World Housing Encyclopedia
an Encyclopedia of Housing Construction in
Seismically Active Areas of the World

an initiative of
Earthquake Engineering Research Institute (EERI) and
International Association for Earthquake Engineering (IAEE)

HOUSING REPORT
Single-family wooden house

Report #	86
Report Date	21-11-2002
Country	JAPAN
Housing Type	Timber Building
Housing Sub-Type	Timber Building : Post and beam frame (no special connections)
Author(s)	Norio Maki, Satoshi Tanaka
Reviewer(s)	Sajal K. Deb

Summary

Japan has a long tradition related to wood construction. The main building of the Horyuji-temple, which was constructed in the late 7th century, is the oldest existing wooden structure in the world. Most Japanese housing is of wood construction. In 1993, 68.1% of the 45.8 million units of housing stock consisted of wooden structures. However, in newly constructed housing, the percentage of wooden structures is decreasing. In 1995, the percentage of

wooden structures in newly constructed housing was 45.5%. The Hanshin Awaji earthquake disaster in 1995 damaged many wooden structures, especially housing that was constructed according to the pre-1980 building code. Despite the severe damage at the time of the Hanshin earthquake and governmental encouragement of seismic upgrading, retrofitting of these houses is not common.

1. General Information

Buildings of this construction type can be found in all parts of Japan. Wood structures comprise a major structural type throughout Japan. Only in the Okinawa prefecture in the southern part of Japan does the non-wood structure housing stock exceed the wood structure housing stock. This type of housing construction is commonly found in both rural and urban areas.

In 1993 the percentage of non-wooden structure housing in urban areas (40.8%) was larger than that in rural areas.

This construction type has been in practice for more than 200 years.

Currently, this type of construction is being built. .


Figure 1: Ordinary housing in 1970s-80s (wall: mortar finish)


Figure 2: Ordinary housing after 1990s- (wall: metal, ceramic finish) source:http://inpaku.dpri.kyoto-u.ac.jp/en/join/live/index.html


Figure 3: Traditional housing in old downtown (Japanese Shophouse, Machiya) source: http://www.machiya.or.jp/

2. Architectural Aspects

2.1 Siting

These buildings are typically found in flat, sloped and hilly terrain. They do not share common walls with adjacent buildings. There is no specific data on a typical separation distance between buildings. Minimum separation distance is decided mainly by building code regulation for the insulation duration within a room. The Civil Code also regulates a minimum distance of at least 50 cm. Traditional shop houses in Japan, Machiya, do not have a separation distance between buildings When separated from adjacent buildings, the typical distance from a neighboring building is 0.5 meters.

2.2 Building Configuration

It is different throughout the country, depending on the location of the housing. Single-family housing in urban and suburban areas is typically just one building, and farmers' houses in rural areas consist of 2-3 buildings, including the main house, storage, etc. There are also apartment houses of wood in urban areas. In 1998 single-family housing was still the major architectural type in Japan (57.5%), and 93% of single-family houses were wooden structures.

2.3 Functional Planning

The main function of this building typology is single-family house. Many types of wooden structures are used for housing, including the traditional shop house, "Machiya," which exists in old downtown areas (a mixed-use building), and wooden apartment buildings, "Mokuchin," which are cheap rental housing. In a typical building of this type, there are no elevators and 1-2 fire-protected exit staircases. There is no special requirement for exits in 2-3 story single-family houses. However, there are strict requirements on the materials used for the window frames, walls, and roofing in urbanized areas to prevent fire spread.

2.4 Modification to Building

Modification of utilities in the kitchen and bathroom, or extension of the living space is common. However, seismic retrofitting is not very common.

Figure 4: Traditional housing for wealthy merchant 1 (Yoshijima family house in Takayama)

3. Structural Details

3.1 Structural System

Material	Type of Load-Bearing Structure	#	Subtypes	Most appropriate type
Masonry	Stone Masonry Walls	1	Rubble stone (field stone) in mud/lime mortar or without mortar (usually with timber roof)	☐
		2	Dressed stone masonry (in lime/cement mortar)	☐
	Adobe/ Earthen Walls	3	Mud walls	☐
		4	Mud walls with horizontal wood elements	☐
		5	Adobe block walls	☐
		6	Rammed earth/Pise construction	☐
	Unreinforced masonry walls	7	Brick masonry in mud/lime mortar	☐
		8	Brick masonry in mud/lime mortar with vertical posts	☐
		9	Brick masonry in lime/cement mortar	☐
		10	Concrete block masonry in cement mortar	☐
		11	Clay brick/tile masonry, with wooden posts and beams	☐
			Clay brick masonry, with	

