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
Timber log building

Report #	56
Report Date	05-06-2002
Country	RUSSIAN FEDERATION
Housing Type	Timber Building
Housing Sub-Type	Timber Building : Wood panel walls
Author(s)	Mark Klyachko, Andrey Benin, Janna Bogdanova
Reviewer(s)	Svetlana Uranova

Summary

This is a rural housing construction practice widespread in the forests of Russia. Buildings of this type are common for seismically prone areas of Russia (Far East, Siberia, Baikal Lake Region, North Caucasus). The load-bearing structure is made of wood. To construct the walls, timber logs are sawn horizontally in a square or circular cross section with special end joints (similar to dovetail joints). Buildings have timber roofs and fieldstone or concrete strip

foundations. Typical seria 146-115-77 cm of 'Giprolesprom' for seismic regions is an example of this building type. Seismic performance of these buildings is good if the construction quality is adequate.

1. General Information

Buildings of this construction type can be found in seismically prone areas of Russia (Far East, Siberia, Baikal Lake Region, North Caucasus) where this construction type covers 5 to100% of the housing stock. This type of housing construction is commonly found in rural areas. This construction type has been in practice for more than 200 years.

Currently, this type of construction is being built. This is a traditional construction practice in the region followed for many centuries.


Figure 1A: Typical Building

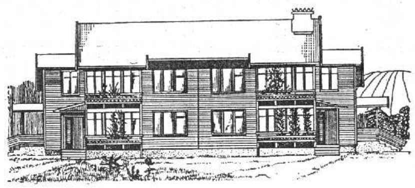
Figure 1B: Typical Building


Figure 1C: Typical Building (Source: www.usadba.spb.ru)


Figure 1D: Typical Building (Source: www.sovex.spb.ru)

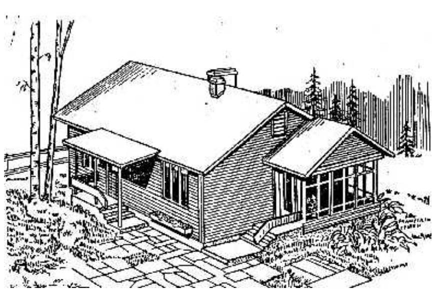
Figure 2A: Key Load-Bearing Elements

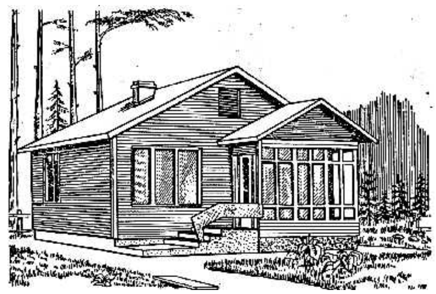
Figure 2B: Perspective Drawing of aTypical Building

2. Architectural Aspects

2.1 Siting

These buildings are typically found in flat terrain. They do not share common walls with adjacent buildings. It can be more than 10 meters also When separated from adjacent buildings, the typical distance from a neighboring building is 10 meters.

2.2 Building Configuration

All buildings are rectangular in shape. Windows: 10-15%; Doors: 5-8%.

2.3 Functional Planning

The main function of this building typology is multi-family housing. In a typical building of this type, there are no elevators and 1-2 fire-protected exit staircases. Each unit has its own entrance.

2.4 Modification to Building

Building modifications are not common.

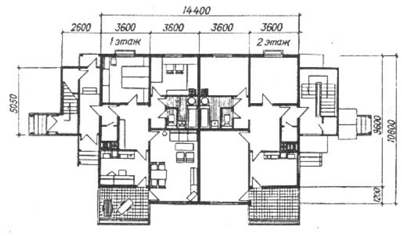

Figure 3: Plan of aTypical Building

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	☐
	Confined masonry	11	Clay brick/tile masonry, with wooden posts and beams	☐
		12	Clay brick masonry, with 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)	☐

3.2 Gravity Load-Resisting System

The vertical load-resisting system is others (described below). The load-bearing structure is made of wood. Walls are made of horizontal square sawn timber logs with special end joints (similar to dovetail joints), as illustrated in Figure 4B. Vertical wall elevation is shown on Figure 4A. Buildings have timber roof and fieldstone or concrete strip foundation.

3.3 Lateral Load-Resisting System

The lateral load-resisting system is others (described below). Same as vertical load-resisting system.

3.4 Building Dimensions

The typical plan dimensions of these buildings are: lengths between 14.4 and 14.4 meters, and widths between 6.6 and 9.9 meters. The building has 1 to 2 storey(s). The typical span of the roofing/flooring system is 3.6 meters. The typical storey height in such buildings is 2.7 meters. The typical structural wall density is up to 10 %. 8-12%.

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)	☐	☐
Timber	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	☐	☐
	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	☑	☑

Wood planks or beams that support slate, metal asbestos-cement or plastic corrugated sheets or tiles.

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	☐

Isolated footings are common in some cases.

