وزارة التعليم العالي والبحث العلمي

جامعة ديالى

كلية الهندسة

# دراسة تأثير اضافة مواد الزركونيا ورماد قشور الرز النانوية على خصائص الخرسانة

**رسالة مقدمة الى**

**مجلس كلية الهندسة / جامعة ديالى**

**وهي جزء من متطلبات نيل درجة الماجستير في علوم هندسة المواد**

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**1444 هـ** **2023م**

**Ministry of Higher Education**

**and Scientific Research**

**University of Diyala**

**College of Engineering**

# Study the Effect of Nano Zirconia and Nano Rise Husk Ash Materials on the Properties of the Concrete

**A Thesis Submitted to Council of College of Engineering**
**University of Diyala in Partial Fulfillment of the Requirements**
**for Master Degree in Materials Engineering Science**

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## 1.1 Introduction

Sustainable development is the process of using finite resources to meet future generations' needs without compromising the natural environment's integrity, stability. The cement industry emits a large amount of $CO_2$, making the development of sustainable concrete technology a significant challenge [1]. Concrete is a an important building material, but its use is problematic due to $CO_2$ emissions and the consumption of native rock and minerals. Designers and developers are exploring alternative materials like rice husk ash (RHA) to reduce $CO_2$ emissions in civil engineering projects. RHA is a by-product of rice husk processing and is growing in popularity due to environmental concerns and resource and energy conservation[2]. Adding nanomaterials in small quantities affects the behavior of cement mortar, such as the effect of adding nanoparticles ($SiO_2$ or $Al_2O_3$) on the mechanical properties of the mortar such as hardness and water absorption. The results showed that the mortar containing nanomaterials had better hardness than the mortar without nanomaterials in all tests [3]. Recent research explores the use of nanoparticles (NPs) as additives in concrete and cement-based products for improved mechanical and durability properties. However, NPs have been found to negatively impact workability, although some cases may improve[4]. Nanomaterials can significantly improve cementitious composites' mechanical strengths and durability by acting as ultrafine aggregates, filling small voids, and reducing calcium hydroxide $Ca(OH)_2$ crystal size, this accelerates the hydration process, increasing $Ca(OH)_2$ consumption and calisum silicate hydrate C-S-H gel production [5]. Nanomaterials like nano-silica, carbon tubes, and titanium dioxide enhance concrete properties in both fresh and solidified states. By partially substituting these nanomaterials and combining them with other cementitious materials, strength, workability, and durability can be enhanced. The field of nanotechnology is rapidly developing, and its potential to revolutionize concrete production has gained global interest[6]. Nanoparticles in cementitious materials can enhance durability, strength, and structural efficiency, resulting in better quality and longer structures' life spans. With a high surface-area-to-volume ratio, nanoparticles provide more reactive sites, increasing reaction efficiency. studies found that adding zirconium oxide-synthesized nanoparticles to cement mortars with limestone aggregates improved microstructural properties and physical-mechanical characteristics.The reinforcement effect was attributed to the influence on nucleation locations, inhibition of large calcium hydroxide $Ca(OH)_2$ crystal growth [7]. Concrete is a complicated building material with different qualities in its fresh and hardened stages. Excess water evaporates during curing forming ultra-fine holes that allow water absorption and chloride ion penetration resulting in reinforcement corrosion. Cementitious composites are commonly utilized to improve conventional concrete. Studies have focused on the effect of nano-sized cementitious composites on concrete, as nano-sized particles and micro/macro-scaled content have the greatest influence on concrete performance[8]. Rice husk ashes (RHA) when combined with cement has been shown to improve concrete's fresh qualities, workability, consistency, and setting time. It also increases compressive, tensile, and flexural strength through amorphous silica reactions. Rice husk ashes also enhances concrete's characteristics, such as water absorption, chloride resistance, corrosion resistance, and sulfate resistance. As a strong pozzolanic material, RHA can substitute for cement by 10%-20% without effecting performance. This partial replacement can help manage waste and promote economy in the construction industry [9].

