

CURRICULUM VITAE

Naveen Krishnan

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EDUCATION

- January 2022 - Present **Ph.D. in Civil Engineering**, Oregon State University, Corvallis, USA
Research area: Corrosion in reinforced concrete, corrosion performance of additively manufactured stainless steel clads
Guide: Prof. Burkan Isgor
- January 2019 – August 2021 **M.S. in Civil Engineering**, Indian Institute of Technology Madras, Chennai, India
CGPA: 8.83/10
Thesis title: *Field performance assessment and an attempt for electrochemical modelling of cathodic protection systems in reinforced concrete.*
Guide: Dr Radhakrishna G. Pillai.
- August 2013 – August 2017 **B. Tech. in Civil Engineering**, Government Engineering College Kottayam, India
CGPA: 7.97/10
Project report title: *Performance evaluation of cement polymer composite (CPC) coated and uncoated steel reinforcement in concrete*
Guide: Dr Dhanya B. S.

JOURNAL PUBLICATIONS

- JP1. **Krishnan, N.**, Veedu, Z. D., Shah, D., and Liao, H. (2020). “Hybrid anodes for accelerated cathodic protection of corroding concrete structures”, *The Indian Concrete Journal*, Vol. 94, No. 11, pp. 101-110
- JP2. **Krishnan, N.**, Kamde, D. K., Veedu, Z. D., Pillai, R. G., Shah, D., and Velayudham, R. (2021). “Long-term performance and life-cycle-cost benefits of cathodic protection of concrete structures using galvanic anodes”, *Journal of Building Engineering*.

CONFERENCE PUBLICATIONS

- CP 1. D.V, Zameel., **Krishnan, N.**, Kamde, D.K., Pillai, R.G. (2018) “Effect of resistivity of the concrete on the performance of sacrificial anode cathodic prevention (SACP) Systems” NIGIS CORCON 2018, Jaipur, India.
- CP 2. **Krishnan, N.**, Kamde D.K., Pillai, R.G. (2019) “8 – Year performance of cathodic protection systems in reinforced concrete slabs and life-cycle cost benefits” Rilem SMSS 2019, Sustainable Materials, Systems and Structures, Rovinj, Croatia.

POSTER PRESENTATION

- PP 1. **Krishnan, N., Pillai, R.G.** (2019) “Understanding the throwing power of galvanic anodes in reinforced concrete structures using numerical simulations” NIGIS CORCON 2019, Mumbai, India (**Won best poster award**).
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ACADEMIC ACHIEVEMENTS

- Received NACE India Foundation Scholarship Award of 2019 by the National Association of Corrosion Engineers (NACE) for continuing the research in corrosion and its related issues in reinforced concrete structures.
 - Best Student Poster Award of CORCON 2019, International Conference and Expo on corrosion, Mumbai, India, conducted from 23 – 26th September 2019 for the poster titled “Understanding the throwing power of galvanic anodes in reinforced concrete structures using numerical simulations”.
 - 1st Prize in inter-college concrete cube mixing competition organised by Govt. Engineering College Kottayam as part of the technical fest RITU 2014.
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RESEARCH EXPERIENCE

i. Field performance assessment and an attempt for electrochemical modelling of cathodic protection systems in reinforced concrete

- *M.S. work under the guidance of Dr Radhakrishna G. Pillai, Associate Professor, Indian Institute of Technology Madras, Chennai, India (ONGOING)*

