GALVANIC LIQUID APPLIED COATING SYSTEM
For Protection of Embedded Steel Surfaces from Corrosion

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Authors
Joseph Curran
Jerome Curran

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Dynacs, Inc.
Chemical Instrumentation and Processing Lab
NASA, Kennedy Space Center
Kennedy Space Center, FL 32899

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Introduction

Corrosion of reinforcing steel in concrete is an insidious problem facing Kennedy Space Center (KSC), other Government Agencies, and the general public. These problems include KSC launch support structures, highway bridge infrastructure, and building structures such as condominium balconies. Due to these problems, the development of a Galvanic Liquid Applied Coating System would be a breakthrough technology having great commercial value for the following industries: Transportation, Infrastructure, Marine Infrastructure, Civil Engineering, and the Construction Industry.

This sacrificial coating system consists of a paint matrix that may include metallic components, conducting agents, and moisture attractors. Similar systems have been used in the past with varying degrees of success. These systems have no proven history of effectiveness over the long term. In addition, these types of systems have had limited success overcoming the initial resistance between the concrete/ coating interface. The coating developed at KSC incorporates methods proven to overcome the barriers that previous systems could not achieve.

Successful development and continued optimization of this breakthrough system would produce great interest in NASA/KSC for corrosion engineering technology and problem solutions. Commercial patents on this technology would enhance KSC's ability to attract industry partners for similar corrosion control applications.

Goals/ Phases

The present effort is directed at several goals:

- Phase I concentrated on formulation of coatings with easy application characteristics, predictable galvanic activity, long-term protection, and minimum environmental impact. These new coating traits, along with the electrical connection system will successfully protect the embedded reinforcing steel through the sacrificial cathodic protection action of the coating.
- Phase II will improve on the coating formulations and include optimizing metallic loading as well as incorporating a moisture attractor (humectant) into the coating for continuous activation. In addition, development of optimum electrical connections will continue.
- Phase III will incorporate improvements from the previous phases to the test blocks.
- Phase IV will incorporate the final upgrades onto large reinforced concrete structures that are heavily instrumented. The phase IV goal is to move the testing from small blocks (11"x 6" x 4.5") to seven larger slabs, six- 4'x 4' x 7" and one- 4'x8'x7". The new concrete design mix will include chlorides, at 15 lbs/ yd^3, to simulate a contaminated reinforced concrete structures.

Phase I Summary

The test results of Phase One are shown in Table 1. These data were measured Jan. 10-16, 2000, at the Beach Corrosion Facility. The blocks were exposed to the outdoor environment for approximately six days, during which there were two rain events, one minor and one major. The data for the major event are shown in Table 1, both before and after the rain. When the current and potential data are graphed and correlated with weather data, it can be seen that coatings with magnesium included have a longer protection period. This protection period starts sooner and ends later than the coatings without magnesium added.

Table 1. Results Summary of Phase One Measured in Concrete Test Blocks

TEST PARAMETERS Phase I Designations				**BEFORE RAIN**		**AFTER RAIN**		**CHANGES**[1]		**PROTECTION SUMMARY**[2]	
Block #	**Mg %**	**Zn %**	**Active**[3]	**I (uA)**	**V (mV)**[4] **Ag/AgCl**	**I (uA)**	**V (mV)**[4] **Ag/AgCl**	**ΔuA**	**ΔmV**	**Corrosion**	**Protection**
1	25	75	No	0	-30	270	-260	270[5]	-230[5]	?	Good
3	0	100	Yes	na	-300	na	-330	na	-30[5]	Yes	na
4	0	100	Yes	400	-300	700	-350	300	-50[5]	?	Good
5	100	0	Yes	[6]	[6]	[6]	[6]	[6]	[6]	[6]	[6]
6	100	0	No	0	-30	5	-40	5	-10	No	Fair
7	0	100	No	0	-50	5	-130	5	-80[5]	?	Fair
8	50	50	No	5	-60	20	-100	15	-40[5]	No	Fair
9	50	50	Yes	0	-170	350	-350	350[5]	-180[5]	No	Good
10	25	75	Yes	[6]	[6]	[6]	[6]	[6]	[6]	[6]	[6]

[1] Change in current and voltage occurs from time rain starts to about 0.7 days later.

[2] *Protection* denotes a subjective evaluation of the current and voltage at the rebar, whether there is sufficient negative voltage and sufficient current to prevent rebar corrosion. The NACE standard, RP0169-96, was used as a guideline for determining protection (with a sacrificial coating in place) potential of the rebar.

[3] *Active* denotes salt-ponded to induce corrosion.

[4] Referenced to an Ag/AgCl half cell (manufactured by Broadley James) at 199 mV vs. standard hydrogen electrode (SHE).

[5] Sharp peak occurred after each rain.

[6] Bad electrical connection caused invalid data.

