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Structural Health Monitoring Of RCC Slab Using PZT Material: An Overview

Vijay Kumar Sonkar[1], R. D. Patel[2]
[1]*P.G. Student,* [2]*Associate Professor, Department of Cvil Engineering*
MMM University of Technology, Gorakhpur, Uttar pradesh, India

Abstract- In order to study the damage detection or structural health monitoring of RCC slab by the using of PZT smart material. During the process of monitoring or analyzing the damage, simply PZT patches are attached to the surface of reinforced concrete slabs and this research objects with Electromechanical Impedance Method were adopted for further analysis and detection. Calculation rules with consistent rule are found. Root mean square method (RMSD) and the correlation coefficient deviation (CCD) damage indices are capable of detecting the structural damage. The damage index changes regularly with the distance of damages to the sensor. This relationship can be used to determine the damage location. The newly proposed damage index is accurate in determining the damage location.
Keywords- PZT; Electromechanical Impedance method; damage index; reinforced concrete slab; damage detection

I. INTRODUCTION

Development of innovative techniques for structural health monitoring with many intelligent materials are applied to structural health monitoring in civil engineering. The EMI technology was introduced in detail, and it was found that this technology could not only be useful in the judging subtle damage in machinery, but also be useful for damage diagnosis of aviation parts and large civil engineering structures. In order to study the performance of PZT damage detection, scholars have considered varied forms of damage, such as holes or notches. Damage indices like RMSD, CCDM and MAPD have been used to test the effectiveness, so as to get rules and practical methods of PZT damage monitoring.

II. LITERATURE REVIEW

To detection and analysis of damage portion with the help of PZT material .The researches work done by various authors in India and abroad are given below:

Liang; et al; (1994) they analyzed coupled electro-mechanical analysis of adaptive material systems-determination of the actuator power consumption and system energy transfer.

Bhalla; et al; (2004) they worked on analyzing structural Health Monitoring by Piezo-Impedance Transducers. According to experimental tests on reinforced concrete frame structures under the different damage conditions examined, both the conspicuous and inconspicuous damages and their locations could be identified by the RMSD indices. Later on, the EMI technology was introduced in detail, and it was found that this technology could not only be useful in the judging subtle damage in machinery, but also be useful for damage diagnosis of aviation parts and large structures.

III. PZT-STRUCTURE COUPLED MODEL THEORY

Smart structures with piezoelectric patches[2] are generally utilized as a part of exact situating control of structures, dynamic control of vibration and repair of splits. Numerous scientists have embraced static technique and vibration limited component strategies to lead structure vibration examination. Liang et al. thought impedance model innovation was more suitable for mirroring the physical substance of auxiliary framework. Exploiting the reverse piezoelectric impact of piezoelectric materials, Liang furthermore, his partners inferred a 1D model of the collaboration in the middle of PZT and structures (Figure 1).

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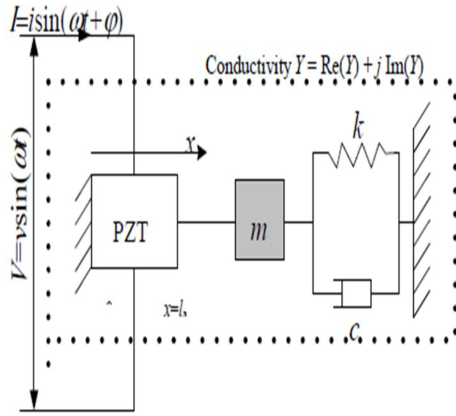


