



# Seismic Provisions in Building Code of Pakistan

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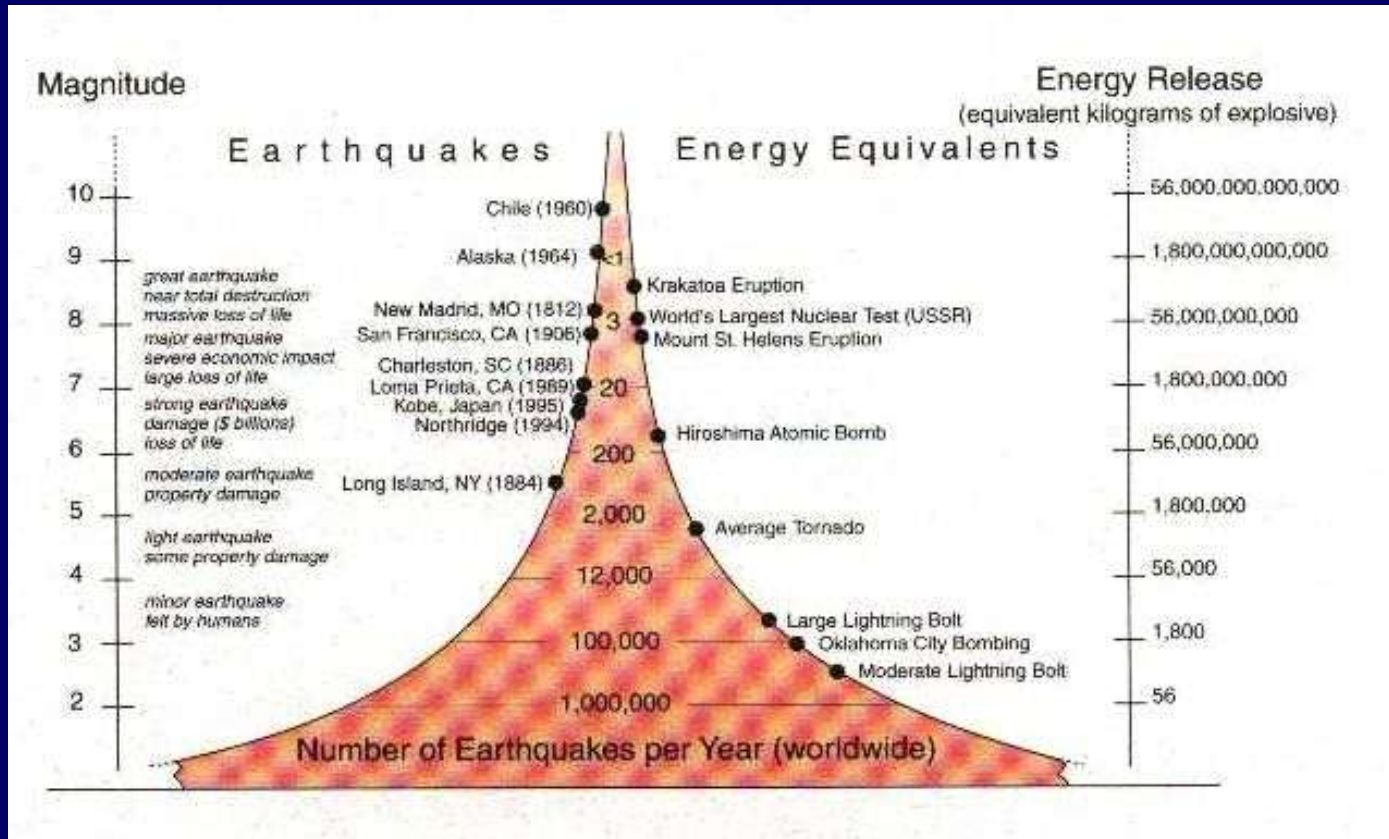
# Topics

- Introduction
- Earthquake Design Philosophy
- BCP Special Provisions for Seismic Design of RC structures
- Special Provisions for Seismic Design of Masonry Structures



