Geography Foundation

16/Sep/24

Geomorphology

12:00 – 2:30 | Lec 11

Isostasy –

- Principle – Mechanical stability of Land Form
  - How matter of Earth can be distributed
  - Based on study of Gravitation Anomaly

Pratt's Theory

- Compensation Theory
- L.F have diff. densities & density get compensat^n beyond line/Plane of compensation

Airy's Theory

- Floatation Theory (based on Archimedes Principle)
- L.F have same densities & roots underneath vary ∴ called as Roots Theory

Plate Tectonics interpretation of Isostasy -

- Plate Tectonics is in more to closer to Airy's Theory.
- Land forms stabilise because of roots & not because of density compensation
- However there are 2 modification according to Tectonics interpretation-

1] Land forms do not float individually. Land forms are not like separate blocks of wood floating on water. Isostasy ∴ is not a local but a regional phenomenon

2] Land forms seem to float like they are floating on a stretched membrane & Isostasy balance for all land form is happening toge-ther

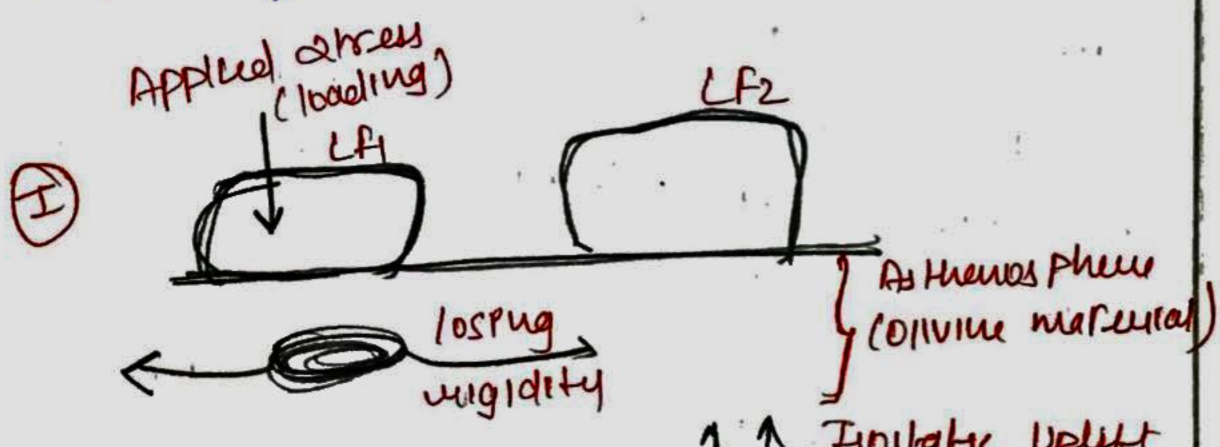
- Earth surface may be imagined as relatively rigid plane which has flexural rigidity. All of this together floating on relatively less rigid & softer medium underneath. i.e

Rigid Lithospheric plate floating over semi molten Asthenosphere

- The floatation is possible because of Olivine of Asthenosphere which have unique property of loosing rigidity under sustained stress.

- ~~As a consequence of Olivine behaviour~~

- As a consequence of Olivine behaviour, the land form & features of Earth's surface are linked to one another. Stress imbalance in one part of the world impact land forms in other parts of the Globe