The final selection of 25 % Mg and 75 % Zn was made on the basis of the depolarization method (instant-off). The results of these measurements, made in the field on Jan. 21, 2000, are shown in Table 2. A graph of the depolarization test is shown in Fig. 1. The best performer was considered to be the largest positive change in the rebar potential after disconnection.

Table 2. Results Summary of Phase One Depolarization Test Conducted at the KSC Beach Corrosion Test Site (Procedure reference: NACE RP0290-90).

Mg/Zn	Active	Block #	Depolarization, mV[1]
25/75	NO	1	156
0/100	YES	4	78
100/0	YES	5	Bad Connection
100/0	NO	6	35
0/100	NO	7	47
50/50	YES	9	28
25/75	YES	10	145
50/50	NO	8	Not measured

[1] Referenced to an Ag/AgCl half cell at 199 mV vs. standard hydrogen (SHE) (manufactured by Broadley James).

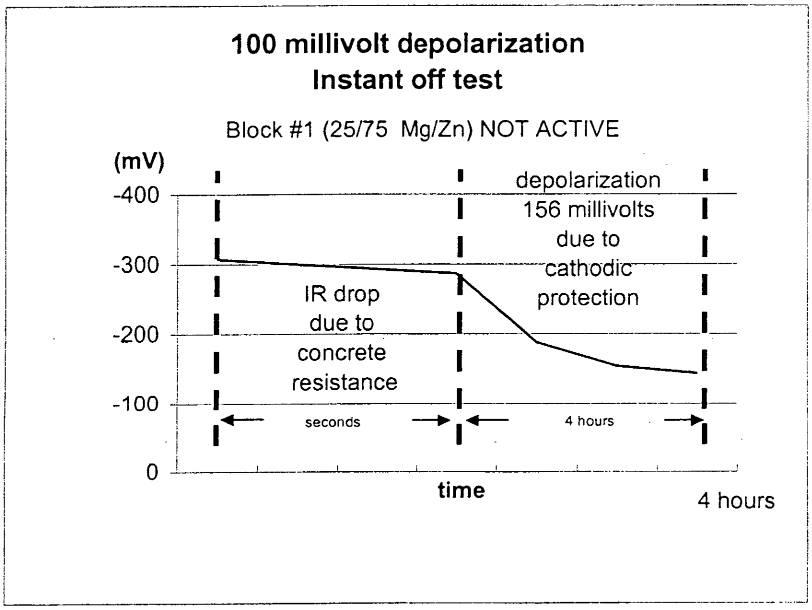

Figure 1. Results of Phase One Depolarization Test

Phase II Tasks:

- **A.** Identify moisture-attracting agents for incorporation into the liquid applied coating formulation.
- **B.** Redesign coating formulation
- **C.** Coat test blocks with new formulation.
- **D.** Monitor new coating formulation for effectiveness.
- **E.** Design test slabs to evaluate new coating formulation.
- **F.** Fabricate test slabs

Phase II Summary

Task A. Identify moisture-attracting agents for incorporation into the liquid applied coating formulation: Table 3 shows the seven humectants selected for incorporation in the coating.

Table 3. Humectants chosen for Phase Two evaluation

Our Abbreviation	Name	Humectant Type
CaS	Calcium sulfate	Inorganic salt, hygroscopic
LiN	Lithium nitrate	Inorganic salt, strongly hygroscopic
CuSPH	Copper sulfate pentahydrate	Inorganic salt, already fully hydrated
SG	Silica gel, grade 62, 60-200 mesh, 150 Angstroms	Silica alumina solid powder, inorganic drying agent
PSS	Polystyrene sulfonic acid	Poly(styrene sulfonic acid-co-maleic acid) sodium salt, 1 to 1 styrene/ MAH mole (Aldrich), polymer drying agent
TEG	Tri-ethylene glycol	Organic liquid, hygroscopic
CuS	Copper sulfate	Inorganic salt, unhydrated
NoPB	No paint, blank	Control 1
NoHC	Coated, no humectant	Control 2

Lithium nitrate was one of the humectants in the published study (B. S. Covino, et al., *Materials Performance*, Dec., pp 28-32, 1999). Upon mixing the lithium nitrate in the coating containing zinc and magnesium, the mixture got warm and appeared grainy. Thus, the mixture with lithium nitrate was brushed on the test block instead of sprayed. We also tried lithium bromide, but it reacted with and solidified the mixture, becoming hot and eventually flaming slightly after a few hours in the mixing beaker. PSS and TEG were listed as desiccants in 1997 ASHRAE Fundamentals Handbook, section 21.3.

Task B. Redesign coating formulation: The same basic formula for coating ingredients in Phase One was re-used in Phase Two, but the humectant was added to the coating matrix. From Phase One, the chosen metal combination was "75 % zinc and 25 % magnesium" (see table 4). In actuality, this was a volume designation. The *volume of metal* was the criterion to hold roughly constant in the coating formula; the base volume was 151 mL of Zn (441 g of Zn powder), enough to ensure that the coating will be electrically conductive. The original table of metal ingredients is shown below. These amounts were put into 150 g of coating vehicle. The coatings were sprayed onto the test blocks, one coating on each block and studied in Phase One. In Phase Two, the total amount of coating vehicle in a batch was reduced to 100 g, and the other ingredients were proportionately reduced (see table 5).

