STRUCTURAL DESIGN OF EARTHQUAKE-PROOF FRAMELESS IN-SITU CONCRETE RESIDENTIAL BUILDINGS IN THE USSR

by

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SYNOPSIS

This report is a short survey of the in-situ housing construction development in seismic areas of the USSR. The paper deals with the principal solutions and designs of structures in in-situ earthquake-proof frameless buildings: walls, floor-slabs, reinforcement systems.

Experience in design of such buildings is also much referred to, particularly in the branch of seismic calculations.

INTRODUCTION

The growth of population in large cities and new settlements has called for a comprehensive and efficient land-use. It has entailed the construction of higher buildings in cities and diversity in town planning and architectural solutions in civil construction. In seismic areas the above factors had to be added to the problems of seismic stability and durability of structures along with economizing in building materials and money, the latter being of prime importance.

Because of the fact that the frameless in-situ buildings possess high bearing capacity, spatial rigidity and stability they meet these requrements much better than any other buildings.

At present the construction of in-situ buildings is going on in the seismic regions on a wider scale than anywhere else. In the European part of the USSR the following

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resort-towns can serve as the examples: Sochi,Yalta, Kishinev and Baku,the capitals of the Union Republics; in the Asian part of the country - Alma-Ata,Dyushanbe,Ashkhabad, Frunze,also the capitals of Union Republics.

The in-situ construction is being done by industrialized methods using repetative forms and tunnel and large-size shuttering.

STRUCTURAL SOLUTIONS

In-situ and precast/in-situ frameless buildings are designed along the lines of the following structural systems:

- with in-situ load-bearing internal and external both longitudinal and cross walls;
- with in-situ load-bearing internal longitudinal and cross walls and with external curtain-walls.

The buildings of the first structural system are characterized by a relatively higher seismic stability,and, hence being more universal, can be erected in 7-8 point seismic force areas.It is suggested that they may be constructed in -10 point force areas; the buildings of the second structural system are designed for 7 and 8 point seismic force regions.

The choice of material for load-bearing walls is one of the most important problems in design of earthquake-proof buildings.At the beginning, as a rule,heavy cincrete was used for in-situ walls: thus, external in-situ walls were made of three layers-internal bearing layer,insulating plates or shells,external protective layer.Such a solution left much to be desired from the technological point of view: the labour comsumption is considerable,it is difficult to ensure the stability of insulatioh and the designed thickness of the load-bearing layer.

The use of structiral thermal insulating concretes based on porous artificial aggregates (keramzite,agloporite) has come into common practice in current in-situ housing construction. On the one hand,it permits to simplify the structure of in-situ external walls and the erection techniques. The keramzite concrete buildings were constructed in Alma-Ata and Baku, the agloporite concrete ones - in Dyushanbe. The specific weight of Light aggregate concrete in completed buildings is from 1400 to 1800 kg/m^3, the prisme concrete strength being 205 kgf/cm^2.

In design of vertical bearing in-situ diaphragmes a special attention is being paid to the reinforcement of the most importane components, such as lintels and joints between lintels and walls as well as to the reinforcement along doors and window openings. Strength tests have proved, in particular, the efficiency of evenly distributed lintel reinforcement [2].

The reinforcement of in-situ diaphragms is made of flat welded frames, meshes and spatial frames. Reinforcement elements are manufactured by special plants.

The non-load-bearing are made of large blocks (units) for example, as in Kishinev the 13-16-storey high housing blocks, or, if climate allows, are nearly wholly glazed (14-storey high heusing blocks in Sochi, 16-storey high boarding-house dormitories in Adler). The units are made of insulating concretes based on artificial porous aggregates. The volume weight of such concretes may range between 900 and 1200 kg/m^3, depending on the volume weight of the aggregate.

External non-load-bearing walls can be made not only of large blocks (units), but also of curtain walls, which is considered quite a promising solution. The use of light insulating concrete panels is planned in designs of precast in-situ 9-storey high buildings and of 9-and 12-storey high buildings to be erected respectively in Yalta and Kishinev.

The overall weight of the building can be considerably reduced by means of using external asbestos/cement curtain walls having internal efficient thermal insulation layer.

Structural design of floor-slabs depends upon the spans between the load-bearig walls,general lay-out of the building,erection methods and capacities of local building industrial enterprises. In the USSR there have been practised the following three types of structures: precast,precast/in-situ and in-situ ones.