## 1.2 Literature Review

### 1.2.1 $ZrO_2$Nanoparticles

**Ali Nazari et al.(2010)**[10] Investigated the impact of substituting $ZrO_2$ nanopartices with the average diameter of 15 nm were used with four different contents of 0.5%, 0.1%, 1.5% and 2.0% by weight for cement on the compressive strength and workability of concrete. The study detected that although the use of $ZrO_2$ nanoparticles led to a strengthened concrete, with a maximum replacement level of 2%, the final strength of the concrete increased by only 1% of cement replacement. This was because the addition of more $ZrO_2$ nanoparticles to new concrete caused the fast consumption of $Ca(OH)_2$, and the reactivity of the $ZrO_2$ nanoparticles resulted in larger amounts of reaction products and decreased particle packing density, which were the causes of the high compressive strength of the blended concrete.

**A. H. Shekaria et al. (2011**)[11] Studied the effect of incorporating constant content(1.5%) from nano $ZrO_2$, nano-$Fe_3O_4$, nano-$TiO_2$ and nano-$Al_2O_3$ particles into high-performance concrete. The research involved several tests, including compressive strength tests, tensile strength tests, water absorption tests. The results revealed that all the tested nanoparticles had a remarkable effect on enhancing the durability of the concrete when compared to control samples. The introduction of nanoparticles resulted in a significant reduction in chloride permeabilit ranging from 20% to 80%.

**Farzad Soleymani(2012)**[12] Studied how partially replacin portland cement with $ZrO_2$ nanoparticles affects the flexural strength of concrete. The study involved replacing portland cement with weight percentages of( 0.5, 1.0, 1.5, and 2)wt%, and then curing the samples in water for 7, 28, and 90 days. The strength of the samples was evaluated through a bending strength test.

The results indicated that soaking the samples in water for an additional 28 days led to a stronger and more compacted gel. The addition of nanoparticles improved the pore structure of the concrete, with the extent of improvement increasing as the nanoparticle content decreased.

**Farhad. M. et al.(2016 )**[13] Studied addition of $ZrO_2$ nanoparticles with particle size for nano materials of (50) nm. and five different percentages (0.1%, 1%, 2.5%, 5% and 10%)to cement to improve both the mechanical and physical characteristics of the concrete. The best results were obtained when cement was coated with 5% $ZrO_2$ nanoparticles with the mixed samples exhibiting a 67% decrease in total water absorption, a 38% increase in vickers hardness, and a 58% increase in wear resistance. porosity decreased by 51.68% and dry density increased by 1.9%. The researchers used split tensile strength, flexural strength, and setting time techniques to study the modified cement and found that $ZrO_2$ nanoparticles could be used as additives in concrete structures to enhance their function.

**Raeid Kadhium(2017)**[14] Studied the effect of using nano powder materials, such as $Al_2O_3$ and $ZrO_2$ with an average particle size of 20 nm to partially replace cement in concrete at three different percentages (0.5%, 1.5%, and 2.5%) by weight of cement. XRD analysis was conducted to evaluate the activity and potential of incorporating these nanoparticles and recycled materials of selective cement mortar in concrete samples after 28 days of hydration. The study found that the pozzolanic reaction of gamma alumina ($\gamma$-$Al_2O_3$) nanomaterials and $ZrO_2$ with concrete contributed to improved performance this may be due to the nanoparticles reacting with CH produced during the hydration process leading to significant pozzolanic reactivity and an improvement in the microstructure of cementitious systems thereby enhancing the mechanical properties of the cementitious materials.

**M. Danial, et al.(2018)** [5] They researched the application of suitable amounts of nanoparticles such as ($SiO_2$, $TiO_2$, $Fe_2O_3$, CuO, $ZrO_2$, $ZnO_2$, $Al_2O_3$, $CaCO_3$, $Cr_2O_3$) with various weight percentages (1,1.5,2,2.5,3,3.5,4,4.5,5,5.5)wt% as a partial substitute for cement greatly improves the mechanical strengths and durability qualities of cementitious composite. This is primarily due to the fact that nanomaterials act as ultrafine aggregate, not only filling the tiny voids in the composite but also acting as a kernel, reducing the size of $Ca(OH)_2$ and accelerating the hydration process, resulting in more $Ca(OH)_2$ consumption and the production of a large quantity of C-S-H gel. also the use of nanoparticles lowered the workability of cementitious composites significantly,this might be because the replacement of cement with nanoparticles increased the overall surface area, requiring more water to moisten the surface.

