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Failure Screening By Using Ultrasonic Tomography Testing Method

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Abstract: Industries routinely use ultrasonic testing, a well-established Non-destructive Testing method, to detect signs on interior surfaces. Ultrasonic testing procedures have evolved from the conventional A-Scan design, which relies on sound waves travelling in straight lines, to more complicated arrangements that let sound waves to bend in both advantageous and harmful directions at a specified moment. Ultrasonic Tomography Testing was used in this work to locate and see the interior flaw of a concrete construction. This study aims hich to identify the internal flaw in concrete structure by using Non-Destructive Testing analysis and to visualize the steel bar in concrete structure by using Non-Destructive Testing analysis. All the operational procedure would be carried out by following the ASME V: article 1, article 4 and article 5 Code and Standard. Ultrasonic technique is advantageous for analysing variations in homogeneity and discovering faults in internal concrete buildings, as recently shown. In general, ultrasonic testing is a valuable instrument for the assessment of concrete structures, as it permits the development of extremely accurate three-dimensional tomographic pictures of the concrete parts being evaluated and enables correct diagnosis based on the acquired data.

Keywords: Non-Destructive, Ultrasonic Tomography, Internal Flaw, Concrete Structure, 3D Imagining Tomography

1. Introduction

In order to find indications on internal surfaces, industries commonly utilise the well-established Non-destructive Testing technique known as ultrasonic testing. From the traditional A-Scan design, which depends on sound waves flowing in straight lines, to more complex arrangements that allow sound waves to bend in both beneficial and detrimental directions at a specific time, ultrasonic testing techniques have advanced. By using an improved method of data gathering, this mathematical processing of waveforms creates an image of the volume being studied and enables the detection of a minute or even microscopic signal.

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The use of NDT techniques to ensure the quality of concrete structures has advanced significantly in recent years. Research has led to the development of a wide toolbox of techniques for the analysis of concrete structures. This development has been fuelled by technology and knowledge transfer from other fields of materials testing and medical [1]. A fundamental area of study that enables determining the quality and state of material deterioration in construction materials is non-destructive testing (NDT) of cementitious materials. Information about the microstructure of composite materials can be provided using ultrasonic non-destructive testing (NDT) procedures [2] [3] [4] [5]. In mechanical and civil engineering, NDT is frequently used for quality control of newly constructed buildings as well as for determining the extent of damage to older buildings and structures whose behaviour is in doubt. The objectives of this research are to identify the internal flaw in concrete structure by using Non-Destructive Testing analysis and to visualize the steel bar in concrete structure by using Non-Destructive Testing analysis.

2. Materials and Methods

Figure 1 shows the flowchart of this research that to be followed for completing the research.

