

Project: Evaluating the Performance of Existing Reinforcement for Oklahoma Bridges

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Midwest Bridge Preservation Partnership

Outline

- Objectives
- Research
- Summary of results

Objectives

- Evaluate corrosion performance of epoxy-coated, galvanized, and ASTM A1035 (MMFX ChromX) reinforcement

Objectives (Continued)

- Evaluate of deck panels from I-35 bridge (epoxy-coated and conv)
- Visually evaluate performance of A1035 reinforcing steel with Ipanex admixture in I-35 bridge deck

Objectives (Continued)

- Perform 100-year life cycle cost analyses for reinforcement under study

Reinforcement

Conv

ECR

A1035

A767

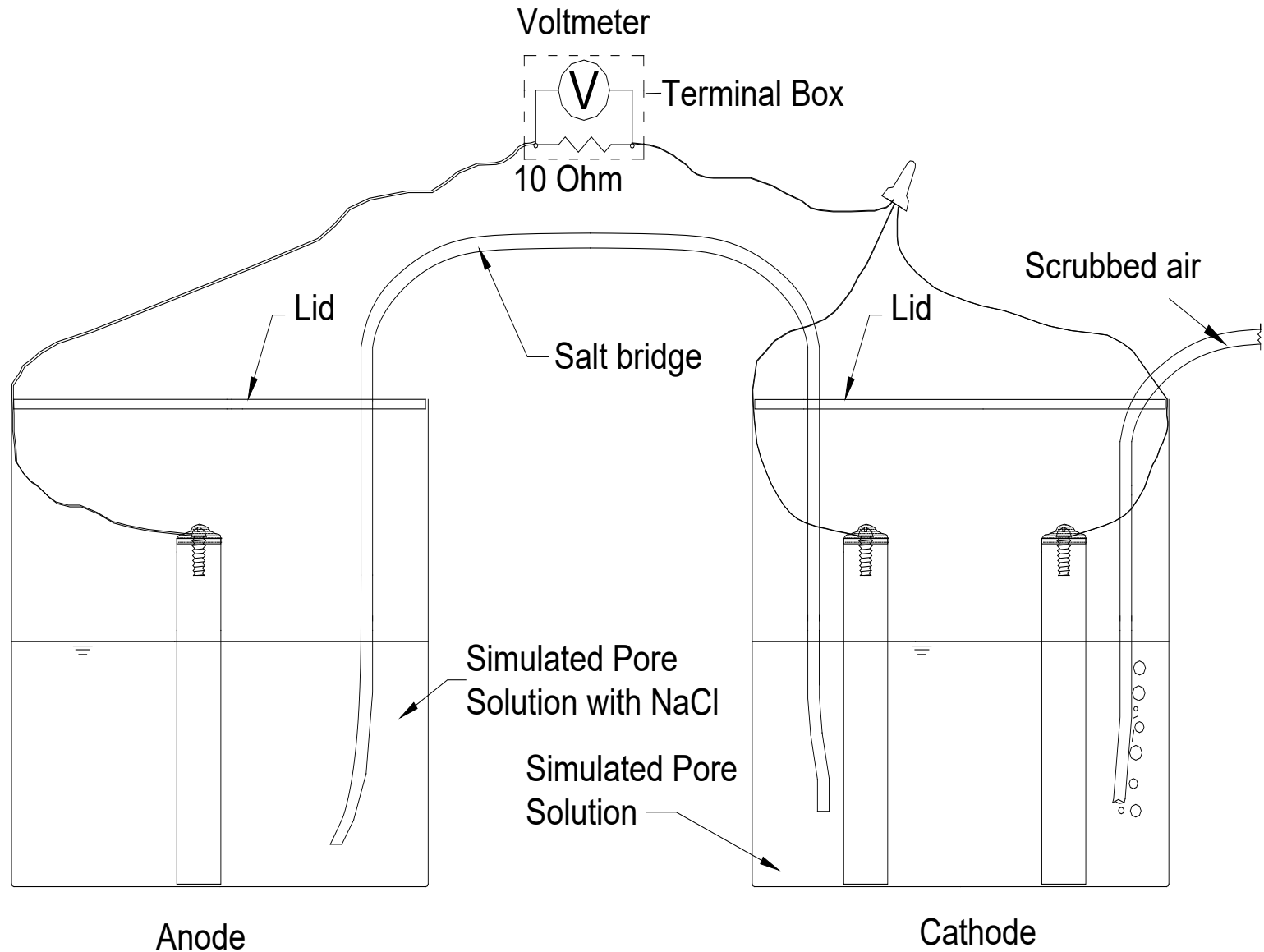
A1094



Corrosion Test Methods

- Rapid Macrocell test
- Southern Exposure test
- Cracked Beam test

Rapid Macrocell Test





Rapid Macrocell Test Program

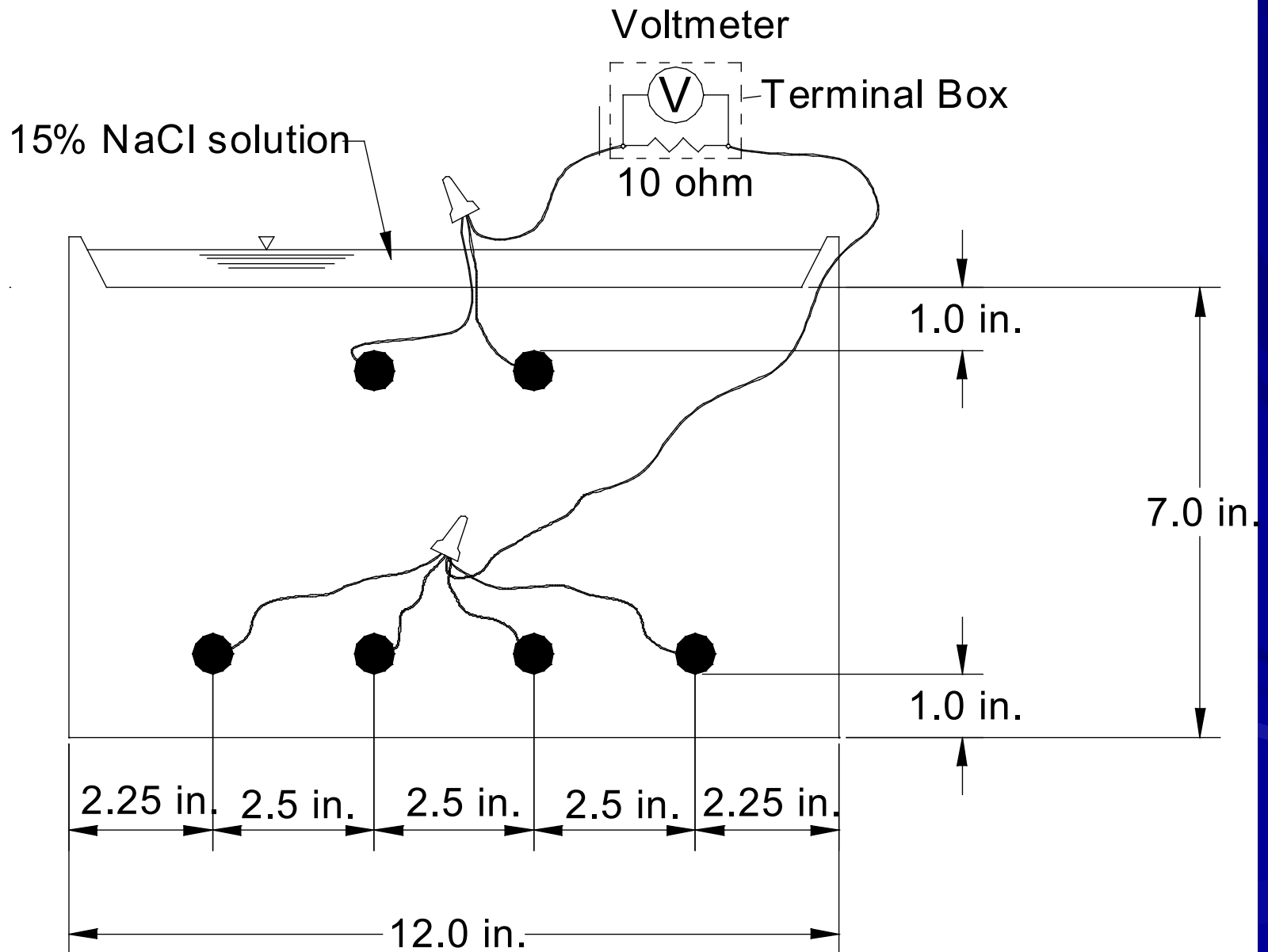
- Conventional Reinforcement
- Epoxy-Coated Reinforcement
 - 4 holes
 - Undamaged
 - UV Exposure
- A1035 Reinforcement
- A767 and A1094 Reinforcement
 - 4 holes
 - Undamaged
 - Bent

ECR UV Exposure

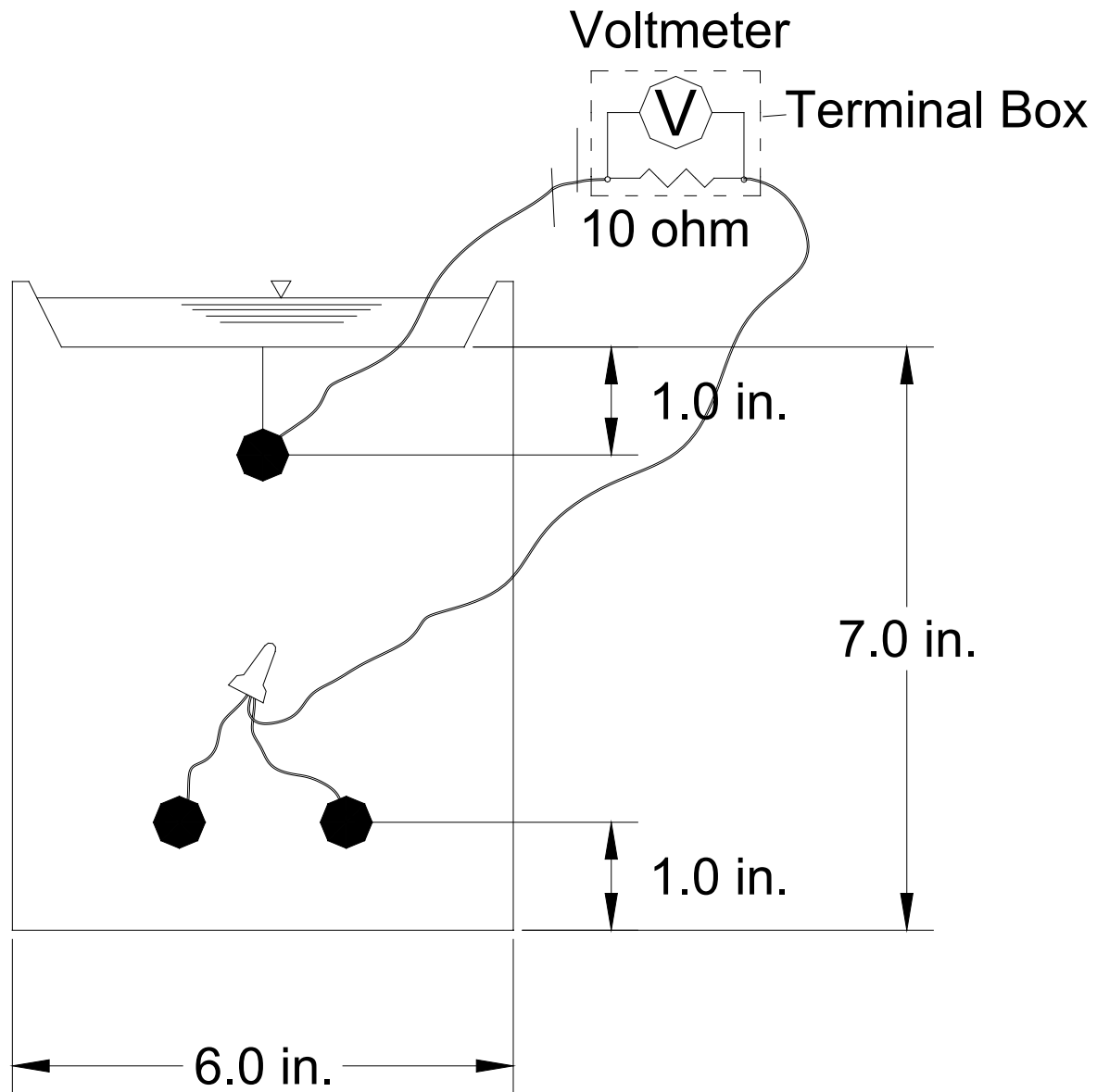


- 1000 hours of UV exposure
- Additional specimens 100, 200, 250, 500 hours of UV exposure

