Subject: Engineering Chemistry

Date:

CO:

EXPERIMENT 5:

Corrosion Assessment in Rebars of RC Structures Using PZT Patches

Objectives:

This simulation experiment is based on experimental data measured during actual accelerated corrosion tests carried out on reinforced concrete (RC) structures:

- 5A) Bare Rebar
- 5B) Embedded Rebar

Theory:

The corrosion of steel reinforcement is one of the main causes of damage and premature failure of reinforced concrete structures, increasing the costs for inspection, maintenance, restoration, and replacement of infrastructure. Recently, Dr. Talakokula and Prof. Bhalla (2015) proposed a new corrosion assessment approach based on the mechanical impedance EMI technique (Refer thesis of Dr. Vislalakshi Talakokula for more information). Figures 1(a) and 1(b) present the experimental setup for the rebar corrosion related laboratory experiments for bare rebar and embedded rebar respectively.

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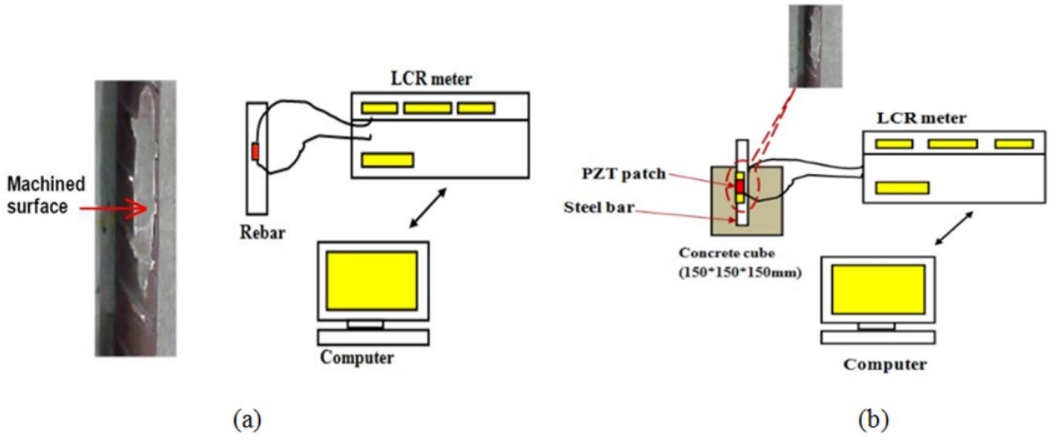

Figure 1: Data acquisition setup for accelerated corrosion in (a) bare rebar (b) embedded rebar

EXERIMENTAL DETAILS

In the accelerated corrosion experiments of bare rebar, following components are used:

- Copper rod acting as Cathode.
- Bare rebar acting as Anode.
- PZT patches bonded to rebar which is further connected to LCR meter by electrodes.
- Beaker containing brine solution whose salinity is 35 parts per thousand.

For accelerated corrosion experiments in embedded rebars, the components are same except that a 150 x 150 x 150 mm concrete cube with an embedded bar replaces the bare rebar as shown in Figure 2(a) and 2(b) respectively.

EXPERIMENTAL PROCEDURE

The setup for accelerated corrosion for bare rebar and reinforced concrete is shown in Figure 2(a) and 2(b) respectively. Through this animation, the user can visualize the process of accelerated corrosion and can obtain signatures of the PZT patchs bonded to rebar during

various stages. Figure 2 shows a screenshot of the animation. The user can visualize the process by plotting in excel and observe the changes in signature with increasing corrosion.

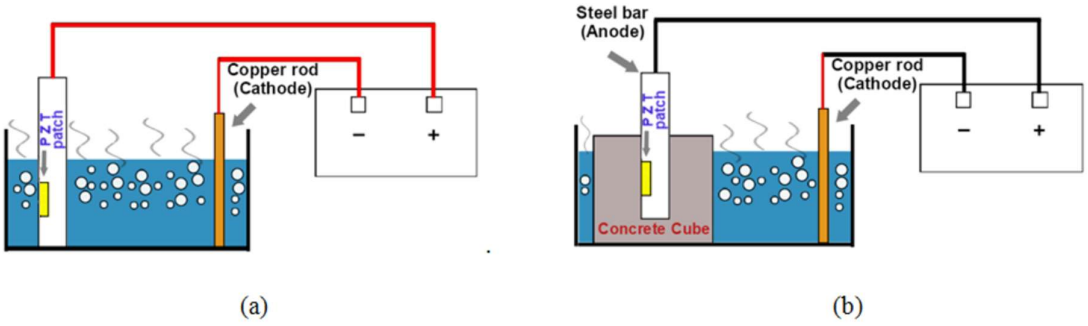

Figure 2: Setup for accelerated corrosion (a) Bare rebar (b) Reinforced Concrete

To statistically quantify damage, compute root mean square deviation (RMSD) in conductance by following equation directly in MS excel:

$$RMSD(\%) = \sqrt{\frac{\sum_{i=1}^{n}(G_i^1 - G_i^0)^2}{\sum_{i=1}^{n}(G_i^0)^2}} \times 100$$

where

G_i^0 = Baseline conductance value at i^{th} frequency.

G_i^1 = Conductance value after a damage at i^{th} frequency.

n = No. of frequency data points

As an exercise plot a histogram of RMSD for the various damaged states. Note your observations and draw conclusions.

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Apparatus:

A) For Bare Rebar:

1. Empty Tank
2. Brine solution
3. Copper rod as cathode
4. Bare rebar as anode
5. PZT patch
6. Power supply
7. Bare rebar holder
8. Copper rod holder

B) For Embedded Rebar:

1. Empty Tank
2. Brine solution
3. PZT patch
4. Power supply

5. Copper rod as cathode
6. Copper rod holder
7. Concrete cube containing rebar as anode

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SELF EVALUATION:

Corrosion Assessment in Rebars of RC Structures Using PZT Patches

Q1. In the accelerated corrosion experiments of bare rebar, components are used:

- ○ a: Copper rod
- ○ b: Bare rebar
- ○ c: PZT patchs bonded to rebar
- ◉ d: All of the above

Q2. In this experiment which solvent is used?

