# Psychological Structuring of citizen's willingness for seismic reinforcement of houses *

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ABSTRACT

The Japanese Islands are said to have entered at the seismic activity term from the time of the Kobe earthquake (1995). And it is said that the big earthquake from Hokkaido to Kyushu occurs in the probability of 90% within 50 years.

When such a big earthquake occurs, collapse of a structure is one of main causes of bringing about serious damage. The Building Standard Law was improved in the past earthquake, and the building structure which is less than a Building Standard Law act has the very high danger of collapse and it is because many victims by an earthquake are also generated by building collapse. In the damage situation of the southern Hyogo earthquake which occurred in Heisei 7, the dead (death from pressure and death in the flames) who consider collapse of a residence as a cause actually formed about 90 percent of the whole, and the most was the existing disqualified structure.

From this, in order to reduce the damage after an earthquake, it is recognized also from this thing that prior hard measures, such as antiseismic reinforcement of the existing disqualified structure, are required, and it becomes important to perform the antiseismic reinforcement of a residence immediately for that purpose.

Now, according to Headquarter of Earthquake Research Promotion, the Tonankai and Nankai earthquakes will be expected to happen at 80~90% in 50 years at 40~50% in 30 years from now on.

However, as the present condition of Kochi Prefecture, according to a residence and land investigation estimation, the rate of the formation of building earthquake-proof within the prefecture is about 60%, and is a level which is much less than 75% of the national average.

Moreover, since the support system to the antiseismic reinforcement which a local-goverment supports etc. is not utilized enough, it can observe that it is low in civic consciousness about the measure against antiseismic reinforcement.

As such a cause, there are dearth of information about earthquake resistant and the labor burden in procedure and antiseismic reinforcement is a big-ticket burden, even if it uses local government support system. It is thought that these have been obstacles.In order to overcome this present situation, examination of the prior measure system which reduces earthquake damage is important.

Antiseismic reinforcement promotion is prevention of not only mitigation of the death toll immediately after disaster but a road blockade, mitigation of the cost which disposal takes and a labor burden, the increase in the participant in initial support in a stricken area etc, and it leads also to mitigation of the expense concerning a makeshift house or housing reconstruction.

But, since the source of revenue which can be distributed to various measures is limited, it is necessary to specify the subject which should be tackled immediately for the time being, and to implement a measure efficiently. In the goverment, it aims at making the rate of antiseismic reinforcement of a building 90% by the Heisei 27 year as a statement of principles, and the measure planning support for attaining this serves as pressing need. Then, it set up on the theme of antiseismic reinforcement promotion of the existing disqualified structure for the purpose of "improvement in the rate of antiseismic reinforcement" of the whole country including Kochi Prefecture. And it aims at building the antiseismic reinforcement consciousness model as a policy evaluation tool for supporting the design of policy for it.

## 1. Introduction

### 1.1 Background and Aim

After the Hanshin-Awaji Earthquake (1995), Japan has entered the period of seismic activities. It is said that the probability of a big earthquake hitting anywhere from Hokkaido to Kyushu in the next 50 years is 90%. Moreover, unknown active faults exist all over Japan, therefore, an earthquake can occur anywhere and anytime.

One of the main reasons why massive damages occur during big earthquakes is due to the collapse of buildings. In the past, the Building Standard Law has been revised every time an earthquake occurs and the reason for this is because there is an extremely high possibility that buildings that do not meet the standard may collapse, and victims of earthquake are often victims due to the collapse of buildings. According to the data on due to the earthquake that occurred in the southern Hyogo prefecture in 1995, approximately 90 % of the deaths (due to fire or crushed to death) were due to the collapse of houses that did not meet the standard.

It has become widely recognized that in order to decrease the damages of the earthquake it is necessary to create policies prior to the earthquake such as anti-seismic reinforcement and that is it important to promote anti-seismic reinforcement of houses.

At present, according to the earthquake investigation by the research headquarters, it is predicted that the percentage of a Tonankai or Nankai earthquake to occur in the next 30 years is 40-50% and 80-90% in the next 50 years.

However, when considering the present situation of Kochi prefecture, according to the estimate by housing and land survey, the rate of anti-seismic reinforcement in Kochi prefecture is around 60%, which is much lower than the national average of 75%.

Moreover, people have not made practical use of subsidy for anti-seismic reinforcement supported by the local government, which indicates that people's consciousness toward measures for reinforcement is quite low. Some of the reasons for this include insufficient information toward anti-seismic reinforcement, the hassle of various procedures, as well as the amount of costs for reinforcement, since the average amount necessary for reinforcement is approximately 2.6 million yen and even with the subsidy from the local government approximately 2 million yen would need to be paid by the owner of the building. In order to resolve this situation, it is necessary to examine various policies through the paradigm shift that pre-disaster measures are more significant than post-disaster measures in order to decrease damages from earthquake.

By promoting anti-seismic reinforcement, not only will it decrease the number of deaths after disasters, but also prevent road closures and decrease the costs and burden of labor to clean it up, increase the number of participants for initial support at the site of the earthquake which may be effective in promoting early activities for restoration, as well as decrease the costs for temporary housing and reconstruction of houses.

