2. REINFORCING TWO-STONE WALL CONSTRUCTIONS

The galvanised wire-mesh wall reinforcement works in four ways to strengthen the stone wall constructions against stress forces that may occur during earthquakes:

- Within the thickness of the wall, especially in two-stone construction.
- Over the length of the wall, against bending of the wall.
- Within the length of the wall, providing lengthwise ties and shear strength.
- In the height of the wall along door and window openings and wall corners to reinforce piers.

The following illustrations clarify these methods.

Reinforcement within the Thickness of the Traditional Two-Stone Wall

Traditional stone walls are 18"-20" thick (46-50cm) and composed of two lines of semi-dressed stones (inner and outer faces). Small pointer stones are used throughout the construction (both on the inside and outside faces) to balance the stones vertically in the façade of the wall. When some of these pointer stones begin to fall out of the construction due to erosion or vibration, the wall becomes unstable and eventually will bulge and collapse.

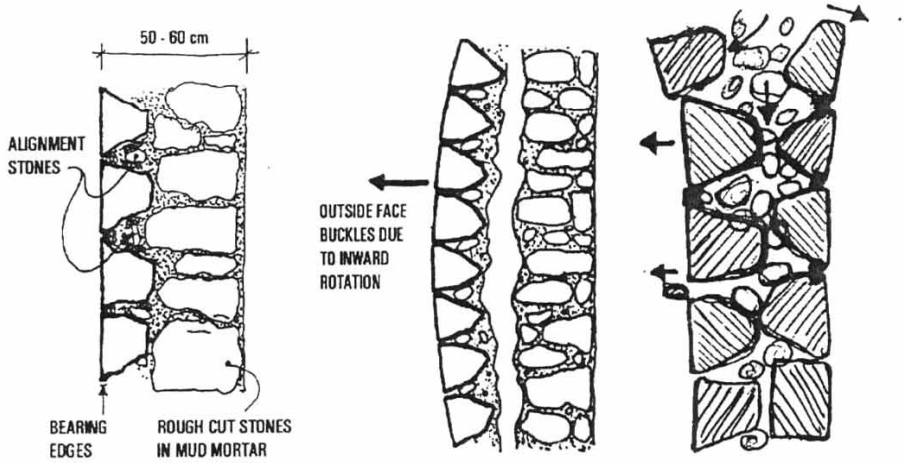

FIGURE 1. FAILURE OF A TWO-STONE WALL DURING AN EARTHQUAKE VIBRATION DUE TO INSUFFICIENT THROUGH-STONES

In order to provide a binding between the inner and outer wall faces, traditionally tie-stones are placed at regular intervals of about three feet, horizontally and vertically. The galvanised wire-mesh reinforcement provides through-connections at one-foot intervals in the wall length, horizontally and vertically. That is NINE times better than traditional through-stones. The two faces of the wall are adequately anchored to each other with the wire-mesh and will not easily separate.

When the wire-mesh wall reinforcement is placed in every other horizontal course, it will tie all the layers and stones together. For this reason it is recommended that for two- and three-storey houses the walls of the lower floor and the foundation are reinforced with the wire-mesh in all alternate layers.

