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METHODS OF SEISMIC LOADS DECREASING DURING BUILDING RECONSTRUCTION

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Classification of existent buildings by their ability to resist seismic impact is needed in order to improve antiseismic qualities of existent buildings and constructions. The improvement of antiseismic properties can be attained by realization of certain strategy. The example of a building reconstruction with multispan coverage is presented.

Поліпшення антисейсмічних якостей існуючих будівель і споруд потребують проведення класифікації існуючих будівель за ознакою їх здатності протистояти сейсмічним діям. Поліпшення антисейсмічних властивостей може бути досягнуто шляхом реалізації певної стратегії. Наведено приклад реконструкції будівлі із багатопрогонним покриттям.

Introduction

The activation of the earth seismic activity observed in a number of regions of the world, requires not only the observance of building rules during new earthquake proof buildings construction, but also preparation of the existent structures to possible earthquakes.

The extensive reconstruction of existent buildings, which is under way in Ukraine at present, allows to carry out such preparation.

The work was conducted at the department of computer technologies in construction at NAU together with Research Institute of Building Constructions (L.I. Krivelov) and Research Institute Project Reconstruction (G.N. Ageeva).

Research analysis

In general technical decisions of increasing the degree of building seismic stability, can be divided into two groups, namely, increasing building strength and decreasing the values of seismic loads.

The traditional problem is building of new earthquake-proof buildings and constructions. The increase of new buildings durability is regulated by introduction of new higher values of seismic intensity, and also by consideration of degree of building responsibility. The technical decisions can be referred to passive methods of seismic stability increase.

The decrease of seismic loading is achieved due to the decrease of a building mass and application of active seismic protective methods [1].

Maximal decrease of bearing and enclosing constructions mass is the main measure, which decreases values of the inertia seismic loading during new building construction.

The latter can be achieved not only due to application of effective light materials but also thanks to the rational arrangement of these constructions. Actually the elements of buildings must be constructed in such a manner that a possibility of plastic deformations development and dispersion of energy were provided.

Seismoisolation is referred to the methods of active seismic protection.

It is the installation of artificial bases which would substantially isolate buildings from fluctuation of the ground.

Systems with increased dempfiration are another known method and consist in application of a various sort dempfires and central connections, which would disseminate energy of fluctuations.

Isolators of the bases are effective ways of reducing the level of seismic impacts. Layered elastic materials with friction between layers can be applied in this situation. Supports of constructions can be similarly arranged. Thus layers can include viscous materials or devices.

Devices which in of foreign seismic construction practice received the name “connectors” can be included in the central connections.

The later work by the principle of automobile shock-absorbers.

Rather volumetric sites of monolithing joints of columns, crossbars can play the same role in skeletons. At fluctuations of a building these sites will become places of energy dissipation.

As possible constructive decisions which show complex application of such actions, it is possible to recommend a design of a frame building with crossbars of Virendel beam type (trusses with parallel chorts) with the height equal to the height of a floor.

The space between racks can be filled with effective soud-or heat-proof materials depending on the protection type.

Absence of a continuous wall reduces the weight of this element and, as a result, the value of inertial seismic forces is increased too.

Racks of such crossbars are supposed work mainly on cut and arising friction will promote dissipation of mechanical energy. The so-called adaptive systems are referred to group of active methods of seismic protection. They consist in application of constructive elements, which change dynamic characteristics of a building during earthquake. Such elements can be switched off during earthquake from the general constructive system of a building or be included in the last one at some certain values of displacement. Systems with dynamic reducers of fluctuations are more diff icult ones.

Problem stating

The second problem is improvement of antiseismic qualities of existing buildings and constructions. It first of all requires the classification of existing buildings by the signs of their ability to withstand seismic influence. It is necessary to estimate relation between elastic and plastic properties of the construction elements, to investigate the schemes of work transformation of some elements in the zones of plasticity or brittle destroying with appearance of the friction surfaces.

Improvement of antiseismic qualities can be reached due to the increase of strength, to giving plastic properties to some elements, changing or improvement of building structural schemes as incorrect from the antiinfluence to seismic forces of point of view by decreasing building mass, and isolation of bases. Added diagonal cables, elements, which would work on cutting and as a result also on friction can be included in the number of building elements.

Strengthening of columns and beams can be made due to applying of new effective materials, well as carbon fiber plastics.

The strategy of improvement of antiseismic properties of existing buildings is shown in the fig. 1.