# Introduction

- Earthquake Occurrence



# Introduction

- Displacement due to Earthquake

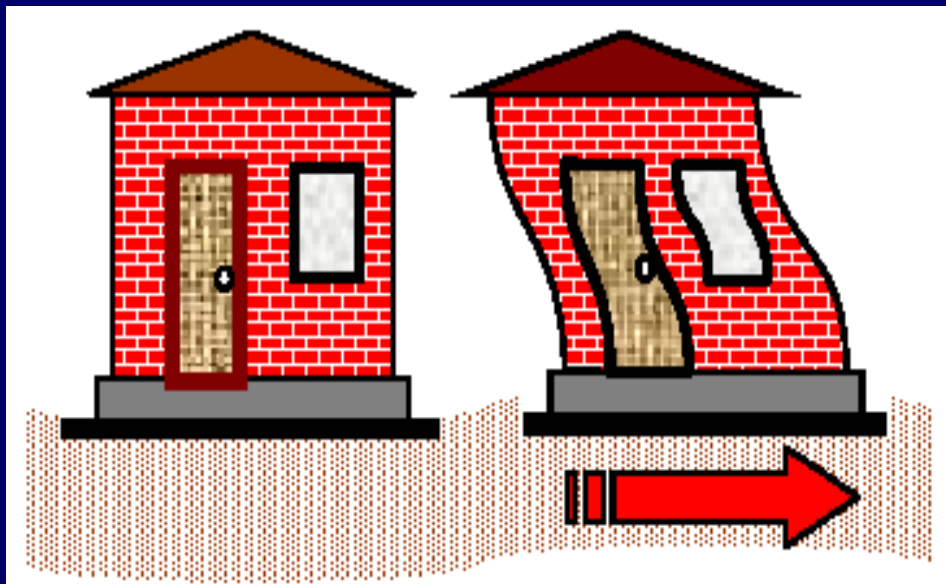


Figure 1: Effect of Inertia in a building when shaken at its base

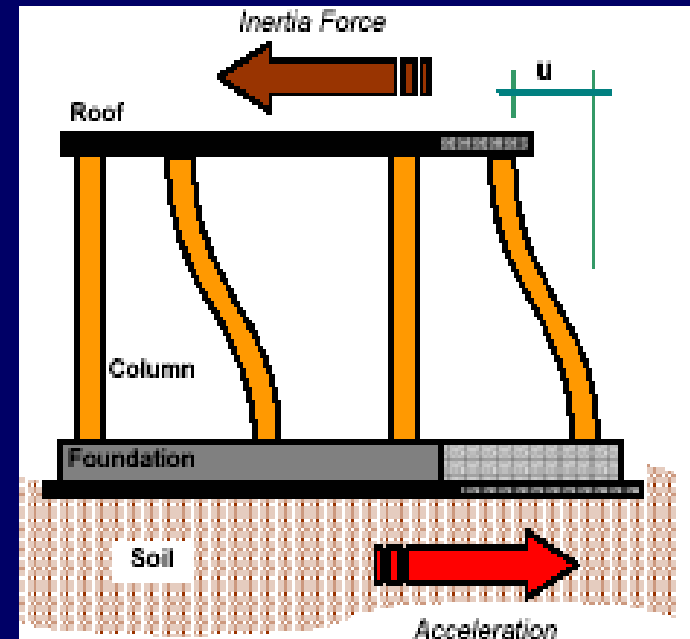


Figure 2: Inertia force and relative motion within a building



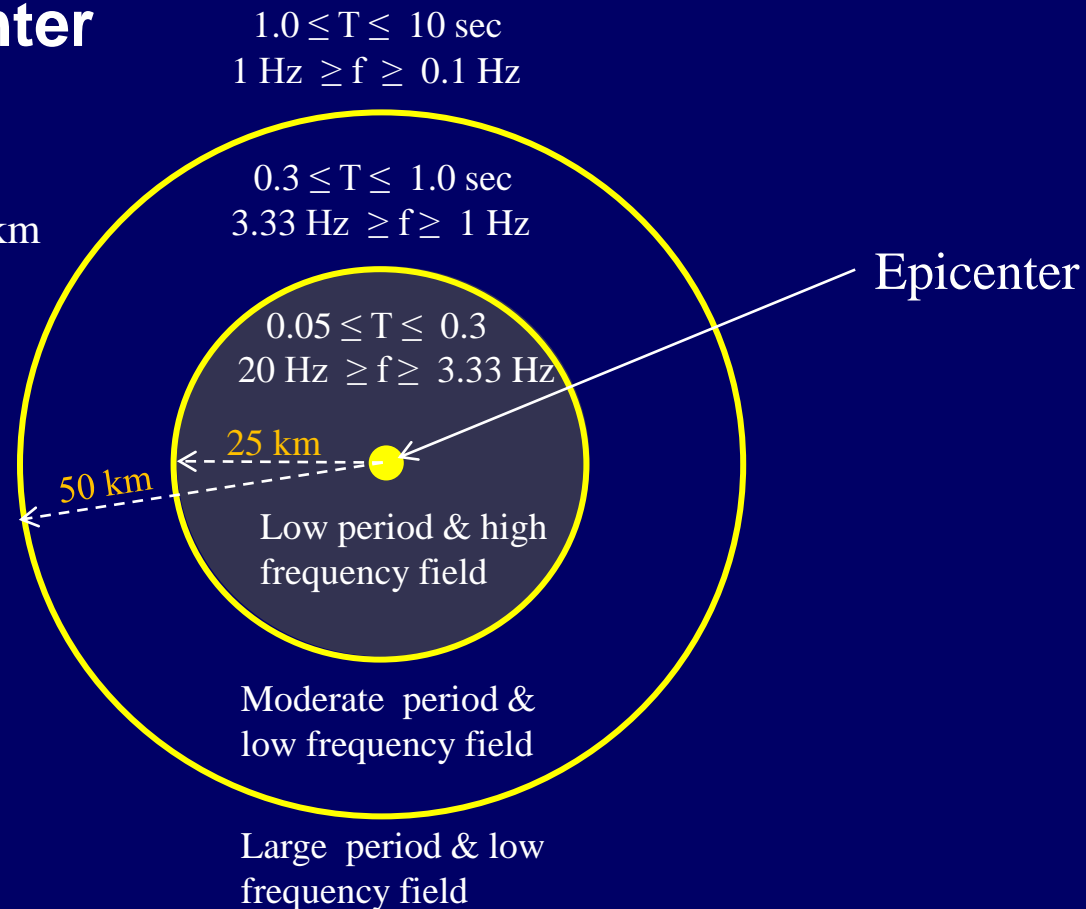
