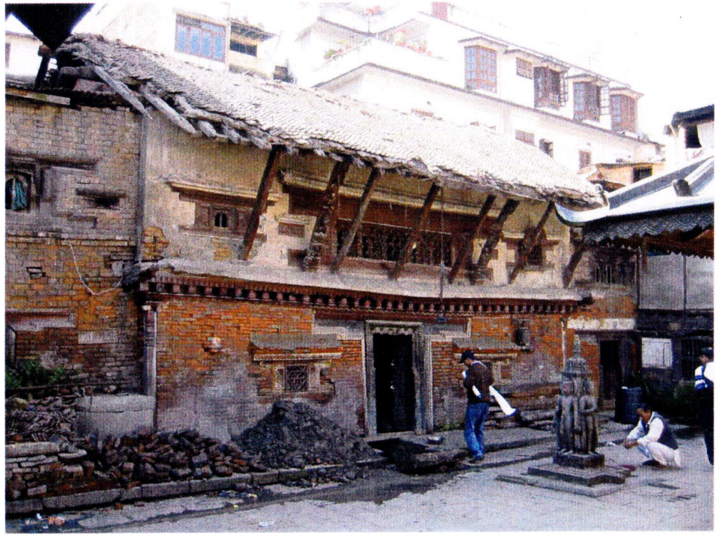


Structural Report
Itum Baha, Kathmandu

November 2002
Dipl. Ing. Matthias Beckh

Structural Report

A) Existing condition:

The existing structural fabric of Itum Baha's south wing was investigated thoroughly during two site visits on November 18th and 25th, 2002.

Excavations at the existing foundation walls that were carried out by mid November, unveiled a surprisingly high water table. Water was found only 50 cm below courtyard level. Due to that fact, the base condition of the existing foundations could not be inspected. Based on observations of similar structures, it can be assumed that the brick foundation wall reaches a base of large rubble stones about 1m below the courtyard level.

The load bearing walls of Itum Baha are made of locally produced fired brick - maapa - laid in mud mortar. Most parts of the brickwork are in poor or even extremely poor condition. Heavily decayed brickwork can be seen along the entire northern and southern wall of the south wing. Here, rising damp has caused spelling of the bricks and washed out the mud mortar in the evaporation zone of the wall, between 50 -180 cm above ground level. Below this zone, heavy efflorescence and moss can be seen along the walls. The extreme leaching of salts also indicates an advanceddenutrition of the mortar. The rising water, exacerbated by an unusually high water table, has led to a substantial weakening and decomposition of the structure.

At the second floor, many of the joists are rotten and severely affected by wet rot, fungus and insect infestation. However, some of the joists appear to be still in usable condition and will be reused in the renovated structure. Many of the timber windows on the second floor level show boreholes caused by insects that have led to a partial decomposition of the wood.

After the removal of the roof tiles and planking, the roof structure was inspected on 25th November. What became visible was a timber structure in its ultimate state of decay. The purlins were completely rotten and had partially collapsed, most of the timber pegs broken off or in a state of distress. All of the top connections of the rafters had been rotten away. The lower ends of the rafters and the eave boards had been rotten and partially broken off. Similarly, the joists at the third floor were in a progressed state of decomposition, with some of them having already collapsed. Altogether, the existing roof is beyond repair and has to be completely rebuilt, using entirely new timber elements.

B) Renovation:

Considering the high seismic activity in Nepal and the extreme damage the building suffered during the 1934 earthquake, it is an outspoken aim of the renovation work at Itum Baha to include necessary seismic strengthening measures. These interventions should, however, be unobtrusive and respect the traditional construction techniques. The implemented strengthening measures will increase the cohesiveness of the building by tying some of the weaker elements more firmly together. By doing that, differential movement of the building will be reduced during seismic action and the structure is more apt to act as one single unit. Since old photographs that were taken just after the 1934 earthquake document the deficient behavior of the traditional roofs, special attention will be given to their improvement. Bearing the high water table and the severe damages of brickwork and timber that were caused by rising water in mind, the introduction of a horizontal water barrier is of utmost importance. Most parts of the existing walls of the south wing will have to be reconstructed. This is well justified by their extremely bad shape and their lack of historic importance, since most parts of the south wing were rebuilt after the 1934 earthquake.

