ORILLIA INDUSTRIAL DISTRICT ASSOCIATES I
WASHINGTON STATE LIMITED PARTNERSHIP
P.O. BOX 99354
SEATTLE, WA 98199

ADDENDUM #2 - IRAP REPORT
ORILLIA I SITE SLAG MATTER

GeoEngineers

June 3, 1997

Consulting Engineers and Geoscientists
Offices in Washington, Oregon, and Alaska

Washington State Department of Ecology
Northwest Regional Office
3190 - 160th Avenue Southeast
Bellevue, Washington 98008-5452

Attention: Glynis Carrosino

Report Addendum #2
Orillia Industrial District Property
(Lots 1 through 4)
Kent, Washington
File No. 5538-002-85

Based on a telephone conversation with Mr. Glenn Woo of Orillia Industrial District Associates I on May 28, 1997, we understand that additional clarification is necessary regarding institutional controls recommended for the site. The subject site consists of Lots 1 through 4 and is located southwest of the East Valley Highway and South 180th Street intersection in Kent, Washington. Our "IRAP Summary Report" dated April 16, 1997 summarizes subsurface soil and ground water analytical results for the site.

Because of the presence of slag fill and contaminants identified during our subsurface characterization of the site we recommended that institutional controls be implemented at the site in order to prevent direct human contact with the slag fill and ground water in the area of slag fill. The institutional controls, which include an asphalt cap or an equivalent surface barrier, ground water monitoring of downgradient well GMW-1, and a restrictive covenant on the use of ground water beneath the site, are recommended to be protective of human health and the environment. An excerpt from our recommendations for long-term controls at the site presented in our "IRAP Summary Report" is as follows: "All areas not covered by a building must be capped by asphalt pavement of an adequate thickness that will decrease the potential of cracking and excessive wear. The asphalt pavement cap should be used to limit human exposure to the slag fill and reduce infiltration of stormwater." The following further clarifies this recommendation:

GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Telephone (206) 861-6000
Fax (206) 861-6050

- The asphalt cap or equivalent surface barrier should be placed in areas where slag fill is present. The cap does not need to be placed in areas where buildings will be constructed. The areas where slag fill has been identified include the southeast portion of Lot 3 and the majority of Lot 4. See Figure 4 of our "IRAP Summary Report" for approximate slag fill locations.
- We understand that the City of Kent may require that about 10 percent of the development consist of landscaped areas. Slag fill could be removed from areas that require landscaping or in areas where institutional controls cannot be feasibly implemented. If slag fill is excavated, we recommend that it be characterized by an environmental professional prior to off-site disposal at an approved landfill or recycling facility. In areas where slag fill has been removed, a cap would not be necessary.
- Alternatively, a cap consisting of an impermeable liner beneath 12 to 24 inches of soil and topsoil could be placed in landscape areas where slag remains. The liner should be "keyed" into the asphalt pavement or should be designed to slope to an engineered drainage system that prevents infiltration of surface water into the slag fill.
- Based on the current subsurface information, it is our opinion that institutional controls are not necessary for Lots 1 and 2 because (1) slag fill has not been encountered on these lots, and (2) ground water samples obtained from GMW-1, which is located between the known slag fill and Lots 1 and 2, are in regulatory compliance.

These recommendation clarifications are based on current subsurface information. If slag fill or contaminants of regulatory concern are observed during construction in areas not identified in our previous reports, we recommend that institutional controls be implemented in those areas. These recommendations do not represent design specifications. They are intended to provide a general description of institutional controls necessary for Ecology's consideration of a no further action determination for this site.

We recommend that a work plan and specifications be prepared prior to construction to address cap and/or liner design. We also recommend that the construction controls summarized in our "IRAP Summary Report" be followed and that the key points presented in our "Development Considerations for Slag Fill" report dated April 17, 1997 be considered in development plans prior to construction at the site.

Please call if you have questions or comments regarding this submittal.

Yours very truly,

GeoEngineers, Inc.

