Earthquake Hazard and Disaster Management in Iran

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Iran Strong Motion Network (ISMN)

BHRC

Disaster Management

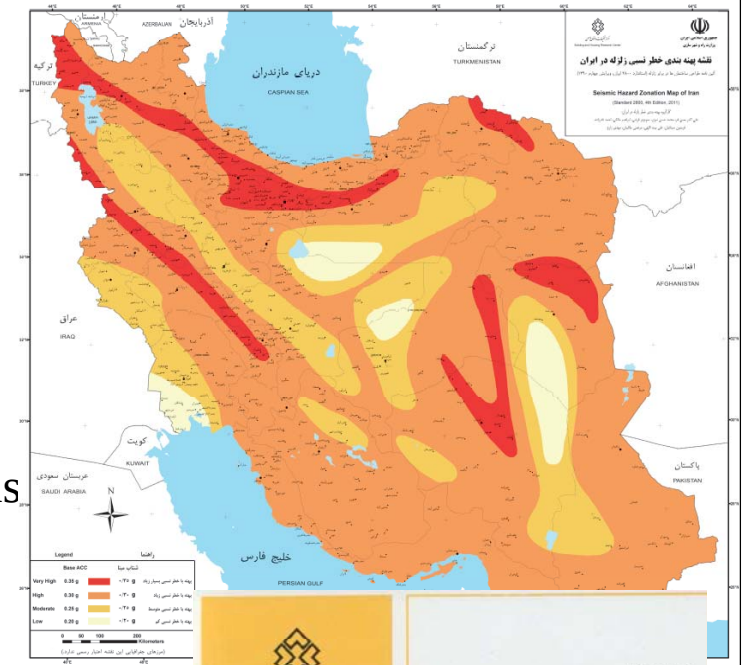
Four main phases in order to lessen the impact of disaster:

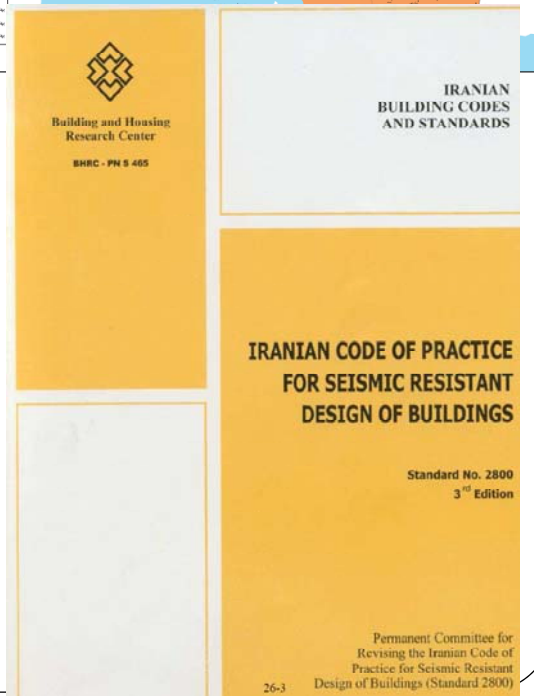
1. Mitigation (actions taken to prevent or reduce the cause, impact, and consequences of disasters)
2. Disaster preparedness (pre-event planning, training, and educational activities for events that cannot be mitigated)
3. Crisis leadership and emergency response
4. Recovery plan

Disaster Preparedness: pre-event planning and mitigation

- What to do before occurrence of a destructive earthquake?

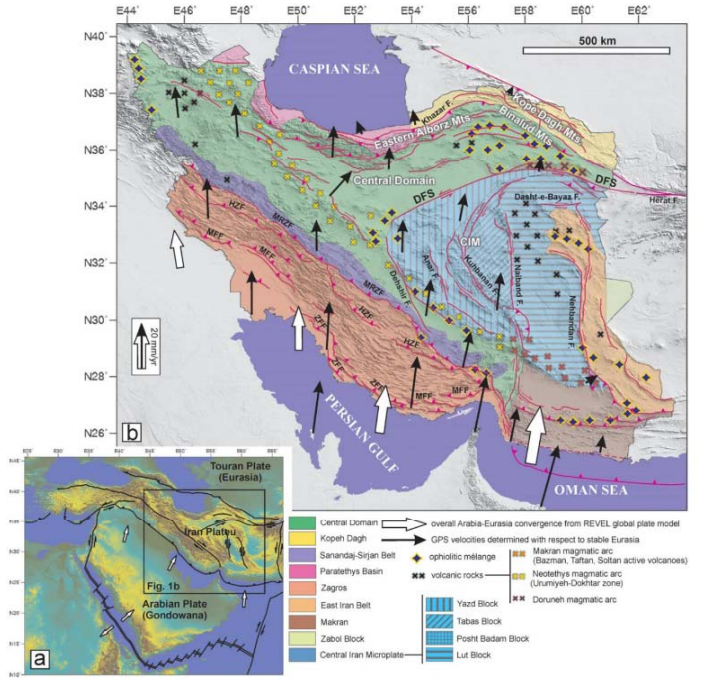
1. Identify the hazard itself (earthquake hazard)
2. Calculate the hazard (gathering all information that is needed,…)
3. Translate the information and resulted hazard calculation to the practical outputs (regulations, national building codes, urban planning,…)
4. Development of the Earthquake Early Warning (EEW) and Rapid Response systems to be used during and shortly after earthquake occurrence.



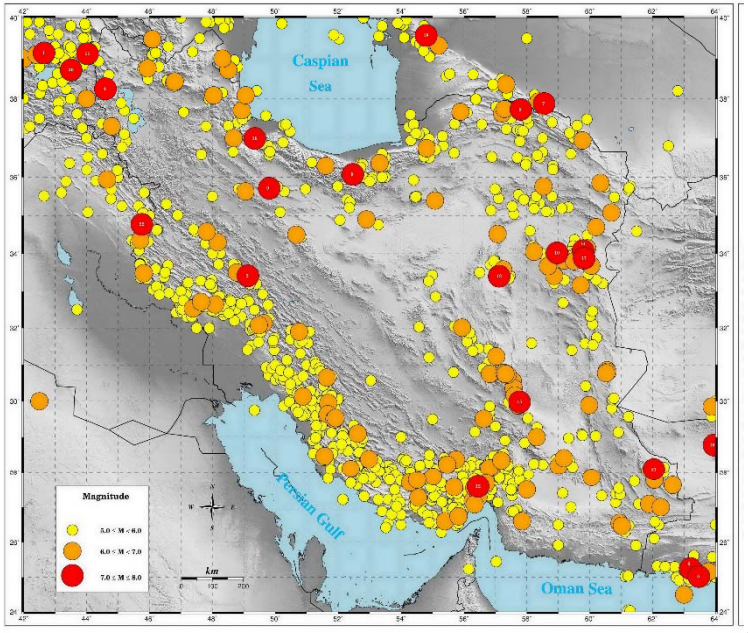


Iran Seismicity

- Iran is located in the mid Alpine-Himalayas seismic belt
- Experienced many destructive earthquakes:
  - Buin-Zahra earthquake (September 1, 1962 -M7.2, -12000 casualties)
  - Dasht-e Bayaz and Ferdows earthquakes (August 31, 1968 -M7.3; September1, 1968 -M6.4 -15000 death)
  - Tabas earthquake (September 16, 1978 -M7.4 -18000 death- damage~ $11 million),
  - Rudbar-Manjil earthquake (June 21, 1990 -M7.4 -35000 -50000 death- 60,000 injured - $8 billion damage (National Geophysical Data Center)),
  - Bam earthquake (December 26, 2003-M6.6 -exceed 40,000 deaths-30000 injured- 75000 homeless-damage~ $290 million -iiees).
  - Sarpol-e Zahab earthquake (November 12, 2017 -M7.3- 630 deaths- 8,100 injured-70000 homeless-damage~ $1.25 billion)



