

Earthquake Evacuation Plan Lesson Plan

Time: Five 50-minute class periods. Some prior planning is necessary for this activity. Data showing when the school was built and modified, student numbers, and basic floor plan need to be gathered prior to the activity. Knowledge of construction types used in building the school is also helpful to have in advance of the activity.

Objectives:

1. To analyze our school to determine how it might be affected by an earthquake.
2. To look at risks in and around the school and determine safe evacuation routes to travel following an earthquake.

Topics covered previous to this activity:

1. Create a seismic risk map for the U.S.
2. Discuss seismic risk in the U.S. emphasizing the high risk areas. This is a good time to use the Seisvol demonstration to show that earthquakes are concentrated along plate boundaries all over the world. This is also a good time to introduce Richter Magnitude into the picture.
3. Earthquake video demonstrating the impact of earthquakes on people. I have used the video "Aftershock."
4. Demonstration showing the types of earthquake waves and how they move.
5. Activity demonstrating how to locate the epicenter of an earthquake.
6. Faults activity which allows students to explore some of the fault types and the stresses that cause them.

Lesson:

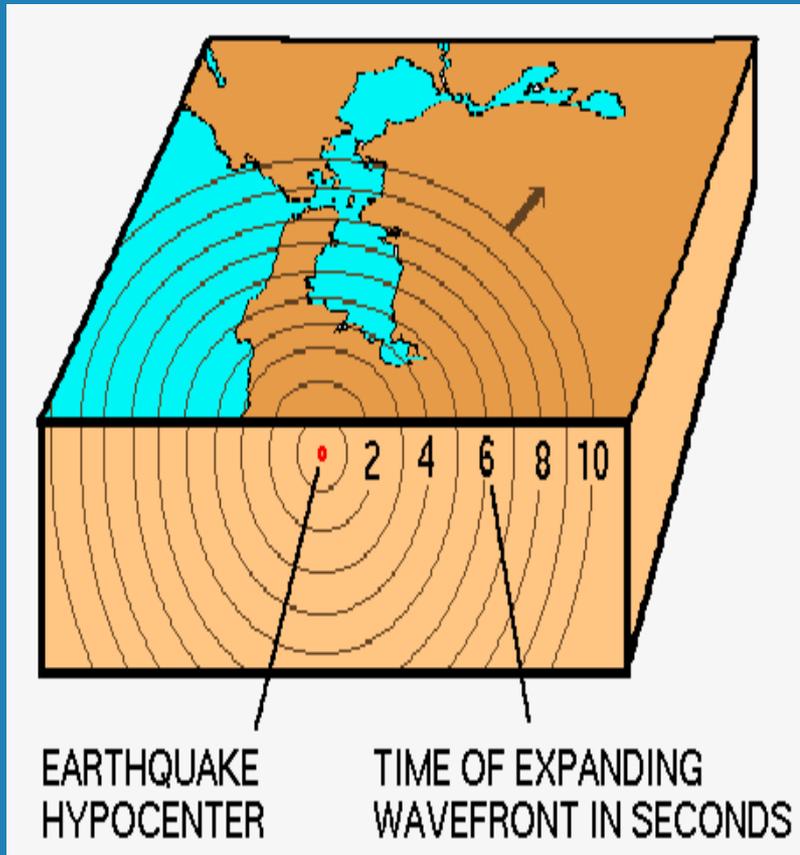
1. Introduce activity by giving rationale: not in a high risk area but are surrounded by zones of higher risk which could transmit damaging waves to our area. Our goal: to produce an earthquake evacuation plan. This is different from the fire evacuation plan currently in use.
2. Structure: divide class into groups of 2-3. Each group will produce a plan to be submitted to an administrator for review.
3. Day 1:
 - a. View Power Point presentation (here as a PDF file) which shows high risk areas surrounding northern Idaho (Borah Peak, Yellowstone area north into Montana, Wasatch Fault, Seattle subduction zone; less risk, Sandpoint, Riggins, Walla Walla have smaller earthquakes)
 - b. Hand out photos and descriptions of various construction types
 - i. Spend most time on concrete & masonry structures since these are most often used in school construction
 - ii. Cover old concrete frame, cladding, concrete frame and unreinforced masonry construction techniques

4. Day 2:
 - a. Examine the rapid visual screening form (RVS) that we will use to evaluate our school (there are 2 versions here – one with a photo of MJHS, one is totally blank so you can add your own school photo)
 - b. Provide each team with a RVS form and walk around the school and evaluate the school. (How to implement a rapid visual screening was presented by Stephen Weiser during an IGS Geology and Geologic Hazards summer workshop several times in Sandpoint, Idaho. If you were not at either of these workshops, you may just have the students explore the exterior of their school building looking for possible sources of structural failure that potentially could occur during an earthquake of moderate or higher intensity).
5. Day 3:
 - a. Obtain floor plan of the school
 - b. Walk through the interior of the school and mark exits, fire extinguishers, and potential earthquake hazards
6. Day 4: Formalize the evacuation plan providing for safe evacuation of the student body and staff. Summarize data on the form titled “Seismic Risk Evaluation and Earthquake Evacuation Plan for MJHS”. Attach RVS sheet, school floor plan with exit routes and potential hazards clearly marked and submit. Students may wish to color-code blocks of students within the building using matching colored arrows to mark exit routes for each block.
7. Day 5: Have students present their plans to the class allowing for peer review and critique.

