Well built **STONE** houses can better withstand earthquakes. Here are **10 TIPS ON HOW TO BUILD BACK SAFER**

1. **GET TECHNICAL ADVICE BEFORE YOU START**

2. **BAND YOUR HOUSE TOGETHER**

3. **TIE YOUR HOUSE TOGETHER WITH TIESTONES**

4. **BUILD YOUR HOUSE WITH GOOD MATERIALS**

5. **TIE YOUR GABLES UP**

6. **TIE YOUR ROOF DOWN**

7. **TIE YOUR FLOORS TO YOUR WALLS**

8. **BUILD A STRONG SHAPE**

9. **HAVE A SAFE SITE AND ESCAPE ROUTE**

10. **BUILD ON STRONG FOUNDATIONS**
#1: Get Technical Advice Before You Start

The recommendations provided in this leaflet/poster should help you to build back safer than before in stone.

1. You can build a house out of many different materials such as stone, bricks, timber or concrete, but the most important thing is that you know how to use the materials properly or find a mason to build the house who does. A badly built house in any material can be dangerous!

2. These messages are based on what made houses fall down and why some stone houses stood up. They are not intended as a substitute for training but just to help explain basic principles of strong stone houses.

3. It is important to register your damaged home with the local authorities before you begin rebuilding, and speak to them about building permits and how you can follow the building codes.

4. The government is planning a major reconstruction assistance program which will include training in earthquake resilient construction methods.

5. Ensure you or masons helping you build your house are trained in earthquake resilient construction methods.

6. If you have any questions seek technical assistance from a trained mason or your local authority.

7. These tips are only as general guidance for small traditional houses made from stone, if you are building bigger buildings or using other materials there are many other things you must consider! Get technical advice, use trained masons, use a trained engineer, and build back safer!
#2: BAND YOUR HOUSE TOGETHER

Banding prevents your walls from being pulled or pushed apart.

PROVIDE STRONG BAND CONNECTIONS

Some bands failed because of weak connections.

PROVIDING BANDS IS ESSENTIAL

Provide as many bands as you can

Building code compliant

1. Top of wall band
2. Floor plate band
3. Window and door lintel band
4. Window sill band
5. Bottom of wall band

ENSURE BAND CONTINUITY

It’s important to make strong connections at band corners, band intersections, and where bands intersect door openings.

USE STRONG MATERIALS FOR BANDING

Reinforced concrete band
Timber band
Bamboo band (Strips with skin removed)
#3: TIE YOUR HOUSE TOGETHER WITH TIESTONES

Tiestones (including throughstones and cornerstones) hold your walls together and reduce the risk of walls collapsing or peeling apart.

**Cornerstones**
Cornerstones strengthen your walls and help reduce the risk of corner collapse. Use them on every corner in your building.

**Tiestone Materials**
Choose strong materials for use as tiestones.

- Select long flat stones for use as tiestones. Shape stones with a tool if needed.
- Reinforced concrete tie
- Timber dowel tie

**Throughstones**
Throughstones help prevent your walls from peeling apart.

- Carefully select long and flat throughstones. Make sure they span the thickness of the wall.
- Use throughstones at a maximum 2 foot vertical and horizontal spacing.

**Tiestones at Walls**
Tie your walls together, otherwise they can easily collapse.

KEY MESSAGE
NUMBER #3 OF 10
VERSION 3 - 25/NOV/2015
#4: BUILD YOUR HOUSE WITH GOOD MATERIALS
Some houses fell down because poor quality materials were used. Using good materials in the right way is essential for a strong house.

STONE SELECTION
Select large rectangular stones if possible. Do not use round stones. Stones should be made rectangular.

If using stones from your demolished house, clean any mortar from them.

STONE USAGE
Small stones and mud between your outer and inner wall can push your walls apart in an earthquake. Instead use well stacked larger stones between your inner and outer wall.

MORTAR
Whether you use cement mortar or mud it is important to have the stones touching as much as possible. Rub the stones until they touch and minimise the gap/space between the stones as much as possible. The gap/space should be completely filled with mortar.

Mud Mortar
It's important to use good quality mud, free of Gravel. Mud should be thoroughly kneaded with water to make it similar to roti dough. Adding an amount of lime or cement or additional fibres for example cow / buffalo dung / hemp will make it stronger. Mix any additives thoroughly.

