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A SYSTEM FOR THE PROBABALISTIC ASSESSMENT OF EARTHQUAKE MOTIONS

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SUMMARY

The Hokkaido Development Engineering Institute developed the system to calculate the earthquake movement by a statistical probability method using previously recorded data of actual seismic wave acceleration and the seismic scale of the Meteorological Agency. The purpose of this system is to correctly estimate the scale of expecting earthquake movement: the sensible vibration and measurable seismic wave acceleration at the place where road construction is planned and the surroundings.

This system was developed to investigate the systematic relations between the Japanese seismic scale, measured seismic wave acceleration, and an acceleration distance decay equation. This system has functions such as editing and managing information, expecting regions where an earthquake will occur and the sensible vibration, making Contour drawing, and providing the system information.
The calculated values of annual probability of assumed seismic wave acceleration and sensible vibration in a random place acceleration to be able to be used as an earthquake proof index considering about conditions environmentally characteristic in the region. However, the estimated value is greatly affected by regional conditions, the number of earthquake information, and measured seismic wave acceleration records, so additional earthquake information in future and further investigation to make the system more precise as the forecast will have less probable errors are necessary.

INTRODUCTION

Hokkaido lies in one of most active earthquake prone areas of Japan. Earthquake activity is particularly active in the Tsushima Kamchatka ocean trench stretching from the North-West Bight of Japan to the Kamchatka Peninsula. The Pacific Plate underlying this trench is considered to be large factor in the strong ocean trench type earthquakes in Hokkaido. There is also a further plate to the west of Hokkaido in the Japan Sea Bight that

is a cause of earthquakes. Like in the rest of Japan, Hokkaido has numerous active faults and these give rise to earthquakes directly under cities and other centers as well as other types of earthquakes occur here.

In recent years Hokkaido has been subjected to the Kushiro Bay (magnitude 7.8), the Hokkaido South West Bight (magn. 7.8) in 1993, and in 1994 the East Hokkaido Bay (magn. 8.1) earthquakes. Considering earthquake frequencies in the past these were very rare earthquakes. Still, the incidence of strong earthquakes is relatively high and the effect of earthquake damage on living conditions in Hokkaido is large. The three above earthquakes all resulted in damage to civil engineering structures.

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There is an urgent need to consider earthquakes in engineering design and reasoned earthquake countermeasures are needed. In establishing these, the basic conditions are determined from the projected force of earthquakes in the areas where structures are planned. The establishment of a suitable prognostic basic for evaluation is difficult due to the very various characteristics of earthquake movements, the scale of earthquakes, the origins of earthquakes, and the geological conditions as well as the interplay among these factors and the changes they give rise to.
The Hokkaido Development Engineering Institute has developed a system to calculate earthquake movements by statistical probability methods using seismic records on the seismic scale of the Meteorological Agency of Japan and information of seismic wave acceleration. The report here provides details of this system to evaluate probable accelerations at any geographical point in predicting earthquakes.

OUTLINE OF THE SYSTEM

The estimation system of probability acceleration is aimed at predicting accurate earthquake intensities at places where construction of roads and other facilities are planned. The estimated intensity uses available seismic records for an area and allows calculation of the estimated magnitude and accelerations at earthquakes (in gal. Actual measurement and for I – III types of soils) for a given place and probability interval of incidence. For the user of the system there is a need to relate the earthquake proofing design to an accurate understanding of earthquake magnitudes in the design area. For practical use the system has records of past data of earthquake magnitudes and accelerations.

The available data includes details of earthquakes, magnitude of earthquakes, details of accelerations and the acceleration functionalism away from the center of earthquakes. First the various data are recorded, including details of the earthquake, time of occurrence of sensible earthquakes, position of epicenters, and magnitudes. The data of the intensity of the earthquake includes the time of occurrence of the earthquakes, the place name where the earthquake occurred, latitude, longitude, and the magnitude on the Japanese earthquake scale. Acceleration data includes the time and place of the earthquake movements as well as the maximum acceleration. The data of the area damping includes factors of the formula to calculate maximum acceleration in the horizontal direction according to the Specifications for Highway Bridges.

