A Proposal of Seismic Isolation Suitable for Developing Countries

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Housing in Developing Countries

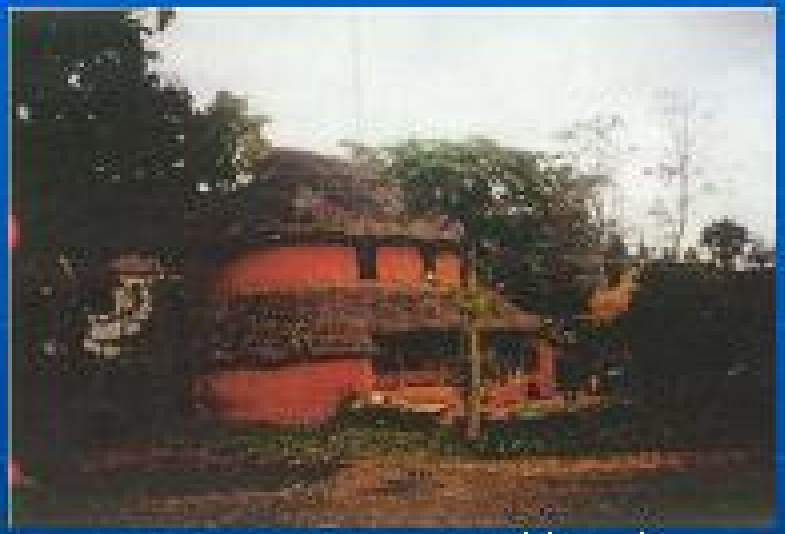
Three typical buildings in Urban Nepal

Brick with Cement mortar

Column-Beam system with Brick Infill

Traditional house with Brick and Mud-mortar, Tile roof

Typical rural buildings



Nepal

Figure 5 (b): A historical three story building, with single room at each floor, well standing the past seismic events.

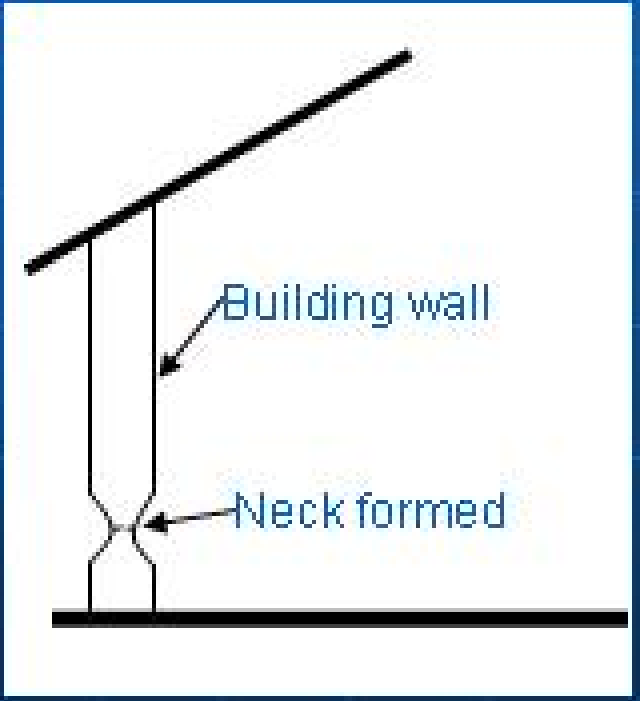
Pakistan

Stone Oval shaped house in Rural Nepal
One room Stone house in Pakistan

Source: World Housing Encyclopedia
http://www.world-housing.net/index.asp

Base Isolation for low cost buildings (?)

- Li (1984): April 13, 1960 earthquake in Tuqiato Village, Jilin Province, Northern China
- Most houses collapsed, one survived
  - Neck in the root of the wall because of weathering
  - Natural base isolation: Upper part of the house slided



Application on Masonry Buildings

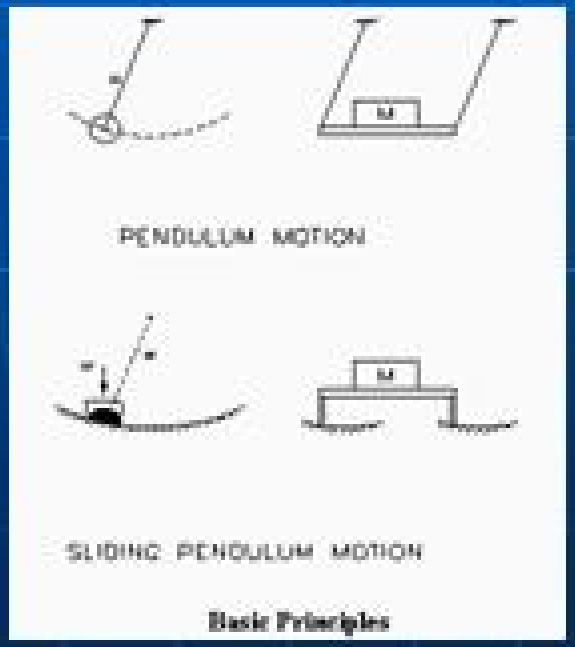
Demonstration Project
Killari School Building, India