Earthquakes



What happens during an Earthquake?



- When an earthquake happens, waves appear in the ground much as when a rock is thrown into a mud puddle

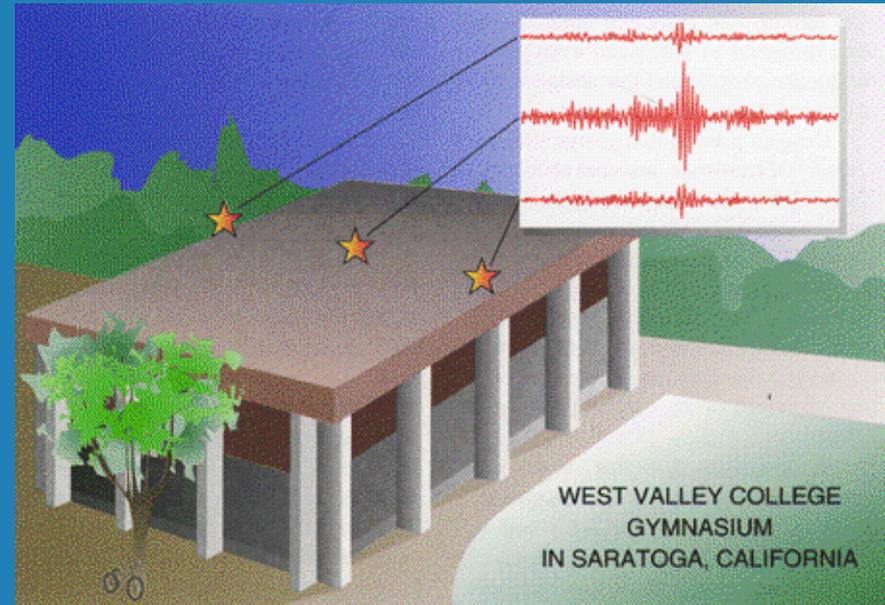


How many kinds of waves are produced during an earthquake?

- ∩ There are 3 kinds of waves produced during the earthquake
- ∩ p-wave = primary wave
- ∩ s-wave = secondary wave
- ∩ l-wave = long wave

What causes the damage during the earthquake?

- ⌚ When earthquake waves reach the surface of the Earth, they cause the ground to roll like waves on the ocean
- ⌚ Damage occurs when structures are not able to handle the stress





Are some structures safer than others?

- ⌚ Generally, the more rigid the building material, the more susceptible the structure is to damage

