Non-structural Hazards Assessment and Mitigation

GeoHazards Society

GeoHazards Society INDIA

www.geohaz.in

The next four days

- Disasters Risk Management
- Understand hazards in South Asia
- Non-structural hazards in schools and hospitals
- Falling Hazards
  - Identification/ assessment
- Falling Hazards Mitigation
- Sustainability of the project

Sendai Framework

2015-2030

Goal

- Prevent and reduce disaster risk through economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures.
- Increase preparedness for response and recovery.
- Make communities more resilient.

7 Global Targets

1. To reduce deaths caused by disaster.
2. Reduce the number of people affected by disasters.
3. Reduce economic loss of disasters.
4. **Reduce damage to critical infrastructure specially health and education facilities by developing their resilience.**
5. Help countries to develop national and local DRR strategies.
6. Enhance international cooperation and provide sustainable support to those in need.
7. Develop multi hazard early warning system and make them available to the world community

Guiding Principles

1. It is the responsibility of the state to reduce disaster risk with the help of international cooperation.
2. DRR require responsibility to be shared by national authorities and central government and other stakeholders.
3. DRR is to be aimed at protecting human assets and rights.
4. DRR need to incorporate all the people irrespective of their sex, caste, age, religion.
5. DRR activity will also involve empowering of local communities and authorities.
6. DRR need to focus on multiple hazards and risk, should incorporate scientific data and traditional knowledge.
7. DRR is essential to achieve sustainable development.
8. **For DRR one need to focus on mitigation rather than response.**
9. Post disaster one need to focus on "Build Back Better"
10. Developed nations have to assist less developed and island nations in the long run.

Priorities for action

1. **Understanding Disaster Risk**
2. **Strengthening disaster risk governance to manage disaster risk**
3. **Investing in disaster risk reduction for resilience.**
4. **Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction.**

Role of Stakeholders

- Women participation is critical for any new policy on disaster risk management.
- **Children and youth are agent of change and hence are to be a part of the DRR strategy.**
- Old age people and people with experience are also to be a part of DRR strategy.
- Traditional knowledge of indigenous people should also be used.
- Private businesses need to incorporate business continuity planning.

Sustainable Development Goals

- Goal 11: Sustainable cities and communities
- 11.5: reduce casualties and affects of disasters.
- 11 b and 11 c: sustainable increase capacity by 2020 and work in line with Sendai Framework.

Two Cities

- Same Intensity of hazard, say an earthquake
- Same time of the day
- Same Population
- Same results?
- What is different?
- Why are two cities having different risks?
- What constitutes risk at a place?

Hazard

H

- Hazard is a physical event that can potentially **trigger a disaster.** Such a physical event in itself need not necessarily result in a disaster

Vulnerability

V

- Vulnerability is the degree to which the built environment is susceptible to losses **(largely depends on nature of** buildings, types, ages **etc)**

Vulnerability

Vulnerability

Vulnerability

Hazard, Risk, Capacity & Vulnerability

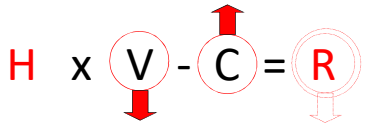
- Hazard is a physical event that can potentially **trigger a disaster.** Such a physical event in itself need not necessarily result in a disaster
- Vulnerability is the degree to which the built environment is susceptible to losses **(largely depends on nature of** buildings, types, ages **etc)**
- Capacity is the resources of communities to cope with a threat or resist the impact of a hazard.
- Risk is the probability/likelihood of a disaster happening.

Ingredients of Risk

H V C R

Hazard Vulnerability Capacity Risk

Ingredients of Risk



Hazard x Vulnerability – Capacity = Risk

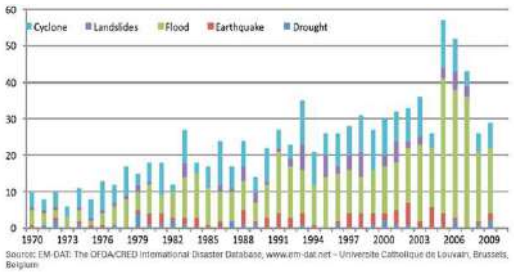
Risk Mitigation

- Increase Capacity
  - Awareness generation
  - Training of Architects, Builders, Contractors, Designers, Engineers, Financiers, Government, Homeowners, Industries…Media, NGOs…Teachers. Everyone!!
- Decrease Vulnerability
  - Future Buildings
    - Enforce Building byelaws
  - Lifeline Structures remain functional
  - Existing Buildings
    - Structural Mitigation –Retrofitting
    - Falling Hazards Mitigation

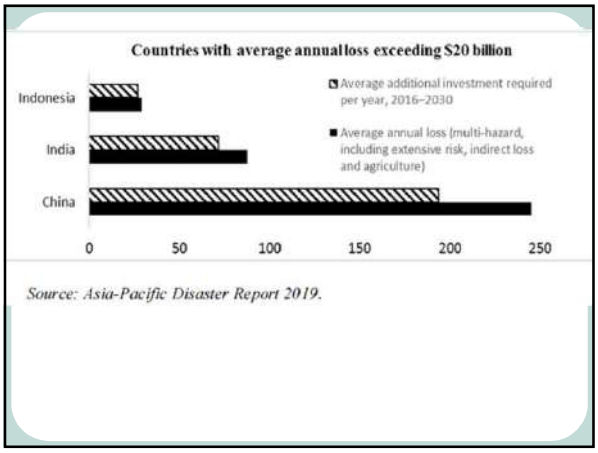
Multiple hazards are affecting South Asia countries

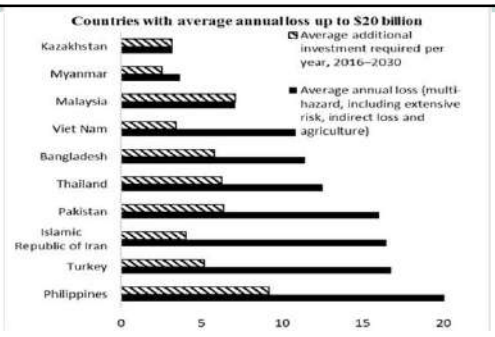
Can you identify few of them?

Total no. of Natural Disasters in South Asian Region 1960-2009



It mentions mostly floods





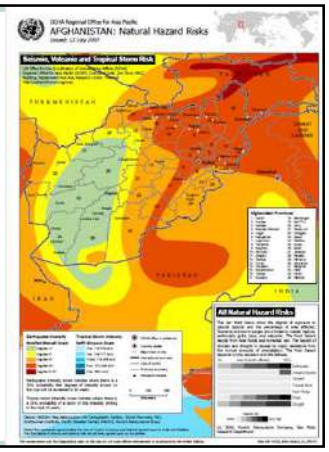
Including Nepal and Sri Lanka

What hazards should we plan for?

- Earthquake
- Landslides
- Windstorms
- Rock falls
- Fires
- GLOF
- Tsunami
- Flood
- …Be aware of every hazard that can affect you