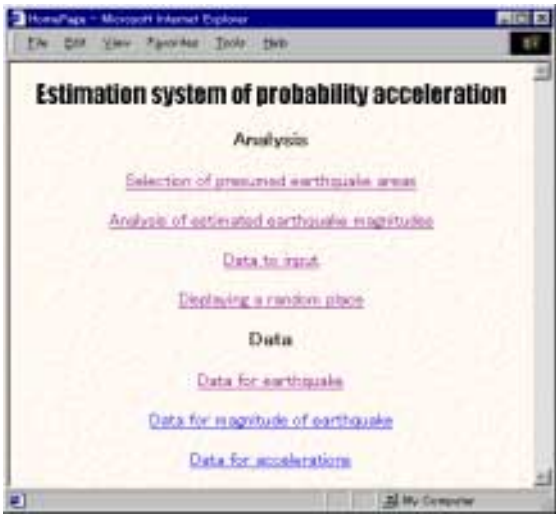

Figure 1: Estimation system of probability acceleration

PROCESS OF THE ANALYSIS

The process of the analysis with the present system comprises three steps, starting with the probability interval of the earthquake (Step 1), acceleration at the place of measurements (Step 2), and estimated value for a certain place (Step 3).

Step 1 utilizes the seismic data for the area in question adding up earthquakes registering above magnitude one on the Japanese scale, dividing with the number of years that records are available and form the magnitude of the earthquakes the estimated probability interval for earthquakes is calculated.

Step 2 uses the seismic data for past earthquakes in the area, and for the time of earthquakes larger than magnitude one on the Japanese scale it evaluates the time of the actually measured acceleration, to establish the measured acceleration for an area. Further from the estimated maximum accelerations of the different soils and with the damping data considering the distance between the place of the earthquake and place where measurements took place the epicenter and magnitude are calculated.

Step 3 uses the basic data obtained in Step 1 and Step 2 in calculations for a given place in the area of interest and considering the probability interval for an estimated earthquake magnitude, the estimated acceleration (Actual measurement and for each soil type) is calculated.

OPERATION OF THE SYSTEM

For the civil engineering designer calculating the estimated magnitude and acceleration of earthquakes the system needs input to set the area to be investigation, analyze the estimated earthquake magnitude, other data to input, and specific data for the place being investigated.

Selection of presumed earthquake areas:

The designer has to indicate the earthquake active area that affects seismic movements related to the structure in the area planned for construction. In determining this area it is important to let experience guide the establishment of areas where seismic movement will occur and single out the special seismic conditions of an area.

The system here uses statistical processing and suggests probabilities wherefore the selection of the area for analysis is extremely important. In making this selection it is recommended to use records of past earthquakes.

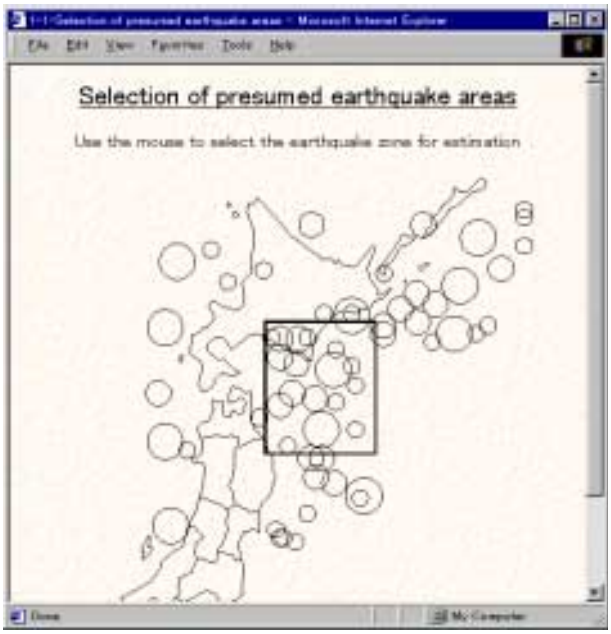

Figure 2: Selection of presumed earthquake areas

Analysis of estimated earthquake magnitudes:

The analysis uses past records of earthquakes for the area in question as well as the period of incidence and estimated magnitudes and acceleration of earthquakes in the statistical probability calculations. The estimated accelerations are in gal units, Actual measurement and for I – III types of soil. These soil types are: Type I for well-developed diluvial ground and rock, Type III for weak alluvial ground, and Type II for diluvial and alluvial ground, which be long to neither I nor III.