**Danna L. et al.(2019)** [15] Showed in their study that the increased surface activity of $ZrO_2$ nanoparticles(15.18 and 17.79 nm) is responsible for strengthening.The study identified three mechanisms, namely the filling effect, nucleation effect, and phase transition effect, which contribute to reinforcement. The particles fill in the gaps or pores created during the cement hydration process, resulting in the filling effect. They also act as preferred sites for cement hydration products. This results in higher concentrations of the C-S-H and prevents the development of calcium hydroxide crystals $Ca(OH)_2$.

**Zahraa Fakhri Jawada et al. (2020)** [16] Conducted a study in which they added $ZrO_2$, $SiO_2$, $Al_2O_3$, and $CaCO_3$ nanoparticles at different concentrations. Four different contents of each nanoparticle type (1%, 1.5%, 3%, and 5%) of cement weight were used and compressive strength was measured at 7 and 28 days. The results indicated that the addition of $ZrO_2$ and

$SiO_2$ nanoparticles increased compressive strength mixtures containing 3%. Beyond this point the compressive strength decreased but still remained higher than that of the standard blend. Moreover, mixtures containing 3% nano $SiO_2$ exhibited the highest tensile strength reaching 42.5 MPa.

**Zainab Jawad et al.(2020)** [17] They studied adding nanopowder to concrete improved its compressive strength, tensile strength, workability, and water absorption. Adding nano zirconia(NZ)(170nm) in proportions(0.1,0.3,0.5,0.7,0.9,1.1)wt% to cement increased compressive strength by 0.7wt% while splitting tensile strength increased with concentration. Nano $ZrO_2$ powder increased compressive strength by 52.3 MPa in NZ at 90 days. Higher splitting tensile strength was observed in specimens compared to the control. Overall, the concrete achieved a maximum compressive strength and tensile strength of 0.7wt%.

### 1.2.2 Rice Husk Ash (RHA)

**Ghassan Abood Habeeb et al. (2010)**[18] In this study, rice husk ash (RHA) was burned in a furnace-cement the chemical composition of RHA was analyzed using X-ray fluorescence spectrometry (XRF) revealing a high content of amorphous silica (88.32%). Increasing the fineness of RHA was observed to enhance their interaction and slightly enhance its specific surface area. However, the addition of RHA increased the demand for super plasticizer, which had to be increased with the increase in RHA fineness and content to maintain the required workability. Concrete with 10% RHA showed a significant increase in compressive strength, and up to 20% replacement of cement with RHA did not have an adverse effect on the strength. Moreover, the study found that increasing the fineness of RHA could enhance the strength of blended concrete. The study concluded that the RHA used in this research could be a highly effective pozzolanic material.

**Hwang Chao et al.(2011)**[19] In this study, RHA was burnt in a steam boiler within the temperature range of 600 to 800°C, resulting in a mixture of amorphous and partially crystalline silica. The non-ground RHA had a high silica content and could be used as a pozzolanic material inconcrete. To enhance its pozzolanic activity, RHA was ground for one hour using a ball mill, resulting in an average particle size of 12 microns. The finer particles had a greater pozzolanic reaction improving the mortar's compressive strength. RHA concrete had comparable or better properties than the control specimen without RHA, reducing $CO_2$ emissions during cement production. Up to 20% of ground RHA could be blended with cement without affecting concrete strength and durability.

**B. H. Abu Bakar et al.(2011)**[20] In their study, rice husk was burnt in a gas furnace at 700C for 6 hours. The ash was subsequently ground using a laboratory ball mill with porcelain balls. The study investigated the impact of grinding on the physical properties of rice husk ash (RHA) and portland cement and identified the optimal grinding time for producing a highly reactive product with minimal grinding energy. A dosage of 15% RHA by weight of the binder was utilized in all experiments. The study found that increasing the grinding time resulted in higher specific gravity and fineness of the RHA but also caused changes in its morphology. The resulting concrete demonstrated good strength and low porosity.

**Celso Yoji Kawabata1 et al.(2012)** [21] In their investigation, rice husk was burnt at 600°Cfor 3 hours before cooling naturally. The resultant ash was then crushed for around 10 hours in a ball mill. RHA use resulted in enhanced strength. furthermore, when used as a replacement for up to 10% of the control lightweight aggregate concrete, RHA improved properties related to carbonation resistance and chloride ion penetration.This is especially significant because lightweight aggregate concrete is an insulating material that reduces energy consumption in buildings. Furthermore, the use of RHA, a raw material obtained from (agricultural, industrial) waste, helps to build sustainability by lowering clinker usage in lightweight concrete without compromising durability.

**Lee-Kuo Lin et al.(2013)**[22] Showed in their study that self-sintered RHA can be used as a partial replacement for cement in concrete production. The self-sintering process was conducted at different temperatures (500°C, 700°C, and 900°C), and the percentage of RHA used in the concrete mix varied between (0, 5, 10, 20, 40)%. The study also examined the effect of RHA percentage (0, 10, 20) on concrete strength. The results showed that when the RHA replaced 20% of cement the long-term strength of the concrete increased significantly, this is because the RHA provided enough pozzolanic material to allow for cement hydration and pozzolanic reaction which increased the overall strength of the concrete. However, if more RHA was added the strength of the concrete decreased slightly but it was still able to meet the general design strength. This approach can help to reduce the environmental impact of concrete production and promote sustainability in the construction industry.

**Arvind Kumar et al.(2016)**[23] In their study, they prepared husks ash was through uncontrolled combustion for approximately 72 hours in air at a temperature range of 400-600 °C. The collected powder was sifted through a standard 75 μm . The pozzolanic activity of RHA depends on its silica content, crystallization stage and ash particle size and surface area with only a small amount of carbon allowed. Improved RHA obtained through controlled combustion and/or grinding can be used as a pozzolanic in cement and concrete. The use of RHA offers many advantages, including improved strength and durability properties. Environmental benefits associated with waste disposal, and reduced carbon dioxide emissions.

**Karthik M. P et al.(2017)** [2] According to their findings, RHA created controlled burning of rice husk is a highly reactive and pozzolanic substance that may be utilized as an additive in concrete to improve its strength and im permeability. The study investigated the strength related properties such as compressive strength, splitting tensile strength, and flexural strength of concrete specimens produced with varying percentages of RHA as cement replacement (0, 10, 12.5, 15)% of RHA. When testing the specimens after 7 and 28 days of curing,the study revealed that 12.5% cement replacement with RHA in concrete resulted in the greatest strength attributes when compared to other replacement levels.

**Binyamien I. Rasoul (2018)** [24] He investigated the influence of the physical characteristics and chemical composition of rice husk Ash as an additive on the qualities of mortar and concrete in the range of 0% to 80% of cement by weight on ordinary Portland cement (OPC). The silica structure, chemical composition, physical properties, and microstructure form of rice husk ash were quantitatively analyzed using a variety of advanced techniques such as X-Ray Diffraction (XRD), X-Ray Fluorescence (XRF), Laser diffraction particle sizing, and scanning electron microscopy (SEM).

**Uday,Sultan ui Iffat (2021)** [25] According to them studied the chemical composition of rice husk ash (RHA) plays a significant role in its impact on concrete after a 7 day curing period. It was found that controlling the burning temperature is crucial to maintain the amorphous state of silica in RHA. To enhance the pozzolanic activity, non-reactive ashes need to be finely crushed, while burning temperatures between 500°C and 700°C for one hour result in increased reactivity due to the micro porous structure and larger surface area of the ash particles. Two models were developed with different percentages of RHA replacement (5% and 10%), and the experimental results were compared to a model without RHA. The findings indicated that the presence of RHA positively influenced the compressive strength of concrete at an early stage.

**Solomon Asrat Enda et al. (2022)** [9] Studied RHA production methods where rice husks could be burned either through open field burning or controlled burning. The quality of RHA, including amorphous silica and carbon content, depends on the temperature and duration of the firing process. Burning rice husks under specific conditions generates RHA with high pozzolanic activity and consistent properties, which can significantly enhance the strength and durability of cement and concrete. The type of silica formed after the combustion process is determined by the burning temperature. RHA particles have an irregular shape, porous surface structure, and non uniform dispersion.The pozzolanic reactivity of RHA is influenced by factors such as amorphous content, specific surface area, and particle fineness. Controlled combustion and grinding can improve these factors, resulting in higher pozzolanic reactivity. The pore structures of RHA vary depending on the rice type, calcination temperature, burning time, holding time, and other factors. therefore, selecting the right rice type and using an appropriate incineration and grinding process is important for producing RHA with higher pozzolanic reactivity.

