

Grygorii GASII

Poltava National Technical Yuri Kondratyuk University, Poltava, Ukraine

Oleg ZABOLOTSKYI

MTS Company LTD, Almaty, Kazakhstan

CONSTRUCTIVE CONCEPT OF COMPOSITE STRUCTURES FOR CONSTRUCTION INCLUDING GEOLOGICAL SPECIFICS

The task of the study is consider some specifics of design and construction of composite structures in seismic regions on the example of Kazakhstan including geological specifics of Almaty city. The new constructive concept for seismically dangerous areas was proposed. This is the composite steel and concrete structural frame, which was developed in Poltava National Technical Yuri Kondratyuk University.

Keywords: composite structures, design, construction

INTRODUCTION

Belonging cities to the seismically active regions is a major problem in the development of urban infrastructure. Construction of residential and public buildings in particular requires certain measures to reduce the risk of destruction in consequence of earthquakes. These measures may include special designs that dampen dynamic effects or the use of materials that are able to resist dynamic forces and influences. In this study considered some designs using earthquake-resistant composite materials. It is steel-concrete composite material. As analysis of recent research and publications has shown, the steel-concrete composite material is used very widely in various fields of civil construction [1-5].

1. THE MAIN MATERIAL

One of the main effects that causes the specifics of design and construction in the Republic of Kazakhstan is the seismicity of the area. In some regions of the country, seismicity of the construction area reaches nine points, but with the category of soils, seismicity construction sites can be up to ten points. In the Republic of Kazakhstan in seismically dangerous areas are the following areas: 1) East Kazakhstan Region; 2) Almaty Region; 3) Jambyl Region; 4) South Kazakhstan Region; 5) Kyzylorda Region.

There are specifics of the design and construction in Kazakhstan in current work shown by the example seismological and geological and climatic conditions of Almaty city that is the part of the Almaty region on seismic risk rank.

Area of Almaty city is divided into several construction sites with the seismicity of nine and ten points. Ten Seismicity caused by occurrence in the top weak layers of soil (mostly clay soils of the first and even the second type of subsidence).

Usually geotechnical sections at construction sites of Almaty are similar. Typically it are: 1) the first layer is a bulk or plant soil that are not suitable for foundations; 2) the second layer is clay soil (not subsidence or first and second type of subsidence) is not suitable for foundations or suitable depending on the number storeys of building and application of events for removal subsidence of soil; 3) the third layer is solid (gravel or pebble soil).

Including the geological specifics there is a need to build structures with underground or basement and usage stronger sandy or gravel soils instead of soft clay soil by replacing and pounding base to achieve design parameters in accordance with state regulatory requirements [6]. There is also a requirement in accordance with [6] bury the base of foundation below ground level not less than 10% of height above ground of the building. The foundation is made above the basis as a continuous monolithic slabs or monolithic cross belts. Compaction of the bases are paying great attention with compulsory metering degree of compaction and other parameters given in project. When buildings are designed in seismically dangerous areas there is important to providing symmetry vertical bearing structures relative to the central axis of the building. It is strongly required to coincide the center of the building and the center of mass of bearing designs. This location of the support structures gives minimal effort in the elements under seismic loads, and hence the lowest possible reinforcement structures. Of course, in practice not always possible to achieve complete symmetry, but we always strive to this. Even at the stage of conceptual design constructors work together with architects to location bearing elements for maximum symmetry.

There are frame and frame-wall constructive systems of buildings in Almaty. Among all type of frameworks usually used system in the form spatial frame with vertical stiffness diaphragm. This choice conditioned to the fact due seismic effects there are significant horizontal forces on the floors of a building and this frame resists these forces without exceeding the allowable horizontal displacement floors of buildings, which can not be achieved without the usage of stiffness diaphragm.

The foundations are made usually as a monolithic slab thickness from 500 to 900 mm depending on number of storeys, from concrete B20 or B25 according to [7] and reinforcement A-III (A400) and A-I according to [8]. Strengthening of the foundation performed using basic (background) reinforcement with cells 200×200 mm and additional reinforcement. There are additional reinforcement in the bottom zone that is held in between the basic reinforcement (Fig. 1a) and the top zone below the basic in one or more rows (Fig. 1b).