Concrete/masonry structures



Soft story structures

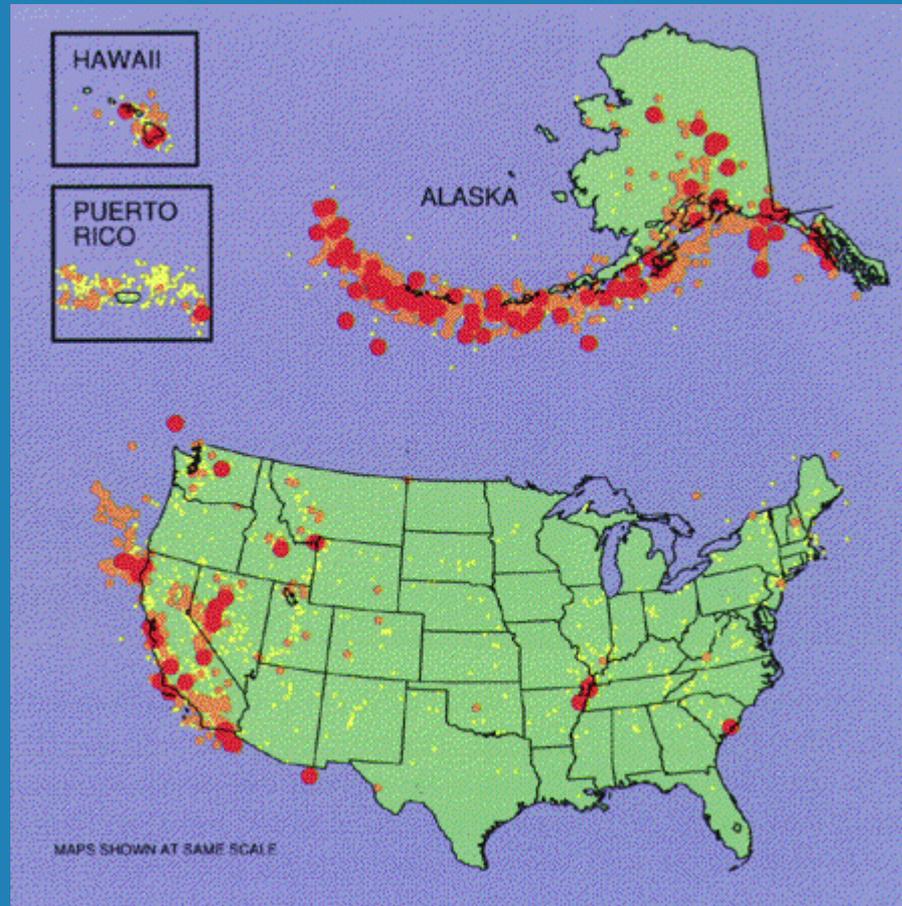


Wood framed structures

- ∞ When more flexible wood framed structures are damaged, generally this indicates a much larger earthquake event
- ∞ This may also indicate more unstable ground beneath the structure



Where is the greatest earthquake risk in the U.S.?



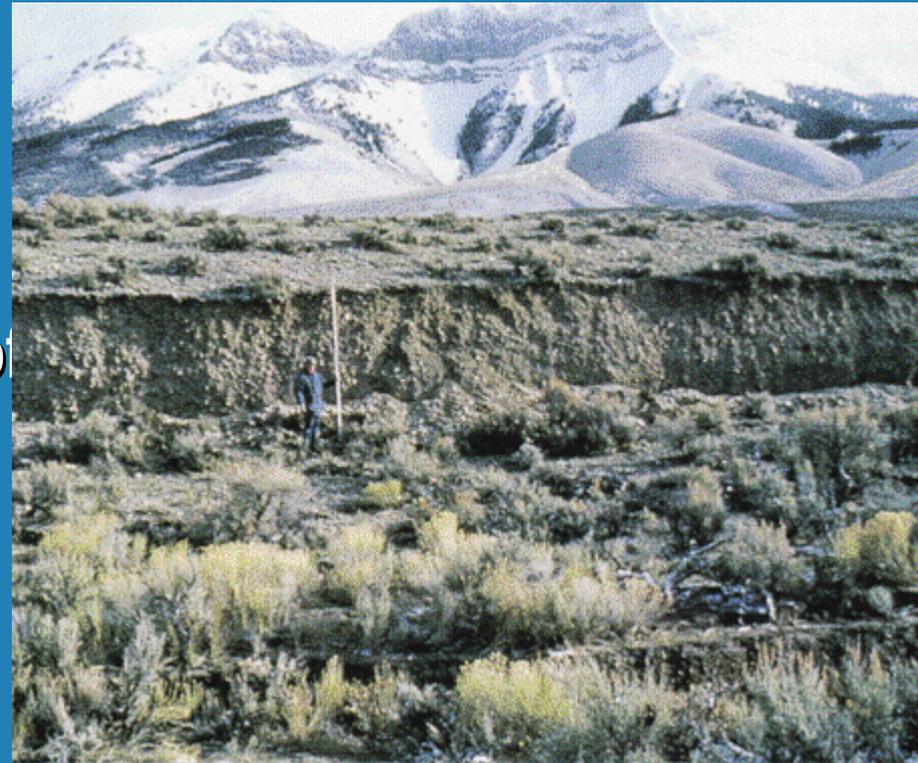


What is the earthquake risk here in Moscow?

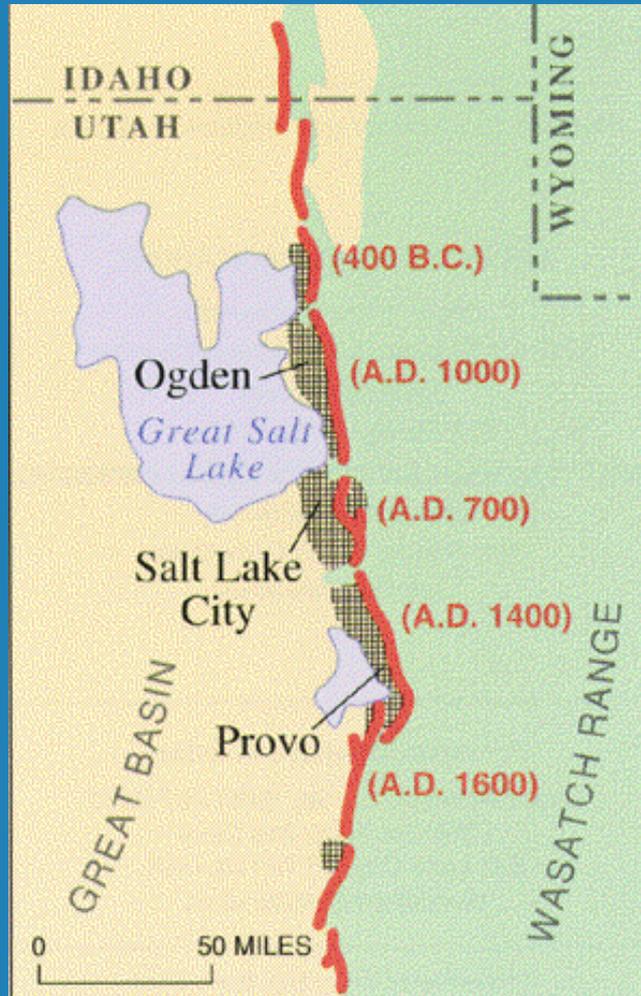
- Ω Idaho has many faults which are clustered both north and south of Moscow
- Ω On January 31, 2000 a mag. 3.6 quake near Bayview may have helped trigger a landslide along the road to Cape Horn
- Ω In 1983...

