figure 21.

From the image it is clear that by using GO strength of a concrete can be increased but upto certain percentage of GO can enhance the strength i.e 0.2% of water can increase the strength, furthermore it leads to decrease the strength of the mortar than 0.2% GO gives.

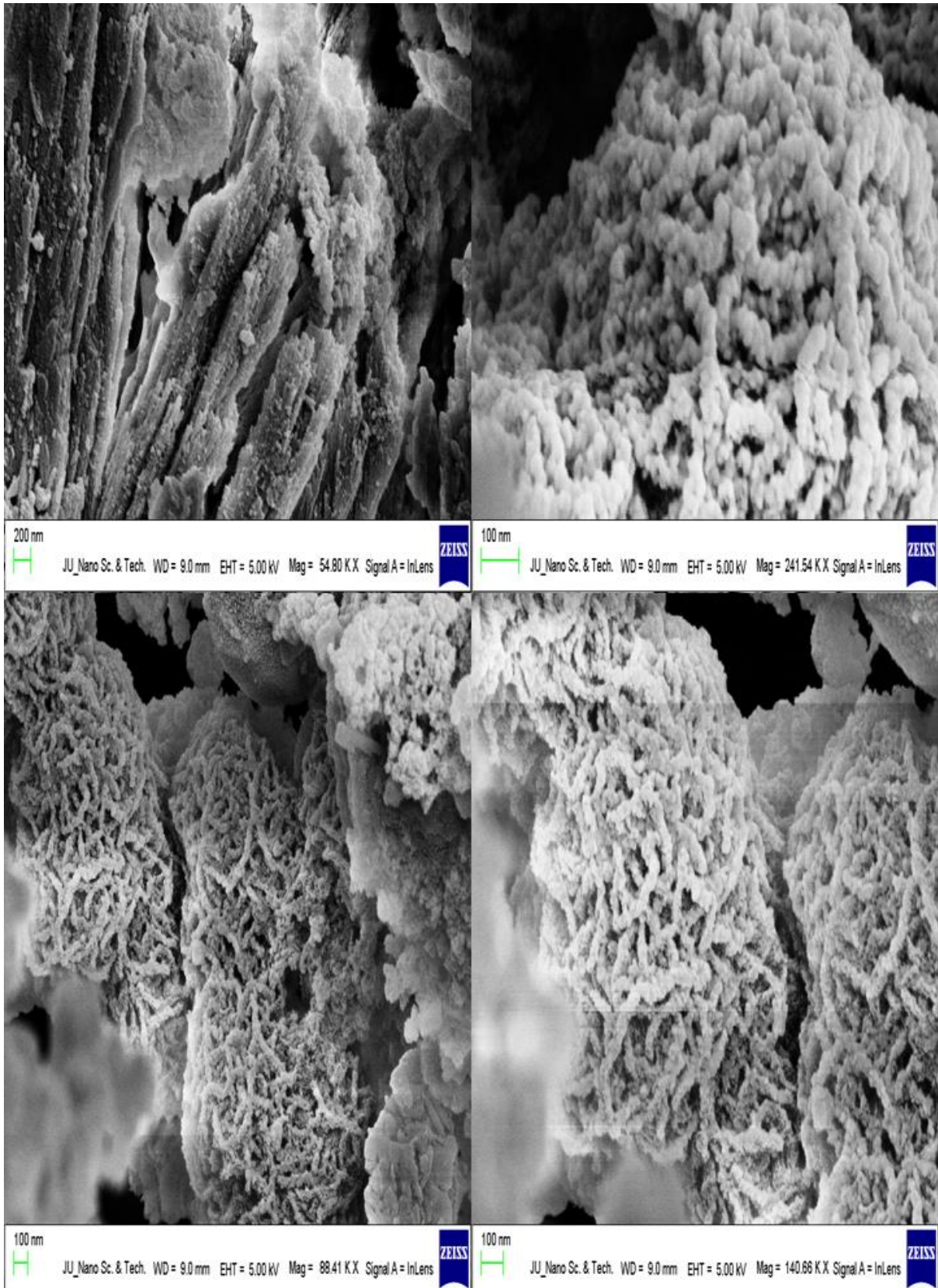


Fig. 21: FESEM image of 0.2% GO dispersion on cement mortar

Experiment 2: Use of plastic dust in concrete mixture as aggregate replacement to achieve M25 strength

Concrete a composite man-made material, is the most widely used building material in the construction industry. It consists of a rationally chosen mixture of binding material such as lime or cement, well graded fine and coarse aggregates, water and admixtures (to produce concrete with special properties). In a concrete mix, cement and water form a paste or matrix which in addition to filling the voids of the fine aggregate, coats the surface of fine and coarse aggregates and binds them together. The matrix is usually 22-34% of the total volume. Freshly mixed concrete before set is known as wet or green concrete whereas after setting and hardening it is known as set or hardened concrete. The moulded concrete mix after sufficient curing becomes hard like stone due to chemical action between the water and binding material.

Ordinary ostensible blend proportioning frequently determined by standard guideline, for example, 1:1:2; 1:2:4; 1:3:6, and so forth have restricted hugeness as these are with little thought for the materials that will be utilized. Since the amount of fine total is fixed independent of the concrete and the most extreme size of total, impressive varieties in quality are gotten by this strategy. Along these lines, ostensible blend extents, self-assertively fixed, have little use in solid blend plan. Another reason not for ostensible blend idea is that the water-concrete proportion, a most significant factor overseeing solid quality, isn't indicated for ostensible blends, and must be kept as low as conceivable gave that the blend is completely compacted cement. The purpose of concrete mix design is to ensure the most optimum proportions of the constituent materials to meet the requirements of the structure being built. Mix design should ensure that the concrete[15]:

- agrees to the determinations of basic quality set down, which is generally expressed as far as the compressive quality of standard test examples.

- consents to the sturdiness necessities to oppose nature in which the structure will serve its useful life.
- Be fit for being blended, transported, compacted as proficiently as conceivable without undue labour.
- Should be economical.

Concrete mix proportions can be expressed in terms of volume or weight. The present trend is towards specifying mixes in terms of minimum strength requirements (usually with a specified minimum cement content), rather than by volume proportions. For example, M 20 design mix should have a characteristic strength of 20 N/mm², M 25 mix shall have a characteristic strength of 25 N/mm², and so on as given below[16]:

Grade designation	Specified characteristic compressive strength of 100-mm cubes at 28 days, fck, N/mm²
M 20	20
M 25	25
M 30	30
M 35	35
M 40	40

Table 4: characteristic compressive strength of 100-mm cubes at 28 days for different grade concrete

Here in this experiment we will discuss about M 25 grade concrete using replacement of fine aggregate with plastic dust. The gainful utilization of waste material speaks to a methods of reducing a portion of the issues of strong waste administration . The reuse of waste is significant from various perspectives. It spares furthermore, support regular assets that are not recharged, it diminishes the contamination of nature and it likewise makes a difference to spare and reuse vitality creation forms. Wastes what's more, mechanical side-effects ought to be considered as possibly significant assets only anticipating suitable treatment also, application. Plastic wastes are among these wastes; their transfer effectsly affects the earth because of their long biodegradation period, and in this way one of the sensible strategies for decrease of their negative impacts is the utilization of these materials in different businesses. Concrete assumes a significant job in the helpful utilization of these materials in development. A little bit portion of these materials can be helpfully fused in concrete, both as a component of the cementitious cover stage or as totals, it is imperative to understand that not all waste materials are reasonable for such use.

