CAPTER ONE

INTRODUCTION

1.1 Background

A nondestructive examination can be defined as an examination carried out without damaging the sample or origin and without affecting its properties or there uses the definition includes a group of tests that use different techniques.

Ultrasoundiswaveswhosefrequencyisgreaterthanthefrequencyheardby the human ear (20 _ 20000 Hz), and these waves behave the behavior of electromagneticandlightwavesintermsofrefractionandreflectionaswell as they can travel in gaps [1].

Ultrasonic Testing (UT) uses a high frequency sound energy to conduct examinationsandmakemeasurements.Ultrasonicinspectioncanbeusedfor flaw detection I evaluation, dimensional measurements, material characterization, and more. A typical UT inspection system consists of several functional units, such as the pulser/receiver, transducer, and display devices. A pulser/receiver is an electronic device that can produce high voltageelectricalpulse.Drivenbythepulser,thetransducerofvarioustypes and shapes generates high frequency ultrasonic energy operating based on the piezoelectricity technology with using quartz, lithium sulfate, or various ceramics. Most inspections are carried out in the frequency range of 1 to 25MHz. Couplets are used to transmit the ultrasonic waves from the transducer to the test piece; typical couplets are water, oil, glycerin and grease.

Non destructive testing of concrete aims to clarify some of its hardening properties without any damage ,and to clarify the quality and homogeneity of the concrete sample ,the examination is done in various devices ,through theses testes it's possible to determine the resistance to compression and densityandtheextentofthepresenceofinternalcracksandgapsandplaces of rebar and surface hardness, nondestructive tests areamong the most importanttestesthathelpinpreparingreportsintheeventofproblemsinthe concrete such as gaps and cracks[2].

1.2 Research Problem

Detecting and reviewing concrete defects is very important to avoid future damages,thestudyinvestigationmoremethodsofdetectinggapsandcracks using ultrasound and finding better methods of examination through the results of the detection in several differentways.

1.3 PreviousStudies

Sung Woo Shin, JinyingZhu ,2008, The relationship between the spectral energy transfer and the ratio of depth cracks in concrete was studied using experimental results, The spectral energy transmission ratio is applied for crack-depthestimation.Experimentswereperformedonaconcreteslabthat containsasurface-breakingcrackwithdepthlinearlyvaryingfrom10to160 mm(0.4to6.3in.).Theobtainedresultsdemonstratethatthespectralenergy transmission ratio depends only on the depth of the crack and is very sensitive to changes in depth[13].

Shiotani ,Aggelis 2012, Determination of surface crack depth and repair effectiveness using Rayleigh waves, wave inspection is described on a cracked concrete bridge deck, where the cracks were repaired with epoxy agent. It is concluded that the investigation demonstrated the efficiency of theinjection,sincewaveenergyandvelocitywererestored[14].

Paritoshgiri ,spandanmishra ,2019, Detection of Gaps in Concrete–Metal Composite Structures Based on the Feature Extraction Method Using Piezoelectric Transducers, A feature extraction methodology based on lamb waves is developed for the non-invasive detection and prediction of the gap in concrete–metal composite structures, such as concrete-filled steel tubes. Apopularfeatureextractionmethod,partialleastsquaresregression,is utilised to predict the gaps. The data is collected using the piezoelectric transducers attached to the external surface of the metal of the composite structure. A piezoelectric actuator generates a sine burst signal, which propagates along the metal and is received by a piezoelectric sensor. The partial least squares regression is performed on the raw sensor signal to extract features and to determine the relationship between the signal andthe gap size, which is then used to predict the gaps. The applicability of the developedsystemistestedontwoconcrete-metalcompositespecimens.The first specimen consisted of an aluminium plate and the second specimen consistedofasteelplate.Thistechniqueisabletodetectandpredictgapsas low as 0.1 mm. The results demonstrate the applicability of this technique for the gap and debonding detection in concrete-filled steel tubes, which are critical in determining the degree of composite action between concrete and metal**[**15**].**

1.4 The Objectives of thisResearch

1.4.1 GeneralObjective

1. To focus at the importance of using ultrasonictest.

2. To minimize the use of NDT methods for confirmingresult

3. To minimize cost andtime

4. preserving facilities from future collapse through nondestructivetesting

1.4.2 Specific Objectives

Determine the depth of cracks and gaps in concrete ,and compare two methods of measurement directly and indirectly .

1.5 ResearchMethodology

The methodology to accomplish this work can be summarized in the phasesbelow:

First phase: prepare concrete samples by using molds of specific dimensions ,then submerge them in water for seven days ,and then remove them for the purpose of conducting the tests .

Second phase: examination of concrete samples by using ultrasound by passing before and after cracks ,and in places where there are no gaps.

Last phase: comparing the results of the ultrasound examination of the samples regarding to the depth of cracks and gaps with the previously known true depth.

1.6 ResearchLayout

Theresearchcontentfivechapters,chapteroneincludeanintroductionabout research ,chapter two include the basic principles ,destructive and nondestructive testing ,types and testing methods ,chapter three include the ultrasonic testing, using ultrasonic for concrete ,chapter four include Experimental part ,material and method ,chapter five includes the results , desiccation, recommendation and conclusion.

CAPTER TWO
PASIC PRINCIPLE

2.1 Destructive testing:(DT)

Destructive testing (DT) is a form of organism analysis that involves applying a fracture test to a specific substance to determine its physical properties,suchasmechanicalpropertiesofstrength,durability,flixbiltyand hardness , its frequently used as a test for items produced in large quantities inwhichthecostofdestroyingalimitednumberofsamplesiseconomically viable[8].

In destructive testing, or (Destructive Physical Analysis DPA) tests are carried out to the specimen's failure, in order to understand a specimen's structural performance or material behavior under different loads. These tests are generally much easier to carry out, yield more information, and are easier to interpret than nondestructive testing. Destructive testing is most suitable,andeconomic,forobjectswhichwillbemass-produced,asthecost of destroying a small number of specimens isnegligible.

Destructive testing (DT) includes methods where your material is broken down in order to determine mechanical properties, such as: Tensile Testing (TT), Hardness Testing (HT) Stress Rupture Testing (SRT),...[3].