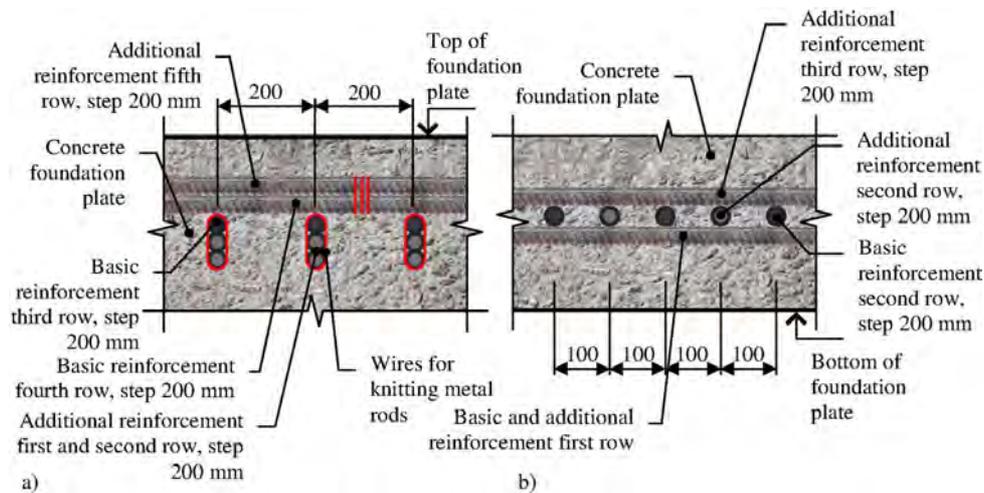


Fig. 1. Reinforcement of top zone (a) and bottom zone (b) of the foundation plate [9]

Columns are reinforced longitudinal and transverse reinforcement. Cross-sectional area of longitudinal reinforcement at construction site seismicity nine and ten points should be at least 1.2% of the cross-sectional area of the column. The diameter of transverse reinforcement must be at least 8 mm. Joints of column and beams should be reinforced with locked transverse reinforcement, which are set with step no more than 100 mm (Fig. 2).

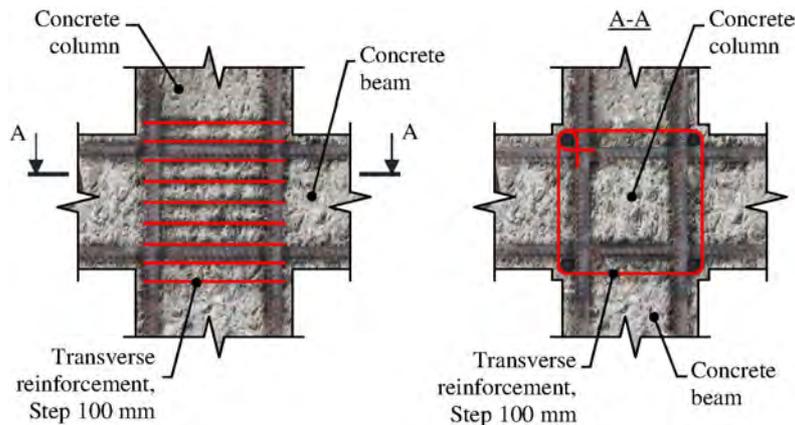


Fig. 2. Reinforcement of joints of columns and beams [9]

Walls (diaphragms) are reinforced at zones. There are two zones reinforcement of walls: 1) Peripheral zone. It is area near the end faces of the walls, openings and faces the intersection of walls; 2) Field zone. It is the rest area of wall, which need reinforcement.

Reinforcement of peripheral zones is performed with spatial frames, which located in areas 0.1-0.2 length of the length of the wall. Reinforcement of field

zones is performed with flat vertical frames that connect the horizontal reinforcement. Connection of longitudinal reinforcement, which have a diameter more than 22 mm and longitudinal reinforcement of columns is performed with welding. Moreover, the welded joints in height are placed in the run. Instead of welding, is widely used threaded couplings.