Concrete contains various blemishes and smaller scale splits. The fast engendering of smaller scale breaks under a connected burden is viewed as in charge of the low elasticity of cement. It is sensible to expect that the elasticity as well as the flexural quality of cement can be considerably expanded by presenting firmly separated filaments. These filaments would capture the proliferation of miniaturized scale splits, consequently postponing the beginning of tractable splits and expanding the elasticity of the material.

Materials and Mix Design:

The materials used in this study are as follows:

Cement: Type I Portland concrete adjusting to IS Code – IS 8112: 1989 for 43 Grade Ordinary Portland Cement was utilized in a wide range of total substance blends.

Fine aggregate: The fine aggregate was normal sand of 4.75 mm greatest size acquired. The properties of the fine aggregate was resolved what's more, satisfied by IS: 2386. Table 04 presents the properties of the sand, and its degree is introduced in Table 06.

Properties	Limit
Sulfate (%)	0.8
Finesse modulus	2.37
Absorption (%)	2.71
Max size (mm)	4.75
Density (kg/m ³)	1688
Specific gravity	2.57

Table 5: Properties of Fine Aggregate

Sieve size (mm)	Accumulated percentage passing	Limit of I.S.: 2386 zone
4.75	96.5	90–100
2.36	89.16	85–100
1.18	80.7	75–100
0.6	68.4	60–79
0.3	24.97	12–40
0.15	3.81	0–10

Table 6: Sand passing percentage from different sieve size

The table shall be described as fine aggregates, I, II, III and IV. Here the accumulated percentage of passing sands are fall under Zone I category.

Coarse Aggregate: Common pulverized stone aggregate of most extreme size 20 mm and 8-10 mm and mass thickness of 1545 kg/m³ was used for the experiment.

Waste Plastic: Waste plastic represents the discarded waste from plastic containers that were collected from plastic manufacturing plants. After collection of waste plastic crushed them into fine particles and analysed them for sieving and other physical properties like density. The specific gravit of the plastic is found 0.92.

Mix Design:

In order that not more than the specified proportion of test results are likely to fall below the characteristic strength, the concrete mix has to be proportioned for higher target mean compressive strength f'_{ck} . The margin over characteristic strength is given by the following relation:

$$f'_{ck} = f_{ck} + 1.65 s$$

Where,

f'_{ck} = target mean compressive strength at 28 days in N/mm^2

f_{ck} = characteristic compressive strength at 28 days in N/mm^2 ,

s = Standard Deviation

According to IS Code 10262-2009[17], the Design Mix Procedure is Carried Out:

1. Design Stipulation:

- Characteristic Compressive Strength required in 28 days: $25N/mm^2$
- Maximum size of aggregate: 20 mm(angular)
- Degree of workability: 0.90 Compacting factor
- Degree of quality control: Good
- Type of exposure: Moderate

2. Test data of Materials:

- Cement used: OPC- 53 grade (IS 269-1989)
- Specific gravity of cement: 3.15
- Specific gravity of fine aggregate: 2.60
- Specific gravity of Coarse aggregate: 2.65
- Water absorption of fine aggregate : 4.2%
- Water absorption of coarse aggregate: 0.6%
- Free moisture of fine aggregate: 2.0%

- Free moisture of coarse aggregate: NIL

Coarse aggregate confirming to Table 2 of IS: 383-1970

Fine aggregate confirming to Zone –I of Table-4 IS: 383-1970

TABLE 2 COARSE AGGREGATES

(Clauses 4.1 and 4.2)

IS SIEVE DESIGNATION	PERCENTAGE PASSING FOR SINGLE-SIZED AGGREGATE OF NOMINAL SIZE						PERCENTAGE PASSING FOR GRADED AGGREGATE OF NOMINAL SIZE			
	63 mm	40 mm	20 mm	16 mm	12.5 mm	10 mm	40 mm	20 mm	16 mm	12.5 mm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
80 mm	100	—	—	—	—	—	100	—	—	—
63 mm	85 to 100	100	—	—	—	—	—	—	—	—
40 mm	0 to 30	85 to 100	100	—	—	—	95 to 100	100	—	—
20 mm	0 to 5	0 to 20	85 to 100	100	—	—	30 to 70	95 to 100	100	100
16 mm	—	—	—	85 to 100	100	—	—	—	90 to 100	—
12.5 mm	—	—	—	—	85 to 100	100	—	—	—	90 to 100
10 mm	0 to 5	0 to 5	0 to 20	0 to 30	0 to 45	85 to 100	10 to 35	25 to 55	30 to 70	40 to 85
4.75 mm	—	—	0 to 5	0 to 5	0 to 10	0 to 20	0 to 5	0 to 10	0 to 10	0 to 10
2.36 mm	—	—	—	—	—	0 to 5	—	—	—	—

Fig. 22: Table 2 of IS: 383-1970

TABLE 4 FINE AGGREGATES*
(Clause 4.3)

IS SIEVE DESIGNATION	PERCENTAGE PASSING FOR			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15

Fig. 23: Table-4 IS: 383-1970

3. Calculation:

Step-1: Target Mean Strength of Concrete: $f'_{ck} = f_{ck} + 1.65 s$

$f_{ck} = 25 \text{ N/mm}^2$

$s = 4.0$ (From Table 1 for M25 of IS-10262-2009)

Table 1 Assumed Standard Deviation
(Clauses 3.2.1.2, A-3 and B-3)

Sl No.	Grade of Concrete	Assumed Standard Deviation N/mm ²
(1)	(2)	(3)
i)	M 10	3.5
ii)	M 15	
iii)	M 20	4.0
iv)	M 25	
v)	M 30	5.0
vi)	M 35	
vii)	M 40	
viii)	M 45	
ix)	M 50	
x)	M 55	

Fig.24: Table 1 for M25 of IS-10262-2009

$$\text{So, } f'_{Ck} = f_{ck} + 1.65 s$$

$$= 25 + (1.65 * 4) = 31.6 \text{ N/mm}^2$$

Step-2: Selection of water cement ratio:

- From Table Free water cement ratio required for target mean strength of 31.6 N/mm² is 0.44.

