Part – 1 Introduction

- Corrosion in concrete for wastewater facilities and conveyance systems is generally caused by chemical and microbiological attack.

- Chemicals in wastewater can be from the chemicals already in the sewage or from new chemicals added for treatment.

- Microbiological attack is caused by bacteria in the sewage that react with and convert hydrogen sulfide to sulfuric acid which attacks the matrix of concrete.

- The focus of this discussion will be on the corrosion in concrete due to hydrogen sulfide (H_2S) and microbiological attack:
  - the problems it causes;
  - how to repair and protect the concrete.

Part – 2 Development of Corrosion

- Wastewater contains plenty of sulfate (SO_4).
- Slime layer on the pipe wall, sludge and silt deposits on the pipe invert contain sulfate reduction bacteria (SRB).
- SRB consumes SO_4 for oxygen and releases sulfide ion ($S^{=}$) back into the water.

- Sulfide ion forms aqueous hydrogen sulfide ($H_2S_{(aq)}$) and hydrogen sulfide gas ($H_2S_{(g)}$).
- $H_2S_{(g)}$ produces thiosulfuric acid and polythionic acid and CO_2 produces carbonic acid.
- These acid gases dissolve into the water on the moist surface of the concrete above the waterline and react with calcium hydroxide, the pH of the surface is reduced.

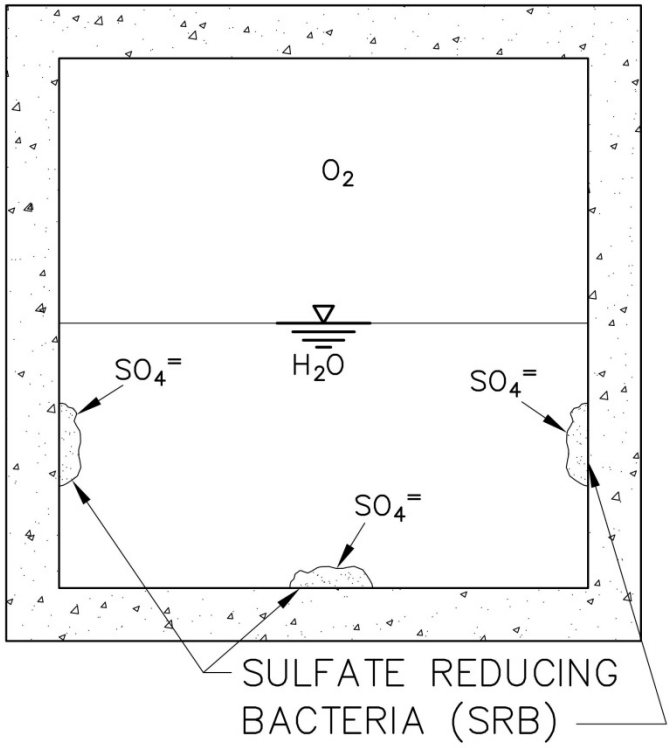
- New concrete has a pH of 11 to 12. When the pH is lowered to 9.5 or less, the growth of Thiobacillus Sulfur Oxidizing Bacteria (SOB) on the concrete surfaces above the water is initiated.

- SOB consumes the H_2S gas, oxidizes it and turns it into sulfuric acid (H_2SO_4).

- H_2SO_4 attacks the matrix of the concrete and causes decomposition of concrete.

