# 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
# Traditional wood frame construction (yurta)

| | |
|---|---|
| **Report #** | 35 |
| **Report Date** | 05-06-2002 |
| **Country** | KYRGYZSTAN |
| **Housing Type** | Timber Building |
| **Housing Sub-Type** | Timber Building : Post and beam frame (no special connections) |
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| **Reviewer(s)** | Marjorie Greene |



## Summary

This type of building is the national traditional dwelling of the Kyrgyz people. It is a light portable construction. The bearing structure of a yurta is a special wood frame, consisting of wood poles. The wood frame is covered by felt tension cloth. The floors are traditionally covered with felt rugs (koshma). Yurtas can be easily disassembled and moved to new places. They are warm in winter and cool in the summer. The buildings have only one door and one

opening in the roof. Yurtas are circular in plan. The diameter is usually 4 m#6 m. This type of building is used at the present time by shepherds, particularly during the summer, for celebrations and funerals, and as temporary buildings during extreme situations in Kyrgyzstan. The yurta is a very light structure, has a symmetrical plan, and has good seismic resistance.

# 1. General Information

Buildings of this construction type can be found in Kyrgyzstan, typically in the mountains. 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. .


Figure 1A: Typical Building

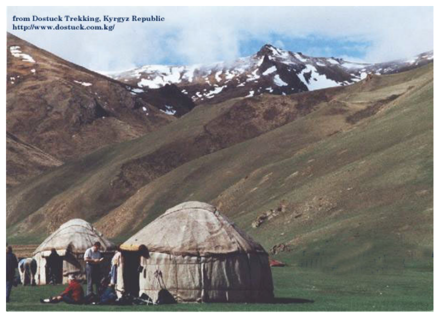

Figure 1B: Another view of a typical building

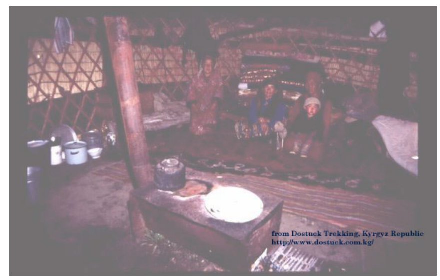

Figure 1C: Interior view of yurta


Figure 2A: Key Load-Bearing Elements


Figure 2B: Key Load-Bearing Elements


Figure 2C: Key Load-Bearing Elements


Figure 2D: Key Load-Bearing Elements

# 2. Architectural Aspects

## 2.1 Siting

These buildings are typically found in sloped and hilly terrain. They do not share common walls with adjacent buildings. This is the minimum distance as a rule When separated from adjacent buildings, the typical distance from a neighboring building is 10 meters.

## 2.2 Building Configuration

The typical building shape for a yurta is a circle. House has no windows and has one door 1.9(h) m X 0.9 m. There is also a circular opening in the roof.

## 2.3 Functional Planning

The main function of this building typology is single-family house. In a typical building of this type, there are no elevators and 1-2 fire-protected exit staircases. Yurta has one door. The bearing structure is very light; if the yurta collapses it is not typically dangerous for its inhabitants.

## 2.4 Modification to Building

Typically there are no modifications made to a yurta.

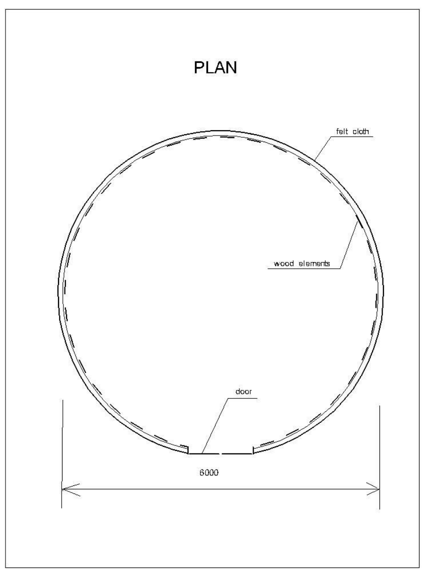


Figure 3: Plan of a Typical Building

# 3. Structural Details

## 3.1 Structural System

| Material | Type of Load-Bearing Structure | # | Subtypes | Most appropriate type |
|---|---|---|---|---|
| | 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) | ☐ |

| | | | | |
|---|---|---|---|---|
| Masonry | 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 | ☐ |
| | | 36 | Thatch | ☐ |
| | | 37 | Walls with bamboo/reed mesh and post (Wattle and Daub) | ☐ |
| | | 38 | Masonry with horizontal beams/planks at intermediate levels | ☐ |

| | | | | |
|---|---|---|---|---|
| Timber | Load-bearing timber frame | 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). Gravity Load-Bearing Structure consists of the frame formed by the wooden poles.

