Repair of Concrete Utility Poles With the Use of Migrating Corrosion Inhibitors

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CORTEC CORPORATION
Environmentally Safe VpCI®/MCI® Technologies

MCI®
MIGRATING CORROSION INHIBITORS
FROM GREY TO GREEN

Special Thanks

- Agenda
  - Project History & Recent Conditions
  - Problem & Challenges
  - Project execution
  - Corrosion Testing

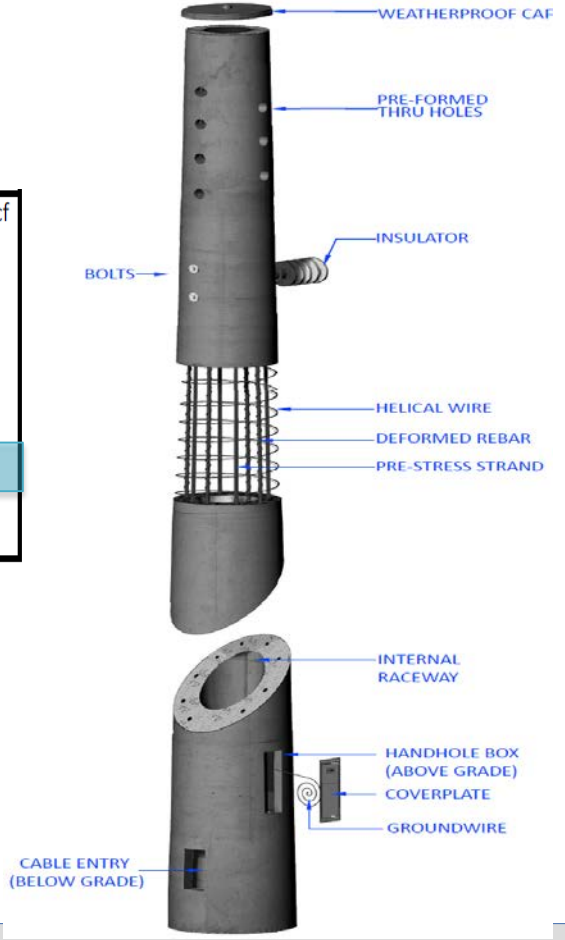
Concrete Lighting Poles

- Location: Windsor, ON, Canada
- Design Service Life = 75 years
- Age when inspected 19 years – 48 years
- Pre-tensioned poles
  - Steel rebar reinforcement
  - Helically Reinforced
  - Centrifugally spun cast
- Aggressive environment
  - Hot summers, freezing winters, deicing salts

Pole Diagram & Dimensions

Pole	Class	Length	Tip	Taper	Butt	Tip Thickness	Butt Thickness	Inside Taper	Surface Area, sf	Volume, cf
E250-BPR	B	25	4.75	0.18	9.25	1.875	2.5	0.205	45.8	5.9
E300-BPR	B	30	4.75	0.18	10.15	1.875	2.5	0.201	58.5	7.8
E350-DPR	D	35	7.75	0.18	14.05	2.25	3.25	0.209	99.9	18.4
E400-EPR	E	40	7.75	0.18	14.95	2.25	3.25	0.205	118.9	22.1
E450-FPR	F	45	7.75	0.18	15.85	2.25	3.25	0.202	139.0	26.1
E500-GPR	G	50	8.25	0.18	17.25	2.5	3.5	0.200	166.9	33.8
E550-GPR	G	55	8.25	0.18	18.15	2.5	3.5	0.198	190.1	38.9
E600-HPR	H	60	8.25	0.18	19.05	2.5	3.5	0.197	214.4	44.3
E650-HPR	H	65	8.25	0.18	19.95	2.5	3.5	0.195	239.9	50.0

Pole Catalogue Number	Nominal Pole Length (ft.)	Concrete Pole Class	Ultimate Moment At Grade (K - ft.)	Equiv. Wood Pole Class *1	Above Grade Pole Height (ft.)	Burial Depth *2	Pole Tip (in.)	Diameter Butt (in.)	Nominal Pole Weight (lbs.)
E - 550 - DPR - G	55' 0"	D	68.2	4	47' 6"	7' 6"	6.5"	16.4"	4455
E - 550 - EPR - G	55' 0"	E	86.4	3	47' 6"	7' 6"	6.5"	16.4"	4480
E - 550 - FPR - G	55' 0"	F	109.2	2	47' 6"	7' 6"	6.5"	16.4"	4900
E - 550 - GPR - H	55' 0"	G	136.5	1	47' 6"	7' 6"	8.25"	18.15"	5750
E - 550 - HPR - G	55' 0"	H	168.3	H1	47' 6"	7' 6"	8.25"	18.15"	5875



