Mathematical Models for Estimating Earthquake Surge Vulnerability and Resource Availability and Planning.

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Abstract-

The main objective of this study is to develop a mathematical model for estimating earthquake surge vulnerability and availability of resources for reinforcement system, using simple mathematical equation. Earthquake is a sudden movement of earth's crust due to the result of release of stress by volcanic activity. Earthquake damage depends upon what area it hit. India is one of the most earthquake disaster prone countries of the world. It is very difficult to predict earthquake disaster. So, it is very much needed to have a very strong reinforcement system. Mathematical modeling is an effective tool in forming such models.

Keywords- Mathematical Models, Earthquake, Community Assessment, Earthquake Surge Reduction.

Introduction-

India has had a number of the world's greatest earthquakes in the last century. In fact, more than 58% area in the country is considered prone to damaging earthquakes. The northeastern region of the country as well as the entire Himalayan belt is susceptible to great earthquakes of magnitude more than 8.0. The main cause of earthquakes in these regions is due to the movement of the Indian plate towards the Eurasian plate at the rate of about 50 mm per year. Besides the Himalayan region and the Indo-Gangetic plains, even the peninsular India is prone to damaging earthquakes as clearly illustrated by the Bihar earthquake (1934), Asam earthquake (1950), Uttarkashi earthquake (1991), Maharastra earthquake (1993), Gujrat earthquake (2001) Indian earthquakes have shown some remarkable features which have implications on strategies for reducing earthquake disasters in the country. This paper attempts to provide an overall perspective of past Indian earthquakes and the interesting features of the same.

It is important to have the correct perspective on *earthquake magnitude* and *earthquake intensity*: two terms often misunderstood. *Earthquake magnitude* is a measure of the size of the earthquake reflecting the elastic energy released by the earthquake. It is referred by a certain real number on the Richter scale (*e.g.*, magnitude 6.5 earthquake). On the other hand, *earthquake intensity* indicates the extent of shaking experienced at a given location due to a particular earthquake.

It is very much difficult to attain efficient information about the timing and intensity of earthquake. But, if we have some good planning for responding the earthquake disaster then we can minimizes loses at a certain level. The planning factor involves many parts like Information system of the area, awareness, training, human resources, Fire and emergency services, transport facilities etc.

Research Methodology-

The following research methodologies are adopted for the proposed research paper:

- Identification of the problem and defining the parameters for study
- Collection and study of available related literature
- Mathematical formulation of the problem by using simple equation.
- Numerical solution of the problem
- Interpretation of results.
- Conclusion

Mathematical Model and its parameters-

The Mathematical equation formulated was

$$V_r = 10 - (\bar{y} + \bar{x})$$

Where V_r is the range of Vulnerability, $\bar{y}$ is the physical and infrastructural resources of the area that could be useful to help before, during and after the disaster, and $\bar{x}$ is the personal capacities of an individual and the family.

$$\text{Let } \bar{y} = \frac{(T_1 + R_1 + M_1 + I_1)}{4}$$

T_1= Transportation facilities of the area

T_1= 5, if the transportation facility of the community is available and adequate.

T_1= 3, if the transportation facility of the community is available but not adequate.

T_1= 1, if the transportation facility of the community is not adequate.

T_1= 0, if there is no transportation facility .

R_1 = Road facilities in area

R_1 = 5, if the road facilities in area are available and adequate during the disaster.

R_1 = 3, if the road facilities in area are available but not adequate during the disaster.

R_1= 1, if the road facilities in area are not adequate during the disaster.

R_1 = 0, if there is no road facilities during the disaster.

M_1 = Medical facilities of area

M_1 =5, if the medical facilities of area are available and adequate during the disaster.

M_1 =3, if the medical facilities of area are available but not adequate during the disaster.

M_1 =1, if the medical facilities of area are not adequate during the disaster.

M_1 =0, if there is no medical facility during the disaster.

I_1 = Infrastructural facilities of area

I_1 = 5, if there are Infrastructural facilities of area are available and adequate during the disaster.

I_1 = 3, if there are Infrastructural facilities of area are available but not adequate during the disaster.

I_1 = 1, if there are Infrastructural facilities of area are not adequate during the disaster..

