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U.S. Army Corps of Engineers
Regulatory Branch
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Attn: Gail Terzi and Michelle Walker

Washington State Department of Ecology
Shorelands and Environmental Assistance Program
3190 160th Avenue Southeast
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Attn: Ann Kenny, Environmental Specialist

Subject: Implications of Preliminary Findings from the Nisqually Earthquake of 28 February 2001 on the Seattle Tacoma International Airport Third Runway - Embankment Fill and West MSE Wall Expansion Project

Applicant: Port of Seattle
Reference: 1996-4-02325

INTRODUCTION

Observations of damage to mechanically stabilized earth (MSE) walls and extensive liquefaction from the Nisqually earthquake of 28 February 2001 emphasize the seriousness of concerns over the adequacy of these aspects of the proposed Third Runway (Third Runway) Expansion Project at Seattle Tacoma International Airport (SeaTac). In a letter dated 16 February 2001, GeoSyntec Consultants (GeoSyntec) provided technical review comments on the investigation, analysis and design relating to construction of the embankment fill and West MSE Wall elements of the Third Runway project. GeoSyntec prepared the letter of 16 February 2001 on behalf of the Airport Communities Coalition. On 28 February 2001, following issuance of our comments, the Seattle/Tacoma area was subject to a significant earthquake. In terms of the severity, the ground motions induced by the earthquake of 28 February 2001, now

Exhibit 403
Date 2/19/02
Witness Kavazanjian
Diana Mills, Court Reporter

known as the Nisqually earthquake, are best described as moderate. However, despite the moderate severity of ground motions, there were numerous instances of ground failure and structural damage throughout the affected area, including at SeaTac and other regional aviation facilities. Furthermore, significant damage was reported to at least two MSE walls. In light of the relatively moderate intensity of the ground motions in the Seattle/Tacoma area due to the Nisqually earthquake, observations of damage to MSE walls and extensive liquefaction and lateral spreading punctuate our concerns over the adequacy of these aspects of the design for the Third Runway project. This letter summarizes the relevance of the preliminary findings from post-earthquake investigations of the Nisqually earthquake as they relate to the embankment fill and West MSE wall elements of the proposed Third Runway Expansion Project at the Seattle Tacoma International Airport.

SOURCES OF PRELIMINARY DATA

Sources of the preliminary data on the Nisqually earthquake discussed in this letter include:

- The University of Washington Seismology Laboratory web site at http://www.geophys.washingon.edu/SEIS/EQ/
- The Earthquake Engineering Research Institute (EERI) preliminary reconnaissance report at http://www.eeri.org/Reconn/Nisqually_Wa_2001/Nisqually.htl; and
- The Pacific Earthquake Engineering Research Center (PEER) preliminary reconnaissance report at http://peer.berkeley.edu/nisqually/geotech/

DESIGN GROUND MOTIONS

One of the concerns expressed by GeoSyntec in the letter of 16 February 2001 was that "Seismic design ground motion criteria have not been established and

there do not appear to be any established seismic performance criteria for the wall." Project documents discussed design for ground motions with between 10 percent and 2 percent probability of being exceeded in 50 years and appeared to implicitly endorse the 10 percent in 50 year standard used in the Uniform Building Code for residential structures. The impact of the moderate levels of strong motions associated with the Nisqually earthquake on operations, including the cessation of airport operations for several hours, demonstrates the importance of the airport as a regional "lifeline" - a conduit for supplies and people necessary for earthquake response activities. Design ground motions should clearly be higher than those associated with ordinary residential structures.

In the letter of 16 February 2001, GeoSyntec also expressed concern that "There are inconsistencies in the results of the Probabilistic Seismic Hazard Analysis (PSHA) performed by Hart Crowser that cast doubt on the validity of the analysis." We note that preliminary data on the ground motions at SeaTac in the Nisqually earthquake indicate that the peak horizontal ground acceleration (PGA) was around 0.19 g (University of Washington Seismology Laboratory). This reported PGA is approximately equal to the value from the Hart Crowser probabilistic analysis with a 50 percent probability of being exceeded in 50 years. As the 1949 earthquake was at the same approximate location as the Nisqually event and of larger magnitude, it must be assumed that ground motions in the 1949 event were even larger than those measured in the Nisqually event. Therefore, the ground motions from the Hart Crowser analysis with a 50 percent probability of being exceeded in 50 years have been exceeded twice in the past 52 years. This observation suggests that the Hart Crowser analysis may have underpredicted expected ground motions at the project site.