# Introduction

- Earthquake characteristics with respect to distance from epicenter

Near Field: 0 to 25 km

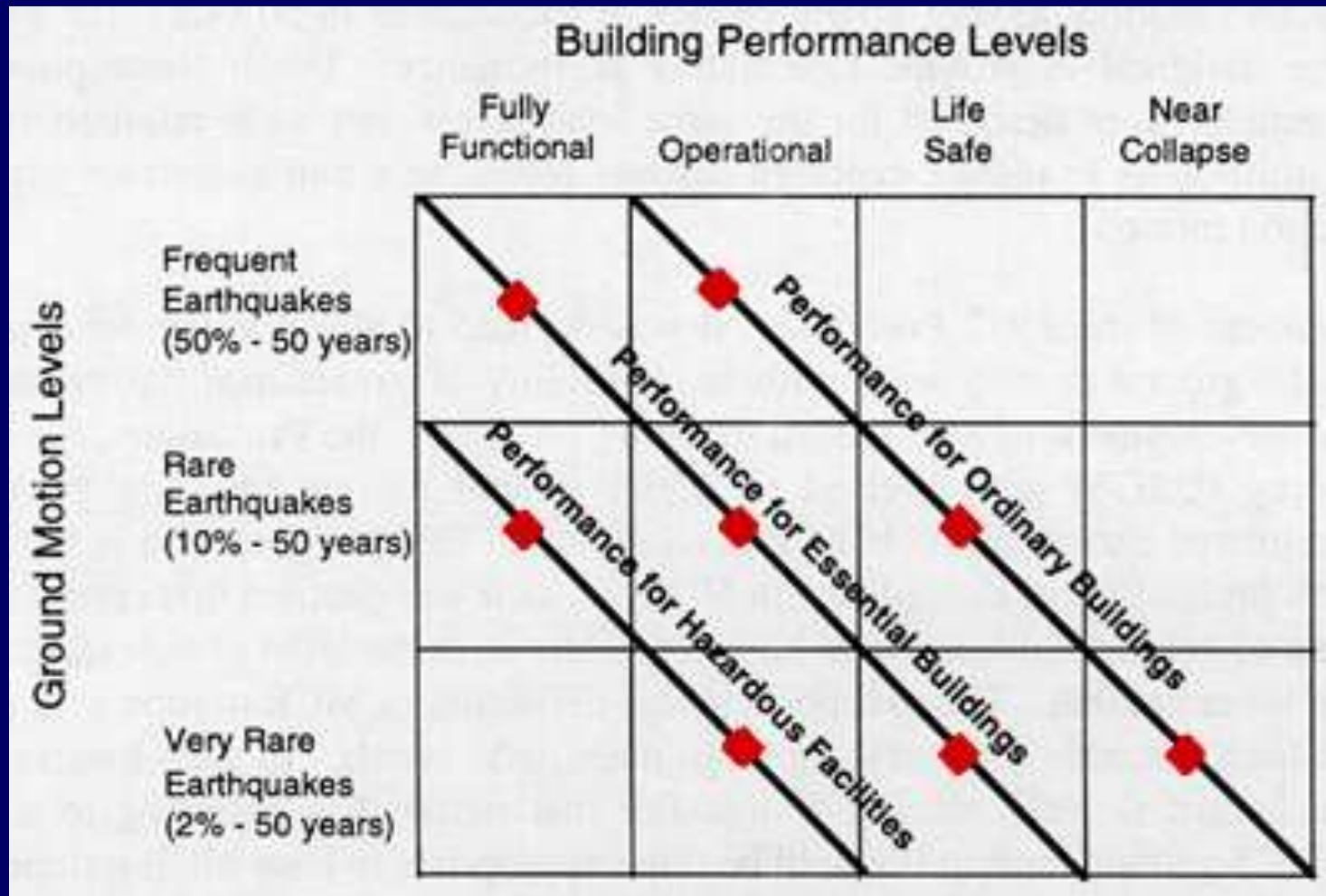
Intermediate Field: 25 to 50 km

Far Field: Beyond 50 km





# Earthquake Design Philosophy





# RC shake table test Japan

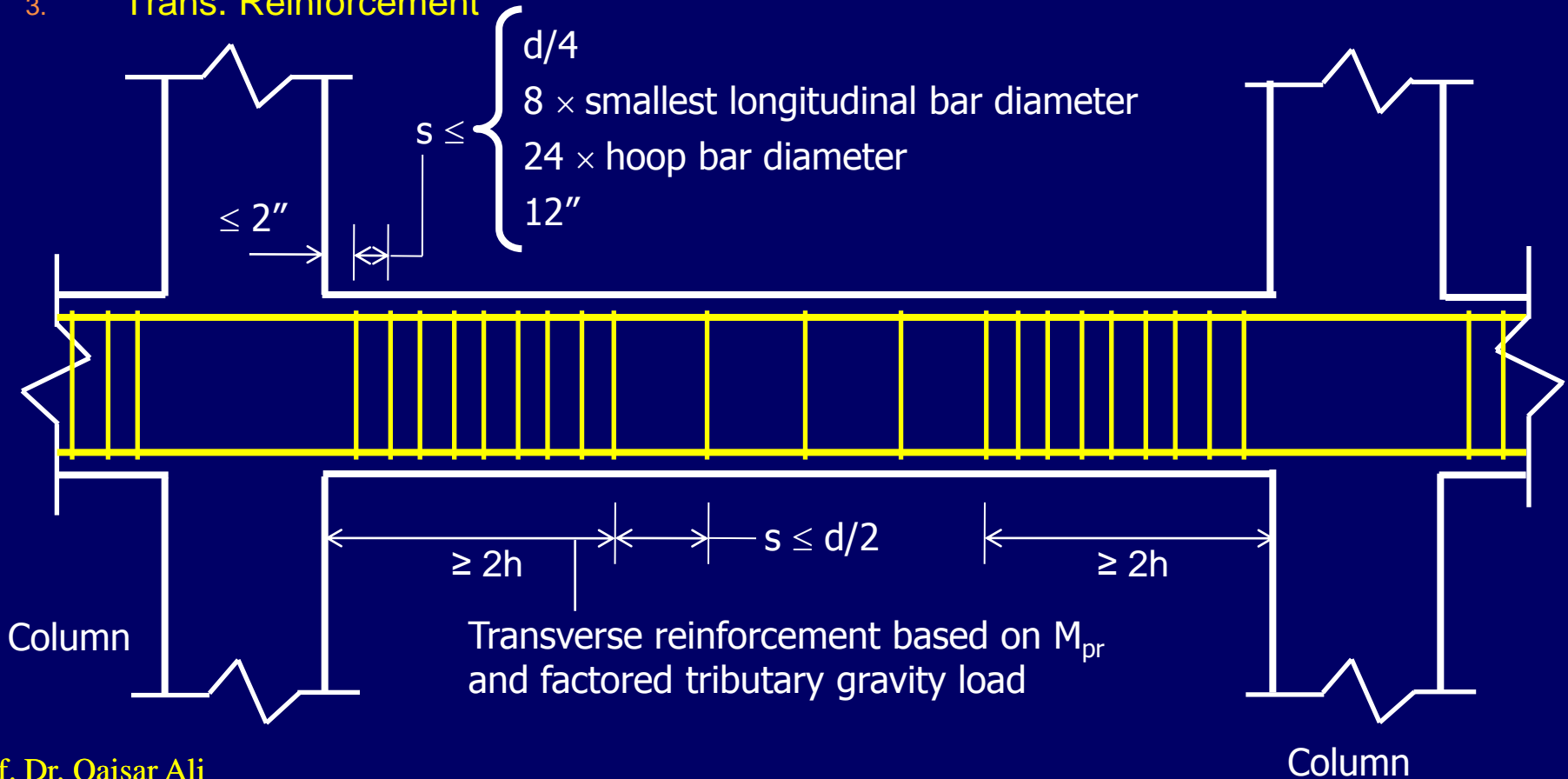