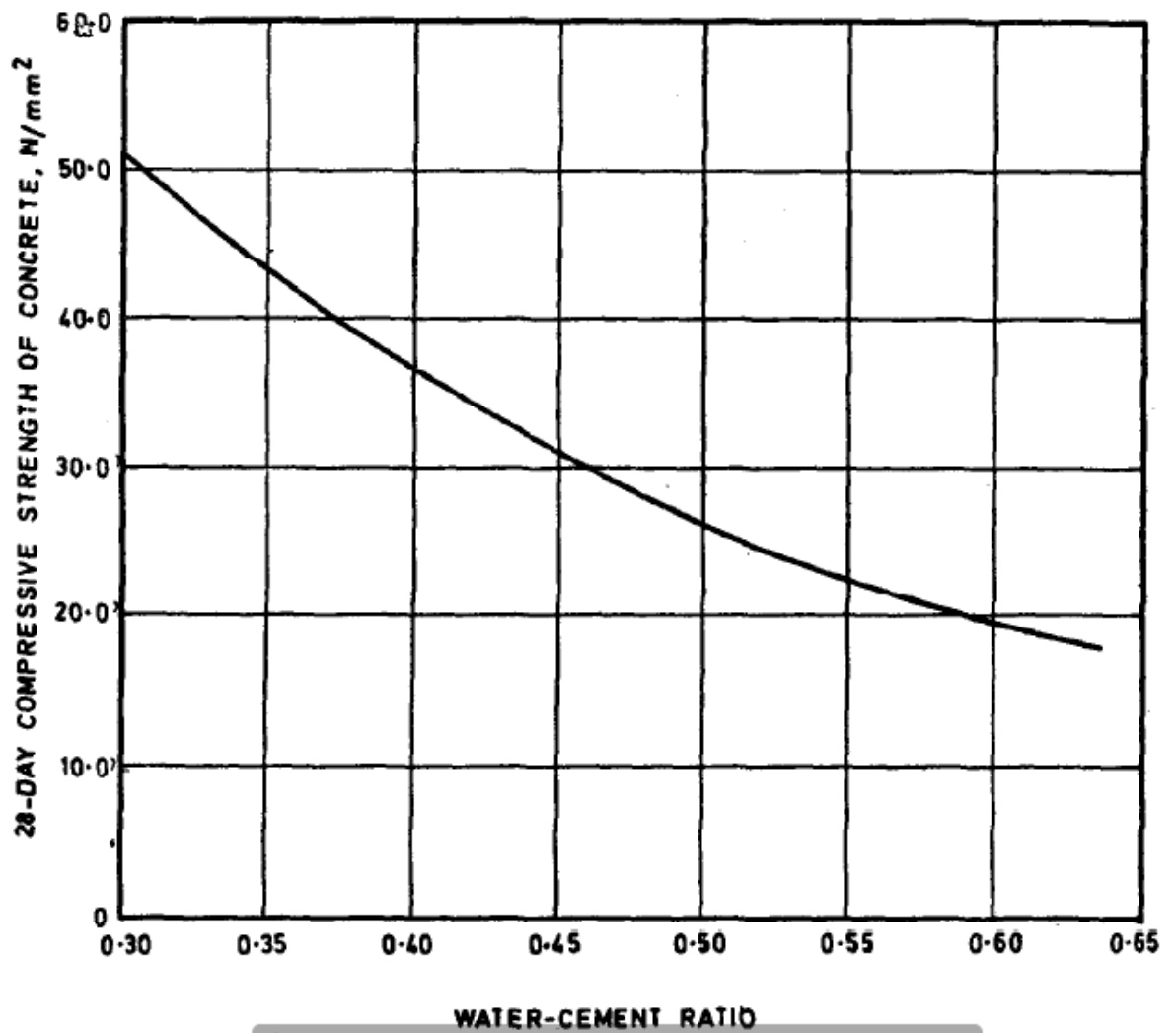


Fig. 25: Generalised relation between free water cement ratio and compressive strength of concrete

- Now from table IS: 456 2000 the maximum water cement ratio for moderate exposure is 0.50.

Table 11.1 Maximum Water-Cement Ratio and Minimum Cement Content for Durability Considerations Under Different Conditions of Exposure

<i>Type of exposure</i>	Plain concrete			Reinforced concrete		
	<i>Maximum Free water-Cement Ratio, by Weight</i>	<i>Minimum cement content, kg/m³</i>	<i>Minimum grade of concrete</i>	<i>Maximum free water-cement, ratio, by weight</i>	<i>Minimum cement content kg/m³</i>	<i>Minimum grade of concrete</i>
Mild	0.60	220	–	0.55	300	M 20
Moderate	0.60	240	M 15	0.50	300	M 25
Severe	0.50	250	M 20	0.45	320	M 30
Very Severe	0.45	260	M 20	0.45	340	M 35
Extreme	0.40	280	M 25	0.40	360	M 40

Fig. 26: IS: 456 2000 water cement ratio for moderate exposure

- W/C ratio is taken minimum from above two values, i.e. 0.44.

Step-3: Estimation of Air content:

For maximum size of aggregate of 20 mm the air content is taken as 2% from figure 27.

TABLE 3 APPROXIMATE AIR CONTENT

NOMINAL MAXIMUM SIZE OF AGGREGATE mm	ENTRAPPED AIR, AS PERCENTAGE OF VOLUME OF CONCRETE
10	3.0
20	2.0
40	1.0

Fig. 27: Approximate air content

Step-4: Selection of Water and Sand content:

- From Table 2 of IS- 10262-2009, for maximum 20 mm. size coarse aggregate water(m³)= 186 m³/ kg of concrete and sand =35%.

- For changing in value of water cement ratio, compacting factor and sand belonging to zone 1. So a correction is required.

Table 2 Maximum Water Content per Cubic Metre of Concrete for Nominal Maximum Size of Aggregate
(Clauses 4.2, A-5 and B-5)

Sl No.	Nominal Maximum Size of Aggregate mm	Maximum Water Content ¹⁾ kg
(1)	(2)	(3)
i)	10	208
ii)	20	186
iii)	40	165

Fig. 28: Table 2 of IS- 10262-2009

TABLE 6 ADJUSTMENT OF VALUES IN WATER CONTENT AND SAND PERCENTAGE FOR OTHER CONDITIONS

(Clauses 3.3.4 and 4.1)

CHANGE IN CONDITION STIPULATED FOR TABLES 4 AND 5	ADJUSTMENT REQUIRED IN	
	Water Content	Percent, Sand in Total Aggregate
(1)	(2)	(3)
For sand conforming to grading Zone I, Zone III or Zone IV of Table 4 of IS : 383-1970*	0	+ 1.5 percent for Zone I - 1.5 percent for Zone III - 3.0 percent for Zone IV
Increase or decrease in the value of compacting factor by 0.1	± 3 percent	0
Each 0.05 increase or decrease in free water-cement ratio	0	± 1 percent
For rounded aggregate	- 15 kg/m ³	- 7 percent

*Specification for coarse and fine aggregates from natural sources for concrete (*second revision*).

Fig. 29: Table 6 of IS- 10262-2009

Correction:

Change in Condition	Water Content(%)	% of sand in total aggregate
For deerness-W/C ratio(0.60-0.40) that is 0.16. Hence $\frac{0.16}{0.05} * 1 = 3.2$	0	-3.2
For increase in Compacting Factor(0.9-0.8)=0.1. Hence $\frac{0.1}{0.1} * 3 = 3.0$	+3	0
For sand confirming to Zone-I of Table IS- 383-1970	0	+1.5
Total	+3	-1.7

Hence, required water content= $(186 * \frac{3}{100}) = 191.6 \text{ lit/m}^3$.

And sand=(3.5-1.7)= 33.3%.

Step-5: Determination of Cement content:

W/C = 0.44 and water = 191.6 lit/m³. Hence, $\frac{191.6}{\text{Cement}} = 0.44$

i.e. Cement = 435.45 Kg/m³. > 300 Kg/m³. Hence ok.

Step-6: Determination of fine and coarse aggregate:

For 1 m³ , entrapped air in wet concrete =2%.

Therefore, absolute volume = $(1 - \frac{2}{100}) = 0.98 \text{ m}^3$.

