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August 9, 2012

Salmon School District #291
907 Sharkey Street
Salmon, Idaho 83467

RE: Salmon Elementary and Middle School
Salmon, Idaho
Soil Sulfate Assessment Results
Job # 12060.L03

Dear Ken:

We received the results of the soil testing completed for the sample provided from the school property at the Salmon Elementary and Middle School. As various concrete elements, particularly the tops of foundations walls and interior concrete slabs are experiencing continued deterioration; the soil samples were tested to determine the Sulfate content.

The deterioration of concrete exposed to sulfate is the result of the penetration of aggressive agents into the concrete and their chemical reaction within the cement matrix. The three main reactions typically observed include conversion of hydrated calcium, formation of gypsum and decomposition of the hydrated calcium silicates. The form and extent of damage to the concrete depends on the sulfate concentration and also upon the physical and capillary characteristics of the concrete. The permeability and surface porosity of the concrete affect how it will perform when exposed to sulfate attack.

The results of the testing prepared by Strata indicate that the sulfate content in the sample provided was 1811 ppm (parts per million). According to the code document for concrete; *"ACI 310-08: Building Code Requirements for Structural Concrete"*, sulfate content above 1500 ppm (parts per million) would place the sulfate exposure in the severe category. New concrete structures in this sulfate exposure category are required to use Type 5 cement. This type of cement has a very low (C_3A) composition which provides high sulfate resistance. The maximum content of (C_3A) allowed is five percent for Type V Portland cement. Minimizing the (C_3A) content reduces the chemical reaction between sulfate ions and (C_3A). This reaction causes disruptive expansion and leads to concrete deterioration.

While it appears likely the concrete in the foundations of the Pioneer elementary school is being adversely impacted by sulfate exposure, we believe that freeze thaw cycling is also contributing to the deterioration of the foundations. Placement of reinforcing without adequate cover also appears to have contributed to the problems. In several locations, the horizontal reinforcing in the top of the foundation walls has been exposed by the deterioration and spalling of the original concrete. In locations where the horizontal reinforcing has been exposed, we recommend that new concrete be "built up and around" the exposed reinforcing. Details and specifications can be developed for the placement of this new concrete. In areas where the reinforcing has not be exposed, sulfate resistant patching materials can be used to repair the damage and prevent further deterioration of the foundations. Use of a concrete sealer on surfaces that are exposed to repetitive moisture cycles would also serve to minimize the potential for further sulfate degradation.

In addition to the deterioration in the foundations at the Elementary school, sulfate intrusion has caused deterioration of the concrete roof system in two non-occupied areas of the Middle School. The rooms, identified in the original construction documents as the Mechanical and Fuel Storage Rooms, both have significant areas in the roof construction that show residue from sulfate intrusion. Deterioration has exposed reinforcing in both the beams and deck in some areas. Repair of the concrete in these rooms will be significantly more difficult than the proposed foundation repairs. However, it may be possible to prevent further deterioration by providing a new concrete overlay and sealer on the roofs of these rooms. Further investigation will be required to determine if this is a viable and economical solution.

Both buildings have areas where the concrete slabs on grade appear to be experiencing problems related to attack from sulfate bearing sub-grade below the slabs. The slabs in question have heaved up creating uneven areas in the floors. It should be noted that sulfates in the sub-grade are not harmful to the concrete as long as the sub-grade remains dry. Water is needed to dissolve the sulfates and transport the sulfate ions into the concrete. Moist soil conditions are required and are often provided by groundwater drawn up the through the sub-grade by capillary action. Continuing heave is anticipated in the floor slabs however the progression should be slow and allow for removal and replacement of the damaged floor areas over time. The most critical item to prevent continued problems with sulfate attack from the sub-grade is to place all new floor slabs on a moisture barrier. This moisture barrier can be placed immediately below the new concrete floor slab or be covered with 2" of sand placed between the vapor barrier and the new concrete slab. Concrete used for the new floor slabs should have a low water cement ratio. The moisture barrier may impact the rate of cure for the new concrete slabs and therefore detailed specifications regarding the concrete mix design, concrete placement and concrete curing methods should be provided.

At this time, the deterioration of the concrete foundations, roof elements and floor slabs do not represent a significant risk of collapse. Remediation of the deterioration can be completed as funds allow. We strongly recommend that all efforts to repair or replace damaged concrete be completed with detailed drawings and specifications to assure that the work will accomplish the required solution and prevent further problems related to concrete performance.

Please contact me if you have any questions regarding the information contained in this letter.

Respectfully Submitted

Janene A. Welch, P.E., S.E.
JAW/mlm

Enclosures: (1) Strata Test Results

STRATA
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Integrity from the Ground Up

Project: Salmon School District:
Middle and Elementary School Evaluation
Client: Stapley Engineering
Job Number: 12060

Client Number: STAENG
Project Number: BO12307A
Lab Number: B12L0919
Report Date: 7/23/2012

Test Results

Resistivity
AASHTO T 288

Resistivity = **1,235 ohm-cm**

pH of Soils
AASHTO T 289

pH = **8.8**

Water Soluble Sulfate Content
AASHTO T 290

Sulfates = **1,811 ppm**

Reviewed by: