

Basic Residential Earthquake Insurance and Criteria of Total Loss Claims for Reinforced Concrete Structures

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Abstract- A basic earthquake insurance policy associated with total loss coverage has been implemented in Taiwan to transfer risk caused by devastating earthquake. Acceptance of such an insurance claim depends on two criteria. One is that a building is identified as uninhabitable and required rebuilding. The other is that the repair to replacement cost ratio of a building exceeds 50%. Whether the first criterion is met or not depends on the building damage state which can be determined through a damage rating system based on post-earthquake damage inspection on structural components and system. However, the second criterion has not been implemented for an adjuster to follow without detail financial loss estimation by specialized engineers. Besides, there is no reference to show that these two criteria are consistent. This paper aims to link post-earthquake damage of structural components and direct financial loss for RC residential buildings based on post-earthquake damage evidence. As a result, the second acceptance criterion can be implemented. The statistical analysis shows that the two criteria are consistent in average. A new assessment procedure by incorporating criteria in terms of both damage and direct financial loss has been introduced. With this loss model, half loss coverage or partial loss coverage could be introduced into the basic earthquake insurance in this region.

Keywords- Residential Earthquake Insurance; Earthquake; Total Loss Claims Identification; Reinforced Concrete Structure; Underwriters

I. INTRODUCTION

The recent earthquakes in many countries have caused serious loss in lives and property. Many areas have wide-ranging damages, and the restorations are immense in scale. The difficulty in acquiring funding affects the subsequent reconstructions. Taiwan, in particular, is located along the Circum-Pacific seismic zone and was affected by the collision between Eurasian plate and Philippine plate. Earthquake activities are frequent, which threaten Taiwanese people at all times. The 921 Chi-Chi earthquake devastated central Taiwan in 1999, and the memory is still fresh. In addition to meeting the earthquake specifications and implementing strict quality control during construction, structural safety needs to take into account risks in future earthquakes. Further, in order to control earthquake risk, earthquake insurance is one of the methods to transfer financial impact [1].

In order to reduce risk, Taiwan's government has actively promoted basic residential earthquake insurance since the 921 earthquake, hoping to manage the risks by transferring them to earthquake insurance. Taiwan Residential Earthquake Insurance Program (TREIP) has been created by the Ministry of Finance (MOF) as part of the implementation of a comprehensive disaster prevention and risk management program. Within the insurance act, Taiwan Residential Earthquake Insurance Fund (TREIF) was established to facilitate a risk sharing mechanism between insurance companies and the government to cover insured residential earthquake loss. TREIF is responsible for the basic earthquake insurance of residential buildings.

According to the current basic residential earthquake insurance policy, residential buildings that have collapsed or are severely damaged as a direct result of earthquakes may apply for claims identification to reduce property loss. However, when processing such claims, the underwriters need to have qualified adjusters to carry out damage assessment. Effective and simple approaches are required for the adjusters to assess damages. Whether the assessment process is convenient and expedient as well as whether the outcome is reasonable and accurate will directly affect the effectiveness of the entire claims operation and beneficiary's rights. This paper will first introduce Taiwan's residential earthquake insurance system, followed by the operational process of total loss claims for earthquake insurance. RC buildings are targeted to further illustrate the damage determination criteria and assessment workflow created by Sinotech Consultants, Inc. to aid the Residential Earthquake Insurance Fund (hereafter referred to as the Fund). Finally, actual cases are used to illustrate that the assessment methodology of adopting damage factor or the ratio between repair cost and redeployment cost can reflect the extent of damage more reasonably than the existing methods.