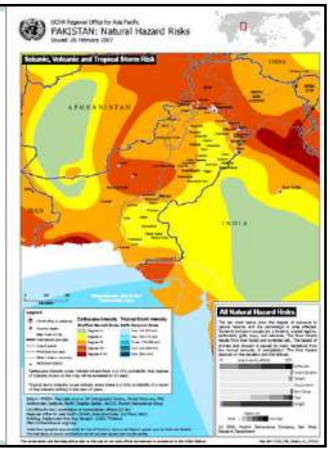
Afghanistan

- Earthquake
- Landslides
- Flash floods
- Draught
- Fires
- Wind

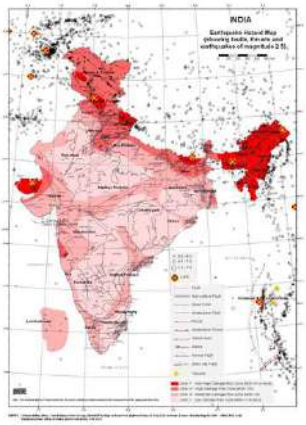


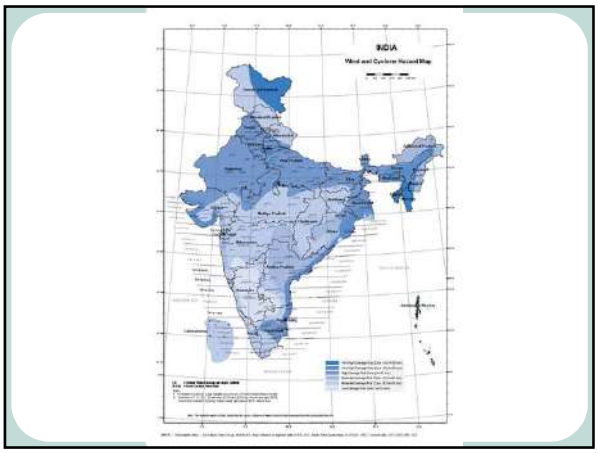
Pakistan

- Earthquake
- Landslide
- Floods
- Tsunami
- Storms
- Wind
- Fire

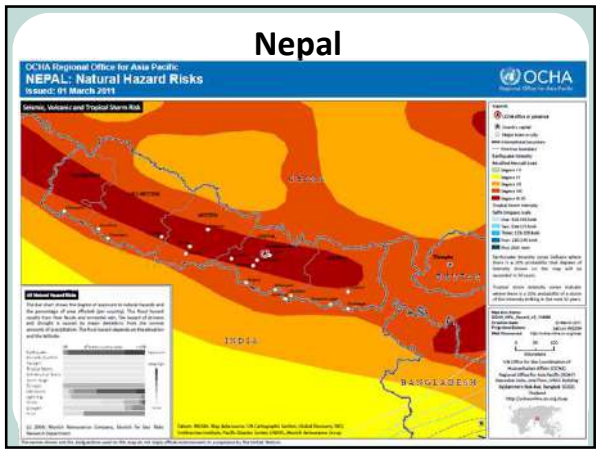


India

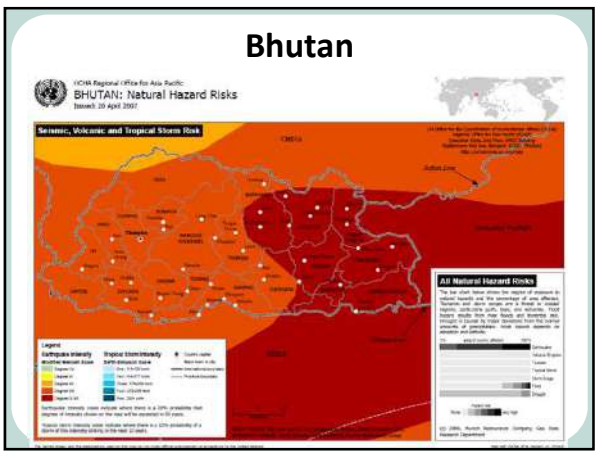




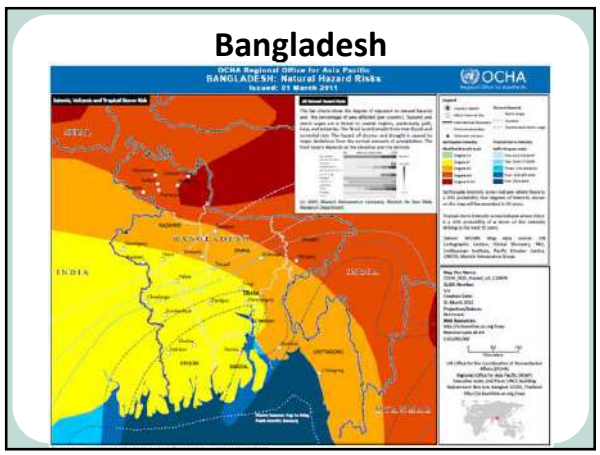
Nepal

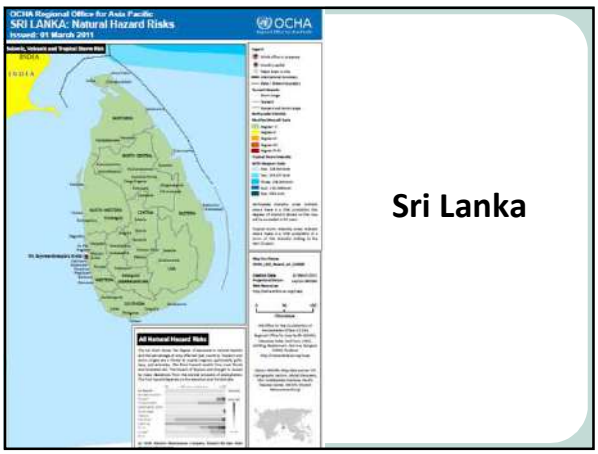


Bhutan

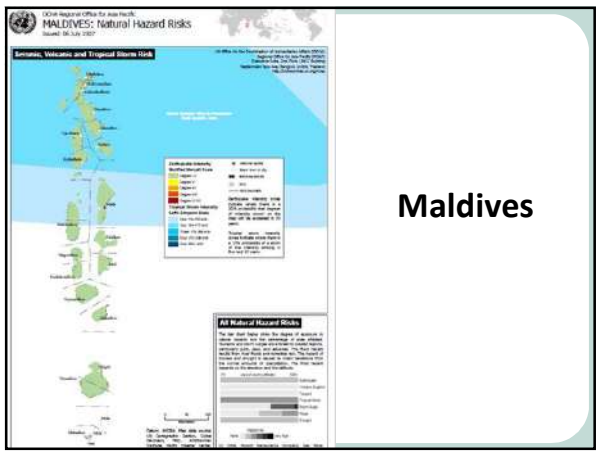


Bangladesh





Sri Lanka



Maldives

Flood Hazard in South Asia

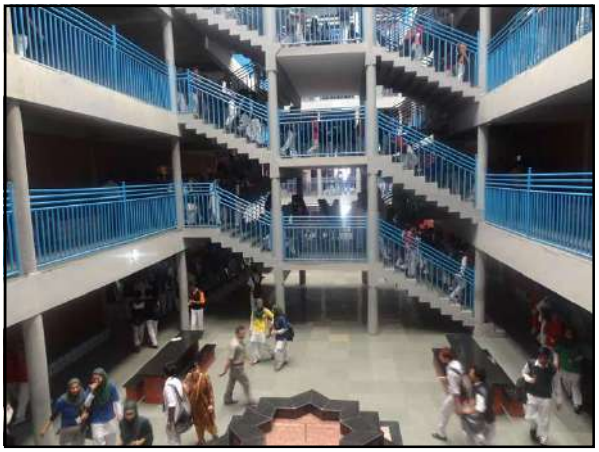
- Flood is a major recurring hazard in the region.
- River flooding is not limited to monsoon season but happens due to cloud burst as well, specially in the hilly terrain.
- Beside river flooding a new threat has emerged which is also know as “urban flooding”.
- Low lying areas gets flooded during heavy showers.
- Climate change will have drastic impact on such flooding in coming few years.

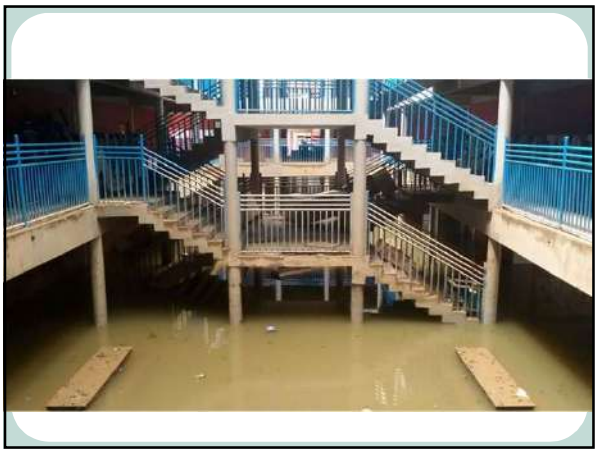
Flood Hazard

- Is the site likely to be affected by a flood?
- Likely to be cut off in a flood?
- Is it in the Flood Risk zone?
- Has it flooded before?.
- River, stream in close proximity to the site?
- Does the site has proper drainage system?

Burn Hall School Kashmir

400 mts away from river





Four strategies for Flood Disaster Risk Management

- Keep flood away from the people (schools)
- Keeping people away from the floods
- Preparing people from the flood disasters
- Helping people in flood disasters

Schools safe from such hazards

- Keeping critical and important items on the top floors
- Generator, Electrical panels, fuel tank, water pumps should be on heights.
- Only classrooms on the ground floors
- Linkage to proper early warning system

Winds

- Can affect in the form of
  - Cyclone.
  - Tornadoes
  - Thunderstorms

Thunderstorm

Wind hazard management

- Design the structure considering expected wind speed in the region.
- Consider constructing a safety shelter in cyclone and tornado prone region
- Listen carefully to weather warning
- Fix the non-structural elements well before hand, such as:
  - Tin/plastic fiber roof
  - Glass
  - Water tanks
  - Radio/communication towers etc.