For the reconstructed walls of the south wing, concrete ring beams will be introduced just below the plinth on the ground floor level. The ring beams – sitting on top of the old foundation walls - will ensure a joint action of the reconstructed walls during seismic activity. Moreover, they will provide an adequate damp proofing against rising damp in the walls.

Some lower parts of the existing brick wall at the western side of the south wing will remain. At the horizontal transition between the existing wall and the new brickwork, copper sheets (20 gauge) will be installed to prevent the capillary rise of moisture in the structure. For longer wall portions, the copper sheets will be staggered by one brick course vertically. This will avert a weak horizontal joint that would otherwise be disadvantageous during seismic motion. The copper sheets will be joined with folded ends that will be pounded together.

At the second floor level, the timber joists will be connected to the outer timber cornice with galvanized steel angles. On top of the floor joists, one-inch thick water resistant plywood panels (4 ft. x 8 ft.) will be mounted with stainless steel screws. The panels have to be staggered in plan to create a stiff diaphragm that can brace the adjoining walls. In combination with the tight connection between floor joists and the cornice, the floor slab will help to stabilize the structure during the event of an earthquake and transfer the lateral loads evenly into the shear walls. To make use of the demolished brickwork, crushed bricks can be added to the mud bed on top of the plywood panels. To keep the traditional look of the ceiling, timber planking can be inserted between the joists and the plywood panels.

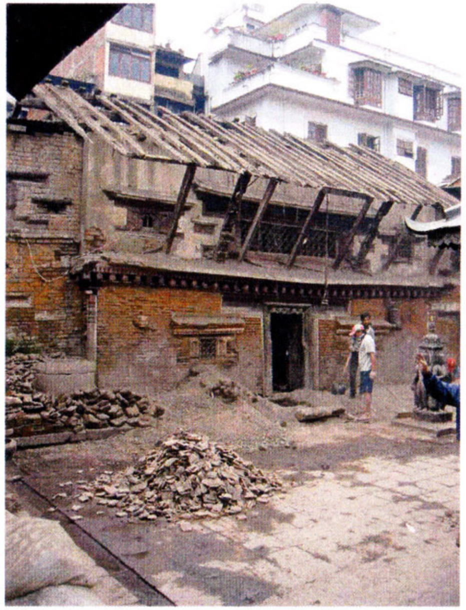
At the roof level, enhanced cohesiveness between the roof structure and the bearing walls will be introduced by keying the wall plates into the masonry. This will be achieved by stainless or galvanized steel pins (2 cm diameter with 30 cm embedment at every 100 cm on center). To further strengthen the loose and often weak traditional joinery (with timber peg connections), every fourth joists will be connected to the wall plate with a stainless steel bolt. Similarly, every fourth rafter will be connected to thepurlin with a stainless steel bolt. Also, every fourth pair of rafters will be joined at the top purlin in addition to the timber peg connection with a galvanized steel tie. The previously described roof connections will be staggered, so that one timber element is always – at one single, but shifting position – securely fixed to another element. This will combine an enhanced cohesiveness of the roof with a reasonable degree of flexibility and ductility in the joints. A controlled amount of flexibility, as provided by the traditional timber peg joints, is favorable, since it allows dissipating some of energy that is induced by a possible earthquake.

In the same manner as on the second floor level, water resistant plywood panels shall be mounted on top of the rafters and joists at the roof level. On top of the plywood panels, two layers of water-proof irrigation foil will be bonded to protect the roof structure from infiltrating water.

The roof struts will be attached to the purlin with a small stainless steel strap. This strap not only reduces the risk of dislodgement of the strut during seismic motion, but is also a precautionary measure against theft. At the bottom, the end grain of the timber strut will be protected against moisture by a thin bituminous sheet.

We think that the described interventions are a well balanced answer to both, the earthquake hazard the building is facing and the spirit of its traditional construction methods.

