



March 26, 2025

Transmitted via email to: William.Johnson@deq.oregon.gov

Department of Environmental Quality
Agency Headquarters
700 NE Multnomah St, Ste 600
Portland, OR 97232

Attn: William “Ian” Johnson, DEQ Fuel Tank Seismic Stability Inspector

**Re: Response to Oregon Department of Environmental Quality’s Review
Linnton Asphalt Terminal Seismic Vulnerability Assessment
Portland, Oregon**

Dear Mr. Johnson:

At the request of Owens Corning, Inc. (terminal owner), Sage Geotechnical, LLC (Sage) and Norwest Engineering, Inc. (Norwest, prime engineer) provided engineering services to support a Seismic Vulnerability Assessment (SVA) of Owens Corning’s Linnton Asphalt Terminal in Portland, Oregon. In 2024, the SVA was submitted for the Oregon Department of Environmental Quality’s (DEQ) review and comment. DEQ’s review comments are addressed in the following documents:

1. This letter and its attachments. DEQ’s comments and Sage’s responses are provided in Table 1 (attached).
2. The updated SVA. The SVA has been signed and sealed by members of the assessment team.

Owens Corning is committed to compliance with the 2022 Oregon Laws Chapter 99 (Law) and Oregon Administrative Rules (OARs) 340-300-0001 through 340-300-0009. Accordingly, Owens Corning submitted a facility-wide SVA for its Linnton Asphalt Terminal. The SVA was submitted by the June 1, 2024, deadline identified in OAR 340-300-0003(3)(a).

Although the SVA was complete at time of submittal, updates were needed to improve the readability of the geotechnical appendix and in-text references to the appendix. These updates have since been made.

OAR 340-300-0003(6)(a) sets forth the requirements for the geotechnical portion of the SVA, and the SVA submitted by Owens Corning meets these requirements. The “Seismic Vulnerability Assessment Forms – Form 1: Questions for the Geotechnical Assessment of Each Facility” (hereinafter, assessment form) is inconsistent with the requirements in OAR 340-300-0003(6).

In the assessment team's opinion, the exhaustive questions and requests on the assessment form are designed to elicit more information than is needed to assess the seismic vulnerability of the facility. Where the OAR sets forth clear/fixed requirements for the geotechnical portion of the SVA, the assessment form includes additional questions and requests that seem irrelevant to the determination of seismic vulnerability. Nevertheless, the assessment team has attempted to respond to each question/request. Complete responses are provided in the attachments.

The assessment form includes arbitrary requirements that cannot be justified by the Law or the OAR. One such requirement is a maximum spacing of 200 ft between subsurface explorations (e.g., boreholes and/or cone penetration test soundings) advanced along berms. This spacing requirement appears to come from the American Association of State Highway and Transportation Officials' (AASHTO) *LRFD Bridge Design Specifications*; however, the AASHTO standard is neither relevant to industrial facilities, like the asphalt terminal, nor is it referenced in the Law or the OAR.

Although it is seeking an exemption to OAR 340-300, Owens Corning has completed the facility-wide SVA in good faith and in compliance with OAR 340-300. The assessment team has concluded that the terminal is vulnerable to damage during an earthquake, and additional geotechnical investigation and analyses are unlikely to alter this conclusion.

If Owens Corning does not receive an exemption, the results of the existing geotechnical, structural, and safety assessments will be used to prepare Risk Mitigation Implementation Plans (RMIPs). Owens Corning will use the SVA, the Law, the OAR, and its own operational goals to develop the RMIPs, with the understanding that the RMIPs could necessitate more detailed geotechnical, structural, or safety investigations and analyses, depending on the selected risk-mitigation strategy.

SAGE GEOTECHNICAL, LLC & NORWEST ENGINEERING, INC.



Daniel Simpson, PE, GE
Principal Geotechnical Engineer
Sage Geotechnical, LLC



Michael Smith, PE
Director of Engineering
Norwest Engineering, Inc.

Attachments: Table 1. Geotechnical Checklist Comments and Responses
Attachment 1. Supplemental Information