In most cases, protecting designs is made from autoclaved concrete blocks (heat insulation blocks). These heat insulation blocks are a good insulating material, moreover, walls that have thickness of 400 mm for climatic district of Almaty do not require additional insulation. These structures are non-bearing therefore in case of dynamic effects they need reinforcement. Strengthening of structures perform reinforced with vertical inclusions, steel bars or bilateral reinforcing mesh. In practice, there is used reinforcement from steel bars (Fig. 3) [9].

Partitions are made of hollow concrete blocks with a thickness of 90 mm to 190 mm, depending on the height of the building. Blocks are made with half dry vibrocompression of cement-sand mixture. Laying performed with a solution not mark below M50 and ligation of vertical joints. All vertical channels filled plastic concrete B10 with small filler. Vertical reinforcement is made from rods with a diameter of 12 (16) A-III (A400) and with step of bars 400 mm, horizontal reinforcement is performed every 600 mm (3 lines) as a grid, which is made from reinforcement wire Bp-I. Vertical reinforcement is connected between the top and bottom floors by means put segments of reinforcement rods in drilled wells. Such partitions quite good resistance to dynamic effects and therefore widely used in seismic activity areas.

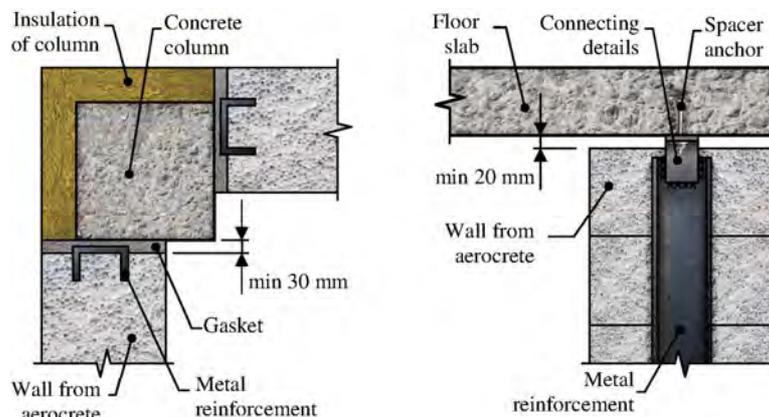


Fig. 3. Strengthening masonry with steel bars [9]

2. THE NEW CONSTRUCTIVE CONCEPT

The purpose of this chapter is to present the new kind of spatial composite structure made from strength materials for civil construction, in particular to floor and roof system - the composite steel and concrete structural frame (CSCSF). Novelty

of CSCSF lies in effective application properties of materials [10]. The CSCSF consists different kinds of structural elements: slabs, steel space trusses. The steel space trusses are made from segments of steel tubes or rods. The slabs are used as the top chords, steel space trusses are used as diagonals. The diagonals and slab create space module [10] that is main element of CSCSF. The CSCSF are assembled on construction site from space modules (Fig. 4). The structural elements are joined by bolted connections but sometimes in specific case can be joined by welded connections. Choice of a connection type are depend on function of structures, span and shape, but preference is given to bolted connections because they are relatively easy to assemble, maintain, and they are able to carry the high loads including dynamic that typically appear in structural members of structures.

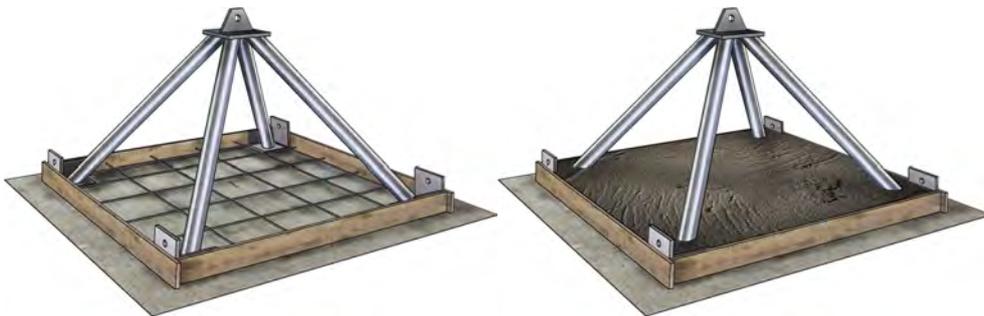


Fig. 4. Manufacturing of the space module for composite steel and concrete structural frame [10]