2.1.1 Types of destructivetesting

In destructive testing the product is exposed to actual or simulated use environments and is tested according to the conditions required for the product , from these tests .[8]

- The tensiletesting
- Hardness testing
- Creeptesting
- Fatiguetesting
- Collisiontest
- Bending test

2.2 Non Destructive testing (NDT)

Nondestructive testing (NDT) is the process of inspecting, testing, or evaluating materials, components or assemblies for discontinuities, or differencesincharacteristicswithoutdestroyingtheserviceabilityofthepart or system. In other words, when the inspection or test is completed the part can still beused.

Non-destructive testing (NDT) is a mechanism used to detect defects in materials and structures, either during manufacturing or while in service. Typically,themethodsusedareultrasonic's,radiography,magneticparticle, eddycurrent,dyepenetrantandvisualmethods.Thisimportantandgrowing industry is involved in applying these proven techniques and procedures to thefullrangeofengineeringstructures.WhenNDTisdeployedtobesteffect as part of the complete engineering design process, it ensures the safe, reliable and long-lasting integrity of structures, such as power stations, aircraft, oil & gas installations and other safety-critical plant. The field of NDT is a very broad, interdisciplinary field that plays a critical role in inspectingthatstructuralcomponentandsystemsperformtheirfunctionina reliable fashion. Certain standards has been also implemented to assure the reliability of the NDT tests and prevent certain errors due to either the fault in the equipment used, the miss-application of the methods or the skill and the knowledge of the inspectors. Successful NDT tests allow locating and characterizing material conditions and flaws that might otherwise cause planestocrash,reactorstofail,trainstoderail,pipelinestoburst,andvariety of less visible, but equally troubling events. However, these techniques generally require considerable operator skill and interpreting test results accurately may be difficult because the results can be subjective. These methodscanbeperformedonmetals,plastics,ceramics,composites, cermets, and coatings in order to detect cracks, internal voids, surface cavities, delamination, incomplete c defective welds and any type of flaw that could lead to premature failure.[3]

Thereareseveraltypesofnondestructivetestingsuchasvisualtesting(VT), liquid penetrates testing (PT), eddy currant testing (ET), magnetic practical testing(MT), radiographic testing (RT), ultrasonic testing (UT), thermal inferred testing(FT),we will talk in the section visual testing (VT), liquid penetrates testing (PT), eddy currant testing (ET), magnetic practical testing(MT)

There are many NDT techniques methods used depending on four main criteriasuchasMaterialType,DefectType,DefectSizeandDefectlocation five The most frequently used test methodsincluding:

Visual testing (VT), Eddy current testing (ET), Magnetic particle testing (MT), Liquid penetrates testing (PT), Ultrasonic testing (UT) and Radiographic testing (RT).[4]

2.2.1 Visual Testing(VT)

Often overlooked in listings of NDT methods, visual inspection is one of the most common and Powerful means of non-destructive testing. Visual testingrequiresadequateilluminationofthetestsurfaceandpropereyesight ofthetester.Tobemosteffectivevisualtestingrequirestraining(Knowledge of product and process, anticipated service conditions, acceptance criteria, record keeping, For example). It is also a fact that visual testing ultimately must substantiate all defects found by other NDTmethods[4]

2.2.2 Liquid Penetrates(PT)

Liquid penetrate inspection (PT) reveals surface flaws by the “bleed-out” of penetrating medium against a contrasting background. This is done by applying penetrate to the pre-cleaned surface and flaw of the item being inspected. The penetrate is applied to the surface and allowed to remain on the surface for a prescribed time (dwell time); the penetrate liquid will be drawn into any surface opening by capillary action. Following removal of excess penetrate an application of a developer reverses the capillary action and draws penetrate from the flaw. The resultant indications reveal the presence of the flaw so that it can be visually inspected and evaluated [4]

2.2.3 Magnetic Particle Testing(MT)

Magnetic particle testing is used for the testing of materials, which can be easily magnetized.

This method is capable of detecting open to surface and just below the surface flaws. In this Method, the test specimen is first magnetized either by using a permanent or by anelectromagnet

On the other hand, by passing electric current through or around the specimen.Themagneticfieldthus Introducedintothespecimeniscomposed of magnetic lines of force. Whenever there is a Flaw, which interrupts the flowofmagneticlinesofforce,someoftheselinesmustexitandreenterthe specimen[5].

2.2.4 Radiographic Testing (RT)

Radiography uses an x ray device or radioactive isotopes as a source of radiation,whichpassesthroughthematerialandiscapturedonfilmordigital device

After processing the film, an image of varying density is obtained. Possible imperfections are identified through density changes.[5]

2.2.5 Ultrasonic Testing(UT)

Ultrasonic inspection uses high frequency sound waves to detect imperfections or changes in properties within the material.

Itcanalsobeusedtomeasurethicknessofawiderangeofmetallicandnon-metallic materials where access from one side only isavailable[5].

2.3 Types of defects anddiscontinuities

The types of defects that nondestructive testing is called upon to find can be classed into three groups :

(1) Inherent defects : introduced during the production of the basematerial
(2) Processing defects : introduced during the processing of thematerial
(3) Service defects : introduced during the operatingcycle

Discontinuities are generally categorized according to the stage of the manufacturing or use in which they initiate therefore discontinuities are categorized in four groups which are [8].

(1) Primarydiscontinuities
(2) Fabricatingdiscontinuities
(3) Processingdiscontinuities
(4) Servicediscontinuities

2.3.1 Defectexamples

There are many defects that are detected by various nondestructive testing methods forexample

1. Cracks and gaps

During the manifesting process cracks or gaps may occur within the material structure or during her service she may weaken over time an be subject to erosion there are two types of cracks surface cracks and internal cracks .

2. Segregation

Material segregation almost always occurs at discontinuities material these discontinuities include grain boundaries dislocations laminations and pores , Segregation increases the concentration of one type of molecule in a given area of material ,it creates material that is less homogeneous .

3. Fatigue

It is gradual and focused structural de formation that occurs when the material is subjected to periodic and repeated loads .

4. Blowholes

Tiny gas bubbles are called porosities but larger gas bubbles are called blowholes , such defects can be caused by air entrained in the melt , steam or smoke from the casing sand , or other gasses from the melt .