# BCP Provisions for RC structures

- Provision for Beams

3. Trans. Reinforcement







# BCP Provisions for RC structures

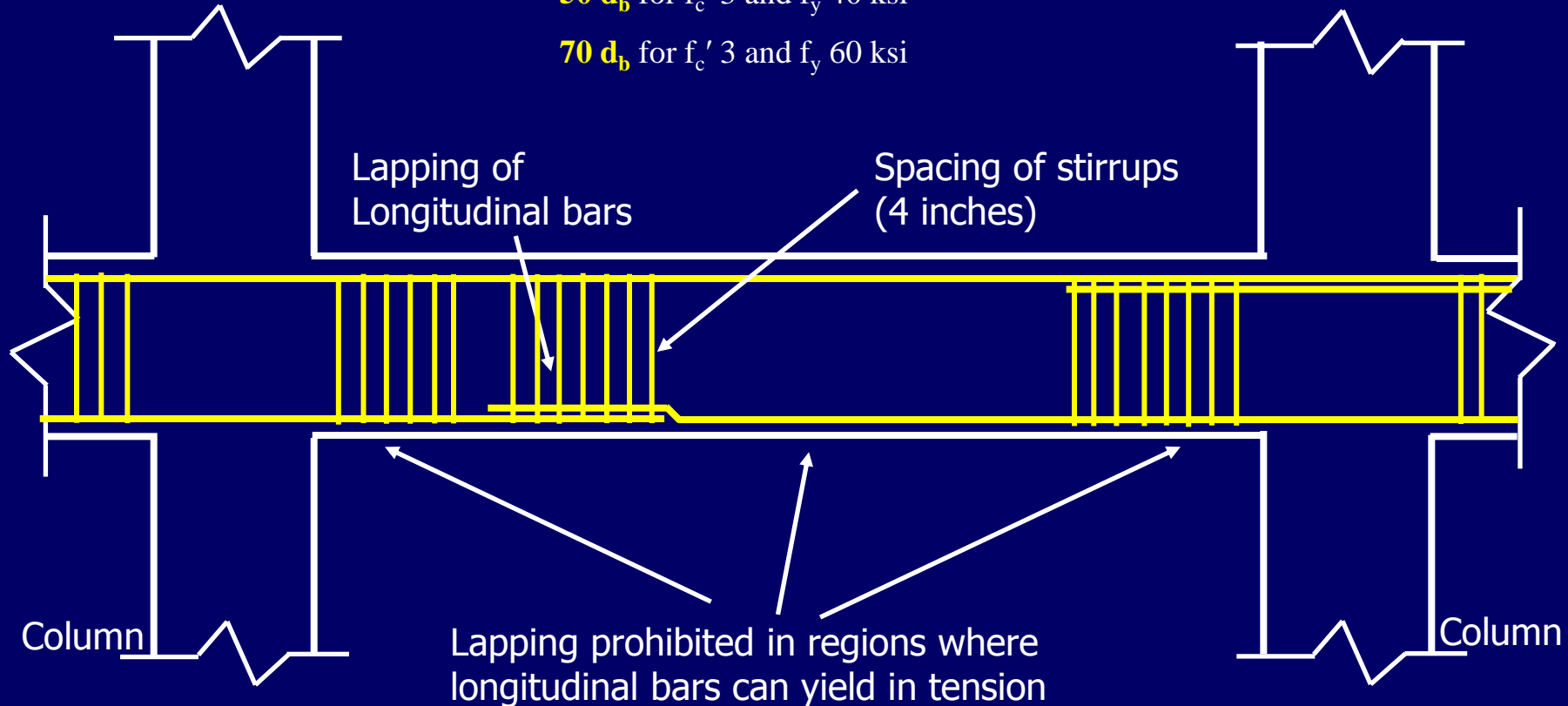
## Provision for Beams

### 4. Lap splices

$$\text{Lap splice length} = 1.3 l_d = 1.3 \times 0.05 f_y / \sqrt{f_c'}$$