	Confined masonry	12	concrete posts/tie columns and beams	☐
		13	Concrete blocks, tie columns and beams	☐
	Reinforced masonry	14	Stone masonry in cement mortar	☐
		15	Clay brick masonry in cement mortar	☐
		16	Concrete block masonry in cement mortar	☐
Structural concrete	Moment resisting frame	17	Flat slab structure	☐
		18	Designed for gravity loads only, with URM infill walls	☐
		19	Designed for seismic effects, with URM infill walls	☐
		20	Designed for seismic effects, with structural infill walls	☐
		21	Dual system – Frame with shear wall	☐
	Structural wall	22	Moment frame with in-situ shear walls	☐
		23	Moment frame with precast shear walls	☐
	Precast concrete	24	Moment frame	☐
		25	Prestressed moment frame with shear walls	☐
		26	Large panel precast walls	☐
		27	Shear wall structure with walls cast-in-situ	☐
		28	Shear wall structure with precast wall panel structure	☐
Steel	Moment-resisting frame	29	With brick masonry partitions	☐
		30	With cast in-situ concrete walls	☐
		31	With lightweight partitions	☐
	Braced frame	32	Concentric connections in all panels	☐
		33	Eccentric connections in a few panels	☐
	Structural wall	34	Bolted plate	☐
		35	Welded plate	☐
Timber	Load-bearing timber frame	36	Thatch	☐
		37	Walls with bamboo/reed mesh and post (Wattle and Daub)	☐
		38	Masonry with horizontal beams/planks at intermediate levels	☐
		39	Post and beam frame (no special connections)	☑
		40	Wood frame (with special connections)	☐
		41	Stud-wall frame with plywood/gypsum board sheathing	☐
		42	Wooden panel walls	☐
Other	Seismic protection systems	43	Building protected with base-isolation systems	☐
		44	Building protected with seismic dampers	☐
	Hybrid systems	45	other (described below)	☐

There are several structural systems that are used in Japanese wood housing. While post and beam construction is most common, some buildings of this type are of balloon frame construction.

3.2 Gravity Load-Resisting System

The vertical load-resisting system is timber frame. Gravity load-bearing structure consists of a system of posts and beams. Wooden posts, with cross-sectional dimensions ranging from 105 to 150 mm, carry gravity loads. The roof structure is made out of wood and it is covered by roof tile or slate. The roof load is transferred to the wood frame. The roof-supporting system in Japan is different from that of western countries and it is based only on vertical and horizontal members. There are no diagonal members, common for similar construction in western countries.

3.3 Lateral Load-Resisting System

The lateral load-resisting system is timber frame. Japanese wooden housing is built using "post-and-beam" construction. Lateral load resistance is provided by wooden shear walls with interior diagonal brace members or alternatively, with plywood or manufactured wood panels ("particle board") nailed to the vertical wooden members. The building code regulates the number and dimensions of shear walls. Metal joints and plates are used to stiffen the wood frame in recent wooden housing. However, the traditional Japanese house did not have a diagonal brace. A thin lumber running through posts, called Nageshi, and a thick wood post, provide lateral resistance. The traditional Japanese carpenter was reluctant to use a diagonal brace because it could cause a diagonal crack in a mud-plastered wall.

3.4 Building Dimensions

The typical plan dimensions of these buildings are: lengths between 0 and 0 meters, and widths between 0 and 0 meters. The building has 1 to 3 storey(s). The typical span of the roofing/flooring system is 1.8-2 meters. Typical Plan Dimensions: There is a wide variation in dimensions. Typical Number of Stories: Building code regulations limit the height of wooden structures to a maximum of three stories. A special permit is necessary for wooden buildings with four or more stories. Typical Story Height: This story height measurement does not include the height of the basement. Therefore, the story height of first floor includes the typical story height, plus the height of basement and is usually 3.4 meters. Typical Span: Modular coordination is conducted according to Tatami mat size in Japanese housing. The typical module dimension in Japanese housing ranges between 0.9-1 meter. The typical span (distance between the posts) is equal to two modules (i.e. 1.8-2 m). The typical storey height in such buildings is 2.8 meters. The typical structural wall density is none. There is a wide variation in wall density.

3.5 Floor and Roof System

Material	Description of floor/roof system	Most appropriate floor	Most appropriate roof
Masonry	Vaulted	☐	☐
	Composite system of concrete joists and masonry panels	☐	☐
Structural concrete	Solid slabs (cast-in-place)	☐	☐
	Waffle slabs (cast-in-place)	☐	☐
	Flat slabs (cast-in-place)	☐	☐
	Precast joist system	☐	☐
	Hollow core slab (precast)	☐	☐
	Solid slabs (precast)	☐	☐
	Beams and planks (precast) with concrete topping (cast-in-situ)	☐	☐
	Slabs (post-tensioned)	☐	☐
Steel	Composite steel deck with concrete slab (cast-in-situ)	☐	☐
	Rammed earth with ballast and concrete or plaster finishing	☐	☐
	Wood planks or beams with ballast and concrete or plaster finishing	☐	☐
	Thatched roof supported on wood purlins	☑	☐
	Wood shingle roof	☐	☐

Timber	Wood planks or beams that support clay tiles	☑	
	Wood planks or beams supporting natural stones slates	☐	☐
	Wood planks or beams that support slate, metal, asbestos-cement or plastic corrugated sheets or tiles	☐	☐
	Wood plank, plywood or manufactured wood panels on joists supported by beams or walls	☐	☐
Other	Described below	☑	☑

3.6 Foundation

Type	Description	Most appropriate type
Shallow foundation	Wall or column embedded in soil, without footing	☐
	Rubble stone, fieldstone isolated footing	☑
	Rubble stone, fieldstone strip footing	☐
	Reinforced-concrete isolated footing	☐
	Reinforced-concrete strip footing	☑
	Mat foundation	☐
	No foundation	☐
Deep foundation	Reinforced-concrete bearing piles	☐
	Reinforced-concrete skin friction piles	☐
	Steel bearing piles	☐
	Steel skin friction piles	☐
	Wood piles	☐
	Cast-in-place concrete piers	☐
	Caissons	☐
Other	Described below	☐

Infrequently, deep foundations are also used.

Figure 5: Traditional housing for wealthy merchant 2 (Yoshijima family house in Takayama)

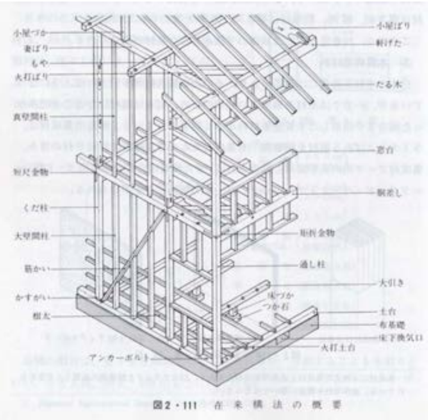

Figure 6: Structural system (source: Uchida, 2001)

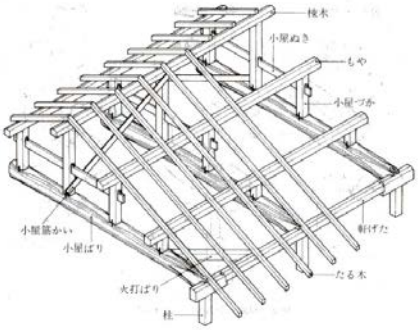

Figure 7: Roof (Source: Uchida, 2001)

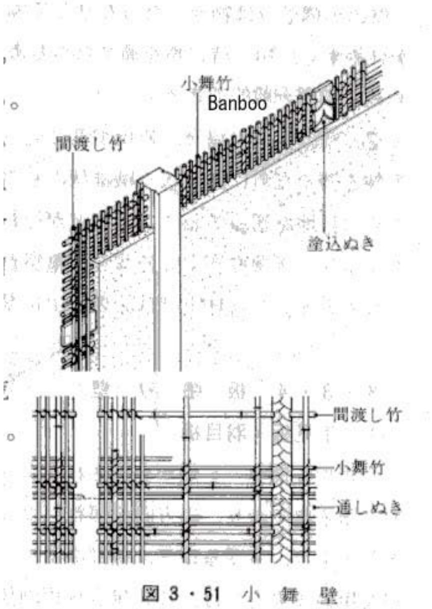

Figure 8: Traditional walls (source: Uchida, 2001)