Fig-1.1D Model of PZT-structure coupled interaction

Under the effect of a basic consonant exchanging voltage V, the PZT stuck on the observed structure surface goes about as a component, of which one end was settled, while the flip side was associated with the principle structure. The PZT impedance qualities can be communicated by the coupling relationship between the mechanical impedance of the piezoelectric and the principle structure driving point. The piezoelectric mathematical statement is composed as takes after:

$$D_3=\varepsilon_{33}^T E_3+d_{31}T_1 \quad Y^E \qquad (1)$$

$$S_1=\frac{T_1}{Y^E}+d_{31}E_3 \qquad (2)$$

in which, D3 is the electric removal over the PZT transducer, 1 S the strain in course 1, and 1 T is pivotal anxiety along PZT; Y E = Y E (1+η j) is the unpredictable versatile Young's modulus of PZT sensor under a steady electric field; 33 ε T =ε T (1−δ j) is the dielectric consistent of PZT sensor under a consistent stress, η and δ are the mechanical misfortune element and dielectric misfortune variable; 31 d is piezoelectric consistent. By element damaging of PZT sensor, the one-dimensional vibration expression can be communicated by the accompanying comparison:

$$Y_{11}^E \frac{\partial^2 u}{\partial x^2} = \rho \frac{\partial^2 u}{\partial t^2} \qquad (3)$$

The size of PZT is 2l$\times w \times h$. By integrating over the entire surface of the PZT sensor we can get the complex admittance (reciprocal of piezoelectric impedance)

$$\bar{Y} = G + jB = \omega j \frac{wl}{h} \times \left[\left(\overline{\varepsilon_{33}^T} - d_{31}^2 \overline{Y^E}\right) + \left(\frac{Z_a}{Z+Z_a}\right). d_{31}^2 . \overline{Y^E}. \left(\frac{tankl}{kl}\right)\right] \qquad (4)$$

Z is the mechanical impedance of PZT under short-circuited condition; k is the number of waves which is related to angular frequency ω , density ρ and Young's module of an external excitation, and can be described as κ =ω $\sqrt{\rho / \overline{Y^E}}$.

On the off chance that there are damages in structures, auxiliary parameters, for example, mass M, solidness K and damping C will probably change. As such, the mechanical impedance of the structure will change. In any case, every one of the parameters of the PZT stay unaltered, so the mechanical impedance of the observed structure is the main component that will influence the change of impedance (or induction). Hence, any identified change of the impedance signs can be ascribed to the damage to the honesty of the structure.

IV. DAMAGE INDEX

For good checking of structures, a critical damage list is demonstrated by the genuine part of the PZT sensor's impedance, the progressions of which can be effortlessly recognized and evaluated measurably. In structure good observing, root mean square record (RMSD) is generally connected to distinguish damages:

$$\text{RMSD} = \sqrt{\frac{\sum_{i=1}^{N}(y_i - x_i)^2}{\sum_{i=1}^{N}(x_i)^2}} \quad (5)$$

X_i and y_i are the impedance measured before and after damage. Take the CC index as damage index. The CC index equals the covariance of two measured data divided by their standard deviation:

$$\text{CC} = \frac{Cov(x,y)}{\sigma_x \cdot \sigma_y} \quad (6)$$

$$\text{Cov} = \frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})(y_i - \bar{y}) \quad (7)$$

in which, σx and σy are standard deviation of x and y, $\bar{x}$ and $\bar{y}$ are the mean values of x and y. At the same time, CCD and the high power of CCD are used to determine the damage:

$$CCD = 1 - CC \quad (8)$$

According to the mathematical statistics theories, a new damage index is put forwarded as:

$$\frac{R_y}{R_x} = \frac{\sqrt{\frac{\sum(y_i - \bar{y})^2}{\sum y_i^2}} - \sqrt{\frac{\sum(x_i - \bar{x})^2}{\sum x_i^2}}}{\sqrt{\frac{\sum(x_i - \bar{x})^2}{\sum x_i^2}}}$$

Where x_i and y_i are the impedance values getting from test before and after the damage, $\bar{x}$ and $\bar{y}$ are the average values of x and y.

V. DISCUSSION

Impedance Curve
Damage Index
The Range of Damage Location
Impedance signal test can do on the exposed PZT, as appeared in Figure 2.

