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PREDICTION OF EARTHQUAKE USING F.E.M TECHNIQUES

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Abstract: This proposal deals with the use of Finite Element Method to model the EARTH as a WHOLE to predict Earthquakes on time- scale .Here the EARTH is considered as a whole and hence a change recorded at any place when applied in the model can help us figure its effects elsewhere. This helps in the PREDICTION of events like Earth Quakes. The methodology used here is FEM where the model is generated from its latitudes and longitudes and from the z- axis towards the Earth's interior. The properties along the z-axis can be studied using specially designed satellites. The satellites may use Ultra-Sonic Waves for the study. Once the EARTH is modelled from the data collected, F.E.M techniques can be used for time scale Earth Quake predictions by incorporating the observed changes and its effects in the model.

I. F.E.M TECHNIQUE INVOLVED

STEP 1:- PROBLEM DEFINITION

AIM

To predict Earthquakes.

OBJECTIVE

To model the earth in 3 dimensional form to use F.E.M techniques in-order to predict earthquakes.

STEP 2:- PROBLEM SIMPLIFICATION

- (i) A representative model of the earth may be defined on time scale by studying the external shape from the latitudes and longitudes of the earth.
- (ii) The interior properties can be represented by studying the properties of crust, mantle, inner core and outer core namely the properties like pressure, temperature, heat, mass and density.

STEP 3:- PROBLEM SOLUTION in SPACE, TIME and SUBSYSTEMS

- (i) The Earth may be represented as a whole from its Latitudes and Longitudes
- (ii) From the point of intersection of Latitudes and Longitudes ie x and y Co-ordinates, z axes may be drawn towards the interior portion of the Earth to generate the complete form of Earth.
- (iii) The solid form of the Earth generated may be differentiated as Crust, Mantle, Outer Core and Inner Core according to the data that may be collected later or from existing data like depth and radius of each layer.
- (iv) The differentiation mentioned above depends on various properties like density, temperature, pressure, plate boundary points, types and properties of rocks etc
- (v) As all the above data change with time they are time dependent.

STEP 4:- DATA REQUIREMENT

The requirement of following data are very essential.

- (i) Plate boundaries and the shape functions of different tectonic plates.
- (ii) Depths of Crust, Mantle, Inner and Outer Core with respect to the intersection of z axes drawn into the model of Earth.
- (iii) Pressure variations towards the interior of Earth
- (iv) Temperature variations with respect to changes in heat and mass towards the interior of the Earth.
- (v) Density variations and the distribution of various types and properties of rocks with change in depth.
- (vi) Magmatic presence and its extend.
- (vii) Position of water table, presence of water and other hydrogeological factors.
- (viii) The depth of oceans and ocean beds.

(ix) Man - made effects on Earth which has direct and indirect effects on Earthquakes like

- Explosions
- Constructions
- Drillings and Diggings etc

STEP 5:- CONCEPTUAL MODEL

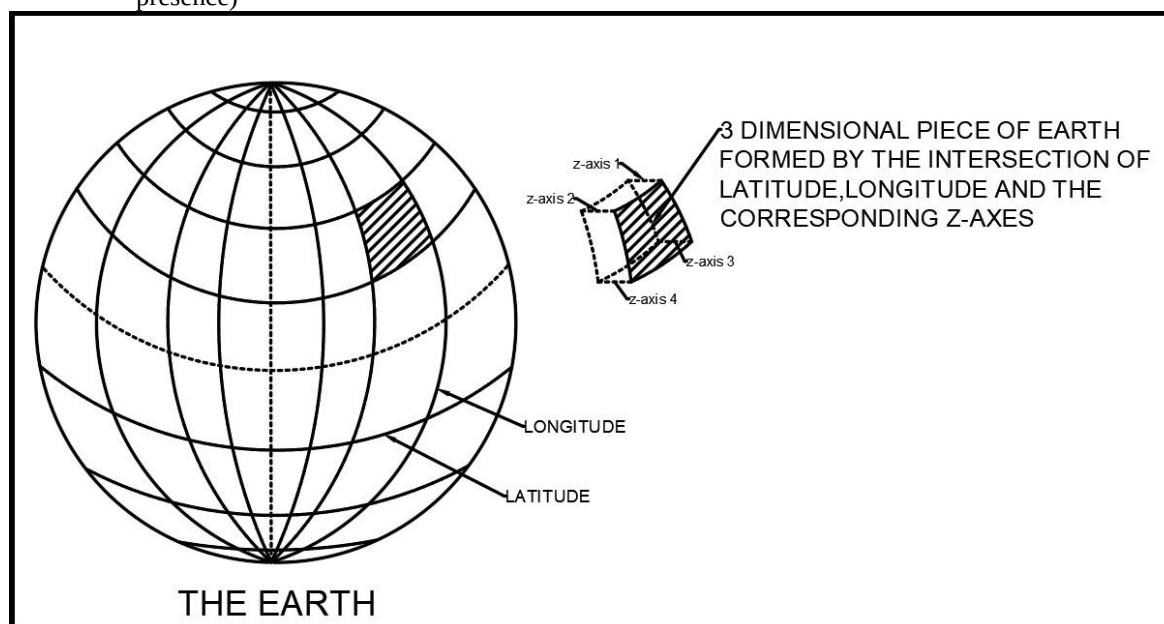
Once the required data are obtained, they may be incorporated into the model at each co-ordinates(x,y,z) giving rise to a three dimensional model of the Earth.