Borah Peak Earthquake

- ∞ ...a magnitude 7.3 quake centered near Mt. Borah rocked the state of Idaho
- ∞ The earthquake was of moderate intensity here in Moscow



Are there other earthquake risk areas near us?



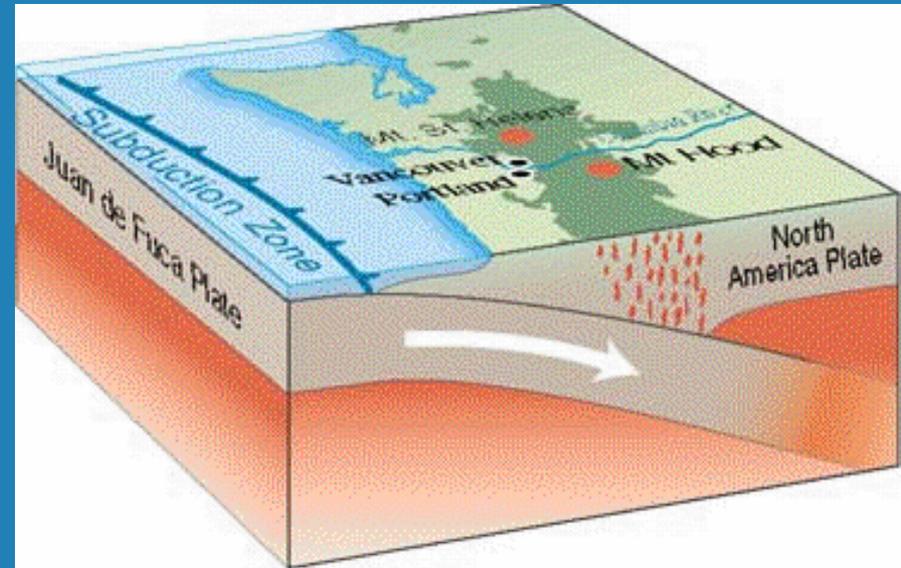


Risk areas to the south of Idaho

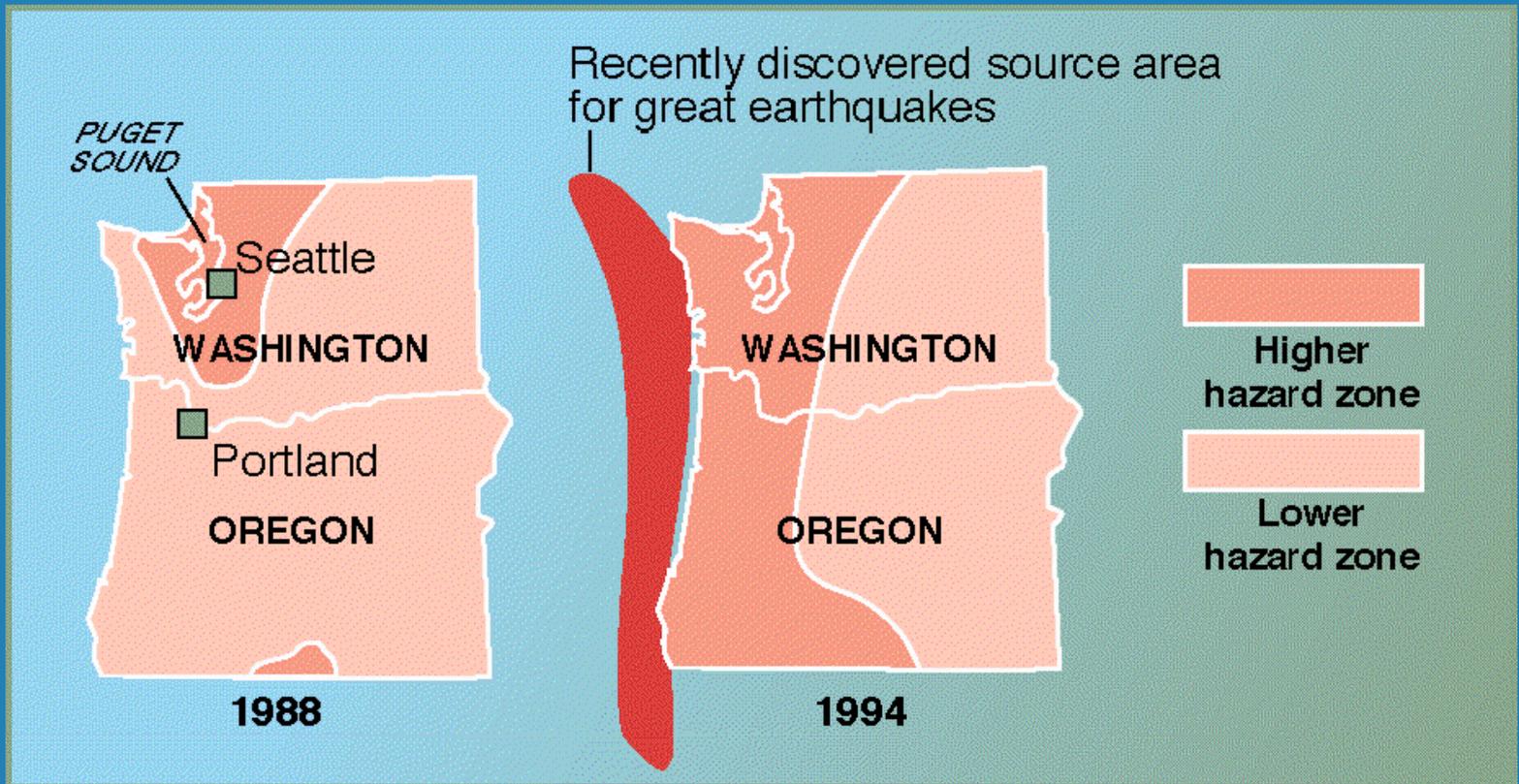
- ⌚ A major fault line lies along the Wasatch Range in Utah
- ⌚ According to data gathered here, this area could experience a major earthquake at any time

Risk areas to the west of Idaho

∞ Along the Washington/Oregon coast, one segment of the Earth's crust slides beneath the other thus creating a major earthquake hazard



Risk zones along the northwest coast