Fig 2 . Test Equipment

To further analysis and experiment and plan of placing of concrete slab, after this determination can do on the basis of impedance curve for each PZT smart material.

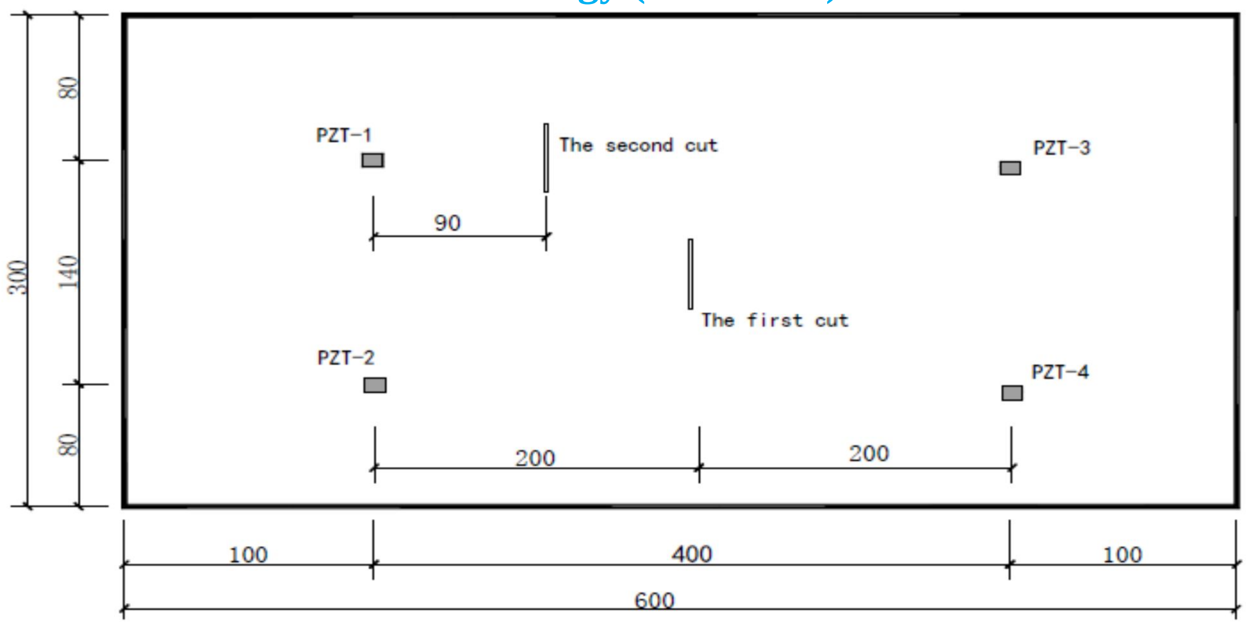


Fig- 3 Plan of concrete slab

of a damaged area. Compared with the RMSD index, the new damage index *Ry/Rx* is effective for A simply supported reinforced concrete slab is tested with the slab plane divided into four parts. In each of the four divided parts, a piezoelectric is attached to the center of the surface. The EMI method is used to test the impedance values of five kinds of damage condition at different frequency bands. The calculation and analysis is conducted using the RMSD and CCD indices. From the calculations it could be seen that the EMI method is not sensitive to the cracks when used to monitor the damage of reinforced concrete material. Along with the increase of the degree of damage, when the depth of the damage was more than 1/2 the thickness of the slab, the damage indices would have a larger growth, and the two different kinds of indices show consistent rules and they could monitor the amount of damage of reinforced concrete slabs well. The newly proposed damage index *Ry /Rx* increases as the amount of damage increases. It can monitor the amount of damage of reinforced concrete slabs as well. Preliminary judgment can be made from the information provided by the four PZT. The damage index changes regularly with the distance between the PZT and the damage location, which is helpful to determine the location detecting the damage location, and can give more accurate results.