Jana Moff for DAC

David A. Cook
Project Geologist

Kurt R. Fraese
Associate

DAC:KRF:vvl
Document ID: P:\5538002.RA2

One copy submitted

cc: Glenn Woo, P.E.
1928 Clise Place W.
Seattle, WA 98199

Development Considerations for Slag Fill
Orillia Industrial District
Associates I Property
Kent, Washington

April 16, 1997

For

Orillia Industrial District Associates I

GeoEngineers

April 16, 1997

Consulting Engineers and Geoscientists
Offices in Washington, Oregon, and Alaska

Orillia Industrial District Associates I
1928 Clise Place West
Seattle, Washington 98199

Attention: Glenn Woo, P.E.

Development Considerations for Slag Fill
Orillia Industrial District Associates I Property
Kent, Washington
File No. 5538-002-85

INTRODUCTION

This letter presents a discussion of development considerations regarding the slag fill located at the Orillia Industrial District (Orillia) property located southwest of the East Valley Highway and South 180th Street intersection in Kent, Washington. The Orillia site is approximately 7 acres in size and consist of four parcels, Lots 1 through 4, (formerly lots C & E, tax parcel #312305-9033-03). As presented in our "IRAP Summary Report" dated April 7, 1997 we made the following recommendations related to contamination associated with the slag fill:

1. A handling and disposal plan should be prepared prior to construction and any contaminated ground water encountered for the slag fill during site development and maintenance.
2. Soil excavated at the site should be evaluated for potential contaminants prior to off-site disposal.
3. Dewatering effluent should be tested for contaminants if construction dewatering is necessary for site development.

In addition to the contamination-related construction controls outlined above, the expansive nature of the slag fill must be considered prior to site development. It is our opinion that the potential expansive properties of the slag fill will create the most challenging development issues at the site.

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DEVELOPMENT CONSIDERATIONS FOR SLAG FILL

BACKGROUND

Approximately the southwestern two-thirds of the property is underlain by fill that contains slag (Figure 2). The slag fill extends to depths as great as 13 feet or more. Based on test pit observations made by GeoEngineers and others, the slag ranges from very dense, massive deposits to loose sandy material mixed with other soil fill. An estimated 50,000 cubic yards of fill at the property consists entirely or partly of slag.

GeoEngineers is not aware of the specific source of the slag at this site. However, slag from a variety of steel mill sites was used as fill material in the Kent valley in the mid-1980s. **The Jorgensen Steel Company (now changed to Jorgensen Forge) located at 8531 E Marginal Way So. in Seattle, is most likely source of the slag.**

Slag is a waste product of metal production. Originally molten, congealed slag is visibly similar to lava. The composition and characteristics of slag vary with the type of metal being produced. Slag produced by steel mills typically contains one-third to one-half non-hydrated lime (primarily CaO). The lime is added as a fluxing agent during steel production. Lime can absorb water through hydration for many years after the slag has been created. This hydration process can produce volume expansions of 10 percent or more. Therefore, without proper precautions, construction with or above steel mill slag can result in significant post-construction problems.

GeoEngineers' recent experience on a developed site underlain by slag from a steel mill in Seattle documented significant and damaging post-construction problems associated with the slag, despite the fact that the slag had been in place more than 30 years prior to site development. Asphalt pavements and curbs in the parking areas suffered severe distress from vertical and lateral expansion of the underlying slag. We found that most of the areas of severe distress occurred where underground utilities had been constructed within the slag. The construction process removed the slag in the utility trenches and crushed the slag adjacent to the trench walls. This allowed for lateral expansion of the slag into the trenches, where weaker backfill materials were present. The pavements and curbs above the trenches were put into compression through the lateral expansion of the slag. The result was buckling of pavements in the form of sinuous ridges up to 6 inches high above the utility trenches. Differential ground movements also resulted in damage to underground utilities and two buildings in an office park complex. The major foundations for the buildings were supported below the slag fill. However, the floor slabs and some of the wall foundations were supported above the slag. Even though the slag was more than 30 years old and the buildings had been in place for eight years, differential movements were experienced between the floors, walls and major structural elements of the two buildings. The differential movements were expressed by jammed doors, cracked walls and fractured floor slabs with offsets along some of the floor cracks.

