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KTA-TATOR, INC.
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September 5, 2008

Subject: **KTA-Tator, Inc. Project No. 260766**
Results of Slip Coefficient and Tension Creep Testing

EXECUTIVE SUMMARY

zinc-rich primer was tested for Class B slip coefficient and tension creep properties using ASTM A490 bolts according to the requirements of Appendix A of the *Specification for Structural Joints Using ASTM A325 or A490 Bolts*, prepared by the Research Council on Structural Connections (June 30, 2004). The primer exhibited a Slip Coefficient of 0.52 and passed the 1,000-hour Creep Deformation test. The primer is certified Class B at a maximum thickness of 4 mils.

SPECIMEN PREPARATION PROCEDURES

The following sections describe the surface preparation and coating application procedures used to prepare the slip coefficient and tension creep specimens.

Substrate Material

The test specimens were fabricated from 5/8" thick cold rolled carbon steel plate.

The slip coefficient test specimens were comprised of flat (no raised edges, protruding defects or warp) 4" x 4" plates with a 1" hole drilled 1 ½" from one edge and one 5/8" width side machined smooth. The planarity (surface flatness) of both sides of each specimen was checked on a machined, cast steel surface prior to surface preparation. A "test specimen" is represented by a set of three plates. Five sets (3 specimens per set) and five (5) spare test plates (a total of 20 plates) were prepared for slip coefficient testing.

The tension creep specimens were also flat (no raised edges, protruding defects or warp) 4" x 7" plates with two 1" holes drilled 1 ½" from each end. The planarity (surface flatness) of both sides of each specimen was checked on a machined, cast steel surface prior to surface preparation. A "test specimen" is represented by a set of three (3) test plates. Three specimens (9 plates) and three (3) spare test plates (a total of 12 plates) were prepared for tension creep testing.

Surface Preparation

The fabricated test plates were prepared by solvent cleaning per SSPC SP1, "Solvent Cleaning," then abrasive blast cleaned (except edges) to achieve an SSPC-SP5, "White Metal Blast" using a blend of approximately 95% SAE Steel Shot S280 and 5% G80 steel grit conforming to SSPC AB2 to generate a nominal 50 µm (2 mil) surface profile depth. The degree of surface cleanliness was verified using photographic reference "A SP5" of SSPC Visual Standard No. 1 (VIS 1), "Guide and Reference Photographs for Steel Surfaces Prepared by Abrasive Blast Cleaning." The surface profile depth was measured in accordance with ASTM D4417, "Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel," Method C (replica tape). Surface profile measurements were obtained from both sides of sixteen randomly selected test specimens using Testex® X-Coarse (1.5-4.5 mils) replica tape. The measured surface profile depth ranged from 2.2 to 2.6 mils.

Coating Application and Curing

Application of the coatings to the slip and creep plates was conducted using airless spray application. Specimens were oriented horizontally in customized holders, and the edges were not coated. The coating was applied using a Speeflow 60:1 airless spray pump. Actual mixing and application conditions were recorded on the Test Panel Preparation Forms. Carwell Specialty Coatings provided Product Data and Application Instructions. Coating thickness was measured on both sides of each specimen in accordance with SSPC-PA2 "Measurement of Dry Coating Thickness with Magnetic Gages" using a PosiTector® Model 6000-F1 nondestructive electro-magnetic coating thickness gage verified for accuracy using plastic calibration shims. The applied thickness was 50µm (2 mils) greater than the coating manufacturers maximum coating thickness (4 mils). The actual coating thickness measurements were recorded on the Coating Thickness Forms. The specified maximum thickness was 5 mils. Therefore the test thickness was

7 mils, as Appendix A of the *Specification for Structural Joints Using ASTM A325 or A490 Bolts* requires the addition of 2 mils dry film thickness to the manufacturers recommended maximum thickness.

Mating of Test Surfaces Based on Coating Thickness

After curing, surfaces with common coating thickness characteristics (and within the target thickness range) were mated for both the slip coefficient and tension creep testing. The following table contains the mating surfaces and the average coating thickness on each test face.

Specimen No.	Plate ID, Face and Coating Thickness End Panel	Plate ID and Coating Thickness Middle Panel		Plate ID, Face and Coating Thickness End Panel
		Front (F)	Back (B)	
1 (Slip)	1B (6.0 mils)	11 (5.8 mils)	11 (5.1 mils)	6F (6.2 mils)
2 (Slip)	2B (6.4 mils)	12 (5.9 mils)	12 (5.1 mils)	7F (5.9 mils)
3 (Slip)	3B (6.3 mils)	15 (5.9 mils)	15 (5.2 mils)	8F (5.9 mils)
4 (Slip)	14F (5.4 mils)	19 (5.3 mils)	19 (6.0 mils)	18B (6.1 mils)
1 (Creep)	26F (5.4 mils)	28 (5.0 mils)	28 (5.9 mils)	32B (5.8 mils)
2 (Creep)	29B (6.0 mils)	27 (5.5 mils)	27 (6.0 mils)	24F (6.1 mils)
3 (Creep)	25F (5.6 mils)	21 (5.3 mils)	21 (5.7 mils)	30B (6.0 mils)

TESTING EQUIPMENT AND PROCEDURES

The following test equipment and procedures were employed to perform the slip coefficient and tension creep testing. All testing was performed according to the procedures set forth in Appendix A of the *Specification for Structural Joints Using ASTM A325 or A490 Bolts*, prepared by the Research Council on Structural Connections (June 30, 2004) and KTA Standard Operation Procedure (SOP) T7095-R.6, "Determining the Slip Coefficient and Tension Creep of Coatings Used in Bolted Joints (Slip and Creep Testing)." ASTM A490 bolts were employed and Class B (>0.5) slip was targeted.

Slip Coefficient Equipment and Test Procedure

The KTA 50 ton capacity slip coefficient test frame is equipped with an Enerpac 10,000 psi (70 kips) load cell controlled by a Sensotec GM (controls horizontal clamping force and a Sensotec SC2000 (controls vertical force and displays the distance the center plate moves in relation to the two end plates). The load cell, linear transducer and digital controllers are calibrated annually by US Calibration Services, Inc.

Three (3) test plates (4" x 4") comprised a "test assembly." Results were obtained for four replicate test assemblies; a fifth replicate could not be evaluated with the number of samples that were prepared due to an equipment malfunction. Each test assembly was loaded onto the 7/8" diameter horizontal rod, based on contact surfaces having similar coating thickness (shown in the table above). The middle plate (having two contact surfaces) is oriented so that the load is applied to a machined edge by the vertical force platen, while the two end panels (having only one contact surface each) are oriented so that the bottom, machined edges are positioned on the LVDT platen. A clamping force of 49 kips was applied to the test assembly, then a compressive load was applied to the machined edge of the middle plate at a rate not-to-exceed 25 kips/minute, to induce a slip. An X-Y plotter simultaneously recorded the load and slip values. The results of the five replicate tests and the average coefficient of slip are contained in the test results section of this report. The slip load for each test assembly is divided by two times (2X) the clamping force to obtain the slip coefficient. Five replicates are usually obtained for the slip coefficient test, however due to an equipment malfunction, only four replicates were obtained and reported with the acceptance from AASHTO personnel.

Tension Creep Equipment and Test Procedure

Tension creep testing was performed on a multi-chain reinforced steel test frame with a maximum capacity of 200,000 pounds. Three (3) test plates (4" x 7") comprised a "test assembly." Three replicate test assemblies (total of 9 plates) were assembled using ASTM A490 bolts manufactured by LaJuene Bolt Company. A Certificate of Analysis is on file. All bolts were from Lot # 61411. A calibrated load cell was used to apply 39.2 kips of vertical pull to the chain and the load was maintained using heavy duty springs positioned in the base of the test frame. Magnets positioned on the edges on the test plates and calibrated micrometers were used to detect movement. The relative creep was measured between the outside plates and the center plate on both sides of the assembly. The accuracy of each measurement is 0.0001 in (+/- 0.00005). Readings were obtained from each micrometer and the main spring tension micrometer up to twice daily (morning and afternoon) for a maximum duration of 1000 hours (42 days). Readings were not obtained on weekends/holidays. Measurements were recorded on form KTA T7095B (attached). The load was applied for 1,000 hours or until failure, which is noted by a creep deformation of greater than 0.005 in. The creep deformation was calculated

using the average reading of the two displacements on each side of the specimen. The difference between the average after 1,000 hours and the initial average reading taken within 30 minutes after loading the specimens was defined as the creep deformation of the specimen. This value was recorded for each interface of each specimen on Form KTA T7095B (attached). The results of the tension creep testing are contained in the test results section of this report. It should be noted that an unexpected result was obtained for the main spring tension value on 8/13/08. The slip coefficient test was being utilized on 8/12/08 and the possibility exists that the value was obtained in error due to inadvertent contact with the micrometer.

TEST RESULTS

Following are the results of the slip coefficient and tension creep testing

Slip Coefficient Results

Slip Load Data

Product	Result 1	Result 2	Result 3	Result 4	Result 5	Mean
Zinga	*49,200*	*37,200*	*59,200*	*58,000*		

Slip Coefficient Values

Product	Result 1	Result 2	Result 3	Result 4	Result 5	Mean
Zinga	*0.50*	*0.38*	*0.60*	*0.59*		***0.52***

** Calculated as mean slip load / 2X the clamping force*

Tension Creep Results

Value	Assembly 1	Assembly 2	Assembly 3
Initial Micrometer Reading	*0*	*0*	*0*
Final Micrometer Reading	*0.0013"*	*0.0009"*	*0.0000"*
Creep Deformation	*0.0013"*	*0.0009"*	*0.0000"*
Total Creep Deformation ***(Pass is <0.005)***	***0.0022"***		
Reload Assembly @ 49 kips* ***(Pass is <0.015)***	*0.0018*	*0.0009*	*0.0000*

** Clamping force x design slip COF x 2*

KTA FORM T7095A
COMPRESSION SLIP TEST DATA

Project No: *260766*
Client: *AASHTO*
Coating Manufacturer:
Coating Name: *Zinga*
Coating Product No.
Batch No. *A: M101*
Technician A: *Carly M. Pravlik*
Technician B: *Stanford J. Galloway*

Set #: *1*
Coating Application Date: *6/24/08* Surface Profile (Actual): *2.2-2.6 mils*
Cure Time (Actual): *28 Days* Cure Conditions: *62-84°F, 31-72% RH*
Slip Test Date: *7/22/08*

Coating Thickness	Specimen #1	Specimen #2	Specimen #3	Specimen #4	Specimen #5
Interface #1 A/B *	*6.0 mils/5.8 mils*	*6.4 mils/5.9 mils*	*6.3 mils/5.9 mils*	*5.4 mils/5.3 mils*	
Interface #2 C/D *	*5.1 mils/6.2 mils*	*5.1 mils/5.9 mils*	*5.2 mils/5.9 mils*	*6.0 mils/6.1 mils*	
	(1B/11F-11B/6F)	*(2B/12F-12B/7F)*	*(3B/15F-15B/8F)*	*(14F/19F-19B/18B))*	
Test Start Time	*1400*	*1415*	*1435*	*1505*	
Clamping Force (49 kips ± 0.5)	*49 kips*	*49 kips*	*49 kips*	*49 kips*	
Load / Slip at	NA	NA	NA	NA	NA
10 ”					
20 ”					
30 ”					
40 ”					
50 ”					
60 ”					
1 ’ 10 ”					
1 ’ 20 ”					
1 ’ 30 ”					
1 ’ 40 ”					
1 ’ 50 ”					
2 ’					
2 ’ 10 ”					
2 ’ 20 ”					
2 ’ 30 ”					
2 ’ 40 ”					
2 ’ 50 ”					
3 ’					
3 ’ 10 ”					
3 ’ 20 ”					
3 ’ 30 ”					
3 ’ 40 ”					
3 ’ 50 ”					
4 ’					
Displacement	▼	▼	▼	▼	▼
Ks (Slip Load)	*0.50*	*0.38*	*0.60*	*0.59*	

Mean Ks	*0.52*

Slip load / 2X clamping force = mean slip coefficient of 0.52

KTA FORM T7095A
COMPRESSION SLIP TEST DATA

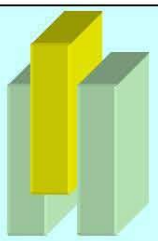
Comments/Observations:

Pass 0.5 Slip Coefficient. Proceed to Tension Creep Test

Test Data Reviewed by: *Carly M. Pravlik* Date: *July 22, 2008*

KTA FORM T7095B
TENSION CREEP TEST DATA

Project No: *260766*
Client: *AASHTO*
Coating Manufacturer:
Coating Name: *Zinga*
Coating Product No.
Batch No. *A: M101*
Technician A: *Carly M. Pravlik*
Technician B: *Stanford J. Galloway*



Set #: *1*
Coating Application Date: *6/24/08* Surface Profile (Actual): *2.2-2.6 mils*
Cure Time (Actual): *28 Days* Cure Conditions: *62-84°F, 31-72% RH*
Slip Test Date: *7/22/08*

Test Start Date	*7/22/08*
Test End Date	*9/3/08*

Clamping Force	Bolt #1	Bolt #2	Bolt #3	Average
	48.0 kips	*52.0 kips*	*51.0 kips*	*50.3 kips*