Cyclone Fani

Wind damage reported from Bhutan

Fire Safety

Uncontrolled-Unwanted FIRE

Uncontrolled-Unwanted FIRE

1995 Mandi Dabwali Fire Tragedy, Haryana

More than 500 died including 170 children in a school programme

Surat Fire tragedy

16th July 2004 Kumbakonam Fire tragedy

90 children died

WHAT IS A FIRE?

The air we breathe is about 21 % oxygen.

Fire requires an atmosphere with at least 16 % oxygen.

Fire in 3 minutes

Planning for Fire Safety

- Minimizing the chance of fire
- Early discovery
- Restricting fire spread
- Extinguishing the fire &
- Evacuating the building.

Before the Fire

- Identify the nearest fire exit
- Know your nearest exit (any building)
- Plan and practice escape plans
- Involve the fire department
- Install smoke alarms
- Check time to time if it is working

During the Fire

- Get out and stay out
- Test doors before opening them
- Try to find out which side is burning
- Stay low and go
- Keep calm

What To Do If You Are Trapped

- Close all the doors between you and the fire.
- Fill cracks in doors and cover all vents with a damp cloth to keep smoke out.
- Cover your face with your hands or a wet cloth
- Call the fire department
- Signal rescuers from a window

Key ISSUES - FIRE PREVENTION

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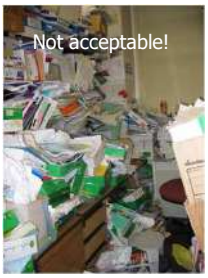


Hazard hunt

Don't use lift during fire

Do not use mobile phones while evacuating

Turn off gas supply before going to sleep

Do you know your local fire station number?

STOP! DROP!! ROLL!!!

Points to remember

Get to know your building – find out your escape routes and the quickest way out of the building
Get the Fire personnel familiar with your buildings

Look at the fire action notices in your area –find out what to do if the alarm sounds, what to do if you find a fire and where to assemble

Be fire responsible – don't do anything that could put yourself and others at risk and report any defects in the fire arrangements

When Fighting a Fire…

Please don't go ahead if:

- Don't know what is burning
- Black smoke coming out
- Fire rapidly spreading
- Don't have adequate equipment

KNOW, where to STOP

Always position yourself with an exit or means of escape at your back before you attempt to use an extinguisher to put out a fire.

Fires

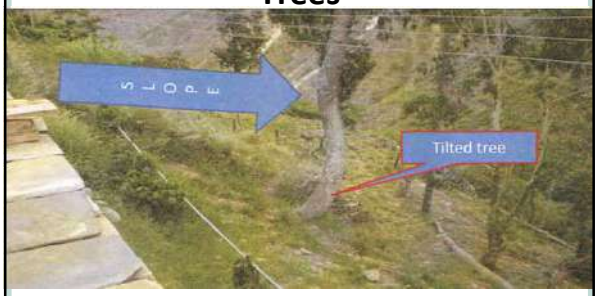
- **Wildfires**
  - Is the site surrounded by forest?
  - Has there been wildfires in the area?
- **Fires**
  - Poor electrical wiring?
  - Clutter of combustible materials?
  - Has there been fires in the facility?
  - Fire fighting equipment? (Water/ Sand buckets)
  - Training?
  - Is combustible material stored in the building?

Site Hazards

Landslide Hazard

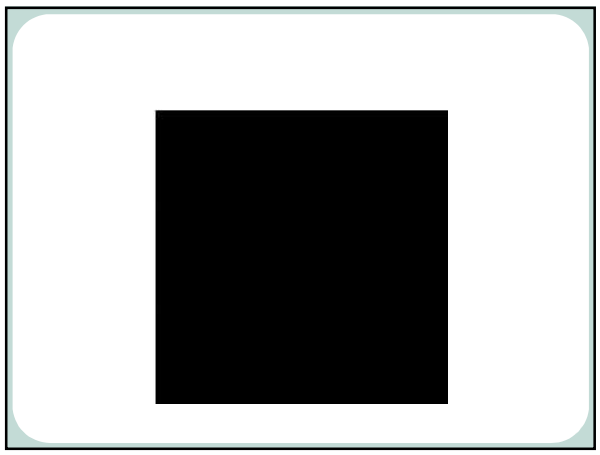
- Unstable slopes near facility
- Are there Fallen rocks or boulders on site?
- Has a landslide happened nearby?
- Trees with curved trunks or leaning trees?
- Steep slope above or below site?
- Landslide scarp, cracks or recent landslide?
- High rate of erosion at site?

Trees



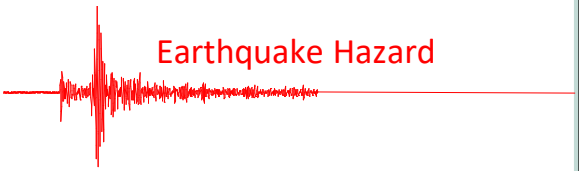
ROCK FALLS

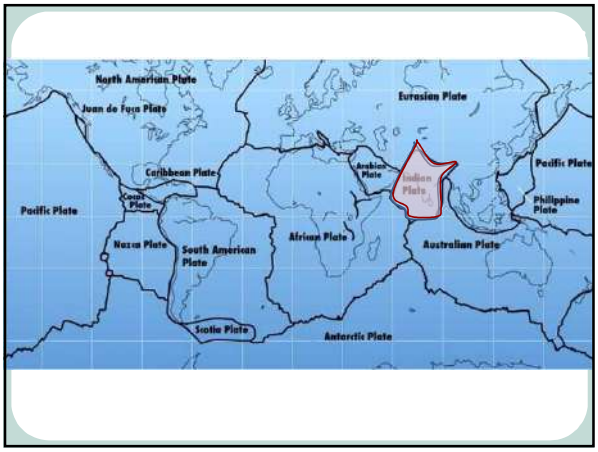
Hill slope, Chungthang :: Building Damage Sikkim earthquake

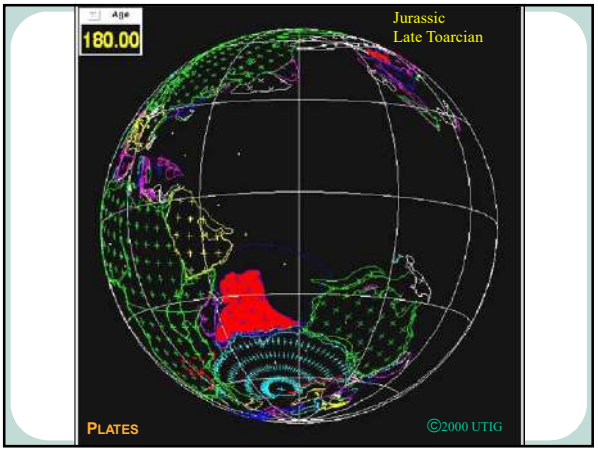


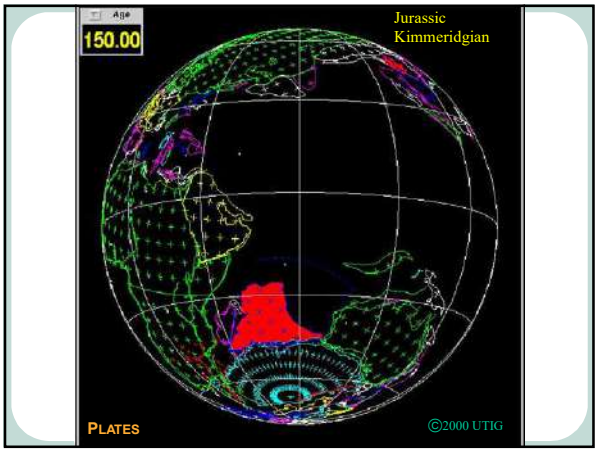
Other Hazards

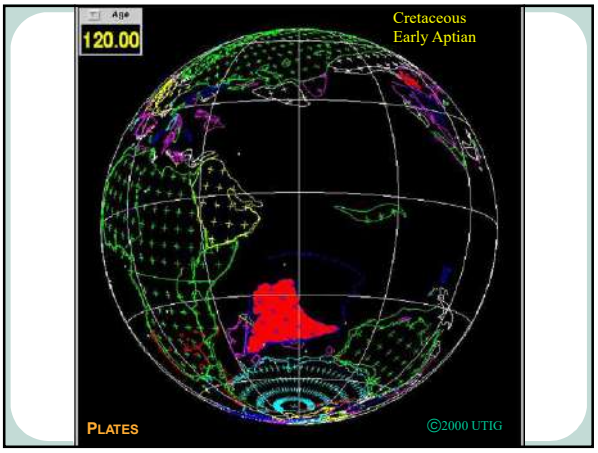
- Is there a petrol pump or fuel storage facility nearby?
- Is there a busy road or highway passing near by?
- Are there high tension wires passing nearby or lying overhead?
- Are there streams and rivulets nearby?
- Is there a forest nearby?

