- **Introduction to Earthquake Risks**
    - Focus on earthquake risks and risk reduction
    - Risk = Hazard × Vulnerability
    - Importance of reducing vulnerability
- **Pillars of Emergency Management**
    - **Mitigation:** Preventing future hazards or reducing effects
    - **Preparedness:** Preparing to handle emergencies before they occur
    - **Response:** Safe reaction to emergencies
    - **Recovery:** Return to normal after emergencies
- **Global Trends in Earthquake Risks**
    - Increased fatalities in large earthquakes over the last centuries
    - Explanations for increased fatalities:
        - No evidence for increased earthquake frequency
        - Increased population and urbanization
- **Population and Earthquake Risk**
    - Graph showing global population growth and cumulative earthquake fatalities
    - Rise in the number of large cities and megacities
    - Hazardous regions: Alpine-Himalayan belt, high population density areas (China, India)
- **Seismic Hazard Factors**
    - Geographic areas prone to large earthquakes
    - Notable countries at risk: Iran, Turkey, China, India
    - Vulnerability × Hazard = Risk framework visualized through maps
- **Mitigation Strategies**
    - Primary focus on building design to withstand earthquakes
- **Building Material Considerations**
    - **Masonry buildings:** Rigid, brittle, susceptible to collapse
        - Example: Adobe structures in Bam, Iran (90% destruction in 2003 earthquake)
    - **Wood:** Flexible, lightweight, better performance in earthquakes
        - Example: Wood frame houses survived the 1906 San Francisco earthquake
    - **Steel:** Strong and flexible but expensive, used in large buildings
- **Building Design Factors**
    - Importance of proper anchoring to strong foundations
    - Risks of sliding off foundations
    - **Soft First Story Collapse:**
        - Multi-story buildings with large openings (e.g. garages) prone to collapse
        - Illustrations of soft story failures in various earthquakes

- **Engineering Solutions for Older Buildings**
  - Retrofitting older buildings to meet codes for seismic safety
  - Historical masonry buildings requiring expensive retrofits
  - Mandatory soft story retrofits in some regions (e.g., California)

- **Natural Resonance of Buildings**
  - Relation between building height and resonance frequency
  - Buildings sway at frequencies related to their height
  - Effects of seismic waves on buildings:
    - Example: Mexico City earthquakes (1985 vs. 2017)

- **Strategies to Mitigate Resonance Effects**
  - Use of shock absorbers to dampen vibrations
  - Base isolation techniques to protect buildings
    - Example: The Cube building in Vancouver with base isolation design

Earthquake Prediction, Forecasting, Early Warning, and Rapid Response

Overview of Emergency Management

- Four pillars of emergency management.
- **Mitigation**: Costly to retrofit old buildings; money should be wisely spent on high-need areas.
- Importance of **earthquake prediction** and **forecasting** for preparedness.

Earthquake Prediction

- Specifies:
  - **Location**
  - **Timing**
  - **Magnitude**
- Must pass statistical tests to be valid.
- Predictions based on **precursor events** (e.g., foreshocks, electrical disturbances, strange animal behaviors).
- **Haicheng (1975)**: Successful prediction led to evacuation but still resulted in 2,000 deaths.
- Contrast with **Tangshan (1976)**: No prediction or evacuation led to 250,000 deaths.
- **Limitations**: Only ~5% of large earthquakes have foreshocks; foreshocks are indistinguishable from regular seismic activity.

Earthquake Forecasting

- Distinct from prediction; assesses the probability of an earthquake of a given magnitude in a specified area over a long interval (e.g., 50 years).
- Illustrated using California's earthquake forecast:
  - **Red polygons**: ~10% chance of a >6.7 magnitude earthquake in 30 years.
  - **Orange**: ~1% chance.
  - **Green**: ~0.1% chance.

- Forecasts utilize:
    1. **Active fault locations**: Mapped through surface geology, remote sensing, seismicity.
    2. **Strain accumulation rates**: Measured via GPS networks.
    3. **Earthquake recurrence intervals**: Estimated through paleoseismology, examining old earthquakes.

Cascadia Megathrust Example

- **50-year probability** for magnitude 8-9 earthquakes: Ranges from ~12% to ~33%.
- Data sources:
    - Recorded fault characteristics.
    - Strain accumulation rates (4 cm/year).
    - Prehistoric earthquake records obtained from turbidite deposits.

Regional Forecasting Limitations

- In many areas (e.g., most of Canada), the data for effective forecasting are lacking.
- Use qualitative hazard estimates where data are insufficient.
- **National Seismic Hazard Map**: Indicates relative likelihood of earthquakes in regions without detailed probabilistic forecasting.

Earthquake Early Warning Systems

- Not the same as prediction; alerts issued post-initiation of rupture.
- Relies on the rapid detection and location of earthquakes using P waves.
- System requirements:
    1. **Seismic station network**.
    2. **Automated algorithms** for rapid evaluation.
    3. **Communication infrastructure** for alerts and safety measures (e.g., alerts to machinery, trains).
- Example: Successful early warning during the **2017 Puebla earthquake**.

Earthquake Preparedness

- Education campaigns are crucial.
- Recommended actions:
    - Know emergency procedures (drop, cover, hold on).
    - Prepare emergency kits and grab-and-go bags.
    - Participate in earthquake drills (e.g., **ShakeOut exercise** in October).

Earthquake Response

- **Rapid response** is critical; most deaths occur due to collapsing buildings.
- Importance of fast assessment of building damage for efficient search and rescue.
- Computer algorithms can rapidly estimate damage distribution.
- Key information needed for mapping human impact:
    - Shaking intensity data.
    - Population exposure data.
    - Building safety standards.

Tools for Rapid Assessment

- **PAGER (Prompt Assessment of Global Earthquakes for Response)**: Quickly estimates population exposure and potential fatalities.
- Example: PAGER estimate within minutes of the **2018 Palau earthquake**.

Challenges in Reporting and Response

- Governments/authorities may initially underestimate fatalities (e.g., Palau earthquake).
- Delay in recognizing true impacts can hinder timely assistance (e.g., Italy's L'Aquila earthquake).
- Remote sensing and satellite imagery can enhance damage assessment.
- **INSAR (Interferometric Synthetic Aperture Radar)**: Can penetrate cloud cover; useful for mapping damage.

Conclusion

- Ongoing development of early warning and damage assessment systems enhances earthquake preparedness, response, and ultimately saves lives.