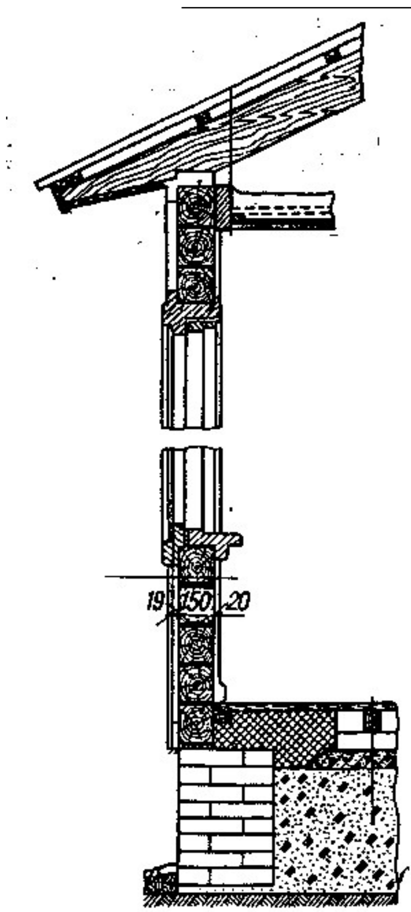

Figure 4A: Wall Section

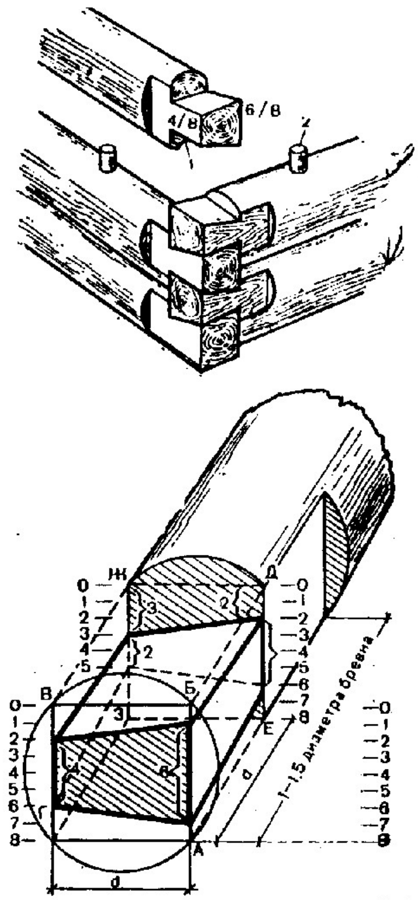

Figure 4B: Timber Log Connection

4. Socio-Economic Aspects

4.1 Number of Housing Units and Inhabitants

Each building typically has 2 housing unit(s). 2 units in each building. Usually there are 2 - 4 units in each building. The number of inhabitants in a building during the day or business hours is 5-10. The number of inhabitants during the evening and night is 5-10.

4.2 Patterns of Occupancy

One family per unit (apartment).

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)	☑

Rich people use timber log houses as cottages.

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)	☐

In each housing unit, there are 1 bathroom(s) without toilet(s), no toilet(s) only and 1 bathroom(s) including toilet(s).

Usually one bathroom per unit. .

4.4 Ownership

The type of ownership or occupancy is outright 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)	☐

Own outright (for one apartment), long-term lease (most common).

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				

5.2 Seismic Features

Structural Element	Seismic Deficiency	Earthquake Resilient Features	Earthquake Damage Patterns
Wall	Poor log connections; Inadequate wall-foundation connections.		
Frame (columns, beams)			
Roof and floors	Poor roof connections (ceiling, tie-beams).		
Other	Frames not provided around openings (doors, windows)		

5.3 Overall Seismic Vulnerability Rating

The overall rating of the seismic vulnerability of the housing type is *D: MEDIUM-LOW VULNERABILITY (i.e., good seismic performance)*, the lower bound (i.e., the worst possible) is D: MEDIUM-LOW VULNERABILITY (i.e., good seismic performance), and the upper bound (i.e., the best possible) is *E: LOW VULNERABILITY (i.e., very good 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
1958	Kamchatka, Kronotsky Gulf	8	IX (MSK)

Some buildings of this type were damaged in the 1958 Kamchatka earthquake.

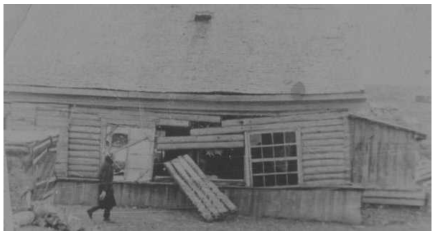

Figure 5A: A Photograph Illustrating Typical Earthquake Damage (1958 Kamchatka earthquake)

