Portland State University
Montgomery Court Building
Structural Seismic Evaluation

KPFF Project No. 96541.00
Client Supplemental Contract No. 90-96-65-04

August 29, 1997

Prepared For:
State of Oregon
State Board of Higher Education
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Submitted To:
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TRANSMITTAL

PSU FACILITIES

PROJECT: Montgomery Court Remodel

DATE: September 3, 1997

TO: Katherine Bang, Plans Examiner
Bureau of Buildings
City of Portland
1120 SW Fifth, Room 930
Portland, OR 97204

WE TRANSMIT: FEMA 178 Seismic Analysis for Montgomery Court Building and Neuberger Hall

REMARKS: Enclosed for your files are two copies of the FEMA-178 studies for the referenced buildings for the City of Portland's use and information as performed by kpff. Addresses are: Neuberger Hall, 724 SW Harrison; Montgomery Court, 1802 SW 10th. Several other studies are underway or recently completed. I'll relay these as they become available. These include the Ondine, Millar Library, and Health & Physical Education (currently being renamed as the Peter Stott Center).

BY: [Signature] Dick Piekenbrock

COPIES TO: Barbara Linn, PSU Facilities; Chuck Stalsberg, Bureau of Buildings

PSU Facilities
P.O. Box 751
Portland, OR 97207
Telephone: 725-3738
Fax: 725-4329

RBP/djl
September 2, 1997

Mr. Dick Piekentrock
Portland State University
Facilities
Post Office Box 751
Mail Stop FAC
Portland, OR 97207-0751

RE: Portland State University
Montgomery Court
FEMA-176 Seismic Evaluation

Dear Dick:

Enclosed please find five copies of our final structural seismic evaluations for Montgomery Court.

If you have any questions or would like to meet and discuss the information presented, please call me.

Sincerely,

Edwin T. Dean, P.E., S.E.
Associate

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1.0 INTRODUCTION

Located at the corner of SW 10th and SW Montgomery Street in downtown Portland, Oregon, the Montgomery Court Building was constructed in two phases circa 1916 and 1925. The building is four stories with a basement. The building is currently being used as a dormitory for student housing and housing for administrative offices. Renovation work is planned to add a small amount of office space to the building ground floor.

The building’s structural system is comprised of an exterior unreinforced masonry (URM) bearing wall and wood frame floor and roof construction. Interior partition walls and columns are of plaster on metal lath wood frame construction. The 1925 addition was constructed using the same structural systems as the original building. For the purposes of FEMA-178 designations, the construction would be classified as Building Type 15, Unreinforced Masonry Bearing Wall Building.

2.0 EXECUTIVE SUMMARY

The building's structural lateral load resisting components were evaluated to determine their capacity to resist earthquake ground motion. The general structural seismic evaluation was performed using criteria of FEMA-178. The seismic evaluation of the existing building’s structure reveals that in a major earthquake the building’s structure is not capable of adequately resisting earthquake ground motion and would likely be damaged. Significant weaknesses were found in the unreinforced masonry exterior walls and in portions of the floor and roof structure. With no anchorage of the exterior walls to the floor or roof structure, there is no positive tie keeping the walls from falling away from the floor or roof. Additionally, the parapet and chimneys are not braced and are also potentially subject to significant earthquake damage. The existing building structures resistance to earthquake ground motions can be increased by various techniques. Adding concrete shear walls, overlaying the floor and roof with plywood sheathing, adding anchors and straps to connect the exterior wall and floor/roof structure, and bracing the building parapets and chimneys are likely the most effective means to seismically strengthen this building. The probable structural cost to seismically strengthen this type of building, would be on the order of $16.00 per square foot, based on FEMA-156 estimation procedures.

