

**APPLICATION OF NON DESTRUCTIVE TEST FOR STRUCTURE
EVALUATION**

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ABSTRACT

The aim of the present paper is to check the accuracy of Ultrasonic Pulse Velocity (UPV) and Rebound Hammer for assessing concrete strength that are widely used in structural field. Even though there are many methods for Non Destructive Test (NDT) but every method have it own boundaries and which mean the method cannot afford an accurate and consistence result for difference cases and to detect different defect. The NDT is applied on jetty Lembaga Kemajuan Ikan Malaysia (LKIM) at Kuantan, Pahang. The structure that has been test is the slab that was constructed in year 1989 and 2001. A general series of tests which are compression test, rebound hammer and UPV was carried out at laboratory to obtain a correlation of the NDT results with compressive strength. 24 concrete cubes of sizes 150 x 150 x 150 mm has been made and subjected to two curing condition which is water curing and air curing for 1 day, 7, 14 and 28 days. For each day stated, 3 cubes which subjected to water curing and 3 cubes subjected to air curing was tested. To get the exact result of the cube strength, compression test applied to the concrete cube. Before the compression testing applied, the cube strength checked by using UPV and rebound hammer. The data obtained from each test has been evaluated and the accurate and precise device was determined. From this research, the most accurate NDT method is Ultrasonic Pulse Velocity

ABSTRAK

Tujuan kertas ini ditulis adalah untuk mencari ketepatan alat sama ada “Ultrasonic Pulse Velocity (UPV)” atau “Rebound Hammer” dalam menguji kekuatan konkrit di mana telah banyak digunakan di dalam bidang struktur. Walaupun terdapat banyak cara dalam ujian tanpa musnah (Non Destructive Test) tetapi setiap cara mempunyai sempadan dan tidak dapat memberi keputusan yang tepat dan konsisten bagi setiap kes dan kerosakan yang berlainan. Ujian tanpa musnah ini akan dilakukan di jeti Lembaga Kemajuan Ikan Malaysia (LKIM) di Kuantan, Pahang. Struktur yang akan di siasat adalah lantai yang dibina pada tahun 1989 dan 2001. Ujian musnah (Destructive Test), “Rebound Hammer” dan “UPV” akan dilakukan di makmal dengan tujuan untuk mencari hubungan ujian tanpa musnah dengan kekuatan konkrit. 24 bongkah konkrit yang bersaiz 150 x 150 x 150 mm akan dibuat dan diletakan pada dua keadaan yang berbeza iaitu dalam air dan di udara bagi 1, 7, 14 dan 28 hari. Setiap hari yang dinyatakan, 3 bongkah kiub yang diawet di dalam air dan 3 lagi dibiarkan diudara diuji. Bagi mendapatkan keputusan yang betul bagi kekuatan setiap bongkah konkrit ujian musnah dilakukan. Sebelum ujian musnah dilakukan setiap bongkah konkrit akan diuji dahulu dengan “Rebound Hammer” dan “UPV”. Data yang telah diperolehi akan di evaluasi dan alat yang tepat dan persis akan ditentukan. Daripada kajian ini, kaedah ujian tanpa musnah yang paling tepat adalah “Ultrasonic Pulse Velocity (UPV)”.

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LIST OF SYMBOLS

d	-	Distance from the surface to the discontinuity in the test piece
c	-	Wave speed
f	-	Frequency
l	-	Length between 2 transducers. (unit in km)
t	-	Transit time (unit in s)
v	-	Velocity (unit in km/s)

LIST OF ABBREVIATION

- UPV - Ultrasonic Pulse Velocity
NDT Non Destructive Test

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Nowadays there are many development have been held in Malaysia. In order to pursue the vision of year 2020, urbanization will be widen, more latest and advance technology will be applied in daily life and economy will be increase to be comparable to other developed country such as Singapore or Hong Kong. It also means many building will be build to fulfill the desire of development. Instead of building, maintenance of existed building such as historical building also important as it is a proof of the existing of certain culture of community. The purpose of maintaining the existing building not only for historical value, but also saving cost for construct new building, multiple usage of the building example house turns into a kindergarten, avoiding wasting of the building, aesthetic value if the building were left unused, and not including some individual does this for their own sentimental value.

