Accelerated Corrosion on Reinforcing Steel Bars Procedure: Passive Layer Generation

Procedure title	Accelerated Corrosion on Reinforcing Steel Bars Procedure: Passive Layer Generation	
Author	Victor Alejandro Calderon	
Date of creation/revision	Date Created: 05/06/2021	Date last revised: 05/06/2021
Principal Investigator	Mervyn J Kowalsky	
Location	Building and room number	

1. This standard operating procedure (SOP) is for

☐ Specific laboratory procedure or experiment

This document outlines the procedure to perform the generation of the passive layer in reinforcing steel bars. This documents assumes that the specimen is already inside the container where the specimens will develop the passive layer. The passive layer is generated by using a saturated pore solution of calcium hydroxide. The solution concentrations were obtained from the study by Ghods et al. [1]

[1] P. Ghods, O. B. Isgor, G. McRae, and T. Miller, "The effect of concrete pore solution composition on the quality of passive oxide films on black steel reinforcement," *Cem. Concr. Compos.*, 2009.

2. Process or experiment description

The reinforcing steel bars are placed in an airtight container and are submerged in a calcium chloride saturated solution.

The required chemicals are listed below:

- Sodium hydroxide
- Potassium hydroxide
- Calcium sulfate dehydrate
- Calcium hydroxide
- Distilled water

Other equipment:

- Beaker 500 ml
- Glass mixing rod
- Disposable 1 gal bucket or equivalent glass container
- Measuring scale
- Spoon for the handling of chemicals
- Paper sheets for spills
- Funnel

3.	**Hazard and risk assessment**.

Chemical hazard: All the chemicals in this procedure are irritants and eye hazard.

Irritant
Skin irritation, category 2
Specific target organ toxicity following single exposure, category 3

Corrosive
Serious eye damage, category 1

Skin Irritation 2
Eye Damage 1
Specific Target Organ Toxicity, Single Exposure (respiratory) 3

4.	**Safety equipment** *Specify all equipment needed to perform the procedure safely and to respond to emergencies.*
4.a.	Engineering / ventilation controls N/A
4.b.	Personal protective equipment • Safety glasses/goggles • Nitrile gloves with puncture resistance • Lab coat • N95 mask • Chemical spill kit
4.c.	Location of nearest emergency safety equipment

Item	Location
Eyewash/safety shower	**See laboratory floor plan**
First aid kit	**Safety box**
Chemical spill kit	**Contact lab manager**
Fire extinguisher	**See laboratory floor plan**
Fire alarm manual pull station	***See laboratory floor plan***
Telephone	**(919) 515-3000**
Other	

5.	**Step-by-step methodology** *The methodology explained below is made for 1 liter (L) of saturated solution. If required multiply the concentrations below by the desired volume.*

Step 1: Prepare the work area, place shipping paper on counter or table of specimen preparation. Place underneath each specimen containers.

Step 2: Turn on scale and ensure the scale is level. In the 1 gal container measure the following masses for each of the components:

- Saturated calcium hydroxide $(\mathrm{Ca(OH)_2})$ (approximately 1.8 g)
- 4 g Sodium hydroxide $\left(\mathrm{Na(OH)}\right)$,
- 11.22 g potassium hydroxide (KOH)
- 13.77 g of calcium sulfate dehydrate $(\mathrm{Ca(SO)\_4} + 2\mathrm{H_2}O)$
- 1 L distilled water

Step 3: Saturate the water with calcium hydroxide, mixing thoroughly with the glass rod until no lumps are left. Mix in the remaining chemical agents.

Step 4: Using a funnel saturate the rebar specimen with the solution. Repeat the process until the specimen is completely covered with the saturated solution.

Step 5: Close the airtight container. The container must be airtight, failure to do so the calcium hydroxide will carbonate and the passive layer will not be generated. Label the chemical contents of the container. Place a transparent tape on top the label. This must be done per Fire Marshall requirements.

Step 6: Wait for a minimum of 8 days for the passive layer to develop on the surface of the specimen.

Step 7: Open the container and start the unwanted material disposal procedure for the solution.

Step 8: Continue with the accelerated corrosion process.

6.	**Designated area** .

Room temperature area.

7.	**Special handling procedures, transport, and storage requirements** *Describe special handling and storage requirements for hazardous chemicals used in this procedure, especially those that are highly reactive/ unstable, flammable toxic and corrosive. Describe secondary containment requirements for transport between laboratory rooms.*

The disposal of the solution should be performed as follows.

Step 1: In a container such as a bucket, slowly pour the solution in the bucket making sure to not spill the solution.

Step 2: Pour the solution in the cement waste designated container.

Step 3: Clean any droplets in the working area.

8	**Unwanted material disposal** **Identify and list all hazardous waste to be generated and appropriate disposal procedures. Include liquid and solid waste.**

The procedures outlined by EHS should be followed. The unwanted material generated in this process is the calcium hydroxide solution. A waste accumulation label should be obtained and correctly disposed after the passive layer generation process is performed.

9.	**Emergency procedures**

Life-threatening emergencies (for example, medical event, fire, explosion, large-scale spill or release, toxic or flammable gas leak, valve failure)

- Call 911. Provide dispatch the following information: your name and call back number, location of the incident, material released, if known, if there are any injured persons, and their location.
- Pull the nearest fire alarm.
- Exit the building using the nearest stairway.
- Proceed to the designated assembly area.
- Provide information to emergency responders as able.

Chemical spills

1. Determine if it is a "major" or "minor" spill. Minor spills are well contained, able to be cleaned using the spill kit at hand and clean-up would not require special PPE such as a respirator.
2. Assist anyone who may have been contaminated or injured during the spill.
3. Clean up minor spills using appropriate spill control equipment.
4. Call 911, NCSU Police ((919) 515-3000) and EHS ((919) 515-7915) for all major spills.
5. Contain major spill with appropriate absorbent only if trained to do so and your safety is not compromised.
6. Post "DO NOT ENTER" on entrance door and evacuate the area.

   Do not re-enter until Emergency Responders have cleaned up the spill and declare the area safe for reentry.

If personnel exposed to chemicals

1. Call 911 to seek emergency medical help.
2. Assist exposed person away from incident or source of exposure, to the emergency shower or eyewash. Do this only if able and personal safety is not compromised. Exposed person decontaminates using the nearest emergency shower or eyewash.

   2.1. Pull the safety shower lever to start the water flowing (or push the eyewash lever to start the water flowing).

   2.2 To wash off chemicals from your eyes, hold your eyes open to get the water under your eyelids.

   2.3 Remove all contaminated clothing and shoes to effectively wash chemicals off your body.

   2.4 Stay under the water for at least 15 minutes to wash all the chemicals off.
3. Report incident
4. Seek follow-up medical treatment.

Building maintenance emergencies (for example, power outages, plumbing leaks, fume hood malfunction)
Call *(919) 515-2991* to report facility emergency.

10.	**Training requirements** *List the general and laboratory-specific training required for authorized users of this SOP*

☐ EHSA Chemical and Lab Safety Training
☐ CFL Safety Training
☐ Laboratory Unwanted Material Management Training