For the precast floor-slabs there are mostly used cellular slabs with pre-stressed reinforcement,as in the 14-storey housing block in Sochi.

The structures of the second type comprise a certain number of slabs composed of prefabricated components,the remaining slabs being concreted in-situ.This solution was adopted when erecting the dormitory block of "The Actor" sanatorium building constructed in slip-forms (Sochi) and certain housing blocks built in travelling shuttering in Kishinev.

The in-situ slabs,depending on the methods of erection,either are resting on special supporting projections (when constructed in slip-forms), or have a continuous in-situ binding to the walls (when made in travelling shuttering).

From the structural point of view the in-situ variant looks more preferable for it makes it possible to provide for the necessary rigidity of the floor-slabs discs in their planes so that no cast-in parts or welding are needed,as it is the case with the precast variant, and the result of the former being the decrease in the consumption of metal.

CALCULATIONS AND RESEARCH

All the calculations necessary to ensure the in-situ building capacity to withstand earthquake forces are made on the basis of the dynamic theory of seismic resistance, which has primarily been developed in the USSR [3], and, in its present form is the foundation of the respective sections in the Building Norms and Regulations [4].

Most calculations are automatically programmed and processed with computres. Such programmes, as "Parad", developed at TSNIIEP zhilischa and TSNIPIASS [5] ,"Razdan (KievZNIIEP) and APR-5 (Lenprojekt) are applied on a wide scale.

The calculation theoretic analysis carried out at TSNIIEP zhilischa by means of "Parad" programme and the computer "Minsk-2" has shown that under conditions of to-day lintels can be made without rated reinforcement, it causing no damage to their load-bearing capacity.For instance, in buildings with narrow spans between internal load-bearing 16cm thick walls the rated earthquake force being of 7 points, the 16-storey high lintels can be made of concrete through all the height (i.e.with only structural reinforcement) [6].

To-day the mathods allowing for the most comprehensive consideration of the spatial nature of the in-situ frameless structure behaviour are regarded as the most promising ones by way of perspective. Along with it there are going investigations and research into the methods of approximate calculations necessary for estimating the seismic load values and load-bearing capacity of the building at primary design stages.

In design and calculation of in-situ earthquake-proof buidlings the results of laboratory and field tests are also used,in particular,thevibro-tests of a 10-storey high large-scale model of the residential building with long spans between internal load-bearing walls [8] and of the 13-storey high precast/in-situ house with narrow spans between external and between internal load-bearing walls (the tests were made at TSNIIEP zhilischa).

THE COMPLEXES AND SERIES OF IN-SITU BUILDINGS

The accummulated experience made it possible to pass over from design and construction of individual structures to that of sanatorium and urban complexes. For example, there were erected the 16-storey high blocks of a boarding house in Adler (TSNIIEP of medical and resort buildings), 8-storey high housing blocks (Tadjikgiprostroy) in Dyushanbe, 20-storey high residential buildings in Kishinrv (Moldgiprostroy).

To introduce the in-situ structures into the civil earthquake-proof construction on a wider scale designs of the series of residential buildings have been developed to be practised in cities and urbanized settlements. Each series is designed with regard to a definite climatic region and its specific earthquake activity. Designs have been made on the basis of the structural solution common to the given series and chosen with consideration for available local materials and industrial capacities of the area.