- ◉ a: Brine solution
- ○ b: HCl
- ○ c: H_2SO_4
- ○ d: None of the above

Q3. In the experiment the rebar is made as

- ◉ a: Anode
- ○ b: Cathode
- ○ c: Both a & b
- ○ d: None of the above

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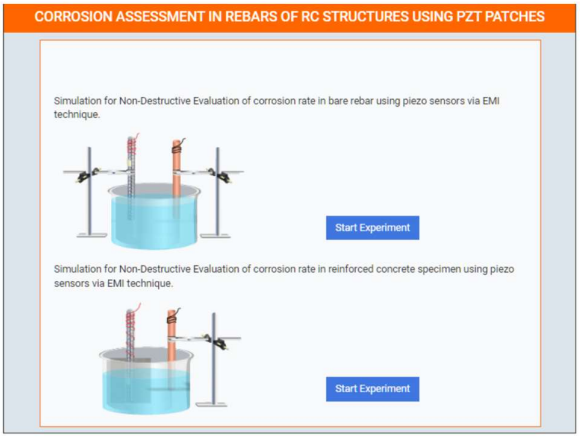
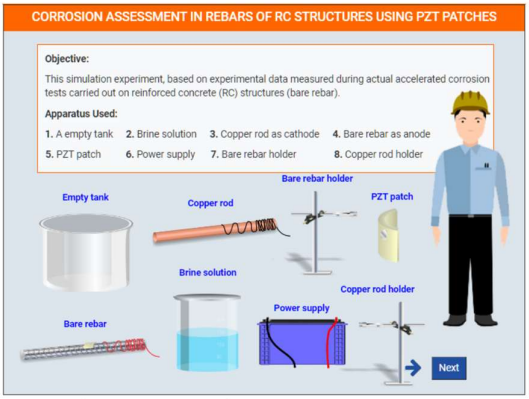
PROCEDURE:

EXPERIMENT 5 A: BARE REBAR

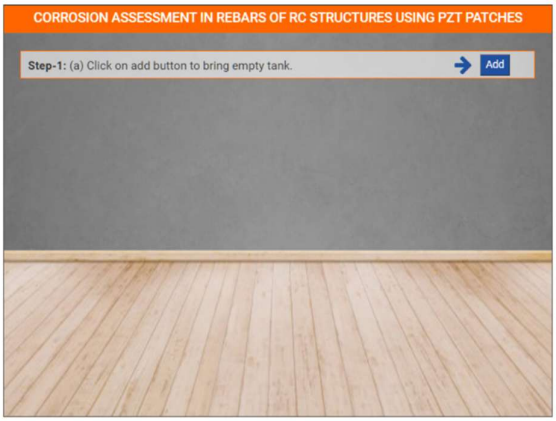
Select experiment for bare rebar



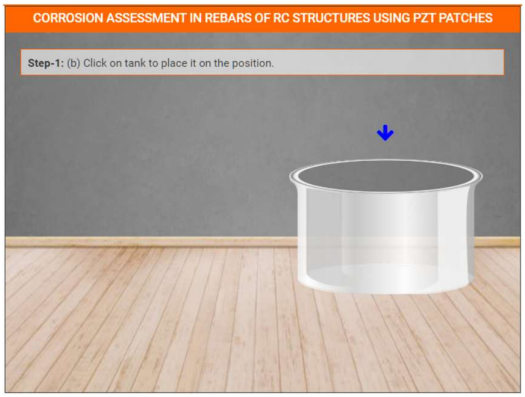
Click next button to start the experiment.



Step-1: (a) Click on add button to bring empty tank.



Step-1: (b) Click on tank to place it on the position.



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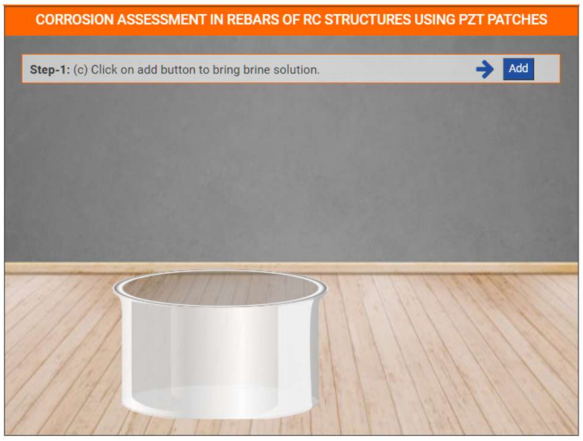
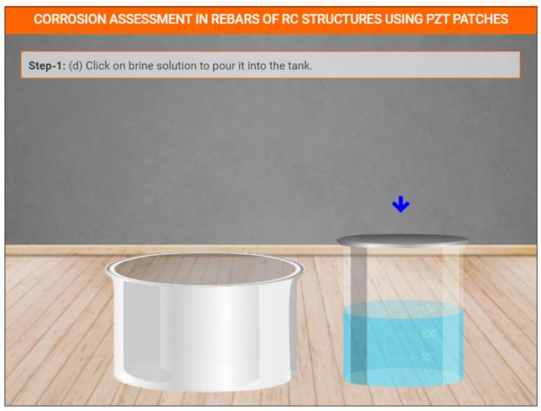
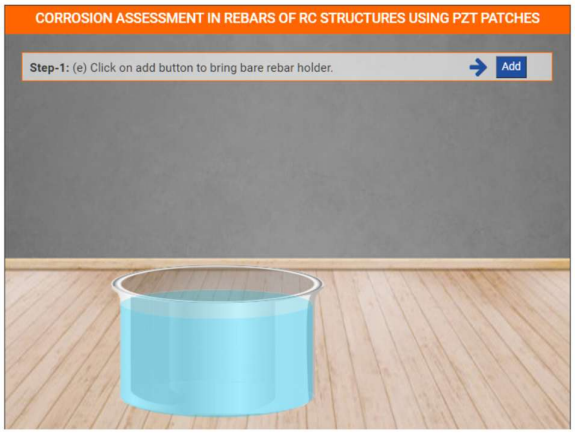
Step-1: (c) Click on add button to bring brine solution.



