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USE OF IMPULSE RESPONSE INSTRUMENT IN CONCRETE PAVEMENT: A REVIEW

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ABSTRACT

In the concrete structure the defects like excessive honeycombing, crack in the structure, etc are the concerns to be noticed. Actually in most of the cases the defects are unable to find out but the soundings of the hammer is used to detect the locations of the delaminations. The evaluation of the concrete surface with the extensive surface cracking can be evaluated with the help of NDT test such as impulse response. The causes of the cracking can also be studied so that it can be avoided. The present study deals with the experimental investigations carried out by the different researchers.

Contribution/ Originality: This study contributes in the existing literature as the present review work is essential in India to do such kind of non destruction testing. This type of testing is essential in many structures so that the structure shall remain safe.

1. INTRODUCTION

The flexible pavements include the construction to be carried out by the asphalt material or bitumen material whereas the rigid pavement consists of the construction of cement concrete with reinforcement or without. When compared with the rigid pavement then the flexible pavement is considered to be economical option [1]. The specimen is crushed to determine the strength of concrete but it is considered as the destructive test. The destructive tests are also used e.g. Benkelman beam test and Dipstick profiler which allows no damage to building (non destruction test), also have the benefits of inventory for the structure. But the destruction test only are applied to investigate the properties of concrete structures more widely. The reason behind it is that of simple to operate the instrument / equipment as well as economical as far as cost is concerned. They are prepared for the field use of measurements and continuous use of it Reshma and Shrikant [2].

The internal conditions of the structure made up of cement concrete can be analyzed with the help of non destructive testing equipments which have the advantages of fast testing and get more knowledge about the

structural behavior to assess the life of that structure [3]. The local spots could be drilled or cored so that the internal conditions can be known, in early days such kind of assessment was available. Most of the time earlier, the deteriorated structures are only made assessment [4].

The study contained the visual inspection only and the cracks, spalling of any defects can be recored with the help of ultra sonic pulse velocity. The investigation for the voids in between the concrete floor and the aggregates inside it using impulse response method usually carried out. The impact echo testing instruments are also used to assess the floor thickness of concrete structure and the core cutting usually aid to know the quality of concrete material [5]. The repair techniques can be used only when the causes of cracking are known and that is the reason the study is carried out. The repair technique was based upon the injecting grout in to the voids which are located between the concrete surface and aggregate layer inside the concrete [6].

Impulse response testing is also a more widely used technology that is used for many applications in the civil engineering field. This includes deep foundation, drilled shafts, timber piles, etc. This technology uses the sonic echo method that is very useful. The abutments, piers and thick tunnel walls are also the applications of this method. ASTM C1740 has used this technology very successfully to detect the different defects in the concrete structure like cracks, debonding, delamination and voids, this has the technology of mechanical waves which made the instrument a cutting edge [7]. ASTM 11470 deals with the standard practice for evaluating condition of concrete plates using the impulse response method within the concrete structures.

The impulse response method has been widely used in the civil engineering field to assess the concrete structure. For evaluation of the integrity finding of the concrete drilled shafts, this technique was used in the year 1960 as developed by the researchers. Civil engineers are not familiar with that technology and they did not know that it can be use for the concrete structures like concrete toads, deck slab and other structures also. The impact echo technique and impulse response techniques are similar to use in theory but have certain differences and that makes them unique [8].

2. METHODOLOGY

2.1. Testing Equipment

To propagate the stress waves through any structure, the impulse response technique uses the low strain impact method. Most of the instrument / equipment consist of a hammer (sledgehammet) having weight of one kg and it also has a load cell on its head to note down the readings. Double side head of 50 mm diameter is provided to the hammer. The one end is provided with rubber tip to provide the impact having low stress level (up to 700 psi), the another end is provided with aluminum tip for the impact having stress value more than 700 psi. The goephones are used for the measurement of the response given by the structure wher that impact is made. Geophones and the hammer are both linked to any computer for the acquisition of data generated in the process. The figure no.3 shows the typical equipment and the connections made with the computer [8].

