

Modeling and Experimental Analysis of Residential Buildings from Local Materials

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Abstract:The problem statement and analysis of the series of tests on models of low-rise buildings constructed from local materials. In given to article, considered results called on serieses tests on model low-rise buildings built from local material.

Keywords: experiment, local construction materials, model, wooden and reinforced concrete frames.

I. INTRODUCTION

Earthquakes occur in those areas of the globe in which nature has created specific geological structures. Earthquakes usually occur in mountainous and rock-shaped areas. As is known, Kyrgyzstan is a seismically active mountain region located on a multitude of tectonic faults. Therefore, the presence of the threat of destructive earthquakes is quite explainable. As The research results show, the overwhelming part of Kyrgyz Republic is exposed to 8-9 point earthquakes/1/. Therefore, there is an obvious need for construction in such conditions of earthquake-resistant residential properties.

At present, traditional types of individual housing construction from «soil blocks» and «adobe raw» (saman) have developed in the territory of Kyrgyz Republic. These construction materials are practiced in both rural and urban areas. In this regard, the urgent need to develop seismic design and planning solutions for residential buildings using local building materials.

Analysis of the results of recent earthquakes shows that private houses that do not meet building codes have collapsed and led to dire, tragic consequences. For example, the strong earthquake that occurred on October 5, 2008 (8 points in the epicenter) in the village of Nura of the Alay region caused great loss of life and clearly showed that people were mostly not prepared for natural disasters. Almost all residential buildings, built primarily of clay materials and without complying with earthquake resistance standards, are completely destroyed. A preliminary engineering survey of destroyed and surviving buildings in the village of Nura showed that in buildings erected with the use of building products made from clay materials, the seismic resistance standards were not observed. Here the skeletons of the building were erected by the traditional method using building products made of clay materials.

Note that the process of building new residential buildings in a similar way is carried out in residential areas of Bishkek.

The use of clay in construction since ancient times has been practiced in countries with hot and dry climates - in Egypt, Iran, Turkey, China, etc. In Central Asia, in particular Kyrgyz Republic, houses of various structures are built using clay. As historical experience shows, ease of preparation, availability and ubiquity of raw materials, lack of transportation costs and cheapness have contributed to the wide distribution of structures made of clay.

In connection with the above, let us dwell on the following four methods /2/ construction of residential houses from local materials practically implemented in the territory of Kyrgyz Republic:

- №1. Houses with walls built of claymaterial «sokmo»or «pakhsa» from various clay pieces of irregular shape;
- №2. Houses with walls constructed from the laying of «bricksraw»(unfired) or blocks of regular shape;
- №3. Wooden-framed houses filled with clay materials called «synch»;
- №4. Houses made of «reinforced concrete frame» filled with raw brick or various materials of clay.

Let us dwell in detail on the analysis of the form:

№1.«sokmo» or «pakhsa» is the most common method of wall construction during construction from materials on the territory of the Kyrgyz Republic clay - technology. When erecting a clay wall, specially made forms or formwork are used, their height is 50-60 cm, the laying is similar to the laying of raw bricks, but the connection of the corners is weak. When erecting a clay wall, they use «sokmo»- clay for tamping. To study the behavior of such houses, an experiment was conducted on such a house on the seismic platform of the Kyrgyz State University of Construction, Transportation and Architecture named after N. Isanova. When building this model, clay was used,

although in most cases the soil that was mined in the place where the house is built and in its surroundings is used in practice. Such houses can only be considered as temporary housing. The results of the experiment convinced that the models of houses built according to the «sokmo» method already with a 5-6 point (in terms of acceleration) earthquake completely crumble (Fig. 1).

«Pakhsa» is a clay wall high 50-60 cm, which is erected with the help of special formwork. Another way is as follows. A shovel need to separate a piece of clay mass, throw it on the straw that was scattered in advance, wrap it well, roll it all the way around, and manually put it inside its «gualyak». Houses with pakhsa walls are built around the entire perimeter, in rows of 50-60 cm in height. There should be sometime between installing the layers until the bottom layer dries, then the next layer is put. In other words, it is required to continue laying the next layer only after the bottom layer of the pakhsa wall is able to bear the weight of the next round.



Fig1. General view of the model of the house «sokmo» after the experiment

№2. Houses with walls built of «brick raw» and blocks of regular shape are very often found in the countryside and new buildings in the suburbs of the city of Bishkek. The peculiarity of this type of wall is that due to the fit of bricks and blocks in the corner joints the walls do not settle. Masonry of this type is almost the same as brickwork. The thickness of the walls of mud brick can be taken in 1; 1.5 or 2 bricks, and from blocks of regular shape - 1 or 1.5 blocks. This type of wall without adequate reinforcement, as well as the previous one, is not earthquake resistant and needs to be reinforced. In order to demonstrate a visually simple method of strengthening such walls, a large-scale model of a house was built on seismic platform of the KGUSTA named after N. Isanova, and a relatively inexpensive reinforcement was done in advance. The main feature of strengthening this model is to strengthen the inside and outside of the wall with nets of cords with surface gunning sand-cement mix. According to the results of the experiment, it was found that the model of a house built of raw brick with simple reinforcement has a much higher resistance to earthquake compared to a house of simple «sokmo»(Fig. 2).



Fig2. General view of the model of the house, made of brick raw, after the experiment

In these figures, you can see a lot of useful sides of the reinforced model, such as hauling a net of cords and splashing sand-cement mixture under high pressure, with the result that the plaster clings to the wall. With a 6-7 point (in terms of acceleration) earthquake, the plaster remained stuck to the wall and did not fall off, which proves its relative resistance to earthquake.

№3. «Synch» - the building of such a structure is often used in the most populated areas of Central Asia, for example in the Batken region of the Kyrgyz Republic and in the border areas of Batken region of Tajikistan /3, 4, 5/. The wooden frame is built to carry the load from the roof and ceiling of the diagonal angle of 45° boards and insulating materials. The cross section of the supporting pillars can be rectangular or round. To fill the frame is used mainly «gualyak». Similar to «synch» home can be recommended as a simple and reliable construction with local materials. This type of houses with a wooden frame can be used as a model in seismic zones, as well as housing for victims of natural disasters. The cross sections of the supporting pillars of the lumber should be dimensions: - 100x50 mm, 50x50 mm, struts - 50x30 mm (Fig. 3) and the sill - 150x150 mm; 150x100 mm. Another option, the supporting pillars of the logs must be of circular cross section diameter of 60-80 mm, planed on all sides, to square, to make even, so that they were attached to the base and mounted on top of the other logs.



Fig 3. The process of construction of a model house of wooden frame "synch"

When filling the frame, it is necessary to ferment (real) clay to prepare shuttering the right size, add clay, various additives, such as straw, pour the dough around the perimeter, tightly tamping. When filling the wall, wait, let the clay dry and solidify the solution to a certain extent. Houses of similar design are considered very resistant buildings for earthquake compared to other buildings, and it is recommended to build such houses in seismically hazardous areas. Results of the experiments showed that the 7-8 point (in terms of acceleration) of an earthquake, collapsed filling, but the wooden frame was durable and resistant (Fig. 4). We emphasize that when a strong earthquake is not possible tragic consequences, and crumbling filling easy restore later. Another factor that should be recalled - parts of houses, such as the foundation and wooden supports, or wooden supports and the roof, etc. must be joined together and work as one.

Here are some examples using homes «synch» type with an analysis of shortcomings.



Fig 4. General view of the model house of «synch» after the experiment

Houses of this type are built on a bad foundation, because the stones are placed in a solution of clay, and between the foundation and filling the frame is not bunch. Therefore, the stones must be filled with clay instead of concrete and, in addition, such a foundation must be associated with a wooden frame. In other words, the foundation

must be laid inside the wire with the release of a length of 0.5 m. Step wire should be no more than 1 meter, more often, the better. Mudsill established on the foundation, you must also secure the wire (Fig. 3), a diameter of \varnothing 6mm or anchor bolts M10 -12 mm.

№4. The House of «reinforced concrete frame» with the filling of the raw bricks or different materials from clay. Today, home of similar design are used mainly in buildings around the city of Bishkek and in many regions. However, this type of homes being built relatively less than normal houses without amplification. In the construction of buildings such a construction, firstly by pouring the foundation with concrete necessary to lay reinforcement upright columns at the corners by four rods in each corner, in the openings of doors and windows - on the two bars. Secondly, at the intersections of the walls where there is a switch-reinforced, it should continue to the level beams, however, every 60 cm in height should go at least two rods at the joint between the wall supports. Third, soaked in clay should be added to the straw, set the formwork, which is done using a series of wall height of 60 cm. Then, they should be associated with left of the pillars of the rods by transverse networks. By the same method the following series of stacked to a level crossbar. Above the concrete supports and erected walls constructed of reinforced concrete circular zone (seismic belt). Further, the two reinforcing bars projecting from the foundation around the edges of doors and windows, it is necessary to put a circular belt and tie, put formwork and pour concrete (Fig. 5). This element is called a concrete or reinforced concrete core /4, 5, 6/.



