PORTLAND STATE UNIVERSITY
SCIENCE ONE

PRELIMINARY
SEISMIC EVALUATION

Prepared for:
SRG Partnership, P.C.
Portland State University
Portland, Oregon

Prepared by:
DEGENKOLB ENGINEERS

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Mr. Roz Estimé  
SRG Partnership, P.C.  
621 SW Morrison Street, Suite 200  
Portland, Oregon 97205

Reference: Portland State University, Science One  
Preliminary Seismic Evaluation  
Portland, Oregon  
[Degenkolb Job Number 98502.00]

Dear Roz:

At your request, we have performed a preliminary evaluation of the Science One building at Portland State University in Portland, Oregon, to determine its expected performance during a design basis earthquake. This letter report serves to summarize our findings, and includes a possible seismic strengthening scheme, a discussion of typical costs for seismic rehabilitation, and a discussion of the City of Portland requirements regarding the seismic upgrade of this facility. Also included are figures and photographs of the building in Appendix A, copies of the structural checklists in Appendix B, and project calculations in Appendix C.

Our work is based on the following:

1. A review of available architectural and structural design drawings for the original building, prepared by Skidmore, Owings and Merrill Architects, dated July 1964.

2. A site visit on December 18, 1998, to verify original construction details, perform a nonstructural survey, and investigate feasibility of proposed strengthening techniques.
Building Description

Science One was constructed in 1965, and is located near the northwest corner of Portland State University in Portland, Oregon (see Figure 1). The building houses both classrooms and laboratory spaces, and includes a large auditorium at the first floor level. The structure sits on a slightly sloping site (from west to east), and is bordered by SW Mill on the south and SW 10th on the east.

Science One is five stories above grade, with a penthouse on the roof, and basement and sub-basement levels below grade. The building is rectangular in plan, and has dimensions of 176 x 80 feet above the first floor. The basement levels are 200 x 100 feet in plan. Story heights are approximately 14 feet and 1 inch for the two basement levels, 20 feet and 9 inches for the first level, and 12 feet and 6 inches for the remaining levels.

The gravity load-resisting system consists primarily of steel framing and concrete core bearing walls. The penthouse roof, roof, and floors above grade all consist of reinforced concrete one-way slabs, spanning between steel beams and girders, and supported by steel columns. At the second floor, all of the steel columns become discontinuous to allow for an auditorium at the first level. Five-foot deep steel plate girders span north-south at the second floor to transfer loads out of the steel columns and into the large concrete columns below the second level. The mezzanine and auditorium are completely supported off of the first floor level. The mezzanine, first level, and basement levels all consist of reinforced concrete one-way slabs spanning to concrete beams and girders, supported by concrete columns and perimeter concrete walls. There are four stair and elevator cores in the building that each consist of reinforced concrete bearing walls. The interior columns are founded on concrete spread footings, and the perimeter concrete walls are founded on concrete strip footings. The sub-basement level is a concrete slab-on-grade.
The lateral force-resisting system of the building consists entirely of reinforced concrete diaphragms and reinforced concrete shear walls around the four stair and elevator cores in the building (see Figure 2). The core walls are typically eight inches thick above the first floor, ten inches thick below the first floor, and have many large openings for doorways. The lateral system for the mezzanine and the auditorium consists of reinforced concrete diaphragms, reinforced concrete shear walls for the mezzanine and reinforced masonry shear walls for the auditorium. The mezzanine and auditorium walls rest on the first floor slab, and do not continue below the first floor. At the first level, 10 inch thick perimeter concrete retaining walls substantially increase the amount of shear wall in both directions (see Figure 3).

Performance Objective

In accordance with the requirements of the City of Portland for existing buildings, we have evaluated the Science One building for a life-safety performance objective for the design earthquake. This objective is defined in FEMA 178, the National Earthquake Hazard Reduction Program (NEHRP) Handbook for the Evaluation of Existing Buildings, published by the Federal Emergency Management Agency. This performance objective is meant to ensure that a building will not collapse, and that exit paths from the building will not be blocked, but that the building may be heavily damaged, and may be unable to be occupied after a major earthquake. The design earthquake hazard is defined as an earthquake with a 10% chance of exceedance in 50 years as defined by the mean spectral amplification factors included in the 1988 NEHRP Recommended Provisions. The City of Portland requires that the seismic hazard in Portland be defined as an effective peak velocity-related acceleration ($A_v$) of 0.3, and an effective peak acceleration ($A_g$) of 0.3, in place of those values specified in FEMA.

Discussion of Building Deficiencies

Based on the checklist procedures of FEMA 178, a number of possible deficiencies in Science One's lateral force-resisting system have been identified:

- The concrete shear walls in the east-west direction do not appear to have sufficient in-plane shear strength to resist design earthquake forces above the first level. Based on the quick check procedures, the walls have a demand to capacity ratio of 2.0.
Many of the existing walls are slender and have large openings for doorways, with spandrels over the openings that act as coupling beams. These coupling beams have inadequate strength and ductility to enable the walls to work together.

At the ends of a number of walls, boundary elements are not provided. At other locations where boundary elements are provided, they have inadequate strength and ductility to resist design earthquake forces. This is especially critical just above the first floor as the walls transition into the basement levels.

Based on the procedures of FEMA 178, a number of deficiencies in the Science One's nonstructural components have been identified:

- Partitions and fixed glass do not appear to be detailed to accommodate the expected interstory drift.
- Suspended ceiling systems do not appear to be adequately braced to the structure, and ceiling tiles do not appear to be secured with clips over exit routes. The edges of the suspended ceiling do not appear to be separated from the enclosing walls, which may make them subject to distortion and damage under the expected building drifts.
- We did not observe any independent support of the light fixtures in the suspended ceilings, or bracing of emergency lighting equipment.
- The building contains a substantial number of storage cabinets and other heavy furniture that do not appear to be anchored to the structure to resist overturning.
- Breakable items stored on shelves do not appear to be restrained from falling.
- A number of pieces of mechanical and electrical equipment do not appear to be adequately anchored or braced to the building. Systems including gas, fire suppression, and HVAC do not appear to be braced and lack flexible couplings.
- Compressed gas cylinders do not appear to be properly restrained.
Expected Building Performance

Based on the checklist procedures of FEMA 178, Science One does not appear to meet life safety for the design level earthquake. We believe that a detailed evaluation as well as some seismic strengthening will be required to obtain a life-safety performance objective for Science One.

Note that the FEMA 178 procedures used for this evaluation are screening tools, and by nature, are quite conservative for a building of this type and size. For example, the quick check of shear ignores any reinforcing steel in the wall and any contribution of perpendicular walls to the overall strength of the core. A detailed evaluation may show that the performance of this building is better than we have concluded.

Possible Seismic Strengthening Scheme

The key to strengthening Science One at this stage is addressing the lack of shear strength in the east-west direction. Multiple seismic strengthening schemes may be appropriate for this structure. These should be explored in more detail in a detailed seismic study. One possible strengthening scheme may include all of the following elements:

- Strengthen the existing east-west shear walls with new reinforced concrete shear walls. These elements should be attached to the diaphragms and existing walls at each level, and should extend all the way to the foundation even though most of the load may be transferred to other walls below the first floor. The ends of the new walls could also improve the deficient boundary elements in the existing walls.
- Add new steel or concrete collectors at each of the new shear wall locations and attach to the diaphragm with epoxy anchors.
- All nonstructural components and building contents that pose a hazard, as described above, should be corrected.
Typical Costs for Seismic Rehabilitation

To estimate the potential cost of seismic strengthening without doing a detailed analysis of the structure, the historic cost data contained in FEMA 156, *Typical Costs for Seismic Rehabilitation of Existing Buildings - Second Edition*, can be used. The cost data covers only the structural costs of the strengthening work, and does not include costs for extensive architectural remodeling, nonstructural strengthening, or collateral hazards such as asbestos mitigation or ADA compliance. As the data was developed for use on large inventories of buildings, the range of cost developed for single buildings can be quite large.

For Science One, the estimate of seismic strengthening costs using FEMA 156 range from a low of $7.57 per square foot to a high of $31.81 per square foot based on a moderate confidence range. We would estimate, based on our experience with this type of structure, the actual cost would be in the lower half of this range. Based on an estimate of a 110,000 square foot building, the low estimate structural cost to retrofit Science One would be about $835,000. The middle estimate structural cost to retrofit Science One would be $1.7 million.

City of Portland Requirements

Current City of Portland requirements do not require existing buildings to be structurally upgraded when undergoing an extensive architectural renovation (except for unreinforced masonry buildings which undergo renovation of greater than $15 per square foot over a two-year period). However, when an alteration for which a building permit is required has a value more than $100,000, the City of Portland requires a FEMA 178 evaluation to be submitted to the City for review. The evaluation we have completed on Science One satisfies this City requirement.

In some cases, the City has required additional measures beyond the FEMA 178 investigation on certain structures. These projects usually involve some removal, addition, or alteration to a building's lateral force-resisting system. With regards to the alterations proposed for this project, we do not currently believe that a full upgrade will be required. However, it is difficult to predict what the City of Portland might require for Science One without further discussions with the appropriate city officials.
Summary

The Science One building at Portland State University is a five-story steel frame and concrete shear wall building located in Portland, Oregon. We have evaluated the building's seismic performance using FEMA 178, in accordance with the City of Portland requirements. Based on our evaluation, the building lacks adequate walls in the east-west direction to adequately resist the design lateral forces. Without further analysis or seismic strengthening, the building does not meet the life-safety performance objective of FEMA 178 for the design level earthquake. A strengthening scheme which involves adding reinforced concrete walls to the outside of the existing concrete core walls, adding new collector elements, and addressing the nonstructural hazards, could bring the building up to a life-safety performance level. This type of strengthening work may cost between $7.57 and $31.61 per square foot based on FEMA 156.

We appreciate the opportunity to evaluate Science One at the PSU campus. If you have any comments or questions regarding this evaluation, please do not hesitate to call us.

Very truly yours,

DEGENKOLB ENGINEERS

Jeffrey R. Soulages
Associate

Christopher L. Thompson
Principal

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Attachments
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