Nexus Global Research Journal of Multidisciplinary; Vol-1. Issue- 6 (Dec 2025):363-365

ISSN: 3108-2750 (Online)

Nexus Global Research Journal of Multidisciplinary

Journal homepage: https://nexusglobalresearch.com/journal/ngrjm/

Opinion Article

Development of a Global Unified World Corrosion Map for Steel Reinforced Concrete Structures

Raja Rizwan Hussain [1],

[1]*Professor, Civil Engineering Department, College of Engineering, King Saud University, Riyadh, Saudi Arabia*

OPINION

One of the most threatening durability issues faced by reinforced concrete structures around the world is the corrosion of steel reinforcement bars [1]. Buildings, bridges, dams, tunnels, concrete pavements, marine structures, coastal platforms etc. all are compromised by the corrosion of rebars. In spite of extensive research work done in the field of corrosion, there is a clear lack of unified durability design for corrosion in the global framework. Due to this reason, the world is still unable to completely control this issue comprehensively in a unified manner. Therefore, the need of the hour is to come up with a Global Unified World Corrosion Map (GUWCM) for steel reinforced concrete structures. This global corrosion mapping will surely help a lot in better corrosion management for civil infrastructure throughout the world in a unanimous way. Although corrosion maps have been developed in the past [2-8]. But there exists a difference of opinion among them. Also, some corrosion maps are created only for certain countries, regions or some specific materials and environmental conditions. An international platform is needed to integrate all the existing corrosion maps w.r.t environment, material as well as performance. This will be a huge contribution to the research, guidance, design, codes and policy making for corrosion resilient steel reinforced concrete infrastructure.

Problem Identification: Divided Information in a Connected World

The major problem is that all the corrosion assessment approaches are primarily regional or national. Countries that have strong research infrastructure have developed their own corrosion maps as per their local environmental exposure conditions, climate and service requirements. On top of that these efforts in various regions of the world are divided and not interconnected. This causes lack of standardization framework and incompatibilities of methodologies across the borders. At the same time several other middle- and low-income regions of the world do not have corrosion maps at all. They don't even have the basic corrosion database for their country. This all results in the incomplete or inappropriate application of corrosion data. Corrosion engineers and decision makers are unable to come up with appropriate corrosion models. This leads to under designed reinforced concrete infrastructure for corrosion resulting in unexpected failure of the structures and/or much increased maintenance costs. This put to risk the human safety and burden on the municipal budget. All this disrupts the development of the country. In addition to these factors, there are climate change alerts, rising temperature, variations in the moisture and increase in sea level etc. All this results in the existing corrosion models becoming outdated calling for the need of an urgent and unified update. Partial and fragmented understanding of the corrosion is dangerous and cannot be replied upon.

Need for a Unified World Corrosion Map

Corresponding author: Raja Rizwan Hussain

DOI: 10.5281/zenodo.18233117

Received 12 Dec 2025; **Accepted** 22 Dec 2025; **Available online** 31 Dec 2025.

All the above said issues can be dealt by a single solution which is the development of a unified world corrosion map. It would serve a common platform to link the diversified corrosion database into a coherent and dynamic representation for this global risk of corrosion in RC structures. What needs to be incorporated in this map includes a) environmental variables (chloride ions, humidity, moisture, temperature, carbon dioxide concentration) [9-10], b) material availability (type of steel rebars, concrete, their chemical composition, SCMs, inhibitors and coatings) [11-14], c) attributes of reinforced concrete (depth of cover, mix design, corrosion protection methods), d) data from the field (measurement of degradation, failures and history of inspection) etc. With the availability of all this data it will be possible for the corrosion engineers to manage corrosion at any location in the map worldwide. It will also help in the development of corrosion benchmarks and standardization of the criteria. Gap in knowledge and research would be visible to identify. The policy makers and investors would be able to make the right decisions for the RC asset management.

Benefits for the World

The GUWCM's impact would go to all including the engineers, researchers, scientists and the society overall for multiple domains. The corrosion engineering practice will become global by the use of data driven technologies to mitigate corrosion. The advancement in research would be universal. The standardized data would support the machine learning, deep learning and artificial neural networks resulting in AI-corrosion models [15]. The governments would benefit by the proper policy and planning to manage the corrosion in RC infrastructure by identifying the high-risk corrosion zones. The map would also serve the education and capacity building by educating the students and engineers.

Future Challenges

The vision of GUWCM is no doubt very ambitious and challenging. It requires specified data standards, protocols for measurement as well as the collaborative works for all the institutions and nations around the world. The challenges to overcome may include the ownership of data, the quality control and the framework for all the countries and regions. Collection and synthesis of global research data in real time and space domains, gathering geological information w.r.t the corrosion mapping, worldwide quality control and updating all the items up to state of the art will all be very challenging. The international cooperation among all the nations for collection of all the complex RC infrastructure data for each one of them will not be an easy task although doable, feasible and very impactful. Advanced technologies will be needed for the smart remote sensing and sensor networks, GIS and the cloud-based programs. An overall collective will power is needed by all the researchers, engineers, professionals, industries, institutions as well as the funding agencies globally.

Call for Action

In this era of inter-connected and shared development, the GUWCM for steel-reinforced concrete structures should be recognised as a universal need and priority. The call of the hour is for the international standard organizations such as the NACE, ISO, RILEM, ASTM, ACI and JCI to intervene and accomplish this task. All the universities and research facilities should contribute to the data sets, latest models and expertise in the area of corrosion. The industry leaders and high-tech giants must intervene for the development of successful practical applications and co-funding this corrosion research mega project. In addition to these, all the governments should also play their role to support the development of GUWCM for combating the corrosion related durability issues of steel reinforced concrete structures for the generations to come.

