Development of modern design solutions to increase the stone buildings' seismic resistance in the reconstruction process

Viktor Muradyan* and *Artur* Umarov

Don State Technical University, 344010, Rostov-on-Don, Russia

Abstract. The article discusses the possible design solutions to improve the seismic resistance of stone buildings. In particular - the device of anti-seismic belts at the floor level, the device of dowels and nodes for connecting the floor slabs with the walls and among themselves, the reinforcement of the walls with steel clips, as well as the installation of transverse frames, if the maximum distances between the transverse walls' axes are not observed.

1 Introduction

Increasing the seismic resistance of buildings during the reconstruction process is an important and urgent issue due to the fact that often in buildings constructed in the middle - end of the last century, there are no structural solutions imposed by modern standards for the buildings located in seismic regions.

BC 14.13330.2018 "Construction in seismic regions" is the main regulatory document that establishes the requirements for the calculation, taking into account seismic loads, for structural and space-planning solutions of buildings and structures that ensure their seismic resistance in new construction and re-construction [1].

2 Method

We considered the modern methods of design solutions [2-6], which compensate for the absence of missing requirements established by design standards. In this article, they are given on the example of a reconstruction object in the city of Vladikavkaz.

Before the structural solutions' development, a detailed instrumental survey of the building was carried out, as a result of which it was found that the building was in a limited working condition. This category of technical condition was assigned to the building due to the identification of defects and damage that led to a decrease in the bearing capacity of structures, as well as a result of deviations from the regulatory documents' requirements.

* Corresponding author: muradyan2007@yandex.ru

Fig. 1. General view of the reconstructed building

Defects and damage to the building, as well as the measures for their elimination within the framework of this article will not be considered. Let us dwell in more detail on the design solutions for increasing the seismic resistance of the building.

3 Results and discussion

Taking into account the requirements of BC 14.13330.2014 [1], CTR 36554501-016-2009 [7] Section 8 "Construction in seismic regions" in the design documentation on the survey results to increase the seismic resistance of the building, provides for anti-seismic belts at the level of all floors without opening the brickwork of the walls, increasing the stiffness of the floors by providing connections between hollow-core reinforced concrete floors.

The introduction of additional stiffeners ensures the perception of forces from the design seismic effects at 9 points.

At the attic floor level, after dismantling the roof, an anti-seismic belt is performed (see Fig. 2).

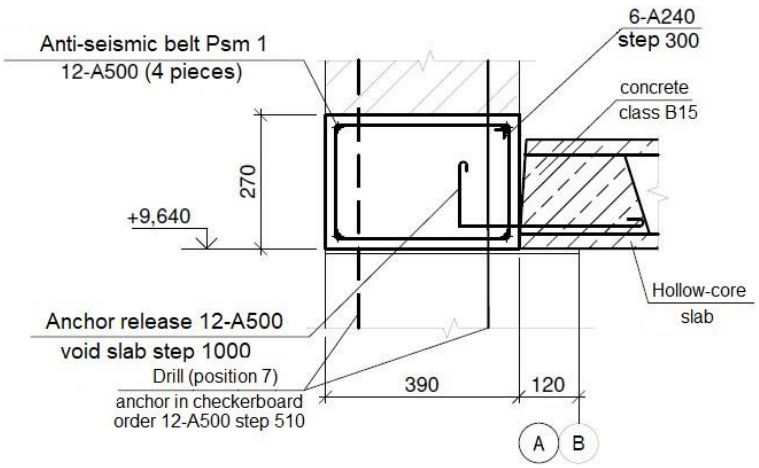

Fig. 2. Anti-seismic belts at the attic floor level

According to the regulatory requirements of clause 6.14.11 BC 14.13330.2018 [1], for all overlaps, it is necessary to perform anti-seismic belts without opening the outer walls (see Fig. 3).