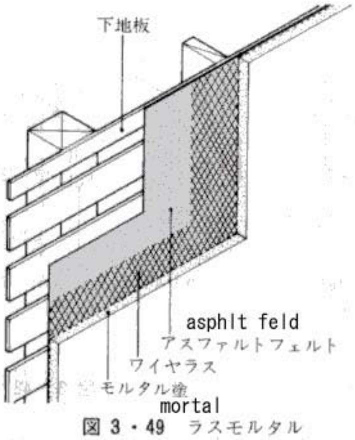

Figure 9: Wall (source: Uchida, 2001)

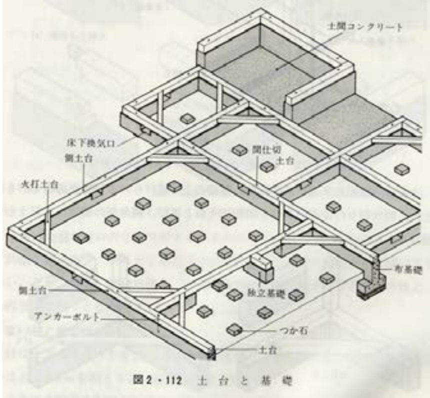

Figure 10: Basement (source: Uchida, 2001)

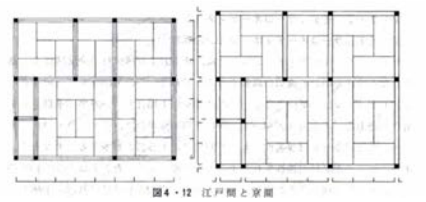

Figure 11: Modular coordination (source: Uchida, 2001)

4. Socio-Economic Aspects

4.1 Number of Housing Units and Inhabitants

Each building typically has 1 housing unit(s). 1 units in each building. As noted above, most wood housing is still single-family, 1 unit per building. However, for multi-family housing, the average number of units is 8.78. The number of inhabitants in a building during the day or business hours is less than 5. The number of inhabitants during the evening and night is less than 5. In 2000, the average number of members in a Japanese family was 2.69 persons.

4.2 Patterns of Occupancy

In 1998 single-family housing still constituted the dominant housing stock (57.5%). However, the percentage of multi-family housing continued to increase from the 1965 level of 12.5% and comprised 37.8% of the housing stock in 1998. (The percentage of semi-detached housing had decreased to 4.2% by 1998). This data is based on the entire housing stock in Japan, and not just on wooden structure housing and unit base.

4.3 Economic Level of Inhabitants

Income class	Most appropriate type
a) very low-income class (very poor)	☐
b) low-income class (poor)	☐
c) middle-income class	☐
d) high-income class (rich)	☐

There is no specific data about each economic class and each housing type. In 2002, the average condominium price in

Tokyo was JPY 39 million compared to the average annual salary of JPY 7.4 million.

Ratio of housing unit price to annual income	Most appropriate type
5:1 or worse	☐
4:1	☐
3:1	☐
1:1 or better	☑

What is a typical source of financing for buildings of this type?	Most appropriate type
Owner financed	☑
Personal savings	☑
Informal network: friends and relatives	☑
Small lending institutions / micro-finance institutions	☐
Commercial banks/mortgages	☑
Employers	☐
Investment pools	☐
Government-owned housing	☐
Combination (explain below)	☑
other (explain below)	☐

A quasi-governmental housing loan company distributes low interest housing loans for the middle class and 32% of the housing stock constructed after World War II has been purchased through this financing. In each housing unit, there are 1 bathroom(s) without toilet(s), 1 toilet(s) only and 1 bathroom(s) including toilet(s).

Housing units without a private bathroom number 1,278,700 and housing units without a private latrine number 290,400. .

4.4 Ownership

The type of ownership or occupancy is renting, outright ownership , ownership with debt (mortgage or other) , individual ownership and long-term lease.

