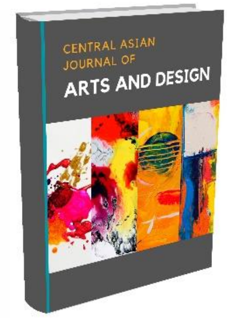
CENTRAL ASIAN JOURNAL OF ARTS AND DESIGN
VOLUME: 02 ISSUE: 11 | 2021



CENTRAL ASIAN STUDIES

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CENTRAL ASIAN JOURNAL OF ARTS AND DESIGN

Journal homepage: http://cajad.centralasianstudies.org/index.php/CAJAD

The Choice of Configuration of Buildings When Designing in Seismic Areas

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Annotation

The article deals with the issues of ensuring the seismic resistance of buildings and structures based on the choice of optimal schemes for the relative position of the bearing elements in the plan.

ARTICLE INFO

Article history:
Received 01 Sep 2021
Received in revised form 27 Oct
Accepted 28 Oct 2021
Available online 30 Nov 2021

Keywords: seismic resistance of buildings and structures, configuration in terms of load-bearing elements, closed configuration, examples of building configuration, correct choice of configuration

Introduction

The design of buildings and structures for seismic regions in accordance with the requirements of KMK 2.01.03-96 "Construction in seismic regions" must be carried out in compliance with the relevant principles, which include the reduction of seismic loads by applying rational space-planning solutions and structural forms [1-7].

In this case, the most important influence on the seismic resistance of buildings and structures is exerted by their configuration in plan and in height, as well as the location of all the main bearing elements (walls, columns, diaphragms, stiffeners, staircases, floors, etc.).

In all cases, it is required that the shape of buildings and structures be simple and symmetrical, for example, square, round, rectangular, and vertical load-bearing elements must be placed symmetrically over the entire height without interruption. Otherwise, there is a danger of the appearance of torsion and stress concentration at the fracture points, at the cuts and incoming corners of buildings (Fig. 1), where, first of all, their destruction occurs during seismic action [8-11].

Materials and methods

Under the influence of a real seismic load, various variants of destruction of structural elements are possible; however, with the correct distribution of the load on the supporting elements, an even operation of the entire building is ensured. If one of a large number of load-bearing elements begins to collapse, then the required resistance to the applied loads is still provided by the remaining elements. Therefore, the configurations of buildings, in which there is a concentration of seismic loads, causing a sequential accumulation of significant forces in a gradually decreasing number of load-bearing structural elements, is impractical to apply [12-18].

A closed configuration of buildings in the plan with an inner courtyard may be advisable in seismically active regions of Central Asia with a dry hot climate, and the accepted ratio of the dimensions of the height and width of earthquake-resistant buildings should usually not exceed 3 - 4 [1,2,3]. For example, in the famous skyscrapers of America this ratio does not exceed 8 - 9, and in the Ostankino TV tower it is 9. Otherwise, there is a danger of their overturning. It is advisable to provide the center of gravity of high-rise buildings and structures as low as possible.

In high-rise buildings with great flexibility, vibrations corresponding to higher tones are observed, and at the same time, maximum forces can occur where their occurrence, it would seem, is not obvious, since usually the most significant earthquake loads act at the level of the soil base. The structures of the lower floor perceive vertical and horizontal loads acting in the upper levels [15-24]. At the same time, the aesthetic requirements for the lower floor determine the maximum release of planning space. As well-known examples of such a solution to the ground floor plan, the following should be cited: a cantilever overhanging box of a building, a building with a free first floor (resting on racks), a residential building or a hotel with a spacious garage in the lower floor (with columns located at a great distance from each other). from a friend), etc.

Structural solutions of such buildings do not meet the requirements for optimal seismic resistance of the configuration, which requires strong vertical load-bearing elements in the lower tier of the building to absorb seismic loads. The criteria for aesthetic perception, therefore, are in conflict with the requirements of earthquake design [25-31].

Studies have shown that the forces caused by earthquakes are significantly greater in buildings with large dimensions, which is associated with wave-like vibrations of the base (the wavelength can be less than the size of the building, which leads to different vibrations along the length of the building). In this case, the stiffness of the floors, redistributing the horizontal seismic load between the vertical bearing elements, may also be insufficient [32-41].

It is shown that with a complex plan, the connection of individual parts of buildings can be rigid, with complex angles, verified calculations. It is preferable to divide the buildings into separate simple and symmetrical blocks using anti-seismic joints, the width of which should not be less than the maximum possible movement of adjacent blocks towards each other. Otherwise, collisions of parts of the building are possible, leading to destruction during an earthquake. Collisions are especially dangerous in overlap areas located at different levels in adjacent blocks [42-45].

