The Current State of Earthquake Resistance Regarding University of Idaho Historic Buildings

Research Paper for Seismic Design - ARCH 466
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**Abstract**

The University of Idaho in Moscow, Idaho is home to several unreinforced structures. Due to the potential high risk of collapse in a seismic event, these historic buildings pose a serious threat to human life. Retrofit efforts have been moved to a lesser priority than that of other non-life threatening campus improvements such as aesthetic walkway alterations.

This paper will look at three high-risk structures, in particular the Steam Plant, to shed light on the current lack of focus on retrofit projects at the University of Idaho. The problem was acknowledged on the UI campus by recognizing buildings of similar construction that have historically failed in other places around the world due to strong lateral forces. The problem was approached in this research paper mainly by reviewing engineering documents thoroughly compiled by Coughlin Porter Lundeen, who investigated the problems in depth. These documents were provided courtesy of the UI Facilities Department. Recommendations were made from the above research.

The solution to the problem is to reconsider the allocation of current funding plans, from aesthetic upgrades, into seismic upgrades of the buildings on the UI campus that pose a threat in the event of high lateral forces produced by an earthquake. The goal is to allow seismic retrofits to drive the purpose for the upgrades, rather than less life threatening aesthetic or facility upgrades.

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**Research**

The University of Idaho in Moscow, Idaho, is home to some beautiful historic buildings, many of which date back to the beginning of the early 1900's. One example is the Administration Building, without question the most iconic image of UI, which was constructed mostly out of multi-wythe masonry. Another is the Heating Plant, which will be discussed most in this paper due to its high embodied risk. How will these historic structures perform in the event of major ground shaking in the Palouse region? Have these buildings of concern been sufficiently upgraded to anticipate a major seismic event? What currently are the materials being used to support these very heavy structures, and how do these materials hold up during significant ground shaking? Most importantly, should anything be done to improve them, even though the Palouse Region only has a 0.08 to 0.10 probability of receiving a serious event as seen on Figure 1 in the Appendix (Seismic Hazard, 2012)? With the soil composition that many of these potentially dangerous buildings were constructed on, they may be at moderate risk with reference to Figure 2 (Geological Hazards). A notable consideration is the proximity of Moscow to the seismically active Intermountain West Region, due to lateral spreading of the two mountain regions of the West Coast Range and Rocky Mountains (Coughlin Porter Lundeen, 2012, p. 1). These questions will be discussed in an attempt to bring awareness to those who need to consider these problems in Moscow, Idaho.

As must be considered in all major retrofit projects, there must be a motivation to even begin considering the problems at hand. The author recognizes that there are perhaps hundreds of different reasons that motivate the issues in regards to this research. For the sake of brevity, only a few of the most important concerns will be covered. These concerns include human life safety, loss of investments, and the lowered creditbility of the University of Idaho as a whole.

Beginning here with human life safety, it may be unanimously agreed upon that loss of life is a tragedy that must never be accepted if it is avoidable in any capacity. In the past, there have been numerous events that exemplified poor construction, disregard for quality architectural configuration, and followed a dogmatic approach to the built environment (Wang, 1981); each of these has caused significant loss of life. The buildings in question on the UI campus do not necessarily follow any stylistic modernist designs, but are in fact quite unique to Moscow, Idaho. The concern in regard to life safety here is, were these buildings constructed with high quality, and will architectural configuration be enough to prevent a serious failure of the structure? Also concerning life-safety is the question of whether in the event of high ground motion, will these buildings be able to stay up long enough for every individual to exit the building safely before failure? The latter question should be at the top of every concern regarding how to preserve the lives of occupants.

