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
Tunnel form building

Report #	101
Report Date	15-10-2003
Country	TURKEY
Housing Type	RC Structural Wall Building
Housing Sub-Type	RC Structural Wall Building : Moment frame with in-situ shear walls
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Summary

This type of rapidly constructed, multi-unit residential form has been used in Turkey since the late 1970s and early 1980s. It has demonstrated superior earthquake resistance and has also been increasingly utilized as permanent housing in post-earthquake reconstruction programs. Initially, the tunnel form building was targeted for multi-unit residential construction for public or privately sponsored housing projects. Typically, a single building may contain 15 or

more stories and up to 40 or 50 residential units. This contribution has been motivated by our intention to not only familiarize readers with the architectural or structural features of the building type, but to also underscore its noteworthy seismic performance that stands in stark contrast to Turkey's recent experience.

1. General Information

Buildings of this construction type can be found in densely populated urban areas with limited land available for development. During the last decade, tunnel form buildings have also been the choice for rebuilding earthquake-affected towns and urban areas because they fulfill the requirements of easy and rapid construction, and because their acknowledged excellent earthquake performance that makes them popular with occupants. This type of housing construction is commonly found in both sub-urban and urban areas.

The use of "suburban" in this text does not correspond to its commonly understood connotation in, e.g., the USA. We mean districts and areas in newly developed parts of urban areas that are located on the outskirts or peripheries of existing settlements.

This construction type has been in practice for less than 25 years.

Currently, this type of construction is being built. .

Figure 8: An Application of Half-Tunnel Forms

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. The Turkish Building Development Law requires a minimum separation distance of 6 m for detached buildings. Tunnel form buildings are usually in the 12-16 story range, so the space between them is converted into common lawns by developers, and the buildings have substantial separation distances between them When separated from adjacent buildings, the typical distance from a neighboring building is 10 meters.

2.2 Building Configuration

The buildings enjoy a wide variety of plan and elevation shapes as illustrated in Figures 1-6. The construction sequence, described in detail in Section 4, creates walls and floor slabs typically without openings during the primary concrete placement. Windows looking outside and interior doors or partitions are usually crafted from precast panels or lightweight concrete blocks. When architectural form allows it, doors may also be formed by leaving openings in the formwork during the primary casting.

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. Internal staircases are the primary means of escapes during fires and other types of emergencies. In a number of instances owners have installed external spiral steel staircases when the internally provided staircases did not meet the size and space requirements of the official specifications.

2.4 Modification to Building

The peculiar construction technique does not allow any structural modifications to the building.

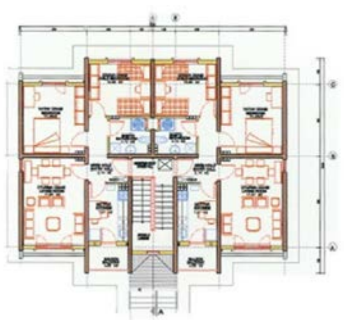

Figure 1: Selected Plan Configuration-1

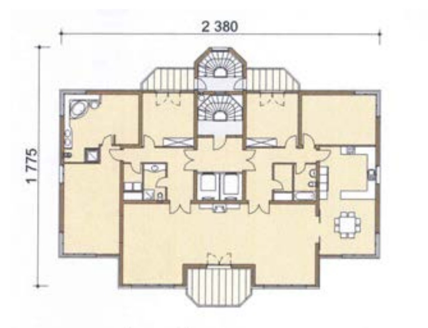

Figure 2: Selected Plan Configuration-2

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 reinforced concrete structural walls (with frame). The walls and the slab carry all gravity loads. Gravity loads are transferred uniformly to the walls by slabs. A mat foundation is commonly used to transmit the gravity loads to the soil.