The literature commonly indicates that slag expansion through hydration is typically complete within a few years after the slag is exposed to weather and moisture. GeoEngineers

has found this to be misleading. It appears that the hydration process can result in a cemented mass of slag that becomes very strong and competent. The cemented mass has significant strength that likely limits expansion. Furthermore, the blocks of slag in a fill mass may become hydrated only around the outer edges, leaving non-hydrated lime in central portions of slag fragments.

Construction disturbance of slag fill creates opportunities for renewed hydration and expansion of the slag by breaking fragments of slag to expose non-hydrated portions of the slag to the elements. Very old fills composed of steel mill slag may contain considerable slag that has not undergone complete hydration.

Slag samples can be crushed and tested to evaluate their potential for swelling. In 1992, Law Engineering conducted autoclave expansion tests on three fill samples containing slag from the Orillia property. Based on the test results, Law Engineering concluded that "some of the slag at this site is susceptible to swelling over time." A copy Law Engineering's slag testing report is presented as Attachment A.

GeoEngineers conducted Expansion Index tests on three samples of slag from this site in 1992. These tests did not indicate expansion, but the tests were of short duration. GeoEngineers concluded that "the slag is more likely than not to be nonexpansive." A copy of our slag testing report is presented as Attachment B.

CONSTRUCTION MEASURES TO MITIGATE EXPANSION OF STEEL MILL SLAG

Any construction operation within potentially expansive slag fill could result in local disturbance of the fill and opportunities for renewed expansion of the slag. This could lead to differential ground movements, with the greatest amount of movement located in the vicinity of excavations that disturb the slag.

Measures can be taken to reduce the risks of post-construction problems associated with expansive steel mill slag. Specific measures to be employed would depend on the planned locations and grades of buildings, floor slabs, retaining walls, foundations, pavements and utilities. Generally, design and construction options to minimize problems associated with expansive slag include the following:

- Remove the Slag from Critical Areas: The slag fill can be removed from building footprint areas, utility corridors and other areas with structures sensitive to differential ground movements. The excavated slag could be exported from the site to a permitted landfill or reused on site as fill in less critical areas. However, because of the documented contaminants in the slag fill, on-site reuse would need to be done with appropriate consideration to covering the slag fill with a cap and minimizing the infiltration of water through the slag.

- Locate Critical Structures and Utilities away from Slag Areas: The northeastern part of the property does not appear to be underlain by slag fill. Structures and utilities located in this area could be constructed using normal practices for this area, without special precautions related to the slag.
- Place Additional Fill at the Site: Non-expansive fill could be imported to the site and placed over the slag fill. The purpose of the additional fill placement is to keep construction activities above the slag fill so that physical disturbance of the slag is eliminated or minimized. If additional fill is imported to the site, compressible native soils that underlie the existing fill will experience consolidation under the weight of the new fill. Therefore, adequate planning and preloading would be necessary to minimize the potential for damaging post-construction settlements related to new loads imposed by fill for structures.
- Isolate Foundations, Slabs and Utilities from the Slag: Building foundations and floor slabs can be supported structurally on pile foundations that extend through the slag fill to underlying competent materials. Utilities can be constructed at shallow depths to avoid slag or within utility corridors where the slag has been removed.
- Minimize Infiltration of Water: Building roof drains and drainage from pavement areas should be captured in tight lines and routed away from slag areas. Any on-site detention of stormwater should be done in lined facilities that do not leak, or in areas located outside of the slag fill zone.

TESTING OF SLAG FILL

Several of the mitigation options described above will result in site development costs that are significantly higher than a similar site without slag fill. To date, however, it has not been established conclusively that the slag at this property is expansive. Through discussions with another geotechnical consultant, we are aware that numerous slag samples from the Birmingham Steel site are currently being tested for potential swelling characteristics. To date, none of the samples being tested have demonstrated a swelling potential. The Birmingham Steel site is the most likely, but not the only, potential source of the slag at the Orillia Industrial site.

Considering that the slag at this site has not yet been proven to be expansive, we recommend that at least 10 samples of the slag be obtained from different locations and depths on the property and tested for swell potential. If any of these samples demonstrate expansion during testing, then one or more of the mitigation measures described above will be appropriate. However, if none of these samples are expansive, more detailed testing of the slag can be done in proposed construction areas. If these samples also are not expansive, site development with normal construction practices should be feasible.