Now, for fine aggregate Volume(V)= $(W + \frac{c}{sc} + \frac{1}{p} * \frac{Fa}{SFa}) * \frac{1}{1000}$

And for coarse aggregate volume(V)= $(W + \frac{c}{sc} + \frac{1}{1-p} * \frac{Ca}{SCa}) * \frac{1}{1000}$

Where, W = Water content

c = Cement content

Sc = Specific Gravity of cement

p = Fine aggregate ratio obtained in table

Fa and Ca = Mass of Fine aggregate and coarse aggregate respectively

SFa and SCa = Specific Gravity of fine and coarse aggregate respectively

SFa = 2.64

SCa= 2.84

Hence, $V_{\text{fine}} = (191.6 + \frac{435}{3.15} + \frac{1}{0.314} * \frac{Fa}{2.64}) * \frac{1}{1000}$

Or, $0.98 = (191.6 + \frac{435}{3.15} + \frac{1}{0.314} * \frac{Fa}{2.64}) * \frac{1}{1000}$

Or, Fa = 546.25 Kg

And, $V_{\text{coarse}} = (191.6 + \frac{435}{3.15} + \frac{1}{0.686} * \frac{Ca}{2.84}) * \frac{1}{1000}$

Or, Ca = 1256.18 Kg

Mix proportion by mass

Water	Cement	Fine Aggregate	Coarse Aggregate
191.6 liter	436 kg	546 kg	1256 kg
0.44	1	1.25	2.88

Table 7: Mix proportion by mass

Procedure:

Now weigh the required quantity for mixing up and proceed. For 6 100 mm cube sample required are as follows:

Water in liter	Cement in Kg	Fine Aggregate in Kg.	Coarse Aggregate in Kg
2.8	3.829	3.52	5.28

After casting of Normal Concrete replacement of fine aggregate with plastic dust is to be carried out with different percentage i.e. 5%, 10%, 20% and 30% and castings are done on 100 mm cubes. During casting when percent of plastic replacement increases there is a hydration issue and that's why



Fig.30: Mixing of sand, cement, plastic dust & aggregate

polycarboxylate ether super plasticiser is used with 0.5% of cement used to gain the fluidity. Then put them into water for curing and after 14, 21 and 28 days compressive strength is carried out on the samples.

Result and Discussion:

After curing of the samples after 14, 21 and 28 days respectively samples are weighed and put them into the compressive testing machine for testing of compressive load.



(a)

(b)

Fig.31: (a) M25 concrete after casting (b) Curing is done of the samples

After the load testing following observations are observed:

	Sample number	Weight in gm.	14 days curing load in KN	21 days curing load in KN	28 days curing load in KN
Normal Concrete	1.	2595	420	.....	.....
	2.	2575	370	.....	.....
	3.	2560	.....	580	.....
	4.	2535	.....	500	.....
	5.	2545	.....	.....	630
	6.	2530	.....	.....	650
5% plastic replacement Concrete	1.	2455	350	.....	.....
	2.	2495	360	.....	.....
	3.	2510	.....	330	.....
	4.	2475	.....	380	.....
	5.	2425	.....	.....	400
	6.	2440	.....	.....	440
10% plastic replacement Concrete	1.	2430	340	.....	.....
	2.	2345	280	.....	.....
	3.	2430	.....	340	.....
	4.	2340	.....	280	.....
	5.	2430	.....	.....	360
	6.	2385	.....	.....	340

20% plastic replacement Concrete	1.	2275	210	.....	.....
	2.	2300	220	.....	.....
	3.	2265	.....	230	.....
	4.	2310	.....	210	.....
	5.	2255	.....	.....	230
	6.	2280	.....	.....	240
30% plastic replacement Concrete	1.	2045	110	.....	.....
	2.	2145	150	.....	.....
	3.	2145	.....	150	.....
	4.	2040	.....	130	.....
	5.	2140	.....	.....	160
	6.	2135	.....	.....	130

Table 8: Load variation of concrete by different percentage of plastic replacement in 14, 21 and 28 days respectively

Strength of normal concrete after 28 days: $65\text{N/mm}^2 \leq 31.6\text{ N/mm}^2$

Strength of 5% plastic replacement concrete after 28 days: $44\text{N/mm}^2 \geq 31.6\text{ N/mm}^2$

Strength of 10% plastic replacement concrete after 28 days: $36\text{N/mm}^2 \geq 31.6\text{ N/mm}^2$

Strength of 20% plastic replacement concrete after 28 days: $24\text{N/mm}^2 \leq 31.6\text{ N/mm}^2$

Strength of 30% plastic replacement concrete after 28 days: $16\text{N/mm}^2 \leq 31.6\text{ N/mm}^2$

% decrease of 5% plastic replacement concrete is 32.3%

% decrease of 10% plastic replacement concrete is 44.62%

% decrease of 20% plastic replacement concrete is 63.1%

% decrease of 30% plastic replacement concrete is 75.38%

Though for all the replacement of plastic strength is decreased. But 5% and 10% replacement of fine aggregate is still greater than the characteristic strength value. Load for different concrete is shown below:

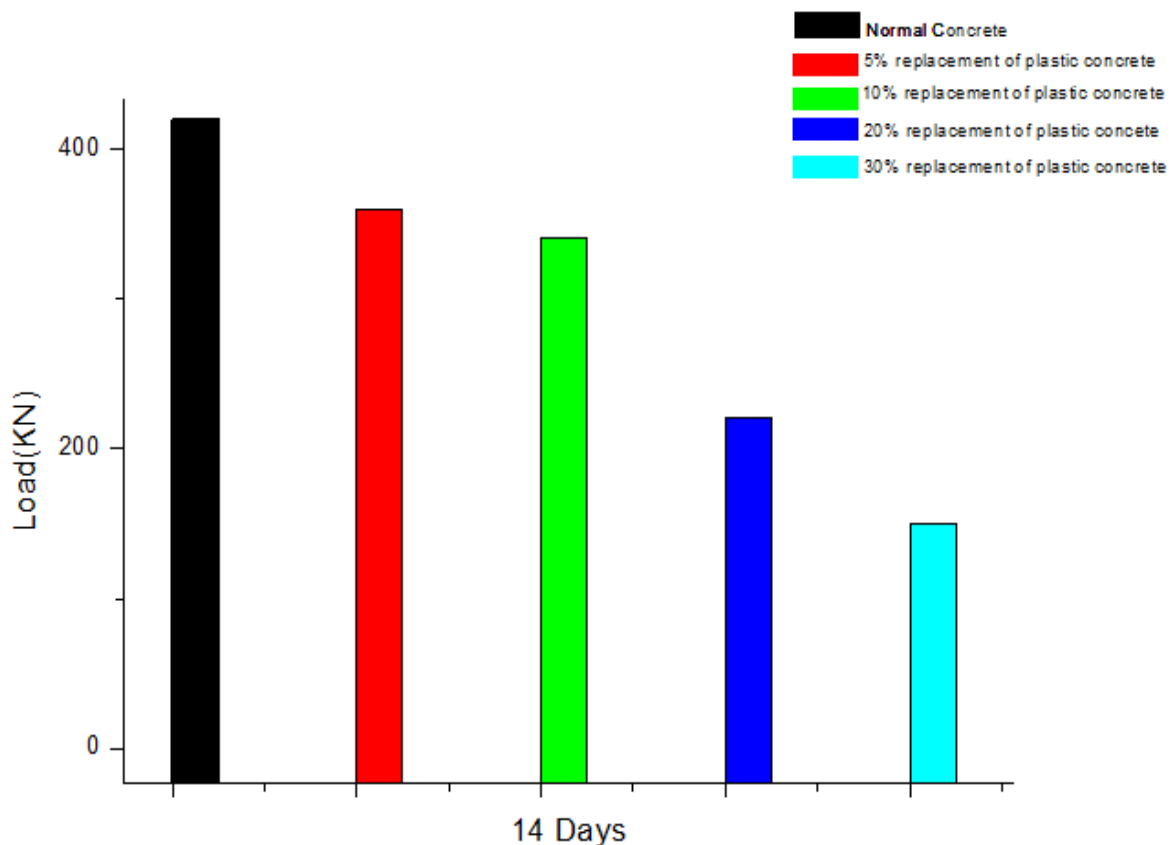


Fig.32 : Load variation for 14 days

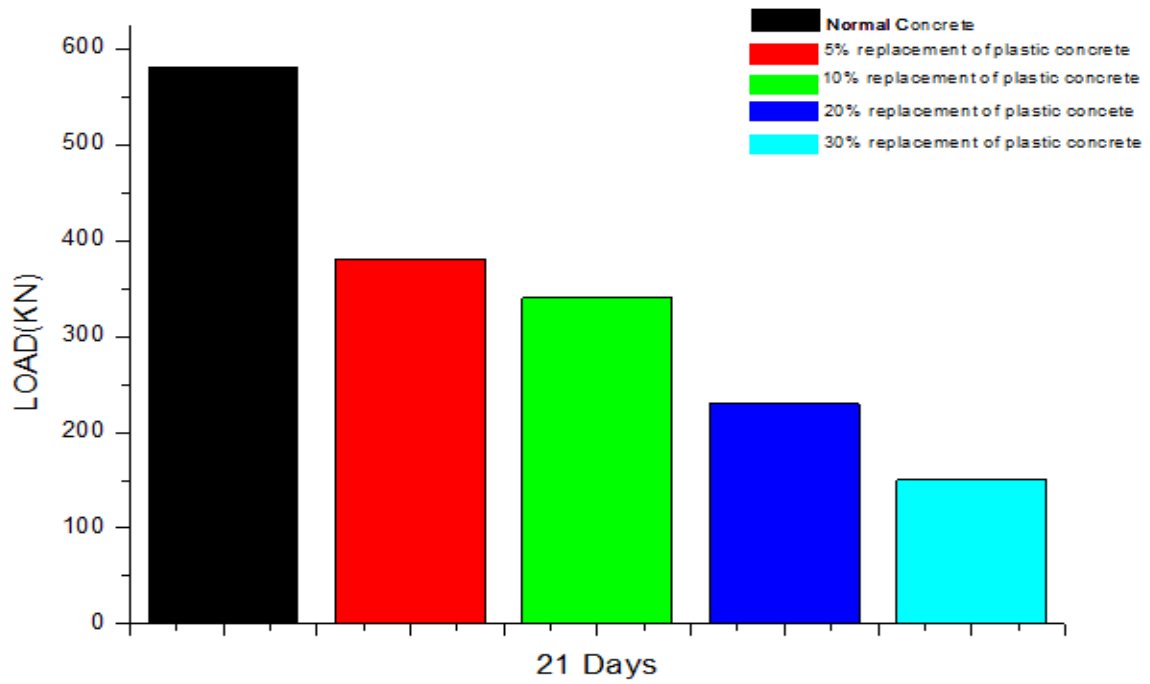


Fig.33: Load variation for 21 days

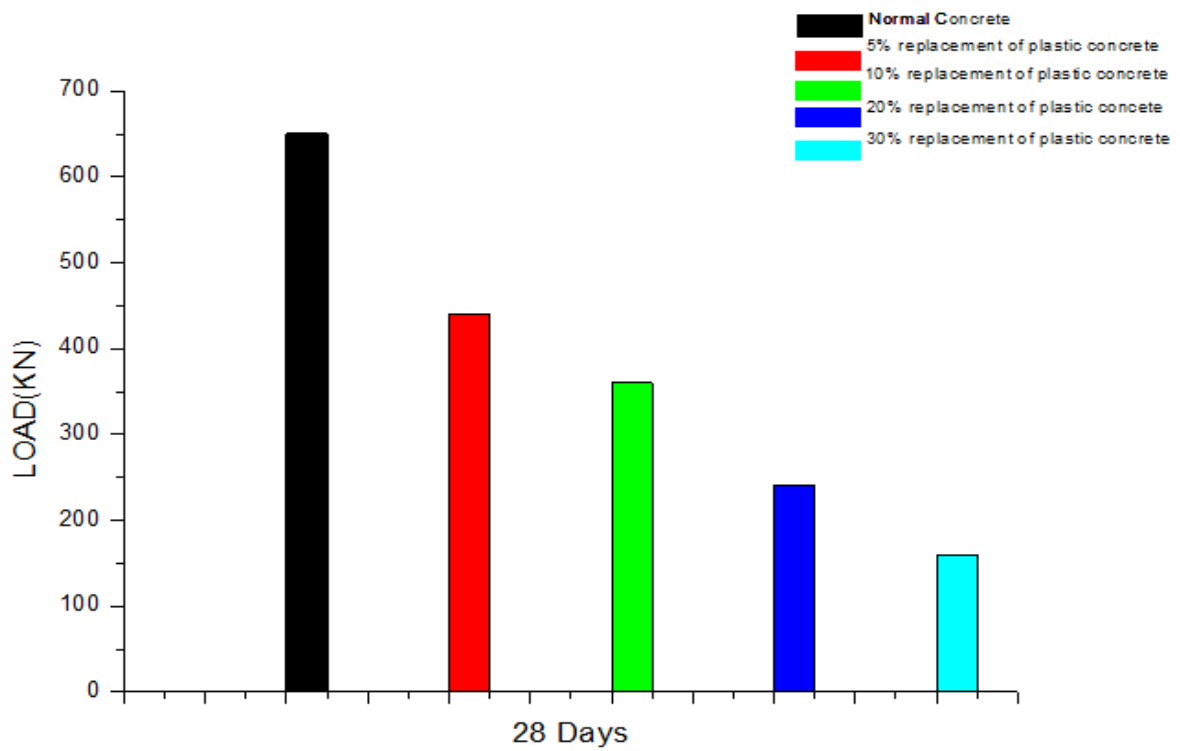


Fig.34: Load variation for 28 days

Reason behind the strength reduction is the lack of hydration and due to this there is a poor bonding between cement and sand and due to this there are large microcracks and when load is applied on them crack starts propagating from these cracks and failure takes place. And also due to plastic there is a lack of hydration so that there are no effect of curing as the days increases. So there is a saturation of load taking capacity of cubes. The surface morphology of all the concretes i.e normal concrete, 5% plastic replacement, 10% plastic replacement, 20% plastic replacement and 30% plastic replacement are taken by FESEM which are given below in figures 35,36,37,38,39 respectively.