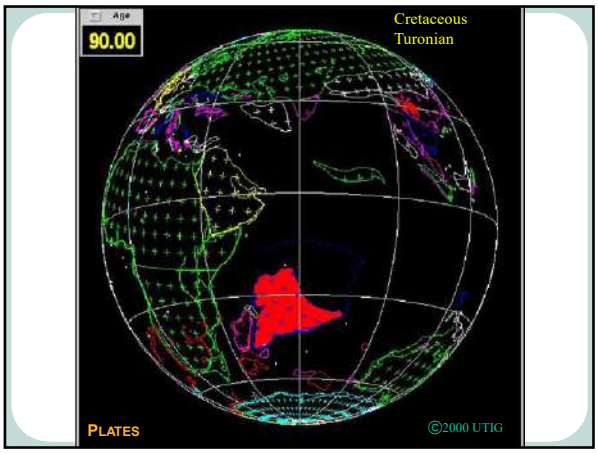








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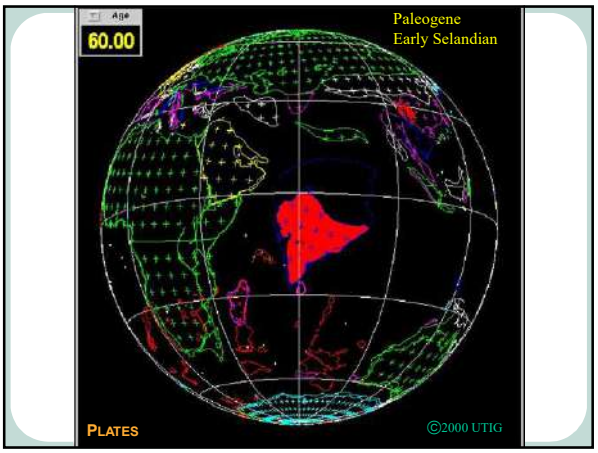
Cretaceous
Turonian
PLATES
©2000 UTIG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Early Selandian
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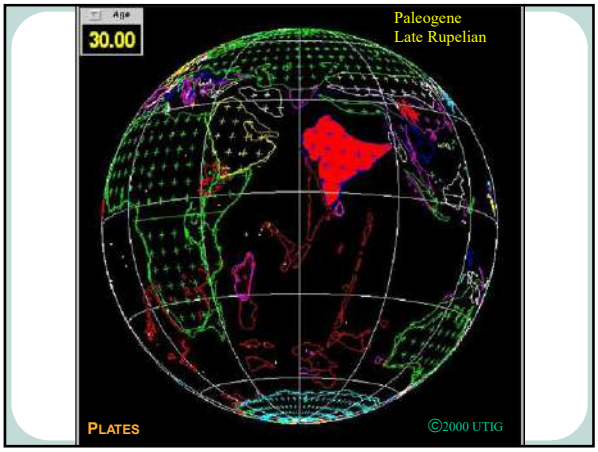
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Paleogene
Late Rupelian
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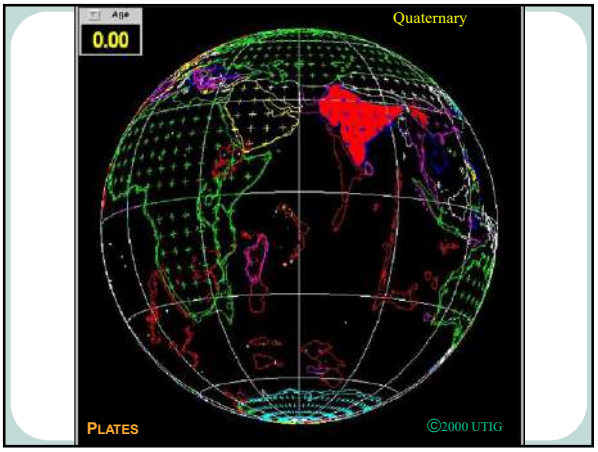
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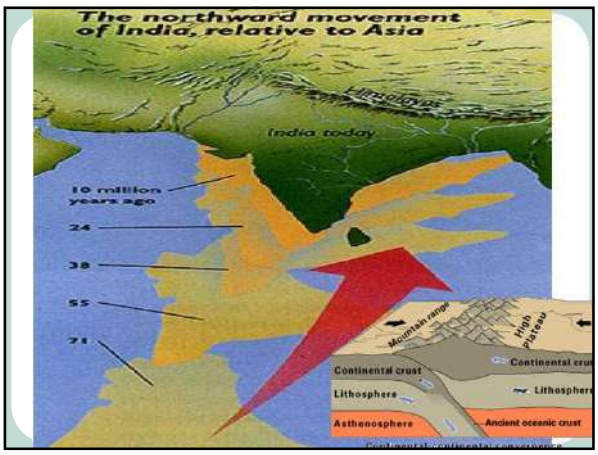
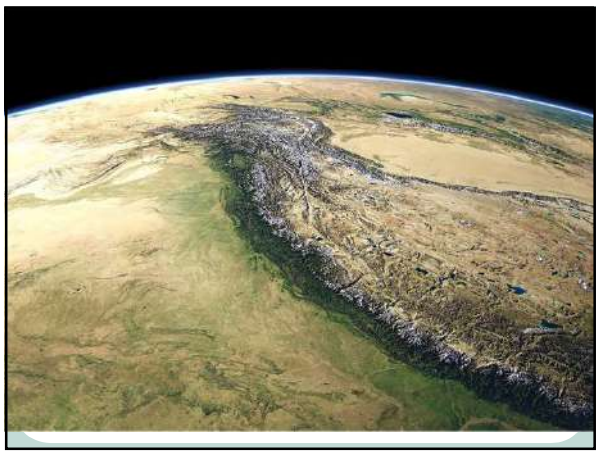
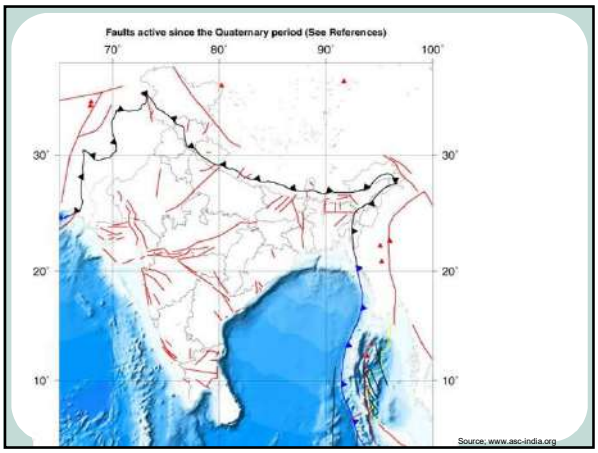
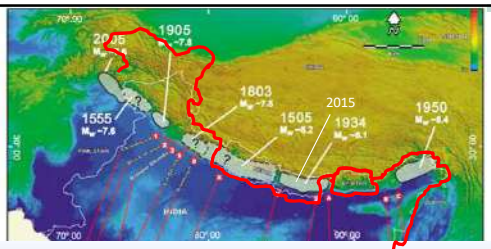

The northward movement of India, relative to Asia
India today
10 million years ago
24
38
55
71
Mountain range
High plateau
Continental crust
Lithosphere
Asthenosphere
Ancient oceanic crust







- When the stress becomes too much at any part of the plate boundary, it breaks resulting in what we feels as a great earthquake.
- Earthquakes release energy in plate boundaries.
- Where there hasn't been a large earthquake, the stresses are building up
- The further away you are from the last earthquake, the closer you are to the next one!

