USE OF TIN AND TITANIUM DIOXIDE NANOPARTICLES FOR ENHANCING PROPERTIES OF CEMENT MORTAR

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RISALPUR CAMPUS

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This research is dedicated to our parents and teachers.

For their endless love, support and encouragement

APPROVAL SHEET

This is to certify that the contents and format of this research titled ‘‘use of tin and titanium dioxide nanoparticles for enhancing properties of cement mortar” submitted by FYP Group # 3 in partial fulfillment of the requirements for the award of degree of BS have been approved.

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ABSTRACT

Major construction industries always prefers good strength and absorption of construction materials since its inception. Weak in strength materials has disastrous effects on structures stability, durability, and aesthetics. In Recent times there are many studies going on to enhance the structural capacity of concrete and mortar. There is large room of improvement at Nano scale in concrete. The current global practices to eradicate menace of concrete failures are use of chemical agents and Nano particles apart from use of good construction practices. This study is therefore an effort to control this menace by use of nanoparticles of Tin and Titanium; known for its improved qualities. The physical system associated with this real time problem is selection and addition of different concentration of said nanoparticle in the cement mortar (cubes of 2x2x2 inches) to check the post peak behavior. Furthermore absorption test is also performed on the sample having different concentration of nanoparticles. Moreover, it is pertinent to mention that we have tested the samples in CTM (compression testing machine) which is highly effective to relate its behavior with actual loadings and accurate readings. The suggested procedure and its results will serve as guideline for structural strength improvements of concrete and further research work for optimizing the procedure.

ACKNOWLEDGEMENTS

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CHAPTER 1

INTRODUCTION

1.1 Background

Nanotechnology (NT) is an arising field of science identified with the agreement and control of matter at the nanoscale i.e, at measurements between roughly 1 and 100 nm. Nanotechnology includes nanoscale science, designing, and innovation that include imaging, modeling, measuring, and manipulating matter at this length scale.

NT is not new in existence and science. Recent improvements in characterization and testing materials at the nanoscale have prompted a new chapter in nanotechnology-based materials in fields of polymers, plastics, hardware, vehicle assembling, and medication. Matter can display uncommon physical, chemical, and biological properties at the nanoscale, varying in significant manners from the properties of mass materials and single particles or atoms.

Concrete, the most ubiquitous material on the planet, is a nanostructured, multiphase, composite material that ages over time. It is composed of an unstructured phase, nanometer- to micrometer-size crystals, and bound water. The properties of concrete exist in, and the degradation mechanisms occur across, multiple length scales (nano to micro to macro) where the properties of each scale derive from those of the next smaller scale.

Constructing buildings have always relied on technological innovations. New developments have continuously been taking place in the world which has led us to construct the high rise and huge skyscrapers. Over the course of time our needs have undergone a serious transformation in the way the construction industry has also witness a profound transformation.

About $3x10^{10}$ (Bn) tons of cement is used yearly by the construction industry, majority being used by the developing states (Guillaume, 2014). Other than the new construction the bulk portion of cement based materials is also used by the restructuring and renovation works due to natural disasters and manmade disasters that include wars.

The mixture of cement with fine sand and some fine admixtures is called mortar. It is used as a binding material for bricks, blocks, stones and few other members of the structure. The major disadvantage that arise the need to restructure or enhance the strength of mortar is its resistance to the lateral and tensile moments. Pertaining to these engineers started the alternatives and modifications including the use of nano particles.

Nanoparticles have taken a major role in different material implications due to their unique properties of large surface area, density, resilience and surface effects (Mohajerani, et al., 2019). Nanotechnology has a remarkable application in almost every flied. The unique properties, such as high surface to volume proportions, the use of Nanoparticles therefore have increased in almost every filed but most importantly in civil engineering they are being ventured up gradually to make wonders for sustainability. Metallic oxide nanoparticles have a very positive effect on the ions permeability, strength and durability (Al-Rifaie & Ahmed, 2016). One of the chemical compounds which can be tested for water proofing and allied strength is Titanium di oxide. Titanium dioxide has been used for almost a century in a wide range of industrial and consumer products which includes paints, coatings, adhesives also floor covering, roof materials, catalyst and many more. Titanium dioxide exists in nature as the notable mineral rutile, anatase and brookite. It is used as a fractional trade of bond in concrete for enhancing its quality also compressive flexural and rigidity. And the other is Tin which is understudy worldwide.

1.2 Importance of Nanoparticles

In the construction industry, mortar, cement and concrete paste are the most generally utilized materials, because of their ease of production, low expenditure, great execution, and flexible applications. Notwithstanding, the fallbacks of these concrete based materials (CBMS), like low tension resistance, cracking nature and probability of abrupt failure (because of their brittle nature), have prompted various ways of degradation in the specialized properties of concrete based materials and significant expenses of fixing them. As the principle concrete hydration item, calcium–silicate–hydrates (C–S–H) is the primary stage that joins aggregates together, forming the strength and other major visible properties of concrete based materials. The size of the asic of C–S–H lies in the nanometer range. Understanding the nature of C–S–H at the nanoscale ought to work with the productive control of the physicochemical idea of concrete based materials. In this way, the utilization of nanomaterials in concrete based materials, which have exceptional effect on the adjustment of C–S–H, is probably the most ideal approaches to handle the defects of concrete based materials.

Presently, the utilization of nanomaterials to improve the mechanical properties and toughness of concrete based materials has gotten significant consideration. It is accepted that the improvement impacts by admixing nanomaterials in concrete based materials are predominantly due to two methodologies:

(1) Performing as a fantastic filler

(2) Involves in the cement hydration.

The photocatalytic impact of nano titanium is likewise normally revealed in the researches, which enriches concrete based material`s surface with a self-cleaning capacity in the presence of ultraviolent light. In any case, the functionalization of concrete composites by admixing nanomaterials is outside the extent of this survey. Nano Tin and Titanium effects of concrete are generally admiring except few flaws.

a. Nano Titanium

Because of nanoscale the physical and chemical properties like melting point, magnetic effect, plasticity etc are different from their natural existence form. Titanium dioxide was first discovered in 1970 to be effective for photocatalytic properties, since then it's been in use in different paints, cosmetics and building facades. However the basic research of nano TiO_2 as a admixture in concrete have shown good indicators. Many researchers have added this stable nanocompound into their research works. The surface area of the nanomaterial is generally larger than that of micro-material, which has the potential to adsorb more other particles around them efficiently. In this study TiO_2 nanoparticles are mixed into the cement to improve the microstructure of concrete.

b. Nano Tin

Tin is a chemical element with the symbol Sn. Been a silvery metal it has a faint yellow tone. Tin, is malleable and soft enough to be cut with less force. Same as Nano TiO_2 Sn also shows little different properties at nano scale as compared to their macro scale existence. Sn is good in ductility and its behavior overrides the mixture in which it is mixed and makes bond. Been a metal its oxides gives the hydrophobic character to the mixture.

1.3 Problem statement

Defects in concrete structures cause the great monetary, human and spatial and temporal losses in the lifetime of the structures. To counter the strength and seepage issues of concrete metal oxides have been in research since decades.

Enhance the strength and durability of concrete (Mortar) to counter any structural defect caused by natural or artificial agent by adding Titanium and Tin nanoparticles in the mixture of cement and sand.

1.4 Objective of the study

The objectives of this project are kept simple, pragmatic and attainable keeping in view the available time span.

The focus of our research is enlisted below:

a. To check the effectiveness of nanoparticle (titanium dioxide and tin) in strength control.

b. Analyze the post peak behavior using stress strain relations.

1.5 Justification of the study

a. Structural defects are major issues in almost every civil engineering structure.

b. Immense importance to highlight the use of nanoparticles which may lead to new indigenous techniques in strength control.

c. Exceeding cost of repair vis-a-visa service life of structure increases.

1.6 Significance

a. Prevent failure of concrete parts of the building

b. To prevent ingress of dampness and moisture inside building

c. Reduce the maintenance cost

d. Improve aesthetics

e. Long-lasting/safe construction

1.7 Aim of study

To study and analyze Indigenous method of strength and seepage control through use of Nanoparticle Titanium dioxide (TIO_2) and tin in cement mortar mix by making cubical blocks.

1.8 Research Question

The study focused on answering the following questions:

a. What effects do the nanoparticles will bring in the physical properties of the mortar?

b. How can the enhanced physical properties benefit the structural building?

c. Can Titanium dioxide and tin (nanoparticle) be used to integrate the mortar cubes at the nano scales?

d. What is the cost effect of using Titanium dioxide and tin (nanoparticle) for strength control?

1.9 Limitations

The sample of nanoparticles of tin and titanium were 1 gram and 4 grams respectively. Out of this limited quantity only 6 cubes (2 in x 2 in) of TiO_2 and 3 cubes of tin were made. All the cubes had different composition of the respective samples. 3 x normal samples were also made for the results comparison. Research does not cover any microscopic analysis of the cubes pre and post compressive tests due to the non-availability of the said apparatus. Moreover, the nanoparticle (titanium dioxide and tin) is not abundantly available commercially. The research was conducted under natural conditions hence the weather conditions could not be controlled.

1.10 Organization of the study

The thesis comprises of five chapters. Detail of each chapter is appended below:

Chapter I: In this chapter a brief introduction to the use of nanoparticles as the strength augmenter of concrete has been given. It also explains the background along with the problem statement.

Chapter II: This chapter highlights the literature review based on researches done on global level. The need of cement replace has also been discussed.

Chapter III: The following chapter covers the structural selection for testing, concentration of nanoparticle applied, and method of application.

Chapter IV: The chapter includes results, discussion, data analysis and presentation. Brief explanations have been given for the understanding of the reader.

Chapter V: This chapter covers findings, conclusions and suggested recommendations basing on the research.

1.11 Summary

In this chapter a brief introduction to the use of nanoparticles as the strength augmenter of concrete has been discussed. It also explains the background along with the problem statement. It also included the aim of the study, the objectives and research question. The significance and delimitations of the study were discussed at the end of the chapter.

CHAPTER II

LITERATURE REVIEW

2.1 Operational Definitions

2.1.1 Nanoparticle

Nanoparticle is also known as ultrafine particle of matter that is between 1 and 100 nanometers (nm) (Wikipedia, 2020).

2.1.2 Nanotechnology

It is emerging field of science related to the understanding and control of matter at the nanoscale, i.e., at dimensions between approximately 1 and 100 nm. Nanotechnology encompasses nanoscale science, engineering, and technology that involve imaging, measuring, modeling, and manipulating matter at this length scale (Wikipedia, 2020).

2.1.3 Titanium dioxide

A white unreactive solid which occurs naturally as a mineral(rutile) and is used extensively as a white pigment (Lexico Dictionarie, 2020).

2.1.4 Tin (Sn) Nanoparticles

Nanodots or nano powder are circular or faceted high surface metal particles. Nanoscale Tin Particles are regularly 10-20 nanometers (nm) (Wikipedia, 2020).

2.2 Main approaches of Nanotechnology

Nanotechnology considers two main approaches:

2.2.1 The top-down approach

The approach wherein large systems are contracted to the nanoscale at the same time keeping their unique properties without atomic-stage control (e.g., miniaturization withinside the area of electronics) or decompose from large systems into their smaller composite parts).

2.2.2 The bottom-up approach

Known as ‘‘molecular nanotechnology” or ‘‘molecular manufacturing” (example:

www.nano.gov) in which materials are engineered from atoms or molecular components through a process of assembly or self-assembly (Figure 1).

Transportation Research Circular E-C170: Nanotechnology in Concrete Materials

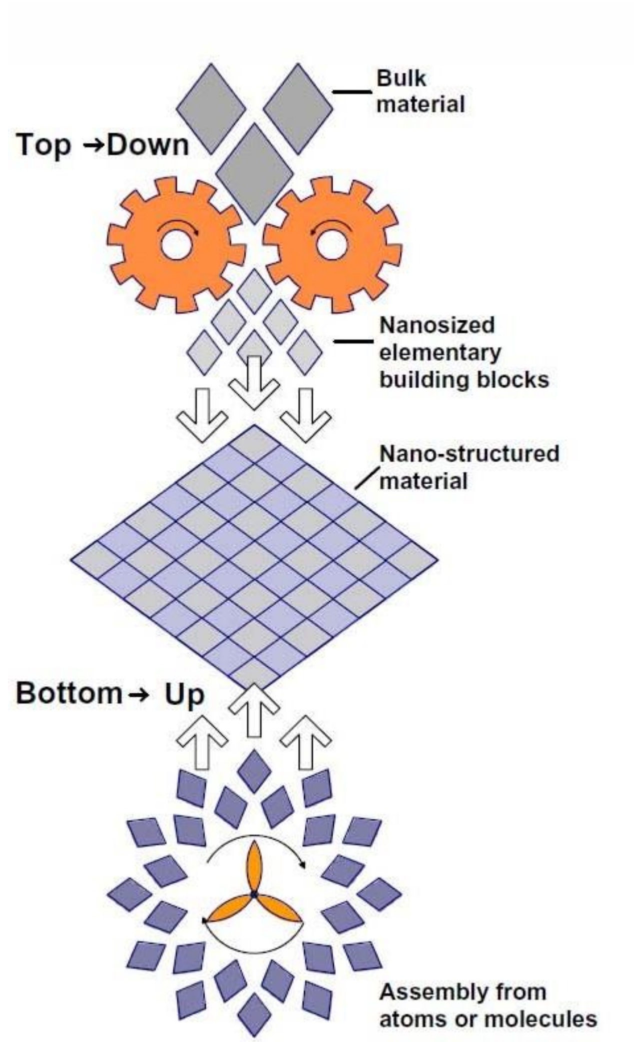


FIGURE 1 The top-down and bottom-up approaches in nanotechnology (Sanchez and Sobolev, 2010).