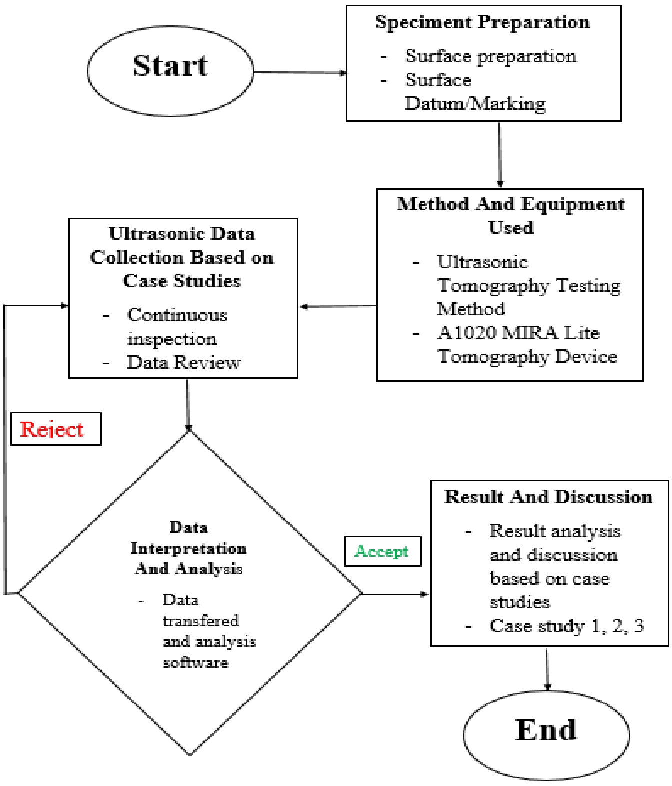


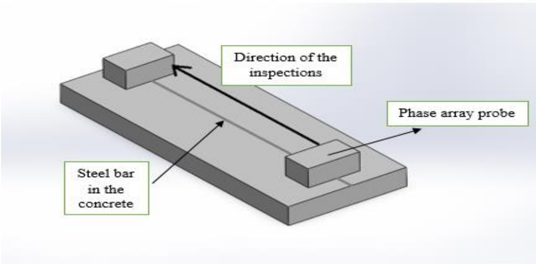
Figure 1: Research Flow Chart

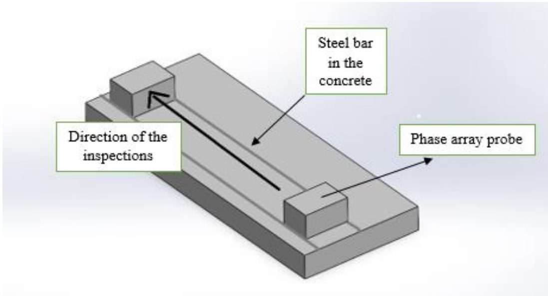
2.1 Equipment and Specimen

The equipment used was A1020 MIRA Lite tomography is an electronic unit to which M4002 matrix antenna array is connected using a cable [6] while for the specimen used for the inspection was a concrete structure with the size of 1000mm x 400mm x 80mm. Generally, the method of non-destructive testing which is ultrasonic tomography would be applied on the surface of the concrete structure that having the datum for the probe array to be placed. All the data collected repeatedly until the desired result obtained.

2.3 Operational Simulations

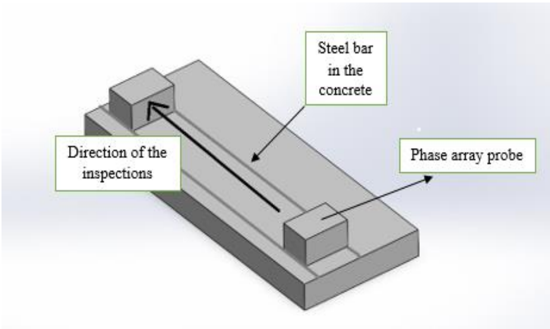
All of the data collections was based on the 3 case studies demonstrated in Figure 2. Case study 1 was to identify the internal flaw of concrete structure, case study 2 was to visualize the appearance of the steel bar and case study 3 was inspection on the concrete where expected to be not having the steel bar.

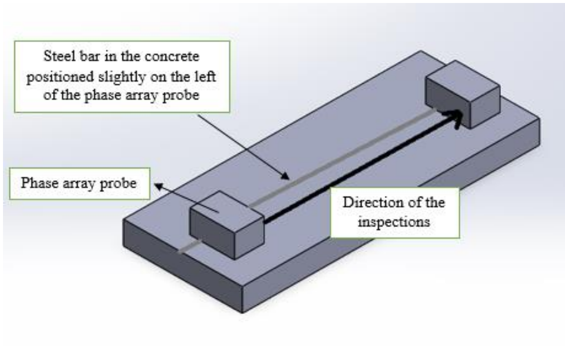




Case Study 1

Case Study 2 (1st Condition)





Case Study 2 (2nd Condition)

Case Study 3

Figure 2: Different case studies representing different arrangement of measurement

2.4 Data Interpretation

Data interpreted by using the analysis software of concrete as shown in Figure 3. After the data had been collected, it is being transferred into the software of concrete analysis to being interpreted and analysed. If the result was not enough to achieve the requirement, then the operation of ultrasonic tomography was repeated, collecting the data again, doing the analysis on software until the desired result were achieved.