If these currently in-use structures become completely unusable after a seismic event in Moscow, Idaho, not only does the University of Idaho face the question of lives lost, but also loss of investments accrued. It is more than likely that the University as a whole has already recovered the cost of the buildings of concern. In some cases the University may benefit from complete replacement of the older buildings. An acquaintance of the author, Ryan Tarinelli, who is a student of the College of Music, claims from personal experience that there is one building in particular that he believes is beautiful, but should be replaced. Ridenbaugh Hall, the longest standing building on the UI campus since 1901 is a testament to proper loading, and a beautiful historic building. Listed on the National Register of Historic Places, Ridenbaugh was constructed primarily of “brick, set on a native basalt foundation. This blocky red brick building rises three stories and is topped with a truncated hip roof. Its dimensions are 78' x 96', 15,712 sqft. (Morton, 1890-1961).” Ridenbaugh is a beautiful building indeed, with hand crafted exterior finishes, a symmetrical floor plan, and continuous load paths. However, according to Mr. Tarinelli, Ridenbaugh does not fit the needs of those who use the space today. It currently serves as practice rooms for musical instrumentalists and vocalists. In this example (occupants aside) there have already been many upgrades to the building, such as careful refinishing, added entries, plumbing upgrades, electrical alterations, harmonic dampening, and many very expensive musical instruments rest quietly in the practice rooms. The loss of this building may equal a more sophisticated space for practicing, but would mean a significant loss to the University as an investment.

A more significant danger lies in more important buildings on campus, such as the Heating Plant, also known as the *Steam Plant*, which will be discussed in further detail later. The danger these buildings pose to human life and investment should now be obvious, but there is one more motivating factor that must be considered as well – that is reputability of the University. As the author has discovered during his research, there has already been a significant study into the matter of seismic resistance concerning 31 UI campus buildings, which includes the buildings already mentioned in this paper. Although the research conducted by Coughlin Porter Lundeen Engineers was completed recently in January of 2012, the sluggish effects of bureaucracy and the slow-moving action that so typically coincides with the acquisition of funding may be the reason why UI would lose credibility with past, present, and future stake-holders. The institution’s creditability would especially be at stake if the University already knew about the serious implications of a major seismic event, which the Facilities department is currently aware of.

The buildings of concern are listed in the Appendix at the end of this essay, may be referenced in alphabetical order, and have short descriptions concerning their material composition, size, and date. The problem at hand is whether these buildings are capable of handling a seismic event, and if anything should be done about it.

The Steam Plant poses perhaps the highest risk in several ways. Also see the Appendix for a detailed description regarding the Steam Plant. One: If the plant fails, then most of the UI campus would be at risk. Although there are backup systems around campus, they may also become compromised in a serious ground shaking event and are only capable of lasting for the duration of their capacity. Risk two: During Moscow's cold season, when in the past temperatures have dropped to below -4°, students, faculty, and costly research projects that span 20 or more years could be at risk in a crisis. Three: Given past examples of earthquakes such as the El Centro earthquake of 1940 with a Richter Magnitude level 7.1 (Historic Earthquakes, 2012), the Steam Plant may not be capable of handling a seismic event of this level (see building description in Appendix).

These problems are only amplified when other issues are taken into account. When a building is unexpectedly loaded top-heavy, also known as an inverted pendulum, an excessive amount of momentum reversal increases the chance of structural failure. In recent years, many new mechanisms have been added to the roof of the Heating Plant. Although these new devices are of high quality, and will last for many years, they may also be the literal downfall of the Heating Plant since they have been installed at the roof level and are very heavy. As shown in lectures by Kenneth Carper and in the Uniform Building Codes or International Building Codes, the Equivalent Static Load Analysis defines the factor that has always driven the resulting force, or shear force (V) from ground motion and building response (Carper, 2013). The defining factor is Weight. Each subsequent addition of load that a building receives equals an additional multiple in relation to the seismic inertial force being applied. The above being true, there is an obvious risk of loss of the Heating Plant on the University of Idaho campus.