3.0 SCOPE

KPFF has been retained by the State of Oregon to conduct a general structural seismic evaluation of the Portland State University, Montgomery Court Building. We have reviewed only the primary structural elements resisting lateral forces. The NEHRP - Handbook for the Seismic Evaluation of Existing Structures, FEMA-178, June 1992 was used as the basis of our assessment of this building as it relates to seismic hazards. The bibliography in Section 8.0 contains a list of resources used in developing this assessment.

Our evaluation includes a limited field reconnaissance to observe the general physical status of the building and the site, a review of available design drawings of the original structure, assessment of significant structural deficiencies observed, and discussion of structural strengthening concepts to rehabilitate serious deficiencies.

KPFF Consulting Engineers

August 29, 1997
Observations, analyses, conclusions and recommendations contained in this report reflect our best engineering judgment. Concealed problems with the construction of the buildings may exist that cannot be revealed through our review. KPFF, therefore, can in no way warrant or guarantee the condition of the existing construction of the building and the building site.

4.0 OBSERVATIONS

Our observations of the Montgomery Court Building are drawn from a review of available design drawings of the original construction, a walkthrough of the structure, and our experience with structures of similar construction. The following sections present our comments of our review of the available documents and site visit, respectively.

DOCUMENT REVIEW

A list of the documents reviewed is contained in the Bibliography of this report. These documents were reviewed to provide us with insight to the types of structural systems used in this structure. Our observations are presented in two different subsections. The first are observations about the general construction of the building and the second are observations pertaining to the potential seismic performance of the building.

General Structural Observations

The Montgomery Court Building was constructed in two parts, first as a L-shape building in circa 1916, and second with a south wing addition in 1925. The 1916 building plan has an overall dimension of 100' x 100' with each wing of the L-shape plan having a width of 40'. The 1925 south wing addition, added a 100' x 40' rectangular section, creating a C-shaped building plan. The typical floor is approximately 10,500 square feet, and the total building area over five floors would be approximately 52,500 square feet. The original building was designed by A.E. Doyle Architects and the addition was designed by Lawrence and Holford Architects. Architectural drawings for both of these designs were provided to us as listed in the Bibliography section of this report.

The exterior of the building is a 17" thick URM wall supported on an 18" thick concrete basement wall. Reinforcing steel was not identified for the concrete wall at any location on the drawings. The concrete basement walls, interior plaster on metal lath walls, and interior posts are supported on concrete spread footings.

Floor construction consists of 2' x 16' joists at 16" on center spanning between the exterior bearing walls and interior partition walls or interior wood girders. Roof construction is similar to the floor, only with 2' x 8' joists at 24" on center supported on pony walls bearing on the fourth floor ceiling joists and girders. The floor and roof are likely sheathed in either straight or diagonal boards, however, no indication of such were found on the drawings.

Existing Lateral Load Resisting System

Lateral wind forces and earthquake ground motions imposed on the building are resisted by the exterior URM walls and the interior lath and plaster partition and bearing walls. The plank floor and roof would act as a diaphragm to connect the exterior and interior walls together and transmit the internal earthquake forces to them.
SITE RECONNAISSANCE

On Monday, May 12, 1997, KPFF representatives walked through the Montgomery Court Building and reviewed the general condition of the structure. As with most finished and occupied buildings, much of the structure is concealed and is not accessible or visible. The main objective of this reconnaissance was to evaluate the structure exposed to view; to look for signs of overstress, settlement, or deterioration; and become generally familiar with the building and its construction. Additionally, an attempt was made to verify, the extent possible, that the construction of the building structure was consistent with the design represented on the original 1916 and 1925 drawings. No attempts were made in this review to perform materials testing or exploratory demolition to evaluate the existing construction.

Our walkthrough began by walking around the perimeter of the building and inspecting the condition of the masonry wall. The clay masonry units and mortar appeared to be in very good condition. Cracks in the masonry and loose mortar were not found in our survey around the building. Particular attention was paid to checking re-entrant corners at windows, where again, the wall appeared to be in good condition. At the building roof, the building parapet and chimney were unbreached except for a large terra cotta appendage over the main entrance at the corner of SW Montgomery and SW 10th Avenue. Inside the building, the plaster on metal lath and floor diaphragms had no significant signs of deterioration. The condition of the masonry walls from the interior was not exposed to view because of the plaster overlay, except at the basement where the masonry appeared to be in good condition.