CHAPTER THREE

ULTRASONIC TESTING

3.1 UltrasonicWaves

Ultrasonic waves, like sound waves are mechanical vibrations having frequencies above the audible range. The audible range of frequencies is usually taken from 20 Hz to 20 kHz. Sound waves with frequencies higher than 20 kHz are known as ultrasonic waves. In general ultrasonic waves of frequency range 0.5 MHz to 20 MHz are used for the testing of materials. They can propagate in solid, liquid and gas but not in vacuum. Sound can travel in the form of beam similar to that of light and follows many of the physicalrulesoflight.Ultrasonicbeamcanbereflected,refracted,scattered or diffracted Ultrasound is a form of mechanical vibration [1].

3.2 Characteristics OF WavePropagation

a. Frequency

Thefrequencyofawaveisthesameasthatofthevibrationoroscillationof theatomsofthemediuminwhichthewaveistravelling.Itisusuallydenoted by the letter (f) and is expressed as the number of cycles per second. The internationaltermforacyclepersecondisnamedafterthephysicistH.Hertz and is abbreviated asHz

Frequency plays an important role in the detection and evaluation of defects[6].

b. Velocity

The speed with which energy is transported between two points in a medium by the motion of waves is known as the velocity of the waves. It is usually denoted by the letter (v). SI unit of velocity is meter per second (m/s)[6].

c. Wavelength

DuringthetimeperiodofvibrationT,awavetravelsacertaindistanceinthe medium. This distance is defined as the wavelength of the wave and is denotedbytheGreekletterλ.Atomsinamedium,separatedbydistance(λ) willbeinthesamesateofmotion(i.e.inthesamephase)whenawavepasses through the medium[6].

d. Acousticimpedance

Theresistanceofferedtothepropagationofanultrasonicwavebyamaterial is known as the acoustic impedance. It is denoted by the letter (Z) and is determinedbymultiplyingthedensityofthematerial(ρ)bythevelocity(v) of the ultrasonic wave in the material[7].

$$Z = v \tag{3.1}$$

e. AcousticPressure

Acoustic pressure is a term most often used to denote the amplitude of alternating stresses on a material by propagating ultrasonic wave. Acoustic pressure (P) is related to the acoustic impedance (Z) and the amplitude of particle vibration (a) [7] .

$$P = Za \tag{3.2}$$

f. AcousticIntensity

The transmission of mechanical energy by ultrasonic waves through a unit cross section area, which is perpendicular to the direction of propagation of the waves, is called the intensity of the ultrasonic waves. Intensity of the ultrasonic waves is commonly denoted by the letter (I). Intensity (I) of ultrasonic waves is related to the acoustic pressure (P), acoustic impedance (Z) and the amplitude of vibration of the particles (a) as [7].

$$I = P^2/2Z \quad (3.3)$$

And

$$I = pa/2 \quad (3.4)$$

3.3 Types Of UltrasonicWaves

Ultrasonic waves are classified on the basis of the mode of vibration of the particles of the medium with respect to the direction of propagation of the waves, namely longitudinal, transverse, surface and lamb waves [3].

3.3.1 Longitudinal Waves

In longitudinal waves, the oscillations occur in the longitudinal direction or the direction of wave propagation. Since compression and expansion forces areactiveinthesewaves,theyarealsocalledpressureorcompressionwaves. They are also sometimes called density waves because material density fluctuatesasthewavemoves.Compressionwavescanbegeneratedingases, liquids, as well as solids because the energy travels through the atomic structure by a series of compressions and expansionmovements[3].

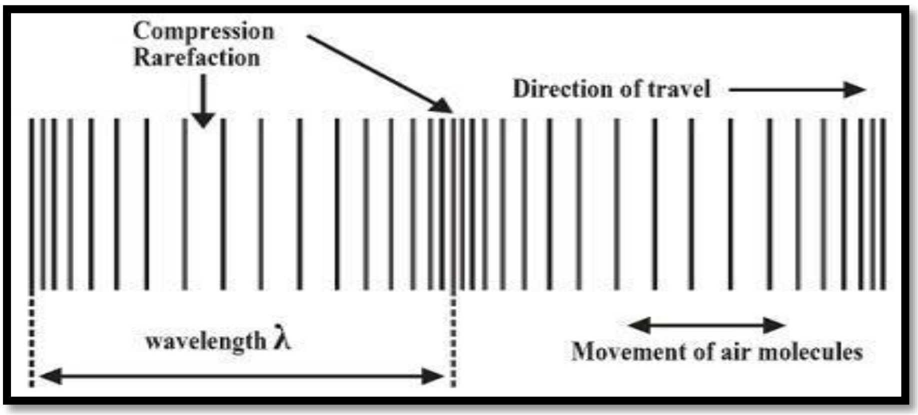

Fig 3.1 **:**longitudinal wave

3.3.2 Transversewaves

In the *transverse or shear waves*, particles oscillate at a right angle or transverse to the direction of propagation. Shear waves require an acoustically solid material for effective propagation, and therefore, are not effectively propagated in materials such as liquids or gasses. Shear waves are relatively weak when compared to longitudinal waves. In fact, shear waves are usually generated in materials using some of the energy from longitudinal waves[3].