Laboratory testing to document the potential for slag expansion can be done using traditional consolidation testing apparatus. We recommend crushing pieces of the slag to an

average particle size of 5 mm or less, compacting the slag into a mold, saturating the samples and measuring the change in sample height under a nominal confining load. Elevated temperatures accelerate the hydration process, but normal room temperatures are adequate to document potential swelling in crushed slag samples. Unless elevated temperatures are used, the samples should be tested for a period of at least four weeks to allow sufficient time for hydration to occur. We estimate that slag sampling and laboratory testing costs will be approximately $5,000. Our estimate assumes that (1) a GeoEngineers geologist or engineer would be on site for one day to collect slag samples from at least 10 test pits, and (2) a backhoe and operator would be subcontracted for one day to excavate the test pits. We estimate that a report summarizing the slag testing results would be approximately $2,500.

LIMITATIONS

We have prepared this letter for use by Orillia Industrial District Associates I and their authorized agents in their evaluation of subsurface conditions at the Orillia site. This report may be made available to regulatory agencies. The report is not intended for use by others, and the information contained herein is not applicable to other sites. If a lending agency or other parties intend to place reliance on the product of our services, we require that those parties indicate in writing their acknowledgment that the scope of services provided and the general conditions under which the services were rendered are understood and accepted by them. This is to provide our firm with reasonable protection against open-end litigation by third parties with whom there would otherwise be no contractual limits to their actions.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted geotechnical engineering practices in this area at the time this letter was prepared. No warranty or other conditions, express or implied, should be understood.

We appreciate the opportunity to be of service to you. If you have questions concerning this report or if we can provide additional services, please call.

Yours very truly,

GeoEngineers, Inc.

David A. Cook
Project Geologist

Kurt R. Fraese
Associate

James A. Miller, P.E.
Principal

DAC:KRF:JAM:cms
Document ID: P:\5538002.SLG

Attachments

Two copies submitted

cc: Washington State Dept. of Ecology
Northwest Regional Office
3190 160th Ave. S.E.
Bellevue, WA 98009-5452
Attn: Glynis Carrosino

ATTACHMENT A

SEP-03-1992 10:48 FROM Law Associates

TO: KRF
FAX #:

FROM: GWA
FAX #:
PHONE #:

DATE: 9/4/92
PAGES INCLUDING THIS PAGE: 8

Facsimile Cover Sheet

Law Environmental, Inc.
2150 North 107th Street, Suite 570
Seattle, Washington 98133
Telephone: 206-367-6600
Fax: 206-367-9442

Date: 9-3-92

Time: _____

No. of Pages 8
(including cover sheet)

Operator: _____

Verify: Yes/No

Fax To:

Name: GARY HENDERSON

Company: GEO ENGINEERS

Fax #: 206-521-6521

Fax From:

Name: James Maroncelli

Telephone: 206-367-6600

[X] F.Y.I.
[ ] Review & Return
[ ] Please Call

[ ] For Your Review
[ ] For Your Approval
[ ] Please Copy To Following: _____

Please notify _____ if you wish to receive a hard copy.

Comments:

LAW ENGINEERING

GEOTECHNICAL, ENVIRONMENTAL & CONSTRUCTION MATERIALS CONSULTANTS

August 21, 1992

Law Environmental, Inc.
2150 North 107th, Suite 160
Seattle, WA 98133

Attention: Mr. Jim Maroncelli

Subject: Physical and Chemical Test Results
Bulk Samples Containing Slag
Potential Home Depot, Orillia One Property
Kent, Washington
Law Engineering Project No. 56303498.01

Gentlemen:

Law Engineering has completed the authorized testing and evaluation of bulk samples containing slag. Our work is outlined in Law Environmental Proposal No. 34-2020 (Amended), addressed to Home Depot USA, and dated July 15, 1992. This letter describes the test program along with our conclusions and recommendations.

BACKGROUND

We understand Home Depot USA is considering the purchase of property in Kent, Washington, between East Valley Highway and South 180th Street. They are planning a retail store with surrounding parking areas. Geotechnical explorations by other consultants and Law Environmental revealed the presence of significant amounts of fill materials which contain some slag and slag-like materials such as foundry sand.