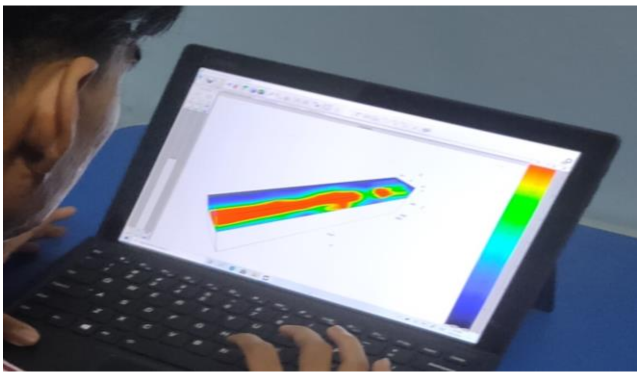


Figure 3: The data interpretation and analysis

3. Results and Discussion

Case Study 1 (Detecting Internal Defects in Concrete)

Applicable to concrete examination, enabling imaging of the interior structure of objects made of concrete, reinforced concrete, and other stones. The process uses the pulse-echo method for one-sided object access. The tool is applicable for concrete inspection for locating conduct ducts and conduits, detecting external inclusions, holes, honeycombing, fractures, and other faults inside concrete objects, and evaluating the state of reinforcement in concrete. By processing tomographic data, a more informative image of the structure is produced.

This study was based on the application of MIRA tomography to identify internal defects in concrete structure commonly used for the buildings and constructions. The scan was made along the length of the concrete structure, as can be seen in Figure 4 segment.

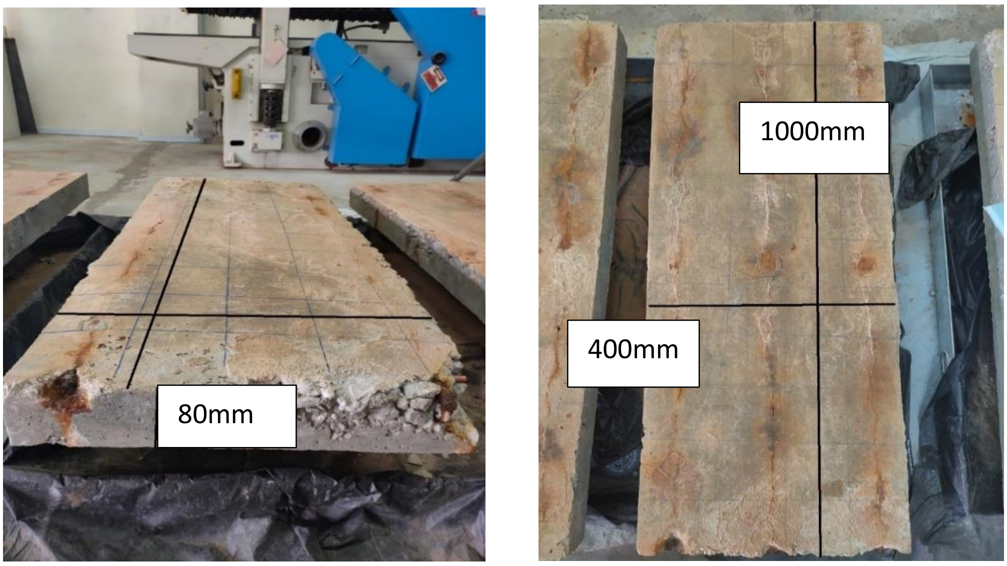


Figure 4: The image and actual size of the specimen

The frequency chosen for the operation of this case study 1 was 60 kHz, and the pulse ratio was 3100 m/s. After collecting the data, the findings were loaded into the programme to build a 3D picture of the interfaces of reflected elements. On the photos created by the programme, the various interfaces present at each segment are visible. Figures 5 and 6 depict the outcomes.

