Enhancing Airport Resilience with Earthquake Early Warning (EEW) Systems

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Caption: Theme building at LAX

Introduction

- Airports play a role in disaster response and recovery, including emergency relief operations
- Earthquakes pose significant risks to airports
- EEW can provide advance notice before strong shaking occurs

Image Source: "SFO Airport Tower" by ruifo is licensed under CC BY-NC-SA 2.0.
Caption: ATC tower at SFO

EEW

Overview of Earthquake Early Warning (EEW)

POTENTIAL BENEFITS FOR AIRPORTS

- Provides real-time warnings to personnel and passengers
- Reduces injuries by allowing passengers and personnel to take protective actions
- Enables automated safety actions (e.g., shutting down fuel lines and stopping elevators)
- Minimizes service disruptions by allowing airports to initiate emergency protocols before severe shaking occurs.

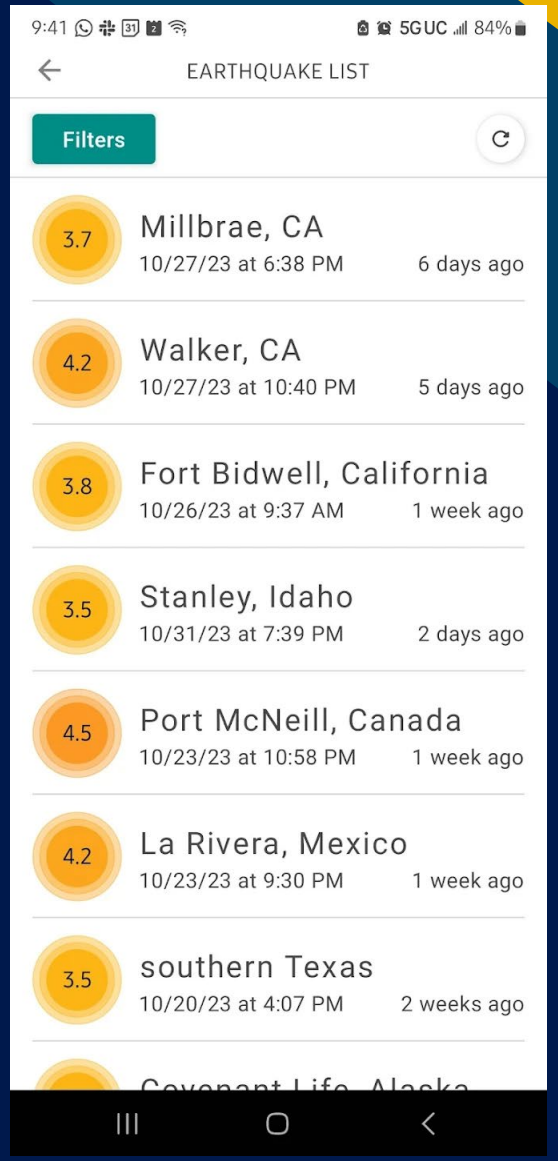
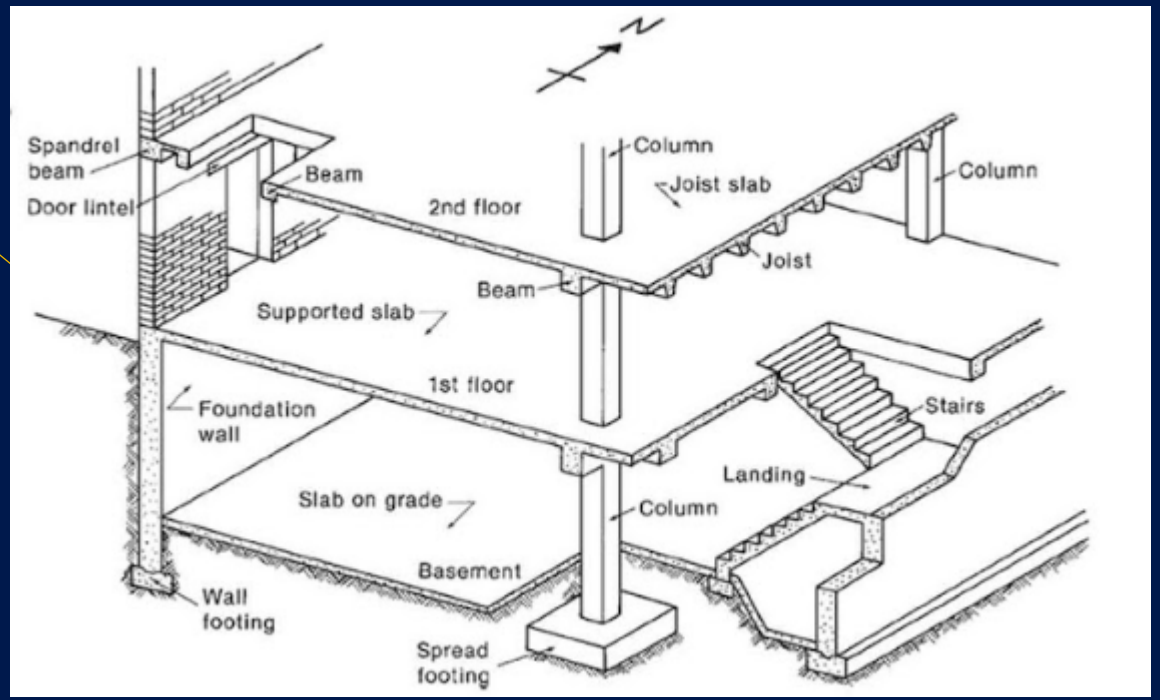