## 3.3 Lateral Load-Resisting System

The lateral load-resisting system is timber frame. Lateral load-resisting system consists of the very stable, evenly spaced wooden poles that form the frame.

## 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 is 1 storey high. The typical span of the roofing/flooring system is 5-6 meters. Typical Plan Dimensions: Plan shape is circle. Diameter varies from 5 to 6 meters. The typical storey height in such buildings is 4 meters. The typical structural wall density is none. Summary thickness of wall with wood pole is about 10 cm. Wall density is on the order of 5%.

## 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 | ☐ | ☐ |

| | | | |
|---|---|---|---|
| Timber | 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 | ☐ | ☑ |

Wooden pole.

### 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 | ☐ |

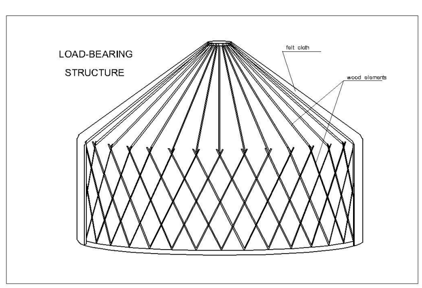


Figure 4: An Illustration of Key Seismic Features and/or Deficiencies

# 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. The number of inhabitants in a building during the day or business hours is less than 5.   also 5-10.   The number of inhabitants during the evening and night is less than 5.  also 5-10.

## 4.2 Patterns of Occupancy

Yurta is a dwelling unit for one family.

## 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) | ☐ |

80% poor and 20% middle class inhabitants occupy building of this type.

| 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 no bathroom(s) without toilet(s),  no toilet(s) only and  no bathroom(s) including toilet(s).

## 4.4 Ownership

The type of ownership or occupancy is outright ownership.

| 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) | ☐ |

# 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:<br><br>Less than 25 (concrete walls);<br><br>Less than 30 (reinforced masonry walls);<br><br>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:<br><br>For brick masonry construction in cement mortar : less than ½ of the distance between the adjacent cross walls;<br><br>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 | | Light weight bearing structures. | |
| Frame (columns, beams) | | | |
| Roof and floors | | | |
| Other | | | |

Yurtas have not been seriously damaged in earthquakes.

## 5.3 Overall Seismic Vulnerability Rating

The overall rating of the seismic vulnerability of the housing type is *F: VERY LOW VULNERABILITY (i.e., excellent seismic performance)*, the lower bound (i.e., the worst possible) is E: LOW VULNERABILITY (i.e., very good seismic performance), and the upper bound (i.e., the best possible) is *F: VERY LOW VULNERABILITY (i.e., excellent 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 |
|---|---|---|---|
| 1986 | Kairakum | 6.8 | VII |
| 1992 | Suusamir | 7.4 | IX |

During the indicated earthquakes and many others, yurtas had no damages.

# 6. Construction

### 6.1 Building Materials

| Structural element | Building material | Characteristic strength | Mix proportions/dimensions | Comments |
| --- | --- | --- | --- | --- |
| Walls | felt cloth. | | | |
| Foundation | | | | |
| Frames (beams & columns) | wood pole. | | | |
| Roof and floor(s) | | | | |

### 6.2 Builder

Usually shepherds live in yurtas. They assemble the yurtas themselves. It can also be used as a temporary building by any person.

### 6.3 Construction Process, Problems and Phasing

The yurta is erected by its inhabitants/owners without any special building expertise or knowledge of building techniques. The construction of this type of housing takes place incrementally over time. Typically, the building is originally not designed for its final constructed size.

### 6.4 Design and Construction Expertise

There is no special expertise associated with this building type. This building type is erected without engineers and architects.

### 6.5 Building Codes and Standards

This construction type is not addressed by the codes/standards of the country. The year the first code/standard addressing this type of construction issued was Yurtas were used before introduction of building codes. SNiP II-7-81. Building in Seismic Regions. Design code. The most recent code/standard addressing this construction type issued was 1981. Year the first code/standard addressing this type of construction issued: Yurtas were used before introduction of building codes. 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.

### 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 not required to build this housing type.

### 6.7 Building Maintenance

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

### 6.8 Construction Economics

About 50-70 US$/m². One day for 4 persons.

## 7. Insurance

Earthquake insurance for this construction type is typically unavailable. For seismically strengthened existing buildings or new buildings incorporating seismically resilient features, an insurance premium discount or more complete coverage is unavailable.

# 8. Strengthening

## 8.1 Description of Seismic Strengthening Provisions

## 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?

N/A.

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. Seismic Hazard and Buildings Vulnerability in Post-Soviet Central Asia Republics
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2. Buildings and Constructions Design in Seismic Regions
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