World Housing Encyclopedia Report

Country: Kyrgyzstan

Housing Type: Reinforced concrete frame buildings without beams (seria KUB).

Contributors:
Svetlana Uranova
Ulugbek T. Begaliev

Primary Reviewer:
Svetlana Brzev

Created on: 6/5/2002
Last Modified: 7/2/2003

Table of Contents

1 General Information

1.1 Country
Kyrgyzstan

1.3 Housing Type
Reinforced concrete frame buildings without beams (seria KUB).

1.4 Summary
Frame buildings without beams were introduced in the last decade of the Soviet Union (period 1980-1989) in some of the Soviet Republics: Kyrgyzstan, Tadjikistan, Caucasian region of Russia etc. This type of precast construction is known as seria KUB. This type of apartment buildings is usually 5-9 stories high; in some cases these buildings are 12 stories high. The load-bearing structure consists of precast reinforced concrete columns and slabs. Precast column elements are usually two stories high. Typically, column spans are equal to 6m. Precast slab elements are made of solid concrete without ribs, and the dimensions are: 3 m x 3 m X 0.16 m (length X width X thickness). Most buildings of this type have some kind of lateral load resisting elements, such as: cast-in-situ shear walls, or precast shear walls, or shear cross braces etc. All precast structural elements are combined in 3-D moment frame by means of a special joint system. Partitions are made of brick masonry or small concrete block masonry. This building type is considered to be very vulnerable in earthquakes. The seismic resistance of buildings of this type depends on the type of column-to-slab joints. Similar structures were damaged in the 1988 Spitak (Armenia) earthquake.

FIGURE 1: Typical Building

1.5 Typical Period of Practice for Buildings of This Construction Type

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

Is this construction still being practiced?	Yes	No
	X	

1.6 Region(s) Where Used
Frame buildings without beams were used in Duchanbe (Tadjikistan), Nalchik (Russia), Almaty

(Kazachstan).
There are some such buildings in Bishkek (Kyrgyzstan).

1.7 Urban vs. Rural Construction

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

2 Architectural Features

2.1 Openings

Walls are not the part of load-bearing structure in frame buildings without beams. If lateral load-resisting elements (e.g. shear walls) are present, the overall wall area usually does not exceed 1% of the floor area. These shear elements are solid (without openings), and are usually located between columns inside the building.
Typical size of window openings is: 1.2 to 1.5 m (height) X 2 m (width), doors: 2m (height) X 0.9-1 m (width). Overall window area constitutes up to 30 or 40% of the exterior wall area. Less than 10% of the partition walls are perforated by door openings.

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)		
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

Typical shape of a building plan for this housing type is rectangular or square with some modifications at the perimeter.

2.4 Building Function

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

2.5 Means of Escape

There is one stair in one building unit. Building unit consists of 2-6 apartments (housing units) at each floor level. Each building contains 1-4 building units.

2.6 Modification of Buildings

Usually, modifications are made in non-load-bearing elements e.g. exterior and interior walls.

3 Socio-Economic Issues

3.1 Patterns of Occupancy

Each floor in a building unit consists of 2-6 housing units. One family occupies one housing unit. Depending on the number of building units and stories in a building, number of families occupying one building ranges from 10 to 120; with a common occupancy of 36 to 40 families per building.

3.2 Number of Housing Units in a Building

36 units in each building.

Additional Comments: Ranges from 10 to 120, commonly equal to 36.

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		
10-20		
> 20	X	X
Other		

3.4 Number of Bathrooms or Latrines per Housing Unit

Number of Bathrooms: 1
Number of Latrines: 0

3.5 Economic Level of Inhabitants

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

Additional Comments: It is estimated that 60% poor inhabitants and 40% middle class inhabitants occupy buildings of this type.