Thus, the fundamental idea at the back of nanomodification of substances is that of bottom-up engineering, beginning with engineered adjustments to the molecular shape with a purpose to have an effect on the majority of the material. Conceptually, that is without a doubt an imitation of nature. In practice, the advent of nanotechnology represents a revolution in the improvement of high performance and long-lasting techniques in various fields of science.

2.3 Nano Based Materials

a. **Nanoparticles for water proofing**: Nanoparticles are ultrafine particles sized among 1 and 100 nanometers. Creating nano water proofing via use of nanoparticle is one of the most modern damp proofing answers in today's knowledge. This approach makes use of the nano-sized debris to penetrate the tiniest crack or bounding them with debris to create a superior long-lasting coating. Nanoparticles now no longer best fill the cracks however it could prevent anything entering that is probably coming from the outside surroundings. While maximum of the other elution generally tends to become weaker via way of means of the time nano waterproofing remains long-lasting and powerful over the time. Nano particles are highly UV and climate resistance which make them long-lasting even beneath stresses of severe temperature fluctuations. The conventional waterproofing membranes generally tend to lose efficiency or effectiveness and destroy down even the nanoparticles live strongly bonded to the substrate and save them from breaking down beneath diverse severe conditions. Since the nano debris are physically very tiny, the waterproof coating is completely invisible. Therefore, the nano waterproof coating does now no longer alternate the aesthetics of the structure.

(1) **Effectiveness of nanoparticles for water proofing.** The trouble of seepage has been a problem considering forever. The speedy improvements in technology and era have allowed us to apply nanoparticles to provide eco-friendly merchandise to govern seepage with the aid of using waterproofing in all sorts of constructing material. The inherent porosity and microcrack are essential on at the back of inflicting water seepage and water leakage in constructing . Waterproofing is a remedy that is anticipated to make impervious and impermeable to water. Another important location in construction is coating paints and isolation cloth coatings; coatings that are widely used on doorways walls and windows. To supply floor with a requisite protection or a special function, a layer has to be placed to the bottom to offer a coating. Applications of nano technology to paint can furnish insulating surfaces to it and those paints are synthetic with the aid of incorporating nano-sized cells to the pore and as a result limiting the trails for thermal conducting.

2.4 Use of Nanoparticles in construction

Nanomaterials, with their inherent alternate in molecular shape, have paved ways for production of substances to be applicable extra effectively and beneficially in the industry of production. Benefits such as introduced strength, cost-effective use of herbal production , decreased density of nanoparticle can be sought along with lower energy usage. It is envisioned that the usage of nanoparticle will lead to safer means, faster, low coating and extra efficient employment of production substances. Making use of technology, nanoparticles offer an efficient and balanced technique with the aid of using the maximum out of production processes and substances with the aid of giving them extra durability, slicing costs and presenting the person with diverse and more advantageous substances that had been formerly tough to obtain. The inculcation of unique features and technical traits like water-resistance and fog resistance among many different through changing nano shape of a molecule appear appealing in production. However, different industries nano particles increases in chemical, organic and mechanical industries, the development industry has additionally started adopting it with innovative products with advanced traits being researched constantly. Some of the traits that nanoparticle provides are related to improvement of stronger and lighter systems for enhancing properties of cement materials, increasing compressive strength of concrete, enhancing joints in pipes, presenting effective insulation towards heat and sound. Properties of glass may be more advantageous and thereby making it extra reflective or opaque, making it water repellant, safety towards UV light and enhancing efficiency. The following table indicates Nano substances that may be utilized in buildings with viable advantages (Daniyal, Azam & Akhtar, 2020):

Table 2.1 Use of Nanoparticles in Construction (Daniyal, Azam, & Akhtar 2018).

NANOMATERIAL		BASE MATERIAL	POSSIBLE BENEFITS	REFERENCES
a.	Carbon Nanotube CNT	Cement and concrete	Enhancing strength by reinforcing the molecular structure.	M.A. Ahmed, 2015; lijirna, 2002, Malgorzata, 2014
		Ceramics	improved strength and thermal properties	Becher, 1991

		Nano electrical	increased mechanical strength	Saafi & Romine, 2005
b.	Silicon Di oxide SiO_2	Cement and concrete	Enhancement and durability of mechanical strength	Bahadori & Hoseini, 2012
		Glass	Alter reflective properties and better insulation	Rana, Rana, & A. Kumari, 2009
c.	Titanium Dioxide TiO_2	Solar cell	IPP (Independent/non-utility power generation)	Serpoae & E. Pelizzetti, 1989
		Glass	self-cleaning properties	Guerrini, 2012
		Cement and concrete	strength and decreased water absorbing properties	azan,Slladi
d.	Ferric Oxide (Fe20 3)	Cement and concrete	improvement in Strength	Nazari, Sliadi, Shari Shamekhi, & Khadern 1990
e.	Copper oxide (CuO)	Cement and concrete/steel	Improvement in strength and durability	Nazari, Rafieipour & Shadi, 2011
f.	Aluminum oxide (A12O3)	Cement and concrete/steel	Improvement in strength and durability	Zhenhla, Huafeng, Shan, Yang & Mia o,
g.	Zirconium oxide (ZrO2)	Cement and concrete/steel	Improvement in strength and durability	Nazari, R, Riahi, Shamekhi & Khademno, 2010
h.	Zinc dioxide (ZnO2)	Cement and concrete/steel	Improvement in strength of cement and concrete	NAZAR.II & RlAHI, 2011

2.5 Use, of Nanoparticles for concrete

Nanoscale debris are not new in both nature or science. Recent trends in visualization and size structures for characterizing and trying out substances on the nanoscale have brought about an explosion in nanotechnology-primarily based on substances together with polymers, plastics, electronics, vehicle manufacturing and medicine.

2.6 Concrete Behavior

a. Concrete is the maximum ubiquitous fabric withinside the world, is a nanostructured, multiphase, composite fabric (Sanchez and Sobolev, 2010). It is composed of an amorphous phase, nanometer- to micrometer-length crystals and certain water.

b. Mechanical conduct of concrete substances relies upon a super quantity of structural factors and phenomena which are powerful on a micro and nanoscale. The length of the calcium silicate hydrate (C-S-H) phase which is the number one element answerable for energy and in cementitious systems, lies withinside the few nanometers range (Taylor, 1997). The shape of C-S-H is just like clay, with skinny layers of solids separated with the aid of using gel pores packed with interlayer and adsorbed water (Mehta, 1986). This has vast effect on the overall performance of concrete due to the fact that the shape is touchy to moisture movement, at instances ensuing in shrinkage and consequent cracking. (Jennings et al., 2007).

c. Improvement of nanotechnology-primarily based on concrete substances calls for a multidisciplinary method, along with groups of concrete substances experts: civil engineers, chemists, physicists and substance scientists. Porro et al. (2010) provided a top-level view of the way nanotechnology may be implemented to concrete generation, emphasizing the multidisciplinary method wanted for a hit breakthrough for composition and processing parameters. Grove et al. (2010) recognized possibilities for nanotechnology to new concrete merchandise and substances, and additionally for enhancing the sustainability and decreasing the environmental footprint of concrete.

d. Moreover, Birgisson et al. (2010) recognized the subsequent key breakthroughs in concrete generation which are maximum to achieve results from using nanotechnology:

(1) Development of high-overall performance cement and urban substances as measured with the aid of using their mechanical and sturdiness properties

(2) Development of sustainable concrete substances and systems through engineering for distinctive unfavorable environments, decreasing power intake in the course of cement production, and improving safety.

2.7 Nano-Based Research in Concrete

2.7.1 High-Performance Cement and Concrete Materials

The addition of nano fine particles can enhance the properties of concrete. Nano silica and nano titanium dioxide are likely the maximum mentioned components utilized in nanomodified concrete. Nanomaterials can enhance the compressive power and ductility of concrete.

2.7.2 Changes in Mechanical Properties of concrete

Addition of nanomaterials in matrix to enhance mechanical properties of concrete behavior has emerged as a promising field of study. Most of the concrete-associated studies to this point has been performed with nano silica (nano-SiO2). Manufacture of nanosized cement debris and the improvement of nano binders (Lee, 2005; Sobolev, 2005) confined numbers of investigations had been carried out.

2.7.3 Formation of Dense Microstructure and More Efficient Cement Hydration

Scanning electron microscopy (SEM) microstructural research of mortar specimens with and without nanoparticles have discovered the mechanisms for improving overall performance with nano-SiO2 . When a small number of nanoparticles is uniformly dispersed in a cement paste, the hydrated merchandise of cement is deposited at the nanoparticles.

2.7.4 Addition of silica Nano particles

The addition of silica nanoparticles has essential implications for the hydration kinetics and the microstructure of the paste such as:-

a. A boom withinside the preliminary hydration rate

b. A boom of the quantity of Calcium silicate hydrate gel withinside the paste through pozzolanic reaction

c. Reduction of porosity

d. Development withinside the mechanical properties of the Calcium silicate hydrate gel itself.

2.7.5 Effects of SiO_2 and Ferric oxide on Compressive Strength of Concrete

Research confirmed that the compressive and flexural strengths of cement mortars containing SiO_2 and Ferric oxide nanoparticles have been better than the ones of simple cement mortar (Li et al., 2004; L. Hui, 2004). The experimental outcomes displayed that the compressive strengths of mortars with nano silica (NS) have been all better than the ones of mortars containing silica fume at 7 and 28 days.

2.7.6 Effects of Al_2O_3

Nano $Al2O_3$ became determined to be a very powerful in growing the modulus of elasticity of cement mortar. With 5% of nano $Al2O_3$ (about a hundred and fifty nm common particle size), the elastic modulus enhances by 143% at 28 days(Zhenhua et al., 2006). A right blending process became decided in order to make sure adherence of nano $Al2O_3$ debris at the sand surfaces.

2.7.7 Effects of synthetic nano-ZrO_2

The impact of artificial nano-ZrO_2 powder addition in cement at the energy improvement of Portland cement paste was studied (Fan et al., 2004). Reduction in porosity and permeability, enhancement in compressive energy, and development in microstructure of cement paste have been determined because of the addition of nano-ZrO_2 powder in cement. Pore filling has been recognized as feasible mechanisms for development.

2.7.8 Effects of CNTs-CNFs

Higher Tensile Strength, Ductile, and Tougher Concrete CNTs-CNFs are capabille applicants to be used as nano reinforcements in cement based substances.. Research has proven that flexural electricity and stiffness of cementitious substances may be improved with the aid of using low concentration. It is stated that including small quantities of CNTs (1%) may grow each compressive and flexural electricity (Mann, 2006).

2.7.9 Use of Nano porous Thin Film Technology Improved Concrete Performance

Nanoparticles delivered for the duration of blending have an impact on the microstructure of the paste without making any extensive development withinside the interfacial transition zones

(ITZ). The addition of nanoparticles as NPTF on mixture floor earlier than concrete blending turned into powerful manner to enhance the ITZ and thereby the overall performance of concrete (Munoz and Meininger 2010). Water suspended nanoparticles (i.e., colloidal suspension) are used to coat aggregates via dip- or spray- coating methods.

2.7.10 Incorporation of NPTFs

Improvements in compressive, tensile and flexural strengths and reduction in drying shrinkage were determined through the incorporation of NPTFs in mortar and concrete..(Meininger and Munoz,2010)

2.7.11 Nanomaterials for Electrical Conductivity and Stress-Sensing of Concrete

The addition of CNTs handled with H_2SO_4 and HNO_3 or untreated CNTs to cement paste effects in, to lower the electric resistivity and a phenomenal enhancement in compressive strength. The cement paste with handled CNT reinforcement confirmed better mechanical strength, better compressive sensitivity and decrease electric conductivity than untreated CNT (G. Li et al., 2007).

2.7.12 Effects of Nano-Ferric oxide

Concrete with nano-Ferric oxide may have self-diagnostic capacity of strain in addition to development of compressive and flexural strengths (Li et al., 2004; Xiao and Oui 2004).

2.7.13 Effects of Calcium carbonate Nano particles

Use of calcium carbonate debris with floor area ≥10 m^2/g in mortar to enhance hardened properties inclusive of excessive permeability to water vapor,however low permeability to liquid water was observed (Cervellati et al., 2006).

2.7.14 Effects of Nano clay Particles

Nano clay debris have proven to be effective in lowering shrinkage of concrete (Chang et al., 2007; Kuo et al., 2006; Morsy et al., 2009; He and Shi, 2008).

2.7.15 Effects of nano-TiO_2

Concrete containing nano-TiO_2 has confirmed to be very powerful for the self-cleansing of concrete. Nano-TiO_2 triggers a photocatalytic degradation of pollution (e.g., NOx, carbon monoxide, risky natural compounds, chlorophenols, and aldehydes from automobile and commercial emissions) (Vallee et al., 2004; Murata et al., 1999; Chen, 2009). Photocatalytic concrete pavement blocks have been discovered to be very powerful in eliminating NOx via photocatalytic response of TiO_2 (Kamitani et al., 1998; Murata et al., 2002).

2.7.16 Properties of Tin

(1) Relative density: Varies for different allotropes
(2) Malleability: Very malleable metal; soft enough to be cut with a knife
(3) Ductility: Not ductile enough to be drawn into wires
(4) Tensile strength: Fairly strong
(5) Melting Point: 232C
(6) Conductivity: Good conductor of heat and electricity.