Table 4. Phase One metal designations and actual weights used in coating formulations with 150 g of commercial coating vehicle.

PHASE ONE DESIGNATION,	MAGNESIUM,		ZINC,		THINNER,
% volume of total metal volume	g	mL	g	mL	mL
Mg100 %	102	210	0	0	15
Mg75 % Zn25%	76	156	110	38	12
Mg50 % Zn50 %	50	103	220	75	10
Mg25 % Zn75 %	25	51	331	113	7
Zn100 %	0	0	441	151	5

Table 5. Phase Two coating matrix ingredients.

PHASE TWO INGREDIENT	WEIGHT, g	VOLUME, ML
Commercial Coating Vehicle	100	112
Mg	17	35
Zn	167	57
Thinner	18 **	18
Humectant	45	55
TOTAL	347	190

**Approximate amount; added to enhance flow

Task C. Coat test blocks with new formulation: Table 6 shows the concrete block test matrix with humectants and the polarization values. Block ID numbers 19 and 2 were controls, number 19 with no coating or humectant, and number 2 with coating but no humectant. Characterization of open circuit potential (OCP) is done by placing the given block in a 3-liter pool of 3.5 % sodium chloride in DI water. An EG&G Princeton Applied Research Potentiostat/Galvanostat model 273A was connected between the counter electrode and the rebar, and a 10 mV amplitude wave was swept from 100 kilo-Hertz to 100 micro-Hertz over a 20-hour period. From these measurements, the software calculated *Rp*, the rebar-to-concrete interfacial resistance, *C*, the concrete capacitance, and *Rs*, the concrete resistance.

Table 6. Open Circuit Potential, mV vs. Calomel Electrode

ID #	Anode Dis-connected	Anode Connected	Delta	DATE 1st OCP	CHEMICAL	STATUS 09/06/2000
14	-528	-716	-188	07/14/2000	CaS	Coated
15	-385	-496	-181	07/14/2000	LiN	Coated
16	-516	-568	-52	07/14/2000	CuSPH	Coated
17	-539	-649	-110	07/14/2000	SG	Coated
18	-308	-493	-185	07/14/2000	PSS	Coated
24	-509	-661	-152	07/31/2000	TEG	Coated
20	-383	-510	-127	07/14/2000	CuS	Coated
19	-392	-436	-44	07/14/2000	NoPB	Uncoated
2	-355	-817	-462	08/02/2000	NoHC	Coated/No Hume.

Task D. Monitor new coating formulation for effectiveness: The blocks were connected to the remote data acquisition system at the Beach Lab, and the blocks were exposed to the outdoor environment for a few weeks until a lightning strike. No data is available at that time. The blocks were re-characterized in the NASA MSL Lab and re-placed on the racks at the BCTF and connected to the RDAS in the Beach Site Lab (see figure 2). Potential, current, and weather data generated is being recorded and accessed remotely. The results continue to be positive, showing the coating system to be functioning properly.

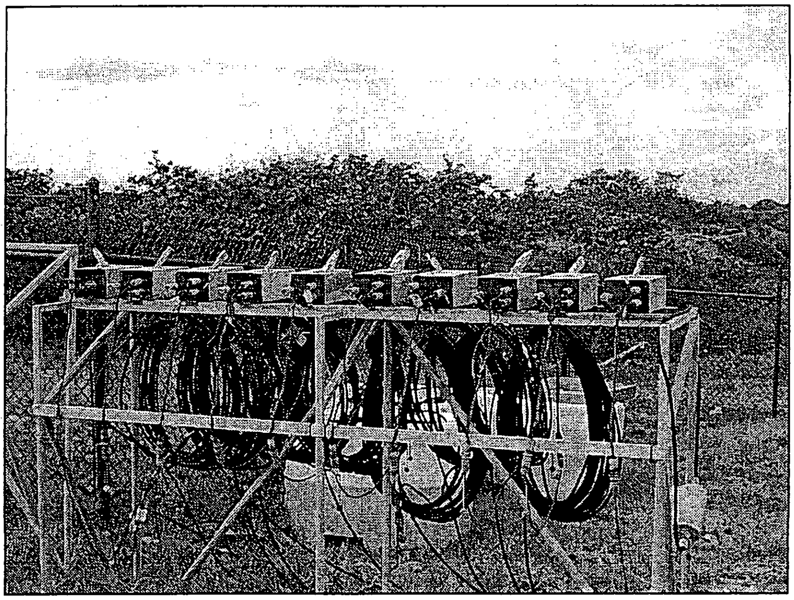

Figure 2. Test Blocks

Task E. Design test slabs to evaluate new coating formulation: Test slabs simulating balconies have been designed. Each slab contains two #5 mats of reinforcing steel, two to four embedded reference half-cell electrodes and a current density probe. Five slabs were designed with 2” cover and the remaining two with 3” cover as shown in the typical design drawing (see figure 3).