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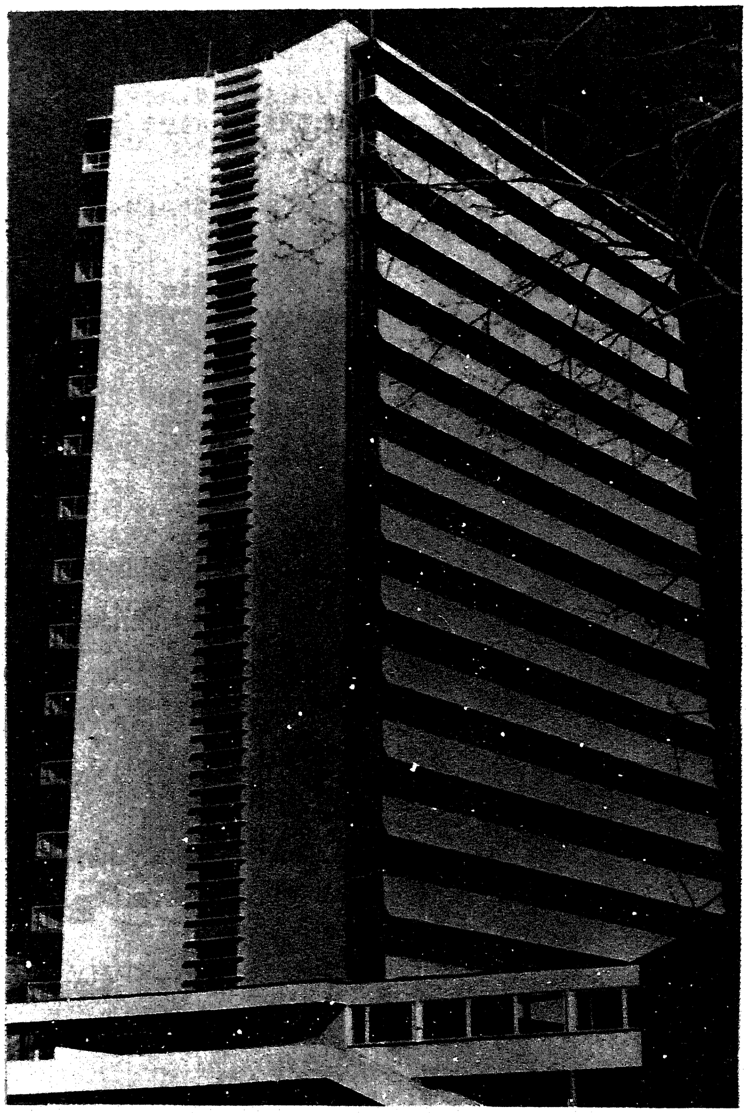

