

Corrosion Protection and Service Life Extension of Reinforced Concrete Roofing System in Existing Buildings

(DST – SERB: TARE Scheme Project)

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Sponsoring Agency : DST - SERB

Project Scheme : TEACHERS ASSOCIATESHIP FOR RESEARCH EXCELLENCE (TARE)

Research Grant : Rs. 18.3 Lakhs

Duration : November 2018 – March 2022



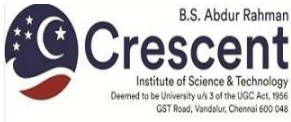
SEPTEMBER 2021

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Roopa Roopa <roopa@crescent.education>

Sanction Order : TAR/2018/001322

SERB_Administrator@serbonline.in <SERB_Administrator@serbonline.in>
To: info@serbonline.in

Wed, Mar 6, 2019 at 3:51 PM



Science and Engineering Research Board

(Statutory Body Established Through an Act of Parliament : SERB Act 2008)
Department of Science and Technology, Government of India

Dear Ms. Roopa Vijayaraghavan,

The below details for **Science & Engineering Research Board (SERB)** Sanction Order (*attached to this mail*)

Sanction Order No TAR/2018/001322
Sanction Date 22 February, 2019
PI Name Ms. Roopa Vijayaraghavan
Institute/University B S ABDUR RAHMAN CRESCENT INSTITUTE OF SCIENCE AND TECHNOLOGY ,
Seethakathi Estate Vandalur, Kanchipuram, Tamil Nadu-600048
PI Number **Account** 165702000000440
Bank & Branch Name INDIAN OVERSEAS BANK VANDALUR BRANCH, [G.S.T ROAD, VANDALUR, CHENNAI - 48](#)
Amount INR 275000/-
In Rupees Two Lakh Seventy Five Thousand
UTR No UBINH19059039232 / SAA434597951
Transaction Date 28 February, 2019

SERB Reference Number:

Bill No
GIA/10148
Diary No / Finance No SERB/F/11211/2018-2019

Sanction Order No TAR/2018/001322
Sanction Date 22 February, 2019
PI Name Ms. Roopa Vijayaraghavan
Institute/University B S ABDUR RAHMAN CRESCENT INSTITUTE OF SCIENCE AND TECHNOLOGY ,
Seethakathi Estate Vandalur, Kanchipuram, Tamil Nadu-600048
PI Number **Account** 2722101001741
Bank & Branch Name Canara Bank IIT - Madras Branch, Canara Bank , IIT-Madras Campus Post office, Sardar Patel road, Guindy, Chennai - 600 036
Amount INR 335000/-
In Rupees Three Lakh Thirty Five Thousand
UTR No UBINH19059039231 / SAA434597950
Transaction Date 28 February, 2019

SERB Reference Number:

Bill No
GIA/10148
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2. However, if any unspent balance is to be **refunded**, kindly ensure that the unutilized amount may be refunded immediately by way of an **a/c payee cheque/DD** drawn in favour of "**Fund for Science & Engineering Research**", payable at **New Delhi** and **forwarded to the undersigned at the address given below:**

--

Under Secretary

Science & Engineering Research Board (SERB)

(A statutory body under the Government of India's Department of Science & Technology)

5 & 5A, Lower Ground Floor, Vasant Square Mall

Vasant Kunj, New Delhi 110070

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PROGRESS REPORT

1. Project Title: Corrosion protection and service life extension of reinforced concrete roofing system in existing buildings	DST No: TAR/2018/001322
2. PI(Name &Address): Roopa Vijayaraghavan Assistant Professor, Department of Civil Engineering roopa@bsauniv.ac.in B S Abdur Rahman Crescent Institute of Science and Technology (Deemed University (Private)) Seethakathi Estate Vandalur Kanchipuram-600048 (Tamil Nadu)	Date of Birth 10.03.1985
3. Co-PI(Name & Address): Dr.Radhakrishna G. Pillai Associate Professor, Department Of Civil Engineering Indian Institute Of Technology Chennai (Institution Under Central Government) I.I.T. Post Office Chennai Chennai-600036 (Tamil Nadu)	Date of Birth 15.11.1976
4. Broad area of Research : Repair and Rehabilitation of Structures Sub Area : Sacrificial Anode Cathodic Protection systems 5. Approved Objectives of the Proposal: <ul style="list-style-type: none"> • To perform field inspections and quantitatively assess the concrete strength, level of chloride contamination, corrosion potential, and corrosion rate in reinforced concrete (RC) roofs in buildings. •To perform long-term laboratory study mimicking field conditions and assess the performance of sacrificial anode cathodic protection (SACP) systems for slabs with various levels of chloride contamination. •To analyze the long-term corrosion data and develop rational design methods for preventing and protecting RC roofs from premature corrosion and extend service life using SACP systems. 	
Date of Start: 27.11.2018	Total cost of Project: 18.3 Lakhs
Date of completion: 26.11.2021	Expenditure as on <u>31.03.21</u> Capital – 4.14 Lakh General -
6. Methodology : 1500 Chara Half Page Phase 1: To Assess the condition of Existing Buildings In this phase, buildings with different distress level (slight, moderate, severe) or age (10, 20, 30 Years) will be selected and categorised. In every building, concrete powder samples will be collected at different depth levels from the terrace slab to assess the chloride content. Corrosion condition of the roof slab will be studied by monitoring the corrosion potential and corrosion rate for a definite period using sophisticated equipments. Compressive strength of the slab will	