2.7.17 Nanoparticle Titanium dioxide

The foremost properties of TIO_2 nano particle are as follows:

(1) Carrosion immunity

(2) High electricity

(3) Reflective floor texture

(4) Low thermal expansion

(5) Self-cleaning (picturegraph catalytic)

(6) Reduce settrng time

(7) Increase hydration process

(8) Reduce extent of pore

(9) The element Titanium discovered in 1791 through William Gregor, in England. It is received through ores and compound to be crafted from natural titanium. Titanium dioxide is used in

cement and concrete, and affects the structure at molecular level to enhance its properties like flexural electricity and rigidity. Moreover, the durability can also be multiplied through inhibiting first-rate degrading elements and stopping micro cracking. The titanium dioxide nano particles whilst added to concrete improves its behavior. This compound can also be used as a notable reflective coating on Solar cells. Through effective photo catalytic reactions titanium dioxide can wreck down natural pollutants, thereby decreasing air pollutants whilst it is applied to out-door floors of buildings.

2.8 Summary

The review of the literature discussed in this chapter is based on researches done at global level and uses of nano particles in construction.

CHAPTER III

EXPERIMENTAL METHODOLOGY AND PROCERDURES ADOPTED TO CHECK EFFICACY OF TiO_2 AND TIN NANOPARTICLES

For checking the efficacy of TiO_2 and Tin Nanoparticles to improve the mechanical properties of cement mortar, we have decided to check the post peak behavior of the cement mortar.

3.1 Materials Characterization

Following are the specification of material use for the preparation of cubes: -

a. Cement: Ordinary Portland cement (OPC) type 1, (grade 52.5) was used. This was standard OPC which met the requirement of ASTM C150-04 (ASTM C150-04, 2004). Following are the chemical composition of the cement is being used in Pakistan.

   1. Calcium Oxide = 70%
   2. Silicon dioxide = 23%
   3. Aluminum Oxide = 04%
   4. Ferric Oxide = 03%

b. Sand: coarser to medium sand was used.FM=2.45

c. Titanium dioxide - 4.3g

d. Tin - 0.28g

3.2 Concentration of Titanium dioxide and Tin

Total 11 x cubes of 2-in x 2-in x 2in of were prepared with varying concentration of Titanium dioxide and Tin Nanoparticles. Out of these 11 samples ,2 were controls having standard concentration of sand and cement, Six were having various concentration of Titanium Dioxide, and three were having concentration of Tin Nanoparticles. The concentration use for the Titanium dioxide were 1g, 0.65g, and 0.5g per sample. while the concentration for the Tin were 0.15g, 0.08g, and 0.05g per sample. Computation of Concentration in relation to weight of Titanium dioxide with respect to weight of cement in each sample. The concentration in each sample is as follows: -

S/No	Formulation ID	Cement (%)	TiO2(%)	Tin(%)	W/C Ratio
1	C1 & C2	100 (56g)	0	0	0.4
2	TiO_2-A1 & TiO_2-A2	98.22	1.79 (1g)	0	0.4
3	TiO_2-B1 & TiO_2-B2	98.84	1.16 (0.65g)	0	0.4
4	TiO_2-C1 & TiO_2-C2	99.12	0.89(0.5g)	0	0.4
5	Tin-D1	99.73	0	0.27(0.15g)	0.4
6	Tin-E1	99.85	0	0.14(0.08g)	0.4
7	Tin-F1	99.91	0	0.089(0.05g)	0.4

Two control blocks also prepare with standard concentration of cement for comparison of results with Titanium dioxide and Tin containing mortar mix due to its proven properties in the field:

a. It is use for bind masonry units like stone, bricks, blocks, cement.

b. It is use for plastering of wall and slabs to make them impervious.

c. As a filler material in Ferro cement works and stone masonry.

d. To fill cracks and joints in the wall.

e. Use of cement mortar gives a neat finishing work to wall and concrete work.

f. For pointing the joints of masonry.

g. For preparing the building blocks.

3.3 Distribution of TiO_2 and Tin concentration in cubes

The cement mortar is used to prepare for the standard blocks. The dimension of the block is 2-in Length x 2-in width x 2in height. Total 11 cubes were prepared with different concentration of Titanium dioxide (TiO_2) ad Tin nanoparticles. Out of these eleven samples, two were controls having standard concentration of cement and sand (1:4), six were having different concentration of Titanium dioxide TiO_2, and tree were having different concentration of tin nanoparticles. Concentration of these nanoparticles have already mention in the above section. Pictorial view of the standard 2 in cube is as follows: -

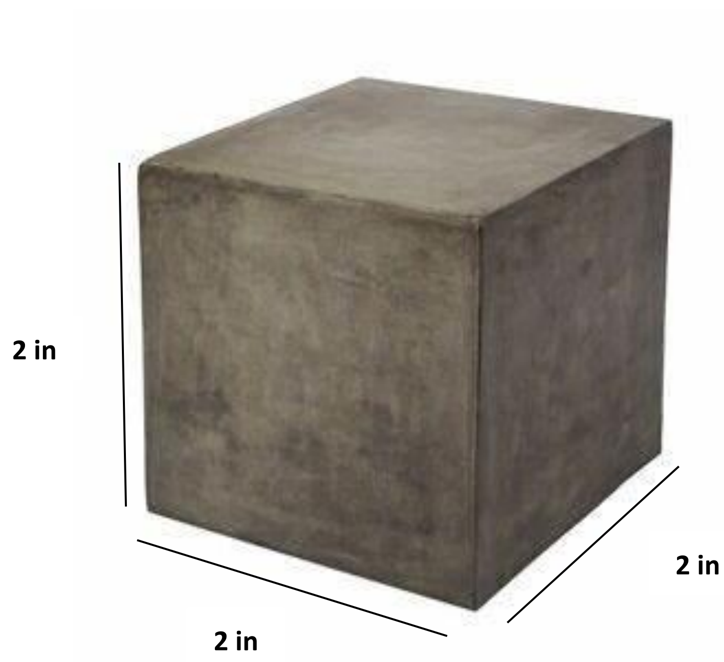


Figure 3.1: Dimension of cube

Figure 3.2: Mold use of making cubes

3.4 Apparatus use for casting the Cubes

a. Pan
b. spatula
c. weight machine
d. hammer
e. sieve
f. Graduated cylinder

3.5 Sample Preparation

Extreme care was required for the mixing of Titanium dioxide (TIO_2) and Tin nano particles with the cement. For the purpose of obtaining a good results, required concentration of both Tin and Titanium dioxide (TIO_2) nano particles for each block were separated. The percentage of nanoparticles for each block was calculated against weight of dry cement. Varying concentrations of both the nanoparticles by weight have already mention in the previous table. Dry cement in a small quantity was mixed with the required concentration of nanoparticles by using a electric blender. First of all dry mixing of cement was carried out with the Tin and Titanium dioxide (TIO_2) nanoparticles. The mixing in such a small amount helped to mix the titanium and the Tin Nanoparticles thoroughly and homogeneously in a cement concentration. Separate mortar for each block was prepared with required concentration and poured in mold. In order to ensure the removal of air from the mortar and sticking against the wall of the mold, tamping rod and oil were used. The sole purpose of following this procedure is to ensure wasting of nanoparticles which were already in a very less quantity. After the dry mixing and preparation of mortar total 11 x block were prepared, out these 11 x samples, two samples were declared as control, six were having varying concentration of Titanium dioxide (TIO_2) and three were having varying concentration of Tin nanoparticles. To avoid early setting of mortar before pouring in the mold, single mortar for single mold was prepared at a time. Proper marking and formulation ID was given for each sample in order to avoid confusion. IDs of samples are already mentioned in the above table. Proper curing was done by putting all the samples in a curing tube for the period of 28 days in order to gain the required strength. The water to cement ratio was 0.4.

3.6 PRECAUTIONS

Following precautions were taken during casting of samples

a. The mold should be oiled before use.

b. The weighing should be done accurately.

c. The temperature and humidity must be accurately controlled.

d. Temping should be done properly.

e. The cubes should be place in the water tank after removing from mold.

f. Care must be taken while opening the mold.

3.7 Calculations

For one cube

a.	Dimension of cube	= 2in x 2in x 2in
b.	Volume of cube	= 8 inch cube
c.	Cement sand ratio	= 1:4
d.	Total weight of mortar required(dry)	= 280 g
e.	Weight of cement required (dry)	= 280/5 = 56 g
f.	Weight of sand required (dry)	= 224 g
g.	Water to cement ratio	= 0.4
h.	Water (ltrs)	= 28 ml

Total Requirement (3xstrips)

i.	Weight of cement required (dry)	= 616 g
j.	Weight of Sand required (dry)	= 2464 g

3.8 DETERMINATION OF ABSORPTION

Following Two methods were undergone to determine the absorption of water

a. British Standard (BS)
b. Indian Standard (IS)

3.8.1 BRITISH STANDARD

In this experiment total 7 cubes were molded, 6 out of them were made from different concentrations of titanium dioxide and 1 cube was controlled. They were tested according to the British standards (BS 1881-122;1983). First of all dry the cubes in the oven for 72 hours. They were placed in such a manner that they had free access of air to all surfaces of specimen. Let them get cold, after removing the specimen weigh them instantly and cool them for 24hrs in dry airtight jar. Then place these specimens in water and let them soak completely for 30 min, now it is time to take out each cube and dry gently from the cloth as soon as possible until all the water drained from surface. Now weigh each specimen.

$$\text{Water absorption \%} = \frac{W_1 - W_2}{W_2} \times 100$$

Where

W_1 = wet mass of unit in kgs

W_2 = dry mass of unit in kgs

3.8.2 INDIAN STANDARD

The molded specimen were completely immersed in water at 24^{o} C which is room temperature and then weighed while suspended in water by a metal wire they shall be removed from water and allowed to drain for a minute. Surface water is removed from a cloth and weighed.

All specimen are then dried in oven at 100^{o}C to 115^{o}C for not less than 24 hours and then weighed after 2hours

$$\text{Water absorption} = \frac{W_1 - W_2}{W_2} \times 100$$

W_1 = wet mass of unit in kgs

W_2 = dry mass of unit in kgs

Note: the same procedure is to calculate the absorption using salt water acquired from bore in 25 Engineers unit located in Risalpur cantt.

3.9 Compression testing machine (CTM)

Compression test was performed according to the ASTM C109/C109M by using the automatic compression testing machine (CTM). Samples were placed in the machine with the application of load of 0.9 KN/s. Two cameras were also installed for the recording of results. One of them was covering the sample and other was Infront of the reading meter.

3.10 Summary

This chapter represented the way in which varying concentrations of nanoparticle of titanium dioxide and tin were added in the cement mortar and used in making cubes.

3.11 Pictorial section

Figure 3.3: Weighing the dry material.

Figure 3.4: Weighing the dry material.

Figure 3.5: Mixing of Material using Mixture machine.

Figure 3.6: Preparation of Cement Mortar

Figure 3.7

Figure 3.8

CHAPTER IV

RESULTS

4.1 Stress strain graphs

4.1.1 Control (c)

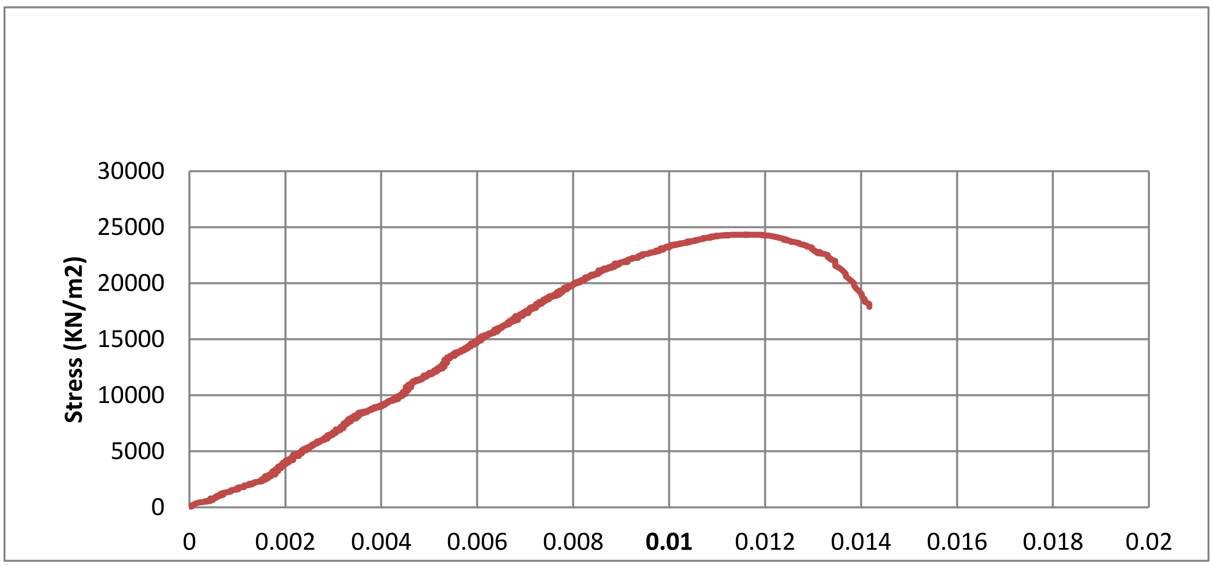


Figure 4.1.1

All the samples were tested on compressive testing machine. Control sample developed the visible crack on 82.7 kN. Test was done under load controlled conditions at 20% degradation. The corresponding stress strain curve is shown in the above graph.