Step-1: (d) Click on brine solution to pour it into the tank.



Step-1: (e) Click on add button to bring bare rebar holder.



Step-1: (f) Click on add button to bring bare rebar.

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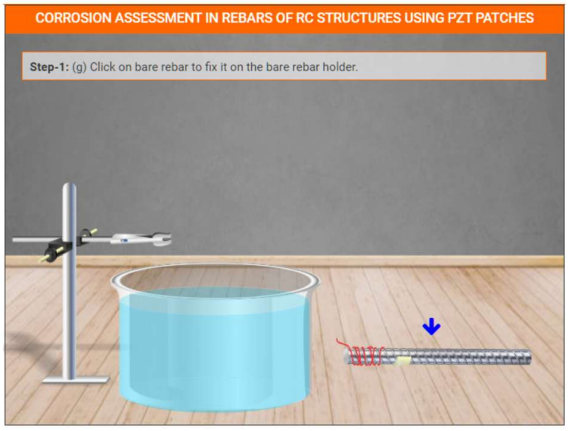
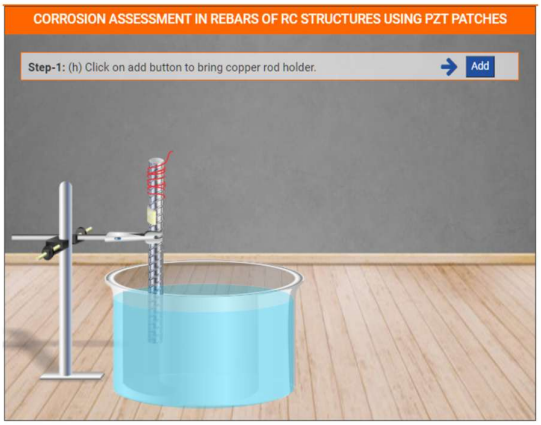
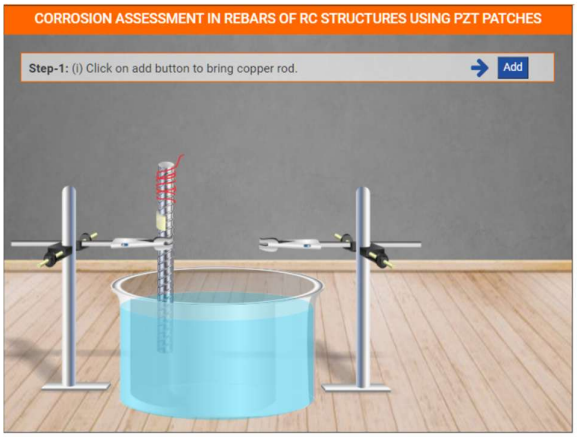
Step-1: (g) Click on bare rebar to fix it on the bare rebar holder.



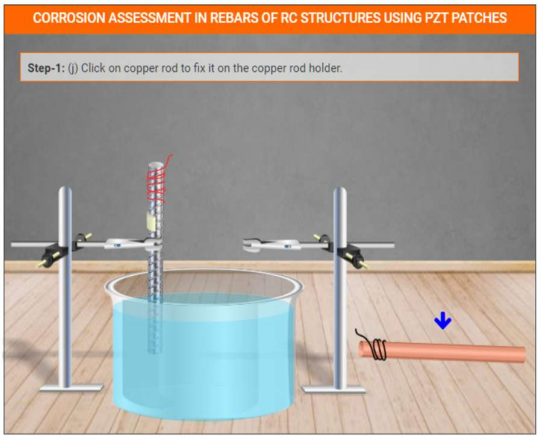
Step-1: (h) Click on add button to bring copper rod holder.



Step-1: (i) Click on add button to bring copper rod.



Step-1: (j) Click on copper rod to fix it on the copper rod holder.



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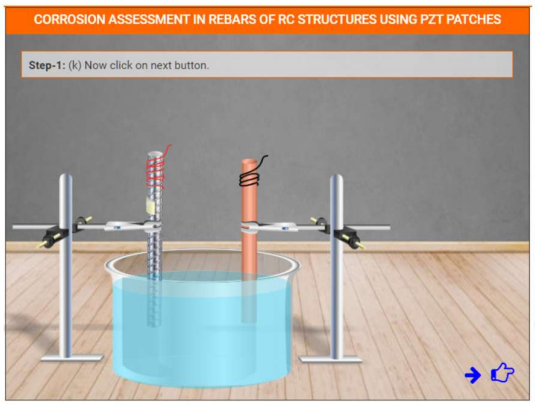
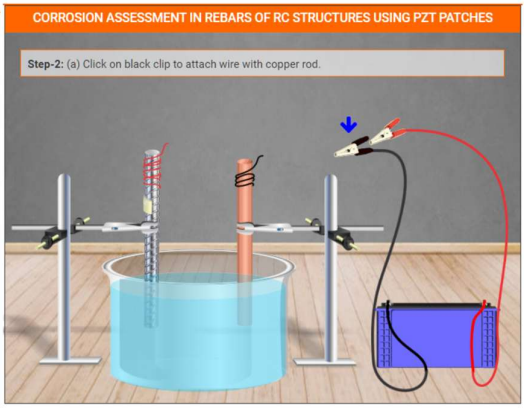
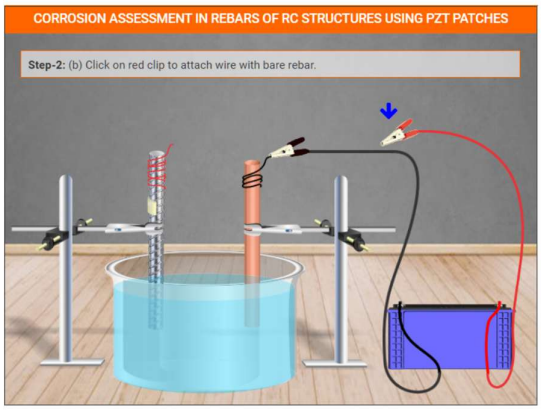
Step-1: (k) Now click on next button.