The review of the visible structural elements, with the exception of the items noted above, showed no signs of significant overstress, settlement, or deterioration.

5.0 STRUCTURAL EVALUATION

The building structure’s lateral load resisting components were evaluated to determine their capacity to resist earthquake ground motion. The general structural seismic evaluation was performed using the criteria of the Special Provisions for URM’s in Appendix C of FEMA-178, Handbooks for the Evaluation of Existing Buildings, utilizing an effective peak ground acceleration of 0.3g.

In this document the base shear, or the total seismic force on the building, is calculated by a prescribed formula accounting for geographic seismicity, the type of building structure, its stiffness, and its overall mass. The base shear is distributed to each story based on a weighted proportion of the floor’s mass and height above the ground. The structure is analyzed with the distributed story forces to determine the demand, or the strength required, of each component of the structure. The demand on each structural component is compared to the capacity of the existing structural element. For a given structural element, a demand-capacity ratio (DCR) is the demand divided by the capacity of the existing element and is a relative measure of how much more or less is required of the structure than its current condition. A DCR of 1.0 means the demand is equal to the element’s existing capacity. A DCR of more than one means the structure is required to resist more than it is likely capable. For example a DCR of 2.0 means the element is required to resist a force twice its existing strength. A DCR of less than one means the structure has reserve capacity.

Existing Masonry Walls

The unreinforced masonry perimeter walls comprise the primary lateral resisting elements for the building. The walls are generally broken up by windows or doors into wall piers. Each pier at a particular floor resists a portion
of the accumulated story forces relative to its stiffness. As shown in Table 5.1, the demand on the masonry piers is likely to be higher than its current capacity. The masonry piers shown are typical for each wall indicated at the lower floors where accumulated forces are most critical. The high DCR's are largely reflective of the increased seismicity and changes in the structural design provisions that have occurred since the early 1900's. The Park Block Elevation piers have a lower typical DCR because there are fewer penetrations by doors and windows. The SW 10th Avenue Elevation piers have a lower DCR because the wall is longer at approximately 140'.

Table 5.1 Typical Masonry Pier Demand-Capacity Ratio (DCR)

<table>
<thead>
<tr>
<th>Location</th>
<th>DCR</th>
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<tbody>
<tr>
<td>Montgomery St. Elevation</td>
<td>3.9</td>
</tr>
<tr>
<td>Park Block Elevation</td>
<td>1.9</td>
</tr>
<tr>
<td>Courtyard Elevation</td>
<td>3.9</td>
</tr>
<tr>
<td>10th Ave Elevation</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Existing Diaphragm

The floor diaphragms consisted of hardwood floors over wood joists and crosswalls. The diaphragms in the shorter direction of each wing had DCR well below 1.0, indicating sufficient reserve capacity. In the longer direction, the diaphragms were only slightly overstressed as shown in Table 5.2.

Table 5.2 Floor Diaphragm Demand Capacity Ratio (DCR)

<table>
<thead>
<tr>
<th>Floor</th>
<th>Diaphragm Location</th>
<th>North Wing</th>
<th>West Wing</th>
<th>South Wing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td></td>
<td>1.1</td>
<td>1.0</td>
<td>2.2</td>
</tr>
<tr>
<td>2nd</td>
<td></td>
<td>1.6</td>
<td>0.9</td>
<td>1.2</td>
</tr>
<tr>
<td>3rd</td>
<td></td>
<td>1.1</td>
<td>0.9</td>
<td>0.9</td>
</tr>
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</table>

Seismic Strengthening Concepts and Costs

Various options are available for seismically strengthening the building's lateral load resisting systems. Some common techniques include:

- Applying new reinforced shotcrete to the interior (or exterior) of the URM walls.
- Filling in existing window or door openings with reinforced concrete or reinforced masonry.
- Providing additional concrete shear walls or steel braced frames at the interior or perimeter of the building.