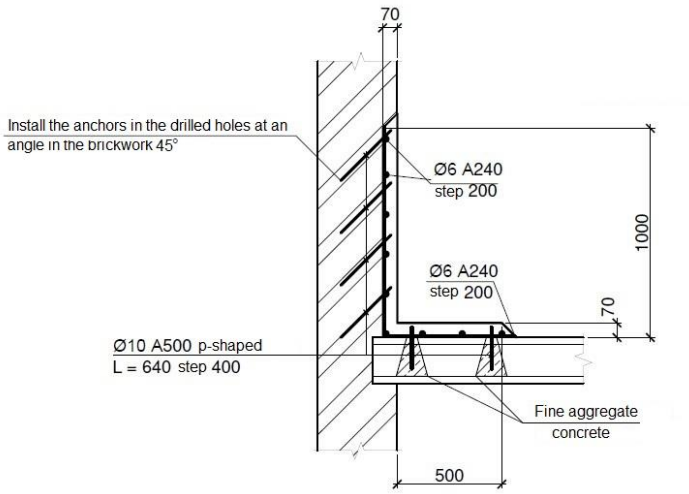

Fig. 3. Anti-seismic belts without opening the outer walls

For this purpose, it is necessary to punch niches along the perimeter of the walls to a depth of 70 mm. In niches at an angle 30-45° drill holes for anchors to the surface of the walls in the masonry. It is necessary to clean the floor slabs along the walls to a width of at least 1.0 m, to punch the holes in floor slabs above voids Ø150mm for embedding anchors. After that installation of the mesh, concreting and embedding the walls in the niches with concrete on a fine aggregate of the class B22,5 should be performed.

To ensure the connections between hollow reinforced concrete floor slabs in the seams, installation of dowels is provided (see Fig. 3).

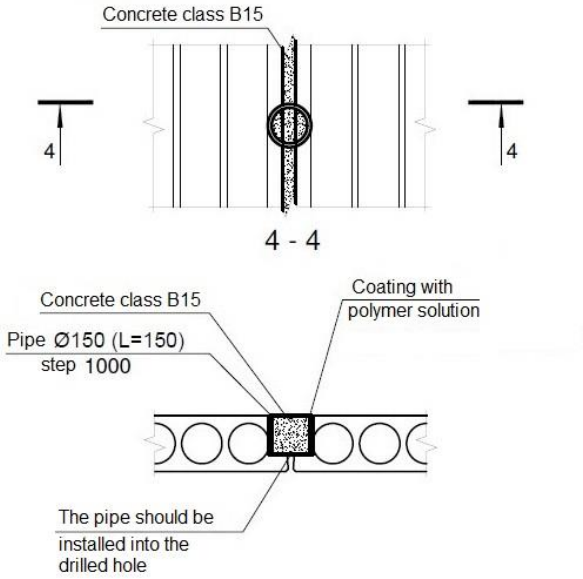

Fig. 4. Keys for connecting floor slabs

In the places where the keyways are installed, the surface of the overlap is cleaned, concrete is drilled in the joint zone of the slabs. Pipe segments are installed in the formed recesses Ø159x3,5 outside covered with a polymer solution. Pipes are embedded in concrete on fine aggregate of the class B22,5.

Also, to ensure the connection of floor slabs with walls and with each other, according to the requirements a.6.3 BC 14.13330.2018 [1] the specialists of the department Reinforced concrete and stone structures, DSTU developed the nodes presented in Figures 4 and 5.

