SEISMIC STABILITY OF COMPOSED WALL STRUCTURES MADE OF NATURAL STONE

Yu.V.Ismailov[I)]
E.V.Ilchenko[II)]
A.P.Pochapsky[III)]
K.I.Tarnovsky[IV)]
A.A.Chuprina[V)]

SYNOPSIS

In some regions of aseismic construction the absolute volume of stone house-building is constantly growing. In this connection the industrialization of such construction type becomes a pressing necessity.

This problem may be solved by passing from the traditional wall masonry, small blocks and other piece wall elements to assembling the walls of buildings of large blocks with the height equal to a storey. Such blocks may be fabricated from the abovementioned small-piece materials and are called composite blocks.

The commercial production of large composite blocks made of limestone with the compressive strength of 3.5 - 5.0 MPa is organized in Kishinev. Such blocks were used for constructing of some 2 - 5 storeyed houses. This experience indicates the economical expediency of mass production and use of composite blocks in aseismic construction.

The development of the large composite blocks design was preceded by analysis of different solutions in this field. In most cases framing of reinforced concrete was provided along the side planes of the composite blocks. That's why the blocks underwent heat treatment or were subjected to the prolonged influence of the normal the temperature-moisture conditions. Besides the block production needed large expenditure of manual labour. The expenditure of cement and steel for I m^3 of blocks made up 0.4 - 0.6 kN and 0.I7 - 0.26 kN respectively.

The authors have formulated the requirements which the design and manufacturing process of composite blocks should satisfy. The main determining factors were the high seismic stability and economical expediency of their use.

Three main design versions of large composite blocks were developed (fig. I). In all cases the framing of reinforced concrete along the side planes of the composite blocks were

I - Chief of the Seismic Stability Laboratory, Central Scientific Research Institute for Building Structures.

III - Senior Engineer of the same Laboratory.

V - Senior Scientific Worker of the same Laboratory.

II - Construction Laboratory Chief, Kishinev Trust "Selstroj".

IV - Manager of the Kishinev Trust "Selstroj".

changed for two rods of stressed reinforcement. In contrast to the prestressed ferro-concrete constructions the minimum prestressing value of the composite blocks masonry is taken equal to 0.04 - 0.06 MPa, which value provides the integrity of blocks during transportation and mounting.

When working loads are calculated the prestressed condition of the masonry and reinforcement of the blocks is not taken into account.

From the technical point of view such solution makes it possible to transport blocks to the construction site immediately after their fabrication, without waiting for ageing of mortar within the masonry joints. There is no need of heat treatment of the composite blocks.

The composite blocks are manufactured of small or large limestone blocks with the cement-limestone or cement-clay mortar the compressive strength being not less than 2.5 MPa. The longitudinal reinforcement is produced of hot-rolled reinforced steel, the transverse - is made of ordinary wire with the diameter of 3 - 5 mm.

The cement expenditure for I m^3 of blocks makes up 0.2 - 0.3 kN, steel - 0.09 kN.

Each developed version of the composite blocks has its own design - technological features.

The first version of the composite blocks is a small-block masonry with the mortar joint width of IO mm (fig. Ia). The composite block is reinforced with two vertical rods and the transverse reinforcement in the form of a net with rhombic cells.

The reinforcement is placed within the mortar layer between the front and inner rows of masonry. Such reinforcement is the most effective under the horizontal loading of the building walls. The diameter of the vertical rods is determined by the results of the building walls design for a special loads combination. The minimum diameter of vertical rods is determined according to the mounting loads. The upper ends of the vertical rods terminate in mounting loops.

The lower row of the masonry in such block is made as a beam of the complex construction with metal elements to which the lower ends of vertical rods are welded. The beams are produced beforehand and introduced into the block as a built up element.

The second version of the composite blocks is a large-block structure with the mortar joint width of 20 mm (fig.Ib). The vertical reinforcement in such blocks is placed into closed cylindrical channels with the diameter of 70 mm bored out within the limestone blocks. The channels are injected with cement mortar either during the composite blocks production or after their assembling. This permits to protect the reinforcement against corrosion and provides its compatibility with masonry.

Like in the first version the longitudinal reinforcement is made in the form of two rods with loops at their upper ends.

The anchor profiles are welded to the lower ends of the vertical rods and are interconnected by means of electric welding by two reinforcement rods with the diameter of 8 mm.