List of earthquakes in the region

Date	Magnitude	Longitude	Latitude	Area Affected
6 June 1505	~8.2	29.50	83.00	Lo-Mustang, Nepal-China border
16 June 1819	8.2	23.00	69.00	Rann of Kachchh, Gujarat
26 August 1833	7.6	27.70	85.50	Nepal-Bihar border region
19 February 1842	7.7	34.70	71.00	Alignar Valley, Afghanistan
11 November 1842	6.8	-	-	Pabna, Bangladesh
24 January 1852	6.6	29.30	68.60	Kahun, Balochistan
14 July 1885	6.8	24.50	90.00	Near Sirajganj, Bangladesh
12 June 1897	8.1	25.50	91.00	Shillong Plateau, Meghalaya
4 April 1905	7.8	32.10	76.40	Kangra-Dharamsala, Himachal Pradesh
20 October 1909	7.1	30.00	68.00	Kachhi Plain, Balochistan
8 July 1918	7.1	24.50	91.80	Srimongal (Srimangal), Bangladesh
9 September 1923	7.0	24.94	90.32	Mymensingh, Bangladesh
15 January 1934	8.1	27.55	87.09	Nepal-Bihar border region
30 May	7.8	29.60	66.50	Quetta, Balochistan

28 November 1945	8.1	25.15	63.48	Makran Coast, Balochistan
15 August 1950	8.6	28.38	96.76	Chayu (Zayu)-Upper Assam
21 March 1954	7.0	24.50	95.10	Myanmar-Manipur border
29 August 1970	7.0	26.02	95.37	Myanmar-Nagaland border
4 April 1983	7.0	05.70	94.72	Off the coast of Aceh, Indonesia
18 April 1983	7.0	27.78	62.06	Iran-Pakistan border
1713	7.0			Bhutan Arunachal Pradesh
11 June 1806	7.6			Tibet
12 June 1897	8.0			Shillong
15 January 1934	8.0			Bihar Nepal
15 August 1950	8.6			Indo China Border
26 January 2001	7.7			Bhuj
26 December 2004	9.1-9.3			Aceh, Indonesia
21 September 2009	6.3			Bhutan
18 September 2011	6.9			Sikkim

Earthquakes in the region

No.	Date	Day of the week	Location	Time	Magnitude	Max. Intensity	Deaths
1	16 June 1819	Wednesday	Cutch	11:00	8.3	IX	1500
2	12 June 1897	Saturday	Shillong	16:25	8.7	XII	1500
3	4-Apr-1905	Tuesday	Kangra	6:11	8	X	19000
4	15-Jan-1934	Monday	Bihar-Nepal	14:13	8.3	X	11000
5	15-Aug-1950	Tuesday	Arunachal P	19:39	8.6	X	1530
6	21-Jul-1956	Saturday	Anjar	21:02	6.1	IX	115
7	10-Dec-1967	Sunday	Koyna	4:30	6.5	VIII	200
8	21-Aug-1988	Sunday	Bihar-Nepal	4:39	6.6	IX	1004
9	20-Oct-1991	Sunday	Uttarkashi	2:53	6.4	IX	768
10	30-Sep-1993	Thursday	Killari(Latur)	3:53	6.2	VIII	7928
11	22-May-1997	Thursday	Jabalpur	4:22	6	VIII	38
12	29-Mar-1999	Monday	Chamoli	0:35	6.6	VIII	63
13	26-Jan-2001	Friday	Bhuj	8:46	7.7	X	13805
14	8-Oct-2005	Saturday	Kashmir	8:58	7.6	VIII	>80000
15	21-Sep-2009	Monday	Mongar	14:53	6.2	VII	12
16	18Sept.2011	Sunday	Sikkim	18:10	6.9	VII	8735
17	??		??	??	?	?	???

GeoHazards International

Few would disagree that our children deserve the right a safe to education…

..yet time and time again we fail our children with unsafe, unprepared schools

Does time matter?

- Earthquake at 11:00 am?
- Earthquake at 11:00 pm?

Day time earthquake affect more percentage of children

India, January 26, 2001
M 7.7 Bhuj Earthquake

- **872 children in schools died**

Nepal 2015

Pakistan, October 8, 2005
M 7.8 Kashmir Earthquake

- **Saturday, 8:50 a.m.** Children were in school.
- About **20,000** school children were killed in school collapses. At least **50,000** school children were seriously injured and may have disabilities.
- More than **10,000** schools collapsed.

Mass grave at the site of high school collapse in Balakot

Bhutan, Sept 21, 2009, 14:53 hrs
Mongar Earthquake M 6.3

- **12** people lost their lives.
- Some children were in school.
- **Many schools had sent children home early in preparation for the Blessed rainy day**
- Luck

Schools are Vulnerable to Earthquakes

- In the past many years:
  - thousands of children have been killed in schools
  - Hundreds of schools with major damage but children were not inside at the time of the earthquake

Why is School Safety important?

- Being prepared can save lives
- The department can lead schools to become prepared so that we can minimise losses and disruption.

What happens in a school during a large earthquake?

- Violent shaking
- Falling items
- Very hazardous locations, such as near windows or in chemistry lab
- Injuries
- Power outage
- No telephone service
- Fires might develop
- Blocked doors and exits
- Damaged and cluttered hallways or stairways
- Students are frightened and separated from their families
- Dangerous routes home

What does an earthquake looks like

Unprepared School

Fear
Panic
Disorder
Confusion
Lack of proper response
Unnecessary consequences

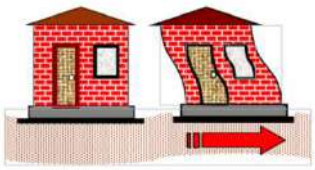
Prepared School

Less fear
Lives saved
Fewer losses
Injuries prevented
Organized evacuations
Devastating consequences reduced

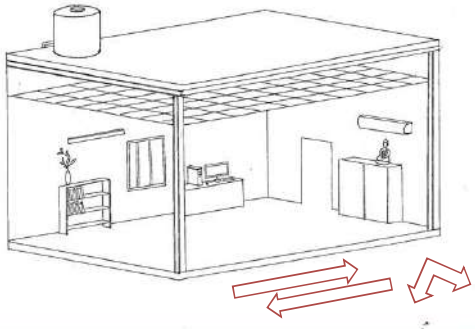
FALLING HAZARDS

Earthquake affects buildings

How do earthquakes affect buildings?



How do earthquakes affect Objects inside buildings



Not all buildings collapse in earthquakes

Not all earthquakes collapse buildings

Falling Hazards?

The Building need not collapse for an earthquake to cause losses.

"Messive' Damage

Non-structural damage

In Book Store and Libraries

School Library after earthquake in New Zealand

Schools

What happens inside a building

What can happen if an object falls, slides, or topples?

- It could injure or even lead to death of a person (L)
- It could block an exit (E)
- Financial Loss (F)

Also, for some items:

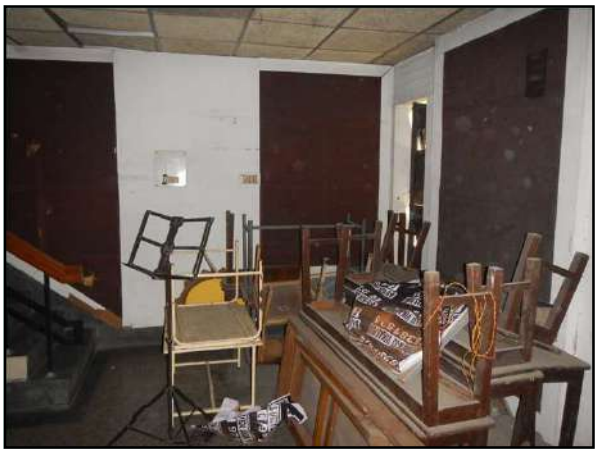
- Operational loss (O)

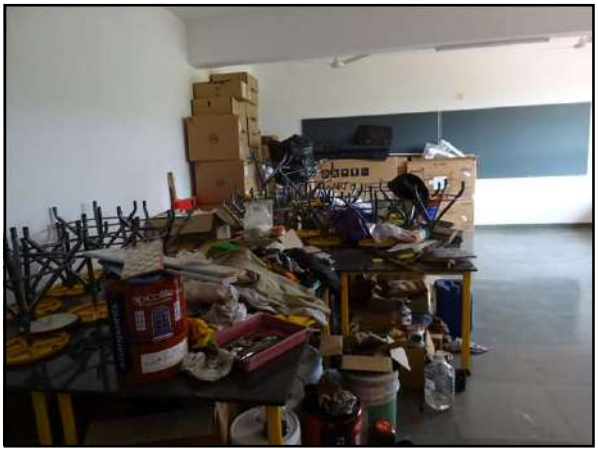
Let us look around few schools

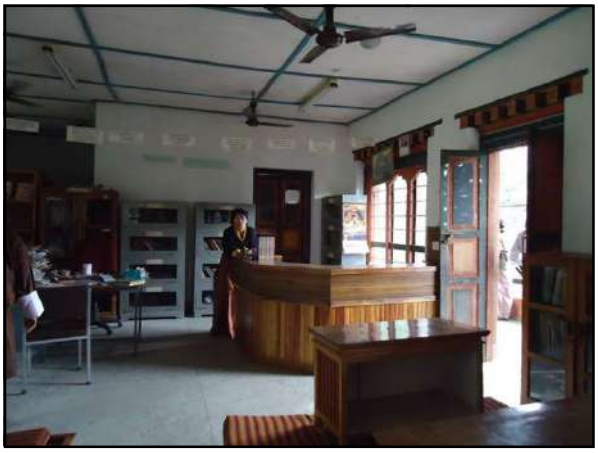
What are the hazards here?