Recent Conditions

- Lots of cracking
- Visible signs of corrosion (spalling/ stains)
- Rusted exposed rebars and helical reinforcement
- Some poles have actually failed

Recent Conditions

Challenges

- Thin Structure (Shallow Cover)
- Hollow Core
- Helical Reinforcement
- Saw Cutting Prohibited
- Effective Corrosion Rate Testing

- Other Challenges:
  - Low $$$
  - Time window for these repairs (due to traffic control)
  - Previous patching work failed

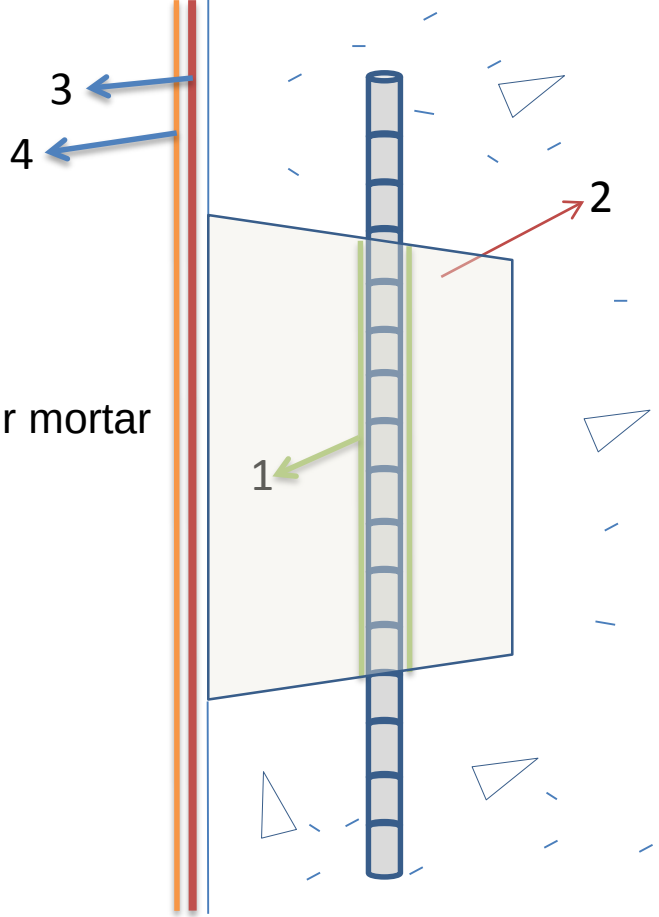
Objectives

- Extend service life expectancy of the poles within budget
- Apply corrosion inhibitors in the repairs
- Use quickly applied solutions (due to time restrain)
- Seal concrete surface with silanes
- Monitor corrosion rates over time

Repair Proposal

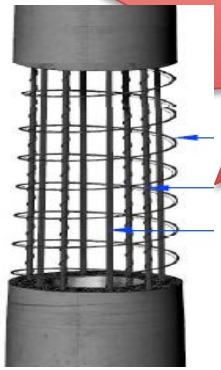
- Follow ICRI guidelines for patch repairs

1. Treat corroded rebars
2. Use migrating corrosion inhibitors within the repair mortar
3. Topically apply surface applied corrosion inhibitor
4. Apply silane sealer on the finished surface



Proposal Rejected!!

NO SAW CUTTING



NO CONCRETE CHIPPING BEHIND REBAR

Proposal Revised!

Revised Repair Proposal

- Only hammering or light jack hammering is to be used to chip damaged concrete
- The corrosion treatment of the rebar will not be extended to the back side of the rebars if that concrete is sound
- The contractor has proposed also to jacket the poles with HPFRC
  - Adds structural capacity and strengthening
  - Easier than patching as poles are loaded with conduits, signs and elec. boxes

Work Execution

- Concrete chipping

And more corrosion!

Work Execution

- Cleaning rebars

- Apply passivation grout with corrosion inhibitor

- Installing forms

- End product
  - Concrete was manually poured (mix design included FA, ACCI, Steel fibres)
  - Additional cover thickness




Next steps

- Apply surface applied corrosion inhibitor
- Apply silane sealer on the finished surface
- Corrosion monitoring

Corrosion Measurements

- Challenges
  - Poles are with round surfaces not flat
  - Rebar detection devices could not be used
  - Only vertical rebars corrosion was inspected
  - The helical reinforcement could interfere with the readings
  - Weather!

Corrosion Measurements

Connectionless Technique

Or

Galvanostatic Pulse Technique

Corrosion Measurements

- Strategy
  - Use connection-less technique
  - Guesstimate rebar spacing by creating imaginary grid
  - Measuring corrosion along vertical rebars only (not helical reinforcement)

Corrosion Measurements

- Strategy
  - Do simple sounding test to predict delamination
  - Measure corrosion rates and repeat measurements if R^2 is low

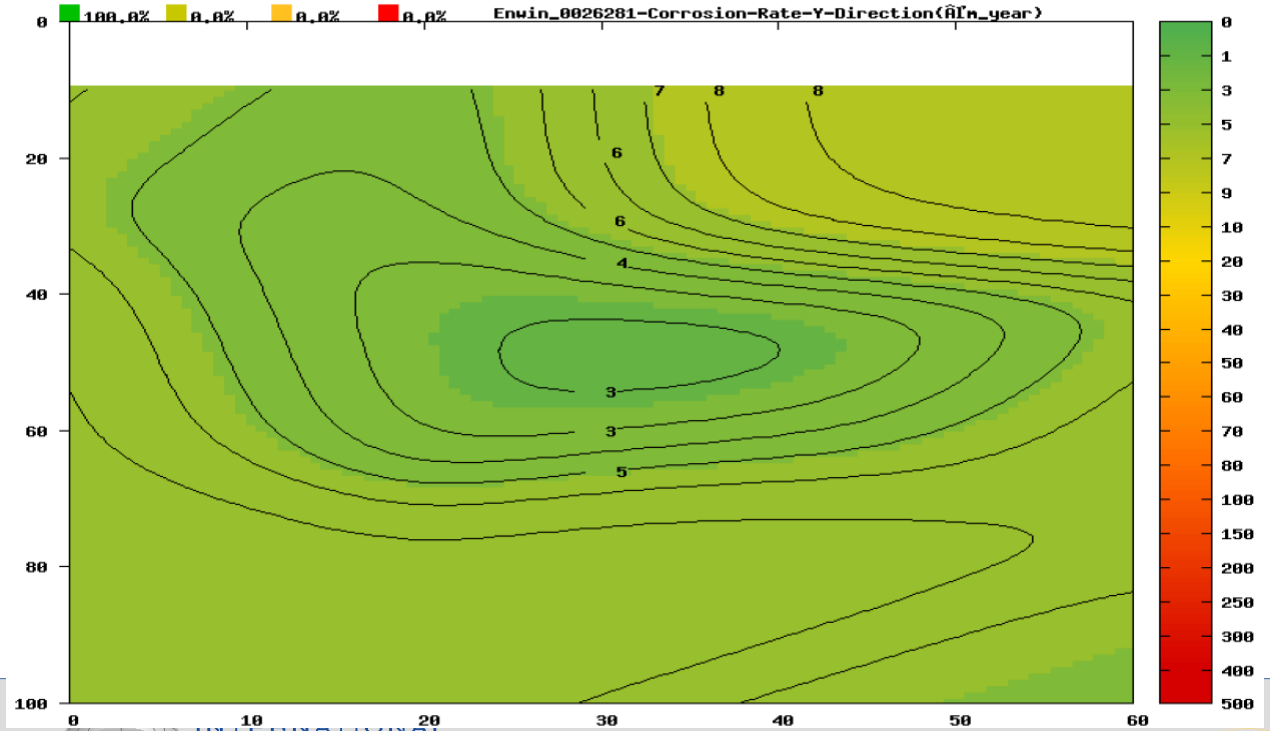
Corrosion Measurements

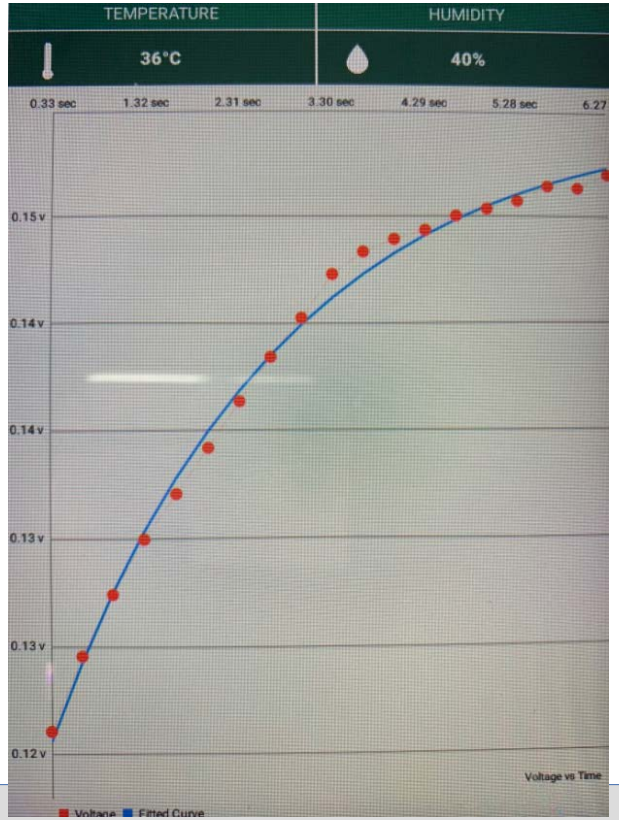
Results (Pole 1)

X	Y	Current Y	Rp(Y)	Corr Rate(Y)	Conc Res (Y)	Temp	Humidity	R^2 (Y)
60	100	1.68E-01	61678	4.9	363	42	31%	0.99
60	60	1.49E-01	48838	6.2	353	38	35%	0.98
50	18	1.35E-01	33728	8.9	252	37	36%	0.97
40	75	2.67E-01	45474	6.6	201	36	37%	1
40	50	1.49E-01	145674	2.1	401	36	40%	1
40	20	1.24E-01	36305	8.3	221	36	38%	0.99
20	20	2.18E-01	85292	3.5	276	36	41%	1
0	10	1.28E-01	52387	5.8	415	36	38%	0.95
0	50	1.18E-01	44917	6.7	548	36	39%	0.99
0	80	1.42E-01	46566	6.5	451	35	39%	0.98
Average			60086	5.95	348	37	37%	0.985

Results (Pole 1)