II. TAIWAN'S RESIDENTIAL EARTHQUAKE INSURANCE SYSTEM

The 921 Chi-Chi earthquake caused the most devastating loss in lives and property in hundred years. According to statistics, 2445 were dead with 11305 injured, 38935 buildings collapsed, and 45320 partially collapsed. Countless other public buildings

were damaged. It is estimated that the national economic loss reached NT\$360 billion [2]. This earthquake reminds Taiwanese people the impact of earthquake as well as the importance of earthquake management. We began to study in depth the various management measures and construct earthquake insurance system. The government took the residential earthquake insurance systems in Japan and California as well as society's consensus into consideration and quickly amended the clause 138-1 of Insurance Act which incorporated the requirement that insurance industry must have earthquake insurance as well as the risk sharing mechanism. This became the foundation of Taiwan's residential earthquake insurance system.

Basic residential earthquake insurance began to be covered since April 2002 under residential fire insurance policy. In other words, insuring residential fire insurance will automatically be insured for earthquake. The duration is for one year, and the dollar amount of each insured item uses the reconstruction cost of the building as the calculation basis (number of unit areas multiplied by building cost per unit area; please refer to Residential Building Cost Reference Table in Taiwan Area by the Non-Life Insurance Association). The maximum amount insured per building is NT\$1 million, with the entire nation adopting the same rate. Currently, the annual premium for each insured item is NT\$1,350. In terms of risk sharing, Taiwan's residential earthquake insurance adopts a multi-tier risk sharing mechanism. The first tier consists of Taiwan's insurance industry which collectively assumes a part of the residential earthquake risk. The other part is then assumed by the second tier, which is reinsured by the reinsurance companies both in Taiwan and abroad. Because the earthquake loss may very well exceed the maximum financial capability of the insurance and reinsurance industries, the managing authorities are required to establish a risk assumption mechanism. Hence, the Implementation of Residential Earthquake Collective Insurance and Risk Sharing Mechanism was revised on November 26th, 2007 to Implementation of Residential Earthquake Insurance Risk Distribution Mechanism [3]. According to the amended Implementation, each non-life insurance company needs to give all of its residential earthquake insurance businesses to the Earthquake Insurance Fund which assumes and then distributes all the risk. The assumption ceiling is currently around NT\$70 billion for residential earthquake insurance. The assumption ceiling is calculated based on the insured dollar amount of each earthquake. If the total amount payable for insured loss exceeds the limit of total amount from each tier, the amount paid to the beneficiary will be reduced proportionally. Currently, earthquakes are defined as the same event if more than 2 earthquakes take place within consecutive 168 hours.

The current residential earthquake insurance policy covers total loss or inferred total loss by fire, explosion, avalanche, subsidence, sliding, crack, and dam break brought by earthquake as well as tsunami, high tide, and flood caused by earthquake. Inferred total loss includes: being notified of demolition, ordered for demolition, directly demolished, or determined by assessing personnel qualified by the Fund, condemned by architects association, structured, civil, and geotechnical engineers association, or uninhabitable with rebuilding cost exceeding 50%. Once the insured residence is deemed to meet the total loss claims criteria, the underwriters will pay the insured amount. Therefore, total loss claims standard affects the insured parties greatly.

III. TOTAL LOSS CLAIMS PROCESSING OPERATION

After the earthquake, the beneficiary may apply for claims at the underwriters, residential earthquake insurance fund, or the centralized disaster area claims processing centers. Total loss claims determination is assessed by the qualified assessing personnel at the underwriters based on the damage assessment form. When this method cannot determine or the beneficiary reject the assessment, earthquake insurance fund will either convene a re-assessment council or commission professional engineers to carry out the assessment. If the beneficiary still refuses the new assessment, litigation or arbitration may be possible [4], as shown in Figure 1.

