Applying Electrical Impedance technique for Structural Health Monitoring.

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Abstract: Using the electrical impedance method, old concrete slab was measured. Based on the electrical impedance measurement, the structural integrity of concrete was assessed. In the paper, one such case is investigated and the results substantiate the real condition existing in the concrete slab.

1. Introduction: The structural integrity of concrete structure is a concern due to aging infrastructure. Damage sensing can be conducted by ultrasonic measurement, acoustic emission detection and by other techniques. Real time monitoring allows to know the damage growth. Several nondestructive methods such as ground penetrating radar, acoustic emission, ultrasonic pulse velocity is used for structural health monitoring.

2. Objectives: In this study, electrical impedance method-frequency relationship was used for characterizing aged pavement slab.

3. Materials and Methods: The EIS technique work on the frequency domain and using LCR device the impedance data is obtained from 20 Hz to 300KHz.By using the impedance curve and impedance data, the bulk resistance was calculated. Also from the data, the contact resistance was determined. From the overall impedance data, the concrete condition was ascertained. In addition to that, interface condition between steel concrete, between reinforcement bars and cracks inside the concrete was established from the impedance frequency relationship.

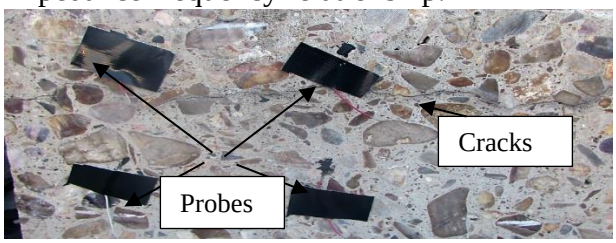


Image1

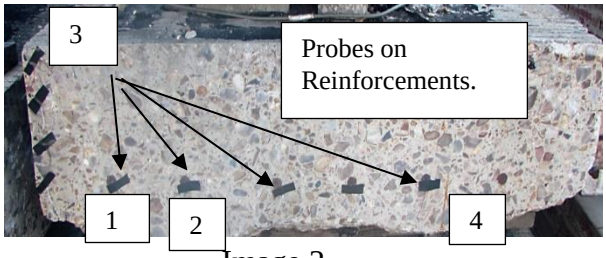


Image 2

On old concrete slab, short wires are placed on the concrete surface. Wires were placed on the exposed steel surface embedded in concrete. Proper contact between the wires and surface is necessary to get the impedance data. Using the LCR, the impedance is measured between concrete surface, bar and concrete and in between bars. From the impedance measurement, bulk resistance is measured. The resistance is correlated to resistivity using K factor. (L/A).

Modeling

Vipulanandan Case 2 model between impedance and frequency for special bulk material was used to plot the impedance frequency relationship.

ZII= Rb + $\frac{Rc}{1+Cc^2Rc^2w^2}$ + $\frac{wRc^2Cc}{1+Cc^2Rc^2w^2}$.where Rb is bulk resistant is contact resistant and w is the angular frequency.

4. Results and Discussions: The impedance curve between the probes in Image 1, where a crack appears in the horizontal direction is plotted. Also, an impedance curve with no visible crack is plotted and it is compared with that of image 1.

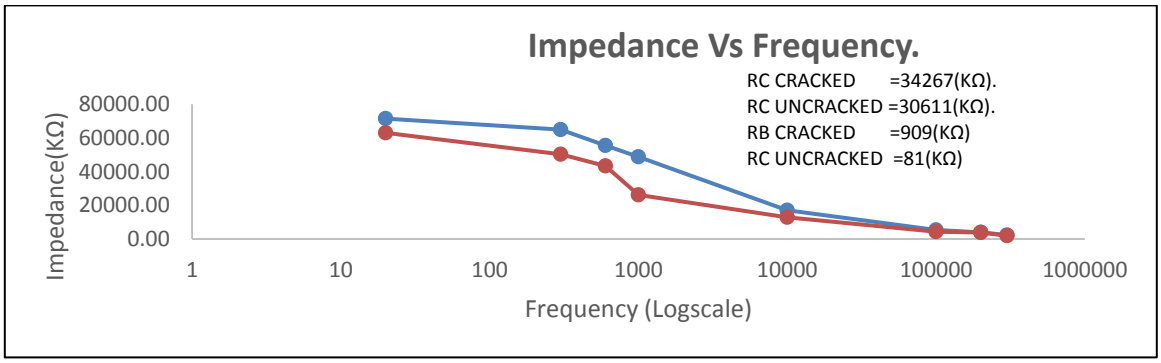
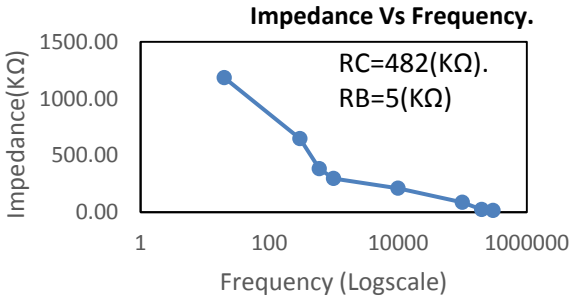


Fig 1(Impedance vs frequency of cracked and uncracked concrete section)

From the figure, it can be inferred that the visible crack on the surface of concrete is reflected in the impedance reading. Higher bulk resistance observed in the concrete specimen show the influence of crack on the measurement.



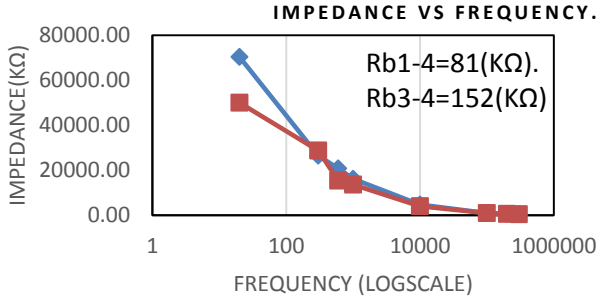


Fig 2 (Impedance vs frequency in probe 1-2) **Fig 3(Impedance VS frequency in probe 1-4,3-4)**

As shown in Image 2, the resistance between probe 1-2 is shown in Fig 3, the range of impedance in (KΩ) as compared to concrete surface. The interface condition between concrete and steel can be established from the readings. Additionally, the impedance graph between bar and outside concrete surface is plotted. In Fig 4, the resistance between bar and concrete is plotted, higher bulk resistance is observed when the distance is increased between the probes. It shows the sensitivity of the method and measurement.

The concrete resistivity(ρ) value for the surface concrete layer is calculated by initially finding the K factor using the ρ(initial) of concrete as 3.1(Ωm). Using the bulk resistant of the uncracked section, the resistivity was found to be 2700(Ωm).

5. Conclusion

Electrical Impedance technique can be effectively applied for the structural health monitoring of concrete structures.

6. Acknowledgement.

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7. References

[1] D V Ribeiro, A C Souza ,J C C Abrantes. “Use of electrochemical impedance spectroscopy to monitor the corrosion of reinforced concrete.” Ibracon structures and Materials Journal.