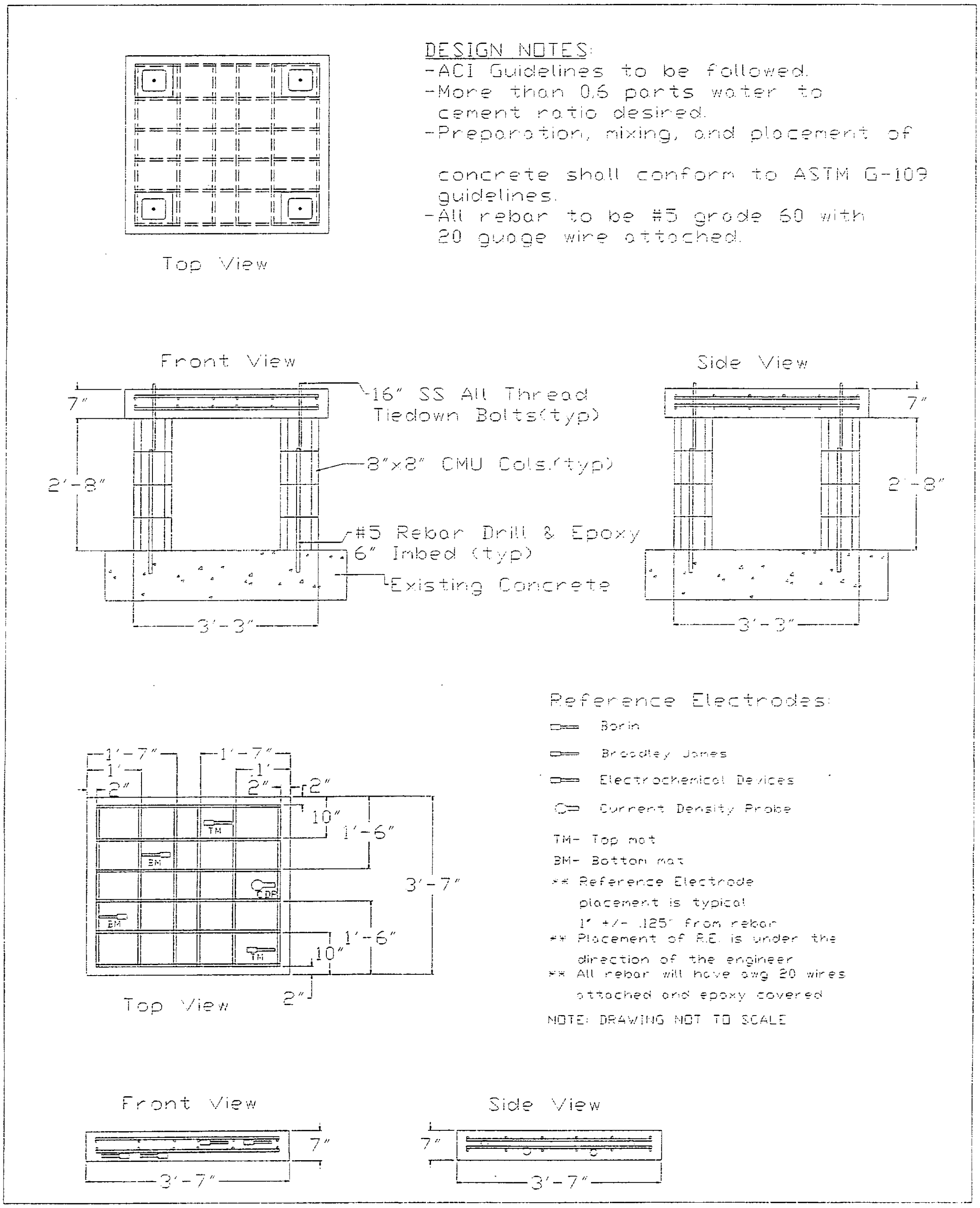

Figure 3. Typical Simulated Reinforced Concrete Structure Design.

Task F. Fabricate test slabs: A contractor was selected to construct the slabs off site. The test slabs were fabricated according to specifications, delivered, and installed at the NASA Beach Corrosion Test Facility (BCTF) in December 2000. Two additional slabs were ordered and were built onsite in March, 2001. The blocks are numbered one thru five and the additional slabs lettered "A" and "B"(see figure 4). The were protected from the weather using tarps and will remain covered until the application of the coating system (see figure 5).