Cement Mortar Mix #1
Be careful! Cement mortar is not always safer if you don’t know how to use it.

1 Part Cement
6 Parts Sand

Cement Mortar Mix #2

1 Part Cement
2 Parts Lime
9 Parts Sand

Large stones, no overlap
Small stones
Large stones, long overlap

The larger the stones you use and the more they overlap the better.
#5: TIE YOUR GABLES UP

Many gables fell down. Making gable materials lighter and fixing them to the roof structure can make them safer.

**FIX YOUR GABLE TO THE ROOF STRUCTURE**

Not tied

All gables should be tied to the roof and walls.

**USE LIGHTER GABLES**

Heavier  Lighter

Stone  Timber  CGI

Bricks

Lighter gables will attract less force in an earthquake.

**USE END RAFTERS**

**WINDOW OPENINGS**

Any openings should be banded on all sides.
#6: Tie Your Roof Down
Some houses fell down because the roof collapsed pushing the walls apart.

**Use Lighter Materials**
- Stone tiles
- Concrete tiles
- Clay tiles
- Wood
- Thatched mud
- CGI

Heavy / Worse → Lighter / Better

**Use Strong Roof Connections**
- Use a wall plate at the top of your walls and firmly tie your roof to it. Make sure your roofing material is connected well to frame. Using nails, rope or wire, make sure your rafters have a strong connection with the ridge beam.
- Roof and wall plate connection #1
- Roof and wall plate connection #2
- Roof and wall plate connection #1 perspective
- Ridge beam and rafter connection

**Brace Your Roof**
- Your roof is like the top of a box, a stiffer roof will give you a stronger house.
- Collar tie
- Cross bracing of rafters
#7: Tie your floors to your walls

Strong floors with strong connections to the walls on all four sides can help stop your walls falling down in an earthquake.

Connect your floors to all your walls

It is important to have a strong connection between your floors and walls.

Strong floor

The stronger your floor, the stronger your house. Use nails, tie wire, rope or dowels.

No nails, tie wire or dowels

2 nails, diagonal

Nail sizes

Wooden floor joists over timber band

Wooden floor joists over concrete band

Strong connections between posts and floors

KEY MESSAGE
NUMBER #7 OF 10
VERSION 3 - 25/NOV/2015
#8 : BUILD A STRONG SHAPE
The shape of your house and the design and construction of your walls are important for a stronger house.

SHAPE
Use a regular shape that is not too narrow. L and U shapes will twist during earthquakes.

HEIGHT
Don’t build more than 2 storeys plus an attic when using stone. If you want to build a taller building you need to get technical advice. Floor to floor height should not exceed 9’10”.

DOOR AND WINDOW OPENINGS
Large openings weaken a wall. Place openings away from corners and leave at least 3ft gap from corners and between openings.

LONG WALLS NEED SUPPORT
For a longer house use regular wall supports or buttresses. It is important to build any internal walls from the same strong material and thickness as your outer walls.
#9: HAVE A SAFE SITE AND ESCAPE ROUTE
Choose a safe location for your house. Even if you can’t choose there are still things you can do.

**CHOOSE A SAFE SITE**
Avoid flood prone areas, like the bottom of valleys or near river beds.

Don’t build on steep slopes. Look for landslide signs (cracks, fallen trees)

Remove damaged buildings first.

**MAKE YOUR SITE SAFER**
Ensure proper water drainage of the site.

**POSITIVE YOUR HOUSE SAFELY**
Keep a safe distance between your house and slopes or cliffs.

**HAVE AN ESCAPE PLAN**
Ensure safe escape for everybody from the site. Have a preparedness plan, which includes all occupants and family members.
#10: BUILD ON STRONG FOUNDATIONS

A house is stronger if it is built on strong foundations.

PLINTH BAND

Plinth bands add strength to the footings. Plinth bands must be continuous.

DIG TO FIRM GROUND

Foundations should be minimum 2’6” deep. For soft ground you may have to dig deeper to reach firm soil.

THE RATIO IS IMPORTANT

The foundation should be as deep as it is wide.

TIESTONES

Tiestones are just as essential in the foundation as they are in the wall above.