However, it is necessary to implement policies effectively by specifying themes that are urgent at present since financial resources for various measures are limited. The basic guideline of the government is to raise the rate of anti-seismic reinforcement of buildings to 90% by the end of 2015, and the support to propose such measures to accomplish this goal has become an urgent task. This paper considers the theme of promoting anti-seismic reinforcement of buildings that currently do not meet the standard and aim to "improve the rate of anti-seismic reinforcement" in Japan including Kochi prefecture. Moreover, another objective is to construct an anti-seismic reinforcement consciousness model as a tool to evaluate policy for the support of policy proposal.

*Keywords: Anti-seismic reinforcement, Logic model, Quantitative model

1.2 Procedure

This study constructed a logic model of the structure of decision-making for not carrying out anti-seismic reinforcement, by structuralizing the issue of the low rate of anti-seismic reinforcement based on the "survey concerning the factors obstructing anti-seismic reinforcement" conducted by the Building Research Institute in 2006. Upon establishing the priority strategic goal for the study as improving the rate of anti-seismic reinforcement, a survey was conducted targeting the people of Kochi, in order to extract information on the elements to be included in the logic model. Next, the relationship model equation of the factors was defined based on the logic model, and a multiple regression analysis was conducted from the results obtained from the survey concerning independent and dependent variables including related elements, affiliation and environment and finally obtained a function for the logic model. Lastly, all the model equations were combined and a function for "execution of anti-seismic reinforcement" was constructed by the logistic curve.

As a result, we aim at supporting the design to spread an anti-seismic reinforcement policy in the future.

## 2. Structuralization of the problem and the logic model

Even if many people recognize the importance of anti-seismic reinforcement, the reinforcement itself will not be conducted if there are no policies to implement such measures. In order to promote the spread of anti-seismic reinforcement it is necessary to consider policies to support measures for the people.

Thus, in order to enforce anti-seismic reinforcement, the study extracted and classified the factors of obstacles from 2006 documents and materials from the Building Research Institute concerning the factors of obstruction that people felt as burden. Some of the examples of factors of obstruction include "I do not think that a big earthquake will occur where I live", "I am not sure of the effects of anti-seismic reinforcement", "The cost for reinforcement is expensive", "I cannot trust the construction workers", "The application procedure for subsidy is too much of a hassle". These various factors were classified to consider the relationship of each factor. Among them, we excluded factors that relate to affiliation (gender, age, income, structure, number of years that the building existed, etc), and constructed the logic model as indicated in Fig. 1. It will become possible to evaluate a policy appropriately and design policies rationally by constructing such logic model.

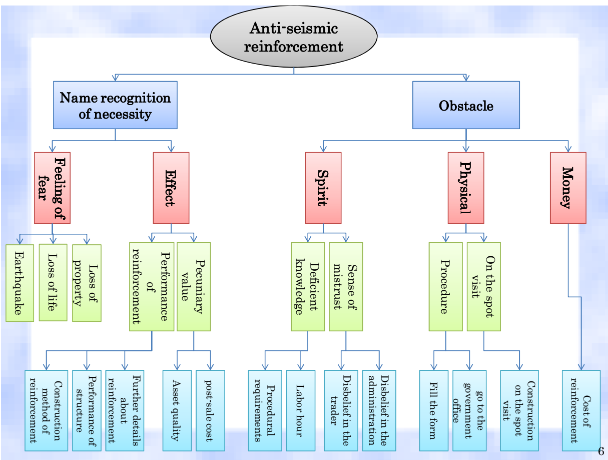


**Fig. 1 Logic model**

The following two logic model has been constructed: "name recognition of the necessity for reinforcement" as the main factor to decide whether people carry out anti-seismic reinforcement and "the impact of the obstacle that obstruct people from going through with anti-seismic reinforcement (even if they recognize the necessity of it" (hereinafter obstacles).

First, concerning the elements that make up the "name recognition of the necessity", after excluding factors such as affiliation and environment the following two elements, "name recognition of feeling of fear" and "name recognition of the effects" were established, using the examples of factors of obstruction from the 2006 materials of the Building Research Institute. Here, "feeling of fear" refers to the fear of an earthquake regardless of the frequency or size and the presumed loss of life and assets due to the occurrence of the earthquake. "Effect" refers to the effect of the efficiency of the reinforcement obtained from reinforcing the building against earthquake by anti-seismic reinforcement and monetary effect obtained from the decrease in fixing costs after the earthquake against presumed damages after the earthquake and the increase in property value due to anti-seismic reinforcement. Here, "affiliation" refers to gender, age, income, family members, number of years the building has existed and the structure of the building. Moreover, "environment" refers to the frequency of earthquake in different regions and whether the ground is firm or not.