3.3 Lateral Load-Resisting System

The lateral load-resisting system is reinforced concrete structural walls (with frame). Structural walls provide the lateral-load resistance. The walls and the slab are cast in a single operation using specially designed half-tunnel-steel forms (upside down U shape) that maintains a certain size as shown in Figures 7 and 8. This cuts down the construction time significantly. The wall and the slab form a monolithic joint. The following construction sequence is implemented. 1) The tunnel forms are first cleaned and coated with form oil. Then they are placed in their positions by using the kicker as the guide (Figures 7 and 8). 2) The wall reinforcement is placed before the tunnel formwork is positioned. Reinforcement steel and electric conduits are set in their places on the tunnel form (Figure 9). 3) Walls, slab and kickers are cast. The next morning the formwork is ready to be stripped and carried to the next location by a crane. In accordance with the design, steel blockouts may be installed on the formwork panels to form the plumbing openings. Figures 10 and 11 show the elevation and plan of a typical building constructed by this technique. Figures 12 to 15 show samples of the reinforcement detailing and the structural drawings taken from the blueprints of a typical building.

3.4 Building Dimensions

The typical plan dimensions of these buildings are: lengths between 10 and 30 meters, and widths between 10 and 30 meters. The building has 10 to 15 storey(s). The typical span of the roofing/flooring system is 3-5 meters. Typical Plan Dimensions: The multi-story housing construction of this type typically has a rectangular plan. The ratio of long side to short side has a typical range of 1.0 to 2.0. Typical Number of Stories: The reconstruction applications in the earthquake-affected areas have number of stories between 2-6. But the multi-story residential houses are taller typically 10-15 stories high. Typical Story Height:The tunnel forms used allow story height to range from 2.30 m to 3.0 m. Typical Span: Typical span lengths have a range of 2.1 to 5.70 m. The typical storey height in such buildings is 2.8 meters. The typical structural wall density is up to 10 %. 2% - 6% The typical density of structural walls is about 4 percent of the area of one floor. This density may vary from 2 to 6 percent depending on the thickness of the wall, the span and the plan dimensions of the building. Both principal directions usually have the same 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)	☐	☐
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	☑	☑

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	☐

It consists of reinforced concrete end-bearing piles and reinforced concrete skin-friction piles.

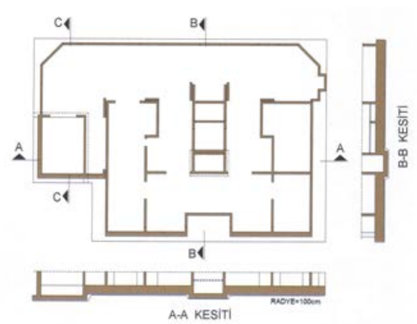

Figure 3: Selected Plan Structural Configuration-1

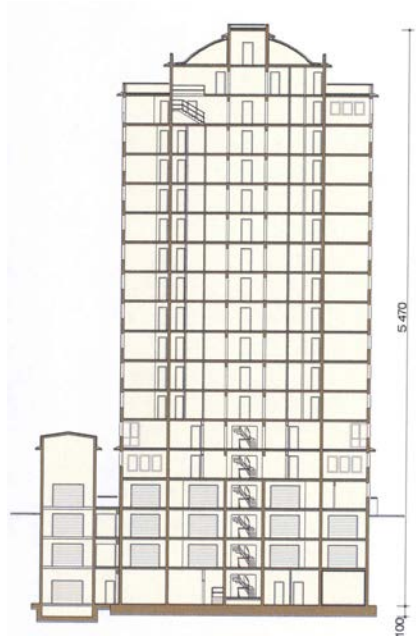

Figure 4: Selected Elevation Configuration-1

Figure 5: Selected Elevation Configuration-2

Figure 6: Selected Elevation Configuration-3

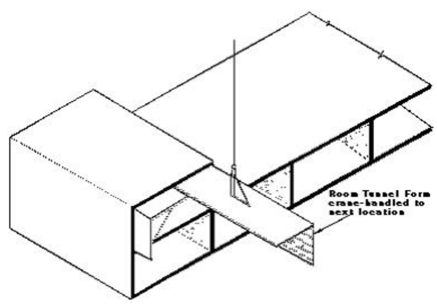

Figure 7: Half-Tunnel Forms Handled by Cranes

Figure 9: Reinforcement Details for Walls with and without Openings

Figure 10: A Typical Tunnel Form Building Nearing Completion (Note Masonry Facade Elements)