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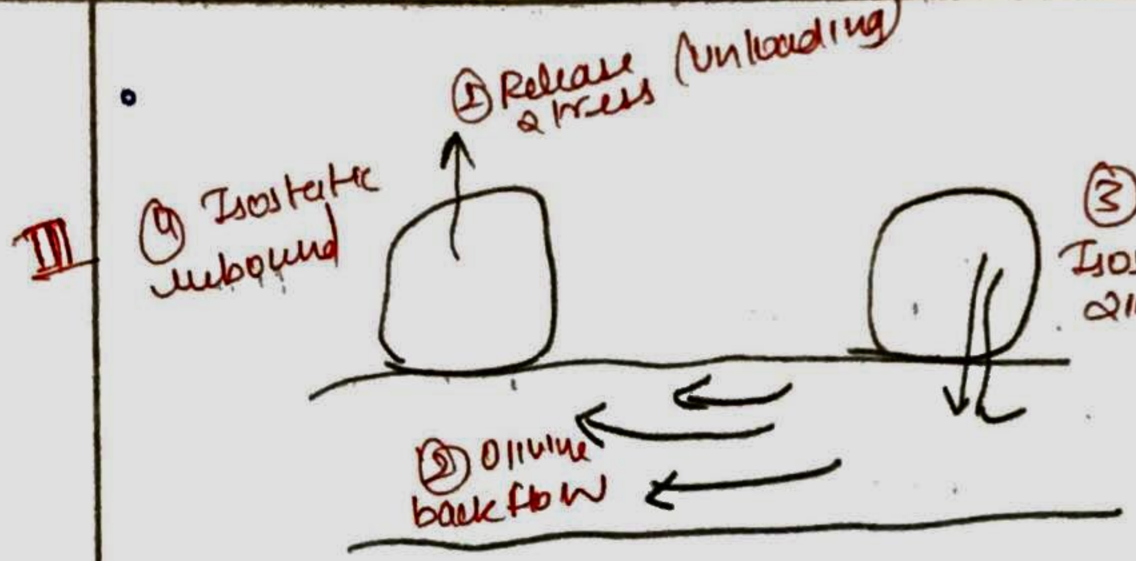

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• Examples of Isostatic balance -

1] Gradual upliftment of Scandinavian highland arising at rate of 1-5cm

• With the melting of Ice shelf of Pleistocene Ice age, Scandinavia is witnessing gradual upliftment & port locations have been pushed further land wards

2] Reservoir induced seismicity (RIS) -
Ex Koyna Dam, 3 Gorges dam, Itaipu dam - all have instances of Earth quakes

③ Melting of Arctic & Antarctic & release of water into Ocean & sea level rise, can have an impact on Isostatic Imbalance

④ Similarly, large scale urban construction Mining, Deforestation are examples of change in natural distribution of material, this can also create seismicity & Earthquakes

Reference - pg 138-139 (Geomorphology by SS)
↳ Global Isostatic ~~Imbalan~~ Adjustment

Earth Quakes -

- EQs are violent shaking of the earth
- EQ can be because of -

a] Natural factors

- Volcanism
- Land slide
- Plate collision/interaction
- Avalanche
- Isostatic imbalance
- Natural slippage & movement at faults
- & location of Rifting

b] Human factors

- Construction
- Mining
- Dynamite explosion
- Reservoir Induced seismicity

(1) • Shallow Earthquakes earlier were easy to explain because Deep Mantle dynamism was not known. EX - Wegener explained shallow EQ as consequence of SIAL moving & scrapping the SIMA floor

(2) One of earliest theories of EQ is **Elastic Rebound Theory (ERT)** - when stresses build up on the crust, rocks & earth surface, the rocks and the crust get deformed & resist the stress till a limit but once the limit is crossed the crust & rock can break, forcing vibration that manifest as EQs