Image Source: MyShake Google Play Store
Caption: An app screenshot depicting a list of recent earthquakes

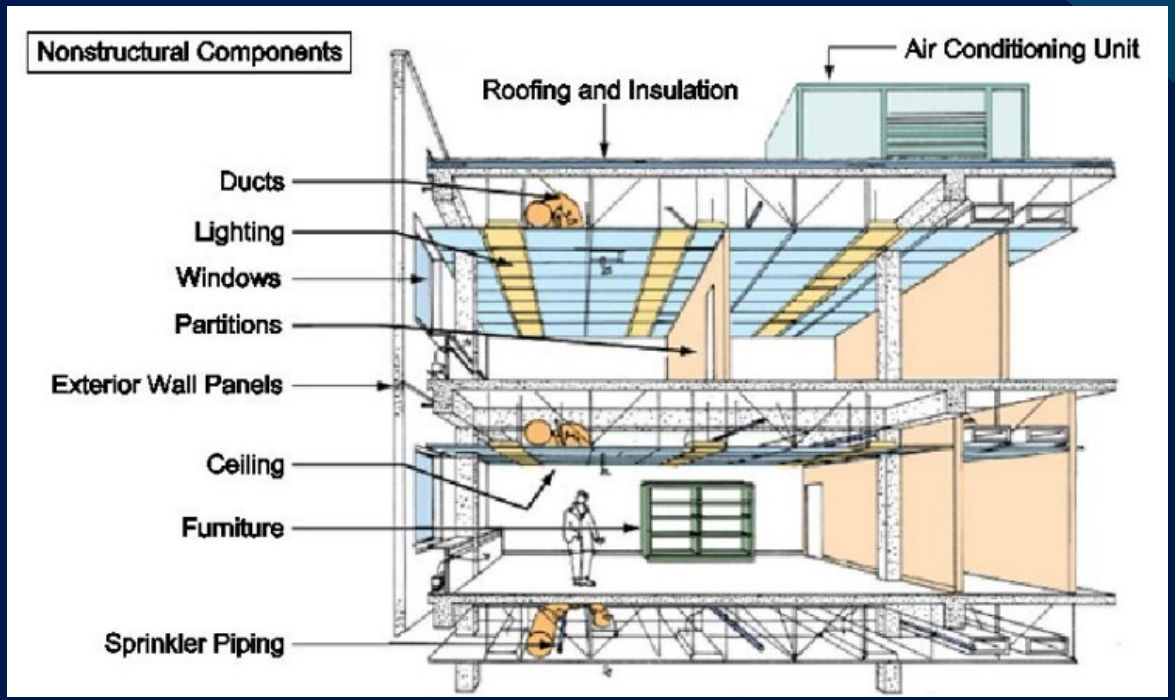
Earthquake Risks to Airports

SEISMIC THREATS TO AIRPORT INFRASTRUCTURE

Structural Damage



Nonstructural Damage



Earthquake Risks to Airports

SEISMIC THREATS TO AIRPORT INFRASTRUCTURE

Liquefaction

Fuel and Pipeline Damage

Applications Most Relevant to Airports

Alerts and Automated Actions

- Staff vs. public facing alerts
- Automated action (e.g., elevators/conveyances; people movers; baggage handling systems; fire bay doors; fuel, water, and gas lines; etc.)

