Progress and Challenges of Earthquake-Resistant Housing: Examining the Discussions Following the 2016 Kumamoto Earthquake

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Abstract

The current earthquake-resistant building codes (new earthquake resistance standards) are based on the Building Standards Act, including the amendments effected in 1981. With regard to wooden buildings, some provisions were strengthened in 2000 (2000 standards), and currently, the structures belonging to three standards are mixed (including old earthquake resistance standards before 1981). The government is promoting earthquake resistance of houses by enacting the Act on Promotion of Seismic Retrofitting of Buildings, along with providing support for earthquake-proofing examinations and retrofitting costs. The proportion of earthquake-resistant housing is only about 82% as of 2013, and the government has set its sights on 95% by 2020. In the discussions on the damage caused to residences by the 2016 Kumamoto Earthquake, revising the Building Standards Act was postponed as the current earthquake-resistant building codes were found effective. A policy to promote earthquake-proofing examinations and the retrofitting of residences that do not meet the 2000 standards is being put forward, and further government support is desired.

Introduction

In the Great Hanshin-Awaji Earthquake that occurred in 1995, 4,831 people died (88% of the earthquake's direct death toll) because of the collapse of residences. The damage was concentrated in buildings built prior to 1981 and did not conform to the current earthquake-resistant building codes.[1] The government has since established the Act on Promotion of Seismic Retrofitting of Buildings (Act No. 123 of 1995), as well as establishing earthquake resistance targets. Through a support system for earthquake-proofing examinations and retrofitting, the government has also promoted earthquake-proofing buildings. Meanwhile, the damage caused to houses by the April 2016 earthquake[2] that had Kumamoto as its epicenter led to discussions around reviewing the existing earthquake-resistant building codes. Based on the trends of these discussions, this paper reviews the outline of earthquake-resistant building codes, with particular focus on wooden residences, and lays out the current progress and issues attendant to making residences earthquake-resistant.[3]

I Earthquake-Resistant Building Codes

1 *Provisions for Earthquake Resistance under the Building Standards Act*

The Building Standards Act (Act No. 201 of 1950) defines its purpose in Article 1 as "the minimum standards concerning the premises, structures, facilities and uses of buildings are established, with the aim of protecting the public's life, health and property, to contribute to public welfare." Article 20 of the same Act stipulates the classification of buildings into four categories according to scale and structure; defines the principle of structural safety (structural capacity) that each must observe; and regulates specific technical standards (specifications). The method of structural calculation is specified by the Order for Enforcement of the Building Standards Act (Cabinet Order No. 338 of 1950).[4] Specifications include criteria for bases, foundations, pillars, braces (reinforcement materials placed diagonally between pillars), and wall volume calculations, among other things. The structural calculations ascertain whether a building is safe with regard to load or external force with a statutory calculation formula. While the specifications contain items that can be substituted via structural calculation, they also establish "provisions

* The most recent access date for information located on the Internet in this paper is December 21, 2017.

1 "Building Damage Caused by the Great Hanshin-Awaji Earthquake", Ministry of Land, Infrastructure, Transport and Tourism website

2 Hereinafter referred to as the 2016 Kumamoto Earthquake.

3 As materials summarizing the situation of housing earthquake resistance in 2007, OTSUKA Michiko, "The Current Status and Issues Facing Earthquake-Resistant Housing," *ISSUE BRIEF*, No. 568, 2007.3.8.

4 Article 20 of the Building Standards Act reads, "Buildings shall conform to the following criteria stipulated in the following items respectively according to classification of the building stipulated in the said each of following items specified below as being structurally safe form dead load, live load, snow load, wind load, ground pressure, and water pressure as well as earthquakes or other vibration or impact." (Emphasis author's)

concerning durability” (Article 36, Paragraph 1 of the Order for Enforcement)[5], which all buildings must adhere to regardless of structural calculation. In the case of small-scale buildings, including wooden two-story houses, only the specifications are applied, and structural calculation is not required (see Table 1). The earthquake resistance of small-scale buildings rests on elements such as wall volume calculations.[6, 7]

Table 1 Differences in Structural Capacity Regulations based on Building Size

Building Standards Act Article 20, Paragraph 1	*Size / Structure of Building*	*Structural Calculation The Order for Enforcement Article 81*	*Specifications The Order for Enforcement Article 36*
No. 1	High-rise building with height of over 60 m	Required Time History Response Analysis (2)	Provisions Concerning Durability
No. 2	Large-scale building with height of less than 60m ・Wooden buildings with a height greater than 13m or an eaves height of more than 9m (Article 6, paragraph 1, item 2 of law) ・Four-story or more steel frame building (Article 6, paragraph 1, item 3 of law) ・Reinforced concrete or steel-reinforced concrete building with height exceeding 20m (Article 6, paragraph 1, item 3 of law) ・Other buildings specified by a Cabinet Order (Article 36-2 of the Order for Enforcement) Of the above, a height exceeding 31m a height less than 31 m	Response and Limit Capacity Calculation (3)	Provisions Concerning Durability
		Horizontal Load Carrying Capacity Calculation (4)	Partially Exempt
		Allowable Stress and Supplemental Analysis Calculation (5)	All Applicable

[5] Specifically, it includes the principles of structural design, material quality, durability, workability, and fire resistance of steel elements.

[6] The wall volume calculation ensures that the building’s structure is safe with regard to horizontal forces such as seismic force and wind pressure using simple calculations involving placement and volume of bearing walls. On the other hand, the structural calculations ensure safety by not only considering horizontal forces but also vertical forces such as snow load, roof load, floor load, and others (Japan Housing Finance Agency, *Understand it! Points for Wooden Housing Structural Plans: Wall Volume Calculation, The 4 Categorization Methods, N Value Calculation* (Yoku Wakaru! Mokuzo Jutaku no Kozo Keikaku no Pointo), 2007, p. 14).

[7] SUZUKI Hitomi and SUGIHARA Hitomi, *<Illustrated> Fully Understand the Building Standards Act Latest Edition* (Zukai Yoku Wakaru Kenchiku Kijunho), Nippon Jitsugyo Publishing, 2011, pp. 208-214.

Building Standards Act Article 20, Paragraph 1	*Size / Structure of Building*	*Structural Calculation The Order for Enforcement Article 81*	*Specifications The Order for Enforcement Article 36*
No. 3	Medium-scale building with a height of 60m or less ・Wooden buildings with three stories or more or over 500m² in total area (Article 6, paragraph 1, item 2 of law) ・Non-wooden buildings with two stories or more or over 200m² in total area (Article 6, paragraph 1, item 3 of law) ・Masonry structure with a height greater than 13 m or an eaves height of more than 9 m →	Allowable Stress Calculation (6) →	All Applicable
No. 4	Small-scale building (One that does not match the criteria above) →	Unnecessary →	All Applicable

Notes: (1) Larger buildings require more advanced structural calculations, but even small buildings can choose advanced structural calculations. For example, with a building corresponding to No. 3 in the table above, it is also possible to select holding horizontal load carrying capacity calculation.
(2) Stress degree (the resistance force generated inside the object against an external force) and deformation generated in each part of the building due to load and external forces are calculated continuously.
(3) For the deformation and the like of buildings subjected to loads and external forces, estimates are excluded and calculations done directly (specifications not a precondition).
(4) Calculate the horizontal load carrying capacity (resistance to horizontal forces) possessed by each floor and ensure that it exceeds the necessary horizontal load carrying capacity.
(5) In addition to the allowable stress amount, the rigidity ratio (the degree of deformation in the horizontal direction of each floor) and the eccentricity ratio (the degree of the torsional vibration caused by the deviation in the center of rigidity, which is the center of the structure's strength with respect to the center of gravity and horizontal forces) are confirmed.
(6) Ensures that the degree of stress generated in the major components of the structural capacity of the building (foundations, walls, pillars, etc.) is within the allowable stress limits for both the long term (i.e., dead load) and short term (i.e., seismic forces).
Sources: Created by the author on the basis of the provisions of the Building Standards Act, as well as the following: SUZUKI Hitomi and SUGIHARA Hitomi, *<Illustrated> Fully Understand the Building Standards Act Latest Edition* (Zukai Yoku Wakaru Kenchiku Kijunho), Nippon Jitsugyo Publishing, 2011, pp. 208-214; Understanding the Building Regulations Research Association, *Building Regulations PRO: Illustrated Building Application Law Manual: 2017*, Dai-Ichi Hoki, 2017, pp. 242-243; Annotated Building Standards Act Editorial Committee ed., *Annotated Building Standards Act*, Gyosei, 2012, pp. 263-268.