The Facilities department at UI has already taken some measures regarding the above issues. Thanks to the work of Coughlin Porter Lundeen Engineers (CPL), a Seattle firm, an extensive report (three-inch thick document plus 1.5-inch thick building plan details) has been made to assess the risks to UI buildings and provide some solutions. Thanks to the ability of an architect's desk to collect dust while unreferenced materials lie unused, this report has sat with still papers, where it has been neglected for over a year. In the building plans of the report, they outline an easy to understand risk assessment that may be seen in the Appendix (Figure 3). It may be easy to see, for example, that the Heating Plant has the highest risk factor. This is due to several factors determined by occupancy code requirements, age of structure, importance, and potential loss of life factors (Figure 4). The engineering document also specifies what may be done to correct the potential hazards. A great amount of care and detail has gone into accounting for every upgrade, how many fasteners may be required, shear wall retrofits, and more. Thanks to ROEN Associates, based in Spokane, WA, who worked with CPL, the extensive document outlines their findings of cost estimates for all 31 buildings on the main University campus to receive seismic upgrades.

According to Guy Esser, University of Idaho Project Architect, "There just isn't enough time and money." As usual time and money are the major factors in deciding the fate of human life. Is there actually not enough money however? There may be plenty of funding to be distributed into building upgrade projects, but it has been focused into less important concerns.

This would probably be the equation factor values used to determine where to funnel funding (these are the author's creation):

Time = t(1.5); Money = m(2.3); Human Life = h(.75); Investment = i(.82)

Apply the above factors into any human concern, and one will determine the practical priority level (again, the author's creation). Even though the University faces potentially significant losses to human life, investment, and reputability, the seriousness of these hazards are obviously not of critical concern to those who make the final decisions. It is obvious by simply looking at future projects on the University website (www.uidaho.edu) such as the expansions to the University of Idaho Coeur d'Alene Campus, or *Phase One* Transportation Plan Improvement (University of Idaho Facilities, 2013) on the Moscow campus, which would cost an estimated five million dollars (Transportation, 2012). Although from an institution's perspective, sometimes the most immediate pressing matter is of most concern, and from the above examples the pressing matter is increasing reputability, not life safety. However, according to the cost and vulnerability analysis performed by CPL Engineers and ROEN Associates, the Steam Plant would require as low as $700,000 for Life Safety, and only a small increase in comparison up to $825,000 for Immediate Occupancy requirements (Figure 5). An additional estimate to performance improvements of the Steam Plant increased the amount to about two million dollars (Coughlin Porter Lundeen, 2012, p. 21). The numbers are clear, and if the University of Idaho is seriously interested in the safety of its patrons and staff, then it may need to seriously reconsider where they direct funding.

University of Idaho as a whole would be making a serious mistake by spending up to five million dollars on filling pot holes, straightening street curbs, and applying more aesthetic decorative curb appeal at high-volume street zones. Although expansion is important to a

University's future prosperity, distributing money to construct additional buildings around campus or even at remote campuses is not an effective use of funds when existing buildings need critical attention. The University as a whole must seriously consider what matters when the campus has no less than 31 buildings that pose a risk to people, property, and reputability. In particular the Steam Plant is not only the highest risk building in terms of structural and architectural failure, but it is also, above all, the most critical for sustaining the rest of the campus in the case of a serious seismic event.

Local problems will be discovered during seismic upgrades, and will be solved as a result of the already intended construction efforts. This would allow early detection of hidden problems that are not currently known. The answers presented here are specific to the potential of a serious seismic event and the risk to life-safety of students, faculty, and others. This study should be valuable to the administrators, investors, and the education community regarding the University of Idaho. Preventing serious damage to the university would avert a catastrophic failure of facilities and reduce loss of life, investment, and reputation due to a seismic event. The author believes that the University of Idaho must take steps to ensure the safety of those who live and work there. The solution is to back off from aesthetic additions and improvements, then use that funding to address the serious issues at hand regarding seismic retrofits and upgrades – starting with the most important first, the Steam Plant. Redirecting funds from *Phase One* (the street improvement project) alone could ensure that power failure does not occur in the coldest parts of the year, not to mention correcting many of the other structures that pose a high threat to human life.

