NON DESTRUCTIVE TEST (NDT) OF DIFFERENT WELDED JOINTS
AND
COMPRESSION TEST OF WOODEN BLOCK

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Declaration of Authorship

We, Md. Mohsin Sarder, Md. Manirul Islam and Abdul Haque declare that this thesis titled, “NON DESTRUCTIVE TEST (NDT) AND COMPRESSION TEST” and the work presented in it are our own and has been generated by me as the result of my own original research.

We confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University.
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
3. Where we have consulted the published work of others, this is always clearly attributed.
4. Where we have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely our own work
5. We have acknowledged all main sources of help.
6. None of the part of this work has been published before submission.

Signed:

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Abstract

Problems and defects of all kinds arise in the development and use of mechanical devices, electrical equipment, hydraulic systems, transportation mechanisms and the like. However, an extremely wide range of nondestructive testing (NDT) methods are available to help you examine these different problems and various defects in an assortment of materials under varying circumstances. It is imperative that you select the best method to solve a particular problem. And that requires a sufficient understanding of the basic processes involved to realize the advantages of each NDT method available. In addition to practical hints and pertinent comments for the resolution of day to day problems, this book gives sufficient basic theory to comprehend the principles of each method so that the most appropriate can be selected and used to its fullest advantage. Typical illustrative calculations and a comprehensive bibliography are provided.

Acknowledgement

First of all we are very grateful to almighty Allah, who has blessed us with knowledge and ability to write this report successfully.

Our respected thanks go to Md. Ali Azam, our respected supervisor of thesis who brought the concept to our attention and contributed by his constructive suggestions and criticism to the improvement of this research work. He has always been kind and patient in making us aware of every possible problem that we might encounter while dealing with this research. The necessary instructions and materials provided by him literally helped us a lot to understand the situation better and analyze it effectively. Without his keen supervision, it was virtually impossible for us to finish this report successfully in time.

We would like to thank the Sonargaon University (SU) in general. As a student of Department of Mechanical Engineering we would like to thank the department for providing us opportunity and support throughout the whole path in completing the thesis.

Finally we would like to thank our parents and family for their support at every aspect of the journey and our respective teachers whose teachings and lessons have guided us through this path.

Objects

In this study the followings are the main objectives:

1. To inspect a component in a safe, reliable, and cost effective manner without causing damage to the equipment or shutting down plant operations.
2. To find out the different types of welding defect from welded materials.
3. To gather knowledge on testing procedure.

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Chapter 1

INTRODUCTION

Non-destructive testing (NDT) is the process of inspecting, testing, or evaluating materials, components or assemblies for discontinuities, or differences in characteristics without destroying the serviceability of the part or system. In other words, when the inspection or test is completed the part can still be used. In contrast to NDT, other tests are destructive in nature and are therefore done on a limited number of samples ("lot sampling"), rather than on the materials, components or assemblies actually being put into service. These destructive tests are often used to determine the physical properties of materials such as impact resistance, ductility, yield and ultimate tensile strength, fracture toughness and fatigue strength, but discontinuities and differences in material characteristics are more effectively found by NDT. Today modern non destructive tests are used in manufacturing, fabrication and in-service inspections to ensure product integrity and reliability, to control manufacturing processes, lower production costs and to maintain a uniform quality level. During construction, NDT is used to ensure the quality of materials and joining processes during the fabrication and erection phases, and in-service NDT inspections are used to ensure that the products in use continue to have the integrity necessary to ensure their usefulness and the safety of the public.

1.1 NDT Test Methods

The six most frequently used test methods are MT, PT, RT, UT, ET and VT. Each of these test methods will be described here, followed by the other, less often used test methods.

1. Visual Testing (VT)
2. Liquid Penetrant Testing (PT),
3. Magnetic Particle Testing (MT),
4. Ultrasonic Testing (UT),
5. Radiographic Testing (RT) and
6. Electromagnetic Testing (ET).

1.2 Visual Testing (VT)

Visual testing is the most commonly used test method in industry. Because most test methods require that the operator look at the surface of the part being inspected, visual inspection is inherent in most of the other test methods. As the name implies, VT involves the visual observation of the surface of a test object to evaluate the presence of surface discontinuities. VT inspections may be by Direct Viewing, using line-of sight vision, or may be enhanced with the use of optical instruments such as magnifying glasses, mirrors, boroscopes, charge-coupled devices (CCDs) and computer-assisted viewing systems (Remote Viewing). Corrosion, misalignment of parts, physical damage and cracks are just some of the discontinuities that may be detected by visual examinations.

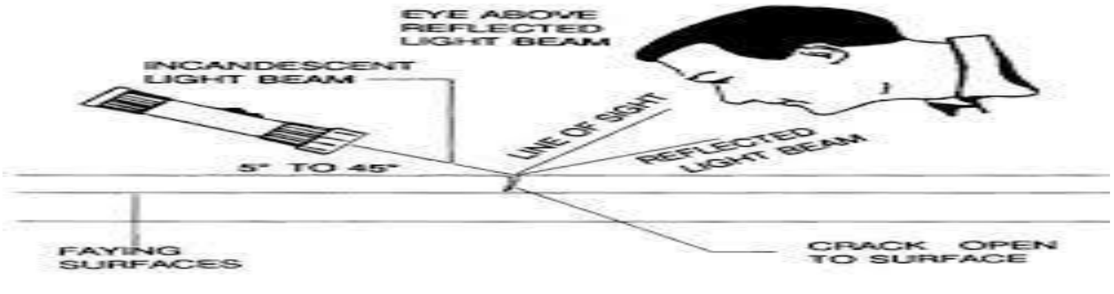


Fig-1.2: Visual Testing

1.3 Liquid Penetrant Testing (LPT)

The basic principle of liquid penetrant testing is that when a very low viscosity (highly fluid) liquid (the penetrant) is applied to the surface of a part, it will penetrate into fissures and voids open to the surface. Once the excess penetrant is removed, the penetrant trapped in those voids will flow back out, creating an indication. Penetrant testing can be performed on magnetic and non-magnetic materials, but does not work well on porous materials. Penetrants may be "visible", meaning they can be seen in ambient light, or fluorescent, requiring the use of a "black" light. The visible dye penetrant process is shown in Figure. When performing a PT inspection, it is imperative that the surface being tested is clean and free of any foreign materials or liquids that might block the penetrant from entering voids or fissures open to the surface of the part. After applying the penetrant, it is permitted to sit on the surface for a specified period of time (the "penetrant dwell time"), then the part is carefully cleaned to remove excess penetrant from the surface. When removing the penetrant, the operator must be careful not to remove any penetrant that has flowed into voids.

1.4 Magnetic Particle Testing (MT)

Magnetic Particle Testing uses one or more magnetic fields to locate surface and near-surface discontinuities in ferromagnetic materials. The magnetic field can be applied with a permanent magnet or an electromagnet. When using an electromagnet, the field is present only when the current is being applied. When the magnetic field encounters a discontinuity transverse to the direction of the magnetic field, the flux lines produce a magnetic flux leakage field of their own as shown in above figure. Because magnetic flux lines don't travel well in air, when very fine colored ferromagnetic particles ("magnetic particles") are applied to the surface of the part the particles will be drawn into the discontinuity, reducing the air gap and producing a visible indication on the surface of the part.

1.5 Ultrasonic Testing (UT)

Ultrasonic testing uses the same principle as is used in naval SONAR and fish finders. Ultra-high frequency sound is introduced into the part being inspected and if the sound hits a material with a different acoustic impedance (density and acoustic velocity), some of the sound will reflect back to the sending unit and can be presented on a visual display. By knowing the speed of the sound through the part (the acoustic velocity) and the time required for the sound to return to the sending unit, the distance to the reflector (the indication with the different acoustic impedance) can be determined. The most common sound frequencies used in UT are between 1.0 and 10.0 MHz, which are too high to be heard and do not travel through air. The lower frequencies have greater penetrating power but less sensitivity (the ability to "see" small indications), while the higher frequencies don't penetrate as deeply but can detect smaller indications.

The two most commonly used types of sound waves used in industrial inspections are the compression (longitudinal) wave and the shear (transverse) wave, as shown in above figure. Compression waves cause the atoms in a part to vibrate back and forth parallel to the sound direction and shear waves cause the atoms to vibrate perpendicularly (from side to side) to the direction of the sound. Shear waves travel at approximately half the speed of longitudinal waves.

1.6 Radiographic Testing (RT)

Industrial radiography involves exposing a test object to penetrating radiation so that the radiation passes through the object being inspected and a recording medium placed against the opposite side of that object. For thinner or less dense materials such as aluminum, electrically generated x-radiation (X-rays) are commonly used, and for thicker or denser materials, gamma radiation is generally used.

Gamma radiation is given off by decaying radioactive materials, with the two most commonly used sources of gamma radiation being Iridium-192 (Ir-192) and Cobalt-60 (Co-60). IR-192 is generally used for steel up to 2-1/2- 3 inches, depending on the Curie strength of the source, and Co-60 is usually used for thicker materials due to its greater penetrating ability.