In some cases the technology makes it advisable to place the longitudinal rods onto the side planes of the composite blocks. This is the third version of the composite block design (fig. Ic). The anchor units in these blocks are similar to those of the second version.

The transverse reinforcement in the blocks of the large-block construction is provided by means of flat reinforcement nets placed within the mortar joints every other joint along the block height.

The given composite blocks construction makes it possible to anchor them reliably with each other and with the antiseismic belt of the building. The upper ends of the vertical rods are mounted monolithically within the antiseismic belts of the building. There may be several ways of connecting the blocks with the lower-lying belt depending upon the composite blocks design (fig. 2).

The composite blocks with a large-block masonry may be reinforced by means of removable vertical reinforcement which is removed after the block mounting. Such blocks are used in the regions of Magnitude 7 earthquakes in 7-storeyed dwellings with frameworks, in stone houses up to 2 storeys height, in agricultural buildings of little significance and in industrial buildings of the auxiliary type.

The production of the composite blocks is preceded by the machining of the limestone blocks which comprises their calibration, cleaning of technological dust and producing grooves or inner channels (in large blocks).

The composite blocks are produced in horizontal position using the metallic forms-trays. When working with small limestone blocks the trays with flaps are used. Into such a tray the composite beam is put first and then - the stones of the face layer. The gaps between them are fixed by means of metal rods covered with rubber which prevent flowing out of the mortar onto the front plane of the block and provide the mortar joint profile shaping. After placing the reinforcement net the longitudinal reinforcement is welded to the inserted elements of the beam and the mortar is fed into the form to the joints between the stones.

Then the distribution of stones of the inner layer of the block is performed. To get the plastered inner plane the open surface of the composite block is covered with mortar after which the tray is vibrated during 20 - 30 sec. The mortar is smoothed. The plastered layer width constitutes 8 - I2 mm. In I5 - 30 min after fabrication the tray with the composite block is carried to the tilter and fixed onto it. The upper and side flaps of the tray are opened and together with the block it is turned into an almost vertical position. Anchor means are fastened to the protruding ends of the vertical reinforcement. Screwing up the anchoring nuts with the torque wrench the vertical rods are tightened with the force being conveyed to the masonry through the removable distribution plates.

The reinforcement being stressed the composite block is transported by means of crane to the technological post where metallic rods covered with rubber are removed from the joints, small defects are removed from the front surface of the block and if necessary the slots are milled across its narrow side planes.

The composite blocks of the second and third versions are manufactured on rigid trays without flaps. The blocks of limestone are allocated across the tray with 20 mm gaps by means of a mechanical laying means. The gaps across the narrow side planes of the composite block are covered with plates.

When fabricating the composite blocks of the second version the tubes are inserted into the channels and the gaps between the blocks are filled with mortar. In 5 - IO min the tubes are removed and the reinforcement rods are inserted into the channels.

The third version of the composite blocks is simpler to produce since the reinforcement rods are placed into open gaps immediately after filling the gaps between the limestone blocks with mortar.

The blocks of the large-block masonry do not vibrate, since the mortar joints of 20 mm width are filled completely with the mortar (Sl = I2 cm) by means of a mortar pump.

A large series of the composite blocks was tested for central compression and for combined influence of the vertical and horizontal loading.

The central compression testing has shown that comparing with the hand masonry the supporting power of the composite blocks is at least 70 - 80% higher. This fact may be explained by the more complete filling of the joints with mortar.

The testing of composite blocks for the combined vertical and horizontal loading action confirmed their high seismic stability. Three types of the extreme condition of the underload blocks were determined: crumpling of stone at the underload corners of the block; reaching the yield limit in the extended reinforcement areas and fracture of the block across the tilting sections. It is necessary to note that the composite block fracture is not as brittle as that observed at testing of the conventional masonry fragments.

The composite blocks of the described design are used for building of 2 - 5 storeyed houses. The design of a 9-storeyed dwelling is completed. The gained experience has shown a high effectiveness of using the large composite blocks instead of the conventional masonry.

The volume of wet processes and hand labour is reduced significantly, the construction terms are reduced as well, and the construction of a stone house becomes a full-unit-construction with the walls cost cutting down for 30 - 32%.