### 1.2.3 Corrosion in Concrete

**V. Saraswathy et al. (2007)** [26] Indicated in their study that mixing rice husk ash with portland cement can result in concrete that is both durable and valuable. The inclusion of rice husk ash can enhance the concrete's early strength and produce a calisium silicate hydrate (C-S-H) gel around the cement particles, which could improve its resistance to cracking. The researchers evaluated the concrete's corrosion performance using techniques like open circuit potential measurements, rapid chloride ion permeation test, and impressed voltage test.

**K. Ganesan et al.(2008)** [27] Conducted a study to evaluate the physical, chemical, and properties of RHA produced from the residue of a particular rice mill's boiler burned husk. The study found that blending RHA with cement by up to 30% could enhance the strength and permeability characteristics of concrete. Additionally, the study revealed an interesting correlation between water absorbtion, chloride penetration, and chloride diffusion.

**Og˘uzhan Kelestemur, Bahar Demirel(2010**) [28] According to their study, the mechanical and physical properties of concrete samples were studied by replacing cement with finely ground pumice (FGP) at different concentrations of 5%, 10%, 15%, and 20 wt%. It also studies the corrosion behavior of reinforcing steel introduced into these samples. Corrosion studies were conducted to determine the effect of silica fume (SF) additive on the corrosion of steel reinforcement embedded in FGP-treated concrete. Corrosion studies were carried out to investigate the influence of silica fume (SF) additive on the corrosion of reinforcing steels embedded in FGP-treated concrete. The first stage assessed the corrosion potential of reinforcing steels every day for 160 days, while the second stage used cathodic polarization curves to calculate anodic and cathodic polarization values and corrosion currents. The study found that the addition of FGP resulted in a decrease in the specimens' mechanical strength and an increase in the reinforcing steel's corrosion rate. However, the addition of SF significantly reduced the corrosion rate of the reinforcing steel.

**R. E. Nu´nez-Jaquez, et al.(2012)** [29] In this study it was evaluated the corrosion rate of steel in reinforced concrete when 20% sugar cane bagasse ash by weight of cement is added. Six prismatic specimens (7 *7 *10 cm) with a steel rod implanted were created. Three of the cements contained 20% sugar cane bagasse ash by weight, whereas the other three did not. The corrosion rate was evaluated using polarization resistance after all specimens were put in a 3.5% NaCl solution. The findings revealed that reinforced concrete incorporating sugar cane bagasse ash performed well.In compared to reinforced concrete without the addition, it has the lowest corrosion rates.

**G. Mangaiyarkarasi* and S. Muralidharan(2014)**[30] In their study, they developed an inhibitor injection to prevent reinforcement corrosion in chloride-contaminated concrete. The injection was tested in different cement environments and was injected into ordinary portland cement (OPC) and portland slag cement (PSC) with different chloride concentrations. The electro-injection process showed high inhibition efficiency, significantly reducing the corrosion rate of embedded concrete steel even in the presence of aggressive chloride ions. The long-term performance of electro-injection process in concrete slabs was studied for 3 months, and it was found that it enhanced the inhibitory property and removal of free chloride ions from contaminated concrete. FT-IR results confirmed that the inhibitor formulation formed a negative layer on the surface of the rebar even in the presence of chloride.

**Luca Bertolini, et al.(2016)** [31] Through their study, they showed how it is damaged the passive layer on steel bars in concrete by carbonation or chloride penetration, which could lead to corrosion. The study found that carbonation reduced the alkalinity of concrete, thereby destabilizing the passive layer. Additionally, moisture content and environmental exposure were found to influence the corrosion rate of steel in contact with concrete. In the presence of moisture and oxygen, pitting corrosion could occur. Furthermore, chloride ions could locally disrupt the passive film, even in alkaline concrete, leading to corrosion. The study also found that steel bars corroded more quickly in chloride contaminated concrete.