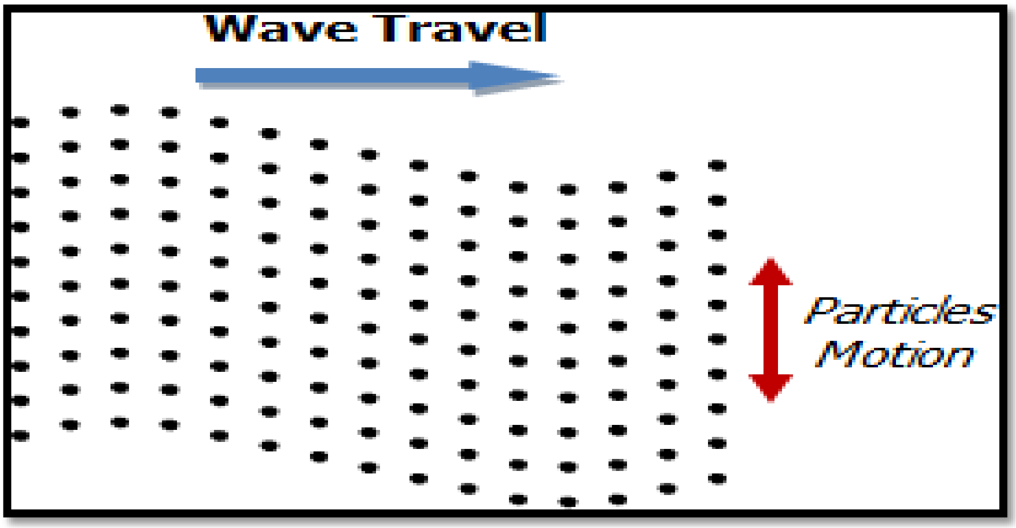

Fig 3.2 **:**Transverse Wave

3.3.3 Surfacewaves

Surface waves were first described by Lord Rayleigh and that is why they are also called Rayleigh waves. These type of waves can only travel along a surface bounded on one side by the strong elastic forces of the solid and on the other side by the nearly non-existent elastic forces between gas molecules. Surface waves, therefore, are essentially non-existent in a solid immersedinaliquid,unlesstheliquidcoversthesolidsurfaceonlyasavery thinlayer.Thewaveshaveavelocityofapproximately90percentthatofan equivalentshearwaveinthesamematerialandtheycanonlypropagateina region no thicker than about one wavelength beneath the surface of the material. At this depth, the wave energy is about 4 percent of the energy at the surface and the amplitude of vibration decreases sharply to a negligible value at greater depths[8].

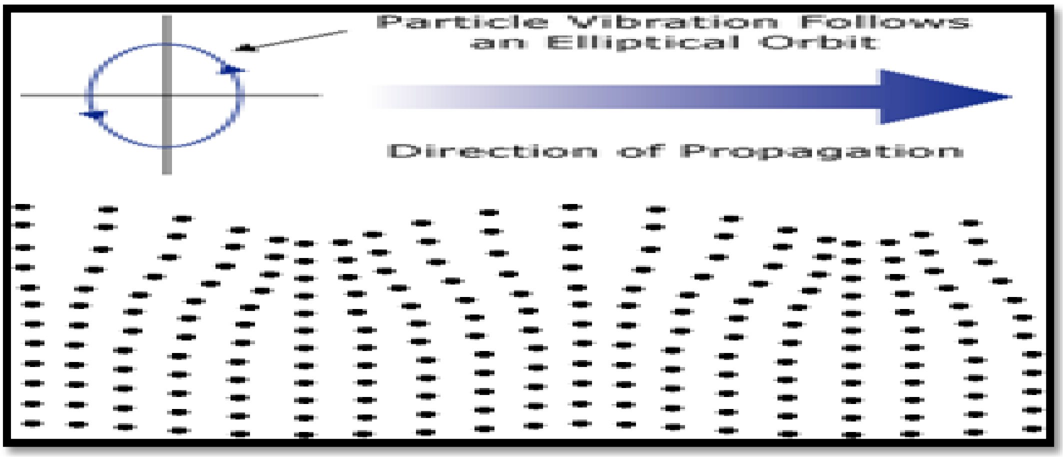

Fig 3.3 **:**Surface Wave

3.3.4 Lamb or latewaves

If a surface wave is introduced into a material that has a thickness equal to threewavelengths,orless,ofthewavethenadifferentkindofwave,known as a plate wave, results. The material begins to vibrate as a plate, i.e. the waveencompassestheentirethicknessofthematerial.Thesewavesarealso called Lamb waves because the theory describing them was developed by Horace Lamb in 1916. Unlike longitudinal, shear or surface waves, the velocities of these waves through a material are dependent not only on the typeofmaterialbutalsoonthematerialthickness,thefrequencyandthetype ofwave[8].

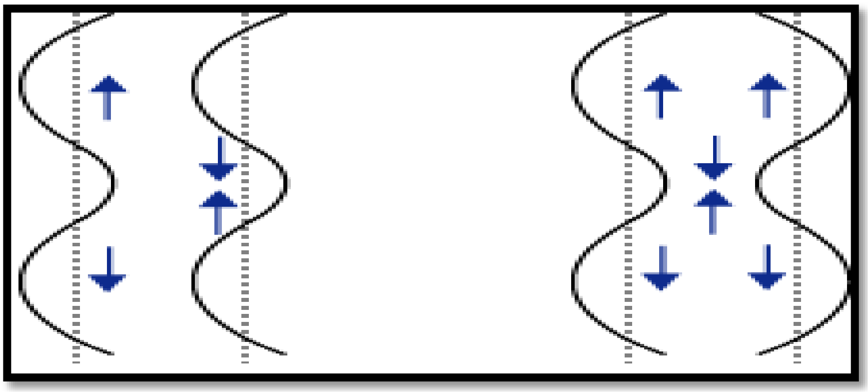

Fig3.4 PlateWave

3.4 Reflection and transmission at normalincidence

When ultrasonic waves are incident at right angles to the boundary (i.e. normalincidence)oftwomediaofdifferentacousticimpedances,thensome ofthewavesarereflectedandsomearetransmittedacrosstheboundary.The surfaceatwhichthisreflectionoccursisalsocalledaninterface.Theamount ofultrasonicenergythatisreflectedortransmitteddependsonthedifference betweentheacousticimpedancesofthetwomedia.Ifthisdifferenceislarge then most of the energy is reflected and only a small portion is transmitted acrosstheboundary.Whileforasmalldifferenceintheacousticimpedances most of the ultrasonic energy is transmitted and only a small portion is reflected back[8].

3.5 Reflection and transmission at obliqueincidence

Ifultrasonicwavesstrikeaboundaryatanobliqueangle,thenthereflection and transmission of the waves become more complicated than that with normal incidence. At oblique incidence the phenomena of modeconversion (i.e. a change in the nature of the wave motion) and refraction (a change in the direction of wave propagation) occur [8].

3.6 Generation of ultrasonicwaves

Generationofsoundisaphenomenonwhereindifferentformsofenergyare converted into sound energy which in turn is the energy of mechanical vibrations. For example, in the case of piezoelectric transducers electrical energyisconvertedtosoundenergy.Inmagnetostrictivetransducersitisthe effect of magnetic field which is utilized to induce mechanical vibrations in some special materials. In mechanical transducers it is the shock or friction which generates ultrasound. The electromagnetic generation of sound is by theuseofthefactthatifamagneticalternatingfieldactsuponanelectrically conductive body, eddy currents are induced in it. Due to the interaction betweeneddycurrentsandtheexternalmagneticfieldaforcecalledLorentz force is produced in the test piece which generates the sound. In the electrostatic process a force acts between the plates of a capacitor. If one plate of the capacitor is movable then sound can be generated by an alternating voltage. Use can also be made to convert thermal energy into sound energy. A sudden heating up of a solid surface causes a sudden local extensionofthematerial.Themechanicaltensionsproducedbythisprocess excite sound waves with a wide frequency spectrum. Laser lights and electron beams are usually used for very rapid and strongheating[7].