Patan, November 28th, 2002
Dipl. Ing. Matthias Beckh


1


2


3


4

5

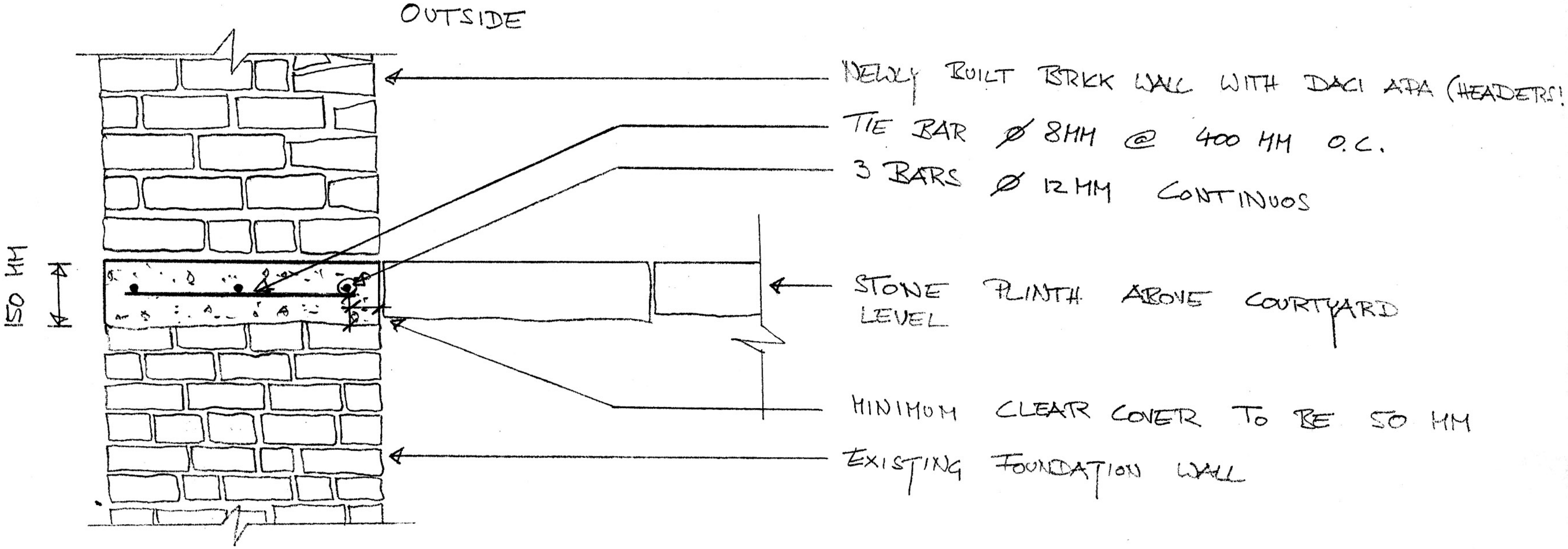
6

7

Photographs:

1) View without roof tiles and planking.
2) Western door of the south wing, seen from courtyard.
3) Excavated foundations inside.
4) Excavated foundations outside.
5) South wall of south wing.
6) Decayed joists at second floor level.
7) Rotten connection of rafters at the top purlin.

