RESEARCH REPORT DOCUMENTATION PAGE

1. Report No.	2. Report Date	3. Contract No.	4. Project No.
ND 2001-01	November 2001	N/A	IM-2-094(011)289

5. Title and Subtitle

Use of Stainless Steel Alternative for a Corrosion Resistance Structure

6. Report Type

Work Plan ☐
Construction ☒
Evaluation ☐
Final ☐

7. Project No.

8. Project No.

9. Project No.

10. Project No.

11. Author(s)/Principle Investigator(s)

Rhaub Walker

12. Performing Organization Name and Address

NDDOT M+R ☒
NDDOT OTHER* ☐
NDSU ☐
UND ☐
UGPTI ☐
OTHER* ☐
*see supplementary notes

North Dakota DOT
Materials and Research Division
300 Airport Road
Bismarck ND 58504-6005

13. Sponsoring Agency Name and Address

North Dakota DOT
Materials and Research Division
300 Airport Road
Bismarck ND 58504-6005

14. Supplementary Notes

15. Abstract

Purpose and Need

The deterioration of reinforced concrete structures has long been a problem to highway agencies. The major cause of the deterioration results from corrosion of the steel due to chlorides. The cost of using stainless steel rebar is prohibitive for highway construction at this time but a new product known as Nuovinox, a carbon steel rebar clad with stainless steel is reported to be a stainless steel alternative priced considerably lower than stainless steel.

Objective

The objective of this research study is to determine if a carbon steel rebar clad with stainless steel is a cost effective new method of combating the effects of chloride intrusion.

Scope

A bridge was constructed with stainless steel clad rebar as part of project number is IM-2-094(011)289. The bridge is located West of Valley City on Interstate 94 at reference mile 290. The National Bridge Number is 94-290.803. The bridge is 0.025 Miles long and begins at station 5353+67.69 and ends at station 5354+98.69. The project will be evaluated at five, ten, fifteen, and twenty years. The bridge deck will be inspected for cracks, delamination, deterioration, and will also be tested for chloride intrusion.

Summary

Comments from Mike Flaagen, NDDOT project engineer: If we continue to use this material, we need to learn more about it's characteristics. We need to know how to accept it in the field and look for irregularities in the coating. The supplier should do a better job of bending the bars to the correct dimensions. Many of the bent bars were not exactly bent to the dimensions shown in the plans. This mainly affected installation because the bars were tougher to fit in place. In some cases the contractor had to cut bars to the correct length and cap them.

Other than these comments, Mike Flaagen reported that no other differences were noticed in construction using the stainless steel clad rebar.

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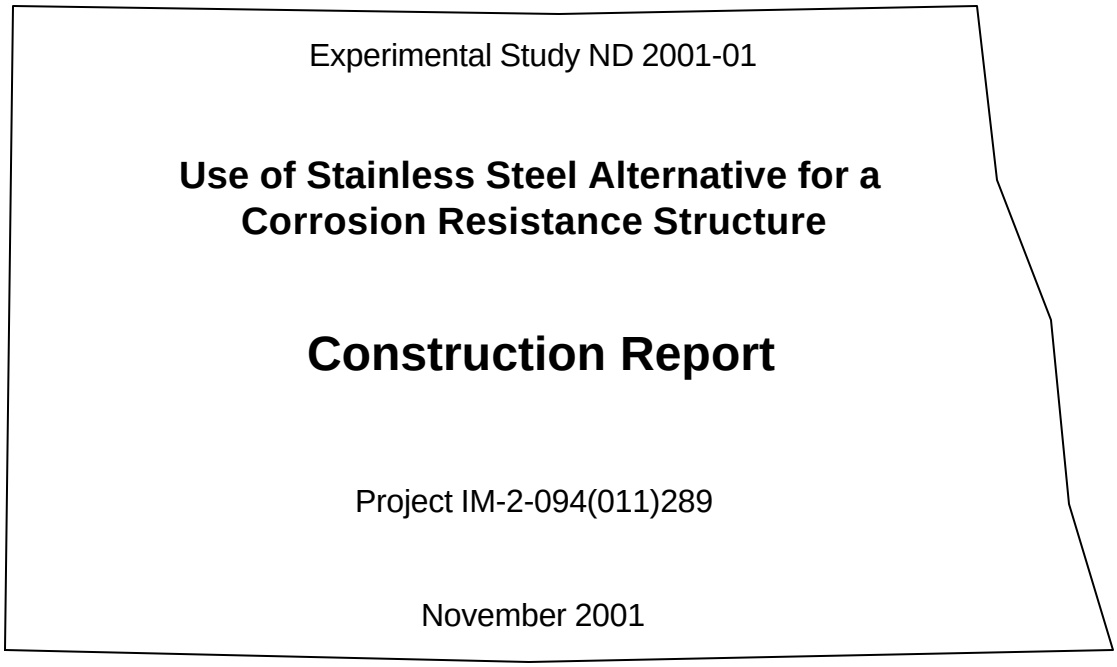
Stainless Steel Corrosion Bridge Deck Rebar Stelax Nuoviox 316L	No restrictions. This document is available to the public from: North Dakota Department of Transportation Materials and Research Division: 300 Airport Road Bismarck ND 58504-6005 Office: (701) 328-6900	39 19. File type/Size Pdf/2.1 MB

NORTH DAKOTA
DEPARTMENT OF TRANSPORTATION

MATERIALS AND RESEARCH DIVISION



Experimental Study ND 2001-01

Use of Stainless Steel Alternative for a Corrosion Resistance Structure

Construction Report

Project IM-2-094(011)289

November 2001

Prepared by

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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

EXPERIMENTAL PROJECT REPORT

EXPERIMENTAL PROJECT

EXPERIMENTAL PROJECT NO.

	STATE	YEAR	-	NUMBER	SURF
1	**ND**	**2001**	-	**0 1**	

CONSTRUCTION PROJ NO: **IM-2-094(011)289** (8)

LOCATION: **Barnes** (28)

EVALUATION FUNDING (48)
- 1 **X** HP&R
- 2 CONSTRUCTION
- 3 DEMONSTRATION
- 4 IMPLEMENTATION

NEEP NO. (49):

PROPRIETARY FEATURE? (51): X Yes / No

SHORT TITLE

TITLE (52): **Use of Stainless Steel Alternative for a Corrosion Resistance Structure**

THIS FORM

DATE (140): MO. **1 1** - YR. **0 1**

REPORTING: 1 **X** INITIAL 2 ANNUAL 3 FINAL

KEY WORDS

KEY WORD 1 (145): **STAINLESS STEEL**	KEY WORD 2 (167): **CORROSION**
KEY WORD 3 (189): **BRIDGE DECK**	KEY WORD 4 (211): **REBAR**
UNIQUE WORD (233):	PROPRIETARY FEATURE NAME (255): **STELAX NUOVINOX 316L**

CHRONOLOGY

DATE WORK PLAN APPROVED: (277)	DATE FEATURE CONSTRUCTED: (281)	EVALUATION SCHEDULED UNTIL: (285)	EVALUATION EXTENDED UNTIL: (289)	DATE EVALUATION TERMINATED: (293)
09-99	**11-01**	**11-21**		

QUANTITY AND COST

QUANTITY OF UNITS (297): 44,000

UNITS (305):
- 1 LIN. FT
- 2 SY
- 3 SY-IN
- 4 CY
- 5 TON
- 6 **X** LBS
- 7 EACH
- 8 LUMP SUM

UNIT COST (*Dollars, Cents*) (306):
Rebar is $0.59/lb
Fabrication is $0.12/lb
Freight estimate is $2,000.00