Southern Exposure Test



Cracked Beam Test



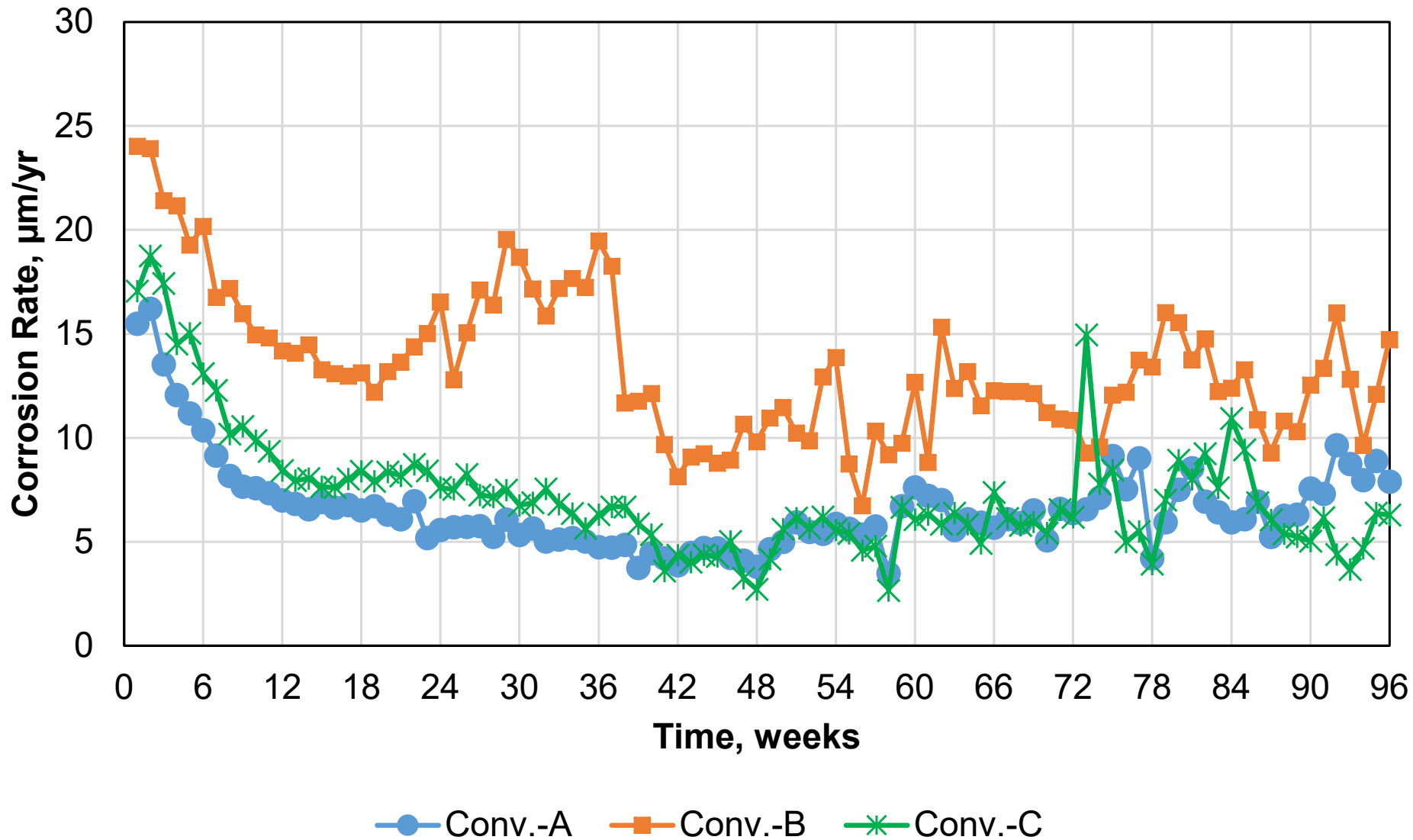


Southern Exposure/Cracked Beam Test Program

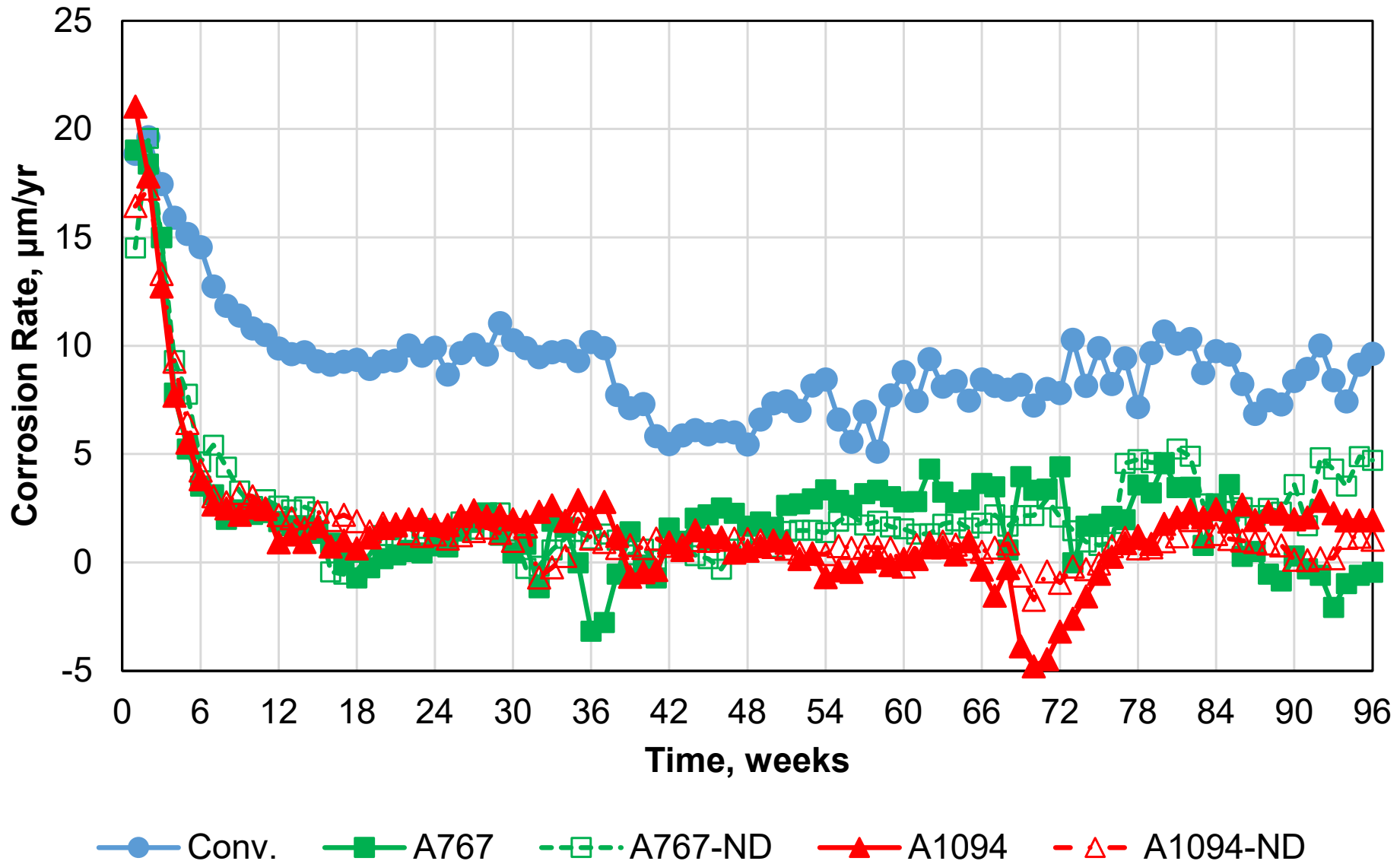
- Conventional Reinforcement
- Epoxy-Coated Reinforcement
 - 10 holes
 - Undamaged
 - UV Exposure
- A1035 Reinforcement
- A767 and A1094 Reinforcement
 - 10 holes
 - Undamaged
 - Bent
- Ipanex (Conv and A1035)
- Xypex (Conv and A1035)