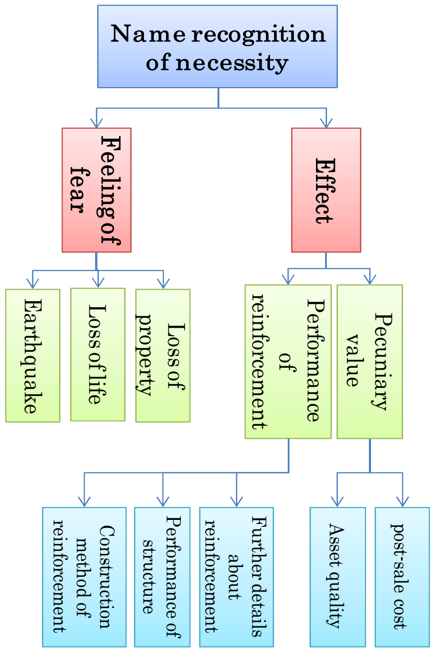


**Fig. 2 Logic model (name recognition of the necessity)**

Figure 2 shows the logic model for the part of "name recognition of necessity". The execution of anti-seismic reinforcement (=A) is decided by name recognition of necessity (=N) and the size of obstacles (=O) in executing the reinforcement. "Name recognition of necessity" is decided by the feeling of fear

(=F) toward the earthquake and the size of the effect (=E) by conducting anti-seismic reinforcement. We shall call the lower factors of feeling of fear as "name recognition of the fear of earthquake" (a), "name recognition of the fear of losing life" (b), "name recognition of the fear of losing one's asset" (c), and the lower factors of "feeling of effect" as "effect of the efficiency of reinforcement" (d), and "monetary factors" (e).

Next, the elements that make up "obstacles" consist of "spirit or mental", "physical" and "monetary or financial" obstacles. Here, "spirit or mental" obstacles refer to the resistance to antiseimsic reinforcement technology that which results from the guard against fraudulent construction workers and lack of knowledge. "Physical" obstacles refer to the physical burden such as the application procedure and keeping an eye on the construction. Moreover, "monetary" obstacles refer to obstacles concerning the burden of costs needed for anti-seismic reinforcement and diagnostic check.

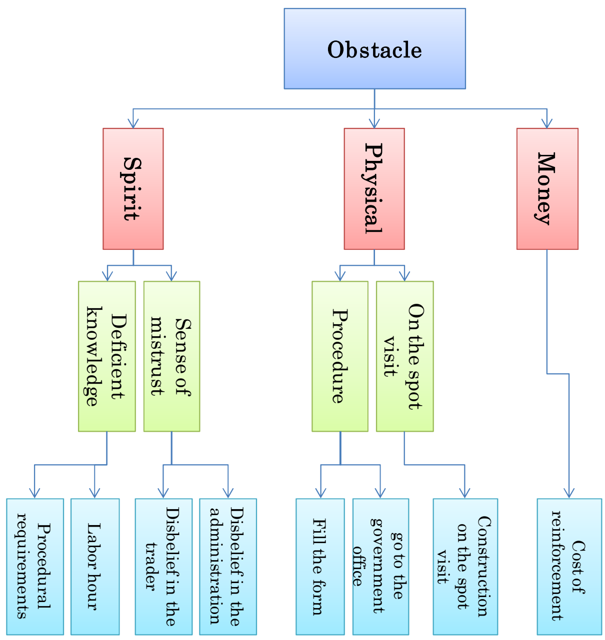


**Fig. 3 Logic model (obstacles)**

Fig. 3 shows the logic model for the part of "obstacles". "Obstacles" are decided by the spirit (=Sp) and physical (=Ph) obstacles, and the amount of monetary (=Mo) obstacles. The lower factors of spirit or mental obstacles are "lack of knowledge concerning construction and procedure" (f), "distrust toward construction workers and administration" (g), and the lower factors of physical obstacles are "procedure such as filling out application forms" (h) and "watching over the construction" (i).

## **3. Survey**

### 3.1 Objective of the survey

It was necessary to conduct a survey to verify the justification of the logic model constructed in Fig. 1 as well as quantify the strength and degree of the relationship among the various factors within the model.

In doing so, we composed a survey to investigate the influence of the name recognition of the necessity of "feeling of fear" and "effect" and "spirit or mental", "physical", and "monetary obstacles and what methods would be effective in developing the policies in the future.

Moreover, the aim of the survey was to consider what influence affiliation has on the consciousness toward anti-seismic reinforcement and changes in people's consciousness, by providing information on predicted damages of the earthquake that may occur in the future and policies concerning anti-seismic reinforcement which correspond to name recognition of necessity such as feeling of fear and effect and spirit or mental, physical and monetary obstacles, which makes it is possible to grasp the changes in the response results before and after providing the information.