Lessons Learned Over Time: Learning from Earthquake Series, II EERI, 1999

Application in Masonry Buildings

- Friction Pendulum Syste
  - Court of Appeals, San Francisco

Installed Bearing



Basic Principles

Bearing Components

Earthquake Protection Systems, Inc, California

Friction System Base Isolation

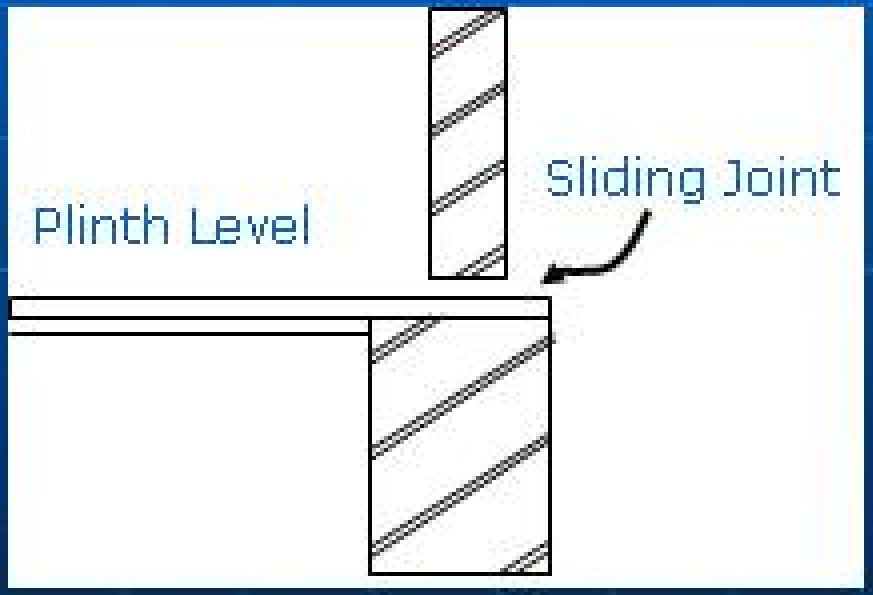
- Flexible layer and energy dissipation in single system
- Robust
  - Insensitive to frequency variation
  - Insensitive to amplitude variation in input excitation
- Large sliding
- Residual displacement

Friction System Base Isolation

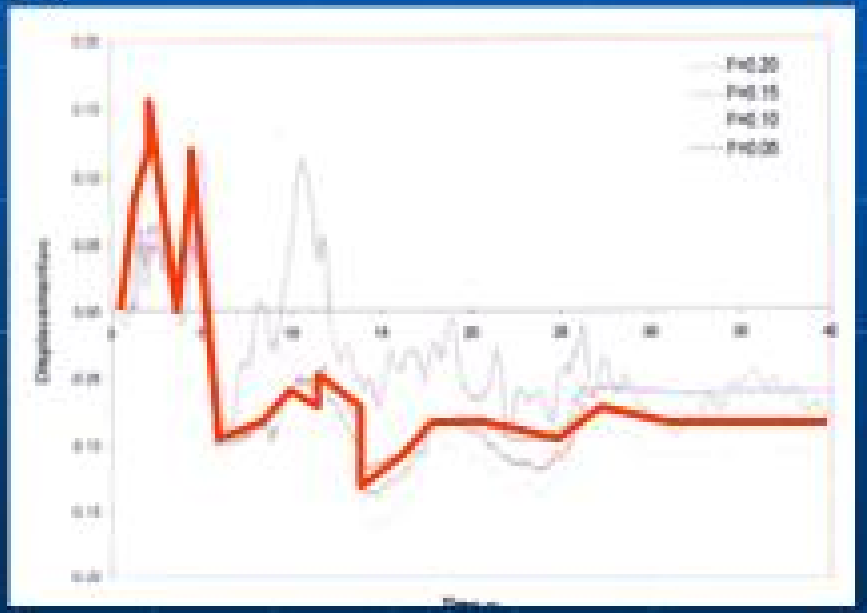
- 20-30 cm thick brick masonry wall (Unreinforced)
- Wood diaphragm at floor level
- Sliding type of base Isolation
  - Smooth surface at plinth level
  - Sand grain (crushing strength is important)
  - Another layer of smooth surface
  - Super structure

