MANUAL FOR POST-EARTHQUAKE REBUILDING IN NEPALESE VALLEYS

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ASSOCIATION FRANCAISE DU GENIE PARASISMIQUE FRENCH ASSOCIATION FOR EARTHQUAKE ENGINEERING

www.facebook.com/rebuildingnepal http://afps-seisme.org "Earthquakes don't kill people... Improperly design buildings do !"

When the shaking from the Himalayan earthquake occurred just before noon on April 25, most of the victims were within buildings hastily constructed and poorly built.



This earthquake may have caught Nepal by off guard, but that doesn't mean it came as a surprise. In fact Nepal is located on a well-known tectonic plate boundary where Indian Plate goes beneath Asia forming the Himalayan mountain range. This plate collision gives raise to frequent earthquakes, some of them being particularly strong with return period of few centuries.

And the resulting devastation came as no surprise, because buildings in cities and in villages of high Nepalese valleys are not constructed to stand up to a quake.

Since it's impossible to predict an earthquake with reliability, the most efficient preventive action is to (re) build with earthquake-resistant principles.



This pedagogic document, prepared by the French Association for Earthquake Engineering, aims at applying these simple but efficient earthquake resistant principles to one storey traditional houses in Nepalese valley villages using available materials at those isolated places.

Thierry WINTER and colleagues who worked on this guide









AFTER QUAKE

EFFECTS OF EARTHQUAKE ON MASONRY BUILDINGS (BRICKS, RUBBLE STONES)



Total collapse

The main damages of masonry buildings under earthquake are in particular : - The failure of the junctions between wall elements with the separation's walls and walls at the corner of masonry buildings - Bulging delamination and collapse of stone masonry buildings.

If the walls are not connected at

at the junctions and the walls could

their own junctions and with the roof, cracks appears

collapse under earthquake.



Stone wall delamination with buckled walls



Gable collapse (no reinforcement vertical and horizontal band between walls)

Walls going out of plumb (bad connection between roof and walls)

Collapse of large part of wall in the middle long walls or delamination (No lateral connections)



Collapse of corner (no reinforcement band between walls)

For a good seismic behavior and avoid the collapse, make a monolith building as a gift package



Don't do it !

Do it !

Well design buildings

Do not stack buildings.

NO !

No piles for accommodating slope.

NO !

Preparation of horizontal platforms

EVACUATION OF RAINWATERS

How to build earthquake-resistant TRADITIONAL STONE HOUSE (ONE STOREY) ?

Seismic resistant layout

Fundamental ratios between wall thickness, maximum length, width and height of the walls must be respected.

- a. Wall thickness (e) greater than 40 cm [40"].
- b. Wall width (W) lower than half of wall length (L).
- c. Maximum wall height lower than 6 times the wall thickness.
- d. Maximum sub-length between cross-walls lower than 10 times the wall thickness and lower than 3 m [10'].
- e. Wall length greater than 1.2 m [4'] must be preserved on each side from door and windows.
- f. Window and door width lower than 1.2 m [4'].

An example is given L on the drawing

Building materials

WALLS IN RUBBLE STONES WITH MUD MORTAR

Detail of seismic bands with WOOD

Connection between transverse walls

Connection between transverse walls

TIMBER ROOF

TIMBER ROOF

ROOF IRON PANEL

Minimum tools required

5.

4.

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8.

7.

2.

For the platforms preparation and excavations : 1, 2, 3 For the construction : 4, 5, 6, 7, 8

6.

3.

CONSTRUCTION ABOVE FOUNDATIONS AND PLINTH SEISMIC BAND

Place 60 cm [24"], 40 cm [16"] and 30 cm [12"] long bags on the lower part of the plinth seismic band in order to reach a global horizontal plane above the seismic band as shown on the drawing.

Place 60 cm [24"] long bags at the base of the vertical poles up to the height of the plinth seismic band.

CONSTRUCTION OF WALLS

1st bag layer

Complete the 1st layer by respecting the distribution of various bag sizes (colors). Do not forget the internal and outer strengthening along vertical poles.

Watch out ! Bag tongues pass over the "full" bags. Crash the peaks of cut bamboo cut across upper tongues and lower bags for linking filled bags.

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1

4

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1st bag layer seen from above

Construction of walls

Next bag layers

Layers 8, 12 and 16 similar to the forth layer

LINTEL SEISMIC BAND IMPLEMENTATION

As previously mentioned, seismic bands hold the walls together and ensure integral Box action. As for the plinth band (plate 35), this lintel seismic band is made of double bamboo, 10 cm [4"] in diameter, at the top of each wall. Start with two opposite walls.

Placing of the flue

Attention not to leave the flue against PVC bags: keep it away using with stones or/and clay.

$C \, \text{onstruction} \,$ of walls

$C \, \text{onstruction} \, \text{of walls}$ and connections for roof

INFILL THE SPACE BETWEEN BAMBOO WITH SMALL STONES AND MUD MORTAR

Before placing the seismic band bamboo on the two other opposite walls, arrange 30 cm [12"], 40 cm [16"] and 60 cm [24"] long bags on the top of the walls similarly to first bag layer (as shown on the drawing).

$C_{\mbox{ONSTRUCTION}}$ of walls and connections for roof

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2.55 m

8'4"

V

2.40 m

[8]

BAG LAYERS ABOVE THE LINTEL SEISMIC BAND

2.75 m

[9]

2.90 m 🔺

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[10'7"]

Place bags up to 10 cm [4"] from the top of poles. Respect the same arrangement than for first, then second, then third, then forth layers.

Lay down the 4 (or plus) wood purlins lintels (according to snow effects): be care that the two central one are located at the center beneath the overlapping of the galvanized metallic panels. Place the roof framework

with straw.

CONSTRUCTION of roof

Fix the galvanized metallic panels to the wood purlins by means of 8 nails by metallic panels, 4 at the top and 4 the base of the metallic panel overlapping.

ROOF IMPLEMENTATION

Stones are added stabilize roof against wind.

Insulate the roof with wisps of straw and fix them with rope set on the wood purlins.

ROOF STABILIZATION

INSULATION OF THE ROOF

Prepared by

1. Earthquake-resistant traditional buildings

Marc BOUCHON : AFPS Expert (Civil Engineer) Youssef JARADEH : ARCADIS Expert (Civil Engineer) – AFPS member Caterina NEGULESCU : BRGM Expert (Civil Engineer) – AFPS member Jean PICCHIOTTINO : AFPS Expert (Civil Engineer)

2. EARTHQUAKE-RESISTANT BAG-BUILDINGS

Eric PASQUIER : Head of the Société d'Aménagement de la Savoie and « Soutiens d'Avenirs » (NGO) president Georges RENAUD : CEO of STEBAT group (Civil Engineer) Pierre RIEGEL : Head of EQUATERRE (Engineering Geologist)

3. Network diffusion

Samuel AUCLAIR : BRGM Engineer (Seismologist) – AFPS member Ghislaine VERRHIEST : Ecology French Ministry (Risk Expert) – AFPS member Richard GUILLANDE : SIGNALERT CEO – AFPS member

4. Drawings and final design

Marie Gabrielle BERLAND : Independent worker – www.mgberland.com

5. Global conception and coordination

Thierry WINTER : BRGM Public Policy Deputy Director (Natural risk expert) AFPS member