UNIVERSITY OF WASHINGTON
TRIANGLE PARKING GARAGE
VENTILATION STUDY
100% Report for review

March 15, 2010

Submitted to

University of Washington
Andy Casillas
(206) 685-9055

UW# 203207
WH #09041.03
1) Introduction
The Triangle Parking Garage is a two level below grade parking structure. An abandoned 23.5 foot wide by 7 foot high garage entrance is located on the north side of the parking garage adjacent to NE Pacific Place (see photos 1 and 2 in Appendix A). This entrance is presently serving as a makeup air path for the garage exhaust system. Revisions to NE Pacific Place will cause significantly more pedestrian traffic to cross by this open entrance. For security reasons, access to the parking garage through this opening will be blocked off. The scope of this study is to look at the impact of closing, or partially closing the abandoned north garage entrance will have on the garage ventilation system.

2) Ventilation System Description
The parking garage is mechanically exhausted by five fans GEF-1 through GEF-5 located in four mechanical rooms. All fans have variable frequency drives which are controlled based on an occupancy schedule and input from carbon monoxide sensors located throughout the garage. The exhaust fans were installed with the original garage construction in 1987. Variable frequency drives, carbon monoxide sensors, and carbon monoxide control panels were added in 1998.

The upper level is served by GEF-1, GEF-2, and GEF-4 for a total scheduled exhaust rate of 152,500 cfm. The floor area of the upper garage is 91,773 square feet giving a ventilation rate of 1.66 cfm / square foot.

The lower level is served by GEF-3 and GEF-5 for a total scheduled exhaust rate of 107,500 cfm. The floor area of the lower garage is 74,391 square feet giving a ventilation rate of 1.44 cfm / square foot.

Makeup air for the exhaust is provide through an abandoned 164 square foot vehicle entrance on the north side of the garage, an active 315 square foot vehicle entrance in the north west corner, and by two pedestrian openings to the UW hospital tunnel in the south west corner of the garage totaling 147 square feet. Excluding leakage through cracks, the air velocity through the openings based on scheduled airflows is 415 feet per minute.

3) Code Analysis
The 2006 Seattle Mechanical Code table 403.3 “Required Outdoor Ventilation Air” states that enclosed parking garages shall be provide with 1.0 cfm / square foot of outdoor air and comply with section 404 of the code. Based on scheduled airflows from the 1986 drawings, the upper level ventilation rate is 1.66 cfm / square foot and the lower level ventilation rate is 1.44 cfm / square foot. Scheduled airflows do meet current code. However, the only way to confirm that code is met is to have airflows verified by a testing and balancing contractor.

Section 404.1 of the Seattle Mechanical Code requires that systems being controlled with carbon monoxide sensors maintain carbon monoxide levels below 35 ppm. The sequence of operations in the 1998 construction drawings which installed the carbon monoxide sensors has a setpoint of 35 ppm carbon monoxide, thus satisfying this portion of the code.

Section 404.1.3 of the Seattle Mechanical Code requires provision of mechanically supplied makeup for enclosed parking garages with more than 3 floors above or below the nearest entrance or exit. The lowest level of the Triangle Parking Garage is 1 floor below the nearest entrance / exit, therefore no mechanically supplied makeup air is required.
4) **Recommendations**

Completely closing the north parking garage entrance would reduce the makeup air openings from 626 square feet to 462 square feet. This would increase the air velocity through these openings from 415 feet per minute to 562 feet per minute.

The exhaust system static pressure will increase if the north entrance is closed. How much of an increase in static pressure can be added and still allow the fans to meet code requirements of 1.0 cfm / square foot? The fan laws state that the square of the initial airflow (Q1) divided by the final airflow (Q2) is equal to the initial static pressure (SP1) divided by the final static pressure (SP2).

\[
\frac{SP1}{SP2} = \left(\frac{Q1}{Q2}\right)^2
\]

\[
SP1 = 0.48 \times SP2
\]

The above equations tell us that if the present exhaust system airflows are meeting design document schedules, then the system static pressure to meet code required airflow would be about half that of the current system static pressure. Put another way, there would have to be a significant increase in system pressure to cause the airflow to drop to code minimum if the current system is at design conditions. Closing off the north garage entrance will not cause enough of a pressure drop to drop airflow below code minimum if the fans are presently meeting design requirements.

**Recommendations:**

1. Maximize free area when closing off north entrance by installing a chain link fence. This will insure that current airflow rates are maintained.

2. If a chain link fence is not an option, we recommend having existing airflows verified by a testing and balancing contractor. If the total exhaust airflow is at least 135,000 cfm for the upper level and 95,000 cfm for the lower level, then blocking the north entry with a louver having at least 50% free area will still allow for airflows to be above code required minimum. After the louvers are installed, have testing and balancing contractor confirm final airflows with all exhaust fans at 100% speed.

3. If the north parking garage entrance is to be fully closed off, we recommend temporarily blocking off the entrance and having a testing and balancing contractor measure the exhaust airflows. If the upper level exhaust is greater than 92,000 cfm and the lower level exhaust is greater than 75,000 cfm, then permanently blocking the north entrance is ok.
APPENDIX - A (photos)
Photo 1 (looking south toward abandoned parking garage entrance from under NE Pacific Place bridge)
Photo 2 (looking north from abandoned parking garage entrance towards Drumheller Fountain)