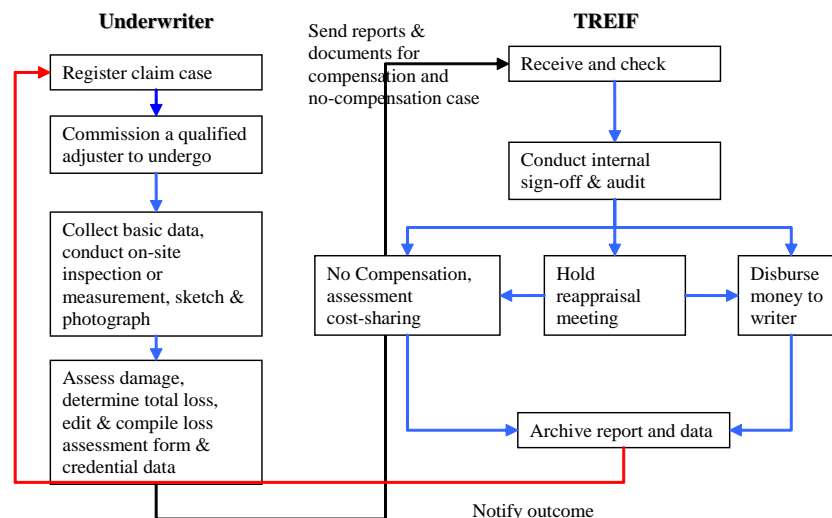


Fig. 1 Residential earthquake insurance claims processing workflow

Qualified adjusters are defined as qualified insurance personnel who have participated in residential earthquake insurance's assessment training programs for damaged buildings and do not necessarily have professional trainings in civil or structural engineering. The total loss assessment methodology is primarily based on the damage assessment form and standard set by earthquake insurance fund. For more complex damages, professional assessment by engineers is still preferred.

IV. DAMAGE EXTENT ASSESSMENT AND DETERMINATION STANDARD

According to policy terms, the current claims criteria are “uninhabitable and required to be demolished and re-built, or required to be re-paired to be habitable, and the repair costs more than 50% of rebuilding cost.” The assessment uses assessment form. However, the Fund's original insurance damage assessment form was set forth in accordance with the 2003 “Post-Earthquake Condemned Building Emergency Assessment Operation Standard” and was amended by the Tai-Nei-Yin 0960803884 order issued by the Ministry of the Interior [5]. The red label selection merely indicates structural damage with safety concerns, but the building has not completely collapsed. In addition, using post-earthquake on-site survey to assess the damage extent of overall structures and the components can not clearly correlate with the repair cost. The assessment form is based on whether the overall building structure has toppled over or collapsed, the damage extent of structure-related categories, as well as geotechnical damages, etc. Selections serve as the basis for claims processing, but the extent of damage can not be defined objectively. Moreover, a building deemed “uninhabitable” by the selections and needed to be paid may not meet the requirement of “being uninhabitable without repair which is more than 50% of re-building cost”. The validity of current claims criteria is also questioned.

According to the policy statistics between 1~11/2007 from earthquake insurance fund's database listed in Table 1 [6], reinforced concrete structures consist 76.66% and are the most numerous, followed by steel concrete or steel reinforced concrete and reinforced bricks.

TABLE 1 RESIDENTIAL EARTHQUAKE INSURANCE POLICY FOR BUILDING TYPES

Building Types	Policy Number	Proportion
Reinforced Concrete	1,399,400	76.66%
Steel or Steel Reinforced Concrete	188,556	10.33%
Reinforced Bricks	168,050	9.21%
Bricks	13,666	0.70%
Metal	1,545	0.08%
Wood	1,337	0.07%
Stone	63	0.00%
Others	52,924	2.90%

Because RC buildings consist 3/4 of all policies, Sinotech Consultants, Inc. assisted the Fund to create a basic insurance total loss claims determination standard for residential earthquakes in 2008. Through establishing correlation between structural damage and building's damage extent, a quantified total loss claims determination standard is set forth and is incorporated into the Residential Earthquake Insurance Building Damage Assessment Form. Qualified adjusters may determine whether the damage to RC buildings meet the criteria for claims based on the Residential Earthquake Insurance Building Damage Assessment Form and the claims assessment and determination standard illustrated in Figure 2. After the affected households applied for claims, qualified adjusters need to first conduct actual on-site survey and collect relevant damage data to carry out damage assessment. Subsequently, the claims are then either determined via assessment results or submitted to the re-assessment meeting. The workflow for total loss claims assessment and determination includes: on-site survey and investigation, damage assessment, and claims determination.