REFERENCES

1. Raja Rizwan Hussain (2012) "Corrosion of Steel Reinforced Concrete Under Severe Environmental Conditions" 2nd Edition, ISBN: 1480107425, ISBN13: 9781480107427, CreateSpace publishers, pp. 330.
2. Z. Wang, Y. Wang and A.J. Sobey (2021) "Chapter: Development of a global corrosion map towards digital twin applications for marine structures", Developments in the Analysis and Design of Marine Structures, Edited by Jorgen Amdahl, C. Guedes Soares,

Proceedings of the 8th International Conference on Marine Structures (MARSTRUCT 2021, 7-9 June 2021, Trondheim, Norway), ISBN: 9781003230373, CRC Press.

3. Hao Wenkui, Chen Xin, Xu Lingling, Han Yu, Chen Yun, Huang Luyao, Zhu Zhixiang, Yang Bingkun, Wang Xiaofang and Zhang Qiang (2023) "Drawing of Atmospheric Corrosion Map of Carbon Steel and Galvanized Steel for Power Grid", Journal of Chinese Society for Corrosion and protection, Vol. 43 Issue (4): 795-802.
4. Wenkui Hao, Lingling Xu, Xin Chen, Yan Jin, Yu Han, Xinghui Zhang, Yun Chen, Luyao Huang, Bingkun Yang, Zhixiang Zhu and Xiaofang Wang (2022) "Classification and spatial mapping of atmospheric corrosion of China", npj Materials Degradation volume 6, 27th December 2022, Article number: 100.
5. Ana C. Santa, José A. Tamayoa, Cristian D. Correa, Maryory A. Gómez, Juan G. Castaño and Libia M. Baenac (2022) "Atmospheric corrosion maps as a tool for designing and maintaining building materials: A review", Volume 8, Issue 9, September 2022, e10438.
6. W. D. Ganther, I. S. Cole, A. M. Helal, W. Chan, D. A. Paterson, G. Trinidad, P. Corrigan, R. Mohamed, N. Sabah and A. Al-Mazrouei (2010) "Towards the development of a corrosion map for Abu Dhabi", Materials and Corrosion, 16 December 2010, DOI: 10.1002/maco.201005816.
7. Darelle T. Janse van Rensburg, Lesley A. Cornish and Josias van der Merwe (2019) "Corrosion map of South Africa's macro atmosphere", South African Journal of Science, On-line version ISSN 1996-7489, Print version ISSN 0038-2353, S. Afr. j. sci. vol.115 n.7-8 Pretoria Jul./Aug. 2019, DOI: 10.17159/sajs.2019/4901.
8. Ivan Cole, Penny Corrigan and Nguyen Viet Hue (2012) "Steel Corrosion Map of Vietnam" Corrosion Science and Technology, Vol.11, No.4(2012), pp.103-107.
9. Hussain Raja Rizwan and Tetsuya Ishida (2011) Enhanced electro-chemical corrosion model for reinforced concrete under severe coupled actions of chloride and temperature, Construction and Building Materials Journal, DOI: 10.1016/j.conbuildmat.2010.09.014, Vol. 25, Issue 3, pp. 1305-1315.
10. Hussain Raja Rizwan and Tetsuya Ishida (2009) Critical Carbonation Depth for Initiation of Steel Corrosion in Fully Carbonated Concrete and the Development of Electrochemical Carbonation Induced Corrosion Model, International Journal of Electrochemical Science, ISI, ISSN: 1452-3981, Vol. 4, Issue 8, pp. 1178-1195.
11. Abdulaziz Al- Negheimish, Abdulrahman Alhozaimy, Raja Rizwan Hussain, Rajeh Al-Zaid, J.K.Singh and D.D.N.Singh (2014), Role of manganese sulfide inclusions in steel rebar in the formation and breakdown of passive films in concrete pore solutions, *NACE Corrosion Journal*, ISI, Journal ISSN: 0010-9312, DOI: http://dx.doi.org/10.5006/0941, Jan 2014, Vol. 70, Issue 1, pp. 74-86.
12. **Raja Rizwan Hussain, Abdulrahman Alhozaimy, Abdulaziz Al-Negheimish and DDN Singh (2014), Time-dependent variation of the electrochemical impedance for thermo-mechanically treated versus plain low alloy steel rebars in contact with simulated concrete pore solution,** Construction and Building Materials Journal, Elsevier, ISI, DOI: 10.1016/j.conbuildmat.2014.09.099, Dec 2014, Vol. 73, pp. 283–288.
13. Abdulrahman Alhozaimy, Raja Rizwan Hussain and Abdulaziz Al-Negheimish (2020) "Electro-chemical Investigation for the Effect of Rebar Source and Surface Condition on the Corrosion Rate of Reinforced Concrete Structures under Varying Corrosive Environments", Construction and building materials Journal, Elsevier, ISSN: 0950-0618, paper accepted January 2020, published 30 May 2020, DOI: https://doi.org/10.1016/j.conbuildmat.2020.118317, Vol. 244, Article # 118317
14. Abdulrahman Alhozaimy, Raja Rizwan Hussain, Abdulaziz Al-Negheimish, DDN Singh and Mshtaq Ahmed (2024) "Kinetics and mechanism of gallic acid as an ecofriendly corrosion inhibitor for steel rebars in mortar", Nature Scientific Reports Journal, 5th most cited journal in the world, ISSN 2045-2322, published 28th December 2024, Vol. 14 (1), Article number: 31015.
15. Tao Huang, Chunfeng Wan, Tingbin Liu, Yan Ai and Changqing Miao (2025) "Data-driven corrosion level prediction of rust-damaged reinforced concrete: An interpretable machine learning approach", Materialstoday communications, Volume 48, September 2025, 113400, DOI: 10.1016/j.mtcomm.2025.113400.