**Dante Galeota, et al.(2018)** [32] They revealed in their study that due to the high alkalinity of non-carbon concrete, which reinforces the steel bars in the concrete is protected from corrosion by passivation, a microscopic oxide layer on the steel surface. Low pH in concrete pore water due to carbonation, as well as chloride concentration exceeding the threshold can cause diffusion or local collapse of the oxide layer. As a result, steel corrosion reinforcement takes place, if enough moisture and oxygen are available. The corrosion products occupy more than twice the volume of the steel an can generate high pressures, resulting in cracking of the concrete, followed in some cases by spalling of the cover.

**Miguel Angel Baltazar, et al. (2019)** [33] Indicated in their study that using supplemental cementitious materials like silica fume to replace up to 20% of portland cement can minimize its consumption. During the first 105 days, specimens containing silica fume and AISI 304 stainless steel reinforcement displayed potential applied ($E_{corr}$) values indicating a 10% likelihood of corrosion and corrosion current density ($I_{corr}$) values showing reinforcement passivity. $I_{corr}$ readings ranged from 105 to 365 days, suggesting that the crucial chloride threshold value was not achieved. The authors attributed this result to silica fume capacity to reduce concrete porosity, resulting in decreased chloride ion permeability. The study revealed that concrete mixes using extra cementitious ingredients are both durable and environmentally friendly.

**Shengpin Liu ,Wu Zhao (2020)** [34] Studied the impact of mineral admixtures marble dust (MD) and silica fume (SF) on the resistance of reinforced concrete to corrosion. The researchers substituted ordinary portland cement with mineral admixtures and evaluated the corrosion of carbon steel in a 5% weight solution of sodium chloride. The results indicated that the sample with the partial substitution of admixtures cement exhibited better corrosion resistance and potential than the other samples.

**B.G. Rolón , P. Fuentes Castañeda(2021)** [35] They showed in their study that using 5wt% of wheat husk ash, corn straw, and sorghum straw in concrete. The concrete produced by each group is then subjected to both conventional and modified processing. Modified treatment of sulfuric and nitric acids was incorporated to match the levels of nitrous and sulfur oxides seen in industrial environments. The ages of the two treatment types were 7, 28, and 90 days. The corrosion resistance of concrete was measured using implanted steel bars, and varying curing conditions had an impact on the properties of the concrete investigated. These results are also under regular and modified curing conditions, and the losses produced with wheat and corn ash enhance the compressive strength, density, and corrosion rate.

**Yu Wang , Zhangfeng Guo (2022)** [36] In the study used pozzolanic materials as partial alternatives to portland cement in concrete, which could improve the resistance of compression and resistance to corrosion of carbon steel rebars. Specifically, the use of synthetic and natural pozzolanic such as silica fume (SF) led to a significant increase in compression resistance and a SEM examination of the steel surface showed that the concrete structure was more intense and homogeneous than a portland cement (p.c)sample.

## 1.3 Conclusion Remarks

1-Most of researchers studied the effect of addition nano-zirconia $ZrO_2$ and rise husk ash on the mechanical properties Such as compressive strength, splitting strength and workability of concrete and mortar.

2-Some of researchers studied the effect of addition(NRHA, $NZrO_2$5wt%YPSZ) on the chemical properties of concrete such as(corrosion rate).

3- There are no previous studies on the synthesis of rice husk nano ash.

4- Most researchers used different temperatures and burning durations starting from (300 to 1000)°C and studied the effect of temperature and burning duration on the composition of the ash formed from rice husks.

5- Based on previous studies the current study focused on producing nanoscale rice husk ash as a sustainable material and partially replacing it with ordinary portland cement, in addition to using ($NZrO_2$-5wt%YPSZ) nanoparticles and studying their effects on each of the physical, mechanical, and chemical properties, especially corrosion.

## 1.4 Outline of the Research

**This thesis consists of the following five chapters:**

- Chapter one consists of a general introduction to sustainability in building materials by using nano-materials as partial substitutes for cement, improving concrete's mechanical, physical, and chemical properties. It also discusses previous studies on this topic.
- Chapter two explores nanomaterials, their classification, and their role in modern construction methods. It describes ordinary portland cement components, industrial nano-zirconia, and rice husk ash materials, and their use to enhance concrete properties.
- Chapter three: This chapter contains the experimental work for adding nanomaterials (NRHA, $NZrO_2$-5wt%YPSZ) to concrete, as well as a description of the devices and tests utilized in the study.
- Chapter four: This chapter discusses all of the results obtained after adding nanomaterials (NRHA, $NZrO_2$-5wt%YPSZ) to the concrete mixture, based on the results of the characterisation tests as well as the mechanical, physical, and chemical testing.
- Chapter five:- provides an overview of the most important results obtained via the use of nanomaterials, as well as the limitations of the study and the most essential recommendations for the future.