3.7 PiezoelectricTransducers

The conversion of electrical pulses to mechanical vibrations and the conversion of returned mechanical vibrations back into electrical energy is the basis for ultrasonic testing. This conversion is done by the transducer using a piece of piezoelectric material (a polarized material having some parts of the molecule positively charged, while other parts of the molecule arenegativelycharged)withelectrodesattachedtotwoofitsoppositefaces. Whenanelectricfieldisappliedacrossthematerial,thepolarizedmolecules will align themselves with the electric field causing the material to change dimensions. In addition, a permanently-polarized material such as quartz (SiO_2) or barium titan ate ($BaTiO_3$) will produce an electric field when the material changes dimensions as a result of an imposed mechanical force. This phenomenon is known as the piezoelectriceffect[8].

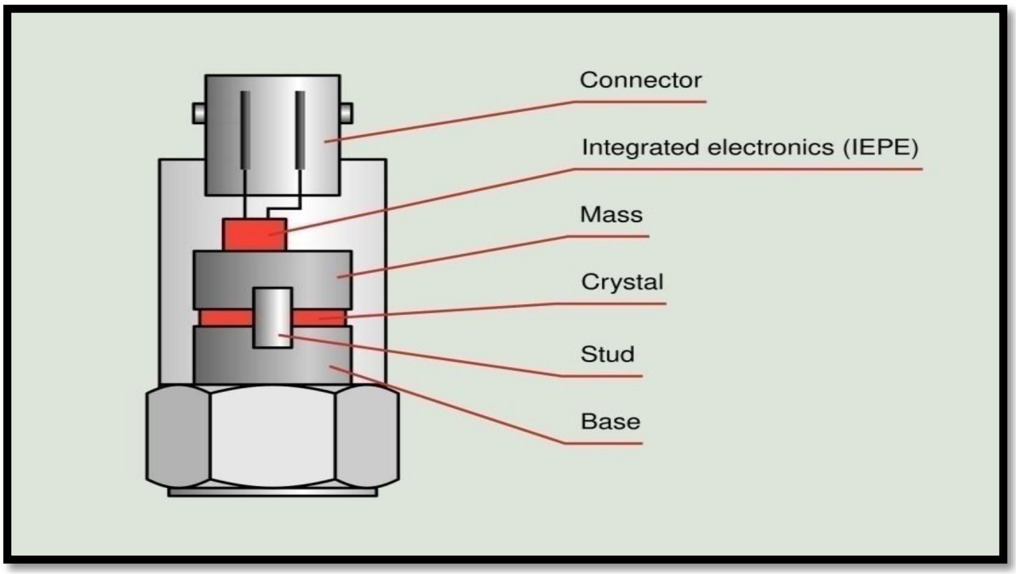

Fig 3.5 : Piezoelectric Transducers

3.8 Basic Ultrasonic TestMethod

Ultrasonic waves arriving at an interface between two media are partially reflected into the medium from which they are incident and partially transmitted into the other medium. The method of ultrasonic testing which utilizes the transmitted part of the ultrasonic waves is the through transmission method while that which makes use of the reflected portion of the waves is classified as the pulse echo test method. Another method which is used for the ultrasonic testing of materials is the resonance method[7].

3.8.1 through transmission method

In this method two ultrasonic probes are used. One is the transmitter probe and the other is the receiver probe. These probes are situated on opposite sides of the specimen

Presence of an internal defect is indicated by a reduction in signal amplitude, or in the case of gross defects, complete loss of the transmitted signal [8].

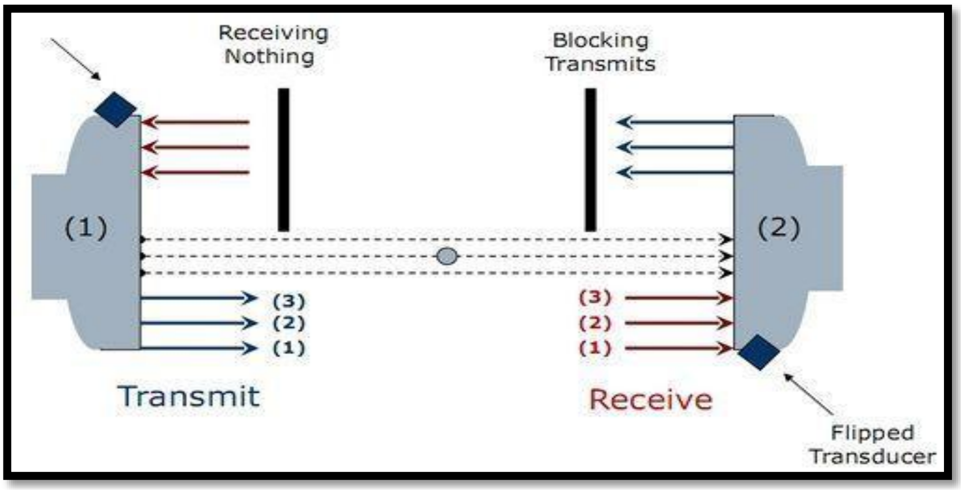

Fig 3.6 **:**Transmission method

3.8.2 Pulse echomethod

This is the technique most commonly utilized in the ultrasonic testing of materials. The transmitter and receiver probes are on the same side of the specimenandthepresenceofadefectisindicatedbythereceptionofanecho before that of the back wall echo. Mostly the same probe acts as the transmitter as well as the receiver. The CRT screen is calibrated to showthe separationindistancebetweenthetimeofarrivalofadefectechoasagainst that of the back wall echo of the specimen, therefore, the location of a defect can be assessed accurately. The principle of the pulse echo method[8].