Application of Isolation System

Traditional (historical) masonry building
Modeled and analyzed by simplified model
Sliding type isolation was used

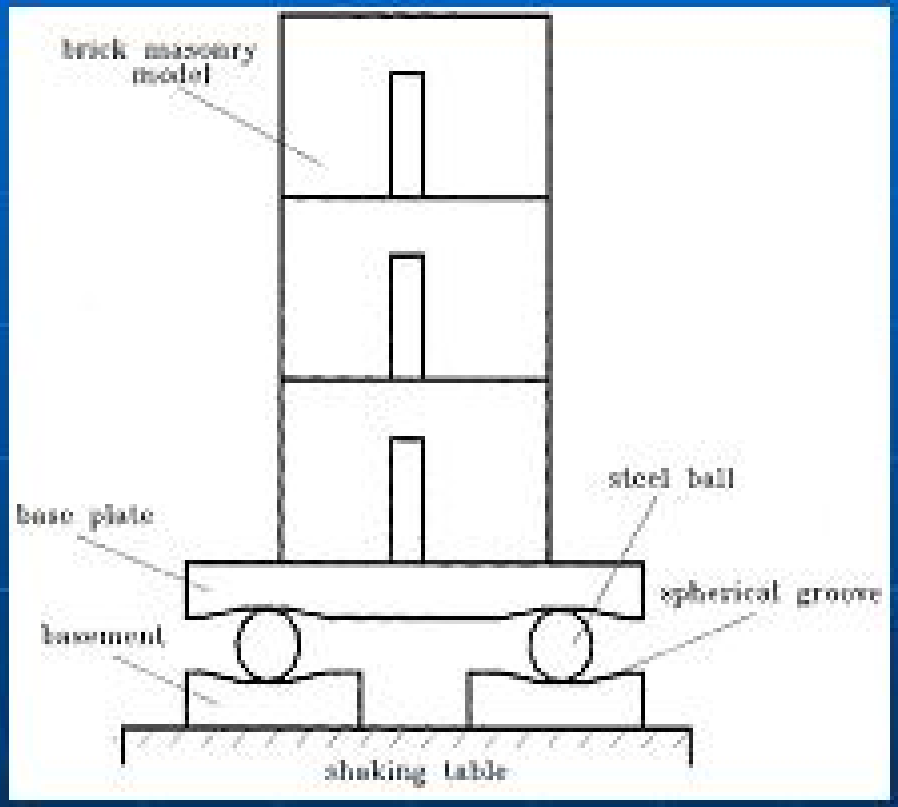


Schematic Diagram



Residual displacement from the Analytical Model

Base Isolation by Ball Systems



Transmissibility Ratio

Fixed base : 1.54

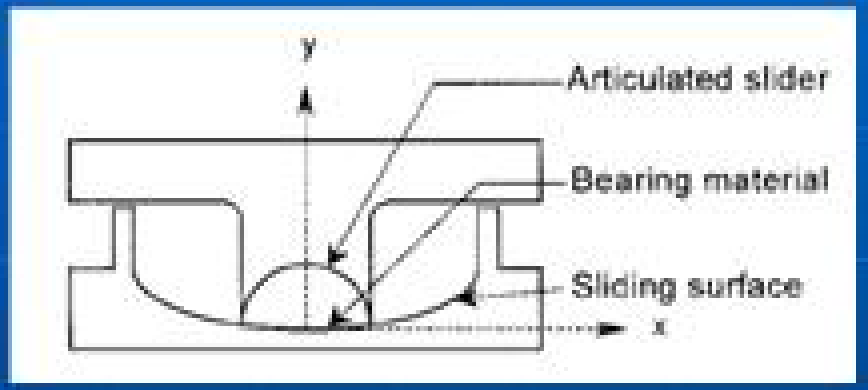