Table 1
Owens Corning Linnton Asphalt Terminal
Checklist Comments and Responses

| No. | DEQ Comment | Response |
|-----|---|---|
| 1 | Provide a scale plan or plot drawing of the entire facility, including all tanks, berms, marine terminals, loading racks, pipelines, etc. [GEO1] | See Appendix A, Figure A-1 and Figure A-2, and Appendix B. |
| 2 | Provide all available soil data, boring logs, and geotechnical reports developed for the site since the original design and as-built properties of the facility. [GEO2] | See Appendix A-1 |
| 3 | Provide locations of all existing boreholes or CPTs on the plan or plot drawings. [GEO3] | See Appendix A, Figure A-2. |
| 4a | Boring or CPT depth shall be a minimum of 100ft (Appendix E, API 650, MOTEMS Section 3106F.2.2, ASCE 7, Section 20.1. [GEO4] | Noted. Some CPTs were refused above 100 ft bgs due to dense soil conditions. |
| 4b. | Borings are to be onshore and offshore (if any marine structures are present). [GEO4] | Offshore borings are unnecessary to establish seismic vulnerability. The marine structures are vulnerable. Offshore borings may be performed during the risk mitigation analyses for the marine structure. |
| 4c. | Spacing of boreholes or CPTs along the berms shall not be more than 200 ft. (AASHTO, Table 10.4.2-1). For the perimeter of tank farms, there must be a minimum of one record at each corner. If there are minimal or no differences, this may be adequate. If not, a spacing of 200 ft along the berm or perimeter is necessary if there are erratic subsurface conditions encountered (AASHTO, Table 10.4.2-1). [GEO4] | We assume the reference here is to AASHTO's <i>LRFD Bridge Design Specifications</i> , which is a guide specification for vehicle bridge design and state highway transportation projects used by the general public. Nowhere in Table 10.4.2-1 is there a reference to tank farms, secondary containment, above ground storage tanks, or pipe supports. Furthermore, nowhere in OAR 340-300 (the "Rules") is there a minimum number, depth, or extent of exploration required. In our opinion, the historic subsurface data are sufficient for assessing seismic vulnerability of an industrial facility, in particular when the conclusion is vulnerability. Additional exploration may be performed during the risk mitigation and implementation phase. |

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| 4d. | If CPTs are used, a few cases of verification of results should be compared to those from adjacent borings. Relationships between the SPTs, CPTs and full borings should be provided, using the latest geotechnical references and procedures. [GEO4] | The data includes co-located CPTs and borings (see Figure A-2b). |
| 4e | Provide geologic cross sections (color) of the facility to provide stratigraphy of the site, and to establish the site classification. [GEO4] | A geologic cross section (color) is provided on Figure A-3. We are not aware of how the site classification is determined from a geologic cross section. A seismic site classification calculation is provided in Appendix A-3-1. |
| 4f | If any other geotechnical data (other than COT, SPT, or borings) was available, provide details and dates. [GEO4] | None other available. |
| 4g | Employ contemporary standards of practice for all new soil investigations. [GEO4] | Noted. CPT testing was completed in general accordance with ASTM D5778. Mud-rotary borings were completed with split spoon sampling in general accordance with D1586. |
| 4h | Verify compliance with items (i) through (v) of OAR 340-300-0003(6)(a). [GEO4] | We are in compliance. Section 5.1.1 is laid out in the same format as the rules in OAR 340-300-0003(6) for easy comparison of our content to the rules. See SVA Section 5.1.1, the subsection titles in the SVA match the subheadings under OAR 340-300-0003(6)(a). |
| 5 | The following considerations must be addressed in the geotechnical design report. [GEO5] | The SVA should not be considered a design report; nothing in the Rules indicate a design should be a result of the SVA. The future risk mitigation implementation plan may have elements of design. The SVA has been prepared to meet the requirements of the Rules and should be evaluated accordingly. |

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| 5a | Liquefaction potential in "Sand-Like" Soil and Cyclic Degradation in "Clay-Like" Soil How was cyclic resistance ratio evaluated (simplified or site-specific)? [GEO5] | <p>Simplified. This is addressed in great detail in SVA Section 5.1.1.2.2 and Appendix A-2. Supplemental information is provided below:</p> <p>The average $S_{u,r}$ discussed in SVA Section 5.1.1.2.2 was computed based on liquefaction FS with a FS cutoff of 1.0 (see comment/response to question 5f for additional discussion on using FS=1.0). This means that all soil layers with FS<1.0 were assigned a residual shear strength based on their CRR (i.e., the sand-like approach), regardless of their I_c. In other words, layers that are clay-like and may only degrade 85 percent or so of their static strength were still assigned a sand-like residual shear strength if they were triggered (i.e., FS <1.0). This is a conservative approximation/simplification.</p> <p>As discussed in Section 5.1.1.2.2, CPT soil behavior type I_c was used to determine susceptibility to liquefaction. Specifically, we selected $I_c > 3.0$ as not susceptible to liquefaction. Typically, an I_c of 2.6 is used to determine susceptibility (i.e., $I_c < 2.6$ is not susceptible per Robertson and Wride 1998). Comparing the site-specific Atterberg limits and water content data indicate that an I_c higher than 2.6 is appropriate. Based on correlation between water content, plasticity index, and I_c, the cutoff of 3.0 was determined to be applicable.</p> |
| 5b | If a site-specific response analysis has been performed, was it one or two dimensional? [GEO5] | Not applicable. |
| 5c | What ground motion parameters were used? [GEO5] | See SVA Section 5.1.1.2.1 and Appendix A-3. |
| 5d | What methodology was used to calculate residual shear strength? [GEO5] | See SVA Section 5.1.1.2.2. |
| 5e | What safety factor for liquefaction in sand (CRR/CSR). [GEO5] | Not sure what is the question here? A safety factor of 1.0 was used to distinguish between triggered and not triggered. |