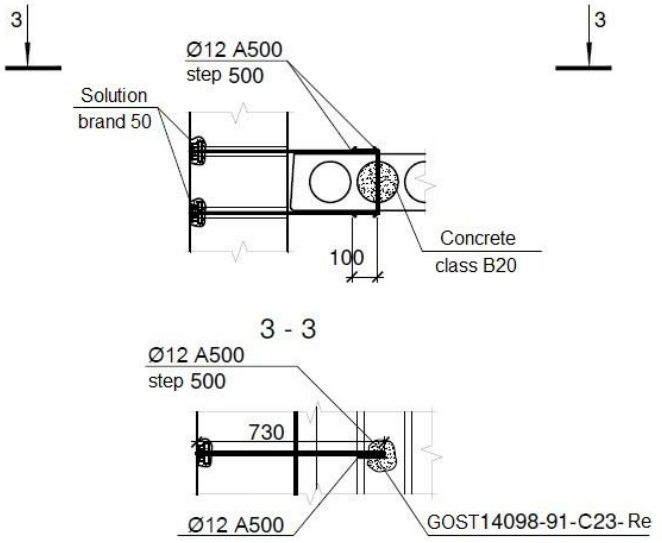

Fig. 5. Connection node of floor slabs with walls

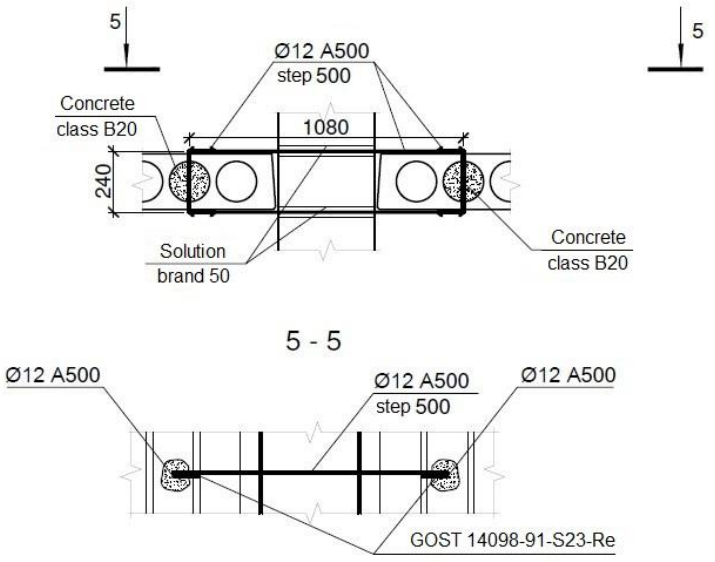

Fig. 6. Connection node of floor slabs adjacent to the walls, to each other

All piers that do not meet the requirements a. 6.14.10 BC 14.13330.2018 [1], must be reinforced with steel angle clips.

