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(54) THE METHOD OF ANTI-SEISMIC PROTECTION OF FRAMES AND FILLING WALLS IN FRAME BUILDINGS

(57) The method of anti-seismic protection of frames and filling walls in frame buildings whereby a cushioning layer (3) based on polyurethane is applied between the skeleton frame (1) and at least vertical surfaces of the filling wall (2) adjacent to the skeleton frame (1), wherein it is recommended that the cushioning layer is also applied between the upper surface of the filling wall (2) and the adjacent horizontal beam of the skeleton frame (1).

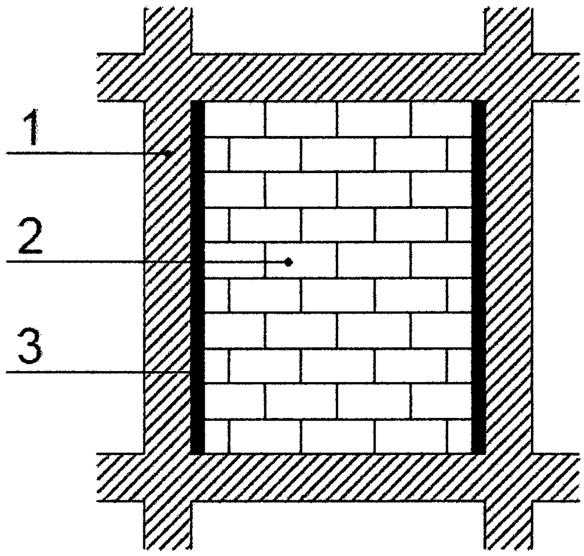

Fig.2

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Description

[0001] The subject of the invention is the method of protection of building structures made in the framework technology, before or after the occurrence of damage caused by the movement of the ground on which the structure was founded. In particular, the proposed method may be used in seismically active areas, mining damage areas and in buildings standing on unstable ground.

[0002] Structures made of reinforced concrete or steel frames and masonry filling walls are often used in civil engineering due to their speed of execution and structural-architectural versatility. Structures in frame technology are also erected in seismic areas. However, during an earthquake, the horizontal movements of the skeleton frame cause the frame and the filling wall to become detached as well as cracks in the corners of the filling walls and their braking, as shown schematically in Fig. 1. The characteristic horizontal movements of earthquakes cause dynamic forces to appear, acting in the plane and perpendicular to the plane of the wall. A wall weakened in this way may fall out of the frame completely or partially, causing human casualties and great material damage. The whole structure of the building, weakened by the fall of the wall, may collapse or overturn under the influence of seismic vibrations.

[0003] The seismic protection used so far consists in fixing the filling walls to a reinforced concrete or steel frame with the use of rigid mineral mortars, or additionally connectors, anchors or rigid composites, glued e.g. on epoxy resin or mineral mortar. This causes the wall to remain rigidly bonded to the frame, and vibrations and deformations of the frame are transmitted directly to the wall, causing damage to the wall or columns in the frame. Such effects occur not only during seismic shocks. They also occur as a result of the subsidence of the building's subsoil and the building itself, and even as a result of uneven frame loads caused, for example, by its one-sided expansion due to intense sunlight and subsequent shrinkage when cooling down.

[0004] In this case, cracks occur in the filling walls due to differences in thermal expansion of the different materials used for the frame (reinforced concrete, steel) and filling walls (ceramic, lime-sandstone, aerated concrete or concrete blocks, etc.). Usually such cracks are not dangerous, but it is practically impossible to remove them, as they are constantly renewing themselves, thus worsening the utility value of the premises.

[0005] Various attempts have been made to seismically protect the building.

[0006] It was proposed in the American patent application US2018347221 A1 (YASHRAJ MAHESH; WADKAR OMNEEL), among other things, to strengthen the filling walls with a mesh from wire, fibreglass or welded from metal rods.

[0007] According to the Chinese utility model application CN205399726 U (HENAN XIAN NEW BUILDING MAT CO LTD) for steel I-beam framed buildings, the gap between the wall and the horizontal beam can be filled with polyurethane material, which acts as insulation and improves the aseismicity of the building
The way of making walls with increased earthquake resistance, consisting in introducing strengthening elements into holes in bricks, was revealed in the Russian patent document RU2656423 C2 (KOCHETOV OLEG SAVELEVICH) These elements are led through the whole height of the wall and the holes are filled with elastomeric concrete, e.g. based on polyurethane.

[0008] Another patent document of the same creator RU2665720 C1 (KOCHETOV OLEG SAVELEVICH), apart from the above-mentioned wall reinforcement, describes the way of their tongue-and-groove connection between each other, with the play filled with rubber inserts. However, it was not proposed to use other materials apart from rubber.

[0009] On the other hand, the Chinese utility model application CN203741998 U (XIAMEN UNIVERSITY OF TECHNOLOGY) describes how to connect the columns and beams of the steel frame structure by using polyurethane insertion cushions at the joints. These inserts separate the clamps from the load-bearing elements connected by pins and act as shock absorbers absorbing the vibration energy at the joints of the load-bearing elements.

[0010] Japanese patent documents JP2011006896 A (KAZAMA GIKEN KAIHATSU:KK) and JP2000204693 A (KANEGAFUCHI CHEMICAL IND) propose the use of polyurethane foam to strengthen the structure of the building and at the same time increase its seismic resistance.

[0011] The inventions known from the state of the art do not effectively solve the problem of seismic protection of filling walls in frame buildings, especially with framework made of reinforced concrete or steel, as well as the problem of temporary repairs of walls damaged by shocks or slow movements of the rock mass. The proposed solution to this problem significantly reduces the risk of collapsing of the walls during an earthquake and after the shocks have ceased, or can even eliminate this risk, increasing the safety of people during evacuation from the building and rescue operations, as well as during the execution of safety measures and liquidation of damages.