Airfield and Air Traffic Control (ATC) Applications

- Possible alerts for ATC and pilots
- Temporary flight restrictions for affected airports
- FAA Regulations and airport/tower implementation
- Coordination with FAA and adjacent airports to manage diverted flights

Benefit-Cost Analysis

QUANTIFICATION OF BENEFITS

- Alerts
  - Staff-facing
  - Public-facing
- Automated actions
  - Elevators
  - Fire Bay Doors
  - Fuel Systems
  - Water Systems
  - Gas Systems
  - Baggage Systems
  - Airport People Mover
- Airside Response

- ✓ EEW benefits calculated for most of the use cases in PSP and LAX
- ✓ Calculated benefits are due to reduction in
  - ➢ Injuries and deaths
  - ➢ Infrastructure damage and corresponding repairs (e.g., elevator)
  - ➢ Occurrence of secondary hazards (fire, explosion, flooding)

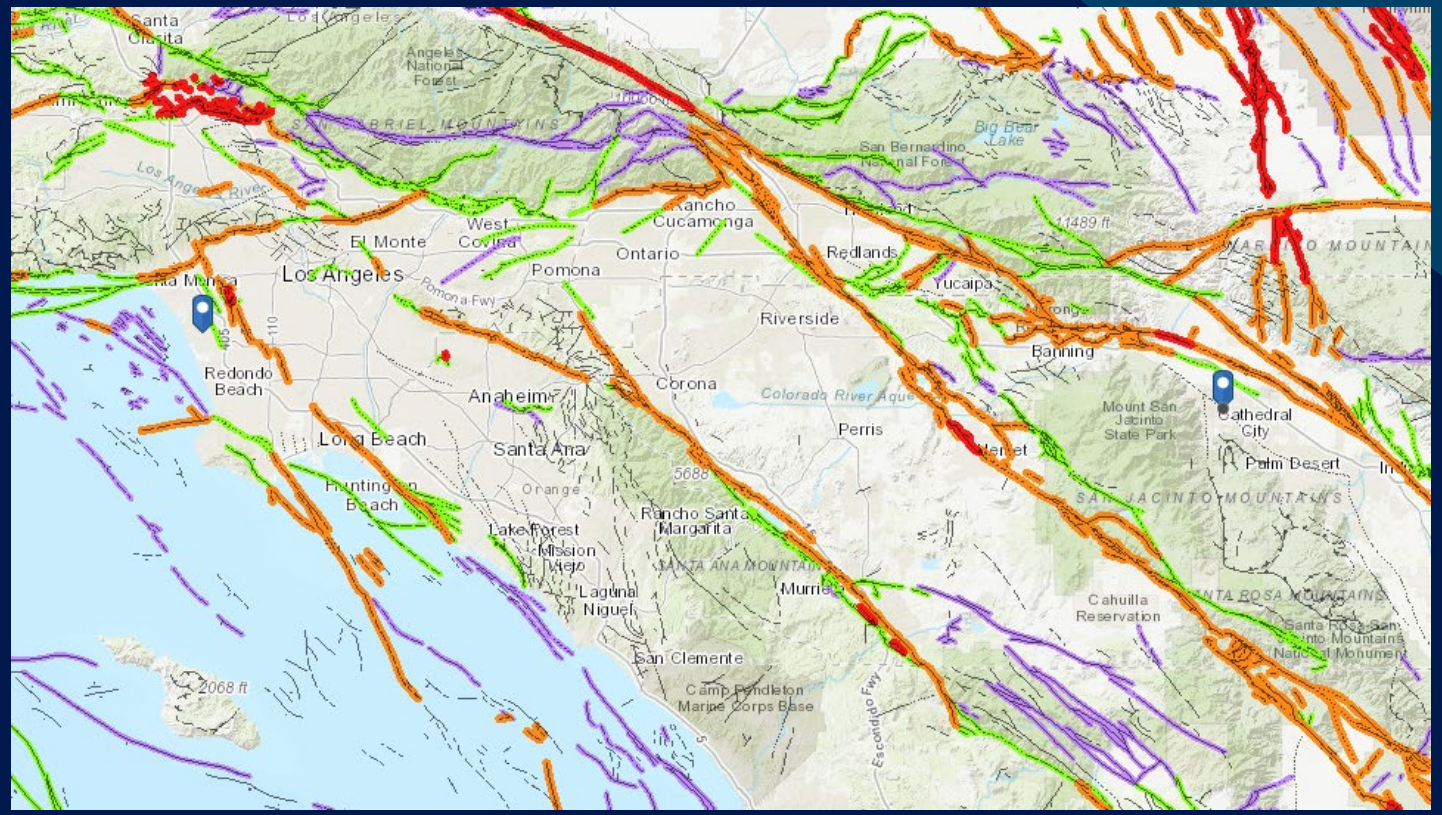
Benefit-Cost Analysis

QUANTIFICATION OF COSTS

- **Delivering EEW notification to airports:**
  - ✓ Server purchase, setup, maintenance
  - ✓ Internet connectivity
- **Operational integration and implementation:**
  - ✓ Costs associated with linking the EEW notification to each use case (e.g., communicating with the PA system, transmitting the alarm signal and actuating a valve or controlling an elevator)
- **Training and maintenance:**
  - ✓ Regular system testing
  - ✓ Staff training
  - ✓ Emergency drills

Case Studies: Los Angeles (LAX) & Palm Springs (PSP) International Airports

- **LAX Airport Background**
  - 2023 – 566,000 flights, 36 million enplanements
  - 4 runways, 10 terminals
  - Located near several active fault zones, including the Newport-Inglewood Fault and within proximity to the Santa Monica and Hollywood faults
- **PSP Airport Background**
  - 2023 – 62,000 flights , 1.6 million enplanements
  - 2 runways, 2 terminals
  - Located near several active faults, including the San Andreas Fault, and the Banning and Garnet Hill strands



Summary of the Benefits and Costs of Different EEW Applications at LAX and PSP

EEW

Application	PSP			LAX		
	Benefit ($M)	Cost ($M)	BCR	Benefit ($M)	Cost ($M)	BCR
Smartphone Alert	0.150	0.076	2.0	3.10	0.12	25.8
