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NCSD SEISMIC – CONCORD ELEMENTARY SCHOOL

At the request of North Clackamas School District, we have prepared this more in-depth review of the seismic issues at Concord Elementary School. The school, at 3811 SE Concord Road in Milwaukie, was partially seismically upgraded in 2000 / 2001, but significant seismic hazards were not addressed. We understand that Riverside Elementary School is being considered for closure, with students moved to Concord Elementary, and that there are concerns about the remaining seismic hazards at Concord. This letter report will address seismic hazards in general, the structural systems at Concord, previous upgrades at Concord, remaining seismic retrofits to be done, and relative risks.

Seismic awareness in Oregon was practically nonexistent before the early 1960's, and the region was believed to be seismically and volcanically inactive. Structural Codes, such as they were, did not include mandatory provisions for seismic loads until 1961, and those first mandatory values were much lower than current requirements. Over the ensuing years, based on emerging knowledge and on effects of local and distant earthquakes, the requirements were gradually increased. In 1935 when the main school building was built at Concord Elementary, and again in 1948 when the east classroom addition was built, the materials, methods, and details of construction were low-capacity compared to current standards.

The original 1935 school building at Concord Elementary was constructed with a wood-framed roof system. That roof was minimally attached to the unreinforced brick and clay tile double-wythe walls at the building exterior and to the wood framed corridor and interior demising walls. The main floor framing was also wood framing, and the basement walls were unreinforced or minimally reinforced concrete up to grade and masonry above (creating a weaker hinge point partially up the walls. Again, connections between the main floor and the walls were minimal in comparison to current requirements. The 1948 addition was of similar construction to the 1935 building, with similar issues.

In the year 2000, some improvements were planned for Concord Elementary, and our firm was retained as structural engineers for that work. We had been employed by a firm in 1993 that had evaluated and designed repairs for the Molalla High School building after the Scotts Mills earthquake that year. Molalla High School was built similarly to Concord Elementary, and had significant damage that could have taken lives had the earthquake not happened during spring break. Brick entry walls collapsed around and onto the main entry / exit of the school. That entry was almost identical to the west entry at Concord, and we were asked to provide preliminary seismic reports for Concord and Riverside Elementary Schools.

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Estimates were prepared for a full seismic upgrade at Concord based on our findings, but the budget was limited and only the entry areas and the east wall of the gymnasium were strengthened for out of plane forces (blowout). Our estimate at that time for the work that was included in the year 2000 bond was $550,000. We had estimated a cost of $600,000 to $700,000 to upgrade the entire unreinforced masonry wall (URM) perimeter for out-of plane forces (as was done at the entries), but that work did not include in-plane reinforcement to brace the overall building lateral systems.

Our year 2000 estimate for full upgrade of the building to life / safety performance level (where the building is damaged but still repairable and is designed to survive the earthquake relatively intact) was one million dollars or more. For an immediate occupancy-level upgrade (where the building use is uninterrupted), we had estimated two million dollars or more. The estimate to complete upgrades to life / safety level in the recent Phase 2 evaluation of Concord Elementary was $1,638,000, based on a unit cost of $35 per square foot and on the work that has already been completed. With inflation, those estimates are compatible.

In 2000 / 2001, reinforcement was designed for limited URM areas around the four main entries / exits at Concord, for the entire east wall of the 1948 addition (required to provide a safe exit path between that wall and the property line fence to the east), and for the east wall of the gymnasium. That work comprised a total of 435 lineal feet of wall (measured separately for each level of the building). The remaining non-upgraded URM walls that adjoin classroom and staff areas total an additional 973 lineal feet. The required work on stud strongback walls, brick veneer ties, and strap attachments to the roof and floor framing will have a higher incremental increase in cost over the 2000 entry reinforcement estimates since some economy was lost in doing the projects separately.

The existing unreinforced exterior walls should also be upgraded to provide adequate in-plane shear capacity for the seismic loads of the building structure. Even if the walls are designed to resist seismic loads out of plane (blowout), if the in-plane forces in an earthquake exceed their limited shear capacity, the pier elements between window openings could fail. Failure of the exterior wall piers would cause the entire exterior load-bearing walls to fail, and the perimeter of the roof to collapse into classroom and staff support areas. This problem was considered in planning the limited year 2000 upgrade, with the concept that in an earthquake, students would be advised to move to the interior hallways if inside the building, and move away from the exterior walls if outside. Since the interior corridors are likely to sustain significant damage but not collapse, and the exits have been strengthened, this compromise allows the students and staff to evacuate the building safely. There are still areas inside and outside the perimeter of the building that would be very hazardous to occupy during an earthquake. Many of the NCSD schools have similar areas of risk, including Riverside, particularly where there are long bands of windows without significant shear walls.