Cracked Beam Tests

CB – Conv 3 heats



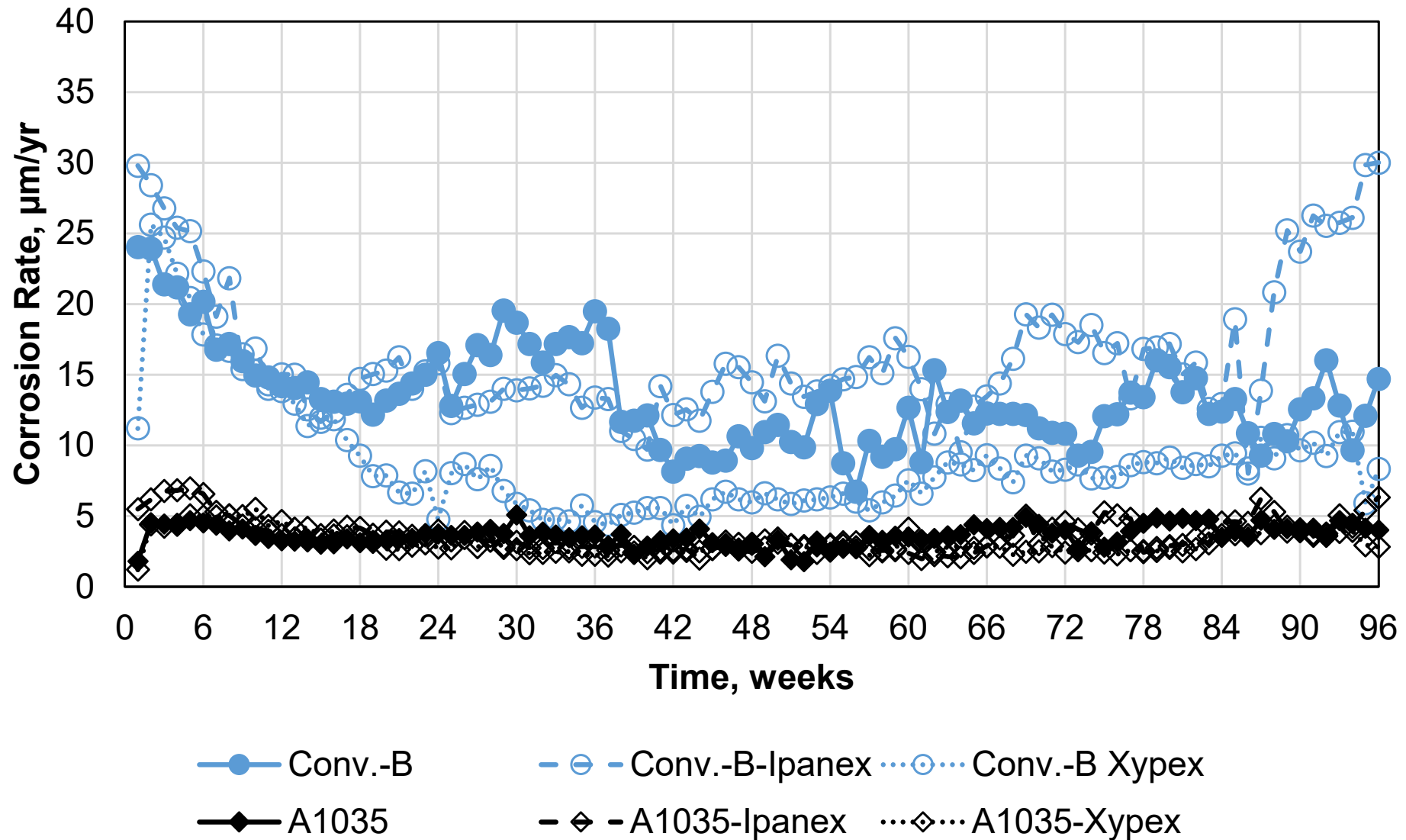
CB – Conv, A767, A1094



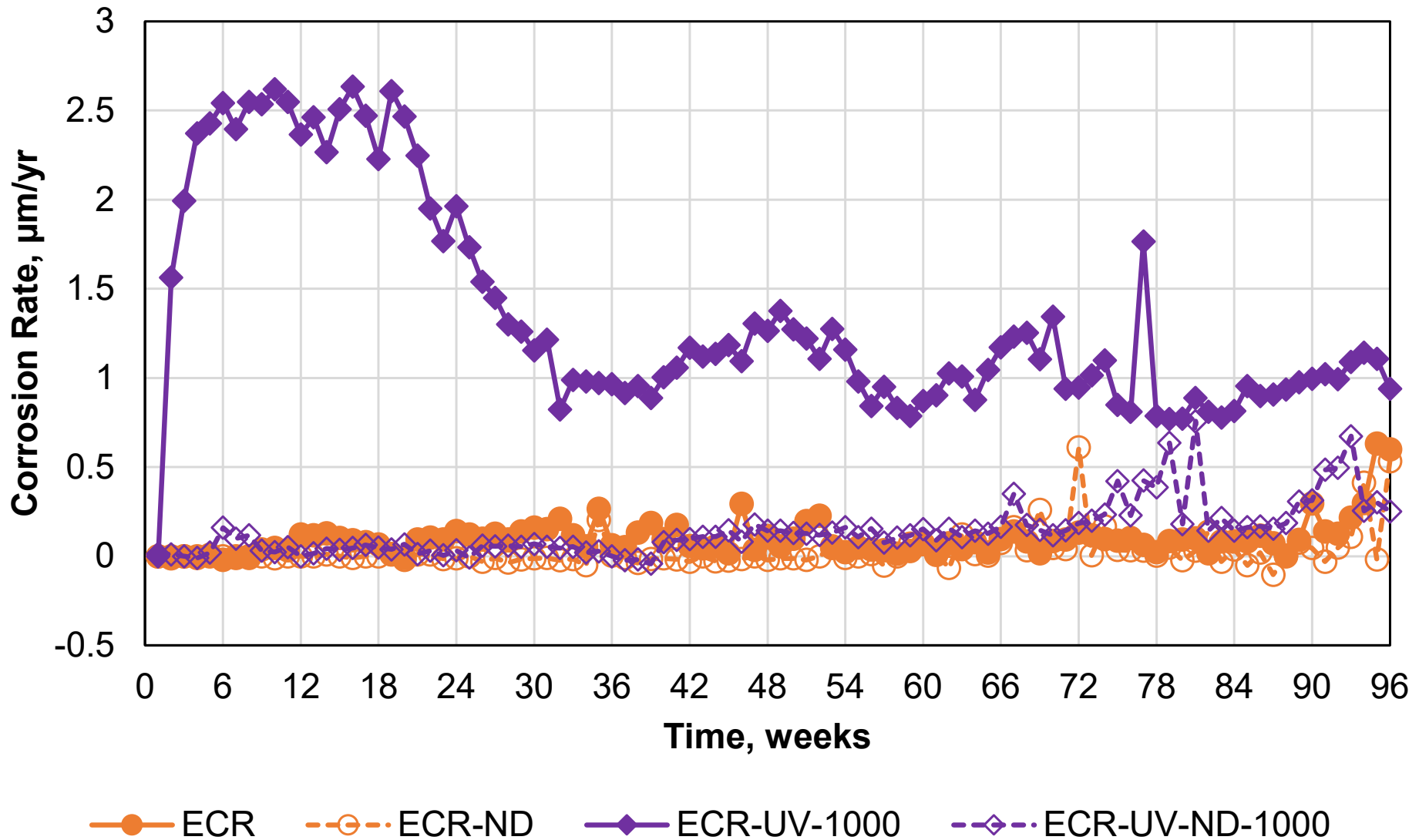
Bent A767 and A1094 bars

- exhibit about twice the corrosion losses of straight A767 and A1094 bars