Tectonic setting of Iran in the Middle East and major convergence vectors of the region. Javadi et al. (2015)



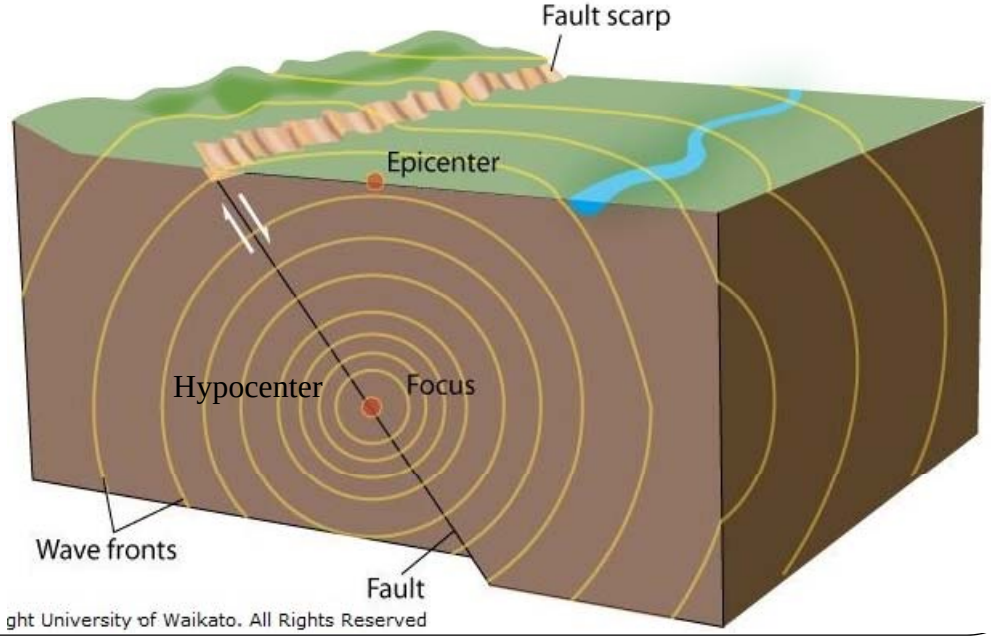
irsc.ut.ac.ir/seismicity

Some Basics

- <u>What is earthquake?</u>
  - Most common and most destructive natural disaster
  - Sudden release of stored strain energy accompanies fault slip and generates seismic waves
  - Seismic wave travel through the earth's crust and cause the shaking that we feel.

Scattering of seismic waves from the epicenter to the surrounding are

Kobe earthquake (**M**6.9), 1995
http://www.coolgeography.co.uk



Earthquake Effects

Sarpol-e Zahab earthquake, 2017,
photo by M. Shahvar

- **Ground Shaking (causes most of damage)**
  - Caused by the passage of seismic waves
- **Damage to the life lines:**
  - Networks include power, energy and telecommunication systems, transportation, water and sewage, gas and fuel liquids, and waste collection systems.
  - Severe economic consequences; Adverse effect on the environment and quality of life after an earthquake

Nepal, 2015
https://journeys.dartmouth.edu/NepalQuake-CaseStudies/

- **Liquefaction:**
  - Occurs when a saturated or partially saturated soil loses strength and stiffness in response strong ground shaking.

Liquefaction after the 1964 Niigata earthquake, Japan

Earthquake Effects

- **Tsunami:**
  - Giant waves caused by earthquakes or volcanic eruptions under the sea
- **Landslide**
  - The movement of rock, earth, or debris down a sloped section of land.
  - The biggest landslide– Seymareh, Iran in Southwest Iran (about 30 billion tones of rock moved in a single event!)
- **Fire**
  - Fires, often associated with broken electrical and gas lines, is one of the common side effects of earthquakes

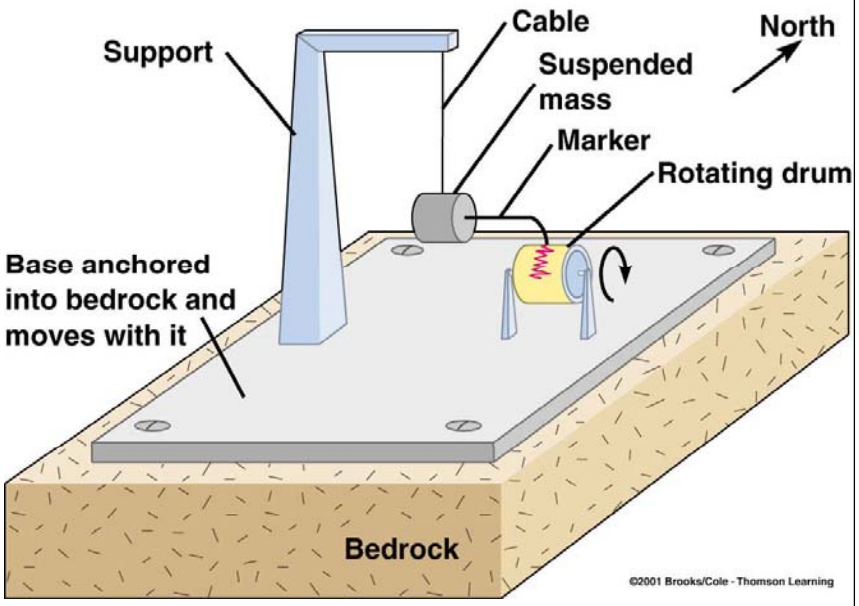
2011. Miyako City, Japan. http://www.telegraph.co.uk/

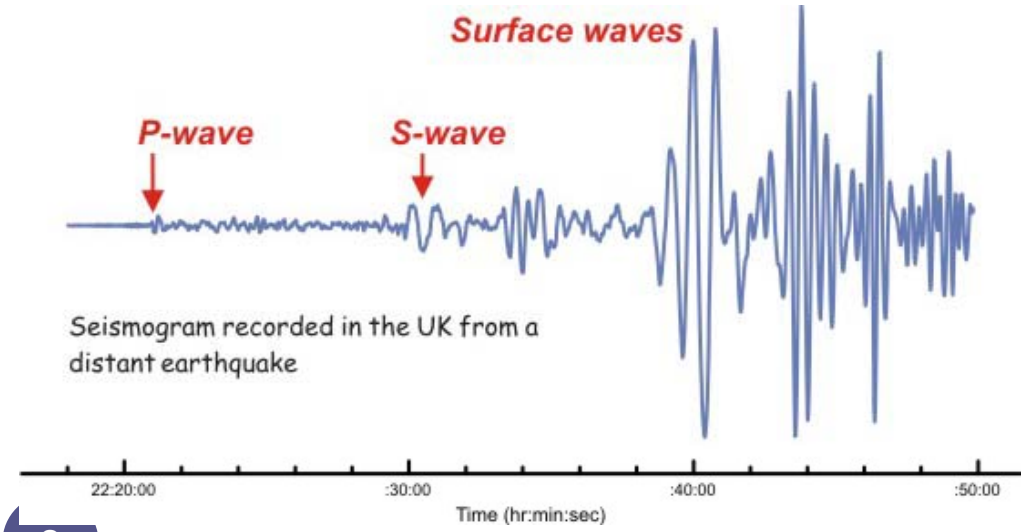
http://www.weatherwizkids.com

Loma Prieta, CA 1989. https://www.nbcnews.com

Earthquake Recording

- **Seismograph (**seismometer)
  - An instrument used to detect and record earthquakes
- **Seismogram**
  - A graph output by a seismograph.
  - It is a record of the ground motion at a measuring station as a function of time.