**50 d<sub>b</sub>** for  $f_c' \geq 3$  and  $f_y \leq 40$  ksi

**70 d<sub>b</sub>** for  $f_c' \geq 3$  and  $f_y \leq 60$  ksi





# BCP Provisions for RC structures

- Provision for Columns

1. Size

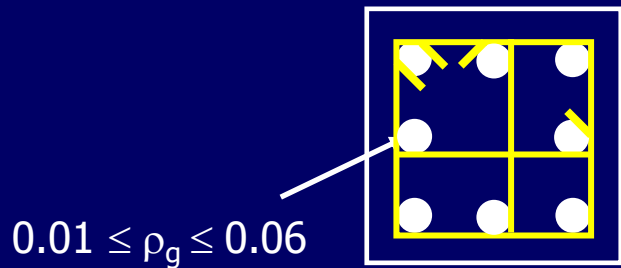
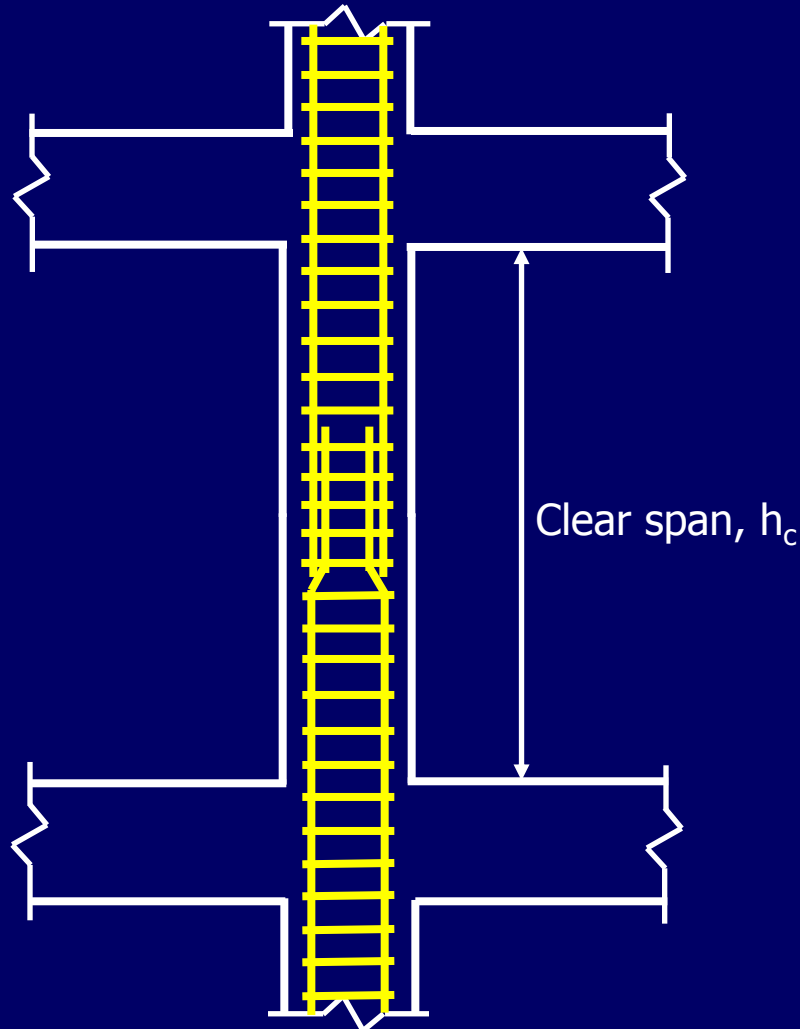
- a) Each side at least 12 in
- b) Shorter to longer side ratio  $\geq 0.4$ .