Worldwide, many reinforced concrete structures are repaired frequently to meet their designed service life. Repeated patch repairs can lead to continued corrosion and eventual replacement of structures, and huge life cycle costs (LCC). On the other hand, the strategy of cathodic protection using galvanic anodes (CP strategy) can enhance the service life and reduce LCC. However, most of the repair projects do not consider using CP with patch repair because of the (i) lack of sufficient long-term field data to substantiate the claim of protection using galvanic anodes and (ii) wrong perception of the possibly high initial cost of repair with galvanic anodes and lack of consideration of LCC. Also, the interpretation criteria for the assessment method of these techniques are based on experiments conducted on metals in low resistive electrolyte systems (e.g., pipeline and offshore). This thesis focuses on these issues. First, the details on the long-term performance of CP systems in two case studies are presented. The data indicated that the galvanic anodes successfully controlled the chloride-induced corrosion for up to ≈ 14 years. Then, the installation details and the testing methodology for the instantaneous performance assessment of CP are provided. Based on 700 days of monitoring results from two structures, it was observed that the conventionally used “100 mV criterion” for qualifying a CP system in concrete was not achieved in many cases when the corrosion rate is less than 2 mA/m². Finally, this thesis also presents the preliminary research on developing a new non-destructive test for assessing CP systems in reinforced concrete systems.

ii. Electrochemical repair of the corroded sunshade of 105-year-old President’s house (Rashtrapati Bhavan) building in Delhi, India

- *Naveen Krishnan, Deepak Kamde, Radhakrishna G. Pillai (May 2018 – Present)*

The project aims to arrest the corrosion in the heavily corroding sunshades of the 120-year-old Rashtrapati Bhavan (The President’s house) in Delhi, India. The sunshade is made up of lime mortar with mild steel rebars embedded as reinforcement. Cathodic protection (CP) using sacrificial galvanic anodes and hybrid-galvanic anodes were implemented on a 10 m stretch of the sunshade as a pilot project. The objective of the pilot study is to assess the performance of

CP in lime-based concrete and the feasibility of installation. The installed CP system was monitored for one year, and the amount of depolarisation shift induced in the concrete is recorded for evaluating the performance of the galvanic anodes. Initial results of the potential shift obtained from the concrete area where two-stage hybrid-galvanic anodes are installed showed a significant reduction in corrosion potential, and the rebars are passivated.

iii. Performance evaluation of admixed corrosion inhibitors (ACI) in arresting corrosion

- *Sripriya Rengaraju, Radhakrishna G. Pillai, Naveen Krishnan (May 2018 – January 2019)*

The long-term corrosion performance is assessed using the standard ASTM G109 test. Concrete specimens with different w/c ratios are cast using OPC and with fly ash replaced OPC. The comparative performance based on corrosion initiation is studied. Also, the reliability of the standard ASTM G109 test in assessing the performance of highly resistive (LC3) concrete was studied. The results suggested that the ASTM G109 test can be used for assessing the performance of OPC and fly ash based concrete, while the highly resistive concrete lead to macro-cell corrosion within a single rebar

iv. Effect of resistivity of repair material on the performance of sacrificial anode cathodic protection system

- *Naveen Krishnan, Deepak Kamde, Radhakrishna G. Pillai, (May 2018 – January 2019)*

Patch repair using a galvanic anode cathodic protection (SACP) system is an effective repair technique that eliminates the need for repeated repair. However, due to the limited database on the long-term performance of galvanic anodes (SACP anodes) installed in concrete, there is a hesitation to adopt this technique in the Indian repair market. The project aimed to understand and compare the instantaneous performance of different galvanic anode systems available and also to develop a database on the long-term performance of different CP systems installed in different concrete systems

v. Performance evaluation of Cement polymer composite coated (CPCC) and uncoated TMT steel reinforcement bars

- *Naveen Krishnan, Priscila Cisily Thomas, Swathi R. Pillai, Adarsh Babu, Dhanya B.S. (January 2017 - June 2018) Undergraduate Project*

The project aimed to evaluate the performance of cement polymer composite (CPC) coated and uncoated TMT steel bars in resisting corrosion initiation. A modified test set-up similar to the standard ASTM G109 test was employed to assess the corrosion initiation where steel rebars collected from the site were used. It was observed that the mortar specimen cast with a 0.5 water/cement ratio exhibited corrosion initiation faster than the specimens cast with a 0.4 or 0.35 water/cement ratio.