2 *Current Earthquake-Resistant Building Codes*

The current earthquake-resistant building codes are based on the provisions of the Building Standards Act, significant revisions to which were made in June 1981; in light of this, the codes are called "new earthquake-resistant building codes." The building codes from before the revision are distinguished by the use of the term "old earthquake-resistant building codes." The new earthquake-resistant building codes require the existing "essentially no damage due to medium-scale seismic motion (seismic intensity of about 5" (primary design), as well as "no collapse / destruction due to large-scale seismic motion (seismic intensity of about 6 to 7)" (secondary design).[8] With respect to wooden houses, according to the revision of the law in 2000, the specifications were improved (hereinafter referred to as the "2000 building codes"[9]) by clarifying the connection method for splices (constructions that connect two elements in the same direction) / joints (constructions that connect two elements orthogonally or obliquely) and the placement method for bearing walls. At present, therefore, the specifications for buildings based on the old earthquake-resistant building codes, the new earthquake-resistant building codes, and the 2000 building codes are mixed (see Table 2).

Table 2 Differences in Earthquake-Resistant Building Codes (Wooden Residences) by Age

Age	*Building Codes*	*Building Standards Act Provisions*		
		Wall Volume	*Wall Placement*	*Joint*
Prior to May 1981	Old Earthquake-Resistant Building Codes	Wall volume capable of withstanding earthquakes of seismic intensity 5 or greater	No Specific Provisions	
From June 1981	New Earthquake-Resistant Building Codes	Wall volume not damaged by earthquakes of seismic intensity Upper-5 or greater, and do not collapse from intensity Upper-6 - 7		
From June 2000	2000 Building Codes		Specify 4-category division method(1) or eccentricity ratio calculation(2)	Clarify provision for ends of diagonal braces and bearing wall column heads / bases(3)

Notes: (1) A method for confirming the balance of the side ends of a bearing wall (1/4 of a unit obtained from dividing the wall into four portions) via the calculation stipulated by the "Stipulation of Criteria for the Installation of Frames of Wooden Buildings" (Notification No.1352 of the Ministry of Construction (May 23, 2000)).
(2) A structural calculation for confirming that the eccentricity ratio is 0.3 or less.
(3) Detailed specifications defining the method of connecting the brace end, column head, and column base are stipulated in "Stipulation of Structural Methods for Wooden Joints and Connections" (Notification No.1460 of the Ministry of Construction (May 31, 2000)).
Source: Created by the author on the basis of Nikkei Home Builder, "Why New Earthquake-Resistant Houses Collapsed - Common Sense for House Building -", Nikkei Business Publications, 2016, pp. 33, 102; Japan Housing Finance Agency, "Understand it! Points for

8 "Summary of the Earthquake-Resistant Building Codes of the Building Standards Act." Ministry of Land, Infrastructure, Transport and Tourism website
9 Nikkei Home Builder ed., *Why New Earthquake-Resistant Houses Collapsed: Common Sense for House Building* (Naze Shin-Taishin Jutaku ha Taoretaka), Nikkei Business Publications, 2016, p.102.

Wooden Housing Structural Plans – Wall Volume Calculation, The 4 Categorization Methods, N Value Calculation–", 2007.

II Current Status of Making Housing Earthquake-Resistant

1 *Past Efforts Promoting Earthquake Resistance*

(1) Promotion of Retrofitting Earthquake Resistance based on the Act on Promotion of Seismic Retrofitting of Buildings

The Act on Promotion of Seismic Retrofitting of Buildings was established in 1995 as a reaction to the damage done to buildings in the Great Hanshin-Awaji Earthquake. This Act promotes making buildings earthquake-resistant by imposing earthquake-proofing examinations and the obligation to make efforts of retrofitting on the owners of buildings that are used by large numbers of people and that could potentially collapse—all this is accomplished via the guidance and advice of the relevant government agencies. A 2005 amendment (Article 4) established the basic policy for the government's promotion of earthquake-proofing examinations and building retrofitting. Prefectures decided to establish a regional earthquake-proof retrofit plan based on the same policy (Article 5), and so, planned earthquake resistance retrofits came to be promoted.[10] The regional earthquake-proof retrofit plan was agreed upon by all prefectures as of April 1, 2017, and 97.5% of municipalities, which are obligated to make efforts to take action (Article 6), have formulated plans.[11]

The 2013 amendment refers to large-scale buildings (hospitals, shops, inns, etc.) of a designated size or greater that are used by an unspecified number of people, as well as disaster-prevention-base buildings (government buildings, evacuation centers, etc.) designated by prefectures are obligated to make public the results of their earthquake-proofing examinations.[12] In addition, the amendment now includes housing and small-scale buildings, which were not covered by the law previously, such as in the case of apartment housing. These newly-covered types of buildings are obligated to make efforts towards undertaking earthquake-proofing examinations and retrofits to all existing buildings that did not meet current building codes. In addition, measures were taken for issues such as alleviating the resolution requirements for buildings possessing a classification, such as apartment buildings, for which large-scale retrofits were deemed

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10 "Points of the Amended Act on Promotion of Seismic Retrofitting of Buildings and Summary of Related Systems." Ministry of Land, Infrastructure, Transport and Tourism website

11 "Schedule for the Development of Regional Earthquake-resistance Retrofit Plan and Status of Subsidy System for Earthquake-resistance Retrofitting." *ibid*.

12 For details on the buildings subject to mandatory earthquake-proofing examinations, see "List of Regulation Objects in the Act on Promotion of Seismic Retrofitting of Buildings." *ibid*.

necessary for earthquake resistance so that matters could be decided by the classification possessor or by a simple majority instead of 3/4 of those with voting rights.[13]

(2) Support for Earthquake-proofing Examinations / Retrofits

The Ministry of Land, Infrastructure, Transport and Tourism has been running the "Housing and Building Safety Stock Formation Project" since 2009 to secure the safety of housing and building stocks. Within this project, national and local public entities provide a certain amount of assistance to earthquake-proofing examinations / retrofits of houses and buildings carried out by building owners. For example, in earthquake-proofing examinations of houses (including apartment buildings), national and regional governments each provide subsidy to the extent of a third of the expenses. Regarding seismic retrofitting, the national and regional expense assistance amounts are each 11.5%.[14] The results of the country's support (cumulative), as of the end of 2016, are state-subsidized earthquake-proofing examinations for approximately 1,055,000 units and state-subsidized earthquake-proof retrofitting for approximately 204,000 units (about 78,000 detached housing units and 126,000 shared-residence homes).[15] In addition, support was ramped up by the housing and building safety stock formation projects under the "Earthquake-proofing Response Emergency Promotion Project," established by a 2013 amendment.[16] In other areas, tax measures have been established to reduce income tax and property tax when seismic retrofitting work is carried out to incentivize earthquake-proofing, as well as a financing system via the Japan Housing Finance Agency of up to 10 million yen (for individuals; 80% of construction expenses limit).[17, 18]

Given the status of the support system in rural areas, 86.5% of the nation's municipalities have established subsidy systems for earthquake-proofing examinations

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[13] "Outline of the Act on Promotion of Seismic Retrofitting of Buildings." *ibid.*; Ministry of Land, Infrastructure, Transport and Tourism Housing Bureau Building Guidance Division, "Regarding the Amended Act on Promotion of Seismic Retrofitting of Buildings," *People and Country 21* (Hito to Kokudo 21), 39(3), 2013.9, pp. 55-58.

[14] "Housing / Building Safety Stock Formation Project (Core Business of the Social Capital Development Integrated Grant, Disaster Prevention, and Safety Grant)", p. 1. *ibid*.