Fig 5. The process of construction of model homes from the «reinforced concrete frame»

According to the results of experiments conducted in the laboratory of "Seismic Construction", we can see that in the 7-8 point (in terms of acceleration) earthquake, in a house built in compliance with all building technologies and methods, there is only a crack in the plaster at home and in the field connection clay walls with concrete elements at the level of window sills and jumpers (Fig. 6).



Fig 6. General view of the model house of «reinforced concrete frame» after the experiment

Obviously, such a house construction are resistant to earthquakes, compared to the other listed three types of structures. It should be noted that in these houses, reinforced concrete supports very strongly the strength higher than those of the clay wall blocks. This fact must always be taken into account. To do this, in corners of walls, horizontal grid clutches associate with rod releases of reinforced concrete columns. If the proposed technology will not be respected, the house will not be able to withstand a strong earthquake.

Of course, we can offer other technologies erection of buildings. For example, the first to build a wall with remaining seats in the corners and intersections of walls for pouring concrete columns and cores, and then pour the concrete elements. With this method, the intersection of the grid at the corners left after 60 cm high walls should be provided with reliable communications by pouring concrete supports with a mesh protruding from the wall. In practice, in new buildings around the city of Bishkek, widespread house with reinforced concrete poles and the gaps between them forcing more crude blocks. It is not entirely respected building codes for seismic resistance of buildings can hardly be charged. Also found at home with the presence of the horizontal seismic belt, but without the vertical columns. This is natural, and a gross violation of useless use of resources. Mainly to provide seismic protection three main parts of the building must be linked together, (foundation, walls and roof) and by the earthquake will work as a unit. Poorly built seismic belt may even exacerbate the devastating effect of the earthquake. At the same time, there are buildings that have all these columns, cores and seismic belt, but remain in the concrete cavity (cavities), with non-uniform filling and low cement content. This, along with too thin valves, also cannot provide seismic stability of the building. Therefore, we recommend that you contact your local architecture and relevant organizations for projecting detailed project. And during the construction should strictly comply with the design requirements.

II. CONCLUSION

Of the four convicts designs of houses can be made conditional to the pedestal of seismic resistance of their placement on the economic component, technology, construction and resistance to earthquakes, and the results of experimental studies:

- *In the first place - the house with "reinforced concrete frame"* - skeletons of houses of this structure assume the entire burden in the event that our recommended construction techniques (methods) are met. At the same time, increasing the budget a little, spend a little more money you can put into the opening all doors and windows reinforced concrete cores, connect them together with foundation. The wall on both sides - inside and outside - to strengthen the grid and firmly connected with reinforced concrete columns and cores, covering the top with a solution;

- *In the second home type "synch"* - each element of such houses is well interconnected with other elements and work with them in unity. Houses of this type are houses being built quickly and easily compared with others and do not require extra transport costs so we recommend in areas at risk of earthquakes to build houses of this design;

- *In third place* - the house with walls constructed of brick raw or blocks of regular shape, as well as pasha home - feature walls of this type is that the joints of angles, bricks, blocks-fit to each other crosswise, thereby allowing the walls to separate, and the stability of the bricks is far superior to other characteristics such as materials made from clay. A pakhsha house - due to the fact that around the perimeter - without interruption - performed masonry with the addition of various binder additives, mainly straw, clay present, to a height of 50-60 cm in rows - a monolithic, unitary structure. If the wall on both sides - inside and outside - to strengthen (reinforce), covering the mesh and under strong pressure from the top to spray sand-cement mortar, plaster, then these homes can take second place;

In fourth place - the house with walls built of mud-brick material or different ground (clay) pieces of irregular shape - the reason that such houses are often subjected to destruction - firstly, their supporting structures are not linked; - Secondly, anti-seismic measures are not taken;

-*Thirdly* - are consequences of improper use of houses.

As a result of our research presented, once again we see that the houses built without sufficient knowledge of and compliance technology construction of residential buildings, made of clay in various forms (sokmo, brick raw and pakhsha), are not resistant to earthquakes.

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