4.1.2 Sn- 0.15 -D1

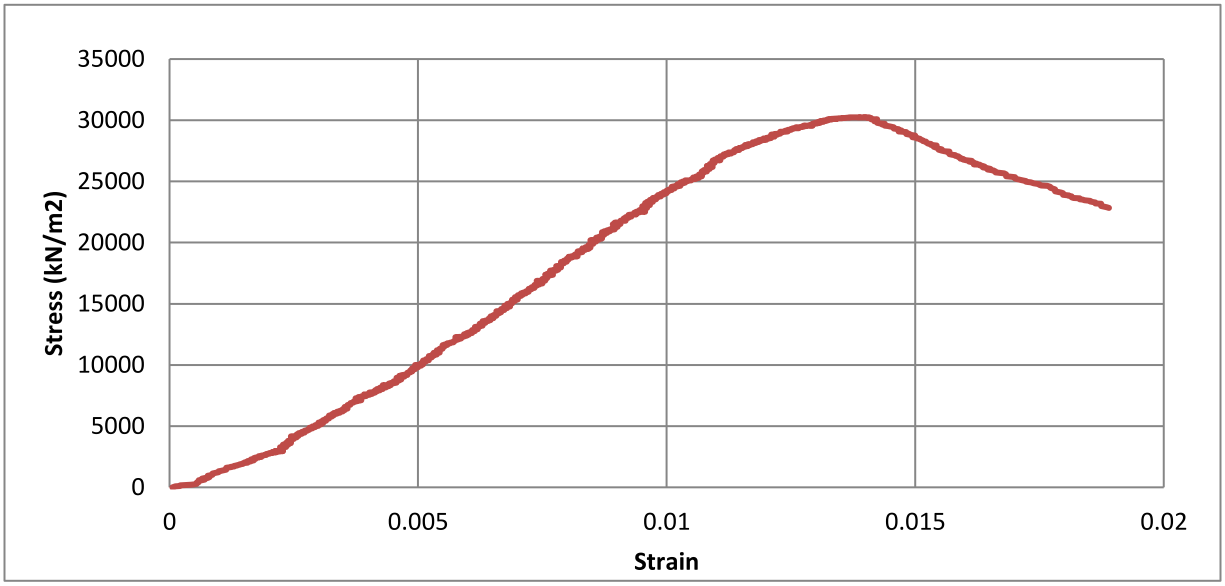
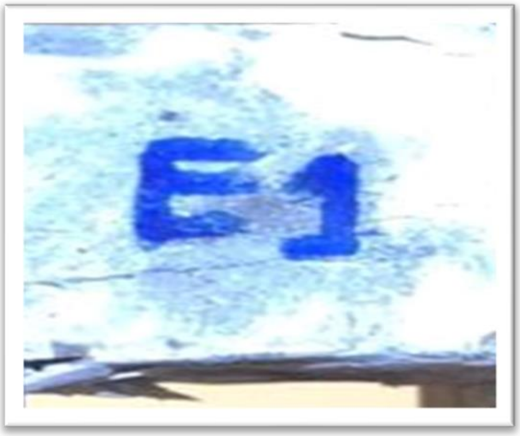


Figure 4.1.2

Tin 0.15 gm sample developed the visible crack on 61.10 kN. Test was done under load controlled conditions at 20% degradation. The corresponding stress strain curve is shown in the above graph.

4.1.3 Sn- 0.08-E1



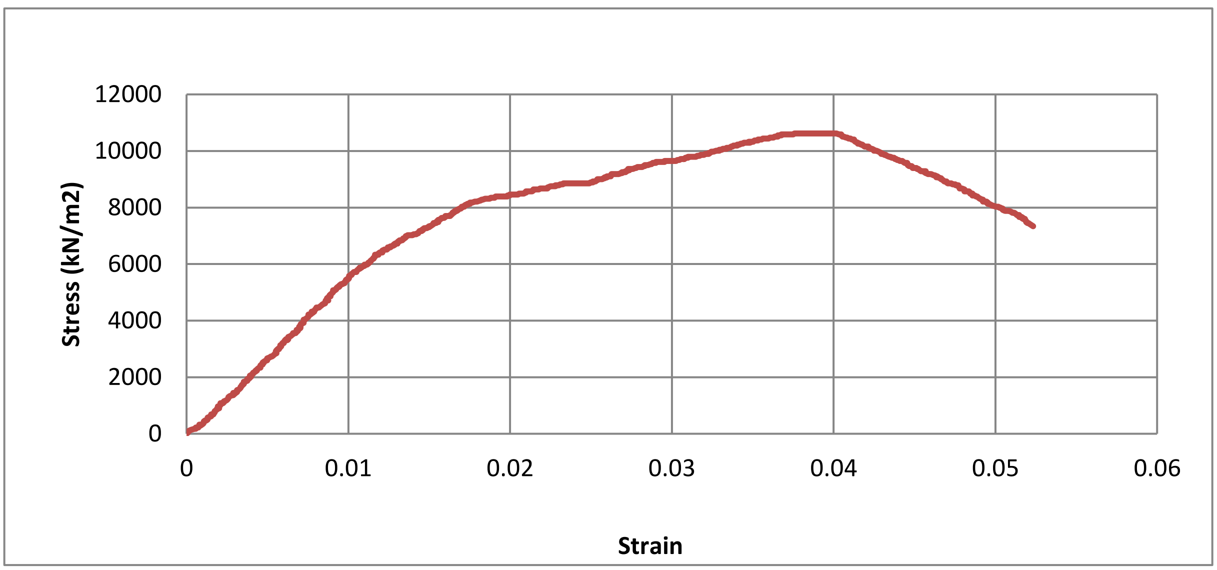


Figure 4.1.3

Tin 0.08 gm sample developed the visible crack on 31.35 kN. Test was done under load controlled conditions at 20% degradation. The corresponding stress strain curve is shown in the above graph.

4.1.4 Sn-0.05-F1

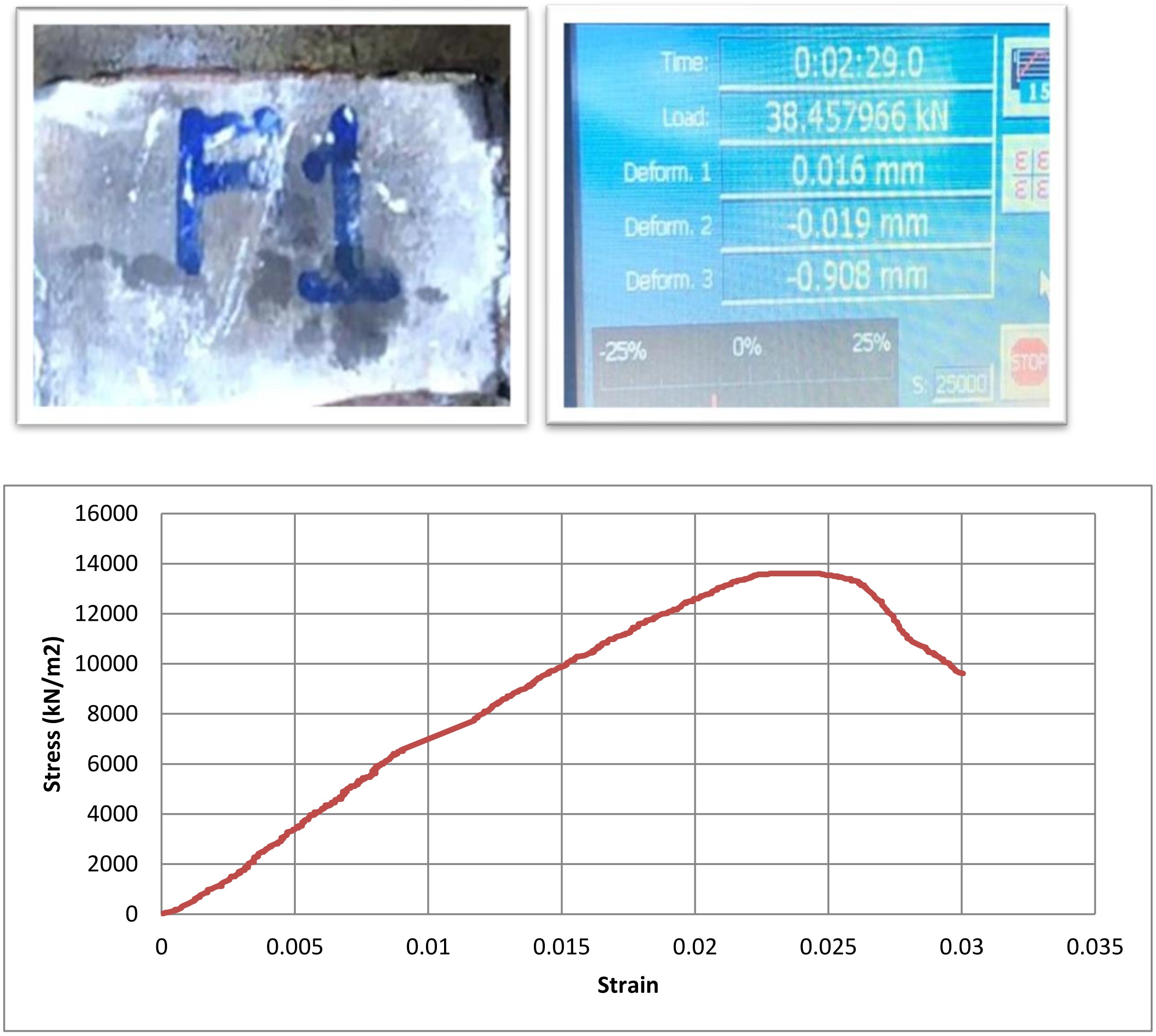


Figure 4.1.4

Tin 0.05 gm sample developed the visible crack on 38.45 kN. Test was done under load controlled conditions at 20% degradation. The corresponding stress strain curve is shown in the above graph.

4.1.5 TiO_2-1-A1

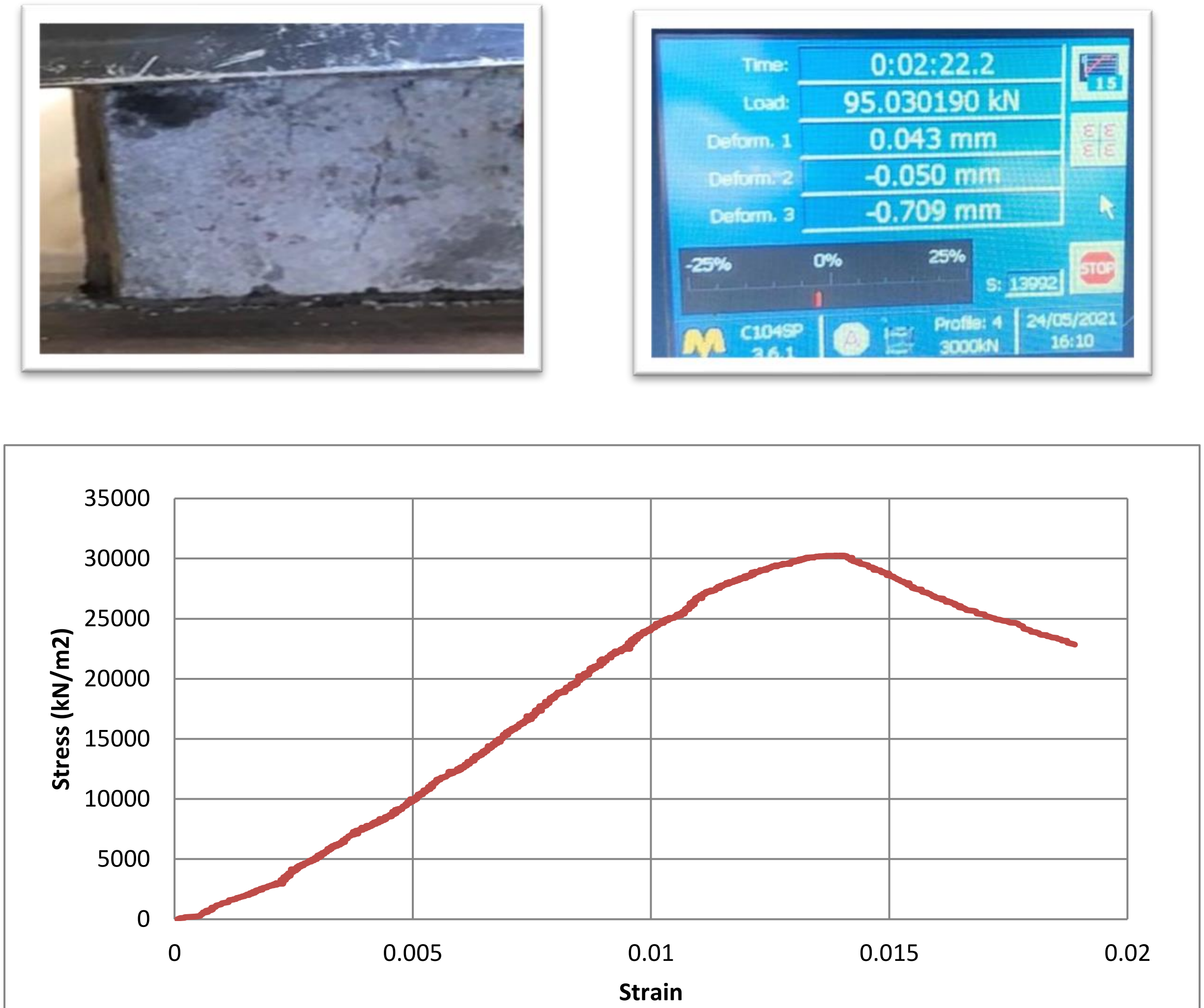


Figure 4.1.5

Titanium 1 gm sample developed the visible crack on 95.03 kN. Test was done under load controlled conditions at 20% degradation. The corresponding stress strain curve is shown in the above graph.