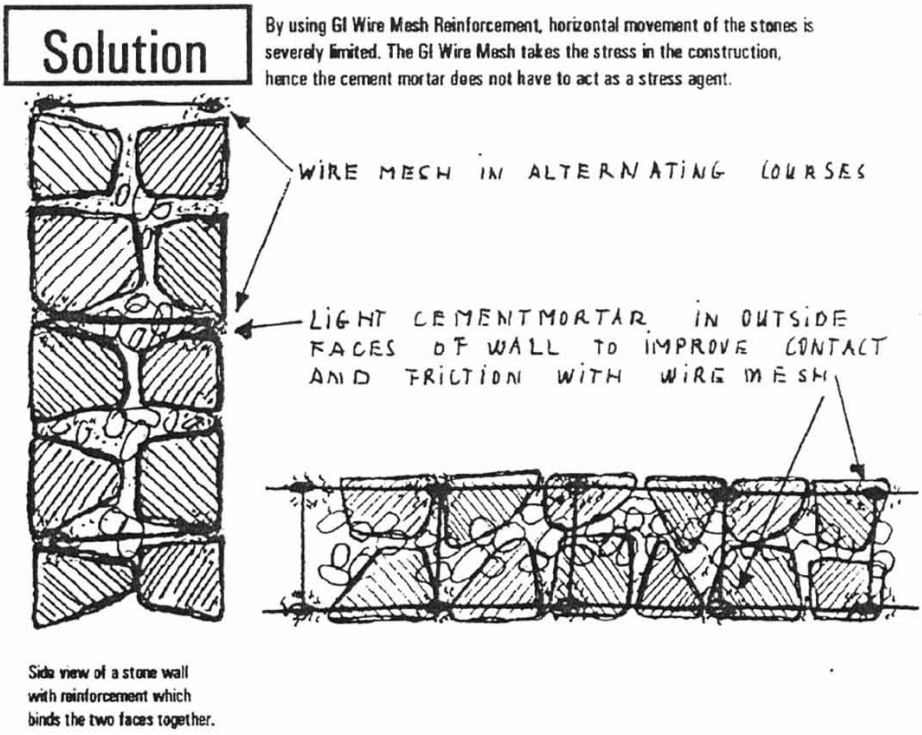

FIGURE 2. THE WIRE-MESH PROVIDES FULL ANCHORAGE BETWEEN THE TWO FACES OF THE STONE WALL

Against the Bending of a Wall

The bending of unsupported wall sections during an earthquake is caused by the weight (mass) of the wall. While a stone construction can resist high pressure, it does not resist stress forces. With a horizontal force against the side of the wall, that wall will bend and open up on the other side. During an earthquake this movement happens repeatedly, rapidly alternating opposite force directions. If stones are not kept in place, small stones will fall out of the wall and the resistance against compression will fail. Subsequently the wall will collapse.

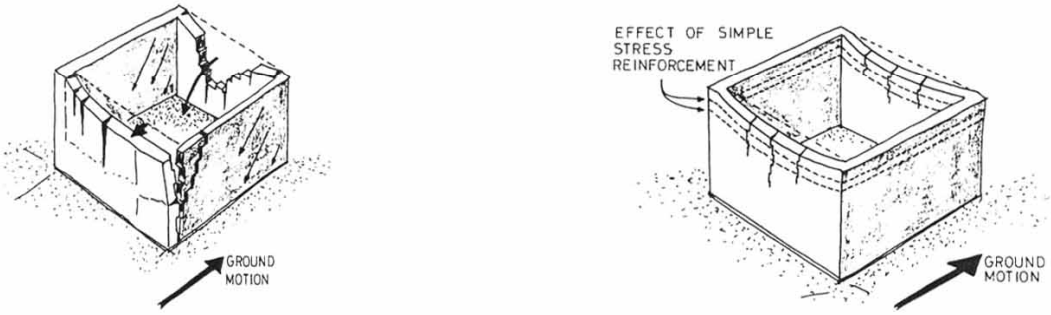

FIGURE 3. EARTHQUAKE FAILURE DUE TO THE BENDING OF A NON-REINFORCED WALL

The wire-mesh reinforcement in an 18" two-stone wall has two parallel wires of 2.3mm (distance between is 17") in the outer faces of the wall. When this reinforcement is placed in alternating masonry courses, it will provide lateral reinforcement in the wall[4].

To ensure good contact between wire and stones, the knots in the wire-mesh are placed in light cement mortar (10:1). The pointing of the spaces between the stones in the same outside face is equally important as the stress and compression together form the resistance to bending.

The horizontal bending forces of a long wall (with an earthquake) increase with the length of the unsupported wall. For this reason it is recommended that the length of each unsupported wall section is not longer than 10 ft., equivalent to the height of a living room.