[15] "Results of the Government's Support System for Earthquake-proofing Examinations (As of the end of FY2016)." *ibid*.

[16] "Housing / Building Safety Stock Formation Project (Core Business of the Social Capital Development Integrated Grant, Disaster Prevention, and Safety Grant)", *op. cit.* (14), pp. 2-3.

[17] *ibid*., pp. 4-5.

[18] Regarding these support measures, the Ministry of Land, Infrastructure, Transport and Tourism requested 14 billion yen for the "Earthquake-proofing Response Emergency Promotion Project" (1.17 times the national expenditure from the previous year) in its FY2018 budget request. In the request for taxation system reform, it is a special measure for property tax (1/2 reduction) related to buildings that have undergone seismic retrofitting to be extended for two years ("Strengthening countermeasures against empty houses and trees", *Nikkei Home Builder*, No. 220, 2017.10, pp. 16-17; Ministry of Land, Infrastructure, Transport and Tourism, "FY2018 Ministry of Land, Infrastructure, Transport and Tourism Tax Reform Request," 2017.8, p. 9.).

(85.7% of houses), and 85.0% (84.5% of houses) have a subsidy system for seismic retrofitting.[19] For both examinations and retrofitting, the apparent trends are that urban municipalities have a high rate of establishing systems, while rates in rural areas are low.[20]

(3) Housing Performance Representation System

In 2000, the "Housing Performance Representation System" was established on the basis of the Housing Quality Assurance Act (Act No. 81 of 1999). Under this system, third-party institutions accredited by the country evaluate the performance (structural capacity, sound insulation, energy-saving performance, etc.) of housing and an "earthquake resistance rating" that evaluates seismic performance in three stages from the aspects of damage prevention and collapse prevention[21] was introduced. Grade 1 is equivalent to the seismic performance required by the Building Standards Act; Grade 2 corresponds to seismic performance at 1.25 times; and Grade 3 corresponds to seismic performance of 1.5 times. In the housing specifications, such as those for long-life quality housing[22] and the long-term fixed-rate mortgaging, "Flat 35S" of the Japan Housing Finance Agency requires seismic performance that is equal to or higher than Grade 2 earthquake resistance.[23]

According to the Association for Housing Performance Evaluation and Indication[24],

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[19] "Planned Formulation of Regional Earthquake-proof Retrofit Plan by Local Governments and Organizational Status of Subsidy System for Seismic Retrofitting", Same as note (11). When the prefecture implements direct subsidies, it counts the number of municipalities that can receive assistance. The Japan Building Disaster Prevention Association has published a list of regional earthquake-proof retrofit plans and support systems for each prefecture ("Prefectural Earthquake-proof Retrofit Plan / Support Systems," Japan Building Disaster Prevention Association website).

[20] "Reference 2. Implementation Status of Subsidy System related to Earthquake-proofing Examinations (as of April 1, 2017)," Ministry of Land, Infrastructure, Transport and Tourism website; "Reference 3. Implementation Status of Subsidy System related to Seismic Retrofitting (as of April 1, 2017)," *idem*.

[21] Damage prevention is evaluated from the viewpoint of "No damage serious enough that it requires to repair via large-scale construction against the force of a once-in-several-decades sized force"; Prevention of collapse is evaluated from the viewpoint of "Even with damage, will not collapse in a way that threatens human life against the force of a once-in-a-century force." "Strength against Earthquakes (Structural Stability)." Association for Housing Performance Evaluation and Indication website).

[22] Based on the "Act for Promotion of the Adoption of Long-Life Quality Housing" (Act No. 87 of 2008), housing that has been certified as taking measures toward use in good condition over a long period of time can receive reduced interest rates on mortgage and special tax measures (the Association for Housing Performance Evaluation and Indication, "Summary of the Long-life Quality Housing Certification System New Construction Version," 2017.4). The technical standards related to buildings are applied to the standards of the Housing Performance Representation System, ("What is a Long-life Quality Housing," The Association for Housing Performance Evaluation and Indication website).

[23] "Summary of the Housing Quality Assurance Act," Ministry of Land, Infrastructure, Transport and Tourism website; Nikkei Home Builder, *op. cit.* (9), p. 221. Although the original system only covered newly built houses, existing housing were made subject to the act as of December 2002.

[24] The registering agencies conducting housing performance evaluations based on the Housing Quality Assurance Act are member institutions.

the adoption rate of the Housing Performance Display System, which is the ratio of the number of planned housing performance evaluations to new housing construction commencements, has remained at approximately 20% since 2006 and was 23.3% as of 2016.[25] While the low adoption rate is a problem, construction costs to raise the earthquake resistance grade from 1 to 3 are said to have increased by only a few percentage points, and benefits such as earthquake insurance discounts[26] are also available. Thus, the government has positioned it as an effective means of improving seismic performance.[27]

2 *Progress on Earthquake-proofing Housing*

The earthquake-proofing of housing as of 2013 is estimated to be about 82% nationwide (see Table 3). Out of a total of approximately 52 million units, approximately 37 million units have been built since 1982, and of those constructed before 1981, approximately 6 million homes have added earthquake resistance with seismic retrofitting and the like, leading to a total of about 43 million households having been made earthquake-resistant.[28] The number of houses estimated to have insufficient earthquake resistance is estimated to have decreased by approximately 2.5 million units in 10 years from being at approximately 11.5 million units in 2003, most of which is accounted for by rebuilding. Thus, it is believed that no more than 550,000 units have undergone seismic retrofitting in the past 10 years.[29]

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[25] "Penetration Trends for the Housing Performance Representation System," 2015.8. The Association for Housing Performance Evaluation and Indication website; "Comparison of Number of New Constructions and Yearly Designed Housing Performance Evaluation Issued Housing Units," (Regarding the Implementation Status of the Housing Performance Representation System based on the Housing Quality Assurance Act (2016 Results) Reference Materials), 2017.8.31. Ministry of Land, Infrastructure, Transport and Tourism website

[26] For earthquake insurance with a starting date after July 1, 2014, Grade 1 Earthquake-resistance (prevention of structural collapse) can receive a 10% discount, with 30% for Grade 2, and 50% for Grade 3 ("System Benefits," Housing Performance Evaluation and Indication website).

[27] "Earthquake-resistant Building Codes and Earthquake-resistance Grade Effectiveness 'Proved' in the 2016 Kumamoto Earthquake," *The Asahi Shimbun*, 2017.8.2. Under the Housing Performance Representation System for new construction, first, designs are evaluated, then construction and completion time, but condominiums do not have the capacity for individuals to be involved with the design before purchase, and considering the impact on costs and living space, there are few properties that receive a high grade. Meanwhile, more than 90% of detached houses using the system have acquired Grade 3, but aiming for a high grade comes with certain restrictions around the placement of walls and living space layout, which makes balancing both seismic performance and livability a challenge ("Preparing Housing for Earthquakes (3) Measures for New Construction, Seismic Performance? Third-party 'Performance' Evaluations," *The Nikkei*, 2016.6.22.).

[28] "Progress Status of Earthquake-proofing Housing." Ministry of Land, Infrastructure, Transport and Tourism website

[29] "Basic Policy for Promoting Earthquake-proofing Examinations and Seismic Retrofitting of Buildings," (Notification No.529 of the Ministry of Land, Infrastructure, Transport and Tourism, 2016).

Table 3 Progress Status for Earthquake-proofing Housing

	2003	*2013*	*2020 (Target)*
Earthquake-proofing Rate	Approx. 75%	Approx. 82%	95%
Earthquake-Resistant (Built after 1982)	Approx. 28.5 million	Approx. 37 million	Approx. 43.5 million
(Built before 1981)	Approx. 7 million	Approx. 6 million	Approx. 6.5 million
No Earthquake Resistance (Built before 1981)	Approx. 11.5 million	Approx. 9 million	Approx. 2.5 million

Note: In 2003 and 2013, the estimated figures were calculated by the Ministry of Land, Infrastructure, Transport and Tourism on the basis of the "Housing and Land Survey" conducted by the Ministry of Internal Affairs and Communications, and the target values pertain to 2020. The government aims broadly to resolve the issue of insufficient earthquake-resistant housing by 2025.