ttps://socratic.org/

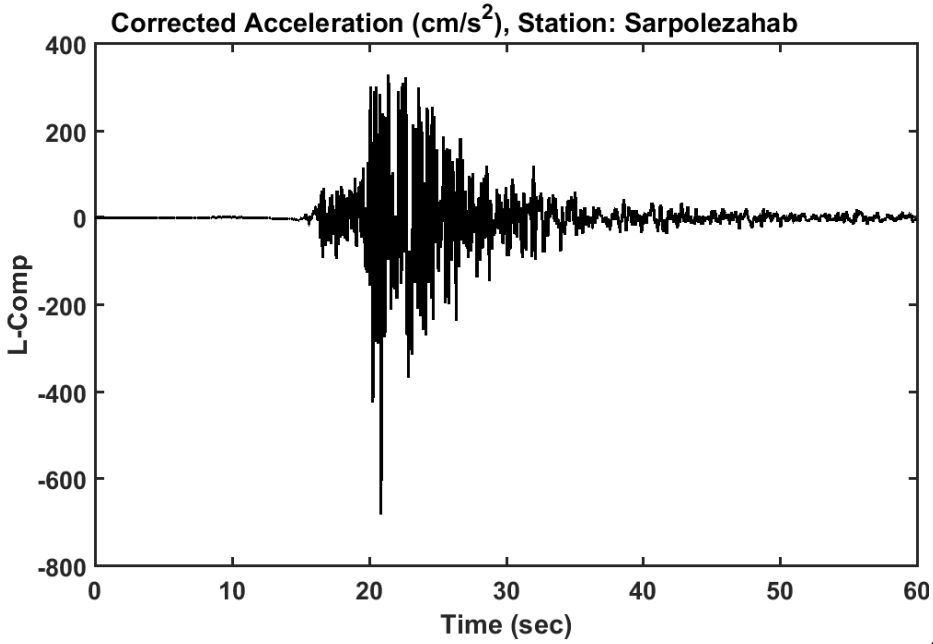
VE-5x Seismometer.
www.geosig.com

Seismometer and Accelerometer

- **Seismometer:**
  - Measures the velocity of a point on the ground during earthquake
  - Very sensitive instrument that can detect movements of the Earth's surface at far distances.
  - Seismograms used for science (earth structure, velocity of layers,..)
  - Clips for strong earthquake in close distances (saturate)

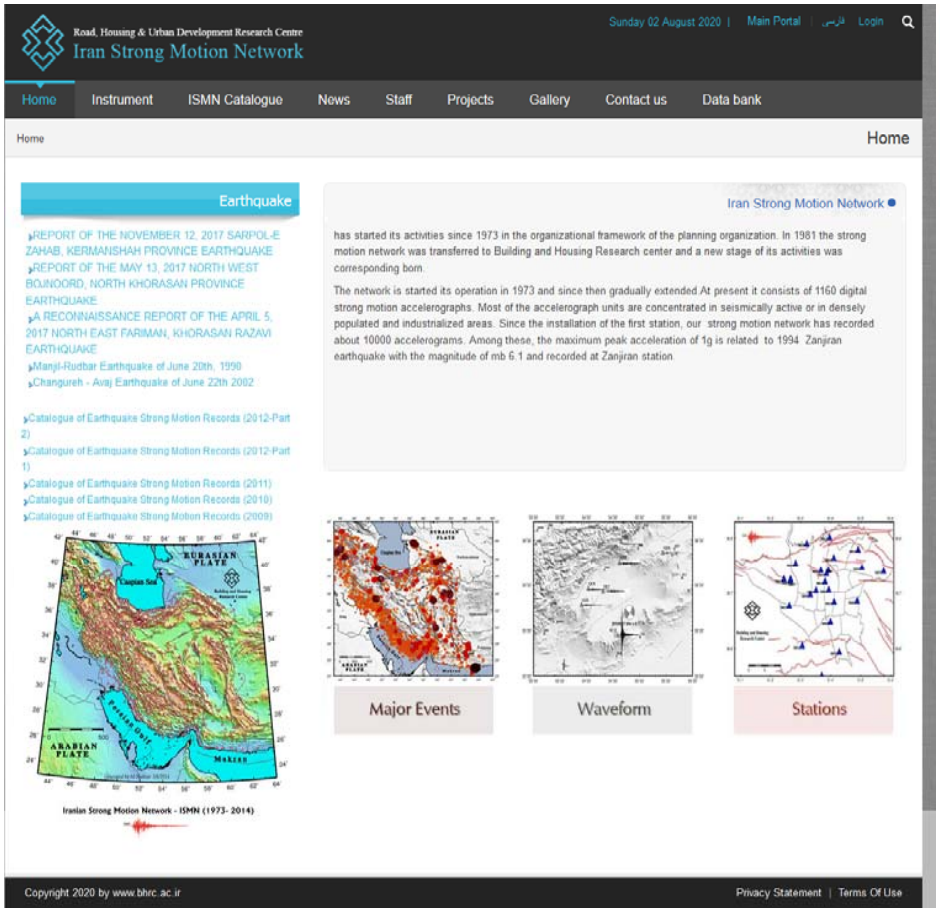
Guralp Fortis and Fortimus strong motion accelerometers

- **Accelerometer:**
  - Measures the acceleration of a point on the ground during earthquake
  - Designed to measure the large amplitude, high-frequency seismic waves typical of large local earthquakes.
  - Less sensitive with wider range (±2g)
  - Accelerograms used more for engineering application



