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Development of an empirical mathematical model to calculate the occurrence of an earthquake

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Abstract: The main focus of this project is to develop an empirical mathematical model using basic concepts of probability distribution to calculate the occurrence of an earthquake at a certain place across India using some common parameters available in the nature.

The basic tool used in the development of this mathematical model is Poisson's Distribution, a huge data set consisting of the information about earthquakes that has been occurring in the past hundred years across India and concept about Seismic zone division of our country.

Introduction: The project uses the concept of the Poisson's distribution to build up an empirical mathematical model; using which we can calculate the occurrence of an earthquake at any place in India along with using the Earthquake data from the last hundred years.

Material and methods: The data used in this experiment is collected from the NCS (National Centre for Seismology) from the last hundred years earthquake data and put into a tabular format to filter out the data of the earthquake having magnitude greater than and equal to 5 on the Richter scale; since they are the actual devastating ones. The sample space is pretty big since there are more than 1000 earthquake data to work with. The Poisson's Distribution is used in the calculation since occurrence of an earth quake is a random and discrete event.

The Poisson's Distribution:

$$P(X=x)=\frac{(e^{-\lambda})*(\lambda^{x})}{x!} \quad \text{---------(EQU 1)}$$

e(Euler's no=2.718), λ(avg no for occurance of the event),x(no of time the event to occur

Here the calculation of the λ is the average of the total number of earthquakes occurred over a certain period of time, and is represented as a formula:

$$\lambda = \frac{\text{Total number of earthquakes}}{\text{Total span of time}}$$