REFERENCES

[1] Liang, C.; Sun, F.P.; Rogers, C.A. Coupled electro-mechanical analysis of adaptive material systems-determination of the actuator power consumption and system energy transfer. J. Intell. Mater. Syst. Struct. 1994, 5, 12–20.

[2] Sun, F.P.; Liang, C.; Rogers, C.A. Structral modal analysis using collocatded piezoelectric actuators-an electromechanical approach. In Proceedings of the North American Conference on Smart Structures and Materials, Orlando, FL, USA, 13 February 1994.

[3] Sun, F.P.; Chaudhry, Z.A.; Liang, C. Truss structure integrity identification using PZT sensor-actuator. J. Intell. Mater. Syst. Struct. 1995, 6, 134–139.

[4] Bhalla, S.; Soh, C.K. Structural impedance based damage diagnosis by piezo-transducers. Earthqu. Eng. Struct. Dynam. 2003, 32, 1897–1916.

[5] Bhalla, S.; Soh, C.K. Structural Health Monitoring by Piezo-Impedance Transducers. I: Modeling. J. Aerosp. Eng. 2004, 17, 154–165.

[6] Victor, G.; Chaudhry, Z.A. Damage detection in thin plate and aerospace structures with the electro-mechanical impedance method. SHM 2005, 4, 99–118.

[7] Lim, Y.Y.; Bhalla, S.; Soh, C.K. Structural identification and damage diagnosis using self-sensing piezo-impedance transducers. Smart. Mater. Struct. 2006, 15, 987–995.

[8] Wang, D.S.; Zhu, H.P. Monitoring of the strength gain of concrete using embedded PZT impedance transducer. Constr. Build. Mater. 2011, 25, 3703–3708.

[9] Na, S.; Lee, H.K. A technique for improving the damage detection ability of the electro-mechanical impedance method on concrete structures. Smart Mater. Struct. 2012, 21, 085024:1–085024:9.

[10] Yan, W.; Cai, J.B.; Chen, W.Q. An electro-mechanical impedance model of a cracked composite beam with adhesively bonded piezoelectric patches. J. Sound. Vib. 2011, 330, 287–307.