AVAILABLE EVALUATION REPORTS

(315): **X** CONSTRUCTION | PERFORMANCE | FINAL

EVALUATION

CONSTRUCTION PROBLEMS (318)		PERFORMANCE (319)	
1	NONE	1	EXCELLENT
2	SLIGHT	2 **X**	GOOD
3 **X**	MODERATE	3	SATISFACTORY
4	SIGNIFICANT	4	MARGINAL
5	SEVERE	5	UNSATISFACTORY

APPLICATION

(320)
- 1 ADOPTED AS PRIMARY STANDARD
- 2 PERMITTED ALTERNATIVE
- 3 ADOPTED CONDITIONALLY
- 4 **X** PENDING
- 5 REJECTED
- 6 NOT CONSTRUCTED

(Explain in remarks if 3, 4, 5, or 6 is checked)

REMARKS

321

The stainless steel clad reinforcing used in the superstructure is Stelax Nuovinox 316L Clad Rebar Grade 60 from Stelax Industries Ltd.
Problems encountered from the supplier were irregularities in the coating and bending the bars to the correct dimensions.

700

Form FHWA 1461

Experimental Study ND 2001-01

Use of Stainless Steel Alternative for a Corrosion Resistance Structure

Construction Report

Project IM-2-094(011)289

November 2001

Written by

Rhaub Walker

Disclaimer

The contents of this report reflect the views of the author or authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not reflect the official views of the North Dakota Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

TABLE OF CONTENTS

Use of Stainless Steel Alternative for a Corrosion Resistance Structure

Objective

The deterioration of reinforced concrete structures has long been a problem to highway agencies. The major cause of the deterioration results from corrosion of the steel due to chlorides.

The cost of using stainless steel rebar is prohibitive for highway construction at this time but a new product known as Nuovinox, a carbon steel rebar clad with stainless steel is reported to be a stainless steel alternative priced considerably lower than stainless steel.

The objective of this research study is to determine if a carbon steel rebar clad with stainless steel is a cost effective new method of combating the effects of chloride intrusion.

Reinforcing steel is protected in concrete by a passive iron oxide layer that forms because of the high pH of the concrete. Corrosion won't occur as long as there are no breaks in the passive layer over the steel. The layer may be broken by two things; one involves carbonation, the other, chloride ions.

Carbonation occurs when carbon dioxide from the air reacts with water to form a weak acid that converts calcium hydroxide within the hydrated cement paste to calcium carbonate. Given time, this reaction can work its way in from the surface of the concrete to the reinforcing steel, reduce the pH of the concrete surrounding the steel, and allow corrosion to begin. However, with a low water to cement ratio, carbonation is seldom a concern.

Most corrosion problems are related to chlorides. It has been noted that the formation of an iron chloride complex ion frees the iron to begin the corrosion process. When the concentration of chlorides gets higher than a threshold level, corrosion starts.

Corrosion has been attributed to the fact that chloride destroys the protective passivation film which is formed on steel surfaces due to the high pH condition in concrete pore solution (pH=12-13).

Research on concrete durability has greatly increased and has demonstrated that many of severe problems, such as cracking, delamination and spalling of concrete, are related to chloride induced steel corrosion. The corrosion induced damage is a serious problem for the structure.

Scope

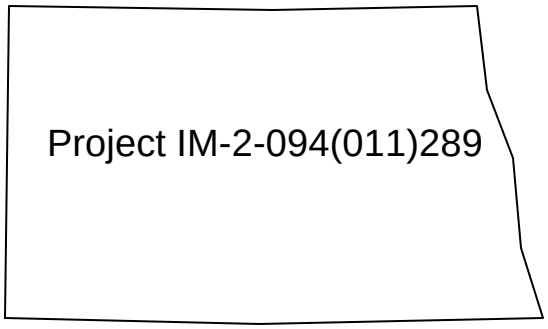
The plans for this project call for the use of a stainless steel clad rebar for its reinforcing steel. The use of this product is limited and ongoing research in many states is being conducted. Unlike epoxy coated rebar, its cladding is resistant to accidental damage and bars can be mechanically handled in the same way as black bars. It can be field bent, cut, and welded. Its chloride threshold is the same as solid stainless. If the coating on epoxy rebar is nicked during transport or installation, resulting in a damage level of only 5%, the chlorine threshold of the damaged bar becomes the same as black bar. Corrosion will then continue underneath the damaged epoxy coating. Typically, epoxy rebar will give corrosion protection for an average of 10 years. The advertised projected life span for stainless steel clad rebar is 75 - 100 years.

Precleaned epoxy coated reinforcing bars are protected with a coating of powdered epoxy that's fusion-bonded to the steel in an assembly fine process. Typically, manufacturers have the capability to coat straight bars, but only a few can coat bent bars. The coating physically blocks chloride ions. However, unless the bars are coated after bending, there's a potential for cracking and chipping of the epoxy coating during bending. Damage to the epoxy coating also may occur during field-handling of the bars.

Location

The bridge is located West of Valley City, North Dakota, on Interstate 94 in reference mile 290. The National Bridge Number is 94-290.803. The project number is IM-2-094(011)289.

The West Valley City Interchange bridge is 0.025 Miles long. The project begins at station 5353+67.69 and ends at 5354+98.69.



Project History

Construction

Construction history at the location of the project is shown in Table 1.

Year	Type	Width (feet)
1958	Structure	40.0
1979	Approach Slab	-
1979	PCC Deck Overlay	-
1985	Rail Retrofit	-
2001	Structure	40.0

Table 1.

Traffic

Traffic data at the location of the project is shown in Table 2.

Design Data				
Traffic	**Average Daily**			**Est. Max Hr.**
Current 2000	Pass: 4115	Trucks 775	Total 4890	490

Table 2.

Design

Construction of two structures on Interstate 94 near Valley City is proposed for the Year 2000. One structure will be constructed using epoxy coated rebar as specified by NDDOT specifications and the other structure will use the Nuovinox rebar during construction. The amount of rebar in each structure is approximately 44,000 pounds.

Test Structure

The work at this site consists of building a new 131 foot long, 3-span spread box girder bridge with a clear roadway width of 40 feet.

The NDDOT project engineer is Mike Flaagan and the NDDOT bridge engineer is Terry Udland. The contractor for this project is Industrial Builders Inc.

The stainless steel clad reinforcing to be used in the superstructure shall be Stelax Nuovinox 316L Clad Rebar Grade 60 from Stelax Industries Ltd. The reinforcing bar list and details for the test structure are located in Appendix A. Photo 1 shows an example of a stainless steel clad rebar. The rebar is manufactured in South Wales, United Kingdom.

