AN ABSTRACT OF THE THESIS OF

Steven R. Trautwein for the degree of Master of Science in Civil Engineering presented on April 24, 1998. Title: Development of A Seismic Rehabilitation Master Plan for the Oregon State University Campus.

Abstract approved: Redacted for privacy

Thomas H. Miller

The recent increase in awareness of the seismic hazards in Oregon has led to a concern regarding the safety of Oregon State University buildings. While the decision has been made to initiate the seismic rehabilitation of campus facilities, the question of which buildings pose the greatest hazards, and are therefore in greatest need of upgrade, has remained unanswered. This study addresses these questions by prioritizing 74 major buildings on the Oregon State University campus (58 of which are academic facilities, the remainder being student life) for seismic rehabilitation. This prioritization is based on relative hazard as measured by estimated loss of life in each building. Loss of life is estimated by multiplying assumed building occupancies by a derived casualty ratio for each building. Casualty ratios and building damage ratios are derived by adapting methodologies developed in ATC-13 and ATC-21. ATC-13 developed a loss estimate methodology for California by surveying a panel of engineering experts. ATC-21 developed a methodology to adjust these estimates for buildings outside of California. It also incorporates the effects of individual building features such as plan irregularities, which tend to increase risk of damage. A subsurface soil investigation was conducted to establish an estimated peak ground acceleration (EPA) of 0.22g as appropriate for a 500-year return period seismic event. Based on this level, the economic loss estimate is \$219 million, which includes both structural and nonstructural damages. For a daytime earthquake (3:00 p.m.), 555 serious injuries and 273 fatalities are estimated. For a nighttime event (3:00 am), 441 serious injuries and 220 fatalities are estimated. A

master plan for seismic rehabilitation is presented based on relative hazards as measured by estimated fatalities in each building. The two highest priority academic facilities are the Administration Building and the Valley (formerly Kerr) Library. The Valley Library is currently undergoing a seismic rehabilitation. The two highest priority student life facilities are Callahan Hall and Wilson Hall.

DEVELOPMENT OF A SEISMIC REHABILITATION MASTER PLAN FOR THE OREGON STATE UNIVERSITY CAMPUS

by

Steven R. Trautwein

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Completed April 24, 1998
Commencement June 1998

Master of Science thesis of Steven R. Trautwein presented on April 24, 1998

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Steven R. Trautwein, Author

ACKNOWLEDGMENTS

I would like to take this opportunity to thank my mother, Sue Trautwein, for her constant encouragement and prodding, even when I didn't want to hear it, and for her faith in me that I'd finally get it done. I'd also like to thank my friends and peers, Drew Hoffman for his inspiration, Valiant Villanueva for his perspective on life, and Kurt Krueger for being there through thick and thin. I would like to express my gratitude to the faculty of the Civil Engineering department, who broadened my horizons both in and out of the classroom, especially Dave Bella, Chris Bell, Steve Dickenson, John Peterson, and Ted Vinson. I also would like to thank Larry Earhart of OSU Facilities Services for his part in providing funding for this study. Finally, I would like to thank my mentor and friend, Dr. Tom Miller, for his guidance and encouragement throughout the course of this project, and for his infinite patience and understanding when other aspects of my life intruded on my efforts to complete this thesis. Thank you all!

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF APPENDIX TABLES

GLOSSARY OF TERMS, ACRONYMS, AND ABBREVIATIONS

A_a: The effective peak [bedrock] acceleration as defined by FEMA 222A. Related to C_a and F_a by the equation $C_a = F_a*A_a$.

Attenuation: The reduction in amplitude (or energy) of seismic waves as they travel from the source of the rupture, through various types of rock and soil, to other locations. Typically, higher frequency waves are attenuated more rapidly than low frequency waves. The result of this is that low frequency shaking is felt at much greater distances than high frequency shaking.

BSH: Basic Structural Hazard. The BSH Score gives an indication of how much damage a building is likely to sustain in an earthquake. It is defined in ATC-21 as the negative $\log_{10}$ of the probability that a building will sustain greater than 60% damage. A BSH Score of 2 equates to a 1% probability of damage greater than 60%, a score of 3 corresponds to a 0.1% probability, etc.... In this report, the BSH for damage greater than 60% is defined as BSH(60). Similarly, BSH(x) corresponds to the probability of damage greater than x%.

C_a: The seismic coefficient as defined by FEMA 222A. This corresponds to the Effective Peak Acceleration (EPA) used to derive loss estimates in this study. Related to A_a and F_a by the equation $C_a = F_a*A_a$.

CDF: Central Damage Factor. Each damage state defined in the damage probability matrix is assigned a specific range of damage. The CDF is the central (average) value within this range.

GLOSSARY OF TERMS, ACRONYMS, AND ABBREVIATIONS (Continued)

Damage State: A categorical definition of the degree of damage a group of buildings is expected to sustain in an earthquake, ranging from damage state 1 (no damage) to 7 (all buildings are destroyed).

Delphi Survey: The method whereby a group of experts are surveyed, the survey results are shared with the experts, a follow-up survey is conducted, and the process is repeated until consensus is reached. This method was used to obtain the damage estimates in ATC-13.

DERIVDPM: The Microsoft Excel 5.0 spreadsheets used to derive the DPMs used in this study.

DOGAMI: Department of Geology and Mineral Industries.

DPM: Damage Probability Matrix. Used to estimate damage for a specific type of building subjected to a given intensity of shaking. When applied to a statistically significant number of buildings, DPMs provide an estimate of the proportion of buildings which will sustain different levels of damage. DPMs are discussed in detail in Chapter III.

Ductile RC MRF: A moment resisting frame building with reinforced concrete members that have been specially detailed to yield in a ductile manner.

EERI: Earthquake Engineering Research Institute.

GLOSSARY OF TERMS, ACRONYMS, AND ABBREVIATIONS (Continued)

EPA: Effective Peak Acceleration. A measure of the intensity of shaking at a site due to a seismic event. Related to PGA (Peak Ground Acceleration) by the equation EPA = 0.75 PGA. EPA is the standard used in the development of damage probabilities in ATC-21-1, from which the DPMs in this study are derived.

F_a: The acceleration based site coefficient used to determine ground accelerations based on bedrock accelerations, as defined in FEMA 222A. Related to C_a and A_a by the equation $C_a = F_a * A_a$.

FEMA: Federal Emergency Management Agency.

g: Acceleration in terms of a fraction of gravity.

GIS: Geographic Information System.

HAZUS: A computer program developed by the National Institute of Building Sciences for loss estimation.

HR: High Rise building.

ICBO: International Conference of Building Officials.

LR: Low Rise building.

GLOSSARY OF TERMS, ACRONYMS, AND ABBREVIATIONS (Continued)

MB: Mean Best. The consensus value for the median level of damage predicted for a specific building type subjected to a specific intensity of shaking, based on the Delphi survey conducted for ATC-13.

MH: Mean High. The consensus value for the high level of damage (containing all but the highest 5% of damage) predicted for a specific building type subjected to a specific intensity of shaking, based on the Delphi survey conducted for ATC-13.

ML: Mean Low. The consensus value for the low level of damage (containing all but the lowest 5% of damage) predicted for a specific building type subjected to a specific intensity of shaking, based on the Delphi survey conducted for ATC-13.

MMI: Modified Mercalli Intensity. A scale used to classify the intensity of shaking caused by a seismic event. It is based on observed phenomenon such as movement of furniture in a building. Definitions are provided in Table 7.

MR: Medium Rise building.

MRF: Moment Resisting Frame building.

M_W: Moment Magnitude. Moment magnitude is assigned based on the energy released by an earthquake.

ND RC MRF: A moment resisting frame building with reinforced concrete members that have not been specially detailed to yield in a ductile manner.

GLOSSARY OF TERMS, ACRONYMS, AND ABBREVIATIONS
(Continued)

NEHRP: National Earthquake Hazard Reduction Program.

NIBS: National Institute of Building Sciences.

Overall Damage Ratio: The average damage predicted for a large sample of buildings subjected to a specific level of ground acceleration.

OSBHE: Oregon State Board of Higher Education.

P(D>x): Probability of damage greater than "x" percent.

PC Frame: A precast concrete frame building.

PGA: Peak Ground Acceleration. A measure of the intensity of shaking at a site due to a seismic event. Related to EPA (Effective Peak Acceleration) by the equation EPA = 0.75 PGA.

PMF: Performance Modification Factor. A factor assigned in ATC-21 to account for the effect of specific building features such as irregular shape. It is subtracted from the BSH Score to produce an adjusted BSH Score. A positive PMF will result in a greater probability of damage.

RCSW: Reinforced Concrete Shear Wall building.

RM SW: Reinforced Masonry Shear Wall building.

GLOSSARY OF TERMS, ACRONYMS, AND ABBREVIATIONS (Continued)

RVS: Rapid Visual Screening. A survey method developed in ATC-21 to quickly identify buildings that may pose a significant seismic hazard and require further investigation.

SEISPLAN: The Microsoft Excel 5.0 spreadsheets used to develop the seismic rehabilitation plan for OSU campus buildings.

Steel Perim MRF: A steel moment resisting frame building with the frames located at the perimeter of the building.

Steel Distrib MRF: A steel moment resisting frame building with the frames distributed both at the perimeter and throughout the interior of the building.

UBC: Uniform Building Code.

UCBC: Uniform Code for Building Conservation.

URM: Unreinforced Masonry building.

This thesis is dedicated to the memory of Eric Scott Trautwein.

DEVELOPMENT OF
A SEISMIC REHABILITATION MASTER PLAN
FOR THE OREGON STATE UNIVERSITY CAMPUS

I: INTRODUCTION

Background

With the growing awareness of the seismic threat to Oregon, there has been an increasing concern over the safety of the buildings in which we live and work. This has been particularly true of places like the Oregon State University campus, where most of the buildings were built without any consideration to the hazards of earthquakes. To better understand the extent of this problem, Dr. Thomas H. Miller of the OSU Department of Civil Engineering undertook a preliminary study with two graduate students. Their findings, reported in "Seismic Risk Assessment and Retrofit Design Concepts for Oregon State University Campus Buildings (Miller et al., 1993)," indicate the potential for significant campus losses if a serious earthquake were to occur. Of the 74 major campus buildings surveyed in their study, 26 were identified to have a high probability of damage beyond repair (defined as damage greater than 60%, i.e., the cost to repair the building is greater than 60% of the building's value). Though casualties were not estimated in this report, structural damage of this magnitude could easily incur a catastrophic loss of life.

In view of this threat, the report recommended several areas for continued study. Two of these were as follows: 1) "develop cost estimates and design concepts for other types of construction on campus [three lift-slab buildings were examined in previous studies], especially unreinforced masonry buildings, which are widely recognized as dangerous and the cause of the majority of earthquake fatalities," and 2) "apply the methodology of the study 'Estimated Future Earthquake Losses for St. Louis City and County Missouri' (FEMA 192, 1990) to predict property damage and casualties on the OSU campus from improved predictions for levels of ground shaking now available."

This thesis encompasses an attempt to address these two issues. Based on the findings of these investigations, a prioritization of campus buildings for seismic rehabilitation is developed. Finally, a seismic rehabilitation master plan for the university is formulated from this prioritization.

Objectives

At the outset of this project, three primary objectives were identified by Dr. Miller in a proposal to Facilities Services (Miller, 1994). These objectives, quoted from the proposal, are as follows:

- "Recommend a specific plan for the first 2 years of a seismic rehabilitation effort at OSU and a more general master plan covering the first 10 years."
- "Produce a flexible tool to be used for prioritizing and planning future seismic rehabilitation at OSU. This will allow for modifications to the master plan as criteria and budgets change. 57 academic buildings and 16 student life buildings will be included in the overall prioritization." (58 academic buildings were actually included.)
- "Perform detailed analyses, and develop retrofit designs and cost estimates for the 2 highest priority buildings of other than lift-slab construction."

Scope

The scope for each of the objectives identified above is limited as follows.

Recommend a seismic rehabilitation plan. This objective includes:

- Using the findings from previous studies of OSU buildings (Miller et al., 1991 and 1992), develop a loss estimate based on the methodologies presented in ATC-13, ATC-21-1, and FEMA 192. This required the following:

  - Determine the seismic threats to OSU, including the effects of subduction zone and local crustal events.
  - Investigate the sub-surface soil conditions throughout the campus, and determine the effects of these conditions on seismic ground acceleration.
  - Develop occupancy estimates for campus buildings.
  - Develop loss estimates, both economic and casualties, for Oregon State University. Use the procedures outlined in ATC-21-1 to adapt the loss estimation methods provided in ATC-13, which was originally developed for California.
- Determine criteria for prioritizing buildings for seismic rehabilitation.
- Develop cost estimates for seismic rehabilitation as an aid in the planning process.

<ins>Develop a tool for the continuation of the plan</ins>. Based on the procedure used to develop the recommended two and ten year rehabilitation plans, develop a spreadsheet that can be modified to adjust the prioritization for seismic rehabilitation as circumstances change.

<ins>Rehabilitation designs and cost estimates for two buildings on campus</ins>. The two buildings ultimately chosen for this phase were not the two highest priority buildings of other than lift-slab construction. During the course of the study, the decision was made to develop the designs and cost estimates for two unreinforced masonry (URM) buildings, one of which was not actually a high priority building. The reasons for this decision are discussed in the report.

This portion of the project was completed by Kanok Sucharitsanchai as his Master's Project Report, entitled "Seismic Analysis, Conceptual Design, and Cost Estimate for Rehabilitation of URM Buildings on the OSU Campus (Sucharitsanchai et al., 1995)." The cost estimates were used for the master plan developed in the second phase of the project.

Organization of the Report

This report is organized into six chapters and two appendices. Chapter II describes the first step of the study, the loss estimate for OSU campus buildings. This chapter details how the loss estimate was developed, what data was used for the loss estimate, and a summary of the investigation into sub-surface soil conditions for the campus. It also provides the results of the loss estimate and identifies the limitations of the procedure used.

The loss estimate required the development of Damage Probability Matrices (DPMs) specifically for Oregon. The development of the DPMs based on the methodologies presented in ATC-13 and ATC-21-1 is covered in Chapter III.

Chapter IV contains the actual master plan for seismic rehabilitation of campus buildings. It covers how the buildings are prioritized and presents the first two years of the plan. It also includes a recommendation for the first 10 years and identifies the limitations of the plan.

Chapter V provides a list of recommendations for further study concerning the issue of seismic rehabilitation, not only for the OSU Department of Civil Engineering, but also for OSU Facilities Services and the Oregon State Board of Higher Education. A list of references is also provided.

Appendix A describes the tool for modifying the seismic rehabilitation plan. The tool itself is a series of Microsoft Excel spreadsheets and is provided in Appendix B. Appendix A essentially takes the form of a user's guide for working with these spreadsheets.

II: LOSS ESTIMATE FOR CAMPUS BUILDINGS

Development of the Loss Estimate

Seismic loss estimation is by no means an exact science. Loss estimates are currently based on empirical data obtained from observations of damage sustained in past earthquakes. An attempt is made to forecast future losses based on historical performance. So many variables are involved, and so many unknown factors influence losses, that it could be considered more of an art than a science. However, loss estimates are critical in the development of earthquake damage mitigation plans. By recognizing where the greatest potential for damage lies, limited resources can be focused on reducing that hazard and, hopefully, reduce losses in future earthquakes.

Developing an accurate loss estimate requires four elements: 1) an estimate of the intensity of shaking, 2) an accurate inventory of the building structures, 3) an accurate inventory of the buildings' contents and occupants, and 4) a method of estimating the extent of damage and casualties to a given building type subjected to a given intensity of shaking. The following sections discuss how these four areas were dealt with in the OSU loss estimate.

Intensity of Shaking

The intensity of ground shaking at a particular site depends on three things: 1) the characteristics of the earthquake, which will produce a specific magnitude and duration of shaking; 2) the path that the seismic waves follow, including the distance from the source to the site in question, and the types of bedrock that the seismic waves travel through; and 3) the site effects at the location under consideration, which involve amplification or damping of the bedrock motion, and which are dependent on the depth and type of the soil layers between the bedrock and the surface. Other soil-related phenomena, such as liquefaction and landslides, can also contribute to damage. Each of these issues will be dealt with in the following sections.

Seismic Sources

The seismic threat to Oregon State University, located in Corvallis, Oregon, comes from two sources. These sources are 1) local crustal earthquakes from faults in the region, and 2) deep subduction zone earthquakes from the Cascadia Subduction Zone (Geomatrix Consultants, 1995).

Local Crustal Events. Local crustal events are caused by the sudden rupture of geologic faults near the earth's surface as the crust is deformed by the relative motion of the tectonic plates upon which it rides (Bolt, 1993). The Willamette Valley, like the rest of the west coast of the United States, is covered with a network of geologic faults. These faults may or may not be currently active. Some of the local faults which have been identified are shown in Figure 1: Known Geologic Faults Near Corvallis, Oregon (Geomatrix Consultants, 1995). Most prominent are the Corvallis Fault (marked number 34 in the figure), the Owl Creek Fault (number 35), the Mill Creek Fault (number 33), and Waldo Hills Fault (number 32). All of these are within a radius of 40 kilometers (25 miles) from Corvallis. Although there has been no seismic activity on these faults in recorded history, they are currently judged to be potentially active. It is probable that unknown active faults exist as well. The maximum projected magnitude for a local crustal event in the Corvallis area ranges from M_w 6.0 to 6.6 (Geomatrix Consultants, 1995), where M_w is the moment magnitude.

Cascadia Subduction Zone Earthquakes. Subduction zones occur where two or more tectonic plates converge and one is forced under the other (Bolt, 1993). Of concern to the Pacific Northwest is the Cascadia Subduction Zone, which extends 1200 km from Northern California into British Columbia. The location of the

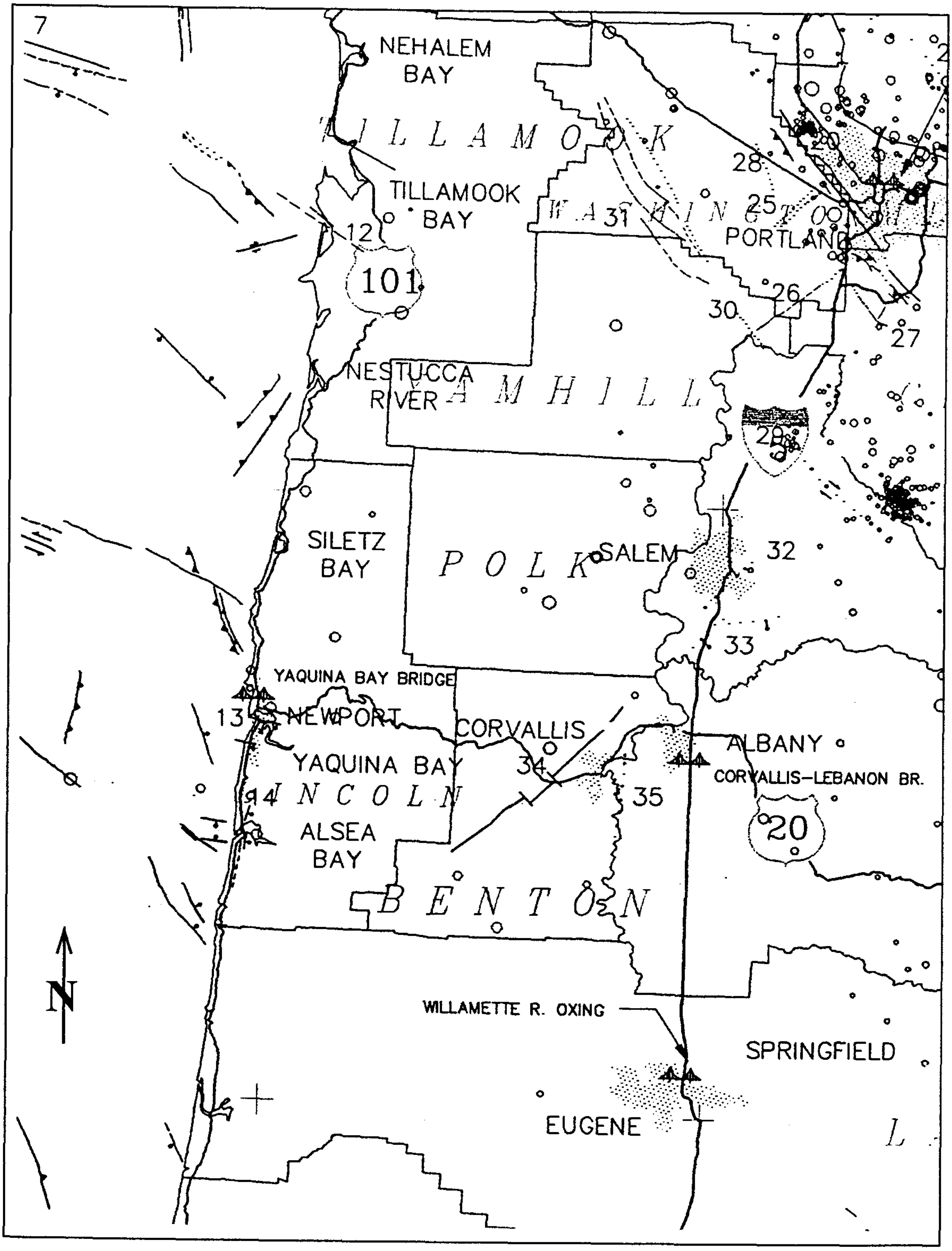

Figure 1: Known Geologic Faults Near Corvallis, Oregon (Geomatrix Consultants, 1995)

Cascadia Subduction Zone is shown in Figure 2: Cascadia Subduction Zone (Geomatrix Consultants, 1995). Subduction zones produce two types of earthquakes: interface and intraslab.

An interface earthquake is caused by a rupture between the subducting plate and the overriding plate. For the Cascadia Subduction Zone, this involves the Juan de Fuca Plate subducting under the North American Plate, as shown in Figure 3: Cross Section of Cascadia Subduction Zone at the Latitude of Portland (Geomatrix Consultants, 1995). Estimates for the maximum magnitude for this type of event range from M_w 8.0 to 9.2 (Geomatrix Consultants, 1995).

Intraslab events are caused by the breakup of the subducting plate as it is assimilated into the Earth's mantle. The estimated maximum magnitude for this type of event within the Cascadia Subduction Zone ranges from M_w 7.25 to 7.75 (Geomatrix Consultants, 1995).

Path Effects

Path effects refer to what happens to the seismic waves as they travel outward from the earthquake source to the site under consideration. The intensity of shaking that will occur at a given site as a result of a specific magnitude earthquake at a specific distance can be estimated based on attenuation relationships. These relationships are dependent on the types of rock and soil that the waves travel through. This was the methodology used to develop seismic hazards maps for Oregon. This work was done by Geomatrix Consultants for their report "Seismic Design Mapping, State of Oregon (Geomatrix Consultants, 1995)," hereafter referred to as the "Geomatrix Report." Since the Geomatrix Report does not identify the potential earthquakes that are a threat to individual regions, the objective of this section is to identify the design-level earthquake. The design earthquake is of interest to provide a reference for comparison against other seismic events. It is not used directly in the loss estimate.

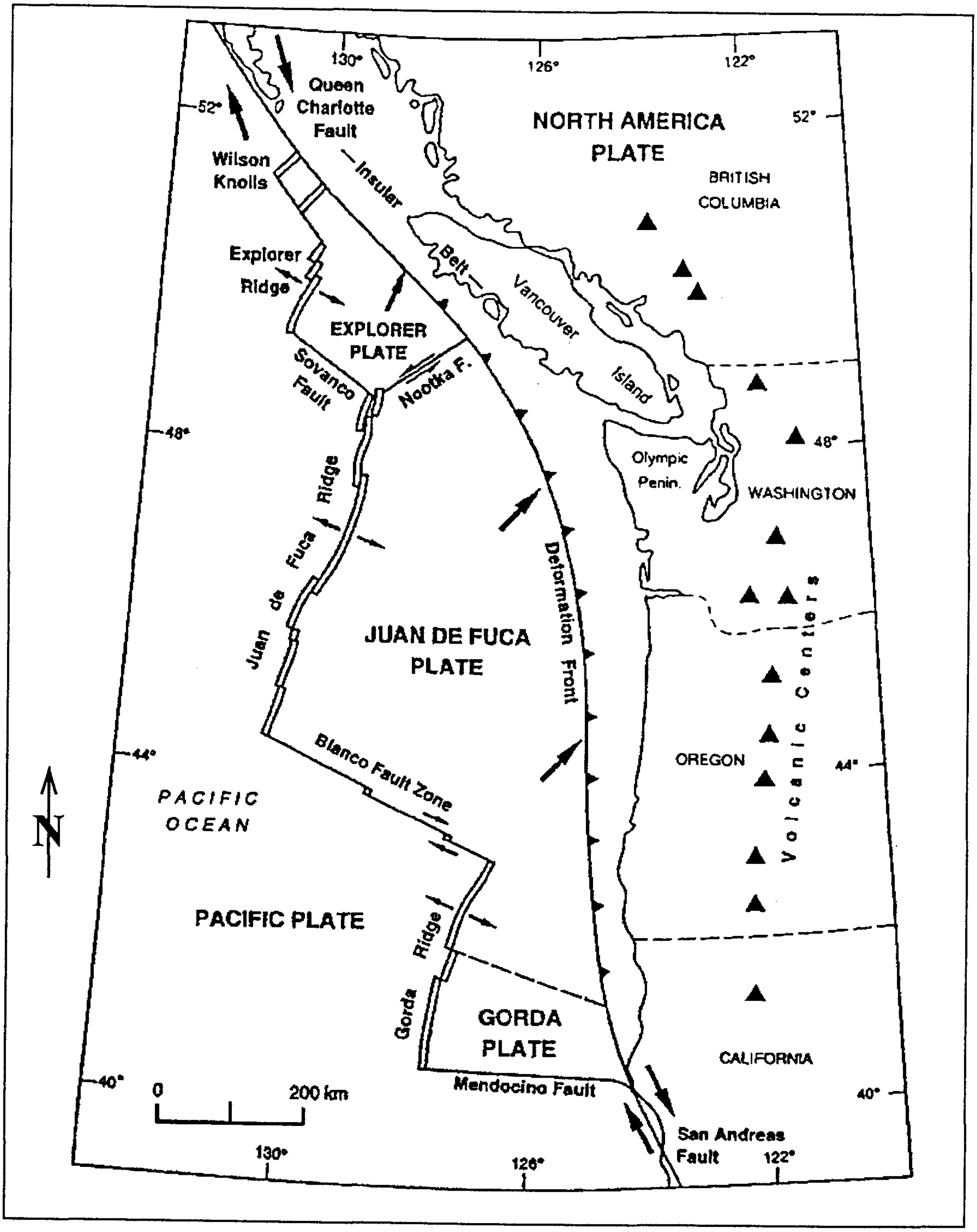

Figure 2: Cascadia Subduction Zone (Geomatrix Consultants, 1995)

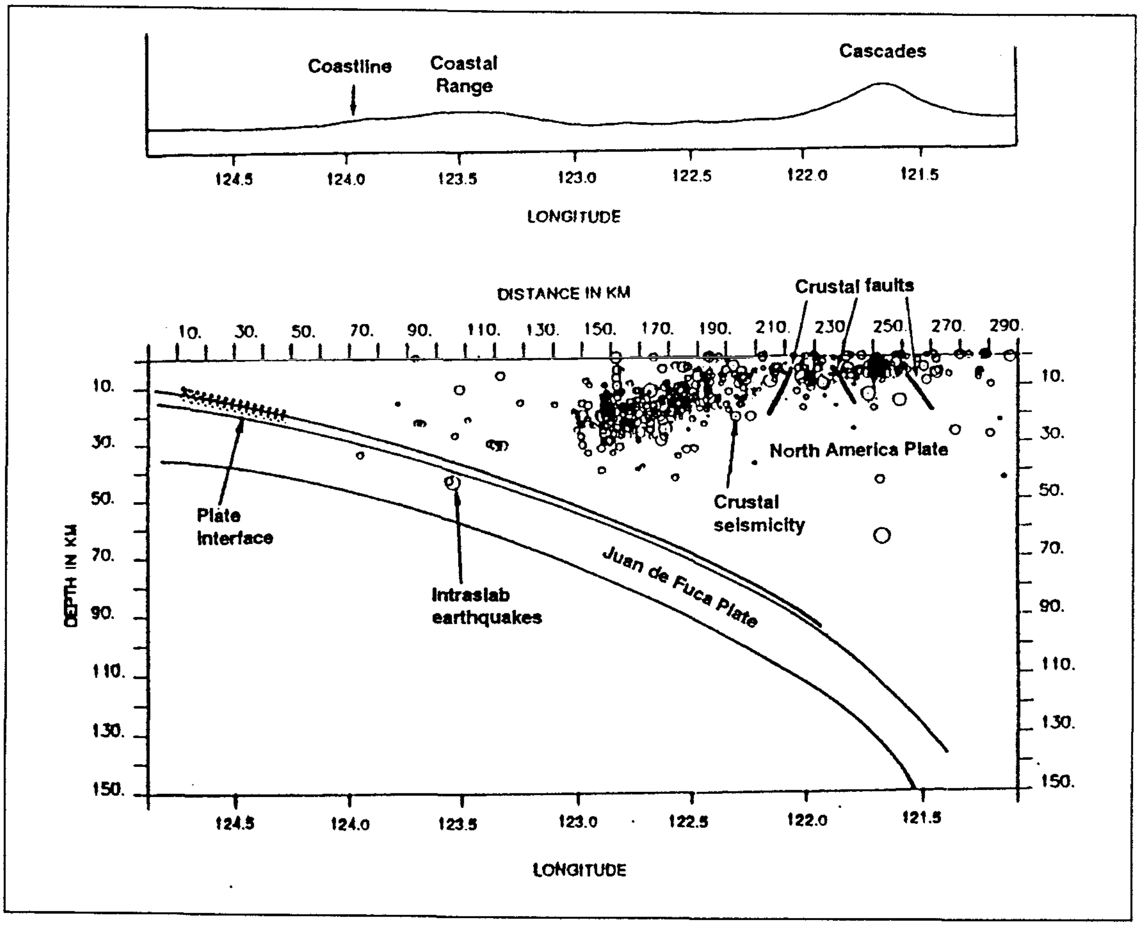

Figure 3: Cross Section of Cascadia Subduction Zone at the Latitude of Portland (Geomatrix Consultants, 1995)

By assigning a probability of occurrence to each of the seismic sources identified, determining the intensity of shaking that each of these sources would produce at sites throughout Oregon, and then combining the hazards at each site to find the maximum probable intensity of shaking, Geomatrix Consultants developed a series of "equal hazard maps" covering the entire state. Similar to contour maps, these maps indicate the estimated maximum Peak Ground Acceleration (PGA) on rock throughout Oregon. Each map is based on a specified return period, either 500, 1500, or 2500 years. The 500 year return period map was developed based on the PGA level which has a 10% probability of being exceeded in a 50 year period (Geomatrix, 1995).

This can be loosely interpreted as the maximum PGA expected to occur on average once every 500 years. The maps for the 1500 and 2500 year return periods indicate considerably higher PGA levels. As recommended for new buildings in the Uniform Building Code (ICBO, 1994a), it is the 500 year recurrence acceleration that is used in this study.

The equal hazard map for the 500 year return period is shown in Figure 4: 500-Year Return Period Acceleration (PGA) Levels on Rock for Oregon. As indicated on the map, for Oregon State University and the Corvallis area, the design bedrock acceleration (PGA) is about 20 percent of gravity (0.195g). The Geomatrix report does not specifically identify which seismic hazard will cause this level of acceleration. However, a rough estimate of possible earthquakes that could produce this level of acceleration can be back-calculated by using attenuation relationships to estimate the magnitude and distance for various sources required to produce bedrock accelerations of 0.195g. The design earthquake will be one that, after attenuation along the path from source to site, results in the design bedrock acceleration of 0.195g. Both subduction zone and local crustal events are investigated in the following sections.

Local Crustal Sources. The "design earthquake" for Oregon State University could be caused by any one of a variety of local crustal events, depending on the magnitude and location of the earthquake. It is possible to determine what magnitude event at what distance would produce a bedrock acceleration of 0.195g at OSU. This can be done based on an attenuation relationship provided in the Geomatrix Report, shown in Figure 5: Attenuation Relationships for Estimating Rock Site Peak Acceleration for North American Crustal Earthquakes. Though many combinations are possible, three potential sources of a bedrock acceleration of 0.195g are a M_w 5 event at a distance of 4 km (2.5 miles), a M_w 6 event at a distance of 10km (6 miles), or a M_w 7 event at a distance of 20km (12 miles). The fault producing this could be any one of those identified earlier, or an unknown fault in the region. Though a particular fault is not identified, we have at least identified possible earthquakes that

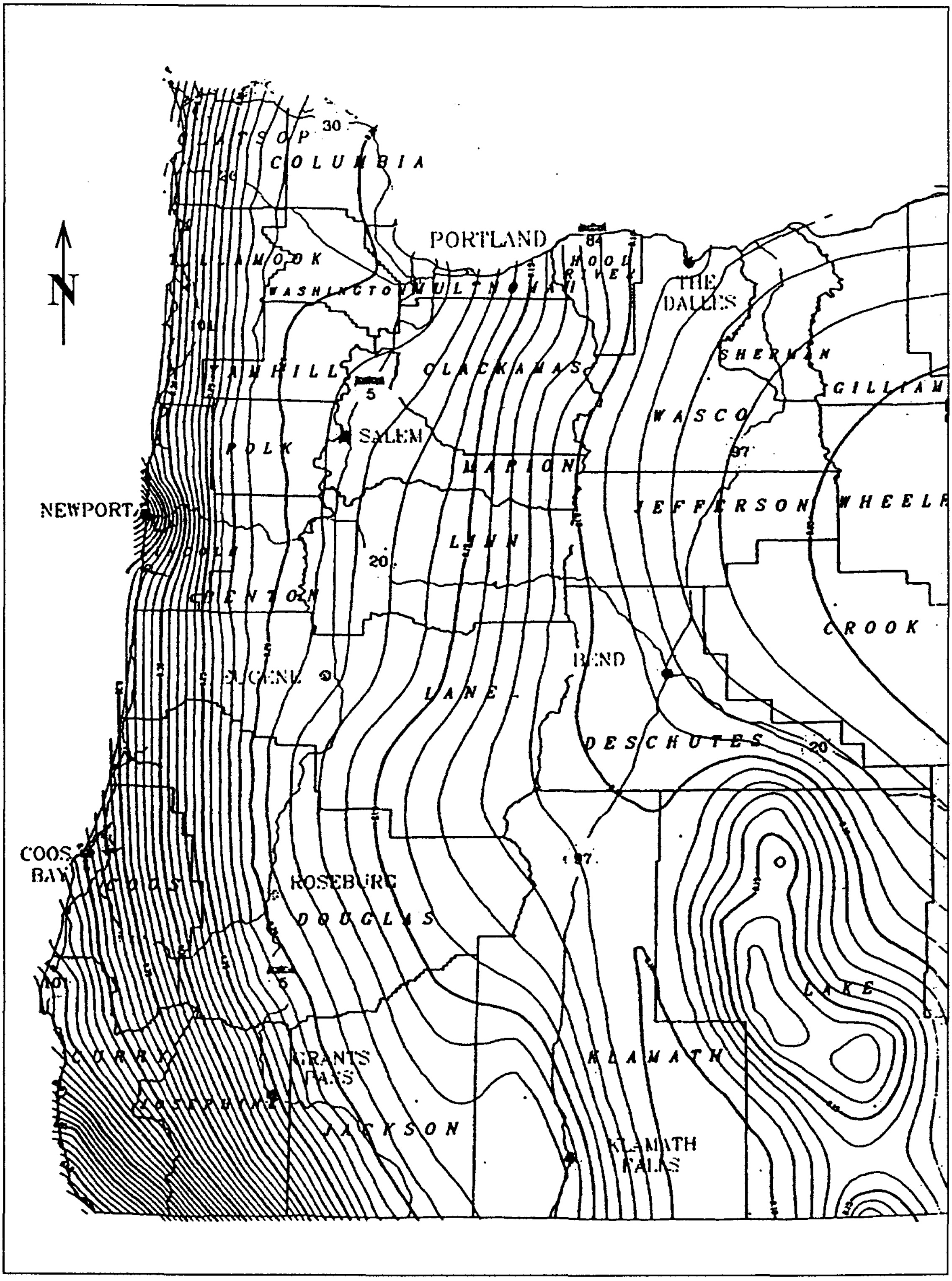

Figure 4: 500-Year Return Period Acceleration (PGA) Levels on Rock for Oregon (Geomatrix Consultants, 1995)

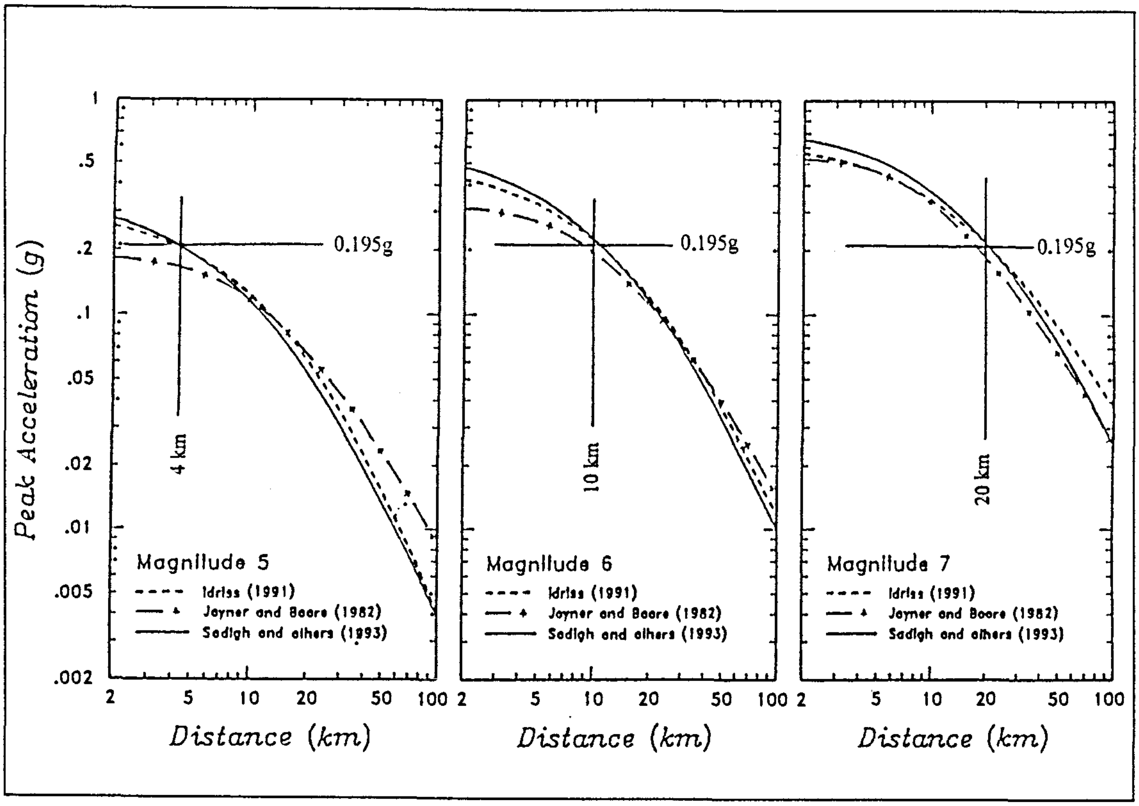

Figure 5: Attenuation Relationships for Estimating Rock Site Peak Acceleration for North American Crustal Earthquakes (Geomatrix Consultants, 1995)

could produce the 500-year return period bedrock acceleration in the Corvallis area. The probability that the 500-year recurrence acceleration will result from a local crustal event is 25%, as shown in Figure 6: Fraction of 500-Year Return Period Peak Acceleration Levels Contributed by North American Crustal Sources (Geomatrix Consultants, 1995).

Subduction Zone Sources. The probability that the 500 year return period peak acceleration would result from a subduction zone source is 75%, based on Figure 6. A subduction zone interface event could occur off the Oregon/Washington coast at a depth of 10 to 20 km (6.2 to 12 miles), as shown in Figure 3. If the rupture were to occur directly to the west of Corvallis, the direct distance to the rupture would be 70 km (43 miles). Based on the attenuation relationship used in the Geomatrix report,

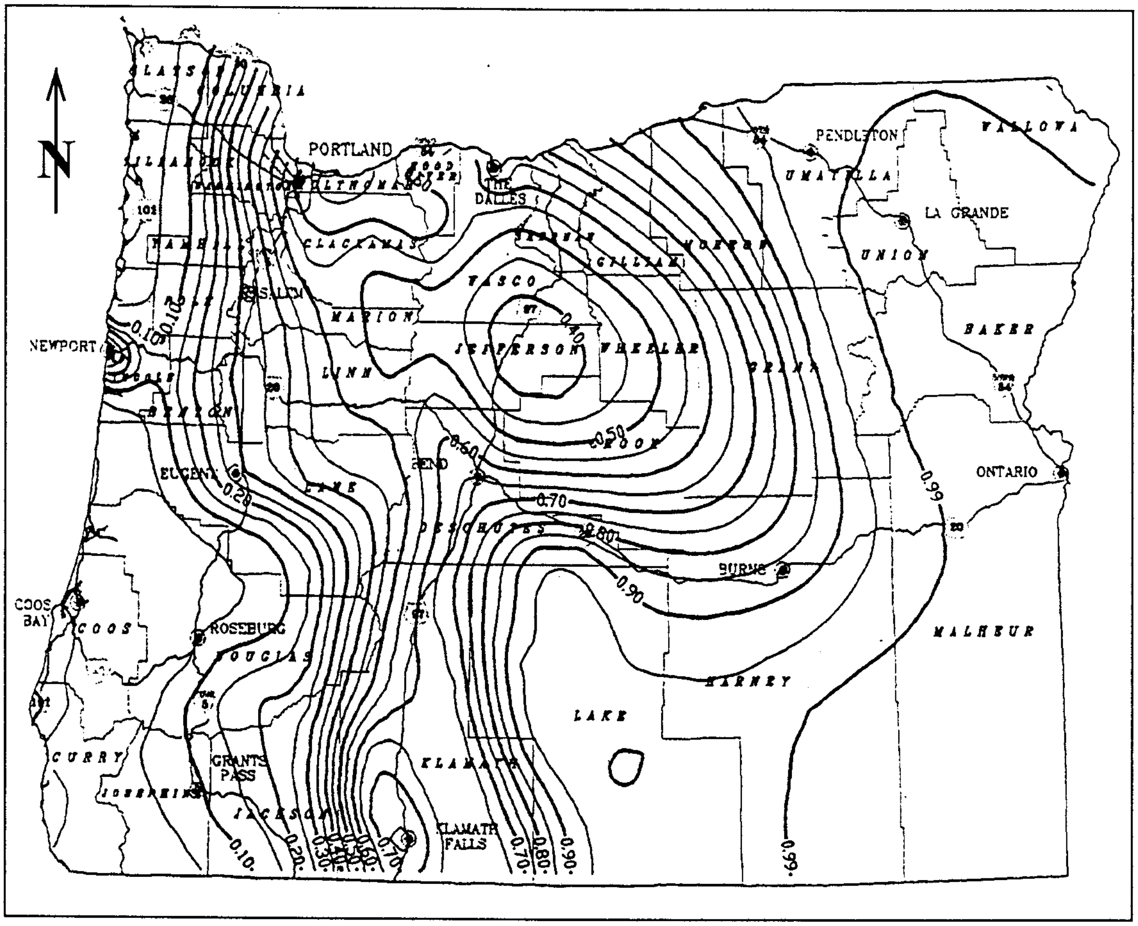

Figure 6: Fraction of 500-Year Return Period Peak Acceleration Levels Contributed by North American Crustal Sources (Geomatrix Consultants, 1995)

shown in Figure 7a, a M_w 9 event would be required to produce the 0.195g design level bedrock acceleration at Corvallis. Although the likelihood of an event of this magnitude is still subject to debate, it is within the realm of possibility considering the 1200 km length of the Cascadia Subduction Zone (Heaton and Hartzell, 1987; Geomatrix Consultants, 1995).

Intraslab earthquakes occur in the subducting plates only within a certain range of depths. They do not occur close to the surface, where the weight of the overriding plate is insufficient to cause the subducting plate to break, and they do not occur at great depths, where the heated slab softens enough that it deforms plastically. Though

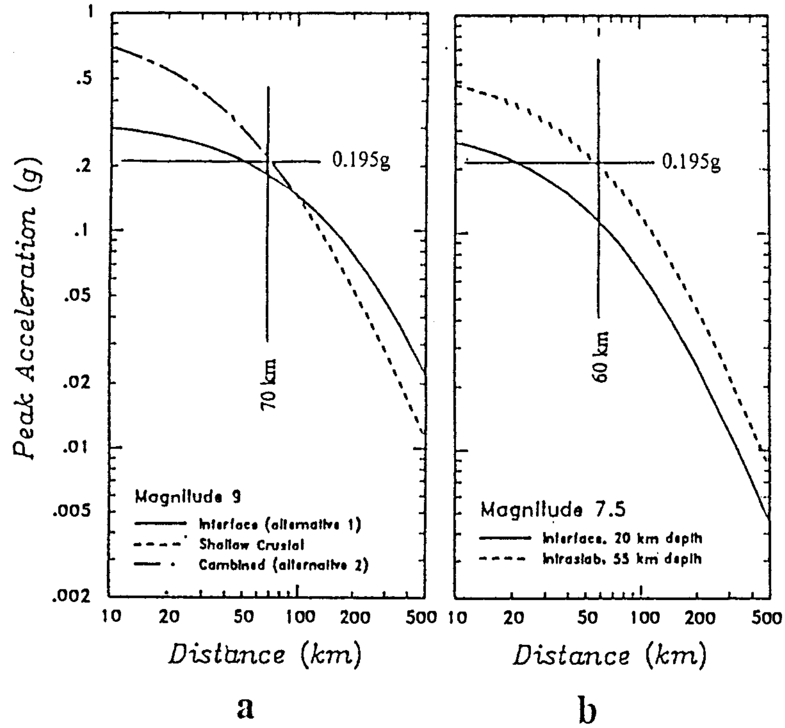

Figure 7: Attenuation Relationships for Estimating Rock Site Peak Acceleration. a) for Subduction Zone Interface Earthquakes, and b) for Subduction Zone Intraslab Earthquakes (Geomatrix Consultants, 1995)

the range of depths where an intraslab event could occur is still a matter of debate, Geomatrix assumes a depth of 55 km (34 miles). Figure 3 indicates that this type of event could occur much closer than an interface event, perhaps under the Coastal Range or even as far inland as the Corvallis area. Based on the attenuation relationships used in the Geomatrix report, shown in Figure 7b, a M_w 7.5 intraslab event at 60 km (37 miles) direct ground distance would produce the 0.195g bedrock acceleration at Corvallis.

Design-Level Earthquake. Though a particular design-level earthquake is not required for a loss estimate, it is helpful to identify the type of earthquake that could produce the design level acceleration. Based on Figure 6, the most significant seismic threat to the Corvallis area is a Cascadia Subduction Zone event, either a M_w 9 interface event at 70 km (43 miles), or a M_w 7.5 intraslab event at 60 km (37 miles). The Geomatrix report did not identify which of these is more probable.

It is less likely, but also possible (25% probability per Figure 6), that a local crustal event could cause the 500-year return period acceleration. Typical local events that could cause 0.195g bedrock acceleration in Corvallis are M_w 6 to M_w 7, within 10 to 20 km (6.2 to 12 miles). This is not to say that larger earthquakes do not occur; or that, for example, a M_w6.5 could not occur within 2 km. At any given location, however, these more serious events have less than a 10% probability of occurring over a 50 year period.

Site Effects

To this point, the discussion has revolved around the Peak Ground Accelerations reported by Geomatrix. The term "Peak Ground Acceleration" is somewhat ambiguous, in that Geomatrix is actually dealing with accelerations at bedrock, which is not typically at the ground surface. To determine what intensity of shaking will be experienced by buildings at the ground surface, site effects must be taken into account.