Figure 7: Anamolies in Clay tile finish



Figure 8: Anamolies in cement mortar finish

The anomolies found in different types of roof finishes are given in the table 1 : The preliminary investigation was done with likert scale of 4 as

- 1 – Anamolies require Immediate Action;
- 2 – Anamolies require action required within 2 years ;
- 3 – Anamolies require action required within 4 – 5 years ;
- 4 - NA

Table 1: Anamolies in roof finishes

	Clay Tile	Cement Mortar	Cool Tile
Loss of pointing in joints in tiles	1.58	4.00	3.00
Improper alignment of tiles	1.58	4.00	3.33

4	2	10	-178,-156,-204,-151,-179,-185,-190,-169,-142,-177,-193,-180
4	3	10	-188,-195,-211,-186,-171,-169,-162,-190,-169,-179
5	1	10	-187,-146,-164,-176,-139,-186,-190,-170,-186,-174
5	2	10	-190-190,-189,-164,-148,-124,-186,-175,-169,-160
5	3	10	-158,160,-161,-188,-186,180,-136,-140,-150,-167

Table 4 : UPV readings of buildings

Site No	Location	Half Cell Potential Readings	Concrete Quality
1	1	3.45,3.64,3.8,3.73,3.97,3.53,3.61,4.03,3.8,3.11,4.32,3.95	Good
1	2	3.12,3.14,4.08,3.68,4.17,4.2,3.14,3.16,3.01,3.45,3.21,3.11	Medium
1	3	2.38,2.25,2.28,2.25,2.24,2.09,2.04,2.12,1.95,3.06,1.9,2.78	Doubtful
2	1	3.68,3.61,3.49,3.73,3.64,3.41,3.66,3.73,3.61,3.33,3.51,3.11	Good
2	2	3.85,4.24,3.47,4.21,4.17,3.31,3.87,4.34,3.33,4.11,4.29,3.14	Good
2	3	3.59,4.24,3.47,3.21,3.66,3.29,3.01,3.09,3.29,3.37,3.9,3.41	Medium
3	1	2.64,2.51,2.67,3.7,3.68,3.42,2.64,3.01,3.24,2.37,3.03,3.7	Doubtful
3	2	3.82,3.45,4.32,3.47,3.7,3.75,4.23,4.34,4.03,3.45,3.49,3.85	Good
3	3	3.72,3.82,3.82,3.41,4.12,3.51,3.19,3.75,3.49,3.22,3.17,3.35	Good
4	1	3.77,3.73,4.17,4.17,3.87,4.45,4.06,3.87,3.31,3.99,3.19,4.29	Good
4	2	4.12,3.61,3.62,3.64,3.9,4.17,4.13,4.11,3.47,3.61,3.68,4.15,	Good
4	3	4.18,3.87,3.75,4.16,3.9,4.13,4.56,4.15,4,3.89,3.76,4.1	Good
5	1	3.39,3.53,3.31,3.82,3.41,4.48,3.95,3.64,3.47,3.7,3.41,3.49	Medium
5	2	4.12,4.38,3.97,3.99,3.57,3.35,3.9,3.66,4.35,4.24,4.29,3.66	Good
5	3	3.41,3.52,3.26,3.07,3.64,3.49,3.59,3.72,3.91,3.69,3.74,3.66	Good

Phase 2: Experimental Studies on slabs

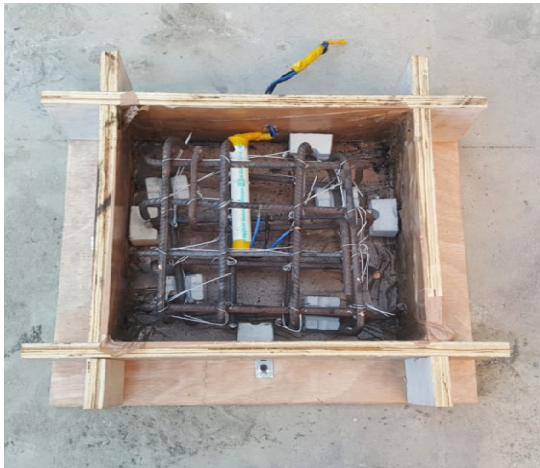
To understand the working efficacy of sacrificial anode cathodic systems on chloride contaminated concrete slabs, the following specimens were cast.