The recording media can be industrial x-ray film or one of several types of digital radiation detectors. With both, the radiation passing through the test object exposes the media, causing an end effect of having darker areas where more radiation has passed through the part and lighter areas where less radiation has penetrated. If there is a void or defect in the part, more radiation passes through, causing a darker image on the film or detector, as shown in above figure.

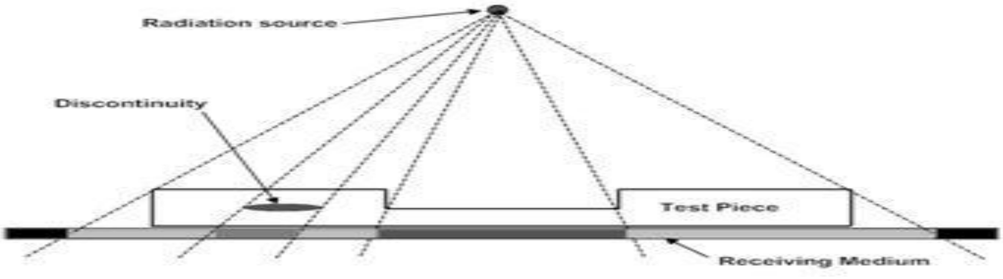


Fig-1.6: Radiographic Testing

1.7 Thermal/Infrared Testing (IR)

Thermal/Infrared Testing, or infrared thermography, is used to measure or map surface temperatures based on the infrared radiation given off by an object as heat flows through, to or from that object. The majority of infrared radiation is longer in wavelength than visible light but can be detected using thermal imaging devices, commonly called "infrared cameras." For accurate IR testing, the part(s) being investigated should be in direct line of sight with the camera, i.e., should not be done with panel covers closed as the covers will diffuse the heat and can result in false readings. Used properly, thermal imaging can be used to detect corrosion damage, delaminations, disbonds, voids, inclusions as well as many other detrimental conditions.

1.8 Vibration Analysis (VA)

Vibration analysis refers to the process of monitoring the vibration signatures specific to a piece of rotating machinery and analyzing that information to determine the condition of that equipment. Three types of sensors are commonly used: displacement sensors, velocity sensors and accelerometers.

Displacement sensors uses eddy current to detect vertical and/or horizontal motion (depending on whether one or two sensors are used) and are well suited to detect shaft motion and changes in clearance tolerances. Basic velocity sensors use a spring-mounted magnet that moves through a coil of wire, with the outer case of the sensor attached to the part being inspected. The coil of wire moves through the magnetic field, generating an electrical signal that is sent back to a receiver and recorded for analysis. Newer model vibration sensors use time-off light technology and improved analysis software. Velocity sensors are commonly used in handheld sensors. Basic accelerometers use a piezoelectric crystal (that converts sound waves to electrical impulses and back) attached to a mass that vibrates due to the motion of the part to which the sensor casing is attached.

Chapter 2

Literature Review

Nondestructive techniques are useful for evaluating the condition of structure, by performing indirect assessment of concrete properties. These techniques have been improved in last few years and the best part is that NDT avoids concrete damage for evaluation. Several researchers perform NDT tests to evaluate the condition of concrete structures. Methods range from very simple to technical depending on the purpose. Several mechanical and physical properties of concrete structures can be used to assess the condition and capacity of the structures. Sanayei et al. (2012) [6] performed static truck load test on a newly constructed bridge, to capture the response of bridge when a truck traveled across it. Amini and Tehrani (2011) [7] designed experimentally four sets of exposure conditions, weight and compressive strength of the samples had been measured before and after the freeze thaw cycles, and the results were analyzed. Loizos and Papavasiliou (2006) [8] performed a comprehensive monitoring and data analysis research study by using Falling Weight deflectometer (FWD) for in situ evaluation of recycled pavements. Proverbio and Venturi (2005) [9] evaluated the reliability of rebound hammer test and UPV test on concrete of different composition and strength. Rens et al. (2005) [10] explained application of NDE methods for bridge inspection, which is Bridge Evaluation Using NDT (BENT). Malavar et al. (2003) [11] used pull off tests to evaluate effects of temperature, moisture, and chloride content on CFRP adhesion. Pascale et al. (2003) [12] carried out an experimental program involving both destructive and nondestructive methods applied to different concrete mixtures, with cube strength varying from 30 to 150 MPa, to define a relation between strength and parameters.

Several researchers performed different types of NDT tests such as mechanical, chemical, electrochemical, and magnetic methods to evaluate the condition by combining the results. Rens and Kim (2007) [15] inspected a steel bridge using several NDT methods such as visual inspection, hammer sounding, Schmidt hammer, and UPV testing including tomographic imaging; results of NDT had been used to determine areas, to be tested with local destructive tests such as compressive strength, chloride testing, and petrographic testing.

Magnetic concrete cover meters are widely used to estimate the cover to steel bars. Bhadauria and Gupta (2007) [16] presented case study of deteriorated water tanks situated in the semitropical region of India.

Parameters measured are concrete cover, carbonation depth, chloride concentration, compressive strength, and so forth. NDT methods used are cover meter, Phenolphthalein indicatortest, Quantab testPotentiometric Titration, Schist's hammer test, and UPV test. Amleh and Mirza (2004) [17] 21|page concrete cover test, Half cell Potential, corrosion rate, electrical resistivity, chloride 21 content at steel level (%), steel bar mass loss (%), absorption, pulse velocity, compressive strength, carbonation depth, petrographic examination, and permeability test. Dias and Jayanandana (2003) [18] used nondestructive techniques of visual inspection, perusal of drawings, ultrasonic pulse velocity measurements, cover-meter surveys, and core testing for the condition assessment; parameters required for evaluating the durability had been identified as (1) depth of carbonation; (2) cover to reinforcement; (3) chloride content; and (4) sulfate content. Bruhwiler and Mivelaz (1999) [19] highlighted the findings of two studies (i) investigated chloride ingress under given climatic conditions and in situ evaluation of concrete cover, (ii) used numerical models to investigate the effects of early age cracking and also determines preventive measures to be taken to limit the development of cracks.

Propagation of waves or reflection of different rays such as X-ray, through concrete structures, can be used to detect the deterioration level of concrete structures. Impact echo method has been used by many researchers to evaluate the condition of concrete.

In this method a spring loaded device is used to generate waves, and these waves are used to detect condition of structures. Kamal and Boulfiza (2011) [20] assessed penetration of alkalis using X-ray mapping of backscattered electron images (BEI) and crosschecked by line and point energy dispersive spectroscopy (EDS) techniques. Shiotani et al. (2009) [21] used Acoustic Emission (AE) technique to evaluate the structural condition of a concrete bridge. Cascante et al. (2008) [22] presented a methodology for the ND evaluation using the multichannel analysis of surface waves (MASW). Zhu and Popovics (2007) [23] applied air coupled impact echo (IE) for NDE of concrete structures; air couple sensor is a small (6.3 mm dia.) measurement microphone located several cms above the top surface of the concrete being evaluated. Results show that air-coupled sensors are effective for IE tests. Nachiappan and Cho (2005) [24] analyzed corrosion products using X-ray diffraction and atomic absorption spectroscopy to find mineral present in them.

Gibson and Popovics (2005) [25] proposed a new approach for NDE of concrete structures based on guided wave theory “Impact Echo resonance in plates corresponds to the zero-group-velocity frequency of the S1 lamb mode.” Akuthota et al. (2004) [26] presented the experimental results of using near field microwave NDT techniques for detecting disbond in a specially prepared carbon fiber reinforced polymer (CFRP) reinforced mortar sample. Gassman and Tawhed (2004) [27] presented the results of an NDE testing program performed to assess the damage in concrete bridge by using impact echo method. Paulson and Wit (2003) [28] described the use of acoustic monitoring system to manage concrete structures, by presenting two case studies. As concrete and steel both are excellent acoustic transmitters, this technique is useful for concrete structures. Grosse al. (2003) [29] described the use of signal-based acoustic emission techniques in civil engineering. Popovics et al. (1998) [30] reviewed one-sided stress wave measurement method in concrete. This method provides valuable information on the state of material, when access to only one side surface is possible, such as for the case of concrete pavements. Nagy (1997) [31] discussed a NDE method for determining “” (Young’s modulus) of concrete at very early ages, by measuring dynamic response frequency on concrete prism with Fourier Transform (FTT) analyze.

Ground penetrating radar (GPR) is another method to locate the rebars, voids, and other defects in concrete structures. Chen and Wimsatt (2010) [32] used 400 MHz ground-coupled penetrating radar (GCPR) to evaluate the subsurface conditions of roadway pavements. Yehia et al. (2007) [33] studied the different NDE techniques used to assess the condition of concrete bridge deck. Experiments performed are infrared thermography, impact echo, and ground penetrating radar (GPR) to detect common flaws in concrete bridge decks. Maierhofer (2003) [34] presented the importance and limitations of ground penetrating radar (GPR) methods. Maser (1996) [35] discussed GPR technology that has been applied to the evaluation of pavements, bridge decks, abutments, piers, and other construction facilities to assess conditions and to evaluate damage and deterioration that develops over time.