Source: Created by the author on the basis of "Progress Status for Earthquake-proofing Housing." Ministry of Land, Infrastructure, Transport and Tourism website

According to the "Housing and Land Survey" published by the Ministry of Internal Affairs and Communications in 2013, the number of houses for which earthquake-proofing examinations were conducted since 2009 was approximately 2.72 million units, which was 8.4% of the total number of homeowners. Approximately 2.33 million households (7.2% of the total number of homeowners) had verified earthquake resistance and approximately 390,000 homes (1.2% of the same) remained unverified. Among the houses without verified earthquake resistance, only approximately 130,000 units (32.7%) had performed some type of seismic retrofitting, and the remaining 260,000 or so units (67.3%) had not performed any seismic retrofitting.[30]

3 *Government Target Setting*

In the Earthquake Disaster Reduction Strategy formulated in 2005 in light of the Tokai Earthquake, the government said that it would raise the earthquake resistance rate of housing to 90% by 2015.[31] In prefectures as well, the goal of raising the earthquake resistance rate to 80%~97% by the same year in the regional earthquake-proof retrofit plan was set as a target. In the questionnaire survey carried out by the Asahi Newspaper Company at the end of 2016, 41 prefectures responded that it would be difficult to achieve their targets by the deadline. Specific reasons include high seismic retrofitting costs and the decline in the motivation for earthquake-proofing because of the increase in elderly and

[30] Statistics Bureau, Ministry of Internal Affairs and Communications, "2013 Housing and Land Survey Preliminary Report Results Summary," 2014.7.29, pp. 12, 73.

[31] Cabinet Office, White Paper on Disaster Management 2005, pp. 134-136.

single households.[32]

As a new goal, the government will raise the earthquake resistance rate of houses to at least 95% by 2020[33] and plans to eliminate houses with insufficient earthquake resistance by 2025.[34] To achieve this target, however, it is necessary to earthquake-proof at least 6.5 million units of housing (of which, about 1.3 million units for seismic retrofitting) by the year 2020, and along with aiming to promote rebuilding, to approximately triple the pace of seismic retrofitting.[35]

III Examinations Held after the 2016 Kumamoto Earthquake

1 *Expert Committee Discussions*

In April 2016, during the Kumamoto Earthquake, earthquakes reaching the maximum seismic intensity of 7 occurred one after another on the 14th and the 16th (Mashiki-machi, Kumamoto Prefecture).[36] The resulting damage to buildings (residences) from the 2016 Kumamoto Earthquake totaled 8,675 buildings as having been completely destroyed, 34,620 buildings as having partially collapsed, and 162,346 buildings as having been partially damaged as of December 2017.[37] To analyze the cause of the damage to buildings affected by the 2016 Kumamoto Earthquake, the National Institute for Land and Infrastructure Management and the Building Research Institute established the "Committee on Factor Analysis of 2016 Kumamoto Earthquake Building Damage" (hereinafter referred to as the "expert committee"). The committee consisted of experts in building structure and those conducting building design and inspections, where they held discussions and

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32 "Earthquake-resistant Housing Unachievable Goals Year 2003 Accomplishments 41 Prefectures 'Difficult,'" *The Asahi Shimbun*, 2017.1.16; "Earthquake-resistant Housing The Cost Burden Barrier Encouraging Owners Municipal Struggles," *idem*.

33 Central Disaster Management Council, "Basic Plan for Promotion of Nankai Trough Earthquake Disaster Mitigation," 2014.3.28, p. 10. Cabinet Office Disaster Information Page website; "Plan for Immediate Countermeasures for the Earthquake," (Decided by the Cabinet on March 31, 2015) p. 31. *idem*. etc.

34 "Basic Plan for Housing for People (National Plans)," (March 18, 2016 Cabinet decision), p. 10. Ministry of Land, Infrastructure, Transport and Tourism website

35 "Basic Policy for Promoting Earthquake-proofing Examinations and Seismic Retrofitting of Buildings," *op*. *cit*. (29).

36 For materials summarizing the damage and support situations, as well as the tasks for recovery and others in the 2016 Kumamoto earthquake, see National Diet Library Research and Legislative Reference Bureau, "Response to the 2016 Kumamoto Earthquake Volume 1," *ISSUE BRIEF*, No.914, 2016.8.1; *idem*., "Response to the 2016 Kumamoto Earthquake Volume 2," *ISSUE BRIEF*, No.915, 2016.8.1

37 Fire and Disaster Management Agency Emergency Response Office, "Earthquakes with Epicenters in the Kumamoto Region of Kumamoto Prefecture (109th Report)," 2017.12.14, p. 3.

published a report[38] in September 2016.

(1) Building Damage Overview

As for wooden buildings, out of the 1,995 buildings that were analyzed in the principal survey in the center of Mashiki-machi, 297 buildings (15.2%) were found to have suffered collapse/destruction. Among the collapsed and destroyed buildings, 214 buildings (72.1%) adhered to the old earthquake-resistant building codes, and the damage rate of the old earthquake-resistant building code housing was remarkably larger than that of the new earthquake-resistant building code housing. However, there was collapsing and destruction even in the housing constructed after the introduction of the new earthquake-resistant building codes. It became clear that the damage rate of the housing built on the basis of the 2000 building codes was lower than those of earlier housing (see Figure 1). Among the seven houses that "followed" the 2000 building code but collapsed, the specifications of the joints were inadequate in the three buildings, and the collapse of the site and an incline in the foundation were confirmed in one building; hence, ground deformation is thought to be one of the primary causes of its collapse. In addition, for the Grade 3 seismic performance buildings under the Housing Performance Representation System, no major damage was found and most of the buildings were undamaged. This is believed to have resulted from the large secured wall volume of the buildings, which served to secure a higher level of earthquake resistance.[39]

(2) Survey Results Summary

In light of the damage situation outlined above, the report concluded that it was necessary to promote the effort to render earthquake-proof those buildings that used the old earthquake-resistant building codes further. With regard to wooden buildings, the report acknowledged that the 2000 building codes were effective in preventing collapse and destruction. However, it has indicated that there were wooden buildings that did not meet those criteria and that efforts to prevent damage were required. In addition, it has concluded

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[38] "Committee for Factor Analysis of the 2016 Kumamoto Earthquake Building Damage Report," 2016.9. National Institute for Land and Infrastructure Management website. In addition, there have been reports of suspected falsification regarding some of the observation data quoted in the report ("2016 Kumamoto Earthquake, Observation Data Falsification? Withdrawal of Related Papers, Ministry of Education, Culture, Sports, Science and Technology Investigating," *The Mainichi*, 2017.10.3. An investigation is currently being conducted by Osaka University, but since the overall argument of the report is based on the survey results on the damage situation to buildings done by the National Institute for Land and Infrastructure Management and the Building Research Institute, the research institute and the Architectural Institute of Japan do not think that the trends in the survey will ultimately affect the results (National Institute for Land and Infrastructure Management and Building Research Institute, "Notice," 2017.12.15).

[39] "Committee on Factor Analysis of 2016 Kumamoto Earthquake Building Damage Report," *ibid*., p. 49.

that using the Housing Performance Representation System was more effective when showing consumers options for securing higher seismic performance for wooden houses.[40]

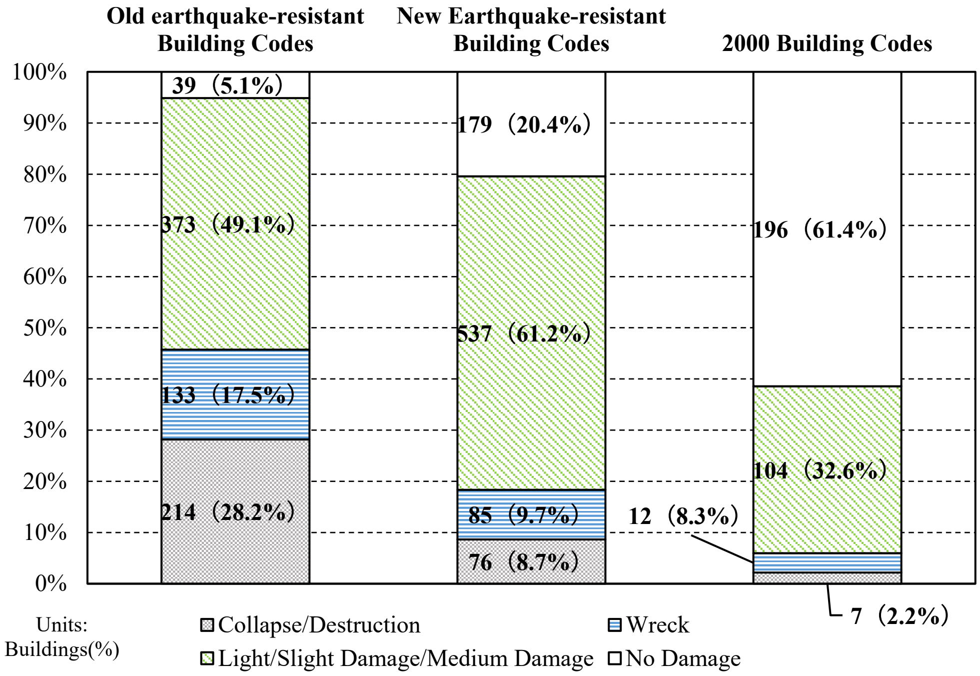

Figure 1 Damage Status of Wooden Buildings in the 2016 Kumamoto Earthquake (By Earthquake-resistant Building Codes)

Source: Created by the author on the basis of "Committee on Factor Analysis of 2016 Kumamoto Earthquake Building Damage," 2016.9, pp. 33, 36. National Institute for Land and Infrastructure Management website

2 *Support from the Ministry of Land, Infrastructure and Transport*

(1) Confirming the Effectiveness of Existing Earthquake-resistant Building Codes

In response to the expert committee's report, the Ministry of Land, Infrastructure and Transport made it clear that they intended to maintain the current earthquake-resistant

[40] *ibid*., pp. 91-93. In addition, although the report states that the effectiveness of the new earthquake resistant building codes can be confirmed for buildings using steel frames and reinforced concrete structure, inadequate welding methods at joints and common Piloti constructions with pillars missing from walls on lower floors have been found in buildings that suffered major damage, and it points out the need for initiatives for reducing damage. For facilities such as government buildings and disaster prevention centers, in which functionality should continue even in the event of a disaster, it is necessary to perform examinations aimed at mitigating damage and maintaining functionality, and for buildings such as apartment housing and offices, the report points out that it is desirable to provide useful information when registered architects and designers ask for flexible designs.

building codes without revising them at the Council for Social Infrastructure Development held on October 5, 2016. Even assuming the effectiveness of the existing earthquake-resistant building codes as having been confirmed during the 2016 Kumamoto Earthquake, they decided to ensure the seismic performance required by the current building codes, including seismic retrofitting of existing stock, rather than further increasing the level of the building codes.[41] However, for existing buildings that were built with the new earthquake-resistant building codes, they recommended that the joint conditions of existing wooden buildings be checked in light of the specifications (the 2000 building codes) clarified in 2000 and decided to separately compile a method for confirming their effectiveness.[42]

(2) Publication of the Wooden Housing Seismic Performance Verification Method under the New Earthquake-resistant Building Codes

In response to the policy of the Ministry of Land, Infrastructure and Transport, the Japan Disaster Prevention Building Association compiled a seismic performance verification method under the New Earthquake-resistant Building Codes for Wooden Housing (the New Earthquake-resistant Wooden Housing Verification Method) in May 2017.[43] This verification method applies to wooden housing using the new earthquake-resistant building standard, which also matches the following: (1) conventional framework construction method[44] (foundation is made of concrete); (2) buildings built between June 1981 and May 2000; and (3) single-story or two-story buildings.[45] If it cannot be determined that the

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[41] Measures have been established to increase subsidies for seismic retrofitting by 300,000 yen per house through 2017 by local governments that are working to raise awareness and provide information for residents' earthquake-proofing awareness as financial support for the promotion of seismic retrofitting ("Subsidy Increase for Residential Earthquake-proofing MITI Damaged in the 2016 Kumamoto Earthquake," *The Nikkei*, 2016.8.23; "Seismic Retrofitting to 95% by 2020 Seismic Retrofitting Marketplace Speeding Up: Changes in Awareness among Users from the 2016 Kumamoto Earthquake," *Housing Tribune*, No. 521, 2016.9.23, pp. 36-37.

[42] Ministry of Land, Infrastructure, Transport and Tourism, "Main Initiative Policies based on Causal Analysis of Building Damage in the 2016 Kumamoto Earthquake," (23rd Council for Social Infrastructure Development Document 1-2), 2016.10.5. In addition, the Housing Performance Representation System and a compilation of guidelines related to continuing functionality for disaster prevention centers are being indicated as initiative policies for maintaining the functioning of buildings.

[43] Japan Building Disaster Prevention Association, "New Earthquake-resistant Building Codes for Wooden Housing Seismic Performance Evaluation Method (New Earthquake-resistant Wooden Housing Verification Method)," 2017.5.

[44] The general construction method using pillars, beams, braces, etc. for wood frame construction (construction method supported by a wall or the floor attached to the structural plywood framework for the wooden framework without reliance on framing (2x4 method)) and prefabrication method houses; since 1981, special building codes enhancements or clarifications have not taken place, so they are exempt.

[45] Wooden houses of three stories or more are obliged to perform a structural calculation, so they are exempt.

building will not collapse (has seismic performance) by an examination[46] conducted by the owner[47], the owner must proceed to avail of efficient verification by a specialist. Seismic retrofitting will be recommended if it is determined that the building does not live up to the building codes (see Figure 2).

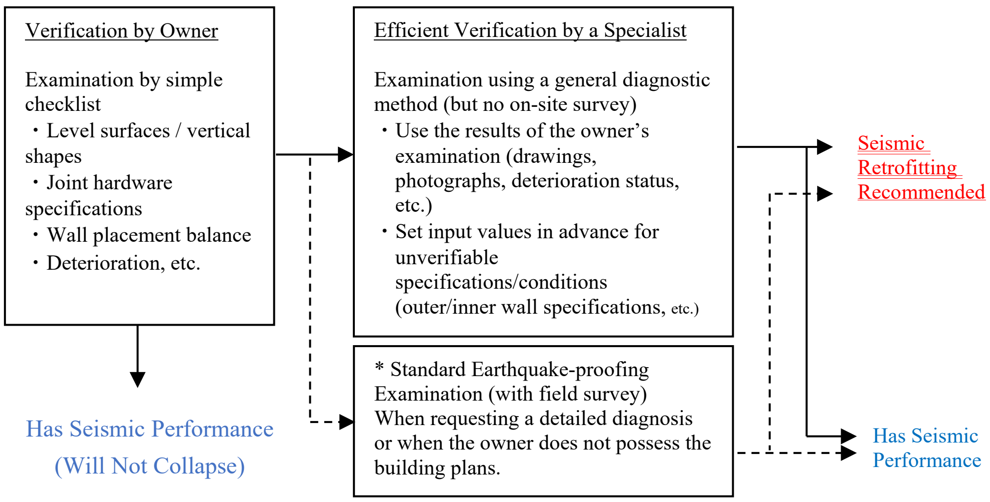

Figure 2 New Earthquake-resistant Wooden Housing Verification Method Flow

Source: Created by the author on the basis of the Japan Building Disaster Prevention Association, "Seismic Performance Checks for Wooden Housing (Owner Examinations): Buildings Built between June 1981 and May 2000," 2017.5.16.