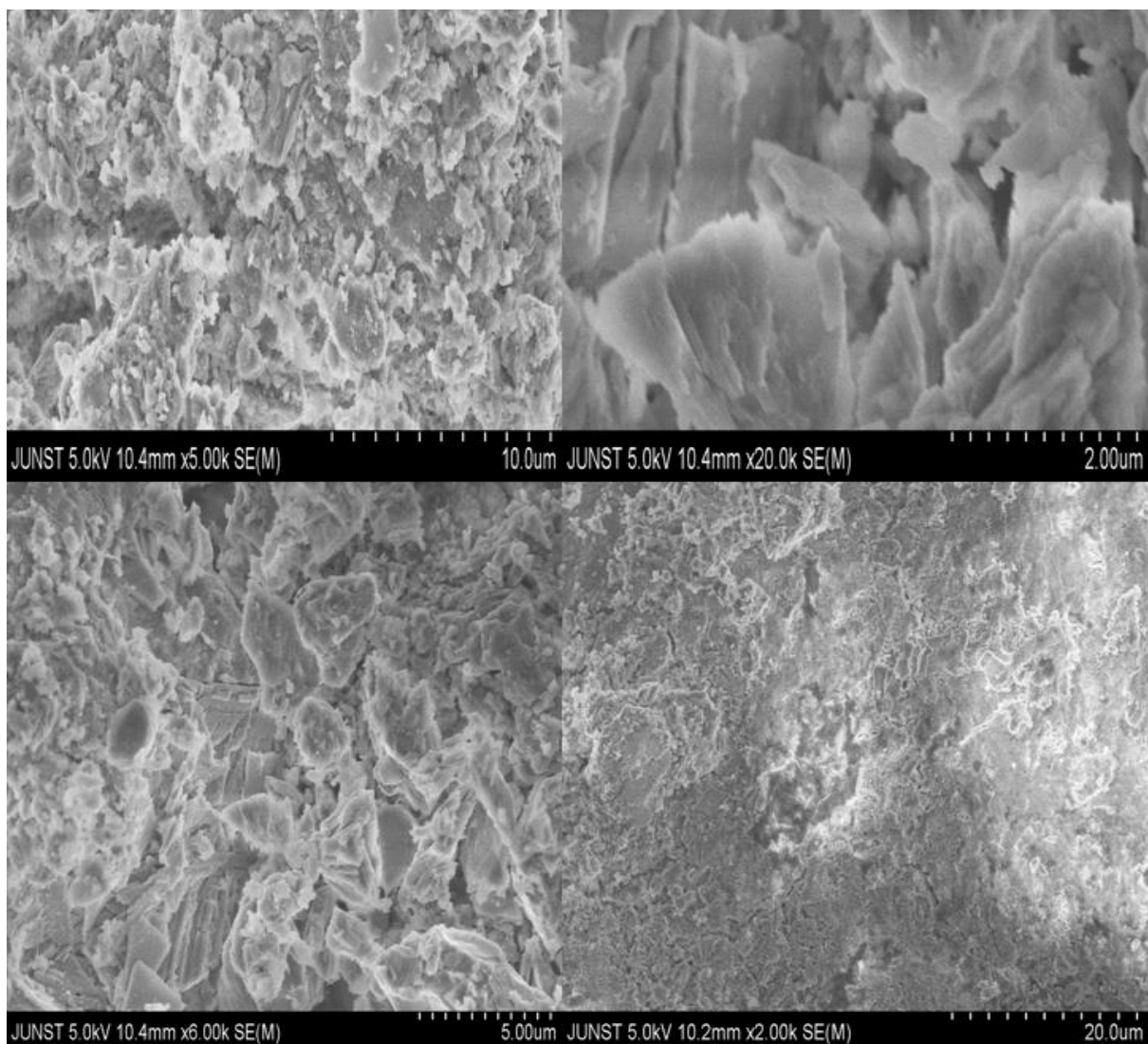


Fig.35: Surface Morphology of normal concrete

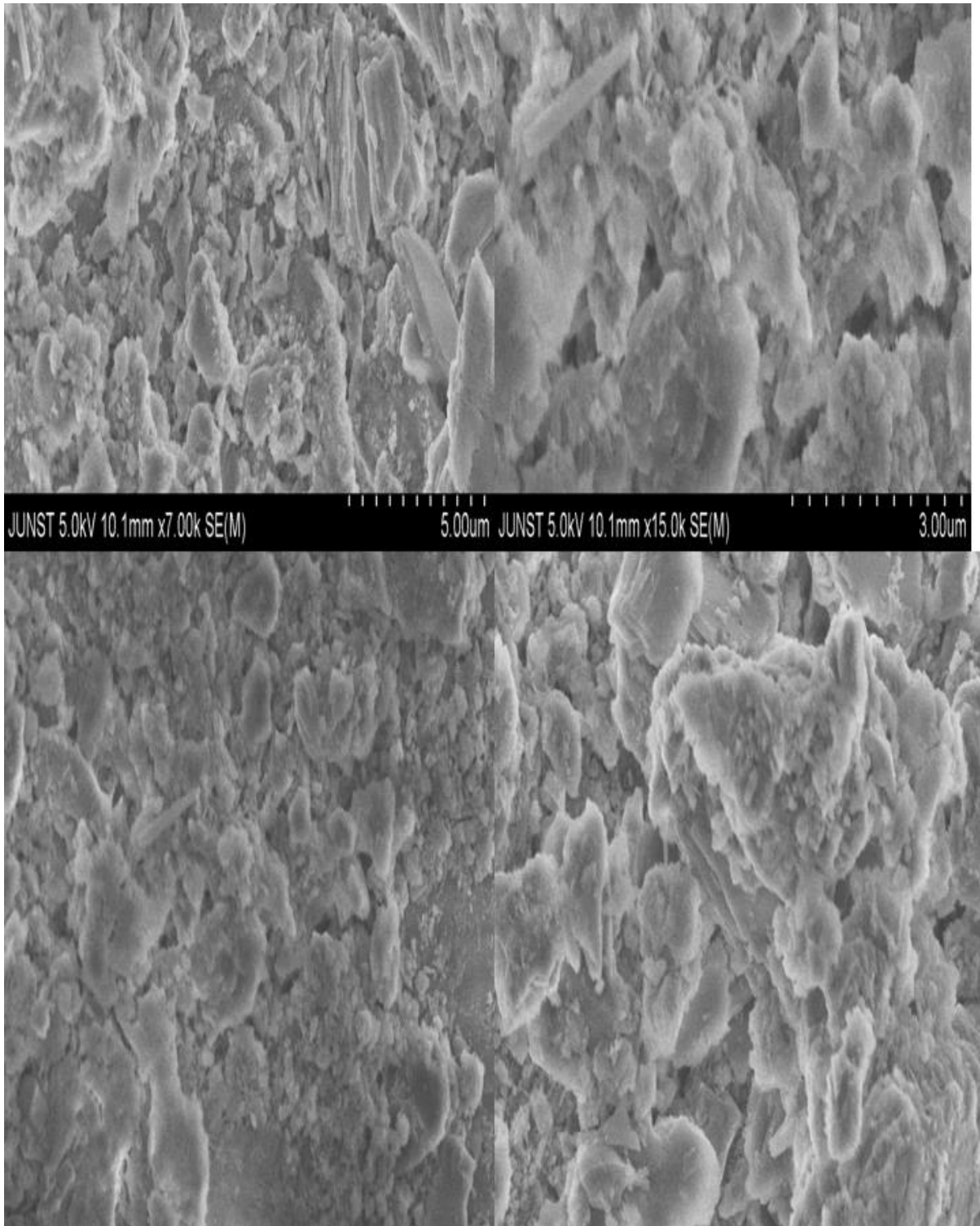


Fig.36: Surface morphology of 5% plastic replacement concrete

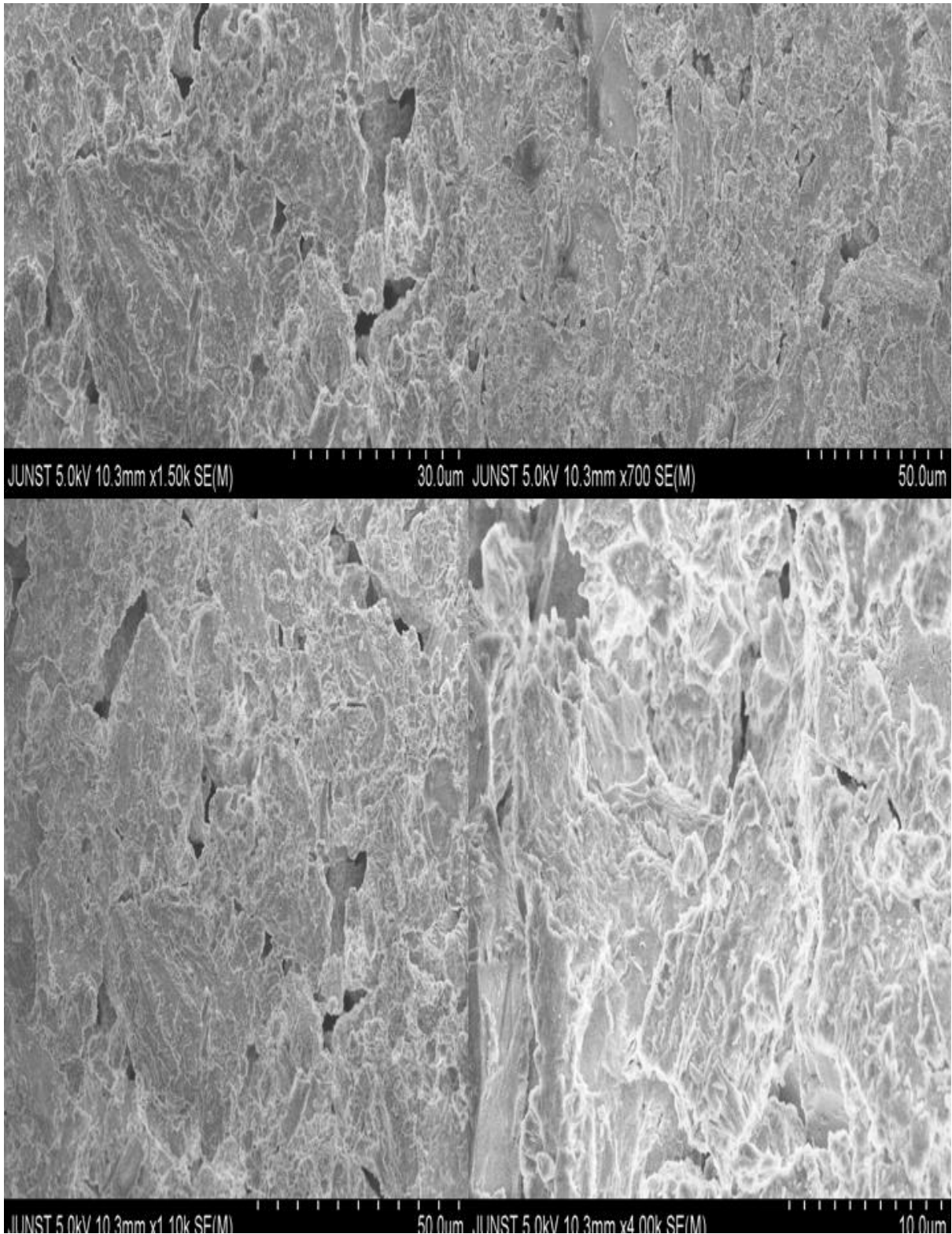


Fig.37: Surface morphology of 10% plastic replacement concrete

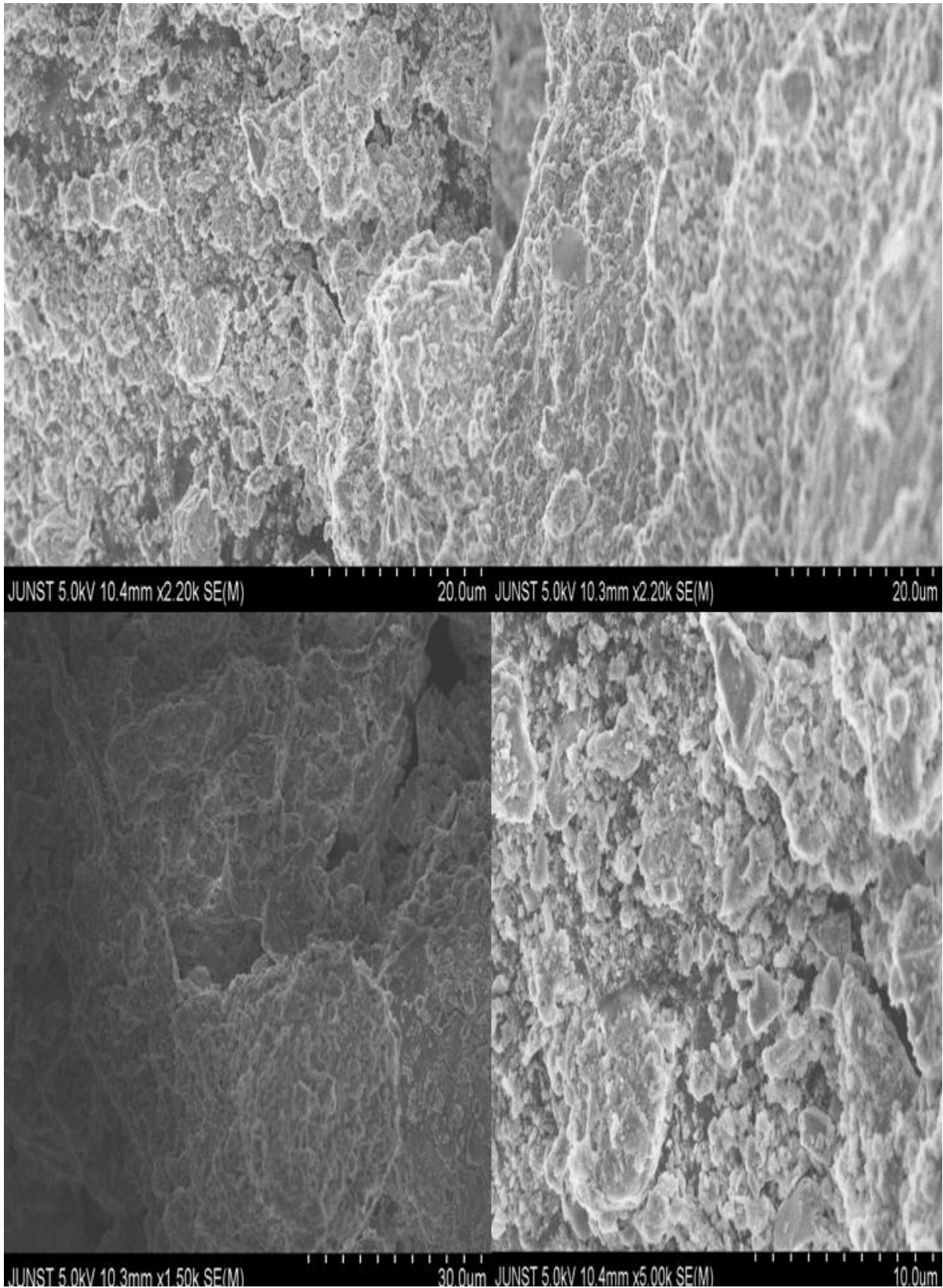


Fig.38: Surface morphology of 20% plastic replacement concrete

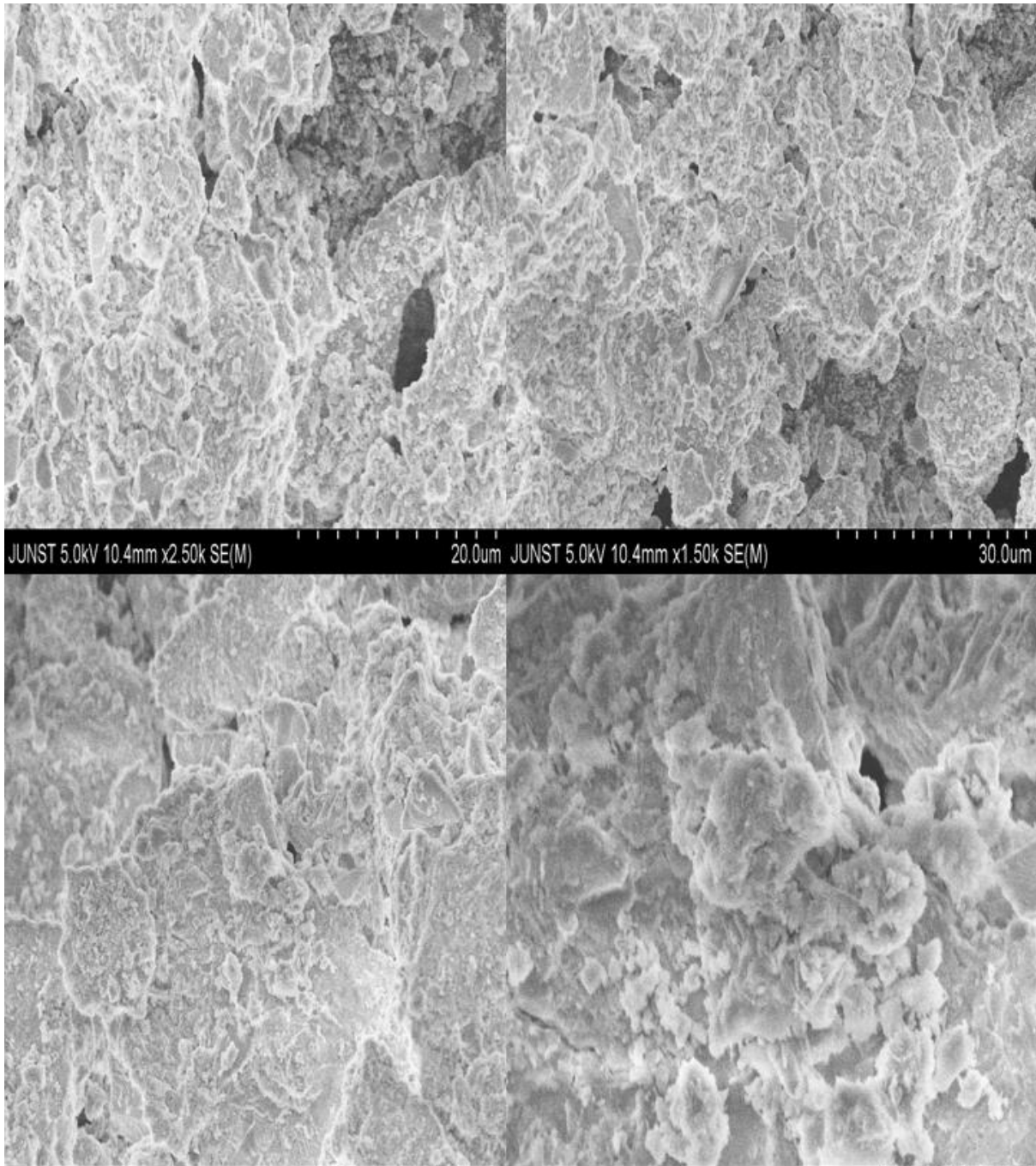


Fig.39: Surface morphology of 30% plastic replacement concrete

From the FESEM image surface topography of all the samples are clearly observed and cracks are more prominent as the % of plastic increases. Bonding between sand and cement is weak and hence less compressive strength. The compressive strength values of all waste plastic concrete mixtures tend to decrease below the values for the reference concrete mixtures with increasing the waste plastic ratio at all curing ages. This may be attributed to the decrease in

the adhesive strength between the surface of the waste plastic and cement paste. In addition waste plastic is hydrophobic material[18] which may restrict the hydration of cement. Due to hydrophobic nature of plastic when increases the percentage of plastic replacement it is observed that there are lack of hydration and the mixture was not taking place well. To mix it properly