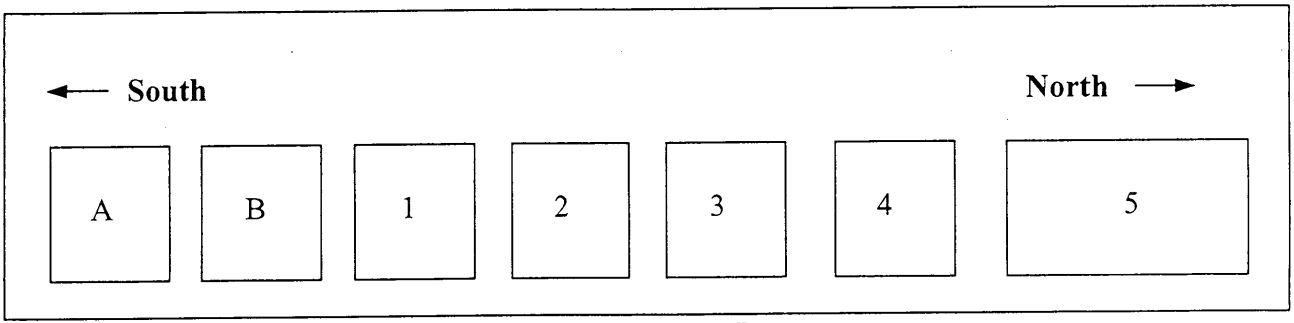

Figure 4. Simulated Reinforced Concrete Structure Layout.

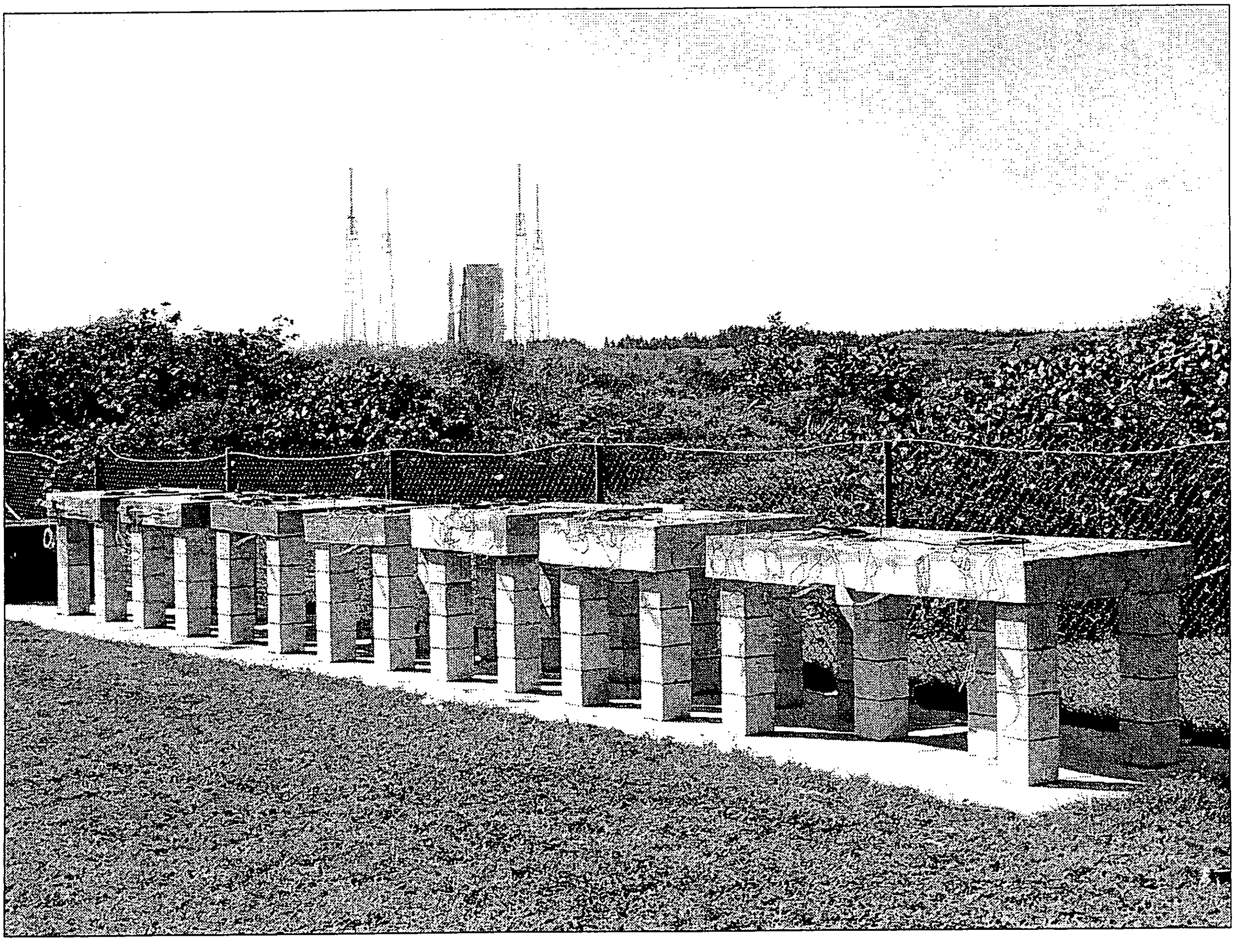

Figure 5. New Simulated Reinforced Concrete Structures.