3.6 Typical Sources of Financing

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

3.7 Ownership

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

4 Structural Features

4.1 Lateral Load-Resisting System

Lateral load-resisting system consists of reinforced concrete columns and slabs. In addition to this, most buildings of this type have some kind of lateral load resisting elements, such as: cast-in-situ shear walls, or precast shear walls, or shear cross braces etc. In case lateral load-resisting elements (shear walls etc.) are not present, lateral load path depends on the ability of slab-column connections to transfer moments. In case of poorly constructed connections this is not possible and in such cases completeness of lateral load path is questionable. However, properly constructed slab-column joints are capable to transfer moment as shown by several full-scale vibration tests on buildings of this type performed in Kyrgyz Republic.

Precast column elements are usually two-story high. Typically, column spans are equal to 6 m. A typical precast column element is shown on FIGURE 2C. Precast slab elements are made of solid concrete without ribs, and the dimensions are: 3 m X 3m X 0.16 m (length X width X thickness). A typical precast slab element is shown on FIGURE 2B. All precast structural elements are combined in a space frame system by means of special joints. The assembly of precast concrete elements is shown on FIGURE 2A and FIGURE 5. Precast concrete floor slabs are lifted from the ground up to the final elevation. Longitudinal steel bars-dowels have been projected from the adjacent slabs and subsequently welded. Transverse reinforcement bars are installed in-situ. Gaps in the connections are filled with concrete at the site. Details of the slab-column connection are shown on FIGURE 4.

4.2 Gravity Load-Bearing Structure

Gravity load-bearing structure consists of reinforced concrete columns and slabs (same elements as in 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	
		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	X
		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	
Steel	Moment resisting frame	23	With brick masonry partitions	
		24	With cast in-situ concrete walls	
		25	With lightweight partitions	
	Braced frame	26	Concentric	
		27	Eccentric	
Timber	Load-bearing timber frame	28	Thatch	
		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	
Various	Seismic protection systems	34	Building protected with base isolation devices or seismic dampers	
	Other	35		

Additional Comments: Shear walls usually do not exist in buildings of this type.

4.4 Type of Foundation

Type	Description	
Shallow Foundation	Wall or column embedded in soil, without footing	
	Rubble stone (fieldstone) isolated footing	
	Rubble stone (fieldstone) strip footing	
	Reinforced concrete isolated footing	X
	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		

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		
	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		
Concrete	Precast solid slab panels	X	X

4.6 Typical Plan Dimensions

Length: 24 - 60 meters
Width: 24 - 60 meters

4.7 Typical Number of Stories

5 - 12
Typically 9.

4.8 Typical Story Height

3 meters

4.9 Typical Span

6 meters

4.10 Typical Wall Density

Walls are not load-bearing structures. If present, shear elements constitute less than 1% of the floor area in a building.

4.11 General Applicability of Answers to Questions in Section 4

This contribution describes prefabricated building construction. Buildings of this type were standarized in the dimensions and tehrefore this form addresses generic structural type rather than the description of one building only.

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 form 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				

5.2 Seismic Features

Structural Element	Seismic Deficiency	Earthquake-Resilient Features	Earthquake Damage Patterns
Wall	Walls are generally partitions (i.e. non load-bearing structures). Poor quality of walls and their joints with columns and floors.		Complete or partial damage.
Frame (columns, beams)	Poor quality of joints.		
Roof and floors	Roof and floor slabs are load-bearing structures. The most deficient part is slab-column joint.		Collapse of floors, damage of joint areas.

5.3 Seismic Vulnerability Rating

	Vulnerability					
	High (Very Poor Seismic Performance) A	B	Medium C	D	E	Low (Excellent Seismic Performace) 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)
1988	Spitak, Armenia	7.5	IX

Additional Comments: Buildings of this type (seria KUB) were not exposed to a major earthquake as yet. However, buildings with a similar load-bearing structure (seria 111) had experienced severe damage or collapse in the 1988 Spitak (Armenia) earthquake. The main cause was considered to be damage and failure of column-slabs joints. The difference between the seria KUB and seria 111 is in the floor slab construction. Seria KUB consists of the smaller floor panels that are joined together in the erected position (see FIGURE 2A). Floor slabs in the seria 111 were large panels cast on the ground and then lifted and erected to the final position. It is expected that these two construction types would experience similar earthquake damage.