During the reconstruction of existing buildings the constructive measures, which would improve their antiseismic properties, have to include the following aims:

– increasing building strength;

– increasing properties of oscillated energy diffusing;

– taking of nonregularity, asymmetry of the structures of bearing carcass;

– changing a possible mechanism of destroying.

Constructive measures consist of:

– instalation of new reinforced concrete or stone walls;

– strengthening of existing walls by installation of reinforced concrete “shirt”, strengthening with metal sheets and so on;

– installation of metal and reinforced concrete tiers;

– strengthening of beams and columns of carcass systems by adding new blocks, installation of steel and reinforced concrete “shirts”.

For realisation of the strategy of increasing seismic stability of existing buildings it is necessary to analyze constructive systems and project discisions of increasing their seismic stability on the basis of public or regional programs realization. It is proposed, that types of buildings can be identified in this analysis, will be defined their technical decisions, described the correctness of the last ones and wrong decisions will be systematized.

At the reconstruction of building we should provide their seismic stability in accordance with modern requirements. It should proceed through modification of some elements, introduction of new elements, change of base properties and constructions of foundations, decrease of external and internal protection construction masses, decrease of temporal and dead loads on the upper floors, eventually, by changing of purposes of some buildings.

Analysis of technical decisions, applied at reconstruction of buildings proofs is a necessary introduction into the constructive system additional walls. They are cutt due to action of inertion seismic forces and appearance of dry friction of diffused energy oscillations.

Presented strategy can also be realized at restoring service qualities of a building, subjected to earthquake. In this case construction decisions have to include additional internal walls-diaphragms.

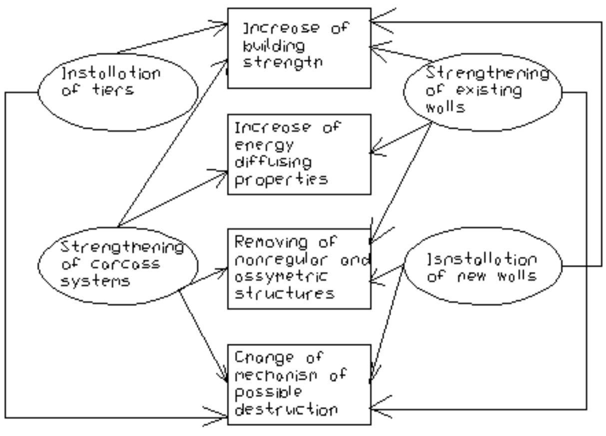

Fig. 1. Strategy of improvement of antiseismic properties of buildings at reconstruction

The installation of external steel or reinforced concrete frames related to the building would be a more difficult solution.

Dispersion of energy in such frames can be decided by two methods. The first one consists in diagonal thrust installation between a few vertical rows of frames. Their principle of work is similar to the work of motor-car shock absorbers. A more simple and more common decision in building practice decision can be connection of columns and girders of such frames with friction.

Solution of the problem

As an example we shall provide constructive decisions of increasing of the reconstructed building resistibility to seismic influences developed by Research institute of Building Constructions. The building was erected in the 80th of the last century in the capital of Ukraine, Kyiv. For Kyiv, according to seismic division into districts, in construction it is not required to use measures of constructive protection (design seismic intensity for Kyiv on the scale MSK-64 is equal to 4 points). At the same time, the design of a building, its long no maintained condition, its purpose, assuming that after reconstruction plenty of people will stay in it, required consideration of the building function.

The well known tragical events in Moscow Aquapark, led to measures undertaken by the Kyiv city state administration to all multyspan coverings buildings.

The building has the sizes 36x36 m in the plan. The ground floor of the building is executed on the basis of the frame system of AI - 04M of design. The first floor is a hall with the size 36x36 m, which is covered by precast reinforced concrete shell of the double positive curvature outlined on the surface of circular carry. The covering shell is supported round the contour by the columns, which are the continuation of individual planimetric columns of ground floor.

In the constructive system of the building neither on the ground, nor on the first floors tiers which could take horizontal loadings have been arranged. At the same time, the covering of the building had a significant weight.

Here one of the covering construction systems, which is erected without supporting woods has been applied. The system applied in the described case was characterized by the presence of the significant edges intended for taking or assembly loads in the precast elements. It has been established during inspection that the volumetric weight of the covering thermal insulation did not correspond to the design one and was essentially higher than the latter.

The building is significantly heights. The height of the ground floor is equal to 3,9 m, the height of the angular columns supporting the case is 9,0 m, the height of the average planimetric columns supporting the shell is 12,6 m. The upper mark of the shell is 16,2 m. In view, of stated above the investor was offered a complex of constructive measures which would lower destruction risk even at 4-rate earthquake.