CB – Conv & A1035 w/ Ipanex or Xypex

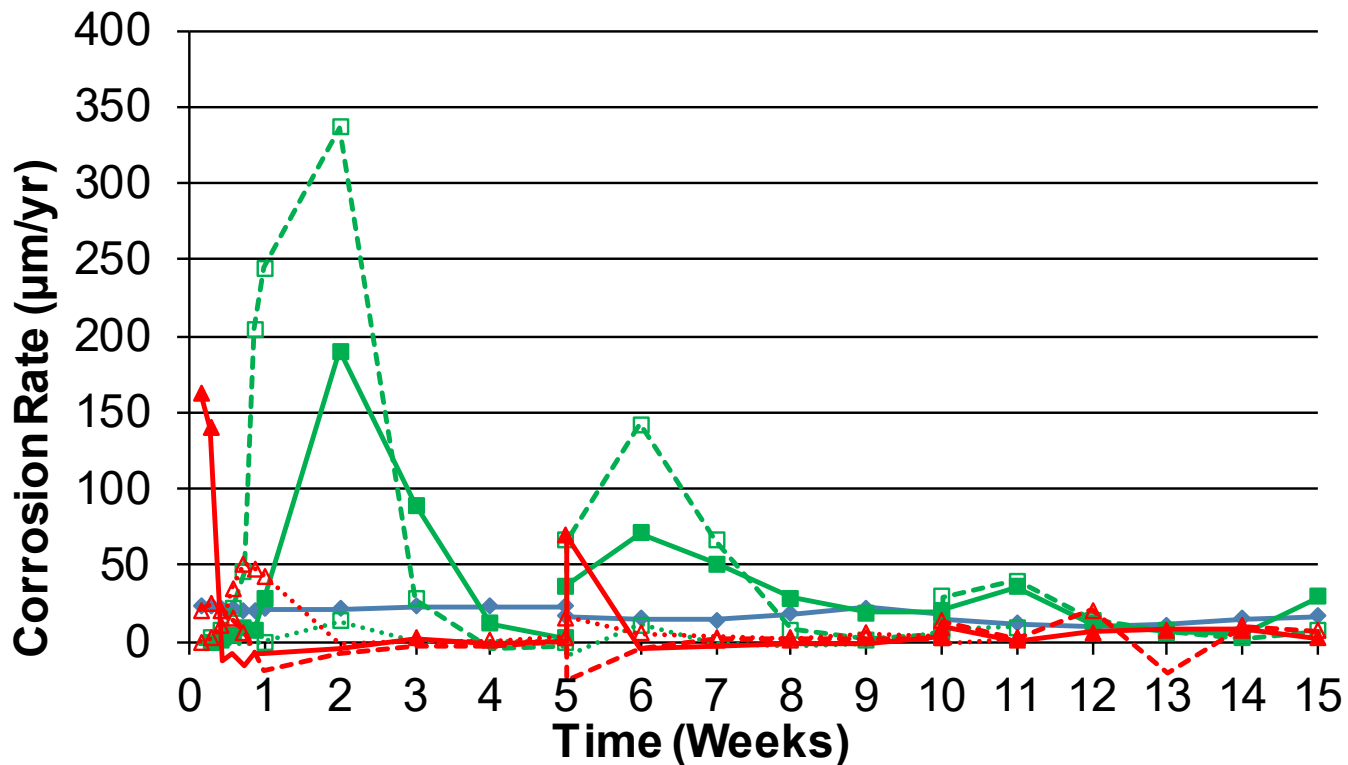


CB – ECR-UV



Rapid Macrocell Test

Conv, A767, A1094



—◆— Conv

—■— A767

---□--- A767-ND

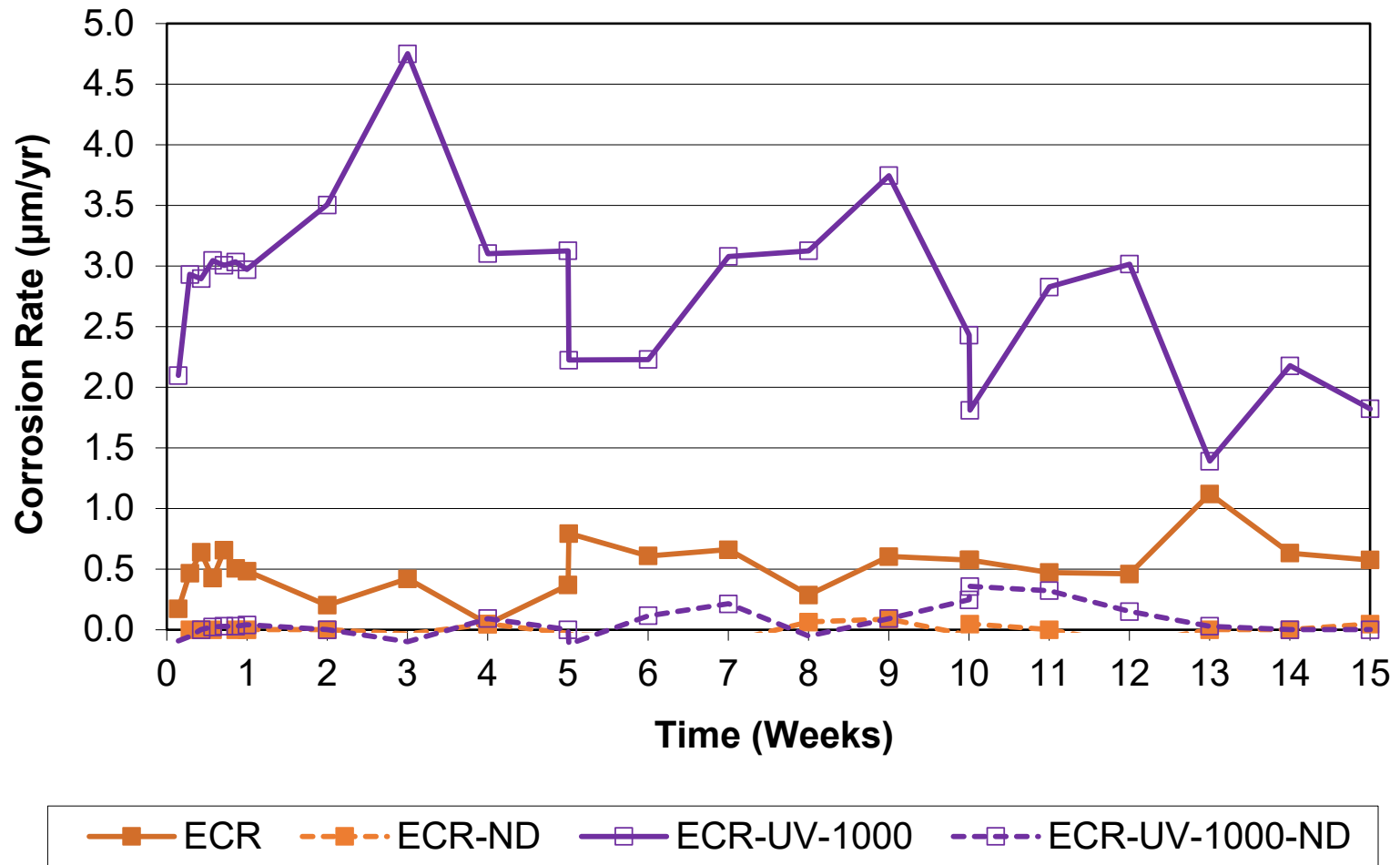