7 Building Materials and Construction Process

7.1 Description of Building Materials

Structural Element	Building Material	Characteristic Strength	Mix Proportions/ Dimensions	Comments
Walls	Brick and gasconcrete masonry	Non bearing structure		
Foundations	Reinforced concrete	10-15 MPa (cube compressive strength)		
Frame				
Roof and floors	Reinforced concrete	30-35 MPa (cube compressive strength)		

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

Anyone can live in buildings of this construction type.

7.3 Construction Process

The construction process is performed by builders. Design institutes develop design documentation. A construction company fabricates precast elements and performs the assembly. Precast elements can be made either at the factory (plant) or at the building site. The main construction equipment includes crane, welding equipment and concrete mixers.

7.4 Design/Construction Expertise

Expertise related to design and construction of this type according to the legal system of Kyrgyzstan was available. Designs for buildings of this type were prepared by specialized design institutes with expertise in this type of construction.

7.5 Building Codes and Standards

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

Title of the code or standard: SNiP II-7-81. Building in Seismic Regions. Design code.
Year the first code/standard addressing this type of construction issued: 1981
When was the most recent code/standard addressing this construction type issued? 1981

7.6 Role of Engineers and Architects

Design for this construction type was done completely by engineers and architects. Engineers played a leading role in each stage of construction.

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	

7.8 Phasing of Construction

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

7.9 Building Maintenance

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

7.10 Process for Building Code Enforcement

Building permit will be given if the design documents have been approved by the State Experts. State Experts check the compliance of design documents with the pertinent Building Codes. According to the building bylaws, building cannot be used without the formal approval by a special committee. The committee gives the approval if design documents are complete and the construction has been carried out in compliance with the Building Codes.

7.11 Typical Problems Associated with this Type of Construction

Defects in the design solution, poor quality of construction resulting in inadequate bearing capacity of column-slab joints.

8 Construction Economics

8.1 Unit Construction Cost (estimate)
For load-bearing structure only (without finishes) about 120 US$/m^2.

8.2 Labor Requirements (estimate)
It would take between 10 and 15 months for a team of 10 workers to build load-bearing structure for a building of this type.

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)	Column-slab joint	Steel and reinforced concrete cantilever.
	Null	Additional shear walls.
New Construction	Column-slab joint	Improved design solutions for column-slab joint.
	Null	Cast in-situ reinforced concrete shear walls
	Floor slabs	Construction of ribbed slabs. Increased slab thickness.

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

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

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

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

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

11 References

King, Stephanie, Vitaly Khalturin and Brian E. Tucker (1996). Seismic Hazard and Buildings Vulnerability in Post-Soviet Central Asia Republics. Proceedings of the NATO Advanced Research Workshop on Earthquake Risk Management Strategies for Post-Soviet Central Asian Republics, Almaty, Kazakhstan, 1996. Kluwer Academic Publishers, Dordrecht, Netherlands.

Uranova, S.K., and Imanbekov, S.T. (1996). Building and Construction Design in Seismic Regions - Handbook. Kyrgyz NIIP Stroitelstva, Building Ministry Kyrgyz Republic, Bishkek, Kyrgyz Republic.