**Appendix**

Main Buildings of Interest - 9 of 31 (Morton, 1890-1961)

- New **Administration Building**, 1909-1936. Concrete base, red brick facing with buff colored Boise sandstone trim, college Gothic style, three stories, U shaped.
- Art and Architecture South, 1904. Granite foundation, red brick facing, basement and two floors, newly retrofitted steel backup gable roof; 64' x 129'.
- Brink Hall, built 1936. Reinforced concrete, red fireproof brick, trimmed with Boise Sandstone. Gable roof, composition shingles, five floors, front 178' long, wings 81' and 129' long respectively, each wing about 29' wide. (Cards)
- Old Engineering Building, 1901-1951. Brick, basement and three floors, 60' x 108', 20,982 sq. ft.
- Forney Hall, 1923. Three story reinforced concrete, mission brick, gable roof with wooden shingles. Basement and sub-basement, collegiate Gothic style, 65' x 140'.
- **Heating Plant** (*Steam Plant*), 1927. ‘Unreinforced masonry, steel joists, timber, and metal roof decking, four stories high. Two major expansions in 1962 and 1974 with concrete floor slabs on structural steel frames. Lateral force resisting consists of varied roof structure and unreinforced masonry walls. Added mechanical systems on roof.’ (Coughlin Porter Lundeen, 2012, p. Appendix A)
- Memorial GYM, 1927. Five stories plus tower, concrete and brick construction, tile and plaster walls, 142' x 201'. Tudor-Gothic style, heavily buttressed, especially at the large front bay. Listed on National Register of Historic Places.
- Morrill Hall, 1906. Four story brick and stone, 65' x 125', 28,246 sq. ft.
- **Ridenbaugh Hall**, 1901. Brick, gabled, three floors, 78' x 96', 15,712 sqft. Set on a native basalt foundation, this blocky red brick building rises three stories and is topped with a truncated hip roof. Listed on National Register of Historic Places.

## Figures

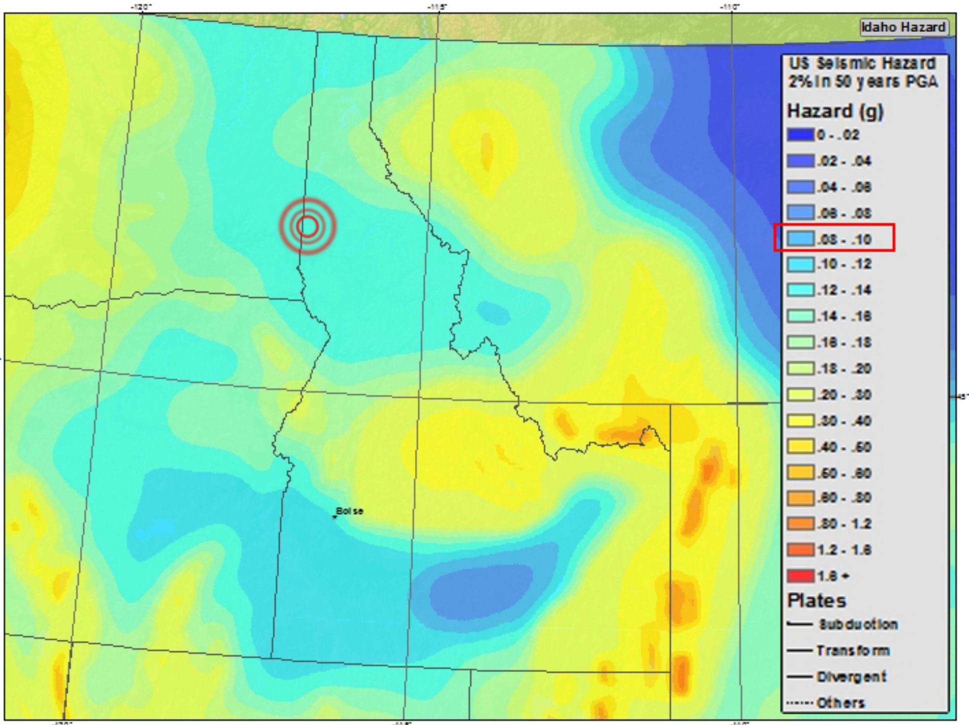


**Figure 1** (*Seismic Hazard Map)*

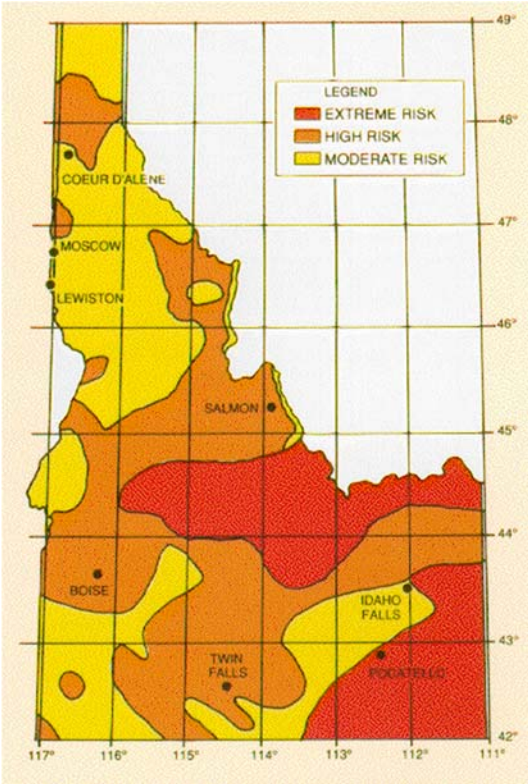


**Figure 2** (*Geological Hazards*)

Table 2: Deficiency Summary

| Vulnerability Prioritization Key | |
|---|---|
| ● | More Critical Vulnerability |
| ◕ | ↑ |
| ◑ | ↓ |
| ◔ | Less Critical Vulnerability |
| S | Structural |
| NS | Non-Structural |

**Deficiency Categories**

| UI Bldg No. | Building Name | Load Path | System Strength & Stiffness | Discontinuities & Irregularities | Anchorage of Elements | Heavy Appendages & Cladding | Heavy Partitions | Other |
|---|---|---|---|---|---|---|---|---|
| 025 | Agricultural Science, '72 Wing | | | ◑ | | ◑ | ◑ | |
| 016 | Art & Architecture Main | ◑ | ◑ | ◑ | ◔ | ◑ | | |
| 054 | Buchanan Engineering Lab | | ◑ | | | ◑ | ◑ | ◔ |
| 014 | College of Law (Menard Law Bldg.) | | ◔ | ◔ | | ◑ | | |
| 055 | College of Natural Resources | ◑ | | | | | ◑ | |
| 043 | College of Education | ◔ | ◔ | ◔ | | | ◑ | |
| 028 | Janssen Engineering Building | ◑ | | ◔ | | ◕ | ◑ | ◑ |
| 423, 013, 029 | Gauss-Johnson Engineering Lab | | ◑ | ◕ | ◕ | ◕ | | ◔ |
| 006 | Graduate Art Studio (GAS House) | ◕ | | | ◕ | | | |
| 065 | Hartung Theatre | | | | ◑ | ◑ | | |
| 038 | College of Mines | ◑ | | ◑ | ◑ | ◔ | ◑ | |
| 019 | Life Science South | | | | | ◕ | | |
| 047 | Renfrew Hall | ◑ | ◔ | ◑ | | | | ◔ |
| 021 | Brink Hall | ◑ | | ◔ | | ◑ | | |
| 004 | Phinney Hall | ◑ | | ◑ | | ◑ | | |
| 025 | Agricultural Science, '51 Wing | ◑ | ◔ | ◑ | | ◑ | ◑ | |
| 022 | Art & Architecture South | ◕ | | ◔ | ◕ | | | ◔ |
| 007 | Forney Hall | ◕ | | | ◕ | ◕ | | ◔ |
| 010 | Hays Hall | ◕ | | ◔ | ◕ | ◑ | ◑ | |
| 056 | Physical Education Building | ◕ | | ◔ | | ◑ | ◑ | ◔ |
| 026 | Lionel Hampton School of Music | ◕ | | ◑ | ◕ | ◑ | ◑ | |
| 017 | Morrill Hall | ● | | | ◑ | ◕ | | |
| 053 | Swim Center | ◑ | ◔ | ● | ◑ | ◑ | ◑ | ◔ |
| 030 | Niccolls Home Economics Building | ◕ | ● | ◑ | | ◔ | | |
| 003 | Art & Architecture North | ● | ◑ | ◔ | ◕ | ◔ | ◑ | ◔ |
| 012 | Student Health Center | ◕ | | ◑ | ◕ | ◑ | ◑ | |
| 018 | Ridenbaugh Hall | ◕ | | | ◕ | ◑ | | |
| 005 | Food Research Center | ● | | | ◕ | ◕ | ◑ | |
| 001 | Administration Building | ● | | ◑ | ◕ | ◕ | ◑ | |
| 015 | Memorial Gymnasium | ● | ● | ◕ | ◕ | ◑ | ◑ | ◔ |
| 011 | Steam Plant - (Immediate Occupancy) | ● | ● | ● | ◕ | ◕ | | ◑ |
| 011 | Steam Plant - (Life Safety) | ● | ◕ | ● | ◕ | | | ◑ |
| | | S | S | S | S | NS | NS | |