What are the hazards here?

What are the hazards here?







What are the hazards here?

17/08/2010

17/08/2010

17/08/2010

Examples of damage – Contents

Preventing Collapse is NOT Enough

2010 M8.8 Maule, Chile Earthquake

Photo credit: William T. Holmes, Rutherford & Chekene

2014 04 12

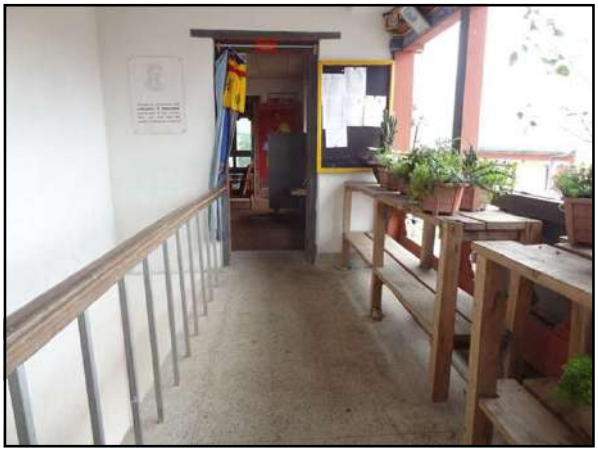
2014 04 12

2014 04 12

2015 05 14

CIPAL
Rinzin

CLASS PP



What we just did is called a hazard hunt

Here are some tips:

- Look at each room in the school with "Earthquake Eyes".
- Take some time and sit in each room, <u>at child level</u>
- Ask yourself "if a major earthquake hit right now, what could injure someone?“

It is not necessary that objects will fall only in case of an earthquake

Prioritization

Locations	Objects and descriptions	Risk Type (Check all that apply)				Priorit
		Life Loss and Injuries	Exit Loss	Financial Loss	Operational Loss	High Mediu Norma
Principal's office	Cupboards, table	✓	✓	-	-	H
	Computer systems	-	-	✓	✓	H/M
	Flower pot	-	-	-	-	N

- The school administration has to take this call
- Prioritization will lead to actual mitigation
- Set deadlines for job completion
- Protect what is most important to you
- Acceptable risk……

Questions

Ways to mitigate falling hazards

- Relocate objects that can injure
- Protect:
  - Anchor, brace or restrain against shaking
    - or -
  - Accommodate movement

Options for Reducing Risk

- Relocate
- Protect:
  - Anchor, brace or restrain against shaking
    - or -
  - Accommodate movement
- Plan for cleanup or breakage

Relocate

Objects that can:

- Block exits
- Fall on someone

Photo credit: Hari Kumar, GHI

Anchor, Brace or Restrain

Objects that can:

- Fall on someone
- Topple and break
- Block exits (if not able to relocate)

Accommodate Movement

Anywhere there is differential motion:

- Pipes between buildings or attachments to water-filters or tanks

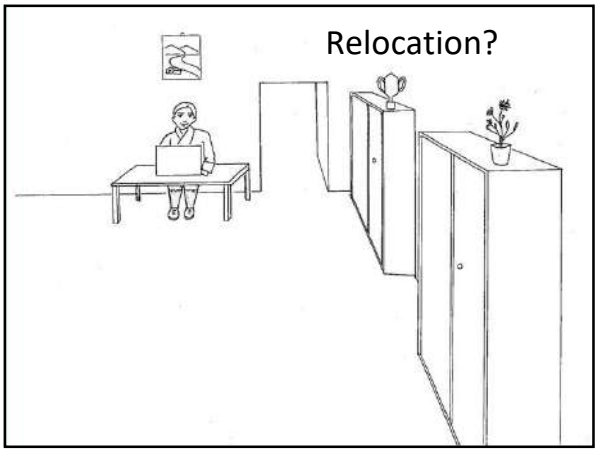
Plan for Cleanup or Breakage

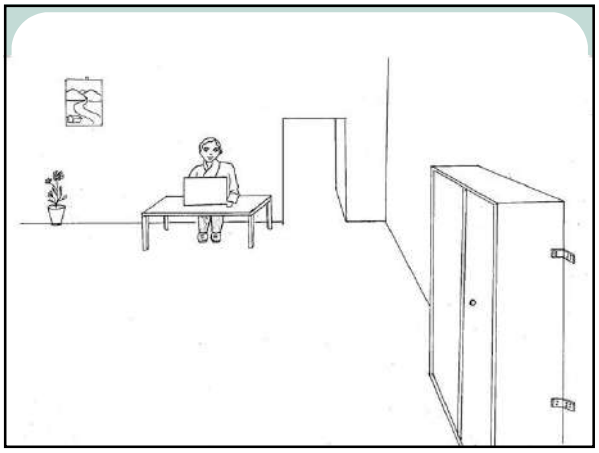
Relocation or restraint may not be practical or possible for items such as:

- Desks
- Chairs

Relocation

- Relocate objects that can
  - Block exits
  - Cause injuries

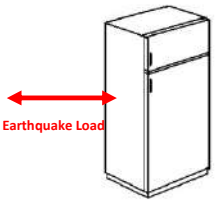




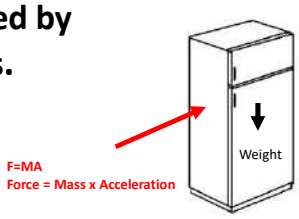
Anchoring Falling hazards

- To teach you how to secure objects properly.
  You will need to:
  - Understand how objects move
  - know how to secure objects at the school so you can teach and supervise others to do it properly
  - identify materials to purchase for securing objects
  - identify the proper tools to use
- Let's get your hands dirty!

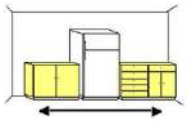
- Earthquake forces push objects side to side.



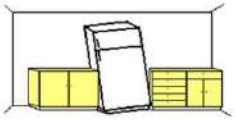
Heavier objects are more effected by earthquakes.



Behaviour of objects

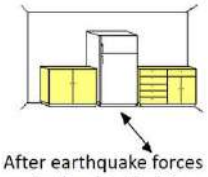


After earthquake forces have pushed and pulled from side to side.

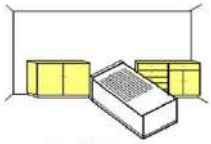


It will tip, but not topple.

Behaviour of objects

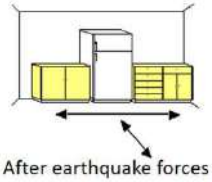


After earthquake forces pushed and pulled from front to back.

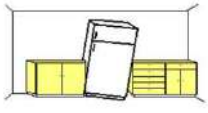


It will topple.

Behaviour of objects



After earthquake forces have pushed and pulled in both directions.



It's hard to tell.

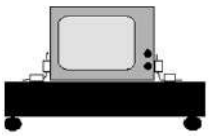
Items that can topple easily are:

- Taller than they are wide and/or deep

-or-

- Heavier on the top than they are on the bottom

Items that will slide easily:



- Have wheels

-or-

- Are too low to topple

-or-

- Are on slippery floors, like tile or wood

-or-

- Are much heavier on the bottom than on the top

The way you secure objects depends on:

- The size, weight, and material of the object
- The surface that you secure the object to (e.g., material wall is made out of)
- The use of the object (does it need to be moved regularly?)