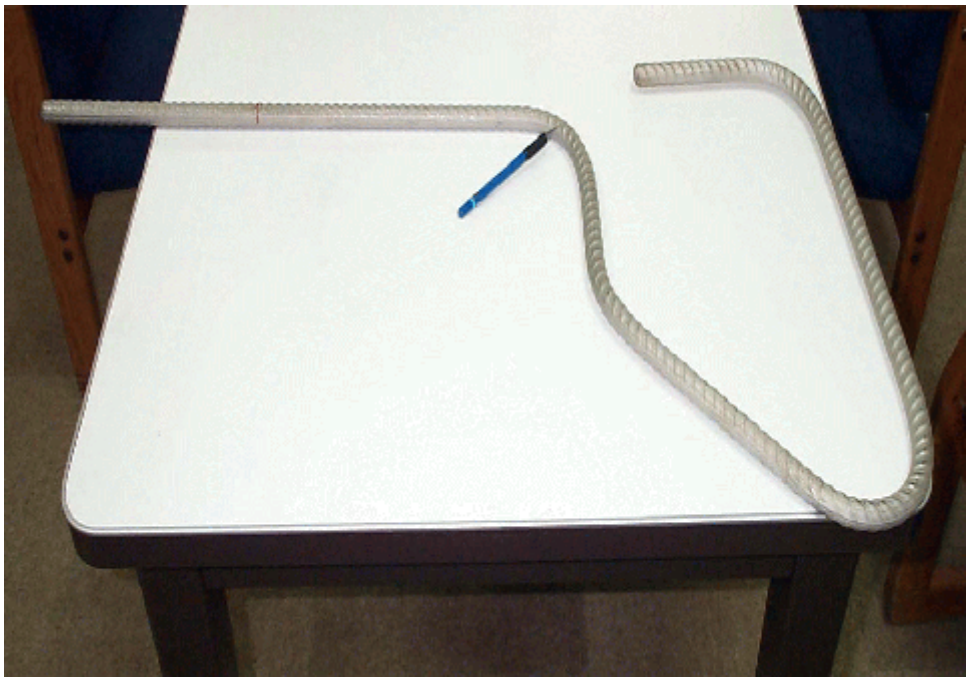


Photo 1. Example of Stainless Steel Clad Rebar

Control Structure

The bridge is located West of Valley City. The project number for the control section is IM-2-094(043)289. The bridge begins at Station 5353+74 and ends at Station 5355+05.

The National Bridge Number is 94-290.803L-3. The bridge was constructed in May of 2000 and the contractor was Industrial Builders Inc.

The type of reinforcing steel used within the bridge deck was epoxy coated rebar.

Material

The following statements are from the manufacturers literature.

Nuovinox 316L is available in Grades 300 MPa, 420 MPa & 520 MPa (Grades 40, 50 & 75) and conforms to ASTM A 615 and ASTM A 955. The outer stainless layer is made from 316L which is an austenitic chrome nickel alloy with Molybdenum. The composition of the inner core can vary depending on the application, for example the Grade size.

The stainless steel clad rebar is made through a patented green process which results in a metallurgical bond during hot-rolling between its outer stainless steel cladding and its carbon steel core. The process is unique in the fact that the cladding is not installed after the bar

is made but rather at the point of its conception. Stainless coil is progressively made into a stainless steel pipe and then plasma welded. The pipes are cut to length and processed high tensile steel turnings are compressed into the interior of the pipe by a 400-t. press. The ends of the pipe are crimped and the resulting billets are fed through a walking beam furnace. When the billet reaches a certain temperature, the billet is rolled. The stainless steel cladding is evenly deposited along the surface and metallurgically bonded to the inner carbon steel core.

The rebar has a corrosion threshold of over 7 kg/cu.m chloride level and is expected to have a 75-100 year life. Epoxy coated rebar has a corrosion threshold of 0.7 - 1.2 kg/cu.m.

An average stainless steel clad thickness is 0.8mm. It is available in the size range of 13 mm (No. 4) to 32 mm (No. 10). Stelax produces Nuovinox 316L in diameters of 5/8 inch to 1.5 inches. The length available is from 20 ft to 38 ft long. Nuovinox rebar is also offered in fully fabricated form to the cutting and bending required, with ends sealed.

Nuovinox has a shear strength between the core and cladding of 300 Mpa when tested according to ASTM A 263-88. It is fatigue tested to 2 million cycles (150 Mpa - 275 Mpa) with no impairment to the metallurgical bond.

Ends can be sealed by welding or by application of stainless steel or plastic caps pre-filled with a suitable sealant.

Testing Performed

Stelax conducted tests on their rebar. Their certificates are based on laboratory tests on regular batch samples taken from different rollings. All tests performed passed the required specifications. These results are found in Appendix B.

Midwest Industrial X-Ray, Inc. located in Fargo, North Dakota tested a sample #5 stainless steel clad rebar. A tensile, microetching and chemical spectrographic test was performed. The tensile test was completed per ASTM A2633,10. The microetching test was completed per ASTM E 488-18. The chemical spectrographic test was completed per ASTM E415-95a and ASTM E 1019-94. All tests passed the required specifications. Appendix C gives the results of these tests.

Cost

The following is a breakdown of the costs associated with the stainless steel clad rebar. The fabrication includes the cutting and bending of the rebar by the supplier.

Structural Rebar 44,000 pounds

Rebar is $0.59 per pound

Fabrication is $0.12 per pound

Freight estimated at $2,000.00

Total cost of Material: $33,240.00

The following are costs associated with the control structure using the epoxy coated rebar. The total cost includes fabrication.

Structural Rebar 40,942 pounds

Rebar is $0.74 per pound

Total cost of Material: $30,297.08

Construction

Site Visit 1.

An on-site evaluation was performed on June 4, 2001 to visually inspect the stainless steel clad rebar. The findings are as follows:

A. Bent bars are not uniformly bent.

B. Bent bars supplied are not fabricated to dimensions detailed in the project plans. The "k" bar legs are too long. This may require cutting of the bars and subsequent treatment such as capping or welding. Depending on the locations of the bars, this may result in an increase in contractor labor.

C. No. 5 bars were substituted for No. 4bars in shipping.

D. Bent bars do not show signs of cracking or wrinkling of cladding at the bends.

E. The inner carbon steel bars appear to be wrapped with stainless steel cladding. Possible variations in diameter of the inner carbon steel bar may result in a raised seam in the cladding

material. See Photo 3. Damage to this seam produces an opening in the stainless steel cladding and entry point for moisture and corrosive materials to come into contact with the carbon steel bar.

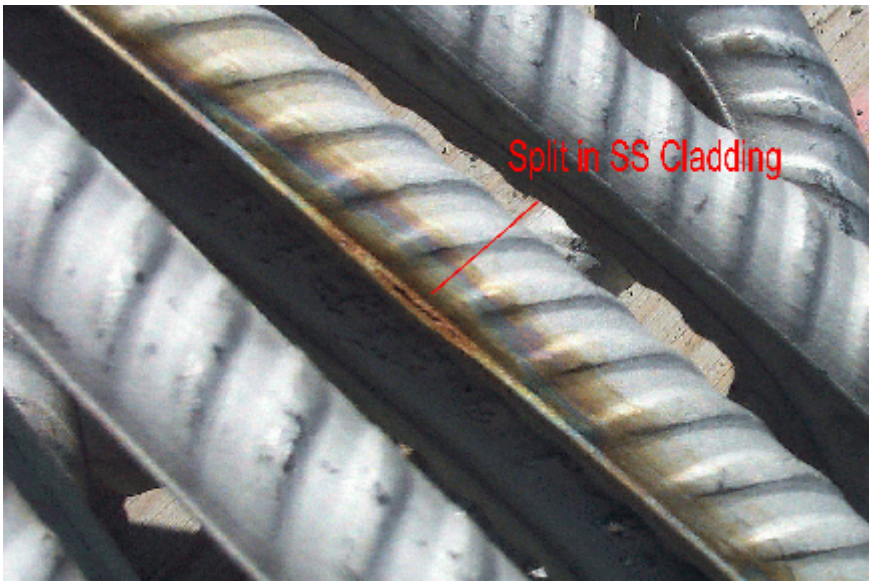


Photo 2. Split in Stainless Steel Cladding (Notice the raised seems)

F. Cuts and breaks were identified in the stainless steel cladding which exposes the inner carbon steel bar. See Photo 2, 3 and 4.