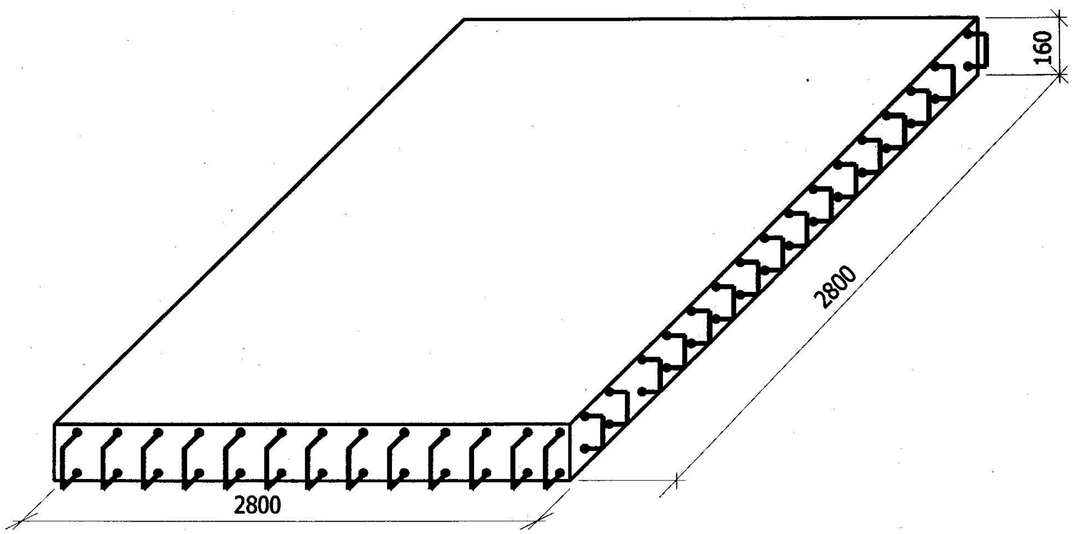
12 Contributors

Name	Svetlana Uranova	Ulugbek T. Begaliev
Title	Engineer	Head of Department
Affiliation		KNIIPC
Address	107-1222 Harwood Street	Vost Prom ZoneCholponatisky 2
City	Vancouver, BC	Bishkek
Zipcode	V6E 152	720571
Country	Canada	Kyrgyzstan
Phone	604-696-0563	996-3312-237564
Fax		
Email	uransv@yahoo.com	utbegaliev@yahoo.com
Webpage		

13 Figures

FIGURE 1: Typical Building

FIGURE 2A: Key Load-Bearing Elements



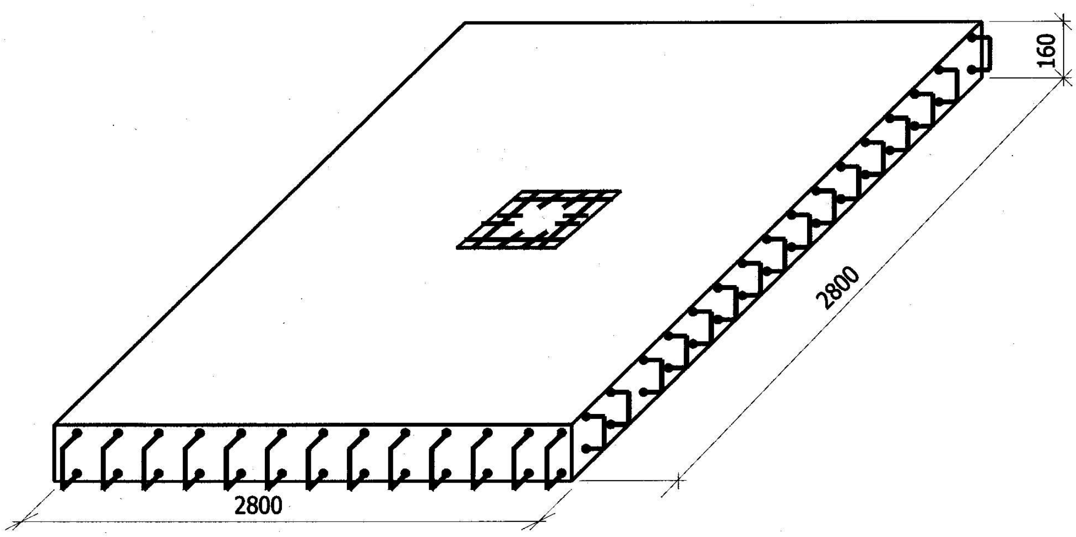


FIGURE 2B: Precast reinforced concrete slabs; a slab to be joined with a column is perforated with a hole at the center.

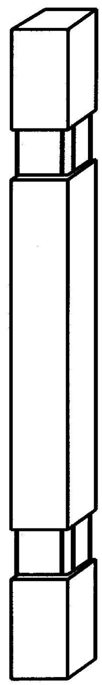


FIGURE 2C: Precast reinforced concrete column element; column contains grooves at the slab location.