Ultrasonic pulse velocity is used by many researchers for the assessment of concrete properties by using travel time of longitudinal waves over a known distance. Sharma and Mukherje (2011) [36] used ultrasonic guided waves for monitoring progression of rebar corrosion in chloride and oxide environment. Terzic and Pavlovic (2010) [37] applied NDT methods that is Image Pro Plus (IPP) and Ultrasonic Pulse Velocity (UPV), on the corundum and bauxite-based refractory concretes. Shah and Hirose (2010) [38] presented an experimental investigation of the concrete applying nonlinear ultrasonic testing technique. Ervin et al. (2009) [39] created an ultrasonic sensing network to assess reinforcement deterioration. Guided ultrasonic waves had been used to monitor reinforced mortar specimens under accelerated uniform and localized corrosion. Stergiopoulou et al. (2008) [40] presented a procedure for NDT of urban concrete infrastructures using UPV measurements and applied to concrete garages. UPV has been used as an indicator of concrete quality. Yoshida and Irie (2006) [41] proposed a macroscopic ultrasonic method, which allows measurement of concrete thickness, crack width, and characteristics using the concrete surface sonic speed. Dilek (2006) [42] discussed the use of pulse velocity, Young’s modulus of elasticity, and air permeability of concrete to evaluate the extent of damage of a concrete. Abo-Quadais (2005) [43] conducted an experimental study to evaluate the effects of concrete aggregate degradation, w/c ratio, and curing time on measured UPV.

Equipment used in this study was the portable ultrasonic ND digital indicating tester (PUNDIT). Lee et al. (2004) [44] used UPV methods for determining setting time of concrete especially high-performance concrete (HPC). Shah et al. (2000) [45] described laboratory-based NDE techniques based on measurements of mechanical waves that propagate in the concrete. Ultrasonic longitudinal wave (L-wave or P-wave) signal transmission measurements have been applied to detect the present of damage in the form of distributed cracking in concrete. Davis et al. (1997) [46] introduced several NDE techniques including UPV, impulse response, parallel seismic, and cross-hole sonic logging for evaluating concrete quality of hazardous waste tanks.

Chapter 3

Ultrasonic Test

Ultrasonic testing is a one types of non destructive method based on sound waves,where use high frequency sound waves than audible sound to detect material thickness , dimension , material integrity also detect and locate internal discontinuity of material.

3.1 Advantage of UT

1. Can inspect thick material than other method
2. Can inspect from one side
3. Can detect small discontinuity
4. Capability to estimating the size, shape and depth of discontinuity.
5. Non hazardous
6. portable
7. Results are immediate.

Disadvantage of UT

1. Need technical knowledge and training .
2. Difficult to inspect rough, irregular part
3. Very small or thin, or not homogeneous are difficult to inspect.
4. Need surface preparation
5. Couplants are needed
6. Discontinuity at the surface are difficult to detect

3.2 Field Application of UT

1.Power plant
2. Ship building
3. Fertilizer
4. Cement factory
5. Re-rolling mill

3.3 Principle of UT

When ultrasounds apply on the test piece by piezo-crystal it travel through the material in the form of wave. Sound wave travel and reflected from back-wall until remain any discontinuity .when any discontinuity remain the sound wave reflected from the discontinuity and show in CRT monitor.

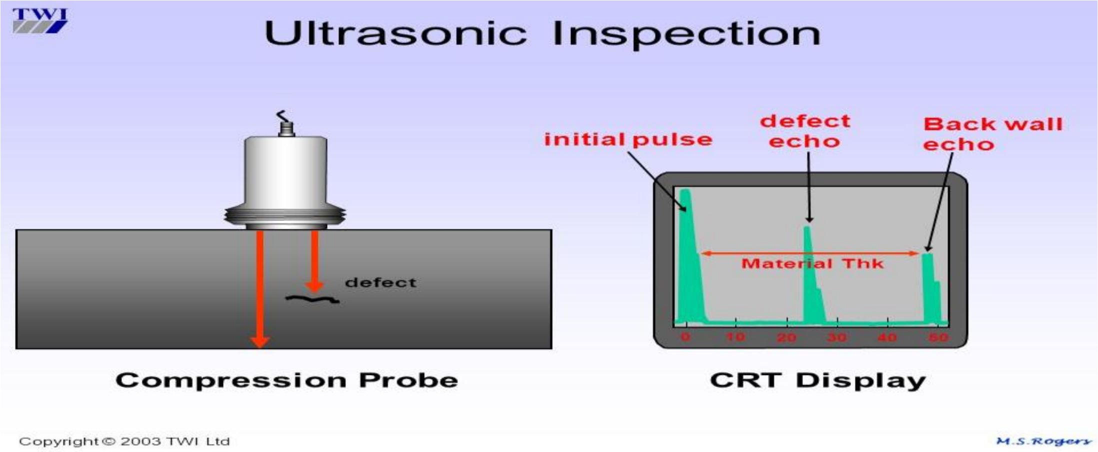


Fig-3.3: Principle of UT

3.4 Ultrasonic Resolution

Resolution is ability to separate the two echoes from two flaws which are close together in depth.

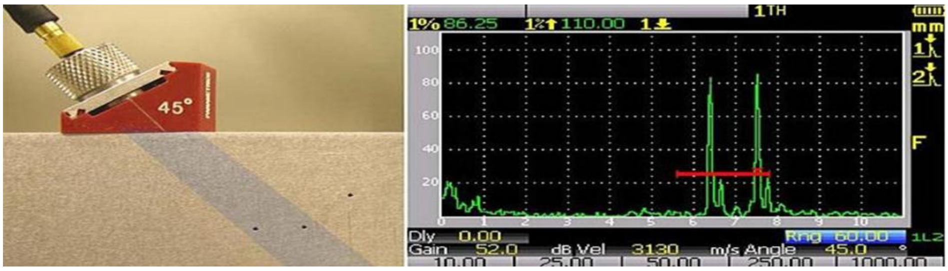


Fig-3.4(1): Ultrasonic Resolution

Probe Sensitivity

Probe Sensitivity is the ability of probe to detect echo from small flow

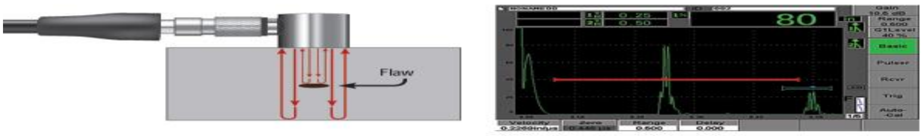


Fig-3.4(2): Probe Sensitivity

3.5 Pulse length

Pulse length is the distance between start to ending point of the pulse. Longer pulse more penetrate power and shorter pulse high resolution and sensitivity.

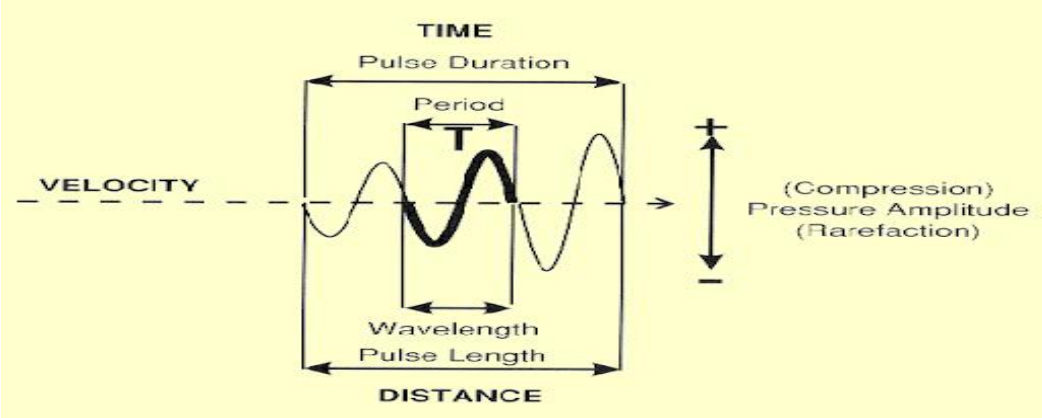


Fig-3.5: Pulse length

3.6 Mode Conversion and refraction

Mode conversion: Energy convert one form to another form or change the nature of wave motion. When sound travels one to another different materials.

Refraction: change the direction of wave propagation, when sound travel from on to another material.

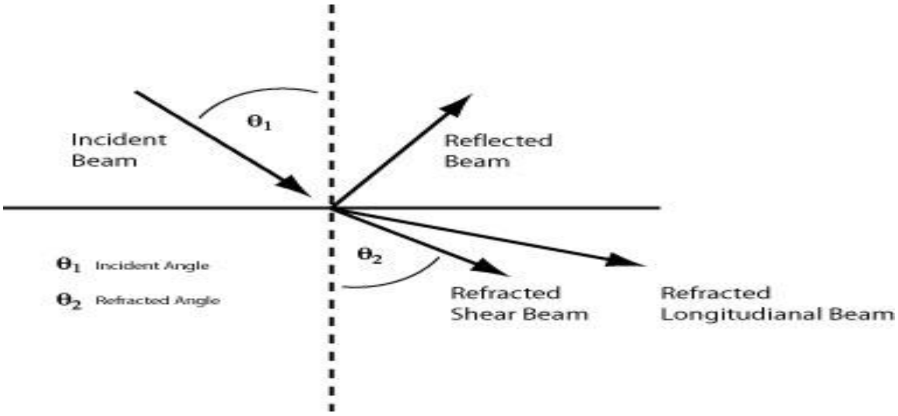


Fig-3.6: Mode Conversion and refraction

3.7 Snell’s Law

The ratio of the incident angle and reflection or refraction angle are equal to their related velocities ratio.