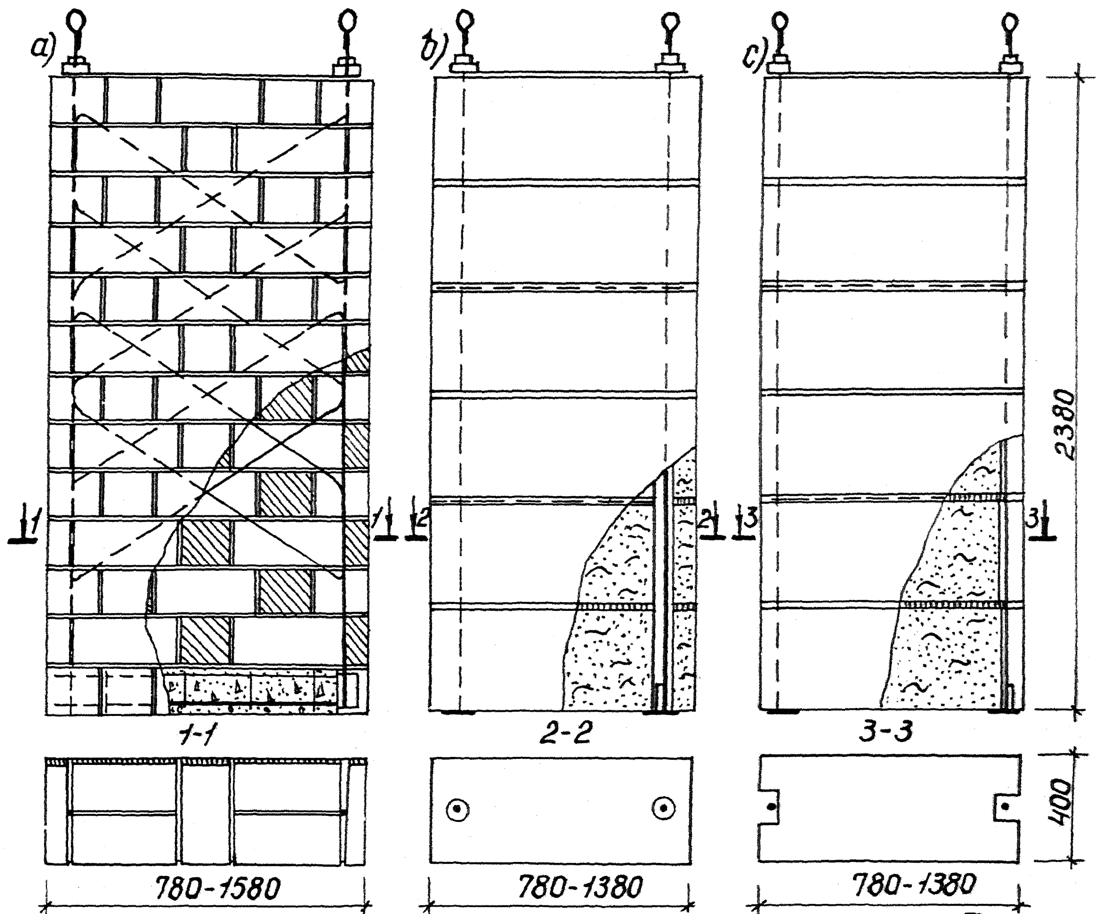

Fig.1

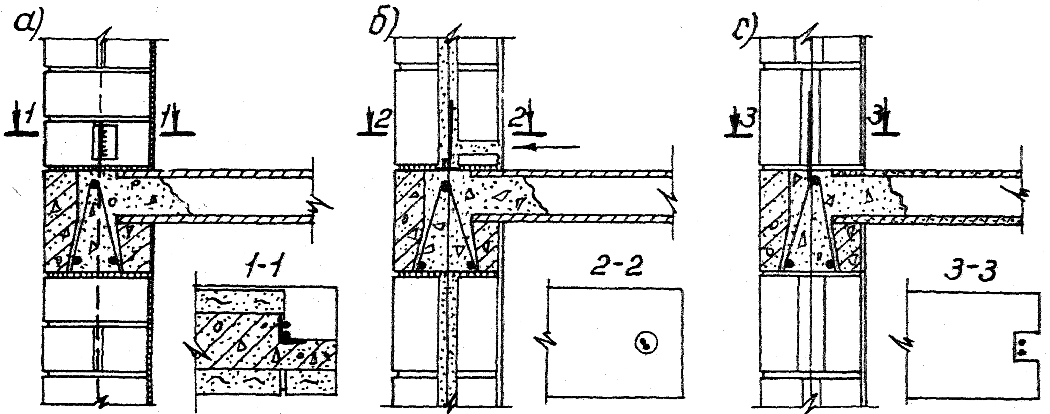

Fig.2