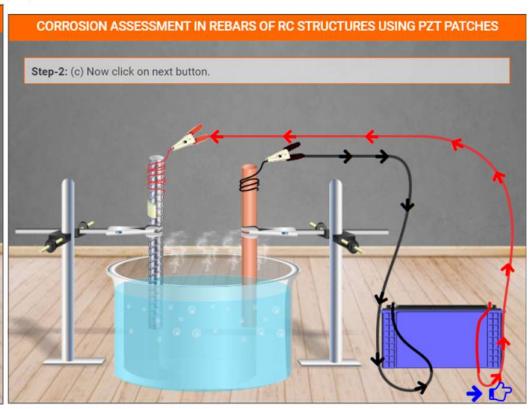
Step-2: (a) Click on black clip to attach wire with copper rod.



Step-2: (b) Click on red clip to attach wire with bare rebar.

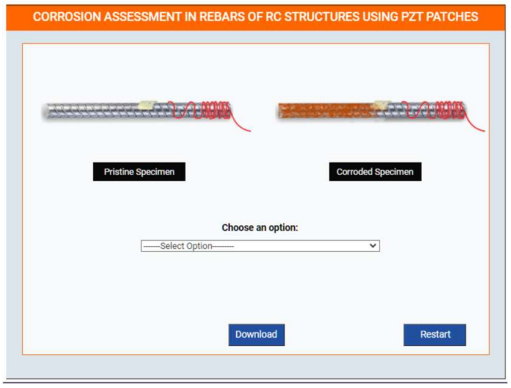


Step-2: (c) Now click on next button.



Select option and download report.

Click restart button to perform experiment again.



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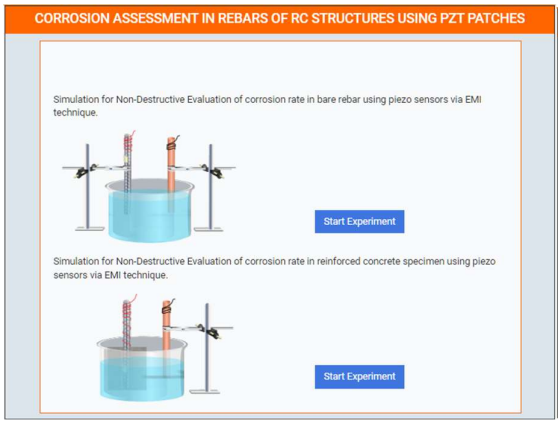
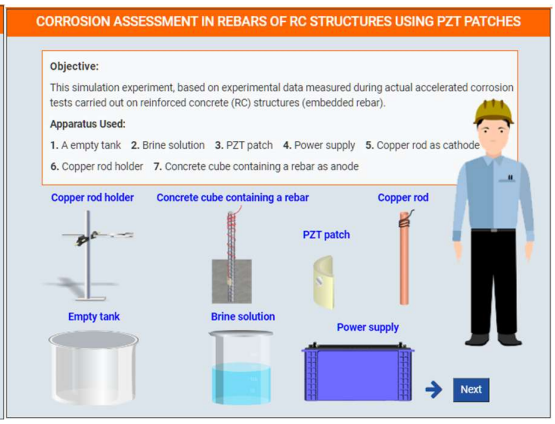
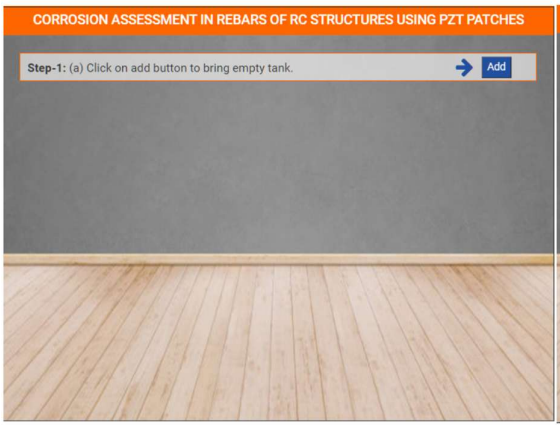
EXPERIMENT 5 B: EMBEDDED REBAR

Select experiment for embedded rebar

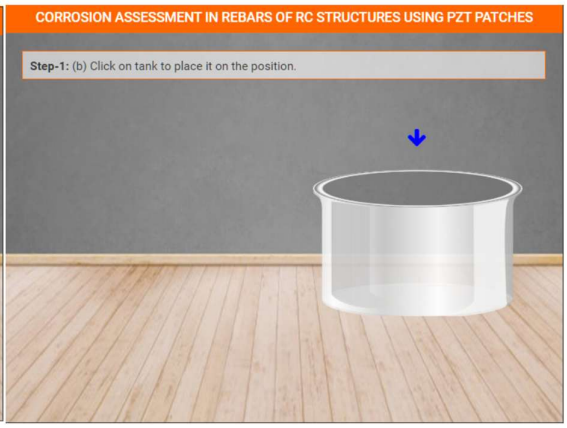




Step-1: (a) Click on add button to bring empty tank.



Step-1: (b) Click on tank to place it on the position.