Snell’s Law describe, $\frac{sin\theta 1}{sin\theta 2} = \frac{V1}{V2}$

Where,$sin\theta 1$ =Incident beam angle

$sin\theta 1$ =refracted beam angle

V1=incident beam velocity

V2=Refracted beam Velocity

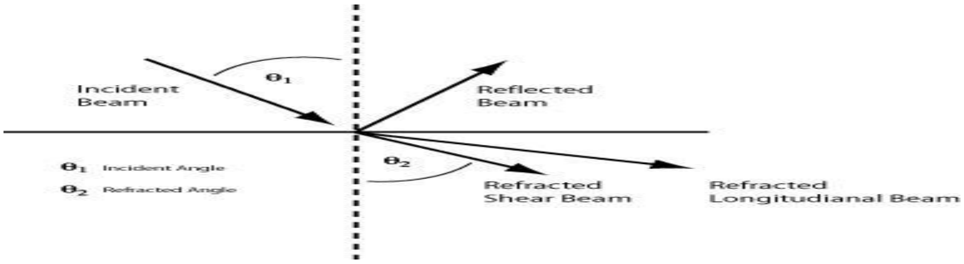


Fig-3.7: Snell’s Law

3.8 Dead zone

The distance between the surface of a test object to the nearest inspectable depth when the crystal is ringing to transmit the sound. it is not possible to detect defects from dead zone.

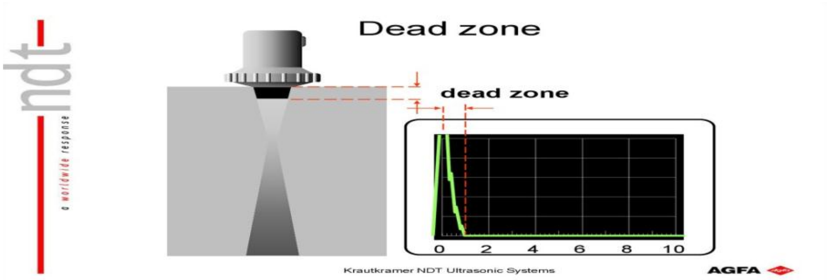


Fig-3.8(1): Dead zone

Near Zone or field

Near zone is the zone where the sound wave pressures at each point is not uniform.

Near field N=D²f/4v

where,

D=probe dia,   f=frequency, V=velocity

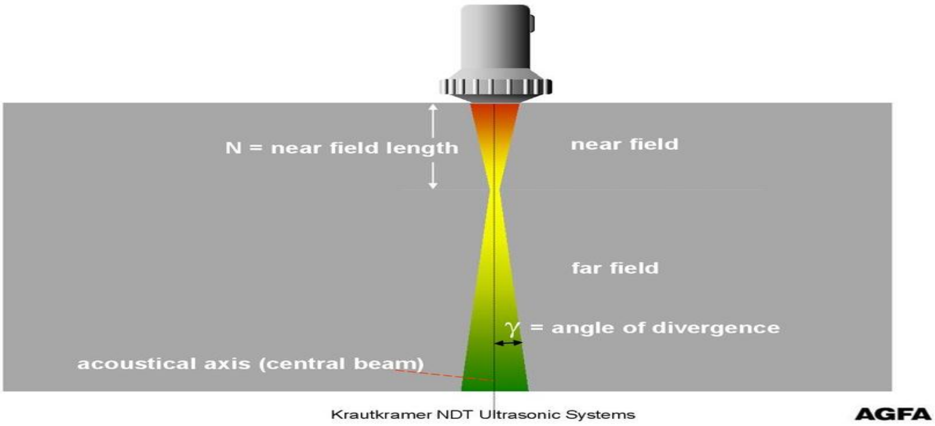


Fig-3.8(2): Near Zone or field

Far Zone or field

The area where the ultrasonic beam is more uniform and spreads out in a pattern originating from the center of the transducer is called the far field.

Far zone,

Sine(ϴ/2=KV/Df

K=edge of beam

(K=1.2)

V=velocity

D=Probe Dia

f= Frequency

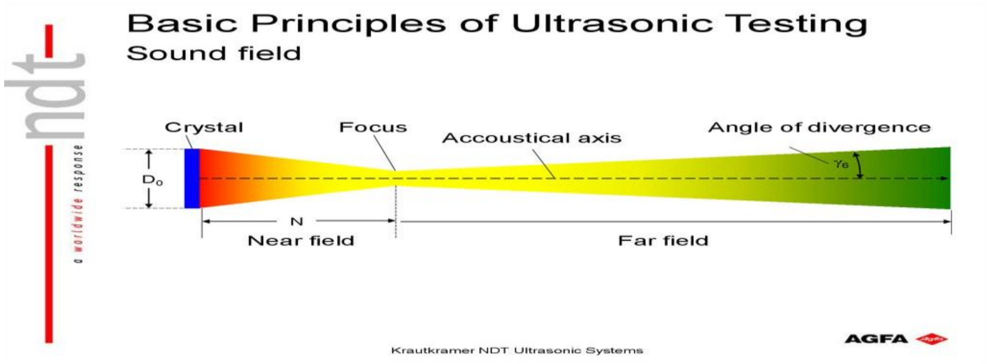


Fig-3.8(3): Far Zone or field

3.9 Ultrasonic Techniques

Ultrasonic inspection can be classified in terms of both the variables measured and the inspection techniques.

Ultrasonic testing techniques are-

1.Pulse-Echo techniques.

2.Through Transmission Techniques.

3.Resonance Techniques

ULTRASONIC TEST REPORT

Inspection date : 02 April 2022
Inspection Place : BV Lab, Gulshan, Dhaka
BV Client : Thesis Group-05
Project Name : UT of Welding Joints.
Welding Prep : Single V
UT Equipment : Einstein TFT II
Calibration block : IIW V1 Block, Reference block
Material : Mild Steel

Report no : BV/UT-1
Range : (1-100) mm
Search unit : 4 MHz, 70˚
Reference level : 60.0 dB
Surface condition : As brush
Couplant : Lube Oil
Thickness : 08 mm
Test area : Butt joint.

W: Web Joint
F: Flange Joint
L→R: Left to Right
R→L: Right to Left

WELD IDENTIFICATION	INDI NO	THK mm	X mm	Y(yw) mm	BPL(w) mm	A dB	D dB	CLASS	L mm	DEPTH mm	y mm	Y-y mm	RESULT	REMARKS
Test Pic No. 01	W-1	08	-	-	-	-	-	-	-	-	-	-	Accepted	Satisfactory
Test Pic No. 02	W-2	08	-	-	-	-	-	-	-	-	-	-	Accepted	Satisfactory

LEGEND; X = Circumferential distance from datum, Y= Distance from weld C/L to probe index. BPL = Beam path length, y = Calculated distance from probe index, L = Length, A = Indication level, D = Indication rating

Defect Code: CR- Crack, IP-Incomplete Penetration, IF – Incomplete Fusion, SL- Slag, P- Porosity, EP- Excess Penetration, CP- Cluster Porosity, CON – Concavity, BSR – Before Stress Relief, ASR – After Stress Relief.

TESTED BY:	CHECKED & APPROVED BY:
Name: MD. Manirul Islam ASNT NDT Level- II	**Name: Walid Hossain (Industry Manager)**
Signature: MIslam BUREAU VERITAS (BANGLADESH) PRIVATE LIMITED DHAKA	**Signature:**
Date: 05-09-2022	**Date:05-09-2022**

TEST CARRIED OUT AS PER CODE & STANDARD OF AWS D 1.1

Chapter 4

Dye Penetrant Test

When the penetrant applied on the cleaned surface of the part, the penetrant entered into the discontinuities by the capillary force. After allowing sufficient time to penetrate, the excess penetrant is removed only from the surface and then the developer is applied on the surface to bring the penetrant out of the discontinuities by its blotting action and make them visible in form of indications.

4.1 DPT process or procedure

Dye penetrant testing should be done according to a basic DPT procedure. DPT basic procedure show below.

1. Pre –cleaning of the test part
2. Application of penetrant and wait for dwell time
3. Removal of excess penetrant from test surface
4. Apply developer
5. Inspection and evaluation of indication
6. Post clean

Fig-4.1: Dye penetrant Test

4.2 Application of penetrant

In liquid penetrant testing, the penetrant is applied to the cleaned surface of the part and sufficient time is allowed for penetration into the discontinuities. If the discontinuities are small, narrow or tight such as pinholes or cracks, capillarity assists to penetrate and when the opening is large, the penetrant penetrate and trapped when applied on surface of the part.