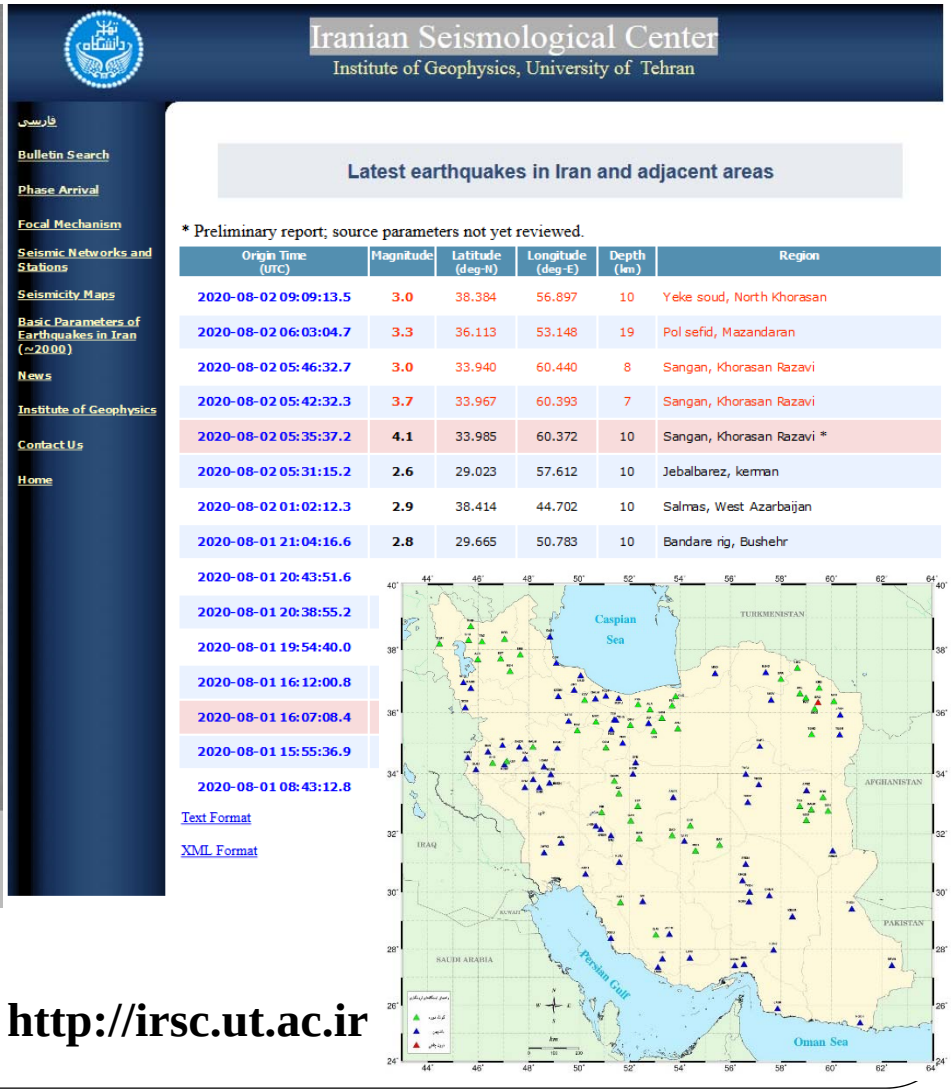
Monitoring Seismic Centers of Iran

- Iran Strong Motion Network



https://ismn.bhrc.ac.ir

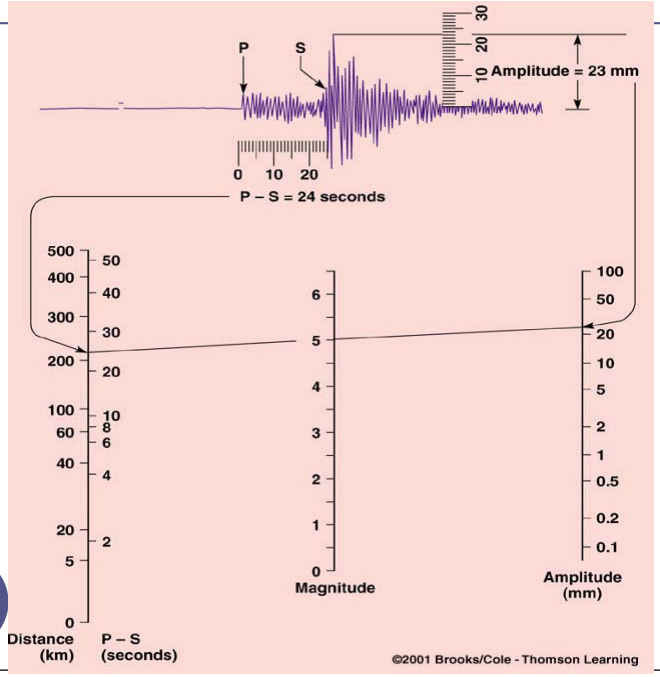
- Iranian Seismological Center



http://irsc.ut.ac.ir

Earthquake Scaling

- **Magnitude** scales originated because of:
  - Desire for an objective measure of earthquake size
  - Calculation using the amplitude of signal on seismograms.
  - Only one number for each earthquake (ex; M7.3 for Sare Pole Zahab Earthquake)
  - Related to the released energy.
- Different type of Magnitudes
  - such as: mb, Ml, Ms, Mw,… depending on what part of signal is used.

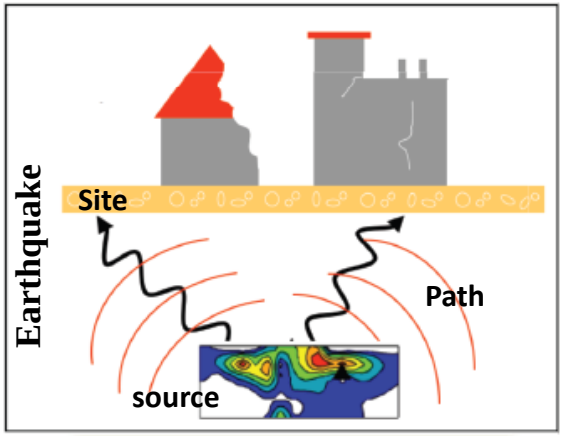


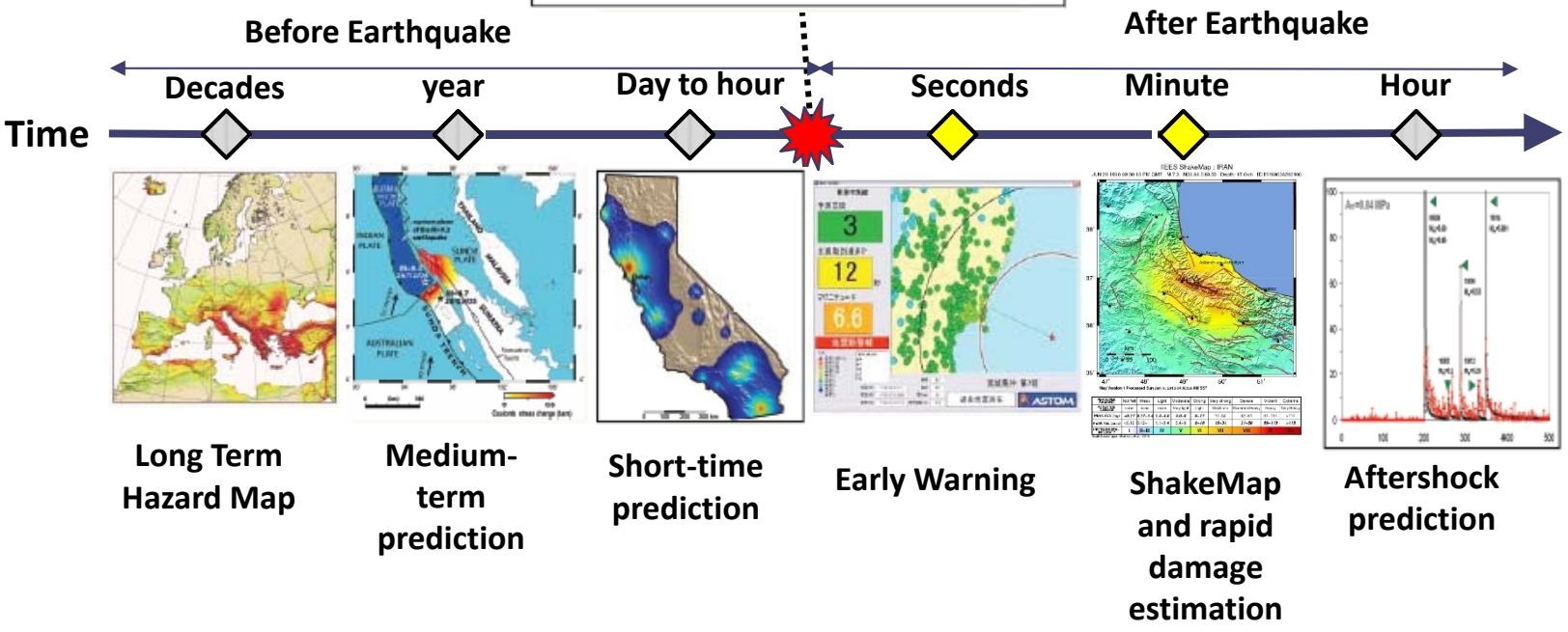
http://www.jma.go.jp/jma/en/Activities/earthquake.html