2.2. Principles of the Impulse Response Method

The stress wave propagation theory is generally used in the acoustic testing equipments; it monitors the exact behavior of the waves that are passing through any structural material. The impulse response method is having different techniques, it measure the response received by the material under testing while impacting. Actually the stress value is more in case of impulse response test while using for the material, there is response from the structure with low frequency range of 0 to 1000 Hz, in a bending mode while impact is made. There is a difference between the impulse response test and impact echo test, the later test is operated under higher frequency range, i.e. more than 1000 Hz, it is operated under the stress waves which are generated in a reflective mode.

Figure-1. The instrumented sledgehammer and geophone used in the IR method [8]

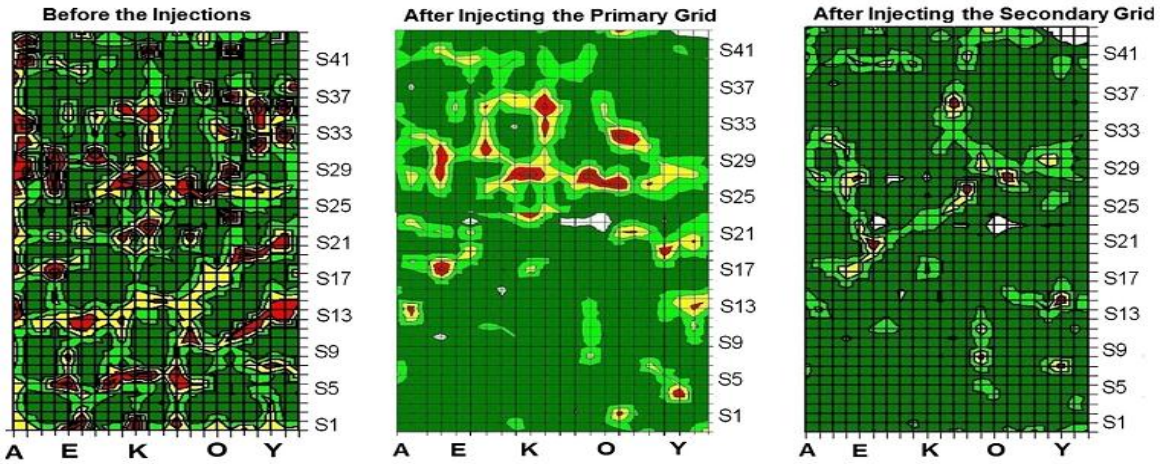

Figure-2. Graph presentation of voids index results from the inspections of the repair using the Impulse-Response method [6]

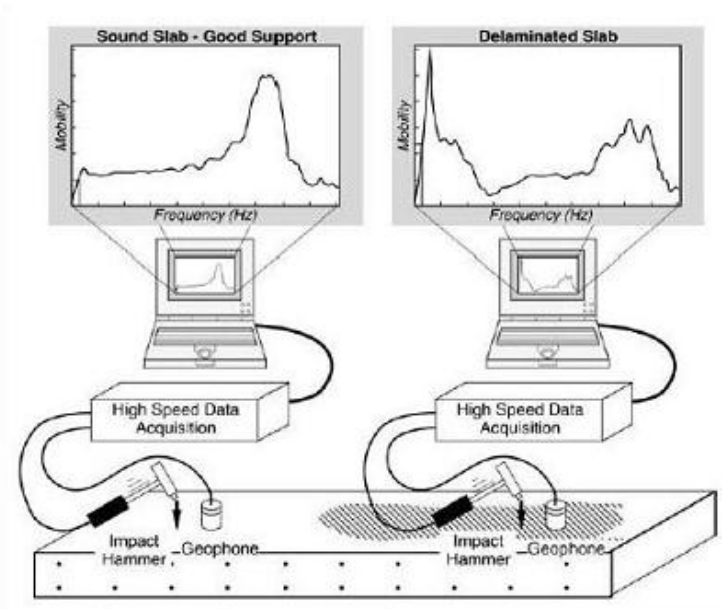

Figure-3. Schematic of the impulse response technique [8]

The fast Fourier transformation is used to obtain the spectrum of the hammer force, spectrum of velocity is also obtained. Finally the surface mobility plot is generated with the formula of "Velocity spectrum i.e. signal get from the geophone is divided by force spectrum i.e. signal get from the hammer load cell". Figure no. 4 shows the mobility plot. The horizontal axis is in the frequency range and vertical axis is in the velocity per unit force.