An important factor that determines the seismic resistance of buildings and structures is the relative position of the main load-bearing elements - columns, diaphragms, stiffeners, load-bearing and self-supporting walls and partitions, cover and floor disks, staircase elements, connections, etc.

So the floors are flexible outside the plane, but rather rigid in their plane, capable of redistributing horizontal loads like a beam between vertical load-bearing elements. The presence of various holes in the ceilings (for laying communications, placing staircases, elevator shafts, lanterns, etc.), especially if they are located asymmetrically, significantly impair the operation of the ceilings under the action of a horizontal seismic load and leads to a complication of the vibrations of the entire structure.

Maintaining the symmetry of shapes recommended in the normative documents indicates that asymmetry contributes to the occurrence of eccentricity between the center of gravity and the center of stiffness, resulting in torsion. Torsion can also occur for other reasons, for example, with an uneven distribution of mass in a structure that is symmetrical in plan; however, the asymmetry of the plan solution almost always leads to torsion. In addition, asymmetry in structures often leads to stress concentration. Stress concentration occurs at the notches of the incoming corners of buildings. However, the solution to the building plan with incoming corners does not have to be asymmetrical (a cruciform building in the plan may have a symmetrical shape).

Results

Therefore, symmetry alone is not enough to reduce stress concentration; when solving building plans, another requirement must be observed - simplicity of configuration.

As shown above, the asymmetric arrangement of vertical load-bearing elements in terms of their different stiffness leads to the appearance of eccentricity between the center of stiffness and the center of mass, and therefore even a structure that is symmetrical in plan is twisted under the action of a seismic load (Fig. 2).

The advantages and disadvantages of the location of the main bearing vertical elements in the plan of the buildings shown in Fig. 3 are analysed. In particular:

- the diaphragms in the scheme "b", located along the perimeter of the symmetrical building, allow better resistance to the action of torsional and overturning moments than in the scheme "a", despite their identical cross-section;
- the buildings shown in the diagrams "c" and "d" can twist in the plan due to the shift of the center of mass and center of gravity, and it is these buildings that are often built in Central Asia, when verandas, loggias, glazed windows are located on the free side shops, etc;

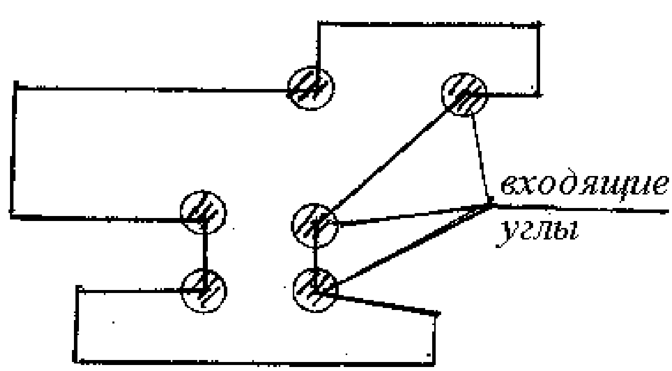

Fig 1. A fragment of a complex plan with dangerous places at the incoming corners of the building

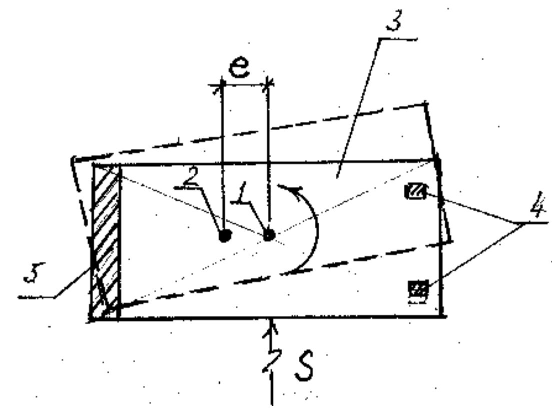

Fig.2. "Twisting" of the building due to the difference in the stiffness of the columns and diaphragms: 1-center of mass; 2-center of stiffness; 3-overlap; 4- column; 5 – diaphragm.