It was also noted that the stainless steel clad rebar was shipped on flatbeds and was strapped on by chains. Stelax Limited had specified that chains were not to be used by the hauling companies. As a result of the chains, some rust residue had formed on the rebar.

Photo 3. Cut in Stainless Steel Cladding

Photo 4. Split in Stainless Steel Cladding near a bend

The Valley City District personnel identified 30 k-type bent bars that were damaged. Stelax provided a welding procedure (compiled by a welding engineer in Alberta Canada) for repair of the damaged bars. The welding procedure for end-sealing and cladding repair of 316L Nuovinox rebar was in accordance with DIN 1733; 1736; and DIN 8556 for welding stainless steel clad plate.

Site Visit 2

An on-site evaluation of the stainless steel clad rebar being placed in the bridge deck was conducted on June 14, 2001. See Photos 5 & 6.

Photo 5. Bridge Deck Forms

Photo 6. Placement of Stainless Steel Clad Rebar

The following was observed from the site visit:

A. The k bars were cut to proper lengths as specified in plans and end welded. See Photo 7.

B. All damaged rebar were welded to prevent unnecessary corrosion from occurring. See Photo 8.

C. All spacers, tie bars and material used within the bridge deck was that of stainless steel.

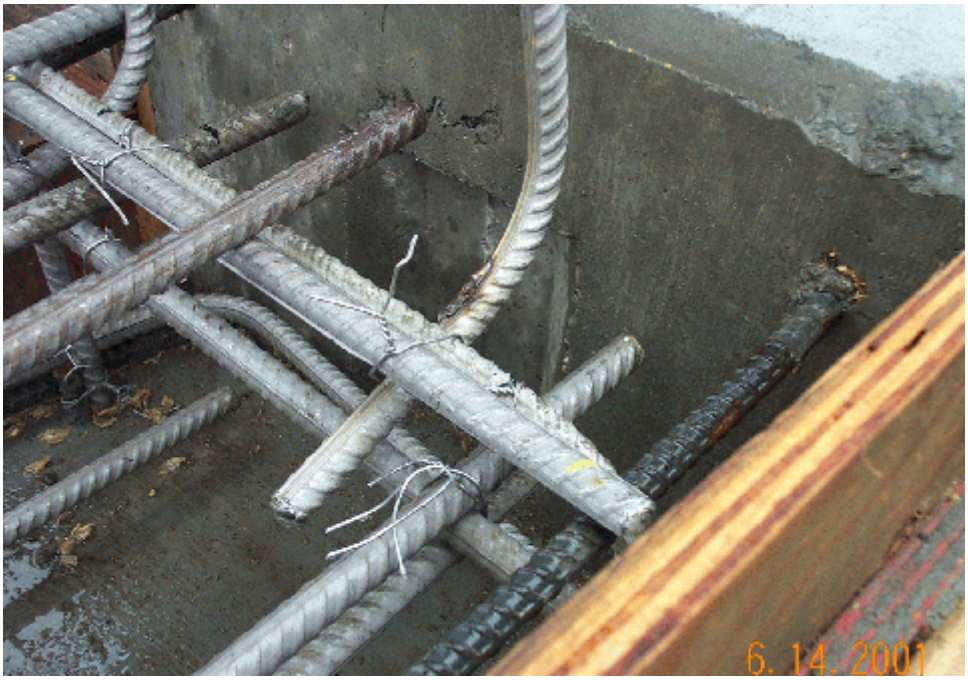


Photo 7. k-type bar cut and welded

Photo 8. Split rebar welded

The bridge deck was poured June 15, 2001. See Photos 9 & 10.

Photos 11 & 12 show the completed bridge deck.

Progress of the bridge deck will continue to be monitored. Visual inspection will be conducted to further study the use of stainless steel clad rebar.

Photos 13-15 depicts the construction and final product of the control bridge with epoxy steel.

Photo 9. Bridge deck being poured

Photo 10. Bridge deck being poured

Photo 11. Finished bridge deck

Photo 12. Side view of finished bridge deck

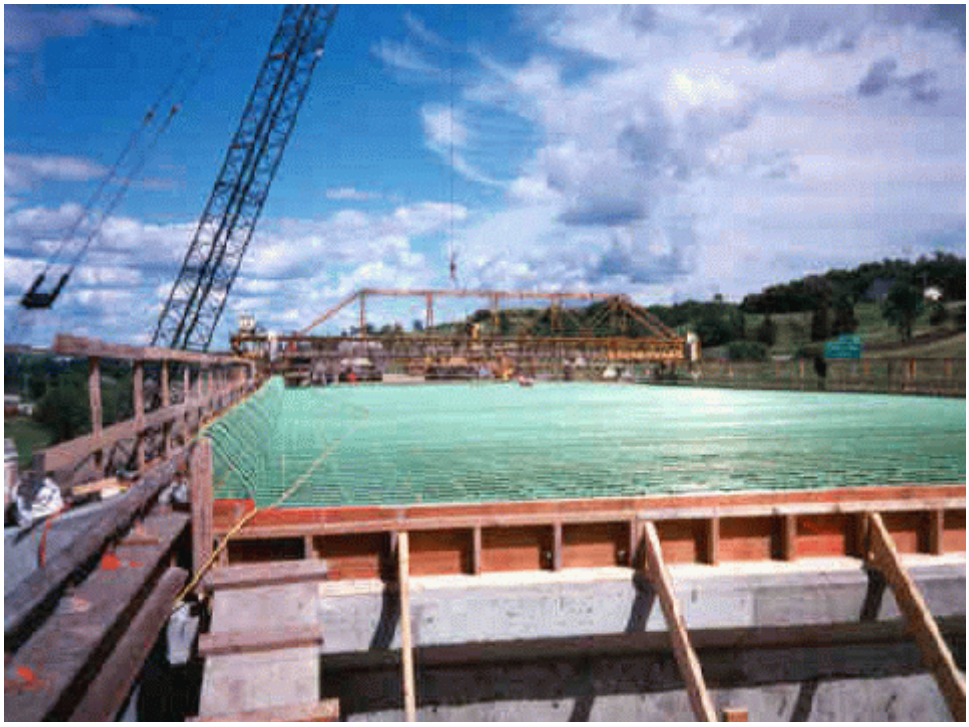


Photo 13. View of the control section bridge deck (epoxy coated rebar)

Photo 14. View of the control section bridge deck being poured

Photo 15. View of the control section bridge deck

Evaluation

The project will be evaluated at five, ten, fifteen, and twenty years.

Evaluation of the West Valley City Interchange bridge will be compared to the control structure.

Summary

Comments from Mike Flaagen, NDDOT project engineer:

1. If we continue to use this material, we need to learn more about its characteristics. We need to know how to accept it in the field and look for irregularities in the coating.

2. The supplier should do a better job of bending the bars to the correct dimensions. Many of the bent bars were not exactly bent to the dimensions shown in the plans. This mainly affected installation because the bars were tougher to fit in place. In some cases the contractor had to cut bars to the correct length and cap them.

Other than these comments, Mike Flaagen reported that no other differences were noticed in construction using the stainless steel clad rebar.