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| 5f | <p>If using a simplified procedure, what current methodology has been used? Is the safety factor less than 1.4, what reduction factor has been applied to the initial shear strength of the soil? [GEO5]</p> | <p>See SVA Section 5.1.1.2.2. As noted above, a safety factor of 1.0 was used to create a simple binary condition of either fully liquefied or non-liquefied and no distinction was made for "partially liquefied" soil. This approach was selected for simplicity and is suitable for the vulnerability assessment. Attachment 1 contains a plot of Liquefaction FS cumulative frequency. As shown, there was one CPT measurement (representing a small fraction of the overall conditions at the site) with a computed FS between 1 and 1.4.</p> <p>Another important consideration here is that in our analyses, the liquefied/residual shear strength was used only for computing seismic bearing capacity (lateral spreading was based on the semi-empirical correlation to Liquefaction FS proposed by Zhang et al 2004). For the seismic bearing capacity calculation, we modeled all soil beneath the water table with a residual shear strength to vertical effective stress ratio of 0.1.</p> |
| 5g | <p>If the Safety Factor is $1.0 < SF < 1.2$, how have the seismically induced ground movements been evaluated. [GEO5]</p> | <p>See above.</p> |
| 5h | <p>If the Safety Factor $SF < 1.0$, what is the residual shear strength. [GEO5]</p> | <p>See SVA Section 5.1.1.2.2.</p> |
| 6 | <p>Provide evaluations for other geotechnical hazards, if applicable: Slope movement, Lateral Spreading, Ground settlement, other surface manifestations. [GEO6]</p> | <p>This is addressed in SVA Section 5.1.1.2. As this is a Seismic Vulnerability Assessment, only seismic hazards were considered.</p> |
| 7a. | <p>Is there a possibility that a slope failure could affect any component of the facility? [GEO7]</p> | <p>See SVA Section 5.1.2. Slope instability (i.e., seismically-induced landsliding due to inertial loading and not a result of liquefaction) is not a risk at this site. Lateral ground movement due to liquefaction-induced lateral spreading and flow failure is a risk.</p> |
| 7b. | <p>If slope failure is possible, has a stability analysis been performed?</p> | <p>No, see above and below responses.</p> |
| 7c. | <p>Are seismically induced ground movements considered?</p> | <p>Yes, the SVA considered liquefaction-induced settlement, lateral spreading, and flow failure.</p> |

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| 7d. | If there are ground movements considered, what methods have been used to analyze them? | Liquefaction-induced settlement was evaluated using empirical procedures proposed by Idriss and Boulanger (2008) and (2014). Lateral spreading and flow failure were evaluated using the Zhang et al (2004) empirical method. This is documented in the SVA. |
| 7e. | Is the expected seismic (DE) displacement greater than 0.1 ft? | Yes. |
| 8a. | What aspects of dynamic SSI have been evaluated (e.g., piles, pipelines, tanks, earth retention systems, or other)? | Rigorous soil-structure-interaction (SSI) analyses were not completed for a myriad of reasons. Chiefly, detailed SSI analysis is not useful for this vulnerability assessment. We have concluded that due to the potential for large liquefaction induced ground movements, it is highly likely that the performance objective [OAR 340-300-0002(18)] will not be met. SSI analyses may be appropriate during the risk mitigation implementation phase. SSI analyses are not required to arrive at the vulnerable conclusion. |
| 8b. | What assumptions and procedures have been used to assess SSI? | See above. |
| 9a. | Describe the local geologic and geomorphologic setting of the facility. | See Section 5.1.1.1.2 of the SVA. |
| 9b. | Include any and all historical geotechnical data, reports, or boring information. | See Section 5.1.1.1.3, Appendix A figures, Appendix A-1, and Appendix A-2 of the SVA. |
| 9c. | Present the subsurface profiles in graphical cross-sections. | See Figure A-3 of the SVA. |
| 9d. | Describe groundwater levels and possible artesian or sub-artesian conditions. | See Section 5.1.1.1.4 of the SVA. |
| 9e. | Identify main subsurface units, based on material type, strength, and deformability. | See Section 5.1.1.1.4 of the SVA. |
| 9f. | Assess lateral variability of subsurface units. | See discussion bullet "liquefaction/seismic strength loss" in Section 5.1.1.2.2 of the SVA. |
| 9g. | Summarize main soil and rock parameters, for each of the identified subsurface units. | See Section 5.1.1.1.4 and Figure A-3 of the SVA. |
| 9h. | Describe the lateral variability to the top of rock, where the rock is present within the depth of concern. | See Figure A-3 of the SVA. |

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| 9i. | What is the likelihood of encountering rock or cobbles that might be present within the soil matrix? | This is addressed in Section 5.1.1.1.4 of the SVA. |
| 9j. | Provide justification for the "site classification" (A-F) for this facility. | See discussion in Section 5.1.1.2.1 of the SVA and also the calculation in Appendix A-3. |
| 9k. | Any additional requirements per Oregon Specialty Code, Section 1803.6. | Noted. |

Attachment 1
Supplemental Information

Liquefaction FS Cumulative Frequency Owens Corning Linnton Asphalt Terminal