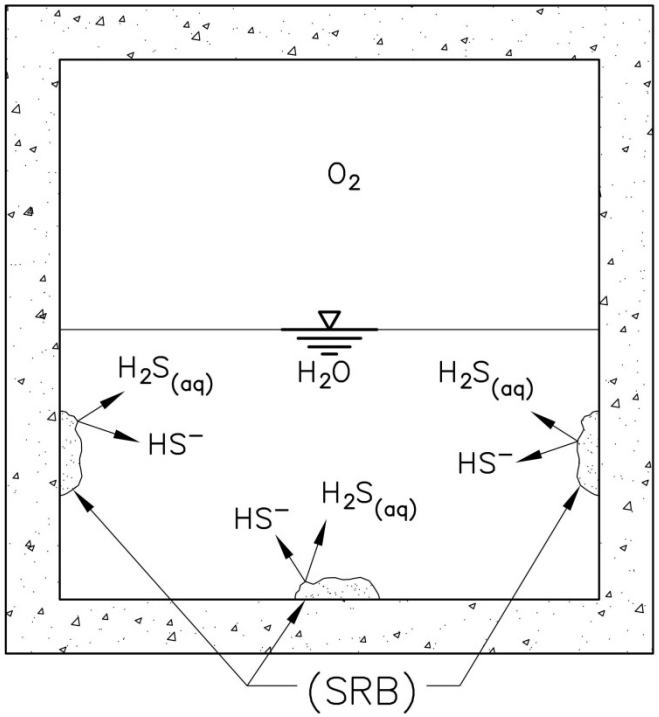
- Concrete surfaces become soft. High flows scour the concrete surface at and above the waterline, causing concrete corrosion to accelerate.

Development of H_2S



$SO_4^=$: BISULFATE ION

Development of H_2S

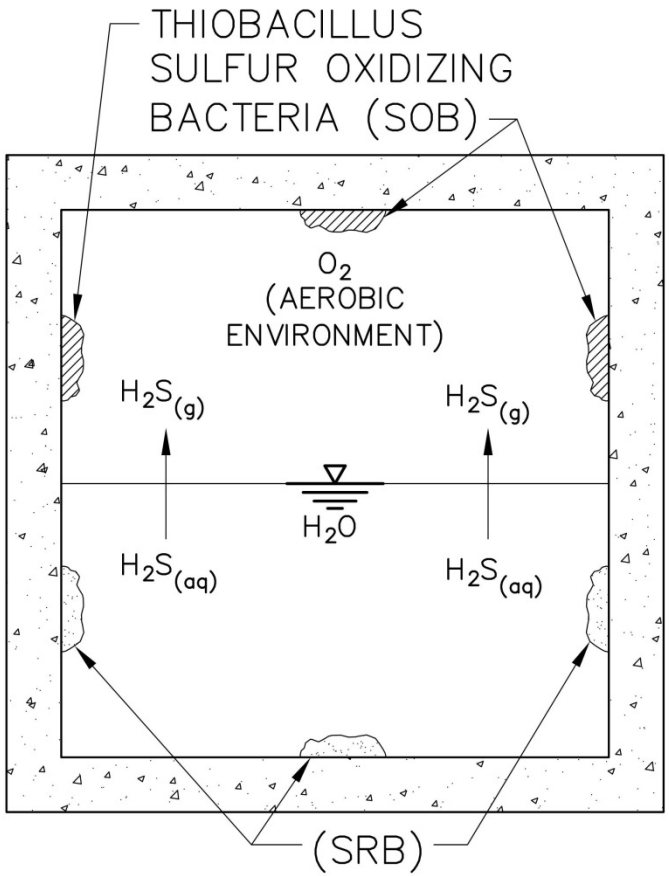


$SO_4^{=} \longrightarrow SRB \rightarrow H_2S_{(aq)} + HS^-$

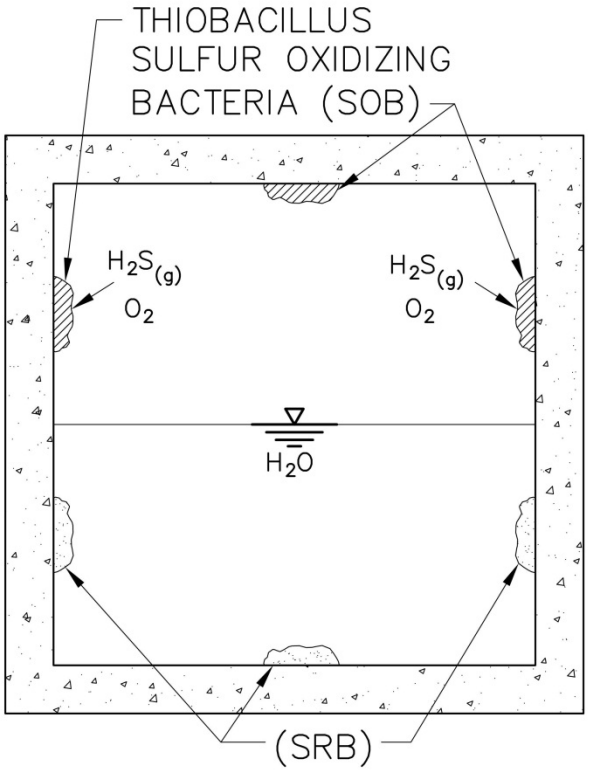
$H_2S_{(aq)}$: HYDROGEN SULFIDE (AQUEOUS)

HS^- : BISULFIDE ION

Conversion of H_2S to H_2SO_4



Conversion of H_2S to H_2SO_4

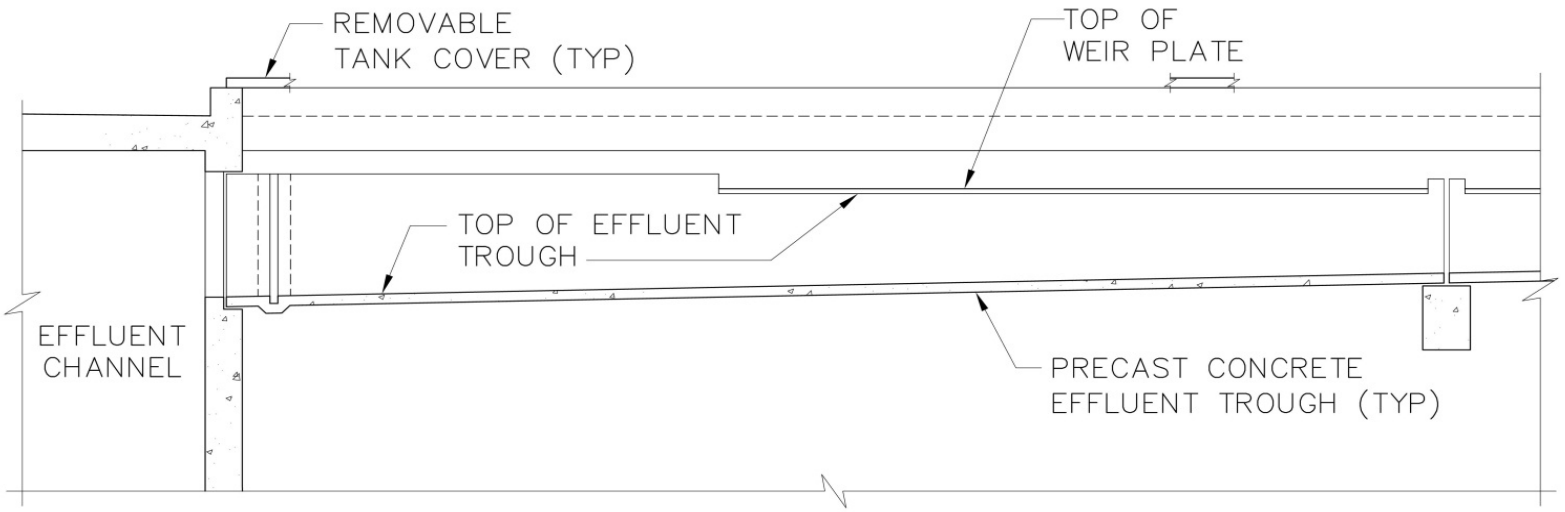


$H_2S_{(g)} \rightarrow SOB(+2O_2) \rightarrow H_2SO_4$

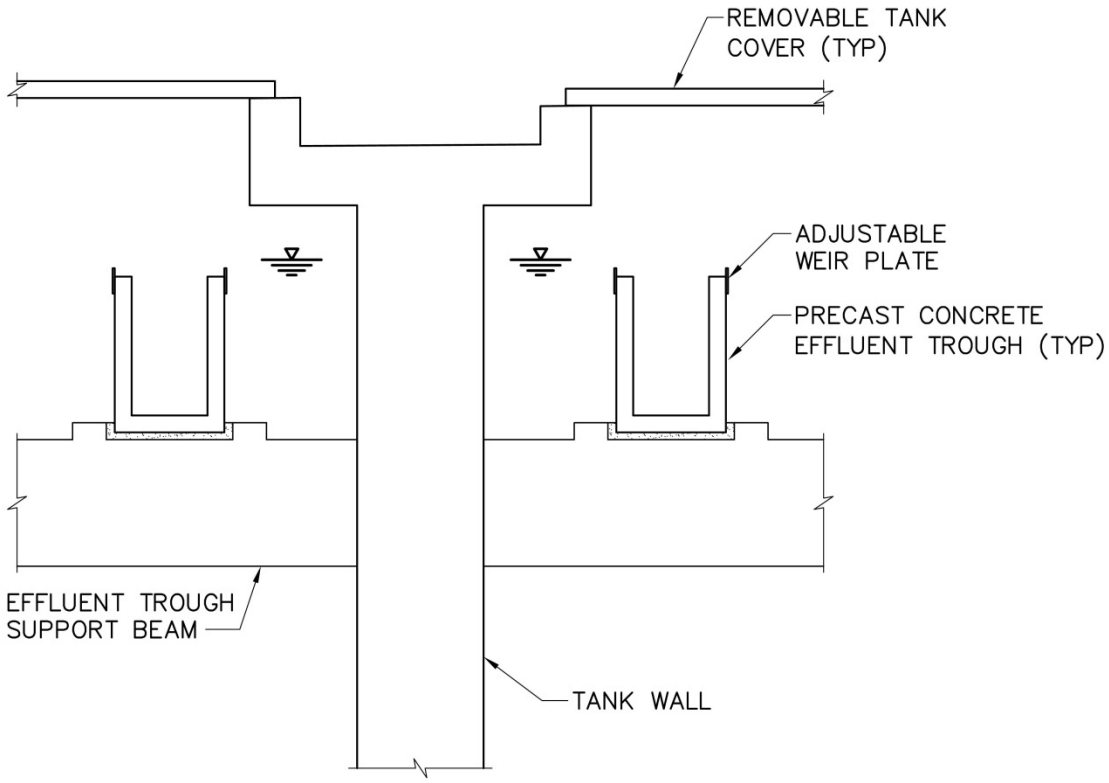
>2ppm

H_2SO_4 : SULFURIC ACID

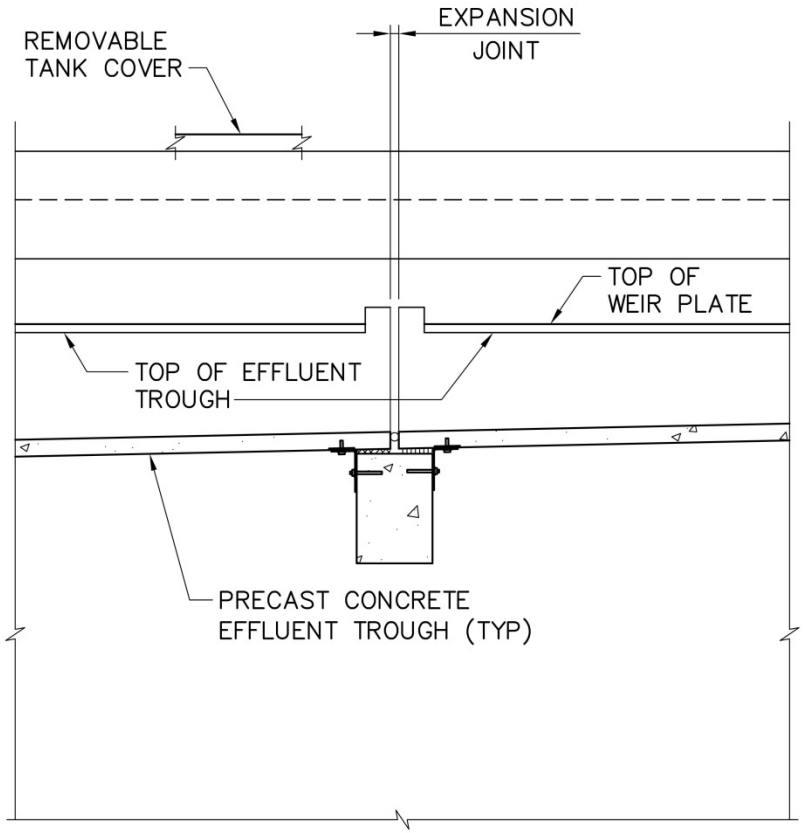
Part 3- Effects of Corrosion



Longitudinal Section Through Effluent Trough



Cross Section of Effluent Troughs & Tank Wall



Section at Adjoining Effluent Trough Segments

Water Flowing Over Weirs into Effluent Trough

Concrete Corrosion Above Water Level at Adjoining Effluent Trough Segments

Concrete Corrosion on Exposed Effluent Trough Surfaces

Concrete Corrosion on Exposed Effluent Trough Surfaces

Concrete Corrosion at Effluent End of Trough

Corrosion of Concrete Over Covered Tank

Concrete Walkway/Beam Over Covered Tank

Concrete Corrosion in Sludge Valve Box

Corroded Drain Pipe

Spalled concrete With Exposed Rebars on Underside of Effluent Channel

Part 4 – Repair Systems and Procedures

- For deteriorated concrete
- For non-deteriorated concrete and new concrete

For Deteriorated Concrete

