California Council of Testing and Inspection Agencies

THE TEST REPORT

A Newsletter of the California Council of Testing and Inspection Agencies

Fall 2008

This Issue

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ASFE Fall Conference Attended by CCTIA Members

By Elizabeth Levi
BSK Associates

In 2003, ASFE started its "Regional Outreach" (RO) program to help address issues confronting regional organizations, such as CCTIA. The philosophy was issues that affect one region would probably affect other regions.

We believe an affiliation with ASFE expands the benefits and resources available to an RO's members, and facilitates better communication than otherwise would exist. Affiliation helps identify and become involved with emerging regional issues and trends (PEGG. Local 150, STD OF Care, State Boards – South Carolina), and regional groups can benefit from better awareness of national developments that could affect their members (ASTM E1527, Third Party Reliance).

With these goals in mind, ASFE sponsored its third annual ASFE RO Summit on Wednesday, October I, 2008, from noon to 5:00 PM. For the first time, they hosted the RO Summit in conjunction with the Fall Meeting in San Francisco. By doing so, they made it very easy for RO representatives to take advantage of the educational, social, and business-networking opportunities ASFE meetings present. Other RO representatives were WACEL, TCEL, CGA (formerly CGEA), NWCEL, and ASFE Board Members.

CORROSIVE SOILS: CAUSES, EFFECTS, and MITIGATION

By Hossein Arbabi
TESTING ENGINEERS, INC.

Soils, like any environment, can be corrosive. If we only used soil to plant flowers and trees, we probably wouldn't care too much – but as it stands, the dirt beneath our feet supports man-made structures of all kinds, and much of our utilities infrastructure is buried in it. While the effects of corrosive soil can cause structural failure and financial burden, mitigating measures taken into account during design and construction, as well as an understanding of the corrosive potential in a particular soil can minimize these issues.

The beginning of a construction project may involve excavation, fill, the addition of soil modifiers, dewatering - any number of processes that are meant to prepare the site for work. But what are the factors that contribute to the corrosive potential of soil? Aeration, moisture content (and/or time of wetness), temperature, pH, and resistivity are the primary telltales. The following is a more detailed description of the manner in which each of the above factors influences soil corrosivity.

Aeration – This is defined as the amount of air trapped within the soil. Aeration is an important factor in corrosion as it is a factor in water retention and evaporation rates. Well-aerated soil is more favorable from a (low) corrosivity standpoint because this generally leads to lower water retention and higher evaporation rates. The particle size and gradation within the soil plays a major role in determining the amount of aeration . Sandy soils are generally desirable, as the relatively large particles allow for better aeration, and facilitate faster evaporation rates after water has been introduced into the soil.   A quick way to classify soils in terms of their aeration is by examining their color. Reddish, brown, or yellow soils indicate good aeration, while gray soil is indicative of poor aeration.

Soils Corrosion Continued

pH (acidity) - Soils can have a wide range of acidity, reaching anywhere from 2.5 to 10. As pH levels of 5 or below can lead to extreme corrosion rates and premature pitting of metallic objects, a neutral pH of about 7 is most desirable to minimize this potential for damage. The intrinsic pH level of a soil can also be affected by rainfall.

Moisture Content & Resistivity – Moisture content is a more important factor in soil corrosivity than any other variable. As water is one of the three components necessary for electrochemical corrosion (the other two being oxygen and metal), corrosion will not occur if the soil is completely dry. Experimental evidence dictates that an increased moisture content decreases resistivity of soils, in turn increasing their corrosive potential. Note that when the saturation point of the soil is reached, additional moisture has little or no effect on resistivity.

The relationship between the resistivity of the soil, a particular soil class, and the corrosion resistance for galvanized steel is summarized in the following table.

Soil Class	Corrosion Resistance in Galvanized Steel	Electrical Resistivity, W-cm
Sandy	Excellent	6,000 – 10,000
Loams	Good	4,500 – 6,000
Clay	Fair	2,000 – 4,500
Peat/muck	Bad	0 – 2,000

Conversely, the relationship between soil resistivity and corrosion potential in uncoated steel is shown in the table below.

Resistance Classification in Uncoated Steel	Soil Resistivity, W-cm	Corrosion Potential
Low	0 - 2000	Severe
Medium	2000 - 10000	Moderate
High	10000 - 30000	Mild
Very High	>30000	None

Temperature – temperature has an effect on soil resistivity and, as a result, corrosive potential. As soil temperature approaches 0° C, resistivity in the soil (for a given moisture content) increases gradually. However, as the temperature continues to decrease there is a *rapid* increase in resistivity with a corresponding decrease in the corrosive potential in the soil.

Other factors that can affect the corrosiveness of soils are levels of sulfates and salts. Generally soils are considered "mildly corrosive" if the sulfate and chloride levels are below 200 PPM and 100 PPM, respectively, for soils with pH levels of between 5 and 10, and resistivity greater than 3000 ohm-cm.