Diaphragms are commonly strengthened or stiffened by adding plywood sheathing to them. Reinforced concrete toppings or steel strapping is also used but is generally more expensive.
Anchors tying the floor diaphragm to the exterior masonry walls and any new seismic strengthening elements are necessary. Anchorage is generally accomplished by epoxying an anchor bolt to the URM walls and tying to straps nailed to the plywood diaphragm. Supplemental strapping would be necessary at the re-entrant corners of the building where stress concentrations occur, as well as adding cross ties at various locations to maintain the out-of-plane integrity of the URM walls.

Construction costs to seismically strengthen a building's structural systems vary significantly between specific projects and are affected by many other associated factors. These costs could be viewed in two categories: Direct and Indirect. Direct costs principally consist of the construction, materials, and labor (contractor overhead and profit included) required for the seismic strengthening and professional and permit fees. Indirect costs would include such things as financing, occupant interruptions/relocation, increased rents, change in property value, loss of revenue, administration, time value of funds, etc. In order to identify a planning program cost for the seismic strengthening required to mitigate the earthquake hazards of this building, FEMA publication 156, Typical Costs for Seismic Rehabilitation of Existing Buildings, December 1994, was used. Using the procedures contained in FEMA-156 for Option Two cost estimation, the mean probable structural strengthening cost for this type of building would be $15.76 per square foot. The worksheet for this cost estimation is contained in the Calculation section of this report. The cost identified herein is the Direct cost and is developed from a life-safety performance objective, in 1997 dollars considering a 4% inflation rate with a narrow confidence range (75%) and a resulting lower to upper bound cost range of $4.28 to $53.16 per square foot.

6.0 GENERAL CONCLUSIONS AND RECOMMENDATIONS

The FEMA-178 evaluation identifies that the building structure does not comply with a number of seismic evaluation criteria. The specific areas where seismic performance deficiencies were identified, are as follows:

Building Systems

- Vertical Discontinuities. Large windows in the lower portion of the URM exterior walls interrupt the continuity of the solid portions of the wall above. This deficiency results in large stress concentrations in the piers that do continue through.

- Torsion. The C-shaped building plan represents a torsional irregularity that will result in stress concentrations occurring at the re-entrant corners of the building.

Masonry Walls

- Earthquake shear and bending stresses exceed the capacity of the existing URM walls.

- Parapets and chimneys require bracing.

Diaphragms

- Plan irregularities. There is no supplemental tension reinforcement at the re-entrant corners of the building plan. Nor is there any reinforcing around the diaphragm openings at the stair and other floor openings.

- Masonry wall anchors. There is no positive steel anchorage between the diaphragm and the exterior masonry walls.
Non-Structural

- Partitions. The partitions and windows are built tight to the structure and would not accommodate much movement during an earthquake. These components would likely be damaged.

- Ceiling Systems. The ceilings in the building are typically lath and plaster attached to the structure. The ceilings would likely be damaged by movement in an earthquake.

- Light Fixtures. Light fixtures are attached to the ceiling and in some locations are pendant type fixtures that would sway in an earthquake.

- Parapets, Comices, Ornamentation, and Appendages. The unreinforced masonry parapets and comices are not braced or otherwise anchored. These components could fail in an earthquake.

- Chimneys. The masonry chimneys do not appear to be anchored to the floor or roof.

- Means of Egress. The walls around the stairs are unreinforced masonry or hollow-clay tile and could potentially collapse into the stairwell during an earthquake blocking egress from the building.

To mitigate the seismic deficiencies identified by the FEMA-178 evaluation, the building's structural and non-structural components would need to be strengthened.