- Clean and remove loose concrete from the surface with high pressure water jetting, 10,000 psi, or sandblasting.
- If reinforcing bars are exposed and corroded, chip out concrete to expose around the bars.
- Apply a migrating corrosion inhibitor on the surface.

- Rebuild the deteriorate surfaces:
  - Apply an underlayment with a fast-setting, high early strength, Portland-based resurfacing material to restore damaged concrete surfaces where required.
  - Underlayment should be trowelable or sprayable formulation for dimensional rebuilding.

- Apply an epoxy aggregate filled mortar intermediate coat (125 mils) by trowelling on the rebuilt surfaces.

- Provide final lining with spray apply sealer over aggregate filled epoxy base layer. Minimum thickness of lining should be two (2) coats of 30-mils each. The sealer provides the substrate for chemical and water resistance.

- Perform spark testing to check for voids or defects in coating. Repair defects.

Troweling underlayment to restore damaged concrete surfaces.

Underlayment with broom finish.

Underlayment with spray finish.

Spray apply final lining (sealer) on ceiling and walls.

Application of final lining (sealer coat) on ceiling.

For Non-Deteriorated Concrete and New Concrete

- Clean the concrete surface with with high pressure water jetting, 10000 psi, or sandblasting.
- Apply a migrating corrosion inhibitor on the surface.
- Trowel in an epoxy filler compound specifically designed to fill small voids, bugholes and irregularities in concrete surfaces to provide a smooth surface.

- Filler compound must be compatible with the protective lining.

- Provide final lining with spray apply sealer over aggregate filled epoxy base layer. Minimum thickness of lining should be two (2) coats of 30-mils each. The sealer provides the substrate for chemical and water resistance.

- Perform spark testing to check for voids or defects in coating. Repair defects.

Surface preparation by sandblasting and grinding.

Application of filler epoxy compound to fill small voids, bug holes and irregularities on beam.

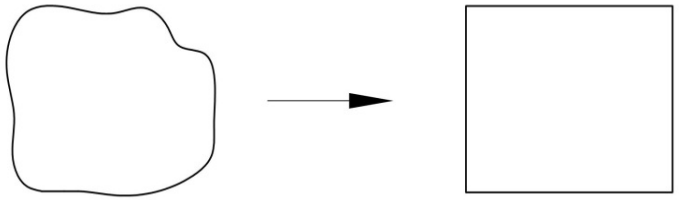
Application of filler epoxy compound to fill small voids, bug holes and irregularities on trough walls.