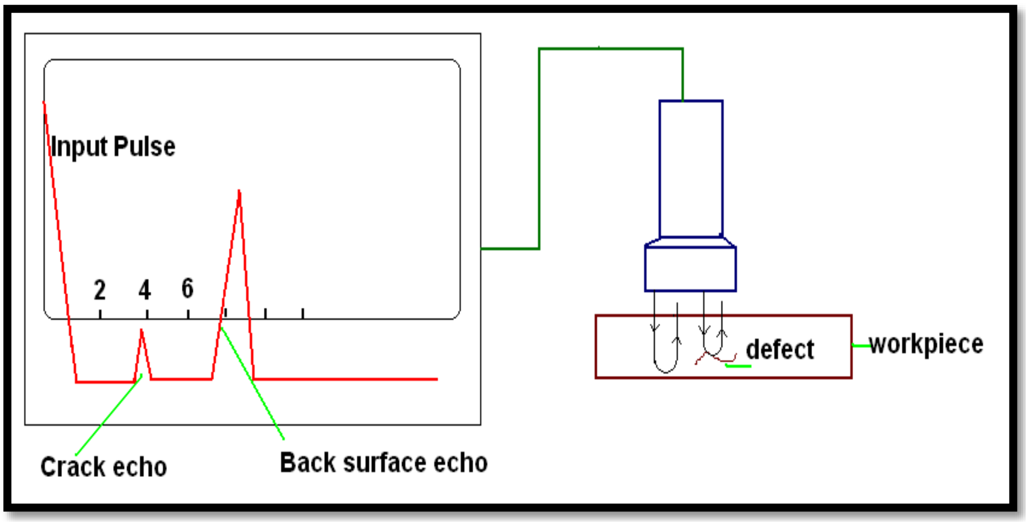

Fig 3.7 **:**Pulse –Echo Method

3.9 Advantages andDisadvantages

The primary advantages and disadvantages when compared to other NDT methods are:

3.9.1 Advantages

- **a.** It is sensitive to both surface and subsurfacediscontinuities.
- **b.** The depth of penetration for flaw detection or measurement is superior to other NDTmethods.
- **c.** Only single-sided access is needed when the pulse-echo technique isused.
- **d.** It is highly accurate in determining the reflector position and estimating its size andshape.
- **e.** It provides instantaneousresults.

f. Detailed images can be produced with automatedsystems.

g. It is nonhazardous to operators or nearby personnel and does not affect the material beingtested.

h. It has other uses, such as thickness measurement, in addition to flaw detection.

3.9.2 Disadvantages

a. Surface must be accessible to transmitultrasound.

b. Skill and training is more extensive than with some othermethods.

c. It normally requires a coupling medium to promote the transfer of sound energy into the testspecimen.

d. Materials that are rough, irregular in shape, very small, exceptionally thin or not homogeneous are difficult to inspect.

e. Cast iron and other coarse grained materials are difficult to inspect due to low sound transmission and high signal noise.

f. Lineardefectsorientedparalleltothesoundbeammaygoundetected.

g. Reference standards are required for both equipment calibration and the characterization offlaws[9].

3.10 Application ofNDT

- Aerospace industry: testing components including aero-engines landing gear and flame parts duringproduction.
- Aircraft overhaul including aero-engine and landing gear components for flaws introduced duringmanufacture.
- Ironcastings–materialquality:testingofdieselenginepistonsuptomarine enginesize.

- Petrochemical Gas industries: pipe-line and tank internal corrosion measurement from outside-weld testing on new work. Automotive LRG tanktesting.
- Railway industry: testing locomotive and volingstak axles from fatigue cracks. Testing rail for heat induced cracking Diesel locomotive engines and structure.
- Mining industry: testing of pit head equipment and underground transport safety criticalcomponents.
- Agriculturalengineering:testingofallfabricated,forgedandcostcomment in agricultural equipment including those in tractorengines.
- Power generation: boiler and pressure vessel testing for weld and plate defect both during manufacturing and in subsequent service Boiler pipe work thickness measurement and turbine altimeter componenttesting.
- Ironfoundry:testingductileironcastingsformetalon100%qualitycontrol basis.
- Shipbuilding industry: structural and welding testing. Hull and baldhead thickness measurement engine componentstesting.
- Steel industry: testing of rolled and re-rolled products including billets, plate sheet and structuralsections[8].

3.11 Using ultrasonic for concrete

The general idea of this test depends on sending ultrasound pulses through theconcreteandsettingitstransmissiontimeasthespeedofthewavesinside thebodydependsonthedensityofthebodyanditselasticproperties,Travel time of ultrasonic waves reflects internal condition of test area. In general, foragiventrajectory,highertraveltimeiscorrelatedtolowqualityconcrete with more anomalies and deficiencies, while lower travel time is correlated tohighqualityconcretewithfeweranomalies.Onceultrasonicwavespreads withinthetestarea,thewaveisreflectedinboundaryofanomaliesresulting in higher travel time. This results in higher transmission time (lower wave speeds) in poor quality concrete and lower transmission time (higher wave speed) in good quality concrete[11].

3.11.1 Concrete

Concrete is a manmade building material that looks like stone. The word “concrete” is derived from the Latin concretes, meaning “to grow together.” Concrete is a composite material composed of coarse granular material (the aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fill the space among the aggregate particles and glues them together.Alternatively,wecansaythatconcreteisacompositematerialthat consistsessentiallyofabindingmediuminwhichareembeddedparticlesor fragments ofaggregates

Concrete is the most common building material used in today's construction industry. It can be cast in any desired shape and fashion and is therefore applicable for most building purposes. Its long life and relatively low maintenance requirements add to its popularity. Concrete does not rot, rust or decay and is resistant to wind, water, rodents and insects. It is a non-combustible material, making it fire resistant and able to withstand high temperatures. In the road sector, concrete is used for a number of purposes, including pavements, bridges, culverts, retaining walls and other structures.

3.11.2 Concretecomponents

Concreteisacompositematerialmadeoffinecoarseaggregateandbounded withliquidcementthathardensovertimeWhenaggregateismixedwithdry Portland cement and water, the mixture forms a fluid slurry that is easily poured and molded into shape. The cement reacts with the water and other ingredientstoformahardmatrixthatbindsthematerialstogetherintoa durable stone-like material that has many uses. the compositions can be listed as follows:

Cement : The purpose of cement is to bind the concrete.

Water : Combining water with a cementations material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely.

Aggregates: Fine and coarse aggregates make up the bulk of a concrete mixture. Sand, natural gravel, and crushed stone are used mainly for this purpose.[10].