Production of space modules can be performed in the plants that produce steel structures, and other plants that have the equipment for processing steel and concrete casting of products. Technologies of processing, assembly, welding, loading and unloading of steel structural member of the CSCSF are similar to the technology of production of conventional steel structures and concrete structures. Manufacturing technology of the CSCSF is divided into two separate processes: fabrication of a steel lattice (frame) and the making of slab.

Construction of the CSCSF is perform by the methods described in [10].

CONCLUSION

The specifics of design and construction in Kazakhstan are connected with a constructive solution of bearing and walling structures. Analysis of the specifics of design and construction was shown for seismically dangerous areas of Almaty. The analysis found that these specifics are caused by seismic danger of these areas and intended for maximum strength and stability of the buildings and structures, and that it is important to provide safety for people in these buildings even in such a dangerous phenomenon as seismic. The new constructive concept for seismically dangerous areas was proposed. It is the composite steel and concrete structural

frame. This structure is the new kind of large-span structures, which have significant advantages; in particular and have lower complexity of manufacturing and assembly than analogues. This structural concept makes it possible to save materials due to the rational using of them. The conclusion that this type of constructions is reliable and efficient in exploitation, allows to save materials was made based on experimental, theoretical and analytical studies and the stress-strain state numerically investigation.

In conclusion, it should be noted that the composite steel and concrete structural frame can have different forms and shapes. This allows to use the structures successfully in construction.

REFERENCES

- [1] Gasii G.M., Technological and design features of flat-rod elements with usage of composite reinforced concrete, Metallurgical and Mining Industry 2014, 4, 23-25.
- [2] Gasii G., Hasii O., Zabolotskyi O., Estimate of technical and economic benefits of a new space composite structure, MATEC Web of Conferences 2017, 116.
- [3] Storozhenko L.I., Gasii G.M., Gapchenko S.A., Design features and technology of installation of new spatial constructions of composite grid-cable coverings, Eastern-European Journal of Enterprise Technologies 2014, 4, 1(70), 67-72.
- [4] Storozhenko L.I., Gasii G.M., Experimental research of strain-stress state of ferrocement slabs of composite reinforced concrete structure elements, Metallurgical and Mining Industry 2014, 6, 40-42.
- [5] Storozhenko L.I., Gasii G.M., The new composite designs for mine tunnel support, Scientific Bulletin of National Mining University 2015, 4(148), 28-34.
- [6] SNiP RK 2.03-30-2006 Construction in seismic areas. Seismic design code.
- [7] GOST 25192-82 Concretes. Classification and general technical requirements.
- [8] GOST 5781-82 Hot-rolled steel for reinforcement of ferroconcrete structures. Specifications.
- [9] Report on research work: "Develop albums of technical solutions for enclosing structures using efficient materials for the construction of individual houses", Astana, KAZNISISSA, 2005.
- [10] Gasii G.M., Types of steel and concrete composite cable space frames, Science and Transport Progress 2016, 6, 158-165.

KONCEPCJA KONSTRUKTYWNA STRUKTUR KOMPOZYTOWYCH DO OBIEKTÓW BUDOWLANYCH Z UWZGLĘDNIENIEM SPECYFIKI GEOLOGICZNEJ

W artykule omówiono wybrane warunki projektowania i budowy struktur kompozytowych stosowanych w zagrożonych sejsmicznie regionach, na przykładzie Kazachstanu, z uwzględnieniem warunków środowiskowych Almaty. Zaproponowano nową konstruktywną koncepcję struktur do zastosowania w obiektach budowlanych wznoszonych w rejonach sejsmicznych. Jest to konstrukcja kompozytowa wykonana ze stali i betonu, opracowana w Poltavskim Państwowym Uniwersytecie Technicznym im. Yuriya Kondratiuka.

Słowa kluczowe: kompozyt, struktury, projektowanie, konstrukcja