### 3.2 Basic guideline of the survey

The response comprised of the following 5 level evaluation "extremely", "very strongly", "some what", "no so much", "not at all" for the question "do you distrust the administration and construction workers when going through with anti-seismic reinforcement?" Moreover, in order to measure the changes in individual's consciousness by providing information on policies concerning anti-seismic reinforcement

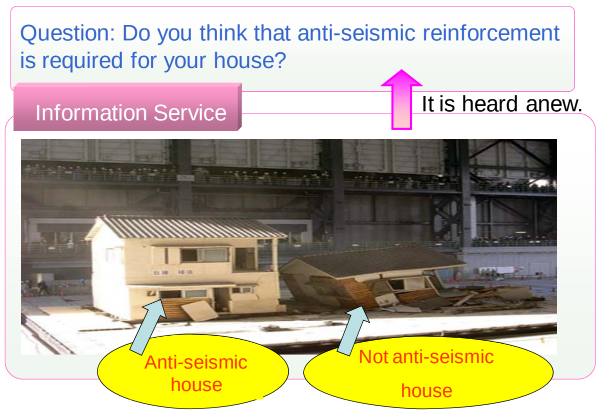

**Fig.4 Survey information (examples)**

After providing the information, the same question was asked again in the following question by stating "we would like to ask you again". The following information was also provided in the survey: "**the chances of Nankai earthquake occurring in Kochi and predicted damages**" in order to raise awareness of the fear against earthquake; **"efficiency that can be expected by carrying out anti-seismic reinforcement and exemption for fixed property tax"** in order to provide information on efficiency and monetary effects; **"flow chart of what is done for diagnostic check and reinforcement"** to provide information to resolve the lack of knowledge; referrals such as **"projects conducted and anti-seismic reinforcement information desk provided by the administration to prevent troubles such as fraudulent construction workers"** to provide information that resolves the distrust and anxiety; flow chart that illustrates the **"procedure for anti-seismic reinforcement and the necessity to watch over the construction work"**; and information on monetary support provided by the local government such as **"subsidy and investment policies"**.

3.3 Outline of conducting the survey

a) Subject of the survey

The subject of this survey was people who live in Kochi prefecture and own a house.

This survey was conducted in cooperation with people from the Kochi University of Technology and Citizen's Alliance for the Promotion of Community Planning.

b) Response rate

Citizen's Alliance for the Promotion of Community Planning: distributed 70, responses 39

Kochi University of Technology: distributed 70, responses 39

Total: distributed 140, responses 68

3.4 Survey results

a) Name recognition of necessity

Figure 5 shows the questions and results concerning name recognition of necessity (Q. 7, Q. 22).

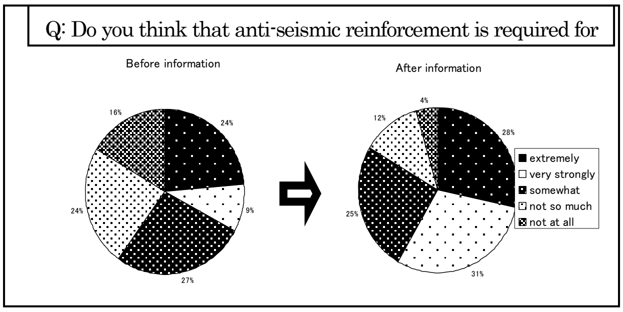


**Fig. 5 Response results**

As indicated in graph in Fig. 5, there was an improvement from 33% to 59% in people who think anti-seismic reinforcement is necessary among those who responded "extremely" and "very strongly" regarding the name recognition of necessity. We are able to see that the degree of recognition for the necessity of reinforcement improved by providing the necessary information. In other words, this implies that it is necessary to promote PR and education in order to raise awareness for the necessity of anti-seismic reinforcement. As illustrated in Fig. 6 and Fig. 7, we can expect the same positive effects in the stage below the awareness of the necessity by providing necessary information.

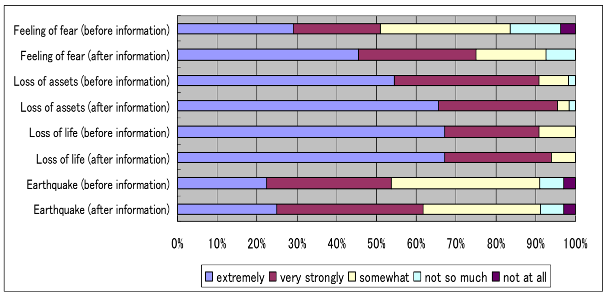


**Fig. 6 Feeling of fear-response results**

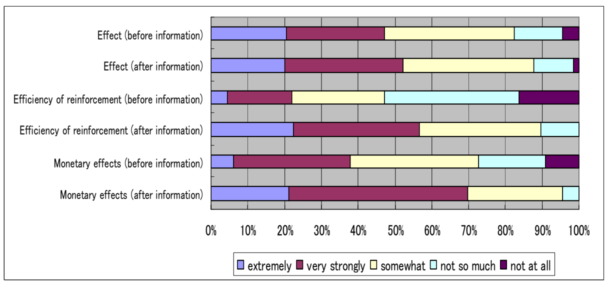


**Fig. 7 Effects- response results**

b) Obstacles

The response results for obstacles are illustrated in Fig. 8 and Fig. 9.