Certain types of slags are known to have expansive properties when subjected to moisture. When free Calcium and Magnesium molecules are present, they can bond to water molecules and swell. This chemical reaction has been observed at many building sites and can occur over long periods of time, such as years or even decades. Structures can and have been damaged by swelling slag. When the slag is confined, it can damage floor slabs and pavements, foundations, retaining walls, utility pipes and other structures. If it is used in concrete as an aggregate, the hardened concrete can be ruined.

396 PLASTERS AVENUE, N.E.
ATLANTA, GEORGIA 30324
404-873-4761
TELEFAX 404-881-0508

Chemical and physical tests can help identify materials susceptible to expansion. However, it is not possible to conclusively prove that a particular slag will be benign, due primarily to the differences in field and laboratory conditions, and limitations of readily available tests.

TESTING PROGRAM

The proposed testing program consisted of chemical tests for Magnesium and Calcium, and two physical tests. The Autoclave Expansion is a physical test normally performed on cement. A small bar measuring 1 inch by 1 inch by 12 inches is molded, by mixing cement mortar with the slag material. Stainless steel pins are cast into the ends to use for precise measuring. Once hardened, the bar is placed into a vessel and subjected to high temperature, moisture and pressure. The bar is then remeasured to determine any length change. The autoclave test simulates long term exposure to the environment.

The second proposed physical test, the Expansion Index, is normally performed on expansive clay soils. Since slag expansion problems normally occur over extended time periods (months and years), we did not perform the Expansion Index due to time constraints.

We received four bulk samples of materials on July 20, 1992. Samples were labeled TP-1, TP-2A, TP-3, and TP-4. We visually classified all samples as black sand and gravel mixed with concrete fragments and slag nodules. Samples from TP-1 and TP-4 appeared similar in texture and color, and were mixed. Sample TP-3 contained a greater percentage of larger slag nodules.

The samples were divided and the chemical tests were assigned to Law and Company, a subcontract chemical laboratory. Chemical tests were performed only on samples TP-3 and TP-1+4 due to budget constraints. The Autoclave expansion tests were performed on samples from TP-2A, TP-3, and TP-1+4 by personnel in our cement laboratory.

TEST RESULTS

Autoclave Expansion: The average bar elongations for TP-2A and TP-3 were 0.03 and 0.05 percent, which are very small amounts. There were slight surface popouts (flaking) on one set of bars (TP-3). The one bar cast from sample TP-1+4 apparently ruptured in the pressure vessel and exhibited severe surface popouts. Photographs of these specimens are available upon request.

Chemical Tests: Test results indicate there are water soluble calcium and magnesium constituents in the samples. The tests cannot distinguish if these are free molecules or if they have already been combined with water prior to testing.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are based upon the physical and chemical test results and our experience with slag at other locations and projects.

The autoclave expansion tests indicate that some particles are expansive, evidenced by the surface popouts and the broken specimen. We recognize that the autoclave environment is much more severe than actual field conditions, however, this simulates long term conditions in the short time available. We believe that some of the slag present at the site is susceptible to swelling over time. The potential volume change and subsequent influence on structures is a function of slag concentration, depth, availability of moisture, and many other factors.

We note that the length change of the bars which remained intact was very small. This may suggest that some of the slag is non-expansive, although not necessarily. It should be pointed out that the actual volume of slag in each specimen was small as it was difficult to grind the metallic materials enough to include in the specimens.

We recommend that the slag be fully undercut from areas where it could be confined, particularly from beneath the building and floor slab. You might consider leaving the slag in-place in the parking areas, although you must accept some risk that swelling could damage the pavements. If you elect to leave the slag beneath the pavements, we suggest you use a flexible pavement section (asphalt). Slag should also be undercut from beneath utility pipes so that possible swelling will not damage them.

Thank you for letting us be of service. Please contact us if we may be of further assistance.

Sincerely,

LAW ENGINEERING, INC.