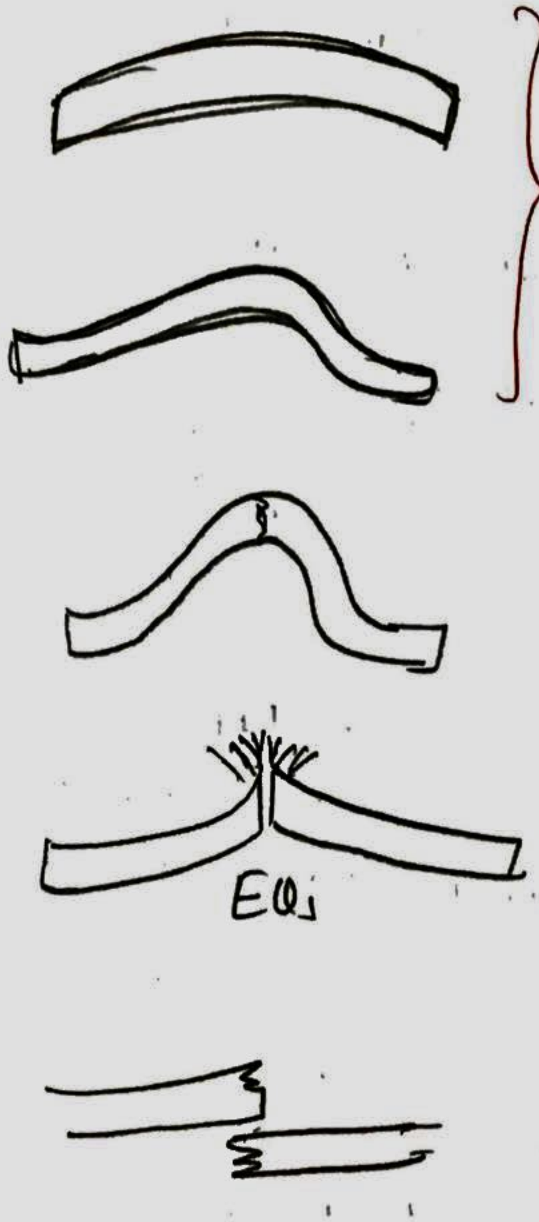


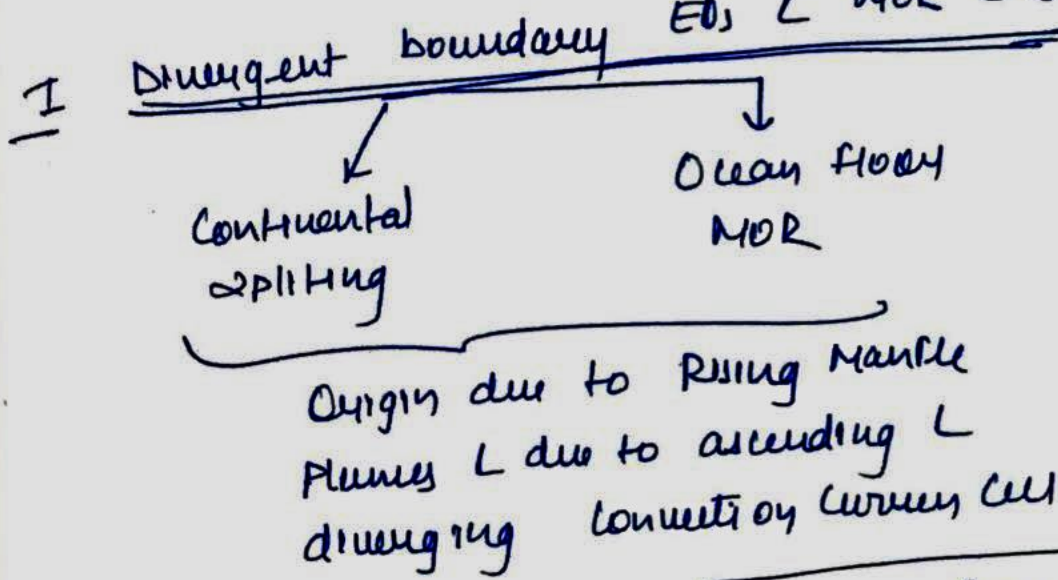
Fig - Elastic Rebound Theory

- The theory is simplistic & cannot explain genesis of stress & donnot relate dynamism of interiors of earth as primary factor in natural factors associated with tectonics EQs & volcanism.

Plate Tectonics interpretation of EQs–

- EQs explained in terms of mantle dynamism, plate interactions & volcanism were relevant
- There are 4 type of major EQ locations–

I Divergent boundary EQs & MOR EQs –



- They will be mostly Shallow focus EQ – due to volcanic eruption or crust fracture (Basalt)
  - ↳ Not very violent EQ & not destructive

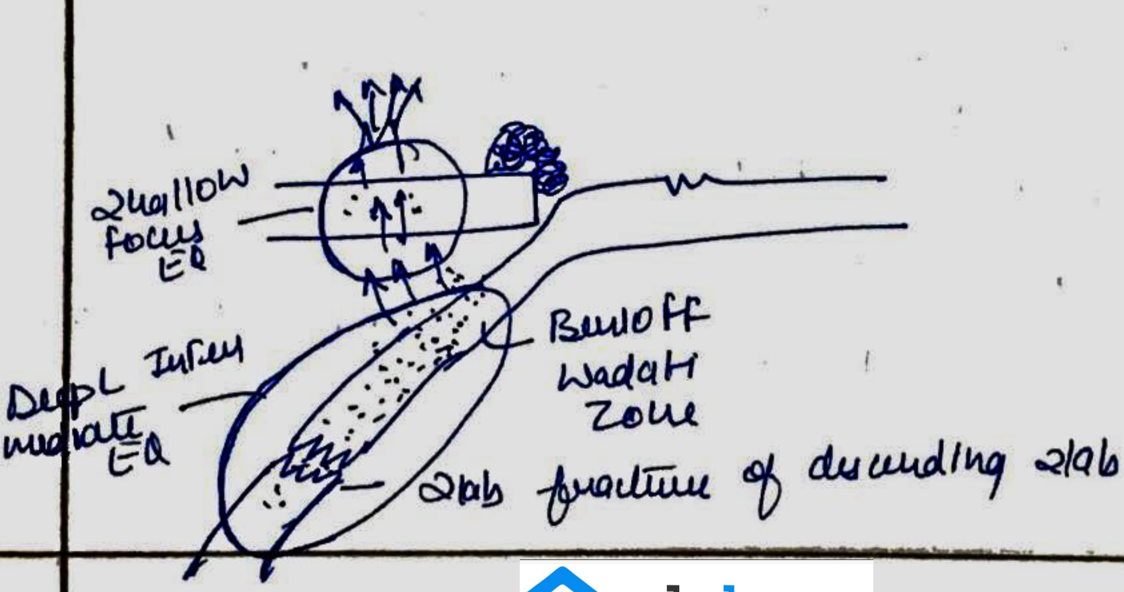
• We can have Intermediate & Deep focus EQ in these locations associated with Mantle Magma movement

II Hot spot Volcanism - Can be shallow focus EQ & Intermediate & Deep focus EQ as well

* Hotspots EQ are also not violent & destructive EQ

III EQs at location of subduction Margin - O-O or O-C type

• Shallow focus EQ = Andesitic eruption ; due to snapping of Ocean floor & also crustal bending & fracture



- The Inclined zone of EQ / Benioff Wadati zone along Ocean floor subduction – reason of EQ is
(a) Mantle slab Friction & (b) melting of descending ocean floor + local volcanic Mantle eddies (local disturbances).
(c) slab fracture of descending slab

- Benioff zone associated with mostly shallow EQ & Intermediate EQ
- subduction zone EQ are some of most powerful EQ. These together make up Circum Pacific EQ belt / Ring of Fire – This belt have >80-85% of most devastating EQ

IV EQs at CC collision boundaries / Trans Eurasian belt of EQ – They are largely shallow focus EQ, not associated with volcanism, very very powerful EQs due to strong compressive forces

Ex EQs of Himalayas, Hindukush, Part of Turkey

• Soft sedimentary rock of C-C collision are also vulnerable to faults because of compressive forces & these faults are prone to EQs

• In Himalayas these fault zones are MCT (Main central thrust) MBF (Main Boundary fault) HFF (Himalayan Front fault)

Ex Joshimath & Badrinath are along MCT whereas Tehri & Devprayag are along Alakhanda fault

[Add. case study of Anatolia fault]

V EQ generally happen along plate boundaries Mobile sedimentary zones of plate collisions

- Interiors of continents away from the plate boundaries are massive cratonic blocks that are geologically stable with highly deformed & metamorphosed rocks. These cratons are not EQ prone. However, the cratonic zones can have ancient fault that can get reactivated & can cause EQs

EQ Zone in India
Map- Next to Next page

- The Indian Peninsular block is a very old stable formation but is not entirely free of EQ. There are numerous old faults which are activated time to time

<u>EX</u> Jabalpur faults, ; Latur- Osmanabad EQ - Bhima fault - Latur fault - Killari fault
& associated EQ

EX Bhuj EQ - Allahbund fault

- EQ Map of India doesnot have any 0 EQ zone

<u>Old EQ Map</u> - Zone 1, Zone 2, 3 & Zone 4, Zone 5
Zone 1 ↓ EQ Free
Zone 5 ↓ Most EQ Vulnerable

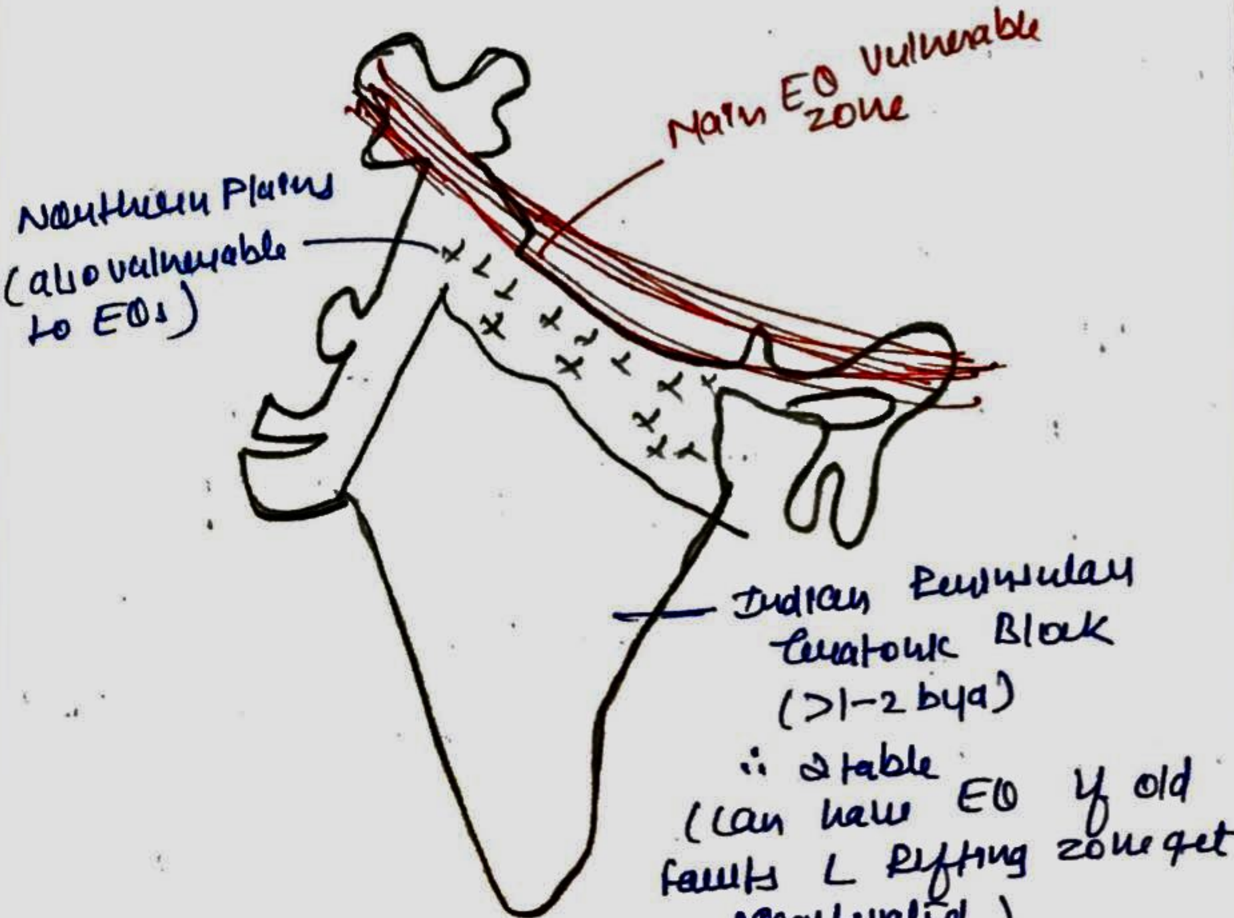
New Map – Zone II, Zone III, Zone IV, Zone V
↓
removed Zone I (No or zero EQ)

+ good parts of Peninsular Plateau falls under Zone 3 & Zone 4 (Peninsular Plateau) – includes Northern located Plains & W. Ghats

– Narmada-Tapi fault zone (Old 3rd arc of Triple Junction)

– Damodar-Mahanadi fault zone

– Son fault zone



PYQs - [Isostasy, Geosynclines, EQs]

Que Critical Analyse the Theory of Isostasy (2001) (60M)

Que Write a short note on Geosyncline (2002) (20M)

Que Define concept of Isostasy and discuss postulates of Airy & Pratt (2007) (30M)

Que Explain the concept of Isostasy as postulated by Airy & Pratt (2011) (30M)

Que How Evaluate how Ray Kober's geosyncline theory explains Mountain building process (2018) (20M)

Que Discuss the methods of Measuring intensity & magnitude of EQs. How are seismic zones demarcated ? (2019) (~~25M~~) [20M]

★ 60 M and 30 M questions are discarded now. Marks and questions are given for your reference of PYQ only.