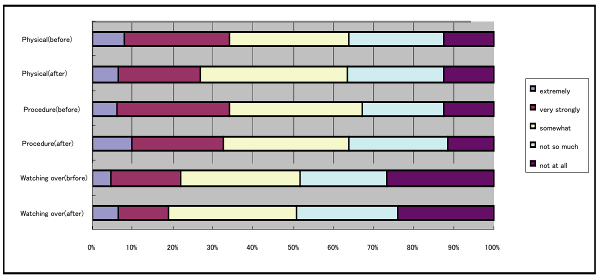


**Fig. 8 Mental obstacles-response results**

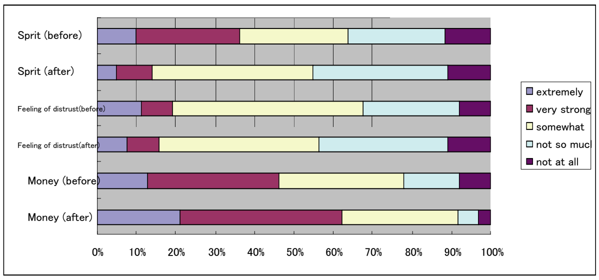


**Fig. 9 Physical obstacles-response results**

## 4. Construction of a quantitative model

### 4. 1 Method for quantification

In order to construct a quantitative model, a multiple regression analysis was conducted based on the results of the survey on "name recognition of necessity" and "obstacles". Next, the model for "consciousness regarding anti-seismic reinforcement" was constructed by combining the obtained results. Moreover, the necessity of the affiliation that may have influence was decided by using the t-value. The value used for affiliation was once again used after numbering them as 1.2.3. in order of those questions (whether one would like to go through with anti-seismic reinforcement) which consciousness had increased after providing information in the survey. Each of the model equation is defined as follows.

a) Constructing a model for the name recognition of necessity

As provided in Fig. 2, the name recognition of necessity is composed by feeling of fear and effect. The model equation is constructed by using multiple regression analysis and by substituting the result of the survey for equation 1. Table 1 shows the result of the multiple regression analysis.

$$N = \alpha_1 \times F + \beta_1 \times E + C \qquad \text{...Eq. 1}$$

( α□β□=parameter C=constant )

Table 1. Name recognition of necessity Regressive analysis results

**Before information**

| Regression analysis | | Coefficient | Standard error | t |
|---|---|---|---|---|
| Multiple correlation coefficient R | 0.72 | Intercept | −0.94 | 0.60 | −1.57 |
| Multiple decision R2 | 0.51 | Feelinng of fear | 0.30 | 0.12 | 2.47 |
| Correction R2 | 0.49 | Effect | 0.83 | 0.13 | 6.44 |
| Standard error | 0.97 | | | | |
| Number of observation | 51 | | | | |

**After information**

| Regression analysis | | Coefficient | Standard error | t |
|---|---|---|---|---|
| Multiple correlation coefficient R | 0.70 | Intercept | 1.56 | 0.52 | 3.03 |
| Multiple decision R2 | 0.49 | Feelinng of fear | −0.005 | 0.12 | −0.05 |
| Correction R2 | 0.46 | Effect | 0.59 | 0.09 | 6.47 |
| Standard error | 0.72 | | | | |
| Number of observation | 51 | | | | |

Equations 2 and 3 before and after providing information are possible when substituting the results of the multiple regression analysis by equation 1.

{before providing information}

$$N = 0.30 \times F + 0.83 \times E - 0.94$$

...Eq. 2

{after providing information}

$$N = -0.005 \times F + 0.59 \times E + 1.56 \qquad \text{...Eq. 3}$$

Discussion: The judgment of not considering the term F (=feeling of fear) can be justified in equation 3, because the coefficient of F (=feeling of fear) is at a low of -0.005 and the t-value at -0.05, and the term does not contribute to N (=need recognition of necessity). The following Table 2 is the result when only E(=effect) expressing N after providing information by only E(=effect).

Table 2. Result of the multiple regression analysis (only E)

Before providing information, there was support that our model that "name recognition of necessity" could be explained possibly by the following two "name recognition of feeling of fear" and name recognition of effect" was right. Moreover, after providing information, it was identified that the "name recognition of necessity" only depended on "name recognition of effect". At this time, one of our future works is to how to explain this fact.

a-1) Conceptualization of the model of feeling of fear

As illustrated in Fig. 2, feeling of fear is composed by earthquake, loss of life, loss of assets and affiliation. The model equation is constructed by using multiple regression analysis and by substituting the results of the survey for equation 4. Table 3 shows the result of the multiple regression analysis. (At) of equation 4 is the explanatory variable of the affiliation of those who responded to the survey. In the case that a sufficient model could not be constructed with only "earthquake", "loss of life", "loss of assets", an affiliation is selected and added as an explanatory variable.

$$F = \alpha_2 \times a + \beta_2 \times b + \gamma_2 \times c + (At) + C \quad \text{…Eq. 4}$$

( a =earthquake b =loss of life c =loss of asset )

At= affiliation α□β□γ□ =parameter

Table 3. Feeling of fear: Result of the multiple regression analysis

[redacted]

Equations 5 and 6 before and after providing information are possible when substituting the results of the multiple regression analysis by equation 4.