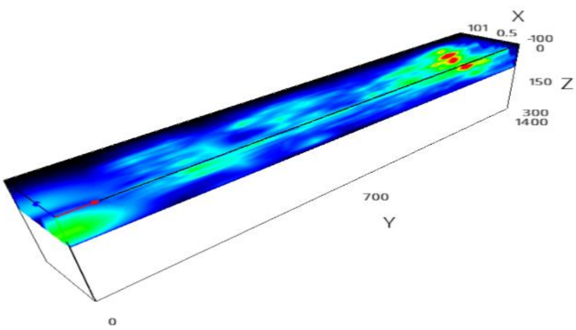


Figure 5: The possible flaw of defect in internal concrete structure

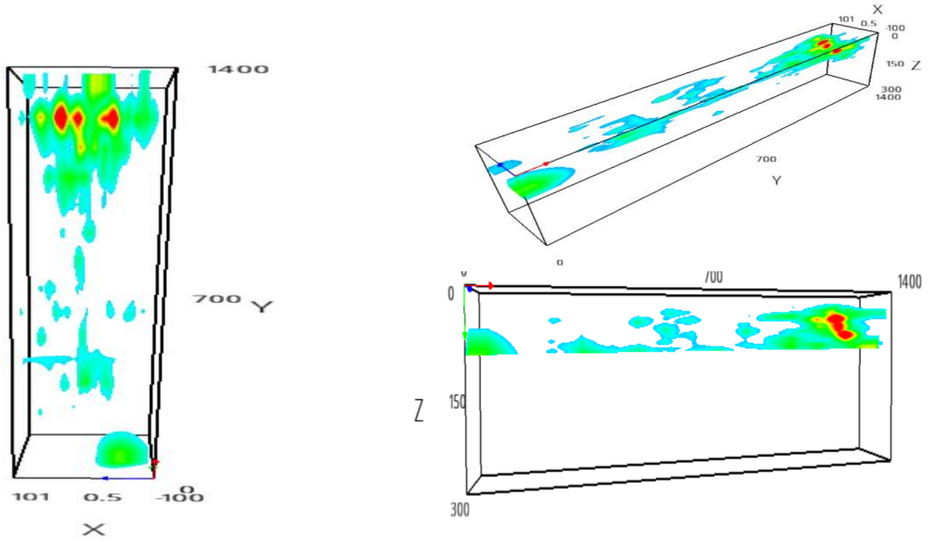


Figure 6: The top, isometric and side view of concrete structure

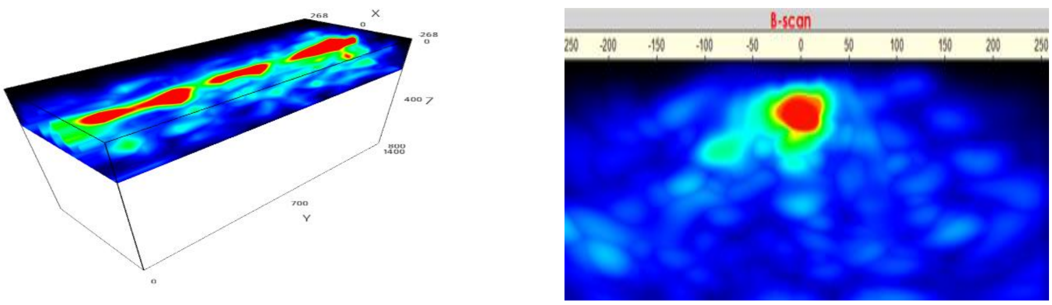
Figure 5 and 6 just show on possible flaw of the defects by the view that had been set from the analysis software. It is can be seen one of the capabilities of the analysis software to interpreted data. Therefore, from the 3D imagining result, the possibility of the flaw internal structure image can be seen by doing ultrasonic tomography inspections.

Case Study 2 (inspection on Concrete with Steel Bar)

The second study case is based on the application of MIRA to visualize the image indications of the steel bar in the concrete structure. At this study, the objective was to visualize the appearance of steel bar along the concrete structure. The actual dimension of the specimen was about 1000mm x 400mm x 80mm while there is a limit on the sensitivity setting of the NDT device so the data would analysed on the software following the requirement of the device.

<u>Direct inspection above the steel bar</u>

Figure 7 show the result of the ultrasonic tomography visualizing the steel bar that positioned in the mid of the phase array probe in the concrete structure with the device setting dimension of 1400mm x 536mm x 800mm. The vertical red colour just show the appearance of the steel bar in the concrete structure.



(a) (b)

Figure 7: (a) Results of case study 2 condition 1 (b)B-scan that show the steel bar in the mid of the phase array probe

As we can see that the red colour one which is the steel bar was positioned directly under the grid of zero where the zero grid was show the centre of the phase array probe.