[0012] The proposed invention consists in making a flexible - and not rigid as so far - connection between the filling wall and the skeleton frame. The wall can be solid or with window and door openings. The elastic layer between the wall and the frame has both separating and connecting functions. Thanks to the invention application the wall is structurally separated from the frame, as a result of which during shocks the frame deformations are not completely transferred to the wall and as a result the forces exerted by the frame on the wall are reduced. At the same time, the wall remains connected to the frame.

[0013] According to the invention, the method of anti-seismic protection of frames and filling walls in frame buildings is characterized by the fact that a polyurethane based cushioning layer is applied between the skeleton frame and at least vertical surfaces of the filling wall adjacent to the skeleton frame. It is advisable that a cushioning layer is also applied between the top surface of the filling wall adjacent to the skeleton frame and the horizontal beam.

[0014] The first variant of the invention, realized during the bricklaying of the filling wall, includes the fixing of the prefabricated polyurethane tape with sand coating to the reinforced concrete or steel frame on all four contact surfaces with the wall with the polyurethane adhesive layer. The polyurethane tape may additionally have an undercut to enable the brick wall to be clamped in the polyurethane. The space between the polyurethane tapes is filled with a wall made of bricks, ceramic hollow bricks, aerated concrete blocks or other commonly used wall construction materials.

[0015] Filling walls are constructed during the construction of new buildings or - in case of elimination of construction damages - they are made in place of walls destroyed by an earthquake. In each of these cases, in the first variant, they are joined rigidly with a mortar with a prefabricated strip glued on the inner perimeter of a reinforced concrete or steel frame. The remains of building material (after possible removal of damaged walls) and the remains of cement milk or other impurities (rust, grease, dust, etc.) are cleaned off the inner surfaces of the frame mechanically. The cleaned surfaces are primed with a polymeric primer, chemically compatible with polyurethane filler. At the same time, and preferably one day in advance, the prefabricated polyurethane tapes with a thickness of 1-3 cm, preferably 1.5-2.5 cm, on the average 2 cm, are prepared and then glued with polyurethane adhesive to the four inner surfaces of reinforced concrete or steel frames. Prefabricated tapes are sand coated on one side, on the side of the filling wall, in order to obtain better adhesion to the mortar connecting the prefabricated tape to the wall. As mentioned above, the space inside the frame, i.e. inside the outline limited by prefabricated tapes, is filled by building a filling wall.

[0016] This solution has proven to be very effective in earthquake simulation tests. The performed protection carried heavy loads and large deformations without significant loss of the wall substance, and the dynamic forces resulting from the seismic extortion were not able to separate the wall from the frame.

[0017] In the second variant of the invention, which is used for the anti-shock reinforcement of an existing wall or for securing a damaged wall, a susceptible polyurethane layer is made, connecting the reinforced concrete or steel frame with the filling wall on two side surfaces and, if possible, the upper surface. The claimed method is based on the fact that the gaps are cut out at the point of contact between the wall and the reinforced concrete skeleton frame, which after cleaning with a stream of compressed air are filled with injected polyurethane, after previous priming with a polymer primer chemically compatible with polyurethane filler.

[0018] The gaps may be pass-through, but in the case of walls weakened by cracks and chipping or bulging walls, it is recommended to perform the operation in two stages, e.g. first from the outside and then from the inside. For this purpose, a gap is cut out with a depth of approximately half of the wall thickness and after cleaning it is filled with polyurethane, and then, after hardening of the polyurethane filling, the operation is repeated on the other side of the wall. Possible small discontinuities of the polyurethane filling are not important for the effectiveness of the protection, as it is primarily intended to serve as a seismic energy dissipation function.

[0019] Alternatively, the whole operation can be performed in sections, especially when access to the wall from the outside is difficult or impossible. Both versions of the existing wall protection method ensure continuous contact between the frame and wall contact surfaces. This eliminates the risk of wall collapse during strengthening and renovation works.

[0020] As the existing filling wall can be rigidly bonded to the frame with mortar or separated from it after the movement of the structure, the condition of the wall should be inspected and the damage, if any, should be repaired. Next, a gap should be made around the wall on 3 edges (top and two sides) using a saw, an angle grinder or a 1-3 cm wide gap should be cut out, separating the filling wall from the frame. The surfaces inside the gap should be cleaned of loose particles (vacuumed, dusted off) and then primed with a chemically compatible polyurethane primer.

[0021] At this point closing sheets made of thin (up to 2 mm thick) fibreglass mesh with the mesh size not more than 2 cm, sunk into the polyurethane filler should be ready, prepared ahead of time (1 day before). The sheet shall be tight.

[0022] If there are holes in the wall in the plane of the gap (e.g. a wall made of hollow bricks), these holes should be closed inside the gap by glueing the closing sheet with polyurethane adhesive.

[0023] In order to close the gaps, for filling injection, the prepared closing sheets should be cut to size to cover the gap on one side of the wall so as to leave an overlap of at least 5 cm on each side of the gap. For example, for a 3 cm wide gap, the sheet should be at least 13 cm wide and at least 10 cm longer than the slot length.

[0024] Sealing sheets shall be glued with polyurethane adhesive to both external surfaces of the wall and frame, preferably after they have been primed with a polymer primer, chemically compatible with the matrix material, sealing the gap space in order to prevent liquid filler from flowing out of the gap. The shape of the panel should be precisely adjusted to the gap and the adjacent edges of the wall and frame.

[0025] Then, small holes are made in the surface of the sealing sheets every 10-50 cm, preferably every 30 cm, on one side of the wall and plastic tubes, e.g. Igelit tubes, serving as packers for applying liquid polymer, are placed in them The diameter of the holes should match the diameter of the tubes. Tubes should be sealed with thermal adhesive at the contact with the sheet.