▷ HORIZONTAL RING BEAM AT FOUNDATION LEVEL

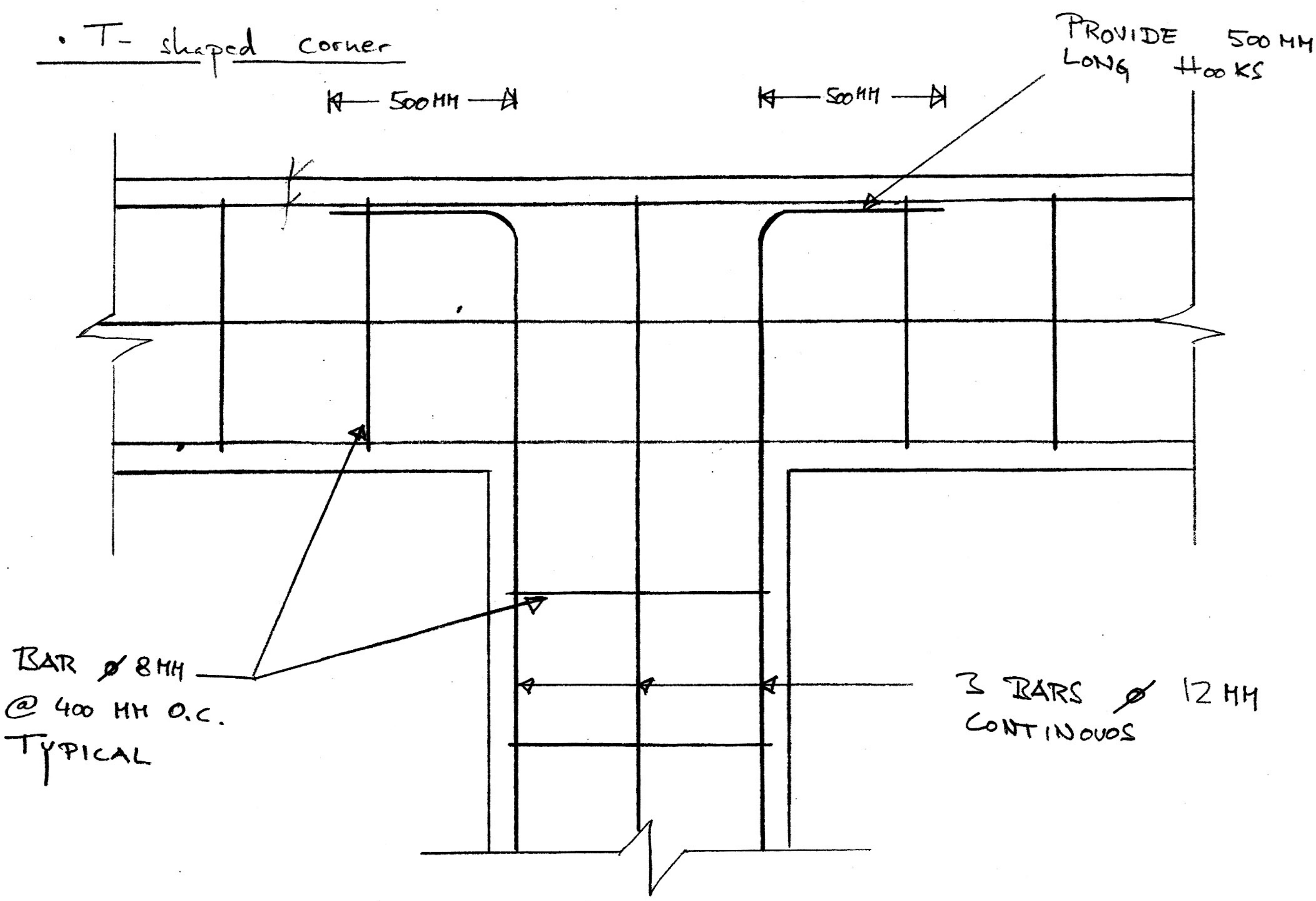


• COMMENTS :

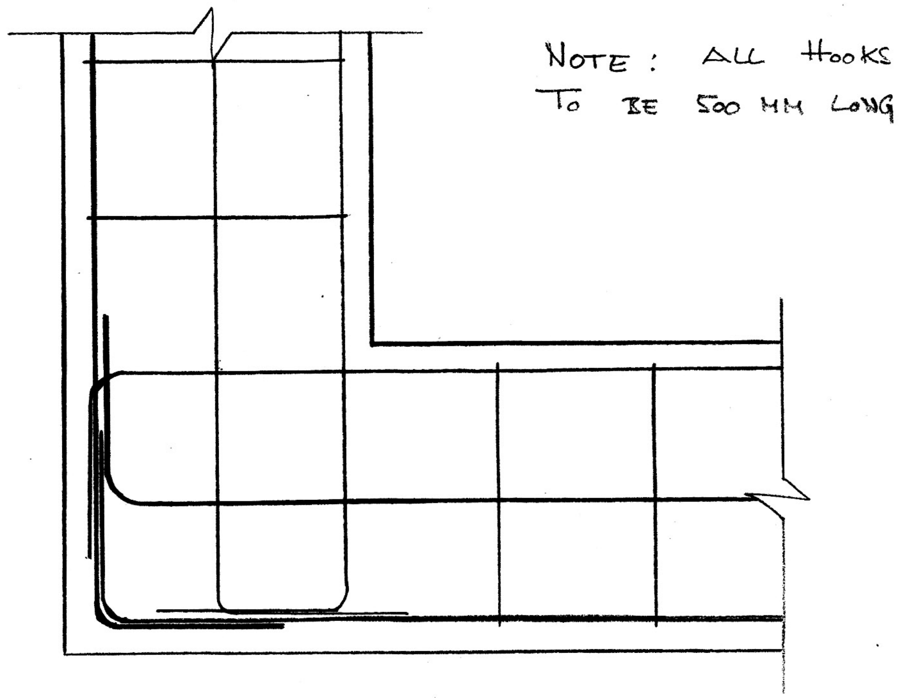
1) THE RING BEAM ACTS AS BOTH, DAMP PROOFING AND STRUCTURAL ELEMENT.
2) NOT TOO MUCH WATER SHOULD BE ADDED TO THE CONCRETE MIX, SO IT DOES NOT BECOME TOO SOUPY.
3) ADD WATER-PROOFING AGENT "SIKA" TO THE MIXTURE.
4) ENSURE CURING AND WATERING OF THE CONCRETE FOR AT LEAST 5 DAYS.