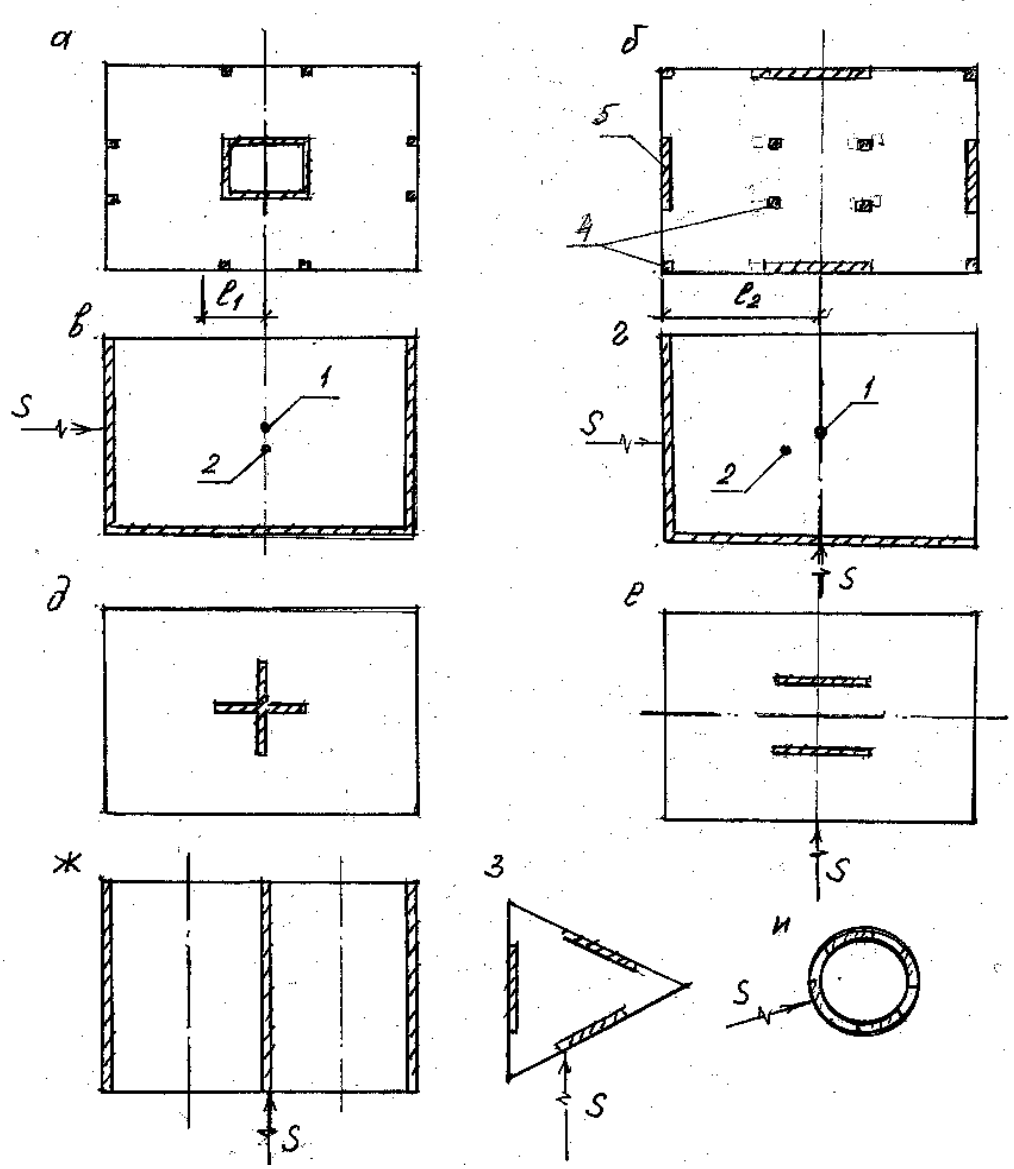

Fig 3. Examples of the location of load-bearing elements in the plan of buildings

- the torsional rigidity of the building is insufficient when the diaphragms are arranged according to the "d" scheme;
- when the diaphragms are arranged according to the schemes "e", "g" - the rigidity of the building will be insufficient in the direction perpendicular to the plane of the diaphragms;
- the magnitude of the seismic load acting in the direction of the planes of the three diaphragms according to the "g" scheme will be different for the middle and extreme diaphragms, since the load area (mass value) for each of them is different, especially if the overlap is not sufficiently rigid;
- a triangular symmetrical plan "z" can lead to torsion of the building if the seismic load is directed parallel to the plane of any of the three diaphragms;
- around symmetrical building plan, the "and" scheme is the most optimal from the point of view of the perception of torsion.

It should also be remembered that vertical elements (columns, diaphragms, etc.) having the same cross-section, but different heights, have different bending stiffnesses. Structures of lower height are capable of, as it was, "pulling" to themselves most of the seismic load and are destroyed in the first place, despite the fact that their bearing capacity under the action of vertical loads is almost the same. Elements, the section of which is developed in the plane of action of the bending moment, also have great rigidity.

Conclusion

Thus, as shown above, the efficiency of designing buildings and structures in seismic regions depends primarily on the correct choice of the building configuration and on the location of all load-bearing elements in the building plan.

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