Mitigation solutions

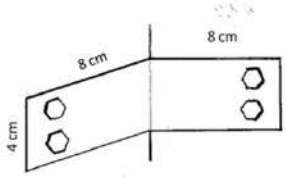
- Cupboards
- Lockers
- Open Rack shelves
- Magazine racks
- Clocks
- Picture frames
- Tube Lights

First things first

It is important to check for wires and pipes inside walls, floors and ceilings before drilling.

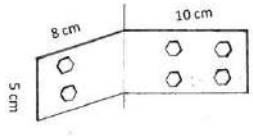
L clamps

- Short Cupboards
- Less than 1.50m height
- Two at the top on either side
- Two at the base for additional safety



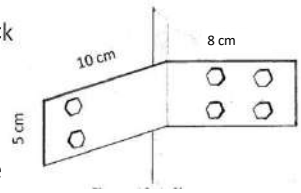
L clamps

- Tall Cupboards
- Taller than 1.50m height
- Two at the top on either side
- Two at the base

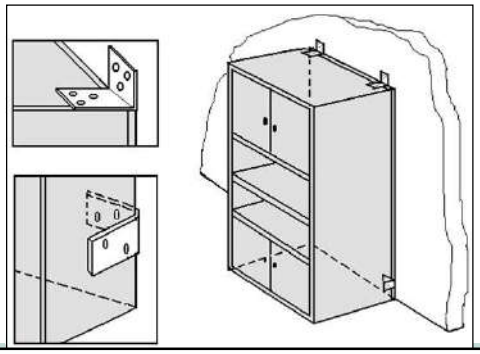


L clamps

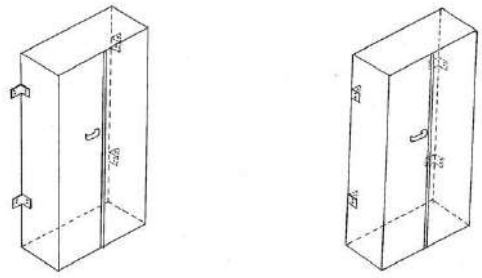
- Cupboards leaning forward
- Or if wall has thick skirting
- Longer leg on cupboard side
- Two on each side



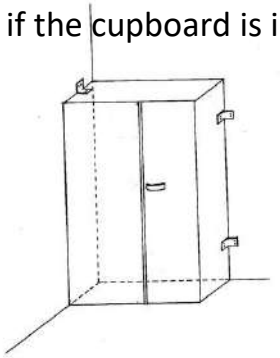
To reduce the visibility of L brackets, they can be mounted to the top of furniture and inwardly mounted at the bottom / sides.



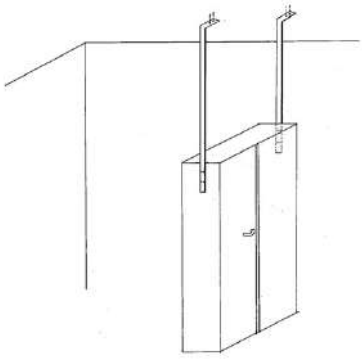
Cupboards



What if the cupboard is in a corner



Freestanding cupboards



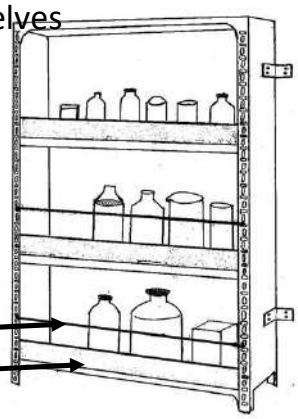
Open rack shelves

Figure 14: Closed/Open slotted rack shelves

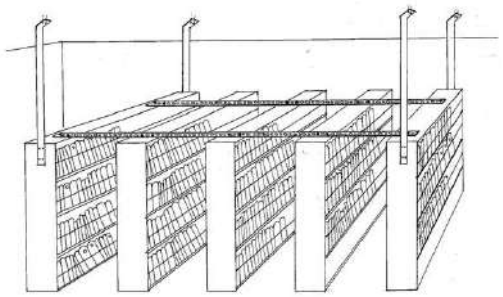
Closed rack shelves

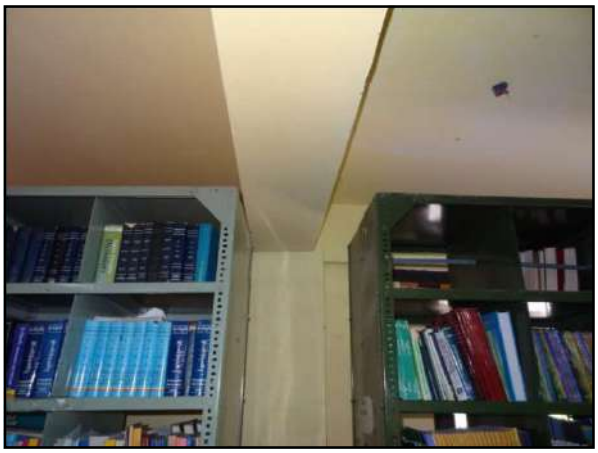
The shelves can be provided with a curtain spring to hold back the supplies.

Occupants can also use a small wooden bracket which can be anchored in front of the shelf to prevent objects from slipping out.



Group of free standing cupboards can be fixed by long L clamps to the roof and can be anchored together using slotted angle.





What are the hazards here?

Glass-window and Glass Partition

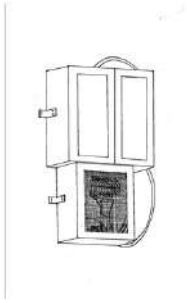
Mitigation Solution

Figure 16:film on Glass

Clocks, picture frames

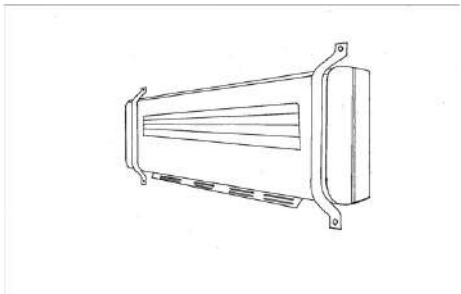
Electric Board

Mitigation Solution



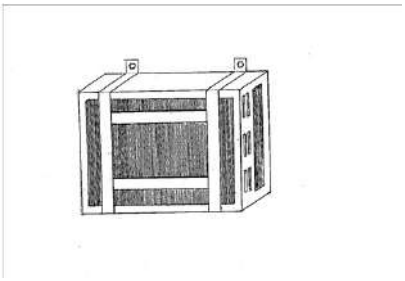
Air Conditioner (Internal)