{before providing information}

$$F = 0.40 \times a + 0.32 \times b + 0.37 \times c - 0.71 \times \varepsilon - 0.57 \times \omega + 1 \quad \text{…Eq. 5}$$

{after providing information}

$$F = 0.25 \times a - 0.03 \times b + 0.68 \times c + 0.08 \quad \text{…Eq. 6}$$

( ε=gender ω=structure )

<u>Discussion:</u> In equation 5, initially a multiple regression of F (=feeling of fear) which was only explained by a (=earthquake), b (=loss of life), c (=loss of assets) was conducted; however a sufficient model could not be obtained as the coefficient of determination R2 was 0.36. Thus, the affiliation "gender (male=1, female=2)" and "structure (wood=1, RC=2, iron=3) were added. On the other hand, in equation 6 a sufficient R2 was obtained from a, b, and c.

Moreover, regarding the contribution rate of the following 3 explanatory variables a, b, and c, which was assumed at the stage of Fig. 2, each term of a, b, and c showed a fixed contribution before providing information, however, we observed that the contribution rate of b was extremely low after providing information.

Regarding the affiliation of the participants of the survey, it was necessary to add "gender" and "structure" before providing information, however, we were able to observe that the model assumed in Fig. 2 initially was valid after providing information. One of the reasons why "gender" and "structure" had a negative effect before providing information could be that women had less feeling of fear than men because they overestimated their house.

a-2) Conceptualization of the model for effect

As illustrated in Fig. 2, effect is composed by the efficiency of the reinforcement and monetary effect, and is analyzed by adding the affiliation which is assumed to have influence. The model equation is constructed by substituting the result of the survey for equation 7 and using multiple regression analysis. Table 4 shows the result of the multiple regression analysis. (At) in equation 7 is the explanatory variable concerning the affiliation of those who responded to the survey. In a case where a sufficient model could not be constructed with "efficiency of reinforcement" and "monetary effect", then an affiliation is selected and added as an explanatory variable.

$$E = \alpha_3 \times d + \beta_3 \times e \times (At) + C \quad \text{…Eq. 7}$$

d( = efficiency of reinforcement e = monetary effect、)

α□β□ =parameter

Table 4 Effect Result of the multiple regression analysis

[redacted]

Equations 8 and 9 are possible before and after information when substituting the results of the multiple regression analysis by equation 7.

{before providing information}

$$E = 0.19 \times d + 0.13 \times e + 0.23 \times \theta - 0.36 \times \omega + 1.43 \ldots \text{式} 8$$

{after providing information}

$$E = 0.53 \times d + 0.24 \times e + 0.09 \times \theta + 0.28 \quad \ldots \text{式} 9$$

[ ω=structure

θ=number of years that the building has existed ]

Discussion: In equation 8, initially a multiple regression of E (=effect) which was only explained by d (=efficiency of reinforcement), b (=monetary effect) was conducted; however a sufficient model could not be obtained as the coefficient of determination R2 was 0.12. Thus, the affiliation "structure" and "number of years that the building existed" were added. On the other hand, after providing information, "structure" was eliminated and d, e and the number of years the building existed remained as a result of the finding explanatory variables that would give a high R2. This reflects that the longer the building has existed the effect of anti-seismic reinforcement could be acknowledged, which is an extremely rational results. Moreover, the coefficient of determination increased from 0.68 to 0.78 after providing information, and recognition structure of effect of those who responded to the survey became more evident.

b) Conceptualization of the model of obstacle

As illustrated in Fig. 3, obstacle is composed by spirit, physical and monetary obstacles. The model equation is constructed by using the multiple regression analysis and by substituting the values of the results of the survey for equations 10, 11, and 12. Table 5 shows the result of the multiple regression analysis.

Obstacle (O) $= \alpha_1 *$ Spirit (Sp) $+ \beta_1 *$ physical (Ph) $+ \lambda_1 *$ monetary (Mo) $+ \gamma_1$ …Eq. 10

Spirit (Sp) $= \alpha_2 *$ lack of information (f) $+ \beta_2 *$ distrust(g) $+ \gamma_2$ …Eq. 11

Physical (Ph) $= \alpha_3 *$ procedure (h) $+ \beta_3 *$ watching over the construction (i) $+ \gamma_3$

※$\alpha_1 \sim \gamma_1$ $\lambda_1$ parameter …Eq. 12

**<u>Conceptualization of the model for obstacle (O)</u>**

Response variable: bstacle(0)

Explanatory variables: Spirit (Sp, Physical (Ph), Monetary (Mo)

Model equation: Obstacle (O) $= \alpha_1$ Spirit (Sp) $+ \beta_1$ Physical (Ph) $+ \gamma_1$ Monetary (Mo) $+ C_1$

<Before providing information>

Obstacle (O) $= 0.151 * (Sp) + 0.152 * (Ph) + \underline{0.209 * (Mo)} - 0.425 * \varepsilon + 1.923$