3.12 Principle and Crack DepthEstimation

The ultrasonic pulse transmits a very small amount of energy through air. Therefore, if a pulse traveling through the concrete comes upon an air filled crackoravoidwhoseprojectedareperpendiculartothepathlengthislarger than the area of the transmitting transducer; the pulse will get diffracted aroundthedefect.Thus,thepulsetraveltimewillbegreaterthanthatthrough a similar concrete without any defect. The pulse velocity method, therefore, is effective in locating cracks, cavities, and other such defects. It should be pointedoutthattheapplicationofthistechniqueinlocatingflawshasserious limitations.Forexample,ifthecracksandflawsaresmalloriftheyarefilled with water or other debris, thus allowing the wave to propagate through the flaw,thepulsevelocitywillnotsignificantlydecrease,implyingthatnoflaws exist[12].

3.13 Direct and Indirect Depth Estimation

Tow methods are used here to determine the crak depth .The first are is termed direct method . In the direct method the ultrasonic device give the depth readings directly .For Indirect one the depth needs using certain mathematical relation and some calculation to fine the depth.

CHAPTER FOUR

EXPERIMENTAL PART

4.1 Introduction

Study to determine the depth of the incision ,and determine the gap inside the concrete in two ways directly and indirectly .

Study Design: concrete sample were prepared by weight ratios 1:2:4 (cement ,sand ,gravel) by calculating the actual volume required (code of practice for regular and reinforced concrete .IS 456- 2000 ,M15) ,and ultrasound examination after making the defects that will be identified

4.2 Material

Two samples of concrete were produced with dimension (20,20,50) cm

A vertical incision was made in the first sample with a depth of 5 cm ,and another incision with a depth of 10 cm in the second sample ,with a width not exceeding 4mm for the two samples .

Fig (4.1) : clarify the crack in the concrete

_ Two samples of concrete were produced with dimension (20,20,50) cm

A gab was created by placing a 4 cm diameter rubber ball into the samples with known dimensions

Fig (4.2) :a concrete sample with an internal gap (TICO PROCQE)

Ultrasonic flow detector for concrete .which is used for nondestructive testing of concrete .in particular, the following properties can be determined:

-Uniformity of the concrete

-Cavities, cracks defects due to fire and frost

-Elasticity module

Concrete strength

-

Fig (3.3) :TICO PROCEQ

Ultrasonic probe is a very important sensor which generate acoustic signals the performance and imaging quality of ultrasonic scanner are highly affected by the characteristic and the structure .

Fig (4.4): Ultrasonic probe

4.3 Method

4.3.1 Samplespreparation:

concrete sample were prepared by weight ratios 1:2:4 (cement ,sand ,gravel),the mixing was done manually and then the molds were preparedin dimensions (20*20*50) for pouring the concrete ,after completing the molding process and filling the molds ,the surface of the samples was modified usingtrowel.

All samples were removed from the molds approximately 24 hours after the time of casting , and after removing the molds the samples were immersed in water for seven days .

4.3.2 Measuring Processes

TICO PROCEQ ultrasound machine was used to detect defects within the produced concrete samples ,the results are reported in the tables in the next chapter.

CHAPTER FAIV

RESULTSAND DISCUSSION

5.1 Results andDiscussion

Obtained by ultrasound of the depth of the incision and the location of the gapinsidetheconcrete,inthischapterwereviewtheresultsanddiscussthem

5.1.1 Finding the depth of the craksThe first way

a. After the ultrasound examination of the first sample ,thefollowing readings were recorded:

Ta =61.5µs **Depth=**50mm

Tb=68.2 µs **L =**100mm

d=$100\sqrt{\frac{(68.2)^2}{(61.5)^2}-1}$ = 47.9mm

it turns out that the calculated depth of fissure in this samples is 47.9 mm while the actual depth is 50 mm.

b. After the ultrasound examination of the second sample ,the following readings were recorded:

Ta =62.1µs **Depth =**100mm

Tb=86.3 µs **L =**100mm

d=$100\sqrt{\frac{(86.6)^2}{(62.1)^2}-1}$ = 96.8**mm**

it turns out that the calculated depth of fissure in this samples is 96.8 mm while the actual depth is 100 mm.

d: slit depth (mm)

L: the distance from the notch (mm)

Ta: the time the wave passed through at a location without a list (µs)

Tb: the time the wave passes through the slit(µs)

The second way

a. After the ultrasound examination of the first sample ,the following readings were recorded:

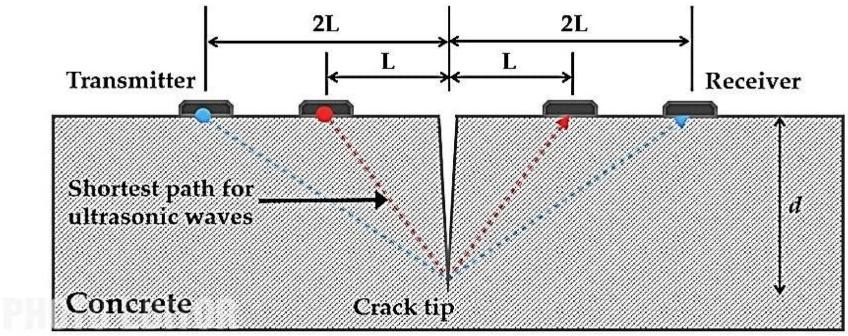

Fig 5.1 second way

T1 **=**68.2µs **Depth =**50 mm

T2**=**161.2µs **L =**100mm

$$d= 100\sqrt{\frac{4*(68.2)2-(161.2)2}{(161.2)2-(68.2)2}} = 42.1mm$$

the calculated slit depth is 42.1 mm, while the actual slit depth is 50 mm

b. After the ultrasound examination of the second sample,the following readings wererecorded:

T1 **=**86.2µs **Depth =**100mm

T2 **=**322µs **L =**100 mm

$$d= 100\sqrt{\frac{4*(86.3)2-(140)2}{(140)2-(86.3)2}} = 91.5mm$$

it turns out that the calculated slit depth of fissure in this samples is 91.5 mm while the actual slit depth is 100 mm**.**

T1: the time the wave passes (L) distance on both sides(µs)

T2: the time the wave passes (2L) distance on both sides(µs)

5.1.2 Detecting the gaps inside theconcrete

a. Ultrasound examination results by direct method is shown in the table (5.1)blowe