## 1.5 Objective of Thesis:

The main objective of this thesis can be summarized in the following points:

1-Preparation of nanomaterial from rice husks and their use as a partial substitute for cement.

2-The use of industrial nanomaterials($ZrO_2$-5wt%YPSZ) as a partial substitute for cement.

3- The primary aim of this study is to investigate the impact of incorporating nanomaterials on the physical, mechanical, and chemical properties of concrete.

4-The focus is on reducing the porosity of concrete and enhancing its microstructure to achieve improved performance.

# Abstract

This research work aims to study the effect of incorporating nano materials, specifically nano- Yttria partially stabilized zirconia (NPs $ZrO_2$-5wt%YPSZ) nanoparticles of rice husk ash (NRHA) on some properties of concrete(physical, chemical and mechanical), and then to compare the effect of the two materials on those Properties.

In this study, nanomaterial was synthesized in the laboratory using rice husks(RH) as the initial material. The prepared nano material underwent characterization tests, including X-ray diffraction (XRD), Energy dispersive X-Ray (EDX), Particle size distribution (PSD), X-Ray fluorescence (XRF) and Field-emission scanning electron microscopy (FE-SEM).

Concrete mixtures were prepared by incorporating (NPs $ZrO_2$-5wt%YPSZ) at varying ratios of (0, 0.3, 0.5, 0.7) wt%, as well as NRHA at (0,5,10,20) wt% as a partial replacement of cement in the concrete mixture. The study focused on evaluating the properties of concrete, including water absorption, porosity, density and compressive strength at different ages (7, 28, and 90) days. Additionally, the splitting strength was assessed at 28 days. While the workability of all mixes were obtained by applying the slump test on fresh concrete. To evaluate the corrosion rate, the tafel extrapolation method was used on three groups of samples, each group was exposed to electrolyte solution containing 5% NaCl at different ages (14, 28, 52 )days.

Results of rice husk ash analysis using X-ray diffraction (XRD) technique and X-Ray Fluorescence(XRF) technique indicated that it primarily consists of amorphous material. It contains a large amount of $Sio_2$.

After the milling process, Field-emission scanning electron microscopy (FE-SEM) analysis of rice husk ash revealed the average particle size (57)nm.

Concrete workability tests indicate that the optimal ratio for (NPs $ZrO_2$-5wt% YPSZ) is 0.5wt%, but increasing it to 0.7wt% results in a significant decrease. Workability initially increased with 5wt% RHA, but decreased as RHA percentage increased to 20wt% , when compared with the reference sample. As a result of the increased fineness and larger surface area of the nanoparticles.

The results of the absorption and porosity test show that (NPs $ZrO_2$-5wt % YPSZ) It has a simple effect on concrete ,while the absorption rate decreased when adding 5 wt% NPsRHA  at comparison with the reference sample, due to the increased gel formation (C-S-H),this led to the closure of pores and reduced the absorption rate.

Density test results showed that adding (NPs $ZrO_2$-5wt% YPSZ) increased the density of concrete. While there was a slight decrease in the density of concrete after addition 20 wt% NPsRHA  compared to the reference sample.

The improvement in the compressive strength when used (NPs $ZrO_2$-5wt% YPSZ) 0.7wt% has been(30.5%),while using5wt% NPsRHA increase compressive strength(105)% for 28 days , compared to the reference sample.

The improvement in the splitting strength when used (NPs $ZrO_2$-5wt% YPSZ) 0.7wt% has been(21.2%), while using10wt% NRHA increase splitting strength(185.7)% for 28 days , compared to the reference sample.

Corrosion tests demonstrated that the nanoparticles are effective corrosion inhibitors, resulting in increased corrosion resistance. After 28 days of exposure to a sea water environment, the addition of  (NPs $ZrO_2$-5wt% YPSZ) 0.7wt% reduced the corrosion rate (58%), whereas the addition 20wt%  NPsRHA   reduced the corrosion rate (80.6%).