CITY OF EDMONTON

EVALUATION OF ANCHOR BOLT REPAIRS

Prepared By: Ball Associates Engineering Ltd.

AUGUST 1, 1996

City of Edmonton

Evaluation of Anchor Bolt Repairs

August 2, 1996
Our File: 15438-2

Ball Associates Engineering Ltd.
#1, 9816 - 47 Avenue Edmonton, Alberta T6E 5P3
Telephone: (403)436-4112 Fax: (403)434-9983

REFERENCE

City of Edmonton Purchase Order: P866617-22

At the request of Mr. J. Mundy, an investigation was undertaken to evaluate repair procedures being used for lamp standard anchor bolts. New style anchor bolts use a proprietary coupler connection to rebuild failed bolts. Old style anchor bolts are repaired by welding. This study was to evaluate repair procedures for the old style bolts.

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CONCLUSIONS

1. Anchor bolts can be repaired to a manageable level of safety by welding reconstruction.

2. Anchor bolts previously repaired by welding should be considered susceptible to failure.

Recommendations are given in the DISCUSSION portion of this report.

PROFESSIONAL ENGINEER ALBERTA
B. E. BALL

PERMIT TO PRACTICE
BALL ASSOCIATES ENGINEERING LTD.
Signature [signature]
Date 6/8/96
PERMIT NUMBER: P 3382
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

EXAMINATION

For my examination, I had discussions with City of Edmonton personnel from the Transportation and Public Works Department. The following information was revealed.

1. In the past, 1 ½ inch diameter anchor bolts have been fabricated from CSA G30.12 grade 400 reinforcing steel, or A325 bolts. Smaller 1" diameter anchor bolts were manufactured from unknown materials. Some of the anchor bolts were galvanized.

2. Anchor bolts normally require repairs resulting from vehicular accidents. Some fractures are flush with the concrete footing.

3. Anchor bolt repairs have been made by welding an extension onto the remaining fracture end. The joint preparation and weld procedure used were left to the discretion of the welder. In recent times, "redi-rod" has been used for the new end of the bolt.

4. Two failed anchor bolts were examined. One was a 1 ½ inch galvanized bolt that exhibited fatigue cracking from a thread root on one side of the bolt. This crack initiated and grew in size because of fatigue loading. The bolt finally fractured by unstable (brittle) propagation of the fatigue crack. This was a short term failure as there was no corrosion on the fracture. The other bolt failure was a 1" diameter bolt that had been repaired by welding. This

bolt had been prepared using a double bevel weld preparation with a bevel that extended across the diameter of the bolt. Fatigue cracks grew to total fracture from incomplete weld penetration on both sides of the bevel preparation.

5. The City of Edmonton has nondestructively tested an anchor bolt assembly that was known to have been weld repaired. Ultrasonic testing revealed reflectors in the cross section of the repaired bolts at a location believed to be the area of weld repair.

DISCUSSION

Failure of the anchor bolts have occurred from accidents, installation practices, and repair practices. The latter two causes of failure can be reduced by adhering to good construction practices. Appendix A contains my recommendations for weld repairs of anchor bolts. A pole assembly installation procedure that specifies lamp standard bearing requirements and anchor bolt tightening procedures is required to reduce the failures from installation practices. (I recommend that the bearing requirements given in CSA-S-16.1 be used as a guide.)

There is a risk of reoccurrence of failure at weld repaired anchor bolts. This risk results from the following concerns identified in my examination:

1. Initiation of flaws because of unknown anchor bolt materials - Some of the 1" diameter bolts are of unknown chemical compositions. These bolts have a cracking risk; cracking in the weld heat affected zone due to hot shortness or insufficient parent material ductility, or cracking in the weld due to alloy dilution of the molten weld metal.

2. Initiation of flaws because of unknown anchor bolt replacement materials - Materials that are designed for machining (the manufacture of redi-rods, for example) frequently contain high quantities of sulphur or lead. While these elements make the material more machineable, they also make the material susceptible to hot-shortness during welding.