Type of ownership or occupancy?	Most appropriate type
Renting	☑
outright ownership	☑
Ownership with debt (mortgage or other)	☑
Individual ownership	☑
Ownership by a group or pool of persons	☐
Long-term lease	☑
other (explain below)	☐

59.8% of the housing was owner-occupied in 1993.

5. Seismic Vulnerability

5.1 Structural and Architectural Features

Structural/ Architectural Feature	Statement	Most appropriate type		
		Yes	No	N/A
Lateral load path	The structure contains a complete load path for seismic force effects from any horizontal direction that serves to transfer inertial forces from the building to the foundation.	☑	☐	☐
Building Configuration	The building is regular with regards to both the plan and the elevation.	☑	☐	☐
Roof construction	The roof diaphragm is considered to be rigid and it is expected that the roof structure will maintain its integrity, i.e. shape and form, during an earthquake of intensity expected in this area.	☑	☐	☐
Floor construction	The floor diaphragm(s) are considered to be rigid and it is expected that the floor structure(s) will maintain its integrity during an earthquake of intensity expected in this area.	☑	☐	☐
Foundation performance	There is no evidence of excessive foundation movement (e.g. settlement) that would affect the integrity or performance of the structure in an earthquake.	☑	☐	☐
Wall and frame structures-redundancy	The number of lines of walls or frames in each principal direction is greater than or equal to 2.	☑	☐	☐
Wall proportions	Height-to-thickness ratio of the shear walls at each floor level is: Less than 25 (concrete walls); Less than 30 (reinforced masonry walls); Less than 13 (unreinforced masonry walls);	☑	☐	☐
Foundation-wall connection	Vertical load-bearing elements (columns, walls) are attached to the foundations; concrete columns and walls are doweled into the foundation.	☑	☐	☐
Wall-roof connections	Exterior walls are anchored for out-of-plane seismic effects at each diaphragm level with metal anchors or straps	☑	☐	☐
Wall openings	The total width of door and window openings in a wall is: For brick masonry construction in cement mortar : less than ½ of the distance between the adjacent cross walls; For adobe masonry, stone masonry and brick masonry in mud mortar: less than 1/3 of the distance between the adjacent cross walls; For precast concrete wall structures: less than 3/4 of the length of a perimeter wall.	☑	☐	☐
Quality of building materials	Quality of building materials is considered to be adequate per the requirements of national codes and standards (an estimate).	☑	☐	☐
Quality of workmanship	Quality of workmanship (based on visual inspection of few typical buildings) is considered to be good (per local construction standards).	☑	☐	☐
Maintenance	Buildings of this type are generally well maintained and there are no visible signs of deterioration of building elements (concrete, steel, timber)	☐	☑	☐
Additional Comments	All structural and architectural features related to seismic resistance, which are indicated above, refer to housing constructed according to the present building code. There are many problems found in housing that was constructed according to the pre-1980 building code.			

5.2 Seismic Features

Structural Element	Seismic Deficiency	Earthquake Resilient Features	Earthquake Damage Patterns
Wall	See Structural Features	See Structural Features	See Structural Features
Frame (columns, beams)	See Structural Features	See Structural Features	See Structural Features
Roof and floors	See Structural Features	See Structural Features	See Structural Features
Other	See Structural Features	See Structural Features	See Structural Features

5.3 Overall Seismic Vulnerability Rating

The overall rating of the seismic vulnerability of the housing type is A: HIGH VULNERABILITY (i.e., very poor seismic performance), the lower bound (i.e., the worst possible) is A: HIGH VULNERABILITY (i.e., very poor seismic performance), and the upper bound (i.e., the best possible) is A: HIGH VULNERABILITY (i.e., very poor seismic performance).

Vulnerability	high	medium-high	medium	medium-low	low	very low
	very poor	poor	moderate	good	very good	excellent
Vulnerability Class	A	B	C	D	E	F
	☑	☐	☐	☐	☐	☐

5.4 History of Past Earthquakes

Date	Epicenter, region	Magnitude	Max. Intensity
1923	Kanto	7.9	7 (JMA) estimated results
1964	Niigata	7.5	6 (JMA)
1995	Hyougo-ken-Nannbu	7.3	7 (JMA)
2000	Tottori-ken-Seibu	7.3	6+(JMA)

