Thickness Measurement of Masonry Wall using Impact-Echo Technique

S.K.Divya1 K.Kiruthika2
1Assistant Professor 2Student

Valliammai Engineering College, Chennai-603 2Velammal Engineering College, Chennai-66

Abstract— Masonry is one of the most durable construction material. Ancient masonry structures can provide hundreds of years of wonderful performance with limited maintenance. Without any doubt, preservation of those structures is more important because they are the wealth of our nation. Heritage buildings require particular surveillance in structural assessment, because of the small amount of knowledge of the inner geometry, constructive materials and state of conservation. When nondestructive testing is used to evaluate a structure, many decisions must be made about the number and location of tests. Cost constraints work to minimize the number of tests while the desire to accurately assess the state of the structure argues for the maximum number. By using the non destructive testing (NDT) techniques, structure can be tested many times through the complete life cycle to ensure its continued integrity. The present study aims at applicability of impact echo in the measurement of thickness in masonry wall.

Key words: NDT, Masonry, Impact Echo Technique

I. INTRODUCTION

There is an increasing demand for ongoing structural maintenance and repair for aging and deteriorated old masonry structures around the world. An evaluation assessment program for maintenance, repair and retrofit work of masonry structures should preferably be non-destructive, non-intrusive, and cost and time efficient[5]. Non-destructive testing (NDT) techniques are increasingly gaining popularity for the assessment of important structures such as bridges, roadways, tunnel linings, nuclear structures and also the structural elements like wall, beam, slab, etc.

The commonly used NDT methods for the evaluation of quality and integrity are rebound hammer, ultrasonic pulse velocity, core sampling & testing etc. In recent times, techniques such as impact echo (IE), pulse echo (PE), ground penetrating radar (GPR), infrared thermography etc., are gaining popularity in the field of civil and structural engineering. These technologies are mainly suited for the detection and characterisation of inhomogeneities in concrete and masonry structures at depths (e.g. concrete cover) between 5 and 100 cm [9]. Among various non-destructive testing (NDT) techniques, impact-echo is suitable for integrity evaluation of masonry structures since it can provide information about the thickness and the presence of flaws. The impact-echo method is a technique for flaw detection in masonry. It is based on monitoring the surface motion resulting from a short-duration mechanical impact. The method overcomes many of the barriers associated with flaw detection in concrete and masonry based on ultrasonic methods [6].

Since its development, the impact-echo method has been used successfully for detecting a variety of defects in plate-like structures including detecting cracks and voids in plain and reinforced concrete slabs; determining the depth of surface opening cracks in slabs; locating voids in prestressing ducts; detecting honeycombed concrete; determining the thickness of slabs with asphalt concrete overlays; detecting delaminations in slabs with and without overlays; and detecting cracks and voids in layered plates.

In a plate such as a concrete slab or wall, the impact-echo response is dominated by reflections between the top and bottom surfaces of the plate and/ or by a defect if one exists. The thickness of the plate or the depth of a flaw can be calculated using a simple formula that relates the depth d to the frequency of wave reflections and to the P-wave speed Cp[8]

\[ d = \frac{C_p}{2f} \]

Where, \( C_p \) - P wave speed
\( f \) - Frequency of wave reflections

It is better practice that NDT engineers have the knowledge and training of various NDT methods available for testing the structure, to select better technique from the available methods according to the condition of structures. Use of different methods for evaluating a single parameter increases the confidence and also validates the results. Combining the results of various NDT methods for assessing the quality of structures has been required for better results. This paper presents the application of impact echo test on masonry structure for the determination of thickness.

II. EXPERIMENTAL PROGRAM

IES system consists of several basic components. These components include the Freedom Data PC computer with a National Instruments Data acquisition card, an IE Pulser Module for driving the IE scan head, an amplifier module designed for IE work, and a scan head with an impactor, a rolling receiver, and distance measurement circuits. A cable assembly connects the test head to the pulser module [4].

![Fig. 1: Impact echo scanning system](image)

Impact produces a high energy pulse that can penetrate deep into masonry. The impact response of thin members, such as slabs and walls, is more complicated than that of long slender members. An impact on the surface produces P- and S-waves that travel into the surface and a surface wave (R-wave) that travels away from the impact point. The P- and S-waves are reflected by internal defects (difference in acoustic impedance) or external boundaries.
When the reflected waves, or echoes, return to the surface, they produce displacements that are measured by a receiving transducer. If the transducer is placed close to the impact point, the response is dominated by P-wave echoes.

![Fig. 2: Principle of impact echo technique](image2)

The fig.3 shows the pattern of surface displacements that would occur. The large downward displacement at the beginning of the waveform is caused by the R-wave, and the series of repeating downward displacements of lower amplitude are due to the arrival of the P-wave as it undergoes multiple reflections between the surface and the internal void.[6]

![Fig. 3: Reflected P waves and S waves from surface](image3)

The IES software is designed to display the waveform, the calculated spectrum and display the thickness corresponding to the dominant frequency peak dynamically. The points are recorded from bottom and its reaches its own position when the save button was clicked. By selecting each and every point the noise in the signal has to be filtered and the corresponding thickness can be noted [4].

![Fig. 4: IES software for analysis](image4)

### III. TEST SPECIMEN

#### A. Specimen 1:
The masonry wall panel (W1) consists of 18 brick layers. The thickness of the wall panel is 476 mm. The arrow shows the scan line direction (bottom to top). The IE test has been proposed to carry out in this wall specimen in order to find the reliability on thickness evaluation in a solid portion. It can be observed from the fig.5, that the wall panel is plastered on both sides.

![Fig. 5: Wall panel, W1 ready for testing](image5)

#### B. Specimen 2:
The masonry wall panel (W2) consists of 10 brick layers. The thickness of the wall panel is 260 mm. The arrow shows the scan line direction (bottom to top). The IE test has been proposed to carry out in this wall specimen in order to find the reliability on thickness evaluation in a solid portion. It can be observed from the fig.6, that the top two layers of the wall panel is un-plastered on both sides.

![Fig. 6: Wall panel, W2 ready for testing](image6)

### IV. RESULTS AND DISCUSSION

#### A. Specimen 1:
The result of the specimen 1 represents the thickness evaluation of the masonry wall which was plastered on both of its sides. The actual thickness of the wall is 480 mm. The fig.7 shows that the data points which are lies in between 475.2 mm to 482.6 mm. So, it is proves that the IE method is more reliable for evaluating the thickness of the wall.

![Fig. 7: IE data collected on wall panel, W1](image7)
Thickness Measurement of Masonry Wall using Impact-Echo Technique

In the fig.9, the spectrum contains a single distinct peak indicates the thickness of the brick masonry wall as 47.62 cm which is close to 48.0 cm. These reflections are from the surface of the wall [7].

B. Specimen 2:
The result of the specimen 2 represents the thickness evaluation of the masonry wall which is un-plastered on the top two layers and the remaining area was fully plastered.

In the fig.12, the spectrum contains a single distinct peak corresponding of the actual thickness of the wall as 260 mm [7]. It is proved that the IE test is more reliable for thickness evaluation.

V. CONCLUSION
Impact echo is a reliable technique in determining thickness of plate like structural components when there is only one side accessibility. However, for a reliable thickness measurement, scanning points selected should be away from the boundaries, geometrical changes, etc. Using the amplitude spectra, the location of defects can also be identified. Impact-echo testing can also be used in later projects to monitor repairs and grouting procedures.

REFERENCES