...□... A767-Bent

—▲— A1094

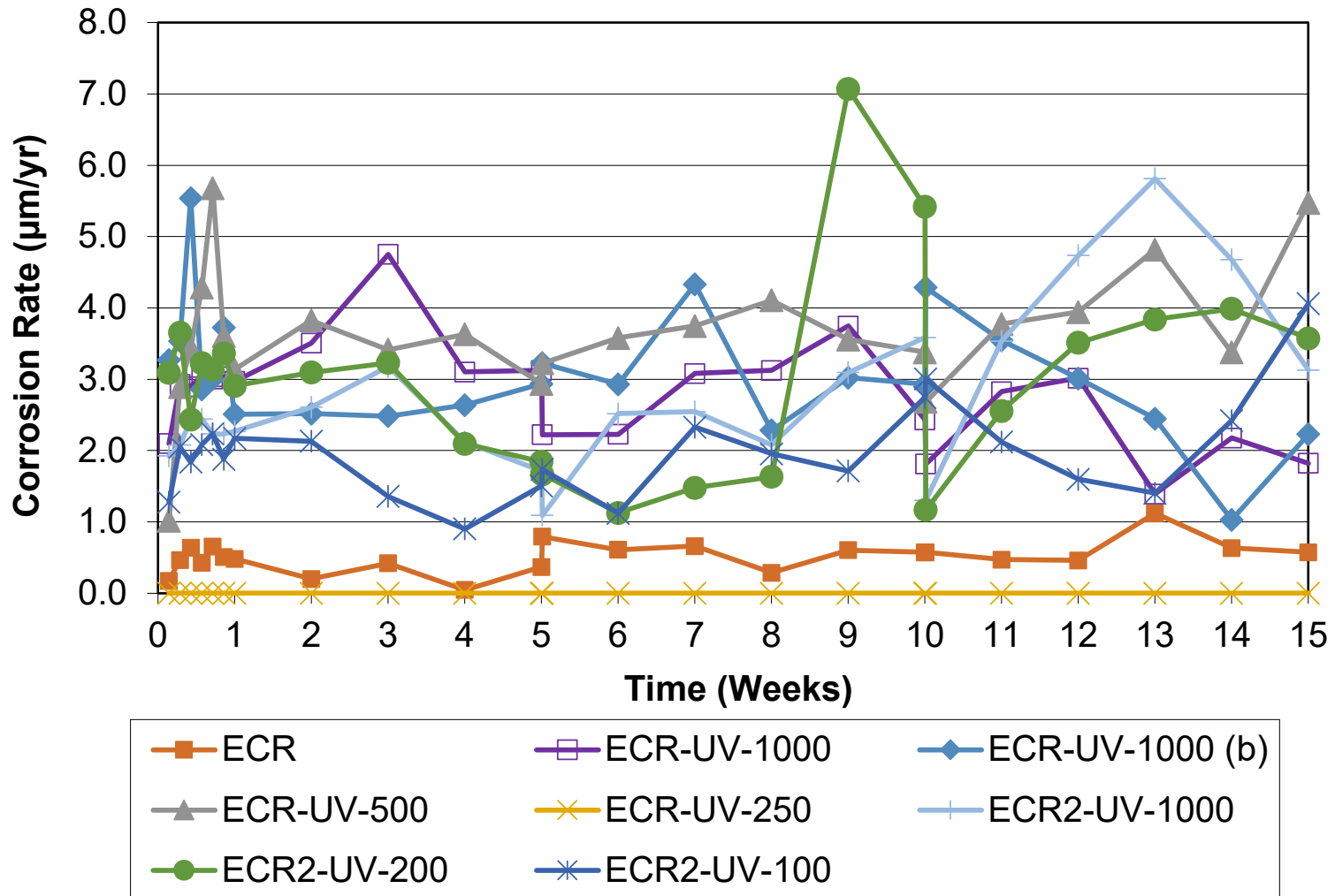
---△--- A1094-ND

...△... A1094-Bent

ECR-UV

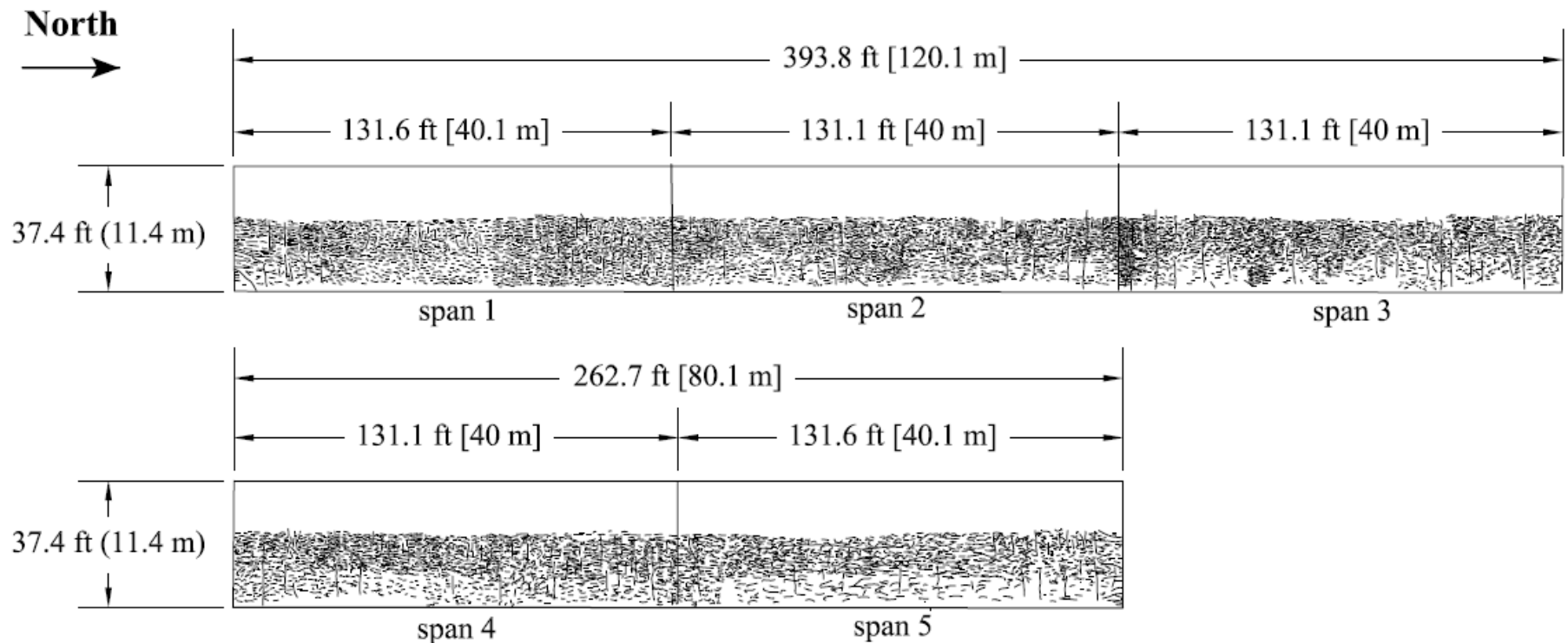


ECR-UV



I-35 bridge over the Chickaskia River – Constructed in 2003

■ A1035 (ChromX) bars and Ipanex admix

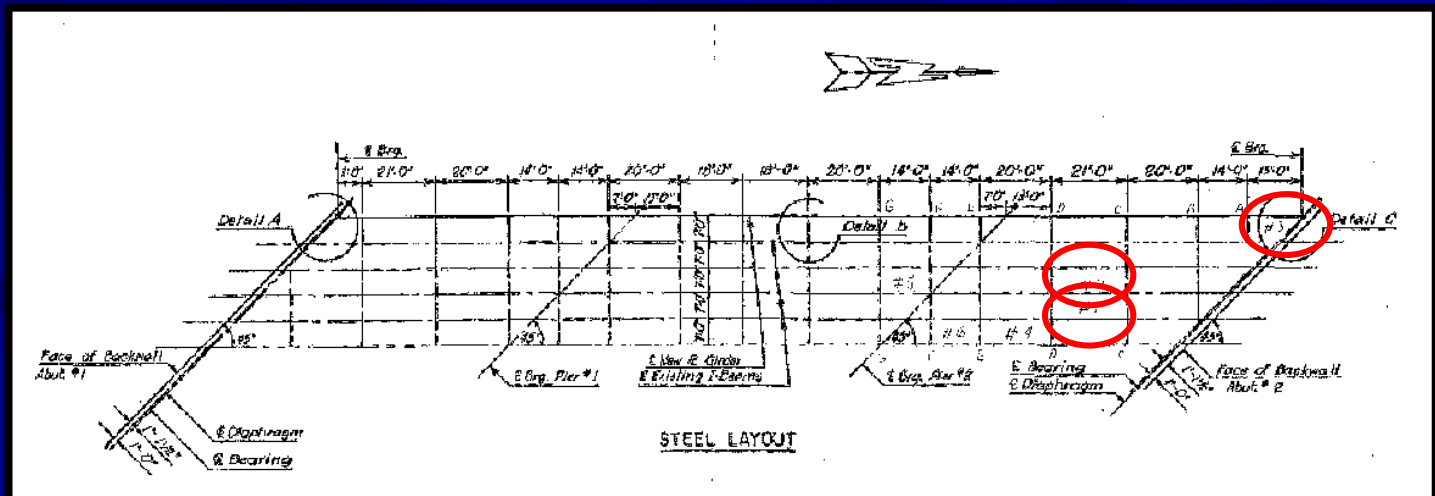


Bridge Number: 26415
Bridge Location: NB I-35 Over

Bridge Length: 656.8 ft (200.2 m)
Bridge Width: 37.4 ft (11.4 m)