<After providing information>

Obstacle (O) $= 0.271 * (Sp) + 0.141 * (Ph) + \underline{0.4 * (Mo)} + 0.159 * \varepsilon + 0.069$

**Table 5**

| | Regression analysis | | | Coefficient | Standard error | t |
|---|---|---|---|---|---|---|
| Before Information | Multiple correlation coefficient R | 0.555 | Intercept | 1.923 | 0.557 | 3.450 |
| | Multiple decision R2 | 0.308 | Spirit | 0.151 | 0.105 | 1.442 |
| | Correction R2 | 0.251 | Physical | 0.152 | 0.105 | 1.450 |
| | Standard error | 0.757 | Money | 0.209 | 0.105 | 1.997 |
| | Number of observation | 53 | Gender | -0.425 | 0.219 | -1.946 |
| After Information | Regression analysis | | | Coefficient | Standard error | t |
| | Multiple correlation coefficient R | 0.667 | Intercept | 0.069 | 0.503 | 0.137 |
| | Multiple decision R2 | 0.445 | Spirit | 0.271 | 0.116 | 2.334 |
| | Correction R2 | 0.398 | Physical | 0.141 | 0.098 | 1.439 |
| | Standard error | 0.674 | Money | 0.400 | 0.113 | 3.540 |
| | Number of observation | 53 | Gender | 0.159 | 0.195 | 0.818 |

<Before providing information>

Obstacle (O) $= 0.151 * (Sp) + 0.152 * (Ph) + \underline{0.209 * (Mo)} - 0.425 * \varepsilon + 1.923$

<After providing information>

Obstacle (O) $= 0.271 * (Sp) + 0.141 * (Ph) + \underline{0.4 * (Mo)} + 0.159 * \varepsilon + 0.069$

**<u>(Discussion)</u>**

A sufficient coefficient of determination could not be obtained with the model equation that was first defined; therefore, a multiple regression was conducted by including the affiliation "gender". However, the coefficient of determination before providing information was 0.308 and after providing information was 0.445 which was not sufficient but the best value obtained. Moreover, the contribution rate of money was higher than any other element, and Table 1 shows that increase after providing information.

b-1) **<u>Conceptualization of the model for spirit or mental obstacle (Sp)</u>**

Response variable: Spirit (Sp)

Explanatory variables: Lack of information (f), Distrust (g)

Model equation: $\alpha_2$ *Lack of information (f)+$\beta_2$ * distrust (g)+$\gamma_2$

＜Before providing information＞

Spirit (Sp)=0.0789＊ (f)+0.8303＊(g)+0.3065

＜After providing information＞

Spirit (Sp)＝0.0852＊ (f)+0.8146＊(g)+0.099

**Table 6**

| | Regression analysis | | | Coefficient | Standard error | t |
|---|---|---|---|---|---|---|
| Before Information | Multiple correlation coefficient R | 0.770 | Intercept | 0.3065 | 0.3718 | 0.824 |
| | Multiple decision R2 | 0.593 | lack of knowledge | 0.0789 | 0.0823 | 0.958 |
| | Correction R2 | 0.580 | feeling of distrust | 0.8303 | 0.0929 | 8.935 |
| | Standard error | 0.749 | | | | |
| | Number of observation | 65 | | | | |
| | Regression analysis | | | Coefficient | Standard error | t |
| After Information | Multiple correlation coefficient R | 0.884 | Intercept | 0.099 | 0.236 | 0.422 |
| | Multiple decision R2 | 0.781 | lack of knowledge | 0.085 | 0.0468 | 1.821 |
| | Correction R2 | 0.774 | feeling of distrust | 0.814 | 0.0552 | 14.76 |
| | Standard error | 0.436 | | | | |
| | Number of observation | 65 | | | | |

＜Before providing information＞

Spirit (Sp)＝0.0789＊ (f)＋0.8303＊ (g)＋0.3065

＜After providing information＞

Spirit (Sp)＝0.0852＊ (f) +0.8146＊ (g) +0.099

**<u>(Discussion)</u>**

The result of the analysis shows that the coefficient of determination of distrust showed a bigger contribution rate than lack of information. Moreover, the coefficient of determination of regression analysis after providing information was higher than before providing information.

b-2) **<u>Conceptualization of the model for physical obstacle (Ph)</u>**

Response variable: Physical (Ph)

Explanatory variables: procedures （h）, watching over construction （i）

Definition equation: $\alpha_3$ *procedures （h） ＋$\beta_3$ * watching over construction （i） ＋$\gamma_3$

