



World Housing Encyclopedia Report

Country: Italy

Housing Type: Brick masonry farmhouse with a "dead door".

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1 General Information

1.1 Country

Italy

1.3 Housing Type

Brick masonry farmhouse with a "dead door".

1.4 Summary

This is a single family farmhouse construction, found throughout the Padania Plain (Reggio Emilia Province). This housing type accounts for approximately 20% of the entire housing stock in the Reggio Emilia Municipality. This building practice is no longer followed. Most of the existing buildings were built in the 19th and 20th century. The residential and agricultural sections of the house are separated by a central area closed at one end and hence called a "dead door". The residential section usually has two floors (typical story height 2.5 - 3.0 m), and a sloping roof. The agricultural portion, usually larger than the residential section, also has two floor levels. The first floor height is on the order of 2.5 - 3.0 m whereas the second story floor height ranges from 5.0 - 9.0 m. As a result, roof in the agricultural part of the building is at the higher level as compared to the residential part. The first floor is used as a cowshed and the second as a hayloft. The load bearing structure consists of brick masonry walls in lime mortar. The walls are characterized with variable thickness, decreasing from 280 mm at the first floor level to 150 mm at the second floor level. There are brick masonry columns in the interior of the agricultural portion at the second floor level. The buttresses can be found in the exterior brick masonry walls. Both the residential and agricultural sections have wooden floors; there are vaulted floors in the central area. In some cases, composite floors made of steel beams and perforated bricks can be found. Although the building plan is very regular, the seismic performance of this building type is rather poor due to the vertical irregularity (offset of the floors in the residential and agricultural sections), the absence of connections between walls and between walls and floors, the thrusting of the roof, and the deterioration of materials.



FIGURE 1: Typical Building

1.5 Typical Period of Practice for Buildings of This Construction Type

How long has this construction been practiced	
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< 25 years	
< 50 years	
< 75 years	
< 100 years	
< 200 years	X
> 200 years	

Is this construction still being practiced?	Yes	No
		X

1.6 Region(s) Where Used

The housing type is found throughout the Emilia-Romagna region, in the south of the Padania Plain. It is widespread in the Reggio Emilia Province. The total number of this building type in the Reggio Emilia municipality is less than 9,000. The percentage of this housing type as a fraction of the entire housing stock in the Reggio Emilia Municipality is approximately 20%.

1.7 Urban vs. Rural Construction

Where is this construction commonly found?	
In urban areas	
In rural areas	X
In suburban areas	
Both in rural and urban areas	

2 Architectural Features

2.1 Openings

In the residential portion a typical window size is 90 x120 cm. Windows are vertically aligned. At the first floor level in the agricultural portion, small windows are often densely distributed. Windows at the second floor level are used more for ventilation than for light in the hayloft. In the central part of the building there is a large door opening. Estimate of the overall window and door areas as a fraction of the overall wall surface area are: residential portion 25%, agricultural portion 15%, central portion 25%, overall 20%.

2.2 Siting

	Yes	No
Is this type of construction typically found on flat terrain?	X	
Is this type of construction typically found on sloped terrain? (hilly areas)		X
Is it typical for buildings of this type to have common walls with adjacent buildings?		X

The typical separation distance between buildings is 10 meters

2.3 Building Configuration

Building plan is usually regular, of a rectangular shape.

2.4 Building Function

What is the main function for buildings of this type?	
Single family house	
Multiple housing units	
Mixed use (commercial ground floor, residential above)	
Other (explain below)	X

Additional Comments: Single family house, mixed residential and agricultural (cowshed and hayloft) use

2.5 Means of Escape

No additional exit stair besides the main stairs.

2.6 Modification of Buildings

No significant structural modification can be observed in this housing type. Bathrooms have been recently added.

3 Socio-Economic Issues

3.1 Patterns of Occupancy

One family typically occupies one house.

3.2 Number of Housing Units in a Building

1 units in each building.

3.3 Average Number of Inhabitants in a Building

How many inhabitants reside in a typical building of this construction type?	During the day / business hours	During the evening / night
< 5		
5 to 10	X	X
10-20		
> 20		
Other		

3.4 Number of Bathrooms or Latrines per Housing Unit

Number of Bathrooms: 1

Number of Latrines: 1

Additional Comments: Originally there was only one latrine outside the building. Bathrooms and latrines inside the building have been added a few years ago.