CASE STUDY

Introduction

We have all seen the news stories about a water main break – they always occur at some major intersection right at rush hour! Traffic is tied up. Business is lost, millions of gallons of water wasted, and thousands upon thousands of dollars spent repairing the damage. Our underground utilities are constantly under attack from corrosion, and in some instances failures are a combination of corrosion and external forces. The following case study describes the failure investigation of buried cast iron pipe that had cracked due to such a combination.

Leaks were discovered coming from an underground 8" diameter cast iron pipe that had been installed 15 years ago. To remedy the situation, 40 feet of pipe was removed and replaced. The typical operating pressure of the pipeline was reported to be 125 psi. Three pipe fragments were submitted to our laboratory for evaluation. A sample of the soil from an area adjacent to the pipe was also submitted.

Observations

The pipe fragments were visually examined and photographed in our laboratory. Shown below are overall views of the interior and exterior of a typical section, photos 1 and 2, respectively. The dark patches on the exterior of the pipe represent a form of corrosion specific to cast iron known as graphitization. This will be discussed in more detail in the next section. The chemical composition and microstructure of the pipe material was analyzed and found to be consistent with cast iron with typical levels of porosity.

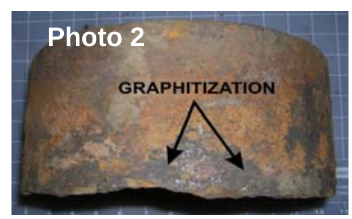

Photo 3 is a magnified view of the exterior of the pipe. This shows the extent of metal loss adjacent to the fracture surface. It is evident from the visual observations that the metal loss is confined to the exterior of the pipe, while the interior exhibited evidence of only mild to moderate corrosion.

A typical fracture surface with severe loss of pipe wall thickness due to graphitization corrosion is depicted in Photo 4. A rough-polished cross section with the same type of corrosion through the entire pipe wall (dark area denoted with arrow) is presented in Photo 5.

As the primary corrosion and subsequent section loss was external, the properties of the soil with respect to corrosivity were examined. The soil sample had a grayish appearance, indicative of poor aeration and potentially high corrosivity. Direct measurement of the soil's pH showed a value of 4.5, indicating an acidic soil. In addition, direct resistivity tests of the soil using the "Wenner four-pin" method indicated a resistivity value of 1800 W-cm, putting the soil in a corrosive category.

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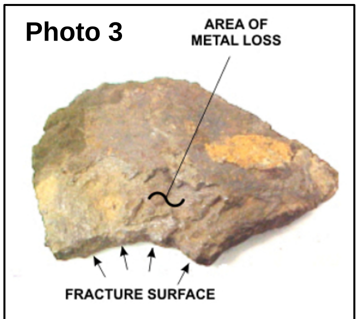
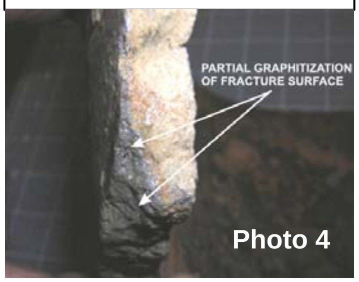
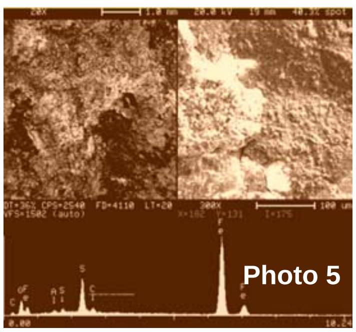
Soils Corrosion—Continued from Page 2







The analysis of the corrosion deposits on the outside of the pipe by Energy Dispersive X-ray (EDX) showed a high concentration of sulfur in addition to smaller amounts of chlorine. Photo 6 is a typical EDX spectrum representing all the elements found.

Discussion

The corrosion mechanism itself is of interest. Gray cast iron is used for pipes due to it's inherent resistance to corrosion. This resistance is due largely to the graphite matrix that forms during the casting process, and is interwoven with a matrix of pure iron. Graphitization corrosion occurs when the iron surrounding the graphite is attacked. The porous graphite matrix is left intact as black patches on the surface of the pipe. This corrosion mechanism, which is specific to gray cast iron, may give the false appearance of a structurally sound material. Unfortunately, the porous graphite has little strength, and makes the pipe prone to cracking under low external stresses.

As stated earlier, (graphitization) corrosion in a soil environment is a function of aeration, moisture content, temperature, pH, and resistivity. Dissolved constituents in the soil may also contribute to corrosion rates. In this instance, the measured low resistivity and low pH are consistent with a corrosive soil. Once a leak started, the moisture content in the soil would rise, greatly increasing the corrosive potential of the environment. In addition, the sulfur present on the exterior surfaces of the pipe section is a strong indication that corrosion is also microbiologically influenced. The sulfur or sulfur compounds in the soil can support the growth of sulfate reducing or

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ASTM Working Items

WK21779 – Revision of C470-08 Standard Specification for Molds for Forming Concrete Test Cylinders Vertically

Subcommittee C09.61 – The task group will consider revisions to the specification to address if single use cylinder molds may be reused and if so, what restrictions or considerations will be added to the specifications to facilitate such reuse.

SAVE THE DATE and WATCH FOR FURTHER INFORMATION

JANUARY 23 & 24, 2009
CCTIA ANNUAL BUSINESS MEETING

TREASURE ISLAND
HOTEL & CASINO

GREAT SPEAKERS, INDUSTRY MEETING, GOOD FOOD, FUN & MORE

UPCOMING MEETINGS & SEMINARS

December 18, 2008 at 3pm
Hilton Pleasanton at the Club
7050 Johnson Drive
Pleasanton, CA

January 23 & 24, 2009 at 2pm
Annual Business Meeting
Las Vegas, NV

March 7, 2009 at 8am
ICC Renewal Seminar
Sacramento, Fresno, Bay Area, San Diego, and Los Angeles

CCTIA C/O ELIZABETH LEVI 1181 QUARRY LANE BUILDING 350 PLEASANTON, CA 94566

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Dynamic Consultants, Inc.	Leighton Consulting, Inc.	URS/D & M Consulting Engineers
ES Geotechnologies	Matriscope Engineering Laboratories Inc.	Youngdahl & Associates, Inc.

Soils Corrosion—Continued from Page 3

sulfur oxidizing bacteria that can in turn create the chemical conditions that can cause graphitization.

As is the case with atmospheric corrosion, the extent of damage due to soil issues may be vastly different within relatively close quarters. This can be due to site-specific conditions in the soil allowing for differential drainage, aeration, acidity, and/or resistivity.

Conclusion

The chemistry of the fragments are typical of cast iron piping material, so material defects are not the likely cause of the failures. Cast irons are brittle by nature and are more fracture sensitive than wrought materials. Based on the significant corrosion and material loss on the exterior of the pipe, the fracture most likely initiated at an area of reduced cross-section, and may have been caused by internal (water pressure) forces, or by some external force including, but not limited to, nearby construction activity, expansion and contraction of the soil, erosion and/or settlement of the soil surrounding the pipe.

Recommendation

There are several methods of preventing corrosion of buried pipes, though most of these methods are only practical for application prior to installation of the piping. For existing buried pipes the most cost-effective method of minimizing or eliminating corrosion is cathodic protection. Cathodic protection involves the use of sacrificial magnesium or zinc anodes connected to the pipe material, which acts as the cathode. Under corrosive environments, the anode will corrode, sparing the cathode (pipe material). Both the replacement pipe sections and existing pipes can be effectively protected by this method.

We recommended that our client contact a firm that specializes in cathodic protection of buried pipes for preventing further corrosion. HArbabi@testing-engineers.com

FAQ 10.043

Is Mortar Testing Required?

Can you clarify the mortar testing requirements according to the 2006 IBC and 2007 CBC? Some people in my area are still using the old UBC Standard 21-16.
Submitted by a Special Inspector from Southern California,

The UBC Standard 21-16 as referenced in previous CBC's is no longer applicable in the 2007 CBC. The new code section for structural testing of masonry (1708.1) is adapted from the ACI 530/ASCE 5/TMS 405 reference, which does not require any field mortar testing for quality assurance. The rational of the reference is that mortar is specified based on long standing prescriptive proportioning or property testing preformed in a laboratory environment that must meet ASTM C270. In either case, material certifications and/or test records should be provided prior to construction to confirm the materials meet the standard and the Special Inspector is responsible for verifying the proper use and proportioning of the material in the field. Per 2007 CBC, Section 2105A.5 essential facilities (schools and hospitals) still require verification testing according to ASTM C1586 for the first three successive days and once every week thereafter for strength requirements only. **William Wahbeh** is the responsible engineer at Signet Testing Laboratories, Inc. and a registered engineer in California. He can be reached at William_Wahbeh@URSCorp.com

Jeffry Cannon with Kleinfelder has added the following comments:

C 1586 specifically states that ASTM C 780 should be used to sample and test mortar from project sites (not C 270), but goes on to say strength verification of field-sampled mortar should not be performed because strengths of test specimens do not equate to actual strengths of the in-place mortar (Section 5.5).

These conflicts between the CBC and the ASTM standards that are referenced in the code have not been rectified to date. It is suggested that if field sampled mortar specimens are obtained for strength testing, specimens are fabricated and tested in accordance with C 780. Some member firms are adding a statement on their reports of laboratory test results indicating that the strengths of the test specimens may not be indicative of the in-place mortar.

One side note to ASTM C 780 is that after initial curing in the field, compression specimens must be cured in moist closets or moist rooms until they are tested. The use of water tanks (curing tanks) is not allowed.. **Jeffry Cannon** is the Materials Technical Discipline Leader for Kleinfelder Inc.'s. He can be reached at JCannon@kleinfelder.com.