This can be done as follows

- Let a particular colour represent a particular property.
(Properties i-ix in STEP 4)
- Let the intensity of each colour be proportional to the value of the property.

STEP 6:- MATHEMATICAL MODEL

- (i) The Conceptual model obtained helps in obtaining the mathematical model which gives us an opportunity to study each piece of Earth formed by the intersection of Latitude, Longitude and interior z axis
- (ii) Since Earth is in the shape of a spheroid there are z axes running parallel along the latitude direction and longitude direction
- (iii) The point of intersection of each z axes breaks THE EARTH into DIFFERENT PIECES of Earth.
- (iv) Each piece of earth shall be taken for thorough study and the boundary equations for each piece may be formed based on the properties mentioned earlier. (Here these are our boundary conditions)
- (v) From the boundary conditions, the governing equation may be formed which may highlight the governing pieces of earth (mainly under stress or under convection currents due to magmatic presence)



STEP 7:- SOLUTION METHODOLOGIES

- (i) Once the mathematical model is ready which may include one governing equation or a series of governing equations, the solution methodology can be analytical, numerical or physical or a combination based on the equations we arrive at, at this stage.

STEP 8:- MODEL DEVELOPMENT

- (i) Here the model should be developed with the help of study of interior properties of the Earth.
- (ii) The interior properties can be found with the help of specially designed satellites which may use Ultrasonic sound waves which may be sent into the earth at each z axes and by studying the variation in the time taken for its return back to the satellite.
- (iii) Sources other than ultrasonic sound waves for the study of Earth's interior may be developed if necessary.
- (iv) The exterior shape may be obtained from satellite pictures.
- (v)

STEP 9:- MODEL VALIDATION

The model here gets validated when all the required parameters become known. Here when the solutions are obtained, they must be cross-checked with previously occurred Earthquake data.

STEP 10:- MODEL SENSITIVITY ANALYSIS

The important model variables have to be investigated during analysis upon model behaviour. This can be done by varying each variable to its upper and lower extremes while keeping others a constant.

STEP 11:- MODEL PREDICTIONS

- (i) Once the model is validated, based on time scale observations, the probable collision of plates or elastic rebound (probable causes of Earthquake) can be predicted and the amount of energy that is going to be released and its effect can also be predicted.
- (ii) This can be experimented and tested based on observations which are available from previous earthquakes by putting them into the model and checking whether the probable output is obtained.
- (iii) With the help of minute explosions created inside the earth, the quakes that are generated originally may be counter checked with predicted ones
- (iv) If actual values and predicted values do have great differences, the model shall be subjected to revisions.

STEP 11:- MODEL TRACKING

Once the model is validated and gives better outputs as predictions; replicas of the model on timescale basis may be kept apart for analysis and to improve the results. This is a kind of tracking of the model. This is because the observations made at a particular instant of time may be different from another.

THE RECORDED CHANGES AT DIFFERENT INSTANCES OF TIME MAY ACT AS A REFERENCE TO PREDICT THE CONSEQUENCES THAT MAY OCCUR IN FUTURE DUE TO A PARTICULAR CHANGE OCCURRING AT PRESENT.

THUS THE PREDICTIONS BECOME MORE ACCURATE.

NOTE:-

- In-order to study interior properties special satellites have to be designed
- These satellites shall study each z axes formed by the intersection of each latitude and longitude which cuts the Earth's interior into different pieces.
- The replicas of the 3D model shall be kept apart on time scale basis to track the changes occurring and to help better predictions.

References

- [i] Y.M. Desai, T I Eldho, A.H Shah, Finite Element Method with Applications in Engineering, Pearson Education, Dorling Kindersley (India) Pvt. Ltd.(2011).