Gas Shutoff	11.500	0.123	93.5	3.60	0.21	17.1
Fire Station Bay Doors	0.044	0.068	0.6	1.05	0.07	15.0
Elevator Stop	0.0048	0.13	0.04	0.07	0.29	0.2
Fuel Shutoff	0	0	NA	3.64	0.18	20.2
Water Shutoff	0.009	0.508	0.02	0.12	0.10	1.2
Baggage System Shutoff	NA	0.078	NA	NA	0.27	NA
Backup Power	NA	0.078	NA	NA	0.065	NA

Policy Considerations for EEW Implementation

EEW

- Will FAA guidelines and requirements be needed for EEW integration at airports?
- State and federal regulations on seismic safety and emergency preparedness
- Comparison with international EEW policies and best practices
- Strategies to encourage wider adoption of EEW in aviation across California and the U.S.

Policy Considerations for EEW Implementation

EEW

Lessons from Other Sectors

- Several case studies from other sectors using EEW such as rail, healthcare, and utilities (e.g., BART, Menlo Park Fire, etc.)
- Successful applications of automated response systems (e.g., stopping elevators, shutting off fuel lines, etc.)
- Potential for cross-sector partnerships for peer exchange of lessons learned

Public Awareness and Outreach Initiatives

- Importance of training airport personnel on EEW procedures
- Educating passengers on EEW alerts and appropriate response actions
- Incorporating EEW drills into standard airport emergency preparedness exercises
- Multilingual and accessible communication strategies for diverse travelers

Key Findings

Potential Barriers to Implementation

- **Financial Constraints: U**pfront costs to decision-makers.
- **Technical Challenges:** Integration with legacy systems
- **Stakeholder Skepticism:** Concerns over reliability and operational impacts
- **Cybersecurity Risks:** Securing EEW data and systems

Additional Research Needs

- Case studies at other CA airports, particularly General Aviation (GA) airports
- Improve warning accuracy
  - More research is needed because false alarms at airports could have notable implications
- Develop model SOPs for warning responses
- Post-deployment research on institutional and economic impacts of EEW at airports

Thank You!

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