Appendix A

BILL OF REINFORCING STEEL, GRADE 60

LETTER PREFIX OF BAR MARK DENOTES SHAPE ~ SEE BAR DETAILS

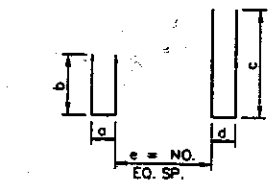
FROM REGION	STATE	FEDERAL AID PROJECT NUMBER	SHEET NO.
8	NO	IM-2-094(011)289	

LOCATION	SIZE	MARK	NO. EACH /SET	NOMINAL LENGTH	DETAILING DIMENSIONS a	b	c	d	e	f	g	h	k
ABUTMENTS	5	A100	28	59'-8"		59'-8"							
	5	A101	8	10'-0"		10'-0"							
	5	A102	32	6'-0"		6'-0"							
	5	C100	4	17'-8"		8'-0"	1'-8"	8'-0"					
	5	C101	38	16'-0"		7'-2"	1'-8"	7'-2"					
	5	C102	48	14'-2"		5'-4"	1'-8"	7'-2"					
	4	C103	72	2'-8"		8"	1'-8"	8"					
	4	C104	48	4'-2"		1'-3"	1'-8"	1'-3"					
	5	D100	8	10'-4"		2'-3"	8'-1"					12	3
	5	SC100	4	120'-4"	8"	6'-1"	7'-10"	1'-7"	7				
PIERS	9	A200	8	34'-2"		34'-2"							
	5	A201	20	34'-2"		34'-2"							
	8	A202	10	34'-2"		34'-2"							
	8	A203	72	15'-10"		15'-10"							
	4	A204	12	39'-2"		39'-2"							
	4	A205	10	39'-2"		39'-2"							
	4	C200	4	7'-8"		1'-2"	5'-4"	1'-2"					
	4	C201	84	3'-2"		6"	2'-2"	6"					
	4	N200	68	16'-4"	2'-2"	5'-6"	6"					0	12
	4	N201	66	9'-8"	2'-2"	2'-2"	6"					0	12
	4	N202	16	10'-10"	2'-2"	2'-9"	6"					0	12
	8	R200	10	39'-10"	2'-9"	34'-4"	2'-9"		12	7.2		12	7.2
	5	R201	2	5'-1"	2'-8"	1'-2"	1'-3"		12	7.2		0	12
	5	R202	2	5'-2"	2'-8"	1'-3"	1'-3"		12	7.2		0	12
	4	SA200	4	111'-3"	35'-11"	38'-3"			2				
	5	SN200	2	93'-4"	2'-2"	1'-4"	6"	2'-8"	9				
	5	SN201	2	315'-0"	2'-2"	2'-10"	6"	3'-1"	27				
	5	SN202	2	317'-4"	2'-2"	2'-11"	6"	3'-1"	27				
	5	SN203	2	94'-2"	2'-2"	1'-4"	6"	2'-9"	9				

LOCATION	SIZE	MARK	NO. EACH /SET	NOMINAL LENGTH	DETAILING DIMENSIONS a	b	c	d	e	f	g	h	k
SUPERSTRUCTURE STAINLESS STEEL CLADDED	5	YA500	329	42'-2"		42'-2"							
	5	YA501	64	16'-6"		16'-6"							
	5	YA502	64	28'-6"		28'-6"							
	5	YA503	18	42'-4"		42'-4"							
	6	YA504	8	37'-10"		37'-10"							
	6	YA505	2	31'-8"		31'-8"							
	6	YA506	10	3'-8"		3'-8"							
	4	YA507	40	3'-8"		3'-8"							
	5	YB500	86	6'-3"		2'-3"	4'-0"						
	5	YB501	38	4'-11"		1'-11"	3'-0"						
	4	YB502	80	2'-11"		1'-0"	1'-11"						
	5	YC500	20	7'-7"	1'-6"	3'-7"	1'-6"	6"				12	1.06
	4	YC501	50	7'-7"	2'-3"	1'-1"	2'-3"	1'-0"				12	0
	4	YC502	25	6'-4"	1'-11"	6"	1'-11"	1'-0"				12	0
	5	YK500	262	4'-11"	1'-4"	8"	11"	8"	1'-0"	2.5"	8"	8.5	12
	5	YL500	262	5'-0"	3"	2'-2"	8"	2'-2"		2.5"		12	1.25
	5	YN500	8	7'-10"	1'-11"	1'-6"	6"					12	1.06
	5	YP500	86	4'-8"	5"	2'-1"	1'-4"			1.25"	10"	12	6.5
	5	YAA500	59	134'-8"		60'-0"	2'-0"	14'-8"	2		130'-8"		
	5	YAA501	12	133'-8"		60'-0"	1'-6"	13'-8"	2		130'-8"		
	5	YSA500	2	74'-10"	3'-2"	34'-3"			3				
	5	YSA501	2	126'-6"	2'-3"	39'-11"			5				

NOTES:

1. FABRICATION AND TOLERANCES SHALL BE IN ACCORDANCE WITH THE CRSI MANUAL OF STANDARD PRACTICE.
2. ALL DIMENSIONS ARE OUT TO OUT OF BARS.
3. NOMINAL LENGTH OF EACH BENT BAR OR CUT BAR IS THE SUM TOTAL OF THE DETAILING DIMENSIONS FOR THAT BAR, UNLESS OTHERWISE NOTED.
4. ADJACENT "AA" BARS SHALL BE TURNED END FOR END SO THAT THE SPLICE LOCATIONS ARE STAGGERED.
5. THE "r" DIMENSION INDICATES THE RADIUS.
6. A "Y" PRECEDING A BAR DESIGNATION INDICATES A STAINLESS STEEL CLAD BAR.



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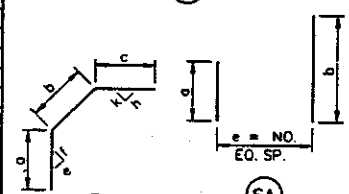
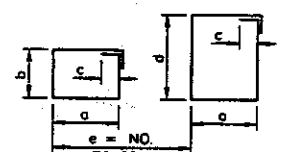
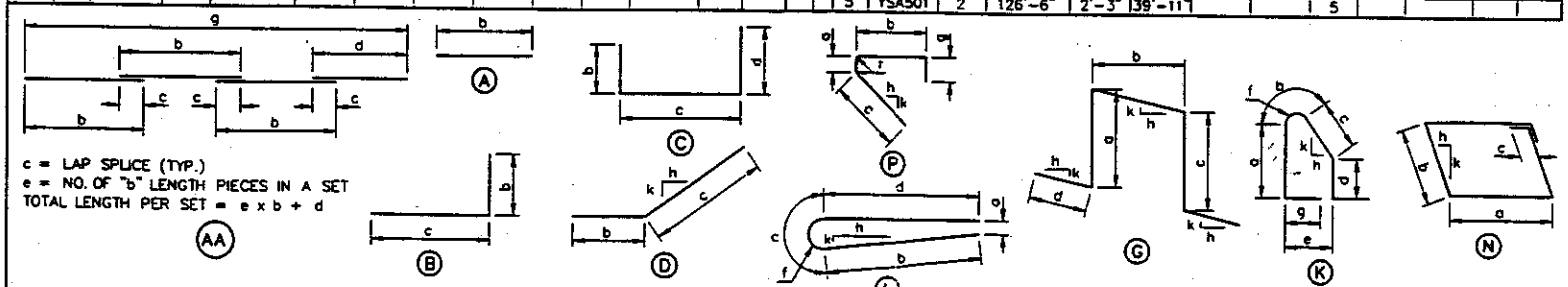


R SA



SN



c = LAP SPLICE (TYP.)
e = NO. OF "b" LENGTH PIECES IN A SET
TOTAL LENGTH PER SET = e x b + d

WEST VALLEY CITY INTERCHANGE

(EAST BOUND)

REINFORCING BAR LIST & DETAILS

94-290.803R-11

REBAR 00DLS3 BWR

c:\dgn\walleysouth\rebar.dgn Jan. 21, 2000 11:51:19

Appendix B

FAX

STELAX (UK) LIMITED
The Wern Works,
Briton Ferry
Neath, SA11 2JX
South Wales, UK

Ph: +44 1639 820 666
Fx: +44 1639 813 020
www.stelax.com
email: nino@stelax.com

TO: Mr Tom Bold-NDDOT
From: Nino Cacace.
Fax:701-328-6913
Date: 11-06-01

Dear Tom,

Re : Test Certificates & bars to be repaired.
Please find attached 2 relevant test certificates. These certificates are based on our laboratory tests on regular batch samples taken from different rollings as per attached typical laboratory reports.