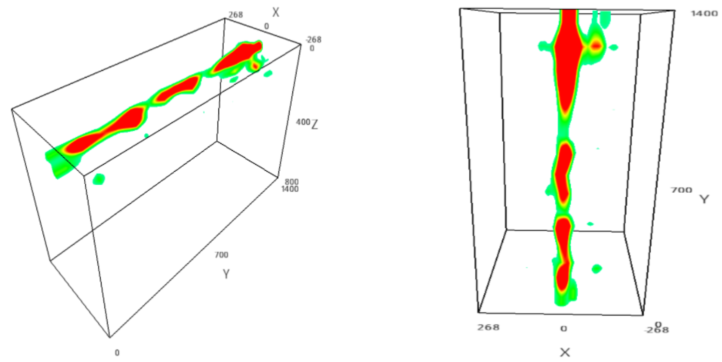


Figure 8: The isometric and top view of the steel bar in the concrete structure.

The software allows viewing the result into something like the Figure 8 shown for a clear image of the steel bar on the concrete structure.

<u>Inspection where the steel bar is on the left</u>

Figure 9 show the result and B-san of the ultrasonic tomography visualizing the steel bar that positioned slightly on the left of the phase array probe in the concrete structure with the device setting dimension of 900mm x 134mm x 200mm. The vertical red colour just show the appearance of the steel bar in the concrete structure. For the colour inequality can be the effect of the improper technique during the inspection method such as not giving enough forces onto the probe for ensuring the transducer making a proper contact with the surface specimen.

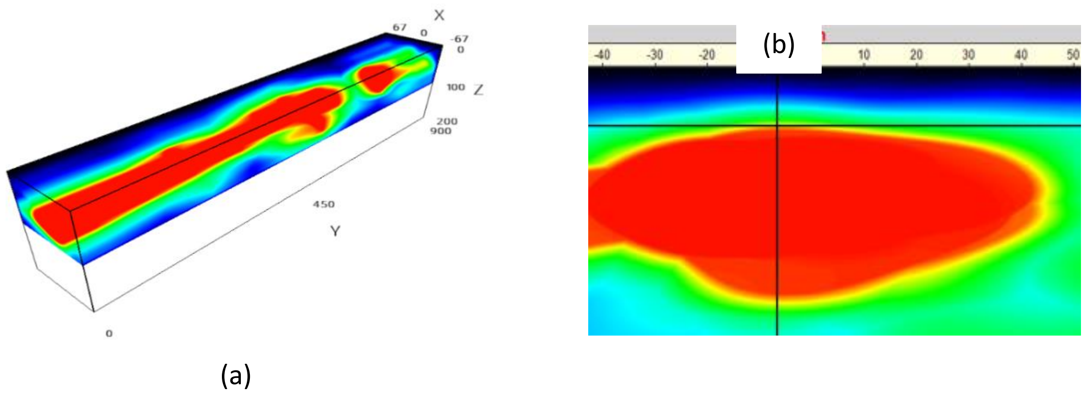


Figure 9: (a) Results of case study 2(condition 2) (b)B-scan that show the steel bar slightly on the left of the phase array probe

The picture above just show that the position of the steel bar was slightly in the negative direction which means it is positioned slightly on the left of the phase array probe. The centre of the phase array probe was on the zero.

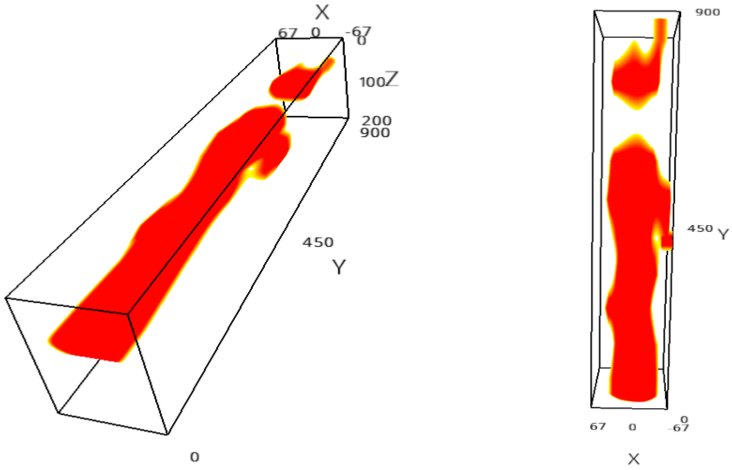


Figure 10: The isometric and top view of the steel bar in concrete structure

Since the sensitivity setting of the device was different for both inspections, then it was showing the different result of ultrasonic tomography in-terms of the intensity of the image colour gain, as in Figure 10. A proper work during the operation was a must to obtain better results.

