ISETC2025

UNIVERSITI TEKNOLOGI MARA

ISETC2025

2 ND INTERNATIONAL SCIENCE, ENGINEERING AND TECHNOLOGY COLLOQUIUM

THE POWER OF SCIENTIFIC INNOVATION

INTELLIGENT SOLUTIONS FOR A SUSTAINABLE WORLD

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PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
Ms. Nurul Nazwa Mohammad
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ISETC 2025 Proceedings Editors

ARTIFICIAL REBAR CORROSION DAMAGE MONITORING IN REINFORCED CONCRETE SLAB STRUCTURES USING THE ELECTROMAGNETIC WAVE TECHNIQUE

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Abstract: This research establishes a quantitative framework for assessing hidden rebar corrosion in reinforced concrete using Ground Penetrating Radar (GPR). Accelerated corrosion (0–60% damage) was induced in rebars at 70–160 mm depths on 200 mm reinforced concrete slab structure. Results demonstrate a nonlinear increase in GPR signal attenuation ($\alpha = \log_{10}(A_0/A_n)$) with corrosion severity, validated up to 0.3979 dB for 60% damage. Signal amplitude decreased ~35% with depth. The method enables precise, depth-resolved corrosion quantification, addressing critical infrastructure monitoring needs. Future work should integrate half-cell potential measurements for broader validation.

***Keywords*:** *Rebar corrosion quantification, electromagnetic non-destructive testing, reinforced concrete deterioration*

INTRODUCTION

Reinforced concrete structures in coastal zones globally face severe chloride-induced rebar corrosion, causing major economic and safety risks, especially in nations like Malaysia with extensive coastlines (Ali et al., 2024; Zhao et al., 2025). Chlorides penetrate concrete, de-passivate rebar, and initiate corrosion. The resulting expansive rust generates internal stresses, leading to cracking, delamination, reduced capacity, and shortened lifespan. Total direct and in-direct corrosion costs are billions, which can be estimated by 3 to 4 percent of the GDP in the industrialized counties (Ball & Whitmore, 2003; Phulara & Bhattarai, 2019), highlighting the urgent need for effective monitoring.

Conventional techniques have critical limitations. Visual inspection only detects surface damage (Zaki et al., 2021). Half-cell potential indicates probability but not rate or section loss and is affected by moisture/cover. These gaps—lack of early detection, quantitative data, and depth resolution—necessitate advanced NDT.

Ground Penetrating Radar (GPR) emerges as a promising alternative. This electromagnetic technique rapidly scans subsurface features, enabling non-invasive depth profiling of rebar (validated to 160 mm herein), corrosion quantification via signal attenuation/hyperbola distortion, and spatial mapping of deterioration.

MATERIALS AND METHODS

i) Specimen Design and Preparation

Concrete targeted 40 MPa compressive strength. The optimal mix (Table 1) achieved 40.2 MPa in 150 mm³ cube tests (ASTM International, 2005). Reinforcement bars (10–25 mm diameter) met tensile strength at least 400 MPa. Reinforced concrete slabs (800×500×200 mm) were cast with rebars embedded at depths of 70, 100, 130, and 160 mm to simulate corrosion scenarios.

Table 1. Concrete Mix Design (per 0.001 m³)

Material weight	Cement (kg)	Water (kg)	Fine aggregate (kg)	Coarse Aggregate (kg)
Content per 0.001m³	4.844	2.278	8.233	11.366

ii) Accelerated Corrosion Induction

To mimic the chloride-induced corrosion in real situation, 20 mm-diameter rebars were subjected to electrochemical acceleration in a 5% NaCl solution using a 50A direct current. Corrosion levels (0%, 10%, 20%, 40%, 60%) were calculated via Faraday's law (ASTM International, 2005):

$$\Delta m = \frac{MIt}{zF}$$

where Δm = mass loss (g), M = Ferrum molecular weight (56 g/mol), I = current (A), t = time (s), z = ionic charge (2), F = Faraday's constant (96,500 A·s/mol).

iii) Non-Destructive Evaluation

GPR analysis:
A 1.6 GHz antenna (GSSI) scanned the slab surface along predefined gridlines. Raw data were processed in RADAN 7 software.

RESULTS AND DISCUSSION

GPR Signal Attenuation as a Corrosion Metric

GPR detected corrosion via electromagnetic signatures. Non-corroded rebars produced sharp, high-amplitude hyperbolas, while corrosion-induced rust caused signal scattering, resulting in widened, lower-amplitude hyperbolas. Signal attenuation (α) quantified corrosion using:

$$\alpha = \log 10\left(\frac{A_0}{A_n}\right)$$

where, A_0 & A_n is the GPR signal amplitude for the non- corroded rebar and corroded rebar, respectively.