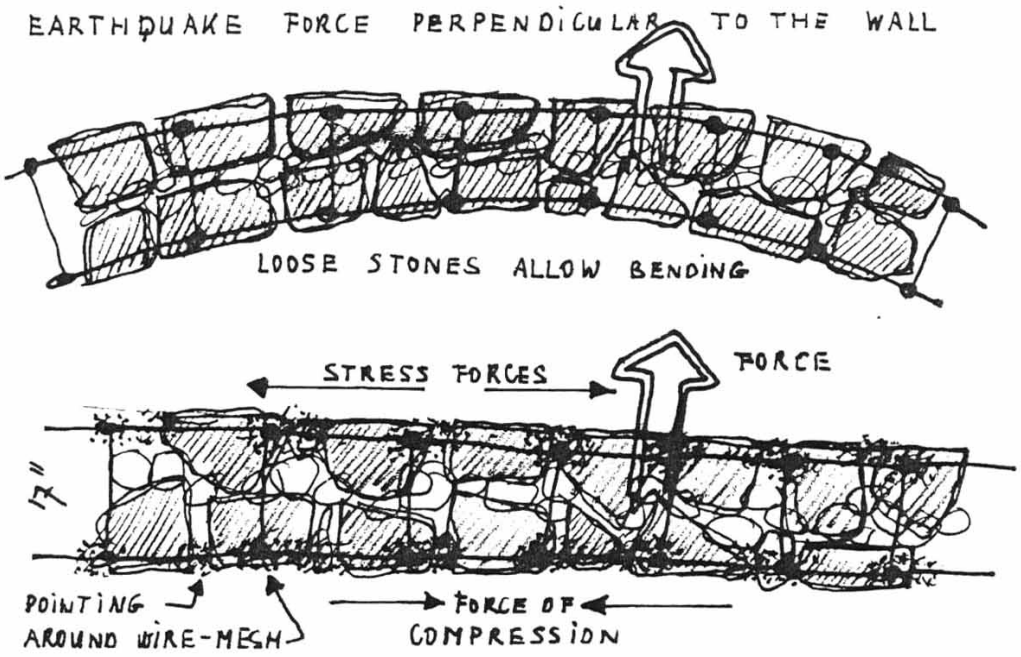

FIGURE 4. THE GALVANISED WIRE-MESH RESISTS AGAINST THE HORIZONTAL BENDING OF THE WALL

The amount of mortar used in the galvanised wire-mesh construction can be considerably less than in a fully masoned stone construction. In a fully masoned stone construction in which the inner part of the wall is filled with the chips from the tailored (dressed) stones and mortar, the amount of cement mortar is about 30% of the total volume of the wall. In the case of the wire-mesh, only the knots in the "ladders" need to be covered with cement mortar. The outer and inner faces of the structural walls need to be pointed with the same cement mortar as well. In this way less than half the amount of mortar (and cement) is used as compared to a fully masoned wall. With stones that fit well on top of each other, the amount of mortar required will be further reduced.

[4] The thicker the wall, the wider the distance between the wires and the internal moment arm; therefore the resistance against the bending force increases. On the other hand, when the wall is thicker, the mass of the wall also increases and so do the earthquake forces. The placement of the wires in the outside faces of the wall is therefore important and very functional in resisting the horizontal bending forces.

FIGURE 5. THE WIRE-MESH NEEDS TO BE LAID IN SOME MORTAR TO IMPROVE CONTACT WITH THE STONES

Reinforcement in the Length Direction of the Wall

Stone wall constructions have a large resistance against static loads, but little resistance against dynamic forces of an earthquake if no additional stress reinforcement is applied. Cement mortar is one of the best reinforcements, but the cost of cement mortar is high. Therefore house builders tend to reduce the amount of cement in the mortar to very low levels. The galvanised wire-mesh reinforcement still works very well with these types of light cement mortar joints.

The following figure illustrates the types of damages that may occur during an earthquake if no wall reinforcement is provided in the length direction of the wall.

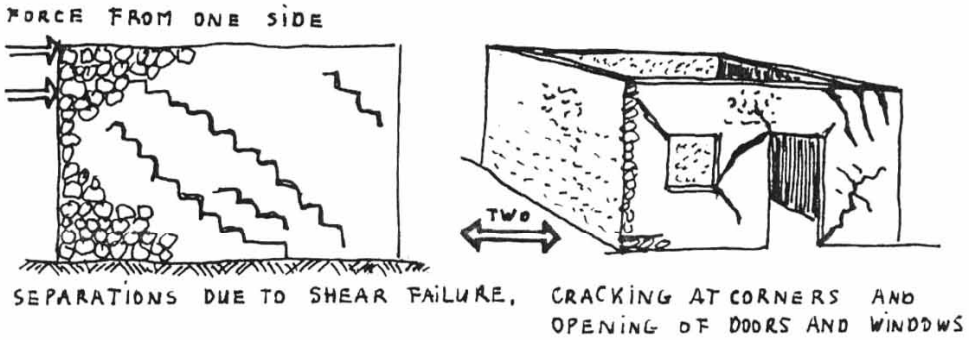

FIGURE 6. FAILURES IN STONE WALL CONSTRUCTIONS CAUSED BY SHEAR FORCES

The stress reinforcement that is required in these walls needs to cross the opened cracks in the wall (drawing), especially in the corners of the walls and around door and window openings. Usually a building starts to fail at the corners of walls and junctions. The wire-mesh takes charge of the stress, while the knots in the wire-mesh reinforcement add to the adherence between the wires and the stones if these are masoned into a light mortar.