John D. Lawrence, PE
Principal Engineer

W. Charles Greer, PE
Corporate Consultant

0349801.lau

July 30, 1992

LAW ENGINEERING

GEOTECHNICAL, ENVIRONMENTAL & CONSTRUCTION MATERIALS CONSULTANTS

LAW ENGINEERING, INC.
LABORATORY TEST REPORT

Client:	Law Engineering - Atlanta Department 563
Project:	Law Environmental - Seattle, Home Depot
Project Number:	5630349801
Date received:	July 24, 1992
Attention:	Mr. John Lawrence

Sample description: Three slag samples contained in separate plastic bags.

Test performed: ASTM C151 - 89 Autoclave Expansion.

Sample preparation: All samples were dried at 230°F (110°C) for 48 hours. After drying, they were pulverized to sizes passing the no.4 sieve. Extra-hard materials retained on the no.4 sieve were not used.

As directed in the Laboratory Assignment Sheet, a mix proportion of one part Type 1 Portland cement : three parts slag by weight was used to prepare the test specimens.

Test Results:

Sample Identification	Autoclave Expansion	Remarks
TP - 2A	0.03%	No surface popouts observed
TP - 3	0.05%	Slight surface popouts observed
TP - 1+4	No reading obtained	Severe surface popouts observed, specimen broken

Date tested: July 30, 1992

Tested by: Al Wheaton
Engineering Technician

Reviewed by: Quincy Kong
Materials Engineer

qk/0349801.rpt

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LAW & COMPANY
Consulting and Analytical Chemists
1788 MONTREAL CIRCLE
TUCKER, GA. 30084
404-934-8200
FAX 404-270-1900

Chemical Report

8/17/92

33320
Number: 886636

Received: 7/24

Mr. John Lawrence
Law Engineering
396 Plasters Avenue
Atlanta, GA 30324

Description: A, TP 1+4 mix

Moisture and Volatile (105°) ..... 8.18 %

All analyses below are performed on dried material.

	Pulverized Sample
Further loss on ignittion @ 600°C ..... (Chief Carbonateous Matter)	3.07 %
Estimated water of hydration	<0.5 %
pH (1-1 slurry deionized water)	10.0 %

	Sample as recieved		Pulverized Sample	
	Water soluble (PPM)	Acid Soluble (Total)(ppm)	Water Soluble (PPM)	Acid Soluble (Total)(ppm)
Iron (Fe)	1	88,000	3	180,000
Aluminum (Al)	5	11,000	50	12,000
Calcium (Ca)	179	25,000	690	35,000
Magnesium (Mg)	<1	7,800	6	9,800
Sodium (Na)	87	515	240	340
Potassium (K)	66	220	130	360
Chloride (Cl)	41	----	160	----
Sulfates (SO_4)	180	130	500	3,400

Note: The sample as received was not homogeneous and consisted of sand, soil larger rocks and slag.

*****

Respectfully submitted,
LAW & COMPANY

BY Thomas E. Fanty

S 38000eh

LAW & COMPANY
Consulting and Analytical Chemists
1969 MONTREAL CIRCLE
TUCKER, GA. 30084
404-934-6200
FAX 404-270-1700

Chemical Report

8/17/92

3320
umber: 886637

Received: 7/24

r. John Lawrence
aw Engineering
96 Plasters Avenue
tlanta, GA 30324

escription: B, TP-3

---

oisture and Volatile (105°) ..... 8.84 %

11 analyses below are performed on dried material.

	Pulverized Sample
urther loss on ignittion @ 600°C ..... (ief Carbonateous Matter)	3.52 %
Estimated water of hydration	<0.5 %
H (1-1 slurry deionized water)	9.2 %

	Sample as recieved		Pulverized Sample	
	Water soluble (ppm)	Acid Soluble (Total) (ppm)	Water Soluble (ppm)	Acid Soluble (Total) (ppm)
ron (Fe)	4	58,000	3	75,000
luminum (Al)	4	9,500	4	10,000
alcium (Ca)	64	12,000	490	28,000
agnesium (Mg)	22	7,000	6	8,200
odium (Na)	12	280	37	350
otassium (K)	20	280	39	810
hloride (Cl)	29	----	104	----
ulfates ($S_0 4$)	180	97	240	1,800

lote: The sample as received was not homogeneous and consisted of sand, soil larger rocks and slag.