MSE WALL SEISMIC DESIGN

In the letter of 16 February 2001, GeoSyntec expressed the concern that "To our knowledge, the computer program FLAC used to evaluate the seismic performance of the wall in the design earthquake has never been demonstrated to reliably predict seismic deformations of earth structures. Therefore, the FLAC analyses do not provide an appropriate basis from which to conclude that the wall can withstand the design

earthquake." Our concern over seismic design of the MSE walls is heightened by the February 8, 2001 letter from Hart Crowser stating that the Reinforced Earth Company (RECo) has been retained by the Port of Seattle to design the MSE walls for the Third Runway project[1]. Design documentation provided by RECo suggests that MSE wall design is governed by static load considerations and that seismic performance is not a significant design concern. The very first sentence of RECo Technical Bulletin MSE-9, *AASHTO Design Method for Reinforced Earth Structures Subject to Seismic Forces* states "It is generally agreed that the stability of retaining walls exposed to earthquakes is not of real concern." However, reports of damage to MSE walls in the Nisqually earthquake demonstrate that the ability of MSE walls to resist seismic loads cannot be taken for granted, particularly for as monumental and important a facility as the Third Runway.

There are preliminary reports that at least two MSE walls suffered significant damage in the Nisqually earthquake. In Tumwater, an MSE wall 9 to 12 ft (2.7 to 3.6 m) high with a segmental masonry facing failed in the earthquake (EERI and PEER). Movement of an MSE wall was also reported at the north end of Terminal 5 in the Port of Seattle (EERI). While details on the two MSE walls that suffered damage are scarce, it is safe to say that neither wall approached the proposed SeaTac West Runway Extension MSE wall in height or importance, given the unprecedented nature of the SeaTac MSE wall and the potential impact of a failure. Failure of one MSE wall and movement of a second wall in this relatively modest earthquake adds emphasis to concerns over the adequacy of the use of an unproven method of analysis for seismic design of the SeaTac MSE wall, a truly monumental structure.

LIQUEFACTION ANALYSIS

In the letter of 16 February 2001, GeoSyntec expressed concern that "Flaws in the liquefaction analysis of foundation soils render the conclusion that the wall will

[1] Letter of February 8, 2001 on "Comments on 404/401 Permit Applications, J-4978-30" from Michael Bailey, P.E., of Hart Crowser to Jonathan Freedman of the U.S. Army Corps of Engineers and Ann Kenny of the Washington State Department of Ecology.

not fail due to liquefaction invalid. Because of these flaws, the extent of potential liquefaction of the subgrade beneath the West MSE Wall and the rest of the Third Runway project may have been underestimated." GeoSyntec also expressed concern that "Inappropriate selection of residual shear strength values means that the conclusion that the wall will not slide on its foundation in the aftermath of a major earthquake is not valid. The selection of residual strength values to represent conditions after a seismic event is unconservative and some values are based upon extrapolation beyond the range of past experience." Liquefaction was perhaps the most pervasive deleterious effect of the relatively moderate ground motions from the Nisqually earthquake. Liquefaction was reported at numerous locations, over a wide area. There were also numerous reports of lateral spreading associated with liquefaction. Locations where liquefaction and lateral spreading was reported include Boeing Field and the Ports of Seattle and Olympia (PEER and EERI). The EERI report suggests that the movement of the MSE wall at Terminal 5 in the Port of Seattle may be related to foundation liquefaction. These reports of liquefaction and of lateral spreading of embankments on liquefied ground in this moderate earthquake further emphasize the importance of foundation liquefaction as a potential source of damage to the proposed SeaTac MSE wall.

We do not know if the area in the vicinity of the Third Runway project experienced liquefaction or ground deformation as a result of the Nisqually earthquake. A careful inspection of the Third Runway project area for evidence of liquefaction and seismic ground displacement is certainly warranted as it may provide important information on the behavior of the local soils subject to earthquake ground motions. Even if liquefaction was not induced at the project site by the moderate levels of ground motion from the Nisqually earthquake, the much stronger levels of shaking associated with the design earthquake for the Third Runway project will undoubtedly generate much more widespread liquefaction and lateral spreading. The observations of liquefaction-induced damage from the relatively modest Nisqually earthquake underscore the need for a thorough analysis of this potential failure mechanism for the Third Runway project.

CONCLUSION

In commenting on the societal implications of the Nisqually earthquake, the EERI preliminary reconnaissance report states that "some of the media and official commentary have overly simplified the comparisons between this event and similar magnitude events like the Northridge earthquake. In this regard, the much lesser damage from this event has the potential for lulling citizens and officials into a false sense of security concerning seismic safety." We urge you to heed the EERI warning and to consider the Nisqually earthquake as a "wake-up call," alerting citizens and officials to the potential implications of the major earthquake that, we know with certainty from the geologic record, will eventually strike the Seattle/Tacoma area. The lessons to be drawn from the Nisqually event for the SeaTac Third Runway Expansion Project are that seismic analysis of the MSE wall and mitigation of the potential for foundation liquefaction are important design considerations and that deficiencies in the analyses performed to date should be remedied before approval is granted for the project to proceed.

Sincerely,

for Patrick C. Lucia, Ph.D., P.E., G.E.
Principal

Edward Kavazanjian, Jr., Ph.D., P.E., G.E.
Principal

Copies to: Peter Eglick, Helsell Fetterman, LLP
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