Earthquake risk is high with the Yellowstone Hot Spot

- Multiple periods of volcanic activity have formed several large caulderns here
- The area is still seismically active with 2 large earthquakes in the last 50 years



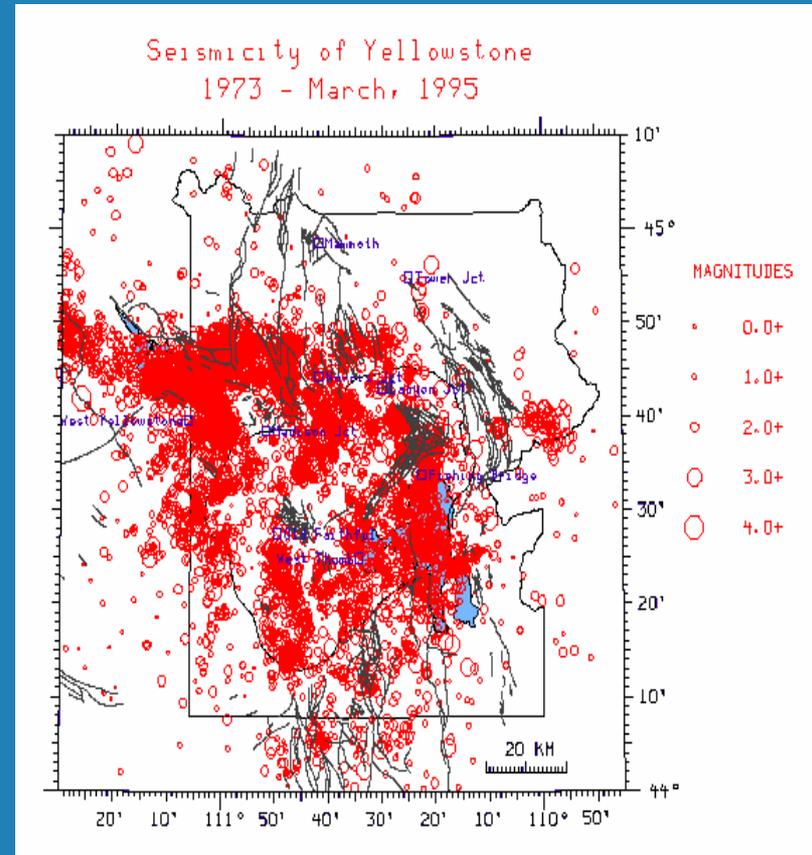
Yellowstone Caldera is still geologically active

- ∞ There are 10,000 thermal features found in Yellowstone Park which include mudpots, fumaroles, hot springs, and geysers.
- ∞ Seismic activity usually is associated



Seismic data from the Yellowstone area

- Earthquakes are common in the Yellowstone area
- The larger earthquakes (magnitude 6 and greater) will be felt here



What would happen to MJHS during an earthquake?