3. Initiation of flaws from uncontrolled weld procedures - Inappropriate weld joint design, inadequate preheat, use of electrodes without controlled hydrogen content, and uncontrolled cooling of welded components make the anchor bolt materials susceptible to stress cracks, nonfusion, incomplete weld joint penetration, and hydrogen cracking.

The flaws that result from previous weld repairs of anchor bolts do not mean failure at the time of repair. Usually these flaws are cracks or crack-like elements that will propagate to failure because of the cyclic stresses inherent at the base connection of a lamp standard. In some instances, the flaws may propagate due to a reduction in fracture toughness with colder ambient temperatures.

I am not aware of any incidence of delayed fracture at repaired anchor installations. The following recommendations are made in the basis of a very low risk tolerance:

1. Establish a policy on anchor assembly replacement and anchor bolt repair.

2. Record the location of anchor bolt repairs.

3. Carry out repairs to damaged anchor bolts in accordance with a standard written procedure (see Appendix A).

4. Install lamp standards on repaired anchor assemblies in accordance with a written procedure that includes standard bearing and anchor bolt tightening. (Do the same for new installations.)

5. Ultrasonically examine weld repaired anchor bolts five of more days after installation using the longitudinal wave method in accordance with CSA W59 dynamic structures. Replace defective welds.

6. Ultrasonically examine weld repaired anchor bolts at high risk locations (vibrations, high traffic volumes) three years after installation in accordance with CSA W59 dynamic structures. Replace defective welds.

The existing weld repaired anchor bolts represent a potential for nonaccident related failure. If the locations of the repairs are known, then recommendation number 6 given above could be used to eliminate the failure risk. If the locations are not known, then the risk should be assessed by the City based on known histories of nonaccident related failures of anchor bolts in Edmonton and other similar metropolitan areas. (I suspect that there is very little risk.)

Anchor bolts that have been weld repaired present an undefined risk in an accident. Generally, welding on a threaded fastener will reduce the toughness of the fastener material (the ability of the material to resist catastrophic failure). The fastener materials employed for anchor bolts are not toughness controlled materials, so that the fracture resisting properties of the anchor bolts is possibly poor. In addition, toughness diminishes as the rate of load application increases. Therefore, properly designed weld repair with no defects present does not represent any greater risk for failure in an accident than the nonrepaired anchor bolt materials.

APPENDIX A

City of Edmonton

Lamp Standard Anchor Bolts
Repair Procedure 15438

June 17, 1996

Ball Associates Engineering Ltd.
#1, 9816 - 47 Avenue Edmonton, Alberta T6E 5P3
Telephone: (403)436-4112 Fax: (403)434-9983

GENERAL

1. This repair procedure is to be followed for the weld repair of lamp standard anchor bolts.

2. Welding repair shall be done using the shielded metal arc welding process (SMAW).

3. Welding parameters shall be in accordance with the attached weld data sheet.

4. The weld joint detail shall be a stud weld, pointed bevel preparation as per the attached weld data sheet.

5. The new stud shall conform to ASTM A307, weldable grade with a minimum carbon equivalent of 0.55.

6. Welding shall be done using E41010 electrodes for the root pass, and E48018-1 electrodes for all fill and cap passes. Electrodes of the E48018-1 classification shall be dry and shall be used within 4 hours of their removal from a newly opened box, or from an electrode storage oven set at 110° C.

7. Dykes shall be used if necessary to keep moisture away from the weld area. If necessary, the area around the anchor base shall be excavated to permit access for welding. Welding repairs shall only be done if dry access to the bolt can be provided.

8. Zinc coatings, paint, rust, and dirt shall be removed from the weld area. A power grinder, power brush, wire brush, or file can be used to clean the area either side of the bevel for a minimum distance of 6 mm.

9. All bolt stubs shall be preheated prior to tacking the new

stud in place. Once the stud is tacked into place, the entire assembly shall be preheated. Preheat requirements are given on the weld data sheets.

10. All stop and start craters shall be ground.

11. Electrode weave manipulation shall be less than 19 mm. Stringer beads are preferred.

12. Each weld pass shall be visually examined, and the weld repaired before proceeding. Quality requirements are given on the weld data sheets.

13. Grind the final weld smooth.

14. Wrap the weld after grinding for slow cooling. Allow the weld to cool to "hand warm" before removing the wrap. Visually inspect the cooled weld for conformance to quality requirements.

15. Apply one coat of a zinc rich paint (such as Galvacon or equal) to the weld repair and exposed portion of the existing anchor bolt.

WELDING PROCEDURE DATA SHEET

No. 15438

DATE June 17/96

Name of Company: City of Edmonton

Company Address:

Wldg. Procedure Specification No. 15438

Applicable Standard(s): NA

CHECK TYPE OF WELDING PROCESS: ☒ Manual (SMAW) ☐ Flux-Core (FCAW) ☐ Submerged-Arc (SAW) ☐ Solid Wire (GMAW)

Welding Position: horizontal

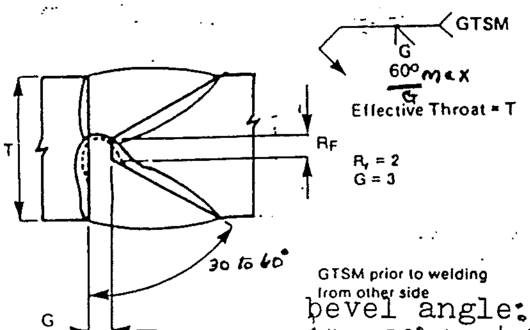
Electrode (Wire) Classification: E41010, E48018-1

Material Designations: A 307, A 325, A 490, G 30.12

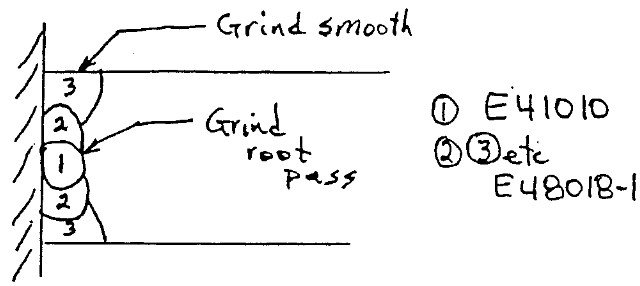
PREHEAT MINIMUM: 175 C

MINIMUM Interpass Temperature: 175 C

MAXIMUM Interpass Temperature:



bevel angle:
1" - 30° to 45°, 1 1/2" - 45° to 60°



SKETCH OF TYPICAL JOINT PREPARATION *(Indicate limits of Tolerances)* TYPICAL PASS AND LAYER SEQUENCE

COMPLETE JOINT PENETRATION GROOVE
- ☒ Back-gouged to sound metal
- ☐ Welded onto steel backing
- ☐ Welded from one side without backing
- ☐ Welded both sides without back gouging
- ☐ Welded onto other than steel backing

GROOVE WELD PARTIAL JOINT PENETRATION
- ☐ Minimum
- ☐ Others (specify) NA

FILLET WELD ☐ NA

JOINT TYPE
- ☒ BUTT ☐ TEE
- ☐ CORNER
- ☐ LAP ☐ EDGE

Automatic or Semi-Automatic: NA

BUTT or FILLET Size	Side No.	Layer Number	Pass Number	Electrode Size	Current Polarity	Amperes		Volts	
	1	1	1	2.5	DCEP	55-85		19-22	
	1	all	others	2.5	DCEP	75-110		19-22	

Revision Date	Explanation	Approval	Engineer's Stamp
		- no surface porosity - no cracks - grind all craters - maximum undercut 1.5 mm	PROFESSIONAL ENGINEER ... ALBERTA