**Figure 3** (Coughlin Porter Lundeen, 2012, p. 11)

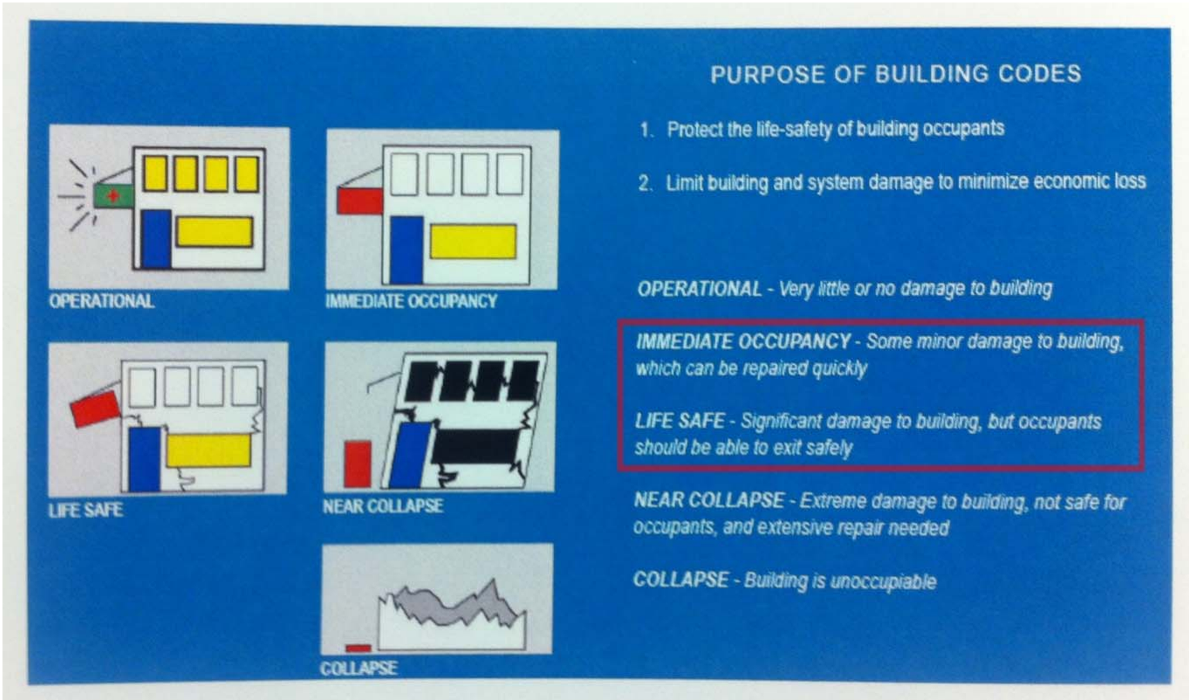


**Figure 4** (Coughlin Porter Lundeen, 2012, p. 2)

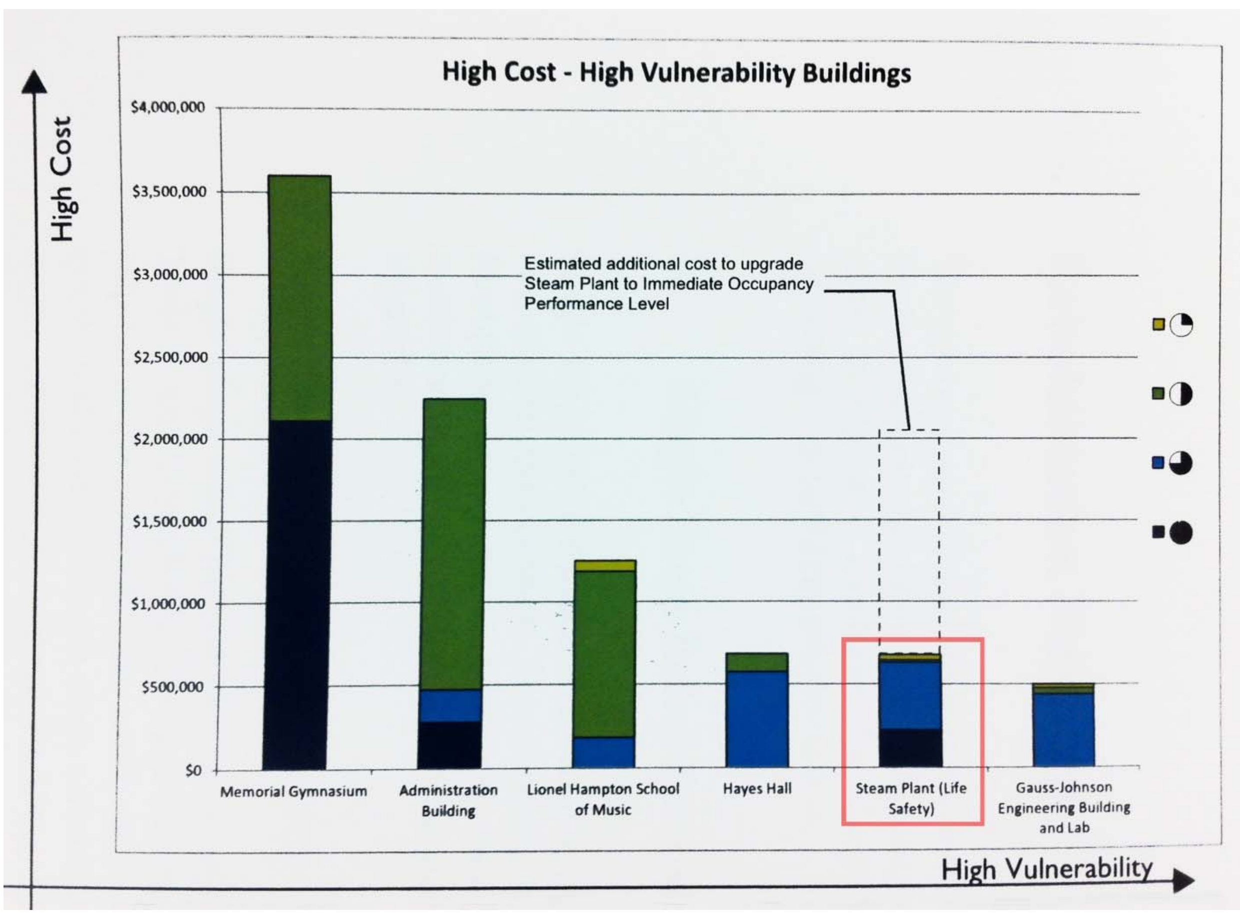


**Figure 5** (Coughlin Porter Lundeen, 2012, p. 21)

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