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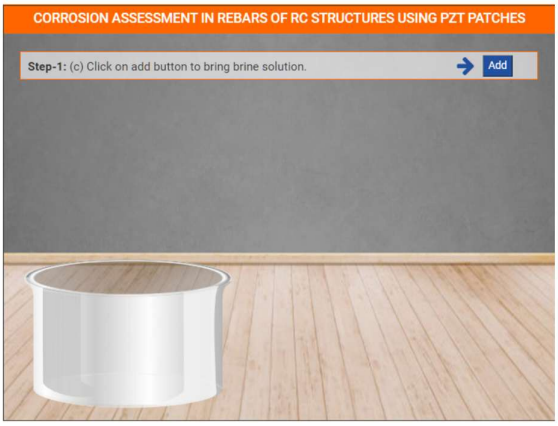
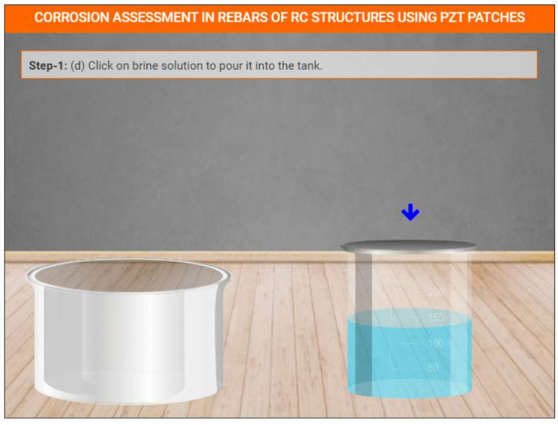
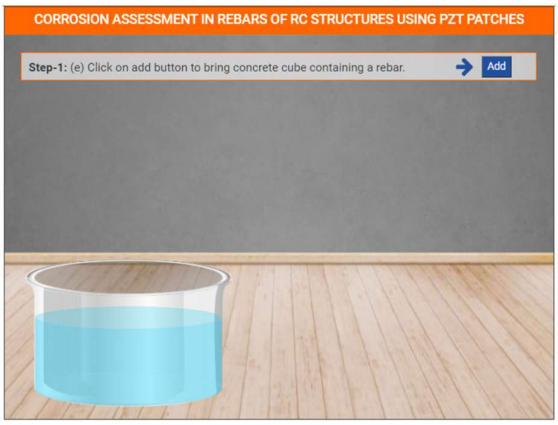
Step-1: (c) Click on add button to bring brine solution.



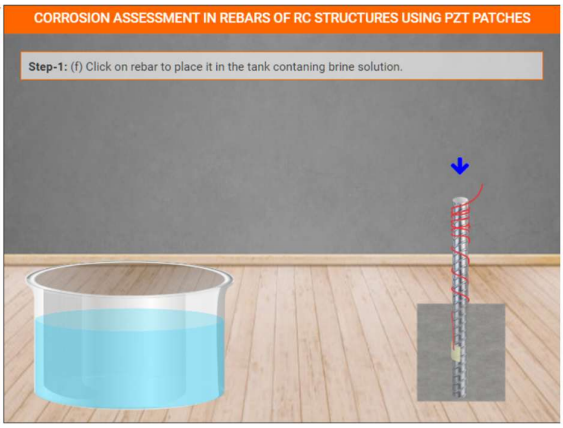
Step-1: (d) Click on brine solution to pour it into the tank.



Step-1: (e) Click on add button to bring concrete cube containing a rebar.



Step-1: (f) Click on rebar to place it in the tank contaning brine solution.



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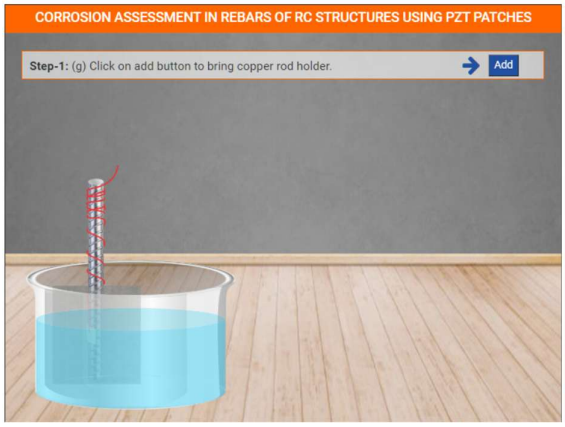
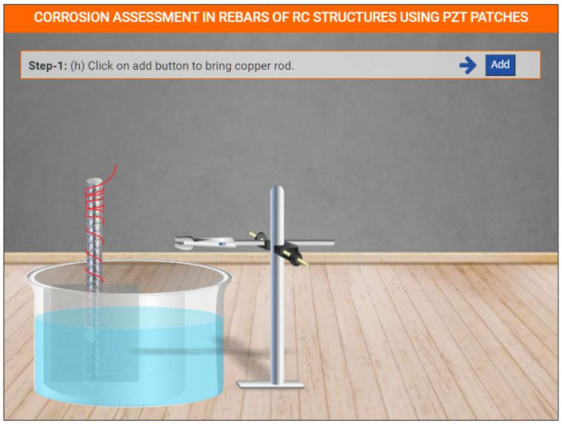
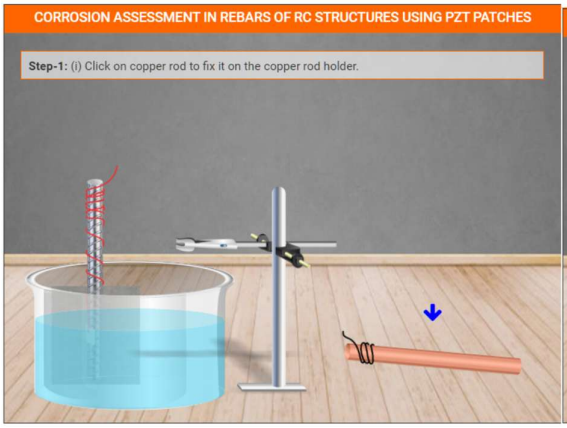
Step-1: (g) Click on add button to bring copper rod holder.



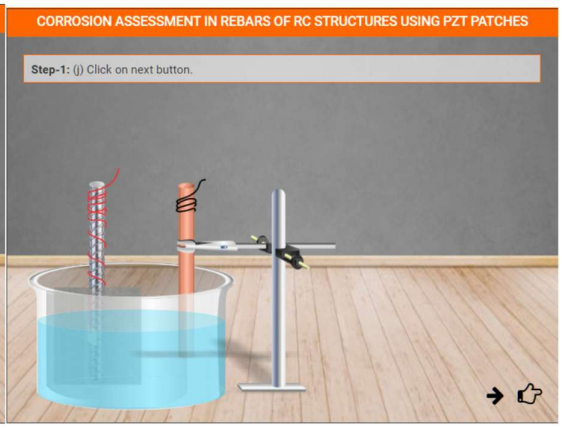
Step-1: (h) Click on add button to bring copper rod.



Step-1: (i) Click on copper rod to fix it on the copper rod holder.



Step-1: (j) Click on next button.