The site effects investigated in this report involve the dynamic response of soils layers near the surface. Once bedrock accelerations are estimated, the next requirement to forecast ground surface acceleration is to develop an understanding of the sub-surface soil profile at the site. With this knowledge, amplifications can be estimated using the method outlined in FEMA 222A, "NEHRP Recommended Provisions for Seismic Regulations for New Buildings (FEMA, 1995)." The objective is to determine Effective Peak Acceleration (EPA) at ground level, from which damage estimates can be developed.

The Effective Peak Accelerations for any given location depends on the underlying soil profile. The soil profiles at OSU were established in a preliminary report entitled "Development of a Microzonation Map for Corvallis (Trautwein and Freeman, 1994)." This report incorporated a collection of 41 soil borings from throughout the campus (Oregon State University Facilities Services, 1994). Though the information for these borings varied according to source and date, several borings did reach to bedrock; others contained information on Standard Penetration Test (SPT) blow counts, natural water content, soil shear strength, and plasticity. Based on the information obtained from the borings, each site is classified according to the soil layers reported. The basis for classification is reproduced in Table 1: Soil Profile Type (FEMA 222A, 1995). Based on the soil borings, the most appropriate soil profile throughout the OSU campus is Type D.

The amplification relationships developed in FEMA 222A are based on Effective Peak Acceleration on bedrock. To determine EPA from the 0.195 g PGA on bedrock, the relationship of EPA = 0.75 PGA (Applied Technology Council, 1988b) is used, resulting in a bedrock EPA of 0.146g. The amplification relationship provided in FEMA 222A is as follows:

$$C_a = F_a * A_a \qquad \text{(eqn 1.4.2.3-1, FEMA 222A)}$$

Where: C_a is the seismic coefficient. This is the design EPA at ground level used for the loss estimate in this report.

F_a is the acceleration based site coefficient from Table 1.4.2.3a in FEMA 222A. From this table, $F_a = 1.5$ for soil profile type D, and $A_a = 0.15$.

A_a is the Effective Peak Acceleration on bedrock.

Table 1: Soil Profile Type (FEMA 222A, 1995)

A	Hard rock with measured shear wave velocity, $\bar{v}_s$ > 1500 m/s (5000ft/sec)
B	Rock with 760 m/s < $\bar{v}_s \leq$ 1500 m/s (2500 ft/sec < $\bar{v}_s \leq$ 5000 ft/sec)
C	Very dense soil and soft rock with 360 m/s < $\bar{v}_s \leq$ 760 m/s (1200 ft/sec < $\bar{v}_s$ $\leq$ 2500 ft/sec) or with either $\bar{N}$ > 50 or $\bar{s}_u \geq$ 100 kPa (2000 psf)
D	Stiff soil with 180 m/s $\leq \bar{v}_s \leq$ 360 m/s (600 ft/sec $\leq \bar{v}_s \leq$ 1200 ft/sec) or with either 15 $\leq \bar{N} \leq$ 50 or 50 $\leq \bar{s}_u \leq$ 100 kPa (1000 psf $\leq \bar{s}_u \leq$ 2000 psf)
E	A soil profile with $\bar{v}_s$ < 180 m/s ($\bar{v}_s$ < 600 ft/sec) or any profile with more than 3 m (10 feet) of soft clay defined as soil with PI (Plasticity Index) > 20, *w* (natural water content) $\geq$ 40%, and s_u < 25 kPa (500 psf)
F	Soils requiring site-specific evaluations: 1. Soils vulnerable to potential failure or collapse under seismic loading such a liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and /or highly organic clays (H>3 m (10 feet) of peat and or highly organic clay where H = thickness of soil) 3. Very high plasticity clays (H > 8m (25 feet) with PI > 75) 4. Very thick soft/medium stiff clays (H > 36 m (120 feet))
EXCEPTION: When the soil properties are not known in sufficient detail to determine the Soil Profile Type, Type D shall be used. Soil Profile Types E or F need not be assumed unless the regulatory agency determines that Types E or F may be present at the site or in the event that Types E or F are established by geotechnical data.	
Nomenclature: $\bar{v}_s$ = Average shear wave velocity $\bar{N}$ = Average blow counts from a standard penetration test $\bar{s}_u$ = Average undrained shear strength H = Thickness of soil PI = Plasticity Index *w* = Moisture content (percent)	

Based on this relationship, the resulting EPA at ground level is 0.22g. This is the EPA used for the loss estimate in this study. Hereafter, all references to EPA and PGA refer to accelerations at the ground surface, not at bedrock.

Other Soil Phenomena

Buildings subjected to an earthquake can be affected not only by ground shaking, but by two other soil-related phenomena: liquefaction and landslides. The threat posed by these hazards is considered to be negligible on the Oregon State University campus, as detailed in the following sections.

Liquefaction. Liquefaction is a phenomenon in which granular soils, usually sandy soils, "take on the characteristics of a dense liquid rather than those of a solid (Bolt, 1993)." Buildings supported by these types of soils can actually sink, or even overturn, if liquefaction occurs. Two criteria are used to identify soils considered to be susceptible to liquefaction: 1) the soil must be a loose, non-cohesive, granular soil (sandy, silty, or gravelly); and 2) it must be saturated or near saturated (at or below the water table). Clay layers and soils with a Plasticity Index (PI) greater than 30% are not generally considered susceptible to liquefaction (Seed, 1990). Based on the survey of the soil boring logs, it appears that a layer of sandy soil (reported variously as fine sands, silty sands, and clayey sands) exists throughout the OSU campus starting at a depth of approximately 5 to 10 m (16 to 33 feet), with a thickness of 3 to 10 m (10 to 33 feet) (OSU Facilities Services, 1994). This layer is considered as a possible source of liquefaction and requires further analysis.

Several approaches to analyzing the susceptibility of a known soil layer to liquefaction are described in "Ground Motions and Soil Liquefaction During Earthquakes" by Seed and Idriss (1982). An attempt was made to evaluate the soils on the OSU campus using some of these methods; however, these methods require a greater understanding of the geotechnical properties of the soils than can be obtained based on the soil borings available. Generally, the silty sand layers identified by the borings are dense enough to identify them as non-liquefiable. This is based on the

Standard Penetration Test (SPT) blow count, which is the only consistent source of information provided by the borings. However, several layers of less dense soils (again based on SPT) are also reported in the boring logs. It is assumed that these intermittent soft layers represent lenses of soil with a significant proportion of high plasticity silts and clays, which results in softer soil and a lower SPT blow count. Based on these criteria, the sand layer identified on the OSU campus is not considered to be susceptible to liquefaction hazards.

Landslides. The threat from landslides caused by earthquakes in other portions of Oregon has been addressed using a simplified hazard classification scheme presented in a report developed for the Oregon Department of Geology and Mineral Industries (DOGAMI) (Wang and Priest, 1995). The DOGAMI report provides criteria for identifying landslide susceptible areas. These criteria are outlined as follows:

> *Highest Susceptibility*: "All existing landslides, igneous rock slopes 33° or greater, non-igneous slopes 26° or greater, all slopes 22° or greater within 1,000 feet of river valleys, and an approximate 60-foot swath along moderate and steep ocean bluffs."
>
> *Intermediate Susceptibility*: "Slopes 18° or greater, slopes 14° or greater within 1,000 feet of river valleys, and an approximately 60-foot swath along moderate and steep ocean bluffs adjacent to those identified in the highest susceptibility zone."
>
> *Lowest Susceptibility*: "Slopes not in the highest or intermediate susceptibility zones, slopes greater than 8.5°, and all remaining bedrock slopes."
>
> *Stable*: "Slopes less than 8.5° in terrace deposits; alluvium; and beach, bar, and dune sands."

The steepest slopes found on the OSU campus are approximately 7°, located near Benton Hall, Pharmacy Hall, Kerr Library, and Snell Hall (Shannon and Wilson, Inc., 1979). Since this is lower than any of the susceptible categories identified in the DOGAMI report, the threat due to landslides is considered to be negligible.

Inventory of Structures

The second element required for a loss estimate is an inventory of the structures. An inventory of the buildings considered for this study, which includes all major buildings on campus, was conducted for a previous report, "Seismic Risk Assessment and Retrofit Design Concepts for Oregon State University Campus Buildings (Miller, Ferguson, and Ch'ng, 1993)." The inventory that was conducted used the methodology presented in ATC-21, "Rapid Visual Screening of Buildings for Potential Seismic Hazards: a Handbook (ATC, 1988a)." This method involves first identifying the type of structural system employed for each building, such as wood frame, steel moment resisting frame, concrete shear walls, or unreinforced masonry. A table of building structural types used in this study is provided in Table 2: Building Structural Classes Used for OSU Loss Estimate. This table includes the building classifications not only for ATC-21, but for the corresponding ATC-13 classes as well. Some buildings consist of a combination of structural systems, and this was noted in the survey. Based on the type of structural system identified, a Basic Structural Hazard (BSH) score is assigned according to the guidelines in ATC-21.

In addition to the structural system, other characteristics of each building were identified in the reports by Miller et al. (1991, 1992). Characteristics that affect seismic performance include plan irregularities, condition of the building materials, subsurface soil conditions, and others. Buildings with certain of these types of characteristics can generally be expected to be more susceptible to damage in an earthquake. A Performance Modification Factor (PMF) is assigned to each of these characteristics, based on the guidelines set forth in ATC-21. The BSH score is

Table 2: Building Structural Classes Used for OSU Loss Estimate

Building Description	ATC-21 Class	ATC-13 Class		
		Low Rise	Med Rise	High Rise
Wood Frame	W	1	1	1
Steel Moment Resisting Frame	S1	15	16	17
Steel Braced Frame	S2	12	13	14
Light Metal Frame	S3	2	2	2
Steel Frame w/ Concrete Shear Walls	S4	3	4	5
Steel Frame w/ Masonry Infill	S5	78	79	80
Concrete Moment Resisting Frame	C1	87	88	89
Concrete Shear Wall	C2	6	7	8
Concrete Frame With Masonry Infill	C3	78	79	80
Tilt Up	PC1	21	22	23
Precast Frame	PC2	82	83	84
Reinforced Masonry	RM	9	10	11
Unreinforced Masonry	URM	75	76	77

adjusted by the PMFs assigned. Both the building structural types and the modifiers applied to each building were used for the loss estimate in this thesis. A list of the Performance Modifiers is reproduced in Table 3: Building Performance Modifiers (ATC-21). The actual values of the Performance Modification Factors (PMFs) vary depending on building type and seismic hazard.

Building Occupancies and Economic Values

The third element required for a loss estimate is an inventory of building occupancies and values. Just as the expected number of casualties is dependent on the number of occupants in the building, the predicted economic loss depends on the value of the building and its contents. It should be noted that the inventories of building

Table 3: Building Performance Modifiers (ATC-21)

Building Feature	Definition/Description
High Rise	8 stories and taller; for URM, above 4 stories
Poor Condition	showing cracks, damage, settlement, etc.
Vertical Irregularity	steps in elevation, inclined walls, discontinuities in load path, building on hill
Soft Story	open on all sides of building, tall ground floor, discontinuous shear walls
Torsion	eccentric stiffness in plan, e.g., corner building, wedge shaped building with one or two solid walls and all other walls open
Plan Irregularity	"L", "U", "E", "T", or other irregular building shape
Pounding	floor levels of adjacent buildings not aligned and less than 4" of separation per story
Large Heavy Cladding	many large heavy stone or concrete panels; glass panels and masonry veneer do not qualify
Short Columns	some columns restrained by half walls or spandrel beams
Post Benchmark Year	building designed after certain key year when code requirement was increased -- different for each building type and municipality
Soil Profile: SL1	rock, or stiff clay less than 200 feet overlying rock
Soil Profile: SL2	cohesionsless soil or stiff clay greater than 200 feet deep
Soil Profile: SL3	30 or more feet of soft or medium stiff clays (use if do not know soil profile)
SL3 <u>and</u> 8 to 20 Stories	8- to 20-story building on SL3 soil profile

occupancies and values were made toward the beginning of this study, in 1995, and reflect estimates for occupancies and values from 1994. While these numbers have changed over the course of the study, the relative values between the different buildings can be assumed to remain approximately constant.

Building Occupancies

Building occupancy rates were estimated to account for either a daytime or a nighttime earthquake. Occupancy for a daytime earthquake was estimated as the average occupancy between 9:30 a.m. and 3:30 p.m., the hours of greatest classroom occupancy. Nighttime occupancy was calculated for 3:00 a.m., which was assumed to be the time of highest residence occupancy and lowest classroom and office occupancy. Occupancies for the dormitories and the College Inn were obtained from the OSU Department of Student Housing (Sherman, 1995). It was assumed that 100% of the reported occupants would be present during a nighttime earthquake, and 50% would be present for a daytime earthquake. Faculty, staff and other university employees were tabulated by the OSU Office of Budgets and Planning (Helvie, 1994). It was assumed that 100% of these people would be present during a daytime earthquake, and that none would be present at night. Classroom occupancies were determined from the Student Schedule Report provided by the OSU Scheduling Office (Dyer, 1994). It was assumed that 100% of the enrolled students are present. Though this assumption probably overestimates the number of people actually in the classrooms, it was assumed that this is compensated for by students studying in the buildings while they are outside of class. Occupancy data for buildings which contain considerable numbers of occupants not covered by one of the previous reports was obtained by contacting people who work in the building. A list of the buildings for which this was required, along with the source of information for each building, is included in Table A-3 in Appendix A. A list of the assumed occupancies for each building, along with a breakdown of the sources used, is provided in Table 4: Assumed Occupancies and Reported Building Values Used for Loss Estimate. In addition to average assumed occupancies, maximum occupancies are also included in Table 4. Chapter IV and Appendix A detail how these maximum occupancies were determined.

Table 4: Assumed Occupancies and Reported Building Values Used for Loss Estimate

Building Name	Assumed Average Day Occup.	Assumed Average Night Occup.	Assumed Max Day Occup.	Assumed Max Night Occup.	Reported Insured Value of Building	Reported Value of Building Contents
Adams	31	0	31	0	$ 734,515	$ 632,643
Admin. Services	397	0	395	0	14,142,645	4,881,238
Ag Sciences II	352	0	316	0	23,684,406	5,945,939
Apperson	190	0	368	0	3,397,121	763,263
Ballard Extension	159	0	158	0	2,654,447	325,032
Batcheller	113	0	178	0	1,609,379	551,049
Benton	40	0	300	0	2,168,637	399,165
Bexell	429	0	972	0	3,991,286	1,794,414
Bloss	126	252	158	316	6,483,568	14,470
Burt	156	0	215	0	7,920,428	10,088,414
Buxton	112	224	154	307	4,113,736	12,783
Callahan	158	315	178	355	5,150,916	14,411
Cauthorn	129	257	148	296	4,146,599	9,124
Childcare Center	150	0	174	0	1,169,768	29,248
Clark Lab	15	0	30	0	954,102	86,313
College Inn	150	300	203	405	8,481,936	74,511
Computer Science	71	0	92	0	1,175,863	2,023,318
Cordley	634	0	1,701	0	21,236,817	17,102,696
Covell	158	0	326	0	2,878,073	703,867
Crop Science	129	0	158	0	5,540,080	1,496,801
Dearborn	182	0	367	0	6,880,995	3,915,637
Dixon Rec Center	125	0	308	0	9,175,743	300,178
Dryden	41	0	91	0	1,870,296	1,386,825
Education Bldg	161	0	429	0	5,877,486	512,237
Electric Comp Engr	191	0	374	0	7,400,787	4,861,089
Fairbanks	104	0	294	0	1,389,368	508,456
Family Study Center	79	0	130	0	1,939,975	288,700
Finley	162	323	180	359	6,545,015	85,587
Gilbert	340	0	651	0	11,672,196	5,564,854
Gilbert Addition	74	0	104	0	6,503,266	803,075
Gill Coliseum	117	0	10,612	0	13,533,970	2,079,660
Gilmore	52	0	79	0	910,150	560,873
Gleeson	96	0	181	0	3,213,875	1,851,556
Graf	34	0	32	0	2,094,033	1,114,822
Hawley	45	90	62	124	4,139,108	20,398
Indoor Target Range	10	0	30	0	363,894	0
Industrial Bldg	35	0	104	0	1,498,510	715,040
Kerr Library	500	0	1,500	0	13,123,995	42,371,776
Kidder Hall	483	0	784	0	10,849,729	2,155,199
Langton	156	0	607	0	5,887,454	347,728

Table 4: Assumed Occupancies and Reported Building Values Used for Loss Estimate (Continued)

Building Name	Average Day Occup.	Average Night Occup.	Max Day Occup.	Max Night Occup.	Insured Value of Building	Value of Building Contents
Lasells Stewart Center	305	0	1,745	0	5,673,025	240,128
Magruder	80	0	132	0	10,188,955	2,255,748
McAlexander	87	0	590	0	3,007,395	71,970
McNary	139	278	164	327	4,992,614	9,531
Memorial Union	374	0	1,610	0	20,153,418	970,435
Merryfield	37	0	67	0	2,413,811	1,038,982
Milam Hall	534	0	1,464	0	11,796,116	1,091,746
Milne Computer Center	52	0	101	0	2,440,659	5,394,275
Moreland	230	0	293	0	2,639,062	377,828
Nash	260	0	352	0	12,187,511	3,073,855
Oceanography	15	0	15	0	305,416	302,318
Parker Stadium, Clubhouse	0	0	250	0	1,287,241	146,199
Parker Stadium, Overall	0	0	35,525	0	9,607,281	52,129
Peavy	382	0	458	0	7,629,363	116,439
Pharmacy	127	0	213	0	5,208,068	1,509,223
Phys Heating Plant	6	0	6	0	11,945,082	119,661
Plageman Bldg	65	0	200	0	3,411,216	331,432
Poling	72	143	83	165	4,264,332	11,970
Radiation Center, Overall	79	0	80	0	6,704,220	1,743,960
Rogers	113	0	298	0	4,776,672	1,881,608
Sackett	119	237	119	237	10,681,581	137,711
Shepard	80	0	125	0	378,255	90,098
Snell	160	0	209	0	13,059,479	1,492,768
Social Science	139	0	254	0	2,711,892	249,852
Strand Agriculture	402	0	951	0	4,875,152	1,921,680
Waldo	147	0	159	0	3,794,432	1,789,824
Weatherford	0	0	0	0	7,566,435	35,948
Weniger	687	0	1,036	0	22,298,048	6,498,919
West International	77	154	121	242	4,881,400	9,786
Wiegand	183	0	417	0	4,460,452	1,066,188
Wilkinson	345	0	449	0	5,883,117	3,243,542
Wilson	144	287	144	287	5,062,768	23,823
Withycombe	225	0	185	0	7,896,622	2,155,037
Women's Bldg	125	0	534	0	6,650,104	967,875

Building Economic Values

The insured value of each building was obtained from the Valuation Reports provided by Elisabeth Dickinson, Risk Manager for the Oregon State Board of Higher Education (Dickinson, 1994). The Valuation Reports also include the value of the contents of each building insured for over $1,000,000, which covers virtually all of the buildings studied in this report. Building insured values and building contents values are included in Table 4.

Damage Probability Matrices (DPMs)

The fourth element required to develop a loss estimate is a method of estimating damage and casualties for a given building type subjected to a given intensity of shaking. This can be accomplished through the use of a tool known as a Damage Probability Matrix (DPM). A DPM reflects the estimated probabilities of damage for each specific building type subjected to a range of intensities of shaking. Damage ratios and casualty rates can be developed from these probabilities. The estimated damage ratio, multiplied by the value of the building and its contents, results in the economic loss estimate. Similarly, the casualty rate multiplied by the number of occupants provides a casualty estimate. An independent DPM must be developed for each type of building under consideration.

ATC-13, "Earthquake Damage Evaluation Data for California (Applied Technology Council, 1985)," provides the basis for the DPMs derived for the loss estimate for OSU. The DPMs developed in ATC-13 are not directly applicable to Oregon. This is due to the fact that the buildings in California have generally been constructed to meet more stringent seismic codes, are more resistant to seismic damage, and are therefore expected to sustain less damage than Oregon buildings, all other things being equal. ATC-21-1, "Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation (Applied Technology Council, 1988b)," provides a method to adjust the data in ATC-13 and develop DPMs for buildings outside of California. Additionally, ATC-21-1 includes the effects of building characteristics such as plan irregularities which tend to increase the probability of damage. The DPMs for Oregon State University were derived based on the procedures outlined in these two publications. A detailed discussion of how the OSU DPMs are derived is provided in Chapter III.

Loss Estimate

The campus wide loss estimate is based on a summation of the individual loss estimates developed for each building in the study. The economic loss estimate for each building is determined by multiplying the value of the building and its contents by an appropriate damage ratio. The damage ratio is dependent on the intensity of shaking, the type of building, and applicable building performance modification factors, and is provided by one of the DPMs developed for this study. The casualty estimates for each building are similarly determined by multiplying the fatality rate and the serious injury rate by the assumed occupancy of the building.

It should be noted and emphasized that the original loss estimate methodology developed in ATC-13 did not intend that the DPMs be used to estimate losses for individual buildings. The DPMs were intended to be used for a large sample of buildings, and to reflect the overall level of damage sustained by all of the buildings. Statistically, the estimated damage ratio for a larger sample of buildings is more likely to reflect the actual overall damage level observed in a design level earthquake. For a single building, predicting 20% damage based on a damage ratio of 0.20 is not statistically defensible. The loss estimates given for individual buildings, therefore, should not be considered to reflect actual relative losses. In light of this, it may seem to be inappropriate to develop a campus-wide loss estimate by summing the loss estimates from the 74 individual buildings, each of which has a high level of statistical uncertainty. However, the sample size of 74 buildings can be expected to make up for this to a degree. Furthermore, it is the relative hazard of the buildings and the resulting prioritization of the buildings that is of greatest concern in this study, and this method does provide an estimate of this relative hazard.

Economic Loss Estimate

Based on the methods described in this chapter, immediate economic losses to OSU campus buildings are estimated to be $219M. This includes structural losses of $166.4M (35.6% of the total insured value of all buildings), and building contents losses of $53.4M (33.5% of total reported building contents). A breakdown of the loss estimate by building is provided in Table 5: Loss Estimate for OSU Campus Buildings. This loss estimate does not include secondary effects such as loss of revenue resulting from the loss of building function.

Loss estimates developed using this methodology are by no means exact. ATC-13 suggests that loss estimates using this methodology are accurate only within a factor of four, with a 90% confidence interval (Applied Technology Council, 1985). This means that there is a 90% probability that the actual damage experienced in a design-level earthquake will lie within the estimated range of $88M to $352M (a factor of four). The central value of this range, $219M, is the value reported as the loss estimate. These estimates are based on reported building values as of 1994.

Casualty Estimate

Based on the methods described in this chapter, it is estimated that a design-level earthquake occurring during the daytime (between 9:30 a.m. and 3:30 p.m.) will result in 273 fatalities (approximately 2.2% of the total estimated campus occupancy), and 555 serious injuries, defined as injuries requiring hospitalization (this is approximately 4.4% of the estimated campus occupancy). If the earthquake were to occur at night (3:00 a.m.), the estimate is 220 fatalities (7.7% of assumed nighttime occupancy) and 441 serious injuries (15.4%). In addition to these casualties, less serious injuries are estimated to number ten times the serious injury rates. A breakdown of the casualty estimates by building is provided along with economic losses in Table 5. Again, this is a probabilistic estimate only, and is not intended to predict losses for individual building.

Table 5: Loss Estimate for OSU Campus Buildings

Building Name	Fatality Estimates Based on: Average Day Occupancy	Fatality Estimates Based on: Average Night Occupancy	Serious Injury Estimates Based on: Average Day Occupancy	Serious Injury Estimates Based on: Average Night Occupancy	Economic Loss Estimates: Insured Building Value ($1000's)	Economic Loss Estimates: Reported Value of Contents ($1000's)	Economic Loss Estimates: Total ($1000's)
Adams	0.0	0.0	0.0	0.0	49	42	91
Admin. Services	47.1	0.0	94.3	0.0	10,372	3,580	13,952
Ag Sciences II	0.2	0.0	0.5	0.0	4,925	1,237	6,162
Apperson	0.0	0.0	0.0	0.0	235	53	288
Ballard Extension	3.3	0.0	6.8	0.0	1,457	178	1,636
Batcheller	0.0	0.0	0.0	0.0	115	40	155
Benton	0.0	0.0	0.0	0.0	156	29	184
Bexell	1.3	0.0	3.2	0.0	1,685	758	2,443
Bloss	7.5	15.1	15.1	30.3	3,355	7	3,362
Burt	0.5	0.0	1.1	0.0	2,497	3,181	5,678
Buxton	11.9	23.7	23.8	47.5	2,931	9	2,940
Callahan	16.7	33.3	33.4	66.9	3,670	10	3,681
Cauthorn	13.6	27.2	27.3	54.5	2,955	7	2,961
Childcare Center	0.0	0.0	0.2	0.0	277	7	284
Clark Lab	0.1	0.0	0.2	0.0	355	32	387
College Inn	0.1	0.2	0.3	0.7	2,047	18	2,065
Computer Science	0.5	0.0	1.2	0.0	554	953	1,507
Cordley	1.9	0.0	4.3	0.0	6,696	5,392	12,088
Covell	0.5	0.0	1.2	0.0	1,215	297	1,513
Crop Science	0.1	0.0	0.2	0.0	1,396	377	1,774
Dearborn	0.1	0.0	0.2	0.0	1,127	641	1,768
Dixon Rec Center	3.2	0.0	6.6	0.0	4,624	151	4,775
Dryden	0.1	0.0	0.3	0.0	790	586	1,375
Education Bldg	0.2	0.0	0.5	0.0	1,873	163	2,037
Electric Comp Engr	0.0	0.0	0.1	0.0	1,033	679	1,712
Fairbanks	0.0	0.0	0.0	0.0	114	42	156
Family Study Center	0.0	0.0	0.0	0.0	215	32	248
Finley	9.7	19.3	19.4	38.8	3,387	44	3,431
Gilbert	0.3	0.0	0.9	0.0	3,267	1,557	4,824
Gilbert Addition	0.1	0.0	0.3	0.0	1,884	233	2,117
Gill Coliseum	0.1	0.0	0.1	0.0	2,358	362	2,721
Gilmore	0.3	0.0	0.6	0.0	322	198	520
Gleeson	0.1	0.0	0.2	0.0	899	518	1,418
Graf	0.2	0.0	0.4	0.0	911	485	1,396
Hawley	4.8	9.5	9.6	19.1	2,949	15	2,964
Indoor Target Range	0.0	0.0	0.0	0.0	142	0	142
Industrial Bldg	0.1	0.0	0.1	0.0	354	169	523
Kerr Library	16.1	0.0	32.6	0.0	5,447	17,586	23,033
Kidder Hall	7.8	0.0	16.3	0.0	5,584	1,109	6,694
Langton	2.9	0.0	6.1	0.0	2,883	170	3,054
Lasells Stewart Center	1.3	0.0	2.9	0.0	1,898	80	1,979

Table 5: Loss Estimate for OSU Campus Buildings (Continued)

Building Name	Fatality Estimates Based on: Average Day Occu-pancy	Fatality Estimates Based on: Average Night Occu-pancy	Serious Injury Estimates Based on: Average Day Occu-pancy	Serious Injury Estimates Based on: Average Night Occu-pancy	Economic Loss Estimates: Insured Building Value ($1000's)	Economic Loss Estimates: Reported Value of Contents ($1000's)	Economic Loss Estimates: Total ($1000's)
Magruder	0.0	0.0	0.0	0.0	1,132	251	1,382
McAlexander Total	0.0	0.0	0.0	0.0	196	5	200
McNary	14.7	29.4	29.5	59.0	3,557	7	3,564
Memorial Union	45.2	0.0	90.6	0.0	16,142	777	16,919
Merryfield	0.1	0.0	0.3	0.0	1,019	439	1,458
Milam Hall	6.3	0.0	13.2	0.0	5,098	472	5,570
Milne Computer Center	0.0	0.0	0.1	0.0	649	1,434	2,083
Moreland	0.2	0.0	0.7	0.0	963	138	1,100
Nash	0.1	0.0	0.2	0.0	1,963	495	2,458
Oceanography	0.0	0.0	0.0	0.0	22	22	44
Parker Stadium, Clubhouse	0.0	0.0	0.0	0.0	257	29	286
Parker Stadium, Overall	0.0	0.0	0.0	0.0	1,047	6	1,053
Peavy	0.0	0.0	0.0	0.0	510	8	518
Pharmacy	4.6	0.0	9.2	0.0	2,551	739	3,291
Phys Heating Plant	0.1	0.0	0.1	0.0	2,926	29	2,955
Plageman Bldg	0.0	0.0	0.0	0.0	639	62	701
Poling	7.6	15.1	15.2	30.3	3,039	9	3,047
Radiation Center, Overall	2.2	0.0	4.4	0.0	2,672	695	3,367
Rogers	0.2	0.0	0.4	0.0	1,401	552	1,952
Sackett	0.0	0.0	0.1	0.2	2,094	27	2,121
Shepard	0.0	0.0	0.0	0.0	26	6	32
Snell	0.9	0.0	2.0	0.0	4,418	505	4,923
Social Science	0.1	0.0	0.4	0.0	989	91	1,080
Strand Agriculture	8.3	0.0	17.2	0.0	2,677	1,055	3,732
Waldo	0.0	0.0	0.0	0.0	297	140	436
Weatherford	0.0	0.0	0.0	0.0	1,483	7	1,490
Weniger	0.1	0.0	0.3	0.0	2,990	872	3,862
West International	8.1	16.3	16.3	32.7	3,478	7	3,485
Wiegand	0.3	0.0	0.7	0.0	1,308	313	1,620
Wilkinson	0.5	0.0	1.2	0.0	1,549	854	2,403
Wilson	15.2	30.4	30.5	60.9	3,607	17	3,624
Withycombe	3.0	0.0	6.1	0.0	3,066	837	3,902
Women's Bldg	2.6	0.0	5.3	0.0	3,651	531	4,183
Total	272.7	219.6	554.5	440.8	166,423	52,458	218,881

Casualty estimates are subject to even more uncertainty than economic damage estimates. While ATC-13 suggests that economic loss estimates are accurate only within a factor of four, casualty estimates are assumed to be accurate only within a factor of ten (Applied Technology Council, 1985). The same 90% confidence interval applies. For a daytime earthquake, this results in a estimated range of 50 to 500 fatalities, and 100 to 1000 serious injuries. For a nighttime earthquake, the estimated range is 40 to 400 fatalities and 80 to 800 serious injuries. These estimates are based on 1994 building occupancies.

Comparison with Other Loss Estimates

At least three other seismic loss estimates have been made in Oregon, all for the city of Portland. The first of these is reported in "An Earthquake Loss Estimation Methodology for Buildings Based on ATC-13 and ATC-21 (McCormack and Rad, 1997)." As with the OSU study conducted for this thesis, the goal of McCormack's study was to adapt ATC-13 and ATC-21 for local use. Though these two studies address different aspects of the problems in different ways, the overall approach is similar. Both incorporate the effects of building Performance Modification Factors (PMFs) as determined for each building through the ATC-21 Rapid Visual Screening surveys. The McCormack loss estimate encompassed approximately 30,000 buildings, with an estimated occupancy of 256,660. The fatality estimate for a daytime earthquake was 5415, or 2.1%. This is remarkably similar to the daytime fatality estimate for Oregon State University, at 2.2%. The building damage cost estimate for McCormack's study was 23% of the total value of the buildings, compared to 35.6% for the OSU estimate.

The second Portland loss estimate is entitled "Earthquake Risk Analysis, Final Report," conducted by Goettel and Horner (1995) for the city of Portland. The Goetttel and Horner study developed fragility curves to derive loss estimates. Fragility curves are a different way of presenting the damage probability distribution curves used in the Oregon State study, which are discussed in Chapter III of this thesis. The fragility curves were derived from engineering judgment and calibrated against ATC-13 and a draft version of the National Institute of Building Sciences (NIBS) study, discussed in the next paragraph. The Goettel and Horner study did not take into account the structural characteristics of individual buildings, as was done in the Oregon State University study and McCormack's study. Fatalities for the greater Portland area were estimated at 1000 to 5000 for a crustal earthquake, and at several hundred for a Cascadia Subduction Zone earthquake (Goettel and Horner, 1995).

The third Portland loss estimate is reported in "Earthquake Loss Estimation Pilot Study for the Portland Metropolitan Region -- Summary Results," by the National Institute of Building Sciences (1997). The objective of the NIBS study was to test a newly developed software application, HAZUS. HAZUS incorporates a geographic information system (GIS) to map the building inventories, soil conditions, lifelines, known faults, and other information. It then combines this data to determine different types of hazards, economic loss estimates, and casualties. Unlike the other studies, the HAZUS authors developed their own damage and casualty rates based partially on ATC-13 and partially on their own judgment and pushover analyses. The scope of the NIBS investigation included all of Clackamas, Multnomah, and Washington counties. The casualties predicted by this methodology are much lower than for the other two Portland estimates. A magnitude 6.5 earthquake in downtown Portland was predicted to result in 39 fatalities if it were to occur at 2:00 p.m., and 22 fatalities if it were to occur at 2:00 a.m.

This large discrepancy in casualty estimates is troublesome and deserves further discussion. It is readily apparent that the estimated casualty rates used by HAZUS are significantly lower than those developed for any of the other Oregon studies. While the authors of the HAZUS methodology were not consulted, it may be that their intent was to reduce the number of casualties predicted based on their observations of losses actually observed in recent West coast earthquakes. For example, the 1949 Puget Sound earthquake produced only $25M in damage and 8 fatalities (Bolt, 1993). This was a MMI VIII (EPA = 0.16g) subduction zone event which was felt throughout the Seattle metropolitan area (Algermissen, 1983). The losses actually observed in this event are significantly lower than anything that would have been predicted by the methodology developed for OSU. While catastrophic losses have been observed in earthquakes in other areas of the world, the historic trend in the United States seems to be toward a lower fatality rate. Perhaps this is a result of construction methods in the U.S. In any event, it is possible that the authors of NIBS intended for their loss estimates to reflect the actual losses observed in more recent events. Further investigation into the source of the discrepancy between the loss estimates presented by the NIBS report and the other Oregon studies is outside the scope of this thesis.

Limitations of Loss Estimate

Inaccuracies in the final loss estimate arise from unavoidable errors in each of the four elements (assumed intensity of shaking; inventory of the buildings and their structural characteristics; assumed values of the buildings and their contents, and building occupancies; and the DPMs developed to make the loss estimate). Any interpretation of the significance of this loss estimate should, therefore, take into account the following limitations:

- The accurate prediction of earthquakes is unrealistic in the foreseeable future. The 500-year return period bedrock acceleration of 0.195g is no more than an estimate of the seismic threat.
- Though it is theoretically possible to obtain accurate inventories of buildings, contents, and occupants, the time and resources required are more than is usually available for a loss estimate. The estimates obtained through this study are close enough to provide a reasonable level of accuracy, especially when the other sources of error are considered.
- The losses associated with different types of buildings subjected to different levels of ground motion can only be measured accurately in actual buildings which have been subjected to seismic loads. The DPMs used to estimate these losses, derived

from the Delphi survey in ATC-13, are primarily based on engineering judgment by experts in the field, and on their knowledge of actual historical data.

- The loss estimate methodologies developed in ATC-13 and ATC-21 are intended for use with a large sample of buildings, and provide an average loss estimate for all of the buildings. The application of these methodologies to individual buildings cannot be construed to predict losses for each individual building. However, it has been used to indicate relative hazards between different individual buildings, which is the main purpose of this study.
- The duration of the seismic event is not considered in the methodology used in the development of the DPMs. This was outside the scope of consideration when the ATC Delphi survey was conducted. Since a large subduction zone earthquake can be expected to last longer than a relatively small crustal earthquake, this could have a significant impact on the losses sustained.

III: Development of Damage Probability Matrices

Damage Probability Matrices reflect the probabilities of different levels of damage given a specific building type subjected to a specific intensity of shaking. When applied to a statistically significant number of buildings of the same type, DPMs provide an estimate of the proportion of those buildings which will sustain different levels of damage. This discussion of Damage Probability Matrices (DPMs) will entail a brief description of what the matrices are and how they are used, coverage of the DPMs derived in other publications, and an in-depth explanation of the method used to derive the DPMs used for the Oregon State University loss estimate.

Background

The DPMs derived and used in this study are modeled after those developed in ATC-13, "Earthquake Damage Evaluation Data for California (Applied Technology Council, 1985)," and ATC-21-1, "Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation (Applied Technology Council, 1988b)." A sample DPM is shown in Table 6: Damage Probability Matrix for Unreinforced Masonry Buildings. The DPM indicates the percentage of unreinforced masonry

Table 6: Damage Probability Matrix for Unreinforced Masonry Buildings

Damage State:		1 none	2 slight	3 light	4 moderate	5 heavy	6 major	7 destroyed	Overall Damage Ratio	Serious Injury Rate per 1000	Fatality Rate per 1000
Range:		0%	0-1%	1-10%	10-30%	30-60%	60-100%	100%			
CDF:		0.0%	0.5%	5%	20%	45%	80%	100%			
EPA (g)	0.05	0.00	0.52	85.21	13.05	1.13	0.08	0.01	7.45%	0.16	0.05
	0.10	0.00	0.00	16.40	74.07	9.13	0.38	0.02	20.07%	0.75	0.20
	0.15	0.00	0.00	1.63	69.84	27.21	1.27	0.04	27.35%	1.59	0.44
	0.20	0.00	0.00	0.15	48.65	47.85	3.26	0.09	33.97%	2.62	0.75
	0.22	0.00	0.00	0.06	40.53	54.82	4.46	0.13	36.48%	3.04	0.89
	0.25	0.00	0.00	0.01	30.02	62.99	6.78	0.19	39.97%	3.69	1.12
	0.30	0.00	0.00	0.00	17.35	70.25	12.02	0.37	45.07%	4.85	1.59

buildings that are expected to sustain damage within each damage state. Seven damage states are defined, ranging from 1 (no damage) to 7 (all buildings are destroyed). The range of damage defining each damage state is listed below the damage state number in the table. This range indicates the damage the buildings would sustain in terms of economic loss as a percentage of the value of the buildings. The Central Damage Factor (CDF) indicates the statistical level of damage assumed for all buildings within a damage state. Probabilities are provided for several levels of horizontal ground acceleration based on Effective Peak Acceleration (EPA), which is expressed in terms of a fraction of gravity (g). The Overall Damage Ratio column indicates the average damage predicted for a large sample of buildings subjected to that level of ground acceleration. This can be interpreted as the economic loss for the building and its contents as a percentage of the value of the building and its contents. The Serious Injury Rates and Fatality Rates indicate how many occupants per 1000 are expected to be seriously injured or killed.

Damage Probability Matrices Developed in ATC-13

The DPMs derived in ATC-13 were developed to provide loss estimates specifically for buildings in California. Because California has a long history of damaging earthquakes, the building codes and construction methods have developed to produce buildings that are more earthquake resistant than buildings in most other parts of the nation. Therefore, the DPMs developed in ATC-13 cannot be used directly for buildings at OSU and must be adjusted as detailed later in this chapter.

The DPMs developed in ATC-13 are based on a series of surveys of 71 experts who have studied the effects of earthquakes on structures. These experts were asked to predict how much damage different types of buildings would sustain at specific levels of ground motion. The damage estimates were based on a “typical” building within the class, and do not reflect the variability in seismic resistance provided by different buildings in the class. Ground motion was defined by the Modified Mercalli Intensity (MMI) Scale. The MMI Scale is reproduced in Table 7. Predictions were

Table 7: Modified Mercalli Intensity (MMI) Scale (Naeim, 1989)

I	Not felt except by a very few under especially favorable circumstances.
II	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated.
IV	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
VI	Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.
VII	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor cars disturbed.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.
XI	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII	Damage total. Practically all works of construction are damaged greatly or destroyed. Waves seen on ground surface. Lines of sight and level are distorted. Objects are thrown into the air.

made for each level from MMI 6 to MMI 12. The effects of earthquake duration were not considered. In the survey of experts, consensus was reached using the Delphi method, which "consists of formulating questionnaires, obtaining individual answers to the questionnaires from experts, iterating the questionnaires one or more times where the information feedback between rounds is carefully controlled by the project manager, and finally aggregating their responses by statistical operations (Applied Technology Council, 1985)." Using the Delphi method, a consensus was reached for the best estimate of damage, interpreted as the "mean value of damage." Consensus was also reached for the high and low limits of damage, which were defined as the boundary limits for the central 90% interval of estimated damage (Applied Technology Council, 1985).

From these estimates, ATC-13 developed damage probability distribution curves based on a statistical beta distribution, which has a very similar shape to a normal or lognormal distribution. These damage probability distribution curves were then used to determine the estimated probability that a particular level of damage will be sustained. A sample of a damage probability curve, based on a lognormal distribution, is provided in Figure 8: Sample Damage Probability Distribution Curve. A lognormal distribution is used in this study instead of the beta distribution used in ATC-13 because the lognormal distribution was used in ATC-21-1, which was the model for this study.

The damage probability curve is then divided into separate areas based on the damage states chosen for the DPM. The area under the curve for each range of damage indicates the percentage of buildings that are expected to sustain that level of damage. An example of this is shown in Figure 9: Schematic Representation of Damage Probability Descretization. The final DPMs in ATC-13 were developed by compiling all the probabilities for each damage state for each intensity of shaking, MMI 6 through MMI 12. A unique DPM was developed for each building type classified.

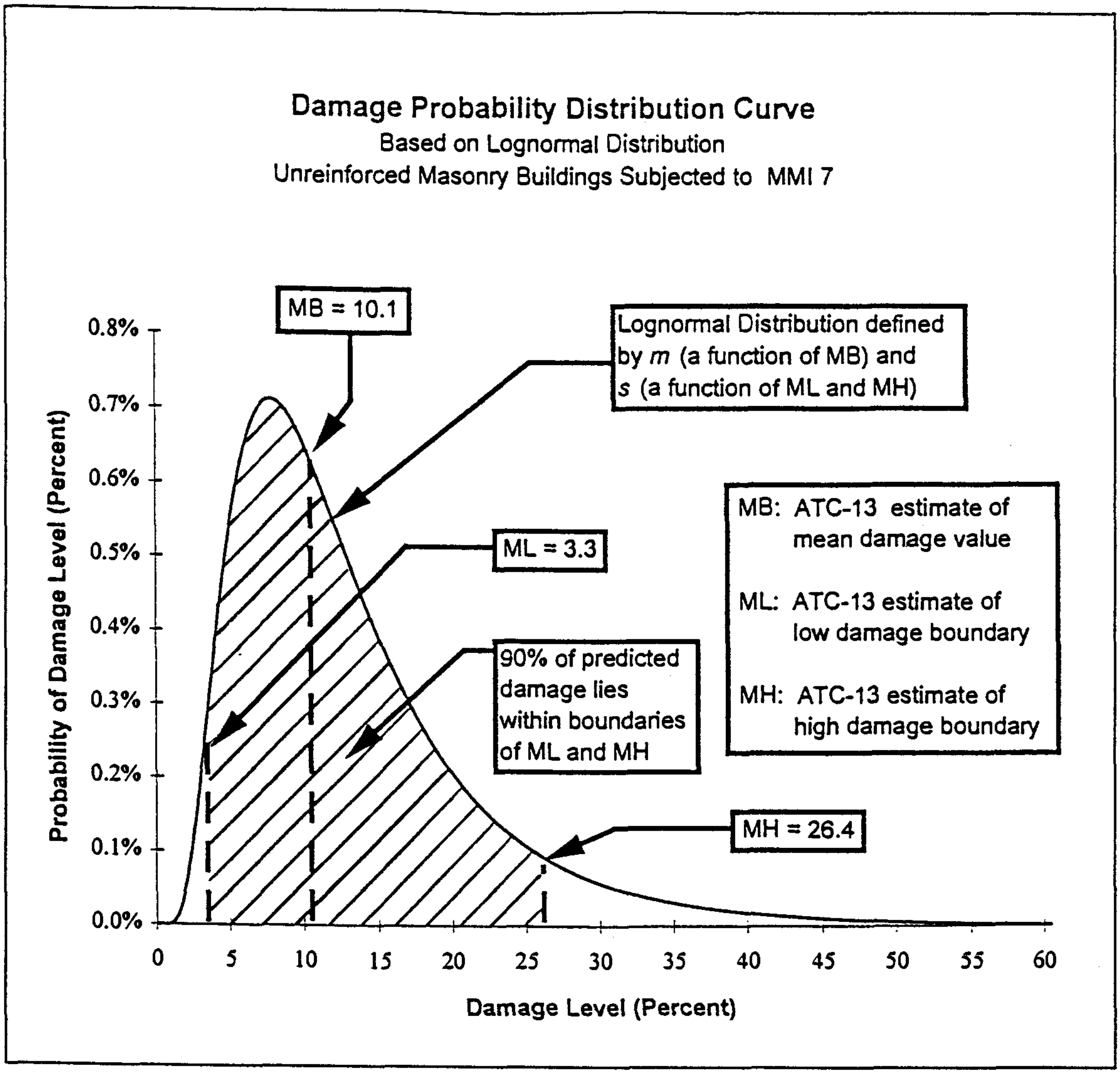

Figure 8: Sample Damage Probability Distribution Curve

Considering the number of assumptions that went into the development of the DPMs in ATC-13, it is apparent that a great deal of uncertainty exists in their application to a loss estimate. In light of this, ATC-13 reports that economic loss estimates developed using this methodology are accurate only within a factor of four. This means that if a \$2.5M loss estimate is projected, the \$2.5M is considered to be the best estimate in the range of \$1.0M to \$4.0M. Similarly, the loss estimates for casualties are estimated to be accurate only within a factor of ten. These ranges,

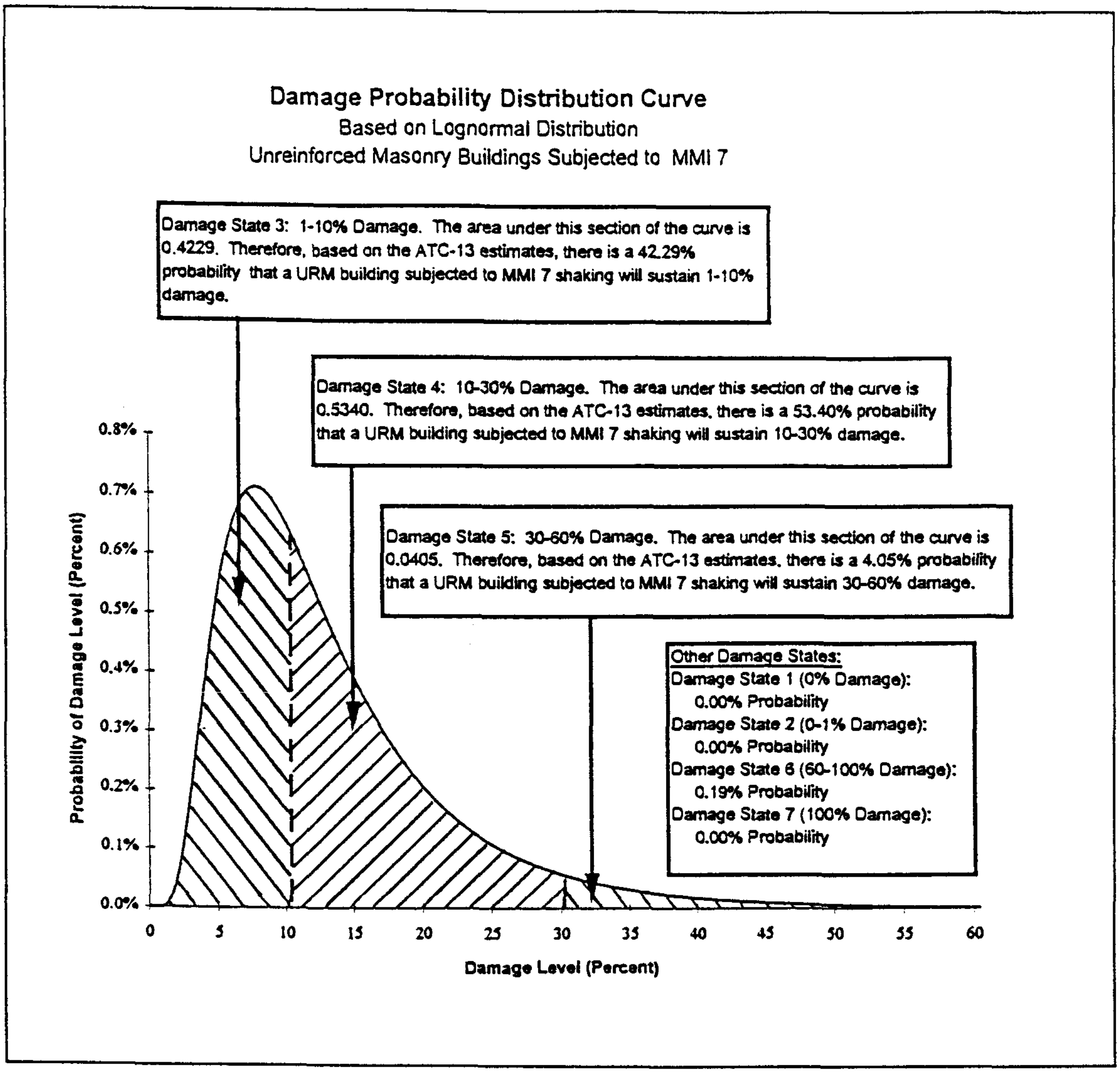

Figure 9: Schematic Representation of Damage Probability Descretization

within the factors of four and ten, reflect the 90% confidence intervals for the economic loss estimate and casualty estimate, respectively.