Table 5.1 :ultrasound results in the direct way

	The actual gab location		**Readings site**		**Ultrasound time µs**
	X	**Y**	**X**	**Y**	
Sample (1)	150	100	150	100	51.6
			200	100	42.8
			250	100	43.1
Sample (2)	200	80	150	80	45.5
			200	80	52.3
			250	80	44.7

It is clear from the examination results shown in the table (direct method)that the transit time of the ultrasound increases significantly in the sites where the gab is known to be located in advance.

b.Ultrasoundexaminationresults by indirectly method is shown in the table (5.2)blowe

Table 5.2 **:**ultrasound results indirectly

Sample No. (1)		Sample No. (2)	
Distance Mm	Ultrasound time µs	Distance Mm	Ultrasound time µs
100	38.2	100	34.5
150	41.8	150	38.7
200	79.3	200	43.2
250	85.9	250	45.4
350	98.6	350	81.2

In the relationship between the examination distance and the wave transit time ,we find that the slop of the curve changes significantly at the places of gap

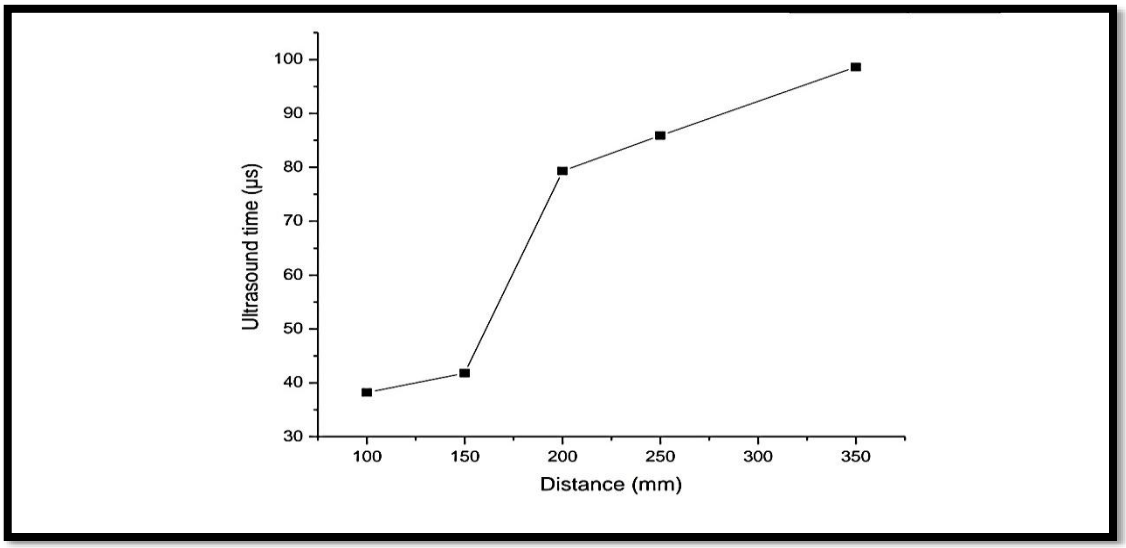

Fig 5.1 : the relationship between distance (mm) and wave transit time µs of sample (1)

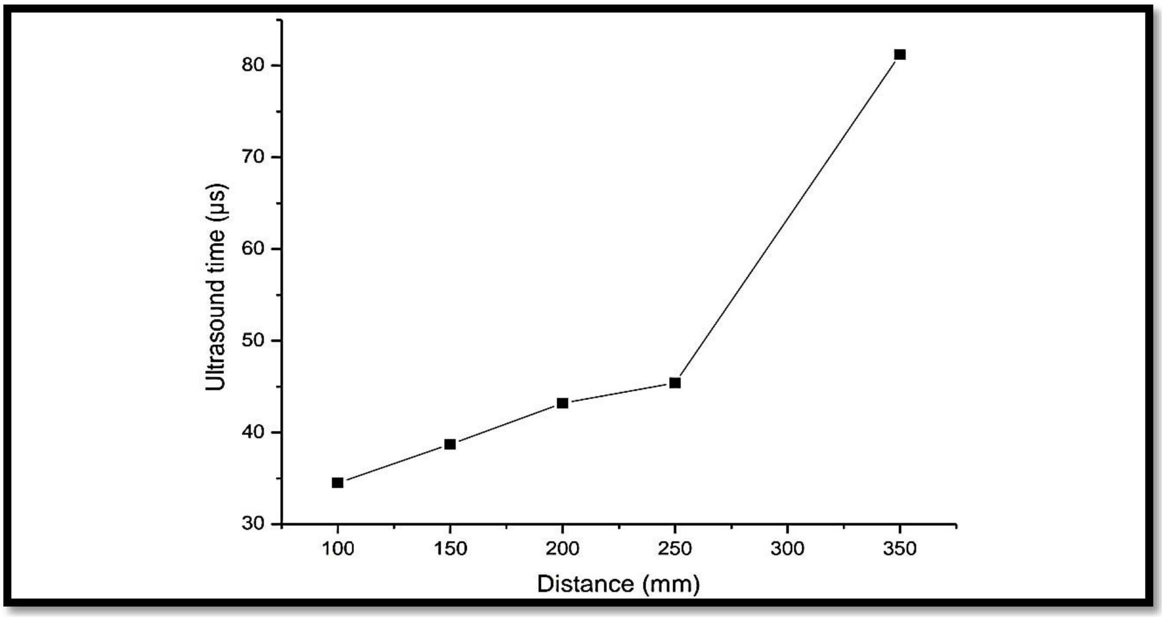

Fig5.2 **:**the relationship between distance (mm)

and wave transit time µs of sample (2)

5.2 Conclusion

Depending on the laboratory work that included the production of the concrete mixture and an ultrasound examination to detect concrete defects and through analysis

The results obtained from this work can concluded as follows:

_ the velocity of the waves increases with the density of concrete.

_theresultsshowedthatthefirstwaytofindthedepthoftheincisionismore accurate than the secondmethod.

_ gaps can be detected with high accuracy by using the direct method of ultrasound examination.

_ the indirect method can be adapted to detect gaps in the event that it is not possible to scan directly

5.3. Recommendation

In this research we recommend to:

- Using ultrasonic for concrete to examine isimportant.

 - more study's in concrete inspection by ultrasonicmethod.

 - More truing in ultrasonic method forconcrete.

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