- Earthquake **Intensity**:
  - Measures the strength of shaking produced by the earthquake at a certain location.
  - Different numbers for each earthquake (varies from place to place -decreases as it moves away from the epicenter)

Earthquake Hazard Actions with Time

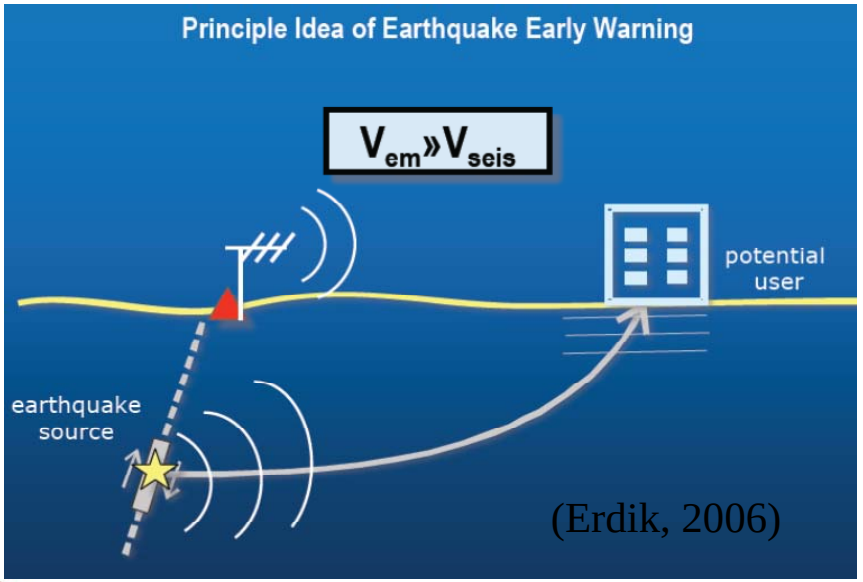
Courtesy of
M. Shahvar



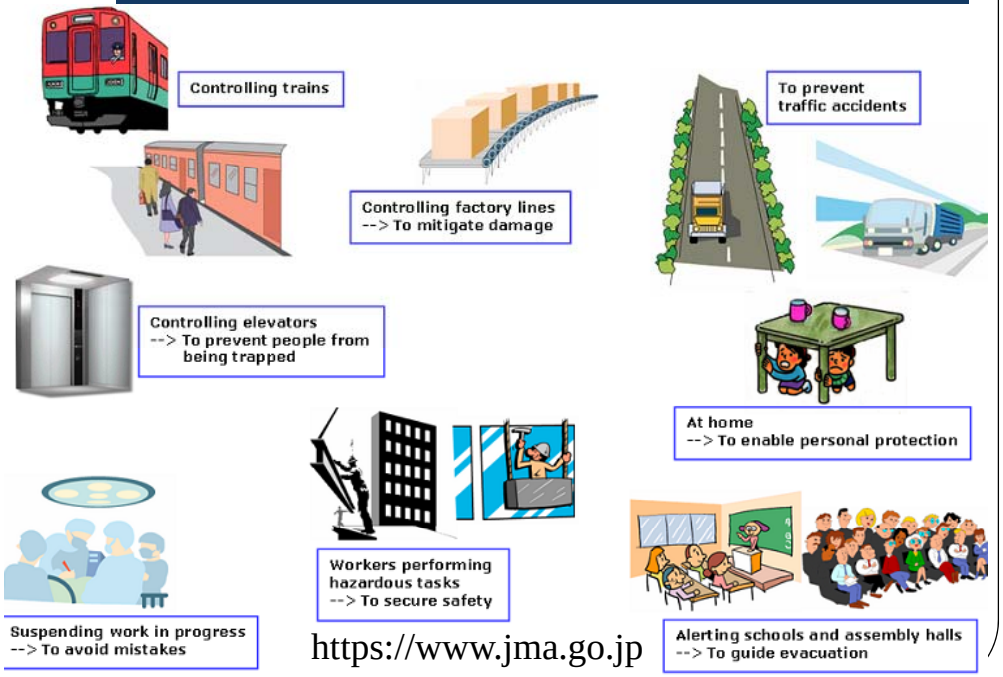


Earthquake Early Warning System (EEW)

- **The EEW system is composed of:**
  - Seismic stations
  - Real-time data communication system
  - Central processing center
  - Broadcasting system

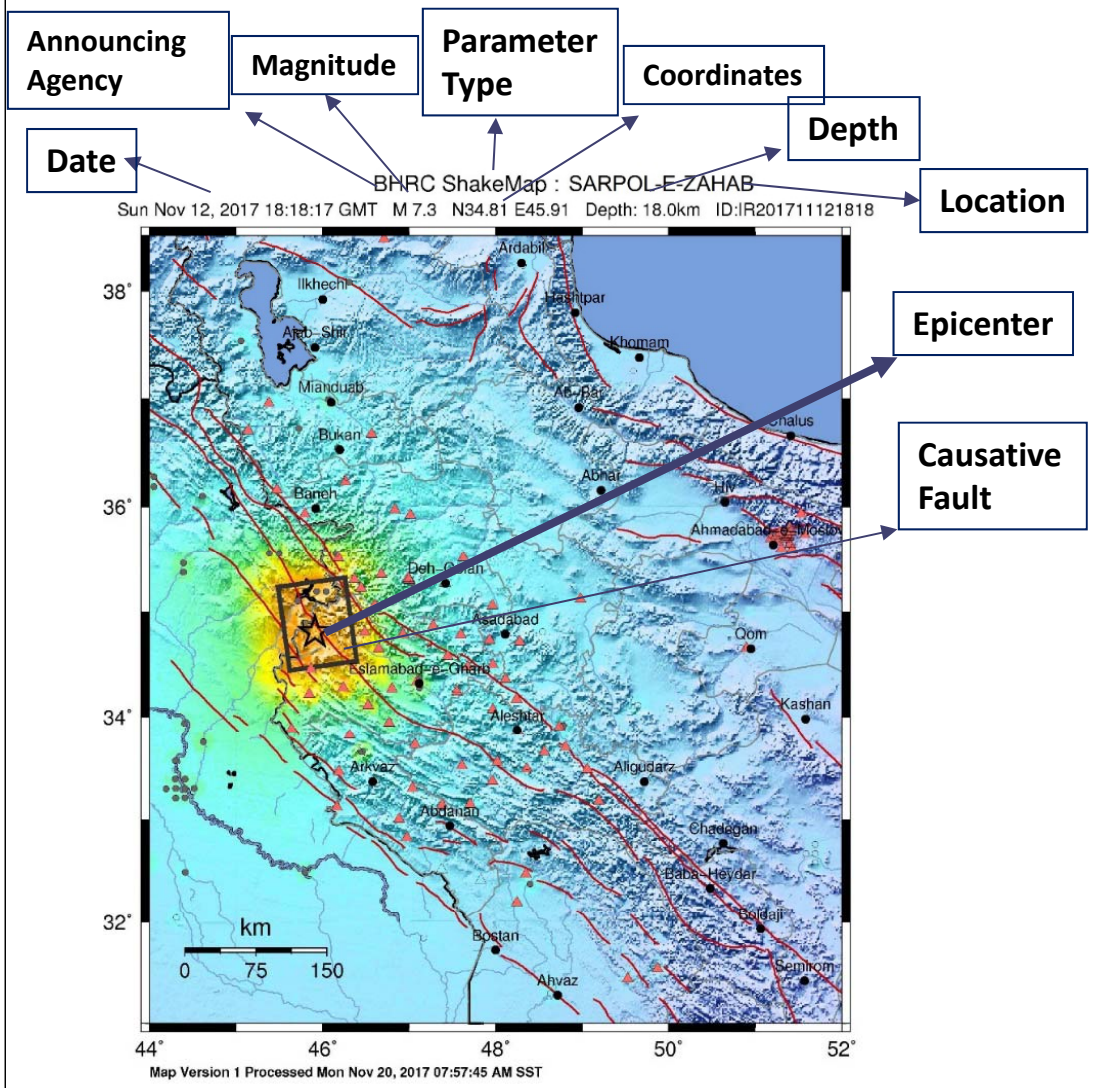


- **When a seismic event occurs:**
  - Close stations triggered by P-waves
  - Ground motion $\xrightarrow{\text{communication system}}$ central processor
  - Estimate source parameters (magnitude, location, intensity, ...)
  - Information $\xrightarrow{\text{distribution network}}$ user