4.1.6 TiO_2-0.65-B1

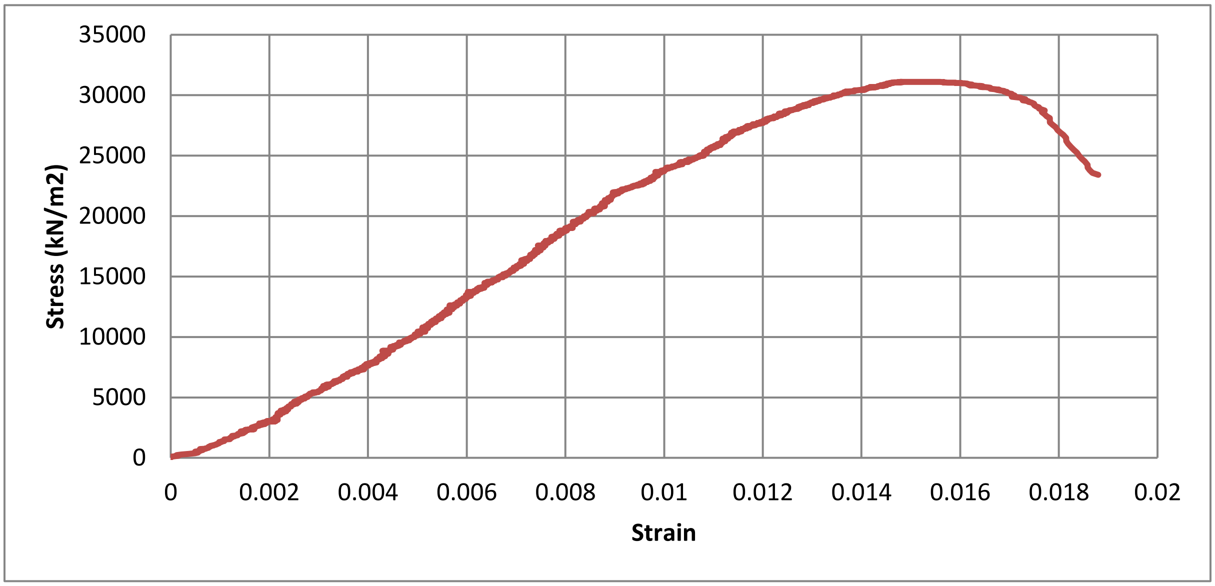


Figure 4.1.6

Titanium 0.65 gm sample developed the visible crack on 97.95 kN. Test was done under load controlled conditions at 20% degradation. The corresponding stress strain curve is shown in the above graph.

4.1.7 TiO_2-0.5-C1

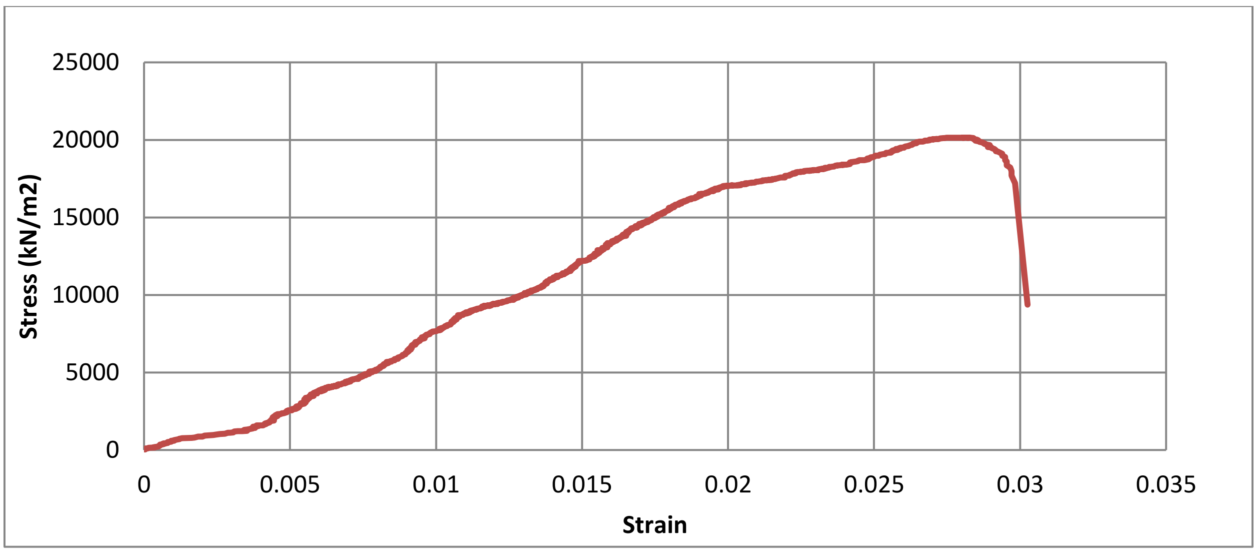


Figure 4.1.7

Titanium 0.5 gm sample developed the visible crack on 66.25 kN. Test was done under load controlled conditions at 20% degradation. The corresponding stress strain curve is shown in the above graph.

4.2 Structural Properties of Nano-Particles admixture mortar

4.2.1 Strain Energy

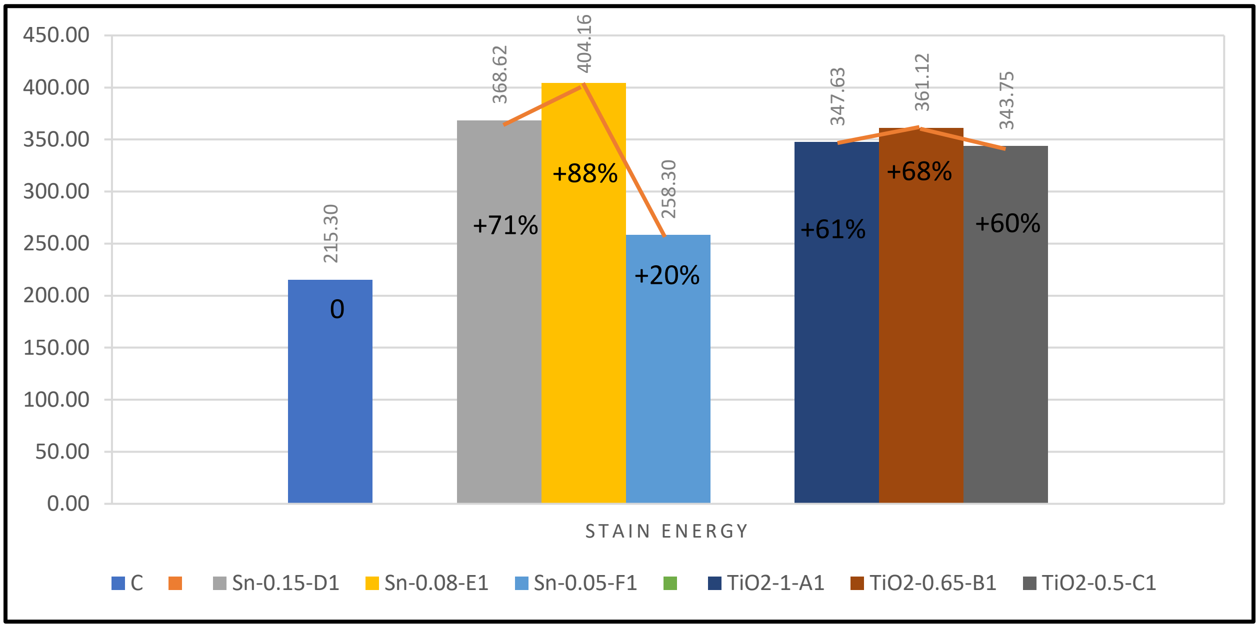


Figure 4.2.1

The strain energy at 20% degradation is shown in the figure 4.1 above. The energy showed an increased trend with the addition of both tin and titanium. Strain energies were calculated using origin pro software for calculations of areas under the curve of stress strain diagrams of each sample. Tin sample with 0.08 grams of tin showed the highest strain energy with an increase of 88 %. Among titanium cubes the highest increase of 68 % was shown by the sample with 0.5 grams of TiO_2.

4.2.2 Pre Peak Strain Energy

Pre peak strain energy was calculated using origin pro to calculate area under the stress strain curve before peak stress of respective cubes with different constituents of Sn and TiO_2. Sn samples showed haphazard trend in pre peak strain energy with the optimum energy increase of 78 % in Sn sample containing 0.08 grams of Sn. Whereas TiO_2 showed an increasing trend with the optimum energy of 75% increase in sample with 0.5 grams of TiO_2.

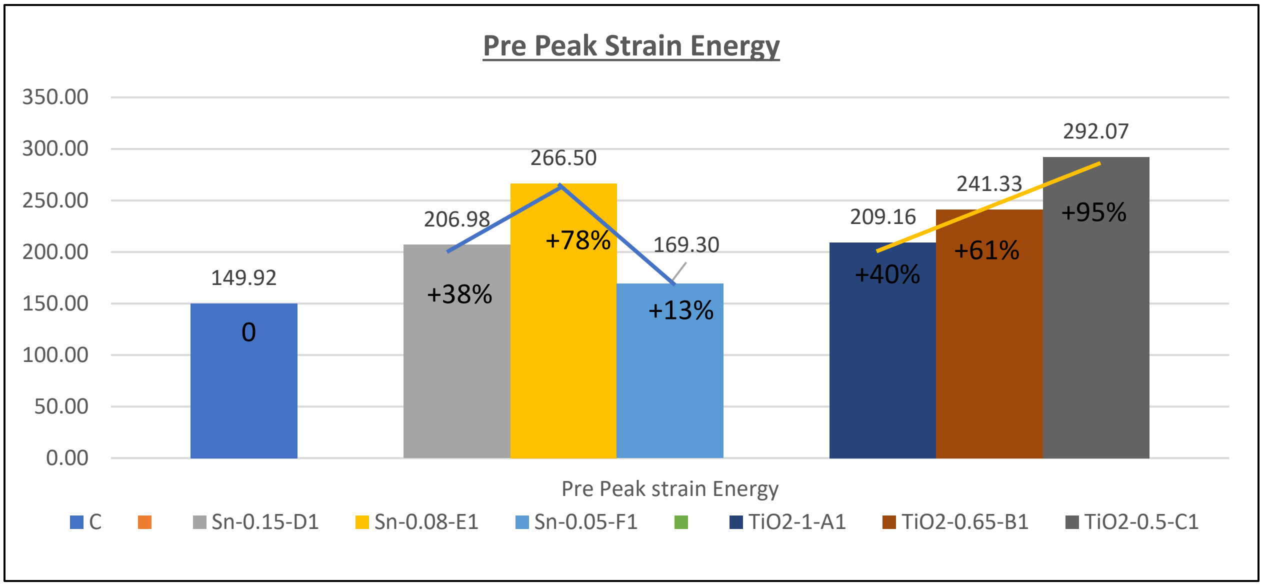


Figure 4.2.2

4.2.3 Post Peak Strain Energy

Post peak strain energy was calculated using origin pro to calculate area under the stress strain curve after peak stress of respective cubes with different constituents of Sn and TiO_2. Sn samples showed a decreasing trend in post peak strain energy with the optimum energy increase of 147% in Sn sample containing 0.15 grams of Sn. Whereas TiO_2 showed decreasing trend with the optimum energy of 112% increase in sample with 0.5 grams of TiO_2.

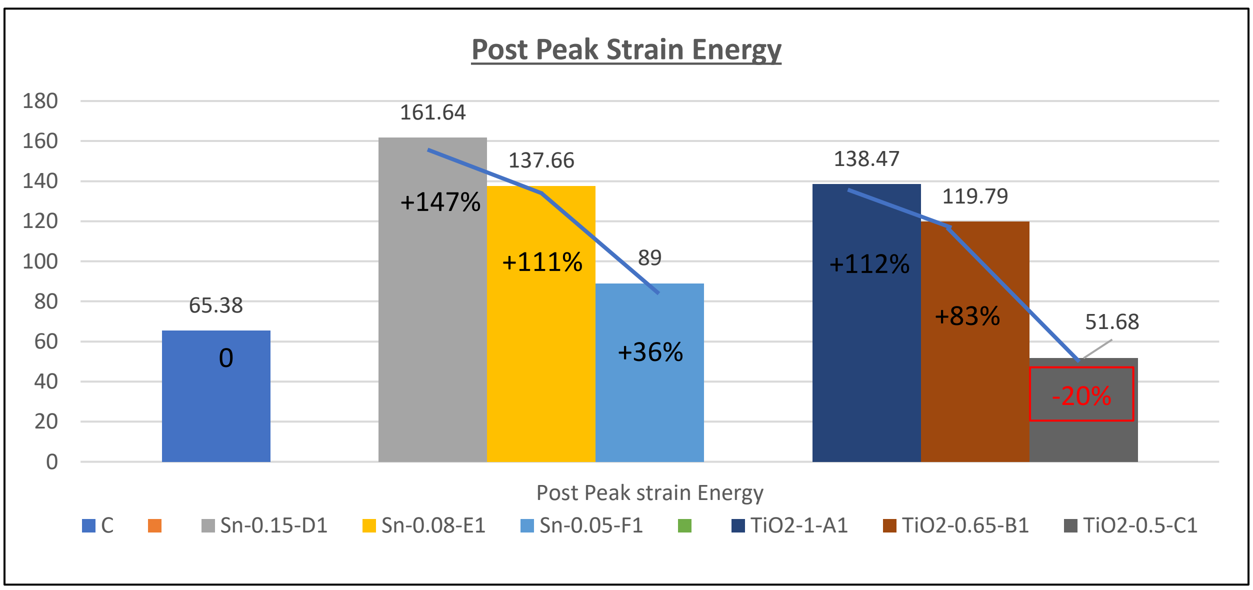


Figure 4.2.3

4.2.4 Ductility

Ductility at 20% degradation was calculated using the expression

Ductility = Ultimate Strain / Yielding Strain

Among tin samples the peak ductility value was given by Sn 0.08 grams with an increase of 278%. After which the trend started decreasing again. Titanium samples showed a decline in the ductility behavior with the decrease in quantity of TiO_2. Maximum ductility value was given by sample with 1 gram of TiO_2 that is an increase by 28 %. While sample with 0.5 grams of TiO_2 showed the negative trend by decrease in ductility by 1.27 %. Ti and Sn are both ductile and malleable in nature. However, Sn being more ductile in nature gives more ductility in mortar cube.