i.e. 12/12, 12/18, 12/24 OK; but 12/36 not O.K



# BCP Provisions for RC structures

- **Provision for Columns**
- 2. Longitudinal Reinforcement



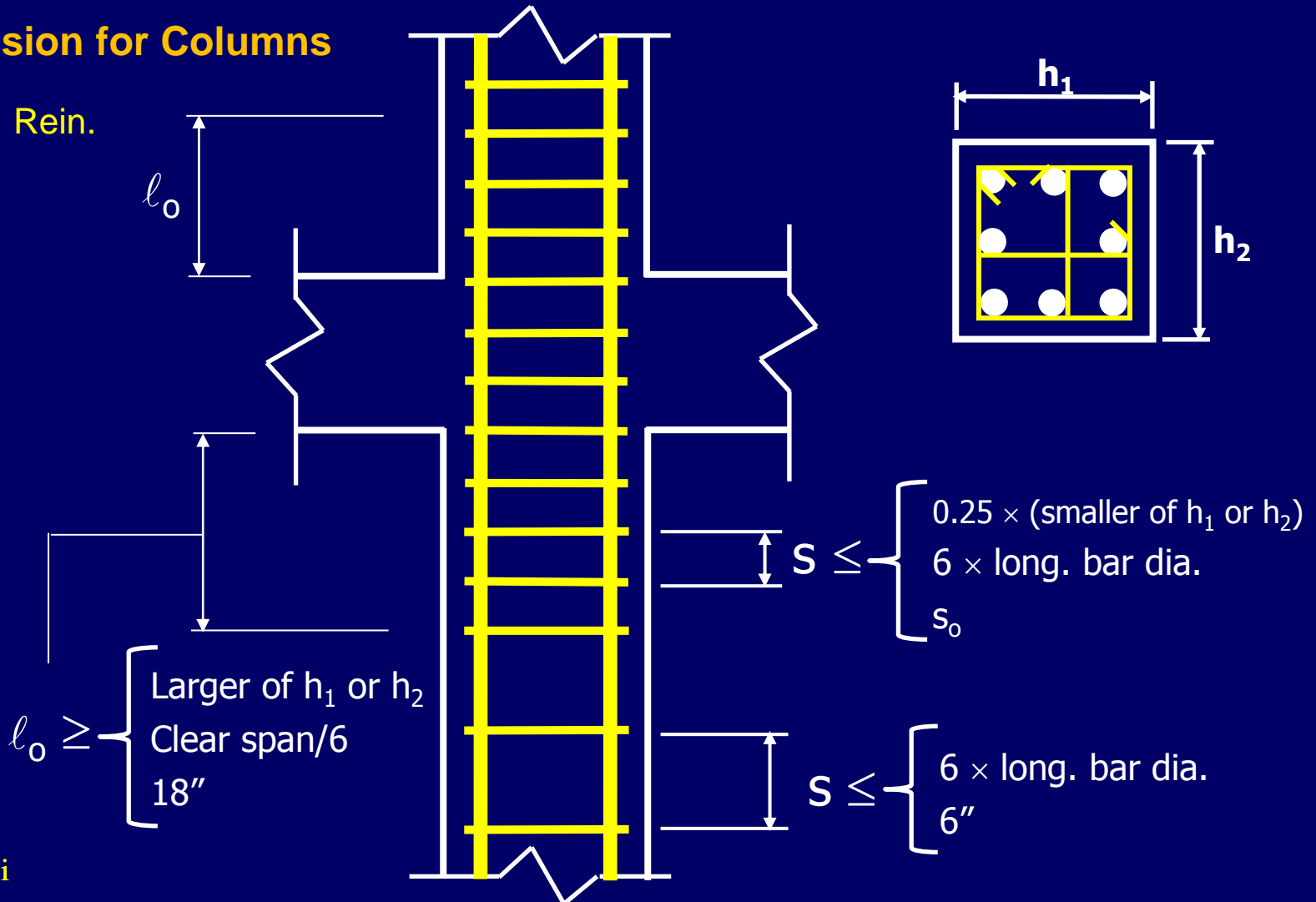
$$0.01 \leq \rho_g \leq 0.06$$



# BCP Provisions for RC structures

- Provision for Columns

- 3. Trans. Rein.