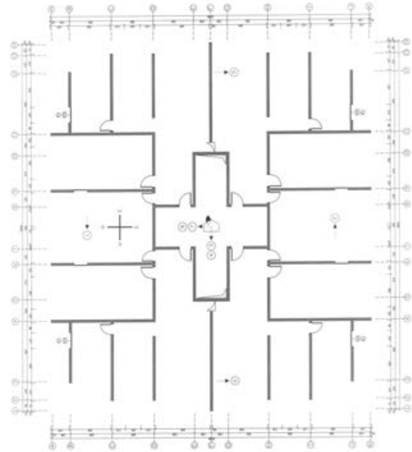

Figure 11: Structural Plan of the Building in Figure 10 (Building Footprint Measures 25x27 m, and Its Height is 25 m)

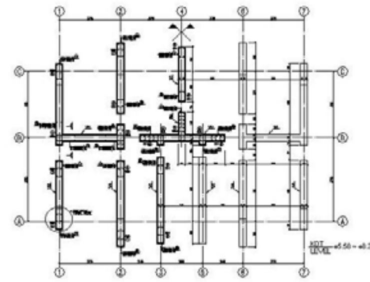

Figure 12: The Structural Plan of a Typical Floor

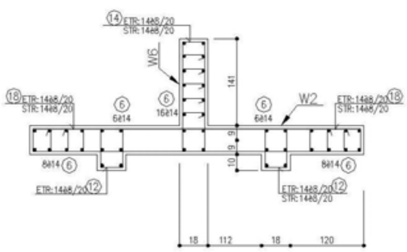

Figure 13: The Structural Plan of a Typical Floor Reinforcement Detailing for a Wall Section Extracted from the Plan Given in Figure 12

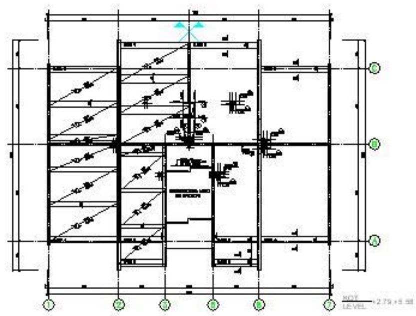

Figure 14: Drawing for the Reinforcement Detailing of a Typical Floor

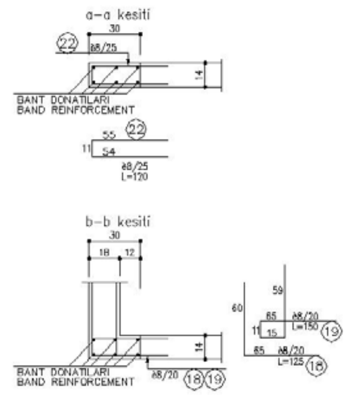

Figure 15: Strip Reinforcement for Section a-a of Figure 14

4. Socio-Economic Aspects

4.1 Number of Housing Units and Inhabitants

Each building typically has 21-50 housing unit(s). 40-50 units in each building. Since the number of stories vary, a unique number for the units in a building is hard to assign. Typically there are four apartment units per floor and average number of floors is 10-12. The number of inhabitants in a building during the day or business hours is more than 20. The number of inhabitants during the evening and night is more than 20. The average size of a family residing in a unit of this type of construction is about 4. During the day, one or two inhabitants reside in their units.

4.2 Patterns of Occupancy

Nearly all occupants are single family or co-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)	☑

Economical level of inhabitants depends strongly on the address of the building which also influences the price of the house unit. In Turkey, there is probably a poor correlation between the income and the price of the house unit people own. Economic Level: The ratio of price of each housing unit to the annual income can be 6:1 for middle class and 3:1 for rich class families.

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 number of successful developers have constructed multi-family housing of this type during the last quarter century. The way it works is as follows: Families wishing to invest in a dwelling unit enter a private contract with the developing company that sets the conditions for the payments and delivery dates. Well managed enterprises have enabled tens of thousands of families to have their own house. Another scheme is for prospective homeowners to form a cooperative whose state of objective is to built multi-unit family housing. In this, families must typically finance about half of the cost of the finished building with the remainder coming from the government housing administration, a government housing financing scheme that was created in 1984 to address the housing shortage in the country. Many of the 1.1 million housing units constructed during 1984-2001 were financed by the housing administration. In each housing unit, there are 1 bathroom(s) without toilet(s), 2 toilet(s) only and 1 bathroom(s) including toilet(s).