Therefore, in order to know how and when maintenance can be done, the condition and performance of the building must be evaluated first. Thus, suitable method must be appropriate choose so that a test can be done. But the test must not damage the existed building because it will increase the cost of maintenance and

repairing. Furthermore, it will decrease the strength of the building and threaten the building user safety. As a consequence, the non-destructive test is the most suitable test that can be applied to facilitate the needs of the maintenance system.

By choosing a suitable method of non-destructive test, the problems that have occurred or might occur can be determined. From here, suitable repair material or repair technology can be verified. However, maintenance needs a system or management so that maintaining operation can be started. This is what this paper will discuss, including what has been said above. The title "Application of Non-Destructive for Structure Evaluation" is chosen for research to answer and analyze the application of non-destructive test in civil engineering and the matter that will be related to this test.

1.2 Background of Study

Nondestructive testing, also called as NDT, nondestructive evaluation (NDE) and nondestructive inspection (NDI). Recently, in construction nondestructive tests are in great variety in worldwide use to detect variations in structure, minute changes in surface finish, the presence of cracks and other physical discontinuities. Other than that, it helps to avoid design failures, prevent accidents and save human life. Most civil engineers will have to consider about this matter because it involves the life or death of the building user. Furthermore, it can make a profit for the user as the longer the building is useful to the user, the better profit can be made. As a result, it will ensure client satisfaction and maintain the consultant or contractor reputation.

There are many methods in non-destructive test such as Rebound Hammer, Profometer and Ultra Sonic Pulse Velocity. Every method of non-destructive test has its own boundary and which means the method cannot afford an accurate and consistent result for different cases and to detect different defects.

The Ultrasonic Pulse Velocity can be used to assess the quality and uniformity of the material. The velocity of an ultrasonic pulse through a material is a function of the elastic modulus and concreteness/density of the material. The method is also useful for estimating crack depth and direction, and determining the thickness of surface layers damaged by chemical attack, fire, etc (Bernie Herlein, 2000). The Profometer is used in order to accurately locate reinforcing bars and welded wire meshes. Besides that the Profometer also used to measures the concrete cover and determines the diameter of the bars. The most easiest and simple method for non-destructive test is Schmidt Hammer. A Schmidt Hammer, also known as a Swiss hammer, is a device to measure the elastic properties or strength of concrete or rock. The hammer measures the rebound of a spring loaded mass impacting against the surface of the sample.

1.3 Definition of Terms

Often, in NDT and Quality control anomaly, discontinuity, defect, flaw, imperfection, non-conformance are the terms used when the material/component tested deviates from requirement/ideality. Though all of them look similar, there exists a vast difference in their meaning and interpretation.

Discontinuity - an interruption, intentional or unintentional in the configuration of the part.

Deterioration - physical manifestation of failure of a material (e.g., cracking, delamination, flaking, pitting, scaling, spalling, staining) caused by service conditions or internal autogenous influences.

Defect - one or several discontinuities that do not meet specifications.

Flaw - means a detectable lack of continuity or a detectable imperfection in a physical or dimensional attribute of a part.

Nonconforming - means only that a part is deficient in one or more specified characteristics. In many instances, a non-conforming part is entirely capable of performing its intended function, even in its non-conforming form. In other instances, a non-conforming part can be reworked to make it conform to specifications. Hence, it should not be automatically assumed that a non-conforming part is unfit for use.

The types of defects that NDT is called upon to find can be classified into three major groups:

- Inherent defects - introduced during the initial production of the base or raw material.
- Processing defects - introduced during processing of the material or part.
- Service defects - introduced during the operating cycle of the material or part.

Some kind of defects or structural variations which may exist in these three groups are, cracks, surface and subsurface, arising from a large number of cases, porosity, tears, machining, rolling and plating defects, laminations, lack of bond, inclusion,; segregation, lack of penetration in welds, pipe, fatigue defects, seams, blow holes and dross shrinkage.

Crack - a complete or incomplete separation of concrete into two or more parts produced by breaking or fracturing.

Crack bridging - the ability of repair or protective surface treatment to remain continuous when installed on a cracked concrete surface.

Fatigue - the weakening or failure of a material subjected to prolonged or repeated stress.

Porosity - the ratio the volume of all voids in a material to the volume of the whole.

Segregation - the differential concentration of the components of mixed concrete, aggregate, or the like, is resulting in nonuniform proportions in the mass.

Shrinkage - a decrease in one or more dimensions of an object or material.

However, even with the highest quality of materials and workmanship, the occurrence of some form of imperfections during manufacture and construction is expected and there will be a typical distribution of imperfection sizes connected with a particular manufacturing and constructing process and quality. The ideal situation is where the inherent distribution of initial imperfection sizes is well separated from the distribution of critical defect sizes which may cause failure. Hence, the role of NDT is not only to detect the defects but also to give information about the distribution.

On the other hand, in the in-service scenario, defects will be generated due to deterioration of the component or structure as a result of one or combination of the operating conditions like elevated temperature, pressure, stress, hostile chemical environment and irradiation leading to creep, fatigue, stress corrosion, embattlement, residual stresses and microstructural degradation which, in turn, it will result in deterioration of mechanical properties, crack initiation and propagation, leaks in pressurised components and catastrophic failures.

NDT techniques are increasingly applied to components or systems for the detection and characterisation of defects, stresses and microstructural degradation to ensure the continued safety and performance consistency of components in industry. NDT techniques improve the performance consistency of components through periodic in-service inspections, by way of preventing premature and terrible failures.

NDT also provide valuable inputs to plant specification and design for example to determine which components are the most likely to fail and then to ensure that those have easy maintenance access for repair or replacement. In the service scenario, it is rather difficult to stop the formation of defects and the growth of defects that already formed.

1.4 Problem Statement

The goal in engineering investigative work is to determine the existing conditions of the structure in question and predict past and future conditions of the structure. Besides that every building needs to be evaluated for performance after the construction.

Evaluation must be done periodically to detect any defects or failures that occur at the structure. Checking for deterioration after a period of service for a structure is compulsory in order to know the life of the building.

However, there are no specific method is prescribed by JKR and Consultant to evaluate building. The choice of methods is up to the resident engineer.

By using non-destructive test there are many methods that can determine defect or failure that occur at the structure and every method have it own parameter. Furthermore every single technique that always been use have their limited boundary which mean the method cannot afford an accurate and consistence result for difference cases and to detect different defects.

Because of there are many method available for Non-Destructive Test, at the moment there seems to be many arguments on the best Non-Destructive Test methods for evaluation.

Thus it is important for the research to carry out in turn to enhance the knowledge of non-destructive test and to search for the best method of non-destructive test method.

1.5 Objectives

- To apply Non-Destructive Method to evaluate the structure of concrete building.
- To investigate the accuracy at the various Non-Destructive method.

1.6 Scope of Study

This type of Final Year Project is about case study. This study will take place at Lembaga Kemajuan Ikan Malaysia (LKIM), Kuantan. A case study will be carried out on a jetty of LKIM.

For this study, Non-Destructive Test method mainly Rebound Hammer and Ultrasonic Pulse Velocity (UPV) will be employed. For Rebound Hammer it will use BS 1881: part 202: 1986 for British Standard and Ultrasonic Pulse Velocity (UPV) it will use BS 1881: part 203: 1986.

All the collected data must be analyze and make comparison in order to know which methods gives the most accurate result. The structure to be evaluated is slab.

Besides that some of laboratory test also need to be done in order to compare with the test that carried out at the site. For laboratory test 24 concrete cubes will be made which for 1 day, 7, 14 and 28 days. The concrete cube will be test using Rebound Hammer and UPV for Non-Destructive Test methods include cube test for destructive methods that using BS 1881: part 116:1983.

1.7 Significant of Study

The significant of the study is to determine any deterioration in the structure or any failure that can contribute into damaging. Other than that non-destructive test essentially refers to all the test methods which permit testing or inspection of material without impairing its future usefulness. Thus non-destructive test methods are extremely valuable in assessing the condition of structures, such as bridges, buildings, and highways.

Because of the current emphasis on rehabilitation and renovation of structures, there is a critical need for the development of non-destructive methods that can be used to evaluate the condition of structures so that effective repair procedures can be undertaken. Other than that the significant of this study is to propose which is the best method for structural evaluation.

Basically the purposes of the non-destructive test are to determine of material properties. Besides that it also for detection, characterizations, location and sizing of discontinuities or defects, determine quality of manufacture or fabrication of a component or structure and lastly is for checking deterioration after a period of service for a component/structure. From all of the purpose of non-destructive test, so it is important to learn about non-destructive test and able to apply it as working as civil engineer.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The goal in engineering investigative work is to determine the existing conditions of the structure in question and predict past and future conditions of that structure. Some investigative options, example removing a brick veneer to see what is behind it significantly alter the conditions found in the field. Therefore, methods which have little effect on the existing conditions, example, nondestructive methods, are highly desirable.