We were surprised and apologise for the 30 odd faulty bars shipped to you, which to us is a high number of rejects.

We rolled these bars last year in November/December before we could install our double-roller guide boxes, which is standard rolling practice for the final rolling stand (where the notches are formed) which ensures that the bar being rolled is centrally fed into the rolls very precisely. Any mis-guiding will cause the bar to be "pinched" on the one side along the longitudinal rib, presenting with a continuous or intermittent "flashing" on that side. Although not desirable in conventional rebar, cladded rebar is more delicate during hot rolling because of the potential damage to the ss-cladding. Our rollings subsequent to January have however been with these double-roller guides and have in effect eliminated the problem.

Most of the North Dakota contract was acid-descaled through our new acid-descaling plant which we commissioned late last year. Our final quality control inspections are now carried out at least 2 days after acid-descaling has been completed allowing time for cladding faults to become visible. Our only explanation due to lack of experience in that the initial batches out of our new system, were inspected too soon after acid descaling, and hence our inspectors would have missed these cladding faults.

We can assure you that our present rollings have extremely few rejects which are mostly completely predictable from rolling conditions (such as temperature or a loose guide in the mill which requires tightening).
We can now guarantee 100% reject-free despatches with our now greater experience in the final quality control inspection after acid descaling.

Yours sincerely,

Nino

Stelax (UK) Ltd

The Wern Works, Briton Ferry, Neath
West Glamorgan, SA11 2JX, Wales, UK
Telephone: 01639 820666 Fax: 01639 813020

CERTIFICATE OF TESTS

ANY RECIPIENT OF A COPY OF A TEST CERTIFICATE WITHOUT THE EMBOSSED STELAX SEAL SHOULD ENSURE THAT IT IS A TRUE AND ACCURATE REPRODUCTION OF THE ORIGINAL.

CERTIFICATE NO: D016 DATE: 12/02/01

CUSTOMER ORDER NO:	DATE:	ORDER NO:	INSPECTION:
E11406	12/02/01		

SOLD TO:
Industrial Builders Inc.
PO Box 405, Fargo,
North Dakota. 58107
Ph: 701-282 4977

CONSIGNED TO:
Incustrial Builders Inc.
1307, County Road
17, North,
West Fargo,
North Dakota. 58078

SPECIFICATION: See attached Nouvinox re-bar specification

PRODUCT: Nuovinox SS 316L Clad carbon steel re-bar
Grade of stainless steel : 316L : ASTM A240 0/97 ASME SA240 0/98

ITEM NO	NO	DIMENSIONS	WT KGS	CAST NO	PIECE NO	YS RE 0.2%	TENSILE U.T.S R.M ksi	ELON %	R.C.A %	B.H.N	CHARPY V NOTCH IMPACT INDIVIDUAL		BEND TEST
1	3	16mm		L0771		504	729	20			N/A	N/A	Satisfactory

SURFACE SMOOTHNESS: Commercial Finish

MACRO STRUCTURE SATISFACTORY
MICRO STRUCTURE SATISFACTORY

CAST NO	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Cu	N	Co
L0771	0.02	0.41	1.31	0.03	0.002	16.61	2.11	10.05			0.034	

COMPANY SEAL

THE RESULTS ARE CERTIFIED AND COMPLY WITH REQUIREMENTS RELEVANT TO THE PRODUCT DESCRIPTION

NOTES THIS MATERIAL IS FREE FROM MERCURY CONTAMINATION
THIS MATERIAL HAS NOT BEEN REPAIR WELDED

CORROSION TESTED TO A262 PRACTICE E SATISFACTORY

Q.A. MANAGER

B-2

B-3

Stelax (UK) Ltd

The Worn Works, Briton Ferry, Neath
West Glamorgan, SA11 2JX, Wales, UK
Telephone: 01639 820668 Fax: 01639 813020

CERTIFICATE OF TESTS

ANY RECIPIENT OF A COPY OF A TEST CERTIFICATE WITHOUT THE EMBOSSED STELAX SEAL SHOULD ENSURE THAT IT IS A TRUE AND ACCURATE REPRODUCTION OF THE ORIGINAL.

CERTIFICATE NO: D015 DATE: 5th JAN. 2001

CUSTOMER ORDER NO: E11408

DATE: 5th JAN. 2001

ORDER NO:

INSPECTION:

SPECIFICATION: See attached Nouvinox re-bar specification

SOLD TO:
Industrial Builders Inc.
PO Box 406, Fargo,
North Dakota. 58107
Ph: 701-282 4977

CONSIGNED TO:
Industrial Builders Inc.
1307, County Road
17, North,
West Fargo,
North Dakota. 58078

PRODUCT: Nuovinox SS 316L Clad carbon steel re-bar
Grade of stainless steel : 316L : ASTM A240 0/97 ASME SA240 0/98

ITEM NO	NO	DIMENSIONS	WT KGS	CAST NO	PIECE NO	YS RE 0.2%	TENSILE U.T.S R.M ksi	ELON %	R.C.A %	B.H.N	CHARPY V NOTCH IMPACT INDIVIDUAL		BEND TEST
1	3	20mm		L0771		549	802	18			N/A	N/A	Satisfactory
2	3	16mm		L0771		504	729	20			N/A	N/A	Satisfactory

SURFACE SMOOTHNESS: Commercial Finish

MACRO STRUCTURE SATISFACTORY
MICRO STRUCTURE SATISFACTORY

CAST NO	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Cu	N	Co
L0771	0.02	0.41	1.31	0.03	0.002	16.61	2.11	10.05			0.034	

COMPANY SEAL

THE RESULTS ARE CERTIFIED AND COMPLY WITH REQUIREMENTS RELEVANT TO THE PRODUCT DESCRIPTION

NOTES THIS MATERIAL IS FREE FROM MERCURY CONTAMINATION
THIS MATERIAL HAS NOT BEEN REPAIR WELDED

CORROSION TESTED TO A262 PRACTICE E SATISFACTORY

Q.A. MANAGER

STELAX (U.K.) Ltd.
LABORATORY TEST REPORT
Q.C.F. 6

SAMPLE INFORMATION

Sample Number:- AA 027
Part Number:- T.B.A.
Batch Number:- N / A

Rolling date:- 01-12-00
Description:-16mm Nuovinox Re-bar

TEST RESULTS

TEST	SPEC	RESULT	PASS / FAIL
Dimensional			
Bar diameter	15.90mm	16.95mm	pass
Gap	6.10mm max	2.71mm	pass
Notch height	0.71mm min	0.83mm	pass
Notch spacing	11.10mm max	10.59mm	pass
Notch angle	45° min	54°	pass
Tensile			
Yield strength	420MPa min	546MPa	pass
Ultimate tensile strength	620MPa min	792MPa	pass
Elongation %	9% min	13%	pass
Weight			
Kg / M	1.567Kg/$_M$ (nominal)	1.946Kg/$_M$	pass
Bend test	No cracking of clad on Outside radius. No Wrinkling of clad on Inside radius.	No cracks	pass
		No wrinkling	pass
Cladding			
Thickness	175um min	0.85mm min	pass
Bonding	No cracks / delaminating	No cracks / delaminating	pass

Comments:-

Note:- Bend test must be performed against longitudinal rib.