[0026] The injection of liquid polyurethane filler starts at the bottom with small portions. When the polyurethane mass appears in the higher tube, the lower one closes tightly and continues the injection through the higher tube. These injection operations are repeated successively until the gaps are completely filled with liquid polyurethane preparation. First the side gaps are filled and then the upper one. After the polyurethane filling has hardened, the parts of the tubes protruding beyond the face of the sheet are cut off.

[0027] The closing sheets are left on the surfaces of the side gaps. They are an additional reinforcement providing a safety reserve in the event that the polyurethane filling is separated from the gap surface in case of large deformations. However, if necessary, for other reasons, the sealing sheets can be removed after the polyurethane filling has cured.

[0028] As in the previously discussed variant of the invention, this solution has proved very effective in earthquake simulation tests. It carried heavy loads and large deformations without any significant loss of substance of the wall, allowing it to be repaired after an earthquake and the building to continue to operate. Dynamic forces from seismic extortion were not able to separate the filling wall from the skeleton frame, making the system very effective and safe to operate.

[0029] According to the claimed invention, after the seismic protection has been performed, the filling wall can be additionally reinforced in the skeleton frame by means of a mesh, the role of which is, on the one hand, to distribute stresses and dampen vibrations more evenly in the wall and at the contact between the wall and the frame, and, on the other hand, to prevent fragments crushed due to shocks from falling out of the wall.

[0030] There are known systems of strengthening building structures (concrete, brick, steel or wooden) with the use of meshes glued onto the wall. The mesh can be metal (drawn, welded from wire or bar) or composite, made of glass, polymer or carbon fibres sunk into the material that bonds the mesh, with fibres arranged in two or more directions. These meshes are fixed to the substrates of structural members using matrixes of epoxy resin or mineral mortar, which are characterised by high rigidity, brittleness, relatively high strength but low deformability and, as a result, low capacity to transfer large deformations. In the case of loading such a composite, the mesh fibres work unevenly, as a rigid matrix (fixing glue or mortar) makes it impossible to even out the stress distribution in all the fibres. As a result, if the load-bearing capacity level calculated for the whole surface of the composite is not reached, the stresses are concentrated in individual fibres and cause their tearing. Fibre rupture can also be caused by a crack in the substrate. In the case of brittle mineral mortars, these local stress concentrations cause local loss of bond between the matrix and fibres and the substrate, and in the case of epoxy resins they initiate brittle destruction in masonry or concrete substrates. These disadvantages translate into a relatively low effectiveness of such reinforcements at the point of occurrence of cracks or under cyclic and dynamic loads, occurring in seismic areas.

[0031] In order to solve the above problems, it is proposed to use a polyurethane susceptible matrix instead of a rigid matrix made of epoxy adhesive or mineral mortar. It is obtained by reducing the concentration of stress maxima and their redistribution to a larger surface area, which leads to activation of a larger area of the composite and protects the fibres from damage. Enabling the deformation of the matrix between the mesh fibres allows for more efficient use of the composite, transfer of higher loads and deformations and energy dissipation. In addition, thanks to the fast bonding of polyurethanes, it is possible to use meshes in the polyurethane matrix to rescue structures that threaten with collapse after an earthquake or a strong bump. The susceptibility and high deformability of polyurethanes enables the application of such a reinforcement system on cracked and unstable substrates. The mesh mounted on susceptible polyurethane does not detach from the substrate. Thus an additional safety reserve can be achieved in a post-critical condition, even in the case of large wall damage, and when the damaged filling wall is protected from falling out of the skeleton frame.

[0032] The polyurethane mesh can also be used for local protection of cracks in walls, restoring the load-bearing capacity of the wall at the point of crack or protecting it against large deformations. In this way, places where significant damage is expected to occur in filling walls can also be protected.

[0033] The mesh in the polyurethane matrix can be attached to various constructional substrates such as concrete, masonry, wood, composites, steel or other metals. The mesh thickness and specific physicochemical properties of polyurethanes are selected according to the desired characteristics of the work of the reinforcement, which depends, among other things, on the properties of the materials used to build the wall. The performance characteristics are determined using standard methods, e.g. earthquake simulation. As a standard, the mesh should be about 2 mm thick and have a mesh side of about 2 cm.

[0034] Various multidirectional composite meshes, made of carbon, steel, basalt, glass, aramid, geopolymer or natural fibres can be used for wall reinforcement. As a matrix, a layer of susceptible polymer adhesive can be applied to the substrate in liquid form with a given thickness, binding the composite meshes in direct contact. You can also use a susceptible polymer adhesive to prefabricate a composite sheet of a given thickness, made of a mesh embedded in a matrix. The sheet is then fixed to the substrate with a polyurethane adhesive layer, preferably after it has been primed with a polymer primer chemically compatible with the matrix material.

[0035] The mesh can be glued to the filling wall itself, but it is recommended that the mesh has at least a five-centimetre overlap around the entire circumference of the wall and is also glued to the skeleton frame. It is recommended that the overlap on the frame should be at least 5 cm wide.

[0036] In order to strengthen the area's most vulnerable to chipping, especially around the corners of the filling wall, the mesh or prefabricated sheet is put on the perimeter or part of the perimeter of the filling wall. The width of the glued mesh or pre-fabricated sheet should be at least 40 cm, preferably 60 cm, with a minimum overlap of 5 cm and preferably 10 cm on the skeleton frame.

[0037] The protection of the filling wall with the mesh in polyurethane matrix can also be used alone to reinforce the walls connected to the skeleton frame directly with mineral mortar, i.e. without using an intermediate polyurethane layer.