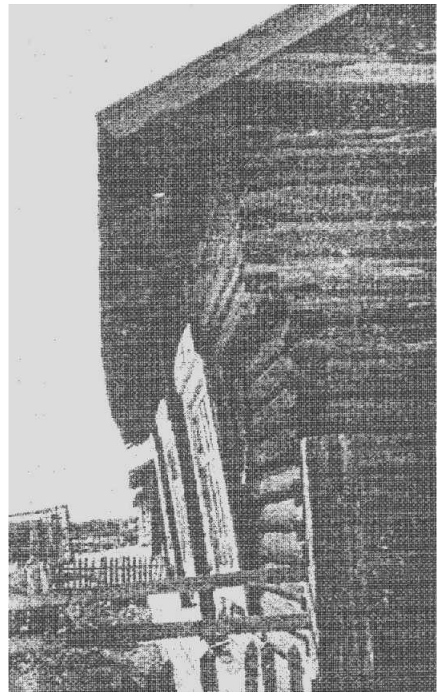

Figure 5B: Wall damage in the 1958 Kamchatka earthquake (showing a side view of the building)

6. Construction

6.1 Building Materials

Structural element	Building material	Characteristic strength	Mix proportions/dimensions	Comments
Walls	Wooden (larch) spars Wooden (larch) logs	800 kg/cm² (ultimate strength) 800 kg/cm² (ultimate strength)		Typical log diameter is 150 - 200 mm
Foundation	Concrete	10 MPa (cube compressive strength)		
Frames (beams & columns)				
Roof and floor(s)	Wooden beams (larch)	800 kg/cm² (ultimate strength)		

6.2 Builder

Anyone can live in buildings of this construction type.

6.3 Construction Process, Problems and Phasing

This construction type is typically built by contractors. Simple carpentry tools are used in the construction. 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

Design expertise related to this construction type buildings is available, including the construction quality procedure developed by the author of this contribution. Special design by Professional Engineers and architects (for typical projects and design applications).

6.5 Building Codes and Standards

This construction type is addressed by the codes/standards of the country. Wood construction Building code, Building Catalog of Typical Project for Housing, Vol.1, Part 2, div.1, #14, seria 115, 1957y. The year the first code/standard addressing this type of construction issued was NA. SNiP II-7-81. Building in Seismic Regions. Design code. The most recent code/standard addressing this construction type issued was 1981. Title of the code or standard: Wood construction Building code, Building Catalog of Typical Project for Housing, Vol.1, Part 2, div.1, #14, seria 115, 1957y. Year the first code/standard addressing this type of construction issued: NA National building code, material codes and seismic codes/standards: SNiP II-7-81. Building in Seismic Regions. Design code When was the most recent code/standard addressing this construction type issued? 1981.

The process consists of issuing permits for the design and construction, including the architectural permits and urban planning/municipal permits. Designers need to have license to practice and are responsible to follow the building codes. Building inspection is performed and the permit is issued.

6.6 Building Permits and Development Control Rules

This type of construction is an engineered, and 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 Owner(s). The maintenance is performed either by the owner (city) or (periodically) by a contractor - a maintenance firm.

6.8 Construction Economics

140 rub/m² (50 - 100 US$/m²)-official rate. 50 - 70 person-days per building.

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 unavailable. The insurance is available as a part of the usual property insurance. About 3-5% of the total estimated property value.

8. Strengthening

8.1 Description of Seismic Strengthening Provisions

Strengthening of Existing Construction :

Seismic Deficiency	Description of Seismic Strengthening provisions used
Walls	- Installation of vertical clenching members in the walls for two-story buildings; - Connecting wood logs using vertical steel bars - Installation of the frames around the openings
Wall-Foundation	

connection	-Installation of the anchorage

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?

No. In general, it is considered that seismic strengthening for this construction is not feasible.

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

N/A.

8.3 Construction and Performance of Seismic Strengthening

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

N/A.

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

N/A.

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

N/A.

Reference(s)

1. Manual on Certification of Buildings and Structures in the Seismic-Prone Areas, Second Edition
   CENDR, Petropavlovsk, Kamchatka, Russia 1990

2. Building Catalog of Typical Housing Projects, Vol.1, Part 2, Div.1, Seria 115, #14

Author(s)

1. Mark Klyachko
   Director, Centre on EQE and NDR (CENDR)
   9 Pobeda Avenue, Petropavlovsk Kamchatka 683006, RUSSIA
   Email:cendr@svyaz.kamchatka.su cendr@peterlink.ru FAX: +7(415)22-8774 +7(812)222-0676

2. Andrey Benin
   Senior Researcher, Centre on EQE and NDR (CENDR)
   9 Pobeda Ave., Petropavlovsk Kamchatka 683006, RUSSIA
   Email:cendr@svyaz.kamchatka.su or cendr@peterlink.ru FAX: (7-415) 22 8774; (7-812) 222 0

3. Janna Bogdanova
   Senior Researcher, Centre on EQE and NDR (CENDR)
   9 Pobeda Avenue, Petropavlovsk Kamchatka 683006, RUSSIA
   Email:cendr@svyaz.kamchatka.su or cendr@peterlink.ru FAX: +7(415)22-8774 +7(812)222-0676

Reviewer(s)

1. Svetlana Uranova
Head of the Laboratory
, KRSU
Bishkek 720000, KYRGYZSTAN
Email:uransv@yahoo.com FAX: 996-3312-282859