Question 12: Discuss the methods of measuring the intensity and magnitude of earthquakes. How are seismic ones demarcated? 20 marks. [Geo- optional] [2019]
Answer 12:

Introduction:
An earthquake is a natural phenomenon characterized by the sudden release of energy in the Earth's crust, resulting in the shaking and vibration of the ground. It is caused by the movement of tectonic plates beneath the Earth's surface.

Body:

Methods of Measuring Intensity:

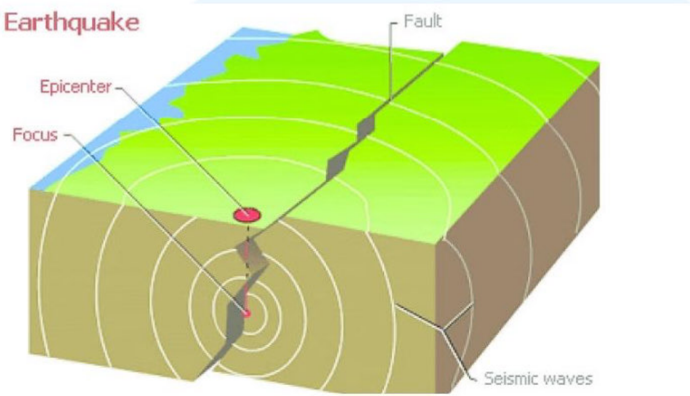
1. Mercalli Intensity Scale: This scale measures the intensity of shaking experienced at a particular location based on observed effects on people, buildings, and the environment. It is subjective and varies from place to place within the affected area.
2. Modified Mercalli Intensity (MMI): An adaptation of the Mercalli Intensity Scale, MMI accounts for modern building practices and urbanization. It provides a more standardized way of measuring earthquake intensity.
3. European Macroseismic Scale (EMS): Used primarily in Europe, this scale assesses earthquake intensity based on observed effects and damage to buildings and infrastructure.

Methods of Measuring Magnitude:

1. Richter Scale: Developed by Charles F. Richter in 1935, this scale measures the magnitude of an earthquake based on the amplitude of seismic waves recorded by seismographs. It is logarithmic, meaning each whole number increase represents a tenfold increase in amplitude.
2. Moment Magnitude Scale (Mw): This scale measures the total energy released by an earthquake, taking into account the area of the fault rupture and the displacement of the Earth's crust.
3. Surface Wave Magnitude (Ms): Surface waves are the largest and slowest seismic waves, and this scale measures earthquake magnitude based on the amplitude of these waves.

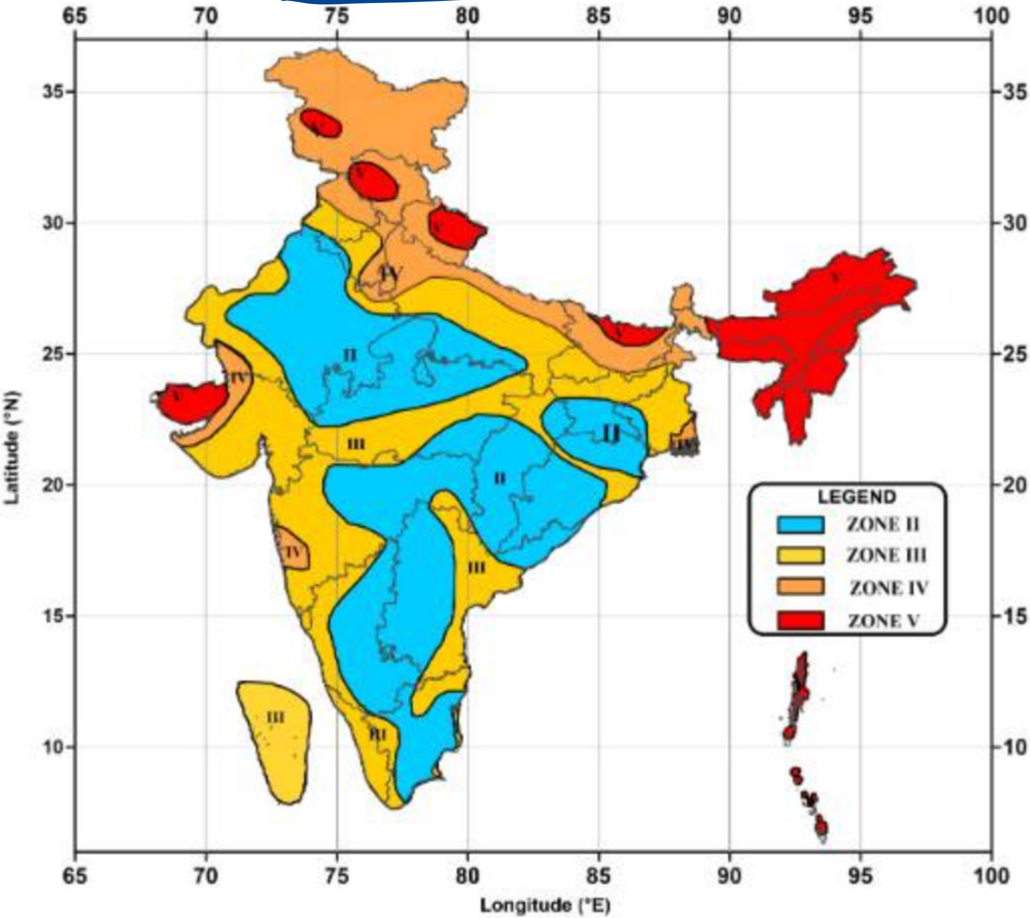
Demarcation of Seismic Zones:

- Seismic zones are demarcated based on various factors including historical earthquake data, active fault distribution, and tectonic settings. These zones are crucial for assessing earthquake hazards, developing building codes, and planning land use.
- For example, the United States and India both have seismic zoning maps that classify regions into different hazard levels based on the likelihood of experiencing ground shaking. These maps aid in emergency preparedness and risk mitigation strategies.



Conclusion:
In conclusion, the measurement of earthquake intensity and magnitude involves various scales and methods tailored to assess different aspects of seismic activity. Seismic zoning plays a vital role in identifying high-risk areas and implementing measures to minimize the impact of earthquakes on human lives and infrastructure.

Zones – PIB



65
70
75
80
85
90
95
100
35
30
25
20
15
10
Latitude (°N)
Longitude (°E)
II
III
IV
LEGEND
ZONE II
ZONE III
ZONE IV
ZONE V

Previously, earthquake zones divided into five zones with respect to the severity of the earthquakes, but Bureau of Indian Standards [IS 1893 (Part I):2002], has grouped the country into four seismic zones.; the first and second seismic zones were unified.

The bureau of Indian standards is the official agency for publishing the seismic hazard maps and codes. It has brought out versions of seismic zoning map: a six zone map in 1962, a seven zone map in 1966, and a five zone map 1970/1984.

Seismic Active Zone

Seismic Zone II

Area with minor damage (i.e., causing damages to structures with fundamentally periods greater than 1.0 second) earthquakes corresponding to intensities V to VI of **MM** scale (MM - Modified Mercalli Intensity scale). It covers the areas which are not covered by other three seismic zones discussed below.

Seismic Zone III

Moderate damage corresponding to intensity VII of **MM** scale. It comprises Kerala, Goa, Lakshadweep islands, remaining parts of Uttar Pradesh, Gujarat and West Bengal, Parts of Punjab, Rajasthan, Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Maharashtra, Orissa, Andhra Pradesh, Tamilnadu and Karnataka.

Seismic Zone IV

Major damage corresponding to intensity VII and higher of **MM** scale. It covers remaining parts of Jammu and Kashmir and Himachal Pradesh, National Capital Territory (NCT) of Delhi, Sikkim, Northern Parts of Uttar Pradesh, Bihar and West Bengal, parts of Gujarat and small portions of Maharashtra near the west coast and Rajasthan.

Seismic Zone V

Area determines by pro seismically of certain major fault systems. It is seismically the most active region, and comprises entire northeastern India, parts of Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Rann of Kutch in Gujarat, part of North Bihar and Andaman & Nicobar Islands.

Earthquake zone V is the most vulnerable to earthquakes, where historically some of the country's most powerful shock have occurred. Earthquakes with magnitudes in excess of 7.0 have occured in these areas, and have had intensities higher than IX.