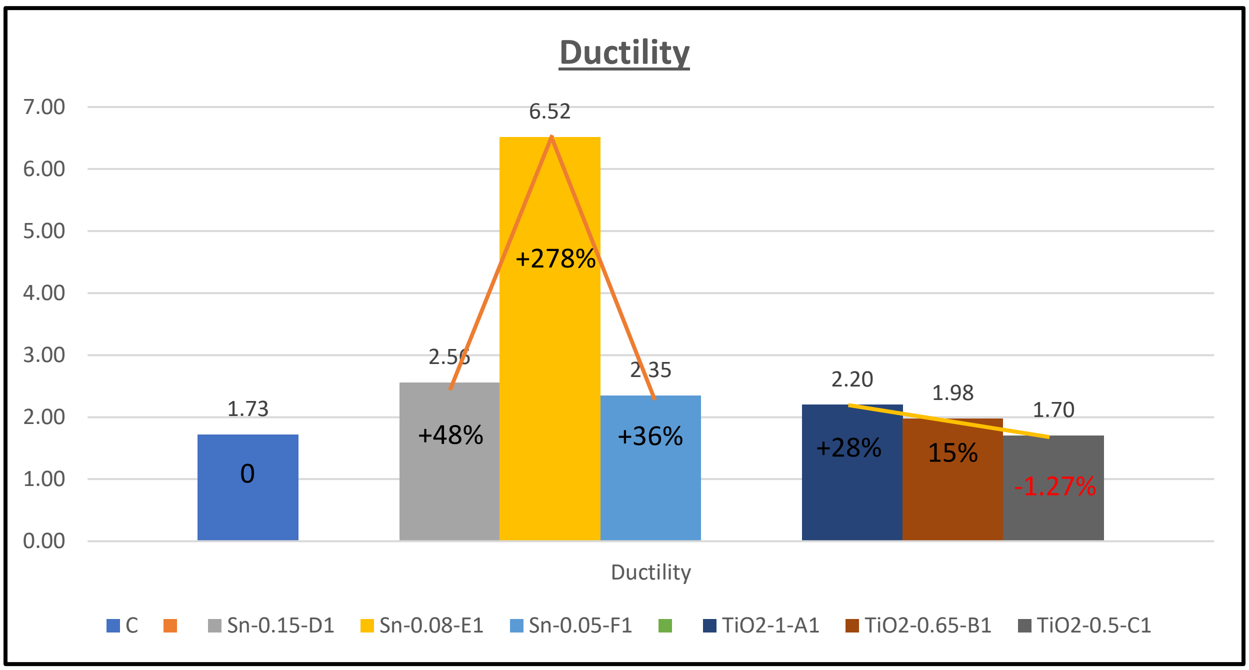


Figure 4.2.4

4.2.5 Peak Stress/Maximum stress

The maximum stress of various samples having different concentration of Tin (Sn) and Titanium dioxide (TiO2) are plotted against the compressive stress of control sample shown in the above fig. the compressive stress of samples having concentration of Tin (Sn) nano particles was decrease as compared to the control. On the other hand, samples having concentration of titanium dioxide (TiO2) nano particles show considerable increase in the compressive stress except the sample having concentration of 0.5g of titanium dioxide TiO2. The average strength reduction and increment are showing in the figure 4.1.5.

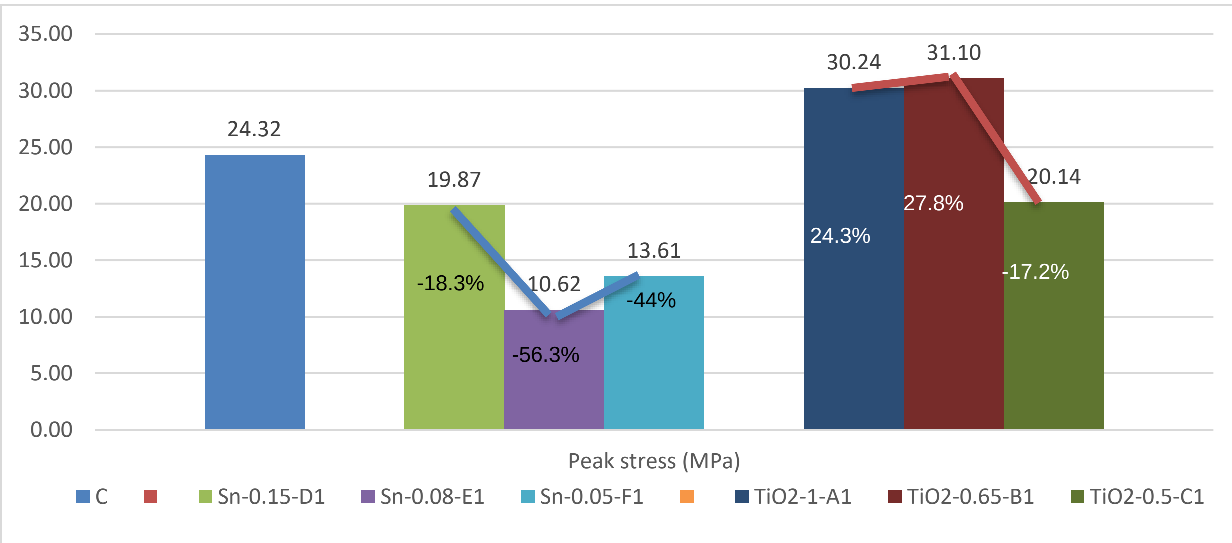


Figure 4.2.5

4.2.6 Peak Strain/ Maximum strain

Maximum Strain results are reported in the above fig. it is calculated by using origin pro software.it is the value against the maximum stress, which read on the horizontal axis. It is observed that samples having concentration of Tin (Sn) and titanium dioxide (TiO2) show considerable Maximum strain as compared to the control sample. The sample having concentration of 0.08g of Tin (Sn) showed the maximum strain with the 232.6% increment.

Whereas the concentration of 0.5g of Titanium dioxide (TiO_2) showed the maximum strain with the 232.6% increment.

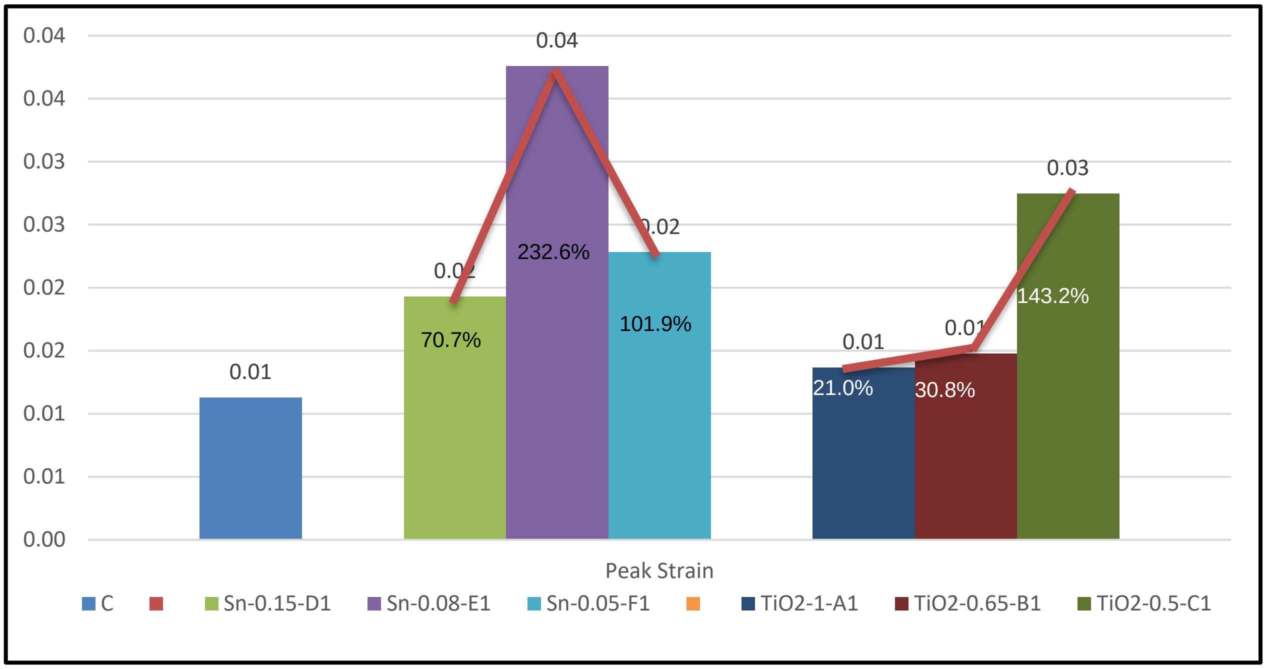


Figure 4.2.6

4.2.7 Ultimate Stress at 20% degradation

Ultimate stress is a point in the stress strain curve showing the maximum value of load which can a sample bear before going into failure. Figure 4.1.7 showing the ultimate stresses of the samples at 20% degradation. Sample with concentration of 0.65g of Titanium dioxide showed the maximum value with 30.77% of increment. whereas the ultimate stress of all the samples having different concentration of Tin showed the reduction with 17.2%, 58.9% and 46% respectively.

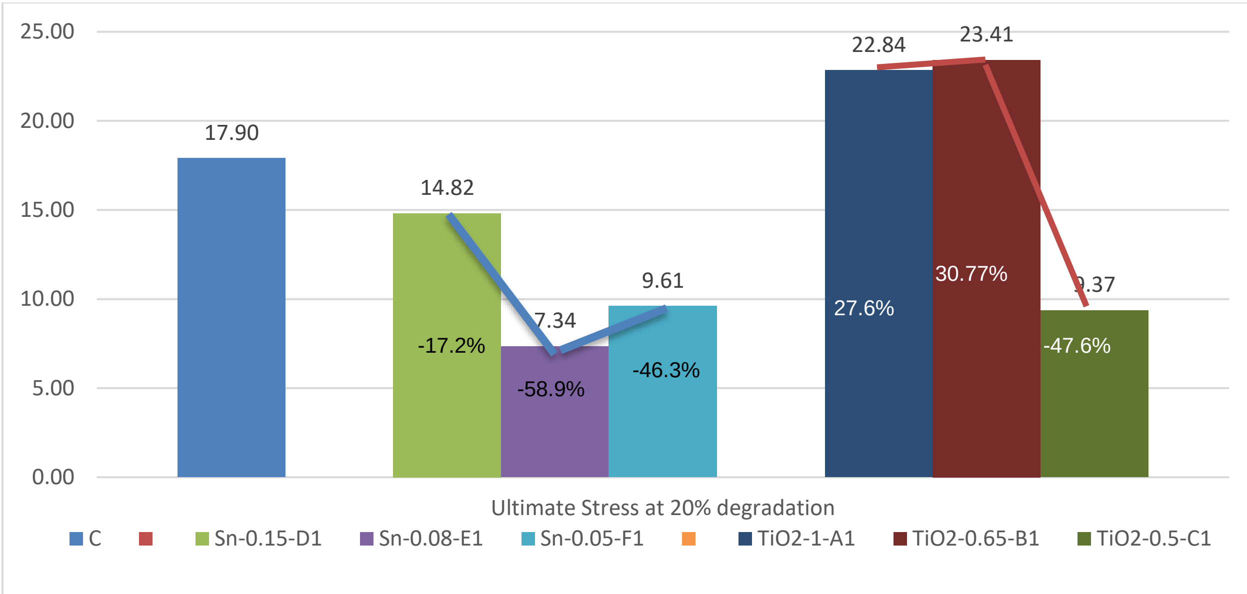


Figure 4.2.7

4.2.8 Ultimate Strain at 20% degradation

The above results were plotted against the value of ultimate strain at 20% degradation. It is the value which comes on the horizontal axis against the ultimate stress. Tin sample having concentration of 0.08g showed the maximum value of ultimate strain with 269.3% increment. Whereas the titanium dioxide sample having concentration of 0.5g showed the maximum value of ultimate strain with 113.5% increment.

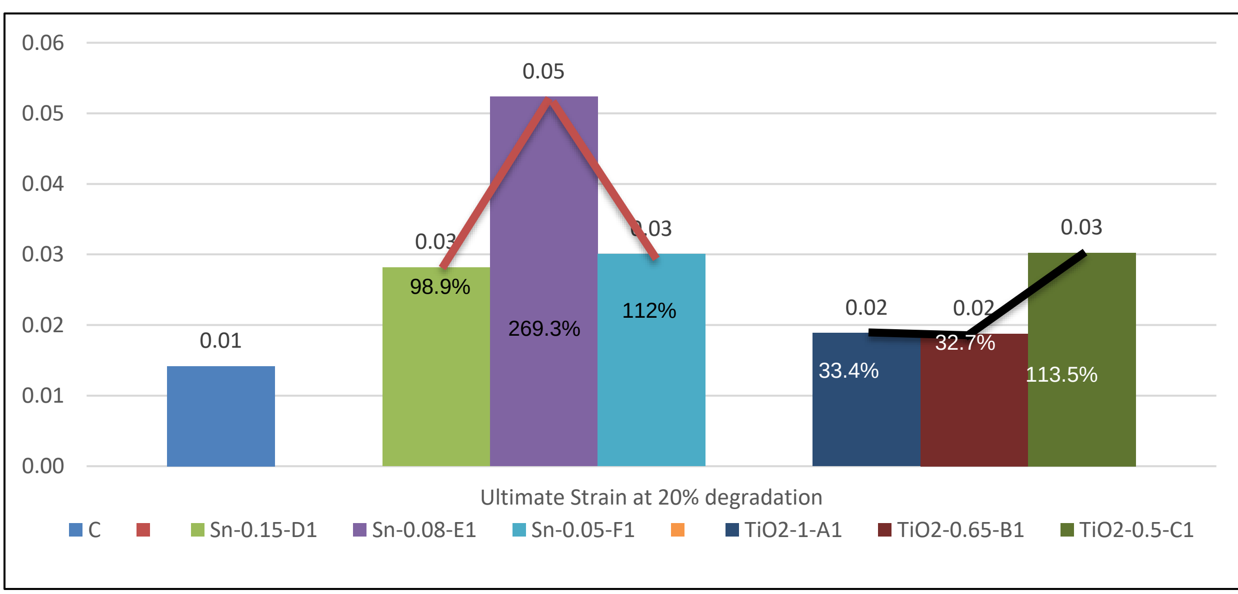


Figure 4.2.8

4.2.9 Yielding Stress

The yielding point is the point in the stress strain graph that show the end of elastic behavior and the start of plastic behavior. Before the yielding point material could deform elastically and returned to its original shape and after the yielding point it could be deformed permanently. It is calculated using origin pro software. The figure 4.1.9 showed that the samples with concentration of Tin nanoparticles have less value of yielding point so less elastic. Sample with concentration of 0.65g of titanium dioxide shows move value so more elastic than control sample.

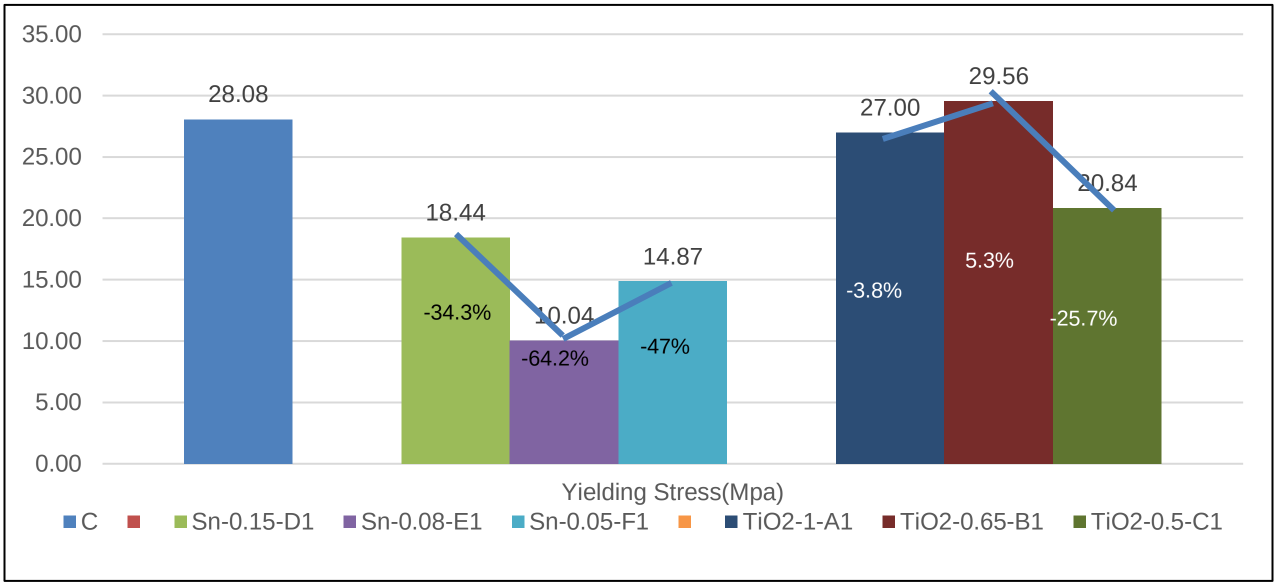
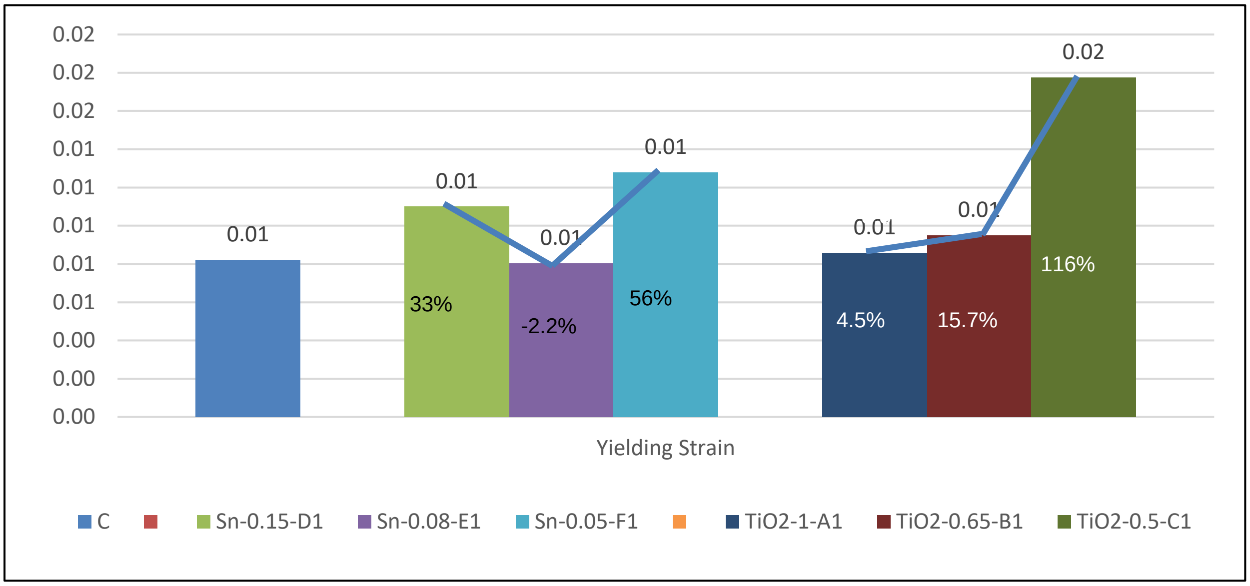


Figure 4.2.9

4.2.10 Yielding Strain

The above fig showed the result of yield strain. It is calculated using origin pro software. It is the value which is calculated against the yielding point. It showed the deformation in the sample till the yielding point. Before this if the load is removed the sample comes to is original shape. Tin and Titanium sample showed considerable increment in the yielding strain against the control sample.


0.02
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0.00
0.01
0.01
0.01
0.01
0.01
0.01
0.01
0.02
33%
-2.2%
56%
4.5%
15.7%
116%
Yielding Strain
C
Sn-0.15-D1
Sn-0.08-E1
Sn-0.05-F1
TiO2-1-A1
TiO2-0.65-B1
TiO2-0.5-C1

Figure 4.2.10

4.2.11 Elasticity

Slope from start to Yield Point

Elasticity is the **slope** of the **stress-strain graph** the steeper the **slope**, the stiffer the material. Elasticity of the specimens was calculated using origin pro. Control specimen showed the best elasticity having the value of 2.67. Sn and TiO_2 being ductile in nature were proved less stiff. Sn samples showed the least elasticity that declined upto 78%. TiO_2 samples were more elastic in nature than the Sn samples but were less stiff than the control. The least elastic was the sample with 0.5 grams of TiO_2.

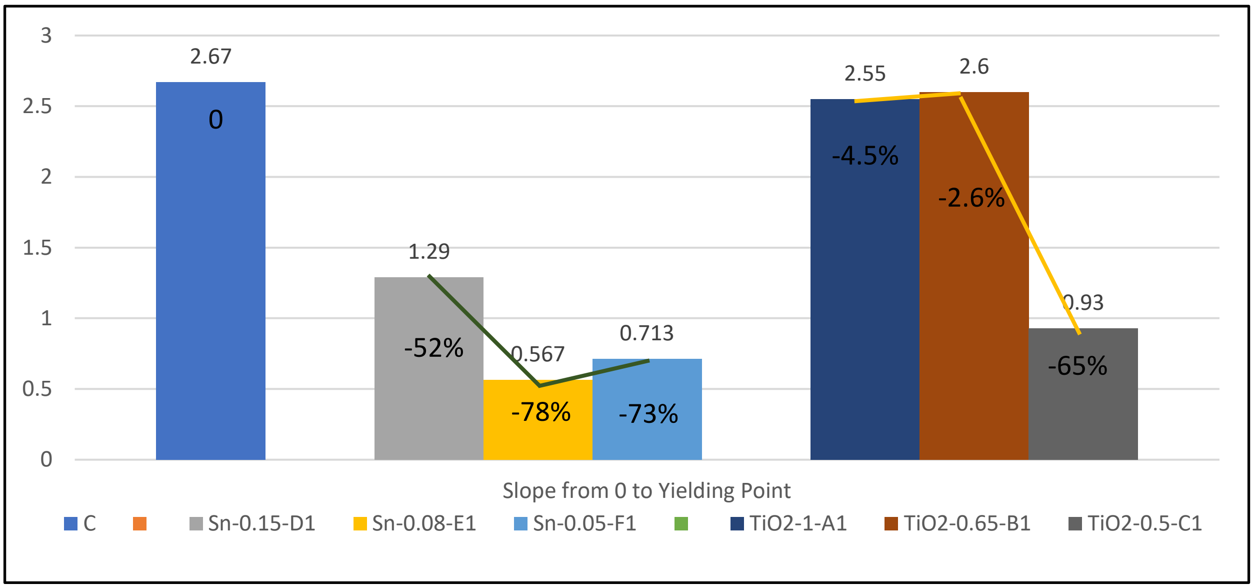

Figure 4.2.11

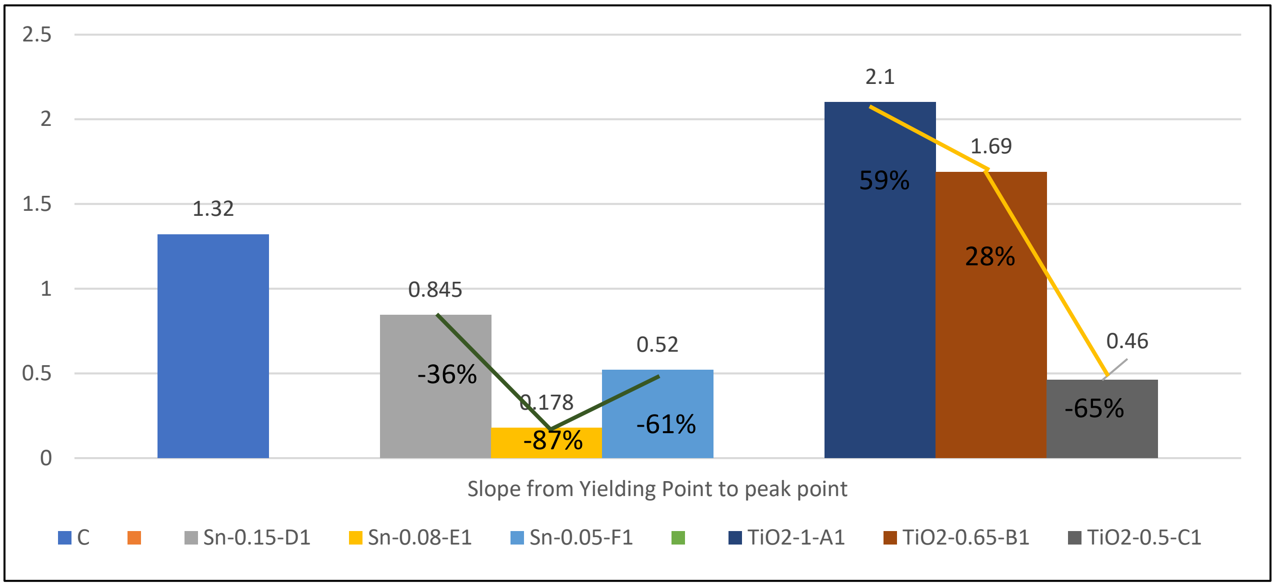

Figure 4.2.12

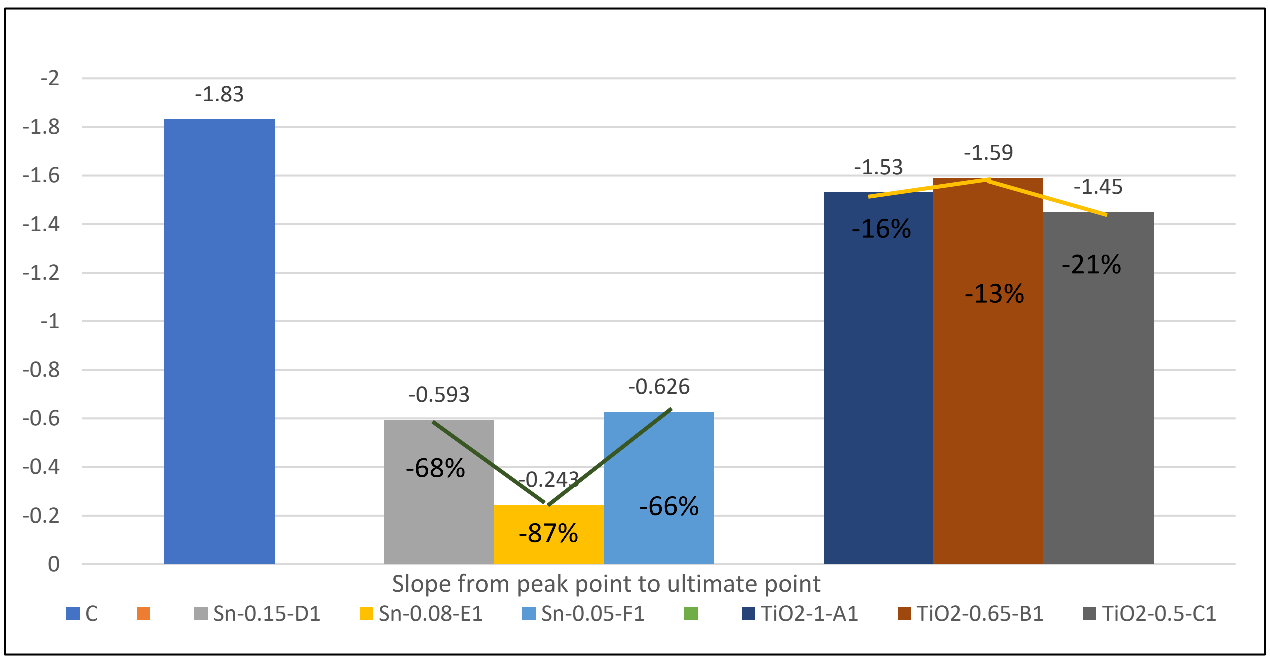

Figure 4.2.13

4.3 Absorption Test

Three types of absorption test were performed according to the British Standard (BS 1881-122:1983), and Indian standard (IS.2185.1.2005). The third method was according to Indian standard (IS.2185.1.2005) using salt water acquired from 25 EB Risalpur Cantt. All the graph showed the decreasing trend. Which mean that with decrease in concentration of titanium dioxide water absorption also decreased. The results showed the decreasing range of water absorption from 19.8% to 28.6%.