Base Isolation : 0.50

Qiang et. Al., 1998, EE & SD

Base Isolation by Ball System with Restoring Facility

Variable Frequency Pendulum Isolator

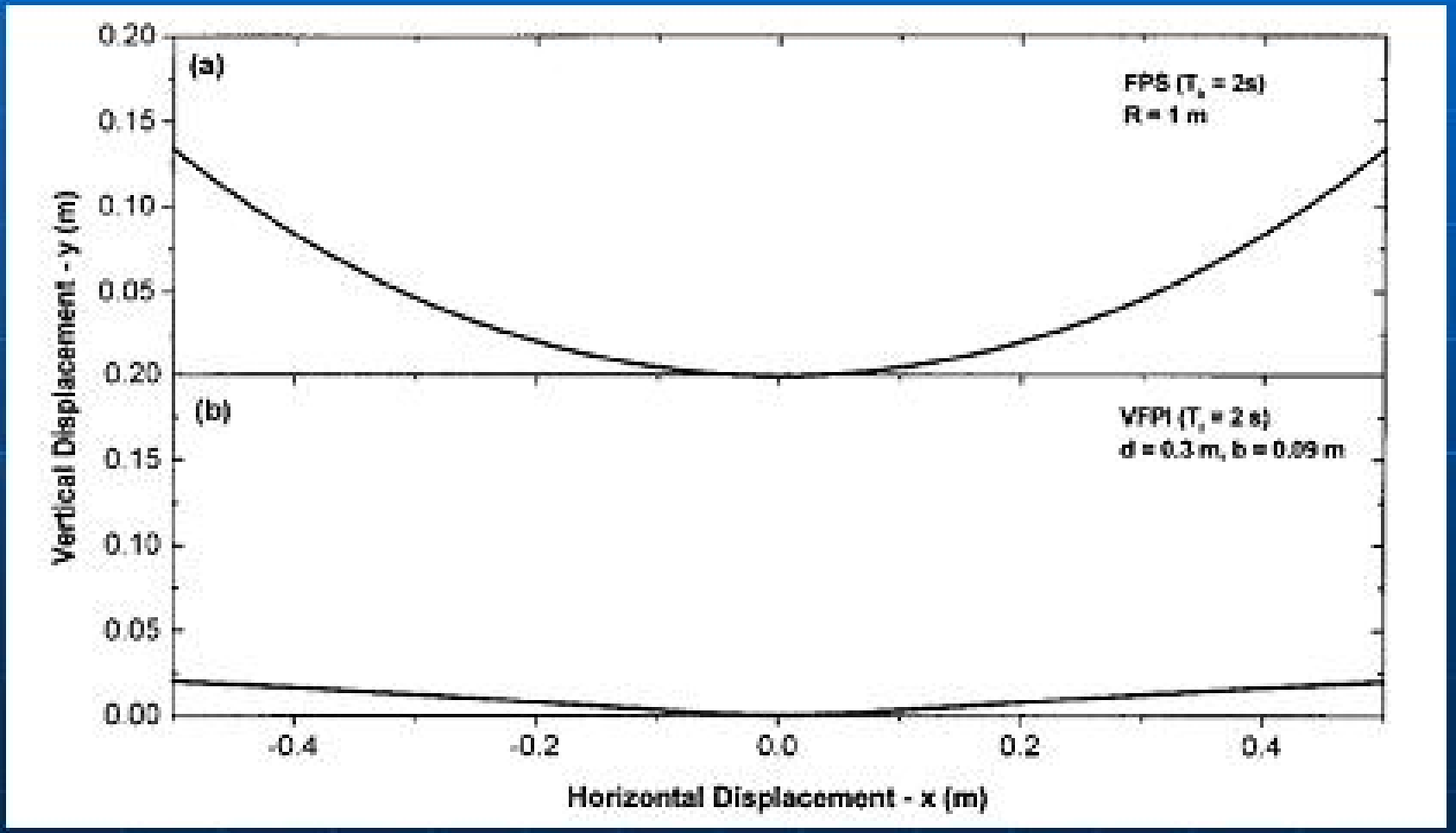
- Curved sliding surface
- progressive period shift at different response levels
- Advantages of both the pure friction (PF) isolation system and FPS



Schematic diagram of curved sliding-surface isolator.