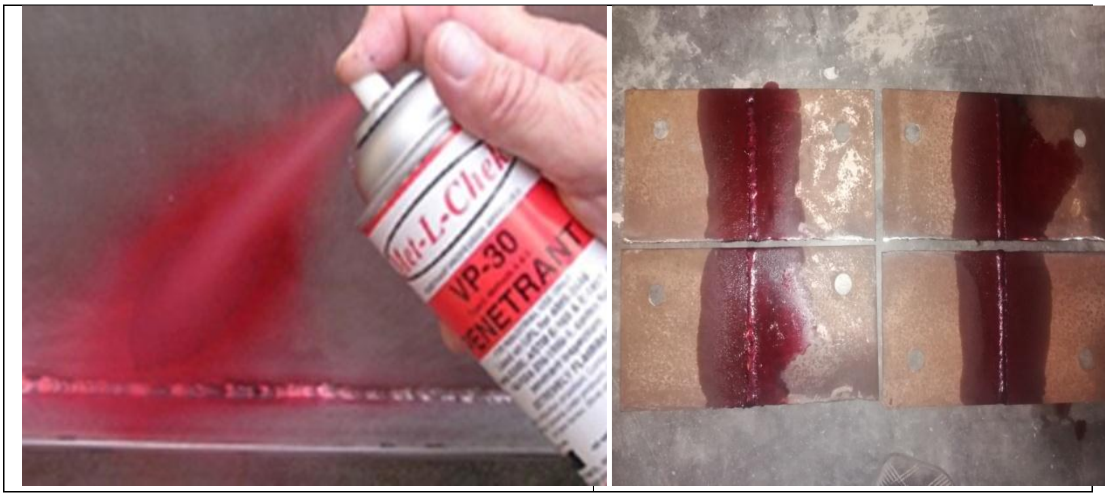


Fig-4.2: Application of penetrant

4.3 Penetrant application technique

Spray :

Usually pressurized spray cans are used at site for spot testing. Also Application of penetrant by spraying from penetrant tank can be accomplished by the use of hose and nozzle. This technique usually used on lab base test.

Brushing:

Penetrant may be applied by swabbing with rags or cloth or by brushing. Either method is acceptable when spray or dipping is not available. Usually swabbing or brushing is used when testing a small or specific area of the part.

Dipping :

The best procedure for application for penetrant is to immersing or dipping the test specimen into a tank of penetrant. .This is not suitable for a small area of a large specimen is to be tested. Time of dipping is enough to extent of full coverage test specimen's surface by sufficient penetrant.

4.4 Dwell Time

Dwell time is the time between application of penetrant and remove of excess penetrant means which time you give the penetrant to penetrate into flaws that’s called dwell time. this time needs enough to penetrate the penetrant into discontinues or flaws. Dwell time

depend on-
1.Temperature
2.Metal type
3. Discontinuity type
4. Penetrant manufacturer
Note: as per ASNT minimum dwell time is 10 minute, maximum dwell is 30 minutes.

4.5 Application of Dry developer:

Dry developer shall be applied only to a dry surface by a soft brush, hand powder bulb, powder gun, or other means, provided the powder is dusted evenly over the entire surface being examined.

Fig-4.5: Application of developer

4.6 Post cleaning

After the final inspection, post cleaning is very important because the residue in the penetrant testing process can be detrimental during further processing or during service of the part. If post cleaning not proper or no post cleaning this effect can appear. Bad effect of no post cleaning-

1. Developer will absorb the moisture from the atmosphere and caused corrosion.
2. Penetrants remaining on the part may adversely affect plating, anodizing
3. Residual oils from penetrant on liquid oxygen system components can result in explosion.
4. Penetrant remaining in the discontinuities will dry and create problem in later inspection by masking of indication or creating high background.

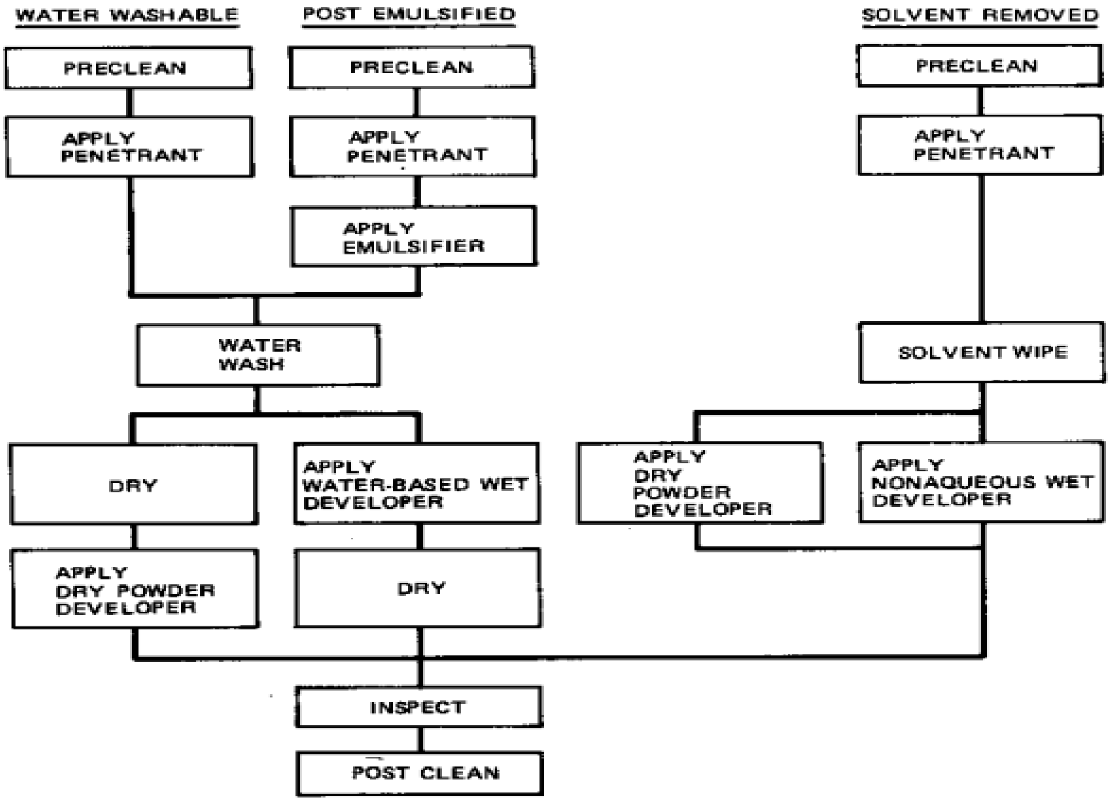


Fig-4.6: Post Cleaning Chart

4.7 Temperature requirement for DPT

As per ASME section-5, article 6, the temperature of the chemical and the surface of the part to be processed shall not be below 40°F (5°C) or above 125°F (52°C) throughout the examination period. Local heating or cooling is permitted provided the part temperature remains in the range of 40°F to 125°F (5°C to 52°C) during the examination. Where it is not practical to comply with these temperature limitations, other temperatures and times may be used as per demonstration and procedure.

Note : temperature requirement as per ISO 3452-1:2013 -10°C-50°C

International atomic energy commission-16ºC–52ºC

4.8 Direction for visible DPT inspection

If visible dye penetrant process is used, the inspection shall be under normal white light or artificial light (hand lamp). Before visible dye penetrant testing must need to check the intensity of visible light .The surface to be examined to ensure adequate sensitivity during the examination and evaluation of indications. The minimum light requirement during inspection for Visible DPT is

As per ASME sec-V, Aricle-6 – 1000 lux (100 fc)