- ⌚ Your assignment is to assess this danger by having teams of no more than 4 completing the following:
 - ⌚ 1. Produce an earthquake assessment of MJHS
 - ⌚ 2. Produce an earthquake evacuation plan for MJHS

CONSTRUCTION TYPES

WOOD - (W) - wood frame

uses - usually a studded frame, or post and beam, most common type of low-rise single family and small commercial, post and beam usually not residential, but larger like warehouses, churches.

damage - studded style resists damage well especially if shear walls: MUST be anchored to foundation, watch for unbraced cripple walls at foundation, unbraced carports, decks, etc. Unbraced chimneys and brick veneers present hazards.

STEEL - (S)

steel frame (S)

uses - commercial and institutional, several types

damage - both types tend to perform well due to steel strength, flexibility and lightness, collapse rare except Mexico City, damage can be permanent, deflections, cladding falls, pounding with adjacent buildings.

steel moment resisting frame (MRF) - steel beams and columns, joints designed to resist twisting rather than being braced.

steel bracing frame (BR) - steel frame with bracing (difficult to see outside) built since late 1800's commercial, institutional and public.

light metal frame (LM) - usually one story metal spans clad with metal

uses - agricultural, industrial factories, warehouses

damage - usually perform well, insufficient tension braces can elongate, building can deform, cladding can fall off.

steel frame-with concrete shear wall (SW) - similar to moment resisting steel except that concrete shear walls resist lateral forces.

steel frame- with unreinforced masonry walls (RC) - walls in filled with URM

uses - older commercial institutional and public

damage - tends to be very stiff and suffers substantial damage in large earthquakes, infill walls buckle and fall, unattached masonry veneer around columns falls, soft story failure, partial failure throughout structure, total failure has seldom occurred but cannot be disregarded.

CONCRETE AND MASONRY (C, PC, RM, URM)

concrete moment resisting frame (MRF)- several subtypes

uses - commercial, institutional, and residential

damage - varies to subtype and date of construction: nonductile concrete (not designed to flex) frame structures with or without infill built in western U.S. from 1950's to 1972 generally more massive than steel and are under-reinforced and low ductility. Examples; shear failure, column failure, hinge formation, substantial nonstructural damage, and pounding. Bending-torsion.

concrete shear wall (SW) - concrete box structural

uses - commercial, institutional, and residential

damage - perform better than concrete frame type, heavy relative to steel frame but are also rigid due to shear walls, shear cracking and openings, and failure at wall construction points can occur.

concrete tilt up (PC1),(TU) - concrete panels cast on ground tilted up to be welded or held by cast in place columns or steel.

uses - lo rise commercial and residential

damage - pre-1970's techniques usually did not require sufficient connections resulting in diaphragm (roof, floor) failure and wall collapse. A prime source of seismic hazard in areas where construction requirements are not high.

precast frame (PC2) - precast concrete members sometimes prestressed, essentially a post and beam structure built of precast elements.

uses - commercial and institutional

damage - highly variable, poorly designed connections fail, stresses result in creep and shrinkage, connections can corrode.

reinforced masonry (RM) - bricks and blocks with reinforcement, wood or steel diaphragms.

uses - usually low-rise perimeter bearing wall structures, small commercial to residential and industrial

damage - can perform well, differences in construction workmanship is problem, damage to walls or collapse is problem as is the connection to the floor or roof.

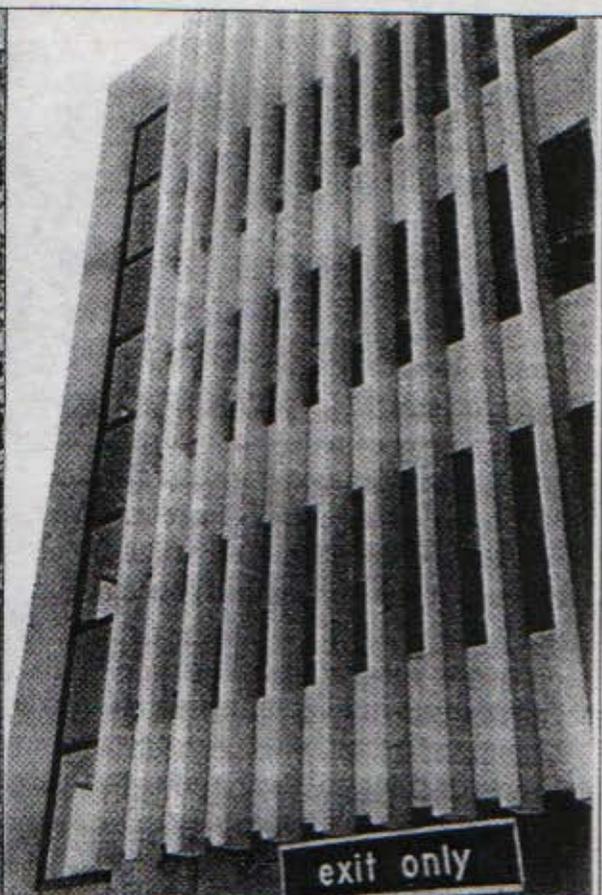
unreinforced masonry (URM) - brick, blocks, and stone held by mortar, bearing walls with wood or steel diaphragm, common pre- 1930's.