The magnitude of each earthquake is JMA magnitude. The 1923 Kanto earthquake killed more than 140,000 people, heavily damaged 120,000 buildings and burned 440,000 buildings. Fire following the earthquake was the most prevalent cause of damage. There were many earthquakes during the 1930s and 40s, such as the Tottori in 1943, which killed 1,083 people, the East Nankai in 1944, the Nankai in 1996, and the Fukui in 1949, which killed 3,769 people. There was a reduction in the number of earthquake disasters during 1950s-80s. However, the Niigata earthquake in 1964 spotlighted damage by liquefaction and the Miyagiken-oki earthquake in 1978 spotlighted damage by a landslide occurring at a hillside housing complex. The 1995 Hyogo-ken Nanbu earthquake killed 6,435 people. They died mainly from the collapse of wooden housing. In 2001 during the Tottori-ken Seibu earthquake, many wooden housing units were damaged by ground motion and liquefaction.

Figure 12: Wooden structure housing damage at the 1995 Kobe earthquake (photo by Michio Miyano)

Figure 13: Wooden structure housing damage at the 1995 Kobe earthquake (photo by Michio Miyano)

Figure 14: Wooden structure housing damage at the 1995 Kobe earthquake (photo by Michio Miyano)

Figure 15: Wooden structure housing damage at the 1995 Kobe earthquake (photo by Michio Miyano)

Figure 16: Wooden structure housing damage at the 1995 Kobe earthquake (photo by Michio Miyano)

Figure 17: Wooden structure housing damage at the 1995 Kobe earthquake (photo by Michio Miyano)

Figure 19: Tools used in construction process (source: http://www1.sphere.ne.jp/tknk-mse/dougu/B3.htm)

6. Construction

6.1 Building Materials

Structural element	Building material	Characteristic strength	Mix proportions/dimensions	Comments
Walls	Sliding (synthetic resin, metal, ceramic) plywood mortar+wood mud + bamboo			The most traditional wall of Japanese wooden housing was made from mud on bamboo frame. Though mortal finish on wood frame was popular in modern wooden structure, now siding on plywood becomes most popular in ordinary wooden structure housing.
Foundation	RC No foundation (just foundation stone)			Traditional Japanese wooden structure does not have foundation. It is just put on foundation stone.

Frames (beams & columns)	Wood RC Steel			Usage of metal joint is encouraged by a present building code. However, metal joint was not used in traditional Japanese housing.
Roof and floor(s)	Roof tile on mud Slate Wood RC			Heavy roof made of mud and roof tile caused collapse of housing at the time of 1995 Kobe earthquake.

6.2 Builder

The builder lives in this construction type.

6.3 Construction Process, Problems and Phasing

Please refer to figure 7a-7h. The construction of this type of housing takes place in a single phase. Typically, the building is originally designed for its final constructed size.

6.4 Design and Construction Expertise

The building standard mandates that buildings of this type must be designed by a licensed architect. The licensing system for architects in Japan is unique in that the license is issued to engineers. There are three licensing levels: Wooden Structure, Second Class, and First Class. To take the examination for a license for Wooden Structure, one must have graduated from a school of architecture or civil engineering; for a 2nd class license, two years experience in the field is required. The 1st class license requires two additional years experience after the 2nd class license is issued. Any licensed architect can design wooden structure housing. For this type of building, the role of the engineer and architect is not large. The building is designed and constructed mainly by a licensed design builder, who is a contractor responsible for both the design and construction of the structure.

6.5 Building Codes and Standards

This construction type is addressed by the codes/standards of the country. Japanese Building Standard. The year the first code/standard addressing this type of construction issued was The first building standard was established in 1919 and dealt mainly with buildings in urban areas, primarily large-scale wooden structure housing. In 1950, the Japanese Building Standard was issued, which addressed almost all wooden structure housing. The most recent code/standard addressing this construction type issued was The last amendment was issued in 2000. The main objectives of this amendment were 1) performance-based regulation, 2) enforcement of a building inspection system, 3) involvement of the private sector in building inspections. Title of the code or standard: Japanese Building Standard Year the first code/standard addressing this type of construction issued: The first building standard was established in 1919 and dealt mainly with buildings in urban areas, primarily large-scale wooden structure housing. In 1950, the Japanese Building Standard was issued, which addressed almost all wooden structure housing. When was the most recent code/standard addressing this construction type issued? The last amendment was issued in 2000. The main objectives of this amendment were 1) performance-based regulation, 2) enforcement of a building inspection system, 3) involvement of the private sector in building inspections.