Coating Thickness	Specimen #1	Specimen #2	Specimen #3
Interface #1 A/B *	*26F/28F (5.4 mils/5.0 mils)*	*29B/27F (6.0 mils/5.5 mils)*	*30B/21B (6.0 mils/5.7 mils*
Interface #2 C/D *	*28B/32B (5.9 mils/5.8 mils)*	*27B/24F (6.0 mils/6.1 mils)*	*21F/25F (5.3 mils/5.6 mils*

Creep Frame Specimen Load (Locked Tension)	*39.2 kips*

Slip Coefficient Category = *Class B (A490 bolts)*

		Micrometer Values (Inches)					
		Main Spring Tension	Specimen # 1		Specimen # 2		Specimen # 3	
Date	***Time***							
Day 1	*am*	*NA*						
7/22/08	*pm*	*0.000*	*0.0000*		*0.0000*		*0.0000*	
Day 2	*am*	*0.001*	*0.0008*		*0.0005*		*0.0000*	
7/23/08	*pm*							
Day 3	*am*	*0.001*	*0.0009*		*0.0006*		*0.0000*	
7/24/08	*pm*							
Day 14	*am*	*0.002*	*0.0010*		*0.0008*		*0.0000*	
8/4/08	*pm*	*0.002*	*0.0011*		*0.0008*		*0.0000*	
Day 15	*am*	*0.002*	*0.0011*		*0.0008*		*0.0000*	
8/5/08	*pm*							
Day 16	*am*							
8/6/08	*pm*	*0.002*	*0.0011*		*0.0008*		*0.0000*	
Day 17	*am*	*0.002*	*0.0012*		*0.0008*		*0.0000*	
8/7/08	*pm*							

TENSION CREEP TEST DATA

		Micrometer Values (Inches)					
Day 18	*am*	*0.002*	*0.0012*	*0.0008*		*0.0000*	
8/8/08	*pm*						
Day 22	*am*						
8/12/08	*pm*	*0.002*	*0.0012*	*0.0009*		*0.0000*	
Day 23	*am*	*0.002*	*0.0012*	*0.0008*		*0.0000*	
8/13/08	*pm*						
Day 24	*am*	*0.011*	*0.0012*	*0.0009*		*0.0000*	
8/14/08	*pm*						
Day 25	*am*						
8/15/08	*pm*	*0.010*	*0.0012*	*0.0009*		*0.0000*	
Day 30	*am*	*0.010*	*0.0012*	*0.0009*		*0.0000*	
8/20/08	*pm*						
Day 31	*am*	*0.010*	*0.0012*	*0.0009*		*0.0000*	
8/21/08	*pm*						
Day 32	*am*						
8/22/08	*pm*	*0.010*	*0.0012*	*0.0009*		*0.0000*	
Day 35	*am*	*0.010*	*0.0012*	*0.0008*		*0.0000*	
8/25/08	*pm*						
Day 36	*am*	*0.010*	*0.0012*	*0.0009*		*0.0000*	
8/26/08	*pm*						
Day 37	*am*						
8/27/08	*pm*	*0.010*	*0.0012*	*0.0009*		*0.0000*	
Day 39	*am*	*0.011*	*0.0012*	*0.0009*		*0.0000*	
8/29/08	*pm*						
Day 43	*am*	*0.011*	*0.0013*	*0.0009*		*0.0000*	
9/2/08	*pm*						
Day 44	*am*	*0.011*	*0.0013*	*0.0009*		*0.0000*	
9/3/08 Final reading following reload to 50.3 kips		*0.027*	*0.0018*	*0.0009*		*0.0000*	

TENSION CREEP TEST DATA

	Specimen # 1		Specimen # 2		Specimen # 3	
	A / B	C / D	A / B	C / D	A / B	C / D
Initial Micrometer Value Average (inches)	*0.0000*		*0.0000*		*0.0000*	
Final Micrometer Value Average (inches)	*0.0013*		*0.0009*		*0.0000*	
Difference = Creep Deformation (Not to exceed 0.005")	*0.0013*		*0.0009*		*0.0000*	
Reload Assembly @ 50.3 kips *(Pass is <0.015)*	*0.0018*		*0.0009*		*0.0000*	

** Clamping force x design slip COF x 2*

FAIL – Creep deformation > 0.005 inches for 1 of 3 specimens.
PASS - Creep deformation < 0.005 inches for all specimens.

PASS – Creep specimens must be loaded in tension to a load calculated as:
$\mathbf{P_u}$ = average clamping force x design slip coefficient x 2

Comments/Observations:

PASS Creep Deformation (<0.005" for all individual specimens)
(<0.005" for all specimens)
(cumulative creep: 0.0027" for all specimens)

Test Data Reviewed by: *Carly M. Pravlik* Date: *9/5/08*