Pranesh et. al. 2000

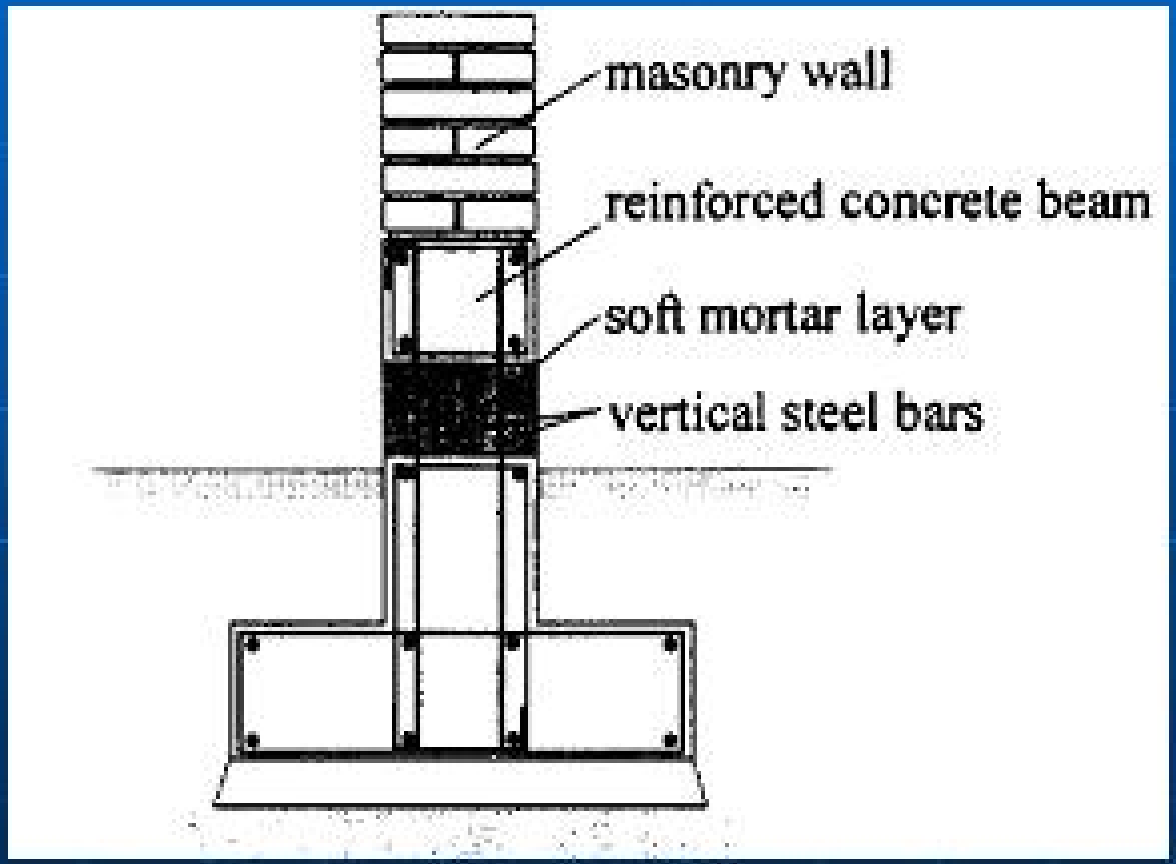
Curved surface instead of plain



Consideration for base isolation

- Cost
  - How much increase in cost is acceptable?
  - Low maintenance cost
- **Technically simple**
  - Semi-skilled and locally trained people should be able to implement
- **Locally available materials**
- **Durable**
  - No change during life time of building

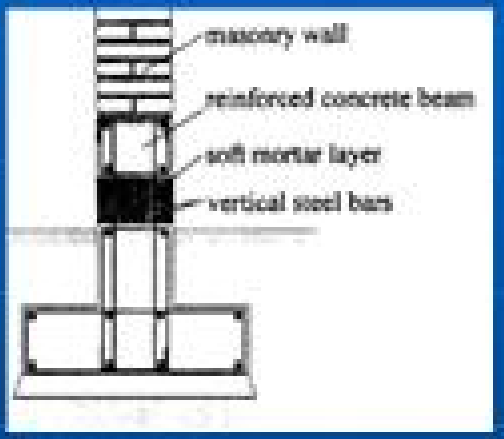
Distributed base isolation system



Chiostrini et al. 2001

Distributed base isolation

- A reinforced concrete beam stays on the mortar layer to form a stiff base for the masonry walls of the first story level.
- The mortar layer is reinforced by a series of vertical bars of mild steel, anchored to the cast-concrete foundation and to the building's base wall.
- A further layer of elastomeric waterproof can be used



Chiostrini et al. 2001

Conclusions

- Low cost base isolation is achievable
- Instead of installation of new system, focus should be on adjustment of existing construction technology
- Separation of super-structure with foundation with restriction in displacement is good alternative
- Various techniques like distributed base isolation and VFPI should be explored for their real field behavior and construction feasibility

THANK YOU