Drawing check - interim inspection - final inspection. The requirement for an interim inspection depends on the scale of the housing. Interim inspections were introduced by an amendment of the building standard in 2000.

6.6 Building Permits and Development Control Rules

This type of construction is a non-engineered, and not authorized as per development control rules. Building permits are required to build this housing type.

6.7 Building Maintenance

Typically, the building of this housing type is maintained by Builder and Owner(s).

6.8 Construction Economics

JPY 0.4-1 million/3.3 m2. Average cost of carpenter/day: JPY 10, 000 - 20,000 without cost.

Figure 18: Stages of housing construction (source: http://member.nifty.ne.jp/koso/hokushin/jiban.html)

7. Insurance

Earthquake insurance for this construction type is typically available. For seismically strengthened existing buildings or new buildings incorporating seismically resilient features, an insurance premium discount or more complete coverage is available. Premium discounts were issued according to the seismicity of the area, age of the building, structure type and quality of the building. The government subsidizes earthquake insurance. Maximum coverage is 50 million yen for structures and 10 million yen for personal property.

8. Strengthening

8.1 Description of Seismic Strengthening Provisions

Strengthening of Existing Construction :

Seismic Deficiency	Description of Seismic Strengthening provisions used
Poor frame joint connection	Fix frame joint using metal connector or plates
Poor connection between foundation and framing	Fix using metal connector
Absence of diagonal brace	Add a diagonal brace or structural plywood into frame
Heavy roof	Use light roof tile or slate

8.2 Seismic Strengthening Adopted

Has seismic strengthening described in the above table been performed in design and construction practice, and if so, to what extent?

Yes. The new building code requires usage of metal joints and of a diagonal brace.

Was the work done as a mitigation effort on an undamaged building, or as repair following an earthquake?

In spite of encouragement by the government through low interest loans, retrofitting work for housing is not very popular. In earthquake recovery activities, people prefer to reconstruct their housing rather than to repair it with seismic upgrades with a view toward its resale value.

8.3 Construction and Performance of Seismic Strengthening

Was the construction inspected in the same manner as the new construction?

No. Few people get building permission for repair or renovations, though the building code requires getting permission for large-scale repairs or renovations.

Who performed the construction seismic retrofit measures: a contractor, or owner/user? Was an architect or engineer involved?

The contractor is the main retrofitter. Building repair by a homeowner is not so popular. Recently, some private companies that are not specialized for building construction have begun to promote housing retrofit service.

What was the performance of retrofitted buildings of this type in subsequent earthquakes?

No data.

Reference(s)

1. 1998 Housing and Land Survey
   Statistics Bureau & Statistics Center, Government of Japan, http://www.stat.go.jp/english/data/jyutaku/index.htm
2. System of Earthquake Insurance (In Japanese)
   Non-Life Insurance Rating Organization of Japan, http://www.nliro.or.jp/contents/rate/index.html
3. Gap between price of mid-raised condominium and average annual salary (In Japanese)
   Urban Developers' Association of Japan, http://www.udaj.or.jp/kairi2002kami.htm
4. Building structure system
   Uchida,S.,
   Ichigaya syuppansya 2001
5. Japanese Housing, Rev.2, Gyousei
   Housing Bureau, Ministry of Construction, Japanese Government 1998

Author(s)

1. Norio Maki
   Chief Research Scientist, 4F Human Renovation Museum, EDM NIED
   1-5-2 Kaigan-dori Wakihama Chuo-ku, Kobe 651-0073, JAPAN
   Email:maki@edm.bosai.go.jp FAX: -5786

2. Satoshi Tanaka
   Assistant Professor, College of Environment, Fuji Tokoha University & Disaster Research
   325 Obuchi, Fuji Shizuoka 611-0011, JAPAN
   Email:tanak_s@fuji-tokoha-u-ac.jp FAX: -372511

Reviewer(s)

1. Sajal K. Deb
   Associate Professor
   Dept. of Civil Engineering, Indian Institute of Technology Guwahati
   Guwahati 781 039, INDIA
   Email:skdeb@iitg.ernet.in; skd_iitg@yahoo.com FAX: 91 361 2690762