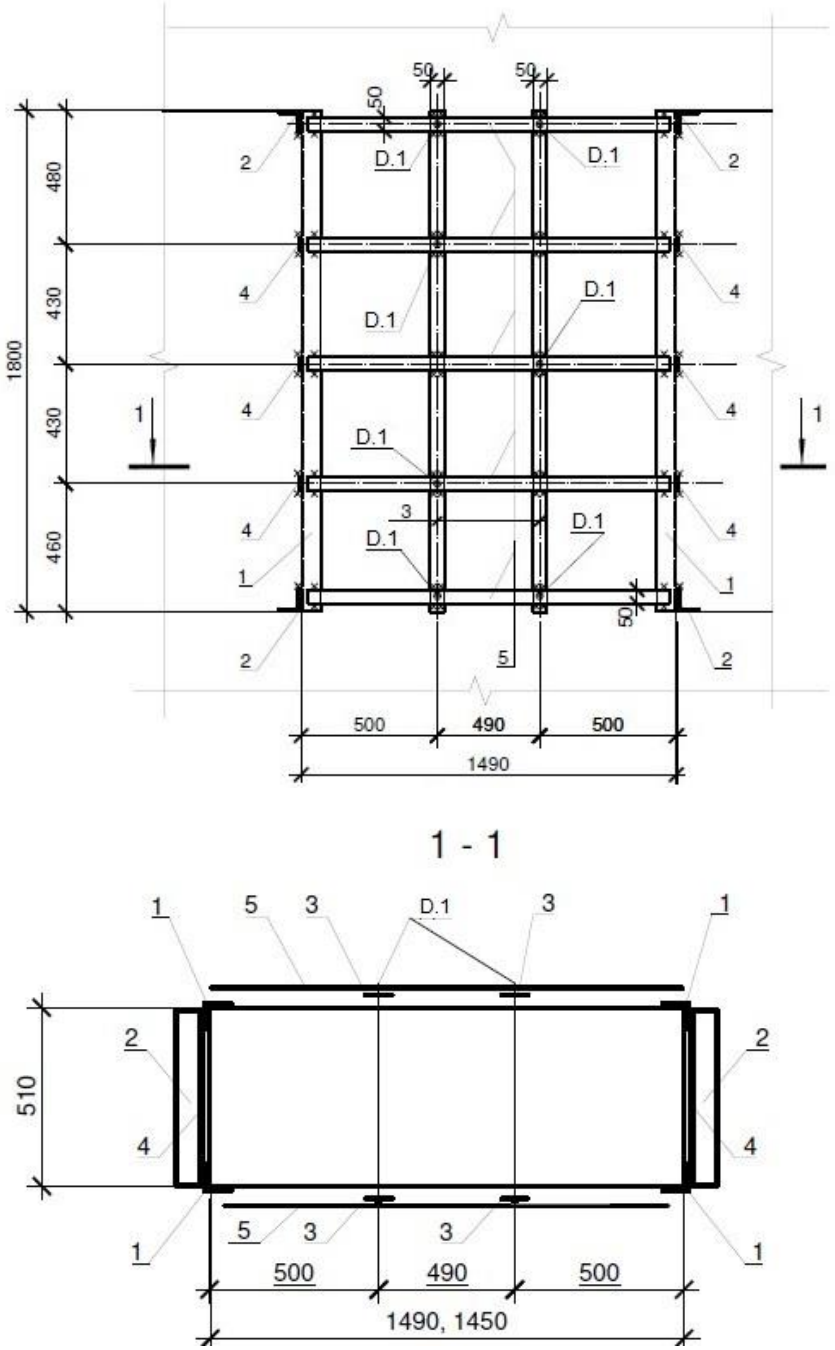

Fig. 7. Reinforcement of walls with steel clips

To fulfill the requirements a. 6.4.9 BC 14.13330.2018 [1] metal frames are installed between the axes of the transverse walls, the distances between which the permissible values exceed (see Fig. 8).