uses - residential, commercial, and industrial, usually 1 - 6 stories.

damage - recognized as most hazardous, observed top fail in many modes including insufficient anchorage, collapse of bearing walls, excessive diaphragm deflection, low shear resistance, wall slenderness.



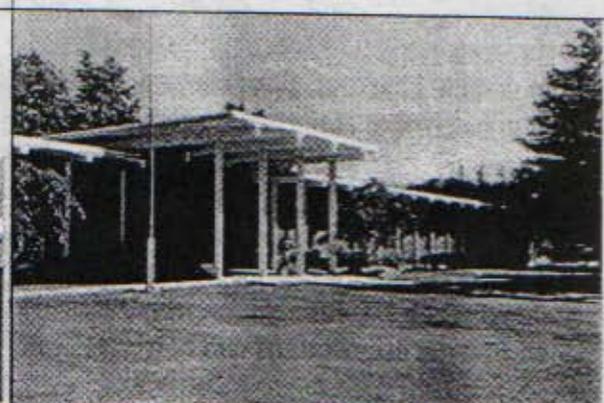
Old concrete frame, soft story, falling hazard



Cladding



Pre-cast concrete frame detail



Pre-cast concrete frame



Pre-cast concrete frame



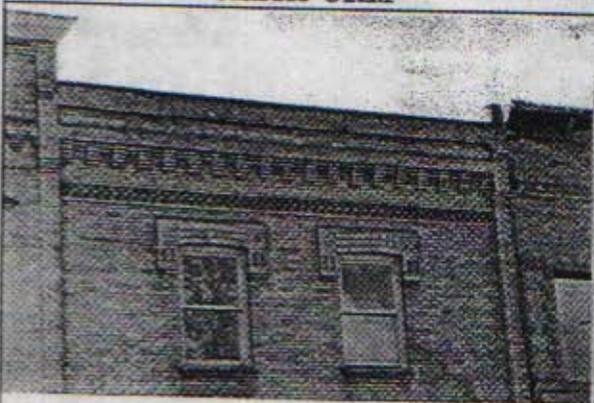
Newer concrete frame, soft story



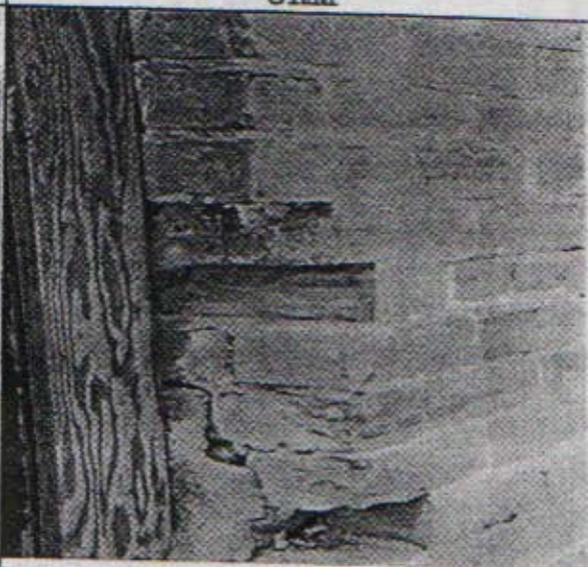
Classic URM



URM



URM detail:



Header course detail



A new "old" building



Seismic Risk Evaluation and
Earthquake Evacuation Plan
for MJHS

TEAM MEMBERS

Date submitted_____

Moscow has very few active faults in the immediate vicinity but lies within a region which has had several large earthquakes in the last century. The major risk areas potentially affecting Moscow are shown below:

Potential Epicenter Location	Potential Magnitude at Epicenter	Potential Intensity at Moscow
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Potential hazards due to earthquakes at Moscow Jr. High School that are numbered and listed below are also marked on the floor plan maps that follow. The red arrows on the floor plans show potential evacuation routes.