[0038] For the implementation of the claimed variants of the anti-seismic wall protection method, two-component or one-component elastic-compressible polyurethane preparations with the bonding accelerator with Shore A hardness after bonding in the range of 15-90 and with high return elasticity and sound-absorbing and vibration-absorbing properties as well as non-conductive electrical charges, are applied in liquid form and shrinkage-free hardening with the beginning of bonding up to half an hour from mixing, characterized by constant Young's modulus with values in the range of 0.3-100 MPa, determined in ----------------measure of deformation in the range of 1.0 to 1.3 in uniaxial tensioning with large deformations and limit tensioning in the range of 1.3-8.0.

[0039] Polyurethane preparations shall be made by adding - in the required proportions - a hardener to the polyurethane resin in the case of a two-component material or by adding a bonding accelerator in the case of a single-component material. The selection of polyurethanes is based on their equivalent stiffness Ez, determined logarithmically over a wide range of large deformations, for engineering deformation in the range 0-30% (eps = 0-30%). Due to the hyper-elastic (non-linear) nature of polyurethanes used according to the invention, their equivalent logarithmic stiffness Ez is determined according to the formula:

$$Ez = [F*(1+eps)] / [A0*\ln(1+eps)]$$

where:

F- tensile force, as defined in the uniaxial tensile test;
A0 - initial cross-section of the component in tension;
In - natural logarithm;
eps - engineering deformation (ratio of length increment to initial length).

[0040] The equivalent logarithmic stiffness Ez clearly defines the material property of the selected polyurethane, which is used to calculate the properties of the polyurethane joint according to the theory of hyper-elastic materials.

[0041] Polyurethanes selected for the implementation of the invention must have a hyper-elastic characteristic that enables to determine for them the equivalent logarithmic stiffness Ez, according to the formula given. The Ez stiffness of polyurethanes used in the joint will be in the range 0,3 - 100 MPa. Examples of the stiffness of polyurethanes are indicated in the material data sheets as the primary stiffness modulus (e.g. for the preparation used to fill the gap between the frame and the filling wall it is Ez = 4.0 MPa).

[0042] Exemplary embodiments of the invention are shown in the drawing below, in which:

Fig. 1 shows a schematic diagram of the location of chips that occurs in the corners of the filling wall during the simulation of seismic shocks in laboratory conditions and the separation of the wall from the reinforced concrete frame to which it is rigidly bonded with mineral mortar;
Fig. 2 shows the basic variant of the invention - the cushioning layer between the two side edges of the filling wall and the skeleton frame;
Fig. 3 shows the extended variant with the cushioning layer between the two side edges and the upper edge of the filling wall and the skeleton frame;
Fig. 4 shows the maximum variant with the cushioning layer between the two side edges, the upper edge and the lower edge of the filling wall and the skeleton frame
Fig. 5 illustrates the execution of the cushioning layer around the newly built filling wall, with additional protection of the reinforcement sheet;
Fig. 6 illustrates the execution of the cushioning layer in the gap between the existing filling wall and the skeleton frame;
Fig. 7 shows a diagram of the hysteresis loop envelope at the stiff connection (A), which is damped at three edges (B) and four edges (C) between the filling wall and the skeleton frame.

[0043] Polyurethane cushioning layer 3 between skeleton frame 1 and filler wall 2 can be made in two ways: either by gluing a pre-fabricated polyurethane tape 5 to skeleton frame 1 or by pressing liquid polyurethane filler 12 into the gap cut-out between skeleton frame 1 and filler wall 2.

[0044] In the first variant of the invention, prefabricated polyurethane tape 5 has quartz sand coating 10, which increases the adhesion of mortar 6 to polyurethane tape 5, which protects masonry elements 7 from damage and from falling off the wall 2. This promotes stability of the filling wall 2 in skeleton frame 1, and in particular reduces the risk of the filling wall 2 slipping out of skeleton frame

1 during strong vibrations perpendicular to the wall surface. For the execution of the cushioning layer 3 the prefabricated polyurethane tape 5 is glued to the skeleton frame 1, previously primed with primer 4, if possible on the four internal contact surfaces of frame 1 with the subsequently constructed filling wall 2.

[0045] In turn, the second variant of the invention provides for the cushioning layer 3 based on polyurethane made of liquid polyurethane filling mass 12, applied by injection between the skeleton frame 1 and vertical surfaces of the filling wall 2, adjacent to the skeleton frame 1. It is recommended that the cushioning layer 3 is also placed between the upper surface of the filling wall 2 adjacent to the horizontal beam of frame 1 and this horizontal beam

In order to prevent the liquid polyurethane filler 12, applied through hole 11 with an Igelit tube (packer), from flowing out of the gap, the gap is sealed with a tight sheet on both sides of filling wall 2 and skeleton frame 1, as shown in Fig. 6. The sheet made of mesh 8 embedded in polyurethane filler 9, preferably with the coating 10, is glued with polyurethane adhesive to skeleton frame 1 and filling wall 2, previously primed with polyurethane primer 4.

[0046] In both variants of the cushioning layer 3 the filling wall 2 and its connection to the skeleton frame 1 can be additionally reinforced by means of a multi-directional composite mesh 8 sunk into a polyurethane matrix 9 of a given thickness, applied to the substrate in liquid form or as a prefabricated composite sheet of a given thickness. The pre-fabricated sheet consists of a mesh 8 embedded in a polyurethane filler matrix **9.** The sheet is glued to the substrate primed with polyurethane adhesives.

[0047] Fig. 7 shows a schematic comparison of the envelope of experimental hysteresis loops for a wall without a cushioning layer (curve A) and with cushioning layers (curve B for 3 edges and curve C for 4 edges). Significantly higher efficiency of walls with a flexible cushion layer 3 between the filling wall 2 and frame 1 was found in comparison with the filling wall 2 rigidly bonded to frame 1 using a rigid mineral mortar. This efficiency is greater both in terms of load capacity (up to 150%) and ductility of the structure (up to 300%), which determines the ability to transfer deformations at the same level of critical stress-strain state. Marking in the Fig. 7 is as follows □ - frame tilt, □ - wall load-carrying capacity.