3.5 Economic Level of Inhabitants

Economic Status		House Price/Annual Income (Ratio)
Very poor		/
Poor	X	10/1
Middle Class	X	10/1
Rich		/

Additional Comments: Percentage of economic status: 50% Poor, 50% Middle Class. House Price over Annual Income has been set as a constant for different economic levels. In case of Middle Class Status, the annual income is greater but also the price of the house is greater, due to a higher level of maintenance.

3.6 Typical Sources of Financing

What is the typical source of financing for buildings of this type?	
Owner Financed	X
Personal Savings	
Informal Network: friends and relatives	X
Small lending institutions/microfinance institutions	X
Commercial banks / mortgages	
Investment pools	
Combination (explain)	
Government-owned housing	
Other	

Additional Comments: This housing type is no longer built

3.7 Ownership

Type of Ownership/Occupancy	
Rent	X
Own outright	X
Own with Debt (mortgage or other)	
Units owned individually (condominium)	
Owned by group or pool	
Long-term lease	
Other	

4 Structural Features

4.1 Lateral Load-Resisting System

The load bearing structure consists of brick masonry walls in lime mortar. The walls are characterized with a variable thickness, decreasing from 280 mm at the first floor to 150 mm at the second floor level. Brick masonry columns (560 mm depth) are present in the interior at the second floor level in the agricultural portion, and the buttresses can be found in the exterior walls. Both the residential and agricultural sections have wooden floors, while the vaults are present in the central area. In some cases, composite floors made of steel beams and perforated bricks can be found. On the second floor of the agricultural portion, diagonal bracing is present

4.2 Gravity Load-Bearing Structure

Same as lateral load-resisting system

4.3 Type of Structural System

Material	Type of Load-Bearing Structure	#	Subtypes	
Masonry	Stone masonry walls	1	Rubble stone (field stone) in mud/lime mortar or without mortar (usually with timber roof)	
		2	Massive stone masonry (in lime or cement mortar)	
	Earthen walls	3	Mud walls	
		4	Mud walls with horizontal wood elements	
		5	Adobe block or brick walls	
		6	Rammed earth/Pise construction	
	Unreinforced brick masonry walls	7	Unreinforced brick masonry in mud or lime mortar	X
		8	Unreinforced brick masonry in mud or lime mortar with vertical posts	
		9	Unreinforced brick masonry in cement or lime mortar (various floor/roof systems)	
	Confined masonry	10	Confined brick/block masonry with concrete posts/tie columns and beams	
	Concrete block masonry walls	11	Unreinforced in lime or cement mortar (various floor/roof systems)	
		12	Reinforced in cement mortar (various floor/roof systems)	
		13	Large concrete block walls with concrete floors and roofs	
Concrete	Moment resisting frame	14	Designed for gravity loads only (predating seismic codes i.e. no seismic features)	
		15	Designed with seismic features (various ages)	
		16	Frame with unreinforced masonry infill walls	
		17	Flat slab structure	
		18	Precast frame structure	
		19	Frame with concrete shear walls-dual system	
		20	Precast prestressed frame with shear walls	
	Shear wall structure	21	Walls cast in-situ	
		22	Precast wall panel structure	
		23	With brick masonry partitions	
Steel	Moment resisting frame	24	With cast in-situ concrete walls	
		25	With lightweight partitions	
		26	Concentric	
	Braced frame	27	Eccentric	
		28	Thatch	
Timber	Load-bearing timber frame	29	Post and beam frame	
		30	Walls with bamboo/reed mesh and post (wattle and daub)	
		31	Wooden frame (with or without infill)	
		32	Stud wall frame with plywood/gypsum board sheathing	
		33	Wooden panel or log construction	
		34	Building protected with base isolation devices or seismic dampers	
Various	Seismic protection systems	35		
	Other			

Additional Comments: Type 7 with lime mortar instead of mud mortar. Brick dimension typically 28 x14 x 6 cm. Lime mortar 1-2 cm thick. Some mortar deterioration, at times due to water infiltration, can be found.

4.4 Type of Foundation

Type	Description	
Shallow Foundation	Wall or column embedded in soil, without footing	X
	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	
	Wood piles	
	Steel skin friction piles	
	Cast in place concrete piers	
	Caissons	
Other		

Additional Comments: In buildings close to rivers, fieldstone strip footing can be found.