*****

Respectfully submitted,
LAW & COMPANY

BY Thomas E. Lantz

ATTACHMENT B

GeoEngineers

September 22, 1992

Geotechnical,
Geoenvironmental and
Geologic Services

Lane Powell Spears Lubersky
1420 Fifth Avenue, Suite 4100
Seattle, Washington 98101-2338

Attention: Mr. Bob Davis

Report Addendum
Geotechnical Engineering Services
Proposed Home Depot Store
Kent, Washington
File No. 2401-006-T03

INTRODUCTION

This addendum to our report dated August 6, 1992 summarizes additional information regarding the slag. Since August 6, additional explorations and testing have been done by Law Environmental, Inc. and GeoEngineers to help define the location and character of the slag.

Law Engineering, in their report dated August 21, 1992, concluded that the slag may be expansive. They recommended that it be removed from beneath the building and floor slab, and suggested there may be some risk to pavement and utilities.

SLAG DISTRIBUTION

Based on these and previous explorations, it appears that fill material containing slag is present in the southern end of the proposed building and in the adjacent parking area to the south and west of the proposed building. Explorations that encountered slag extend about 150 feet north of the south end of the proposed building.

Within the above-defined section of the proposed building area, all but four of the explorations to date encountered slag mixed with fill. Visual estimates indicate that the slag content of the fill is less than 15 percent of the total. Where encountered, the fill with slag

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Tacoma, WA 98409
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Fax (206) 471-0521

extended from a depth of about 2 feet to between 8 and 10 feet. Test pit GTP-5, located near the southwest corner and within the building footprint, encountered a large mass of slag at a depth of 4 feet. The other three explorations encountered no slag.

Outside the building footprint, slag mixed with fill has been encountered south and west of the building footprint. Also, at least four (approximately 1/4) of these explorations has encountered massive slag. The slag or fill with slag is overlain by 2 to 6 feet of other fill and extends to depths of 8 to 13 feet.

TESTING

In addition to the Law Environmental testing, we have run three Expansion Index tests on crushed samples of the slag. At the end of 48 hours, none of the tests showed any expansion. One of the test was continued for three weeks with no expansion.

Chemical testing shows that the slag is basic with a pH ranging from approximately 8 to over 11. Chemical tests by Law Environmental show a high proportion of water-soluble sulfates; particularly for the pulverized 1+4 mix, which experienced severe surface popouts and broke during the Autoclave Expansion test. The sulfates, rather than the presence of expensive material, may have caused the popouts.

CONCLUSIONS

We agree with Law Environmental that it is not possible to conclusively prove whether or not the slag is expansive or benign in the long term. Based on testing done to date, it is our conclusion that the slag is more likely than not to be nonexpansive.

For the most part, the slag appears to be mixed with other material and constitute only a small part of the total fill column. However, there is at least one location, and probably more within the building footprint, where the slag is massive. If the slag is expansive, the uplift would ultimately be greater where the slag is concentrated. However, the time required for weathering and chemical breakdown would also be longer in concentrated areas.

For the most part, the slag and fill material containing slag is above the ground water table. After the site is developed and the surface sealed, leaching of the slag should not be expected. However, due to capillary water and water vapor, there would still be an adequate supply of water to cause swelling if the slag is expansive.

To our knowledge, expansion of iron-based slag has not been a problem in this area. However, large volumes of this slag have not been produced and we know of no building constructed on iron-based slag fill.

RECOMMENDATIONS

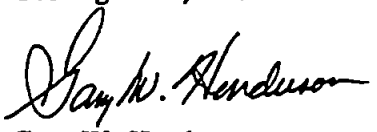
Because of the high pH and sulfates and potential damage to concrete, we recommend that the slag and fill containing slag be removed from under the building foundation. The extent of removal should be at least 4 feet from the piling and other concrete elements of the foundation.

We do not recommend that the slag be removed from under the slab or yard areas. While there is some risk that portions of the slag may be expansive and cause some heaving in the long term, it is our opinion that the risk of significant problems is low.

We trust that the foregoing meets your present needs. Should you have any questions or need additional information, please call.

Yours very truly,

GeoEngineers, Inc.



Gary W. Henderson
Principal

GWH:db
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