https://www.jma.go.jp

Rapid Response System: ShakeMaps



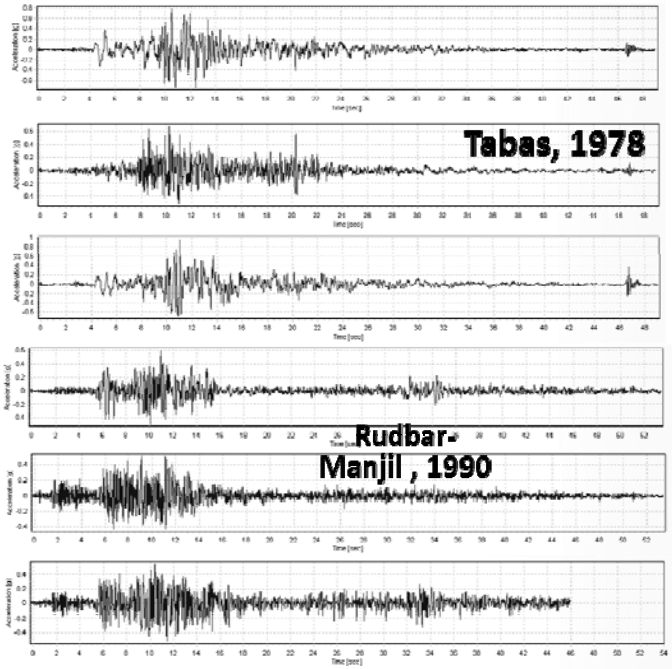
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17–1.4*	*1.4–3.9*	*3.9–9.2*	*9.2–18*	18–34	34–65	65–124	>124
PEAK VEL.(cm/s)	<0.1	0.1–1.1	1.1–3.4	3.4–8.1	*8.1–16*	*16–31*	*31–60*	*60–116*	*>116*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

- First time was introduced by Wald (1999) for south California
- Utilized in Italy, Switzerland, Romania and Portugal.
- Uses available data to show the event parameter (intensity, PGA,..)
- **<u>Application</u>**
  - Show where is the highest damage
  - Input for Damage assessment and Relief
  - Public announcement
  - Planning and training

Courtesy of M. Shahvar

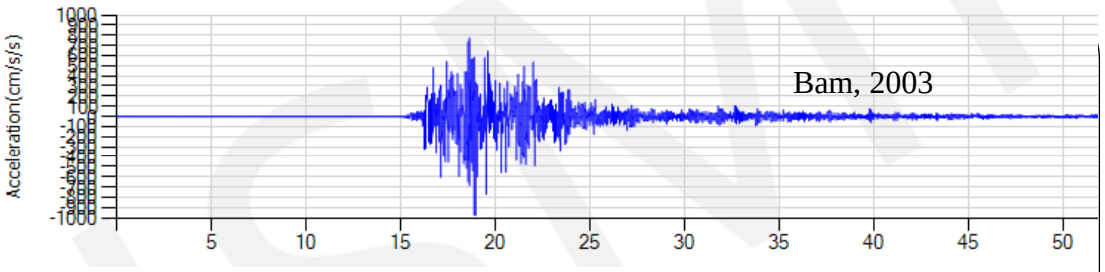
Iran Strong Motion Network (ISMN)

- **1st phase (1972-1990, by Mr. Moinfar)**
  - 270 SMA-1 accelerographs
  - Recorded **Tabas** earthquake (9 records)
  - Recorded **Rudbar-Manjil** earthquake (23 records, a real near fault 3 component accelerograms)
- **2nd phase**
  - Started in 1992
  - 1238 units of digital accelerographs (SSA-2).
  - 1992 -1998, more than 1,100 units were installed.
  - 60 Guralp CMG-5TD digital instruments in 2006.



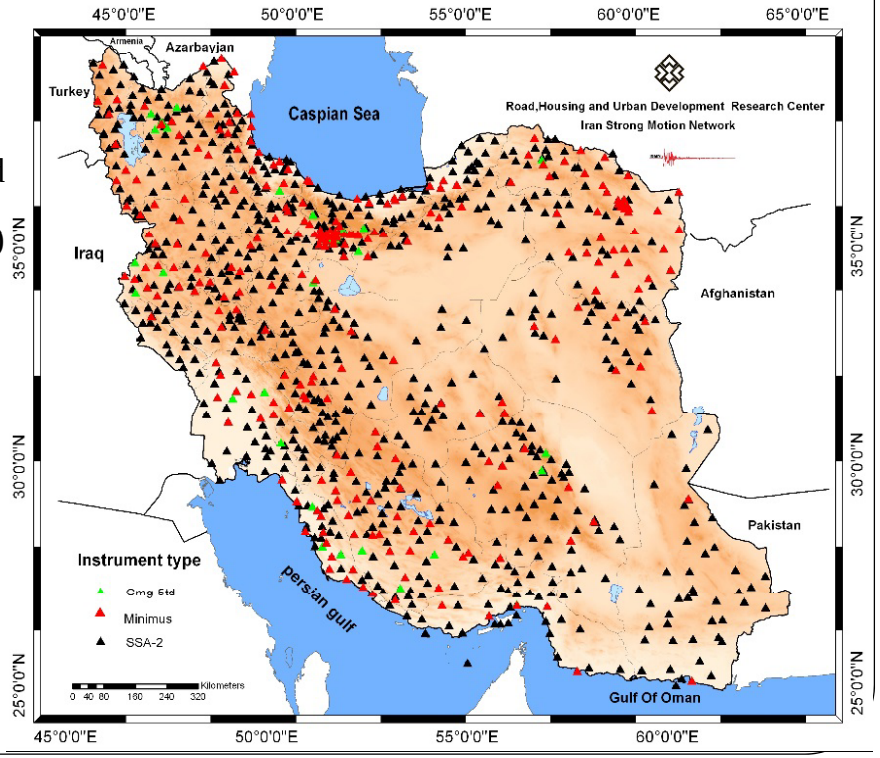
Guralp CMG-5TD

2nd phase



- Recorded many large earthquakes such as:
  - M6.6 Bam Earthquake (27 records, PGA ~ %98 g was recorded on vertical component in Bam station)
  - Twin Ahar–Varzaqan earthquakes of August 11, 2012 (First event, M6.4, 57 records; Second event , M6.3, 75 records)
  - Eastern Turkey earthquake of 23,October 2011 (M7.0, 11 records)
  - September 24, 2013 Awaran- Pakistan earthquake (M7.7, 9 records)
  - November 12, 2017 Sarpol-e Zahab earthquake (M7.3, 113 records)

- **3rd Phase**
  - More than 500 units new modern accelerometers were purchased
  - More than 200 have been installed (since 2017, ongoing process)