Damage Probability Matrices Developed in FEMA-192

FEMA-192, "Estimated Future Earthquake Losses for St. Louis City and County, Missouri (FEMA, 1990)," developed a loss estimate for the St. Louis area based on DPMs derived specifically for the area. Though the FEMA 192 publication did not elaborate on the procedure used to develop these DPMs, it was reported that the methodology was based on that provided in ATC-13, and that the data from the Delphi survey was the basis of the DPM development. As in ATC-13, the DPMs were derived to provide a statistical average for use in developing a loss estimate, and did not consider the strengths and weaknesses of individual buildings. The large geographical area covered in the FEMA-192 study involved so many buildings that a survey of individual buildings was not feasible. It was assumed that the average behavior of hundreds of the same type of building would be representative of damage sustained in an earthquake.

Damage Estimates Developed in ATC-21-1

The purpose of ATC-21-1 (Applied Technology Council, 1988b) is to identify individual buildings which require further investigation for seismic hazards; it is not intended for the loss estimate for large numbers of buildings, as is ATC-13. To do this, ATC-21-1 attempts to account for the various features of an individual building which might make it stronger or weaker than another building of the same class. It does this by assigning Performance Modification Factors (PMFs), which have a significant effect on the damage probabilities estimated.

While ATC-21-1 did not develop DPMs, it did develop probabilities for damage greater than 60%, which is essentially a slice of a complete DPM. Another restriction of ATC-21-1 is that instead of developing damage probabilities for various levels of ground acceleration, probabilities are only provided for high, medium, and low hazard areas, as defined by the NEHRP (National Earthquake Hazard Reduction Program) Seismicity Map (Applied Technology Council, 1988a). The damage probabilities developed for each hazard area are based not only on the projected seismic hazard, but also on the relative seismic resistance of the buildings in that area. This poses a problem in applying these values to Oregon, which was originally categorized as a low seismic hazard area, but is now recognized to have a high seismic hazard. Generally, most existing buildings in Oregon are assumed to have low seismic resistance, as little threat was perceived at the time they were built.

The procedure followed to develop damage probabilities in ATC-21-1 is similar to that developed in ATC-13, except that a lognormal distribution was utilized for the damage probability distribution curves instead of the beta distribution used in ATC-13. ATC-21-1 uses the results of the Delphi survey conducted in ATC-13 and also details how to modify the results for other parts of the nation. As much as possible, the procedure outlined in ATC-21-1 was followed in the development of DPMs for Oregon State University.

Damage Probability Matrices Developed for Oregon State University

The two objectives in developing DPMs for Oregon State University were 1) to provide a loss estimate for the campus, and 2) to provide a means of prioritizing the buildings on campus. As discussed in Chapter IV, the prioritization is based solely on estimated fatalities as a measure of life safety. The loss estimate methodology developed in ATC-13 and used in FEMA-192 is based on a statistical average of damage for a large number of "typical" buildings. With a large number of buildings, a detailed survey of each individual building is often not feasible. However, with the large numbers involved, the average estimate will provide a good overall estimate of the total damage and casualties. The situation at OSU is reversed. Not only is the number of buildings surveyed small (74), but each building is unique and has been subjected to an ATC-21 Rapid Visual Screening (RVS) survey (Miller et al, 1991 and 1992). The RVS survey identified characteristics of each building which indicate that it might behave differently from a "typical" building. In the development of DPMs for OSU, it was desired to incorporate this additional building information provided by the RVS survey data. This will help compensate for the statistically small number of buildings in the estimate, and will also provide a better means for comparing the buildings against each other.

The DPMs developed for OSU are based on the procedures outlined in ATC-21-1. However, since ATC-21-1 did not develop full DPMs, additional steps are required based on the methodology outlined in ATC-13. Still more modifications were required to incorporate the Performance Modification Factors (PMFs) defined in ATC-21 and identified in the RVS surveys of campus buildings (Miller et al., 1991 and 1992). A flowchart of the procedure followed to develop these DPMs is provided in Figure 10: Process Used to Develop DPMs for Oregon State University. A copy of the Microsoft Excel 5.0 spreadsheet file that was developed for the OSU study, named DERIVDPM.XLS, is included with Appendix B. In this spreadsheet, DPMs were only calculated for an effective peak acceleration (EPA) value of 0.22g. As discussed in Chapter II, 0.22g is the estimated ground level EPA based on a bedrock peak ground acceleration (PGA) of 0.195g and the amplification of this acceleration through the soil layers identified at Oregon State. Example portions of the spreadsheet are reproduced in the figures throughout this section. These show the progression of the development of the DPMs and damage and casualty ratios for ATC-13 building class 75, unreinforced masonry.

Data Used to Develop Damage Probability Matrices

The first step is to collect the data required to develop the DPMs. The primary source for this is the Delphi survey data in Table G.1 of ATC-13. A copy of this data is reproduced in Table 8: Data Used to Develop DPMs (ATC-13, ATC-21-1). The value listed as MEANL3 on the ATC-13 table is the mean low estimate of damage provided by the experts surveyed and is listed in the ML (mean low) column in Table 8. Likewise, the MEANB3 and MEANH3 columns indicate the mean best estimate (MB) and the mean high estimate (MH), respectively. The damage estimates represent the economic loss as a percentage of the building value.

The DPMs in ATC-13 were developed specifically for buildings in California, which are generally more structurally resistant to seismic forces due to more restrictive building codes. To account for the relative weaknesses found in buildings in other

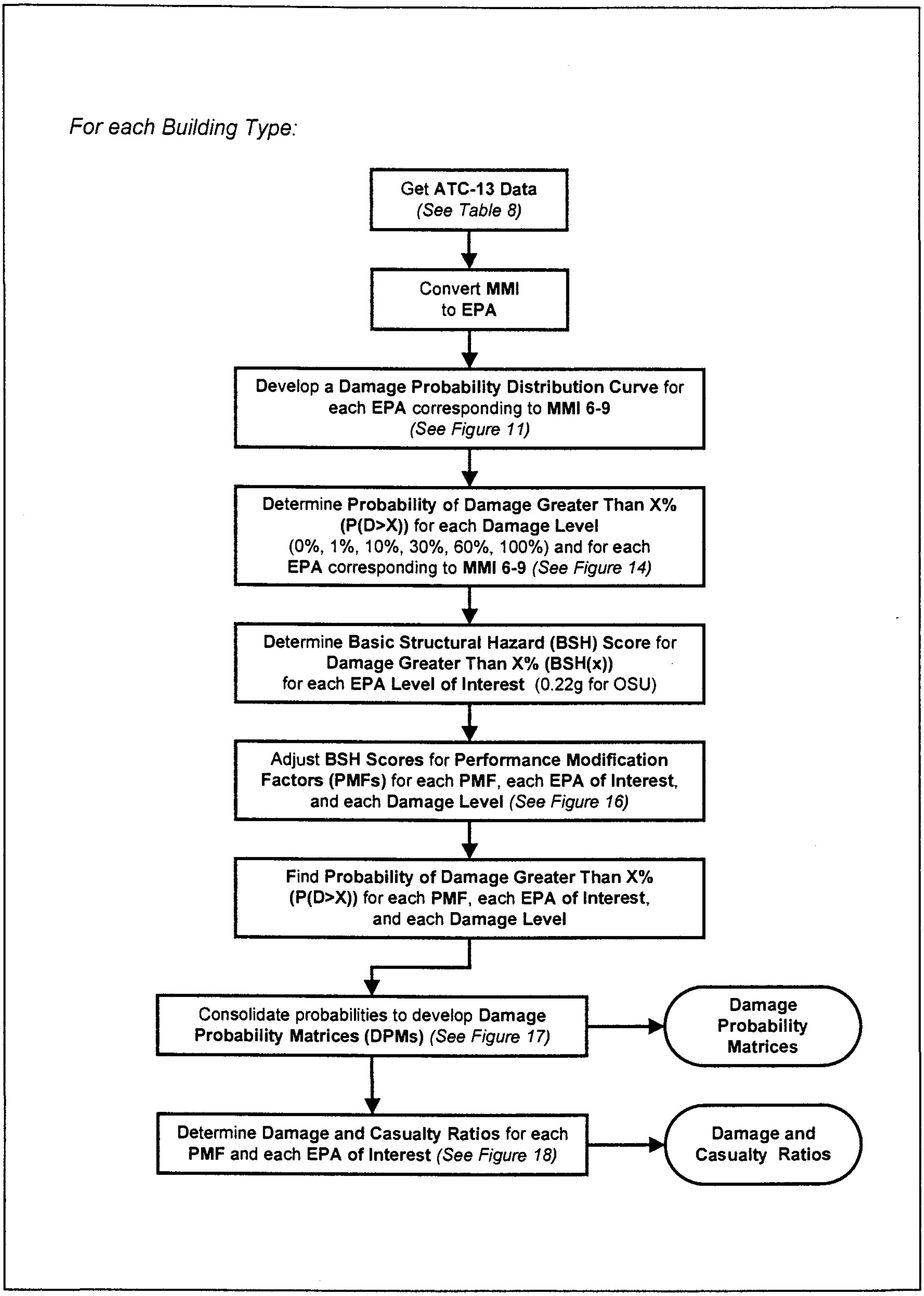

Figure 10: Process Used to Develop DPMs for Oregon State University

Table 8: Data Used to Develop DPMs (ATC-13, ATC-21-1)

Wood

ATC 13 Class:	1	MMI	ML	MB	MH
Mod Constant:	1.0	VI	0.20	0.80	2.60
Casualty Factor:	0.1	VII	0.70	1.50	4.80
		VIII	1.80	4.70	11.00
		IX	4.50	9.20	19.70
		X	8.80	19.80	39.70
		XI	14.40	24.40	47.30
		XII	23.70	37.30	61.30

Light Metal

ATC 13 Class:	2	MMI	ML	MB	MH
Mod Constant:	1.1	VI	0.01	0.40	1.60
Casualty Factor:	0.1	VII	0.50	1.10	2.70
		VIII	0.90	2.10	5.70
		IX	2.10	5.60	10.50
		X	6.00	12.90	23.50
		XI	9.80	22.30	34.40
		XII	17.60	31.30	44.00

RCSW w/ MRF, LR

ATC 13 Class:	3	MMI	ML	MB	MH
Mod Constant:	1.7	VI	0.00	0.50	1.80
Casualty Factor:	1.0	VII	0.70	2.00	5.10
		VIII	1.90	4.70	8.90
		IX	4.40	8.40	15.80
		X	8.00	16.20	28.20
		XI	16.10	26.60	41.10
		XII	23.40	34.80	52.80

RCSW w/ MRF, MR

ATC 13 Class:	4	MMI	ML	MB	MH
Mod Constant:	1.7	VI	0.00	0.40	1.70
Casualty Factor:	1.0	VII	0.70	2.30	5.60
		VIII	3.80	7.00	12.80
		IX	7.30	12.50	22.60
		X	13.40	23.30	37.10
		XI	20.00	32.70	46.70
		XII	31.10	46.30	61.90

RCSW w/ MRF, HR

ATC 13 Class:	5	MMI	ML	MB	MH
Mod Constant:	1.7	VI	0.00	0.60	2.20
Casualty Factor:	1.0	VII	0.90	3.30	7.20
		VIII	3.00	6.90	15.30
		IX	8.50	14.70	28.50
		X	16.30	26.10	46.60
		XI	26.70	45.20	60.10
		XII	36.20	56.90	73.20

RCSW w/o MRF, LR

ATC 13 Class:	6	MMI	ML	MB	MH
Mod Constant:	1.7	VI	0.10	0.50	1.90
Casualty Factor:	1.0	VII	0.80	2.80	6.30
		VIII	2.60	6.60	12.50
		IX	5.60	13.00	22.00
		X	11.50	23.60	34.10
		XI	20.20	35.50	51.20
		XII	31.30	47.60	61.90

RCSW w/o MRF, MR

ATC 13 Class:	7	MMI	ML	MB	MH
Mod Constant:	1.7	VI	0.20	1.00	2.80
Casualty Factor:	1.0	VII	0.60	3.70	7.80
		VIII	3.30	8.80	16.10
		IX	8.00	17.50	29.50
		X	16.40	28.90	44.70
		XI	22.60	39.50	57.90
		XII	33.10	49.80	70.40

RCSW w/o MRF, HR

ATC 13 Class:	8	MMI	ML	MB	MH
Mod Constant:	1.7	VI	0.20	1.20	3.00
Casualty Factor:	1.0	VII	1.00	5.60	10.90
		VIII	4.10	11.80	21.40
		IX	10.50	24.80	39.00
		X	26.10	37.70	57.70
		XI	36.90	54.00	75.00
		XII	48.30	67.10	88.20

RM SW w/o MRF, LR

ATC 13 Class:	9	MMI	ML	MB	MH
Mod Constant:	2.9	VI	0.20	0.80	2.30
Casualty Factor:	1.0	VII	0.90	2.90	7.10
		VIII	2.20	6.00	14.20
		IX	4.60	13.50	27.20
		X	11.90	23.20	40.50
		XI	21.50	41.90	62.20
		XII	31.80	52.30	72.90

RM SW w/o MRF, MR

ATC 13 Class:	10	MMI	ML	MB	MH
Mod Constant:	2.9	VI	0.20	1.20	3.20
Casualty Factor:	1.0	VII	1.50	3.50	8.90
		VIII	2.90	9.90	20.20
		IX	6.60	17.90	32.70
		X	15.80	30.50	51.60
		XI	26.90	46.10	73.60
		XII	38.50	59.70	89.50

(Applied Technology Council, 1985; Applied Technology Council, 1988b). See glossary for abbreviations.

Table 8: Data Used to Develop DPMs (ATC-13, ATC-21-1) (Continued)

RM SW w/o MRF, HR

		MMI	ML	MB	MH
ATC 13 Class:	11				
Mod Constant:	2.9	VI	0.30	1.20	4.00
Casualty Factor:	1.0	VII	1.60	5.10	12.50
		VIII	3.40	13.30	25.90
		IX	11.10	22.50	44.10
		X	19.20	36.80	65.40
		XI	31.30	55.00	82.80
		XII	44.00	70.50	97.20

Braced Steel Frame, LR

		MMI	ML	MB	MH
ATC 13 Class:	12				
Mod Constant:	1.9	VI	0.01	0.60	2.40
Casualty Factor:	1.0	VII	0.40	1.80	5.00
		VIII	1.20	5.10	10.30
		IX	4.60	10.10	18.70
		X	7.90	15.80	27.40
		XI	13.90	27.00	43.40
		XII	19.60	38.80	53.90

Braced Steel Frame, MR

		MMI	ML	MB	MH
ATC 13 Class:	13				
Mod Constant:	1.9	VI	0.01	0.80	2.90
Casualty Factor:	1.0	VII	0.40	5.80	6.50
		VIII	2.20	7.00	13.50
		IX	6.20	11.90	22.10
		X	10.50	20.40	32.80
		XI	17.00	30.10	49.60
		XII	23.00	41.80	62.40

Braced Steel Frame, HR

		MMI	ML	MB	MH
ATC 13 Class:	14				
Mod Constant:	1.9	VI	0.01	0.90	4.90
Casualty Factor:	1.0	VII	0.70	5.40	10.20
		VIII	3.90	10.20	21.80
		IX	10.00	17.70	26.10
		X	14.40	22.80	40.30
		XI	20.60	37.80	61.20
		XII	27.60	50.50	77.50

Steel Perim MRF, LR

		MMI	ML	MB	MH
ATC 13 Class:	15				
Mod Constant:	1.9	VI	0.01	0.70	2.20
Casualty Factor:	1.0	VII	0.50	1.70	3.90
		VIII	2.00	3.80	7.90
		IX	3.70	7.20	11.50
		X	6.90	13.90	20.90
		XI	10.10	22.20	32.20
		XII	16.80	31.40	44.10

Steel Perim MRF, MR

		MMI	ML	MB	MH
ATC 13 Class:	16				
Mod Constant:	1.9	VI	0.01	0.70	2.50
Casualty Factor:	1.0	VII	0.70	2.10	5.10
		VIII	1.60	4.40	9.80
		IX	4.30	8.90	15.80
		X	8.00	15.70	24.60
		XI	12.00	28.20	40.30
		XII	17.10	36.40	51.10

Steel Perim MRF, HR

		MMI	ML	MB	MH
ATC 13 Class:	17				
Mod Constant:	1.9	VI	0.01	0.70	3.50
Casualty Factor:	1.0	VII	0.90	2.40	7.30
		VIII	2.30	6.20	14.20
		IX	5.30	14.50	24.50
		X	9.60	19.80	31.50
		XI	17.00	36.70	50.50
		XII	23.40	44.50	59.10

Ductile RC MRF, LR

		MMI	ML	MB	MH
ATC 13 Class:	18				
Mod Constant:	2.2	VI	0.20	0.40	1.50
Casualty Factor:	1.0	VII	0.70	1.70	4.70
		VIII	2.10	4.10	10.40
		IX	4.00	9.20	16.90
		X	8.70	17.50	26.60
		XI	15.30	25.90	36.30
		XII	28.30	41.90	51.70

Ductile RC MRF, MR

		MMI	ML	MB	MH
ATC 13 Class:	19				
Mod Constant:	2.2	VI	0.40	1.30	3.30
Casualty Factor:	1.0	VII	1.30	3.40	6.90
		VIII	2.30	5.80	12.60
		IX	5.40	10.80	20.10
		X	8.60	16.90	26.30
		XI	16.80	28.40	40.40
		XII	24.10	37.10	51.50

Ductile RC MRF, HR

		MMI	ML	MB	MH
ATC 13 Class:	20				
Mod Constant:	2.2	VI	0.50	1.80	3.90
Casualty Factor:	1.0	VII	1.50	3.20	7.80
		VIII	3.10	6.90	17.50
		IX	6.10	13.70	24.70
		X	10.90	21.50	33.60
		XI	14.80	31.80	47.20
		XII	19.50	38.60	56.80

(Applied Technology Council, 1985; Applied Technology Council, 1988b). See glossary for abbreviations.

Table 8: Data Used to Develop DPMs (ATC-13, ATC-21-1) (Continued)

Tilt Up

ATC 13 Class:	21	MMI	ML	MB	MH
Mod Constant:	2	VI	0.40	1.50	4.20
Casualty Factor:	1.0	VII	1.80	4.20	9.60
		VIII	4.00	10.60	18.20
		IX	9.10	18.50	31.60
		X	15.20	28.70	49.20
		XI	25.60	45.00	69.40
		XII	35.60	62.50	80.20

URM, LR

ATC 13 Class:	75	MMI	ML	MB	MH
Mod Constant:	1.1	VI	0.90	3.10	7.50
Casualty Factor:	1.0	VII	3.30	10.10	26.40
		VIII	8.90	22.50	48.50
		IX	22.10	41.60	74.90
		X	41.90	64.60	93.60
		XI	57.20	78.30	97.30
		XII	72.70	89.60	100.00

High Industrial Chimney, Masonry

ATC 13 Class:	50	MMI	ML	MB	MH
Mod Constant:	1.1	VI	0.00	0.90	10.00
Casualty Factor:	1.0	VII	1.50	6.10	20.00
		VIII	3.60	9.60	50.00
		IX	13.90	20.60	100.00
		X	26.10	38.80	100.00
		XI	37.40	58.20	100.00
		XII	63.30	81.10	100.00

URM, MR

ATC 13 Class:	76	MMI	ML	MB	MH
Mod Constant:	1.1	VI	1.20	4.60	10.90
Casualty Factor:	1.0	VII	2.60	11.40	31.30
		VIII	12.70	28.80	55.00
		IX	28.80	51.40	77.30
		X	45.80	71.70	94.80
		XI	62.00	83.00	98.30
		XII	74.90	91.10	100.00

Steel Distrib MRF, LR

ATC 13 Class:	72	MMI	ML	MB	MH
Mod Constant:	1.9	VI	0.01	0.40	1.90
Casualty Factor:	1.0	VII	0.10	1.40	4.20
		VIII	1.10	2.90	7.60
		IX	2.80	5.80	12.10
		X	4.70	10.80	20.10
		XI	7.10	19.70	31.00
		XII	18.60	32.50	44.10

URM Infill, LR

ATC 13 Class:	78	MMI	ML	MB	MH
Mod Constant:	1.2	VI	0.20	1.70	6.80
Casualty Factor:	1.0	VII	1.70	5.80	18.90
		VIII	3.60	14.10	36.60
		IX	11.60	28.50	58.40
		X	21.50	44.00	79.40
		XI	32.60	60.20	95.40
		XII	47.20	76.10	99.99

Steel Distrib MRF, MR

ATC 13 Class:	73	MMI	ML	MB	MH
Mod Constant:	1.9	VI	0.01	0.80	2.70
Casualty Factor:	1.0	VII	0.30	1.70	4.80
		VIII	1.50	4.30	9.60
		IX	3.20	7.10	14.80
		X	5.50	12.60	19.30
		XI	8.40	19.60	33.70
		XII	11.50	30.30	42.10

URM Infill, MR

ATC 13 Class:	79	MMI	ML	MB	MH
Mod Constant:	1.2	VI	0.60	3.40	10.30
Casualty Factor:	1.0	VII	1.80	8.20	23.20
		VIII	7.20	20.60	40.30
		IX	14.50	33.60	58.80
		X	25.60	47.30	80.40
		XI	41.60	68.00	94.80
		XII	60.30	80.70	99.20

Steel Distrib MRF, HR

ATC 13 Class:	74	MMI	ML	MB	MH
Mod Constant:	1.9	VI	0.01	0.50	2.70
Casualty Factor:	1.0	VII	0.40	2.40	6.50
		VIII	1.70	4.90	12.70
		IX	3.30	9.60	18.60
		X	6.60	16.30	26.40
		XI	8.40	24.20	41.40
		XII	11.80	32.30	50.20

URM Infill, HR

ATC 13 Class:	80	MMI	ML	MB	MH
Mod Constant:	1.2	VI	1.30	4.80	14.70
Casualty Factor:	1.0	VII	2.30	11.00	28.00
		VIII	8.70	23.50	48.40
		IX	18.70	43.90	67.40
		X	33.60	56.20	89.80
		XI	44.80	68.90	99.99
		XII	60.40	76.90	99.99

(Applied Technology Council, 1985; Applied Technology Council, 1988b). See glossary for abbreviations.

Table 8: Data Used to Develop DPMs (ATC-13, ATC-21-1) (Continued)

PC Frame, LR

		MMI	ML	MB	MH
ATC 13 Class:	81				
Mod Constant:	2.9	VI	0.10	1.10	4.20
Casualty Factor:	1.0	VII	0.80	2.80	8.40
		VIII	3.20	8.00	18.90
		IX	10.00	23.20	33.90
		X	18.90	37.60	56.90
		XI	24.20	48.70	68.60
		XII	32.10	60.00	83.90

RM SW w/ MRF, HR

		MMI	ML	MB	MH
ATC 13 Class:	86				
Mod Constant:	2.9	VI	0.80	1.60	3.20
Casualty Factor:	1.0	VII	1.20	2.90	7.10
		VIII	3.10	7.10	14.80
		IX	6.80	13.20	25.20
		X	11.20	24.30	47.40
		XI	19.40	40.10	69.70
		XII	36.00	66.50	89.90

PC Frame, MR

		MMI	ML	MB	MH
ATC 13 Class:	82				
Mod Constant:	2.9	VI	0.00	1.10	4.90
Casualty Factor:	1.0	VII	1.10	3.40	10.10
		VIII	3.30	8.40	21.60
		IX	10.50	27.20	34.50
		X	24.20	43.10	62.90
		XI	29.30	53.70	78.30
		XII	35.70	68.70	93.70

ND RC MRF, LR

		MMI	ML	MB	MH
ATC 13 Class:	87				
Mod Constant:	2.2	VI	0.20	1.30	3.60
Casualty Factor:	1.0	VII	1.90	4.20	10.10
		VIII	5.40	12.10	21.80
		IX	12.80	21.10	38.20
		X	17.50	31.80	50.80
		XI	27.20	47.50	65.60
		XII	42.40	62.00	81.40

PC Frame, HR

		MMI	ML	MB	MH
ATC 13 Class:	83				
Mod Constant:	2.9	VI	0.00	1.10	5.00
Casualty Factor:	1.0	VII	1.00	4.10	9.80
		VIII	3.30	10.10	24.60
		IX	11.90	29.60	39.70
		X	24.70	44.30	63.90
		XI	29.90	54.60	79.60
		XII	35.00	69.70	99.50

ND RC MRF, MR

		MMI	ML	MB	MH
ATC 13 Class:	88				
Mod Constant:	2.2	VI	0.40	1.70	3.90
Casualty Factor:	1.0	VII	2.50	5.10	14.80
		VIII	5.70	13.00	25.70
		IX	13.70	26.50	45.50
		X	21.40	35.70	58.00
		XI	33.50	51.90	74.20
		XII	47.80	67.40	92.60

RM SW w/ MRF, LR

		MMI	ML	MB	MH
ATC 13 Class:	84				
Mod Constant:	2.9	VI	0.10	1.00	2.40
Casualty Factor:	1.0	VII	0.80	2.40	7.60
		VIII	3.10	5.90	12.40
		IX	6.50	11.90	20.10
		X	10.70	18.40	33.40
		XI	19.80	30.90	59.00
		XII	29.40	51.30	79.20

ND RC MRF, HR

		MMI	ML	MB	MH
ATC 13 Class:	89				
Mod Constant:	2.2	VI	0.40	1.70	3.50
Casualty Factor:	1.0	VII	1.70	5.40	13.40
		VIII	6.00	13.30	28.00
		IX	12.60	25.30	44.90
		X	23.70	40.50	65.20
		XI	33.70	55.30	80.30
		XII	54.00	75.80	94.90

RM SW w/ MRF, MR

		MMI	ML	MB	MH
ATC 13 Class:	85				
Mod Constant:	2.9	VI	0.60	1.40	2.90
Casualty Factor:	1.0	VII	1.60	3.50	8.00
		VIII	3.70	8.80	16.80
		IX	8.10	15.20	27.20
		X	13.00	23.70	45.00
		XI	22.80	39.40	69.40
		XII	37.00	37.00	87.50

Long Span

		MMI	ML	MB	MH
ATC 13 Class:	91				
Mod Constant:	1	VI	0.01	0.30	1.60
Casualty Factor:	1.0	VII	0.20	1.10	5.50
		VIII	1.00	4.00	10.60
		IX	3.60	9.00	17.20
		X	7.60	16.10	33.00
		XI	16.00	29.70	45.90
		XII	27.50	45.70	62.50

(Applied Technology Council, 1985; Applied Technology Council, 1988b). See glossary for abbreviations.

parts of the nation, the raw data from ATC-13 must be adjusted. The Damage Factor Modification Constant, developed in ATC-21-1, provides a way to do this. The factor varies for different types of buildings and for different geographic areas. The factors for Oregon are obtained from the low seismicity column (NEHRP Map Areas 1 and 2) in Table B3 in ATC-21-1. Though Oregon is no longer considered a low seismicity area, it does lie in a low seismicity zone in the NEHRP Seismicity Map (Appendix A of ATC-21 (Applied Technology Council, 1988a)). This zone is appropriate to indicate the relative strength of an "average" building based on the perceived seismic threat at the time it was built. The Damage Factor Modification Constants used for the OSU study, identified as the "Mod Constants" in Table 8, are obtained from Table B3 in ATC-21-1 (Applied Technology Council, 1988b).

The last item of information in Table 8 is the Casualty Factor. This factor is used to adjust the injury and fatality rates provided in ATC-13. As stated in Table 9.3 of ATC-13 (transcribed here in Table 9), the injury and fatality rates for light steel and

Table 9: Injury and Fatality Rates (ATC-13)

Damage State	Central Damage Factor (%)	Fraction Injured		Fraction Killed
		Minor	Serious	
1	0	0	0	0
2	0.5	3/100,000	1/250,000	1/1,000,000
3	5	3/10,000	1/25,000	1/100,000
4	20	3/1,000	1/2,500	1/10,000
5	45	3/100	1/250	1/1,000
6	80	3/10	1/25	1/100
7	100	2/5	2/5	1/5

Estimates are for all types of construction except light steel and wood-frame construction. For light steel and wood-frame construction, divide injury and fatality rates by 10.

Transcribed from Table 9.3 of ATC-13 (Applied Technology Council, 1985).

wood buildings are one tenth of the rates for other building types (Applied Technology Council, 1985). Therefore, a Casualty Factor of 0.1 is applied to these two building types, and 1.0 is used for all others.

Converting MMI Scale to Effective Peak Acceleration (EPA)

The mean estimates of damage provided in ATC-13 (ML (mean low estimate), MB (mean best estimate), and MH (mean high estimate)) are developed for MMI 6 through MMI 12. To develop loss estimates based on specific ground accelerations, MMI must be converted to EPA. Equations B4 and B5 in ATC-21-1 are applied directly as follows:

$PGA = 10^{((MMI-1)/3)}$ (units: cm/sec^2) (eqn B4, ATC-21-1)

$EPA = 0.75\ PGA$ (units: cm/sec^2) (eqn B5, ATC-21-1)

To convert from cm/sec^2 to gravity (g), the gravitational constant of 981 cm/sec^2 is used, providing the following:

$$EPA = \frac{0.75 * 10^{((MMI-1)/3)}}{981} \quad \text{(units: g)}$$

The converted values, along with the ML, MB, MH values from ATC-13 for unreinforced masonry buildings (taken directly from Table 8), are shown in the table in the upper left-hand corner of Figure 11: Development of Damage Probability Distribution Curves.

Developing a Damage Probability Distribution Curve for Each EPA Level

The damage probability distribution curves developed in ATC-21-1 (and for the OSU study) were based on a lognormal distribution, as opposed to the beta distribution used in ATC-13. These two distributions are very similar in shape, and

DPM Calculations

Bldg Type: URM, LR **ATC Bldg Class: 75**

MMI	EPA (g)	ML (%)	MB (%)	MH (%)
6	0.035	0.9	3.1	7.5
7	0.076	3.3	10.1	26.4
8	0.165	8.9	22.5	48.5
9	0.355	22.1	41.6	74.9
10	0.765	41.9	64.6	93.6
11	1.647	57.2	78.3	97.3
12	3.549	72.7	89.6	100

Damage Factor Modification Constant for NEHRP Zone 1&2

1.1

Shaded areas are values from Table 8

EPA (g)	m	s	log(s)	log(EPA)	Regression Area
0.035	1.227	0.646	-0.189	-1.450	
0.076	2.408	0.634	-0.198	-1.117	intercept
0.165	3.209	0.517	-0.287	-0.783	-0.694191
0.355	3.823	0.372	-0.429	-0.450	slope
0.765	4.264	0.245	-0.611	-0.117	-0.426213
1.647	4.456	0.162	-0.791	0.217	
3.549	4.591	0.097	-1.012	0.550	

normalized s calculations		
EPA (g)	log(s)	s
0.035	-0.076	0.839
0.076	-0.218	0.605
0.165	-0.360	0.436
0.355	-0.502	0.314

From regression of $\log_{10}(s)$ against log(EPA), MMI 6 - 12.

$$s = \frac{\ln(MH) - \ln(ML)}{3.28}$$

m = ln(MB*Damage Factor Modification Constant)

$\log_{10}(s)$ = intercept + slope * $\log_{10}(EPA)$ (From the procedure in ATC-21-1)

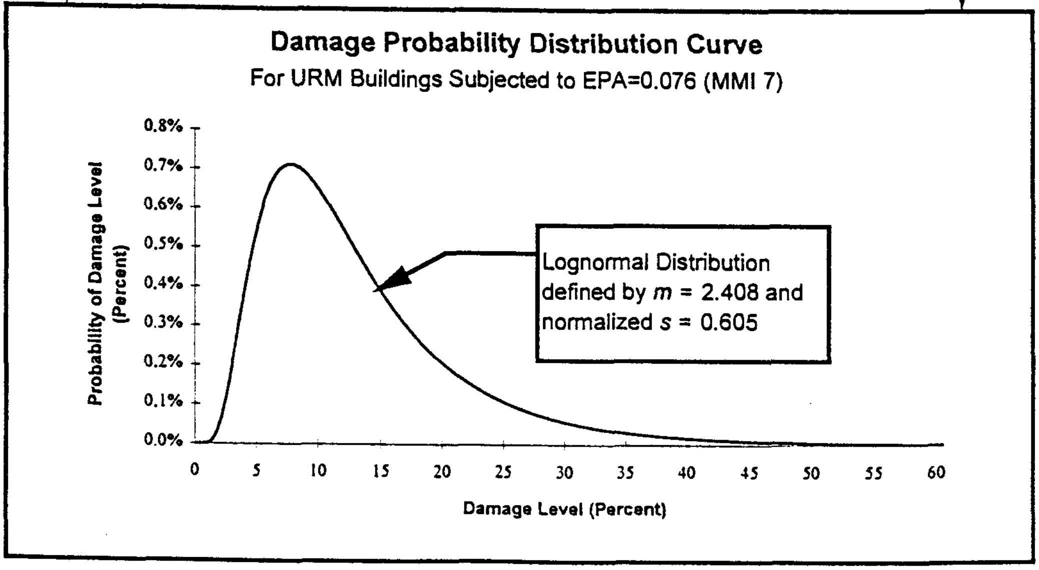

Figure 11: Development of Damage Probability Distribution Curves

are assumed to be usable interchangeably with no appreciable affect on the results of the analysis. The damage probability distribution for each EPA is developed based on the mean value of the normal distribution (assigned the variable "*m*"), and the standard deviation ("*s*"). These two variables were calculated as follows:

$$m = \ln(\mathrm{MB}) \qquad \text{(eqn B2, ATC-21-1)}$$

$$s = \frac{\ln(\mathrm{MH}) - \ln(\mathrm{ML})}{3.28} \qquad \text{(eqn B3, ATC-21-1)}$$

The value for MB is also adjusted by the Damage Factor Modification Constant for the building type in question. MH and ML are derived from MB and the standard deviation, as discussed later. Recall that the purpose of this factor is to adjust the damage estimate based on the relative seismic weakness of non-California buildings. With this adjustment, the actual equation for *m* used in the OSU study is as follows.

$$m = \ln(\mathrm{MB*Mod\ Constant})$$

The portion of the DERIVDPM spreadsheet which develops the m and s values used for the damage probability distribution curves is reproduced and expanded upon in Figure 11: Development of Damage Probability Distribution Curves.

It was assumed in ATC-21-1 that the standard deviation will remain constant at this higher, modified, mean level of damage, so no modification to the standard deviation equation is required based on the Damage Factor Modification Constant. However, the standard deviation is modified in another way. As noted in ATC-21-1 that the values for *s* are somewhat irregular throughout the lower portion of the range of EPAs calculated. To normalize these values, ATC-21-1 regressed log(s) against log(EPA) to find a more consistent value for *s* at each EPA. The values for all EPA levels, from MMI 6 to MMI 12, were used in this regression. (ATC-21-1 states that it only regresses up to MMI 9; however, a review of the Fortran code included with the publication reveals that it did in fact regress up to MMI 12.) The same procedure was followed in the OSU Study. The effect of this normalization on the unreinforced masonry building class is shown in the graph in Figure 12: Comparison of Normalized Log(s) Against Actual Log(s).

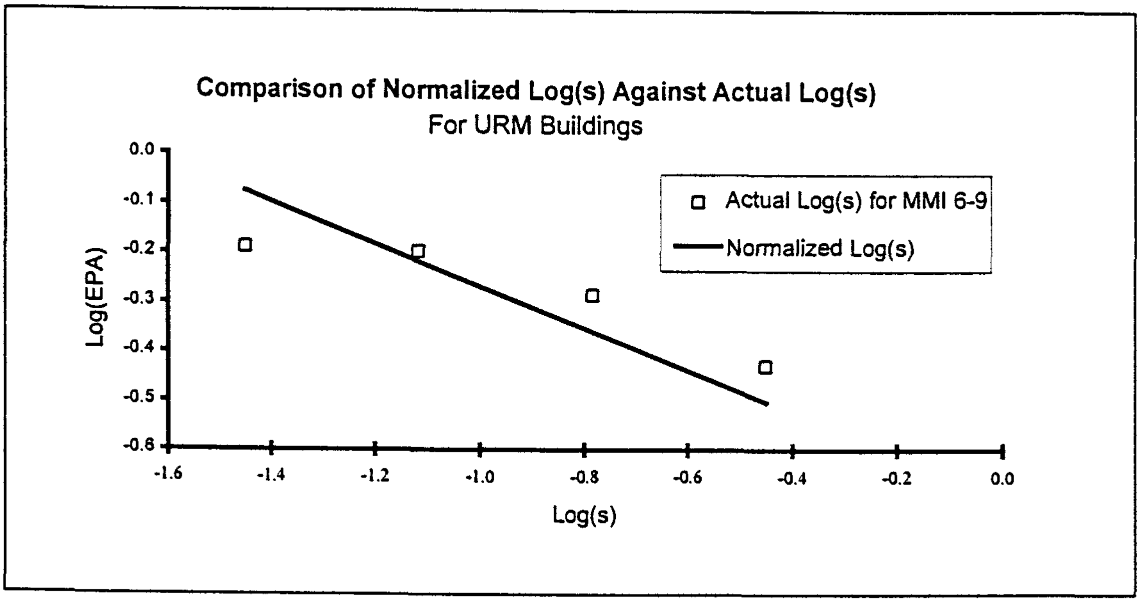

Figure 12: Comparison of Normalized Log(s) Against Actual Log(s)

The damage probability distribution curves developed in ATC-21-1 were based on a polynomial approximation of a lognormal distribution (equation B6 of ATC-21-1). This polynomial approximation worked well for the purposes of ATC-21-1, which determined the probability of damage greater than 60%. However, the approximation deviates from the true lognormal distribution curve for damage levels below about 6%. A comparison of the polynomial approximation and an actual lognormal distribution (based on the LOGNORMDIST function available through the Microsoft Excel spreadsheet program) is provided in Figure 13: Comparison of Damage Probability

Distribution Curves. These distribution curves are functions of *m* and *s* only. The curves developed for the OSU study did not use the polynomial approximation, but the LOGNORMDIST function available through the Microsoft Excel spreadsheet program. The *m* value was adjusted by the Damage Factor Modification Constant, and the *s* value was normalized by regressing log(*s*) against log(EPA) for MMI 6 through 12.

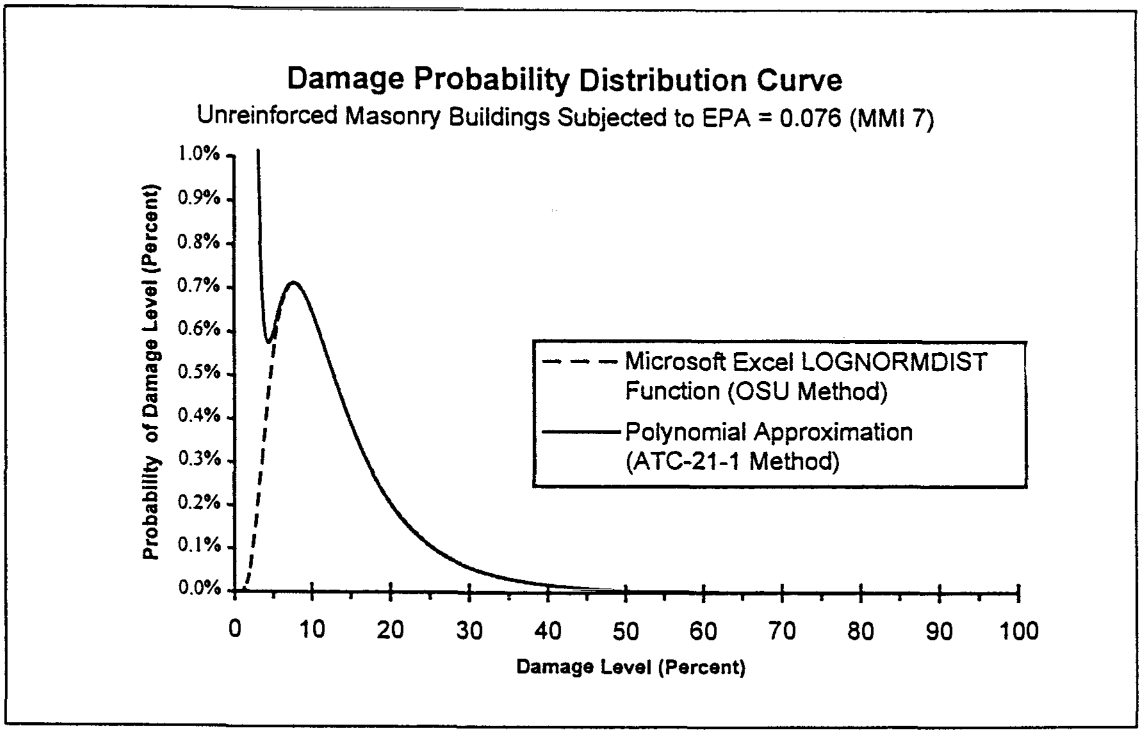

Figure 13: Comparison of Damage Probability Distribution Curves

Determining the Basic Structural Hazard for Damage Greater Than "x" Percent (BSH(x))

Based on the lognormal distributions developed from the *m* and *s* values, the probability of exceeding a given damage level can be determined by finding the portion of the damage probability distribution curve exceeding that damage level.

This is determined in the spreadsheet with a lognormal distribution function (LOGNORMDIST), and is listed in the column labeled P(D>x) (Probability of Damage greater than "x" percent) in Figure 14: Sample Development of BSH(x) for x=0% and x=10%, which shows the portion of the DERIVDPM spreadsheet used to determine the probabilities of damage greater than 0% and 10%, respectively, for the unreinforced masonry building class. A visual representation of how P(D>x) is developed is shown at the bottom of Figure 14.

As in ATC-21-1, P(D>x) values are calculated for the EPA levels associated with MMI 6 through MMI 9. These values are then converted to Basic Structural Hazard (BSH) Scores, as was done in ATC-21-1 for P(D>60%), based on the following equation.

$$BSH(60) = -\log_{10}(P(D>60)) \qquad \text{(eqn B1a, ATC-21-1)}$$

Finally, to obtain BSH scores scaled for any EPA level, ATC-21-1 regressed $\log_{10}(\log_{10}(BSH))$ against EPA to derive an equation whereby BSH could be determined as a function of EPA. ATC-21-1 used only the values corresponding to MMI 6 through MMI 9 in this regression, and this procedure is also followed for the OSU study. However, the OSU study regresses $\log_{10}(BSH)$ against EPA, as opposed to $\log_{10}(\log_{10}(BSH))$ against EPA. This is because the $\log_{10}(\log_{10}(BSH))$ regression cannot be calculated for the extreme ranges considered in the OSU study, which were outside the range of interest in ATC-21-1. However, a comparison of the results of the $\log_{10}(BSH)$ regression versus the $\log_{10}(\log_{10}(BSH))$ regression was made within the range for which the $\log_{10}(\log_{10}(BSH))$ regression can be calculated, and it was found that little difference exists in predicted BSH scores for the EPA values desired. A sample of the two regression methods is shown in Figure 15. (The example is for URM buildings subjected to EPA = 0.076g, with a probability of damage greater than 60%.) The significance of these regressions does not lie in the similarity of the slopes of the lines, but in the fact that the $\log_{10}(BSH)$ regression matches the data points for

Calculations for damage greater than: 0%							Regression	BSH(0) Development Area		
EPA (g)	m	s	P(D>0)	Adjusted	BSH(0)	log(BSH)	Area	EPA (g)	log(BSH)	BSH(0)
0.035	1.227	0.839	1.000	1.000	5.64E-06	-5.249	intercept	0.05	-8.64	0.00
0.076	2.408	0.605	1.000	1.000	1.49E-15	-14.825	3.047	0.20	-43.71	0.00
0.165	3.209	0.436	1.000	1.000	0	#NUM!	slope	0.22	-48.38	0.00
0.355	3.823	0.314	1.000	1.000	0	#NUM!	-233.773			

From previous calculations (Figure 11).

The area under the Damage Probability Distribution Curve (defined by *m* and *s*) greater than "x" percent.

Adjust the value for P(D>x) to 0 if P(D>x) is negative or an error.

BSH(x)= $-\log_{10}$(adjusted P(D>x))

If BSH is zero, an error value of "#NUM!" is returned.

From a regression of $\log_{10}$(BSH) against EPA. If the "#NUM!" error message appears in the $\log_{10}$(BSH) column, that value is ignored.

These scores are collected and adjusted in the next step (Figure 16). Likewise for BSH(1), BSH(30), BSH(60), and BSH(100).

Development of BSH(x) for specific EPA's of interest. At each EPA, $\log_{10}$(BSH) = intercept + slope * EPA.

Calculations for damage greater than: 10%							Regression	BSH(10) Development Area		
EPA (g)	m	s	P(D>10)	Adjusted	BSH(10)	log(BSH)	Area	EPA (g)	log(BSH)	BSH(10)
0.035	1.227	0.839	0.100	0.100	1.001	0.000	intercept	0.05	-0.07	0.85
0.076	2.408	0.605	0.569	0.569	0.245	-0.611	0.963	0.20	-3.18	0.00
0.165	3.209	0.436	0.981	0.981	0.008	-2.082	slope	0.22	-3.60	0.00
0.355	3.823	0.314	1.000	1.000	0.000	-6.541	-20.724			

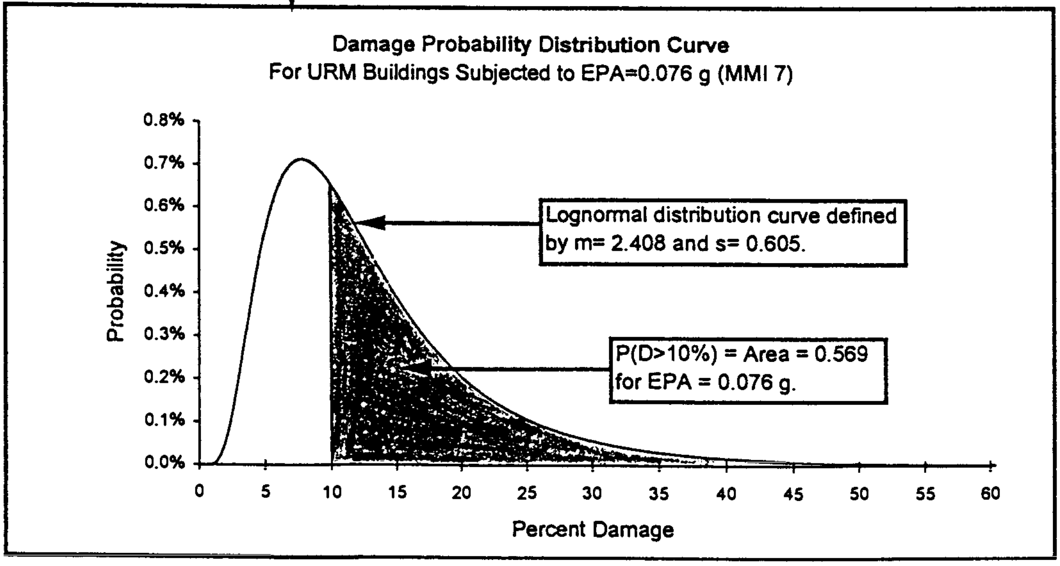

Figure 14: Sample Development of BSH(x) for x=0% and x=10%

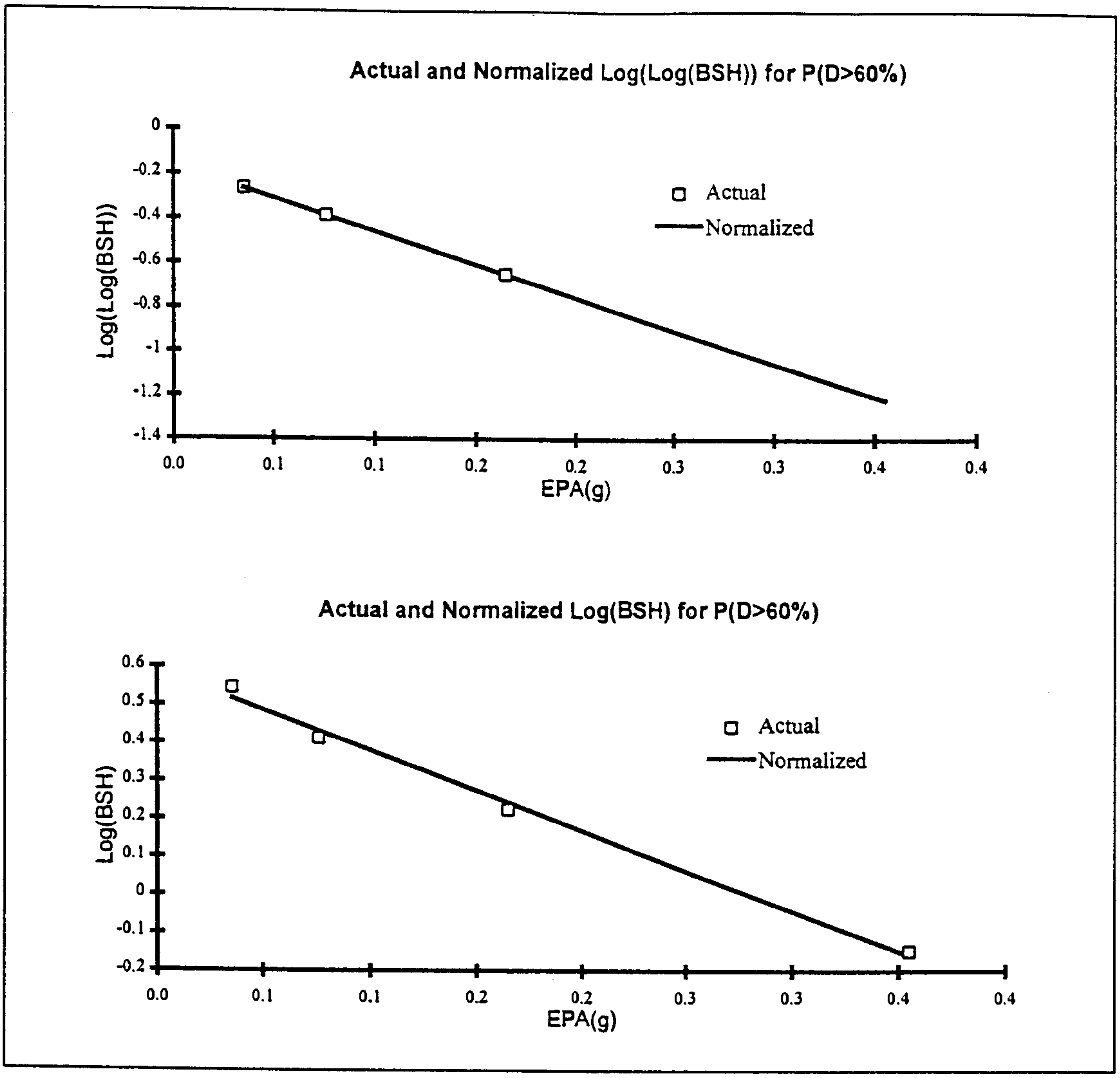

Figure 15: Comparison of Log(BSH) Regression and Log(Log(BSH)) Regression

$\log_{10}$(BSH) almost as closely as the $\log_{10}(\log_{10}$(BSH)) regression matches the data points for $\log_{10}(\log_{10}$(BSH)).

The result at this stage is a list of BSH scores, interpolated for any EPA value desired up to 0.355 g. This is shown in Figure 16: Sample BSH Score Adjustments and Collation of P(D>x) Values. The spreadsheet can provide values for EPA's over0.355g, but these BSH's will be extrapolated beyond the range of EPA values used in the regression, and are therefore subject to more uncertainty.

BSH's for Modifier: 1.0 (Modifier is Sum of Performance Modification Factors)

EPA(g)	(D>0%) UnmodBSH	Adj'd Modifier	ModBSH	(D>1%) UnmodBSH	Adj'd Modifier	ModBSH	(D>10%) UnmodBSH	Adj'd Modifier	ModBSH
0.05	0.00	7.46E-10	0.00	0.00	0.000737	0.00	0.85	0.276389	0.57
0.20	0.00	6.41E-45	0.00	0.00	8.73E-18	0.00	0.00	0.000215	0.00
0.22	0.00	1.35E-49	0.00	0.00	1.21E-19	0.00	0.00	8.29E-05	0.00

EPA(g)	(D>30%) UnmodBSH	Adj'd Modifier	ModBSH	(D>60%) UnmodBSH	Adj'd Modifier	ModBSH	(D>100%) UnmodBSH	Adj'd Modifier	ModBSH
0.05	1.91	0.625372	1.29	3.06	1	2.06	4.21	1.375646	2.83
0.20	0.29	0.095037	0.20	1.47	0.482161	0.99	3.03	0.989182	2.04
0.22	0.23	0.073926	0.15	1.34	0.437473	0.90	2.90	0.946627	1.95

Taken from BSH(x) developed in the Figure 14.

Modified BSH(x) = Unmodified BSH(x) - Adjusted PMF Modifier

$$\text{Adjusted Modifier (PMF)} = \text{PMF} * \frac{\text{Unmodified BSH(x) @ desired EPA}}{\text{Unmodified BSH(60)@ EPA} = 0.05\text{g}}$$

Values used to calculate the DPM for the specified building type and PMF Modifier (See Figure 17)

Probabilities of Damage Exceeding Specified Value (in percent)

EPA (g)	P(D>0%)	P(D>1%)	P(D>10%)	P(D>30%)	P(D>60%)	P(D>100%)
0.05	100.00	99.65	26.97	5.16	0.87	0.15
0.20	100.00	100.00	99.90	63.73	10.17	0.92
0.22	100.00	100.00	99.96	70.43	12.57	1.12

$P(D>x) = 10^{(2\text{-ModBSH(x)})}$ (or 100 if $10^{(2\text{-ModBSH(X)})}$ exceeds 100)

Figure 16: Sample BSH Score Adjustments and Collation of P(D>x) Values

Adjusting for Building Performance Modification Factors (PMFs)

The Performance Modification Factors (PMFs) used in ATC-21-1 were developed specifically for probabilities of damage greater than 60%. Also, the factors used for NEHRP Low Hazard Areas were developed based on low seismicity, at EPA = 0.05g. Since most Oregon buildings were built when the seismic threat was considered low, these low hazard PMFs (once modified) are more appropriate for Oregon buildings than the moderate or high hazard PMFs. To adjust the BSH scores for probabilities of damage other than 60%, and for EPAs other than 0.05g (issues not covered in ATC-21-1), the following modification was applied:

$$\text{Adjusted PMF} = \text{PMF} * \frac{\text{Unmodified BSH(x) @ desired EPA}}{\text{Unmodified BSH(60) @ EPA} = 0.05\text{g}}$$

This adjustment equation was derived during the Oregon State study. It is an attempt to scale down the effect of the PMFs, which have a significant influence on the loss estimate. The rationale is as follows: No adjustment to the PMF is needed at the base BSH score. The base score is what was developed in ATC-21, and is specific for the probability of damage greater than 60% for a building subjected to an EPA of 0.05g. These were the assumed parameters when the authors of ATC-21 assigned PMF values. When these parameters are varied, is seems appropriate to vary the PMF value as well. At other levels of damage and at other EPA's, the PMF is adjusted in this report by a ratio of the desired BSH damage level at the desired EPA over the base BSH score. Other adjustment relationships are possible and were explored in the study, but the adjustment factor given above appears to produce the most consistent results.

A brief sensitivity analysis revealed that the final loss estimate is quite sensitive to the incorporation of PMFs. If BSH scores are not adjusted by PMFs, the casualty estimate is approximately 10% of that reported in this thesis (24 fatalities estimated institution-wide, compared to the estimate of 273 actually presented in this report for a daytime earthquake). Likewise, the application of alternative PMF adjustment relationships resulted in loss estimates ranging from half to over twice the losses ultimately reported. This is a serious limitation of the loss estimate, and may bear further investigation in later studies.

The original BSH scores for each level of damage are adjusted by subtracting the Adjusted PMF from the BSH score to achieve the modified BSH score. This is done for each EPA level desired. The probabilities of damage for each damage level are then determined from the modified BSH score using the following equation (derived from equation B1a, ATC-21-1), and consolidated in a single table.

$$P(D>x) = 10^{-BSH(x)} \qquad \text{(eqn B1a, ATC-21-1)}$$

The portion of the DERIVDPM spreadsheet used to adjust BSH scores for unreinforced masonry buildings, based on a PMF of 1.0, is reproduced in Figure 16: Sample BSH Score Adjustments and Collation of P(D>x) Values. A positive PMF results in a greater probability of damage.

It should be noted that the adjustment for PMFs is one of the most questionable issues in the development of DPMs in this study. The PMFs presented in ATC-21 were assigned solely by those engineers and experts involved in the development of ATC-21. The PMFs assigned were not subjected to the rigorous peer review employed by ATC-13 with the Delphi survey. The intent of these PMFs is to ensure that all hazardous buildings are identified in the ATC-21 Rapid Visual Screening process. In light of this, conservative values were almost certainly assigned in an attempt to prevent these hazardous buildings from not being identified. While this is appropriate to the intent of ATC-21, it is felt by the author of this thesis that incorporating the PMF values assigned by ATC-21 results in a conservative (overly pessimistic) loss estimate. In spite of this, without additional information, the process used in this report is a rationale approach, and does result in a reasonable estimate of relative hazards between buildings.

Consolidating Probabilities to Obtain DPMs for Each PMF

At this stage, Probability Damage Matrices are finally developed by finding the discrete probability for each damage state. The portion of the DERIVDPM spreadsheet used to do this is reproduced in Figure 17: Sample Development of DPM from (P(D>x)) Values. The probability for damage state 1, 0%, is determined by subtracting the probability for damage greater than 0% (P(D>0)) from 100%; the

Damage Probability Matrix for: URM, LR — Class: 75 — Mods: 1

	Dam State	1	2	3	4	5	6	7		Overall	Injury	Fatality
	Range	0%	0-1%	1-10%	10-30%	30-60%	60-100%	100%		Damage	Rate	Rate
	CDF	0.0%	0.5%	5.0%	20.0%	45.0%	80.0%	100.0%	Sum	Ratio	per 1000	per 1000
EPA (g)	0.05	0.00	0.35	72.68	21.82	4.28	0.73	0.15	100.00	10.65	0.91	0.37
	0.20	0.00	0.00	0.10	36.17	53.56	9.25	0.92	100.00	39.66	6.33	2.50
	0.22	0.00	0.00	0.04	29.53	57.87	11.44	1.12	100.00	42.23	7.39	2.97

100 - P(D>0)

P(D>0) - P(D>1)

P(D>1) - P(D>10)

P(D>10) - P(D>30)

Calculations similar to previous columns.

Probabilities for all damage states in row must sum to 100.

P(D>x) values from Figure 16

$$\text{Overall Damage Ratio} = \sum_{DS=1 \text{ to } 7} P(DS) * CDF(DS)$$

$$\text{Casualty Rate} = CF * \sum_{DS=1 \text{ to } 7} P(DS) * CR(DS)$$

Where:

DS is the Damage State
P(DS) is the probability for the given Damage State
CDF(DS) is the Central Damage Factor for the given Damage State
CF is the Casualty Factor (0.1 for wood and light metal buildings, 1.0 for all others)
CR(DS) is the Casualty Rate, as appropriate for either serious injuries or fatalities

Figure 17: Sample Development of DPM from (P(D>x)) Values

probability for damage state 2, 0-1%, is determined by subtracting P(D>1) from P(D>0); and so on. The sum of the probabilities for all of the damage states must equal 100%, as verified in the "Sum" column of the DPM in Figure 17.

In a statistically significant number of buildings, an overall damage level can be predicted as the sum of the estimate percent of buildings in each damage state. This damage level can be more simply expressed as the Overall Damage Ratio. The Overall Damage Ratio is determined by multiplying the probability for each damage state by the Central Damage Factor (CDF) for that state, and summing these for all seven damage states. This process can be summarized by the following equation:

$$\text{Overall Damage Ratio} = \sum_{DS=1 \text{ to } 7} \left(P(DS) * CDF(DS) \right)$$

Where: DS is the Damage State

P(DS) is the Probability for the Damage State at a given EPA

CDF(DS) is the Central Damage Factor for the given Damage State

Casualty rates have been directly correlated to damage levels in ATC-13, as discussed earlier and shown in Table 9: Injury and Fatality Rates. Similar to the Overall Damage Ratio calculations, casualty rates are determined by the following equation:

$$\text{Casualty Rate} = CF * \sum_{DS=1 \text{ to } 7} \left(P(DS) * CR(DS) \right)$$

Where: CF is the Casualty Factor provided in Table 8

DS is the Damage State

P(DS) is the Probability for the Damage State at a given EPA

CR(DS) is the Casualty Rate (either serious injuries or fatalities) for the given Damage State, as provided in ATC-13, and reproduced in Table 9

Damage Probability Matrices are developed for each Performance Modification Factor, or combination of factors, as required. The OSU study requires DPMs for PMFs of -1.5 to 3.0, in increments of 0.5.

Consolidating DPMs to Obtain Damage and Casualty Ratios

The final step required is to consolidate all the damage and casualty ratios from the DPMs for different PMFs into a single table. The portion of the DERIVDPM spreadsheet used to consolidate the damage and casualty ratios is reproduced in Figure 18: Sample Consolidation of Damage and Casualty Ratios.

Damage and Casualty Ratios for: URM, LR
ATC-13 Class: 75

	EPA: 0.20 g			EPA: 0.22 g		
Modifier	Overall Damage Ratio	Injury Rate per 1000	Fatality Rate per 1000	Overall Damage Ratio	Injury Rate per 1000	Fatality Rate per 1000
-1.5	29.407	1.739	0.438	31.848	2.076	0.524
-1.0	30.643	1.918	0.489	33.106	2.261	0.580
-0.5	32.126	2.171	0.573	34.610	2.533	0.676
0	33.969	2.616	0.748	36.476	3.042	0.888
0.5	36.363	3.621	1.200	38.899	4.226	1.435
1.0	39.659	6.333	2.502	42.226	7.388	2.971
1.5	44.536	14.324	6.451	47.116	16.402	7.444
2.0	52.415	38.750	18.651	54.906	42.782	20.639
2.5	66.533	114.441	56.604	68.574	120.770	59.762
3.0	94.946	350.170	174.971	95.318	352.187	175.982

Collected from Damage Probability Matrices developed for each Modifier (Figure 17).

Figure 18: Sample Consolidation of Damage and Casualty Ratios

Use of Damage Probability Matrices Developed for Oregon State University

The damage and casualty ratios developed above can be used directly to estimate economic losses and casualty rates for the Oregon State University campus. As the damage ratio is a direct estimate of the percent damage the buildings will sustain, the appropriate damage ratio for each building can be applied to the economic value of the building and its contents to provide a loss estimate for that building.

Likewise, the serious injury and fatality rates, each based on estimated casualties (per 1000 occupants), can be multiplied by the assumed occupancy of each building (divided by 1000) to estimate casualties for that building.

The statistical significance of applying DPMs to individual buildings must also be considered. The DPMs as developed in ATC-13 were intended for use with large numbers of buildings. Due to the many variables that cannot be accounted for, it is difficult to predict what level of damage an individual building will sustain in an earthquake. These variables include the size, shape, structural design, and condition of the building. However, when the damage ratio is applied to hundreds or thousands of buildings, the predicted damage is more likely to be representative of actual observed damage on average.

The sample of buildings surveyed at Oregon State University does not qualify as statistically significant. The loss estimates made for each individual building are not what was intended by the authors of ATC-13 or ATC-21-1. The intent of these publications is to identify potentially hazardous buildings in order that the risk might be reduced. However, when individual losses are averaged over the entire campus, this study does provide a reasonable estimate of potential losses, based on the limited building data and the limits of the method used to derive the DPMs. Similarly, the *relative* loss estimates between individual buildings do reflect the estimate of the *relative* perceived risks associated with each building. The relative loss estimates can therefore be justifiably used for the seismic rehabilitation prioritization developed in this study.

Limitations of Damage Probability Matrices

There are a number of limitations associated with the DPMs developed for the OSU loss estimate. These limitations are summarized as follows.

- The primary source for developing the DMPs was the Delphi Survey conducted for ATC-13. Although this survey is the best estimate of its kind currently available, it should be recognized that it is nothing more than an estimate based on the engineering judgment of a limited number of experts. It is not based on recorded damages from previous earthquakes. Additionally, the survey was specifically directed towards California buildings. All of these limits are recognized by ATC-13, and are the reason for the limits of uncertainty provided in that document. ATC-21-1 also recognized these limits when it provided adjustment factors for loss estimates in other parts of the nation.

- A significant departure from the methods developed in ATC-13 and ATC-21-1 was the incorporation of Performance Modification Factors into the DPMs developed for OSU. The relationship used to incorporate these factors had a significant impact on the DPMs developed, especially at the extreme ranges of the damage curves, and with higher modifications. While the relationship chosen was judged by the author to be the most appropriate, another relationship might have in fact yielded more accurate results. However, without extensive statistics on damage from previous earthquakes, this question cannot be addressed properly, and is outside the scope of this report.
- ATC-13 and ATC-21-1 state explicitly that the DPMs developed therein should not be used to determine losses for individual buildings. The use of loss estimates for specific buildings herein was only justified due to the fact that it is the *relative* losses that are of primary concern for this study, and not the absolute loss estimate for each individual building.

IV: MASTER PLAN FOR SEISMIC REHABILITATION

Objective of the Plan

The Master Plan for Seismic Rehabilitation is intended to set a course for the rehabilitation of all buildings on campus posing a significant hazard to life safety. The initial plan, developed through this project, will cover the rehabilitation of ten academic buildings and ten student life buildings. This separation was suggested by the Oregon State University Facilities Services office, since the maintenance activities for academic and student life buildings are funded separately. The master plan is based on a prioritization of campus buildings ranked according to estimated lives lost in a design-level earthquake. In addition to the initial plan, the project will provide a tool for the continuation of the plan into the future. As more information becomes available or as circumstances change, the Seismic Rehabilitation Plan can be adjusted using the software developed in this study. It has been suggested by Facilities Services that one academic and one student life building be rehabilitated each year. While this is not essential to the plan, it does provide a basis for planning the progress of rehabilitation.

It should be noted that conducting a seismic upgrade of a building does not guarantee that the building will not sustain damage or produce casualties in an earthquake. Seismic upgrades are intended to decrease these risks, but cannot be expected to reduce them to zero. However, a properly conducted upgrade can be expected to reduce the potential for loss of life significantly. Goettel and Horner (1995) assume that a complete seismic rehabilitation will reduce the death rates by a factor of 1000, and reduce major injuries by a factor of 100. These reductions apply to all building classes.

Building Prioritization

In the development of the master plan, several criteria for prioritizing campus buildings were initially considered. These included life safety (in terms of estimated lives lost), economic loss, cost of seismic rehabilitation, historical importance, ability to relocate the building's function during rehabilitation, special hazards (fire, chemical, radiation, etc.), and efficiency of seismic rehabilitation (as measured by estimated lives saved per dollar spent on rehabilitation). Ultimately, the decision was made by Larry Earhart of OSU Facilities Services to base the prioritization solely on the number of estimated fatalities per building, i.e., life-safety. Academic and student life buildings were to be prioritized separately. Estimated fatalities were to be determined based on the casualty ratios developed for each building, and the assumed occupancy of the building.

Two alternatives for prioritization by life safety are considered. The first prioritization, hereafter referred to as Method A, is based on average building occupancies. The second prioritization, Method B, assumes maximum occupancies. The number of estimated fatalities is used as a basis for comparison because it reflects the overall hazard to human life in each building. Non-fatal injuries could also be used for comparison, but this would not affect the results of the prioritization as the estimates for fatalities and injuries are directly proportional. This was discussed in Chapter II on loss estimates.

Occupancy Data

Assumed occupancy rates are based on the occupancies tabulated for the loss estimate as detailed in Chapter II. These numbers are combined as described in the following paragraphs, and are summarized in Table 10: Building Occupancies Assumed for Prioritization.

Table 10: Building Occupancies Assumed for Prioritization

Building Name	Assumed Occupancies -- Calculated as mean values of day and night occupancies	
	Average Occupancies	Maximum Occupancies
Adams	16	31
Admin. Services	199	395
Ag Sciences II	176	316
Apperson	95	368
Ballard Extension	80	158
Batcheller	57	178
Benton	20	300
Bexell	215	972
Bloss	189	316
Burt	78	215
Buxton	168	307
Callahan	236	355
Cauthorn	193	296
Childcare Center	75	174
Clark Lab	8	30
College Inn	225	405
Computer Science	36	92
Cordley	317	1,701
Covell	79	326
Crop Science	65	158
Dearborn	91	367
Dixon Rec Center	63	308
Dryden	21	91
Education Bldg	81	429
Electric Comp Engr	96	374
Fairbanks	52	294
Family Study Center	40	130
Finley	242	359
Gilbert	170	651
Gilbert Addition	37	104
Gill Coliseum	59	10,612
Gilmore	26	79
Gleeson	48	181
Graf	17	32
Hawley	68	124
Indoor Target Range	5	30

Table 10: Building Occupancies Assumed for Prioritization (Continued)

Building Name	Average Occupancies	Maximum Occupancies
Industrial Bldg	18	104
Kerr Library	250	1,500
Kidder Hall	242	784
Langton	78	607
Lasells Stewart Center	153	1,745
Magruder	40	132
McAlexander	44	295
McNary	209	327
Memorial Union	187	1,610
Merryfield	19	67
Milam Hall	267	1,464
Milne Computer Center	26	101
Moreland	115	293
Nash	130	352
Oceanography	8	15
Parker Stadium, Clubhouse	0	250
Parker Stadium, Overall	0	17,763
Peavy	191	458
Pharmacy	64	213
Phys Heating Plant	3	6
Plageman Bldg	33	200
Poling	107	165
Radiation Center, Overall	40	80
Rogers	57	298
Sackett	178	237
Shepard	40	125
Snell	80	209
Social Science	70	254
Strand Agriculture	201	951
Waldo	74	159
Weatherford	0	0
Weniger	344	1,036
West International	116	242
Wiegand	92	417
Wilkinson	173	449
Wilson	215	287
Withycombe	113	185
Women's Bldg	63	534

Academic Buildings

The estimated average occupancy of academic buildings is the same as determined for the loss estimate in Chapter II. This is the average of the estimated daytime and estimated nighttime occupancy. For the maximum daytime occupancy, it was assumed that all classrooms, offices, libraries, etc. were filled to capacity. All academic buildings were assumed to be empty (occupancy of zero) during the nighttime, even for maximum occupancy.

Student Life Buildings

The average occupancy used for the prioritization was determined by averaging the average day and average night occupancies for each building. The maximum occupancy used for the prioritization was determined by taking the maximum of either the maximum day or the maximum night occupancy for each building.

Results

The prioritizations developed for the academic and student life buildings are presented in Table 11: Prioritization for Academic Buildings, and Table 12: Prioritization for Student Life Buildings. These tables are sorted according to the prioritization by Method A (based on average assumed occupancies). For comparison, these tables also include the rankings by Prioritization Method B (based on the maximum assumed occupancies). The tables also list the estimated costs for the structural seismic rehabilitation of each building. Seismic rehabilitation cost estimates are covered later in this chapter.

The two main differences in the prioritizations by Method A and Method B are that 1) Gill Coliseum increases from a ranking of 39 (Method A) to 11 (Method B), and 2) the Memorial Union increases to the top ranked student life building (Method B) from number 3 (Method A).

Table 11: Prioritization for Academic Buildings

Building Name	Rank by Ave. Occ.	Rank by Max. Occ.
Admin. Services	1	2
Kerr Library	2	1
Strand Agriculture	3	3
Kidder Hall	4	5
Milam Hall	5	4
Pharmacy	6	8
Ballard Extension	7	12
Withycombe	8	14
Langton	9	6
Women's Bldg	10	7
Radiation Center, Overall	11	15
Cordley	12	10
Lasells Stewart Center	13	9
Bexell	14	13
Snell	15	17
Computer Science	16	19
Covell	17	18
Burt	18	21
Wilkinson	19	22
Gilbert	20	23
Wiegand	21	20
Gilmore	22	26
Moreland	23	28
Ag Sciences II	24	37
Graf	25	33
Rogers	26	24
Education Bldg	27	25
Social Science	28	29
Dryden	29	27
Gilbert Addition	30	36

Building Name	Rank by Ave. Occ.	Rank by Max. Occ.
Merryfield	31	30
Dearborn	32	31
Gleeson	33	34
Nash	34	39
Clark Lab	35	35
Weniger	36	38
Industrial Bldg	37	32
Crop Science	38	41
Gill Coliseum	39	11
Phys Heating Plant	40	44
Childcare Center	41	43
Milne Computer Center	42	42
Electric Comp Engr	43	45
Indoor Target Range	44	46
Magruder	45	47
Family Study Center	46	48
Peavy	47	50
Waldo	48	54
Apperson	49	51
Fairbanks	50	49
Batcheller	51	55
Shepard	52	56
Benton	53	52
McAlexander Total	54	53
Adams	55	57
Oceanography	56	58
Parker Stadium, Overall	57	16
Parker Stadium, Clubhouse	58	40

Table 12: Prioritization for Student Life Buildings

Building Name	Rank by Ave. Occ.	Rank by Max. Occ.
Callahan	1	2
Wilson	2	6
Memorial Union	3	1
McNary	4	3
Cauthorn	5	5
Buxton	6	4
Finley	7	8
West International	8	7
Poling	9	10
Bloss	10	9
Hawley	11	11
Dixon Rec Center	12	12
College Inn	13	13
Sackett	14	14
Plageman Bldg	15	15
Weatherford	16	16

The First Two Years of the Master Plan

The plan calls for one academic and one student life building to be scheduled for rehabilitation each year. Based on the prioritizations developed, the first two academic buildings to be rehabilitated should be the Administration Building and Kerr Library. It should be noted that a seismic upgrade of Kerr Library is already in progress in conjunction with the Library expansion at the time of this writing. The first two student life buildings should be Callahan Hall and the Memorial Union. Although the Memorial Union is ranked behind Wilson Hall by Method A, its estimated fatalities for Method B (based on maximum occupancy) far exceed the estimate for Wilson. There are several factors, however, that may complicate the issue. For example, closing the Administration Building will result in a much greater disruption of campus activities than closing a classroom building. It may be less disruptive to postpone the rehabilitation of the Administration Building until one or more other buildings have been rehabilitated, so that the experience gained with these buildings will minimize the disruptions associated with the rehabilitation of the Administration Building. The decisions made with respect to these types of issues are outside the scope or the authority of this project.

Prior to the rehabilitation of any building, a more comprehensive seismic evaluation of the building should be made using the methodology in FEMA-178 (Federal Emergency Management Agency, 1992b). This evaluation is intended to determine if a seismic rehabilitation is warranted, and is much more thorough than the ATC-21 Rapid Visual Screening survey. A preliminary FEMA-178 survey has already been conducted on the buildings identified as top priorities for the first two years of the plan: the Administration Building, Kerr Library, Callahan Hall, and the Memorial Union (partial survey) (Miller et. al., 1992b, 1992c). These preliminary surveys indicate that the buildings do pose a seismic hazard to their occupants.

The First Ten Years of the Master Plan

The first five academic buildings scheduled for rehabilitation should be those listed on the prioritization based on estimated fatalities assuming average occupancy, from Table 11: Prioritization for Academic Buildings. These are the Administration Building, Kerr Library, Strand Agriculture Hall, Kidder Hall, and Milam Hall. The next five buildings -- Pharmacy, Ballard Extension, Withycombe, Langton, and the Women's Building -- would all be excellent candidates for the following five years. However, for this second five year period, Lasells Stewart Center should also be considered as a candidate, due to its high ranking based on prioritization by estimated fatalities assuming maximum occupancy.

There is less ambiguity in the prioritization for student life buildings. The rankings by both occupancy assumptions (average and maximum) are very similar. The first ten buildings according to the Method A prioritization would serve as an excellent plan for the first ten years. For student life buildings, these are Callahan, Wilson, the Memorial Union, McNary, Cauthorn, Buxton, Finley, West International, Poling, and Bloss. It should be noted that West Hall has undergone seismic rehabilitation since the initiation of this report. Also, Weatherford Hall was unoccupied when occupancy data was collected, and should be re-evaluated if this status changes. As with the academic buildings, prior to commencing with the rehabilitation of any of the student life buildings, a FEMA-178 survey should be conducted to verify that a seismic hazard exists.

Rehabilitation Cost Estimates

As an aid in the planning process, cost estimates for the structural rehabilitation of each building have been developed. The cost estimates for each building type (in dollars per square foot) are summarized in Table A-4 in Appendix A, and the resulting cost estimate for each building is provided in Table 13: Seismic Rehabilitation Cost Estimates for OSU Buildings. Additionally, the cost estimate for each building is included in the prioritization tables, as a cross reference. The cost estimates were developed from three primary sources. The first two were from the conceptual rehabilitation design and cost estimate reports developed for specific OSU buildings. The buildings examined in these reports were three lift slab buildings: the Administration Building, Kerr Library, and Callahan Hall (Miller, Ferguson, and Ch'ng, 1993); and two unreinforced masonry buildings: Strand Agriculture Hall and the Social Science building, (Sucharitsanchai, Trautwein, and Miller, 1995). These cost estimates were applied to similar building types on campus.

The third source of the cost estimates was a study conducted for the City of Portland, "Earthquake Risk Analysis Final Report, Volumes One and Two (Goettel and Horner, 1995)." This report provided cost estimates for buildings of different sizes and construction types. The campus buildings were easily fit into the structural class categories provided by the Portland study. The cost estimates were adjusted to reflect the same assumptions made for the OSU cost estimates. This required a

Table 13: Seismic Rehabilitation Cost Estimates for OSU Buildings

Building Name	OSU Study Structural Rehabilitation Cost Estimate ($)	Portland Study Structural Rehabilitation Cost Estimate ($)	Portland Study Nonstructural Rehabilitation Cost Estimate ($)
Adams	N/A	233,659	150,449
Admin. Services	1,027,091	4,630,385	2,216,461
Ag Sciences II	N/A	4,644,390	2,371,681
Apperson	N/A	615,298	382,538
Ballard Extension	695,226	1,108,405	598,143
Batcheller	N/A	435,263	270,608
Benton	N/A	504,851	313,872
Bexell	1,186,064	1,360,106	761,800
Bloss	1,201,826	2,501,968	1,101,815
Burt	N/A	1,628,601	713,817
Buxton	668,989	1,815,126	799,344
Callahan	790,954	2,146,045	945,074
Cauthorn	635,359	1,723,879	759,161
Childcare Center	N/A	301,989	124,670
Clark Lab	N/A	108,251	43,940
College Inn	N/A	3,542,400	1,560,000
Computer Science	232,150	370,119	199,732
Cordley	N/A	6,093,475	3,070,951
Covell	564,041	899,256	485,277
Crop Science	N/A	1,723,721	755,508
Dearborn	N/A	1,924,304	837,915
Dixon Rec Center	N/A	896,977	511,231
Dryden	347,817	554,528	299,247
Education Bldg	604,884	1,101,881	520,416
Electric Comp Engr	N/A	1,885,851	821,171
Fairbanks	N/A	793,451	493,298
Family Study Center	N/A	545,316	228,644
Finley	1,201,769	2,501,850	1,101,763
Gilbert	N/A	2,466,170	1,080,924
Gilbert Addition	N/A	1,361,622	573,872
Gill Coliseum	N/A	5,617,300	2,837,406
Gilmore	244,601	455,579	210,444
Gleeson	N/A	1,203,294	507,143
Graf	571,037	1,040,225	491,296
Hawley	637,111	1,728,632	761,254
Indoor Target Range	63,069	101,261	54,262
Industrial Bldg	N/A	579,711	244,842
Kerr Library	4,562,991	4,782,112	2,445,131
Kidder Hall	1,538,402	1,914,413	988,104
Langton	1,949,557	2,750,956	1,252,186
Lasells Stewart Center	N/A	1,005,909	432,110

Table 13: Seismic Rehabilitation Cost Estimates for OSU Buildings (Continued)

Building Name	OSU Study Structural Rehabilitation Cost Estimate ($)	Portland Study Structural Rehabilitation Cost Estimate ($)	Portland Study Nonstructural Rehabilitation Cost Estimate ($)
Magruder	N/A	2,272,413	989,495
McAlexander	N/A	562,797	750,269
McNary	789,823	2,142,975	943,722
Memorial Union	N/A	4,252,263	2,137,642
Merryfield	412,941	658,356	355,277
Milam Hall	2,220,288	2,542,525	1,426,074
Milne Computer Center	N/A	724,919	305,526
Moreland	428,822	683,674	368,940
Nash	N/A	2,713,383	1,370,928
Oceanography	N/A	167,234	107,679
Parker Stadium, Clubhouse	N/A	320,173	146,687
Parker Stadium, Other	N/A	3,050,455	1,557,348
Peavy	N/A	2,066,892	1,092,260
Pharmacy	625,161	1,106,589	537,862
Phys Heating Plant	N/A	611,976	340,496
Plageman Bldg	N/A	965,506	408,447
Poling	627,319	1,702,064	749,554
Radiation Center, Overall	N/A	1,451,152	619,957
Rogers	N/A	1,641,414	719,433
Sackett	N/A	3,660,659	1,849,536
Shepard	N/A	244,082	151,749
Snell	N/A	2,867,948	1,393,769
Social Science	329,685	525,620	283,647
Strand Agriculture	2,347,658	2,384,775	1,507,883
Waldo	N/A	1,813,118	958,152
Weatherford	N/A	2,703,966	1,366,170
Weniger	N/A	5,302,254	2,744,001
West International	677,498	1,838,210	809,510
Wiegand	N/A	1,719,005	753,441
Wilkinson	N/A	1,796,736	788,255
Wilson	795,382	2,158,060	950,365
Withycombe	N/A	2,235,415	979,784
Women's Bldg	1,770,717	2,030,550	1,137,318

subtraction of $9.00 per square foot for relocation costs (moving occupants out for the duration of the construction), and $4.00 per square foot for nonstructural rehabilitation (such as bracing heavy furniture and suspended ceilings). The Portland study was based on a nationwide survey of actual costs of projects involving seismic rehabilitation for life safety. It does not assume that a certain constant standard of performance for construction or design details must be met (Goettel and Horner, 1995), such as the UCBC (International Conference of Building Officials, 1994b) standard used for the Strand and Social Science conceptual rehabilitation designs.

Both the OSU cost estimates and the Portland study estimates are provided in this report. Until some actual building rehabilitations are conducted on campus, there is no way to know which figures more accurately reflect the costs that can be expected at OSU. Nonstructural rehabilitation costs estimates are also included in Table 13. The cost assumed was $4.00 per square foot, as determined in the Portland study.

Rehabilitation Designs and Cost Estimates

This section summarizes the report "Seismic Analysis, Conceptual Design, and Cost Estimate for Rehabilitation of URM Buildings on the OSU Campus (Sucharitsanchai et. al., 1995)." The purpose of this effort was not to develop complete designs for specific rehabilitation projects on campus, but to gain a better understanding of the rehabilitation design process and what costs might be expected for the rehabilitation of unreinforced masonry buildings in general.

Building Selection

Two unreinforced masonry (URM) buildings were selected for this study. Unreinforced masonry buildings were selected because, as a class, they pose a higher risk in terms of damage and casualties than most other building classes. Concrete lift-slab buildings are another potentially high-risk building class, but these buildings were studied in a previous report, "Seismic Risk Assessment and Retrofit Design Concepts for Oregon State University Campus Buildings (Miller, Ferguson, and Ch'ng, 1993)." The particular URM buildings selected were Strand Agricultural Hall and the Social Science building. Strand was selected because it was identified in Chapter II to be one of the most hazardous URM buildings in terms of estimated lives lost and building damage. The Social Science building was selected, not because of a particularly high potential for casualties and damage, but because it is a smaller, simpler building, and can be expected to provide a better representation of rehabilitation costs on that end of the spectrum.

Conceptual Rehabilitation Designs

Design Procedures. Several structural codes are available to address the seismic upgrade of unreinforced masonry buildings. These include the Uniform Building Code (UBC) (International Conference of Building Officials (ICBO), 1994a); the Uniform Code for Building Conservation (UCBC) (ICBO, 1994b); the NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings (Federal Emergency Management Agency (FEMA), 1992a); and the NEHRP Handbook for the Seismic Evaluation of Existing Buildings (FEMA, 1992b). The UBC and the NEHRP Recommended Provisions were written specifically for new buildings. It is usually uneconomical, if not impossible, to upgrade older buildings to comply with current code requirements. For this reason, the UCBC was developed to address life safety issues in existing unreinforced masonry buildings. This is the primary tool used by Sucharitsanchai to develop the rehabilitation designs for the two URM buildings on campus. While the degree of life safety provided is not as high as for new construction, the UCBC does meet its objective of strengthening buildings and reducing seismic hazards. Prior to conducting the UCBC analysis, Sucharitsanchai conducted a FEMA-178 Quick Check as outlined in the NEHRP Handbook for the Seismic Evaluation of Existing Buildings (FEMA, 1992b). This check is intended to identify buildings requiring strengthening. Based on this criteria, both Strand Hall and the Social Science Building do require strengthening.

Conceptual Design for Strand Agricultural Hall. Based on the UCBC methodology, a design concept was developed to increase the seismic resistance of Strand Agricultural Hall. Strand was constructed in the 1910's as three individual buildings connected by corridors. The North and South buildings, known as the Science and Horticulture buildings, respectively, consist of three stories. The central Agriculture building is four stories high. The rehabilitation design concept consists of three primary elements.

1) New steel frame crosswalls are required to resist lateral forces in the transverse direction of each building. Though these frames require the addition of large caisson foundations, they minimize interference to the interior of the building.

2) Diaphragm ties are required to provide lateral support for the walls subjected to out-of-plane forces. Both tension and shear bolts were incorporated into the design.

3) Existing masonry walls with insufficient in-plane shear strength need to be strengthened by the addition of a concrete overlay. This overlay would be applied as gunite to the interior walls, so that the existing architectural appearance on the building exterior can be retained.

Parapet rehabilitation was not considered necessary for Strand, as the parapets were restored in a 1994 project.

Conceptual Design for Social Science Building. The Social Science building is a single rectangular building consisting of three stories, and was also built in the 1910's. The design concept for the Social Science building is very similar to that developed for Strand. It consists of the same three elements: steel frame crosswalls, diaphragm ties, and gunite shearwall strengthening. The parapet strengthening recommended in Sucharitsanchai's 1995 report was accomplished in 1996 as part of a previously scheduled upgrade project.

Preliminary Cost Estimate

Structural Costs. The cost estimates presented herein reflect costs for the structural components of each project. The cost estimates were developed primarily using the methods and data provided in the 1992 Means Repair and Remodeling Cost Data (R.S. Means Company, 1992a) and the 1992 Means Building Construction Cost Data (Means, 1992b). Costs were adjusted to 1995 values based on the building construction cost index provided weekly in the *Engineering News Record.* Also, a contingency allowance of 20% was added to the final cost estimate.

Nonstructural Costs. Nonstructural costs were estimated based on the information presented in FEMA 74, "Reducing the Risks of Nonstructural Earthquake Damage (FEMA, 1994)." This publication identifies a variety of nonstructural features that commonly pose hazards during and after earthquakes, as well as proposed methods and estimated costs for rectifying these problem areas. The total nonstructural costs were tabulated based on FEMA 74 and an inventory conducted for Sucharitsanchai's report (Sucharitsanchai et al., 1995). The nonstructural costs are separated into two categories: 1) utility and architectural elements (which included suspended piping, HVAC equipment, suspended ceilings, and suspended light fixtures); and 2) furniture and contents (including computers and other office equipment, tall shelving, tall file cabinets, freestanding partitions, and fire extinguishers). All modifications requiring engineering were assumed to require an additional 5 percent cost. The adjustment for nonstructural costs from 1994 dollars to 1995 dollars is negligible, since the change in construction costs (based on the *Engineering News Record* cost index) was only 0.05 percent.

Estimated Costs for Strand Agricultural Hall. The cost for rehabilitating Strand Agricultural Hall, excluding nonstructural work, is estimated at $2,347,460 (in 1995 dollars). This is approximately $20.24 per square foot, based on the building area as reported by the Office of Budgets and Planning. Nonstructural costs (utility and architectural elements only) are estimated at $113,520, or $0.98 per square foot. It should be noted that these costs (and those given below) differ from the values reported in Sucharitsanchai's report (1995). The values per square foot in that report were based on building areas as measured from the original construction drawings. The values given here are based on building areas as reported by the Office of Budgets and Planning.

Estimated Costs for Social Science Building. The cost estimate for the Social Science building, excluding nonstructural work, is $397,650, or $15.11 per square foot. Nonstructural costs are estimated at $71,440, or $3.27 per square foot.

Comparison of Costs. When the structural rehabilitation cost estimates are compared, a disparity appears between the cost for Strand ($20.24 per square foot) and the cost for Social Science ($15.11 per square foot). The reason for this difference lies primarily in the cost for shearwall strengthening in Strand. It was determined that for the Social Science building, only one section of wall on the first floor required additional strengthening. Strand Hall, which contains a fourth story and is considerably more massive, required shearwall strengthening on most of its first story walls and on some walls in the second story. The fact that the walls of Strand are pierced with a higher percentage of windows also contributed to its relative flexibility and need for further shearwall strengthening.

The nonstructural cost estimates also show a significant difference between the costs for Strand ($0.98 per square foot) and Social Science ($3.27 per square foot). The reason for this difference lies in the fact that a greater percentage of floorspace in the Social Science building is devoted to office space. In both buildings, it was observed that offices generally contain more nonstructural hazards such as suspended ceilings, suspended light fixtures, and air conditioning.

The structural costs reported herein are comparable to those estimated for URM buildings in "Earthquake Risk Analysis Final Report, Volume Two (Goettel and Horner, 1995)," prepared for the city of Portland. This report estimates rehabilitation costs for very large (over 100,000 square feet) institutional URM buildings at $20.56 per square foot. Strand Agriculture Hall would fall into this category. Again, our estimate for Strand was $20.24 per square foot. For medium (10,000 to 50,000 square feet) institutional URM buildings, the Portland study estimated rehabilitation costs at $24.09 per square foot. This is the category that the Social Science building would fall into. Our estimate for Social Science was $15.11 per square foot. Both of these estimates are reasonably close to those reported in the Portland study. For nonstructural rehabilitation costs, the Portland study estimated $4.00 per square foot for "light" nonstructural rehabilitation of all institutional buildings. Our estimates were $0.98 for Strand, and $3.27 for Social Science. While the Portland report does not specify exactly what elements are included in "light" nonstructural rehabilitation, it did note that items such as suspended ceilings were included, which indicates that it probably considered the same types of elements identified in the FEMA 74 inventory.

The structural cost estimates developed for the OSU study can also be compared to those found in FEMA publication 157, "Typical Costs for Seismic Rehabilitation of Existing Buildings: Volume II -- Supporting Documentation (FEMA, 1988)." Based on previous rehabilitation in the Los Angeles area, this document reports costs ranging from $32.00 per square foot for historic buildings to $9.65 per square foot for private buildings. Publicly owned buildings were tabulated at $27.75 per square foot. Another study of California URM rehabilitation projects, "The Unreinforced Masonry Building Law and Beyond (Turner, 1990)," reports an average total project cost of $20 per square foot, with a range of $10 to over $100 per square foot. Typical costs for nonstructural rehabilitation of an entire building were not provided in these sources.

Development of a Tool for the Continuation of the Plan

The tool to provide for the continuation of the Seismic Rehabilitation Master Plan consists of a Microsoft Excel workbook, and an accompanying user's guide located in Appendix A. It includes spreadsheets containing the basic data used to develop the prioritizations and cost estimates. As circumstances change or new data becomes available, changes to the appropriate spreadsheets can be made to produce adjusted prioritizations, which can be used in the ongoing planning process.

Limitations of Master Plan Methods

The limitations associated with the master plan for seismic rehabilitation are summarized as follows:

- The prioritizations developed and used for the master plan are based on the methodologies and loss estimates discussed in Chapter II. The limitations of the loss estimate identified in Chapter II will obviously also affect the master plan.
- Similarly, the loss estimate of Chapter II is based on the Damage Probability Matrices developed in Chapter III, and the limitations associated with the development of the DPMs will therefore affect both the loss estimate and the master plan.
- The loss estimate is based on the methodologies presented in ATC-21-1 (Applied Technology Council, 1988) and ATC-13 (Applied Technology Council, 1985). The methodologies developed in these publications are based on "typical" buildings and were originally intended to be applied to large numbers of buildings to evaluate their overall average performance statistically. The application of these methods to specific buildings is arguable, but is the only practical alternative short of a thorough, costly analysis of each building. A great deal of uncertainty exists both in this methodology and in the data collected for the estimates. Until an earthquake occurs, there is no way to know for certain how the individual buildings will perform.

It should also be noted that the loss estimation technique used in this project was developed specifically for the OSU campus, and is based on the specific seismic hazards and soil conditions associated with this location. While the general methodology can be followed and adapted to other locations, the parties involved with this report (S.R. Trautwein, Dr. T.H. Miller, the OSU Department of Civil Engineering, and OSU Facilities Services) assume no responsibility for the results and conclusions obtained in any such undertaking.

V: RECOMMENDATIONS FOR FUTURE WORK

The seismic threat to the Pacific Northwest is becoming an increasing concern for the residents of Oregon. This study, previous studies, and studies in progress are an attempt to address this threat. As noted throughout this report, a number of areas of uncertainty still exist, and could be better understood through additional research. The following sections suggest areas for further work by the OSU Department of Civil Engineering, OSU Facilities Services, and the Oregon State Board of Higher Education.

OSU Department of Civil Engineering

This project has provided a reasonable plan of action to progress with the seismic rehabilitation of the buildings on the Oregon State University campus. While several assumptions were made in the course of the study, the plan as it now stands will provide direct guidance concerning which buildings require the most immediate attention. However, as progress is made in the rehabilitation program, it may be appropriate to question some of the assumptions made and to conduct further research to help make more informed decisions. Possible areas of further study include the following:

- Review of treatment of buildings containing more than one structural type. Most of the buildings on campus contain more than one type of structural system. For multi-structural buildings, it was assumed that each structural type identified in the building contributed equally in the loss estimates and rehabilitation cost estimates. The exception to this was lift slab buildings. For these buildings, it was assumed that the lift slab construction contributed to 50% of the overall performance and rehabilitation cost; the remaining 50% was divided equally between the other structural types present in the facility. Loss estimates were made using weighted averages of damage and casualty ratios based on the relative influence assigned for each structural type identified within the building. A similar procedure was used to determine rehabilitation cost estimates. A further study of the buildings in

OSU Facilities Services

- Development of a plan to implement nonstructural seismic rehabilitation. This project has looked specifically at developing a plan for the structural rehabilitation of campus buildings. However, nonstructural hazards also have the potential for serious consequences, especially in small to moderate earthquakes. Nonstructural hazards can pose a danger even in buildings that can structurally withstand an earthquake, and are more likely to affect a large number of buildings, especially in a small or moderate earthquake. Nonstructural hazards can be just as deadly as structural failure. For example, a small earthquake could cause suspended lights or heavy bookshelves to fall, possibly resulting in fatalities, even though the earthquake did not cause any structural failures. The nonstructural rehabilitation of a building can be conducted at a much lower cost and with less disruption than required for structural rehabilitation. However, any nonstructural rehabilitation plan developed should be implemented in addition to, not instead of, the structural rehabilitation plan submitted in this report.

  A nonstructural rehabilitation plan would ideally cover both utility and architectural elements, which would be the responsibility of Facilities Services, and also furniture and contents, which would be the responsibility of the building managers. FEMA publication 74, "Reducing the Risks of Nonstructural Earthquake Damage (FEMA, 1994)," provides an excellent source of information and guidance for nonstructural rehabilitation. It is also possible that the OSU student chapter of the Earthquake Engineering Research Institute (EERI) could conduct nonstructural seismic hazard surveys of several of the buildings on campus as a community service project. This could be coordinated with Bill Francis, the OSU Manager for Environmental and Public Safety, as a separate project.

- Use the loss estimate developed in this study as an impetus to gain funding for seismic rehabilitation of OSU campus buildings. Hopefully, as the magnitude of the seismic threat becomes more well known, lawmakers will provide the funding required to reduce these hazards in a timely manner.

- Establish a seismic rehabilitation program based on the plan presented in this report to actually start rehabilitating campus buildings. Since work first began on this report, seismic upgrades have been undertaken on both West Hall and Kerr Library. A plan for the rehabilitation of Weatherford Hall is also underway. These upgrades should be continued. It is also recommended that a professional seismic evaluation be conducted prior to the upgrade of each building. The rudimentary evaluation provided by the ATC-21 surveys cannot provide an accurate a picture of the overall hazards in a building. A FEMA-178 seismic evaluation such as that conducted by Kanok Sucharitsanchai in his report can provide a much more comprehensive overview of the actual hazards in a particular building, and will give a better idea of exactly what types of structural augmentation, if any, will be required.
- Contract for Professional Seismic Evaluation of Ten Highest Priority Buildings. It may prove beneficial to conduct a FEMA-178 evaluation of the ten highest priority buildings identified in this report. Based on the results of these investigations, the rankings may be adjusted.

Oregon State Board of Higher Education

- Use the loss estimate developed in this study as an impetus to gain funding for seismic rehabilitation of OSU campus buildings.
- Institute the development of seismic rehabilitation plans for other colleges and universities in Oregon, based on the methodologies and procedures developed in this report.

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APPENDICES

APPENDIX A: USER'S GUIDE TO "SEISPLAN" BUILDING PRIORITIZATION SOFTWARE

Introduction to "SEISPLAN"

Chapter IV: Master Plan For Seismic Rehabilitation of this report provides a firm plan for the first two years of rehabilitation and a rough plan for the first ten years. As stated in that chapter, this prioritization is based on several assumptions. If any of these assumptions change, it might be appropriate to adjust the evaluation provided in this report. To allow for this, the spreadsheets used for the original prioritization have been developed into a software package that can be used by others to make these adjustments. This appendix describes the software developed, named "SEISPLAN," and explains how to use it. This software has been developed specifically for use at Oregon State University. It is certainly possible to adapt it to other campuses or communities, but the authors and sponsors of this report assume no responsibility for any such adaptation or the interpretation of the results developed.

Overview of SEISPLAN

The objective of the SEISPLAN software is to develop a seismic rehabilitation prioritization for buildings based on a number of factors such as building structural type, estimated building occupancies, and estimated ground acceleration at the site of the buildings. With this information given, a fatality estimate is developed based on the casualty ratios developed in Chapter III, Development of Damage Probability Matrices. The prioritization is made by ranking the buildings based on estimated fatalities. Several other criteria for prioritization were also considered as discussed in Chapter IV, but ultimately the decision was made to rank the buildings based on life safety as measured by estimated fatalities. If new information about any building becomes available, the software can easily reprioritize the buildings. It is also possible to add buildings to the list to be evaluated, although this requires more work with the spreadsheet.

Working with the Software

This section details the format of the software, explains how the spreadsheets work together, and explains how the spreadsheets can be adjusted to produce a new prioritization.

Format

The prioritization software was developed in Microsoft Excel version 5.0. The name of the file is SEISPLAN.XLS. A copy of this file is provided on a 3.5 inch disk, and is included as Appendix B. Use of the SEISPLAN workbook requires Microsoft Excel version 5.0 or later. It is assumed that the user of this software has a working knowledge of Microsoft Excel 5.0.

There are eight spreadsheets within the SEISPLAN workbook. Four of these are "data spreadsheets." These are the BLDGDATA, OCCUPANCY, COSTDATA, and RATIOS spreadsheets. It is within these sheets that any changes to the original data will be made, such as might be required if building occupancy estimates are revised. There are three "working spreadsheets." These are the RANKWORK1, RANKWORK2, and COSTWORK spreadsheets. These spreadsheets manipulate the data provided in the "data spreadsheets," prioritize the buildings, and export the prioritization to the "output spreadsheet." The "output spreadsheet," RANKINGS, provides a clear summary of the prioritizations developed in the SEISPLAN workbook.

The spreadsheets in the workbook are color coded to help identify the function of the cells in the spreadsheets. The colors are not reproduced on the copies of the spreadsheets provided. White cells are used for column headings and for data input cells. Generally, only the contents in the white cells should be modified. Gray cells indicate that no entry belongs in that cell. Yellow cells indicate that the value is automatically entered. The spreadsheet does this by looking up the desired value based on a reference entered by the user (the reference will be entered in one of the white cells). Blue indicates that the value is calculated based on a formula in the cell.

Data Spreadsheets

When an updated prioritization is required based on new information, the data in the "input data spreadsheets" must be modified. Usually, this will involve nothing more than replacing the existing values. More work will be required if additional buildings are added or if a particular building is assigned additional sub-structure types. The specific requirements for these procedures are outlined in the spreadsheet descriptions below.

<u>BLDGDATA</u>

This spreadsheet contains information about the structure of each building under consideration. It is the primary spreadsheet from which other spreadsheets draw much of their information. The buildings in the spreadsheet are arranged such that each building is defined by two or more rows of information. The first row contains the summary information for each building. This is referred to as the "main building" row. An additional row is provided for each structural system identified in the building. These are referred to as "sub-buildings." Sub-building rows can be easily identified by noting that

the building names are indented. Each column in the spreadsheet, from left to right, is defined below. A copy of the spreadsheet, along with the original values, is included in Table A-1: BLDGDATA Spreadsheet.

<u>*Building Index Code:*</u> Each row in the spreadsheet is assigned a unique *Building Index Code.* This allows each main building to be distinguished from its sub-buildings, and for its sub-buildings to be distinguished from each other. Other spreadsheets use this number as a lookup reference to retrieve specific information about each building.

Building Number: For administrative purposes, Oregon State University has assigned each university owned building a unique *Building Number*. To aid university personnel in utilizing the results of this software, the *Building Numbers* are included to help identify the buildings. The buildings are arranged on the spreadsheet in order by their *Building Number*.

Building Name: This is the name of each building. Sub-building names are occasionally abbreviated or modified to convey additional information about which part of the building is being considered.

Building Use Code: This number identifies the primary occupational use of the building. Academic buildings are assigned a *Building Use Code* of 0, and student life buildings are assigned a *Building Use Code* of 1. No other numbers are currently used. *Building Use Codes* are assigned to main buildings only.

Building Use: This column identifies the building use based on the *Building Use Code*. It is automatically filled with "Academic" if the *Building Use Code* is 0, and "Student Life" if the *Building Use Code* is 1.

Building Class Code: The *Building Class Code* must be assigned based on the building class as identified in the COSTDATA spreadsheet. For each building, it is necessary to look up the appropriate code and enter it here. Once the *Building Class Code* is provided, the *ATC-21 Building Class*, the *ATC-13 Building Class*, and the *Cost Est Class* (all defined below) are automatically filled in the appropriate columns, based on a cross-reference to the COSTDATA spreadsheet.

<u>*ATC-21 Class:*</u> This column is automatically filled by cross-referencing the *Building Class Code* with the COSTDATA spreadsheet. The *ATC-21 Class* is returned for sub-building rows, and the word "Summary" is returned for main building rows.

<u>*ATC-13 Class:*</u> This is the ATC-13 building class that most closely corresponds to the building structural system identified. This column is automatically filled by cross-referencing the *Building Class Code* with the COSTDATA spreadsheet.

<u>*Sub-building Proportion Factor:*</u> Each sub-building is assigned a factor to indicate how the overall building is influenced by the structural systems identified for each of the sub-buildings. In effect, this produces a weighted average for the entire building based on the sub-buildings. Unless specific information was readily available concerning the relative influence of the different structural types, it was assumed that each sub-building contributed equally to the loss estimates and rehabilitation cost estimates.

The exception to this was lift slab buildings. For these buildings, it was assumed that the lift slab construction contributed to 50% of the overall performance and rehabilitation cost; the remaining 50% was divided equally between the other structural types present in the facility. The original ATC-21 surveys conducted by Ferguson and Ch'ng (Miller et al., 1991 and 1992) did not consider the relative influence of the different structural types identified in each building. The objective of their studies was to identify buildings requiring further investigation, which depends on the most critical structural type found in a building, not a weighted average of the structural types. The sum of all the *Sub-building Proportion Factors* for each building must equal 1.00.

<u>*Building Area:*</u> This is the area of the building as reported by the Valuation Reports provided by the Oregon State Board of Higher Education. It should only be provided for the main building rows. Values for sub-building rows are automatically calculated

by multiplying the *Sub-building Proportion Factor* by the total building area entered in the main building row. The area of the building is not used for the loss estimate, but is for the cost estimate. The total cost estimate for the building is calculated as the sum of the rehabilitation costs of the sub-buildings, which may have different costs per square foot according to their structural system.

ATC-21 Survey Results: This group of columns contains the raw data from the ATC-21 survey of the campus buildings reported in "Preliminary Evaluation of Academic Facilities at Oregon State University for Potential Seismic Hazards (Miller, Ferguson, Mann, and Arguedas, 1991)," and "Preliminary Evaluation of Student Life Facilities at Oregon State University for Potential Seismic Hazards (Miller, Ch'ng, and Ferguson, 1992)," The information is provided for sub-buildings only.

BSH Score: This is the basic structural hazard score, as defined in ATC-21, for low hazard areas. The reason that the low hazard scores are used is that the hazard scores are based not only on the seismic threat, but also on the seismic resistance of the buildings in the area. Buildings in Oregon are considered to have low seismic resistance as discussed in Chapter III of this thesis. With the low seismic resistance of the buildings, the low BSH score is more appropriate than the medium or high scores. The increased hazard due to a higher seismic threat is accounted for by the damage and casualty ratios developed specifically for the threat in the Corvallis area. Though newer buildings in Oregon have a higher structural resistance due to increased requirements in building codes, this is accounted for by modifying the BSH for buildings meeting these code standards.

Performance Modification Factors (PMFs): This group of columns contains the PMFs that were assigned to each sub-building based on the ATC-21 survey of campus buildings. All of the modifiers applied were included except the soil profile modifier. Instead, the effects of the underlying soil layers are accounted for by determining the amplification of bedrock accelerations to the ground surface, then adjusting the damage and casualty ratios according to the ground acceleration. The definitions transcribed below are from ATC-21 and ATC-21-1 (Applied Technology Council, 1988a and 1988b).

High Rise: Buildings eight stories and taller, except unreinforced masonry (URM) buildings; URM buildings above 4 stories.

Poor Condition: Buildings exhibiting deterioration of structural materials, such as cracks, damage, settlement, etc.

Vertical Irregularity: Buildings with major cantilevers, major setbacks, or other structural features that would cause a significant change in stiffness in the upper stories of the building. These features include steps in elevation, inclined walls, discontinuities in load path, and buildings on a hill.

Soft Story: Buildings with structural features that would result in a major decrease in the lateral load resisting system's stiffness at one floor -- typically at the ground floor due to large openings or tall stories.

Torsion: Corner or wedge buildings or any type of building in which the lateral load resisting system is highly non-symmetric or is concentrated at some distance from the center of gravity of the building, such as with a building having one or two solid walls and all other walls open.

Plan Irregularity: Buildings with reentrant corners and long narrow wings, such as L, U, E, T, or other irregular shaped buildings.

Pounding: Inadequate seismic clearance between adjacent buildings. This factor should only be applied when floor levels of adjacent buildings are not aligned, and there is less than 4" of separation per story.

Heavy Cladding: Buildings with many large heavy stone or concrete panels. Glass panels and masonry veneer do not qualify.

Short Columns: The building has columns originally designed as having a full-story height, but which, because of wall sections or deep spandrel beams between the columns, have an effective height much less than the full-story height. This causes brittle failure of the columns and potential collapse.

Post BM Year: (Post benchmark year) Buildings designed after a certain key year when seismic code requirements were increased. This is different for each building type and municipality.

Final Score: This is the final structural hazard score and is determined by subtracting the modifiers from the BSH score, except that the post benchmark year modifier is added instead of subtracted.

Sum of PMFs: This is the sum of all the structural score modifiers applied to each sub-building. This is necessary because the damage and casualty ratios are derived based on three factors: 1) the building structural system, 2) horizontal ground acceleration, and 3) the sum of the PMFs.

OCCUPANCY

This spreadsheet contains all the information used to estimate average and maximum occupancies of the buildings being evaluated. The rationale used in these estimates is provided in Chapter II: Loss Estimate for Campus Buildings. Each column in the spreadsheet, from left to right, is defined below. A copy of the spreadsheet, along with the original values, is included in Table A-2: OCCUPANCY Spreadsheet.

Building Index Code: As defined in the BLDGDATA spreadsheet. The *Building Index Code* for each building in the BLDGDATA spreadsheet must also be entered here.

Building Number: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* with the BLDGDATA spreadsheet.

Building Name: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* with the BLDGDATA spreadsheet.

Budgets and Planning: This group of columns contains information obtained from the Oregon State University Office of Budgets and Planning (Helvie, 1994).

Faculty: This is the reported number of faculty members with an office in the building.

Staff: This is the reported number of staff members with an office in the building.

Student Workers: This is the reported number of student workers assigned to work in the building.

Non-employed Grad Students: This the reported number of graduate students with an office in the building. "Employed" graduate students are counted as "student workers."

Classroom Capacity: This is the reported capacity of all of the classrooms in the building.

Average Daily Classroom Occ: This is the estimated occupancy of all the classrooms in the building, based on the Student Schedule Report (Dyer, 1994), as described in Chapter II.

Housing: This group of columns contains occupancy information for the dormitories and the College Inn, as reported by the Oregon State University Department of Student Housing (Sherman, 1995).

Average Residents: This is the number of residents living in the building, including students and staff such as resident assistants. The number is an average over the course of three terms, Fall 1994 through Spring 1995.

Maximum Capacity: This is the maximum number of people who can live in the building under its current configuration.

Other Sources: This group of columns contains occupancy information for buildings which had occupants other than those accounted for in previous categories (occupancy from the budgets and planning reports, classroom occupancies, and housing occupancies). It was necessary to collect information from other sources for buildings such as the Memorial Union, Kerr Library, Dixon Recreation Center, and the Plageman Student Health Center.

Average Day Occupants: This is the average daily occupancy from sources that could not be accounted for in previous categories.

Max Day Occupants: This is the maximum daily occupancy sources that could not be accounted for in previous categories.

Source Note: This provides a cross reference to a note indicating the source of the information entered in the previous two columns. These notes are provided in Table A-3: Reference Notes for Other Sources.

Subtotals: This group of columns tabulates the total occupancy rates from the data provided from all sources.

Average Day: This is an estimate of the average number of occupants in the building during an average week day. It is automatically calculated by adding the *Faculty*, *Staff*, *Student Workers*, *Non-employed Graduate Students*, *Average Daily Classroom Occ*, 50 percent of the *Average Residents* in housing (one half occupancy is assumed during the day), and *Ave Day Occupants* from other sources.

Average Night: This is an estimate of the average number of occupants in the building during an average night. It is obtained directly from the *Average Residents* in housing. Academic buildings are assumed to be unoccupied at night.

Maximum Day: This is an estimate of the maximum number of occupants that could possibly be in the building at any time during any day. It is automatically calculated by adding the *Faculty, Staff, Student Workers, Non-employed Graduate Students, Classroom Capacity, Maximum Capacity* for housing, and *Maximum Day Occupants* from other sources.

Maximum Night: This is an estimate of the maximum number of occupants that could possibly be in the building at any time during the night. It is obtained directly from the *Maximum Capacity* for housing. Academic buildings are assumed to be unoccupied at night.

Totals to Use: This group of columns contains the occupancies that are transferred to the RANKWORK spreadsheet to estimate casualties.

Average (Day & Night): This is the occupancy used to estimate casualties based on average occupancy in the RANKWORK spreadsheet, and is calculated by a simple averaging of the *Average Day* and *Average Night* occupancies from the *Subtotals* columns.

Maximum (Day or Night): This is the occupancy used to estimate casualties based on maximum occupancy in the RANKWORK spreadsheet, and is calculated by taking the maximum value of the *Maximum Day* and *Maximum Night* occupancies from the *Subtotals* column.

COSTDATA

This spreadsheet provides the seismic rehabilitation cost estimates for each of the building classes identified on campus. These cost estimates were obtained from two sources: the conceptual designs developed for specific buildings on the OSU campus (Miller, Ferguson, and Ch'ng, 1993; and Sucharitsanchai, Trautwein, and

Miller, 1995); and the "Earthquake Risk Analysis" report prepared for the City of Portland (Goettel and Horner, 1995), referred to in this report as the Portland Study. Each column in the spreadsheet, from left to right, is defined below. A copy of the spreadsheet, along with the original values, is included in Table A-4: COSTDATA Spreadsheet.

Building Structural System: This is a description of the main structural system of the building, as defined in ATC-21.

Distinguishing Features: This information is necessary to provide a distinction between building types which are not distinguished sufficiently by the ATC-21 classification system. This was required to differentiate between types of precast concrete/lift slab buildings, and between different types of reinforced masonry buildings. The reason a distinction is required is that the cost estimates differ for these types of buildings, depending on the distinguishing features.

Building Class Code: This is provided as an index reference number for the BLDGDATA and RANKINGS spreadsheets. It is composed of the ATC-13 building class number plus a decimal to indicate relative building area and to provide for distinguishing features. A breakdown of what each digit indicates is as follows:

9 . 2 3

Building size indicator (1 for small, 2 for medium, 3 for large, 4 for very large)

Distinguishing feature indicator (different for each building class)

ATC-13 Building Class

For example, 9.23 is a large reinforced masonry building with concrete deck diaphragms, and 9.13 is a large reinforced masonry building with wood or metal deck diaphragms.

<u>*ATC-21 Class:*</u> This is the ATC-21 building class corresponding directly to the building type identified in the *Building Structural System* column. Two additional classes are also included: "Summary" and "Sub," corresponding to *Building Class Codes* of 0 and 0.5. When "0" is entered for a *Building Class Code* in the BLDGDATA spreadsheet, "Summary" is automatically entered in the *ATC-21 Class* column. This aids in identifying the main buildings in this and other spreadsheets. The "Sub" classification is used only for McAlexander Fieldhouse and Parker Stadium, and facilitates accounting for these buildings requiring special treatment. The section on "Buildings Requiring Special Treatment," at the end of this appendix, explain why this is required.

<u>*ATC-13 Class:*</u> This is the ATC-13 building class that most closely corresponds to the building structural system identified. Building classes are matched based on the descriptions provided in ATC-13 and ATC-21.

<u>*Portland Study Building Class:*</u> This is based on the building class identified by the Portland Study which most closely corresponds to the *Building Structural System* identified. The Portland Study actually labels the classes as 1 through 8. For the purposes of this cost estimate, these were further distinguished by adding S, M, L, and VL (small, medium, large, and very large) to indicate building area.

<u>*Building Area (square feet):*</u> The Portland Study provided different cost estimates for different size buildings. This column indicates which building class should be used for a building of a given area.

<u>*Cost Estimate ($ per square foot):*</u> This group of columns contains the seismic rehabilitation cost estimates for the different types of buildings.

OSU Conceptual Designs (Structural Only): These are the rehabilitation cost estimates for the building types that were evaluated in the two previous studies on campus (Miller, Ferguson, and Ch'ng, 1993; and Sucharitsanchai, Trautwein, and Miller, 1995). Though only five specific buildings were evaluated, the cost estimates are assumed to be representative of all buildings of similar construction.

Portland Study (Total Upgrade): These are the cost estimates provided in the Portland Study (Goettel and Horner, 1995), and include both structural and nonstructural seismic rehabilitation. The scope of what is entailed for both structural and nonstructural rehabilitation is covered in Chapter IV.

Cost Estimate Based on Portland Study (Structural Only): These are the cost estimates for structural rehabilitation only, as provided in the Portland Study (Goettel and Horner, 1995).

Cost Estimate Based on Portland Study (Nonstructural Only): These are the cost estimates for nonstructural rehabilitation only, as provided in the Portland Study (Goettel and Horner, 1995).

RATIOS

This spreadsheet provides the damage and casualty ratios which are used in conjunction with the occupancy and building value data to predict total financial losses, injuries, and fatalities. Damage and casualty ratios are determined based on three factors: effective peak acceleration (EPA), expressed in terms of g (fraction of gravity); the building class; and the building modifier as determined from the ATC-21 survey data. For OSU, ratios are provided for an EPA of 0.22g. This reflects the shaking predicted for the campus area, as discussed in Chapter II. If, at a later date, it is determined that ratios for other intensity levels are appropriate, new ratios must be derived based on the procedure developed in Chapter III of this thesis. (Ratios for some other EPA's have already been determined and are provided on the spreadsheet.) Each column in the spreadsheet, from left to right, is defined below. A copy of the spreadsheet along with the original values is included in Table A-5: RATIOS Spreadsheet.

ATC-21 Class: This is the building class as defined in ATC-21. A definition of each class is provided in Table 2: Building Structural Classes Used for OSU Loss Estimate, in Chapter II: Loss Estimate for Campus Buildings.

ATC-13 Class: This is the building class as defined in ATC-13. A definition of each class is provided in Table 2: Building Structural Classes Used for OSU Loss Estimate, in Chapter II: Loss Estimate for Campus Buildings.

Sum of PMFs: This is the sum of the Performance Modification Factors identified in the ATC-21 survey. Ratios are provided for modifiers ranging from -1.5 to 3.0 in increments of 0.5, which encompasses all of the scores tabulated for OSU buildings in the surveys conducted (Miller et al., 1991, and Miller et al., 1992).

Ratio Index: The *Ratio Index* provides a unique number for each combination of building class and modifier and is used as a cross-reference for the RANKWORK spreadsheet. It is computed by multiplying the *ATC-13 Class* by 100 and adding the *Sum of PMFs*. For example, a building of ATC-13 class 85 with PMFs totaling 2.5 would have a *Ratio Index* of (85x100) + 2.5 = 8502.5.

Damage Ratio: This is the overall damage ratio based on ground motion, building class, and modifiers. It reflects the estimated percent damage to the building and its contents. The *Damage Ratio* is provided for EPA values of both 0.20g and 0.22g. Only the ratios for 0.22g are used for this study. If ratios for other levels of ground motion are desired, they must be derived based on the procedure outlined in Chapter III. It should be noted that these ratios are used only for the loss estimate developed in Chapter II. They are not used in the building prioritization, but are provided for possible future applications.

Injury Rate/1000. This is the number of serious injuries (defined as injuries requiring hospitalization) that are predicted per 1000 building occupants. It is based on ground motion, building class, and modifiers. The *Injury Rate/1000* is provided for EPA values of both 0.20g and 0.22g, and must be rederived if ratios for other levels of ground motion are desired. As with the *Damage Ratio*, these ratios are not used for the prioritization but are included for possible future applications. The injury rate is directly proportional to the fatality rate, so a prioritization developed based on estimated injuries will produce the exact same results as the one based on estimated fatalities.

Fatality Rate/1000. This is the number of predicted fatalities per 1000 building occupants. It is based on ground motion, building class, and modifiers. The *Fatality Rate/1000* is provided for EPA values of both 0.20g and 0.22g, and must be rederived if ratios for other levels of ground motion are desired. The building prioritizations are developed from the fatality estimates based on these ratios.

Working Spreadsheets

These spreadsheets manipulate the data provided on the data spreadsheets to produce the prioritizations. From here, the prioritizations are exported to the output spreadsheet, RANKINGS. The three working spreadsheets are RANKWORK1, RANKWORK2, and COSTWORK. These spreadsheets are described below.

RANKWORK1

The RANKWORK1 spreadsheet utilizes the data from the BLDGDATA, RATIOS, and OCCUPANCY spreadsheets to develop the rankings for prioritization. Very little work by the user is required on this spreadsheet, but there are a few things that should be checked. Each column in the spreadsheet, from left to right, is defined below. This spreadsheet is presented in Table : RANKWORK1 Spreadsheet.

Building Index Code: As defined in the BLDGDATA spreadsheet. The *Building Index Code* for each building in the BLDGDATA spreadsheet must also be entered here.

Building Number: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* with the BLDGDATA spreadsheet.

Building Name: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* with the BLDGDATA spreadsheet.

Building Data: This group of columns contains data retrieved from the BLDGDATA spreadsheet, which is used to determine which damage and casualty ratios to use.

Building Use Code: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* with the BLDGDATA spreadsheet.

ATC-21 Class: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* with the BLDGDATA spreadsheet.

ATC-13 Class: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* with the BLDGDATA spreadsheet.

Proportion Factor: As defined in the BLDGDATA spreadsheet. For the sub-buildings, this column is automatically filled by cross-referencing the *Building Index Code* with the *Sub-building Proportion Factor* in the BLDGDATA spreadsheet. For the main buildings, the *Proportion Factor* is automatically calculated by summing the factors of the sub-buildings.

Validity Check: This column must be checked to ensure that the sum of the *Proportion Factors* for each main building is 1.0. If the sum is 1.0, then this column will read "ok." Otherwise, it will read "err." In this case, the user must investigate why the sum of the *Proportion Factors* is not 1.0. Check the *Sub-building Proportion Factors* entered for the sub-buildings in the BLDGDATA spreadsheet, and adjust them as required. This check is only made for the main building rows, not the sub-building rows.

Sum of PMFs: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* with the BLDGDATA spreadsheet.

Ratio Index: As defined in the BLDGDATA spreadsheet. This column is calculated by multiplying the *ATC-13 Building Class* by 100, and adding the *Sum of Mods*.

Fatality Rates (per 1000): This group of columns contains the fatality rates used for the ranking.

Fatality Rate for 0.22g: As defined in the RATIOS spreadsheet. This column is automatically filled by cross-referencing the *Ratio Index* column with the RATIOS spreadsheet.

Weighted Fatality Rate: This column weights the fatality rates for the sub-buildings and sums them for the main buildings. For the sub-buildings, the *Weighted Fatality Rate* is determined by multiplying the *Fatality Rate* by the *Proportion Factor* for the sub-building. For the main buildings, the *Weighted Fatality Rate* is determined by summing the *Weighted Fatality Rates* for all the sub-buildings of the main building.

Occupancy Data: These columns contain the data from the *Totals to Use* columns in the OCCUPANCY spreadsheet, which is used to make the casualty estimates.

Average (Day & Night): As defined in the OCCUPANCY spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* column with the OCCUPANCY spreadsheet.

Maximum (Day or Night): As defined in the OCCUPANCY spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* column with the OCCUPANCY spreadsheet.

Fatality Estimates: This group of columns contains the fatality estimates based on both average assumed occupancy and maximum assumed occupancy.

Based on Average Occupancy: This column contains fatality estimates based on the average assumed occupancy for each building. It is calculated by multiplying the *Weighted Fatality Rate* by the *Average (Day & Night)* occupancy. It is only calculated for main buildings, except for the special cases of McAlexander Fieldhouse and Parker Stadium, which are detailed in the section "Buildings Requiring Special Treatment" at the end of this appendix.

Based on Maximum Occupancy: This column contains the fatality estimates based on the maximum assumed occupancy for each building. It is calculated by multiplying the *Weighted Fatality Rate* by the *Maximum (Day or Night)* occupancy. It is only calculated for main buildings, except for the special cases of McAlexander Fieldhouse and Parker Stadium, which are detailed in the section "Buildings Requiring Special Treatment" at the end of this appendix.

RANKWORK2

This spreadsheet is used for ranking the buildings, and is reproduced in Table A-7: RANKWORK2 Spreadsheet. Two methods are used for ranking. Method A ranks the buildings according to the estimated number of fatalities based on assumed average occupancy. Method B ranks the buildings according to the estimated number of fatalities based on the assumed maximum occupancy. The ranking is done automatically by pressing the appropriate *Ranking Button* on the spreadsheet, which activates a macro programmed to do the ranking manipulation. The *Ranking Buttons* appear on the spreadsheet as gray buttons similar to the standard Microsoft Windows toolbar buttons. They are labeled for easy identification and appear in Table as boxes with rounded corners. The buttons and their use are detailed after the discussion of the columns in this portion of the spreadsheet.

Method A: Estimated Fatalities Based on Average Occupancy: This group of columns provides the workspace for ranking the buildings based on Method A.

Rank, Method A: This is the rank for each building based on Method A. It is copied directly from the column of the same name at the end of the Method A workspace. The reason that the same information must be provided in two places is that this column is used as a lookup column for the RANKINGS spreadsheet. (The structure of the Microsoft Excel software requires that the lookup column be the first column in the index array. This is strictly a functional issue, required to make the RANKINGS spreadsheet work properly.)

Building Index Code: As defined in the BLDGDATA spreadsheet. Note that only the *Building Index Codes* for the main buildings are used for this section of the spreadsheet. This is different from the other spreadsheets in the SEISPLAN workbook, which include *Building Index Codes* for both main buildings and sub-buildings. The *Building Index Codes* corresponding to the main building for each building to be prioritized must be entered in this column.

Building Number: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* with the BLDGDATA spreadsheet.

Building Name: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* with the BLDGDATA spreadsheet.

Building Use Code: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* with the BLDGDATA spreadsheet.

Estimated Fatalities Based on Method A: This is the estimated number of fatalities based on the assumed average day and night occupancies, as calculated for the building in the RANKWORK1 spreadsheet. It is automatically filled by cross-referencing the *Building Index Code* with the RANKWORK1 spreadsheet.

Rank, Method A: This column contains the rank of the building based on Method A. It is automatically filled in when the *Auto Rank: Method A* macro button is activated. The ranks are assigned in descending order of fatalities estimated, i.e., the building with the highest number of estimated fatalities is designated number 1 in the ranking scale.

Method B: Estimated Fatalities Based on Maximum Occupancy: This group of columns provides the workspace for ranking the buildings based on Method B. This workspace contains the same columns as for Method A, and descriptions of the columns can be obtained from the paragraphs detailing the Method A workspace.

Ranking Buttons: These are the buttons at the top of the *Ranking Area*. A macro has been assigned to each button to perform a sequence of manipulations to the appropriate workspace. The buttons are activated simply by clicking on the button with the computer mouse. Each button is described below.

Auto Rank: Method A: Once all of the appropriate *Building Index Codes* have been entered, the buildings can be ranked by either Method A or Method B. To do this, click on the *Auto Rank: Method A* button, and the macro will sort the appropriate columns, in decreasing order, by *Estimated Fatalities Based on Method A*. The buildings are also separated by *Building Use Code*, so that all academic buildings and all student life buildings are grouped together. The macro then renumbers the *Rank, Method A* column, and recalculates all spreadsheet values. Recalculating is necessary to export the values to the RANKINGS spreadsheet.

Reset: Activating this button will resort the buildings in the Method A workspace by the *Building Index Code*, which was the original order of the workspace. The ranks will also be sorted, so the rank for each building can be read whether the *Reset* button is activated or not. However, in order for the proper numbers to be exported to the RANKINGS spreadsheet, the buildings must be sorted in order of rank. It is imperative that the *Reset* button is not activated immediately before using the RANKINGS spreadsheet. If the *Reset* button is activated, the wrong values will be exported to the RANKINGS spreadsheet. The *Auto Rank* buttons -- both of them -- must be activated for the RANKINGS spreadsheet to work properly.

Auto Rank: Method B: As described for the *Auto Rank: Method A* button, but for the workspace devoted to Method B.

Reset: As described for the *Reset* button for Method A, but for the workspace devoted to Method B.

COSTWORK

The COSTWORK spreadsheet uses the information from the BLDGDATA and COSTDATA spreadsheets to develop rehabilitation cost estimates for each building. The rationale used to develop these cost estimates is provided in Chapter IV, under the section covering Rehabilitation Cost Estimates. As with the RANKWORK1 and RANKWORK2 spreadsheets, very little work by the user is required on this spreadsheet. Each column in the spreadsheet, from left to right, is defined below. A copy of the spreadsheet, along with the original values, is included in Table A-8: COSTWORK Spreadsheet.

Building Index Code: As defined in the BLDGDATA spreadsheet. The *Building Index Code* for each building in the BLDGDATA spreadsheet must also be entered here.

Building Number: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* with the BLDGDATA spreadsheet.

Building Name: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* with the BLDGDATA spreadsheet.

Building Class Code: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* with the BLDGDATA spreadsheet.

Sub-building Proportion Factor: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* with the BLDGDATA spreadsheet.

Building Area (Square Feet): This is the same as the *Building Area (OSBHE Report)* column defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Index Code* with the BLDGDATA spreadsheet.

Sub-building Cost Estimates ($ per square foot): This group of columns contains the rehabilitation cost estimates, per square foot, for each of the sub buildings.

OSU Conceptual Designs (Structural Only): As defined in the COSTDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Class Code* with the COSTDATA spreadsheet.

Portland Study (Structural Only): As defined in the COSTDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Class Code* with the COSTDATA spreadsheet.

Portland Study (Nonstructural Only): As defined in the COSTDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Class Code* with the COSTDATA spreadsheet.

Portland Study (Total): As defined in the COSTDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Class Code* with the COSTDATA spreadsheet.

Total Rehabilitation Cost Estimates for Main Buildings: This group of columns contains the seismic rehabilitation cost estimates for both the main buildings and the sub buildings. The values calculated in these columns are different for main buildings and sub buildings.

OSU Conceptual Designs (Structural Only): This is the total rehabilitation cost estimate for the building based on the *OSU Conceptual Designs* estimate. Estimates were only made for two specific building systems: concrete lift slab buildings, and unreinforced masonry buildings. For all other buildings, a zero is entered by default. Unlike the Portland Study cost estimates, the total cost estimates by the OSU methods are not based on *Sub-building Proportion Factors*. Only one sub-building type within the main building will contain a cost estimate per square foot. The total cost for the building is calculated by multiplying the *Building Area* by the unit cost for the single sub-building type with a non-zero unit cost.

OSU Cost Estimate (String to Export): To clarify the cost estimates in the RANKINGS spreadsheet, this column replaces all zero values in the previous column with "N/A." This is the character string that will be exported to the RANKINGS spreadsheet.

Portland Study (Structural): This is the total rehabilitation cost estimate for the structural system of the entire building, as estimated by the Portland Study method. For the sub-buildings, the cost estimate per square foot is multiplied by the *Building Area*, and by the *Sub-building Proportion Factor*. For the main buildings, the cost estimates for all of the sub-buildings within the main building are totaled to determine the overall cost estimate for the building.

Portland Study (Nonstructural): This is calculated the same way as for the *Portland Study (Structural)* column, but for nonstructural components of the building.

Portland Study (Total): This is the total cost estimate for both structural and nonstructural rehabilitation, and is calculated by adding the *Portland Study (Structural)* to the *Portland Study (Nonstructural)* columns.

Output Spreadsheet -- RANKINGS

There is only one output spreadsheet, the RANKINGS spreadsheet. All information in this spreadsheet is imported from the working spreadsheets. This spreadsheet provides four tables containing the results of the rankings. Two tables contain rankings for the academic buildings (one sorted by Method A, the other by Method B), and two contain rankings for the student life buildings. Each column in the spreadsheet, from left to right, is defined below. This spreadsheet also contains macro buttons to aid in printing out the reports for the rankings in each of the four tables. The buttons are described after the columns. Copies of the four tables in the spreadsheet, along with the original values, are included in Table A-9: RANKINGS Spreadsheet, Academic Buildings, Method A; Table A-10: RANKINGS Spreadsheet, Academic Buildings, Method B; Table A-11: RANKINGS Spreadsheet, Student Life Buildings, Method A; and Table A-12: RANKINGS Spreadsheet, Student Life Buildings, Method B.

Prioritization of Academic Buildings (sorted by Method A: estimated fatalities based on average occupancy): This table contains the prioritization of Academic Buildings according to Method A, which estimates fatalities based on assumed average occupancy. It also contains the ranks for Method B, for comparison. For planning purposes, cost estimates for seismic rehabilitation are also provided.

Building Number: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Rank, Method A* column with the RANKWORK2 spreadsheet.

Building Name: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Rank, Method A* column with the RANKWORK2 spreadsheet.

Building Use Code: As defined in the BLDGDATA spreadsheet. This column is automatically filled by cross-referencing the *Rank, Method A* column with RANKWORK2 spreadsheet. The user should double check that the proper Building Use Code is entered in each row (0 for academic buildings, and 1 for student life buildings).

Estimated Fatalities, Method A: As defined in the RANKWORK1 spreadsheet. This column is automatically filled by cross-referencing the *Rank, Method A* column with the RANKWORK2 spreadsheet.

Rank, Method A: This column contains the ranks, from 1 to the number of buildings being ranked.

Estimated Fatalities, Method B: As defined in the RANKWORK1 spreadsheet. This column is automatically filled by cross-referencing the *Building Name* column with the RANKWORK2 spreadsheet.

Rank, Method B: As defined in the RANKWORK1 spreadsheet. This column is automatically filled by cross-referencing the *Building Name* column with the RANKWORK2 spreadsheet.

Rehabilitation Cost Estimates ($): This group of columns contains the seismic rehabilitation cost estimates based on the two studies discussed in the section covering the COSTDATA spreadsheet.

> *OSU Conceptual Designs (Structural Only):* As defined in the COSTDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Number* with the COSTWORK spreadsheet.

> *Portland Study (Structural Only):* As defined in the COSTDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Number* with the COSTWORK spreadsheet.

Portland Study (Nonstructural Only): As defined in the COSTDATA spreadsheet. This column is automatically filled by cross-referencing the *Building Number* with the COSTWORK spreadsheet.

Prioritization of Academic Buildings (sorted by Method B: estimated fatalities based on maximum occupancy): This table contains the prioritization of academic buildings according to Method B, which estimates fatalities based on assumed maximum occupancy. It also contains the ranks for Method A, for comparison. For planning purposes, cost estimates for seismic rehabilitation are also provided. The columns in this workspace are the same as for *Prioritization of Academic Buildings (sorted by Method A),* and descriptions of the columns can be found in that section. Note that the *Rank, Method B* is the cross-reference lookup value for this table.

Prioritization of Student Life Buildings (sorted by Method A: estimated fatalities based on average occupancy): This portion of the spreadsheet contains the prioritization of student life buildings according to Method A, which estimates fatalities based on assumed average occupancy. It also contains the ranks for Method B, for comparison. For planning purposes, cost estimates for seismic rehabilitation are also provided. The columns in this workspace are the same as for *Prioritization of Academic Buildings (sorted by Method A),* and descriptions of the columns can be found in that section.

Prioritization of Student Life Buildings (sorted by Method B: estimated fatalities based on maximum occupancy): This portion of the spreadsheet contains the prioritization of student life buildings according to Method B, which estimates fatalities based on assumed maximum occupancy. It also contains the ranks for Method A, for comparison. For planning purposes, cost estimates for seismic rehabilitation are also provided. The columns in this workspace are the same as for *Prioritization of Academic Buildings (sorted by Method A),* and descriptions of the columns can be found in that section. Note that the *Rank, Method B* is the cross-reference lookup value for this table.

Macro Buttons: Five buttons have been created at the top of these sheets to aid in the printing of the tables. Each button activates a macro to print the appropriate sheets. The Macro Buttons appear on Table through 25 as boxes with rounded corners.

Print All Sheets: This button will print all tables in the RANKINGS spreadsheet. It appears at the top of Table A-9: RANKINGS Spreadsheet, Academic Buildings, Method A only.

Print Sheet: These buttons will print the individual tables. One button appears at the top of each table.

Copies of the Spreadsheets

The following pages contain copies of each of the spreadsheets described above.