**Table 7**

| | Regression analysis | | | Coefficient | Standard error | t |
|---|---|---|---|---|---|---|
| Before Information | Multiple correlation coefficient R | 0.825 | | | | |
| | Multiple decision R2 | 0.680 | Intercept | 0.443 | 0.231 | 1.915 |
| | Correction R2 | 0.670 | procedure | 0.718 | 0.090 | 8.006 |
| | Standard error | 0.641 | watching over construction | 0.165 | 0.083 | 1.992 |
| | Number of observation | 66 | | | | |
| | Regression analysis | | | Coefficient | Standard error | t |
| After Information | Multiple correlation coefficient R | 0.819 | | | | |
| | Multiple decision R2 | 0.671 | Intercept | 0.528 | 0.223 | 2.364 |
| | Correction R2 | 0.661 | lack of knowledge | 0.620 | 0.097 | 6.392 |
| | Standard error | 0.630 | watching over construction | 0.207 | 0.097 | 2.140 |
| | Number of observation | 66 | | | | |

＜Before providing information＞

Physical (Ph)=0.718＊ (h)＋0.165＊(I)＋0.443

＜After providing information＞

Physical (Ph)=0.528＊(h)＋0.207＊(I) +0.528

**<u>(Discussion)</u>**

It is clear that the contribution rate of procedures is bigger than watching over construction.

c) **<u>[Conceptualization of the model for [execution of anti-seismic reinforcement]</u>**

Lastly, a function to obtain the [execution of anti-seismic reinforcement] was constructed based on the results of the multiple regression model. The model equation is defined as follows.

$$A=(N-O) \quad \cdots \text{Eq. } 13$$

$$N-O(\%)=(F+E)-(Sp+Ph+Mo) \quad \cdots \text{Eq. } 14$$

$$20\% \le N=(F+E)\times 10 \le 100\% \quad \cdots \text{Eq. } 15$$

$$20\% \le O=(Sp+Ph+Mo)\times 100/15 \le 100\% \quad \cdots \text{Eq. } 16$$

A ＝ Antiseismic reinforcement　O ＝ Obstacle
F=Feeling of fear
E=Effect　N=Name recognition of necessity
Ｓｐ＝Spirit　Ｐｈ＝Physical　Ｍｏ＝Money

Estimated values of the higher goals of obstacle (O) and the name recognition of necessity (N) were calculated from the model equations, and the [execution rate of anti-seismic reinforcement] was obtained after subtracting obstacles (O) from name recognition of necessity (N). The model equation of equation 13 was defined because anti-seismic reinforcement was not carried out if there was an obstacle even if people recognized the necessity of anti-seismic reinforcement. Moreover, the value of the % here is the conversion of the 5-level evaluation. Furthermore, in order to set the maximum as 100%, an appropriate value was multiplied to each value and equations 15 and 16 were obtained.

Next, the following distribution illustrated in Fig. 10 was obtained by extracting and accumulating the people who “execute anti-seismic reinforcement” from the results of the survey and extracting the rate from the total and the value of A (=rate of anti-seismic reinforcement) (%) of that rate. After, as a result of applying the non-linear least squares curve to the logistic curve, the following approximation of equation 17 was obtained. Figure 10 shows the actual measurement value and logic curve. The value of a (%) is expressed on the horizontal axis and the rate of people who responded that they would carry out the anti-seismic reinforcement (%) is expressed on the vertical axis.

$$y = \frac{55.25}{1 + 5.65 \times \exp^{-0.09x}} \qquad \cdots \text{Eq. 17}$$

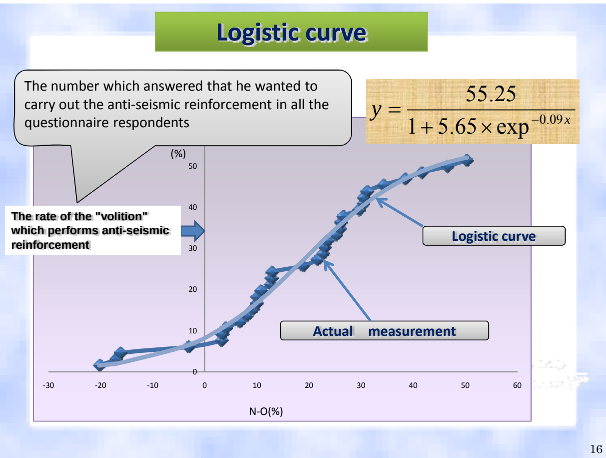


**Fig. 10 Logistic curve**

## 5. Conclusion

This study constructed the structuralization of consciousness and the logic model concerning the name recognition of necessity as factors that obstruct the spread of anti-seismic reinforcement. Moreover, the study also made it possible to quantitatively measure the effect of each policy for the promotion of anti-seismic reinforcement by identifying the degree of which the variables affiliation and environment should be introduced to each factors, especially the change in structure after providing information.

For future works, based on the results of this study and after confirming the universality of the logic model, we would like to conduct similar survey in all prefectures around Japan and evaluate policy set for promotion of the spread of anti-seismic reinforcement and finally conduct policy proposals, jointly with the Building Research Institute.

## References


1) Building Research Institute: *Survey concerning the factors that obstruct the spread of anti-seismic reinforcement*, 2006.

2) “Laws concerning the promotion of anti-seismic reinforcement on buildings” based on the promotion and implementation plan on existing buildings, Koichi version, Department of public works of Kochi prefecture