PLAN

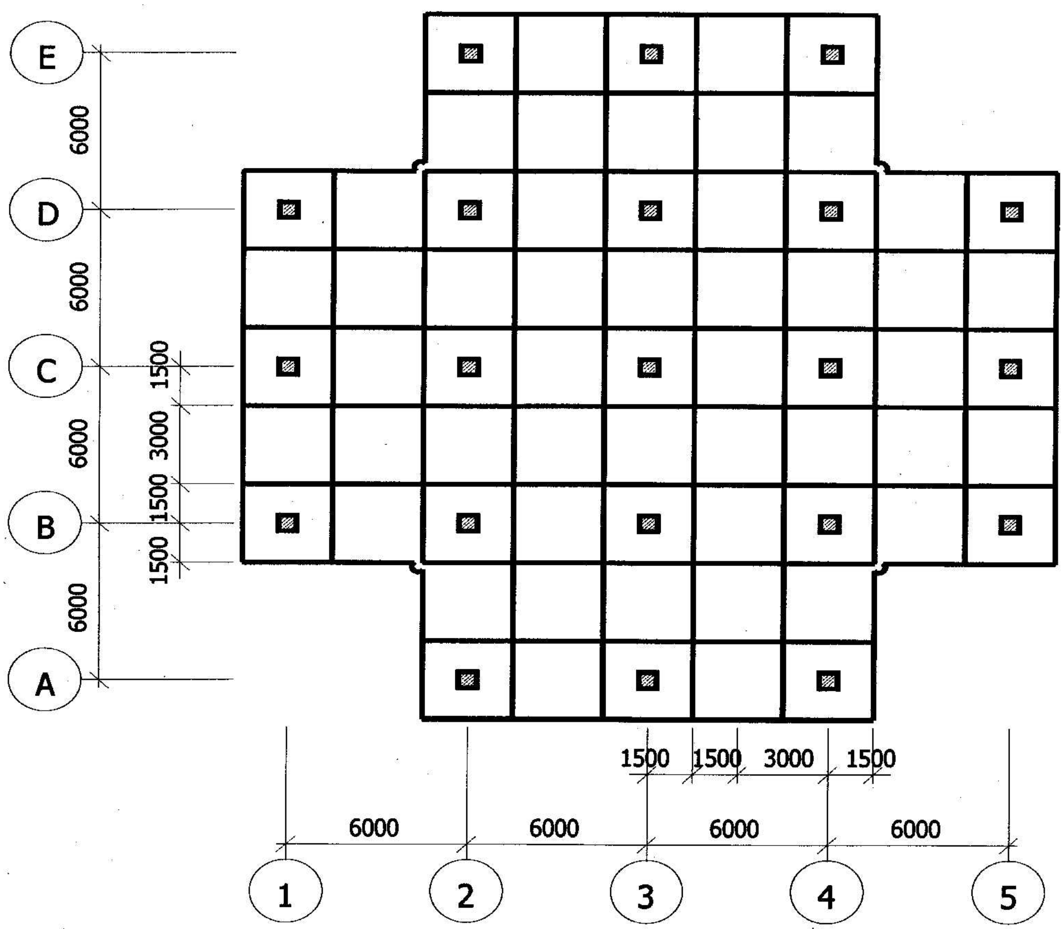
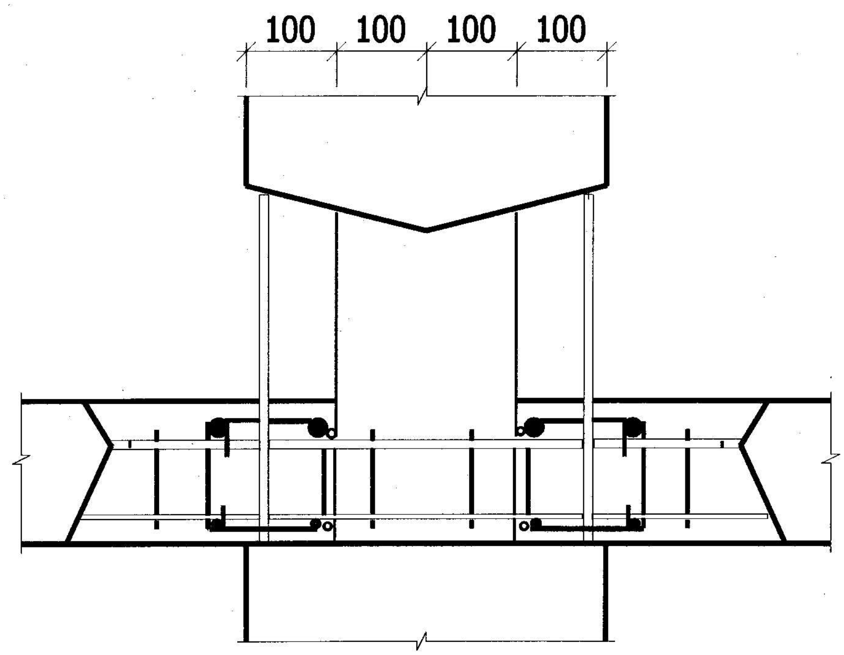
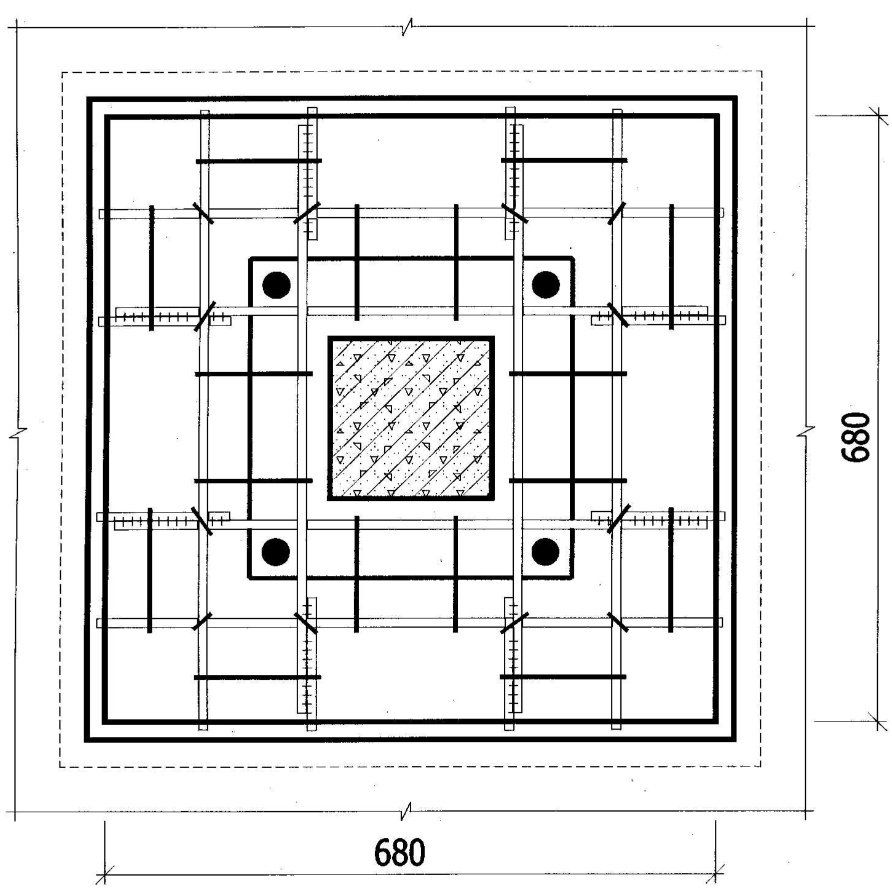


FIGURE 3: Plan of a Typical Building



100
100
100
100



680
680

FIGURE 4: Details of a monolithic column-slab connection

FIGURE 5: