

6. THE THREE DESIGN OPTIONS

A. One-Storey House (Ground Floor Only) Without Future Vertical Increments

With this option it is recommended to have the corners of the walls, lintels and tie-beams realised with the wire-mesh wall reinforcement. External walls only. Floor diaphragms.

Advantages	Disadvantages
Lowest cost in reinforcement. Rs. 4,000 / per house (per floor).	Possible settlement and cracking of foundation.
	Not possible to build an additional storey. Therefore to provide for future housing requirements, land must be purchased (added expense) or valuable agricultural land used for this purpose.
	Without the vertical corner reinforcement fixed to the tie-beam, considerable damage with an earthquake may occur.
	Low value of building as it cannot be safely extended vertically.

B. Two-Storey House Design (Ground Plus One)

With wall reinforcements by means of lintels, tie-beams, along all vertical corners and wall sections, and framing of wall sections around all doors and windows. External and internal walls. Floor diaphragms.

Advantages	Disadvantages
Low cost in reinforcement. Rs. 8,000 / per house (per floor).	Possible settlement and cracking of foundation.
Saves considerable (agricultural) land with the extension of one storey.	Not possible to build higher than the planned one storey. Therefore additional land cost for future housing requirements.
Considering population growth and increased housing demands, the need for additional built space is very likely within 10 years.	First storey needs to be of a lighter construction than the ground floor building.
Value of construction is increased because of its durability.	With an earthquake, possible cracks around openings.

C. Three-Storey Design with Full Reinforcement (Ground Plus Two)

In this case the house is built in phases, but adequate reinforcement applied from the beginning to allow for future vertical additions. Wall reinforcement from foundation upwards in all walls, lintels and tie-beams. Framing of all wall sections around all doors and windows. External and internal walls. Floor Diaphragms.

Advantages	Disadvantages
Low cost in reinforcement. Rs. 12,000 / per house (per floor).	Slightly increased capital cost in the first phase.
Saves considerable (agricultural) land with the extension of one or two storeys.	The second floor needs to be of a lighter construction than the ground (first) floor.
Considering population growth and increased housing demands, the need for additional built space is very likely within 10 years.	The third floor needs to be of a lighter construction than the second floor.
Value of construction is increased because of its durability.	

The above three tables shows that to only build a one-storey (ground floor) house, and with that reduce the cost of the reinforcement, has serious disadvantages for the future as reinforcement cannot be added later. If it is decided at a later stage to build a second storey above the ground floor building, the only possibility to adequately reinforce the construction is to add columns in the existing walls. Such a process will be much more expensive than including reinforcement for two additional storeys during the initial building phase.

Evolutionary Building Design

Most buildings in the Northern Areas are not realised in one or two years. When future extensions are planned, it is recommended to make a good planning of the total house before making the foundations for the first phase of the building. Presently, during the planning stages for new houses, building two- or three-storey houses is not always considered. However, land is becoming increasingly scarce. Within a number of years, the availability of land will become so acute that it will become obligatory to build two- or three-storey houses to accommodate the growing population. As it is very costly to add reinforcement at a later stage, it is wiser to include the needed reinforcement in the foundation and lower walls during the first phase of the building.

Foundation

Depending on the soil type and eventual boulders in the subsoil, adequate reinforcement of the foundation is important to avoid any future cracks in the walls. This means that in every layer of the foundation the wire-mesh needs to be applied, and over the whole width of the foundation as well. To accommodate the wider dimension of the foundation, either special wide wire-mesh "ladders" can be made or several narrower common-size "ladders" can be joined lengthwise, overlapping each other. Non-reinforced foundation will most likely show settlement cracks after some time and during an earthquake the foundation may fail, even if the tie-beams are holding the tops of the walls together. It has been observed that on sloping terrain the high stone foundations are seldom reinforced. This creates a very dangerous situation.

IN FOUNDATION
TWO WIRE-MESH "LADDERS"
ARE OVERLAPPING IN EACH COURSE

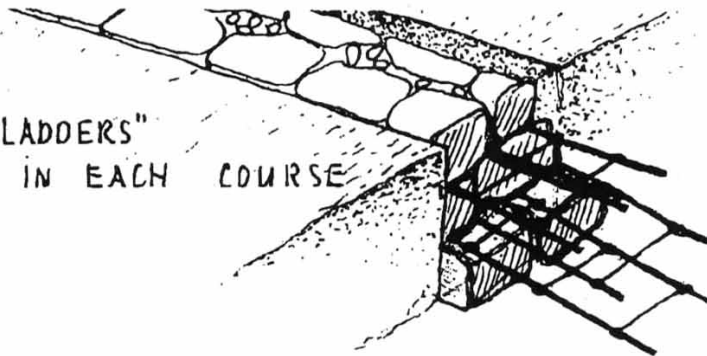


FIGURE 22. POSITIONING OF REINFORCEMENT IN THE FOUNDATION

Slimming of Walls

For buildings that are going to be two or three storeys high, it is necessary to apply a slimming of the stone walls for the higher storeys in order to reduce the weight of the upper storeys. The top storey should be as light as possible, for example using light cavity walls. Cavity walls are also recommended for thermal insulation purposes. Light cavity walls can be made from different types of panelling using traditional materials.

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ANNEXE I. NESPAK REPORT

Excerpt from the National Engineering Services Pakistan Ltd. (NESPAK), Islamabad, report entitled: *Application of Galvanized Wire-Mesh for Stone Wall Construction*



THE EFFECT OF TIME AND SMALL EARTHQUAKES ON WALLS THAT ARE NOT REINFORCED.