[0048] The embodiments of the claimed invention use polyurethane preparations and glass mesh of 1.81/1.42 cm mesh size to make prefabricated tapes separating the filling wall from the skeleton frame, sheets to seal gaps around the filling wall and mesh in the polyurethane matrix to strengthen the filling wall.

[0049] The following polyurethane preparations were used:

- Polyurethane preparation compatible primer;
- liquid filling with two-component polyurethane, with Shore hardness A 55 and Ez module = 4.0 MPa, and a limit deformability of 110%;
- a matrix in the glass mesh composite sheet and its fixing adhesive layer made of two-component polyurethane, with a Shore hardness of A 80 and a modulus of Ez = 16.0 MPa and a limit deformability of 40% .

[0050] Other polyurethane adhesives with hyper-elastic characteristics, hardnesses and equivalent logarithmic stiffness Ez and limit deformability within the above mentioned limits can also be used in combinations to produce a liquid filling of the gap and matrix in the composite sheet.

[0051] In case of the first variant of the invention, shown in Fig. 5, the prefabricated polyurethane tape 5 was 2 cm thick. On one side, the tape had quartz sand coating 10.

[0052] In another version of this variant of the invention, a triangular undercut was used along the central axis of tape 5 with a depth of about 10 mm (not shown in the figure).

[0053] In the second variant of the invention, shown schematically in Fig. 6, a 2 cm wide gap was cut out with an angle grinder around the two lateral and upper edges of the filling wall 2, as shown in Fig. 2. Prefabricated sealing sheets were made of glass mesh 8 with rectangular mesh of 1.81/1.42 cm side and 2 mm thick, and the matrix - polyurethane filling 9 was made of two-component polyurethane with Shore hardness A 55 and Ez module = 4.0 MPa, and a limit deformability of 110%. The top of the sheet was finished with a quartz sand coating 10, which forms protection of the sheet and at the same time the layer increasing adhesion of the mortar, e.g. mineral plaster mortar. The sheets were cut to the width of 14 cm, i.e. with overlaps of 6 cm on both sides of the gap and glued to the substrate with polyurethane adhesive of Shore A 80 hardness and Ez module = 16.0 MPa and 40% limit deformability, after priming with primer 4 compatible with the polyurethane preparation building the sheet matrix. The gap was filled via Igelit tubes (packers) with a diameter of about 12 mm, fixed in holes 11, spaced every 25 cm.

[0054] Additional mesh 8 reinforcing potential damage zones in the corners of filling wall 2, illustrated schematically in Fig. 5, was 80 cm wide, including an overlap of 15 cm on each side of skeleton frame 1 and filling wall 2. It was made of glass mesh 8 with rectangular meshes of 1.81/1.42 cm side and 2 mm thick, and the matrix - polyurethane filling 9 - was made of two-component polyurethane with Shore A 80 hardness and Ez = 16.0 MPa module and 40% deformability limit, which at the same time served as a adhesive fixing to the substrate, previously primed with primer 4 compatible with the polyurethane preparation building the matrix.

List of designations

[0055]

1 - skeleton frame
2 - filling wall
3 - polyurethane cushioning layer
4 - polymeric primer
5 - prefabricated polyurethane tape
6 - mortar
7 - masonry element
8 - mesh
9 - polyurethane filler (matrix)
10 - coating
11 - hole for the tube (packer)
12 - liquid polyurethane filler
13 - crushed wall corners
14 - wall detached from the frame

Claims

1. A method of anti-seismic protection of frames and filling walls in framed buildings **characterised is that** a polyurethane based cushioning layer (3) is applied between the skeleton frame (1) and at least vertical surfaces of the filling wall (2) adjacent to the skeleton frame (1).

2. The method according to claim 1, which is **characterised in that** a cushioning layer (3) is additionally applied between the upper surface of the filling wall (2) and the adjacent horizontal beam of the skeleton frame (1)

3. The method according to claim 1 or 2, **characterised in that** the inner surfaces of the skeleton frame (1) are cleaned mechanically in order to apply the cushioning layer (3), the cleaned surfaces are primed with polymer primer (4), prefabricated tapes (5) are prepared from polyurethane chemically compatible with polyurethane primer, 2 cm thick with one side coating (10), which are then glued with polyurethane adhesive, chemically compatible with polyurethane primer, up to four inner surfaces of the skeleton frame, with coating (10) on the side of the filling wall (2) for better adhesion to the mortar (6) connecting the prefabricated tape (5) to the masonry elements (7) of the filling wall (2), and then the space inside the skeleton frame outline limited by the pre-fabricated tape (5) is filled by building the filling wall (2).

4. The method according to claim 3, **characterized in that** the cut allowing mortar (6) to be clamped in polyurethane around the masonry filling wall (2) is made additionally in the prefabricated polyurethane tape (5) .

5. The method according to claim 1 or 2, **characterized in that** in order to apply the cushioning layer (3) the condition of the filling wall (2) is inspected and the damage is repaired (13), followed by subsequent stages of seismic protection:

   a) tight closing sheets made of thin, up to 2 mm thick, glass fibre mesh (8) with a mesh size not exceeding 2 cm, embedded in polyurethane filler (9) are prepared;
   b) a gap of 1 to 3 cm, preferably 2 cm, is made around the filling wall at the two lateral edges and preferably at the upper edge, using a saw, angle grinder or cutting out such a gap, separating the filling wall (2) from the skeleton frame (1);
   (c) the surfaces inside the gap are cleaned of loose particles and primed with a polyurethane primer (4) chemically compatible with polyurethane filler (12);
   (d) if there are holes in the filling wall in the plane of the gap, these holes shall be closed inside the gap by gluing a closing sheet with a polyurethane adhesive chemically compatible with the filling polyurethane;
   (e) the prepared closing sheets are cut to size to cover the gap, with overlaps of at least 5 cm on both sides of the gap;
   (f) the sealing sheets are glued with polyurethane adhesive to both external surfaces of the filling wall (2) and skeleton frame (1), closing the gap space to prevent liquid filler (12) from flowing out of the gap, wherein the shape of the sheet is being adjusted to the gap and the edges of the filling wall (2) and the skeleton frame (1) adjacent to it;
   (g) holes (11) are made in the surface of the sealing sheets every 10 to 50 cm, preferably every 30 cm (11) on one side of the filling wall and plastic tubes, preferably made of Igelit, used as packers for the application of liquid polymer (12) are placed therein, where the diameter of the holes being adjusted to the diameter of the tubes and the tubes being sealed with thermal adhesive at the contact with the sheet;
   (h) injection of the liquid polyurethane filler (12) starts at the bottom with small portions, and when the polyurethane filler appears in the higher tube, the lower tube is sealed and the injection is continued through the higher tube, and these injection operations are repeated successively until the gaps are completely filled with the liquid polyurethane filler (12), with the side gaps being filled first and then the upper one.

6. The method according to claim 5, **characterized in that** the pass-through gaps are made.

7. The method according to claim 5, **characterized in that** the gap is cut out with a depth equal to half the thickness of the filling wall (2) and after cleaning and sealing it is filled with liquid polyurethane preparation

(12), and then, after the polymer filling (12) hardens, the operation on the other side of the filling wall (2) is repeated.

8. The method according to claim 6 or 7, **characterized in that** the gaps are made and filled with liquid polyurethane preparation (12) in a segmental manner.

9. The method according to any of the above claims, **characterized in that** the surface of the filling wall (2) is levelled and primed with a polymeric primer (4), and a layer of susceptible polymer adhesive, chemically compatible with the primer, is applied to the substrate prepared in this way, in liquid form and of a given thickness, after which a composite mesh (8) of carbon, steel, basalt, glass, aramid, geopolymer or natural fibres is applied, preferably with an overlap of at least 5 cm, preferably 10 cm on the frame (1), covering the surface of the mesh with a polymer adhesive (9).

10. The method according to claim 9, which **characterized in that** the mesh (8) is precoated with polyurethane adhesive and after it has hardened, the prefabricated sheet is fixed to the substrate with polyurethane adhesive.

11. The method according to claim 9 or 10, **characterized in that** the mesh or prefabricated sheet is placed on a selected part of the filling wall (2) in order to strengthen damaged areas.

12. The method according to claim 9 or 10, **characterized in that** mesh (8) or prefabricated sheet is put on the perimeter of the filling wall (2) in order to strengthen the areas most vulnerable to chipping.