Since this verification method was proposed as one that can verify seismic performance while reducing the cost burden on the owner as field surveys by specialists, which are said to generally take from one half to a full day, are not conducted.[48] In addition, the specialists' examinations use the same diagnostic software as conventional general examination methods, and thus, data can be used should earthquake-proofing examinations be performed later.[49] Future seismic performance examinations are expected to be carried

[46] The Japan Building Disaster Prevention Association released a leaflet introducing verification methods to owners: "Checking the Seismic Performance of Wooden Houses (Verification by Owners): Built between June 1981 and May 2000," 2017.5.16. However, for joint hardware, as an example, it says to "visually check the attack and under the floor," but it has been pointed out that it is difficult to judge which part should be checked for those who are not familiar with the architecture ("Simple Checks for Seismic Performance of New Earthquake-resistant Wooden Building for Buildings Built prior to 2000 with no On-site Survey by a Specialist," *Nikkei Architecture*, No. 1097, 2017.6.8, pp. 8-9).
[47] Includes remodeling companies, etc.
[48] When the owner cannot determine that the presence of seismic performance via examination, experts judge the seismic performance on the basis of information in plans and photographs, without conducting an on-site survey.
[49] MORIYAMA Hisako, "Earthquake-proofing Examination Methods for Houses from 1981-2000 Difficult Owner Surveys," *Nikkei Home Builder*, No. 218, 2017.8, pp. 55-61.

out during opportunities such as renovations and building inspections.[50, 51]

IV Issues Related to Earthquake-proofing

1 *Appropriateness of the Building Standards Act and Earthquake-resistant Building Codes*

As stated above, while strengthening the current earthquake-resistant building codes by revising the Building Standards Act has been postponed, a number of issues have been pointed out by experts in response to the 2016 Kumamoto Earthquake.

(1) Taking Multiple Earthquakes into Consideration

The accumulated damage caused by the 2016 Kumamoto Earthquake because of the multiple earthquakes (two earthquakes of seismic intensity 7) had an impact, and it is believed that this led to buildings suffering significant damage, including collapse.[52] While it is assumed that the existing earthquake-resistant building codes prevent collapse even in the face of a strong shake from a seismic intensity 6 to 7 earthquake, it is not standard to assume multiple, powerful shakes, and so there are also those who point out the need for revision.[53] TAKEWAKI Izuru, a graduate school professor at Kyoto University, estimates that an earthquake resistance strength of 1.5 times the current building codes is required to prevent a building's collapse against two seismic intensity 7 shakes.[54] Professor TAKEWAKI indicates that buildings should have more than sufficient strength, rather than meeting the minimum of the earthquake-resistant building codes, to reduce damage to people.[55]

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[50] When buying and selling mainly used houses, specialists (home inspectors) make diagnoses about the deterioration status of a house, determining the presence or absence of defects ("What is Home Inspection (Housing Diagnosis)?" Japan Home Inspectors Association website).

[51] Japan Building Disaster Prevention Association, *op. cit.* (43), pp. 5-6.

[52] Nikkei Business Publications investigated locally collected data and aerial photographs, finding that, in the survey area in Mashiki (57 houses), destruction and significant deformations occurred, and were able to estimate for 17 houses their damage situation before and after the foreshock, where eight of them had not suffered major damage at the stage of the foreshock (Nikkei Home Builder ed., *op. cit.* (9), pp. 20-24).

[53] "2016 Kumamoto Earthquake Earthquake-resistance Anticipated One Major Shake MITI Accumulated Damage, Building Codes Review," *The Mainichi*, 2016.4.26, evening edition.

[54] "Consecutive 7 Earthquakes 1.5x Strength Required Fear of Collapse within Earthquake-resistant Building Codes," *The Mainichi*, 2016.5.19, evening edition.

[55] "One Year Since the 2016 Kumamoto Earthquake 1 in 4 Died Returning Home After Evacuating," *The Sankei Shimbun*, 2017.4.17.

(2) Earthquake Area Coefficients

Under the existing earthquake-resistant building codes, when calculating the seismic force assumed in the structural calculation of large-scale buildings (buildings as defined in Article 6, Paragraph 1, Items 1 - 3 of the Building Standards Act), the earthquake area coefficient is factored in on the basis of past earthquake records calculated for each region.[56] The coefficients differ from region to region, and while the coefficients in the Tokyo, Chubu, and Kansai regions are 1.0, in Kumamoto Prefecture, it is 0.9 (some parts, such as Yatsushiro, have 0.8 as coefficients) (see Table 4). In areas with small coefficients, substantial earthquake-resistant building codes are watered down; however, large earthquakes have occurred in areas with small coefficients, such as the Tottori-seibu Earthquake (2000) and the Niigata-ken-Chuetsu Earthquake (2004). The resulting damage has led to calls for the abolition of the coefficients and reviewing them to make them uniform.[57] Nevertheless, there are also prudent opinions regarding a review that is based on the influence that raising the coefficient would have on existing buildings.[58]

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[56] Article 88 of the Order for Enforcement of the Building Standards Act states that. "The seismic force regarding above ground parts of a building shall be determined, according to the height of each part of the said building, as the overall seismic force acting upon the section supported by each part. The seismic force shall be calculated as the product of the sum of dead load and live load at each part and the seismic story shear coefficient at the height of the said part. The coefficient is stipulated in the same law as, 'A value specified by the Ministry of Land, Infrastructure, Transport and Tourism within a range between 1.0 and 0.7 reflecting the extent of earthquake damage, seismic activity and other seismic characteristics based on the record of earthquakes in the region concerned. It currently uses values defined by the Ministry of Construction in 1980.'"

[57] "Earthquake-resistance Strength Differs by Region Government Passive about Change," *The Tokyo Shimbun*, 2016.4.22. Specially Appointed Professor NAKABAYASHI Itsuki of Meiji University says that, even for small buildings not obligated to perform structural calculations, the thinking about earthquake area coefficients has at least some impact, and if the regional differences disappeared, it would likely lead to progress in seismic retrofitting across the whole country ("Regional Differences in Earthquake-resistance Momentum for a Review Retrofitting Possible for Factories / Company Buildings," *The Nikkei*, 2016.6.27).

[58] "Low Earthquake Area Coefficients How to Fix "Requires National Discussion," *The Sankei Shimbun*, 2016.5.13.

Table 4 Differences in Earthquake Area Coefficient by Region

Number	*Region*
1.0	All areas other than below
0.9	Parts of Hokkaido (Sapporo, Hakodate, etc.), parts of Aomori Prefecture (Aomori City, Hirosaki, etc.), Akita Prefecture, Yamagata Prefecture, parts of Fukushima Prefecture (Aizuwakamatsu, Koriyama, etc.), Niigata Prefecture, parts of Toyama Prefecture (Uozu, etc.), parts of Ishikawa Prefecture (Wajima, etc.), parts of Tottori Prefecture (Yonago, etc.), Shimane Prefecture, Okayama Prefecture, Hiroshima Prefecture, parts of Tokushima Prefecture (Mima District, etc.), parts of Kagawa Prefecture (Takamatsu, Marugame, etc.), Ehime Prefecture, Kochi Prefecture, Kumamoto Prefecture (except below), Oita Prefecture (except below), Miyazaki Prefecture
0.8	Parts of Hokkaido (Asahikawa, Rumoi, etc.), Yamaguchi Prefecture, Fukuoka Prefecture, Saga Prefecture, Nagasaki Prefecture, parts of Kumamoto Prefecture (Yatsushiro, Arao, etc.), Oita Prefecture (Nakatsu, Hita, etc.), Kagoshima Prefecture (excluding Naze and Oshima District)
0.7	Okinawa Prefecture

Source: Created by the author on the basis of "Stipulation of the value of Z, methods of calculating and Rt and Ai and standards for the designation by the Designated Administrative Organization of district where the ground is extremely soft", (Notification No.1793 of the Ministry of Construction (November 27, 1980))

Regarding the revision of the coefficient, the expert committee was unable to conclude that the coefficient impacted the damage situation of the area within the scope of their analysis and raised this as a matter to be considered in the medium-to-long term[59] as the government is not exploring a concrete review.[60] Meanwhile, depending on the local government, there are independent movements to raise the coefficient so as to strengthen earthquake resistance. Shizuoka Prefecture revised the building standards ordinances in February 2017, making it compulsory for the prefecture's buildings to conform to the prefecture's own coefficient of 1.2 (1.0 by the national standard). For wooden buildings, the required wall volume was set at 1.32 times that stipulated by the Building Standards Act.[61] The prefecture estimates that if its own coefficient had been applied, the number of deaths caused by the building collapse from the Nankai Trough earthquakes would have been reduced by approximately 60% while estimating that this would have increased overall construction costs by 1%.[62] Moreover, in Fukuoka, Fukuoka Prefecture, regulations requiring efforts to conform to a coefficient of 1.0 (0.8 by the national standard)

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59 "Committee on Factor Analysis of 2016 Kumamoto Earthquake Building Damage Report," *op. cit.* (38), p. 91.