Table A-1: BLDGDATA Spreadsheet

BLDGDATA -- Building Data

Building Index Code	Building Number	Building Name	Building Use Code	Building Use	Bldg Class Code	ATC-21 Class	ATC-13 Class	Sub-building Proportion Factor	Building Area (OSBHE Report) (sq ft)	ATC-21 Survey Results: BSH Score	Performance Modification Factors (PMF's): High Rise	Poor Condition	Vertical Irregularity	Soft Story	Torsion	Plan Irregularity	Pounding	Heavy Cladding	Short Columns	Post BM Year	Final Score	Sum of PMF's
1	1	Apperson	0	Academic	0	Summary			29,426													
2	1	Apperson			1.12	W	1	1.00	29,426	8.5											8.5	0.0
3	2	Merryfield	0	Academic	0	Summary			27,329													
4	2	Merryfield			75.12	URM	75	1.00	27,329	2.5						1.0					1.5	1.0
5	6	Graf	0	Academic	0	Summary			37,792													
6	6	Graf			75.12	URM	75	0.50	18,896	2.5		0.5				1.0					1.0	1.5
7	6	Graf			87.12	C1	87	0.50	18,896	4.0		0.5				0.5					3.0	1.0
8	7	Covell	0	Academic	0	Summary			37,329													
9	7	Covell			75.12	URM	75	1.00	37,329	2.5						1.0					1.5	1.0
10	9	Batcheller	0	Academic	0	Summary			20,816													
11	9	Batcheller			1.12	W	1	1.00	20,816	8.5			0.5								8.0	0.5
12	11	Dearborn	0	Academic	0	Summary			64,455													
13	11	Dearborn			15.13	S1	15	0.50	32,228	3.5			0.5			0.5					2.5	1.0
14	11	Dearborn			3.13	S4	3	0.50	32,228	4.5			1.0			0.5					3.0	1.5
15	12	Gilbert Addition	0	Academic	0	Summary			44,144													
16	12	Gilbert Addition			87.12	C1	87	0.50	22,072	4.0			1.0		1.0	0.5	0.5			2.0	3.0	1.0
17	12	Gilbert Addition			6.12	C2	6	0.50	22,072	4.0			0.5		1.0	0.5				2.0	4.0	0.0
18	14	Shepard	0	Academic	0	Summary			11,673													
19	14	Shepard			1.12	W	1	1.00	11,673	8.5											8.5	0.0
20	15	Gilbert	0	Academic	0	Summary			83,148													
21	15	Gilbert			87.13	C1	87	0.50	41,574	4.0						0.5					3.5	0.5
22	15	Gilbert			6.13	C2	6	0.50	41,574	4.0						0.5					3.5	0.5
23	16	Gleeson	0	Academic	0	Summary			39,011													
24	16	Gleeson			87.12	C1	87	0.50	19,506	4.0						0.5					3.5	0.5
25	16	Gleeson			6.12	C2	6	0.50	19,506	4.0						0.5					3.5	0.5
26	17	Weniger	0	Academic	0	Summary			211,077													
27	17	Weniger			15.14	S1	15	0.50	105,539	3.5						0.5					3.0	0.5
28	17	Weniger			3.14	S4	3	0.50	105,539	4.5						0.5					4.0	0.5
29	18	Bexell	0	Academic	0	Summary			58,600													
30	18	Bexell			75.13	URM	75	1.00	58,600	2.5						1.0					1.5	1.0
31	19	Rogers	0	Academic	0	Summary			55,341													

Table A-1: BLDGDATA Spreadsheet (Continued)

BLDGDATA -- Building Data

Building Index Code	Building Number	Building Name	Building Use Code	Building Use	Bldg Class Code	ATC-21 Class	ATC-13 Class	Sub-building Proportion Factor	Building Area (OSBHE Report) (sq ft)	ATC-21 Survey Results: BSH Score	Performance Modification Factors (PMF's): High Rise	Poor Condition	Vertical Irregularity	Soft Story	Torsion	Plan Irregularity	Pounding	Heavy Cladding	Short Columns	Post BM Year	Final Score	Sum of PMF's
32	19	Rogers			87.13	C1	87	0.50	27,671	4.0						0.5	0.5				3.0	1.0
33	19	Rogers			6.13	C2	6	0.50	27,671	4.0						0.5					3.5	0.5
34	20	Milne Computer Center	0	Academic	0	Summary			23,502													
35	20	Milne Computer Center			87.12	C1	87	0.50	11,751	4.0											4.0	0.0
36	20	Milne Computer Center			6.12	C2	6	0.50	11,751	4.0											4.0	0.0
37	21	Nash	0	Academic	0	Summary			105,456													
38	21	Nash			3.14	S4	3	1.00	105,456	4.5			1.0								3.5	1.0
39	22	Electric Comp Engr	0	Academic	0	Summary			63,167													
40	22	Electric Comp Engr			15.13	S1	15	0.50	31,584	3.5			0.5		2.0	0.5				2.0	2.5	1.0
41	22	Electric Comp Engr			3.13	S4	3	0.50	31,584	4.5			1.0		1.0	0.5				2.0	4.0	0.5
42	27	Benton	0	Academic	0	Summary			24,144													
43	27	Benton			1.12	W	1	1.00	24,144	8.5			0.5								8.0	0.5
44	28	Education Bldg	0	Academic	0	Summary			40,032													
45	28	Education Bldg			78.12	C3	78	0.50	20,016	3.0											3.0	0.0
46	28	Education Bldg			75.12	URM	75	0.50	20,016	2.5											2.5	0.0
47	30	Pharmacy	0	Academic	0	Summary			41,374													
48	30	Pharmacy, Original			75.12	URM	75	0.60	24,824	2.5	0.5		1.0			1.0					0.0	2.5
49	30	Pharmacy, Addition			6.12	C2	6	0.40	16,550	4.0			0.5			0.5					3.0	1.0
50	34	Kidder Hall	0	Academic	0	Summary			76,008													
51	34	Kidder Hall, Original			75.13	URM	75	0.70	53,206	2.5			1.0			1.0					0.5	2.0
52	34	Kidder Hall, Addition			87.13	C1	87	0.30	22,802	4.0			1.0			0.5					2.5	1.5
53	36	Kerr Library	0	Academic	0	Summary			188,087													
54	36	Kerr Library			15.14	S1	15	0.25	47,022	3.5			0.5								3.0	0.5
55	36	Kerr Library			3.14	S4	3	0.25	47,022	4.5			1.0								3.5	1.0
56	36	Kerr Library			82.24	PC2	82	0.5	94,044	3			1.0								1.5	1.0
57	37	Social Science	0	Academic	0	Summary			21,819													
58	37	Social Science			75.12	URM	75	1.00	21,819	2.5											2.5	0.0
59	38	Strand Agriculture	0	Academic	0	Summary			115,991													
60	38	Strand Agriculture			75.14	URM	75	1.00	115,991	2.5			1.0			1.0					0.5	2.0
61	53	McAlexander Total	0	Academic	0	Summary			57,713													
62	53	McAlexander Office			1.13	W	1	0.30	17,314	8.5			0.5			1.0					7.0	1.5

Table A-1: BLDGDATA Spreadsheet (Continued)

BLDGDATA -- Building Data

Building Index Code	Building Number	Building Name	Building Use Code	Building Use	Bldg Class Code	ATC-21 Class	ATC-13 Class	Sub-building Proportion Factor	Building Area (OSBHE Report) (sq ft)	ATC-21 Survey Results: BSH Score	Performance Modification Factors (PMF's): High Rise	Poor Condition	Vertical Irregularity	Soft Story	Torsion	Plan Irregularity	Pounding	Heavy Cladding	Short Columns	Post BM Year	Final Score	Sum of PMF's
63	53	McAlexander Office, Tot			0.5	Sub																
64	53	McAlexander Fieldhouse			2.13	S3	2	0.70	40,399	6.5			0.5			0.5					5.5	1.0
65	53	McAlexander Fieldhouse, To			0.5	Sub																
66	54	Indoor Target Range	0	Academic	0	Summary			4,174													
67	54	Indoor Target Range			75.11	URM	75	1.00	4,174	2.5		0.5									2.0	0.5
68	56	Phys Heating Plant	0	Academic	0	Summary			26,192													
69	56	Phys Heating Plant, Original			78.12	C3	78	0.50	13,096	3.0			1.0			0.5					1.5	1.5
70	56	Phys Heating Plant, Addition			2.12	S3	2	0.50	13,096	6.5			0.5			0.5					5.5	1.0
71	58	Industrial Bldg	0	Academic	0	Summary			18,834													
72	58	Industrial Bldg			1.12	W	1	0.30	5,650	8.5						1.0					7.5	1.0
73	58	Industrial Bldg			78.22	S5	78	0.70	13,184	3.0						0.5					2.5	0.5
74	60	Adams	0	Academic	0	Summary			11,573													
75	60	Adams			1.11	W	1	1.00	11,573	8.5			0.5			1.0				2.0	9.0	-0.5
76	61	Admin Services	0	Academic	0	Summary			139,078													
77	61	Admin Services, A			3.14	S4	3	0.13	17,385	4.5			1.0		1.0	0.5					2.0	2.5
78	61	Admin Services, A			78.24	S5	78	0.13	17,385	3.0			1.0		1.0	0.5					0.5	2.5
79	61	Admin Services, B			87.14	C1	87	0.13	17,385	4.0			0.5		1.0	0.5					2.0	2.0
80	61	Admin Services, B			6.14	C2	6	0.13	17,385	4.0			1.0		1.0	0.5					1.5	2.5
81	61	Admin Services, Overall			82.34	PC2	82	0.5	69,539	3			1		1	1					0.0	2.5
82	62	Plageman Bldg	1	Student Life	0	Summary			31,419													
83	62	Plageman Bldg			6.12	C2	6	1.00	31,419	4.0						0.5					3.5	0.5
84	67	Ballard Extension	0	Academic	0	Summary			46,011													
85	67	Ballard Extension			75.12	URM	75	1.00	46,011	2.5			1.0			1.0					0.5	2.0
86	68	Burt	0	Academic	0	Summary			54,909													
87	68	Burt			87.13	C1	87	0.50	27,455	4.0			1.0			0.5					2.5	1.5
88	68	Burt			6.13	C2	6	0.50	27,455	4.0			0.5			0.5					3.0	1.0
89	69	Family Study Center	0	Academic	0	Summary			17,588													
90	69	Family Study Center			15.12	S1	15	0.50	8,794	3.5			0.5			0.5				2.0	4.5	-1.0
91	69	Family Study Center			3.12	S4	3	0.50	8,794	4.5			1.0			0.5				2.0	5.0	-0.5
92	70	Wilkinson	0	Academic	0	Summary			60,635													
93	70	Wilkinson			3.13	S4	3	0.40	24,254	4.5					1.0						3.5	1.0

Table A-1: BLDGDATA Spreadsheet (Continued)

BLDGDATA -- Building Data

Building Index Code	Building Number	Building Name	Building Use Code	Building Use	Bldg Class Code	ATC-21 Class	ATC-13 Class	Sub-building Proportion Factor	Building Area (OSBHE Report) (sq ft)	ATC-21 Survey Results												
											Performance Modification Factors (PMF's)											
										BSH Score	High Rise	Poor Condition	Vertical Irregularity	Soft Story	Torsion	Plan Irregularity	Pounding	Heavy Cladding	Short Columns	Post BM Year	Final Score	Sum of PMF's
94	70	Wilkinson			87.13	C1	87	0.40	24,254	4.0					1.0						3.0	1.0
95	70	Wilkinson			6.13	C2	6	0.20	12,127	4.0					1.0						3.0	1.0
96	73	Cordley	0	Academic	0	Summary			236,227													
97	73	Cordley			87.14	C1	87	0.50	118,114	4.0			1.0			0.5					2.5	1.5
98	73	Cordley			6.14	C2	6	0.50	118,114	4.0			0.5			0.5					3.0	1.0
99	75	Withycombe	0	Academic	0	Summary			75,368													
100	75	Withycombe			87.13	C1	87	0.50	37,684	4.0			1.0		1.0	0.5					1.5	2.5
101	75	Withycombe			6.13	C2	6	0.50	37,684	4.0			0.5		1.0	0.5					2.0	2.0
102	79	Ag Sciences II	0	Academic	0	Summary			182,437													
103	79	Ag Sciences II			15.14	S1	15	0.25	45,609	3.5			0.5		2.0	0.5				2.0	2.5	1.0
104	79	Ag Sciences II			3.14	S4	3	0.25	45,609	4.5			1.0		1.0	0.5				2.0	4.0	0.5
105	79	Ag Sciences II			87.14	C1	87	0.25	45,609	4.0			1.0		1.0	0.5				2.0	3.5	0.5
106	79	Ag Sciences II			6.14	C2	6	0.25	45,609	4.0			0.5		1.0	0.5				2.0	4.0	0.0
107	80	Crop Science	0	Academic	0	Summary			58,116													
108	80	Crop Science			87.13	C1	87	0.50	29,058	4.0			1.0			0.5				2.0	4.5	-0.5
109	80	Crop Science			6.13	C2	6	0.50	29,058	4.0			0.5			0.5				2.0	5.0	-1.0
110	81	Milam Hall	0	Academic	0	Summary			109,698													
111	81	Milam Hall			75.14	URM	75	0.50	54,849	2.5			1.0			1.0					0.5	2.0
112	81	Milam Auditorium			87.14	C1	87	0.25	27,425	4.0			1.0			0.5					2.5	1.5
113	81	Milam Auditorium			6.14	C2	6	0.25	27,425	4.0			0.5			0.5					3.0	1.0
114	83	Memorial Union	1	Student Life	0	Summary			164,434													
115	83	Memorial Union			78.14	C3	78	1.00	164,434	3.0			1.0		1.0	0.5					0.5	2.5
116	84	Gilmore	0	Academic	0	Summary			16,188													
117	84	Gilmore			6.12	C2	6	0.30	4,856	4.0		0.5				0.5					3.0	1.0
118	84	Gilmore			78.12	C3	78	0.30	4,856	3.0		0.5				0.5					2.0	1.0
119	84	Gilmore			75.12	URM	75	0.40	6,475	2.5		0.5				1.0					1.0	1.5
120	86	Women's Bldg	0	Academic	0	Summary			87,486													
121	86	Women's Bldg			75.13	URM	75	1.00	87,486	2.5			1.0		1.0						0.5	2.0
122	87	Fairbanks	0	Academic	0	Summary			37,946													
123	87	Fairbanks			1.12	W	1	1.00	37,946	8.5		0.5	0.5			1.0					6.5	2.0
124	88	Clark Lab	0	Academic	0	Summary			7,989													

Table A-1: BLDGDATA Spreadsheet (Continued)

BLDGDATA -- Building Data

										ATC-21 Survey Results												
											Performance Modification Factors (PMF's)											
Building Index Code	Building Number	Building Name	Building Use Code	Building Use	Bldg Class Code	ATC-21 Class	ATC-13 Class	Sub-building Proportion Factor	Building Area (OSBHE Report) (sq ft)	BSH Score	High Rise	Poor Condition	Vertical Irregularity	Soft Story	Torsion	Plan Irregularity	Pounding	Heavy Cladding	Short Columns	Post BM Year	Final Score	Sum of PMF's
125	88	Clark Lab			9.11	RM	9	1.00	7,989	4.0			0.5			1.0					2.5	1.5
126	92	Computer Science	0	Academic	0	Summary			15,364													
127	92	Computer Science			75.12	URM	75	1.00	15,364	2.5		0.5	1.0								1.0	1.5
128	96	Sackett	1	Student Life	0	Summary			142,272													
129	96	Sackett			6.14	C2	6	1.00	142,272	4.0			0.5			0.5					3.0	1.0
130	98	Radiation Center, Overall	0	Academic	0	Summary			47,689													
131	98	Rad Center, Main Bldg			6.12	C2	6	0.20	9,538	4.0			0.5		1.0	0.5					2.0	2.0
132	98	Rad Center, Main Bldg			78.12	C3	78	0.15	7,153	3.0			1.0		1.0	0.5					0.5	2.5
133	98	Rad Center, Reactor Bldg			87.12	C1	87	0.20	9,538	4.0			1.0		1.0	0.5					1.5	2.5
134	98	Rad Center, Reactor Bldg			3.12	S4	3	0.20	9,538	4.5			1.0		1.0	0.5					2.0	2.5
135	98	Rad Center, Reactor Bldg			15.12	S1	15	0.20	9,538	3.5			0.5		2.0	0.5					0.5	3.0
136	98	Radiation Center, Annex			1.12	W	1	0.05	2,384	8.5						1.0				2.0	9.5	-1.0
137	100	Snell	0	Academic	0	Summary			107,213													
138	100	Snell, Original			78.24	S5	78	0.20	21,443	3.0			1.0			0.5					1.5	1.5
139	100	Snell, Original			87.14	C1	87	0.20	21,443	4.0			1.0			0.5					2.5	1.5
140	100	Snell, Original			6.14	C2	6	0.20	21,443	4.0			0.5			0.5					3.0	1.0
141	100	Snell, Addition			87.14	C1	87	0.20	21,443	4.0			1.0			0.5					2.5	1.5
142	100	Snell, Addition			6.14	C2	6	0.20	21,443	4.0			0.5			0.5					3.0	1.0
143	102	Waldo	0	Academic	0	Summary			73,704													
144	102	Waldo			1.13	W	1	1.00	73,704	8.5			0.5			1.0					7.0	1.5
145	105	Langton	0	Academic	0	Summary			96,322													
146	105	Langton			78.23	S5	78	0.50	48,161	3.0			1.0			0.5					1.5	1.5
147	105	Langton			75.13	URM	75	0.50	48,161	2.5			1.0			1.0					0.5	2.0
148	106	Moreland	0	Academic	0	Summary			28,380													
149	106	Moreland			75.12	URM	75	1.00	28,380	2.5											2.5	0.0
150	109	Weatherford	1	Student Life	0	Summary			105,090													
151	109	Weatherford			6.14	C2	6	1.00	105,090	4.0			0.5			0.5					3.0	1.0
152	111	Buxton	1	Student Life	0	Summary			61,488													
153	111	Buxton			9.23	RM	9	0.50	30,744	4.0					1.0	1.0					2.0	2.0
154	111	Buxton			82.13	PC2	82	0.50	30,744	2.5					1.0	1.0					0.5	2.0
155	112	Poling	1	Student Life	0	Summary			57,658													

Table A-1: BLDGDATA Spreadsheet (Continued)

BLDGDATA -- Building Data

Building Index Code	Building Number	Building Name	Building Use Code	Building Use	Bldg Class Code	ATC-21 Class	ATC-13 Class	Sub-building Proportion Factor	Building Area (OSBHE Report) (sq ft)	ATC-21 Survey Results: BSH Score	PMF's: High Rise	PMF's: Poor Condition	PMF's: Vertical Irregularity	PMF's: Soft Story	PMF's: Torsion	PMF's: Plan Irregularity	PMF's: Pounding	PMF's: Heavy Cladding	PMF's: Short Columns	PMF's: Post BM Year	Final Score	Sum of PMF's
156	112	Poling			9.23	RM	9	0.50	28,829	4.0					1.0	1.0					2.0	2.0
157	112	Poling			82.13	PC2	82	0.50	28,829	2.5					1.0	1.0					0.5	2.0
158	114	Cauthorn	1	Student Life	0	Summary			58,397													
159	114	Cauthorn			9.23	RM	9	0.50	29,199	4.0					1.0	1.0					2.0	2.0
160	114	Cauthorn			82.13	PC2	82	0.50	29,199	2.5					1.0	1.0					0.5	2.0
161	115	West International	1	Student Life	0	Summary			62,270													
162	115	West International			9.23	RM	9	0.50	31,135	4.0					1.0	1.0					2.0	2.0
163	115	West International			82.13	PC2	82	0.50	31,135	2.5					1.0	1.0					0.5	2.0
164	119	Hawley	1	Student Life	0	Summary			58,558													
165	119	Hawley			9.23	RM	9	0.50	29,279	4.0					1.0	1.0					2.0	2.0
166	119	Hawley			82.13	PC2	82	0.50	29,279	2.5					1.0	1.0					0.5	2.0
167	120	Parker Stadium, Overall	0	Academic	0	Summary																
168	120	P Stadium, Bleachers			15.12	S1	15	0.50	44,924	3.5			0.5								3.0	0.5
169	120	P Stadium, Bleachers			2.12	S3	2	0.50	44,924	6.5			0.5								6.0	0.5
170	120	P Stadium, Bleachers Tot			0.5	Sub			89,847													
171	120	P Stadium, Pressbox			15.12	S1	15	1.00	29,949	3.5			0.5		2.0					2.0	3.0	0.5
172	120	P Stadium, Pressbox Tot			0.5	Sub			29,949													
173	121	Gill Coliseum	0	Academic	0	Summary			218,262													
174	121	Gill Coliseum (all but ramps)			3.14	S4	3	0.90	196,436	4.5			1.0								3.5	1.0
175	121	Gill Coliseum (ramps)			87.14	C1	87	0.05	10,913	4.0			1.0								3.0	1.0
176	121	Gill Coliseum (ramps)			6.14	C2	6	0.05	10,913	4.0			0.5								3.5	0.5
177	124	Peavy	0	Academic	0	Summary			84,020													
178	124	Peavy			1.13	W	1	1.00	84,020	8.5			0.5		1.0					2.0	9.0	-0.5
179	128	Wiegand	0	Academic	0	Summary			57,957													
180	128	Wiegand			87.13	C1	87	0.50	28,979	4.0			1.0								3.0	1.0
181	128	Wiegand			6.13	C2	6	0.50	28,979	4.0			0.5								3.5	0.5
182	143	Parker Stadium, Clubhouse	0	Academic	0	Summary			15,858													
183	143	Parker Stadium, Clubhouse			3.12	S4	3	0.50	7,929	4.5			1.0		1.0					2.0	4.5	0.0
184	143	Parker Stadium, Clubhouse			9.13	RM	9	0.50	7,929	4.0			0.5		1.0					2.0	4.5	-0.5
185	145	Dixon Rec Center	1	Student Life	0	Summary			92,951													
186	145	Dixon Rec Center			9.13	RM	9	1.00	92,951	4.0			0.5		1.0	1.0					1.5	2.5

Table A-1: BLDGDATA Spreadsheet (Continued)

BLDGDATA -- Building Data

Building Index Code	Building Number	Building Name	Building Use Code	Building Use	Bldg Class Code	ATC-21 Class	ATC-13 Class	Sub-building Proportion Factor	Building Area (OSBHE Report) (sq ft)	ATC-21 Survey Results: BSH Score	Performance Modification Factors (PMF's): High Rise	Poor Condition	Vertical Irregularity	Soft Story	Torsion	Plan Irregularity	Pounding	Heavy Cladding	Short Columns	Post BM Year	Final Score	Sum of PMF's
187	151	Dryden	0	Academic	0	Summary			23,019													
188	151	Dryden			75.12	URM	75	1.00	23,019	2.5						1.0					1.5	1.0
189	153	Magruder	0	Academic	0	Summary			76,115													
190	153	Magruder			15.13	S1	15	0.50	38,058	3.5			0.5			0.5				2.0	4.5	-1.0
191	153	Magruder			3.13	S4	3	0.50	38,058	4.5			1.0			0.5				2.0	5.0	-0.5
192	188	Childcare Center	0	Academic	0	Summary			9,590													
193	188	Childcare Center			87.11	C1	87	0.50	4,795	4.0						0.5				2.0	5.5	-1.5
194	188	Childcare Center			6.11	C2	6	0.50	4,795	4.0						0.5				2.0	5.5	-1.5
195	190	McNary	1	Student Life	0	Summary			72,594													
196	190	McNary			9.23	RM	9	0.50	36,297	4.0					1.0	1.0					2.0	2.0
197	190	McNary			82.13	PC2	82	0.50	36,297	2.5					1.0	1.0					0.5	2.0
198	191	Wilson	1	Student Life	0	Summary			73,105													
199	191	Wilson			9.23	RM	9	0.50	36,553	4.0					1.0	1.0					2.0	2.0
200	191	Wilson			82.13	PC2	82	0.50	36,553	2.5					1.0	1.0					0.5	2.0
201	192	Callahan	1	Student Life	0	Summary			72,698													
202	192	Callahan			9.23	RM	9	0.50	36,349	4.0					1.0	1.0					2.0	2.0
203	192	Callahan			82.13	PC2	82	0.50	36,349	2.5					1.0	1.0					0.5	2.0
204	196	Finley	1	Student Life	0	Summary			84,751													
205	196	Finley			6.13	C2	6	0.50	42,376	4.0					1.0	0.5					2.5	1.5
206	196	Finley			82.43	PC2	82	0.50	42,376	2.5					1.0	0.5					1.0	1.5
207	198	Bloss	1	Student Life	0	Summary			84,755													
208	198	Bloss			6.13	C2	6	0.50	42,378	4.0					1.0	0.5					2.5	1.5
209	198	Bloss			82.43	PC2	82	0.50	42,378	2.5					1.0	0.5					1.0	1.5
210	199	College Inn	1	Student Life	0	Summary			120,000													
211	199	College Inn			6.13	C2	6	1.00	120,000	4.0				2.0		0.5					1.5	2.5
212	200	Lasells Stewart Center	0	Academic	0	Summary			43,211													
213	200	LSC			87.12	C1	87	0.30	12,963	4.0			1.0		0.5	0.5					2.0	2.0
214	200	LSC			6.12	C2	6	0.30	12,963	4.0			1		1.0	1					2.0	2.0
215	200	LSC Auditorium			9.12	RM	9	0.40	17,284	4.0			0.5		1.0	1.0				2.0	3.5	0.5
216	807	Oceanography	0	Academic	0	Summary			8,283													
217	807	Oceanography			1.11	W	1	1.00	8,283	8.5			0.5		1.0	1.0				2.0	8.0	0.5

Table A-2: OCCUPANCY Spreadsheet

OCCUPANCY -- Building Occupancy Data

Bldg Index Code	Building Number	Building Name	Budgets and Planning: Faculty	Staff	Student Workers	Non-employed Grad Students	Classroom Capacity	Average Daily Classroom Occ	Housing: Average Residents	Maximum Capacity	Other Sources: Ave Day Occupants	Max Day Occupants	Source Note	Subtotals: Average Day	Average Night	Maximum Day	Maximum Night	Totals to Use: Average (Day & Night)	Maximum (Day or Night)
1	1	Apperson	30	8	8	27	295	117						190	0	368	0	95	368
2	1	Apperson																	
3	2	Merryfield	27	6	4	0	30	0						37	0	67	0	19	67
4	2	Merryfield																	
5	6	Graf	17	1	0	14	0	2						34	0	32	0	17	32
6	6	Graf																	
7	6	Graf																	
8	7	Covell	29	15	4	0	278	110						158	0	326	0	79	326
9	7	Covell																	
10	9	Batcheller	55	8	9	8	98	33						113	0	178	0	57	178
11	9	Batcheller																	
12	11	Dearborn	84	6	2	9	266	81						182	0	367	0	91	367
13	11	Dearborn																	
14	11	Dearborn																	
15	12	Gilbert Addition	0	4	0	0	100	70						74	0	104	0	37	104
16	12	Gilbert Addition																	
17	12	Gilbert Addition																	
18	14	Shepard	32	3	0	0	90	45						80	0	125	0	40	125
19	14	Shepard																	
20	15	Gilbert	132	16	2	7	494	183						340	0	651	0	170	651
21	15	Gilbert																	
22	15	Gilbert																	
23	16	Gleeson	38	7	1	10	125	49						96	0	181	0	48	181
24	16	Gleeson																	
25	16	Gleeson																	
26	17	Weniger	226	12	3	32	763	414						687	0	1,036	0	344	1,036
27	17	Weniger																	
28	17	Weniger																	
29	18	Bexell	73	16	10	4	869	326						429	0	972	0	215	972
30	18	Bexell																	
31	19	Rogers	58	5	1	3	231	46						113	0	298	0	57	298
32	19	Rogers																	
33	19	Rogers																	

Table A-2: OCCUPANCY Spreadsheet (Continued)

OCCUPANCY -- Building Occupancy Data

			Budgets and Planning						Housing		Other Sources			Subtotals				Totals to Use	
Bldg Index Code	Building Number	Building Name	Faculty	Staff	Student Workers	Non-employed Grad Students	Classroom Capacity	Average Daily Classroom Occ	Average Residents	Maximum Capacity	Ave Day Occupants	Max Day Occupants	Source Note	Average Day	Average Night	Maximum Day	Maximum Night	Average (Day & Night)	Maximum (Day or Night)
34	20	Milne Computer Center	6	35	0	0	60	11						52	0	101	0	26	101
35	20	Milne Computer Center																	
36	20	Milne Computer Center																	
37	21	Nash	157	15	1	2	177	85						260	0	352	0	130	352
38	21	Nash																	
39	22	Electric Comp Engr	45	6	0	0	323	140						191	0	374	0	96	374
40	22	Electric Comp Engr																	
41	22	Electric Comp Engr																	
42	27	Benton	18	5	0	0	0	17				277	4	40	0	300	0	20	300
43	27	Benton																	
44	28	Education Bldg	58	16	1	0	354	86						161	0	429	0	81	429
45	28	Education Bldg																	
46	28	Education Bldg																	
47	30	Pharmacy	41	6	2	10	154	68						127	0	213	0	64	213
48	30	Pharmacy, Original																	
49	30	Pharmacy, Addition																	
50	34	Kidder Hall	182	28	0	5	569	268						483	0	784	0	242	784
51	34	Kidder Hall, Original																	
52	34	Kidder Hall, Addition																	
53	36	Kerr Library	31	30	0	0	0	18			421	1,439	3	500	0	1,500	0	250	1,500
54	36	Kerr Library																	
55	36	Kerr Library																	
56	36	Kerr Library																	
57	37	Social Science	35	12	0	0	207	92						139	0	254	0	70	254
58	37	Social Science																	
59	38	Strand Agriculture	113	21	6	14	797	248						402	0	951	0	201	951
60	38	Strand Agriculture																	
61	53	McAlexander Total																	
62	53	McAlexander Office																	
63	53	McAlexander Office, Tot	6	1	0	0	60	40				23	18	47	0	90	0	24	90
64	53	McAlexander Fieldhouse																	
65	53	McAlexander Fieldhouse, Tot	0	0	0	0	0	0			40	500	10	40	0	500	0	20	500
66	54	Indoor Target Range	0	0	0	0	0	0			10	30	5	10	0	30	0	5	30

Table A-2: OCCUPANCY Spreadsheet (Continued)

OCCUPANCY -- Building Occupancy Data

Bldg Index Code	Building Number	Building Name	Budgets and Planning: Faculty	Staff	Student Workers	Non-employed Grad Students	Classroom Capacity	Average Daily Classroom Occ	Housing: Average Residents	Maximum Capacity	Other Sources: Ave Day Occupants	Max Day Occupants	Source Note	Subtotals: Average Day	Average Night	Maximum Day	Maximum Night	Totals to Use: Average (Day & Night)	Maximum (Day or Night)
67	54	Indoor Target Range																	
68	56	Phys Heating Plant	0	6	0	0	0	0						6	0	6	0	3	6
69	56	Phys Heating Plant, Original																	
70	56	Phys Heating Plant, Addition																	
71	58	Industrial Bldg	0	0	0	0	0	13			22	104	6	35	0	104	0	18	104
72	58	Industrial Bldg																	
73	58	Industrial Bldg																	
74	60	Adams	2	27	2	0	0	0						31	0	31	0	16	31
75	60	Adams																	
76	61	Admin Services	82	297	12	4	0	2						397	0	395	0	199	395
77	61	Admin Services, A																	
78	61	Admin Services, A																	
79	61	Admin Services, B																	
80	61	Admin Services, B																	
81	61	Admin Services, Overall																	
82	62	Plageman Bldg	17	42	4	0	0	0			2	137	7	65	0	200	0	33	200
83	62	Plageman Bldg																	
84	67	Ballard Extension	105	43	1	9	0	1						159	0	158	0	80	158
85	67	Ballard Extension																	
86	68	Burt	145	7	0	3	60	1						156	0	215	0	78	215
87	68	Burt																	
88	68	Burt																	
89	69	Family Study Center	6	1	0	0	46	0			72	77	8	79	0	130	0	40	130
90	69	Family Study Center																	
91	69	Family Study Center																	
92	70	Wilkinson	68	5	0	20	356	252						345	0	449	0	173	449
93	70	Wilkinson																	
94	70	Wilkinson																	
95	70	Wilkinson																	
96	73	Cordley	266	24	11	30	1,370	303						634	0	1,701	0	317	1,701
97	73	Cordley																	
98	73	Cordley																	
99	75	Withycombe	67	10	2	1	105	145						225	0	185	0	113	185

Table A-2: OCCUPANCY Spreadsheet (Continued)

OCCUPANCY -- Building Occupancy Data

Bldg Index Code	Building Number	Building Name	Budgets and Planning						Housing		Other Sources			Subtotals				Totals to Use	
			Faculty	Staff	Student Workers	Non-employed Grad Students	Classroom Capacity	Average Daily Classroom Occ	Average Residents	Maximum Capacity	Ave Day Occupants	Max Day Occupants	Source Note	Average Day	Average Night	Maximum Day	Maximum Night	Average (Day & Night)	Maximum (Day or Night)
100	75	Withycombe																	
101	75	Withycombe																	
102	79	Ag Sciences II	272	32	2	10	0	36						352	0	316	0	176	316
103	79	Ag Sciences II																	
104	79	Ag Sciences II																	
105	79	Ag Sciences II																	
106	79	Ag Sciences II																	
107	80	Crop Science	81	14	1	12	50	21						129	0	158	0	65	158
108	80	Crop Science																	
109	80	Crop Science																	
110	81	Milam Hall	105	19	3	1	1,336	406						534	0	1,464	0	267	1,464
111	81	Milam Hall																	
112	81	Milam Auditorium																	
113	81	Milam Auditorium																	
114	83	Memorial Union	7	27	3	0	0	4			333	1,573	9	374	0	1,610	0	187	1,610
115	83	Memorial Union																	
116	84	Gilmore	43	3	0	3	30	3						52	0	79	0	26	79
117	84	Gilmore																	
118	84	Gilmore																	
119	84	Gilmore																	
120	86	Women's Bldg	30	7	0	0	40	88				457	11	125	0	534	0	63	534
121	86	Women's Bldg																	
122	87	Fairbanks	34	5	1	0	254	64						104	0	294	0	52	294
123	87	Fairbanks																	
124	88	Clark Lab	1	0	0	0	0	1			13	29	12	15	0	30	0	8	30
125	88	Clark Lab																	
126	92	Computer Science	31	2	2	17	40	19						71	0	92	0	36	92
127	92	Computer Science																	
128	96	Sackett	0	0	0	0		0	237	237				119	237	119	237	178	237
129	96	Sackett																	
130	98	Radiation Center, Overall	47	14	0	9	0	9				10	13	79	0	80	0	40	80
131	98	Rad Center, Main Bldg																	
132	98	Rad Center, Main Bldg																	

Table A-2: OCCUPANCY Spreadsheet (Continued)

OCCUPANCY -- Building Occupancy Data

			Budgets and Planning						Housing		Other Sources			Subtotals				Totals to Use	
Bldg Index Code	Building Number	Building Name	Faculty	Staff	Student Workers	Non-employed Grad Students	Classroom Capacity	Average Daily Classroom Occ	Average Residents	Maximum Capacity	Ave Day Occupants	Max Day Occupants	Source Note	Average Day	Average Night	Maximum Day	Maximum Night	Average (Day & Night)	Maximum (Day or Night)
133	98	Rad Center, Reactor Bldg																	
134	98	Rad Center, Reactor Bldg																	
135	98	Rad Center, Reactor Bldg																	
136	98	Radiation Center, Annex																	
137	100	Snell	64	86	9	1	49	0						160	0	209	0	80	209
138	100	Snell, Original																	
139	100	Snell, Original																	
140	100	Snell, Original																	
141	100	Snell, Addition																	
142	100	Snell, Addition																	
143	102	Waldo	76	23	1	18	41	29						147	0	159	0	74	159
144	102	Waldo																	
145	105	Langton	59	8	0	0	90	89				450	14	156	0	607	0	78	607
146	105	Langton																	
147	105	Langton																	
148	106	Moreland	72	6	0	0	215	152						230	0	293	0	115	293
149	106	Moreland																	
150	109	Weatherford	0	0	0	0		0	0	0				0	0	0	0	0	0
151	109	Weatherford																	
152	111	Buxton	0	0	0	0		0	224	307				112	224	154	307	168	307
153	111	Buxton																	
154	111	Buxton																	
155	112	Poling	0	0	0	0		0	143	165				72	143	83	165	107	165
156	112	Poling																	
157	112	Poling																	
158	114	Cauthorn	0	0	0	0		0	257	296				129	257	148	296	193	296
159	114	Cauthorn																	
160	114	Cauthorn																	
161	115	West International	0	0	0	0		0	154	242				77	154	121	242	116	242
162	115	West International																	
163	115	West International																	
164	119	Hawley	0	0	0	0		0	90	124				45	90	62	124	68	124
165	119	Hawley																	

Table A-2: OCCUPANCY Spreadsheet (Continued)

OCCUPANCY -- Building Occupancy Data

			Budgets and Planning						Housing		Other Sources			Subtotals				Totals to Use	
Bldg Index Code	Building Number	Building Name	Faculty	Staff	Student Workers	Non-employed Grad Students	Classroom Capacity	Average Daily Classroom Occ	Average Residents	Maximum Capacity	Ave Day Occupants	Max Day Occupants	Source Note	Average Day	Average Night	Maximum Day	Maximum Night	Average (Day & Night)	Maximum (Day or Night)
166	119	Hawley																	
167	120	Parker Stadium, Overall																	
168	120	P Stadium, Bleachers																	
169	120	P Stadium, Bleachers																	
170	120	P Stadium, Bleachers Tot	0	0	0	0	0	0			0	35,000	15	0	0	35,000	0	0	35,000
171	120	P Stadium, Pressbox																	
172	120	P Stadium, Pressbox Tot	0	0	0	0	0	0			0	525	15	0	0	525	0	0	525
173	121	Gill Coliseum	23	82	7	0	0	5				10,500	15	117	0	10,612	0	59	10,612
174	121	Gill Coliseum (all but ramps)																	
175	121	Gill Coliseum (ramps)																	
176	121	Gill Coliseum (ramps)																	
177	124	Peavy	131	31	0	20	276	200						382	0	458	0	191	458
178	124	Peavy																	
179	128	Wiegand	44	10	0	22	341	107						183	0	417	0	92	417
180	128	Wiegand																	
181	128	Wiegand																	
182	143	Parker Stadium, Clubhouse	0	0	0	0		0				250	15	0	0	250	0	0	250
183	143	Parker Stadium, Clubhouse																	
184	143	Parker Stadium, Clubhouse																	
185	145	Dixon Rec Center	6	1	1	0	0	3			114	300	2	125	0	308	0	63	308
186	145	Dixon Rec Center																	
187	151	Dryden	30	2	0	9	50	0						41	0	91	0	21	91
188	151	Dryden																	
189	153	Magruder	31	21	0	0	80	28						80	0	132	0	40	132
190	153	Magruder																	
191	153	Magruder																	
192	188	Childcare Center	0	0	0	0		0			150	174	16	150	0	174	0	75	174
193	188	Childcare Center																	
194	188	Childcare Center																	
195	190	McNary	0	0	0	0		0	278	327				139	278	164	327	209	327
196	190	McNary																	
197	190	McNary																	
198	191	Wilson	0	0	0	0		0	287	287				144	287	144	287	215	287

Table A-2: OCCUPANCY Spreadsheet (Continued)

OCCUPANCY -- Building Occupancy Data

Bldg Index Code	Building Number	Building Name	Budgets and Planning: Faculty	Staff	Student Workers	Non-employed Grad Students	Classroom Capacity	Average Daily Classroom Occ	Housing: Average Residents	Maximum Capacity	Other Sources: Ave Day Occupants	Max Day Occupants	Source Note	Subtotals: Average Day	Average Night	Maximum Day	Maximum Night	Totals to Use: Average (Day & Night)	Maximum (Day or Night)
199	191	Wilson																	
200	191	Wilson																	
201	192	Callahan	0	0	0	0		0	315	355				158	315	178	355	236	355
202	192	Callahan																	
203	192	Callahan																	
204	196	Finley	0	0	0	0		0	323	359				162	323	180	359	242	359
205	196	Finley																	
206	196	Finley																	
207	198	Bloss	0	0	0	0		0	252	316				126	252	158	316	189	316
208	198	Bloss																	
209	198	Bloss																	
210	199	College Inn	0	0	0	0		0	300	405			1	150	300	203	405	225	405
211	199	College Inn																	
212	200	Lasells Stewart Center	1	4	0	0	0	0			300	1,740	17	305	0	1,745	0	153	1,745
213	200	LSC																	
214	200	LSC																	
215	200	LSC Auditorium																	
216	807	Oceanography	2	13	0	0	0	0						15	0	15	0	8	15
217	807	Oceanography																	
		Institution Totals:												12,473	2,860	71,519	3,420	7,666	73,229

Table A-3: Reference Notes for Other Sources of Occupancy Data

Note Number	Building	Source Notes
1	College Inn	Ilene Zelich, phonecon (737-4100), 8/28/95
2	Dixon Rec Center	Tom Kirtch, phonecon (737-3736), 9/20/95
3	Kerr Library	Kayrle Butcher, phonecon (737-3331), 9/18/95
4	Benton Hall	Sara Schreiber, phonecon (737-5590), 9/20/95
5	Indoor Target Range	Major Hogue, phonecon (737-5608), 9/18/95
6	Industrial Building	David Hardesty, phonecon (737-5004), 9/18/95
7	Plageman	Alison Lake, phonecon (737-3106), 9/19/95
8	Bates Hall	Joann Sorte, phonecon (737-2516), 9/22/95
9	Memorial Union	Mike Henthome, phonecon (737-6256), 9/22/95; and calculations from building area and ATC- 13 estimates for occupancy based on building use
10	McAlexander Fieldhouse	Tom Kirtch, phonecon (737-3736),9/20/95
11	Women's Building	estimate for recreational use based on net recreational area and ATC- 13 occupancy estimates based on building use
12	Clark Lab	Bob Dixon, phonecon (737-3414), 9/18/95
13	Radiation Center	Jack Higginbotham, phonecon (737-7046), 9/20/95
14	Langton Hall	estimate for recreational use based on net recreational area and ATC- 13 occupancy estimates based on building use
15	Parker & Gill	George Goracke, phonecon (737-2136), 9/20/95
16	Childcare Center	Nancy Eller, phonecon (737-4640), 9/19/95
17	Lasells Stewart Center	Lydia Perry, phonecon (737-6444), 9/18/95
18	McAlexander Office	Greg High, phonecon (737-3 5 11), 9/20/95

Table A-4: COSTDATA Spreadsheet

COSTDATA -- Summary of Seismic Rehabilitation Cost Estimates

							Cost Estimates ($/sq ft):			
Building Structural System	Distinguishing Features	Building Class Code	ATC-21 Class	ATC-13 Class	Portland Study Building Class	Building Area (square feet)	OSU Conceptual Designs (Structural Only)	Portland Study (Total Upgrade)	Portland Study (Structural Only)	Portland Study (Nonstructural Only)
Concrete Moment Resisting Frame		87.11	C1	87	4S	under 10,000		44.65	31.65	13.00
Concrete Moment Resisting Frame		87.12	C1	87	4M	10,000 - 49,999		43.96	30.96	13.00
Concrete Moment Resisting Frame		87.13	C1	87	4L	50,000 - 99,999		42.80	29.80	13.00
Concrete Moment Resisting Frame		87.14	C1	87	4VL	over 100,000		38.86	25.86	13.00
Concrete Shear Wall		6.11	C2	6	8S	under 10,000		44.33	31.33	13.00
Concrete Shear Wall		6.12	C2	6	8M	10,000 - 49,999		43.73	30.73	13.00
Concrete Shear Wall		6.13	C2	6	8L	50,000 - 99,999		42.52	29.52	13.00
Concrete Shear Wall		6.14	C2	6	8VL	over 100,000		38.73	25.73	13.00
Concrete Frame with URM Infill		78.11	C3	78	4S	under 10,000		44.65	31.65	13.00
Concrete Frame with URM Infill		78.12	C3	78	4M	10,000 - 49,999		43.96	30.96	13.00
Concrete Frame with URM Infill		78.13	C3	78	4L	50,000 - 99,999		42.80	29.80	13.00
Concrete Frame with URM Infill		78.14	C3	78	4VL	over 100,000		38.86	25.86	13.00
Concrete Tilt-up		21.11	PC1	21	3S	under 10,000		19.05	13.55	5.50
Concrete Tilt-up		21.12	PC1	21	3M	10,000 - 49,999		17.43	11.93	5.50
Concrete Tilt-up		21.13	PC1	21	3L	50,000 - 99,999		15.15	9.65	5.50
Concrete Tilt-up		21.14	PC1	21	3VL	over 100,000		13.85	8.35	5.50
Precast Concrete/Lift Slab	Secondary	82.11	PC2	82	8S	under 10,000	10.88	44.33	31.33	13.00
Precast Concrete/Lift Slab	Class:	82.12	PC2	82	8M	10,000 - 49,999	10.88	43.73	30.73	13.00
Precast Concrete/Lift Slab	RM	82.13	PC2	82	8L	50,000 - 99,999	10.88	42.52	29.52	13.00
Precast Concrete/Lift Slab		82.14	PC2	82	8VL	over 100,000	10.88	38.73	25.73	13.00
Precast Concrete/Lift Slab	Secondary	82.21	PC2	82	8S	under 10,000	24.26	44.33	31.33	13.00
Precast Concrete/Lift Slab	Classes:	82.22	PC2	82	8M	10,000 - 49,999	24.26	43.73	30.73	13.00
Precast Concrete/Lift Slab	S1, S4	82.23	PC2	82	8L	50,000 - 99,999	24.26	42.52	29.52	13.00
Precast Concrete/Lift Slab		82.24	PC2	82	8VL	over 100,000	24.26	38.73	25.73	13.00

Table A-4: COSTDATA Spreadsheet (Continued)

COSTDATA -- Summary of Seismic Rehabilitation Cost Estimates

							Cost Estimates ($/sq ft):			
Building Structural System	Distinguishing Features	Building Class Code	ATC-21 Class	ATC-13 Class	Portland Study Building Class	Building Area (square feet)	OSU Conceptual Designs (Structural Only)	Portland Study (Total Upgrade)	Portland Study (Structural Only)	Portland Study (Nonstructural Only)
Precast Concrete/Lift Slab	Secondary	82.31	PC2	82	8S	under 10,000	7.39	44.33	31.33	13.00
Precast Concrete/Lift Slab	Classes:	82.32	PC2	82	8M	10,000 - 49,999	7.39	43.73	30.73	13.00
Precast Concrete/Lift Slab	C1, C2, S4	82.33	PC2	82	8L	50,000 - 99,999	7.39	42.52	29.52	13.00
Precast Concrete/Lift Slab		82.34	PC2	82	8VL	over 100,000	7.39	38.73	25.73	13.00
Precast Concrete/Lift Slab	Secondary	82.41	PC2	82	8S	under 10,000	14.18	44.33	31.33	13.00
Precast Concrete/Lift Slab	Classes:	82.42	PC2	82	8M	10,000 - 49,999	14.18	43.73	30.73	13.00
Precast Concrete/Lift Slab	not	82.43	PC2	82	8L	50,000 - 99,999	14.18	42.52	29.52	13.00
Precast Concrete/Lift Slab	specified	82.44	PC2	82	8VL	over 100,000	14.18	38.73	25.73	13.00
Reinforced Masonry	RM1: Wood	9.11	RM	9	3S	under 10,000		19.05	13.55	5.50
Reinforced Masonry	or Metal	9.12	RM	9	3M	10,000 - 49,999		17.43	11.93	5.50
Reinforced Masonry	Deck	9.13	RM	9	3L	50,000 - 99,999		15.15	9.65	5.50
Reinforced Masonry	Diaphragm	9.14	RM	9	3VL	over 100,000		13.85	8.35	5.50
Reinforced Masonry	RM2:	9.21	RM	9	8S	under 10,000		44.33	31.33	13.00
Reinforced Masonry	Concrete	9.22	RM	9	8M	10,000 - 49,999		43.73	30.73	13.00
Reinforced Masonry	Deck	9.23	RM	9	8L	50,000 - 99,999		42.52	29.52	13.00
Reinforced Masonry	Diaphragm	9.24	RM	9	8VL	over 100,000		38.73	25.73	13.00
Steel Moment Resisting Frame		15.11	S1	15	5S	under 10,000		44.71	31.71	13.00
Steel Moment Resisting Frame		15.12	S1	15	5M	10,000 - 49,999		44.28	31.28	13.00
Steel Moment Resisting Frame		15.13	S1	15	5L	50,000 - 99,999		43.19	30.19	13.00
Steel Moment Resisting Frame		15.14	S1	15	5VL	over 100,000		37.51	24.51	13.00
Braced Steel Frame		12.11	S2	12	6S	under 10,000		29.27	16.27	13.00
Braced Steel Frame		12.12	S2	12	6M	10,000 - 49,999		28.77	15.77	13.00
Braced Steel Frame		12.13	S2	12	6L	50,000 - 99,999		26.93	13.93	13.00
Braced Steel Frame		12.14	S2	12	6VL	over 100,000		23.66	10.66	13.00

Table A-4: COSTDATA Spreadsheet (Continued)

COSTDATA -- Summary of Seismic Rehabilitation Cost Estimates

							Cost Estimates ($/sq ft):			
Building Structural System	**Distinguishing Features**	**Building Class Code**	**ATC-21 Class**	**ATC-13 Class**	**Portland Study Building Class**	**Building Area (square feet)**	**OSU Conceptual Designs (Structural Only)**	**Portland Study (Total Upgrade)**	**Portland Study (Structural Only)**	**Portland Study (Nonstructural Only)**
Light Metal Buildings		2.11	S3	2	6S	under 10,000		29.27	16.27	13.00
Light Metal Buildings		2.12	S3	2	6M	10,000 - 49,999		28.77	15.77	13.00
Light Metal Buildings		2.13	S3	2	6L	50,000 - 99,999		26.93	13.93	13.00
Light Metal Buildings		2.14	S3	2	6VL	over 100,000		23.66	10.66	13.00
Steel Frame w/ Concrete Shear Wall		3.11	S4	3	8S	under 10,000		44.33	31.33	13.00
Steel Frame w/ Concrete Shear Wall		3.12	S4	3	8M	10,000 - 49,999		43.73	30.73	13.00
Steel Frame w/ Concrete Shear Wall		3.13	S4	3	8L	50,000 - 99,999		42.52	29.52	13.00
Steel Frame w/ Concrete Shear Wall		3.14	S4	3	8VL	over 100,000		38.73	25.73	13.00
Steel Frame with URM Infill		78.21	S5	78	7S	under 10,000		48.29	35.29	13.00
Steel Frame with URM Infill		78.22	S5	78	7M	10,000 - 49,999		48.01	35.01	13.00
Steel Frame with URM Infill		78.23	S5	78	7L	50,000 - 99,999		46.91	33.91	13.00
Steel Frame with URM Infill		78.24	S5	78	7VL	over 100,000		43.57	30.57	13.00
Unreinforced Masonry		75.11	URM	75	1S	under 10,000	15.11	37.26	24.26	13.00
Unreinforced Masonry		75.12	URM	75	1M	10,000 - 49,999	15.11	37.09	24.09	13.00
Unreinforced Masonry		75.13	URM	75	1L	50,000 - 99,999	20.24	36.21	23.21	13.00
Unreinforced Masonry		75.14	URM	75	1VL	over 100,000	20.24	33.56	20.56	13.00
Wood		1.11	W	1	2S	under 10,000		33.19	20.19	13.00
Wood		1.12	W	1	2M	10,000 - 49,999		33.91	20.91	13.00
Wood		1.13	W	1	2L	50,000 - 99,999		37.60	24.60	13.00
Wood		1.14	W	1	2VL	over 100,000		42.72	29.72	13.00
Indicator for Main Building Summary Row		0	Summary							
Indicator for Sub-Summary Row for Special Cases		0.5	Sub							

Table A-5: RATIOS Spreadsheet

RATIOS -- Damage and Casualty Ratios

				Ground Motion = 0.20g			Ground Motion = 0.22g		
ATC-21 Class	ATC-13 Class	Sum of PMF's	Ratio Index	Damage Ratio	Injury Rate/1000	Death Rate/1000	Damage Ratio	Injury Rate/1000	Death Rate/1000
W	1	-1.5	98.5	5.894	0.006	0.002	6.310	0.007	0.002
W	1	-1.0	99.0	6.034	0.007	0.002	6.486	0.008	0.002
W	1	-0.5	99.5	6.197	0.007	0.002	6.686	0.008	0.002
W	1	0.0	100.0	6.385	0.007	0.002	6.914	0.009	0.002
W	1	0.5	100.5	6.605	0.008	0.002	7.174	0.009	0.002
W	1	1.0	101.0	6.860	0.009	0.002	7.473	0.010	0.003
W	1	1.5	101.5	7.159	0.010	0.002	7.816	0.011	0.003
W	1	2.0	102.0	7.511	0.011	0.003	8.214	0.013	0.003
W	1	2.5	102.5	7.927	0.012	0.003	8.679	0.014	0.004
W	1	3.0	103.0	8.426	0.014	0.004	9.229	0.017	0.004
S3	2	-1.5	198.5	5.094	0.004	0.001	5.227	0.005	0.001
S3	2	-1.0	199.0	5.162	0.005	0.001	5.311	0.005	0.001
S3	2	-0.5	199.5	5.249	0.005	0.001	5.417	0.005	0.001
S3	2	0.0	200.0	5.362	0.005	0.001	5.551	0.005	0.001
S3	2	0.5	200.5	5.507	0.005	0.001	5.723	0.006	0.001
S3	2	1.0	201.0	5.696	0.006	0.001	5.944	0.007	0.002
S3	2	1.5	201.5	5.944	0.007	0.002	6.229	0.007	0.002
S3	2	2.0	202.0	6.274	0.008	0.002	6.601	0.009	0.002
S3	2	2.5	202.5	6.719	0.010	0.003	7.094	0.011	0.003
S3	2	3.0	203.0	7.332	0.014	0.004	7.762	0.015	0.004
S4	3	-1.5	298.5	9.368	0.157	0.039	10.283	0.183	0.046
S4	3	-1.0	299.0	10.031	0.183	0.046	10.973	0.211	0.053
S4	3	-0.5	299.5	10.837	0.222	0.057	11.804	0.254	0.065
S4	3	0.0	300.0	11.850	0.289	0.077	12.840	0.326	0.086
S4	3	0.5	300.5	13.184	0.434	0.130	14.198	0.477	0.141
S4	3	1.0	301.0	15.065	0.844	0.304	16.104	0.892	0.315
S4	3	1.5	301.5	17.972	2.267	0.966	19.037	2.314	0.973
S4	3	2.0	302.0	23.020	7.827	3.671	24.099	7.849	3.663
S4	3	2.5	302.5	33.100	30.799	15.063	34.130	30.734	15.011
S4	3	3.0	303.0	56.480	127.940	63.619	57.221	127.727	63.497
C2	6	-1.5	598.5	15.048	0.321	0.080	16.512	0.381	0.095
C2	6	-1.0	599.0	15.486	0.346	0.087	16.944	0.413	0.103
C2	6	-0.5	599.5	15.982	0.379	0.095	17.442	0.454	0.114
C2	6	0.0	600.0	16.556	0.423	0.107	18.028	0.508	0.129
C2	6	0.5	600.5	17.237	0.484	0.124	18.734	0.584	0.150
C2	6	1.0	601.0	18.067	0.577	0.153	19.605	0.700	0.187
C2	6	1.5	601.5	19.114	0.737	0.209	20.711	0.898	0.260
C2	6	2.0	602.0	20.481	1.055	0.337	22.161	1.292	0.422
C2	6	2.5	602.5	22.348	1.787	0.662	24.139	2.185	0.824
C2	6	3.0	603.0	25.031	3.666	1.548	26.962	4.415	1.883
RM	9	-1.5	898.5	22.656	0.947	0.246	24.670	1.199	0.318
RM	9	-1.0	899.0	23.621	1.108	0.299	25.746	1.411	0.394
RM	9	-0.5	899.5	24.808	1.364	0.395	27.058	1.758	0.532
RM	9	0.0	900.0	26.299	1.822	0.586	28.689	2.387	0.807
RM	9	0.5	900.5	28.221	2.738	1.000	30.768	3.630	1.384
RM	9	1.0	901.0	30.778	4.724	1.942	33.500	6.239	2.639
RM	9	1.5	901.5	34.315	9.248	4.148	37.221	11.907	5.423
RM	9	2.0	902.0	39.435	19.847	9.394	42.509	24.468	11.660
RM	9	2.5	902.5	47.255	45.049	21.963	50.390	52.608	25.714
RM	9	3.0	903.0	59.917	105.428	52.191	62.771	115.997	57.469