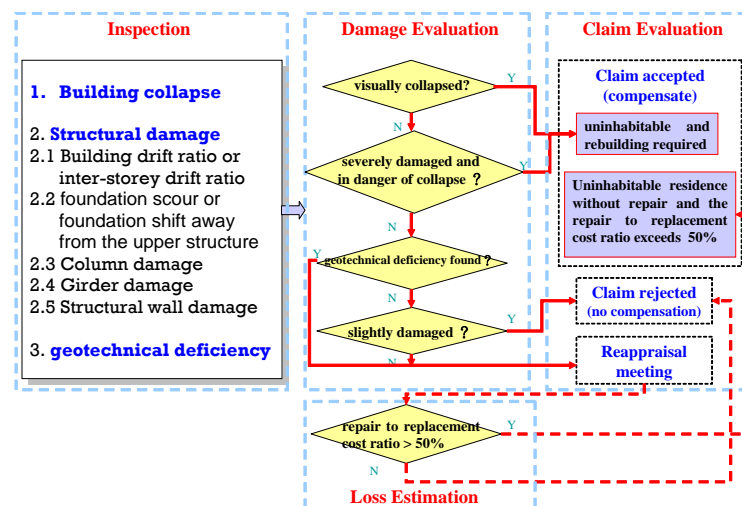


Fig. 2 Total loss claims assessment workflow for RC buildings

The on-site survey can be further classified into determinations in aspects of overall structural toppling over or collapse, structural damage, and geotechnical damage. Of those, geotechnical damage needs to be assessed in detail by professional engineers in the re-assessment council. When eyeballing can determine that the structure has clearly collapsed, the claim is payable because it is “uninhabitable and needs to be demolished and rebuilt”. Otherwise, the determination needs to be made based on the state of structural damage via the following:

(1) Based on structural deformation. 1/3 of the tilt rate of any floor is used to determine whether it meets the criterion of being “uninhabitable and required to be demolished and rebuilt”. Considering the difficulty in carrying out on individual floors, overall tilt rate of the building may be conservatively adopted. However, tilting as a result of geotechnical impact that needs to be submitted to the reassessment council should be excluded.

(2) Based on the damage factor (DF) that corresponds to damage level (DL) of structural component of each floor. Weighted combination gives the story damage factor (SDF) of each story. The maximum value is taken to be the SDF. SDF provided by the assessment form is correlated to story repair cost ratio (SRCR) to give SRCR as the basis for the determination criterion of “repair cost exceeding 50% of the rebuilding cost”. Considering SRCR claims determination criteria are based on case statistics, when $40\% \leq \text{SRCR} \leq 50\%$, the reassessment meeting's professional engineers will conduct detailed assessment. Calculation steps of the newly created Residential Earthquake Insurance Building Damage Assessment Form [7] based on SRCR is given in the following:

Step 1: Calculating the SDF_i of each story

$$\frac{w_C \frac{\sum_{i=1}^{n_C} DF_{C,i}}{n_C} + w_B \frac{\sum_{i=1}^{n_B} DF_{B,i}}{n_B} + w_W \frac{\sum_{i=1}^{n_W} DF_{W,i}}{n_W}}{w_C + w_B + w_W} \quad (1)$$

Note: 1. C = Column, B = Beam, W = Wall

2. In the determination and assessment for total loss, SDF calculation assumes $w_C = 1$, $w_B = 1$, $w_W = 1$, and

$$w_C \frac{\sum_{i=1}^{n_C} DF_{C,i}}{n_C} = \frac{0.1 \times C_I + 0.2 \times C_{II} + 0.3 \times C_{III} + 0.65 \times C_{IV} + C_V}{n_C} \quad (2)$$

$$w_B \frac{\sum_{i=1}^{n_B} DF_{B,i}}{n_B} = \frac{0.1 \times B_I + 0.2 \times B_{II} + 0.3 \times B_{III} + 0.65 \times B_{IV} + B_V}{n_B} \quad (3)$$

$$w_W \frac{\sum_{i=1}^{n_W} DF_{W,i}}{n_W} = \frac{0.1 \times W_I + 0.2 \times W_{II} + 0.3 \times W_{III} + 0.65 \times W_{IV} + W_V}{n_W} \quad (4)$$

i represents the i -th floor.

n_C , n_B , and n_W represent the total number of column and beam components as well as the total length of wall components in meter on that floor.