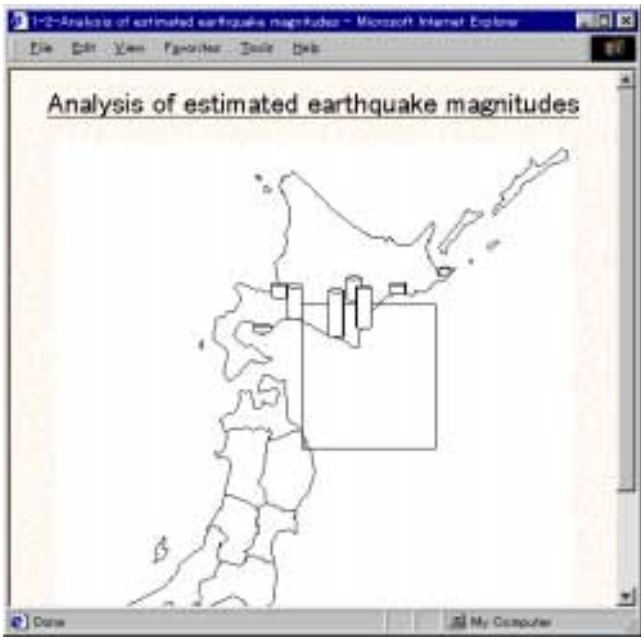

Figure 3: Analysis of estimated earthquake magnitudes

Data to input:

The screen where the conditions are input allows numerical data for the estimated magnitude and acceleration of earthquakes and it is also possible to input other data via the screen.

The functions included here comprise, data of the coastline, latitude, and longitude, data of the area where measurements were mode, and the results of the analysis. The data for the coastline is indicated by colors for Hokkaido, Tohoku, and offshore, all in northern Japan. Latitude and longitude can be input for areas included in the coastline data. Place of measurement can be input for Japanese scale earthquake with the official place names distinguished by color, font, and letter size. The results of the analysis include the estimated earthquake magnitude as well as the accelerations displayed as contours or numerical values with colors, fonts, and letter sizes and for the periods of incidence, the measured data, or different ground types.

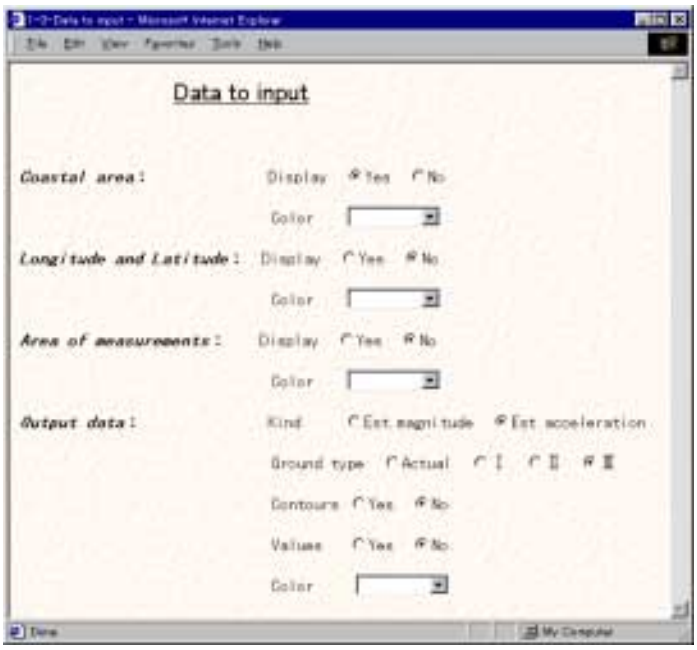

Figure 4: Data to input

Displaying a random place:

The estimated magnitude and seismic wave acceleration of the observation the image that fits the input data for the investigated area is displayed as a map on the screen. The screen shows an outline of Hokkaido and surrounding areas and the contours for the estimated values are superimposed on this. When specific points in this area are activated with the mouse the screen will display the estimated and seismic wave accelerations for the various estimated periods of incidence.

Figure 5: Displaying a random place

CONCLUSIONS

The above reported a system developed from considerations of the relations among earthquake movements, measured accelerations, magnitudes on the Japanese earthquake scale, and the acceleration functionalism.

As a result it is possible for a randomly selected point in the area of calculations to provide indices for earthquake resistant designs by the period of incidence for estimated magnitudes and accelerations of earthquakes and considering the special characteristics for an area. These estimated values are however strongly influenced by the available data and magnitudes of earthquakes as well as the amount of available data of seismic wave accelerations, and there is a need for further data collection to improve the accuracy of the predictions.

POSTSCRIPT

The present is a report of a ”Estimation System of Probability Acceleration at a Certain Place Supposed with Earthquake Area” concerned with the special characteristics of seismic wave accelerations in Hokkaido. Further study of methods of analysis of magnitudes and accelerations due to earthquakes considering local characteristics to provide better quality estimates for earthquake prone areas is necessary