As per BS EN ISO-3059:2012- 350 lux (32.5 fc) for penetrant remove

500 lux (50 fc) for inspection or greater

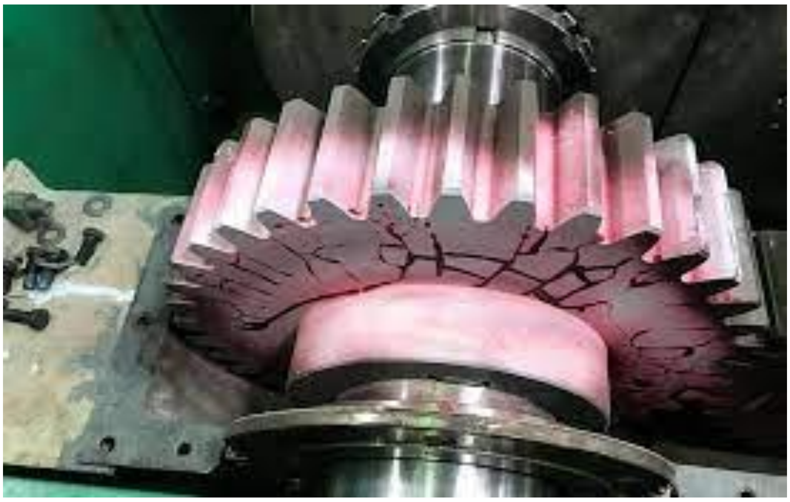


Fig-4.8: visible DPT inspection

DYE PENETRATION TEST RESULT

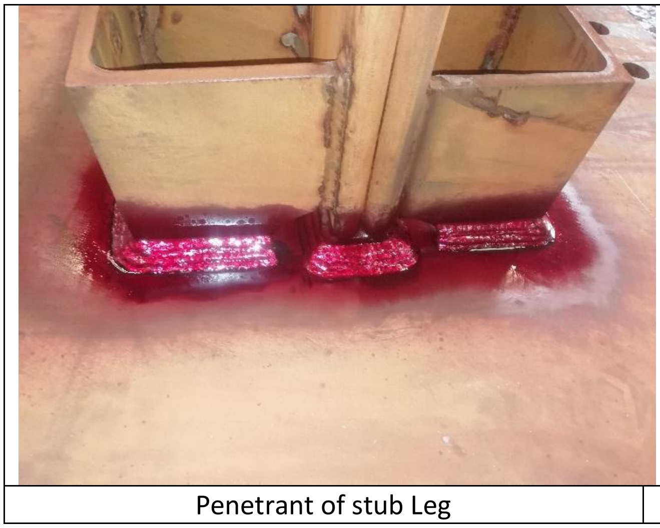
Name of the Project	DPT of Welding Plate & Stub Leg.	Report No:	BV/DPT-01
Name of the Client	Thesis G-36	Page:	Total-03
Location	BV Lab, Gulshan-1, Dhaka	Insp. Date:	05th September, 2022
Conditions of Test Procedures: ASME V			
Penetrant	Brand: MAGNAFLUX (SKL-SP1)	Type: Solvent Removable Red	
Remover	Brand: MAGNAFLUGX (SKC-1)	Type: Solvent Remover	
Developer	Brand: MAGNAFLUX (SKD-S2)	Type: Solvent Based Developer	
Surface Condition	☐ As Weld ☐As Grind ☐ Brush ☒ Other	Surface Temperature	Normal
Penetrate Time	15 Minute	Material	MS
Evaluation	Acceptance Criteria: AWS D1:1		

Inspection Details

SL No	Item Name	Item ID.	Inspection Part	Observation	Remarks
01	Stub Leg-01	5 H-ST 01	Welding Joints	NSD	Acceptable
02		6 H-ST 03	Welding Joints	NSD	Acceptable
03		7 H-ST 02	Welding Joints	NSD	Acceptable
04		8 H-ST 04	Welding Joints	NSD	Acceptable
01	Stub Leg-02	5 H-ST 01	Welding Joints	**P.H**	**Repair**
02		6 H-ST 03	Welding Joints	NSD	Acceptable
03		7 H-ST 02	Welding Joints	NSD	Acceptable
04		8 H-ST 04	Welding Joints	NSD	Acceptable
01	Stub Leg-03	5 H-ST 01	Welding Joints	NSD	Acceptable
02		6 H-ST 03	Welding Joints	NSD	Acceptable
03		7 H-ST 02	Welding Joints	NSD	Acceptable
04		8 H-ST 04	Welding Joints	NSD	Acceptable
01	Stub Leg-04	5 H-ST 01	Welding Joints	NSD	Acceptable
02		6 H-ST 03	Welding Joints	NSD	Acceptable
03		7 H-ST 02	Welding Joints	NSD	Acceptable
04		8 H-ST 04	Welding Joints	NSD	Acceptable
01	Welding Plate	T.P-01	Welding Joints	**P.H**	**Repair**
02	Welding Plate	T.P-02	Welding Joints	NSD	Acceptable
03	Welding Plate	T.P-03	Welding Joints	NSD	Acceptable
04	Welding Plate	T.P-04	Welding Joints	**P.H**	**Repair**
N.B: P = Porosity, UC = Under Cut, C = Crack, P.H = Pin Hole, NSD = No Significant Defect, A = Acceptable , R = Reject					

TESTED BY:	CHECKED & APPROVED BY:
Name: MD. Manirul Islam ***ASNT NDT Level- II***	***Name: Walid Hossain (Industry Manager)***
Signature: MIslam DHAKA	***Signature:***
Date: 05-09-2022	***Date:05-09-2022***

Photographs

	
Penetrant of stub Leg	Developer of Welding Plate-3

Pin Hole of Stub leg

Developer of Stub Leg

Pin Hole of Welding Plate-1

Pin Hole of Welding Plate-4

Chapter 5

Magnetic Particle Test

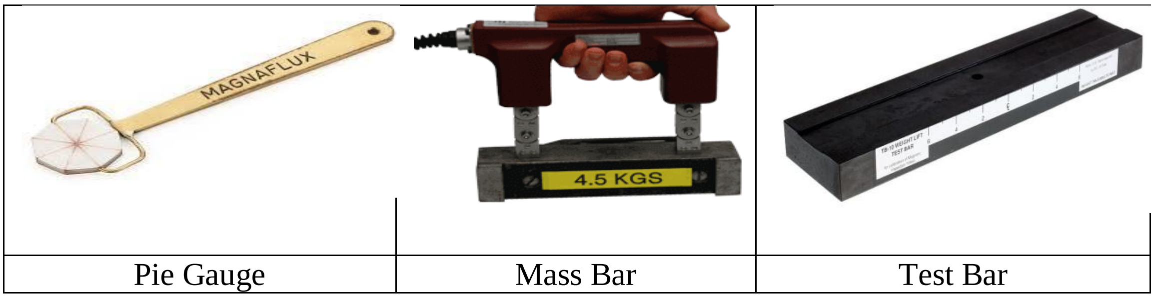
Magnetic particle inspection is an NDT method which may only be used on ferromagnetic materials to detect surface breaking discontinuities and also in certain cases slight subsurface discontinuities up to 4 mm below the materials surface.

5.1 Principle of Magnetic Particle Test

A leakage field is created when a magnetic field is applied to a specimen to be tested, and then ferromagnetic powder or ferromagnetic particles in a liquid suspension are applied to the area being tested. Any discontinuity in the test area that cuts across the magnetic field creates a leakage field. Because a leakage field has a North and South Pole on either side, it will attract a large number of ferromagnetic particles.

Fig-5.1: Magnetic Particle Test

5.2 Magnetic Yoke Calibration



Pie Gauge	Mass Bar	Test Bar

Fig-5.2: Yoke Calibration

5.3 Advantage of MPT

1. Can detect both surface and near-surface indications
2. A relatively fast method of examination.
3. Indications are visible directly on the surface.
4. Indications are visible directly on the surface.
5. Post-cleaning generally not necessary.
6. Post-cleaning generally not necessary.

5.4 Disadvantage of MPT

1. Non-ferrous materials, such as aluminium, magnesium, or most stainless steels, cannot be inspected.
2. Examination of large parts may require use of equipment with special power requirements.
3. Only small sections or small parts can be examined at one time.
4. Detects surface and near-to-surface discontinuities only

5.5 Penetration of Magnetic Flux

Fig-5.5: Penetration of Magnetic Flux

5.6 **Magnetic Field Strength**

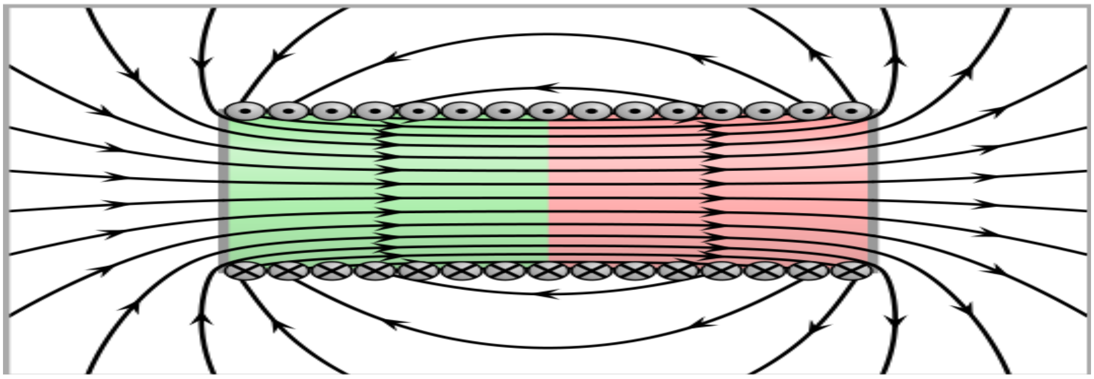


Fig-5.6: Magnetic Field Strength

5.7 Electromagnetic Yoke

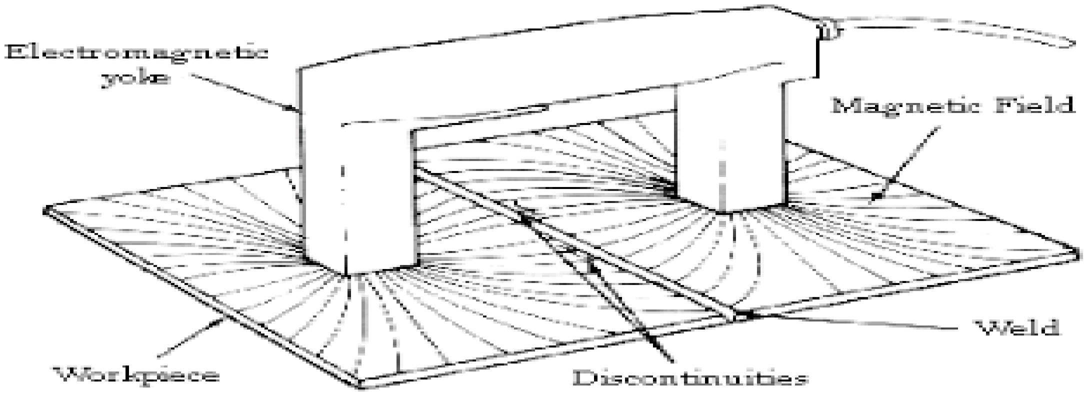


Fig-5.7: Electromagnetic Yoke

5.8 Heat Treatment

It is not necessary to demagnetize if a heat treatment process is to two follow magnetic particle inspection and the spaceman is to be heated beyond its curie point, which is approximately two thirds of materials melting point.