The cross-section of a building is shown in fig. 2.

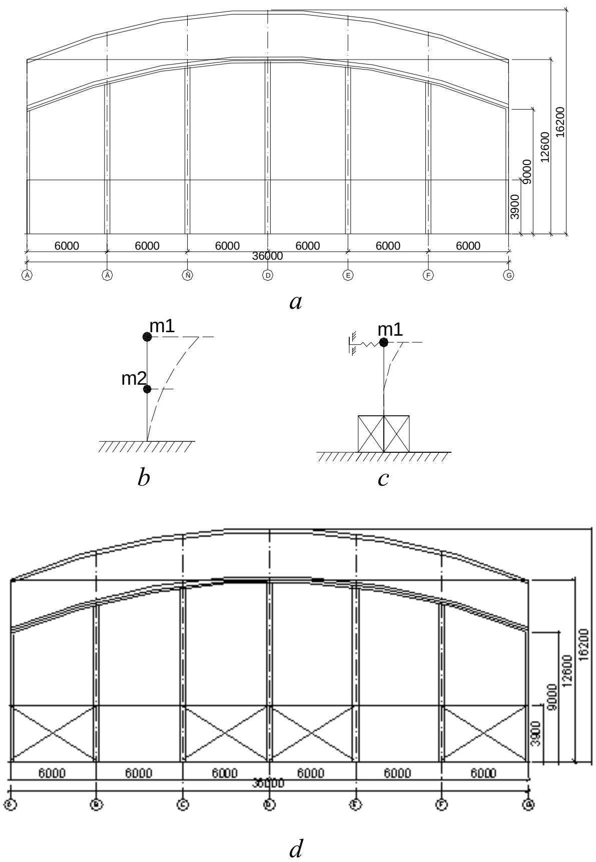

Fig. 2. Reconstructed building:
a is transversal cross-section;
b is schematization of constructive scheme before reconstruction;
c is schematization of constructive scheme after reconstruction;
d is transversal cross-section after reconstruction

The schematizations of building as systems with two degrees of freedom before reconstruction and one after reconstruction are presented near the cross-section.

Actually the shell was reinforced owing to discrepancy of working design loadings to its bearing capacity.

With this purpose angular couplers strengthen the most intense zones of the shell have been put in assembly apertures of precast-monolithic support contour.

The ground floor of the building was strengthened by installing portal steel connections between columns in several places in two directions.

Thus, the ground floor was supposed to be as a rigid body at rather weak seismic influences and fluctuations would be caused only within the limits of the second floor.

Between columns of the first floor crosswise tiers have been established.

They were symmetrically placed in the second steps of the supporting contour from the corners of the building.

On the side of the front entrance in the building the part of overlapping above the ground floor is cut out for the ladders of the front exit to first floor. On this side of the contour two-storied crosswise tiers have been arranged.

It is necessary to point out, that the tiers design of the first floor has been developed in view of industrial art approaches.

The construction of tiers on the shell and technology of installation assumed non tensioned arrangement of the latter, but without observable sagging. Thus an adaptive system of elements has been created which at fluctuations engaging in work, would change dynamic characteristics of the system of the first floor and would get it out of the dangerous resonant range.

The entresol floor has been erected besides the described main tier systems within the part of the first floor. Its steel skeleton also included a system of tiers and was connected to the planimetric columns of the shell.

The tiers of the first floor were not put in this part of the building. In general it broke the system symmetry, but did not contradict the overall aim, namely increasing the building seismic stability as a result of reconstruction.

Conclusions

1. Activization of seismic activity of the Earth demands execution of antiseismic protection measures for existing buildings.

In view of buildings responsibility such measures should be realized in the course of reconstruction in areas where seismicity does not assume undertaking of constructive measures for buildings protection.

2. For realisation of the strategy of increasing seismic stability of existing buildings it is necessary to analyze constructive systems and project discussions of increasing their seismic stability based on the state or regional programs.

This analysis is expected to identify types of buildings, to describe their technical solutions, to determine the latter’s correctness and to systematize the wrong decisions.

3. The presented example of technical decisions of increasing buildings resistance to seismic influences illustrates the approach to reconstruction of a responsible building with multyspan covering.

References

1. *Поляков В.С., Килимник Л.Ш., Черкашин А.В.* Современные методы сейсмозащиты зданий. – М.: Стройиздат, 1989. – 420 с.

2. *Concrete* Structures in 21st Century // Proceeding of the first *fib* Congress 2002. – Osaka: PCEA JCI, 2002.

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