Phase III Tasks:

G. Monitor phase II test blocks for effectiveness.
H. Refurbish test blocks (if needed).
I. Compare and analyze initial and current data.
J. Check and calibrate data acquisition system and cables.

Phase III Summary

Task G. Monitor phase II test blocks for effectiveness: The LAC test blocks were brought in to the O&C building from the beach exposure racks on January 10, 2002 for performance testing. All blocks were allowed to depolarize over a 48-hour period. Each block was then soaked in a tub with four liters of DM water for 24 hours. The coating potential and embedded reference electrodes were checked using a Broadley James Ag/AgCl reference electrode. All embedded Ag/AgCl reference electrodes were determined to be malfunctioning except for one in block 24. Open circuit potentials of the internal reinforcing steel were measured using an external Broadley James Ag/AgCl reference electrode on the surface. The blocks were polarized for approximately 45 minutes or until the potentials stabilized (+/- 5mV) then allowed to depolarize over a four-hour period. Current and potential measurements were taken at specific time intervals for analysis (see table 7). Data collection on test blocks that did not meet NACE RP290 criteria for a 100mV potential shift were stopped and considered for refurbishment.

Table 7. LAC Test Blocks w/ 75% Zn, 25% Mg Coatings (Jan. 2002)

			Potential, mV vs. Ag/AgCl					pol/depol delta (minus ir drop)
Loc.	Block ID#	Humectant	Coating	OCP	Polarized	ocp/pol delta	Depol.(4hr.)	
1	2	None	-725	-193	-610	-417	-202	330 mV
2	10	None	-675	-345	-358	-13	stopped[1]	
3	14	CaS	-395	-383	-383	0	stopped[1]	
4	15	LiN	-263	-390	-348	42	stopped[1]	
5	16	CuSPH	-420	-274	-283	-9	stopped[1]	
6	17	SG	-480	-324	-330	-6	stopped[1]	
7	18	PSS	-340	-200	-266	-66	stopped[1]	
8	19	No Coating	n/a	-245	-255	-10	stopped[1]	
10	24	TEG	-375	-309	-311	-2	stopped[1]	
9	20	CuS	-385	-212	-320	-108	-161	159 mV

1 Stopped due to no effective depolarization after instant off

Task H. Refurbish test blocks (if needed): Blocks 2, 19, and 20 had new C-Probe Ag/AgCl reference cells embedded, were placed back on the exposure racks at the beach site, and were re-hooked to the data acquisition system (DAS) computer on March 4, 2002. The remaining blocks were completely stripped and re-coated on March 7, 2002 with either a Zn/Mg or Zn/Mg/In coating. New C-Probe Ag/AgCl reference cells were embedded into the blocks and potential measurements were recorded before placing on the racks at the beach (see table 8). The blocks were reconnected to the DAS computer on March 11, 2002.

Table 8. Refurbished Block Status (March, 2002)

Location	Block #	Coating % Zn/Mg/In	Coating Dry Thickness	Coating Potential (Ag/AgCl)	OCP-Rebar (Ag/AgCl)	Rebar Polarized Potential (Ag/AgCl)
1	2	75/25/0	old	-725 mV	-193 mV	-610 mV
2	10	75/25/0	38 mil	-1250 mV	-213 mV	-642 mV
3	14	75/25/0	38 mil	-1230 mV	-267 mV	-590 mV
4	15*	75/25/. 2	39.5 mil	-1280 mV	-254 mV	-870 mV
5	16	75/25/0	35 mil	-1230 mV	-150 mV	-615 mV
6	17	75/25/0	38 mil	-1250 mV	-282 mV	-587 mV
7	18*	75/25/. 2	37 mil	-1290 mV	-299 mV	-900 mV
8	19	Uncoated	0	n/a	-245 mV	-255 mV
9	20	75/25/CuS	old	-385 mV	-212 mV	-320 mV
10	24*	75/25/. 2	34.5 mil	-1270 mV	-343 mV	-740 mV

*Indium Added

Task I. Compare and analyze initial and current data: Potentials of the LAC test blocks, phase II, from July, 2000 were compared with potential measurements of the same blocks, phase III, in January, 2002 to evaluate the amount of protection (see table 9).

Table 9. Potential Comparisons Phase II.

Block #	Potential, mv vs. Ag/AgCl OCP 7/2000	Potential, mv vs. Ag/AgCl OCP 1/2002	Delta	Protection*
2	-315	-193	122	Great
10		-345	345	?
14	-490	-383	107	Fair
15	-345	-390	-45	Corroding
16	-480	-274	206	Good
17	-500	-324	176	Fair
18	-270	-200	70	Good
19	-350	-245	105	?
20	-343	-212	131	Great
24	-470	-309	161	Fair

* Effects of phase II

Task J. Check and calibrate data acquisition system and cables: This task was separated into three goals: 1) Check the DAS current readings to a known current input to calculate the circuit resistance for each location, and 2) Check the potential readings of the reinforcing bars on the DAS and compare to readings using a portable dvm, and check the accuracy of the embedded reference electrodes using an external reference electrode on the surface.