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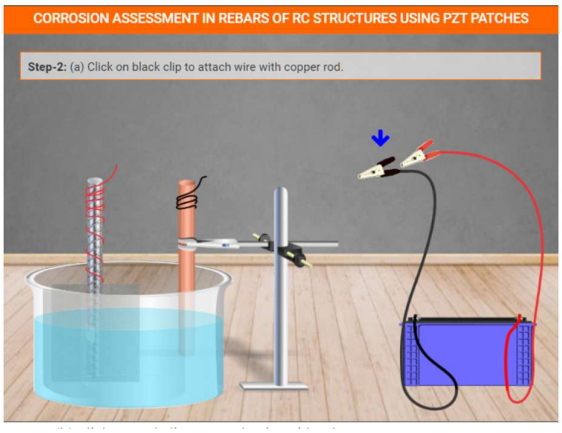
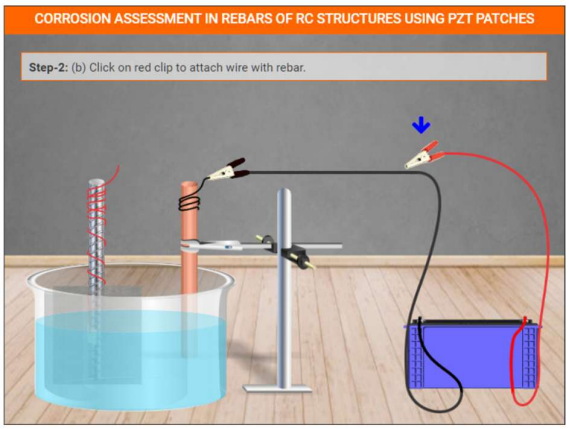
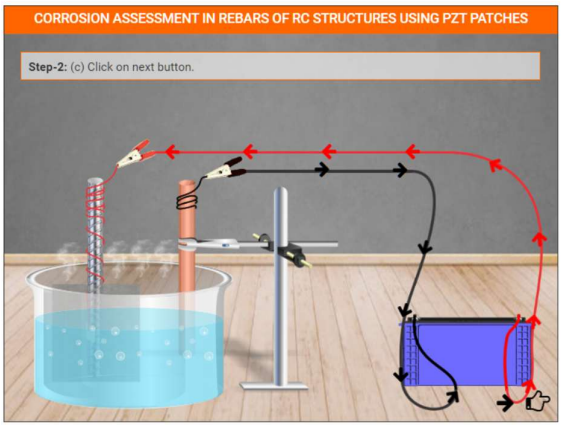
Step-2: (a) Click on black clip to attach wire with copper rod.



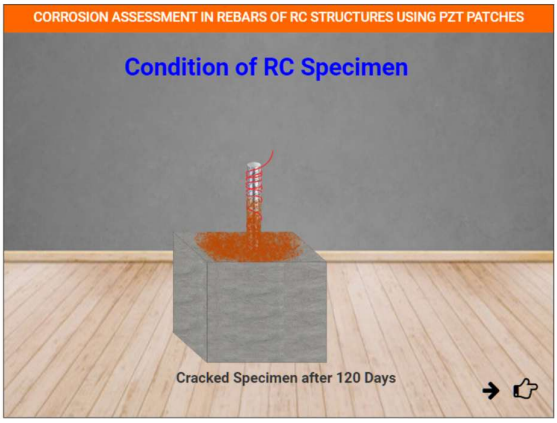
Step-2: (b) Click on red clip to attach wire with rebar.



Step-2: (c) Click on next button.

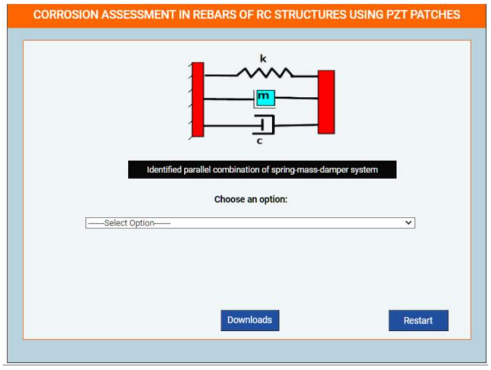


Click on next button.



Select option and download report.

Click restart button to perform experiment again.



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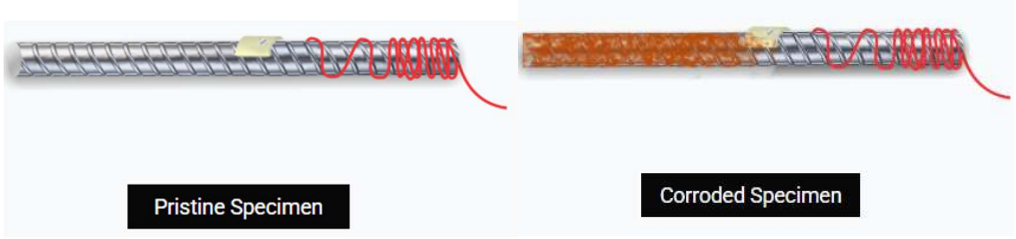
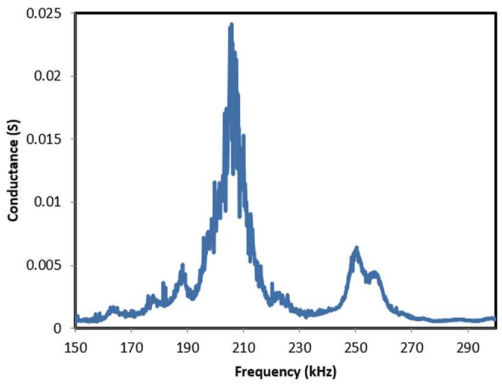
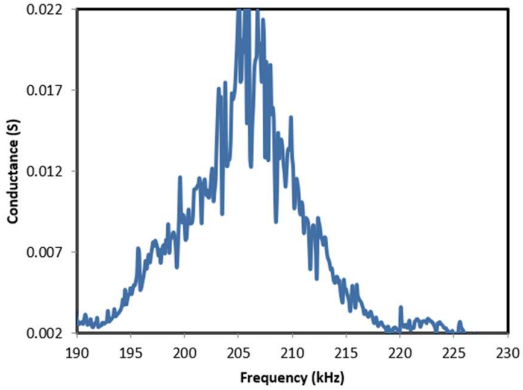
OBSERVATIONS