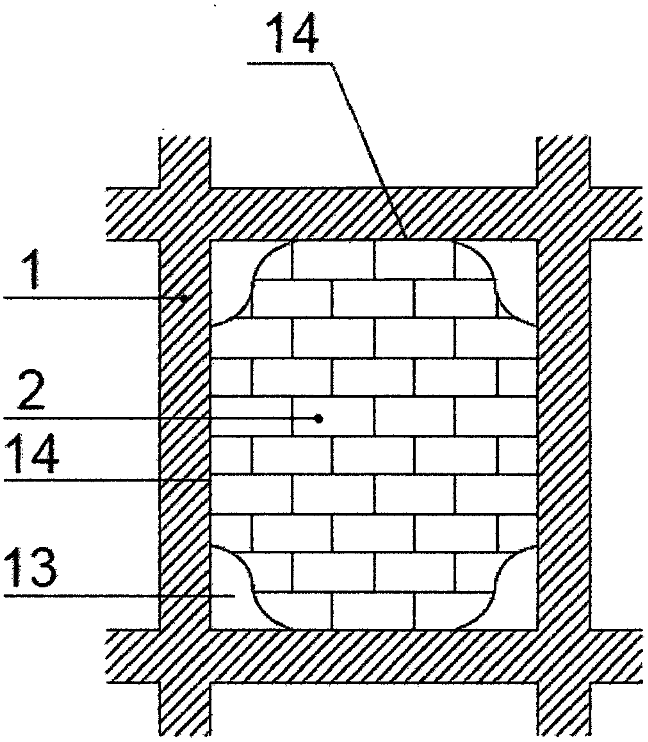

Fig.1

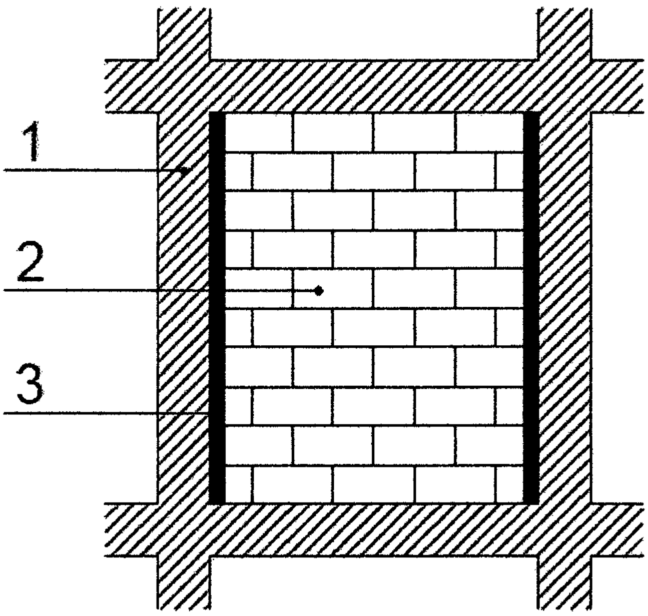

Fig.2

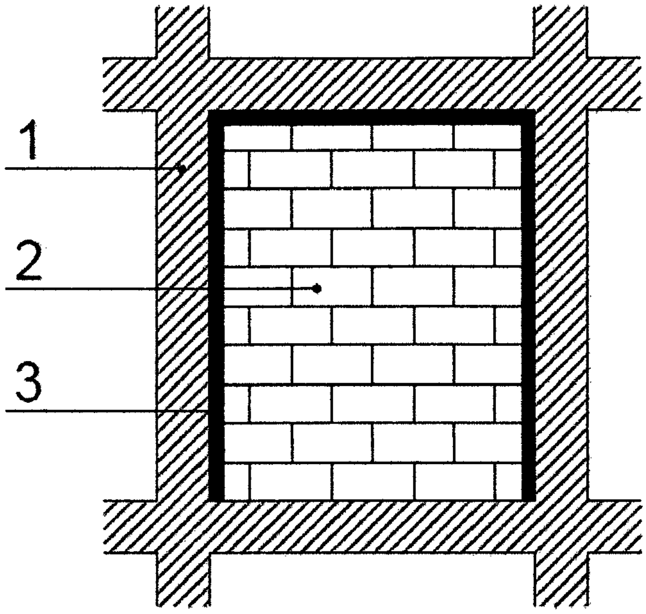

Fig.3

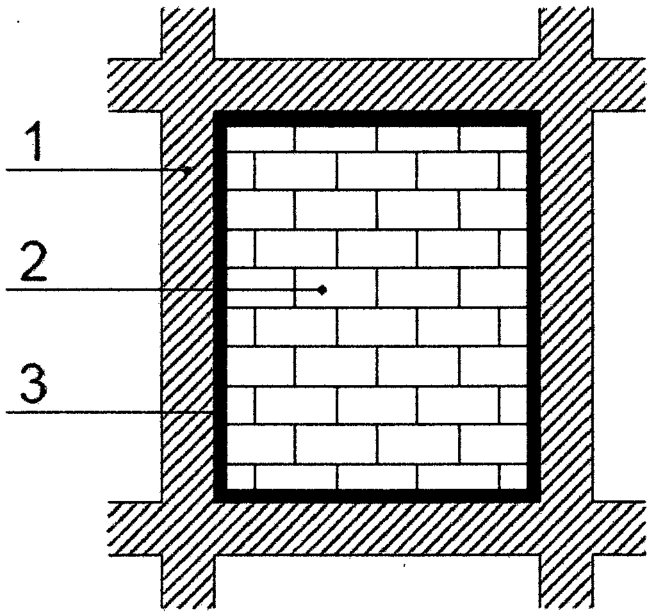

Fig.4

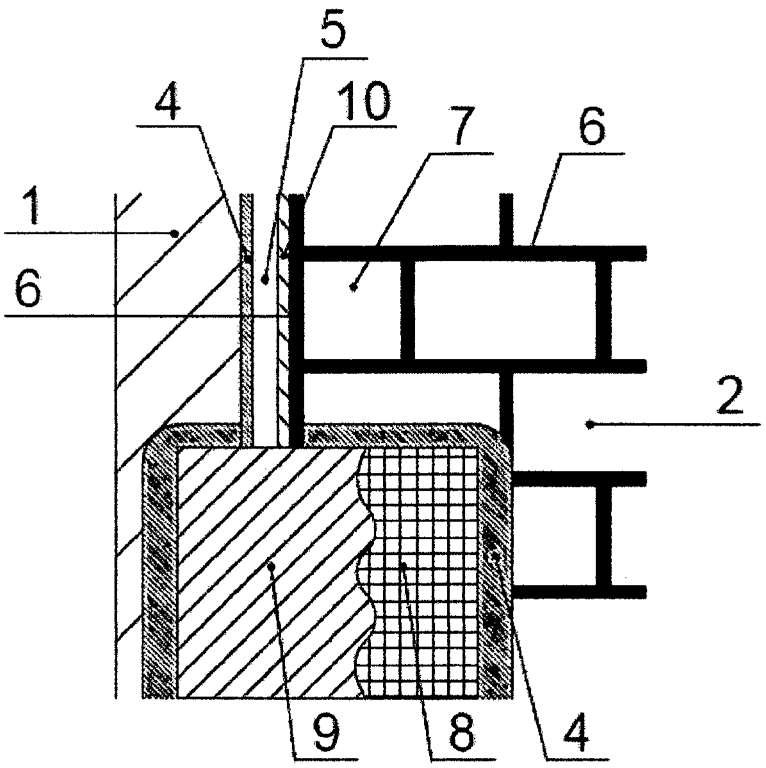

Fig.5

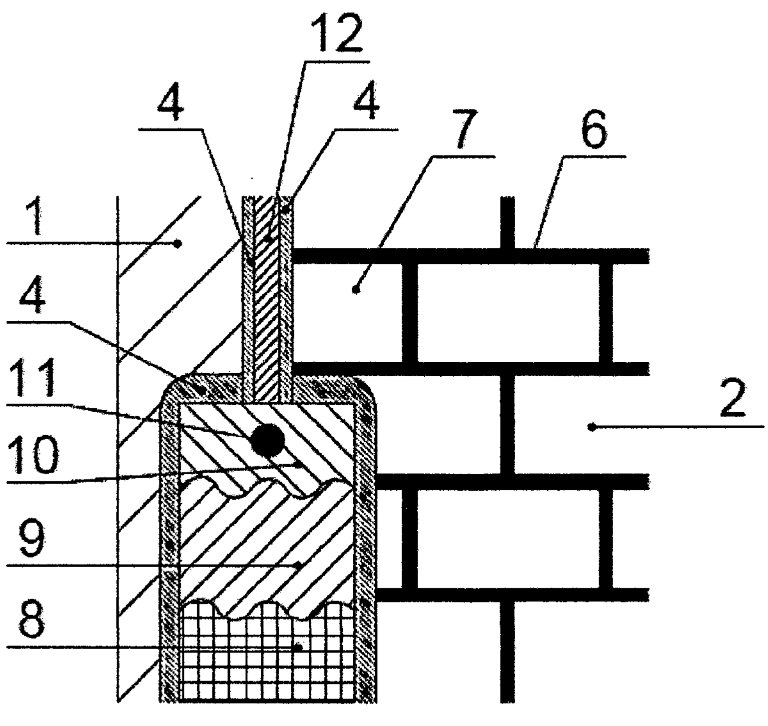

Fig.6

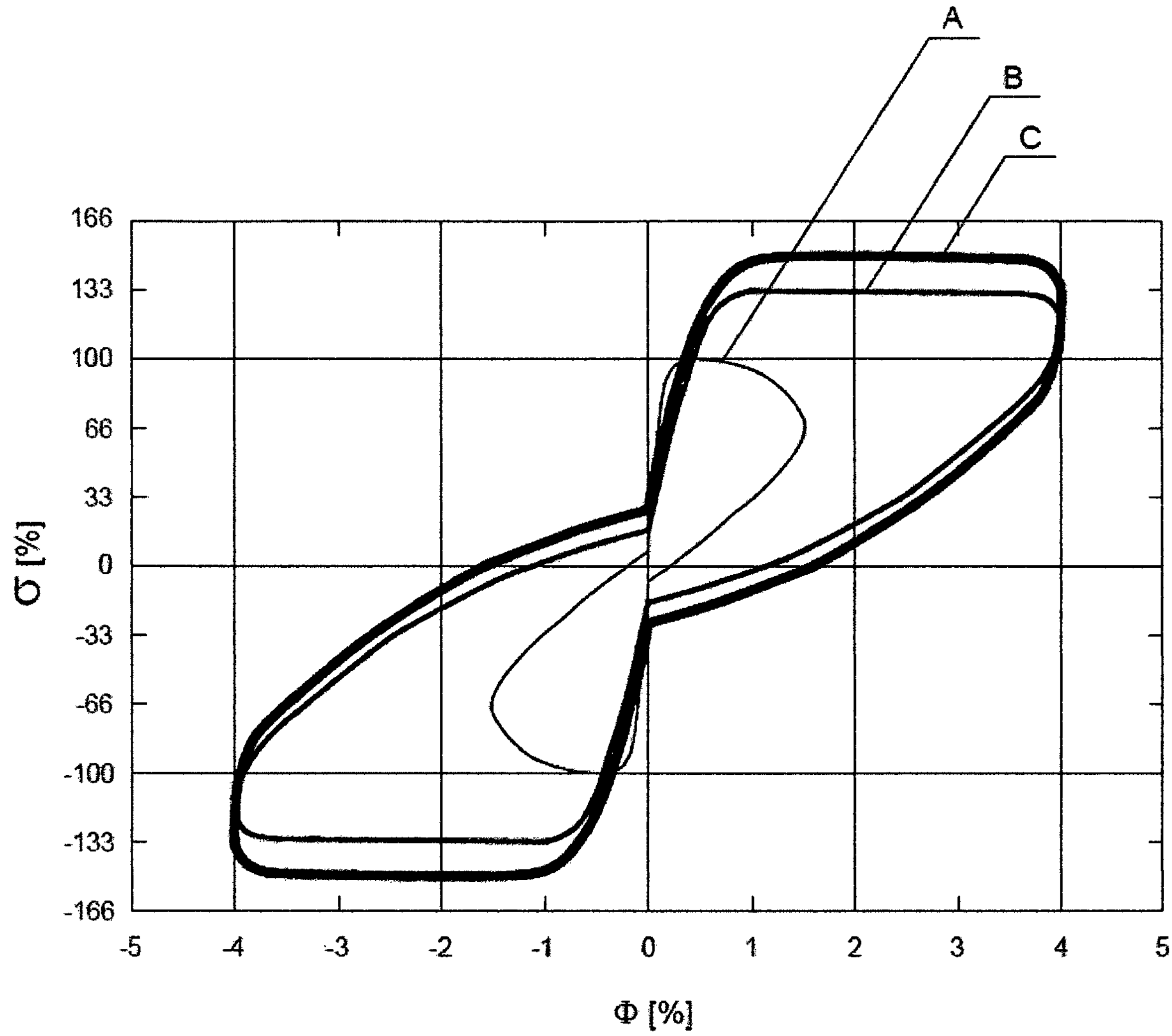

Fig.7

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EUROPEAN SEARCH REPORT

Application Number
EP 20 46 0034

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 3 363 968 A1 (SDA ENG GMBH [DE]) 22 August 2018 (2018-08-22) * paragraphs [0048] - [0060]; claim 1; figures 1-4c *	1,2	INV. E04H9/02
X	CN 103 603 445 A (UNIV SHENYANG JIANZHU) 26 February 2014 (2014-02-26)	1,9-12	
A	* claim 1; figures 1-4 *	5	
A	JP 2004 278212 A (OHBAYASHI CORP) 7 October 2004 (2004-10-07) * paragraphs [0013] - [0018]; figures 1-10 *	5	
			TECHNICAL FIELDS SEARCHED (IPC)
			E04H

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	10 December 2020	Rosborough, John

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10-12-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 3363968 A1	22-08-2018	NONE	
CN 103603445 A	26-02-2014	NONE	
JP 2004278212 A	07-10-2004	JP 4269729 B2	27-05-2009
		JP 2004278212 A	07-10-2004

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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Patent documents cited in the description

- US 2018347221 A1 **[0006]**
- CN 205399726 U **[0007]**
- RU 2656423 C2 **[0007]**
- RU 2665720 C1 **[0008]**
- CN 203741998 U **[0009]**
- JP 2011006896 A **[0010]**
- JP 2000204693 A **[0010]**