Administratively, the following procedures must be implemented as part of the preplanning necessary for an earthquake evacuation plan to work:

Earthquake Evacuation Plan for Moscow Jr. High School



Moscow Jr. High School is typical for many Jr. High and High Schools throughout the state of Idaho. It is primarily a brick and concrete structure which has been added on to several times since it was first built in the 1950's. The core of the building is a reinforced concrete structure with a veneer of brick on the exterior.

An athletic facility (the Fieldhouse) was the first addition. It consists of pre-poured concrete slabs which were formed on the ground and then lifted into place. Each slab is keyed to the next via a tongue and groove joint which is sealed. A roof consisting of a series of metal trusses caps the structure and holds it together. It is classed as a concrete tilt up structure. My students identified this as a major hazard if Moscow were to experience an earthquake of high intensity.



Two additions have been added on to the south end of the school which does not share the same construction type as the core of the school. The additions were cinder block with a veneer of brick added to match the existing school. We were able to view two previous brick south ends of the building in several of the classrooms. These additions were identified as reinforced masonry construction of two different vintages using slightly different building techniques which were probably reflecting changes in building code. Students concluded that they may vibrate at different frequencies during an earthquake and thus present a potential hazard.



Students identified a number of other hazards related to the exterior of the building. Probably the most significant was in an area located along the path used during emergency evacuation of students during fire drills. Near the multipurpose room was a brick chimney with several electrical transformers and the building gas main below it. This area was marked as a potential major hazard during a moderate to high intensity earthquake.



The library at MJHS is housed on the second floor and is cantilevered out over the first floor by about 10 feet. The overhang is supported by a series of concrete posts. This was determined to be a structural hazard. The overhang lies above a major exit along the east side of the building which could be blocked by post failure during an earthquake. This needed to be considered when planning evacuation routes.



Some of the evacuation routes used during other emergency evacuation drills pass by several falling hazards. The exterior of the building is covered with a nonstructural veneer of brick which can vibrate loose during an earthquake and the following aftershocks. Broken glass from the numerous windows was also identified as a potential falling hazard.





Evacuation routes terminate in several large open areas which surround the school. One set of evacuation routes takes students into a soccer field located across a street to the south of the school. Students suggested that the crossing must first be determined safe from falling overhead electrical lines and that someone be assigned as a traffic monitor to allow students to pass safely.

A second series of routes take students and staff into a baseball field which adjoins the school to the east. The cantilevered portion of the library would need to be deemed safe for an evacuation route to this area. Although there are other routes to get to the baseball field, getting all students and staff there would create congestion in some areas within the building during the evacuation.



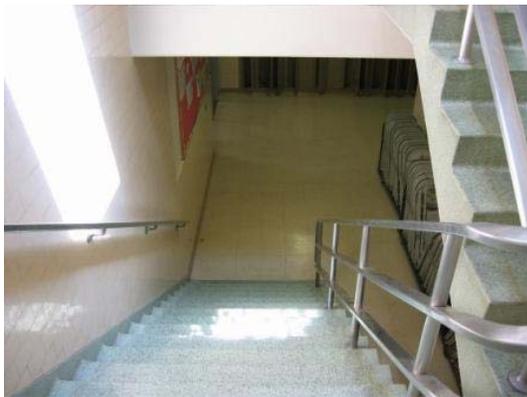
Yet a third set of routes takes students into the parking lot to the west of the building. Students suggested that cars moving during aftershocks, the overhead power line, and the boiler chimney and its associated hazards would make this area's usefulness as an evacuation destination more limited.

Students also inspected the inside of the building for both structural and falling hazards. Within the classroom, students identified the following hazards: breaking window glass, furniture such as display cabinets and book cases falling over, file cabinet drawers coming loose, falling ceiling lights and panels from the suspended ceiling, wheeled carts such as computer desks and overhead carts moving, and spilled chemicals (if they were in use during an earthquake) all represented hazards.



Once the earthquake is over, students would need to leave the classroom and enter the hallway. From this room, there is easy access to a close exit with minimal hazards. Overhead lights and glass doors represent the biggest hazards students would likely face in exiting through this part of the building.

Other parts of the building have numerous student lockers which are frequently unlocked. During a moderate to high intensity earthquake, many of these may come open and spill their contents into the hallway. This would hinder students exiting the building.



A more significant hazard lies in the form of stairs. Moscow Jr. High is a 2 story building with a third partial story with outside access. Moving students down stairs from the second floor would require a quick inspection of the stairs for damage prior to students evacuating down them following an earthquake. Using the elevator to evacuate was ruled out because it would be a major bottle neck and may not work if the power went out.

There were many more potential falling hazards found throughout the building. Some were unique to the kitchen, some to the weight training area and fieldhouse, others were more generally distributed throughout the building. This activity allows students to work at the application level and is a wonderful alternative assessment that can be used at the end of an earthquake unit.