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Optimizing Efficiencies in Multi-Performance Upgrades to Unreinforced Masonry (URM} Buildings

Julie McEvoy Baines
Portland State University

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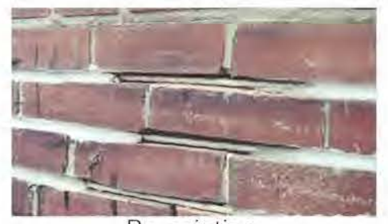
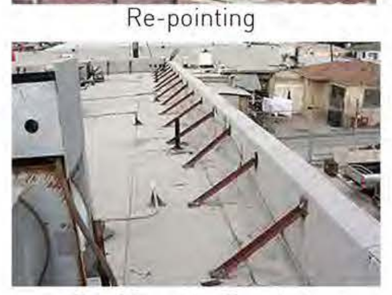
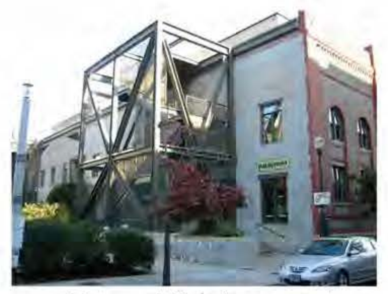
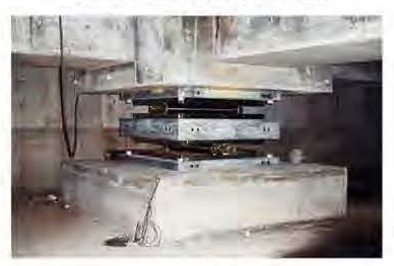
Julie McEvoy Baines
School of Architecture, Portland State University, Portland, Oregon

In 2001, the City of Portland identified over 1,900 URM's, many of which have never been seismically upgraded. These structures will pose a serious risk to occupants both during and after a seismic event. In this collection of historic structures live and work thousands of families, school children, and professionals. Additionally, due to their lack of wall insulation and outdated mechanical systems, these URM buildings tend to perform poorly in terms of their energy use. It is important to understand why energy upgrades to our existing building stock is necessary. Buildings account for 40 percent of the emissions of carbon dioxide and they also consume 71 percent of all electricity used and 54 percent of all natural gas used. In addition, according to the 2010 publication by Next 10, existing buildings represents both a significant drain on our economy and an untapped resource. By increasing our commercial building energy efficiency we could provide significant savings for businesses, universities and our government. We could reduce the need to build new power plants and cut global warming pollution. All the while generating jobs and stimulating economic growth. They point out that our existing building stock represents the greatest opportunity for capturing the low-hanging fruit in energy efficiency rewards. These facts make URMs the ideal candidate for both energy and seismic retrofits.


Re-pointing


Roof Parapet Bracing


External Reinforcement


Base Isolators

Seismic Retrofit Options for URM

Suggestions from Department of Civil & Environmental Engineering, California Polytechnic State University: Rakesh K. Goel, PhD, PE

Re-pointing
– Improving the grout condition
– May not be sufficient for seismic retrofit

Epoxy Injection
– Fill minor cracks with epoxy to restore composite action

Anchoring & Tying
– Tie the floor/roof to the wall
– Anchor unsupported masonry walls

Overlays
– High-strength cement mortar ½ inch to 1 inch thick, reinforced with thin steel wire mesh
– Fiber (Glass or Carbon) Reinforced Polymers (FRP) layers

Bracing
–Steel sections, reinforced masonry, concrete buttress, or FRP strips

Internal reinforcement
– Steel bars inserted in holes drilled in plane of the URM walls
– Improves in-plane and out-of-plane flexural capacity and connection between walls/roof

External reinforcement
– Attach reinforcement (steel plates or angles) to the surface of the URM wall
– Improves in-plane and out-of-plane flexural capacity

Post-tensioning
– Used for URM walls that develop tension due to in-plane or out-of-plane bending
– Insert pre-stressing steel to create compression in the wall

Base isolation and energy dissipation devices
– Used for retrofit of historical buildings but very expensive

Energy Efficiency Upgrades for Existing Buildings

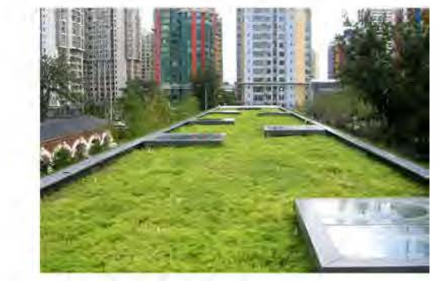
Suggestions from The ENERGY STAR Building Upgrade Manual

Building Envelope
-Add insulation in walls and roof from current levels to the Department of energy's recommended levels.
- Replace windows or add exterior window film
- Add exterior window shading and light shelves
- Install cool roof/green roof

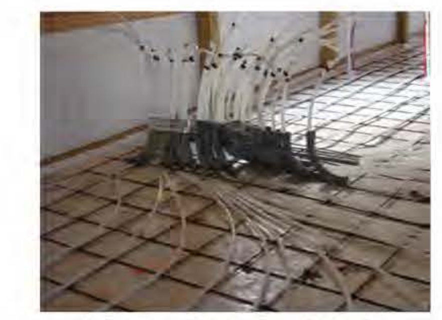
Lighting (natural and artificial)
- Lighting systems have a significant impact on other building systems.
- Including new light sources, fixtures,and occupancy sensors both interior and exterior

Mechanical Systems

Heating/Cooling
- Are the equipment or assemblies in the building nearing the end of their useful lives?
- Define the needs of the building in its current use
- Replacing existing system with one that is properly sized or retrofitting a system so that it operates more efficiently. In addition to saving energy, proper sizing will likely reduce noise, lower the first costs for equipment, and optimize equipment operation, often leading to less required maintenance and longer equipment lifetimes.
-Improve the layout of the existing air and water distribution systems translating into significant fan and pump energy savings
-Adding a direct digital control systems and BACs offer greater accuracy, performance, and energy savings
-Replace supply fan motor with a Variable Frequency Drive


Green Roof w/ Skylights


New insulation


Radiant Heating and Cooling

Possible Synergies of a Multi-Performance Retrofit

add thermal mass/sheer ↔ reduce cooling loads
tie backs/tie back of parapet ↔ new roof with added insulation
stiffen diaphram ↔ new greenroof or skylights
internal bracing ↔ increasing daylighting
stiffen floor plates with concrete ↔ insert radiant floor system in slab

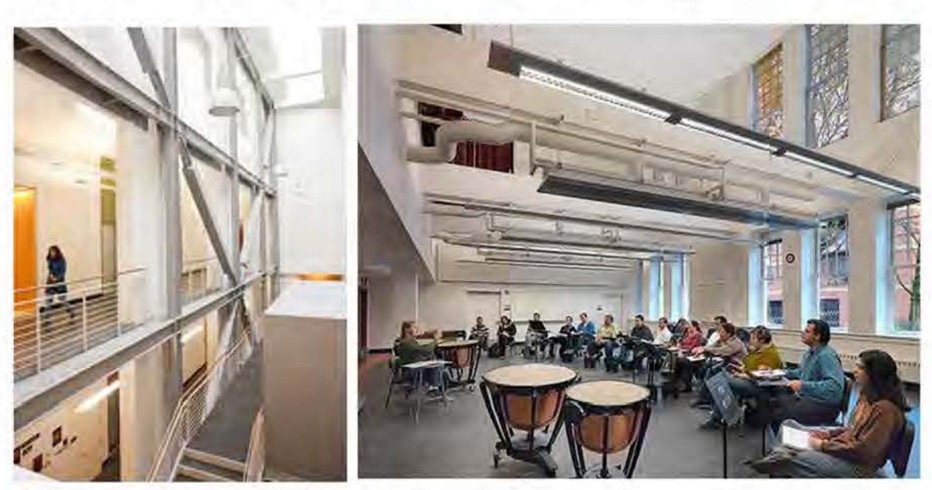
The city of Portland has over 1900 of these historic structures and in them everyday thousands of families, school children, and professionals live and work.

Case Study Examples

Project	Built	Retrofit Yr	Building Type	Size (Sq Ft)	Annual Purchased Energy	MP Retorfit Tactic	LEED Certification
Shattuck Hall	1915	2008	Education	73,500	45.9 kBtu/ft²	1,2,3,4	Gold
Lincoln Hall	1911	2010	Education	136,000	Unknown	1,2,5	Platinum
Lovejoy	1910	2004	Office	20,000	40 kBtu/ft²	1,2,3,4,5,6	Gold

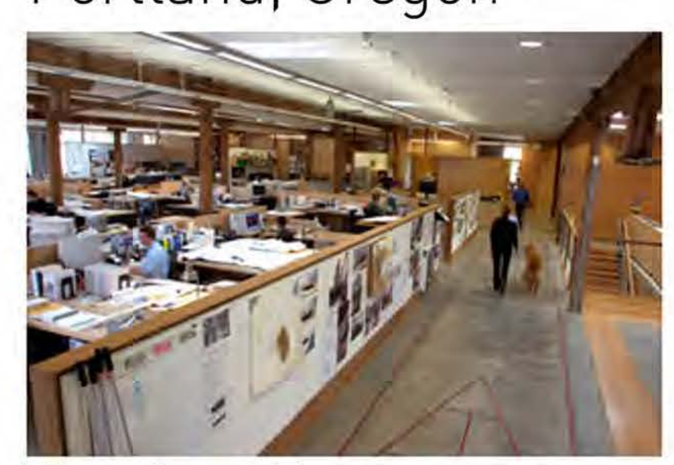
Multi-Performance (MP) Tactics
1 - improved the structural response to extreme loading
2 – maximum daylight to replace electric lighting
3 – uses low-temperature radiant systems
4 – deployed thermal mass effectively
5 – upgraded envelope
6 – passive strategies
All data from NBI Getting to 50 Buildings Database and Boora Website

Lincoln Hall Completed 2010
Boora Architects
Portland State University



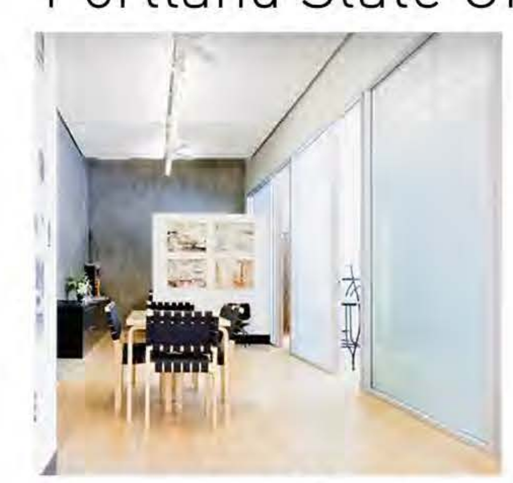
Design Process
Internal bracing allowed for interior walls to be removed improving daylighting

Lovejoy Building Completed 2004
Opsis Architecture
Portland, Oregon



Design Process
Radiant heat and cooling in the new slab floors that was also used to stiffen the diaphragm

Shattuck Hall Completed 2008
SRG Partnership
Portland State University



Design Process
Deployed thermalmass as sheer walls also used to reduce cooling loads