Date:- 19-12-00

Signed:- _____
(Laboratory Supervisor)

Report N° 00035

STELAX (U.K.) Ltd.
LABORATORY TEST REPORT
Q.C.F. 6

SAMPLE INFORMATION

Sample Number:- AA 026
Rolling date:- 01-12-00
Part Number:- T.B.A.
Description:-16mm Nuovinox Re-bar
Batch Number:- N / A

TEST RESULTS

TEST	SPEC	RESULT	PASS / FAIL
Dimensional			
Bar diameter	15.90mm	17.00mm	pass
Gap	6.10mm max	3.13mm	pass
Notch height	0.71mm min	0.88mm	pass
Notch spacing	11.10mm max	10.66mm	pass
Notch angle	45° min	54°	pass
Tensile			
Yield strength	420MPa min	541MPa	pass
Ultimate tensile strength	620MPa min	810MPa	pass
Elongation %	9% min	22%	pass
Weight			
Kg / M	1.567Kg/M (nominal)	1.993Kg/M	pass
Bend test	No cracking of clad on Outside radius. No Wrinkling of clad on Inside radius.	No cracks	pass
		No wrinkling	pass
Cladding			
Thickness	175um min	0.80mm min	pass
Bonding	No cracks / delaminating	No cracks / delaminating	pass

Comments:-

Note:- Bend test must be performed against longitudinal rib.

Date:- 19-12-00 Signed:- _____
(Laboratory Supervisor)

Report N° 00034

STELAX (U.K.) Ltd.
LABORATORY RE-BAR TEST
RECORD SHEET
Q.C.F. 5-1

Batch Number:- N/A	Bar Number:- LAST OFF
Part Number:- T.B.A.	Description:- 16mm Nuovinox Re-Bar

TEST	SPECIN	RESULT	PASS / FAIL
Bar diameter	15.90mm	17.05 mm	Pass
Gap	6.10mm max.	2.99 mm	"
Notch height	0.71mm min.	0.81 mm	"
Notch spacing	11.10mm max.	10.65 mm	"
Notch angle	45° min.	54°	"
Yield strength	420 MPa min.	549 MPa	Pass
U.T.S.	620 MPa min.	802 MPa	"
Elongation %	9% min.	18%	"
Weight ($Kg/_M$)	1.567$Kg/_M$ (nominal).	2.000 Kg/m	Pass
Bend test	No cracking of clad on outside radius. No wrinkling of clad on inside radius.	NO CRACKS NO WRINKLING	Pass
Clad thickness	175 um min.	0.70 mm min	Pass
Clad bonding	No cracks / delaminating.	NO CRACKS NO DELAMINATION	"

Comments:-

Satisfactory

Date:- 03-11-00 Signed:- _____
(Laboratory Technician)

Report N° A00038

STELAX (U.K.) Ltd.
LABORATORY RE-BAR TEST
RECORD SHEET
Q.C.F. 5-2

Batch Number:- N/A	Bar Number:- 25
Part Number:- T.B.A.	Description:- 19mm Nuovinox Re-Bar.

TEST	SPEC'N	RESULT	PASS / FAIL
Bar diameter	19.10mm (Nominal)	20.00 m.m	Pass
Gap	7.30mm max.	3.58 m m	"
Notch height	0.97mm min.	1.28 m m	"
Notch spacing	13.30mm max.	11.93 m m	"
Notch angle	45° min.	54°	"
Yield strength	420 MPa min.	507 MPa	Pass
U.T.S.	620 MPa min.	694 MPa	"
Elongation %	9 % min.	20 %	"
Weight (Kg/M)	2.236Kg/M (nominal).	2.617Kg/m	Pass
Bend test	No cracking of clad on outside radius. No wrinkling of clad on inside radius.	NO CRACKS NO WRINKLING	Pass
Clad thickness	175 um min.	0.80 m m MIN	Pass
Clad bonding	No cracks / delaminating.	NO CRACKS NO WRINKLING	"

Comments:-

Satisfactory

Date:- 13 - 11 - 00 Signed:- [signature]

(Laboratory Technician)

Report N° A00007

STELAX (U.K.) Ltd.
LABORATORY TEST REPORT
Q.C.F. 6

SAMPLE INFORMATION

Sample Number:- AA 028

Rolling date:- 01-12-00

Part Number:- T.B.A.

Description:-16mm Nuovinox Re-bar

Batch Number:- N / A

TEST RESULTS

TEST	SPEC	RESULT	PASS / FAIL
Dimensional			
Bar diameter	15.90mm	16.88mm	pass
Gap	6.10mm max	2.50mm	pass
Notch height	0.71mm min	0.87mm	pass
Notch spacing	11.10mm max	10.62mm	pass
Notch angle	45° min	54°	pass
Tensile			
Yield strength	420MPa min	547MPa	pass
Ultimate tensile strength	620MPa min	802MPa	pass
Elongation %	9% min	13%	pass
Weight			
Kg / M	1.567Kg/$_M$ (nominal)	2.000Kg/$_M$	pass
Bend test	No cracking of clad on Outside radius. No Wrinkling of clad on Inside radius.	No cracks No wrinkling	pass pass
Cladding			
Thickness	175um min	0.95mm min	pass
Bonding	No cracks / delaminating	No cracks / delaminating	pass

Comments:-

Note:- Bend test must be performed against longitudinal rib.

Date:- 08-12-00

Signed:- _____
(Laboratory Supervisor)

Report N° 00036

Appendix C

MIDWEST
INDUSTRIAL X-RAY, INC.
FARGO, ND

TELEPHONE (701) 282-7846
FAX (701) 282-6711

Midwest Industrial X-Ray, Inc.

NONDESTRUCTIVE TESTING

P.O. BOX 133 - 4032 - 7TH AVENUE NORTH
FARGO, NORTH DAKOTA 58107

- RADIOGRAPHY
- ULTRASONIC
- LIQUID PENETRANT
- MAGNETIC PARTICLE
- WELDER CERTIFICATION & QUALITY ASSURANCE
- METALLURGICAL INVESTIGATIONS
- STRESS RELIEVING
- X-RAY

BRANCH OFFICES
—
MINNEAPOLIS, MN
COUNCIL BLUFFS, IA

REPORTED TO: N.D. DOT
Fargo, ND

INVOICED TO:
Same

PROJECT NAME AND LOCATION:	PROJECT NO.:	INVOICE DATE:	INVOICE NUMBER
# 5 Stainless Steel Rebar		6/20/01	9135

DESCRIPTION:	AMOUNT:
Tensile Test Microetch Spectrographic	$171.00
All accounts due on the 10th of month following purchase. A finance charge of 1 1/2 % will be made on accounts over 30 days past due, which is an annual percentage rate of 18%	Pay last amount in this column
ITEM	
7.3.12	
Tensile Test	
1 @ $18.00 / test	$18.00
8.5 Microetch	
8.5.1 Microetch Analysis	
1 @ $28.00 / each	$28.00
8.6 Chemical Spectrographic	
8.6.1 Analysis	
1 @ $125.00 / each	$125.00
PLEASE PAY FROM THIS INVOICE & RETURN YELLOW COPY.	
Thank you. TOTAL:	$171.00

MIDWEST
INDUSTRIAL X-RAY, INC.
FARGO, ND

TELEPHONE (701) 282-7846
FAX (701) 282-6711

Midwest Industrial X-Ray, Inc.