The in-plane shear issues at Concord Elementary are similar to those buildings, except that the URM exterior piers exacerbate the problem since they are brittle and subject to complete failure when seismic cyclical bending and shear loads are applied. In a full seismic upgrade, new shear elements (walls or braced frames) would be added to the existing piers, with some window infill required to provide adequate shear element length at the perimeter. For the 1935 building, the west wall overall length is 212 feet, and although 64 total feet of that length is full height masonry piers, they are all limited to about 4 feet or 6 feet in length and 8 1/2"inches thick. In addition, there are some 8 1/2” x 17” unreinforced masonry piers between windows that are almost 9 feet tall within the openings, and they support a tributary length of the roof of 10 feet. Failure of those small piers at both ends of a bank of windows would cause collapse of the exterior part of the roof within a classroom.

The north and south endwalls of the 1935 building are about 78 feet long overall, with only four 4'foot long wall piers each for a total of 16 feet per end. Also, the north side of the 1948 addition is 133 feet long with only three 8'-9" piers, a 6 foot pier, and a 4 foot pier, for a total of about 36 feet. These piers will suffer major damage due to in-plane and out of plane loading in a design earthquake, and reinforcement of the piers will need to be substantial in most cases due to limited individual and total lengths of walls.

The partition walls between classrooms and the corridor walls are wood framing with lath and plaster, and have some ability to resist in-plane shear loads. However, that ability is limited due to the brittleness and weakness of the plaster, and major damage and loss of plaster can be expected. A long-duration earthquake could cause major damage to those walls. Upgrading those walls would be relatively easy. The plaster finish would be removed from one or both faces, blocking would be installed between studs, holdowns would be installed, and plywood sheathing with a gypsum board finish would be applied to one or both faces of the walls. In addition, top and bottom connections to structure would be strengthened, foundations or support beams added, and the "shear wall" would be extended to the roof to provide a complete load path from roof to foundation.

The roof of Concord Elementary is very irregular, with both vertical and horizontal irregularities. The damage that would occur from areas of the roof structure separating from one another during a significant earthquake should not be a major life / safety issue, but providing continuity strapping to limit those separations should prevent significant roof damage and leaks that could delay occupancy after an earthquake. Areas that are not currently sheathed with plywood should be upgraded with new plywood, along with continuity strapping.

In our evaluation comments in 2000, we addressed the chimney collapse potential at Concord. It was decided not to remove or brace the chimney at that time because the collapse hazard area was in a relatively unoccupied area behind the school. That work should be included in a full upgrade project.

Also in 2000, we noted that some of the mortar joints in the URM walls, both inside and outside the building, were deteriorated. Those mortar joints should be repointed during wall upgrade work.

We have attached a letter and diagram we prepared in September 2001 following the first phase of seismic upgrades at Concord Elementary School. Those documents are a good guideline as to the areas of the school that have not been strengthened, and they reflect the thrust of the work then to upgrade the building to allow for evacuation, but not necessarily to prevent partial collapse.

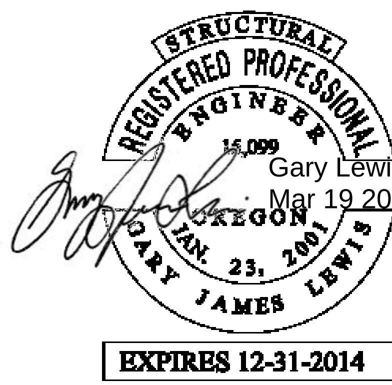
Trying to assess the short-term risks to life / safety can be an exercise in statistics, with very few data points. A recent report by Oregon State University found that the recurrence interval for a subduction zone earthquake along the southern Oregon coast may have been as low as 250 years, contrary to the 300 to 500 years previously believed. The theories of the strength and frequency of these massive earthquakes along the coast are evolving, but what is almost universally accepted is that we have had regular great earthquakes, and we are currently overdue for a magnitude 8.5 or 9 earthquake off the coast of the Pacific Northwest. It is expected that such an earthquake would affect the Portland area similarly to a local magnitude 7.0 strike-slip fault earthquake, but with a duration of four or more minutes. Portland has several local strike-slip faults as well, and they are expected to eventually generate local earthquakes up to magnitude 6.5, with no predictions on when they might occur.

Current seismic design forces are based on soil conditions at the site and their affect on seismic accelerations, on the ductility (flexibility) of the structure, and on the importance (usage) of the structure. The acceleration coefficients used in determining design coefficients are based on expected earthquake intensity, and those coefficients are reduced based on the other factors noted above, in order to arrive at design forces. Those forces are less than the expected actual forces, and buildings are expected to sustain damage but not collapse if designed to those forces.

The earthquake we design for could occur tomorrow, or 100 years from now. Economics prevent us from taking the safest course which would be to upgrade every structure now, but we should continue to work to remove buildings, particularly school buildings, from the hazardous category.

We trust that this information serves your needs, and encourage you to contact us for additional information if needed.

Gary J. Lewis, S.E.



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