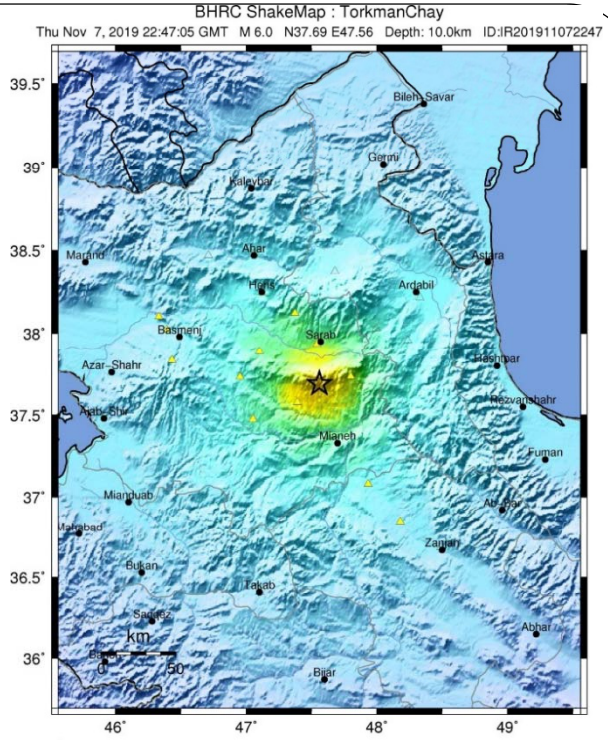


- **Current Status:**
  - 1163 active stations
  - Total of 3 component records: 13940
  - 4 down hole instruments
  - 1 array instrument

Vision

- In a section of the Iran Fifth development Plan, the ISMN development has been emphasized
- Buying more than 2000 devices has been predicted in development phase.
- Replacement of old instruments
- Design and installation of RRS and EEWS in the major cities
- 50 down-hole arrays
- Monitoring of bridges and other critical facilities
- Installation at 100 tall buildings

ShakeMap of Torkamanchay earthquake, November 8, 2019



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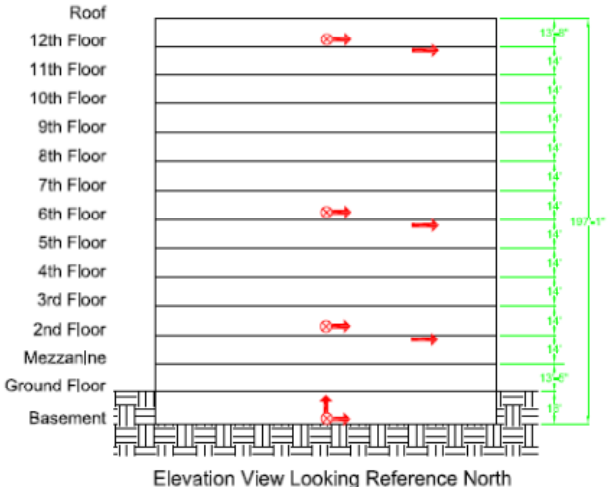
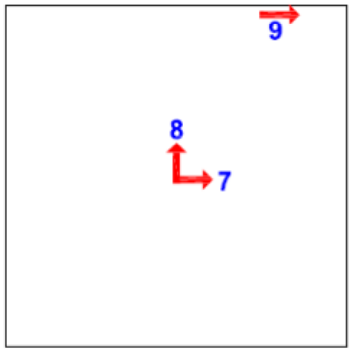
CA: Alhambra, Los Angeles County Public Works - 13 Story Office Building
NSMP Station No: 482

https://earthquake.usgs.gov/monitoring/nsmp/arrays/





Main Organization for Pre-event phase

- Supreme Council of Urban Planning and Architecture of Iran (lead the construction studies in order to safeguard the buildings against natural disasters,…)
- Iranian Seismological Center (Seismic data, Education, Research,..)
- Geological Survey of Iran (Geological maps, hazard maps, …)
- National Disaster Management Organization (NDMO)
- Road, Housing & Urban Development Research Center (ISMN, 2800 National Building code, other research departments)
  - Iranian Code of Practice for Seismic Resistant Design of Buildings, Also known as Iran national Standard No. 2800.
    - 2 Years after Buin-Zahra earthquake, first steps have been taken
    - 1st edition:1988 published by BHRC
    - 2nd edition: started after Manjil earthquake, published in 1999
    - 3rd edition: started after Ghaenat earthquake, published in 2005
    - 4th edition: 2009 started-published in 2014
    - After Sar Pole Zahab earthquake: Appendix to the 4th edition, entitled “Design and Execution Criteria for Non-structural Components”

New Disaster Management Law

- The new Disaster Management Law has been adopted by the Parliament in August 2019.
- Different ministries, research centers, army forces, red crescent, and organizations ,.. are involved.
- The responsibilities are described and every organization knows their job and how to collaborate with other sectors.
- In case of earthquake, BHRC has very important responsibilities such as:
  - Generating hazard maps,
  - Revising the active fault maps,
  - Inspecting the important buildings and critical lifelines,
  - ISMN is responsible for generating the ShakeMaps.

مرجع تصویب: مجلس شوراي اسلامي
شماره ویژه نامه: ۱۱۹۵

پنج‌شنبه،۷ شهریور ۱۳۹۸

سال هفتاد و پنج شماره ۲۱۶۸۷

چاپ

قانون مدیریت بحران کشور

شماره۹۰/۴۴۴۷۳ ۱۳۹۸/۶/۳

حجت‌الاسلام والمسلمین جناب آقای دکتر حسن روحانی

ریاست محترم جمهوری اسلامی ایران

عطف به نامه شماره ۱۰۰۰۱ /۵۱۱۱۴ مورخ ۱۳۹۴/۱/۳۱ در اجرای اصل یکصد و بیست و سوم(۱۲۳) قانون اساسی جمهوری‌اسلامی ایران قانون مدیریت بحران کشور که با عنوان لایحه مدیریت حوادث غیرمترقبه کشور به مجلس شورای اسلامی تقدیم شده بود، با تصویب در جلسه علنی روز دوشنبه مورخ ۱۳۹۸/۵/۷ و تأیید شورای محترم نگهبان، به‌پیوست ابلاغ می‌شود.

رئیس مجلس شورای اسلامی ـ علی لاریجانی

شماره۶۸۷۳۹ ۱۳۹۸/۶/۴

وزارت کشور

در اجرای اصل یکصد و بیست و سوم قانون اساسی جمهوری اسلامی ایران به پیوست «قانون مدیریت بحران کشور» که در جلسه علنی روز دوشنبه مورخ هفتم مردادماه یکهزار و سیصد و نود و هشت مجلس شورای اسلامی تصویب و در تاریخ ۱۳۹۸/۵/۲۲ به‌تأیید شورای نگهبان رسیده و طی نامه شماره ۹۰/۴۴۴۷۳ مورخ ۱۳۹۸/۶/۳ مجلس شورای اسلامی واصل گردیده، جهت اجرا ابلاغ می‌گردد.