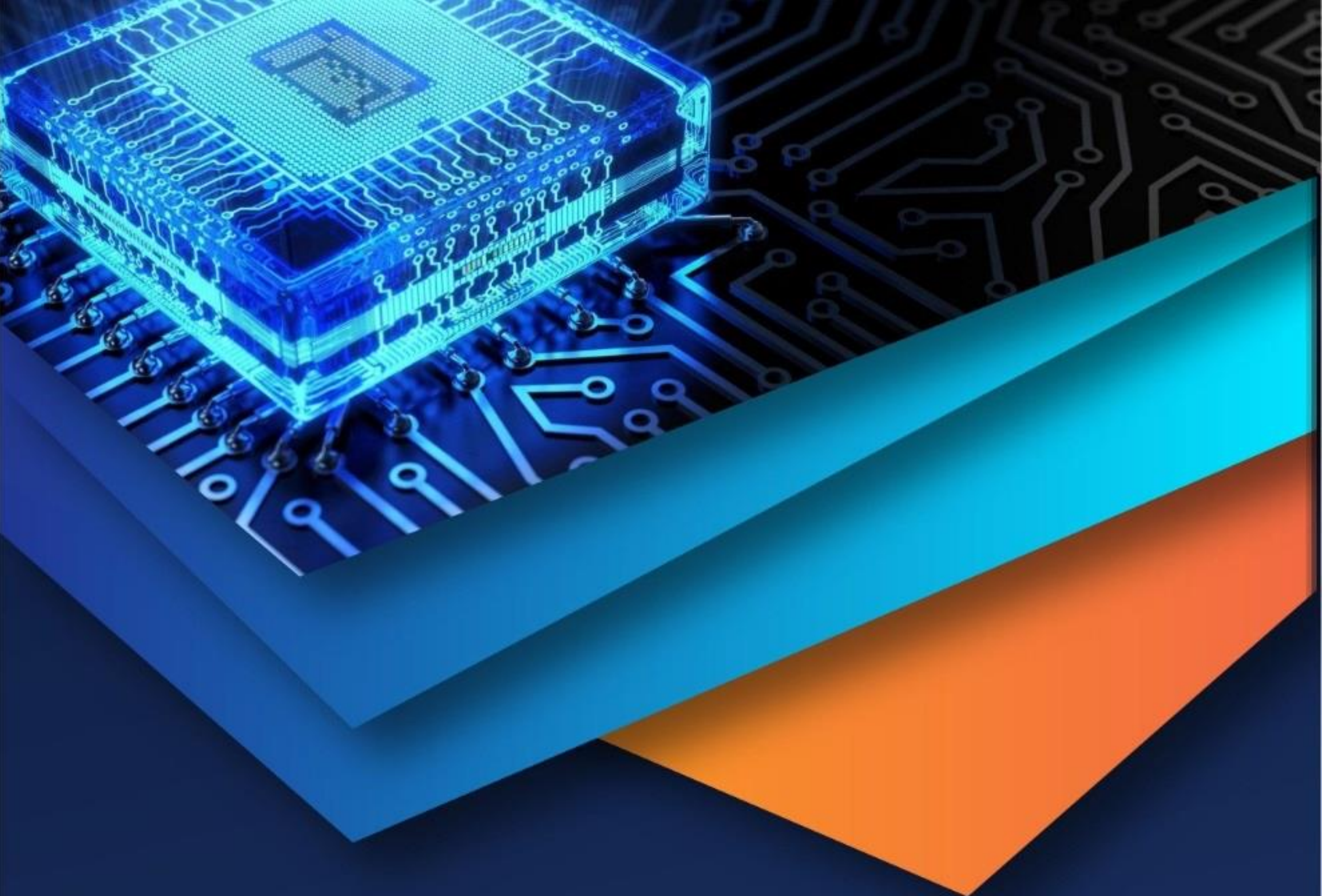
[11] Yan, W.; Wang, J.; Chen, W.Q. Delamination assessment of a laminated composite beam using distributed piezoelectric sensor/actuator. Smart Mater. Struct. 2011, 20, 075011:1–075011:14.

[12] Roberto, M.F.N.; Valder, S., Jr.; Rade, D.A.; Gallo, C.A.; Palomino, L.V. A low-cost electromechanical impedance-based SHM architecture for multiplexed piezoceramic actuators. SHM 2010, 10, 391–402.

[13] Wandowski, T.; Malinowski, P.; Ostachowicz, W.M. Damage detection with concentrated configurations of piezoelectric transducers. Smart Mater. Struct. 2011, 20, 025002:1–025002:14.

Volume 4 Issue III, March 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

[14] Hamzeloo, S.R.; Shamshirsaz, M.; Rezaei, S.M. Damage detection on hollow cylinders by Electro-MechanicalImpedancemethod: Experiments and Finite Element Modeling. Comptes Rendus Mec. 2012, 340, 668–677.
[15] Sepehry, N.; Shamshirsaz, M.; Abdollahi, F. Temperature variation effect compensation in impedance-based structural health monitoring using neural networks. J. Intell. Mater. Syst. Struct. 2011, 22, 1975–1982.
[16] Yang, Y.W.; Sabet, B.D.; Soh, C.K. A reusable PZT transducer for monitoring initial hydration and structural health of concrete. Sensors 2010, 10, 5193–5208.
[17] Yang, Y.W.; Hu, Y.H. Electromechanical impedance modeling of PZT transducers for health monitoring of cylindrical shell structures. Smart. Mater. Struct. 2008, 17, 015005:1–015005:11.



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