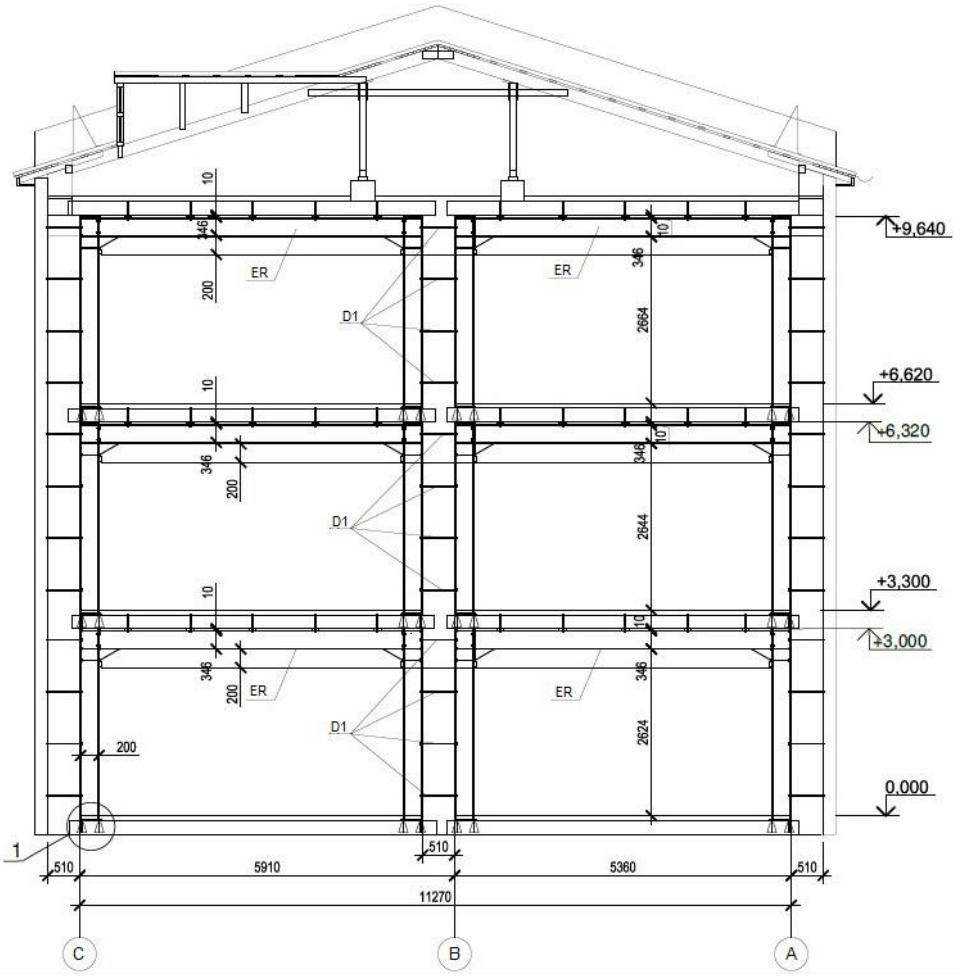

Fig. 8. Cross frames

In the places where the transverse frames are installed in the floor slabs, it is necessary to install the embedded elements MN122-3 [8], to drill out concrete under the anchor of the embedded part, embed it. Vertical link elements (I-beam 20K2) fastened to the walls with anchors Ø12-A240 with a step of 1.0 m, horizontal elements (I-beam 35B1) should be attached to floor slabs with studs Ø12-A240 with a step of 1.0 m.

4 Conclusion

To implement the design solutions for the above-mentioned requirements, other methods can also be applied, for example, using modern amplification methods using composite materials [9-11]. This will increase the rigidity of each structure and the building as a whole.

Development and implementation of these design solutions to improve the seismic resistance of a building using modern methods will make it possible to bring the reconstruction object in accordance with the requirements of regulatory documents to ensure the seismic resistance of a building.

References

1. BC 14.13330.2018 "Construction in seismic areas".
2. P.A. Serbinovsky, D.R. Mailyan, Engineering Journal of Don № **2 (41)**, 70 (2016)
3. D.R. Mailyan, P.P. Polskoy, S.V. Georgiev, Engineering Journal of Don **2 (25)**, 98 (2013)
4. V.N. Aksenov, D.R. Mayilyan, Concrete and reinforced concrete **6**, 5-8 (2008)
5. A.M. Mkrtchyan, V.N. Aksenov, D.R. Mailyan, A.M. Blyagoz, M.V. Smorgunova, New technologies **11**, 127-132 (2013)
6. D. Mailyan, V. Aksenov, N. Aksenov, Advances in Intelligent Systems and Computing **692**, 536-542 (2017)
7. CTR 36554501-016-2009 “Construction in seismic areas. Building design standards ".
8. Series 1.400-15 “Unified embedded products of reinforced concrete structures for fastening technological communications and devices. Issue 1. Working drawings of unified embedded parts. CITP, Gosstroy (USSR) 1980.
9. P.P. Polskoy, D.R. Mayilyan, Engineering Journal of Don **4 (43)**, 169 (2016)
10. P.P. Polskoy, S.V. Georgiev, Engineering Journal of Don **4 (47)**, 241 (2017)
11. P. Polskoy, D. Mailyan, S. Georgiev, V. Muradyan, E3S Web of Conferences 02060 (2018)