PROFESSIONAL RECOGNITIONS AND MEMBERSHIPS

- National Association of Corrosion Engineers (NACE) International (Member since August 2018)
 - Secretary of NACE India Gateway Section (NIGIS), South zone students section from June 2020 to present
 - One of the student organisers of the CORCON 2019 conference conducted at Jaipur in September 2019
 - One of the student organisers of the CORCON 2019 conference conducted at Mumbai in September 2019
 - Editor of first NIGIS South SZ newsletter, COR-Road Journey, released during January 2021
- RILEM, International Union of Laboratories and Experts in Construction Materials, Systems, and Structures (Member since September 2019)
 - Organiser of the 5th Concrete Research in India (CRI) symposium, conducted on the 14th of

September 2019 at IIT Madras, Chennai, India

- ACI, American Concrete Institute (Member since March 2021)
 - Indian Concrete Institute (ICI) (Member since September 2019)
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REPORTS AND PROPOSALS

- R 1. Assisted Dr Radhakrishna G. Pillai in writing a research proposal on “Electrical and Electrochemical modelling of cathodic protection systems in reinforced concrete structures” submitted to DST (Department of Science and Technology) India, February 2021 and is under review.
- R 2. Assisted Dr Radhakrishna G. Pillai in writing the interim reports on the “*Pilot study on the implementation of galvanic anode cathodic protection system in reinforced lime mortar*” that was submitted to the Central Public Work Department (CPWD) of President’s house (Rashtrapati Bhavan), India in June 2019.
- R 3. Assisted Dr Radhakrishna G. Pillai in writing an interim report on “*Effect of resistivity of repair material in galvanic anode cathodic protection system,*” submitted to Vector Corrosion Technologies, Canada May 2019 and June 2020.
- R 4. Assisted Dr Radhakrishna G. Pillai in writing an interim report on “*Condition assessment of reinforced concrete structures and the performance results from installed cathodic protection systems*”, submitted to Delhi Land & Finance (DLF) Ltd., India, in January 2020.
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PROFESSIONAL EXPERIENCES

Jan 2022 – Present	Graduate Teaching Assistant for the Capstone course - CE professional practices, at Oregon State University
Jan 2022 – Present	Graduate Teaching Assistant for the e-campus course, Green Buildings, at Oregon State University
Aug – Dec 2021	Project associate in the BTCM division of the Dept. of Civil Engineering at Indian Institute of Technology Madras, Chennai
Jan – Apr 2021	Teaching assistant for the NPTEL course of Basic Construction Materials
Jan – Apr 2020	Teaching assistant for the NPTEL course of Maintenance and Repair of Constructed facilities
Jul – Nov 2019	Teaching assistant for B. Tech course CE3410, Construction materials laboratory, at IIT Madras
Jan – May 2019	Teaching assistant for B. Tech course CE2330, Construction materials, at IIT Madras
Jan 2019 – Aug 2021	Graduate student in the Dept. of Civil Engineering at Indian Institute of Technology Madras, Chennai (Mentored two summer interns)
May – Nov 2018	Project associate in the BTCM division of the Dept. of Civil Engineering at Indian Institute of Technology Madras, Chennai

WORKSHOPS AND INTERNSHIPS

- One month internship to understand the fundamentals of cathodic protection in concrete structures in the **Institut für Baustoffforschung (Institute for Building Materials Research) at RWTH Aachen University (ibac), Germany, under the guidance of Prof. Dr.-Ing. Michael Raupach**, funded by the IGP program of IIT Madras, from June to July 2019.
 - One-week certification workshop on REVIT software by Autodesk Inc. during June 2017.
 - Winter internship at the Building materials laboratory in the Dept. of Civil Engineering at IIT Madras,
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Chennai, during January 2017.

- Two-day workshop on corrosion in cement and concrete structures (C3S) at the Indian Institute of Technology Madras, Chennai, from 23rd to 24th of August 2016.
 - One month internship at the construction site of the international terminal (T2) of cochin international airport (CIAL) from May to June 2015.
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REFERENCES

Dr. Burkan Isgor

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