C_I , C_{II} , C_{III} , C_{IV} and C_V represent the numbers of columns damages at the levels I, II, III, IV, and V.

B_I , B_{II} , B_{III} , B_{IV} and B_V represent the numbers of beams damaged at the levels I, II, III, IV, and V.

Whereas W_I , W_{II} , W_{III} , W_{IV} and W_V represent total length of walls damaged at the levels I, II, III, IV, and, V on that floor.

In Equations (2)~(4), the value in front of the number of damaged components represent the damage factor (DF) that corresponds to damage level (DL).

Step 2: Take the greatest SDF_i as the SDF , and when $SDF > 0.4$, the damage is severe. The ratio between repair cost and rebuilding cost is entered as “greater than 85%”, or

Step 3: According to SDF calculation,

$$\text{SRCR (\%)} = -5.2171 \times SDF^2 + 4.2401 \times SDF - 0.051 \quad (5)$$

Moreover, the Fund is advised to make the following adjustments to claims processing workflow for earthquake stricken areas:

- Without the yellow or red label, the damage is slight and will not be compensated. If the insured party does not accept the assessment, litigation and arbitration are available.
- With the yellow or red label as well as a detailed assessment, if the detailed assessment deems it to be vulnerable to collapse, compensation will be made. Otherwise, the survey data of damage extent of its structural component will be taken into consideration to conduct determination based on the recommended damage assessment method.
- Regarding claims determination and assessment for RC collective residence, it can consider taking the greater amount between the policy's covered dollar amount and the repair/rebuilding cost of the entire building for claim processing. When the entire building is considered as the unit, the difficulty in inspecting every component structure should also be considered. For damaged floors that can be determined by eyeballing, only the columns, beams, and structural walls are allowed for inspection to assess damage. When the insurance coverage is taken as the unit, $DL \sim DF$ correlation stays the same for the DL component damage level classification, and the calculation for local damage factor is identical to the calculation of SDF using the assessment form. The correlation between LDF and the local repair cost ratio ($LRCR$) should be similar to the correlation between $SDF \sim SRCR$.

V. CASE STUDIES

The coefficient of the equation for quantified standard of RC buildings was acquired from regression analysis via the case data from the nest-building project for the households affected by the 921 earthquake. To test its validity, below adopts the building damage determination cases after the 331 earthquake in 2002 to carry out total loss claims determination to see if it matches the result of claims determination. This damage determination case was applied for by a construction company to Taipei Professional Civil Engineers Association (TPCEA), which was not a post-earthquake emergency determination case mobilized by local government. Therefore, the emergency determination form by the Construction and Planning Agency was not used. Instead, the determination handbook by TPCEA (TPCEA Determination Handbook Editing Committee, 1994) and the determination handbook for building constructions in Taipei City that may endanger neighbouring buildings [8] were used as reference. The basic information and determination results are as follows:

- (1) Building location: New Taipei City
- (2) Building structure: 1 level underground, 7 levels aboveground, reinforced concrete building
- (3) Date completed: 1995
- (4) Determination date: May 2002
- (5) Damage condition: building's maximum tilt rate is 1/111. 1F has the worst damage and is the weak layer; it has 16 supporting columns, 30 supporting beams, and 15m long structural wall. 8 of the arcade's columns as well as columns along the two sides of the stair are severely damaged. The reinforcing steel at the top is deformed, and concrete burst at the top with possible shear burst in the centre. All are level V damage. The beams and structural wall on 1F have no damage. The other damages are non-structural wall damages. The basement is slightly damaged. A few beams and columns have slight-to-medium damages on 2F. No structural damage on 3F. Please see Figure 3 for column damages on 1F.