poly carboxylate ether superplasticizer(PCE) is used to enhance the fluidity of mixture and mix it properly. When 20% and 30% plastic dust was replaced it was observed there was lack of hydration and 0.5% of PCE with weight percentage of water was used to enhance the fluidity and mix it properly.

Conclusion:

Experiment 1:

- Incorporation of GO into cement mortar modifications in mechanical and microstructure properties.
- Nano particle GO enhance the mechanical property i.e compressive strength, mortar samples were tested with different GO percentage i.e. 0.2%, 0.4% and 0.6% to obtain high strength.
- Compressive strength increases upto 44.15% for 0.2% GO and 24.26% for 0.4% GO content when compared to 28 days control sample.
- Compressive strength increases for certain percentage of GO i.e 0.2% GO content sample, then it starts decreasing when percentage of GO is increasing, that is due to the agglomeration of GO near the defect area of mortar.
- 0.2% GO gives best result for well dispersion of GO near crack region and it is observed by FESEM image.

Experiment 2:

- Incorporation of plastic into cement concrete modifications in mechanical and microstructure properties.
- Plastic dust is replaced with fine aggregate with different percentage i.e 5%, 10%, 20% and 30% respectively and mixes them, after casting cure the samples for 14 days, 21 days and 28 days respectively and compressive testing is done.
- Plastic decreases the mechanical properties i.e compressive strength of concrete for 5%, 10%, 20% and 30% replacement of fine aggregate with plastic dust.
- Due to hydrophobic nature of plastic increase of plastic dust into the mixture leads to lack of hydration which is the reason PCE is used during 20% and 30% plastic replacement casting to enhance the fluidity.
- Lack of hydration leads to poor bonding between cement and sand which is the reason behind decreasing of compressive strength[20].
- Due to lack of hydration, poor surface morphology, which leads to propagate crack as early as possible when load is applied.
- Due to lack of hydration curing of the samples are tends to decreases. For every replacement of plastic dust it is observed that after 14 days testing the results are same for all replacement, so it could be concluded that curing effect minimizes using plastic dust.
- One big advantage of plastic replacement is lightweight with respect to normal concrete[19].
- Though plastic replacement shows a decreasing nature in compressive strength it can be used for pavement blocks and also other applications with 5% and 10% replacement of plastic which is economical & eco-friendly for mankind.

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