CORROSION RATE Y-DIRECTION CONTOUR MAP

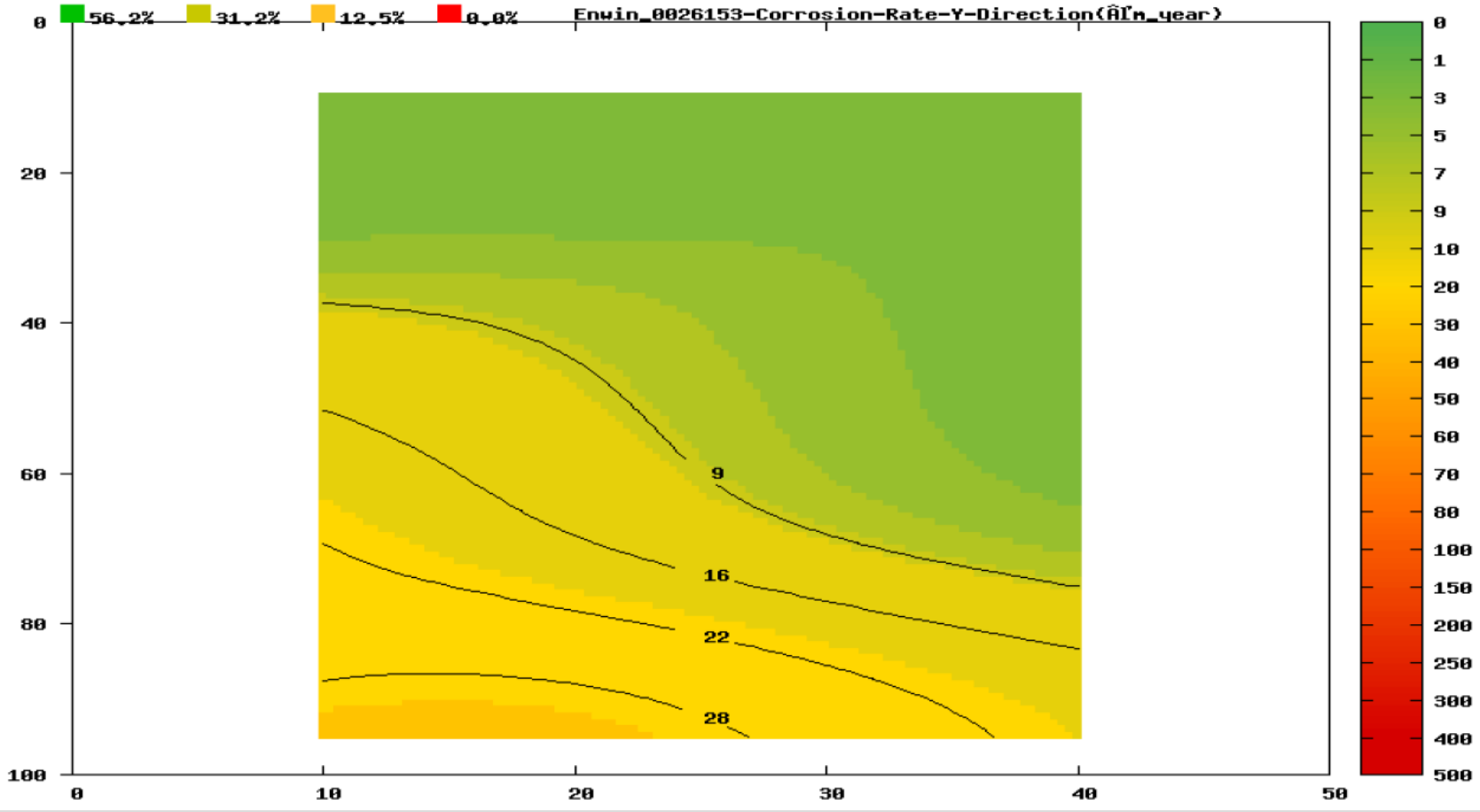




Results (Pole 2)

X	Y	Current Y	Rp(Y)	Corr Rate(Y)	Conc Res (Y)	Temp	Humidity	R^2 (Y)
10	90	4.76E-01	14734	20	182	22	85%	0.92
10	80	3.09E-01	15097	20	197	22	86%	0.96
10	60	3.42E-01	7480	40	116	22	85%	0.99
10	50	2.79E-01	30946	9.7	116	22	85%	1
10	20	1.75E-01	82871	3.6	477	22	86%	0.99
10	10	1.26E-01	77191	3.9	377	22	86%	0.99
20	50	1.15E-01	55809	5.4	819	22	87%	0.97
30	95	2.44E-01	29372	10	343	22	88%	1
20	95	3.25E-01	4667	65	168	22	89%	0.94
20	80	3.84E-01	10273	29	186	22	89%	0.97
20	60	1.82E-01	44620	6.8	737	22	88%	0.99
30	60	1.24E-01	91916	3.3	957	22	88%	0.99
30	90	3.53E-01	15142	20	168	22	88%	0.99
30	75	1.89E-01	73655	4.1	792	22	89%	0.99
40	50	1.83E-01	84805	3.6	492	22	88%	1
40	60	2.10E-01	86878	3.5	977	22	88%	0.98
Average			45341	15.5	444	22	87%	0.98