Table A-5: RATIOS Spreadsheet (Continued)

RATIOS -- Damage and Casualty Ratios

				Ground Motion = 0.20g			Ground Motion = 0.22g		
ATC-21 Class	ATC-13 Class	Sum of PMF's	Ratio Index	Damage Ratio	Injury Rate/1000	Death Rate/1000	Damage Ratio	Injury Rate/1000	Death Rate/1000
S1	15	-1.5	1498.5	8.971	0.142	0.035	9.873	0.166	0.042
S1	15	-1.0	1499.0	9.481	0.158	0.040	10.408	0.185	0.046
S1	15	-0.5	1499.5	10.074	0.180	0.045	11.025	0.209	0.052
S1	15	0.0	1500.0	10.776	0.211	0.053	11.749	0.244	0.062
S1	15	0.5	1500.5	11.628	0.259	0.067	12.624	0.297	0.077
S1	15	1.0	1501.0	12.701	0.346	0.096	13.722	0.392	0.108
S1	15	1.5	1501.5	14.120	0.543	0.171	15.172	0.604	0.189
S1	15	2.0	1502.0	16.130	1.101	0.416	17.221	1.195	0.447
S1	15	2.5	1502.5	19.237	2.963	1.294	20.379	3.136	1.362
S1	15	3.0	1503.0	24.591	9.768	4.620	25.787	10.138	4.786
URM	75	-1.5	7498.5	29.407	1.739	0.438	31.848	2.076	0.524
URM	75	-1.0	7499.0	30.643	1.918	0.489	33.106	2.261	0.580
URM	75	-0.5	7499.5	32.126	2.171	0.573	34.610	2.533	0.676
URM	75	0.0	7500.0	33.969	2.616	0.748	36.476	3.042	0.888
URM	75	0.5	7500.5	36.363	3.621	1.200	38.899	4.226	1.435
URM	75	1.0	7501.0	39.659	6.333	2.502	42.226	7.388	2.971
URM	75	1.5	7501.5	44.536	14.324	6.451	47.116	16.402	7.444
URM	75	2.0	7502.0	52.415	38.750	18.651	54.906	42.782	20.639
URM	75	2.5	7502.5	66.533	114.441	56.604	68.574	120.770	59.762
URM	75	3.0	7503.0	94.946	350.170	174.971	95.318	352.187	175.982
C3/S5	78	-1.5	7798.5	20.198	0.774	0.207	21.945	0.953	0.259
C3/S5	78	-1.0	7799.0	21.418	0.996	0.288	23.257	1.231	0.364
C3/S5	78	-0.5	7799.5	23.016	1.438	0.470	24.967	1.783	0.598
C3/S5	78	0.0	7800.0	25.190	2.450	0.928	27.276	3.028	1.170
C3/S5	78	0.5	7800.5	28.289	5.015	2.151	30.532	6.092	2.642
C3/S5	78	1.0	7801.0	32.968	11.910	5.530	35.374	14.002	6.532
C3/S5	78	1.5	7801.5	40.528	31.007	15.016	43.045	34.947	16.952
C3/S5	78	2.0	7802.0	53.724	84.674	41.842	56.101	91.089	45.032
C3/S5	78	2.5	7802.5	78.731	236.522	117.963	80.095	242.447	120.926
C3/S5	78	3.0	7803.0	100.000	400.000	200.000	100.000	400.000	200.000
PC2	82	-1.5	8198.5	36.433	5.900	2.382	40.340	8.249	3.477
PC2	82	-1.0	8199.0	39.284	9.641	4.215	43.304	13.253	5.952
PC2	82	-0.5	8199.5	42.998	16.920	7.821	47.109	22.458	10.534
PC2	82	0.0	8200.0	48.001	31.222	14.952	52.134	39.483	19.043
PC2	82	0.5	8200.5	54.986	59.481	29.091	58.983	71.082	34.872
PC2	82	1.0	8201.0	65.138	115.496	57.172	68.645	129.841	64.347
PC2	82	1.5	8201.5	80.529	226.720	112.990	82.778	239.233	119.261
PC2	82	2.0	8202.0	100.000	400.000	200.000	100.000	400.000	200.000
PC2	82	2.5	8202.5	100.000	400.000	200.000	100.000	400.000	200.000
PC2	82	3.0	8203.0	100.000	400.000	200.000	100.000	400.000	200.000
C1	87	-1.5	8698.5	28.272	1.602	0.411	30.887	1.976	0.515
C1	87	-1.0	8699.0	29.380	1.790	0.472	32.069	2.208	0.599
C1	87	-0.5	8699.5	30.694	2.070	0.576	33.465	2.577	0.749
C1	87	0.0	8700.0	32.289	2.553	0.778	35.149	3.236	1.041
C1	87	0.5	8700.5	34.275	3.494	1.205	37.237	4.528	1.649
C1	87	1.0	8701.0	36.834	5.505	2.165	39.909	7.213	2.952
C1	87	1.5	8701.5	40.264	10.034	4.384	43.454	12.978	5.800
C1	87	2.0	8702.0	45.083	20.524	9.593	48.361	25.575	12.076
C1	87	2.5	8702.5	52.230	45.163	21.905	55.487	53.344	25.973
C1	87	3.0	8703.0	63.500	103.422	51.104	66.411	114.833	56.809

RANKWORK1

Bldg Index Code	Building Number	Building Name	*Building Data* Bldg Use Code	ATC-21 Bldg Class	ATC-13 Bldg Class	Proportion Factor	Validity Check	Sum of PMF's	Ratio Index	*Fatality Rates (per 1000)* Fatality Rate for 0.22g (per 1000)	Weighted Fatality Rate (per 1000)	*Occupancy Data* Average (Day & Night)	Maximum (Day & Night)	*Fatality Estimates Based On:* Based on Average Occupancy (Actual Fatalities)	Based on Maximum Occupancy (Actual Fatalities)
1	1	Apperson	0	Summary		1.00	ok				0.002	95	368	0.0002	0.0008
2	1	Apperson		W	1	1.00		0.0	100.0	0.002	0.002				
3	2	Merryfield	0	Summary		1.00	ok				2.971	19	67	0.0550	0.1991
4	2	Merryfield		URM	75	1.00		1.0	7501.0	2.971	2.971				
5	6	Graf	0	Summary		1.00	ok				5.198	17	32	0.0884	0.1663
6	6	Graf		URM	75	0.50		1.5	7501.5	7.444	3.722				
7	6	Graf		C1	87	0.50		1.0	8701.0	2.952	1.476				
8	7	Covell	0	Summary		1.00	ok				2.971	79	326	0.2347	0.9687
9	7	Covell		URM	75	1.00		1.0	7501.0	2.971	2.971				
10	9	Batcheller	0	Summary		1.00	ok				0.002	57	178	0.0001	0.0004
11	9	Batcheller		W	1	1.00		0.5	100.5	0.002	0.002				
12	11	Dearborn	0	Summary		1.00	ok				0.541	91	367	0.0492	0.1984
13	11	Dearborn		S1	15	0.50		1.0	1501.0	0.108	0.054				
14	11	Dearborn		S4	3	0.50		1.5	301.5	0.973	0.487				
15	12	Gilbert Addition	0	Summary		1.00	ok				1.541	37	104	0.0570	0.1602
16	12	Gilbert Addition		C1	87	0.50		1.0	8701.0	2.952	1.476				
17	12	Gilbert Addition		C2	6	0.50		0.0	600.0	0.129	0.064				
18	14	Shepard	0	Summary		1.00	ok				0.002	40	125	0.0001	0.0003
19	14	Shepard		W	1	1.00		0.0	100.0	0.002	0.002				
20	15	Gilbert	0	Summary		1.00	ok				0.900	170	651	0.1529	0.5857
21	15	Gilbert		C1	87	0.50		0.5	8700.5	1.649	0.824				
22	15	Gilbert		C2	6	0.50		0.5	600.5	0.150	0.075				
23	16	Gleeson	0	Summary		1.00	ok				0.900	48	181	0.0432	0.1628
24	16	Gleeson		C1	87	0.50		0.5	8700.5	1.649	0.824				
25	16	Gleeson		C2	6	0.50		0.5	600.5	0.150	0.075				
26	17	Weniger	0	Summary		1.00	ok				0.109	344	1036	0.0373	0.1126
27	17	Weniger		S1	15	0.50		0.5	1500.5	0.077	0.038				
28	17	Weniger		S4	3	0.50		0.5	300.5	0.141	0.070				
29	18	Bexell	0	Summary		1.00	ok				2.971	215	972	0.6374	2.8882
30	18	Bexell		URM	75	1.00		1.0	7501.0	2.971	2.971				
31	19	Rogers	0	Summary		1.00	ok				1.551	57	298	0.0877	0.4623

Table A-6: RANKWORK1 Spreadsheet (Continued)

RANKWORK1

Bldg Index Code	Building Number	Building Name	Building Data: Bldg Use Code	ATC-21 Bldg Class	ATC-13 Bldg Class	Proportion Factor	Validity Check	Sum of PMF's	Ratio Index	Fatality Rates (per 1000): Fatality Rate for 0.22g (per 1000)	Weighted Fatality Rate (per 1000)	Occupancy Data: Average (Day & Night)	Maximum (Day & Night)	Fatality Estimates Based On: Based on Average Occupancy (Actual Fatalities)	Based on Maximum Occupancy (Actual Fatalities)
32	19	Rogers		C1	87	0.50		1.0	8701.0	2.952	1.476				
33	19	Rogers		C2	6	0.50		0.5	600.5	0.150	0.075				
34	20	Milne Computer Center	0	Summary		1.00	ok				0.585	26	101	0.0152	0.0591
35	20	Milne Computer Center		C1	87	0.50		0.0	8700.0	1.041	0.521				
36	20	Milne Computer Center		C2	6	0.50		0.0	600.0	0.129	0.064				
37	21	Nash	0	Summary		1.00	ok				0.315	130	352	0.0409	0.1108
38	21	Nash		S4	3	1.00		1.0	301.0	0.315	0.315				
39	22	Electric Comp Engr	0	Summary		1.00	ok				0.124	96	374	0.0119	0.0465
40	22	Electric Comp Engr		S1	15	0.50		1.0	1501.0	0.108	0.054				
41	22	Electric Comp Engr		S4	3	0.50		0.5	300.5	0.141	0.070				
42	27	Benton	0	Summary		1.00	ok				0.002	20	300	0.0000	0.0007
43	27	Benton		W	1	1.00		0.5	100.5	0.002	0.002				
44	28	Education Bldg	0	Summary		1.00	ok				1.029	81	429	0.0828	0.4414
45	28	Education Bldg		C3	78	0.50		0.0	7800.0	1.170	0.585				
46	28	Education Bldg		URM	75	0.50		0.0	7500.0	0.888	0.444				
47	30	Pharmacy	0	Summary		1.00	ok				35.932	64	213	2.2817	7.6536
48	30	Pharmacy, Original		URM	75	0.60		2.5	7502.5	59.762	35.857				
49	30	Pharmacy, Addition		C2	6	0.40		1.0	601.0	0.187	0.075				
50	34	Kidder Hall	0	Summary		1.00	ok				16.187	242	784	3.9092	12.6908
51	34	Kidder Hall, Original		URM	75	0.70		2.0	7502.0	20.639	14.447				
52	34	Kidder Hall, Addition		C1	87	0.30		1.5	8701.5	5.800	1.740				
53	36	Kerr Library	0	Summary		1.00	ok				32.271	250	1500	8.0678	48.4067
54	36	Kerr Library		S1	15	0.25		0.5	1500.5	0.077	0.019				
55	36	Kerr Library		S4	3	0.25		1.0	301.0	0.315	0.079				
56	36	Kerr Library		PC2	82	0.50		1.0	8201.0	64.347	32.173				
57	37	Social Science	0	Summary		1.00	ok				0.888	70	254	0.0617	0.2255
58	37	Social Science		URM	75	1.00		0.0	7500.0	0.888	0.888				
59	38	Strand Agriculture	0	Summary		1.00	ok				20.639	201	951	4.1484	19.6276
60	38	Strand Agriculture		URM	75	1.00		2.0	7502.0	20.639	20.639				
61	53	McAlexander Total	0	Summary		1.00	ok							0.0000	0.0006
62	53	McAlexander Office		W	1	0.30		1.5	101.5	0.003	0.001				

RANKWORK1

Bldg Index Code	Building Number	Building Name	Building Data: Bldg Use Code	ATC-21 Bldg Class	ATC-13 Bldg Class	Proportion Factor	Validity Check	Sum of PMF's	Ratio Index	Fatality Rates (per 1000): Fatality Rate for 0.22g (per 1000)	Weighted Fatality Rate (per 1000)	Occupancy Data: Average (Day & Night)	Maximum (Day & Night)	Fatality Estimates Based On: Based on Average Occupancy (Actual Fatalities)	Based on Maximum Occupancy (Actual Fatalities)
63	53	McAlexander Office, Tot		Sub		0.30					0.001	24	90	0.0000	0.0001
64	53	McAlexander Fieldhouse		S3	2	0.70		1.0	201.0	0.002	0.001				
65	53	McAlexander Fieldhouse, To		Sub		0.70					0.001	20	500	0.0000	0.0006
66	54	Indoor Target Range	0	Summary		1.00	ok				1.435	5	30	0.0072	0.0430
67	54	Indoor Target Range		URM	75	1.00		0.5	7500.5	1.435	1.435				
68	56	Phys Heating Plant	0	Summary		1.00	ok				8.477	3	6	0.0254	0.0509
69	56	Phys Heating Plant, Original		C3	78	0.50		1.5	7801.5	16.952	8.476				
70	56	Phys Heating Plant, Addition		S3	2	0.50		1.0	201.0	0.002	0.001				
71	58	Industrial Bldg	0	Summary		1.00	ok				1.850	18	104	0.0324	0.1924
72	58	Industrial Bldg		W	1	0.30		1.0	101.0	0.003	0.001				
73	58	Industrial Bldg		S5	78	0.70		0.5	7800.5	2.642	1.849				
74	60	Adams	0	Summary		1.00	ok				0.002	16	31	0.0000	0.0001
75	60	Adams		W	1	1.00		-0.5	99.5	0.002	0.002				
76	61	Admin Services	0	Summary		1.00	ok				118.605	199	395	23.5430	46.8489
77	61	Admin Services, A		S4	3	0.13		2.5	302.5	15.011	1.876				
78	61	Admin Services, A		S5	78	0.13		2.5	7802.5	120.926	15.116				
79	61	Admin Services, B		C1	87	0.13		2.0	8702.0	12.076	1.510				
80	61	Admin Services, B		C2	6	0.13		2.5	602.5	0.824	0.103				
81	61	Admin Services, Overall		PC2	82	0.50		2.5	8202.5	200.000	100.000				
82	62	Plageman Bldg	1	Summary		1.00	ok				0.150	33	200	0.0049	0.0301
83	62	Plageman Bldg		C2	6	1.00		0.5	600.5	0.150	0.150				
84	67	Ballard Extension	0	Summary		1.00	ok				20.639	80	158	1.6408	3.2609
85	67	Ballard Extension		URM	75	1.00		2.0	7502.0	20.639	20.639				
86	68	Burt	0	Summary		1.00	ok				2.994	78	215	0.2335	0.6436
87	68	Burt		C1	87	0.50		1.5	8701.5	5.800	2.900				
88	68	Burt		C2	6	0.50		1.0	601.0	0.187	0.094				
89	69	Family Study Center	0	Summary		1.00	ok				0.055	40	130	0.0022	0.0072
90	69	Family Study Center		S1	15	0.50		-1.0	1499.0	0.046	0.023				
91	69	Family Study Center		S4	3	0.50		-0.5	299.5	0.065	0.032				
92	70	Wilkinson	0	Summary		1.00	ok				1.344	173	449	0.2319	0.6036
93	70	Wilkinson		S4	3	0.40		1.0	301.0	0.315	0.126				

Table A-6: RANKWORK1 Spreadsheet (Continued)

Table A-6: RANKWORK1 Spreadsheet (Continued)

RANKWORK1

			Building Data							*Fatality Rates (per 1000)*		*Occupancy Data*		*Fatality Estimates Based On:*	
Bldg Index Code	Building Number	Building Name	Bldg Use Code	ATC-21 Bldg Class	ATC-13 Bldg Class	Proportion Factor	Validity Check	Sum of PMF's	Ratio Index	Fatality Rate for 0.22g (per 1000)	Weighted Fatality Rate (per 1000)	Average (Day & Night)	Maximum (Day & Night)	Based on Average Occupancy (Actual Fatalities)	Based on Maximum Occupancy (Actual Fatalities)
94	70	Wilkinson		C1	87	0.40		1.0	8701.0	2.952	1.181				
95	70	Wilkinson		C2	6	0.20		1.0	601.0	0.187	0.037				
96	73	Cordley	0	Summary		1.00	ok				2.994	317	1701	0.9490	5.0922
97	73	Cordley		C1	87	0.50		1.5	8701.5	5.800	2.900				
98	73	Cordley		C2	6	0.50		1.0	601.0	0.187	0.094				
99	75	Withycombe	0	Summary		1.00	ok				13.197	113	185	1.4847	2.4415
100	75	Withycombe		C1	87	0.50		2.5	8702.5	25.973	12.986				
101	75	Withycombe		C2	6	0.50		2.0	602.0	0.422	0.211				
102	79	Ag Sciences II	0	Summary		1.00	ok				0.506	176	316	0.0891	0.1600
103	79	Ag Sciences II		S1	15	0.25		1.0	1501.0	0.108	0.027				
104	79	Ag Sciences II		S4	3	0.25		0.5	300.5	0.141	0.035				
105	79	Ag Sciences II		C1	87	0.25		0.5	8700.5	1.649	0.412				
106	79	Ag Sciences II		C2	6	0.25		0.0	600.0	0.129	0.032				
107	80	Crop Science	0	Summary		1.00	ok				0.426	65	158	0.0275	0.0673
108	80	Crop Science		C1	87	0.50		-0.5	8699.5	0.749	0.374				
109	80	Crop Science		C2	6	0.50		-1.0	599.0	0.103	0.052				
110	81	Milam Hall	0	Summary		1.00	ok				11.816	267	1464	3.1549	17.2990
111	81	Milam Hall		URM	75	0.50		2.0	7502.0	20.639	10.319				
112	81	Milam Auditorium		C1	87	0.25		1.5	8701.5	5.800	1.450				
113	81	Milam Auditorium		C2	6	0.25		1.0	601.0	0.187	0.047				
114	83	Memorial Union	1	Summary		1.00	ok				120.926	187	1610	22.5829	194.6910
115	83	Memorial Union		C3	78	1.00		2.5	7802.5	120.926	120.926				
116	84	Gilmore	0	Summary		1.00	ok				4.994	26	79	0.1298	0.3945
117	84	Gilmore		C2	6	0.30		1.0	601.0	0.187	0.056				
118	84	Gilmore		C3	78	0.30		1.0	7801.0	6.532	1.960				
119	84	Gilmore		URM	75	0.40		1.5	7501.5	7.444	2.978				
120	86	Women's Bldg	0	Summary		1.00	ok				20.639	63	534	1.2899	11.0212
121	86	Women's Bldg		URM	75	1.00		2.0	7502.0	20.639	20.639				
122	87	Fairbanks	0	Summary		1.00	ok				0.003	52	294	0.0002	0.0009
123	87	Fairbanks		W	1	1.00		2.0	102.0	0.003	0.003				
124	88	Clark Lab	0	Summary		1.00	ok				5.423	8	30	0.0407	0.1627

Table A-6: RANKWORK1 Spreadsheet (Continued)

RANKWORK1

Bldg Index Code	Building Number	Building Name	Building Data: Bldg Use Code	Building Data: ATC-21 Bldg Class	Building Data: ATC-13 Bldg Class	Building Data: Proportion Factor	Building Data: Validity Check	Building Data: Sum of PMF's	Building Data: Ratio Index	Fatality Rates (per 1000): Fatality Rate for 0.22g (per 1000)	Fatality Rates (per 1000): Weighted Fatality Rate (per 1000)	Occupancy Data: Average (Day & Night)	Occupancy Data: Maximum (Day & Night)	Fatality Estimates Based On: Based on Average Occupancy (Actual Fatalities)	Fatality Estimates Based On: Based on Maximum Occupancy (Actual Fatalities)
125	88	Clark Lab		RM	9	1.00		1.5	901.5	5.423	5.423				
126	92	Computer Science	0	Summary		1.00	ok				7.444	36	92	0.2643	0.6849
127	92	Computer Science		URM	75	1.00		1.5	7501.5	7.444	7.444				
128	96	Sackett	1	Summary		1.00	ok				0.187	178	237	0.0333	0.0444
129	96	Sackett		C2	6	1.00		1.0	601.0	0.187	0.187				
130	98	Radiation Center, Overall	0	Summary		1.00	ok				27.38	40	80	1.0814	2.1902
131	98	Rad Center, Main Bldg		C2	6	0.20		2.0	602.0	0.422	0.084				
132	98	Rad Center, Main Bldg		C3	78	0.15		2.5	7802.5	120.926	18.139				
133	98	Rad Center, Reactor Bldg		C1	87	0.20		2.5	8702.5	25.973	5.195				
134	98	Rad Center, Reactor Bldg		S4	3	0.20		2.5	302.5	15.011	3.002				
135	98	Rad Center, Reactor Bldg		S1	15	0.20		3.0	1503.0	4.786	0.957				
136	98	Radiation Center, Annex		W	1	0.05		-1.0	99.0	0.002	0.000				
137	100	Snell	0	Summary		1.00	ok				5.785	80	209	0.4628	1.2091
138	100	Snell, Original		S5	78	0.20		1.5	7801.5	16.952	3.390				
139	100	Snell, Original		C1	87	0.20		1.5	8701.5	5.800	1.160				
140	100	Snell, Original		C2	6	0.20		1.0	601.0	0.187	0.037				
141	100	Snell, Addition		C1	87	0.20		1.5	8701.5	5.800	1.160				
142	100	Snell, Addition		C2	6	0.20		1.0	601.0	0.187	0.037				
143	102	Waldo	0	Summary		1.00	ok				0.003	74	159	0.0002	0.0005
144	102	Waldo		W	1	1.00		1.5	101.5	0.003	0.003				
145	105	Langton	0	Summary		1.00	ok				18.795	78	607	1.4660	11.4087
146	105	Langton		S5	78	0.50		1.5	7801.5	16.952	8.476				
147	105	Langton		URM	75	0.50		2.0	7502.0	20.639	10.319				
148	106	Moreland	0	Summary		1.00	ok				0.888	115	293	0.1021	0.2601
149	106	Moreland		URM	75	1.00		0.0	7500.0	0.888	0.888				
150	109	Weatherford	1	Summary		1.00	ok				0.187	0	0	0.0000	0.0000
151	109	Weatherford		C2	6	1.00		1.0	601.0	0.187	0.187				
152	111	Buxton	1	Summary		1.00	ok				105.830	168	307	17.7795	32.4899
153	111	Buxton		RM	9	0.50		2.0	902.0	11.660	5.830				
154	111	Buxton		PC2	82	0.50		2.0	8202.0	200.000	100.000				
155	112	Poling	1	Summary		1.00	ok				105.830	107	165	11.3503	17.4620

Table A-6: RANKWORK1 Spreadsheet (Continued)

RANKWORK1

Bldg Index Code	Building Number	Building Name	Building Data: Bldg Use Code	ATC-21 Bldg Class	ATC-13 Bldg Class	Proportion Factor	Validity Check	Sum of PMF's	Ratio Index	Fatality Rates (per 1000): Fatality Rate for 0.22g (per 1000)	Weighted Fatality Rate (per 1000)	Occupancy Data: Average (Day & Night)	Maximum (Day & Night)	Fatality Estimates Based On: Based on Average Occupancy (Actual Fatalities)	Based on Maximum Occupancy (Actual Fatalities)
156	112	Poling		RM	9	0.50		2.0	902.0	11.660	5.830				
157	112	Poling		PC2	82	0.50		2.0	8202.0	200.000	100.000				
158	114	Cauthorn	1	Summary		1.00	ok				105.830	193	296	20.3988	31.3258
159	114	Cauthorn		RM	9	0.50		2.0	902.0	11.660	5.830				
160	114	Cauthorn		PC2	82	0.50		2.0	8202.0	200.000	100.000				
161	115	West International	1	Summary		1.00	ok				105.830	116	242	12.2234	25.6109
162	115	West International		RM	9	0.50		2.0	902.0	11.660	5.830				
163	115	West International		PC2	82	0.50		2.0	8202.0	200.000	100.000				
164	119	Hawley	1	Summary		1.00	ok				105.830	68	124	7.1435	13.1229
165	119	Hawley		RM	9	0.50		2.0	902.0	11.660	5.830				
166	119	Hawley		PC2	82	0.50		2.0	8202.0	200.000	100.000				
167	120	Parker Stadium, Overall	0	Summary		2.00								0.0000	1.4092
168	120	P Stadium, Bleachers		S1	15	0.50		0.5	1500.5	0.077	0.038				
169	120	P Stadium, Bleachers		S3	2	0.50		0.5	200.5	0.001	0.001				
170	120	P Stadium, Bleachers Tot		Sub		1.00	ok				0.04	0	35000	0.0000	1.3689
171	120	P Stadium, Pressbox		S1	15	1.00		0.5	1500.5	0.077	0.077				
172	120	P Stadium, Pressbox Tot		Sub		1.00	ok				0.077	0	525	0.0000	0.0403
173	121	Gill Coliseum	0	Summary		1.00	ok				0.438	59	10612	0.0257	4.6530
174	121	Gill Coliseum (all but ramps)		S4	3	0.90		1.0	301.0	0.315	0.283				
175	121	Gill Coliseum (ramps)		C1	87	0.05		1.0	8701.0	2.952	0.148				
176	121	Gill Coliseum (ramps)		C2	6	0.05		0.5	600.5	0.150	0.008				
177	124	Peavy	0	Summary		1.00	ok				0.002	191	458	0.0004	0.0009
178	124	Peavy		W	1	1.00		-0.5	99.5	0.002	0.002				
179	128	Wiegand	0	Summary		1.00	ok				1.551	92	417	0.1420	0.6470
180	128	Wiegand		C1	87	0.50		1.0	8701.0	2.952	1.476				
181	128	Wiegand		C2	6	0.50		0.5	600.5	0.150	0.075				
182	143	Parker Stadium, Clubhouse	0	Summary		1.00	ok				0.309	0	250	0.0000	0.0773
183	143	Parker Stadium, Clubhouse		S4	3	0.50		0.0	300.0	0.086	0.043				
184	143	Parker Stadium, Clubhouse		RM	9	0.50		-0.5	899.5	0.532	0.266				
185	145	Dixon Rec Center	1	Summary		1.00	ok				25.714	63	308	1.6072	7.9201
186	145	Dixon Rec Center		RM	9	1.00		2.5	902.5	25.714	25.714				

Table A-6: RANKWORK1 Spreadsheet (Continued)

RANKWORK1

Bldg Index Code	Building Number	Building Name	Building Data: Bldg Use Code	ATC-21 Bldg Class	ATC-13 Bldg Class	Proportion Factor	Validity Check	Sum of PMF's	Ratio Index	Fatality Rates (per 1000): Fatality Rate for 0.22g (per 1000)	Weighted Fatality Rate (per 1000)	Occupancy Data: Average (Day & Night)	Maximum (Day & Night)	Fatality Estimates Based On: Based on Average Occupancy (Actual Fatalities)	Based on Maximum Occupancy (Actual Fatalities)
187	151	Dryden	0	Summary		1.00	ok				2.971	21	91	0.0609	0.2704
188	151	Dryden		URM	75	1.00		1.0	7501.0	2.971	2.971				
189	153	Magruder	0	Summary		1.00	ok				0.055	40	132	0.0022	0.0073
190	153	Magruder		S1	15	0.50		-1.0	1499.0	0.046	0.023				
191	153	Magruder		S4	3	0.50		-0.5	299.5	0.065	0.032				
192	188	Childcare Center	0	Summary		1.00	ok				0.305	75	174	0.0229	0.0531
193	188	Childcare Center		C1	87	0.50		-1.5	8698.5	0.515	0.258				
194	188	Childcare Center		C2	6	0.50		-1.5	598.5	0.095	0.048				
195	190	McNary	1	Summary		1.00	ok				105.830	209	327	22.0656	34.6065
196	190	McNary		RM	9	0.50		2.0	902.0	11.660	5.830				
197	190	McNary		PC2	82	0.50		2.0	8202.0	200.000	100.000				
198	191	Wilson	1	Summary		1.00	ok				105.830	215	287	22.7800	30.3733
199	191	Wilson		RM	9	0.50		2.0	902.0	11.660	5.830				
200	191	Wilson		PC2	82	0.50		2.0	8202.0	200.000	100.000				
201	192	Callahan	1	Summary		1.00	ok				105.830	236	355	25.0024	37.5697
202	192	Callahan		RM	9	0.50		2.0	902.0	11.660	5.830				
203	192	Callahan		PC2	82	0.50		2.0	8202.0	200.000	100.000				
204	196	Finley	1	Summary		1.00	ok				59.761	242	359	14.4770	21.4541
205	196	Finley		C2	6	0.50		1.5	601.5	0.260	0.130				
206	196	Finley		PC2	82	0.50		1.5	8201.5	119.261	59.631				
207	198	Bloss	1	Summary		1.00	ok				59.761	189	316	11.2948	18.8843
208	198	Bloss		C2	6	0.50		1.5	601.5	0.260	0.130				
209	198	Bloss		PC2	82	0.50		1.5	8201.5	119.261	59.631				
210	199	College Inn	1	Summary		1.00	ok				0.824	225	405	0.1854	0.3337
211	199	College Inn		C2	6	1.00		2.5	602.5	0.824	0.824				
212	200	Lasells Stewart Center	0	Summary		1.00	ok				4.303	153	1745	0.6562	7.5087
213	200	LSC		C1	87	0.30		2.0	8702.0	12.076	3.623				
214	200	LSC		C2	6	0.30		2.0	602.0	0.422	0.127				
215	200	LSC Auditorium		RM	9	0.40		0.5	900.5	1.384	0.554				
216	807	Oceanography	0	Summary		1.00	ok				0.002	8	15	0.0000	0.0000
217	807	Oceanography		W	1	1.00		0.5	100.5	0.002	0.002				

Table A-7: RANKWORK2 Spreadsheet

RANKWORK2 Auto Rank: Method A Reset Auto Rank: Method B Reset

Method A: Estimated Fatalities Based on Average Occ.							Method B: Estimated Fatalities Based on Maximum Occ.						
Rank, Method A	Bldg Index Code	Building Number	Building Name	Bldg Use Code	Estimated Fatalities Based on Method A	Rank, Method A	Rank, Method B	Bldg Index Code	Building Number	Building Name	Bldg Use Code	Estimated Fatalities Based on Method B	Rank, Method B
1	76	61	Admin Services	0	23.5430	1	1	53	36	Kerr Library	0	48.4067	1
2	53	36	Kerr Library	0	8.0678	2	2	76	61	Admin Services	0	46.8489	2
3	59	38	Strand Agriculture	0	4.1484	3	3	59	38	Strand Agriculture	0	19.6276	3
4	50	34	Kidder Hall	0	3.9092	4	4	110	81	Milam Hall	0	17.2990	4
5	110	81	Milam Hall	0	3.1549	5	5	50	34	Kidder Hall	0	12.6908	5
6	47	30	Pharmacy	0	2.2817	6	6	145	105	Langton	0	11.4087	6
7	84	67	Ballard Extension	0	1.6408	7	7	120	86	Women's Bldg	0	11.0212	7
8	99	75	Withycombe	0	1.4847	8	8	47	30	Pharmacy	0	7.6536	8
9	145	105	Langton	0	1.4660	9	9	212	200	Lasells Stewart Center	0	7.5087	9
10	120	86	Women's Bldg	0	1.2899	10	10	96	73	Cordley	0	5.0922	10
11	130	98	Radiation Center, Overall	0	1.0814	11	11	173	121	Gill Coliseum	0	4.6530	11
12	96	73	Cordley	0	0.9490	12	12	84	67	Ballard Extension	0	3.2609	12
13	212	200	Lasells Stewart Center	0	0.6562	13	13	29	18	Bexell	0	2.8882	13
14	29	18	Bexell	0	0.6374	14	14	99	75	Withycombe	0	2.4415	14
15	137	100	Snell	0	0.4628	15	15	130	98	Radiation Center, Overall	0	2.1902	15
16	126	92	Computer Science	0	0.2643	16	16	167	120	Parker Stadium, Overall	0	1.4092	16
17	8	7	Covell	0	0.2347	17	17	137	100	Snell	0	1.2091	17
18	86	68	Burt	0	0.2335	18	18	8	7	Covell	0	0.9687	18
19	92	70	Wilkinson	0	0.2319	19	19	126	92	Computer Science	0	0.6849	19
20	20	15	Gilbert	0	0.1529	20	20	179	128	Wiegand	0	0.6470	20
21	179	128	Wiegand	0	0.1420	21	21	86	68	Burt	0	0.6436	21
22	116	84	Gilmore	0	0.1298	22	22	92	70	Wilkinson	0	0.6036	22
23	148	106	Moreland	0	0.1021	23	23	20	15	Gilbert	0	0.5857	23
24	102	79	Ag Sciences II	0	0.0891	24	24	31	19	Rogers	0	0.4623	24
25	5	6	Graf	0	0.0884	25	25	44	28	Education Bldg	0	0.4414	25
26	31	19	Rogers	0	0.0877	26	26	116	84	Gilmore	0	0.3945	26
27	44	28	Education Bldg	0	0.0828	27	27	187	151	Dryden	0	0.2704	27
28	57	37	Social Science	0	0.0617	28	28	148	106	Moreland	0	0.2601	28
29	187	151	Dryden	0	0.0609	29	29	57	37	Social Science	0	0.2255	29
30	15	12	Gilbert Addition	0	0.0570	30	30	3	2	Merryfield	0	0.1991	30
31	3	2	Merryfield	0	0.0550	31	31	12	11	Dearborn	0	0.1984	31
32	12	11	Dearborn	0	0.0492	32	32	71	58	Industrial Bldg	0	0.1924	32
33	23	16	Gleeson	0	0.0432	33	33	5	6	Graf	0	0.1663	33
34	37	21	Nash	0	0.0409	34	34	23	16	Gleeson	0	0.1628	34
35	124	88	Clark Lab	0	0.0407	35	35	124	88	Clark Lab	0	0.1627	35
36	26	17	Weniger	0	0.0373	36	36	15	12	Gilbert Addition	0	0.1602	36
37	71	58	Industrial Bldg	0	0.0324	37	37	102	79	Ag Sciences II	0	0.1600	37
38	107	80	Crop Science	0	0.0275	38	38	26	17	Weniger	0	0.1126	38
39	173	121	Gill Coliseum	0	0.0257	39	39	37	21	Nash	0	0.1108	39
40	68	56	Phys Heating Plant	0	0.0254	40	40	182	143	Parker Stadium, Clubhouse	0	0.0773	40
41	192	188	Childcare Center	0	0.0229	41	41	107	80	Crop Science	0	0.0673	41
42	34	20	Milne Computer Center	0	0.0152	42	42	34	20	Milne Computer Center	0	0.0591	42
43	39	22	Electric Comp Engr	0	0.0119	43	43	192	188	Childcare Center	0	0.0531	43
44	66	54	Indoor Target Range	0	0.0072	44	44	68	56	Phys Heating Plant	0	0.0509	44
45	189	153	Magruder	0	0.0022	45	45	39	22	Electric Comp Engr	0	0.0465	45
46	89	69	Family Study Center	0	0.0022	46	46	66	54	Indoor Target Range	0	0.0430	46
47	177	124	Peavy	0	0.0004	47	47	189	153	Magruder	0	0.0073	47
48	143	102	Waldo	0	0.0002	48	48	89	69	Family Study Center	0	0.0072	48
49	1	1	Apperson	0	0.0002	49	49	122	87	Fairbanks	0	0.0009	49
50	122	87	Fairbanks	0	0.0002	50	50	177	124	Peavy	0	0.0009	50
51	10	9	Batcheller	0	0.0001	51	51	1	1	Apperson	0	0.0008	51
52	18	14	Shepard	0	0.0001	52	52	42	27	Benton	0	0.0007	52
53	42	27	Benton	0	0.0000	53	53	61	53	McAlexander Total	0	0.0006	53
54	61	53	McAlexander Total	0	0.0000	54	54	143	102	Waldo	0	0.0005	54
55	74	60	Adams	0	0.0000	55	55	10	9	Batcheller	0	0.0004	55
56	216	807	Oceanography	0	0.0000	56	56	18	14	Shepard	0	0.0003	56

Table A-7: RANKWORK2 Spreadsheet (Continued)

RANKWORK2 Auto Rank: Method A Reset Auto Rank: Method B Reset

Method A: Estimated Fatalities Based on Average Occ.							Method B: Estimated Fatalities Based on Maximum Occ.						
Rank, Method A	Bldg Index Code	Building Number	Building Name	Bldg Use Code	Estimated Fatalities Based on Method A	Rank, Method A	Rank, Method B	Bldg Index Code	Building Number	Building Name	Bldg Use Code	Estimated Fatalities Based on Method B	Rank, Method B
57	167	120	Parker Stadium, Overall	0	0.0000	57	57	74	60	Adams	0	0.0001	57
58	182	143	Parker Stadium, Clubhouse	0	0.0000	58	58	216	807	Oceanography	0	0.0000	58
1	201	192	Callahan	1	25.0024	1	1	114	83	Memorial Union	1	194.6910	1
2	198	191	Wilson	1	22.7800	2	2	201	192	Callahan	1	37.5697	2
3	114	83	Memorial Union	1	22.5829	3	3	195	190	McNary	1	34.6065	3
4	195	190	McNary	1	22.0656	4	4	152	111	Buxton	1	32.4899	4
5	158	114	Cauthom	1	20.3988	5	5	158	114	Cauthom	1	31.3258	5
6	152	111	Buxton	1	17.7795	6	6	198	191	Wilson	1	30.3733	6
7	204	196	Finley	1	14.4770	7	7	161	115	West International	1	25.6109	7
8	161	115	West International	1	12.2234	8	8	204	196	Finley	1	21.4541	8
9	155	112	Poling	1	11.3503	9	9	207	198	Bloss	1	18.8843	9
10	207	198	Bloss	1	11.2948	10	10	155	112	Poling	1	17.4620	10
11	164	119	Hawley	1	7.1435	11	11	164	119	Hawley	1	13.1229	11
12	185	145	Dixon Rec Center	1	1.6072	12	12	185	145	Dixon Rec Center	1	7.9201	12
13	210	199	College Inn	1	0.1854	13	13	210	199	College Inn	1	0.3337	13
14	128	96	Sackett	1	0.0333	14	14	128	96	Sackett	1	0.0444	14
15	82	62	Plageman Bldg	1	0.0049	15	15	82	62	Plageman Bldg	1	0.0301	15
16	150	109	Weatherford	1	0.0000	16	16	150	109	Weatherford	1	0.0000	16
				Total:	246						Total:	680	

Table A-8: COSTWORK Spreadsheet

COSTWORK

Bldg Index Code	Building Number	Building Name	Building Class Code	Sub-building Portion Factor	Building Area (Square Feet)	Sub-building Cost Estimates ($ per square foot): OSU Cost Estimate (Structural Only)	Portland Study (Structural Only)	Portland Study (Nonstructural Only)	Portland Study (Total)	Total Rehabilitation Cost Estimates for Main Buildings: OSU Conceptual Designs (Structural Only)	OSU Cost Estimate (String to Export)	Portland Study (Structural)	Portland Study (Nonstructural)	Portland Study (Total)
1	1	Apperson			29,426					0	N/A	615,298	382,538	997,836
2	1	Apperson	1.1	1.0	29,426	0.00	20.91	13.00	33.91			615,298	382,538	997,836
3	2	Merryfield			27,329					412,941	412,941	658,356	355,277	1,013,633
4	2	Merryfield	75.1	1.0	27,329	15.11	24.09	13.00	37.09			658,356	355,277	1,013,633
5	6	Graf			37,792					571,037	571,037	1,040,225	491,296	1,531,521
6	6	Graf	75.1	0.5	18,896	15.11	24.09	13.00	37.09			455,205	245,648	700,853
7	6	Graf	87.1	0.5	18,896	0.00	30.96	13.00	43.96			585,020	245,648	830,668
8	7	Covell			37,329					564,041	564,041	899,256	485,277	1,384,533
9	7	Covell	75.1	1.0	37,329	15.11	24.09	13.00	37.09			899,256	485,277	1,384,533
10	9	Batcheller			20,816					0	N/A	435,263	270,608	705,871
11	9	Batcheller	1.1	1.0	20,816	0.00	20.91	13.00	33.91			435,263	270,608	705,871
12	11	Dearborn			64,455					0	N/A	1,924,304	837,915	2,762,219
13	11	Dearborn	15.1	0.5	32,228	0.00	30.19	13.00	43.19			972,948	418,958	1,391,906
14	11	Dearborn	3.1	0.5	32,228	0.00	29.52	13.00	42.52			951,356	418,958	1,370,313
15	12	Gilbert Addition			44,144					0	N/A	1,361,622	573,872	1,935,494
16	12	Gilbert Addition	87.1	0.5	22,072	0.00	30.96	13.00	43.96			683,349	286,936	970,285
17	12	Gilbert Addition	6.1	0.5	22,072	0.00	30.73	13.00	43.73			678,273	286,936	965,209
18	14	Shepard			11,673					0	N/A	244,082	151,749	395,831
19	14	Shepard	1.1	1.0	11,673	0.00	20.91	13.00	33.91			244,082	151,749	395,831
20	15	Gilbert			83,148					0	N/A	2,466,170	1,080,924	3,547,094
21	15	Gilbert	87.1	0.5	41,574	0.00	29.8	13.00	42.8			1,238,905	540,462	1,779,367
22	15	Gilbert	6.1	0.5	41,574	0.00	29.52	13.00	42.52			1,227,264	540,462	1,767,726
23	16	Gleeson			39,011					0	N/A	1,203,294	507,143	1,710,437
24	16	Gleeson	87.1	0.5	19,506	0.00	30.96	13.00	43.96			603,890	253,572	857,462
25	16	Gleeson	6.1	0.5	19,506	0.00	30.73	13.00	43.73			599,404	253,572	852,976
26	17	Weniger			211,077					0	N/A	5,302,254	2,744,001	8,046,255
27	17	Weniger	15.1	0.5	105,539	0.00	24.51	13.00	37.51			2,586,749	1,372,001	3,958,749
28	17	Weniger	3.1	0.5	105,539	0.00	25.73	13.00	38.73			2,715,506	1,372,001	4,087,506
29	18	Bexell			58,600					1,186,064	1,186,064	1,360,106	761,800	2,121,906
30	18	Bexell	75.1	1.0	58,600	20.24	23.21	13.00	36.21			1,360,106	761,800	2,121,906
31	19	Rogers			55,341					0	N/A	1,641,414	719,433	2,360,847

Table A-8: COSTWORK Spreadsheet (Continued)

COSTWORK

Bldg Index Code	Building Number	Building Name	Building Class Code	Sub-building Portion Factor	Building Area (Square Feet)	Sub-building Cost Estimates ($ per square foot): OSU Cost Estimate (Structural Only)	Portland Study (Structural Only)	Portland Study (Nonstructural Only)	Portland Study (Total)	Total Rehabilitation Cost Estimates for Main Buildings: OSU Conceptual Designs (Structural Only)	OSU Cost Estimate (String to Export)	Portland Study (Structural)	Portland Study (Nonstructural)	Portland Study (Total)
32	19	Rogers	87.1	0.5	27,671	0.00	29.8	13.00	42.8			824,581	359,717	1,184,297
33	19	Rogers	6.1	0.5	27,671	0.00	29.52	13.00	42.52			816,833	359,717	1,176,550
34	20	Milne Computer Center			23,502					0	N/A	724,919	305,526	1,030,445
35	20	Milne Computer Center	87.1	0.5	11,751	0.00	30.96	13.00	43.96			363,811	152,763	516,574
36	20	Milne Computer Center	6.1	0.5	11,751	0.00	30.73	13.00	43.73			361,108	152,763	513,871
37	21	Nash			105,456					0	N/A	2,713,383	1,370,928	4,084,311
38	21	Nash	3.1	1.0	105,456	0.00	25.73	13.00	38.73			2,713,383	1,370,928	4,084,311
39	22	Electric Comp Engr			63,167					0	N/A	1,885,851	821,171	2,707,022
40	22	Electric Comp Engr	15.1	0.5	31,584	0.00	30.19	13.00	43.19			953,506	410,586	1,364,091
41	22	Electric Comp Engr	3.1	0.5	31,584	0.00	29.52	13.00	42.52			932,345	410,586	1,342,930
42	27	Benton			24,144					0	N/A	504,851	313,872	818,723
43	27	Benton	1.1	1.0	24,144	0.00	20.91	13.00	33.91			504,851	313,872	818,723
44	28	Education Bldg			40,032					604,884	604,884	1,101,881	520,416	1,622,297
45	28	Education Bldg	78.1	0.5	20,016	0.00	30.96	13.00	43.96			619,695	260,208	879,903
46	28	Education Bldg	75.1	0.5	20,016	15.11	24.09	13.00	37.09			482,185	260,208	742,393
47	30	Pharmacy			41,374					625,161	625,161	1,106,589	537,862	1,644,451
48	30	Pharmacy, Original	75.1	0.6	24,824	15.11	24.09	13.00	37.09			598,020	322,717	920,737
49	30	Pharmacy, Addition	6.1	0.4	16,550	0.00	30.73	13.00	43.73			508,569	215,145	723,714
50	34	Kidder Hall			76,008					1,538,402	1,538,402	1,914,413	988,104	2,902,517
51	34	Kidder Hall, Original	75.1	0.7	53,206	20.24	23.21	13.00	36.21			1,234,902	691,673	1,926,575
52	34	Kidder Hall, Addition	87.1	0.3	22,802	0.00	29.8	13.00	42.8			679,512	296,431	975,943
53	36	Kerr Library			188,087					4,562,991	4,562,991	4,782,112	2,445,131	7,227,243
54	36	Kerr Library	15.1	0.3	47,022	0.00	24.51	13.00	37.51			1,152,503	611,283	1,763,786
55	36	Kerr Library	3.1	0.3	47,022	0.00	25.73	13.00	38.73			1,209,870	611,283	1,821,152
56	36	Kerr Library	82.2	0.5	94,044	24.26	25.73	13.00	38.73			2,419,739	1,222,566	3,642,305
57	37	Social Science			21,819					329,685	329,685	525,620	283,647	809,267
58	37	Social Science	75.1	1.0	21,819	15.11	24.09	13.00	37.09			525,620	283,647	809,267
59	38	Strand Agriculture			115,991					2,347,658	2,347,658	2,384,775	1,507,883	3,892,658
60	38	Strand Agriculture	75.1	1.0	115,991	20.24	20.56	13.00	33.56			2,384,775	1,507,883	3,892,658
61	53	McAlexander Total			57,713					0	N/A	988,681	750,269	1,738,950
62	53	McAlexander Office	1.1	0.3	17,314	0.00	24.6	13.00	37.6			425,922	225,081	651,003