$$= \frac{227}{58 \text{ years}}$$

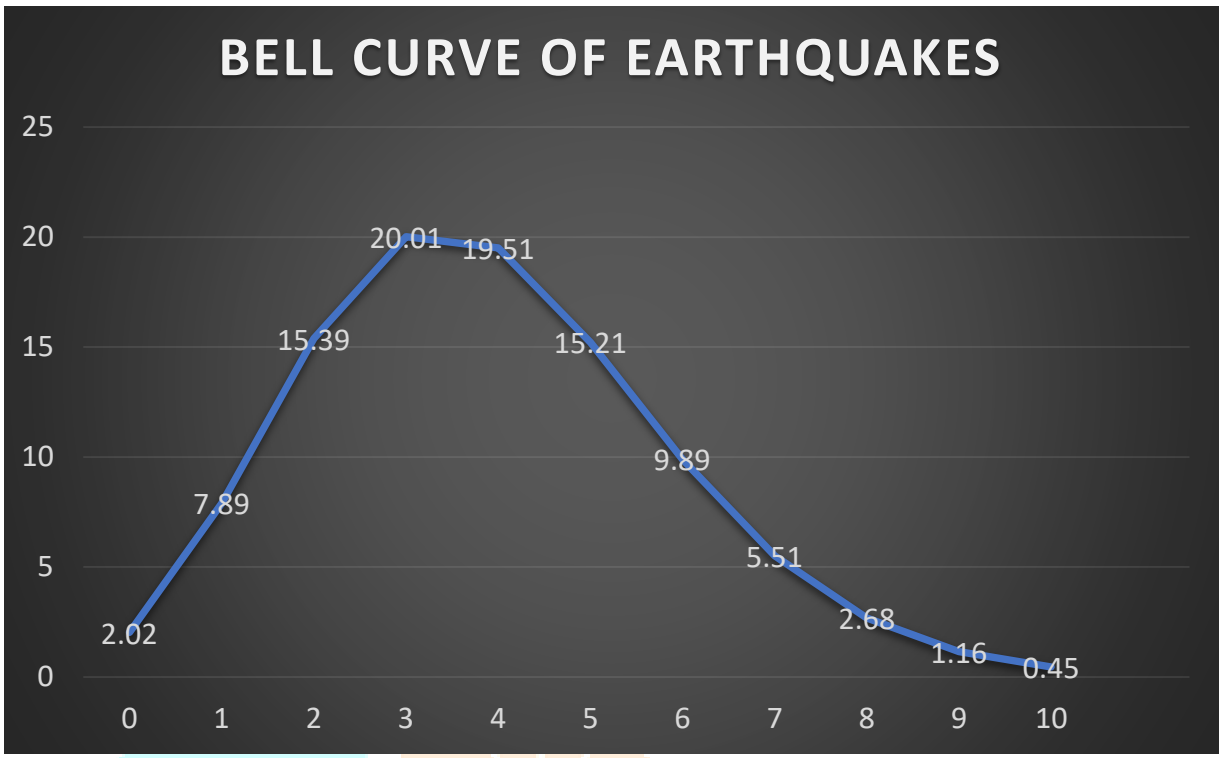
$$= 3.9$$

SUBSTITUTING THE VARYING VALUES OF X IN ABOVE MENTIONED AND ALSO THE VALUE OF λ IN THE EQUATION 1

X= no. of Earthquakes	P(X)
0	2.02%(0.0202)
1	7.89%(0.0789)
2	15.39%(0.1539)
3	20.01%(0.2001)
4	19.51%(0.1951)
5	15.21%(0.1521)
6	9.89%(0.0989)
7	5.51%(0.0551)
8	2.68%(0.0268)
9	1.16%(0.0116)
10	0.45%(0.0045)

Various values for P(x) is obtained by substituting the value of x with whole numbers as shown in the table

Hence putting the obtained values of P(x) in a graphical form, a bell curve is obtained



So, from the graphical representation it is seen that **there will be a minimum of 3 earthquakes** across India having magnitude of 5 or greater than equal to 5 on Richter scale throughout the year anytime and anywhere.
So, we can conclude from the calculation that, probability of occurrence of 3 or more earthquakes with magnitude greater than equal to 5 on Richter scale is

$$1-(p(0)+p(1)+p(2))$$
$$=100-(2.02+7.89+15.39)$$
$$= \mathbf{0.747 \text{ or } 74.70\%.}$$

Hence, to make the project more precise, such that any individual area in India can be calculated, some more parameters had been added up in the calculation, such as the **peak ground acceleration** and **zonal mapping**.

CALCULATION OF THE LOCALISED PROBABILITY OF OCCURRENCE OF AN EARTHQUAKE

FACTORS DEPENDENT:

- **THE ZONATION MAPPING**
- **THE PEAK GROUND ACCELERATION FOR RESPECTIVE ZONE**

THE EARTHQUAKE WILL STRIKE IN THE ORDER OF

1. ZONE V
2. ZONE IV
3. ZONE III
4. ZONE II

****Zone I have been over looked as the chances of occurrence of the earthquake is bleak****

PEAK GROUND ACCELERATION Peak ground acceleration (PGA) is equal to the maximum ground acceleration that occurs during earthquake shaking at a location

SL NO	ZONE	PGA (as a fraction of g)
1	II (LEAST ACTIVE)	0.032
2	III (MODERATE)	0.068
3	IV (HIGH)	0.146
4	V (HIGHEST)	0.314

Now if an earthquake occurs on the Indian subcontinental plate, then zone V will have the highest then come zone IV followed by zone III and zone II effect of the earthquake.

So, the probability of striking zone V= 0.5, zone IV= 0.33 and zone III= 0.17, comparing the PGA values.

****Zone II has been overlooked as it is least active and earthquake rarely hits these places****

Result:

Now the mathematical model to calculate the probability of occurrence of earthquake of magnitude of greater than equal to 5 on Richter scale at any XYZ place situated on Indian Subcontinental plate is:

P(PLACE) = P(INDIA, X) * P(ZONE)

Here **P(INDIA) is 0.747 calculated earlier and the **P(Zone) depends on the location** of the place on the sismic zone map; i.e, whether its zone V or zone IV or zone III .**

Referrences:

- Earthquake datas collected from the govenment website NCS (National Center of Sismology)
  https://seismo.gov.in/MIS/riseq/earthquake
- And other informations from open sources available in Google

Conclusion: As a holistic point of view, India has got a very high risk of being hit by earthquake any time, which can be clearly seen from the various point discussed in this research paper. India being one of the highest populated countries of the world must act wisely and take proper precautions well before in order to avoid huge demolitions and save its civilians from one of the very common yet dangerous natural devastation like Earthquake. Natural calamities like these can only be pre-predicted but cannot be stopped. So, since we are developing ourselves with the various new scientific technologies, then why not try to predict these natural calamities from before hand and try to save some innocent lives as “PRECAUTION IS ALWAYS BETTER THAN CURE”.