رئیس جمهور ـ حسن روحانی

قانون مدیریت بحران کشور

فصل اول: کلیات

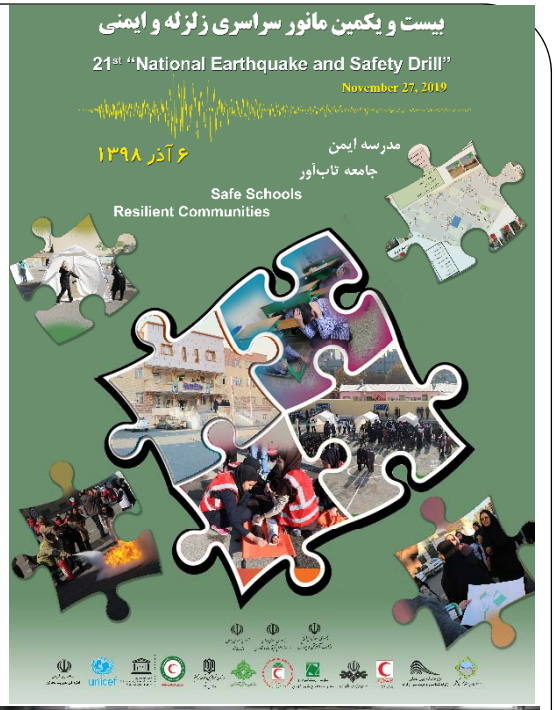
ماده۱ـ به‌منظور ارتقای توانمندی جامعه در امور پیش‌بینی و پیشگیری، کاهش خطر و آسیب‌پذیری، پاسخ مؤثر در برابر مخاطرات طبیعی، حوادث و بحران‌ها، تأمین ایمنی، تقویت تاب‌آوری با ایجاد مدیریت یکپارچه در امر سیاستگذاری، برنامه‌ریزی، ایجاد هماهنگی و انسجام در زمینه‌های اجرائی و پژوهشی، اطلاع‌رسانی متمرکز، ساماندهی و بازسازی مناطق آسیب‌دیده و نظارت دقیق بر فعالیت دستگاههای ذی‌ربط در حوزه حوادث و سوانح و کمک به توسعه پایدار برای مدیریت بحران کشور احکام زیر وضع می‌شود.

ماده۲ـ قوای سه‌گانه جمهوری اسلامی ایران اعم از وزارتخانه‌ها، سازمان‌ها، مؤسسات و شرکتهای دولتی، مؤسسات انتفاعی وابسته به دولت، بانکها و مؤسسات اعتباری دولتی، شرکتهای بیمه دولتی و همچنین مؤسسات و نهادهای عمومی غیردولتی، مؤسسات عمومی، بنیادها و نهادهای انقلاب اسلامی، نیروهای نظامی، امنیتی و انتظامی، کلیه نهادها و واحدهای زیر نظر مقام معظم رهبری با اذن معظمٌ‌له و دستگاهها و واحدهایی که شمول قانون بر آنها مستلزم ذکر یا تصریح نام است، اعم از اینکه قانون خاص خود را داشته یا از قوانین و مقررات عام تبعیت کنند و مؤسسات و شرکتهای وابسته یا تابعه آنها مشمول این قانون می‌باشند.

http://www.rrk.ir/Laws/ShowLaw.aspx?Code=18237

Professional and Public Education

- **Professional Eucation:**
  - Universities and research centers such as: Institute of Geophysics, International Institute of Earthquake Engineering and Seismology (IIEES), Sharif University, ….
- **Public Education:**
  - After each disaster, information is collected and documented in universities, research centers, …
  - Share the data, information and lessens in technical convention (with expertise, students, researchers, practitioners,..)
  - General educational course by NDMO
  - “National Earthquake and Safety Drill” in schools performed each year by collaboration of IIEES, Student organization, NDMO, and Iranian Red Crescent Society.
  - Safety House: Voluntary organization at city districts by NDMO - promoting the preparation and safety of the city and citizens in case of disasters.



Thank you for your attention

Any question?

References

http://www.iiees.ac.ir

https://www.mrud.ir/

http://irsc.ut.ac.ir

https://gsi.ir

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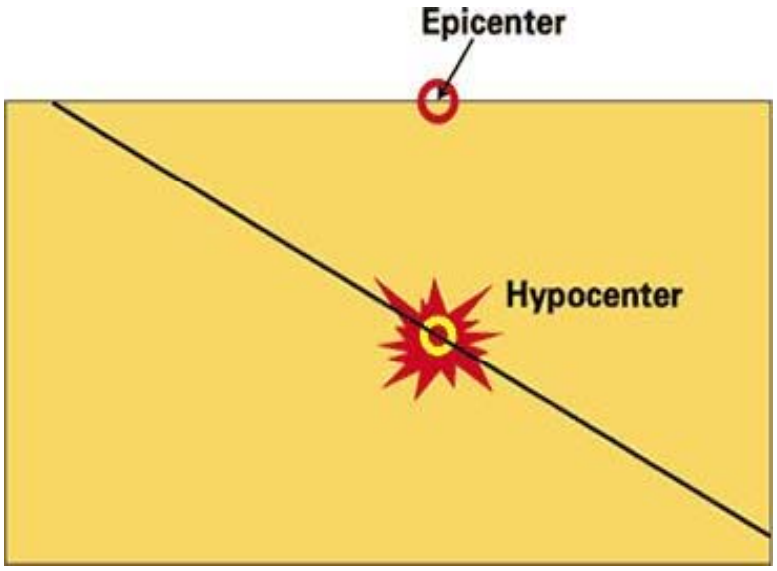
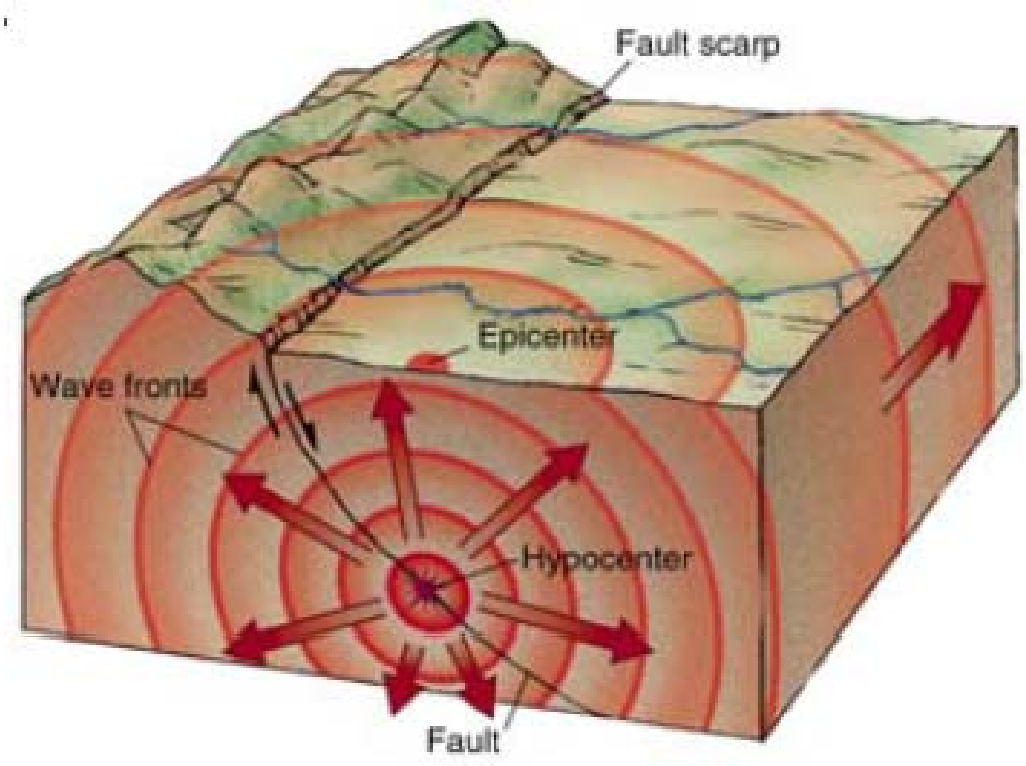
Hypocenter and epicenter

- **Hypocenter:** the point within the earth where an earthquake rupture starts.
- **Epicenter**: is the point on the earth's surface vertically above the hypocenter





(Davidson et al, 2002)