60 "Response to the Question on Earthquake-resistant Building Codes Submitted by the House of Representatives Member OKUNO Soichiro," (October 28, 2016, Accepted Response No. 71).

61 "Will Increase Earthquake-resistant Building Codes for Buildings from October 1, 2017: Making the Shizuoka Earthquake Area Coefficient (Zs) Obligatory," Shizuoka Prefecture website; Specific building codes for capacity for specific parts of buildings, deformation limits are defined in, "2017 Shizuoka Prefecture Bulletin No. 219," 2017.3.28.

62 "Initiative from an Official Taking Action Obligating the '1.2 Regional Coefficient': Shizuoka Prefecture prepares for Danger with Ordinance," *Nikkei Architecture*, No. 1093, 2017.4.13, pp. 62-64.

have been implemented when new construction or remodeling of buildings is started, with a height of more than 20m around the Kego Fault, which is said to have a high probability of earthquakes within the next 30 years.[63]

(3) Special Case No. 4

In the Building Standards Act, not only are structural calculations not obligatory for buildings, such as small wooden detached houses, designed by registered architects (No. 4 building)[64] as prescribed in Article 6, Paragraph 1, Item 4 of the law. Partial omission of the examination related to structural relationship provisions is permitted when validating a building (Article 6-4, Paragraph 1, Item 3 of the law, commonly known as "Special Case No. 4").[65] Regarding Special Case No. 4, there have been cases of houses with low seismic performance built because of incorrect validation of constructions, with voices from many quarters calling for the tightening or abolishment of its operation.[66] In the 2016 Kumamoto Earthquake, among the 77 No. 4 buildings (wooden detached houses) built under the new earthquake-resistant building codes that had their cause of collapse analyzed, 73 had specification violations pointed out. Even with the possibility of design flaws, Mr. KANZAKI Satoshi, a lawyer, has pointed out a problem specific to No. 4 buildings, which is that structural calculations that use only wall volume calculations are exempted.[67]

At present, there is no discussion within the Ministry of Land, Infrastructure, Transport and Tourism regarding whether to obligate structural calculations for No. 4 buildings or to aim at reviewing or abolishing Special Case No. 4 by law[68]. It is believed

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63 "Regarding Earthquake-resistance Measures for Buildings with Eyes on the Kego Fault (Making an Ordinance)," Fukuoka City website. Of the 210 buildings made subject following enactment of the ordinance, there were some cases where the force of the penal regulations was not followed, and only 54 buildings were designed according to the ordinance (*The Tokyo Shimbun*, *op. cit.* (57)).

64 For the specific size and structure of buildings, wooden buildings of two stories or less, with total area of 500m2 or less, a height of 13m or less, or an eaves height of 9m or less are applicable ("A Construction Viewpoint "Special Case No. 4" Makes Disaster Victims Suffer," *Nikkei Home Builder*, (web version), 2016.6.3.

65 As background for the establishment of the special case, after the establishment of the Building Standards Act, the government and municipalities never established an examination system for general wooden housing, the most common type of unit. Additionally, examinations take time and money, which was determined to be a burden on individual workers and small-scale builders (SAWADA Kazuhiro, "On the Current Situation and Issues Surrounding Building Standards: Based on Survey Results of Housing Damage from the 2016 Kumamoto Earthquake," *Construction Policy*, No. 170, 2016.11, pp. 6-9).

66 Nikkei Home Builder ed., *op. cit.* (9), pp. 113-120. Regarding the abolition of Special Case No. 4, there are opposing opinions due to the increased design costs and examination burdens, it has been pointed out that the problem is not the system but the awareness of the person in charge.

67 "Homework from the 2016 Kumamoto Earthquake Seeking Revision Special Case No. 4 Examples and New Earthquake-proofing," *Nikkei Home Builder*, No. 216, 2017.6, pp. 42-47.

68 When a large number of illegal new construction were discovered in 2006 that did not comply with the Building Standards Act, the Ministry of Land, Infrastructure, Transport and Tourism also considered abolishing Special Case No. 4, but the construction industry was opposed, so they left

that municipal bodies will continue to determine their course of action individually.[69] Meanwhile, the possibility of dealing with structural plans not considered by the current specifications (such as skip floors[70] and open ceilings) becoming a discussion subject for future policies has been pointed out.[71]

(4) Considering Direct Downward Rate

Direct downward rate refers to the proportion of columns and bearing walls that are connected to each other between the upper and lower floors of a building and is used as an important index for evaluating structural balance.

Although there is no provision in the Building Standards Act or the Housing Performance Representation System, it is said that the lower the direct rate the lower the effect of the bearing wall.[72] Experts have divergent opinions regarding the direct downward rate. Some believe that it has no relationship with seismic performance, while Professor Emeritus SAKAMOTO Isao of the University of Tokyo thinks that survey results showing that the proportion of accidents increases dramatically when the direct downward rate for columns falls below 50% make it an indicator of quality in the structural plan.[73] Mistakes in construction, along with the lack of design consideration, were determined to be the causes of collapse among the 2000 building codes' houses that were damaged by the 2016 Kumamoto Earthquake, one of which Professor Hiroshi Isoda of Kyoto University proposes was the low direct downward rate.[74]

The expert committee cites "ground deformation" and "the possibility that a large earthquake motion occurred locally" as causes of collapse of new earthquake-resistant housing built in keeping with the 2000 building codes. The government also states that it does not believe that the direct downward rate had an impact and that it is not thinking of

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it. It is thought that the Long-life Quality Housing system was introduced as an alternative (SAWADA, *op. cit.* (65)).

[69] For example, in Osaka Prefecture, No. 4 buildings have to submit wall volume calculation documents when applying for building certification under administrative guidance, as well as undergo inspections, so in practice they have abolished Special Case No. 4 (*Nikkei Home Builder*, *op. cit.* (67)).

[70] Spatial configuration that uses continuously shifted floors.

[71] *Nikkei Home Builder*, *op. cit.* (67).

[72] Nikkei Home Builder ed., *op. cit.* (9), pp. 50-55.

[73] "Ask SAKAMOTO Isao, Professor Emeritus at Tokyo University Make Walls and Columns in the Places They Should Be," *Nikkei Home Builder*, No. 215, 2017.5, pp. 58-59. Professor SAKAMOTO claims that reasons causes of low direct downward rates in wooden housing stem from the development of precutting (cutting and processing the structure of the building beforehand at the factory before on-site construction) leading to housing being constructed without the soundness of the framework being checked and the introduction of the 4-category division method examining wall placement balance based on the 2000 revision to the Building Standards Act, where building codes are met with only the exterior walls even if there are no internal walls on the first floor.

[74] Nikkei Home Builder ed., *op. cit.* (9), pp. 64-69.

incorporating provisions pertaining to the direct downward rate into the Building Standards Act.[75]

2 *Factors that Impede Earthquake-proofing and their Solutions*

(1) Government Analysis

In February 2013, the Ministry of Land, Infrastructure, Transport and Tourism's Council for Social Infrastructure Development released "Regarding Measures to Promote Earthquake-proofing of Housing and Buildings." It raised the following points as impediments to earthquake-proofing: (1) the large cost burden for earthquake-proofing; (2) calling into question the necessity of earthquake-proofing (seismic performance is recognized as existing); (3) the difficulty involved in selecting a tradesperson; (4) the difficulty in judging whether the construction method, cost, effect, etc. are appropriate; (5) concerns over restricted usage during construction work; and (6) the difficulty involved in building consensus among unit owners (for apartment buildings, etc.).[76]

In addition to this report, ONUMA Kentaro of Nomura Research Institute addresses this from the perspective of "changes in the social environment" and "institutional issues" and raises the following factors as impediments to earthquake-proofing: (1) aging owners (feels that "an earthquake may not occur while I'm alive"); (2) an increase in vacant houses (owners' have trouble feeling the benefits of earthquake-proofing, etc.); (3) inadequacy of target items for explaining important matters[77]; and (4) the lack of thoroughness in construction validation.[78]

In addition, in the "Public Opinion Survey on Disaster Prevention" conducted by the

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75 "Response to the Question on Earthquake-resistant Building Codes Submitted by the House of Representatives Member OKUNO Soichiro," *op. cit.* (60).

