ARCH 631. Topic 16 Reading Notes

· Primary force from earthquake to design for is lateral, although different from wind in that the loads are dynamic, making design for seismic resistance complex

· Ground hazards are listed as surface fault ruptures, ground shaking, ground failures and tsunamis

· Ground shaking effects:
  shaking can cause all floors to move laterally, then differently in a "whiplash" due to inertial force on upper mass and lag

· Wind effects:
  dynamic behavior means load values vary and buffeting action can cause oscillation
  oscillation size and frequency depends on wind forces and building stiffness and mass distribution

· Excessive deflections and oscillations impair building functions, and cause occupant discomfort, including motion sickness; analyzing a building to predict motion is difficult and buildings are commonly modeled as spring and mass assemblies

· Methods to reduce motion:
  increase the stiffness of the structure by increasing members sizes, using diagonal braces or other shear planes, or redistributing the placement of material
  build physical damping mechanisms (common at column to beam joints) or friction connections
  install tuned mass dampers that are on rollers and attached to the building with a dashpot

· **Most important design principle:** the general masses and the stiffening lateral-force-resisting mechanisms should be symmetrically located with respect to one another; without this, there will be undesirable torsion effects that are extremely destructive

· Irregular plans will have unsymmetrical mass distribution and each part tends to vibrate differently, so failures can occur at the intersection if there isn't a seismic joint that allows the independent moment

· Irregular stiffening elements can cause the same problems (like with unusually placed elevator cores); open front faces on office buildings must be stiffened, commonly with frames

· Irregular vertical shape (non-symmetries) can also cause torsional effects

· Extremely elongated buildings need seismic joints

· Tall slender buildings are less able to resist overturn

· Cantilevers are susceptible to failure because of vertical moment from vertical acceleration of the ground

· Site and soil conditions may also strongly affect the type of preferred building configuration

· Continuous structures (with slabs or beams) are earthquake resistant because it is able to absorb the energy input associated with ground motions (pins can't); plastic hinges in steel frames require significant energy to form; concrete and steel frames are required to be ductile; column and beam elements are best in line; horizontal elements should fail first

- Redundancy means that if a member fails, another can take it; or in the case of rigid joints, that the joint can become a pin and the frame not collapse
- For rigid floor or roof diaphragms, the stiffness can't be compromised (like by cutting large openings in it)
- Ductile materials are characterized by having large strain with little increase in stress prior to rupture, which means they absorb energy – steel is ductile, reinforced concrete must be designed to be ductile, timber is also a good material, masonry (unless reinforced) is not ductile
- The natural period of vibration is the time required for a structure to complete a full back and forth cycle upon excitation
  long period is a slow completion of a cycle
  short period is a quick completion of a cycle (designed for larger forces)
  resonance is when the frequency of the ground motion approximates the natural frequency of the structural vibration (and motion is amplified)
- Static models determine the size of the base shear based on the dead load of the building, the period of vibration , the geographic location (with reference to seismic activity), the importance factor of the building, and the building construction type
- Choice of flexible or where stiffness is not influenced by nonstructural elements is complicated by soil type and response but are commonly suitable for sites where ground motion periods are short; stiff structures have a few advantages for long period sites; mixed systems good in some places
- Nonstructural elements are those that can interact with the structure and alter the natural period of vibration
- Base isolation and damping systems are being used more to improve performance and reduce damage during an earthquake; they limit the transmission of the shaking action into the structure
- Purpose of earthquake resistant structures is to save lives and reduce property damage
- Building codes are continually revised as a result of information learned through subsequent earthquakes and measurements from recording devises in an increasing number of locations
- The location of the fault or slip between tectonic plates is termed the "focus" or "hypocenter"; the "epicenter" is the surface location above the hypocenter
- Surface faulting is a crack or split; landsides, liquefaction and subsidence are also types of ground failures with liquefaction being result of the change in the water level in the soil reducing the cohesion or friction in sandy soils
- Buildings are effected primarily by the horizontal ground acceleration; waves are categorized as body waves which are primary and secondary (shear)
- Accelerometers measure the acceleration, velocity and displacement; acceleration commonly measured with respect to the acceleration due to gravity (like 0.10g); duration is also important to the damage
- Magnitude is the size of the wave with Richter's scale measuring the maximum amplitude of waves measured (and gives no measure of duration)
- Intensity is the degree of local shaking and building damage based on subjective observations; Modified Mercalli is used in the US and is a twelve point scale (I – XII) with I being not felt...
- Ground shaking causes damage from the inertial force, period and resonance, and from torsion

- Site vulnerability include proximity to active earthquake faults; susceptibility of the site to ground shaking; the potential for ground failure; adjacent structures and land uses that could pose a threat during or after an earthquake; potential for inundation resulting from tsunami or dam failure
- Deep soils can amplify ground shaking intensity, extend duration of voilent shaking and limit attenuation of shaking
- Regional damage and infrastructure damages can isolate a structure
- Seismic codes are within the national building codes; California has its own codes; the Building Seismic Safety Council published the *Recommended Provisions for the Development of Seismic Regulations for New Buildings (NEHRP)* as a resource document to assist in code development
- Codes provide a simple uniform method to determine the seismic forces for any location with enough accuracy; most often it is for base shear (V); there is a vertical shear formula as well; other parts set limits on drift, require overturning to be checked and require calculations for torsion
- Guidelines for performance include:
    - collapse prevention
    - life safety
    - immediate occupancy
- Executive Order 12699 requires federal buildings to incorporate seismic safety measures no matter the location nationally or internationally
- There are earthquakes in Texas including an intensity of VII with some V (cracked plaster) and VI (broken windows)