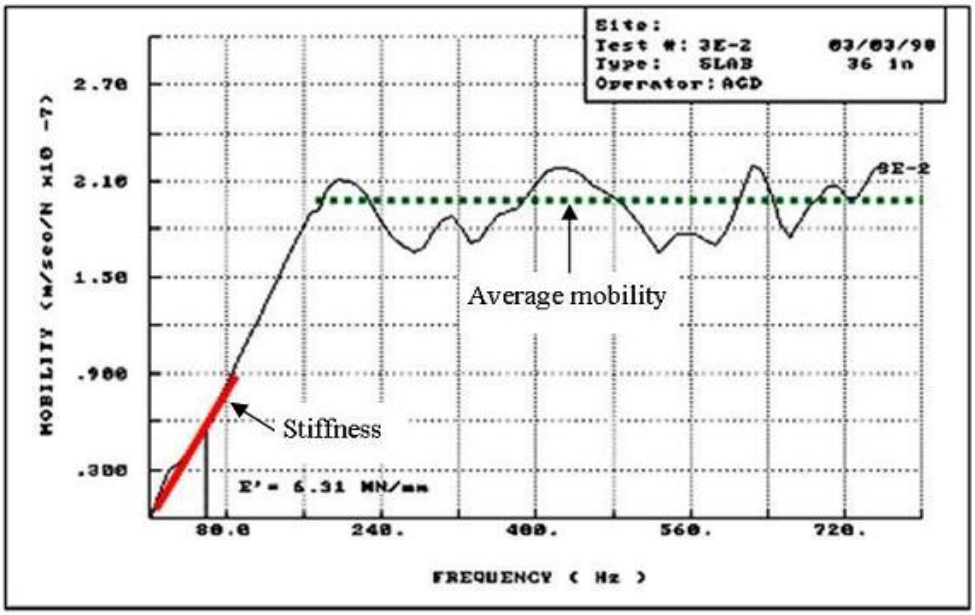

Figure-4. Mobility plot from a testing point from an impulse-response test [3]

The detection of voids is possible through the Impulse response test but for the establishment of proper location. The measurement of overall depth of shaft which is dependent on the designated velocity of wave for Impulse response unit, this is the drawback of the test. But it hold good for the measurement of voids. The table no.1 shows that the wave velocity increases then the measured shaft and the depth of void is also increases. It was observed that the precise location could only be identified at 10000 ft/sec, though the testing equipment could find the location of the present voids in the shaft whenever the reading is taken. Therefore the care has to be taken in the selection of signal velocity in case of Impulse response testing equipment because it is very important. If the impulse response test with the ultra sonic pulse velocity then the estimate of the location of distress shall be found [7].

Table-1. Influence of Different Velocity Values on Feature Depth

Description	Calculated Depth, ft				
	For Velocity =9,000	For Velocity =10,000 ft/sec	For Velocity =11,000 ft/sec	For Velocity =12,000 ft/sec	For Velocity =13,000 ft/sec
Void location	3.7	4.1	4.5	4.9	5.3
Shaft length	7.5	8.4	9.2	10.0	10.9

Stephen and Celik [7]

3. CONCLUSIONS

The following conclusions can be drawn from the research papers studied:

- Impulse response test is very reliable for the detection of any defects such as voids but the precise location calculation is not possible every time as the due care has to be taken for the section of velocity of wave.
- If ultra sonic pulse velocity is used then the improvement in the estimation of wave velocity is possible.
- The impulse response test is used to determine the thickness of the concrete structure
- The impulse response test is unable to find out the defects which are located at an lower elevation.

- The impulse response test is utilized to identify the gap between the sub base and the wearing course.
- The efficiency of work can be increased if the impulse response test used while repairing.

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