Fig-5.8: Heat Treatment

MAGNETIC PARTICLE TESTING RESULT

Name of the Project	MPI of Welding Plate&Stub Leg	Report No:	BV/MPT-1
Name of the Client	Thesis G-36	Page:	Total-03
Location	BV Lab, Gulshan-1, Dhaka	Insp. Date:	05th September, 2022

MATERIAL TYPE : Carbon Steel	TECH : MPI with Yoke	DESCRIPTION : N/A
TYPE OF PART : N/A	NO: 01	PART SIZE : N/A

ACCEPTANCE CRITERIA : AWS D1.1 Table 6.1

INSPECTION STANDARD : AWS D1.1

EQUIPMENT TYPE : Permanent Yoke (Sr. _PY70)	REFERENCE DOCUMENT : ASME Section V, Article 7 & AWS D1.1
MAGNETIC FIELD STRENGTH : 44.10N	INITIAL STATE OF SURFACE : As Welded
METHOD : Non-Florescent (Visible)	SENSITIVITY : Burma Castrol Strip
CONTRAST PAINT : Non aqueous Liquid	SURFACE TEMPERATURE : ≤ 45 ˚ C
MAGNETIC INK : Pre-mixed aerosol spray Can	LIGHTING TYPS : Visible light (≥ 1000 lux)

SURFACE CONDICATION : Smooth with Buffing	PWHT	N. A.	BEFORE	AFTER
ORIGINAL / REPAIR		√	X	X

Inspection Details

SL No	Item Name	Item ID.	Inspection Part	Observation	Remarks
01	Stub Leg-01	5 H-ST 01	Welding Joints	NSD	Acceptable
02		6H-ST 03	Welding Joints	NSD	Acceptable
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04		8H-ST 04	Welding Joints	NSD	Acceptable
01	Stub Leg-02	5 H-ST 01	Welding Joints	**P.H**	**Repair**
02		6H-ST 03	Welding Joints	NSD	Acceptable
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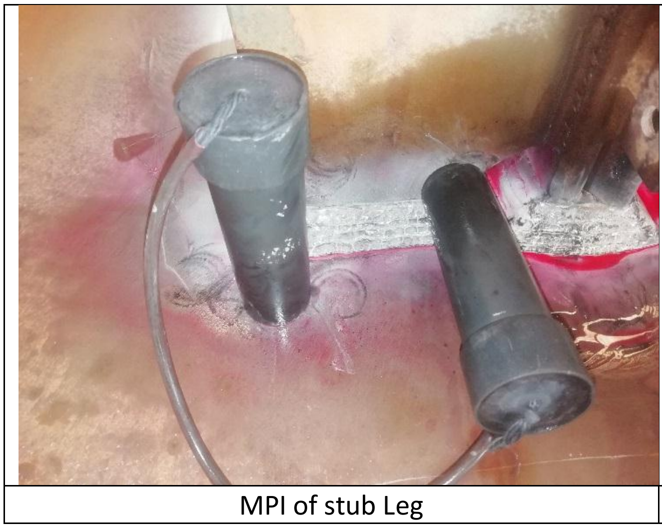
01	Stub Leg-04	5 H-ST 01	Welding Joints	NSD	Acceptable
02		6H-ST 03	Welding Joints	NSD	Acceptable
03		7H-ST 02	Welding Joints	NSD	Acceptable
04		8H-ST 04	Welding Joints	NSD	Acceptable

01	Welding Plate	T.P-01	Welding Joints	**P.H**	**Repair**
02	Welding Plate	T.P-02	Welding Joints	NSD	Acceptable
03	Welding Plate	T.P-03	Welding Joints	NSD	Acceptable
04	Welding Plate	T.P-04	Welding Joints	**P.H**	**Repair**
N.B: P = Porosity, UC = Under Cut, C = Crack, P.H = Pin Hole, NSD = No Significant Defect, A = Acceptable , R = Reject					

TESTED BY:	***CHECKED & APPROVED BY:***
Name: MD. Manirul Islam ***ASNT NDT Level- II***	***Name: Walid Hossain (Industry Manager)***
Signature: MIslam DHAKA	***Signature:***
Date: 05-09-2022	***Date:05-09-2022***

Photographs


MPI of stub Leg

MPI of Welding Plate

	
MPI of Welding Plate	MPI of Welding Plate-4
	
MPI of Welding Plate-1	MPI of Welding Plate-3

Chapter 06

Compression Test of Wooden Block

6.1 Aim

To conduct compressive test on specimen of timber and to determine the respective compressive strengths