4.5 Type of Floor/Roof System

Material	Description of floor/roof system	Floor	Roof
Masonry	Vaulted		
	Composite masonry and concrete joist		
Structural Concrete	Solid slabs (cast in place or precast)		
	Cast in place waffle slabs		
	Cast in place flat slabs		
	Precast joist system		
	Precast hollow core slabs		
	Precast beams with concrete topping		
	Post-tensioned slabs		
Steel	Composite steel deck with concrete slab		
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 single roof		
	Wood planks or beams that support clay tiles		X
	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	Wooden or steel beams with perforated bricks	X	

Additional Comments: Floors and roof are considered to be a flexible diaphragm

4.6 Typical Plan Dimensions

Length: 14 - 14 meters

Width: 14 - 14 meters

4.7 Typical Number of Stories

2

4.8 Typical Story Height

3 meters

Additional Comments: 2.5 - 3.0 m in the residential portion and in the first floor of the agricultural portion.
5.0 - 9.0 m in the second level of the agricultural portion.

4.9 Typical Span

4.0 - 6.0 meters

4.10 Typical Wall Density

5% - 7% at first level, 3% - 4.5% at second level

4.11 General Applicability of Answers to Questions in Section 4

This description refers to a generic construction type.

5 Evaluation of Seismic Performance and Seismic Vulnerability

5.1 Structural and Architectural Features: Seismic Resistance

Structural/ Architectural Feature	Statement	True	False	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.	X		
Building configuration	The building is regular with regards to both the plan and the elevation.		X	
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.		X	
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.		X	
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.	X		
Wall and frame structures-redundancy	The number of lines of walls or frames in each principal direction is greater than or equal to 2.	X		
Wall proportions	Height-to-thickness ratio of the shear walls at each floor level is: 1) Less than 25 (concrete walls); 2) Less than 30 (reinforced masonry walls); 3) Less than 13 (unreinforced masonry walls).		X	
Foundation- wall connection	Vertical load-bearing elements (columns, walls) are attached to the foundations; concrete columns and walls are doweled into the foundation.	X		
Wall-roof connections	Exterior walls are anchored for out-of-plane seismic effects at each diaphragm level with metal anchors or straps.		X	
Wall openings	The total width of door and window openings in a wall is: 1) for brick masonry construction in cement mortar: less than 1/2 of the distance between the adjacent cross walls; 2) for adobe masonry, stone masonry and brick masonry in mud mortar: less than 1/3 of the distance between the adjacent cross walls; 3) for precast concrete wall structures: less than 3/4 of the length of a perimeter wall.	X		
Quality of building materials	Quality of building materials is considered to be adequate per requirements of national codes and standards (an estimate).		X	
Quality of workmanship	Quality of workmanship (based on visual inspection of few typical buildings) is considered to be good (per local construction standards).	X		
Maintenance	Buildings of this type are generally well maintained and there are no visible signs of deterioration of building elements (concrete, steel, timber).		X	
Other				

Additional Comments: Quality of building materials judged on present codes and standards.

5.2 Seismic Features

Structural Element	Seismic Deficiency	Earthquake-Resilient Features	Earthquake Damage Patterns
Wall	Absence of connections and/or iron ties able to prevent the out-of-plane wall overturning. At the second level, masonry wall is very slender with mortar often deteriorated.	Regular layout and solid bricks.	Separation of orthogonal walls, out of plane overturning, shear cracks, corner diagonal cracks due to the roof thrust
Columns	At the second level of the agricultural portion (hayloft) columns can be up to 9.0 m high		
Roof and floors	Flexible floors and roof are not effectively connected to walls. The vault in the central portion is usually very thin. The roof is often thrusting.	Floors and roof are light.	Separation of the floors and/or roof from the walls, beam hammering on walls

5.3 Seismic Vulnerability Rating

Vulnerability						
	High (Very Poor Seismic Performance) A	B	Medium C	D	E	Low (Excellent Seismic Performance) F
Seismic Vulnerability Class	<	0				

- 0 - probable value
- < - lower bound
- > - upper bound

6 Earthquake Damage Patterns

6.1 Past Earthquakes Reported To Affect This Construction

Year	Earthquake Epicenter	Richter magnitude(M)	Maximum Intensity (Indicate Scale e.g. MMI, MSK)
1996	Bagnolo in Piano, Reggio Emilia	4.5	VII MCS
1971	Parmense	5.5	VI MCS
1832	Reggiano	5.2	VII-VIII MCS
1547	Reggio Emilia	4.7	VI-VII MCS

7 Building Materials and Construction Process

7.1 Description of Building Materials

Structural Element	Building Material	Characteristic Strength	Mix Proportions/ Dimensions	Comments
Walls	Solid bricks with lime mortar	characteristic normal stress =6.0 MPa characteristic shear stress=0.3 MPa	1:3 lime/sand mortar	Mortar is often deteriorated
Foundations	Solid bricks with lime mortar		1:3 lime/sand mortar	
Roof and floors	Wooden (or steel beam with perforated bricks)	+25 MPa, -12 MPa (200 MPa)		

7.2 Does the builder typically live in this construction type, or is it more typically built by developers or for speculation?