The specimens were cast in three different sizes as follows:

Category	Size of Specimen	Type
A1	0.3 m X 0.3m X .12 m	Control slab Specimen
A2	0.6 m X 0.6 m X 0.12 m	

A3	0.9 m X 0.9 m. X 0.12 m	Slab specimen with Anodes
B1	0.3 m X 0.3m X .12 m	
B2	0.6 m X 0.6 m X 0.12 m	
B3	0.9 m X 0.9 m. X 0.12 m	

Slab Specimens were cast using 8mm TMT rebars at 80 mm c/c in the top mat and bottom mat by giving a clear cover of 25mm at all sides. At the centre of top slab reinforcement, electrical connection was established using core tin coated wire which is brought to the side face of slab by plastic conduit pipes.



0.3 m X 0.3 m X 0.12 m



0.6 m X 0.6 m X 0.12 m

Fig 9: View of reinforcement arrangement in control slab



0.9 m X 0.9 m. X 0.12 m

Fig: 10 View of Slab specimen with embedded anode and electrical connection

In case of roof slab with sacrificial anodes, the anode was tied to the top mat reinforcement as shown in fig 2. The electrical connection from the anode and top mat reinforcement was created. M20 grade of concrete of mix ratio 1: 1.9: 3.4 and water cement ratio 0.55 was used to cast the

model roof slab. Concrete constituent materials include OPC cement, river sand and 20 mm down graded aggregate and potable water.

After specimens were cast, it was exposed to normal water curing with gunny bags for the 7 days and 3% NaCl solution for the next 21 days (3 weeks) to accelerate the corrosion rate of embedded rebars in the slab. This was followed by exposure to environmental conditions for one year to further accelerate the corrosion of steel rebars in slab.

After one and half year of exposure, the slab specimens were coated with polymer modified slurry on all sides. As a part of test procedure, to determine the corrosion protection efficacy of anodes, the slab specimens will be subjected to alternate wetting and drying for a regime of two days with NaCl solution and five days of natural drying.

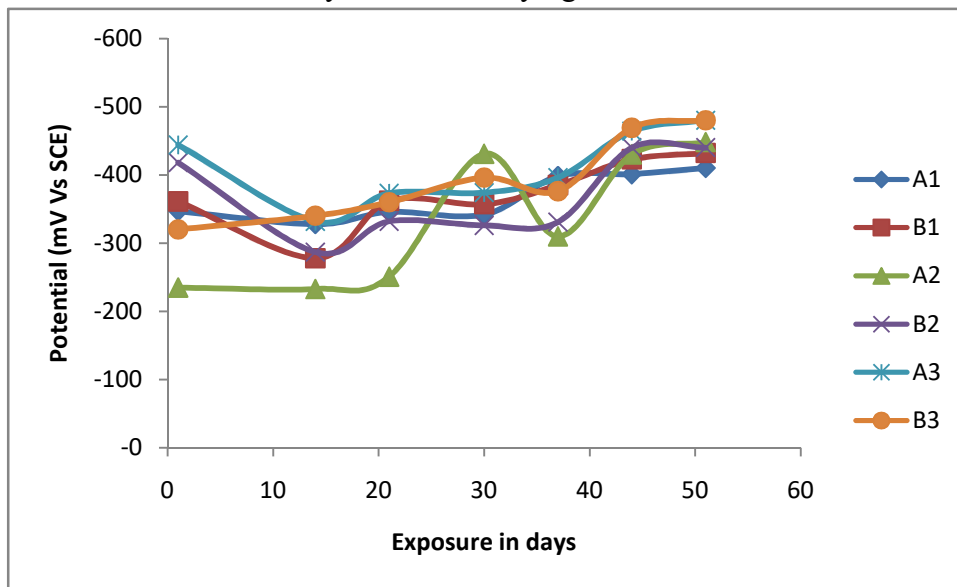


Figure 11. Open circuit potential readings of the slab specimens.

The open circuit potential of the anodes were monitored after the exposure to open environment. The potential of the specimens were monitored till the potential of the specimens measured more than -450 mV so that the corrosion would have initiated. Figure 11 shows the open circuit potential readings of the specimens.

7.2 New Observations: Experimental work is in progress and new observations are to be arrived in the future.

7.3 Innovations: NIL

7.4 Application Potential:

7.4.1 Long Term: The SACP systems could be used for roof slabs in the recently completed projects (with potential threat for corrosion) to enhance the service life of the structures with minimal disturbance to the element.

7.4.2 Immediate: The SACP system could be used for dilapidated or distressed roof slab elements to protect the slab from further structures and enhance the service life.

7.5 Any other Research work which remains to be done under the project (for on-going projects)

Phase 1: Field Observation of at least more 50 buildings in and around Chennai.

Phase 2: Monitoring the potential of the specimens for 1 year in ON condition.

Phase 3 : Analytical Study to Design SACP Systems for distressed roof slab

PhDs Produced no: -

Technical Personnel trained: -

Research Publications arising out of the present project:

-	Experimental work in progress and results are to be published
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List of Publications from this Project(including title, author(s),journals & year(s))

(A) Papers published only in cited Journals(SCI)

Yet to be published

(B) Papers published in Conference Proceedings, Popular Journals etc.

Yet to be published

Patents filed/to be filed: NIL

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