Case Study 3 (inspection on Concrete without Steel Bar)

Figure 11 show the result of the ultrasonic tomography on the concrete structure without steel bar with the device setting dimension of 1400mm x 200mm x 300mm. We can see that there is no appearance of the steel bar in the specimen. The different colour just show the possible flow of internal in the concrete structure. For the colour inequality can be the effect of the improper technique during the inspection method such as not giving enough forces onto the probe for ensuring the transducer making a proper contact with the surface specimen. In this case, a frequency of 60 kHz and pulse velocity of 3100 m/s was used.

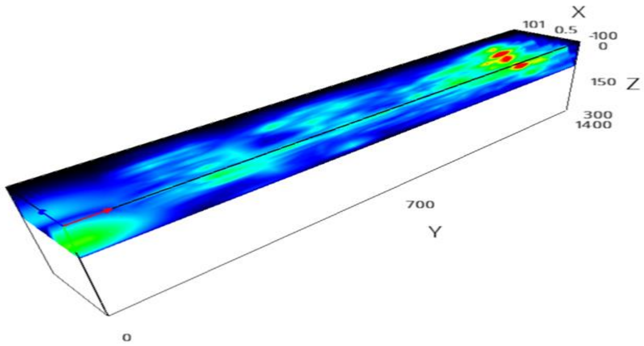


Figure 11: The result of concrete structure expected to be no having a steel bar

This result shows in Figure 12 was to show that the different between the 3D imaging tomography that having the visual of the steel bar and without the steel bar. it is truly show that there was no steel bar in the concrete structure. From the result observations, the initial visual of the steel bar in the concrete structure can be seen by using the ultrasonic tomography method. It is shown that there is the difference either having or not for the steel bar in the concrete structure.

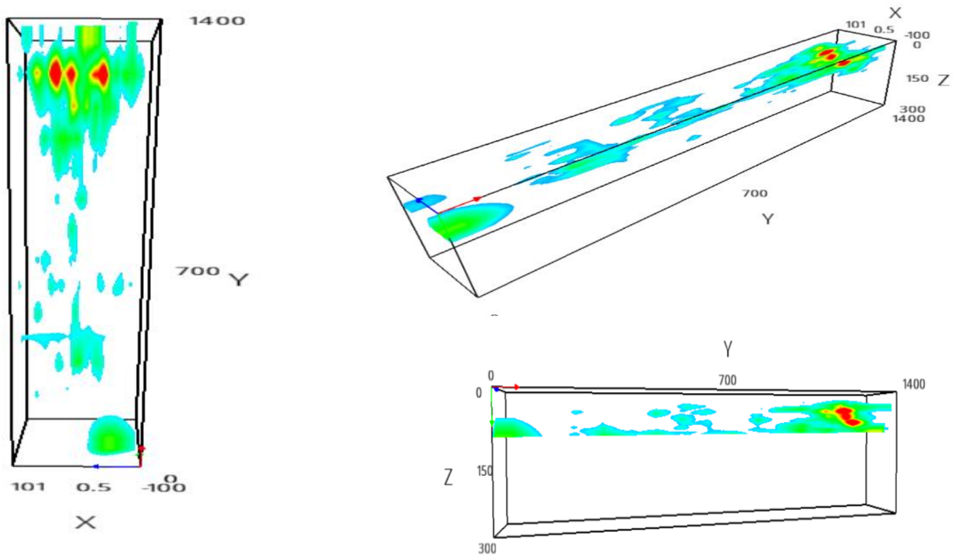


Figure 12: The isometric, top and side view of image without steel bar

4. Conclusion

Generally, this research was successfully finished and the objective of this research was achieved. The findings just shown that ultrasonic technology is beneficial for analysing variances in homogeneity and identifying defects in interior concrete constructions. In this context, the use of 3D ultrasonic tomography is beginning to acquire significance. This tool is an effective approach to construct a three-dimensional depiction of internal faults that could be present in a certain element, and it gives a reasonably thorough analysis of the created pictures, which has shown to be highly valuable in the assessment of real components. Future studies could try for the different methods as well as different equipment so that the non-destructive testing method becomes more significances though out the world of engineering.

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