I_1 = 0, if there is no Infrastructural facility during the disaster.

$$\text{Let } \bar{x} = \frac{(X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7)}{7}$$

X_1 = Agencies providing the early warning information

X_1 = 5, if the agencies providing the early warning information are efficient.

X_1 = 3, if the agencies providing the early warning information are less efficient.

X_1 = 1, if the agencies providing the early warning information are very less efficient.

X_2 = Awareness factor

X_2 = 5, if the people of the area are very much aware about the disaster.

X_2 = 3, if the people of the area are less aware about the disaster.

X_2 = 1, if the people of the area are very much less aware about the disaster.

X_3 = Communication facilities

X_3 = 5, if the communication facilities of the area are working properly during disaster

X_3 = 3, if the communication facilities of the area are less working during disaster

X_3 = 1, if the communication facilities of the area are very much less working during disaster

X_4 = training facilities

X_4 = 5, if the people of area have an updated training about the disaster.

X_4 = 4, if the people of area have training about the disaster for the past year.

X_4 = 3, if the people of area have training about the disaster effect reduction only.

X_4= 2, if the people of area have training about the disaster survival only.

X_4= 0, if the people of area do not have any training about the disaster.

X_5= Economic conditions

X_5= 5, if family is living on an above average living standard.

X_5= 3, if family is living on an average living standard.

X_5= 1, if family is living on a below average living standard.

X_6= Location of the area

X_6=5, if location of the area is in plane region under city management authority.

X_6=4, if location of the area is in plane region under village management authority.

X_6=3, if location of the area is in hill region under city management authority.

X_6=2, if location of the area is in hill region under village management authority.

X_6=1, if location of the area is in high hill region under village management authority.

X_7 = Distance from the national roads

X_7 = 5 if the distance of the area from the national road is 50m - 100 m

X_7 = 4 if the distance of the area from the national road is 101m - 200 m

X_7 = 3 if the distance of the area from the national road is 251 m - 350 m

X_7 = 2 if the distance of the area from the national road is 351m - 500 m

X_7 = 1, if the distance of the area from the national road is 551m - 700 m

X_7 = 0, if the distance of the area from the national road is 701 m and above

The value of the above mentioned variables is equal, considering the factors that weight of every variable are already stated. The factors should be examined very carefully before rating in order to get some valuable result. The result of the equation so gained can be put in the form of the range of vulnerability as stated below-

0 -0.99 = Very non vulnerable

2.00 -3.99 = non vulnerable

4.00 - 6.99 = less vulnerable

7.00 - 9.99 = vulnerable

10.00 = very vulnerable

Mathematical validation of the model-

To prove that this mathematical model can really be used can be implemented, a validation can be executed.

Let us suppose that for a particular region $T_1 = 3, R_1 = 5, M_1 = 3, I_1 = 1,$

$$\text{Then } \overline{\boldsymbol{y}} = \frac{(T_1 + R_1 + M_1 + I_1)}{4}$$

$$\overline{\boldsymbol{y}} = \frac{(3+ 5+ 3+ 1)}{4}$$

$$\overline{\boldsymbol{y}} = 3.$$

Let, $X_1=1, X_2= 3, X_3= 5, X_4= 2, X_5 = 3, X_6 = 4, X_7= 1,$

$$\overline{\boldsymbol{x}} = \frac{(X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7)}{7}$$

$$So, \ \overline{\boldsymbol{x}} = \frac{(1 + 3 + 5 + 2 + 3 + 4 + 1)}{7}$$

$$\overline{\boldsymbol{x}} = 2.7142$$

$$\boldsymbol{V_r = 10 - (\overline{y} + \overline{x})}$$

$$\boldsymbol{V_r = 10 - (3 + 2.7142)}$$

hence, $\boldsymbol{V_r} = 4.2858$

So, this region lies in less vulnerable region.

Conclusion-

The mathematical model described above is a very simple model to understand. The parameters of the model are capable to define the real world situation. Mathematical validation of the model is very much easy to understand. The model is sufficient to answer the questions which are intended ended to ask. We can compute the different results manually with the aid of the parameters indicated in this study.

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