CORROSION RATE Y-DIRECTION CONTOUR MAP

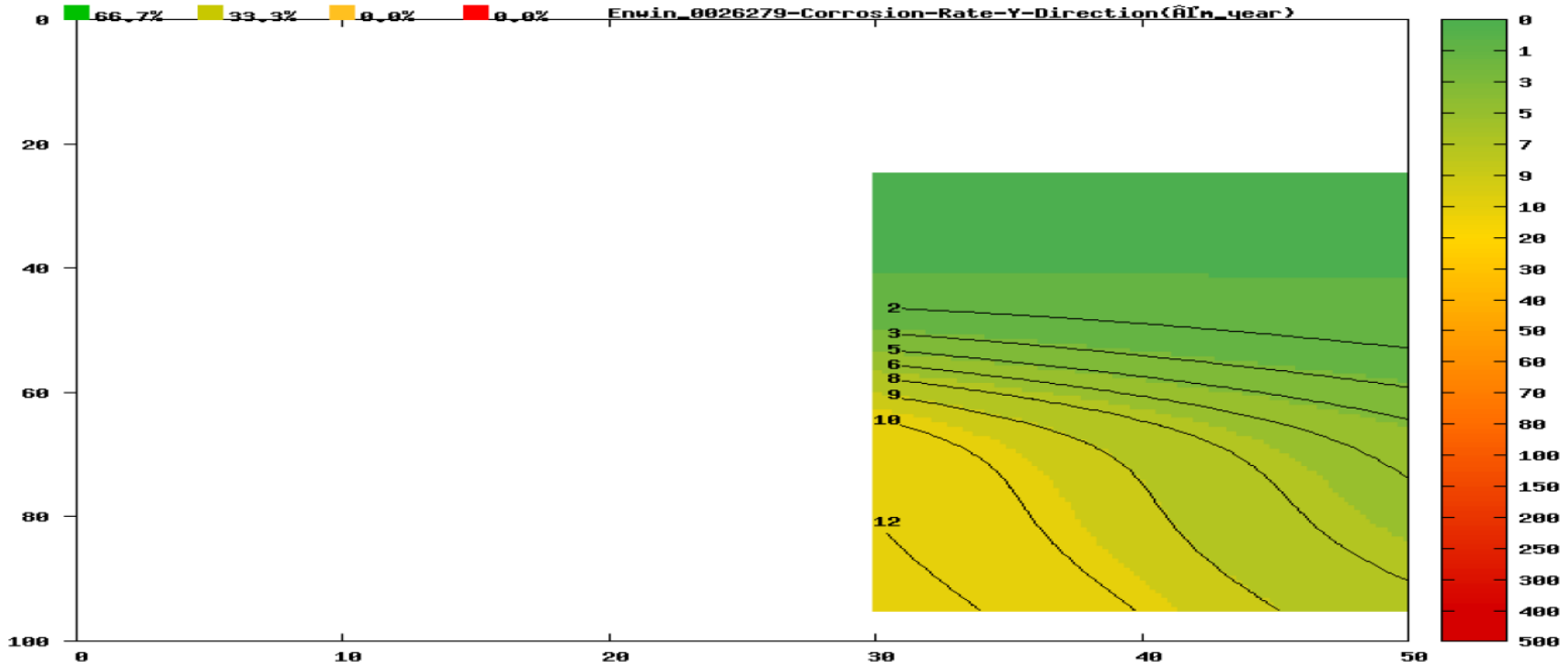


Results (Pole 3)

X	Y	Current Y	Rp(Y)	Corr Rate(Y)	Conc Res (Y)	Temp	Humidity	R^2 (Y)
50	90	3.63E-01	39644	7.6	1095	22	88%	0.95
50	75	1.64E-01	918348	0.33	1568	22	89%	0.9
50	50	1.40E-01	309868	0.97	1196	22	88%	1
30	95	3.93E-01	22377	13	271	22	89%	0.96
40	75	2.13E-01	20304	15	204	22	89%	0.81
40	25	1.05E-01	388795	0.78	6903	22	89%	0.87
Average			283223	6.3	1873	22	89%	0.915

Results (Pole 3)

CORROSION RATE Y-DIRECTION CONTOUR MAP



Pole 3 Pics

Corrosion Testing

- Low corrosion rates despite the visible corrosion damage
- Reasons??
- Geometry, weather influence on readings?

Work in Progress & Future work

- Decide on the best way to take corrosion readings
- Assessment program: annual inspection and corrosion rates monitoring
- Preventive maintenance program for non-corroding intact poles
- Modify concrete design mix for new poles to achieve the targeted SL

Main Findings

- Premature failure in concrete utility poles
- Hollow reinforced poles repairs are tricky!
- Concrete poles need effective maintenance program
- Migrating corrosion inhibitors are resilient and can be incorporated in different repair systems
- An effective way to measuring corrosion rates in concrete cylindrical poles is to be further explored

Thank You!!