4.4 Ownership

The type of ownership or occupancy is renting, outright ownership and individual 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: 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).	☑	☐	☐
	Buildings of this type are generally well maintained and there			

Maintenance	are no visible signs of deterioration of building elements (concrete, steel, timber)	☑	☐	☐
Additional Comments	The concrete strength is typically 25 MPa, which is well above average concrete strength encountered in the country.			

5.2 Seismic Features

Structural Element	Seismic Deficiency	Earthquake Resilient Features	Earthquake Damage Patterns
Wall		The walls being the primary load-carrying members are proven to be the most effective members against earthquakes. Wall density helps in reducing the unit shear, and enables almost elastic response during even strong ground shaking.	Facade elements are usually pre-cast reinforced concrete panels that are placed after the walls have been formed, and attached along their periphery by welding. These have been observed to exhibit minor separation or cracking along their boundary, but this is not considered to be a structural deficiency.
Frame (Columns, beams)	Spandrel beams formed above door openings have been observed to experience cracks when the building is subjected to strong seismic action. This is of little structural significance.		The spandrel beams above the door openings have been observed to suffer shear cracks. This does not lead to a reduced seismic capacity of the system therefore is considered as minor damage.
Roof and floors		The honey-comb pattern of walls and slabs enables slabs to respond in their elastic range.	
Other			

In Turkey, the observations from past earthquakes proved that the structures with adequate amount of shear walls performed quite well.

5.3 Overall Seismic Vulnerability Rating

The overall rating of the seismic vulnerability of the housing type is E: LOW VULNERABILITY (i.e., very good seismic performance), the lower bound (i.e., the worst possible) is F: VERY LOW VULNERABILITY (i.e., excellent 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
1999	Izmit, Turkey	7.4	X (MSK)
2003	Bingol, Turkey	6.4	VII+ (MSK)

This construction type has experienced the two major earthquakes of 1999 and the earthquake of 2003. Neither demolished nor damaged buildings of this type have been reported after these earthquakes. Figures 16-20 demonstrate the conditions of several buildings after these earthquakes. Several buildings surviving the earthquakes of 1999 are shown in Figures 16-18. The building in Figure 16, that is virtually untouched, is located 3-4 km from the fault that was ruptured during the earthquake. In the city of Bingöl, although extensive damage was observed in reinforced concrete frame structures, a group of five story tunnel from buildings (Figure 19) performed superbly without any sign of structural damage. Only minor nonstructural damage in the form of separation of the precast panels from the floors was observed.

Figure 16: The Building Is Part of a Multi-unit Housing Complex That Survived the Earthquakes of 1999 in İzmit without Damage

Figure 17: The Post-Earthquake Condition of Another Tunnel Form Building of a Different Housing Complex in İzmit

Figure 18: This Tunnel Form Building Located in Bekirpasa/Izmit Also Suffered No Damage during the Earthquakes in 1999

Figure 19: Tunnel Form Buildings after the Bingol Earthquake of May 1, 2003

6. Construction

6.1 Building Materials

Structural element	Building material	Characteristic strength	Mix proportions/dimensions	Comments
Walls	Concrete Reinforcing Steel	25 MPa/ 500 MPa		
Foundation	Concrete Reinforcing Steel	25 MPa/ 500 MPa		
Frames (beams & columns)				
Roof and floor(s)	Concrete Reinforcing Steel	25 MPa/ 500 MPa		

6.2 Builder

The construction of this type requires certain capacities the large construction companies have, thus it is typically build by experienced developers.

6.3 Construction Process, Problems and Phasing

See Structural Features. The construction of this type of housing takes place in a single phase. Typically, the building is originally designed for its final constructed size. The tunnel form buildings are built in one construction cycle, and no increments or modifications are possible at a later stage.