EXPERIMENT 5A: BARE REBAR

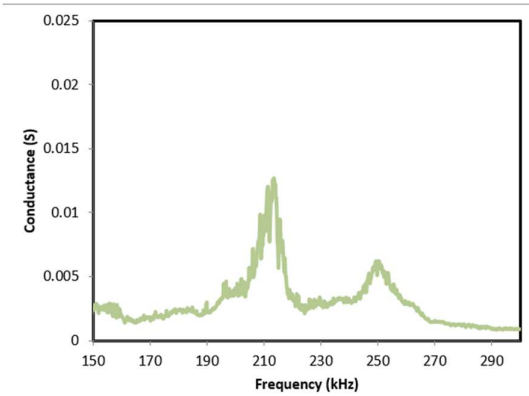


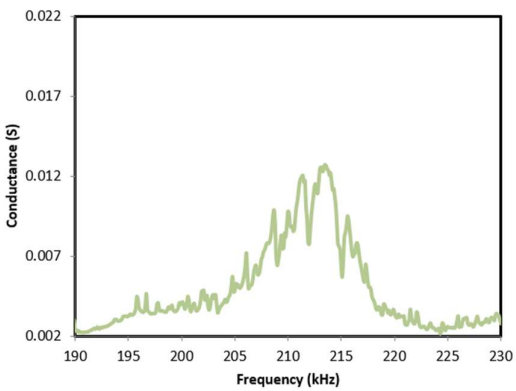
BASELINE SIGNATURE:



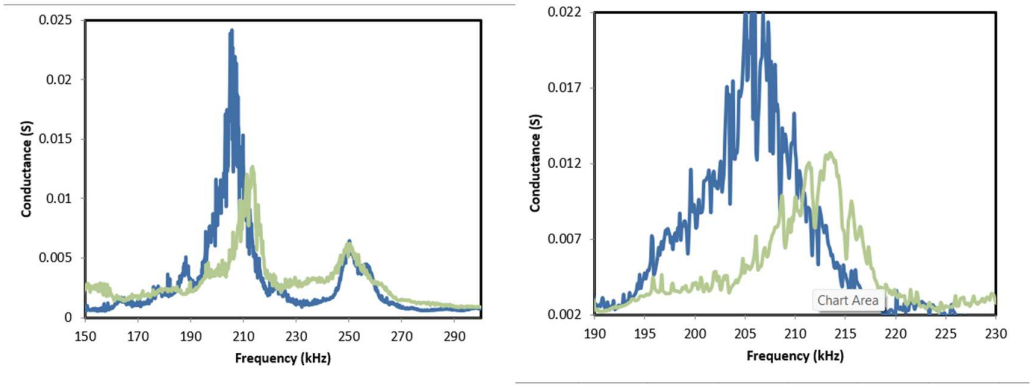


SIGNATURE AFTER HOURS OF ACCELERATED CORROSION EXPOSURE:

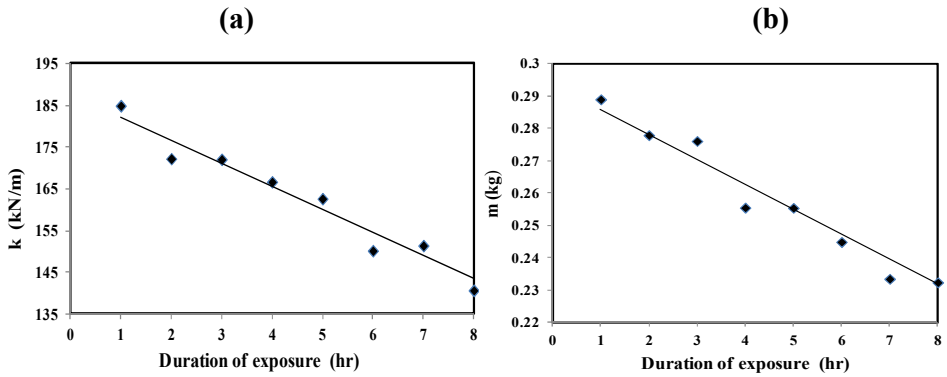




COMPARE BASELINE AND CORRODED SIGNATURE



EXTRACTION OF K AND M VALUES



Variation of extracted system parameters (a) Equivalent stiffness of specimen 1and 2 (b) Equivalent mass of specimen 1 and 2

CALCULATION OF CORROSION RATE

The corrosion rate (mm/year) can be calculated as

$$\Delta_c = \frac{(K * \Delta m)}{(a * T * D)}$$

Where K is a constant equal to 8.76×10^4, Δm is the mass loss in grams, a is the area in cm^2, T is the time of corrosion exposure in hours and D is the density of steel i.e.,7.8g/cm^3.

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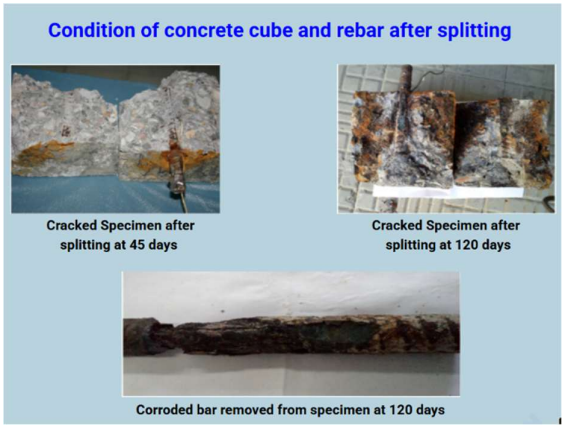
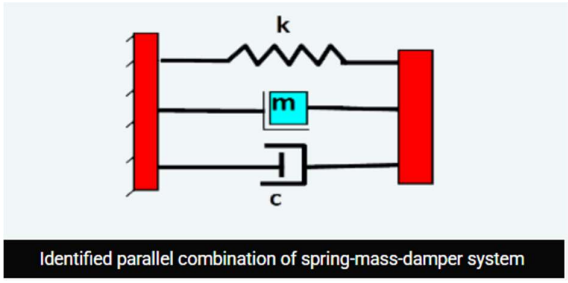
OBSERVATIONS

