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Seismic risk assessment of residential building

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ABSTRACT: The author has developed practical program for assessing seismic risk of residential building without actual site investigation. The program is composed by the questionaire and the evaluation system. the questions are written without technical term and so illustrated with typical scenes. This program is applied to the seismic consulting system of the Tokio Marine and Fire Insurance Co.Ltd. last year.

1 SCOPE OF PROGRAM

A presentation of earthquake preparedness for citizen or clients of insurance dealer should realize actual image of disasters and describe details of vulnerable points.
There are invitable problems for assessing the seismic risk of the residential building.

First, a difficulty of the estimation of the siol classification. Citizen or housewives are not familiar to the soil classification and they could not identify which Type is conform to their home soil.

Second, a confusion of technical terms for citizen or housewives. They could not answer to the question with techn ical terms.

The targets of study are concentrated in resolving these problems for design of the questionaire and data-processing of answers.

2 DESIGN OF QUESTIONAIRE

The author solved these problems by translating technical terms to commonly spoken words, and by presenting alternate questions what they could see in the landscape around their homes than requesting answer for the soil classification.

Figure 1 shows the 2nd page of 12 pages questionaire which is the promoting tool for selling the seismic insurance. Salesmen request answer to questionaire when they visit clients, and figure 2 shows the 3rd page.These papers are originally printed in Japanese, english in figures is provisional translation.

Answers to questions in 2nd and 3rd pages contain the scenery informations of client's house. Number of combination of answers is 4096x5x4=81,920 ,but number of of types of soil is provided three in the Japan building standard law, as shown in the Table 1. Each combination of answers should correspond to the the definite type of soil without fail.

Other questions in 4th to 12th pages are as following,

1.Age of building
2.Structure of frame
3.Roof
4.Number of rooms and openings
5.Floor planning
6.Slope and/or fence against to the next
7.Deterioration of building
8.In which floor of how much storey building
9.A furniture and it's height and depth
10.Stored emergency supply and first aid
12.Other emergency plans

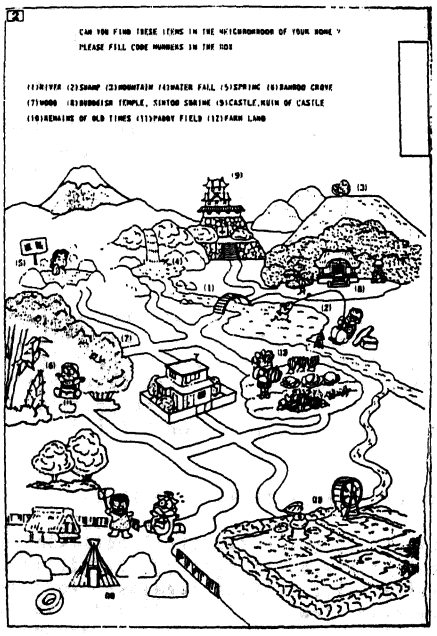

Figure 1 2nd page of the questioniare

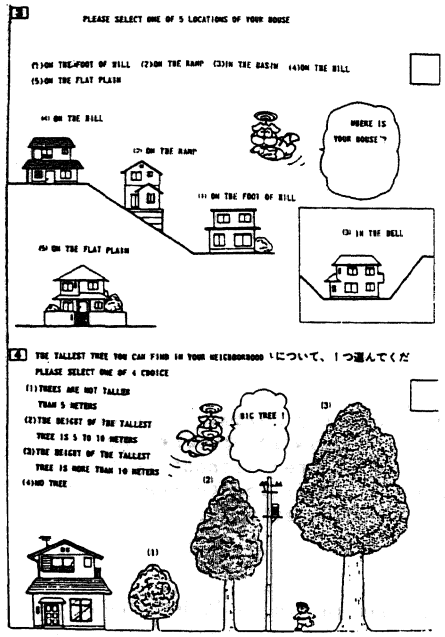

Figure 2 3rd page of the questioniare

3 REASONING PROCESS FOR SOIL CLASSIFICTION

The author has developed a reasoning process for choosing suitable type of soil. The reasoning is integrated by following steps,

1.Determine the relation between scene and type of soil. We weight the relation factor in three ranks as +1, 0 and -1, shown in the Table 2.

2.Sum up points of each type . A type which obtains the highest point is chosen as the suitable type of soil.

3.Type 2 is chosen as better resolution,when two types have equal point.

The process mentioned above is likely to the "AI"(Artificial Inteligence),often applied to the computer aided trouble shooting or the computer aided medical consultation.

4. PROVING OF REASONING PROCESS

Not Every estimated Type of soil is suitable to the actual soil of the site. Over 90% of the estimated Types of soils are acceptable by our experiments,and there is no estimation skip over the Type 2,in other words, mis-takes are limited to Type 2 for 1, or 2 for 3.

5 REASONING OF VULNERABILITY OF BUILDING

A vulnerability of the residential building is infered from it's age,structure,roof,wall area index,eccentricity,condition against to the next and deterioraton.