Fig. 3 Photo of building damage from the case study

- (6) The result of TPCEA's determination: half of the columns on 1F are badly damaged and need to be removed and then rebuilt.

Below performs total loss claims determination with the Fund's original insurance damage assessment form and the damage assessment form after the quantified standards were amended. Claims assessment and determination were undertaken based on the Fund's original assessment form:

- (1) The building overall did not topple over, and there was no effect from geotechnical damage;
- (2) The maximum tilt rate $1/111 < 1/60 \rightarrow$ slight;
- (3) Foundation was not separated, derailed, or eroded from the upper structures;
- (4) Number of columns with V level damages $8/16 = 50\% > 20\% \rightarrow$ serious;
- (5) Beams and structural wall were not damaged \rightarrow slight;
- (6) Determination result does not satisfy the criterion "uninhabitable and required to be demolished and rebuilt" and is in the gray area between the criteria "not compensated" and "uninhabitable and required to be demolished and rebuilt". It needs to undergo determination by the reassessment council to decide whether its repair cost/rebuilding cost $> 50\%$.

Claims assessment and determination based on the damage assessment form after the quantified standard is amended:

- (1) No overall building toppling over or effect from geotechnical damage can be seen visually;
- (2) Building's maximum tilt rate was $1/111 < 1/30$, and the repair cost/rebuilding cost ratio needs to be assessed by the damage extent of structural components;
- (3) 1F had the worst damage of all floors. Of the 16 columns, 8 had damages at level V. The other columns, beams, and structural wall components had no damage;
- (4) $54.65\% > 50\% \rightarrow$ compensate.

If this case was assessed and determined based on the Fund's original assessment form, the damage determined would be between "not compensated" and "uninhabitable and required to be demolished and rebuilt". It would need to go through the reassessment council to have professional engineers calculating the repair cost/rebuilding cost ratio in detail. In addition, assessment and determination calculations were made based on the damage assessment form after the quantified standard was amended, and $SRCR = 54.65\% > 50\%$ was reached, meeting the criterion for claims. This agrees with the conclusion of TPCEA's assessment report that it must be demolished and rebuilt. This also proves that quantified claims standard can more reasonably and accurately reflect the extent of the damage.

VI. CONCLUDING REMARKS

This paper illustrates the current state of residential earthquake insurance and total loss claims determination from the institution, implementation, and technical perspectives. When assessing damage, marking selections should be replaced with quantified damage factor which corresponds to repair cost/rebuilding cost ratio. This ratio should be used to determine whether the criterion "repair cost/rebuilding cost being greater than 50%" is met. Visual identification of collapse or deflection ratio of the lateral movements from structural damage should be used to determine whether the criterion "uninhabitable and required to be demolished and rebuilt" is met. The claims assessment and determination module raised by this paper include on-site survey, damage and loss assessment, as well as claims determination. On-site survey primarily consists of visual determination aided by simple tools to investigate structural toppling over or collapse, structural damage, and geotechnical damage. If it can be visually determined that the overall structure has clearly toppled over or collapsed, the criterion "uninhabitable and required to be demolished and rebuilt" is met, and compensation will be made. Or strategies and suggestions can be given based on the structural damage assessment. Because the new standard for total loss claims was generated from the statistical analysis regression of data on damaged buildings after earthquake, the protection of insured party's rights has been quantified. To ensure the validity and accuracy of the claims standard, a complementary long-term maintenance and verification mechanism is needed. Complete data of such affected cases should continue to be collected in the future. This can also prepare for the future claim cases, file management, data use and analysis. Therefore, building an information application system that meets the demand of actual claims processing is very important. This is the best way to make claims processing of residential earthquake insurance convenient, expedient, and accurate.

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