▷ Horizontal ring beam details :

- T- shaped corner

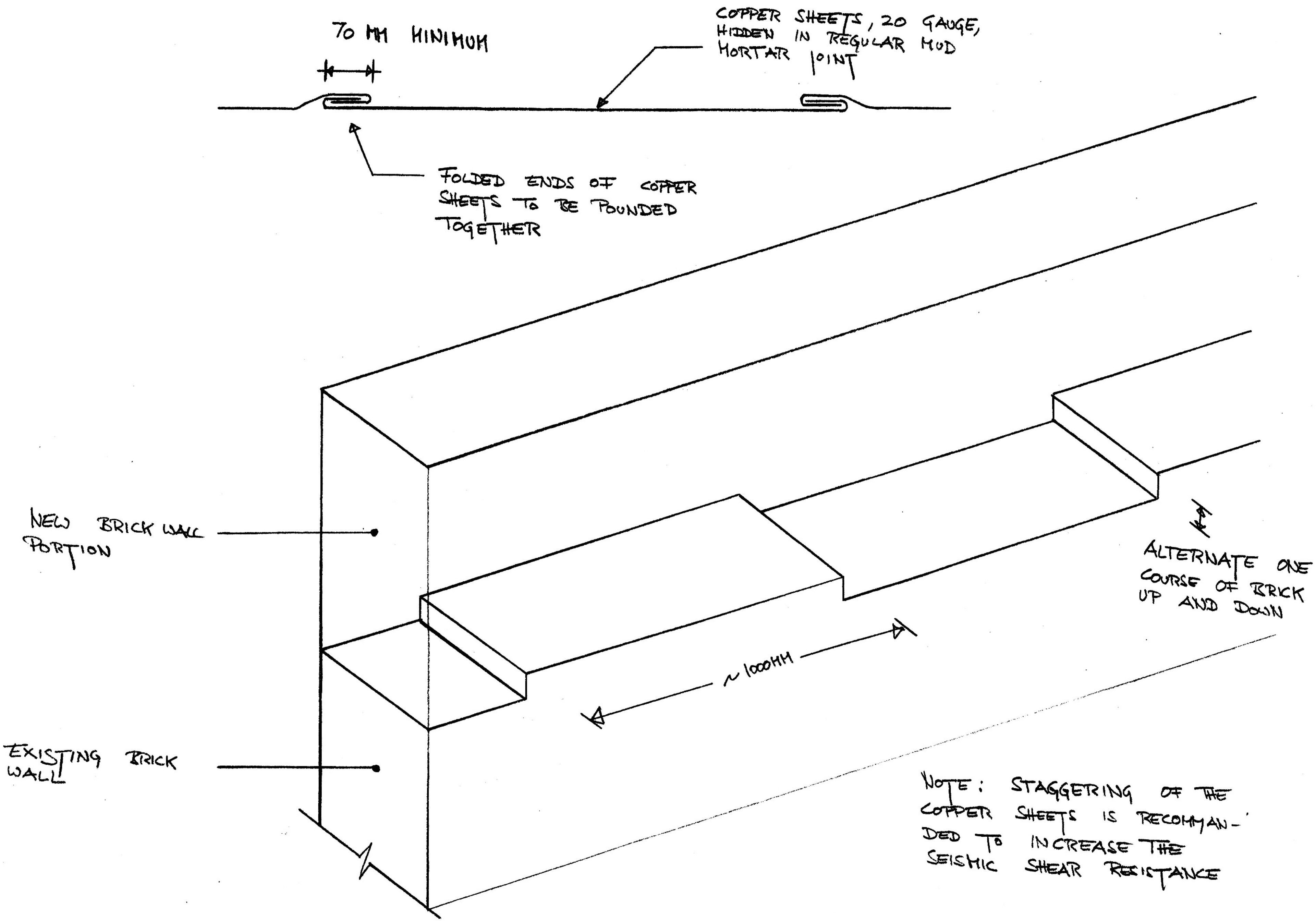


- NORMAL CORNER



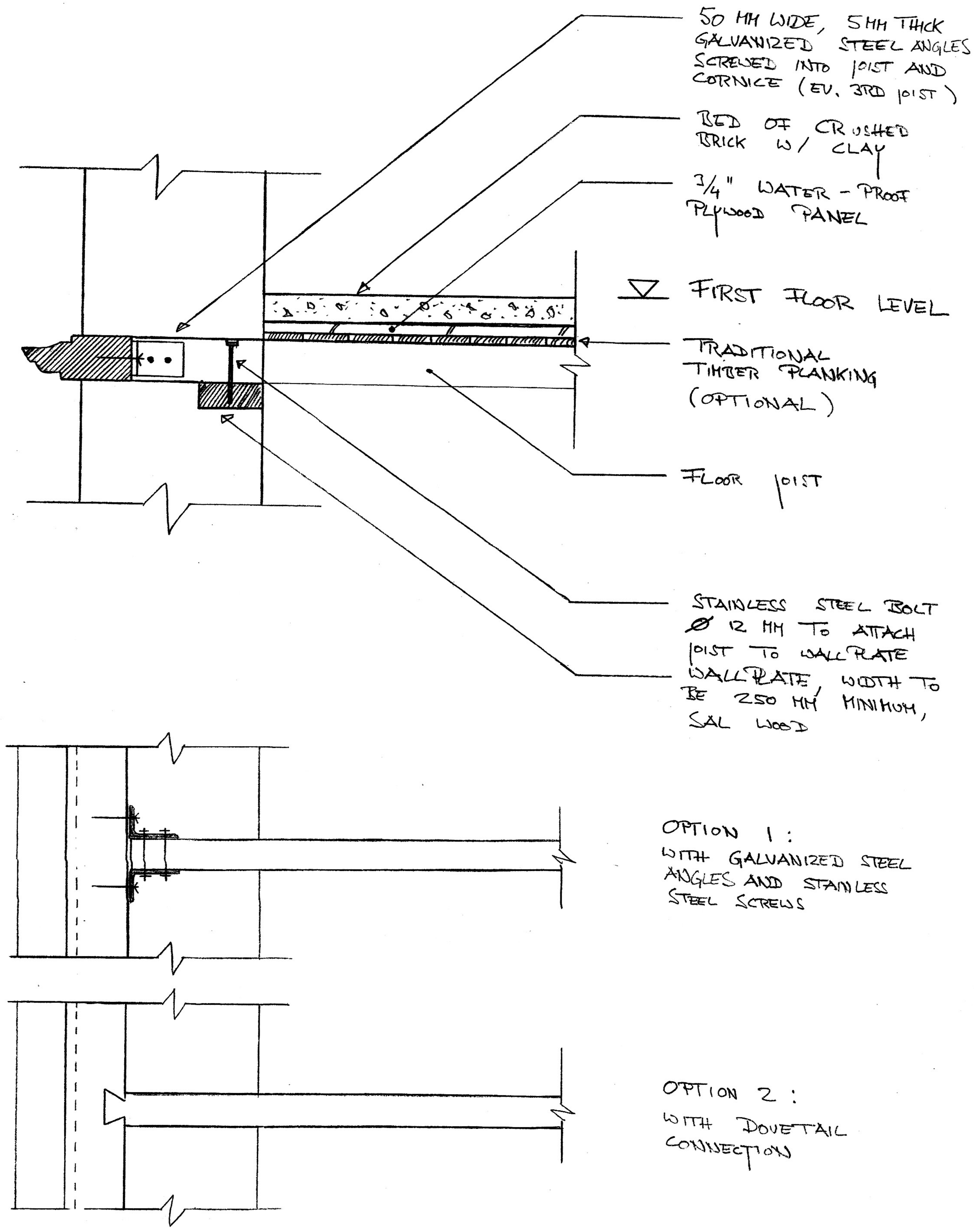
SCALE : 1/20

▷ HORIZONTAL WATER BARRIER WITH COPPER SHEETS



▷ Connection of 1st floor slab to bearing wall

SCALE : 1/20



▷ ROOF STRUCTURE

SCALE : 1/20