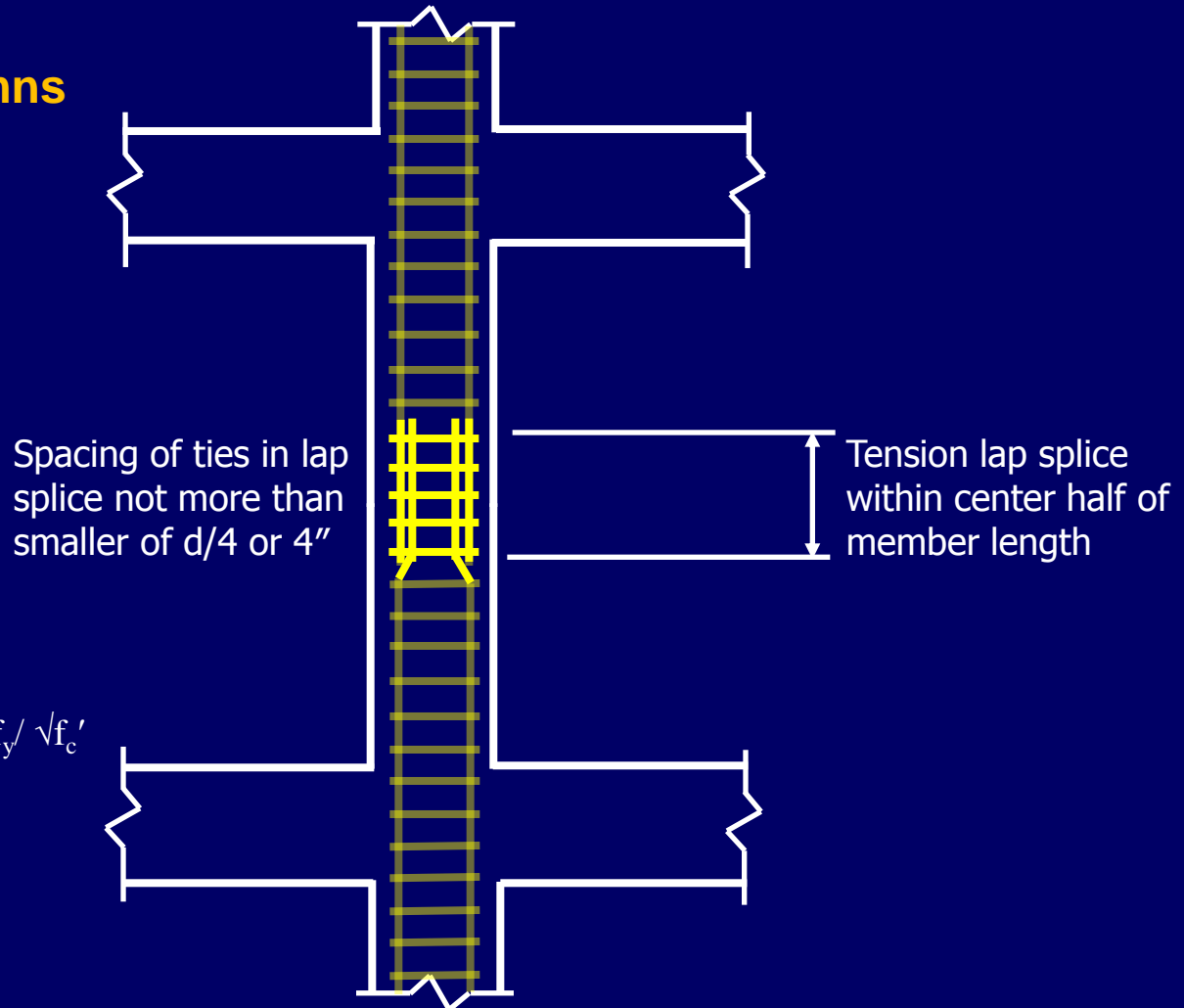




# BCP Provisions for RC structures

- **Provision for Columns**

- 4. **Lap Splice**



Lap splice length =  $1.3 l_d = 1.3 \times 0.05 f_y / \sqrt{f_c'}$

**50  $d_b$**  for  $f_c' \leq 3$  and  $f_y \leq 40$  ksi

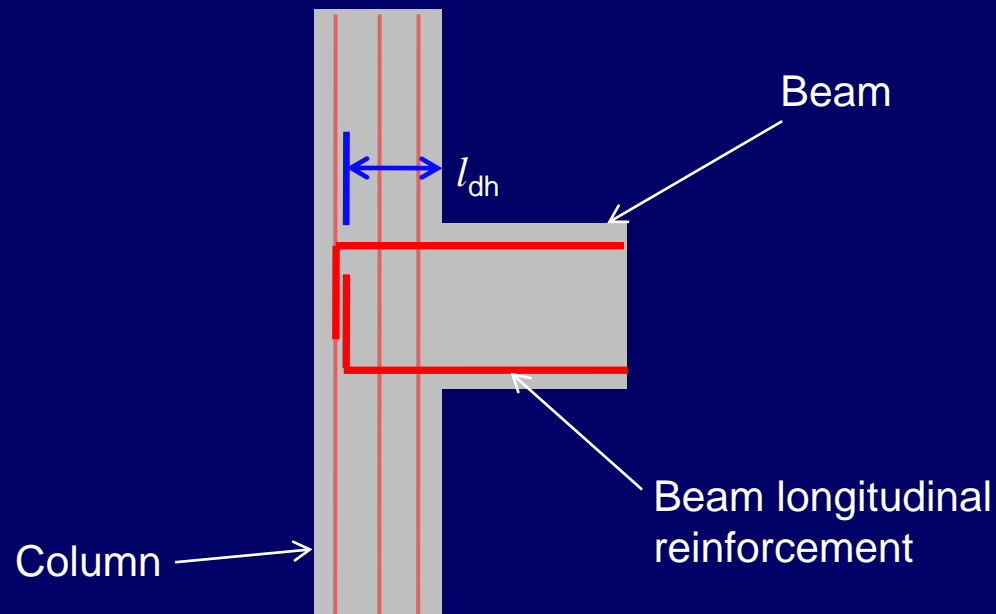
**70  $d_b$**  for  $f_c' \leq 3$  and  $f_y \leq 60$  ksi