Fig. 1. 15-storey sanatorium „Actor" in Sochi

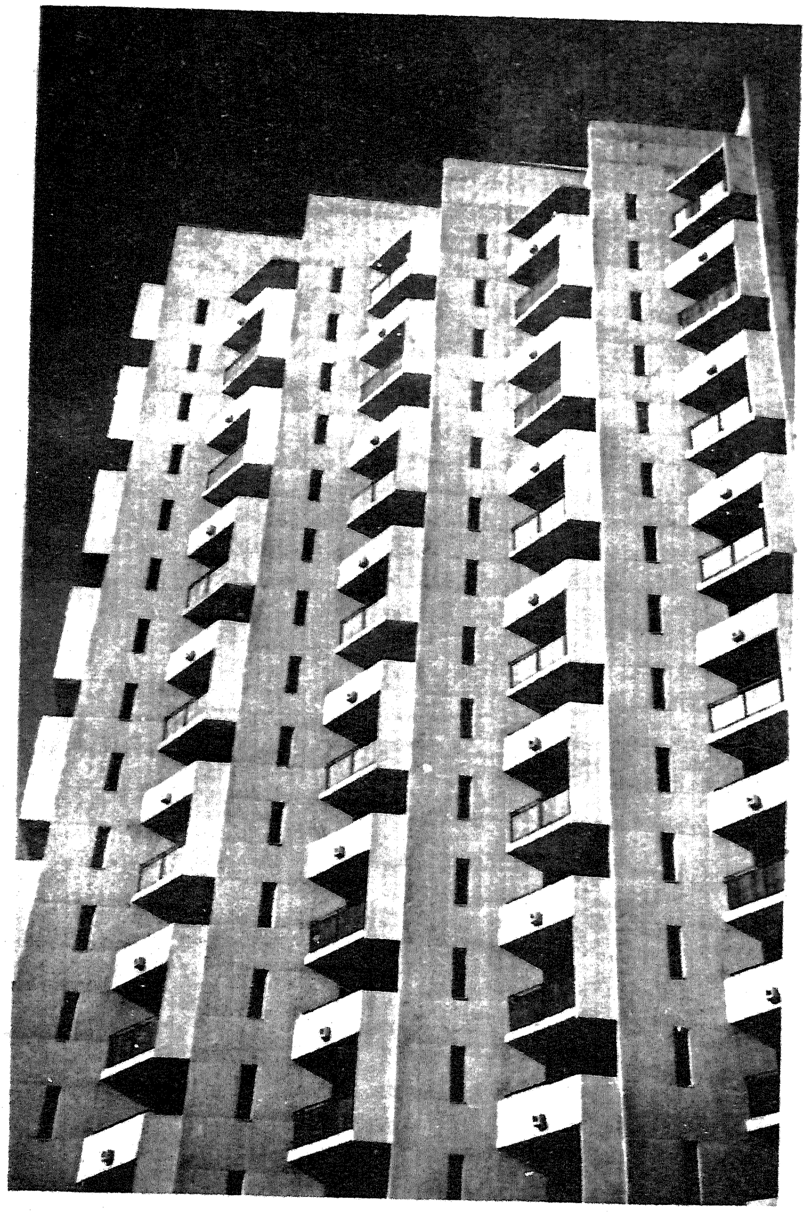

Fig.2 16-storey residential building in Baku a

b

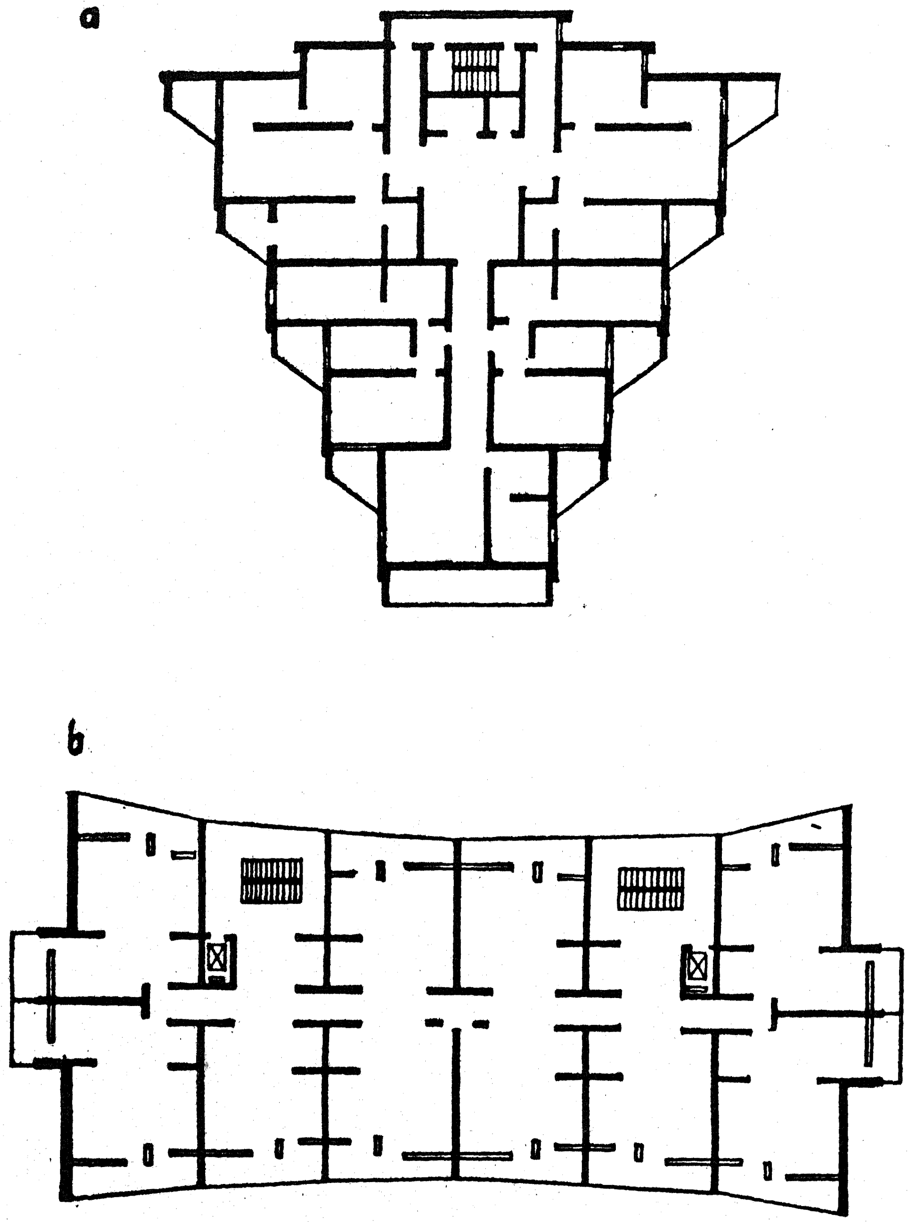

Fig. 3. The structural systems of the earthquake-proof frameless in-situ buildings
a – with internal and external load-bearing walls
b – with internal load-bearing walls