Table A-8: COSTWORK Spreadsheet (Continued)

COSTWORK

						Sub-building Cost Estimates ($ per square foot)				Total Rehabilitation Cost Estimates for Main Buildings				
Bldg Index Code	Building Number	Building Name	Building Class Code	Sub-building Portion Factor	Building Area (Square Feet)	OSU Cost Estimate (Structural Only)	Portland Study (Structural Only)	Portland Study (Nonstructural Only)	Portland Study (Total)	OSU Conceptual Designs (Structural Only)	OSU Cost Estimate (String to Export)	Portland Study (Structural)	Portland Study (Nonstructural)	Portland Study (Total)
63	53	McAlexander Office, Tot	0.5	0.0		0.00	0	0.00	0					
64	53	McAlexander Fieldhouse	2.1	0.7	40,399	0.00	13.93	13.00	26.93			562,759	525,188	1,087,948
65	53	McAlexander Fieldhouse, T	0.5	0.0	0	0.00	0	0.00	0					
66	54	Indoor Target Range			4,174					63,069	63,069	101,261	54,262	155,523
67	54	Indoor Target Range	75.1	1.0	4,174	15.11	24.26	13.00	37.26			101,261	54,262	155,523
68	56	Phys Heating Plant			26,192					0	N/A	611,976	340,496	952,472
69	56	Phys Heating Plant, Original	78.1	0.5	13,096	0.00	30.96	13.00	43.96			405,452	170,248	575,700
70	56	Phys Heating Plant, Addition	2.1	0.5	13,096	0.00	15.77	13.00	28.77			206,524	170,248	376,772
71	58	Industrial Bldg			18,834					0	N/A	579,711	244,842	824,553
72	58	Industrial Bldg	1.1	0.3	5,650	0.00	20.91	13.00	33.91			118,146	73,453	191,598
73	58	Industrial Bldg	78.2	0.7	13,184	0.00	35.01	13.00	48.01			461,565	171,389	632,954
74	60	Adams			11,573					0	N/A	233,659	150,449	384,108
75	60	Adams	1.1	1.0	11,573	0.00	20.19	13.00	33.19			233,659	150,449	384,108
76	61	Admin Services			139,078					1,027,091	1,027,091	4,630,385	2,216,461	6,846,846
77	61	Admin Services, A	3.1	0.1	17,385	0.00	25.73	13.00	38.73			447,310	226,002	673,311
78	61	Admin Services, A	78.2	0.1	17,385	0.00	30.57	13.00	43.57			531,452	226,002	757,454
79	61	Admin Services, B	87.1	0.1	17,385	0.00	25.86	13.00	38.86			449,570	226,002	675,571
80	61	Admin Services, B	6.1	0.1	17,385	0.00	25.73	13.00	38.73			447,310	226,002	673,311
81	61	Admin Services, Overall	82.3	0.5	69,539	7.39	25.73	13.00	38.73			1,789,238	904,007	2,693,245
82	62	Plageman Bldg			31,419					0	N/A	965,506	408,447	1,373,953
83	62	Plageman Bldg	6.1	1.0	31,419	0.00	30.73	13.00	43.73			965,506	408,447	1,373,953
84	67	Ballard Extension			46,011					695,226	695,226	1,108,405	598,143	1,706,548
85	67	Ballard Extension	75.1	1.0	46,011	15.11	24.09	13.00	37.09			1,108,405	598,143	1,706,548
86	68	Burt			54,909					0	N/A	1,628,601	713,817	2,342,418
87	68	Burt	87.1	0.5	27,455	0.00	29.8	13.00	42.8			818,144	356,909	1,175,053
88	68	Burt	6.1	0.5	27,455	0.00	29.52	13.00	42.52			810,457	356,909	1,167,365
89	69	Family Study Center			17,588					0	N/A	545,316	228,644	773,960
90	69	Family Study Center	15.1	0.5	8,794	0.00	31.28	13.00	44.28			275,076	114,322	389,398
91	69	Family Study Center	3.1	0.5	8,794	0.00	30.73	13.00	43.73			270,240	114,322	384,562
92	70	Wilkinson			60,635					0	N/A	1,796,736	788,255	2,584,991
93	70	Wilkinson	3.1	0.4	24,254	0.00	29.52	13.00	42.52			715,978	315,302	1,031,280

Table A-8: COSTWORK Spreadsheet (Continued)

COSTWORK						Sub-building Cost Estimates ($ per square foot)				Total Rehabilitation Cost Estimates for Main Buildings				
Bldg Index Code	Building Number	Building Name	Building Class Code	Sub-building Portion Factor	Building Area (Square Feet)	OSU Cost Estimate (Structural Only)	Portland Study (Structural Only)	Portland Study (Nonstructural Only)	Portland Study (Total)	OSU Conceptual Designs (Structural Only)	OSU Cost Estimate (String to Export)	Portland Study (Structural)	Portland Study (Nonstructural)	Portland Study (Total)
94	70	Wilkinson	87.1	0.4	24,254	0.00	29.8	13.00	42.8			722,769	315,302	1,038,071
95	70	Wilkinson	6.1	0.2	12,127	0.00	29.52	13.00	42.52			357,989	157,651	515,640
96	73	Cordley			236,227					0	N/A	6,093,475	3,070,951	9,164,426
97	73	Cordley	87.1	0.5	118,114	0.00	25.86	13.00	38.86			3,054,415	1,535,476	4,589,891
98	73	Cordley	6.1	0.5	118,114	0.00	25.73	13.00	38.73			3,039,060	1,535,476	4,574,536
99	75	Withycombe			75,368					0	N/A	2,235,415	979,784	3,215,199
100	75	Withycombe	87.1	0.5	37,684	0.00	29.8	13.00	42.8			1,122,983	489,892	1,612,875
101	75	Withycombe	6.1	0.5	37,684	0.00	29.52	13.00	42.52			1,112,432	489,892	1,602,324
102	79	Ag Sciences II			182,437					0	N/A	4,644,390	2,371,681	7,016,071
103	79	Ag Sciences II	15.1	0.3	45,609	0.00	24.51	13.00	37.51			1,117,883	592,920	1,710,803
104	79	Ag Sciences II	3.1	0.3	45,609	0.00	25.73	13.00	38.73			1,173,526	592,920	1,766,446
105	79	Ag Sciences II	87.1	0.3	45,609	0.00	25.86	13.00	38.86			1,179,455	592,920	1,772,375
106	79	Ag Sciences II	6.1	0.3	45,609	0.00	25.73	13.00	38.73			1,173,526	592,920	1,766,446
107	80	Crop Science			58,116					0	N/A	1,723,721	755,508	2,479,229
108	80	Crop Science	87.1	0.5	29,058	0.00	29.8	13.00	42.8			865,928	377,754	1,243,682
109	80	Crop Science	6.1	0.5	29,058	0.00	29.52	13.00	42.52			857,792	377,754	1,235,546
110	81	Milam Hall			109,698					2,220,288	2,220,288	2,542,525	1,426,074	3,968,599
111	81	Milam Hall	75.1	0.5	54,849	20.24	20.56	13.00	33.56			1,127,695	713,037	1,840,732
112	81	Milam Auditorium	87.1	0.3	27,425	0.00	25.86	13.00	38.86			709,198	356,519	1,065,716
113	81	Milam Auditorium	6.1	0.3	27,425	0.00	25.73	13.00	38.73			705,632	356,519	1,062,151
114	83	Memorial Union			164,434					0	N/A	4,252,263	2,137,642	6,389,905
115	83	Memorial Union	78.1	1.0	164,434	0.00	25.86	13.00	38.86			4,252,263	2,137,642	6,389,905
116	84	Gilmore			16,188					244,601	244,601	455,579	210,444	666,023
117	84	Gilmore	6.1	0.3	4,856	0.00	30.73	13.00	43.73			149,237	63,133	212,370
118	84	Gilmore	78.1	0.3	4,856	0.00	30.96	13.00	43.96			150,354	63,133	213,487
119	84	Gilmore	75.1	0.4	6,475	15.11	24.09	13.00	37.09			155,988	84,178	240,165
120	86	Women's Bldg			87,486					1,770,717	1,770,717	2,030,550	1,137,318	3,167,868
121	86	Women's Bldg	75.1	1.0	87,486	20.24	23.21	13.00	36.21			2,030,550	1,137,318	3,167,868
122	87	Fairbanks			37,946					0	N/A	793,451	493,298	1,286,749
123	87	Fairbanks	1.1	1.0	37,946	0.00	20.91	13.00	33.91			793,451	493,298	1,286,749
124	88	Clark Lab			7,989					0	N/A	108,251	43,940	152,190

Table A-8: COSTWORK Spreadsheet (Continued)

COSTWORK

						Sub-building Cost Estimates ($ per square foot)				Total Rehabilitation Cost Estimates for Main Buildings				
Bldg Index Code	Building Number	Building Name	Building Class Code	Sub-building Portion Factor	Building Area (Square Feet)	OSU Cost Estimate (Structural Only)	Portland Study (Structural Only)	Portland Study (Nonstructural Only)	Portland Study (Total)	OSU Conceptual Designs (Structural Only)	OSU Cost Estimate (String to Export)	Portland Study (Structural)	Portland Study (Nonstructural)	Portland Study (Total)
125	88	Clark Lab	9.1	1.0	7,989	0.00	13.55	5.50	19.05			108,251	43,940	152,190
126	92	Computer Science			15,364					232,150	232,150	370,119	199,732	569,851
127	92	Computer Science	75.1	1.0	15,364	15.11	24.09	13.00	37.09			370,119	199,732	569,851
128	96	Sackett			142,272					0	N/A	3,660,659	1,849,536	5,510,195
129	96	Sackett	6.1	1.0	142,272	0.00	25.73	13.00	38.73			3,660,659	1,849,536	5,510,195
130	98	Radiation Center, Overall			47,689					0	N/A	1,451,152	619,957	2,071,109
131	98	Rad Center, Main Bldg	6.1	0.2	9,538	0.00	30.73	13.00	43.73			293,097	123,991	417,088
132	98	Rad Center, Main Bldg	78.1	0.2	7,153	0.00	30.96	13.00	43.96			221,468	92,994	314,461
133	98	Rad Center, Reactor Bldg	87.1	0.2	9,538	0.00	30.96	13.00	43.96			295,290	123,991	419,282
134	98	Rad Center, Reactor Bldg	3.1	0.2	9,538	0.00	30.73	13.00	43.73			293,097	123,991	417,088
135	98	Rad Center, Reactor Bldg	15.1	0.2	9,538	0.00	31.28	13.00	44.28			298,342	123,991	422,334
136	98	Radiation Center, Annex	1.1	0.1	2,384	0.00	20.91	13.00	33.91			49,859	30,998	80,857
137	100	Snell			107,213					0	N/A	2,867,948	1,393,769	4,261,717
138	100	Snell, Original	78.2	0.2	21,443	0.00	30.57	13.00	43.57			655,500	278,754	934,254
139	100	Snell, Original	87.1	0.2	21,443	0.00	25.86	13.00	38.86			554,506	278,754	833,259
140	100	Snell, Original	6.1	0.2	21,443	0.00	25.73	13.00	38.73			551,718	278,754	830,472
141	100	Snell, Addition	87.1	0.2	21,443	0.00	25.86	13.00	38.86			554,506	278,754	833,259
142	100	Snell, Addition	6.1	0.2	21,443	0.00	25.73	13.00	38.73			551,718	278,754	830,472
143	102	Waldo			73,704					0	N/A	1,813,118	958,152	2,771,270
144	102	Waldo	1.1	1.0	73,704	0.00	24.6	13.00	37.6			1,813,118	958,152	2,771,270
145	105	Langton			96,322					1,949,557	1,949,557	2,750,956	1,252,186	4,003,142
146	105	Langton	78.2	0.5	48,161	0.00	33.91	13.00	46.91			1,633,140	626,093	2,259,233
147	105	Langton	75.1	0.5	48,161	20.24	23.21	13.00	36.21			1,117,817	626,093	1,743,910
148	106	Moreland			28,380					428,822	428,822	683,674	368,940	1,052,614
149	106	Moreland	75.1	1.0	28,380	15.11	24.09	13.00	37.09			683,674	368,940	1,052,614
150	109	Weatherford			105,090					0	N/A	2,703,966	1,366,170	4,070,136
151	109	Weatherford	6.1	1.0	105,090	0.00	25.73	13.00	38.73			2,703,966	1,366,170	4,070,136
152	111	Buxton			61,488					668,989	668,989	1,815,126	799,344	2,614,470
153	111	Buxton	9.2	0.5	30,744	0.00	29.52	13.00	42.52			907,563	399,672	1,307,235
154	111	Buxton	82.1	0.5	30,744	10.88	29.52	13.00	42.52			907,563	399,672	1,307,235
155	112	Poling			57,658					627,319	627,319	1,702,064	749,554	2,451,618

Table A-8: COSTWORK Spreadsheet (Continued)

COSTWORK						Sub-building Cost Estimates ($ per square foot)				Total Rehabilitation Cost Estimates for Main Buildings				
Bidg Index Code	Building Number	Building Name	Building Class Code	Sub-building Portion Factor	Building Area (Square Feet)	OSU Cost Estimate (Structural Only)	Portland Study (Structural Only)	Portland Study (Nonstructural Only)	Portland Study (Total)	OSU Conceptual Designs (Structural Only)	OSU Cost Estimate (String to Export)	Portland Study (Structural)	Portland Study (Nonstructural)	Portland Study (Total)
156	112	Poling	9.2	0.5	28,829	0.00	29.52	13.00	42.52			851,032	374,777	1,225,809
157	112	Poling	82.1	0.5	28,829	10.88	29.52	13.00	42.52			851,032	374,777	1,225,809
158	114	Cauthorn			58,397					635,359	635,359	1,723,879	759,161	2,483,040
159	114	Cauthorn	9.2	0.5	29,199	0.00	29.52	13.00	42.52			861,940	379,581	1,241,520
160	114	Cauthorn	82.1	0.5	29,199	10.88	29.52	13.00	42.52			861,940	379,581	1,241,520
161	115	West International			62,270					677,498	677,498	1,838,210	809,510	2,647,720
162	115	West International	9.2	0.5	31,135	0.00	29.52	13.00	42.52			919,105	404,755	1,323,860
163	115	West International	82.1	0.5	31,135	10.88	29.52	13.00	42.52			919,105	404,755	1,323,860
164	119	Hawley			58,558					637,111	637,111	1,728,632	761,254	2,489,886
165	119	Hawley	9.2	0.5	29,279	0.00	29.52	13.00	42.52			864,316	380,627	1,244,943
166	119	Hawley	82.1	0.5	29,279	10.88	29.52	13.00	42.52			864,316	380,627	1,244,943
167	120	Parker Stadium, Overall			0					0	N/A	3,050,455	1,557,348	4,607,803
168	120	P Stadium, Bleachers	15.1	0.5	44,924	0.00	31.28	13.00	44.28			1,405,207	584,006	1,989,213
169	120	P Stadium, Bleachers	2.1	0.5	44,924	0.00	15.77	13.00	28.77			708,444	584,006	1,292,449
170	120	P Stadium, Bleachers Tot	0.5	0.0	89,847	0.00	0	0.00	0	0		2,113,651	1,168,011	3,281,662
171	120	P Stadium, Pressbox	15.1	1.0	29,949	0.00	31.28	13.00	44.28			936,805	389,337	1,326,142
172	120	P Stadium, Pressbox Tot	0.5	0.0	29,949	0.00	0	0.00	0	0		936,805	389,337	1,326,142
173	121	Gill Coliseum			218,262					0	N/A	5,617,300	2,837,406	8,454,706
174	121	Gill Coliseum (all but ramps)	3.1	0.9	196,436	0.00	25.73	13.00	38.73			5,054,293	2,553,665	7,607,959
175	121	Gill Coliseum (ramps)	87.1	0.1	10,913	0.00	25.86	13.00	38.86			282,213	141,870	424,083
176	121	Gill Coliseum (ramps)	6.1	0.1	10,913	0.00	25.73	13.00	38.73			280,794	141,870	422,664
177	124	Peavy			84,020					0	N/A	2,066,892	1,092,260	3,159,152
178	124	Peavy	1.1	1.0	84,020	0.00	24.6	13.00	37.6			2,066,892	1,092,260	3,159,152
179	128	Wiegand			57,957					0	N/A	1,719,005	753,441	2,472,446
180	128	Wiegand	87.1	0.5	28,979	0.00	29.8	13.00	42.8			863,559	376,721	1,240,280
181	128	Wiegand	6.1	0.5	28,979	0.00	29.52	13.00	42.52			855,445	376,721	1,232,166
182	143	Parker Stadium, Clubhouse			15,858					0	N/A	320,173	146,687	466,860
183	143	Parker Stadium, Clubhouse	3.1	0.5	7,929	0.00	30.73	13.00	43.73			243,658	103,077	346,735
184	143	Parker Stadium, Clubhouse	9.1	0.5	7,929	0.00	9.65	5.50	15.15			76,515	43,610	120,124
185	145	Dixon Rec Center			92,951					0	N/A	896,977	511,231	1,408,208
186	145	Dixon Rec Center	9.1	1.0	92,951	0.00	9.65	5.50	15.15			896,977	511,231	1,408,208

Table A-8: COSTWORK Spreadsheet (Continued)

COSTWORK

						Sub-building Cost Estimates ($ per square foot)				Total Rehabilitation Cost Estimates for Main Buildings				
Bldg Index Code	Building Number	Building Name	Building Class Code	Sub-building Portion Factor	Building Area (Square Feet)	OSU Cost Estimate (Structural Only)	Portland Study (Structural Only)	Portland Study (Nonstructural Only)	Portland Study (Total)	OSU Conceptual Designs (Structural Only)	OSU Cost Estimate (String to Export)	Portland Study (Structural)	Portland Study (Nonstructural)	Portland Study (Total)
187	151	Dryden			23,019					347,817	347,817	554,528	299,247	853,775
188	151	Dryden	75.1	1.0	23,019	15.11	24.09	13.00	37.09			554,528	299,247	853,775
189	153	Magruder			76,115					0	N/A	2,272,413	989,495	3,261,908
190	153	Magruder	15.1	0.5	38,058	0.00	30.19	13.00	43.19			1,148,956	494,748	1,643,703
191	153	Magruder	3.1	0.5	38,058	0.00	29.52	13.00	42.52			1,123,457	494,748	1,618,205
192	188	Childcare Center			9,590					0	N/A	301,989	124,670	426,659
193	188	Childcare Center	87.1	0.5	4,795	0.00	31.65	13.00	44.65			151,762	62,335	214,097
194	188	Childcare Center	6.1	0.5	4,795	0.00	31.33	13.00	44.33			150,227	62,335	212,562
195	190	McNary			72,594					789,823	789,823	2,142,975	943,722	3,086,697
196	190	McNary	9.2	0.5	36,297	0.00	29.52	13.00	42.52			1,071,487	471,861	1,543,348
197	190	McNary	82.1	0.5	36,297	10.88	29.52	13.00	42.52			1,071,487	471,861	1,543,348
198	191	Wilson			73,105					795,382	795,382	2,158,060	950,365	3,108,425
199	191	Wilson	9.2	0.5	36,553	0.00	29.52	13.00	42.52			1,079,030	475,183	1,554,212
200	191	Wilson	82.1	0.5	36,553	10.88	29.52	13.00	42.52			1,079,030	475,183	1,554,212
201	192	Callahan			72,698					790,954	790,954	2,146,045	945,074	3,091,119
202	192	Callahan	9.2	0.5	36,349	0.00	29.52	13.00	42.52			1,073,022	472,537	1,545,559
203	192	Callahan	82.1	0.5	36,349	10.88	29.52	13.00	42.52			1,073,022	472,537	1,545,559
204	196	Finley			84,751					1,201,769	1,201,769	2,501,850	1,101,763	3,603,613
205	196	Finley	6.1	0.5	42,376	0.00	29.52	13.00	42.52			1,250,925	550,882	1,801,806
206	196	Finley	82.4	0.5	42,376	14.18	29.52	13.00	42.52			1,250,925	550,882	1,801,806
207	198	Bloss			84,755					1,201,826	1,201,826	2,501,968	1,101,815	3,603,783
208	198	Bloss	6.1	0.5	42,378	0.00	29.52	13.00	42.52			1,250,984	550,908	1,801,891
209	198	Bloss	82.4	0.5	42,378	14.18	29.52	13.00	42.52			1,250,984	550,908	1,801,891
210	199	College Inn			120,000					0	N/A	3,542,400	1,560,000	5,102,400
211	199	College Inn	6.1	1.0	120,000	0.00	29.52	13.00	42.52			3,542,400	1,560,000	5,102,400
212	200	Lasells Stewart Center			43,211					0	N/A	1,005,909	432,110	1,438,019
213	200	LSC	87.1	0.3	12,963	0.00	30.96	13.00	43.96			401,344	168,523	569,867
214	200	LSC	6.1	0.3	12,963	0.00	30.73	13.00	43.73			398,362	168,523	566,885
215	200	LSC Auditorium	9.1	0.4	17,284	0.00	11.93	5.50	17.43			206,203	95,064	301,267
216	807	Oceanography			8,283					0	N/A	167,234	107,679	274,913
217	807	Oceanography	1.1	1.0	8,283	0.00	20.19	13.00	33.19			167,234	107,679	274,913

Table A-9: RANKINGS Spreadsheet, Academic Buildings, Method A

Prioritization of Academic Buildings
(sorted by Method A: estimated fatalities based on average occupancy)

Print All Sheets | Print Sheet

Building Number	Building Name	Building Use Code	Estimated Fatalities, Method A	Rank, Method A	Estimated Fatalities, Method B	Rank, Method B	Rehabilitation Cost Estimates ($): OSU Study Structural Rehabilitation Cost Estimate ($)	Rehabilitation Cost Estimates ($): Portland Study Structural Rehabilitation Cost Estimate ($)	Rehabilitation Cost Estimates ($): Portland Study Nonstructural Rehabilitation Cost Estimate ($)
61	Admin Services	0	23.5	1	46.8	2	1,027,091	4,630,385	2,216,461
36	Kerr Library	0	8.1	2	48.4	1	4,562,991	4,782,112	2,445,131
38	Strand Agriculture	0	4.1	3	19.6	3	2,347,658	2,384,775	1,507,883
34	Kidder Hall	0	3.9	4	12.7	5	1,538,402	1,914,413	988,104
81	Milam Hall	0	3.2	5	17.3	4	2,220,288	2,542,525	1,426,074
30	Pharmacy	0	2.3	6	7.7	8	625,161	1,106,589	537,862
67	Ballard Extension	0	1.6	7	3.3	12	695,226	1,108,405	598,143
75	Withycombe	0	1.5	8	2.4	14	N/A	2,235,415	979,784
105	Langton	0	1.5	9	11.4	6	1,949,557	2,750,956	1,252,186
86	Women's Bldg	0	1.3	10	11.0	7	1,770,717	2,030,550	1,137,318
98	Radiation Center, Overall	0	1.1	11	2.2	15	N/A	1,451,152	619,957
73	Cordley	0	0.9	12	5.1	10	N/A	6,093,475	3,070,951
200	Lasells Stewart Center	0	0.7	13	7.5	9	N/A	1,005,909	432,110
18	Bexell	0	0.6	14	2.9	13	1,186,064	1,360,106	761,800
100	Snell	0	0.5	15	1.2	17	N/A	2,867,948	1,393,769
92	Computer Science	0	0.3	16	0.7	19	232,150	370,119	199,732
7	Covell	0	0.2	17	1.0	18	564,041	899,256	485,277
68	Burt	0	0.2	18	0.6	21	N/A	1,628,601	713,817
70	Wilkinson	0	0.2	19	0.6	22	N/A	1,796,736	788,255
15	Gilbert	0	0.2	20	0.6	23	N/A	2,466,170	1,080,924
128	Wiegand	0	0.1	21	0.6	20	N/A	1,719,005	753,441
84	Gilmore	0	0.1	22	0.4	26	244,601	455,579	210,444
106	Moreland	0	0.1	23	0.3	28	428,822	683,674	368,940
79	Ag Sciences II	0	0.1	24	0.2	37	N/A	4,644,390	2,371,681
6	Graf	0	0.1	25	0.2	33	571,037	1,040,225	491,296
19	Rogers	0	0.1	26	0.5	24	N/A	1,641,414	719,433
28	Education Bldg	0	0.1	27	0.4	25	604,884	1,101,881	520,416
37	Social Science	0	0.1	28	0.2	29	329,685	525,620	283,647
151	Dryden	0	0.1	29	0.3	27	347,817	554,528	299,247
12	Gilbert Addition	0	0.1	30	0.2	36	N/A	1,361,622	573,872
2	Merryfield	0	0.1	31	0.2	30	412,941	658,356	355,277
11	Dearborn	0	0.0	32	0.2	31	N/A	1,924,304	837,915
16	Gleeson	0	0.0	33	0.2	34	N/A	1,203,294	507,143
21	Nash	0	0.0	34	0.1	39	N/A	2,713,383	1,370,928
88	Clark Lab	0	0.0	35	0.2	35	N/A	108,251	43,940
17	Weniger	0	0.0	36	0.1	38	N/A	5,302,254	2,744,001
58	Industrial Bldg	0	0.0	37	0.2	32	N/A	579,711	244,842
80	Crop Science	0	0.0	38	0.1	41	N/A	1,723,721	755,508
121	Gill Coliseum	0	0.0	39	4.7	11	N/A	5,617,300	2,837,406
56	Phys Heating Plant	0	0.0	40	0.1	44	N/A	611,976	340,496
188	Childcare Center	0	0.0	41	0.1	43	N/A	301,989	124,670
20	Milne Computer Center	0	0.0	42	0.1	42	N/A	724,919	305,526
22	Electric Comp Engr	0	0.0	43	0.0	45	N/A	1,885,851	821,171
54	Indoor Target Range	0	0.0	44	0.0	46	63,069	101,261	54,262
153	Magruder	0	0.0	45	0.0	47	N/A	2,272,413	989,495
69	Family Study Center	0	0.0	46	0.0	48	N/A	545,316	228,644
124	Peavy	0	0.0	47	0.0	50	N/A	2,066,892	1,092,260

Table A-9: RANKINGS Spreadsheet, Academic Buildings, Method A (Continued)

Prioritization of Academic Buildings

(sorted by Method A: estimated fatalities based on average occupancy)

Print All Sheets

Print Sheet

Building Number	Building Name	Building Use Code	Estimated Fatalities, Method A	Rank, Method A	Estimated Fatalities, Method B	Rank, Method B	Rehabilitation Cost Estimates ($): OSU Study Structural Rehabilitation Cost Estimate ($)	Rehabilitation Cost Estimates ($): Portland Study Structural Rehabilitation Cost Estimate ($)	Rehabilitation Cost Estimates ($): Portland Study Nonstructural Rehabilitation Cost Estimate ($)
102	Waldo	0	0.0	48	0.0	54	N/A	1,813,118	958,152
1	Apperson	0	0.0	49	0.0	51	N/A	615,298	382,538
87	Fairbanks	0	0.0	50	0.0	49	N/A	793,451	493,298
9	Batcheller	0	0.0	51	0.0	55	N/A	435,263	270,608
14	Shepard	0	0.0	52	0.0	56	N/A	244,082	151,749
27	Benton	0	0.0	53	0.0	52	N/A	504,851	313,872
53	McAlexander Total	0	0.0	54	0.0	53	N/A	988,681	750,269
60	Adams	0	0.0	55	0.0	57	N/A	233,659	150,449
807	Oceanography	0	0.0	56	0.0	58	N/A	167,234	107,679
120	Parker Stadium, Overall	0	0.0	57	1.4	16	N/A	3,050,455	1,557,348
143	Parker Stadium, Clubhouse	0	0.0	58	0.1	40	N/A	320,173	146,687

Table A-10: RANKINGS Spreadsheet, Academic Buildings, Method B

Prioritization of Academic Buildings

(sorted by Method B: estimated fatalities based on maximum occupancy)

Print Sheet

Building Number	Building Name	Building Use Code	Estimated Fatalities, Method A	Rank, Method A	Estimated Fatalities, Method B	Rank, Method B	Rehabilitation Cost Estimates ($): OSU Study Structural Rehabilitation Cost Estimate ($)	Rehabilitation Cost Estimates ($): Portland Study Structural Rehabilitation Cost Estimate ($)	Rehabilitation Cost Estimates ($): Portland Study Nonstructural Rehabilitation Cost Estimate ($)
36	Kerr Library	0	8.1	2	48.4	1	4,562,991	4,782,112	2,445,131
61	Admin Services	0	23.5	1	46.8	2	1,027,091	4,630,385	2,216,461
38	Strand Agriculture	0	4.1	3	19.6	3	2,347,658	2,384,775	1,507,883
81	Milam Hall	0	3.2	5	17.3	4	2,220,288	2,542,525	1,426,074
34	Kidder Hall	0	3.9	4	12.7	5	1,538,402	1,914,413	988,104
105	Langton	0	1.5	9	11.4	6	1,949,557	2,750,956	1,252,186
86	Women's Bldg	0	1.3	10	11.0	7	1,770,717	2,030,550	1,137,318
30	Pharmacy	0	2.3	6	7.7	8	625,161	1,106,589	537,862
200	Lasells Stewart Center	0	0.7	13	7.5	9	N/A	1,005,909	432,110
73	Cordley	0	0.9	12	5.1	10	N/A	6,093,475	3,070,951
121	Gill Coliseum	0	0.0	39	4.7	11	N/A	5,617,300	2,837,406
67	Ballard Extension	0	1.6	7	3.3	12	695,226	1,108,405	598,143
18	Bexell	0	0.6	14	2.9	13	1,186,064	1,360,106	761,800
75	Withycombe	0	1.5	8	2.4	14	N/A	2,235,415	979,784
98	Radiation Center, Overall	0	1.1	11	2.2	15	N/A	1,451,152	619,957
120	Parker Stadium, Overall	0	0.0	57	1.4	16	N/A	3,050,455	1,557,348
100	Snell	0	0.5	15	1.2	17	N/A	2,867,948	1,393,769
7	Covell	0	0.2	17	1.0	18	564,041	899,256	485,277
92	Computer Science	0	0.3	16	0.7	19	232,150	370,119	199,732
128	Wiegand	0	0.1	21	0.6	20	N/A	1,719,005	753,441
68	Burt	0	0.2	18	0.6	21	N/A	1,628,601	713,817
70	Wilkinson	0	0.2	19	0.6	22	N/A	1,796,736	788,255
15	Gilbert	0	0.2	20	0.6	23	N/A	2,466,170	1,080,924
19	Rogers	0	0.1	26	0.5	24	N/A	1,641,414	719,433
28	Education Bldg	0	0.1	27	0.4	25	604,884	1,101,881	520,416
84	Gilmore	0	0.1	22	0.4	26	244,601	455,579	210,444
151	Dryden	0	0.1	29	0.3	27	347,817	554,528	299,247
106	Moreland	0	0.1	23	0.3	28	428,822	683,674	368,940
37	Social Science	0	0.1	28	0.2	29	329,685	525,620	283,647
2	Merryfield	0	0.1	31	0.2	30	412,941	658,356	355,277
11	Dearborn	0	0.0	32	0.2	31	N/A	1,924,304	837,915
58	Industrial Bldg	0	0.0	37	0.2	32	N/A	579,711	244,842
6	Graf	0	0.1	25	0.2	33	571,037	1,040,225	491,296
16	Gleeson	0	0.0	33	0.2	34	N/A	1,203,294	507,143
88	Clark Lab	0	0.0	35	0.2	35	N/A	108,251	43,940
12	Gilbert Addition	0	0.1	30	0.2	36	N/A	1,361,622	573,872
79	Ag Sciences II	0	0.1	24	0.2	37	N/A	4,644,390	2,371,681
17	Weniger	0	0.0	36	0.1	38	N/A	5,302,254	2,744,001
21	Nash	0	0.0	34	0.1	39	N/A	2,713,383	1,370,928
143	Parker Stadium, Clubhouse	0	0.0	58	0.1	40	N/A	320,173	146,687
80	Crop Science	0	0.0	38	0.1	41	N/A	1,723,721	755,508
20	Milne Computer Center	0	0.0	42	0.1	42	N/A	724,919	305,526
188	Childcare Center	0	0.0	41	0.1	43	N/A	301,989	124,670
56	Phys Heating Plant	0	0.0	40	0.1	44	N/A	611,976	340,496
22	Electric Comp Engr	0	0.0	43	0.0	45	N/A	1,885,851	821,171
54	Indoor Target Range	0	0.0	44	0.0	46	63,069	101,261	54,262
153	Magruder	0	0.0	45	0.0	47	N/A	2,272,413	989,495

Table A-10: RANKINGS Spreadsheet, Academic Buildings, Method B (Continued)

Prioritization of Academic Buildings
(sorted by Method B: estimated fatalities based on maximum occupancy)

Print Sheet

							Rehabilitation Cost Estimates ($)		
Building Number	Building Name	Building Use Code	Estimated Fatalities, Method A	Rank, Method A	Estimated Fatalities, Method B	Rank, Method B	OSU Study Structural Rehabilitation Cost Estimate ($)	Portland Study Structural Rehabilitation Cost Estimate ($)	Portland Study Nonstructural Rehabilitation Cost Estimate ($)
69	Family Study Center	0	0.0	46	0.0	48	N/A	545,316	228,644
87	Fairbanks	0	0.0	50	0.0	49	N/A	793,451	493,298
124	Peavy	0	0.0	47	0.0	50	N/A	2,066,892	1,092,260
1	Apperson	0	0.0	49	0.0	51	N/A	615,298	382,538
27	Benton	0	0.0	53	0.0	52	N/A	504,851	313,872
53	McAlexander Total	0	0.0	54	0.0	53	N/A	988,681	750,269
102	Waldo	0	0.0	48	0.0	54	N/A	1,813,118	958,152
9	Batcheller	0	0.0	51	0.0	55	N/A	435,263	270,608
14	Shepard	0	0.0	52	0.0	56	N/A	244,082	151,749
60	Adams	0	0.0	55	0.0	57	N/A	233,659	150,449
807	Oceanography	0	0.0	56	0.0	58	N/A	167,234	107,679

Table A-11: RANKINGS Spreadsheet, Student Life Buildings, Method A

Prioritization of Student Life Buildings
(sorted by Method A: estimated fatalities based on average occupancy)

Print Sheet

Building Number	Building Name	Building Use Code	Estimated Fatalities, Method A	Rank, Method A	Estimated Fatalities, Method B	Rank, Method B	Rehabilitation Cost Estimates ($): OSU Study Structural Rehabilitation Cost Estimate ($)	Rehabilitation Cost Estimates ($): Portland Study Structural Rehabilitation Cost Estimate ($)	Rehabilitation Cost Estimates ($): Portland Study Nonstructural Rehabilitation Cost Estimate ($)
192	Callahan	1	25.0	1	37.6	2	790,954	2,146,045	945,074
191	Wilson	1	22.8	2	30.4	6	795,382	2,158,060	950,365
83	Memorial Union	1	22.6	3	194.7	1	N/A	4,252,263	2,137,642
190	McNary	1	22.1	4	34.6	3	789,823	2,142,975	943,722
114	Cauthorn	1	20.4	5	31.3	5	635,359	1,723,879	759,161
111	Buxton	1	17.8	6	32.5	4	668,989	1,815,126	799,344
196	Finley	1	14.5	7	21.5	8	1,201,769	2,501,850	1,101,763
115	West International	1	12.2	8	25.6	7	677,498	1,838,210	809,510
112	Poling	1	11.4	9	17.5	10	627,319	1,702,064	749,554
198	Bloss	1	11.3	10	18.9	9	1,201,826	2,501,968	1,101,815
119	Hawley	1	7.1	11	13.1	11	637,111	1,728,632	761,254
145	Dixon Rec Center	1	1.6	12	7.9	12	N/A	896,977	511,231
199	College Inn	1	0.2	13	0.3	13	N/A	3,542,400	1,560,000
96	Sackett	1	0.0	14	0.0	14	N/A	3,660,659	1,849,536
62	Plageman Bldg	1	0.0	15	0.0	15	N/A	965,506	408,447
109	Weatherford	1	0.0	16	0.0	16	N/A	2,703,966	1,366,170

Table A-12: RANKINGS Spreadsheet, Student Life Buildings, Method B

Prioritization of Student Life Buildings
(sorted by Method B: estimated fatalities based on maximum occupancy)

Print Sheet

Building Number	Building Name	Building Use Code	Estimated Fatalities, Method A	Rank, Method A	Estimated Fatalities, Method B	Rank, Method B	Rehabilitation Cost Estimates ($): OSU Study Structural Rehabilitation Cost Estimate ($)	Rehabilitation Cost Estimates ($): Portland Study Structural Rehabilitation Cost Estimate ($)	Rehabilitation Cost Estimates ($): Portland Study Nonstructural Rehabilitation Cost Estimate ($)
83	Memorial Union	1	22.6	3	194.7	1	N/A	4,252,263	2,137,642
192	Callahan	1	25.0	1	37.6	2	790,954	2,146,045	945,074
190	McNary	1	22.1	4	34.6	3	789,823	2,142,975	943,722
111	Buxton	1	17.8	6	32.5	4	668,989	1,815,126	799,344
114	Cauthorn	1	20.4	5	31.3	5	635,359	1,723,879	759,161
191	Wilson	1	22.8	2	30.4	6	795,382	2,158,060	950,365
115	West International	1	12.2	8	25.6	7	677,498	1,838,210	809,510
196	Finley	1	14.5	7	21.5	8	1,201,769	2,501,850	1,101,763
198	Bloss	1	11.3	10	18.9	9	1,201,826	2,501,968	1,101,815
112	Poling	1	11.4	9	17.5	10	627,319	1,702,064	749,554
119	Hawley	1	7.1	11	13.1	11	637,111	1,728,632	761,254
145	Dixon Rec Center	1	1.6	12	7.9	12	N/A	896,977	511,231
199	College Inn	1	0.2	13	0.3	13	N/A	3,542,400	1,560,000
96	Sackett	1	0.0	14	0.0	14	N/A	3,660,659	1,849,536
62	Plageman Bldg	1	0.0	15	0.0	15	N/A	965,506	408,447
109	Weatherford	1	0.0	16	0.0	16	N/A	2,703,966	1,366,170

Modifying The Workbook

There are three reasons that the spreadsheets in the workbook might need to be modified. These are as follows:

1. If one or more additional buildings are added to the evaluation.
2. If additional sub-buildings are added to any of the existing buildings.
3. If alternate fatality rates are used.

Modifying by Adding Additional Buildings

If additional buildings are added, several steps must be taken:

- In the BLDGDATA spreadsheet, insert the appropriate number of rows. To maintain continuity, the rows should be inserted according to the *Building Number* of the new building. For each additional building, one row should be inserted for each sub-building, plus one for the main building row. For example, a building with two structural systems identified would require three new rows -- one for the main building, and two for sub-buildings.
- Renumber the *Building Index Code* column in the BLDGDATA spreadsheet. Each row must have a unique *Building Index Code*, and these should run consecutively from top to bottom.
- Renumber the *Building Index Code* columns in the other spreadsheets. Every *Building Index Code* number assigned should be repeated in the OCCUPANCY, RANKWORK1, RANKWORK2, and COSTWORK spreadsheets. Additionally, the *Building Index Code* numbers for the main buildings only should be repeated in the two *Building Index Code* columns (one column for each Method, A and B) of the RANKWORK2 spreadsheet.
- Copy the appropriate equations into the new cells for the additional building. The simplest way to do this is to find an existing building with the same number of sub-buildings, and copy the entire block of rows from that building into the rows for the new building. This is required for the BLDGDATA, OCCUPANCY, RANKWORK1, RANKWORK2, and COSTWORK spreadsheets.

- Fill in the appropriate information in the BLDGDATA and OCCUPANCY spreadsheets. This is the data in the white cells.
- Change the lookup ranges. Throughout the SEISPLAN workbook, data is transferred within and between spreadsheets by means of the VLOOKUP function. This function looks for the requested value in a lookup array, which is a designated section of a spreadsheet. When new rows are added for the new buildings, the lookup arrays must be modified so that the new data is included. All the lookup arrays used in the spreadsheets are identified in Table A-13: Lookup Arrays in SEISPLAN. Each one must be modified by adding the appropriate number of rows to the range. These changes can be made under the INSERT: NAMES: DEFINE menu option in Excel 5.0. The appropriate modifications are indicated by the Front Mod and End Mod columns in Table . The Front Mod is for the adjustment at the beginning of the range, and the End Mod is for the adjustment at the end of the range. The appropriate modifications are as follows.
    1. Front Mod: None. No modification to the beginning of the range.
    2. Front Mod: Acad. Increase the beginning of the range by one row for each academic main building added to the prioritization. For example, if two new academic buildings are added, the beginning of the STLFA1 range should be changed from $U$63 to $U$65.
    3. End Mod: All. Increase the end of the range by one row for each main building and each sub-building added to the prioritization. For example, if one new building consisting of three sub-buildings is added to the prioritization, the end of the ALLBLDATA range should be changed from $AA$220 to $AA$224.
    4. End Mod: Acad. Increase the end of the range by one row for each academic main building added to the prioritization.
    5. End Mod: Main. Increase the end of the range by one row for each main building added to the prioritization. This is not cumulative with the Front Mod increase. For example, if two new academic buildings and one new

student life building are added to the prioritization, the STLFA1 range should be changed from RANKWORK2! $U$63:$AA$78 to RANKWORK2! $U$65:$AA$81.

6. End Mod: St Lf. Increase the end of the range by one row for each student life main building added to the prioritization.

- Rerank the buildings on the rankwork2 spreadsheet. Refer to the section on the RANKWORK2 spreadsheet in this appendix.
- Print the adjusted rankings on the RANKINGS spreadsheet.

Table A-13: Lookup Arrays in SEISPLAN

Name of Array	Range of Cells in Lookup Array	Front Mod	End Mod
ALLBLDATA	BLDGDATA! $A$4:$AA$220	None	All
OCC1	OCCUPANC! $A$4:$T$220	None	All
RANKWORKAREA	RANKWORK1! $A$5:$S$221	None	All
ACADA1	RANKWORK2! $U$5:$AA$62	None	Acad
ACADB1	RANKWORK2! $AE$5:$AH$62	None	Acad
COSTSUMM	COSTWORK! $C$3:$O$219	None	All
ACADB2	RANKWORK2! $AB$5:$AH$62	None	Acad
ACADA2	RANKWORK2! $X$5:$AA$62	None	Acad
STLFA1	RANKWORK2! $U$63:$AA$78	Acad	Main
STLFB1	RANKWORK2! $AE$63:$AH$78	Acad	Main
STLFA2	RANKWORK2! $X$63:$AA$78	Acad	Main
STLFB2	RANKWORK2! $AB$63:$AH$78	Acad	Main
pacada	RANKINGS! $A$5:$J$62	None	Acad
pacadb	RANKINGS! $L$5:$U$62	None	Acad
pstlfa	RANKINGS! $W$5:$AF$20	None	St Lf
pstlfb	RANKINGS! $AH$5:$AQ$20	None	St Lf
ranka	RANKWORK2! $U$5:$AA$78	None	Main
rankb	RANKWORK2! $AB$5:$AH$78	None	Main

Modifying by Adding Sub-building to Existing Buildings

If additional structural systems are identified in a buildings already evaluated, the following steps should be taken:

- In the BLDGDATA spreadsheet, insert the appropriate number of rows under the main building to be modified. One row should be inserted for each sub-building to be added.
- Renumber the *Building Index Code* column in the BLDGDATA spreadsheet. Each row must have a unique *Building Index Code*, and these should run consecutively from top to bottom.
- Renumber the *Building Index Code* columns in the other spreadsheets. Every *Building Index Code* number assigned should be repeated in the OCCUPANCY, RANKWORK1, RANKWORK2, and COSTWORK spreadsheets. The *Building Index Code* numbers provided in the RANKWORK2 spreadsheet should not be modified.
- Copy the appropriate equations into the new cells for the modified building. The simplest way to do this is to find an existing building with the same number of sub-buildings, and copy the entire block of rows from that building into the rows for the modified building. This is required for the BLDGDATA, OCCUPANCY, RANKWORK1, RANKWORK2, and COSTWORK spreadsheets.
- Fill in the appropriate information in the BLDGDATA and OCCUPANCY spreadsheets. This is the data in the white cells. Ensure that the sub-building proportion factors for all of the sub-buildings within the main building add up to 1.00.
- Change the lookup ranges. This is explained in detail under the sixth step in the section above on Modifying by Adding Additional Buildings. The only ranges that must be modified are the ones in which the End Mod column indicates "All."
- Rerank the buildings on the rankwork2 spreadsheet. Refer to the section on the RANKWORK2 spreadsheet in this appendix.
- Print the adjusted rankings on the RANKINGS spreadsheet.

Modifying by Using Alternate Fatality Rates

If alternate fatality rates are used, the new rates are simply entered into the RATIOS spreadsheet. To develop the new fatality rates, see the procedure outlined in III: Development of Damage Probability Matrices.

Buildings Requiring Special Treatment

Two buildings are configured in such a way that they require a different treatment within the spreadsheets from the other buildings. These are McAlexander Fieldhouse and Parker Stadium. With these two buildings, the occupancies for different parts of the building have been identified independently of the *Sub-building Proportion Factors*. For all other buildings, a single occupancy has been estimated for the entire building. Casualties for each sub-building within a building are estimated based on a proportion of occupants, which is assumed to be equal to the *Sub-building Proportion Factor* representing the relative contribution of the structural system of that sub-building, as related to the structural systems of the other sub-buildings.

For McAlexander and Parker Stadium, subtotals are calculated for each portion of the building having a separate occupancy. These subtotals are included in the sub-building rows, and are identified with the word "Sub" in the *ATC-21 Class* column in the BLDGDATA spreadsheet. This is filled in automatically by cross-referencing the 0.5 value in the *Building Class Code* with the COSTDATA spreadsheet. At several places throughout the data and working spreadsheets, values for the subtotals are calculated for the specific parts of the buildings associated with those subtotals. The main building totals are then calculated by summing the values in the rows containing the subtotals.

The treatment of these two buildings should not have any effect on the calculation of new prioritizations as long as the only changes are different values in the existing columns in the input spreadsheets. However, if building occupancies for other buildings are separated as they were for McAlexander and Parker Stadium, then the rows for these buildings should be modified to contain the same type of calculations for the subtotals and main building rows.

Limitations of SEISPLAN

The SEISPLAN workbook was specifically designed to provide for a reevaluation of the prioritization of specific buildings on the Oregon State University campus. While it can also be modified to include other buildings, this will require a comprehensive understanding of what each section of the workbook does. Similarly, any application of this software to other campuses or communities should be undertaken only if all the assumptions made in the development of the OSU loss estimate and prioritization are fully understood, and all appropriate modifications are made as required for the specific site under consideration.

APPENDIX B: 3.5" Diskette Containing DERIVDPM.XLS and SEISPLAN.XLS