As depicted in Table 2 and Figure 1, GPR results showed a strong non-linear relationship between signal attenuation and corrosion severity, increasing from 0.0969 dB (10% corrosion) to 0.3979 dB (60%). Signal amplitude decreased ~35% with depth (70-160 mm). This depth-resolving capability overcomes resistivity testing's spatial limitation.

Table 2. GPR signal attenuation for various rebar corrosion damage

% of corroded rebar damage	10	20	40	60
α (dB)	0.0969	0.2218	0.301	0.3979

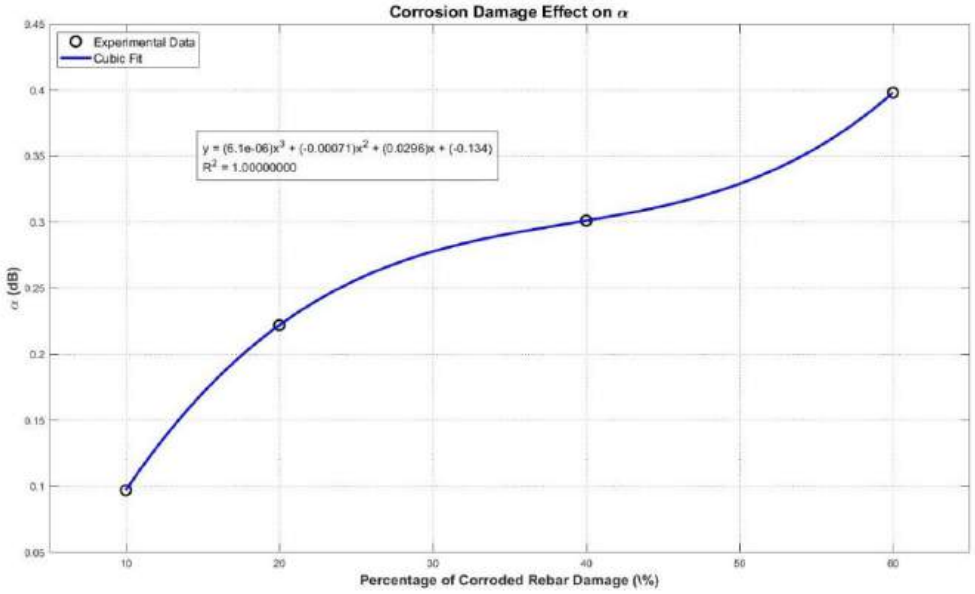

Figure 1. GPR signal attenuation fitting curve for various rebar corrosion damage

CONCLUSIONS

This study establishes that electromagnetic NDT—Ground Penetrating Radar (GPR)—enables precise, depth-resolved quantification of hidden rebar corrosion. Key findings confirm GPR signal attenuation (α) increases non-linearly with rebar corrosion damage ($\alpha = \log_{10}(A_0/A)$).

REFERENCES

Ali, M., Shams, M. A., Bheel, N., Almaliki, A. H., Mahmoud, A. S., Dodo, Y. A., & Benjeddou, O. (2024). A review on chloride induced corrosion in reinforced concrete structures: lab and in situ investigation. *RSC Advances, 14*, 37252–37271. https://doi.org/10.1039/d4ra05506c

ASTM International. (2005). Standard test method for compressive strength of cylindrical concrete specimens (ASTM C39/C39M-2005). https://www.astm.org/c0039_c0039m.html

Ball, B. J. C., & Whitmore, D. W. (2003). Corrosion mitigation systems for concrete structures. *Concrete Repair Bulletin*, *16*, 6–11.

Mahbubi, K., Zaki, A., Rosyidi, S. A. P., & Ibrahim, Z. (2025). Analysis of repair and self-healing concrete corrosion using resistivity method. *Journal of Advanced Research in Applied Mechanics*, *131*(1), 38–56. https://doi.org/10.37934/aram.131.1.3856

Phulara, N. R., & Bhattarai, J. (2019). Assessment on corrosion damage of steel reinforced concrete structures of Kathmandu Valley using corrosion potential mapping method. *Journal of the Institution of Engineers, 15*, 45–54.

Zaki, A., Murdiansyah, L., & Jusman, Y. (2021). Cracks evaluation of reinforced concrete structure: A review. *Journal of Physics: Conference Series, 1783*, Article 012091. https://doi.org/10.1088/1742-6596/1783/1/012091

Zhao, P., Si, Z., Huang, L., He, Y., Liu, X., & Zhang, Y. (2025). A review of the repair measures for reinforced concrete affected by chloride ion corrosion. *Journal of Building Engineering, 102*, 112028. https://doi.org/10.1016/j.jobe.2025.112028

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Kelulusan daripada pihak tuan dalam perkara ini amat dihargai.

Sekian, terima kasih.

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Setuju.

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Timbalan Ketua Pustakawan

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