NONDESTRUCTIVE TESTING

P.O. BOX 133 • 4032 - 7TH AVENUE NORTH
FARGO, NORTH DAKOTA 58107

- RADIOGRAPHY
- ULTRASONIC
- LIQUID PENETRANT

BRANCH OFFICES

MIDWEST
INDUSTRIAL X-RAY, INC.
FARGO, ND

TELEPHONE (701) 282-7846
FAX (701) 282-6711

Midwest Industrial X-Ray, Inc.

NONDESTRUCTIVE TESTING

P.O. BOX 133 • 4032 - 7TH AVENUE NORTH
FARGO, NORTH DAKOTA 58107

- RADIOGRAPHY
- ULTRASONIC
- LIQUID PENETRANT
- MAGNETIC PARTICLE
- WELDER CERTIFICATION & QUALITY ASSURANCE
- METALLURGICAL INVESTIGATIONS
- STRESS RELIEVING
- X-RAY

BRANCH OFFICES

MINNEAPOLIS, MN
COUNCIL BLUFFS, IA

Date: 6/20/01

Test For: N.D. DOT

Material: #5 plated rebar

Base Dimensions and Loading

Sample:	Diameter (in)	Yield (lbf)	Ultimate (lbf)
1	0.625	25800	38500

Stress:	Area (in^2)	Yield (psi)	Ultimate (psi)
1	0.3068	84095	125490

Elongation:	Base (in)	Final (in)	%
1	8.00	9.50	18.8

Platting range of thickness: .031 - .127 inch

MIDWEST
INDUSTRIAL X-RAY, INC.
FARGO, ND

TELEPHONE (701) 282-7846
FAX (701) 282-8711

Midwest Industrial X-Ray, Inc.

NONDESTRUCTIVE TESTING
P.O. BOX 133 - 4032 - 7TH AVENUE NORTH
FARGO, NORTH DAKOTA 58107

- RADIOGRAPHY
- ULTRASONIC
- LIQUID PENETRANT
- MAGNETIC PARTICLE
- WELDER CERTIFICATION & QUALITY ASSURANCE
- METALLURGICAL INVESTIGATIONS
- STRESS RELIEVING
- X-RAY

BRANCH OFFICES
—
MINNEAPOLIS, MN
COUNCIL BLUFFS, IA

Date: 6-20-01

Test For:

Material: #5 plated rebar

Base Dimensions and Loading

Sample:	Diameter (in)	Yield (lbf)	Ultimate (lbf)
1	0.625	25800	38500
Stress:	Area (in2)	Yield (psi)	Ultimate (psi)
1	0.3068	84095	125490
Elogation:	Base (in)	Final (in)	%
1	8.00	9.50	18.8

Platting range of thickness: .031 - .127 inch

Microetching: ASTM E 488-18

Tensile ASTM A2633,10

MIDWEST
INDUSTRIAL X-RAY, INC.
FARGO, ND

TELEPHONE (701) 282-7846
FAX (701) 282-6711

Midwest Industrial X-Ray, Inc.

NONDESTRUCTIVE TESTING

P.O. BOX 133 - 4032 - 7TH AVENUE NORTH
FARGO, NORTH DAKOTA 58107

- RADIOGRAPHY
- ULTRASONIC
- LIQUID PENETRANT
- MAGNETIC PARTICLE
- WELDER CERTIFICATION & QUALITY ASSURANCE
- METALLURGICAL INVESTIGATIONS
- STRESS RELIEVING
- X-RAY

BRANCH OFFICES
—
MINNEAPOLIS, MN
COUNCIL BLUFFS, IA

Report to: N.D. DOT
Fargo, ND

Date: 6/20/01

Subject: Chemical analysis of sample received June 7, 2001

Sample Identification / Description: Steel Sample

Chemical Composition:

	%
Carbon	0.330
Manganese	0.990
Phosphorus	0.010
Sulfur	0.051
Silicon	0.230
Nickel	0.170
Chromim	0.240
Molybdenum	0.050
Copper	0.160
Aluminum	0.034

Test Method: Carbon per ASTM E1019-94; Others per ASTM E415-95a

C-4

Appendix D

FAX

STELAX (UK) LIMITED
The Wern Works,
Briton Ferry
Neath, SA11 2JX
South Wales, UK

Ph: +44 1639 820 666
Fx: +44 1639 813 020
www.stelax.com
email: nino@stelax.com

TO: Mr Tom Bold-NDDOT
From: Nino Cacace.
Fax:701-328-6913
Date: 6-06-01

Dear Tom,

Re : Your e-mail of the 6-6-01

We inspect all Nuovinox bars 100% before dispatch.

All bars especially bent bars are acid-pickled as a final step prior to inspection.

We regret the inconvenience and are standing by to receive your requirements in replacement bars which we shall courier to you.

Attached is a welding procedure, compiled for us by a welding engineer in Alberta.

Yours sincerely,

Antonino Cacace.

Welding Procedure for End-Sealing and Cladding Repair 316L Nuovinox Rebar in Accordance With DIN 1733; 1736; and DIN 8556 for Welding Stainless-Steel Clad Plate.

1.0 PURITY & WELD PREPARATION.

1.1 At all times contamination from Carbon Steel must be avoided such as dragging Nx bars across carbon steel material or worktops. Weld flattening, Pick Hammers and brushes for finishing the weld must be stainless steel.

1.2 Avoid contamination from sulfur . Grinding and Cutting Discs with sulfur free binder must be employed (Synthetic Resin Bonding) when cutting or grinding.

1.3 Weld Area must be cleaned and all rust or flashings removed. No oil or grease must be present.

2.0 PREHEATING.

2.1 No Pre-heating is required.

3.0 WELDING PROCESS.

3.1 TIG welding with cold wire and a straight Argon shield @ 35CFM.

4.0 END SEALING.

4.1 A 2-Layer welding procedure is required to avoid possibility of weld dilution by the carbon steel core at the surface of the end-seal.

4.2 The initial "Buffer Layer" should be with a 309L wire of diameter 3/32" (ER309L ASME SFA 5.9) and a setting of 55AMPS.

4.3 The final layer is to be 316L (ER316L ASME SFA5.9) with a diameter 1/16" and a setting of 55AMPS

The welding technique is to initiate at the outside circumference of the cross section ; gradually spiraling from the outside to the centre until fully welded.

5.0 CLADDING REPAIRS:

5.1 Hair-line cracks should be repaired with a single welding layer of 316L 1/16" diameter & a setting of 35AMPS. All other settings remain the same.

6.0 POST HEAT-TREATMENT.

6.1 None.

7.0 WELD-SEAM AFTER-TREATMENT.

7.1 Wire brushing.

8.0 INSPECTION.

8.1 Visual for pin-holes.

Approved by :

W. Hamilton P.Eng.

Hamilton Engineering
12203-41 Ave. NW
Edmonton.
Alberta T65 0V6