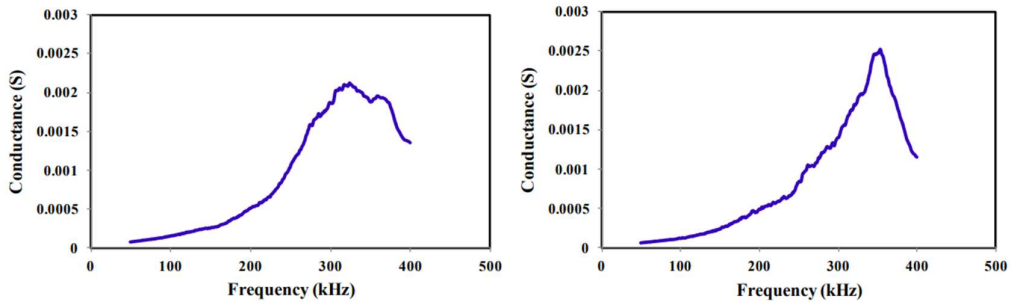
EXPERIMENT 5B: EMBEDDED REBAR



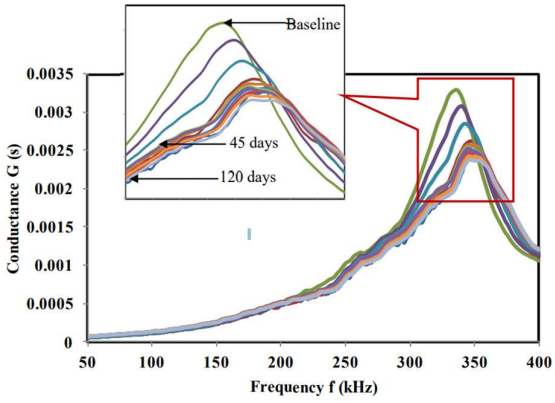


Identified parallel combination of spring-mass-damper system

BASELINE SIGNATURE:



Variation of conductance signatures of specimen 1 during accelerated corrosion process



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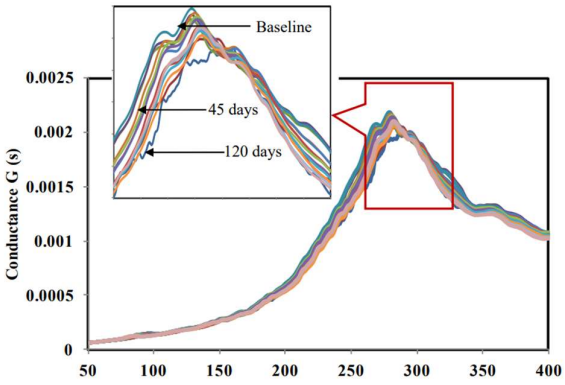
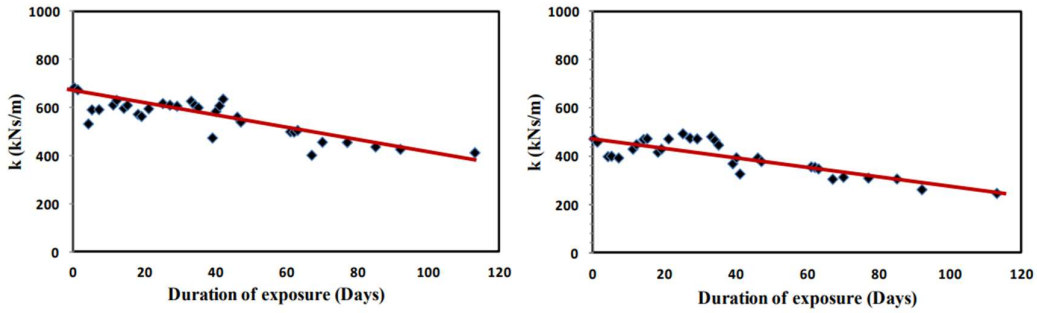
Subject: Engineering Chemistry

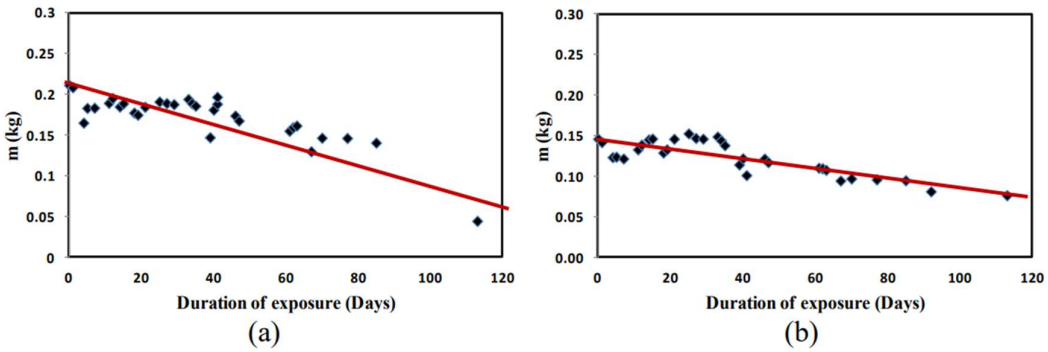
Variation of conduction signatures of specimen 2 during accelerated corrosion process



Variation of PZT identified stiffness with corrosion progress



Variation of PZT identified mass with corrosion progress



Calculation of Corrosion Rate

The corrosion rate (mm/year) can be calculated as

$$\Delta_c = \frac{(K * \Delta m)}{(a * T * D)}$$

where K is a constant equal to 8.76×10^4, Δm is the mass loss in grams, a is the area in cm^2, T is the time of corrosion exposure in hours and D is the density of steel i.e.,$7.8 g/cm^3$.

CONCLUSION

Thus, we have assessed corrosion of rebar in RC structures with PZT patches.