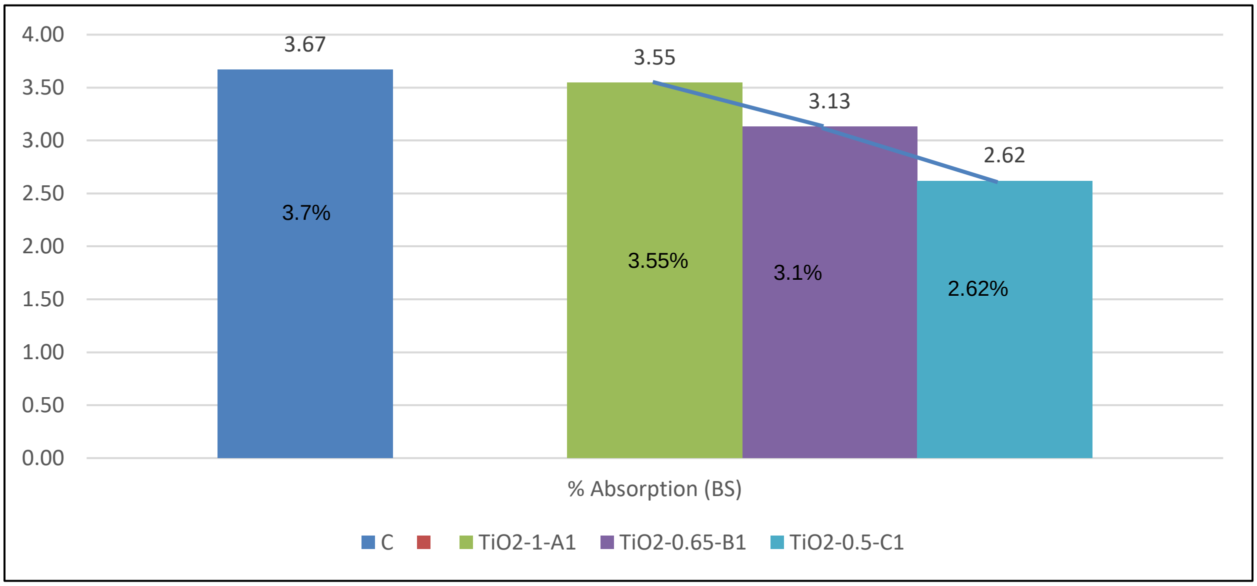

Figure 4.3.1

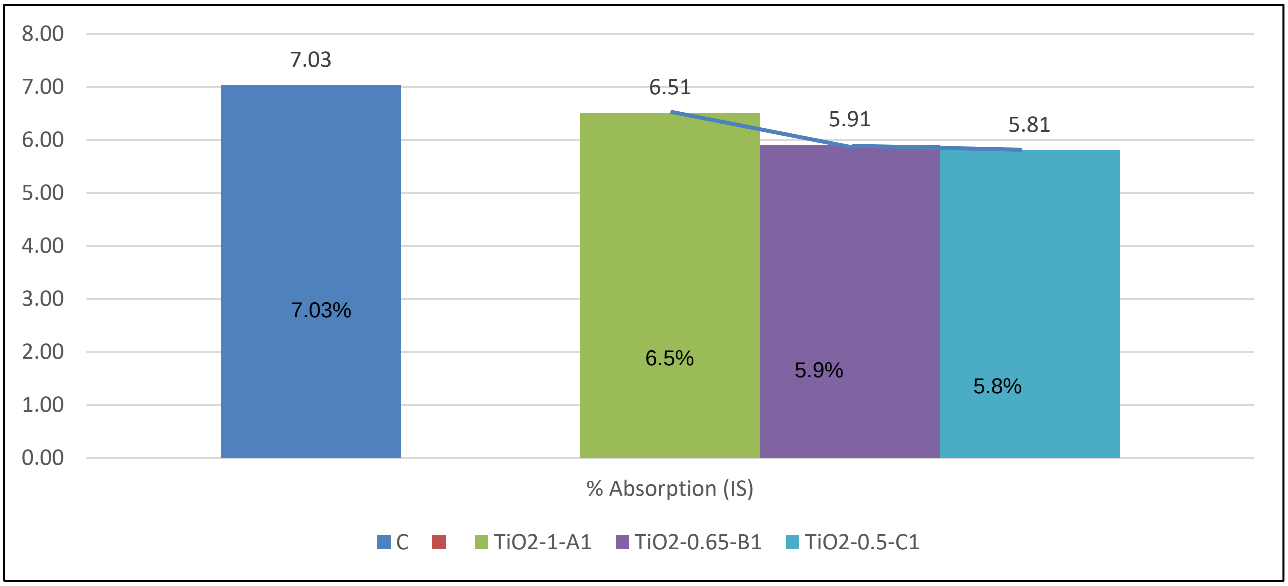

Figure 4.3.2

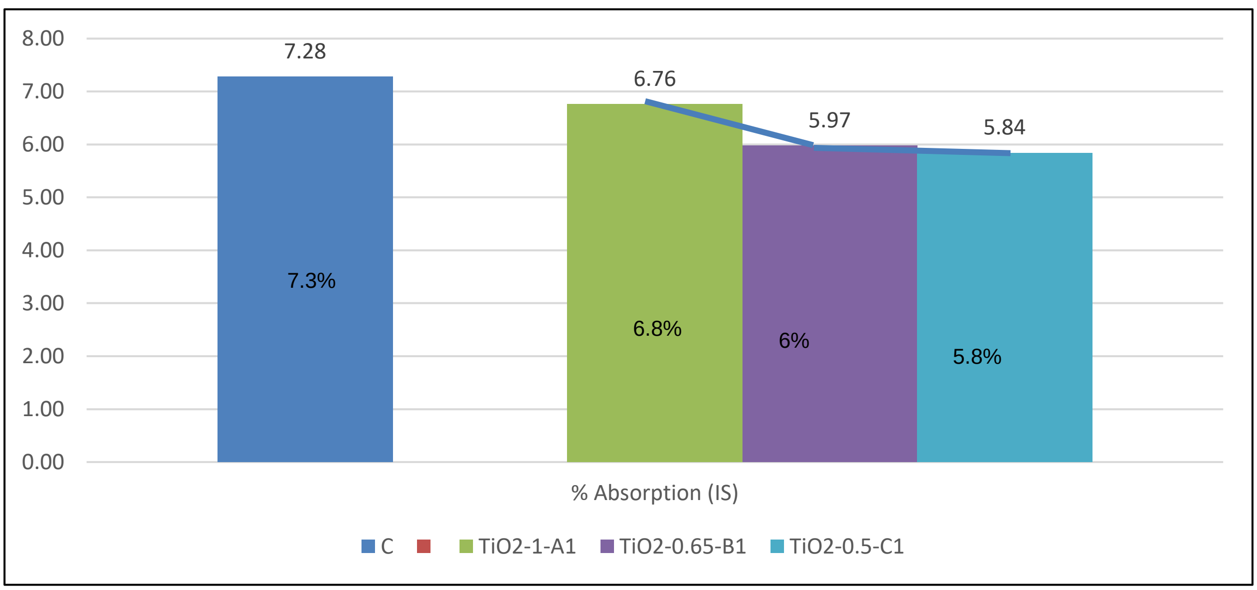

Figure 4.3.3

CHAPTER 5

FINDINGS AND RECOMMENDATIONS

Findings, Recommendations, and conclusion

5.1 Findings

Properties	Tin			Titanium dioxide		
	0.15	0.08	0.05	1	0.65	0.5
	%	%	%	%	%	%
Yielding Stress	-34.3	-64.2	-47.1	-3.8	5.3	-25.8
Yielding Strain	34.0	-2.2	55.9	4.5	15.7	116.3
Peak Stress	-18.3	-56.3	-44.1	24.3	27.9	-17.2
Peak Strain	70.7	232.7	101.9	21.1	30.8	143.2
Ultimate Stress at 20% degradation	-17.2	-59.0	-46.3	27.6	30.8	-47.6
Ultimate Strain at 20% degradation	98.9	269.3	112.1	33.4	32.7	113.5
Pre peak strain energy	38.1	77.8	12.9	39.5	61.0	94.8
Post peak stain energy	147.2	110.6	36.1	111.8	83.2	-21.0
Total strain Energy	71.2	87.7	20.0	61.5	67.7	59.7
Slope from 0 to Yielding Point	-51.7	-78.8	-73.3	-4.5	-2.6	-65.2
Slope from Yielding Point to peak point	-36.0	-86.5	-60.6	59.1	28.0	-65.2
Slope from peak point to ultimate point	-67.6	-86.7	-65.8	-16.4	-13.1	-20.8
Ductility at ultimate Point	48.4	277.6	36.0	27.6	14.7	-1.3
Absorption						
British standard				3.3	14.7	28.6
Indian standard				7.1	17.9	19.8
Indian standard (Salt water)				7.3	15.9	17.4

From table above optimum behavior is shown by sample of titanium dioxide having concentration of 0.65gm.

Legend

% Increase

% Decrease

5.2 RECOMMENDATIONS

a. The experiment to be repeated in a controlled environment with more nanoparticles concentration ratios and more number of cubes, to know the exact behavior of increasing or decreasing trends of different addition ratios of Tin and Titanium.

b. Enough samples should be available to cater for any damage during cube preparations. There were uncertainties related to sample preparation due to the limited samples of tin and titanium. Number of cubes prepared was prone to damage due to different reasons.

c. International practices include the testing and inspection of samples by scanning electron microscopy (SEM), X-ray diffraction (XRD) and mercury intrusion porosimetry (MIP) at micro scales. These practices should be adapted to get a clear idea of structural changes of mortar at nano scale.

d. Only cubes (2in x 2in x 2in) were made from the sample mortar, test should be conducted on flexural and tension members as well to further explore the behavior of nanoparticles in RCC structures.

e. Structural behavior of the nanoparticles in cement mortar should be made to observe as a whole.

f. Cost analysis of nanoparticles with the market availability is another dimension in the research which can be worked for.

CONCLUSION

Tin and titanium dioxide nanoparticles were used to check their efficiency on the properties of cement mortar. Initially titanium dioxide was used to test for its hydrophobic nature and 19.8-28.6% reduction in the water demand was observed. Tin and titanium dioxide were used for assessing the post peak behavior of cement mortar. Tin nanoparticles showed reduction in the properties like the peak/compressive stress and ultimate stress while improvement was observed in ductility and strain energy. Titanium dioxide with concentration of 0.65g (1.16%) improves properties like compressive stress, ultimate stress, strain energy and ductility up to 18.4%, 18%, 67.7% and 14.7% respectively.

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CHAPTER 1

INTRODUCTION

1.1 Background

Nanotechnology (NT) is an arising field of science identified with the agreement and control of matter at the nanoscale i.e, at measurements between roughly 1 and 100 nm. Nanotechnology includes nanoscale science, designing, and innovation that include imaging, modeling, measuring, and manipulating matter at this length scale.

NT is not new in existence and science. Recent improvements in characterization and testing materials at the nanoscale have prompted a new chapter in nanotechnology-based materials in fields of polymers, plastics, hardware, vehicle assembling, and medication. Matter can display uncommon physical, chemical, and biological properties at the nanoscale, varying in significant manners from the properties of mass materials and single particles or atoms.

Concrete, the most ubiquitous material on the planet, is a nanostructured, multiphase, composite material that ages over time. It is composed of an unstructured phase, nanometer- to micrometer-size crystals, and bound water. The properties of concrete exist in, and the degradation mechanisms occur across, multiple length scales (nano to micro to macro) where the properties of each scale derive from those of the next smaller scale.

Constructing buildings have always relied on technological innovations. New developments have continuously been taking place in the world which has led us to construct the high rise and huge skyscrapers. Over the course of time our needs have undergone a serious transformation in the way the construction industry has also witness a profound transformation.

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