This housing type is used by farmers. Buildings were built by local artisans.

7.3 Construction Process

The construction process was driven by the fact that the owners typically had limited financial resources. Buildings were built with poor tools and materials and with low quality standards.

7.4 Design/Construction Expertise

Buildings were built relying on the experience of the local artisans, without any structural or architectural design. The need for cost control is demonstrated by structural elements that are not properly dimensioned and by the wall thickness reduction on the second floor.

7.5 Building Codes and Standards

	Yes	No
Is this construction type addressed by codes/standards?	X	

Title of the code or standard: Technical rules for the design, execution, testing and strengthening of masonry buildings, Ministry of Public Works, 1987

Year the first code/standard addressing this type of construction issued: 1909

When was the most recent code/standard addressing this construction type issued? 1987 for vertical loads, 1996 for seismic loads

7.6 Role of Engineers and Architects

Engineers and architects were not involved in building construction in the past, now one can find them in charge of the structural design for building repairs or upgrades.

7.7 Building Permits and Development Control Rules

	Yes	No
Building permits are required		X
Informal construction	X	
Construction authorized per development control rules		X

Additional Comments: In the past, building permits and authorizations were not required for building construction. Permits and authorizations are required for the building repair or upgrade performed at the present time.

7.8 Phasing of Construction

	Yes	No
Construction takes place over time (incrementally)		X
Building originally designed for its final constructed size	X	

Additional Comments: Buildings were constructed without any design.

7.9 Building Maintenance

Who typically maintains buildings of this type?	
Builder	
Owner(s)	X
Renter(s)	
No one	
Other	

7.10 Process for Building Code Enforcement

In the case of repairs resulting from earthquake damage, as well as upgrades and retrofit, code enforcement and controls during the design and construction are performed by local authority (Region) officials. Public financial contributions are used for repair of earthquake damage, but upgrades and retrofit are privately financed .

7.11 Typical Problems Associated with this Type of Construction

These are old buildings that are typically poorly maintained.

8 Construction Economics

8.1 Unit Construction Cost (estimate)

500 Euro/m² (430 US\$/m²)

8.2 Labor Requirements (estimate)

90 days for 3-4 person team

9 Insurance

9.1 Insurance Issues

	Yes	No
Earthquake insurance for this construction type is typically available		X
Insurance premium discounts or higher coverages are available for seismically strengthened buildings or new buildings built to incorporate seismically resistant features		X

9.2 If earthquake insurance is available, what does this insurance typically cover/cost?

10 Seismic Strengthening Technologies

10.1 Description of Seismic Strengthening Provisions

Type of intervention	Structural Deficiency	Description of seismic strengthening provision used
Retrofit (Strengthening)	Wall	-replacement of bricks with similar ones (sometimes with the insertion of horizontal steel rebars); -insertion of transverse connections made by bricks or steel bars into the wall; -tying of the orthogonal walls; -installation of iron ties; -Concrete jacketing is seldom performed.
	Floors	Construction of new RC slab atop existing beams, tying the floor to the walls, replacement of the existing floor with RC floor
	Roof	-replacement of existing wooden beams, -reinforcement (doubling) of the wooden boarding, -construction of RC ring beam
	Columns	-Confinement with steel elements
	Vaults	-RC slab on existing vaults

Additional Comments: Upgrade or retrofit work have been seldom performed on this housing type.

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

Yes

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

Mainly performed as a repair or upgrade following earthquake damage.

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

Yes

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

A contractor performs the repair/upgrade construction. Architects or engineers are seldom involved in the construction phase, however they are involved in the design phase.

10.6 What has been the performance of retrofitted buildings of this type in subsequent earthquakes?

Good, provided that the retrofitting has been correctly performed.

11 References

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13 Figures



FIGURE 1: Typical Building



FIGURE 2: Key Load-Bearing Elements



FIGURE 3: Critical Structural Detail - Roof Beam Support



FIGURE 4: Seismic deficiency- inadequate wall connection



FIGURE 5A: Wall damage (1996 Bagnolo earthquake)



FIGURE 5B: Wall damage at the roof beam support (1996 Bagnolo earthquake)



FIGURE 6A: Illustration of Seismic Strengthening Techniques



FIGURE 6B: Seismic strengthening technique - installation of the iron ties