6.4 Design and Construction Expertise

Turkish contractors have gained much experience with tunnel form building construction, and have successfully applied this experience in many cases for foreign contracts, e.g. in Russia, North Africa, Caucasia and the Middle East. Although formal engineering registration does not exist in Turkey, these buildings go through a strict design, check, and supervision process. There is currently no specific set of requirements for this construction type in the current seismic design code. The walls are designed and detailed according to the specifications for reinforced concrete walls. Therefore, the choice of strength reduction factor, R, depends on the preference of the design engineer and the contractor for the building at hand. In general, a value between 4 to 6 is used by considering the economy. The higher value requires more restrictive detailing requirements and wall thicknesses that lead to a trade-off rating between speed of construction and cost.

6.5 Building Codes and Standards

This construction type is addressed by the codes/standards of the country. 1. Regulations for Buildings to Be Built in Disaster Areas (1998) 2. TS 500: Requirements for Design and Construction of Reinforced Concrete Structures (2000). The year the first code/standard addressing this type of construction issued was The seismic requirements have been first issued in 1945. The first edition of TS 500 was in 1969. We refer to Contribution No. 64 for a detailed account of the development of building codes and standards in Turkey. Most material codes have been issued by the Turkish Standards Institute at different dates. The most recent code/standard addressing this construction type issued was 1. The seismic requirements have been last issued in 1998. 2. The last issue of TS 500 is dated 2000. Title of the code or standard: 1. Regulations for Buildings to Be Built in Disaster Areas (1998) 2. TS 500: Requirements for Design and Construction of Reinforced Concrete Structures (2000) Year the first code/standard addressing this type of construction issued: The seismic requirements have been first issued in 1945. The first edition of TS 500 was in 1969. We refer to Contribution No. 64 for a detailed account of the development of building codes and standards in Turkey. National building code, material codes and seismic codes/standards: Most material codes have been issued by the Turkish Standards Institute at different dates. When was the most recent code/standard addressing this construction type issued? 1. The seismic requirements have been last issued in 1998. 2. The last issue of TS 500 is dated 2000.

Developer submits designs and other required documents to the relevant local government to receive the construction permit.

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 Builder, Owner(s) and Tenant(s).

6.8 Construction Economics

The average estimated unit construction cost for post-earthquake housing including utilities but excluding land is $154/m2. This usually corresponds to $ 15 000 per housing unit. The approximate cost for the utilities is $30/m2. The total cost of a housing unit including land strongly depends on the location and its architectural finish. One of the main advantages of this construction type is the speedy construction process. The formworks are handled by cranes and the ready mix concrete use minimizes the labor dependency. The cost efficiency is gained by optimizing labor, using less concrete, and minimizing the finishing work. This construction technique greatly reduces construction time by as much as 50% and the costs by 20 percent relative to the conventional methods. It may take up to one year for the construction of a typical building to be completed.

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. DASK, a recently established entity similar to California Earthquake Authority, provides mandatory country-wide insurance for all property up to a ceiling of $40,000. For amounts in excess of this owners must purchase voluntary insurance. Although this construction type has an excellent earthquake performance, the current earthquake insurance coverage treats all concrete structures under the same category when determining the premiums. DASK employs three classifications for the construction type, namely concrete structures, steel structures and masonry buildings. A second factor that is taken into account when determining premiums is the seismic region (based on current seismic zone map) in which the building resides. Work is underway to establish a more refined tariff structure. Insurance provided by DASK covers structure only. In high-hazard areas a dwelling of the type described under this section will have an annual premium of some $40-50.

8. Strengthening

8.1 Description of Seismic Strengthening Provisions

Strengthening of Existing Construction :

Seismic Deficiency	Description of Seismic Strengthening provisions used
Shear cracks in spandrel beams.	Epoxy injection.

Since no reported cases of significant damage have been encountered for this construction type, there are no widely experimented techniques of retrofitting developed and used for this construction type.

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?
The minor damage observed in the spandrel beams is generally accounted for in the design phase thus is repaired by epoxy injection.

Was the work done as a mitigation effort on an undamaged building, or as repair following an earthquake?
Not applicable.

8.3 Construction and Performance of Seismic Strengthening

Was the construction inspected in the same manner as the new construction?
Not applicable.

Who performed the construction seismic retrofit measures: a contractor, or owner/user? Was an architect or engineer involved?
Not applicable.

What was the performance of retrofitted buildings of this type in subsequent earthquakes?
Not applicable.

Figure 20: A Practically Unscathed Building Subjected to the Bingol Earthquake

Reference(s)

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