Hand rolling of final lining (sealer coat) on walls.

Partial coating of final lining (sealer coat).

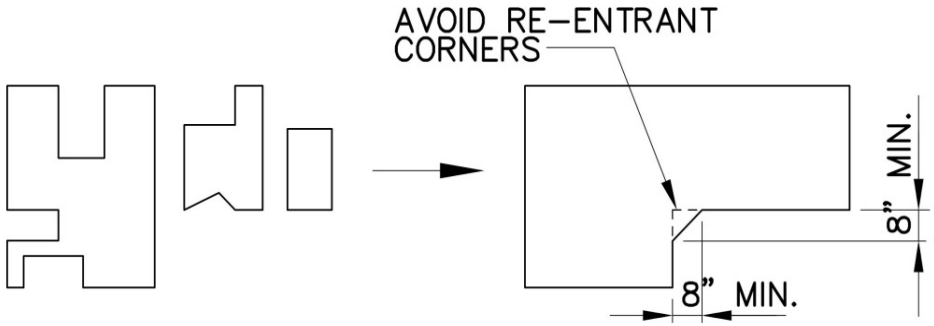
Pinholes in sealer coating.

Spark testing to detect defects and pinholes in sealer coating.



BOUNDARY OF LOOSE AND DELAMINATED CONCRETE

RECOMMENDED PATCH LAYOUT

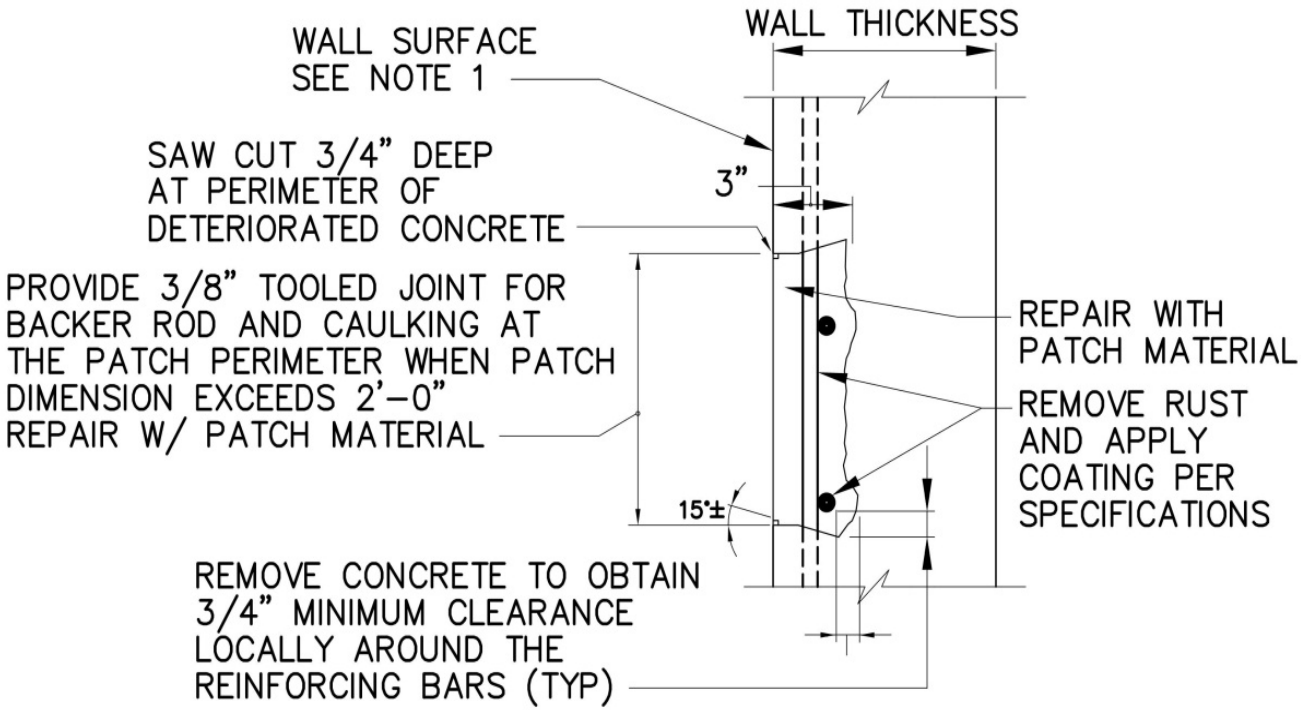


POSSIBLE PATCH LAYOUT

RECOMMENDED PATCH LAYOUT

NOTES:
1. PATCH LAYOUTS SHOULD BE MADE AS SIMPLE AS POSSIBLE.
2. AVOID IRREGULAR SHAPED PATCHES.
3. COMBINE ADJACENT SMALL PATCHES INTO SQUARED OFF LARGER SHAPES.
4. AVOID RE–ENTRANT CORNERS.