Table 1. Soil classification in Japan building standard law

Soil Type	Ground Characteristics	Tc*
Type 1 (Hard Soil)	Ground consisting of rock,hard sandy gravel, etc. classified as Tertiary or older. Or ground whose ground period, estimated by other investigation, is equivalent to that of the above.	0.4
Type 2 (Medium Soil)	Other than Type 1 or 2.	0.6
Type 3	Alluvium consisting of soft delta deposits,topsoil,mud,or the like (including fills,if any),whose deth is 30m or more,land obtained by reclamation of a marsh,muddy sea bottom,etc.,where the depth of the reclaimed ground is 3m or more and where 30 years have not yet elapsed since the time of reclamation. Or ground whose ground period, estimated by calculation or by other investigation, is equivalent to that of the above.	0.8

*Critical period

Table 2. Correlative point between scenery item and Type of soil

(Item)	Type 1	Type 2	Type 3
river	+1	0	+1
swamp	-1	0	+1
mountain	+1	0	0
water fall	+1	-1	-1
spring	+1	0	0
banboo grove	-1	0	0
wood	+1	+1	0
temple,shrine	0	+1	+1
castle,ruin of it	+1	+1	0
remain of old times	-1	0	0
paddy field	-1	-1	+1
farm land	-1	+1	+1
(Location)			
on foot of hill	-1	0	0
on ramp	0	+1	0
in dell	-1	0	+1
on hill	0	0	-1
on flat plain	0	0	+1
(Vegetation)			
<5m	-1	0	0
5 to 10m	0	+1	0
>10m	+1	+1	-1
no tree	-1	0	0

5.1 Wall area index

We request number of rooms and openings of building, and conduce to the alternate for wall area index, while a citizen or housewife could not describe exact wall area .

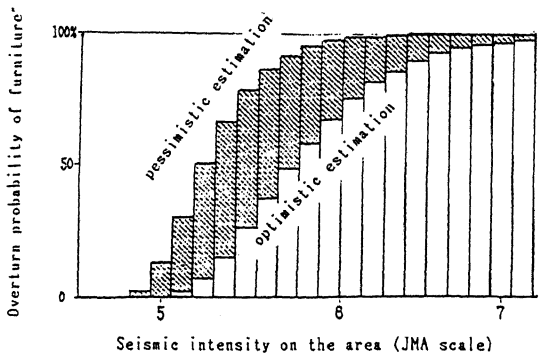

Figure 3 Overturn probability of furniture

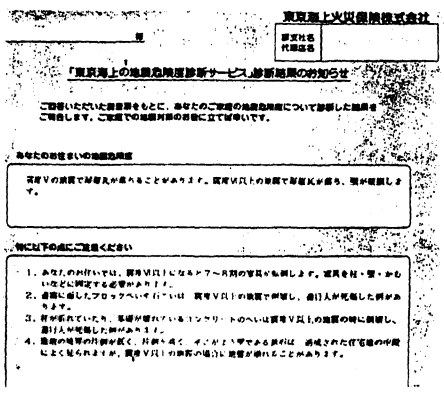

Figure 4 Format for narrative description

A residential building with wooden frame may be vulnerable where the ratio of number of openings,such as windows and doors, to number of rooms is greater than 2.5 according to our statistical study.

5.2 Eccentricity

We estimate an eccentrical vulnerabiity by the floor planning.

5.3 Overturn of furniture

A probability of overturn of the furniture is estimated by it's installation and height and depth ratio according to our empirical hypothesis as following.

1. Critical conditions of overturn are given as, $B/H=a/g$ and $B/\sqrt{H}=S/10$,where B is depth in cm,H is height in cm,a is critical acceleration in cm/s^2 ,a is gravity acceleration, S is critical velocity in cm/s.The second equation is presented by the Building Laboratory of the Ministry of Construction.

The critical velocity is translated to the critical acceleration by the assumption that the critical period of the building is 0.5s.

2. The response magnification factor on the roof is assumed 2 to the ground surface, and a response on the floor of any storey is assumed as proportional as height.

3. A cumulative distribution of the probability is assumed that distribution curve extend from x/3 to 3x,where x is critical acceleration.

4. A critical ground surface acceleration is translated to areal earthquake intensity in JMA scale by response magnification factor of the site defined by it's condition.

5. Finally,overturn probability is printed out as the bar gragh shown in the figure 3 from the computer.

6 NARRATIVE DESCRIPTION

A narrative description of seismic risk assessment and recommendations for improvement of earthquake preparedness are printed out from the computer. Each description is registerd with code number composed by six digits, and this factorial code for the site and building is provided as Table 3. The narrative descriptions variate in 1152 with soil types and buildings.

For example:code 111111 means very old wooden frame building, roof coverd with cray tile, on type 1 soil,no eccentricity,moderate wall area index.
The figure 4 shows the 1st page of the printed format.An example of the narrative description is following,

[Seismic risk] The roof may be partially damaged when shocked with earthquake intensity v in JMA scale, and the roof and wall will be damaged whe shocked with earthquake intensity VI or more.
[Recommendations] Furnitures should be fixed to wall or column. Concrete block fence is dangerous to the pedestrian when shocked with earthquake intensity V or more.
[Probability of overturn of furniture] Fig.3

7 CONCLUSIONS

The program for assessing seismic risk of residential building without actual site investigation is an usefull tool for the salescampaign of earthquake insurance and encouraging promotion of earthquake preparedness.

The author would like to thank Mr.K.Miyagawa and his supervisors from The Tokio Marine and Fire Insurance Co.Ltd.for their cooperations.

Table 3 Factorial code

Factor	Code
Soil classification	1,2,3.
Age of building	1,2,3,4.
Structural classification	1,2,3,4,5.
Roof calssification	1,2,3,4.
Opening	1,2.
Eccentricity	1,2.