Mitigation Solution



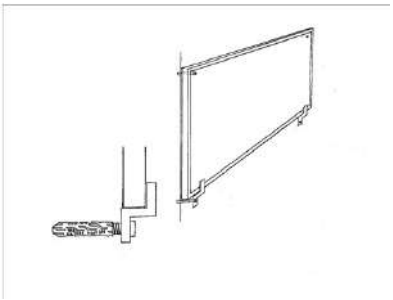
Split Air-Conditioner

Mitigation Solution



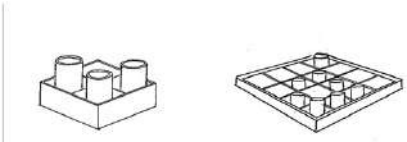
Class-room board

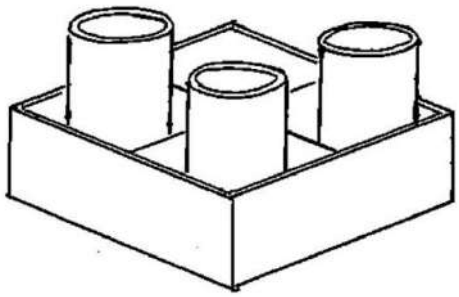
Mitigation Solution



Glassware (Conical flask, Beakers, Bottles and Jars

Mitigation Solutions

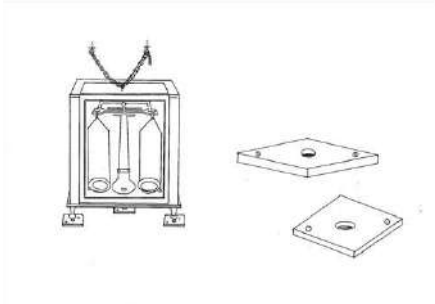




Glassware in laboratories can be kept in unrestrained boxes

Chemistry – Chemical Balance

Mitigation Solution



Physics lab – Bench-mounted items

Mitigation Solution

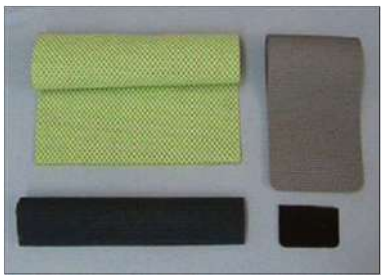
Computer lab – Monitor, UPS & CPU

Mitigation Solution

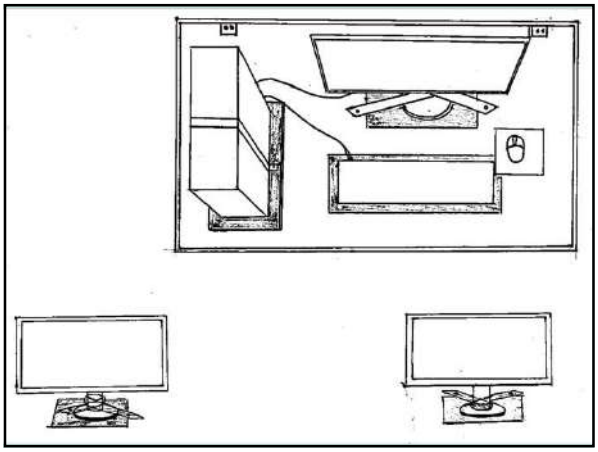
Figure 19: Alternate mitigation solution with using wooden lip and hook and loop

Fasteners

Rubber Mats

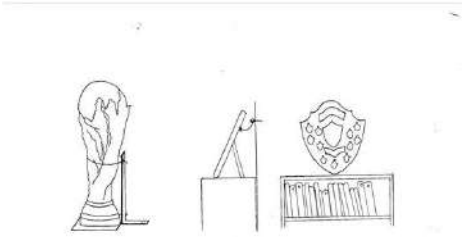


- Contents of cabinets
- Physics lab table
- Small speakers
- Computer, keyboards
- Computer LCD monitors



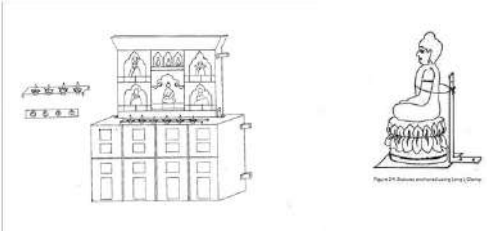
Trophies and Sport Shields

Mitigation Solution



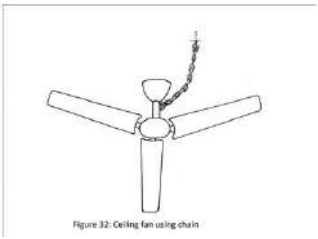
Altar (Internal)

Mitigation Solution



Fans – Ceiling and Wall

Mitigation Solution



Suspended (False) Ceiling

Mitigation Solution

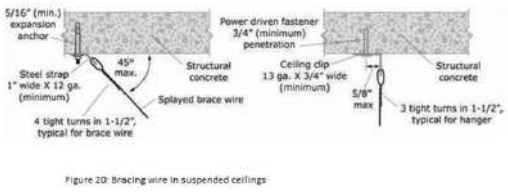


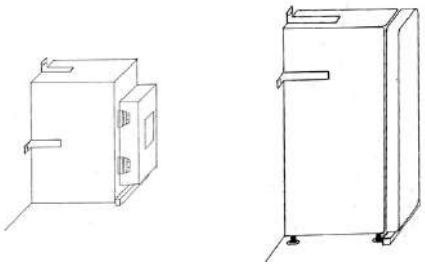
Figure 20: Bracing wire in suspended ceilings

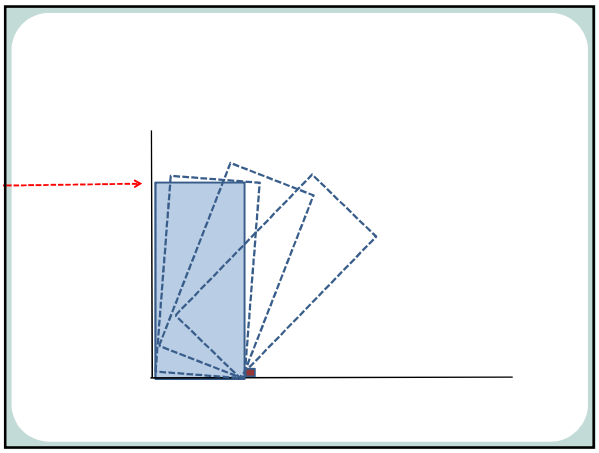
Gas Cylinder

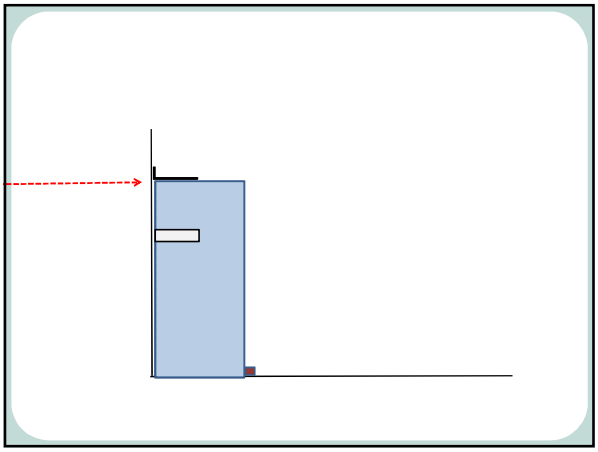
Mitigation Solution

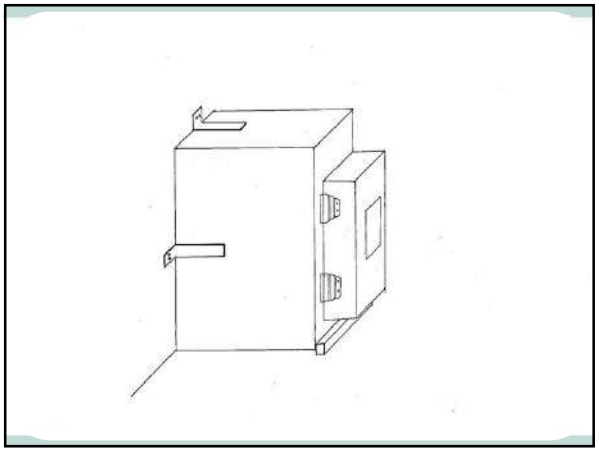
Incubator/Refrigerator

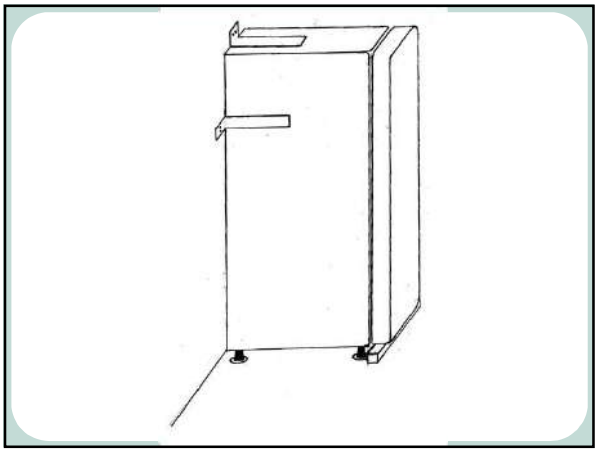
Mitigation Solution





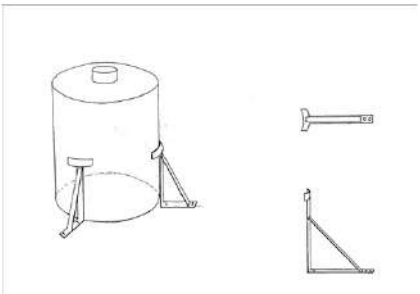






Water Storage Tank

Mitigation Solution



Physics lab – Bench-mounted items

Mitigation Solution

Suspended (False) Ceiling

Mitigation Solution

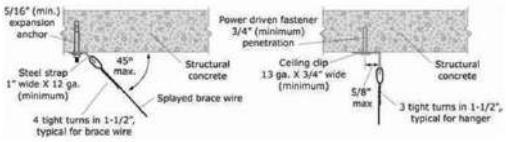


Figure 20: Bracing wire in suspended ceilings

When there is will, there is a way.

For **any** assistance-

Pranav Sethi - 9990220183

Mohd. Mudassir - 7017847838

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geohazsociety@gmail.com

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