76 Council for Social Infrastructure Development, "Regarding the Future of the Building Standards System (First Report) 'Ideal Measures to Promote Earthquake-proofing Housing and Buildings,'" 2013.2. Ministry of Land, Infrastructure, Transport and Tourism website. The report says that, as a direction for promoting earthquake-proofing, thorough earthquake-proofing examinations are necessary to drive awareness of the need for earthquake-proofing, as well as reducing the cost burden of doing so.

77 Under Article 35 of the Real Estate Brokerage Act (Act No. 176 of 1952) and Article 16-4-3-5 of the Regulation for Enforcement of the Real Estate Brokerage Act (Order of the Ministry of Construction No. 12 of 1957), when purchasing, trading, or leasing buildings built under the Old Earthquake-resistant Building Codes (new construction prior to May 31, 1981), if the building has undergone an earthquake-proofing examination under the Act on Promotion of Seismic Retrofitting of Buildings, the person making the transaction of the residential building must exchange documentation and provide explanation of the content. Buildings that have not undergone an earthquake-proofing examination are not subject to this, and in order to avoid a reduction in asset value should an examination find insufficient seismic performance, it is pointed out that it is likely easy to work with the intent not to perform an examination (ONUMA Kentaro, "Issues and Proposals for Earthquake-proofing Housing," *NRI Public Management Review*, Vol. 116, 2013.3, pp. 3-4).

78 *ibid*.

Cabinet Office in 2013, 48.1% answered "not planning to implement" as their intent for implementing earthquake-resistant reinforcement construction and responded with reasons such as "It costs money" (43.5%) and "I do not feel it is necessary" (22.8%).[79]

(2) Measures to Eliminate Impediments

The subsidy for seismic retrofitting under the current system generally limits the total to 23% across both national and local governments[80], leading to many cases in which the burden on the owner exceeds 1 million yen.[81]

Professor KAGIYA Hajime of the Atomi Women's University points out that the number of municipalities offering subsidies related to seismic retrofitting has increased, with many of them doing reinforcement work to meet earthquake-resistant building codes, which is a condition of subsidy payment. He also says that as older houses require more work, adoption is not proceeding, particularly among economically struggling and elderly households. In addition, he states that subsidizing "partial reinforcement" that does not achieve earthquake-resistant building codes and supplementing the full amount of construction costs for households with markedly low incomes should be explored. Prof. KAGIYA mentions that in Sumida Ward, Tokyo, they have introduced a system[82] to raise the subsidy rate from 2/3 to 5/6 when carrying out seismic retrofitting in conjunction with barrier-free improvements. He points out the necessity of making efforts to increase demand for earthquake-proofing using the existing system.[83]

Professor FUKUWA Nobuo of Nagoya University also suggests the necessity to mandate earthquake-proofing when renovating old houses and to mandate establishing a

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79 Cabinet Office Public Relations Office, "Public Opinion Poll on Disaster Prevention Summary," (Fifth Examination Committee for the Ideal Form of National Assistance for Victims Document 2), 2014.2, pp. 11-12.

80 Total value of subsidy rate from national and local governments within the Housing and Building Safety Stock Formation Project.

81 "Earthquake-resistant Housing Cost Burden in the Walls Promotion to Owners Municipalities Struggling," *op. cit.* (32). According to a Japan Building Disaster Prevention Association survey, the construction costs of seismic retrofitting for wooden houses is frequently between 1 million and 1.5 million yen, with an average of roughly 2.11 million yen (HAGA Yuji and YOKOTA Yasuhiro, "Survey on the Actual Condition of Seismic Retrofitting Costs for Wooden Houses," *Building Disaster Prevention* (Kenchiku Bosai), No. 389, 2010.6, pp. 2-8).

82 "Earthquake-resistant and Barrier Free Retrofitting Promotion Support Subsidy System," *Sumida* No. 1636, 2011.4.21, p. 2.

83 KAGIYA Hajime and HORII Hiroyoshi, "Interview Atomi Women's University Professor of Tourism Community Studies Learning about Issues for Urban Disaster Prevention from the 2016 Kumamoto Earthquake Top Priority is Earthquake-proofing Strengthening Elderly Households, Poor Households, and Municipality Office Buildings," *Yomiuri Quarterly*, No. 38, 2016.Summer, pp. 76-83.

partial seismic shelter[84] if not remodeling completely.[85]

The aforementioned Mr. ONUMA points out the effectiveness of mandating earthquake-proofing when ownership is transferred because of purchase, inheritance, and so on. As a further step forward, he proposes that earthquake-proofing examinations and retrofitting be made an obligation for all housing, along with thorough validation of construction.[86]

On the basis of the damage caused by the 2016 Kumamoto Earthquake and the government's previous efforts, the National Governors' Association issued a proposal in July 2017, calling for the drastic strengthening of earthquake resistance measures pertaining to housing. The lack of seismic performance in housing is tied to human lives, and the huge public expenditure of supporting victims who lose their homes squeezes public finances and affects future restoration efforts. Thus, they are seeking measures to reduce the cost burden of earthquake-proofing, as well as providing support for the development of inexpensive construction methods.[87]

In Conclusion

Earthquake-proofing houses is an indispensable measure for alleviating the damage from earthquakes, which requires a reduction in the cost burden for earthquake-proofing examinations and retrofitting by government subsidies and an improvement in seismic performance using the Housing Performance Representation System. For ordinary wooden two-story houses, the responsibility of the designing registered architect increases because the requirements of structural calculation and inspection for building certification are dispensed with.[88] Still, it is critical that the customer take a position of verifying seismic performance without leaving it entirely to the tradesperson.[89] As for the Building Standards Act and earthquake-resistant building codes, while there are calls for

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84 Since earthquake-resistant shelters are able to be set up in a shorter amount of time than construction on an occupied residence or seismic retrofitting, they are an effective option whenever major seismic retrofitting is not economically possible. Within the 25 city wards of Tokyo, grants are provided for establishing earthquake-resistant shelters for the elderly and households with disabilities ("Earthquake-resistant Shelter Support System Summary." Tokyo Earthquake-Resistant Portal Site).

85 FUKUWA Nobuo, "Earthquake-proofing Support is an Upfront Investment," *The Yomiuri Shimbun*, 2017.1.17.

86 ONUMA, *op. cit.* (77), pp. 5-6.

87 National Governors' Association, "Emergency Recommendations on Drastically Strengthening Residential Earthquake Resistance Promotion Measures," 2017.7.27.

88 Cases of registered architects knowingly breaking the law and misusing the examination-less Special Case No. 4 in response to customer demands for "more windows," wanting to "make rooms bigger by minimizing the number of walls" ("Hearing 'More Windows,' 'Fewer Walls,' 'Insufficient Strength,'" *The Tokyo Shimbun*, 2016.6.1).

89 MIYAZAWA Kenji, "Lessons from the 2016 Kumamoto Earthquake Destroyed Homes Prevented with Bearing Walls Wall Volumes Matched to the Ground," *The Yomiuri Shimbun*, 2016.8.6.

reexamination on the basis of the problems revealed by the 2016 Kumamoto Earthquake, there is also concern regarding the increased costs from strengthening the building codes, and balancing that with building safety will necessitate a national dialog.

SENDA Kazuaki, *Progress and Challenges of Earthquake-Resistant Housing: Examining the Discussions Following the 2016 Kumamoto Earthquake* (Research Materials), 2019e-4, Tokyo: Research and Legislative Reference Bureau, National Diet Library, 2019.

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