Bridge Age: 180 Months
Crack Density: 2.715m/m²

ECR



Cow Creek Deck Panel Evaluation (OSU)

- More signs of corrosion at crack locations
- Greater penetration of Cl^- and carbonation at cracks

Cow Creek Deck Panel Evaluation

Conv

■ Uncracked



■ Crack



Cow Creek Deck Panel Evaluation ECR

■ Uncracked



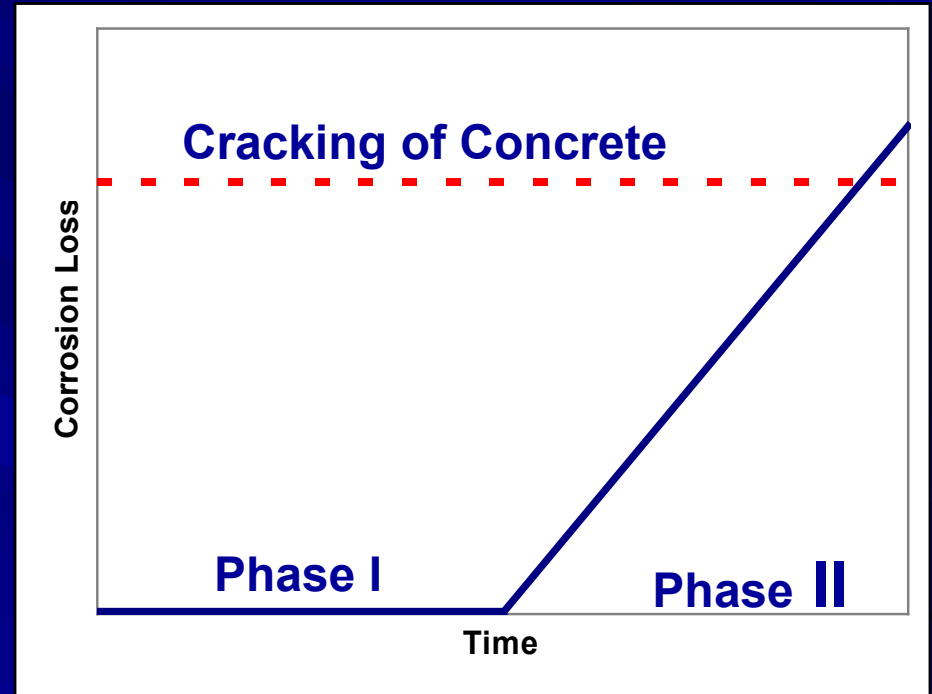
■ Crack



Design Life and Cost-Effectiveness

Chloride Induced Corrosion

- Two phase process:
- Phase I – initiation
 - Time to reach the critical chloride corrosion threshold
- Phase II – corrosion
 - Corrosion products build up around reinforcement



Field Tests



8-in. Deck, 2.5-in. Cover

	Time to Repair, Years					Total Present Cost, \$/yd ²
	1	2	3	4	5	
Conv-A	22	44	66	88		\$929
ECR	43	85				\$512
ECR-UV-1000	17	59				\$724
A767	50	100				\$473
A1094	50	100				\$461
A1035	45	89				\$544

8½-in. Deck, 3.0-in. Cover

	Time to Repair, Years					Total Present Cost, \$/yd²
	1	2	3	4	5	
Conv-A	26	52	77			\$779
ECR	56					\$373
ECR-UV-1000	19	75				\$679
A767	62					\$367
A1094	62					\$356
A1035	55					\$419

8-in. Deck, 2.5-in. Cover

	Time to Repair, Years					Total Present Cost, \$/yd ²
	1	2	3	4	5	
Conv-A	22	44	66	88		\$929
A1035	45	89				\$544
A1035-Ipanex	35	69				\$663
A1035-Xypex	45	90				\$546
Conv-B-Ipanex	19	38	58	77	96	\$1105
Conv-B-Xypex	27	55	83			\$739
Conv-A-Xypex	32	65	97			\$659

8½-in. Deck, 3.0-in. Cover

	Time to Repair, Years					Total Present Cost, \$/yd²
	1	2	3	4	5	
Conv-A	26	52	77			\$779
A1035	55					\$419
A1035-Ipanex	42	83				\$585
A1035-Xypex	55					\$421
Conv-B-Ipanex	22	44	66	88		\$964
Conv-B-Xypex	33	66	98			\$667
Conv-A-Xypex	40	79				\$531

Summary of findings

- ECR and ASTM A1035, A767, and A1094 bars provide greatly superior corrosion performance compared to Conv reinforcement
- Exposure of ECR to UV light for as little as the equivalent of 1.2 months greatly reduces corrosion performance

Summary of findings

- ASTM A767 and A1094 bars provide similar corrosion performance, but are hurt by bends
- Ipanex is not effective. Xypex improves corrosion performance of Conv but not A1035 bars

Summary of findings

- Cow Creek deck panels show that bars are substantially protected in uncracked concrete but perform poorly at cracks
- Cost analysis over 100-years shows that ECR, A1035, A767, and A1094 provide cost-effective corrosion protection systems – 3-in. cover is more cost-effective than 2½-in. cover

Recommendations

- Don't use Conv bars in bridge decks subjected to deicing salts
- Limit UV exposure of ECR to 1 month, down from 2 months in ASTM D3963
- ASTM A767 and A1094 bars can be used interchangeably
- More work needed on effects of bends when A767 and A1094 bars are used

Recommendations

- Use 3-in. cover in place of a 2½-in. cover when using ECR, A1035, A767, or A1094 bars

Questions?



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