6.2 Apparatus Required

Universal Testing Machine and Vernier Caliper

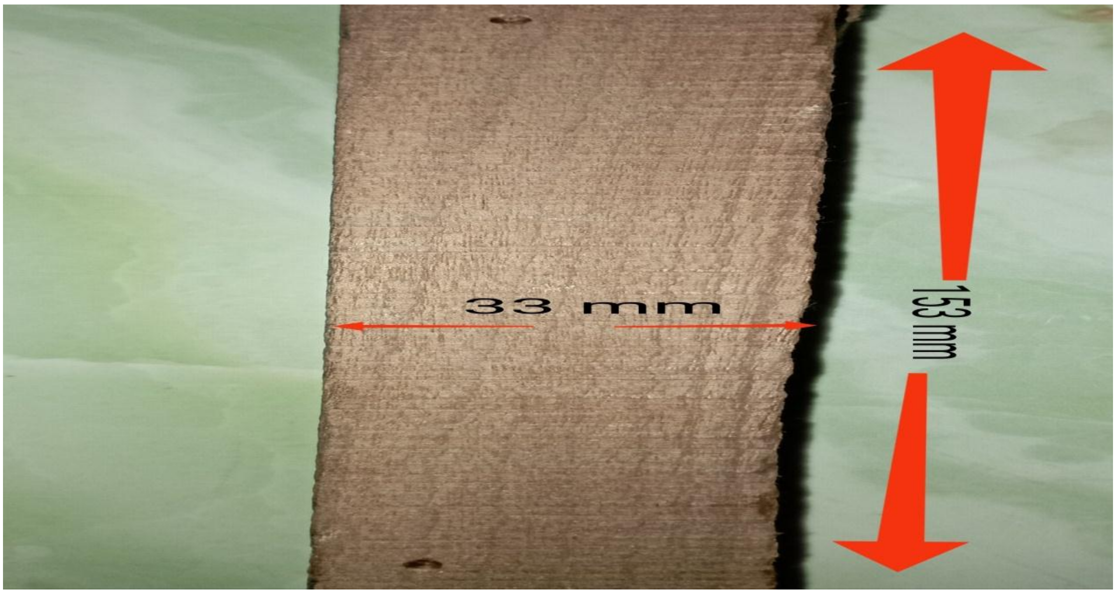


Fig-6.2: Timber Specimen

6.3 Stress and Strain curve

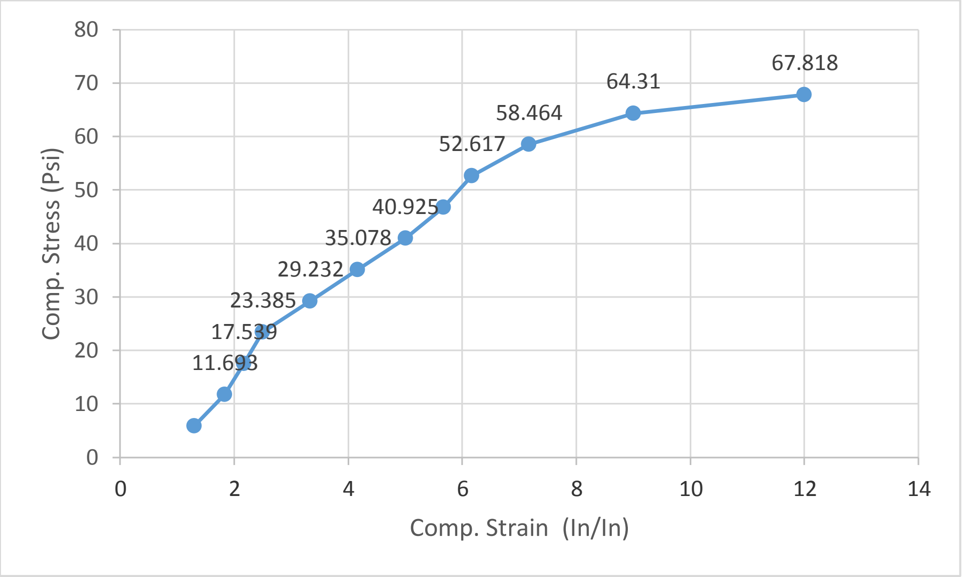


Fig-6.3: Stress-Strain curve

6.4 Load and Elongation curve

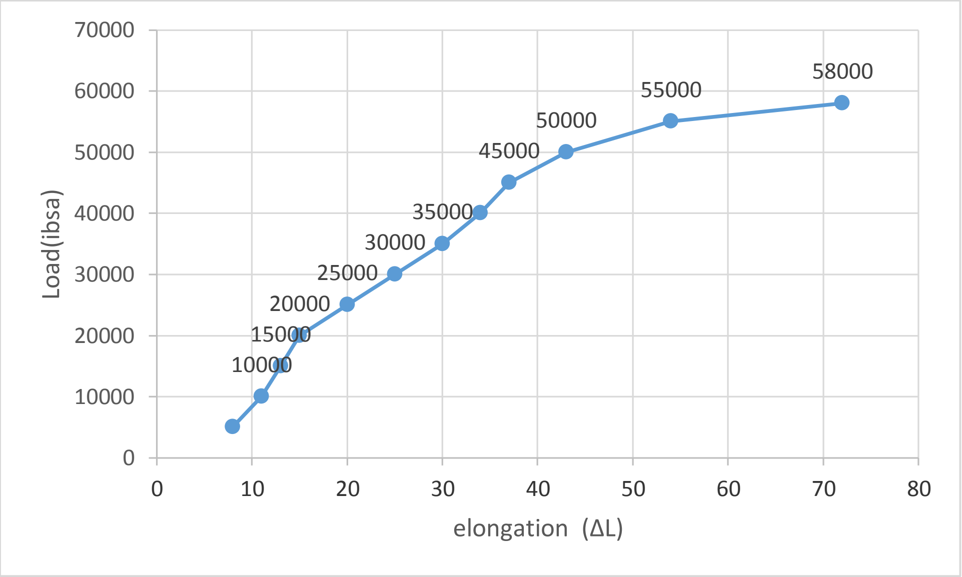


Fig-6.4: Load and Elongation curve

6.5 Formula

Diameter of the specimen, D= 33 mm

Initial Length of the specimen, L= 153 mm

Tensile Stress, σ = {Load (p)/ Area (A)}

Strain, ε = Elongation (ΔL)/ Initial Length (L)

Compressometer Constant= 0.001

Crosssectional Area= 855.23 mm²

6.6 Observation and Calculation

SL. No	Load in ibs (P) N	Elongation (ΔL)	Deformation in (inch)	Stress (psi) P/A	Strain (in/in) (ΔL/L)
01	5000	8	0.008	5.846	0.001333
02	10000	11	0.011	11.693	0.001833
03	15000	13	0.013	17.539	0.002166
04	20000	15	0.015	23.385	0.0025
05	25000	20	0.02	29.232	0.003333
06	30000	25	0.025	35.078	0.004166
07	35000	30	0.03	40.925	0.005
08	40000	34	0.034	46.771	0.005666
09	45000	37	0.037	52.617	0.006166
10	50000	43	0.043	58.464	0.007166
11	55000	54	0.054	64.310	0.009
12	58000	72	0.072	67.818	0.012

6.7 Results

1. Ultimate Strength: σ = Pmax ÷ A= 67.818 N

2. Modulus of elasticity: ε = 67.818÷153= 0.443 N/mm^2

6.8 Discussion

when the load is applied parallel to grains, the wooden sample will take more load to fail, the ability of wood to take more load parallel to grains before failure is because each fibre act as column to the applied load and even after the failure of the single fibre the rest of the fibres will keep on taking the load. When the load is applied perpendicular to the grains, the wooden sample takes comparatively less load. This is because the failure of the single fibre will lead to the failure of the whole sample.

Chapter 7

Conclusion

Non-destructive testing (NDT)is use of non invasive techniques to determine the integrity of a material, component or structure. These techniques allow for inspection without interfering with the specimen’s final use. NDT has a wide range of applications in industries. Especially in railway industries, various NDT techniques such as visual examination, ultra sonic testing, eddy current testing, magnetic particle testing, and thermography, etc., plays a vital role to inspect and monitor the condition of infrastructural.

By testing the timber specimen samples we were able to find out stress, strain, deformation etc. Which will be very useful for us later in real life.

Chapter 8

Future Recommendation

On the basis of results of this study, the following recommendation can be made. GPR and SASW technologies require an extensive amount of manual data analysis. NDT manufacturers should continue to improve the data analysis software with the goal of providing real time results that would be valuable for project and network level pavement assessment. Software to provide real time IE results is available.

If highway agencies expressed an interest in applying NDT for pavement evaluation, the NDT industry would see market potential and continue to develop its equipment.

Highway agencies might consider research funding to support development pf software for project level and network level analysis.

Many highway agencies operate FWD equipment. Research funding should be considered to explore further the use FWD time history data as an NDT tool for identifying pavement discontinuities.

Chapter 9

References

1. K. L. Rens, T. J. Wipf, and F. W. Klaiber, “Review of nondestructive evaluation techniques of civil infrastructure,” Journal of Performance of Constructed Facilities, vol. 11, no. 4, pp. 152–160, 1997.

2. M. K. Lim and H. Cao, “Combining multiple NDT methods to improve testing effectiveness,” Construction and Building Materials, vol. 38, pp. 1310–1315, 2013.

3. P. Shaw and A. Xu, “Assessment of the deterioration of concrete in NPP- causes, effects and investigation methods,” NDT.Net, vol. 3, no. 2, 1998.

4. D. M. McCann and M. C. Forde, “Review of NDT methods in the assessment of concrete and masonry structures,” NDT and E International, vol. 34, no. 2, pp. 71–84, 2001.

5. D. Breysse, G. Klysz, X. Dérobert, C. Sirieix, and J. F. Lataste, “How to combine several non-destructive techniques for a better assessment of concrete structures,” Cement and Concrete Research, vol. 38, no. 6, pp. 783–793, 2008.

6. M. Sanayei, J. E. Phelps, J. D. Sipple, E. S. Bell, and B. R. Brenner, “Instrumentation, non destructive testing, and finite element model updating for bridge evaluation using strain measurements,” Journal of Bridge Engineering, vol. 17, no. 1, pp. 130–138, 2012.

7. B. Amini and S. S. Tehrani, “Combined effects of saltwater and water flow on deterioration of concrete under freeze-thaw cycles,” Journal of Cold Regions Engineering, vol. 25, no. 4, pp. 146–161, 2011.

8. A. Loizos and V. Papavasiliou, “Evaluation of foamed asphalt cold in-place pavement recycling using nondestructive techniques,” Journal of Transportation Engineering, vol. 132, no. 12, pp. 970–978, 2006.

9. E. Proverbio and V. Venturi, “Reliability of nondestructive tests for on site concrete strength assessment,” 10DBMC, Lyon, France, 2005.

10. K. L. Rens, C. L. Nogueira, and D. J. Transue, “Bridge management and nondestructive evaluation,” Journal of Performance of Constructed Facilities, vol. 19, no. 1, pp. 3–16, 2005.

11. L. J. Malavar, N. R. Joshi, and T. Novinson, “Enviromental effects on the short term bond of carbon fibre reinforced (CRPF) composites,” Journal of Composites for Construction, vol. 7, no. 1, pp. 58–63, 2003.

12. G. Pascale, A. D. Leo, and V. Bonora, “Nondestructive assessment of the actual compressive strength of high-strength concrete,” Journal of Materials in Civil Engineering, vol. 15, no. 5, pp. 452–459, 2003.

13. P. F. Almir and F. C. Protasio, “Application of NDT to concrete strength estimation,” NDT.Net, vol. 5, no. 2, pp. 1–6, 2000.

14. B. Chen, M. H. Maher, and E. G. Nawy, “Fibre optic bragg grating sensor for nondestructive evaluation of composite beams,” Journal of Structural Engineering, vol. 120, no. 12, pp. 3456–3469, 1995.

15. K. L. Rens and T. Kim, “Inspection of Quebec street bridge in Denver, Colardo: destructive and nondestru testing,” Journal of Performance of Constructed Facilities, vol. 21, no. 3, pp. 215–224, 2007.

16. S. S. Bhadauria and D. M. C. Gupta, “In situ performance testing of deteriorating water tanks for durability assessment,” Journal of Performance of Constructed Facilities, vol. 21, no. 3, pp. 234–239, 2007.

17. L. Amleh and M. S. Mirza, “Corrosion response of a decommissioned deteriorated bridge deck,” Journal of Performance of Constructed Facilities, vol. 18, no. 4, pp. 185–194, 2004.

18. W. P. S. Dias and A. D. C. Jayanandana, “Condition assessment of a deteriorated cement works,” Journal of Performance of Constructed Facilities, vol. 17, no. 4, pp. 188–195, 2003.

19. E. Bruhwiler and P. Mivelaz, “From corrosion of existing to durability of new concrete structures,” in Proceedings of the International Association for Bridge and Structural Engineering Symposium (IABSE '99), Rio de Janeiro, Brazil, August 1999.

20. A. S. M. Kamal and M. Boulfiza, “Durability of GFRP Rebars in simulated concrete solutions under accelerated aging conditions,” Journal of Composites for Construction, vol. 15, no. 4, pp. 473–481, 2011