SURFACE REPAIR LAYOUTS

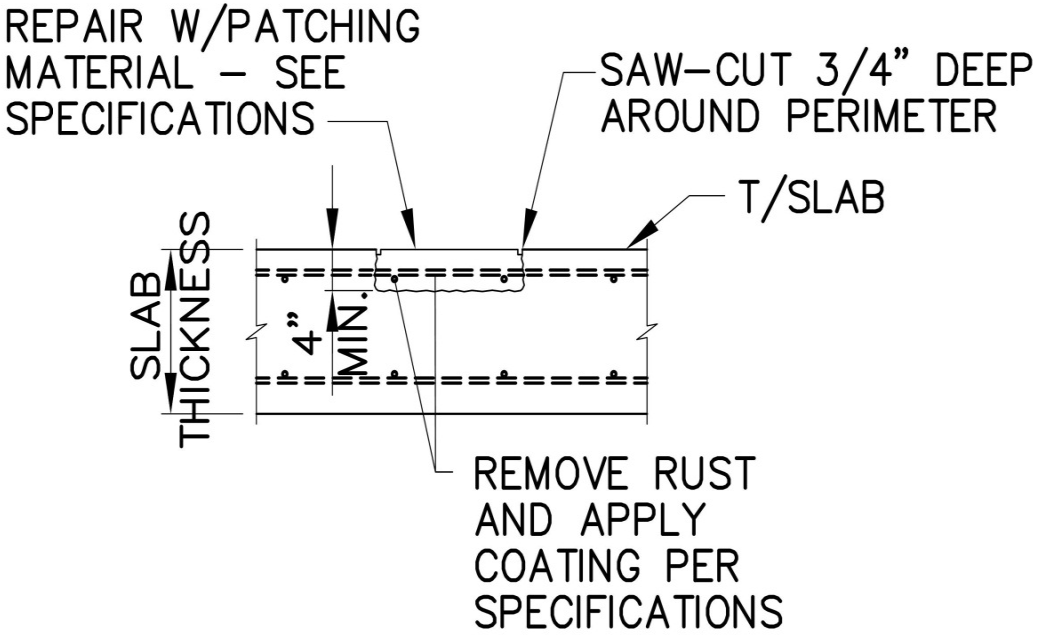


NOTES:

1. THIS DETAIL APPLIES TO SURFACES OF WALLS; INTERIOR OR EXTERIOR AND INSIDE SURFACES OF SUMP WALLS.
2. SEE SPECIFICATIONS FOR PROPER PATCHING MATERIAL.

DETAIL FOR REPAIR OF CONCRETE WALL

CONCRETE REPAIR TYPE-1



NOTES:
1. SAWCUT 3/4" DEEP THE REPAIR AREA.
2. DO NOT CUT ANY EXISTING REINFORCEMENT.
3. REMOVE ALL SOUND AND UNSOUND CONCRETE FROM THE AREA WITHIN SAW–CUT LINES. CLEAN THE AREA OF ALL DEBRIS AND DUST.
4. REPAIR THE CONCRETE, SEE SPECIFICATIONS.

DETAIL FOR REPAIRS TO TOP OF SLAB

CONCRETE REPAIR TYPE–2