1) The circuit resistance was checked by generating a range of current input (20uA-480uA) into each locations cable and recording the value observed for each range (see table 10). The resistance was calculated using Ohm's Law and averaged over the range (see table 11).

Table 10. Current Measurements (3-28-2002)

	Block Location	Input Current (uA) 20	40	80	120	160	240	480
Observed value	1	0.000201	0.000419	0.000824	0.001204	0.001602	0.002412	0.004831
	2	0.000198	0.000430	0.000859	0.001255	0.001689	0.002470	0.004971
	3	0.000215	0.000424	0.000827	0.001218	0.001624	0.002414	0.004815
	4	0.000218	0.000403	0.000803	0.001220	0.001604	0.002408	0.004776
	5	0.000203	0.000408	0.000829	0.001227	0.001630	0.002421	0.004852
	6	0.000206	0.000419	0.000808	0.001222	0.001621	0.002430	0.004853
	7	0.000216	0.000425	0.000826	0.001223	0.001633	0.002425	0.004846
	8	0.000221	0.000430	0.000837	0.001244	0.001650	0.002460	0.004904
	9	0.000232	0.000472	0.000904	0.001345	0.001788	0.002673	0.005317
	10	0.000221	0.000442	0.000833	0.001229	0.001627	0.002433	0.004833

Table 11. Calculated "r" Values For Each Location (3-28-2002)

Block Location	Calculated " r " (Ω)							average	std. Dev.
1	10.1	10.5	10.3	10.0	10.0	10.1	10.1	10.1	0.2
2	9.9	10.8	10.7	10.5	10.6	10.3	10.4	10.4	0.3
3	10.8	10.6	10.3	10.2	10.2	10.1	10.0	10.3	0.3

4	10.9	10.1	10.0	10.2	10.0	10.0	10.0	10.2	0.3
5	10.2	10.2	10.4	10.2	10.2	10.1	10.1	10.2	0.1
6	10.3	10.5	10.1	10.2	10.1	10.1	10.1	10.2	0.1
7	10.8	10.6	10.3	10.2	10.2	10.1	10.1	10.3	0.3
8	11.1	10.8	10.5	10.4	10.3	10.3	10.2	10.5	0.3
9	11.6	11.8	11.3	11.2	11.2	11.1	11.1	11.3	0.3
10	11.1	11.1	10.4	10.2	10.2	10.1	10.1	10.4	0.4

2) The test block cables were configured so a handheld DVM could be installed inline to compare potential readings. The coatings were left on and the potentials were checked both dry and wet using the embedded Ag/AgCl reference electrode and a surface Ag/AgCl reference electrode (see table 12).

Table 12. LAC Block Potential Comparisons (3-28-2002)

Potentials (-mV) Coating On							
	Computer	DVM	Computer	DVM	DVM	Computer	
Block Location	Embedded Ag/AgCl "dry"	Embedded Ag/AgCl "dry"	Embedded Ag/AgCl "wet"	Embedded Ag/AgCl "wet"	Surface BJ Ag/AgCl "wet"	Embedded Ag/AgCl "wet" 20 min	Polarized Delta 20 min "wet"
1*	312	312	470	468	479	536	224
2	228	228	367	363	365	432	204
3	259	259	403	402	386	456	197
4**	285	285	575	571	606	676	391
5	168	170	311	311	301	377	209
6	281	281	382	381	389	452	171
7**	245	245	736	737	706	827	582
8***	278	279	261	261	280	247	-31
9*	210	210	219	222	160	238	28
10**	312	312	478	466	452	547	235

* Original ** In added *** Original Uncoated Control Block

Phase IV Tasks:

G. Prepare test slabs for coating system.
H. Design and install optimum electrical connection between the coating system and rebar.
I. Identify and label wires for installation to computer for data collection.
J. Perform initial tests on slabs and collect data to use for reference.
K. Apply coating system to test slabs, expose slabs to environment, and activate system.
L. Monitor coating system for effectiveness on blocks and slabs.

Task K. Prepare test slabs for coating system: The bottoms of the slabs were cleaned by water jet blasting using a gas powered pressure washer with a head pressure of 2250 psi.

Task L. Design and install optimum electrical connection for the coating system and rebar: A pair of titanium mesh strips (2" x 45") were installed to the underside of the slabs. These strips will be used to serve as an electrical contact between the GLCS and the rebar. The titanium strips were chosen because of its superior corrosion resistance and electrical properties.

Task M. Identify and label wires for installation to computer for data collection: The wires for the rebar connections and electrochemical devices have been identified and labeled. Work is in progress to make the necessary connections and route them to the Beach Corrosion Lab.

Task N. Perform initial tests on slabs and collect data to use for reference: Chloride profiles and pH analysis has been performed at depths of 0.5", 1.0", 1.5", and 2.0", from the top surface, at various locations (see table 13). Resting potentials have been measured using ASTM C-876 procedures and show evidence of corrosion of embedded rebar (see table 14). Further testing using electrochemical techniques will be performed and used as baseline data.

Table 13. Simulated Reinforced Concrete Structure Chloride Content and pH Data

Slab A 2" Cover

Depth:	Cl^- (ppm)	PH
0.5"	5632	11.2
1.0"	2492	11.4
1.5"	2492	11.6
2.0"	3480	11.5

Slab 3 3" cover

Depth:	Cl^- (ppm)	pH
0.5"	2208	11.4
1.0"	3856	11.5
1.5"	3128	11.6
2.0"	2800	11.7

Slab B 2" Cover

Depth:	Cl^- (ppm)	PH
0.5"	3480	11.6
1.0"	3128	11.6
1.5"	2800	11.6
2.0"	2208	11.6

Slab 4 3" cover

Depth:	Cl^- (ppm)	pH
0.5"	188	11.4
1.0"	360	11.6
1.5"	360	11.7
2.0"	360	11.8

Slab 1 2" Cover

Depth:	Cl^- (ppm)	PH
0.5"	1464	11.6
1.0"	3480	11.6
1.5"	2800	11.7
2.0"	1944	11.6

Slab 5 South 2" Cover

Depth:	Cl^- (ppm)	pH
0.5"	1696	11.4
1.0"	3128	11.6
1.5"	2208	11.6
2.0"	2800	11.6

Slab 2 2" Cover

Slab 5 North 2" Cover

Depth:	Cl^- (ppm)	PH
0.5"	360	11.4
1.0"	360	11.7
1.5"	360	11.8
2.0"	360	11.9

Depth:	Cl^- (ppm)	pH
0.5"	320	11.4
1.0"	360	11.4
1.5"	360	11.6
2.0"	360	11.6

Table 14. Rebar Potentials (OCP) referenced to an Ag/AgCl half cell electrode (manufactured by Broadley James) at 199mV vs. standard Hydrogen

Rebar Potentials Ag/AgCl (mV)	Test Slabs						
	A	B	1	2	3	4	5
Top Mat	-381	-350	-150	45	-375	182	-175
Bottom Mat	-345	-350	-220	135	-320	110	-220

Task O. Apply coating system to test slabs, expose to environment, and activate system. Currently the slabs are ready for coating. The base materials have been ordered and received. The procedures and equipment are in place.

Task P. Monitor coating system for effectiveness: Slabs will be monitored after complete fabrication is completed.

Task Summary:

October 2000-September 2001

A. Identify moisture-attracting agents for incorporation into the liquid applied coating formulation: Done. No activity planned.

B. Redesign coating formulation: Done. No activity planned.

C. Coat test blocks with new formulation: Done. No activity planned.

D. Monitor new coating formulation for effectiveness: Blocks will be monitored this year. Slabs will be monitored after fabrication is completed, when additional funding is secured and approved. Report the final results.

E. Design test slabs to evaluate new coating formulation: Done. Minor modifications may be necessary.

F. Fabricate test slabs: Done. A contractor has been selected and the slabs were built during September-October, 2000.

October 2001 – September 2002

G. Monitor phase II test blocks for effectiveness: Test Blocks have been brought in from the beach and tested in the lab. The DAS computer at the KSC beach test site is doing continuous monitoring of block potentials and current measurements.

H. Refurbish test blocks (if needed): Done-Some of the blocks have been refurbished and replaced at the beach for exposure.

I. Compare and analyze initial and current data. Continue to monitor and analyze data.

J. Check and calibrate data acquisition system and cables. Complete for 2002, re-check when needed.

K. Prepare Test Slabs for coating system: Continue preparations for application of the coating system.

L. Design and install optimum electrical connection between the coating system and rebar: Research and development of electrical connection will continue.

M. Identify and label wires for installation to computer for data collection: From lessons learned in the past, reference electrodes and wires will need to be checked when inconsistent data is found. Some of the wiring and electrodes have been damaged in the past from lightening strikes.

N. Perform initial tests on slabs and collect data for reference: Initial Chloride profiles, pH Data, and resting potentials are complete. Initial electrochemical tests need to be performed before start-up. Chloride profiles and pH data along with electrochemical tests will be performed as part of the monitoring schedule.

O. Apply coating system to test slabs, expose slabs to environment, and activate system: Everything is in place and is scheduled for the first quarter of October – September, 2002.

P. Monitor coating system for effectiveness on blocks and slabs: Continue to monitor coating system.

Problems Encountered: The computer monitoring system was damaged by a lightning strike (8/2000). Some of the blocks and wiring were damaged also. Wiring on the test slabs was extensively damaged by field mice (2/2002). Damaged wires repaired (3/2002).