2.2 Definition of Non Destructive Test

According to Pratt D. G. and Lawrence J. (1990), nondestructive testing (NDT) methods are techniques used in order to obtain information about the properties or the internal condition of an object without damaging the object. Other than that NDT basically refers to all the test methods which allow testing or

inspections of material without damage its future usefulness. Thus NDT methods are extremely valuable in assessing the condition of structures, such as bridges, buildings, and highways. Because of the current emphasis on analysis and renovation of structures, there is a critical need for the development of NDT methods that can be used to evaluate the condition of structures so that effective repair procedures can be undertaken.

2.3 Important of Non Destructive Test

Rao B.P.C (2002) has stated in general, the purpose of NDT will fall into one of the following categories:

1. Determination of material properties
2. Detection, characterizations, location and sizing of discontinuities or defects
3. Determining quality of manufacture or fabrication of a component or structure
4. Checking for deterioration after a period of service for a component/structure

Pratt D. G. and Lawrence J. (1990) claims non destructive test (NDT) methods are used to obtain information about a structure in an indirect way. For example, by measuring the speed of stress (sound) waves that travel through an object and a study of how the waves can reflect within the object, hence whether or not flaws exist within the object be determine.

For structural engineers the development of non destructive test (NDT) techniques for evaluating reinforced concrete structures is very important. Currently, the practical techniques that can detect cracks in concrete are by use acoustic impact, infrared thermography, and ground penetrating radar.

However, none of these methods possesses all the desired qualities of a crack detection system, which are consistent under various site conditions, capability for

rapid testing of large areas and ease of use. Furthermore every single technique that always been use have their limited boundary which mean the method cannot give an accurate and consistence result for difference cases and to detect different defects such as cracking and corrosion, there are different method. (Rao B.P.C, 2002)

Besides that one of the important parts of non destructive test (NDT) is in ageing management of concrete structure. This role of NDT is expected to gain important development of NDT method in order to know the right and the most accurate method of NDT for concrete structure. As existing structures age, effective inspection has become a greater issue. This problem probably happens in all country in world. To overcome this problem a consistent inspection should been utilized in order to detected any degradation at an earlier stage, and afterward the consequences of the degradation would be expected and can be significantly lower.

Non destructive test (NDT) has potential applications in three key areas in the management of safety related concrete structures:

- Determination of as-built (or current) structural details
- Detection of flaws
- Characterisation and quantification of flaws

A difference in non destructive test (NDT) techniques for concrete ageing monitoring has been drawn between detection, and characterization and quantification of flaws. All the requirements for NDT techniques in each application are vary. For detection of flaws only requires that a given technique should identify that a flaw is present, and give an approximate indication of location and area. For characterization and quantification techniques should be able to measure the nature and area of a flaw with sufficient sensitivity in turn to allow an engineering assessment of the impact of the flaw on safety and serviceability of the structure to be undertaken.

In many cases, the objective is likely to obtain data for use in an engineering assessment. Examples of point for this assessment include:

- Confirmation of continued satisfactory structural performance
- Evaluation of the significance of an identified flaw
- Re-evaluation of design due to changes in operational conditions (example increased design loads, extended structure life or decommissioning planning).

However it should be noted that alternative techniques such as destructive and semi-destructive techniques are also available to carry out the above tasks. But the attraction of NDT techniques is that they are non intrusive or not damaging the structure and can be less costly or disruptive to implement. Furthermore, another attraction of NDT is the potential for improving the data accuracy and quality about the condition and performance of a structure as this may help to avoid over maintenance and unwarranted expenditure on monitoring or corrective works.

2.4 Requirements for Non Destructive Test in Management of Safety

There are three key requirements for non destructive test (NDT) in the management of safety relate to concrete structures which have been stated before and there are determination of as-built (or current) structural details, detection of flaws, characterization and quantification of flaws.

2.4.1 Determination of As-built

For determination of as-built (or current) structural details is an important NDT application. The requirement for this application can start from inadequate or missing construction records for example drawings and documentation, or suspected