# BCP Provisions for RC structures

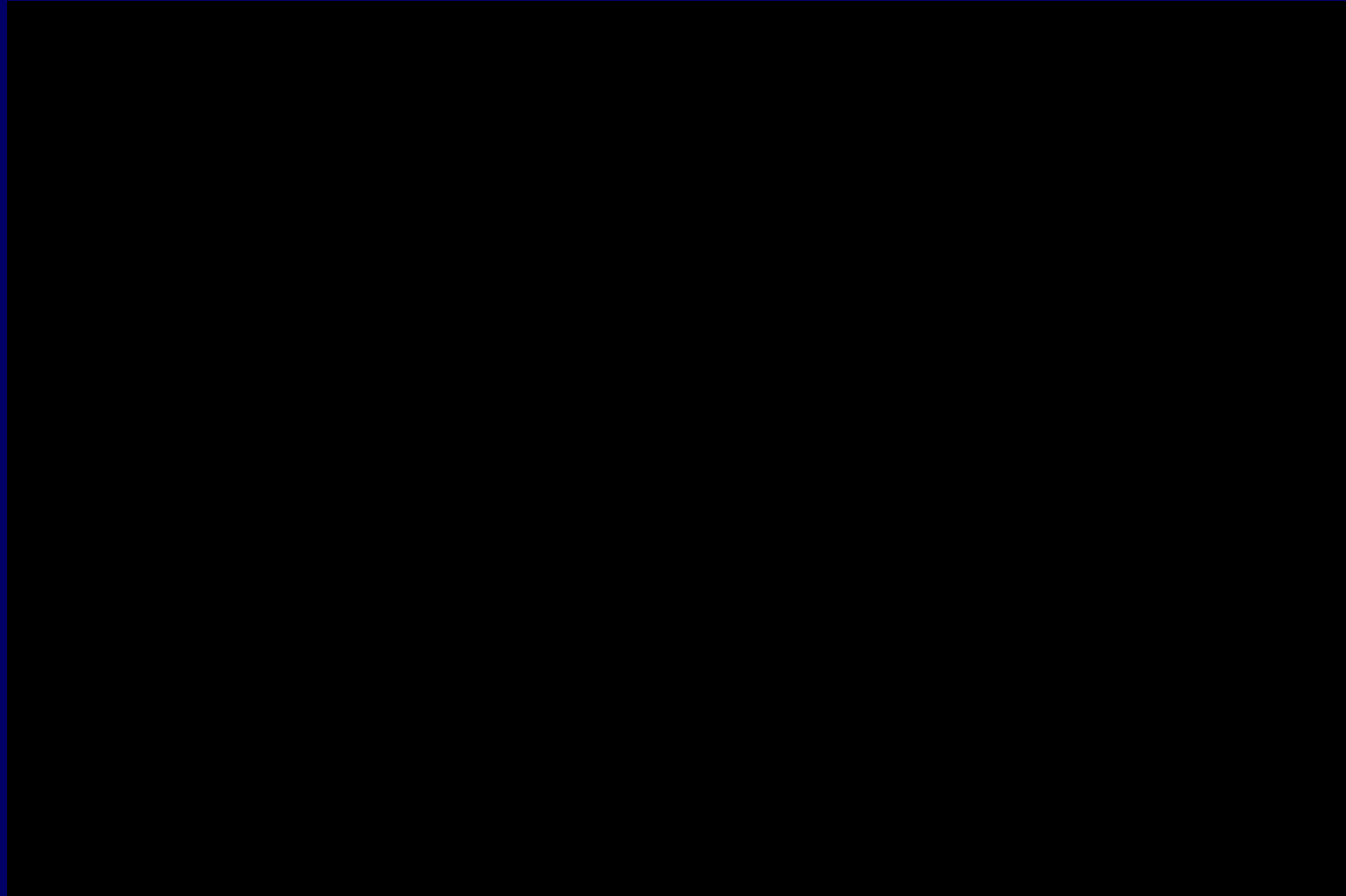
- **Connection**

- **Beam longitudinal reinforcement** that is terminated within a column. must be extended to the far face of the column core. The **development length ( $l_{dh}$ )** of bars with  $90^\circ$  hooks must be not less than  $8d_b$ , 6 in., Or  $f_y d_b / (65 \sqrt{f_c'})$



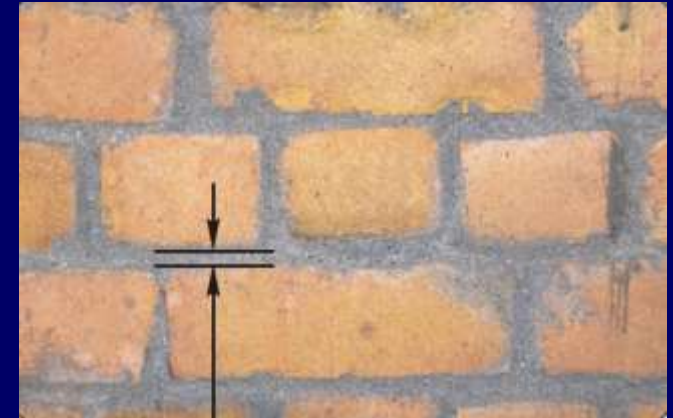


# Masonry test UET and BRI Japan





# Earthquake Safe house: Walls



- Good first class brick, well wet before use
- Mortar 1: 6, joint thickness not more than  $\frac{1}{2}$  inch
- Curing for at least 7 days





# Earthquake Safe house: Walls



Minimum thickness 9 inch (225 mm) Full brick, not half brick



# Earthquake Safe house: Roof

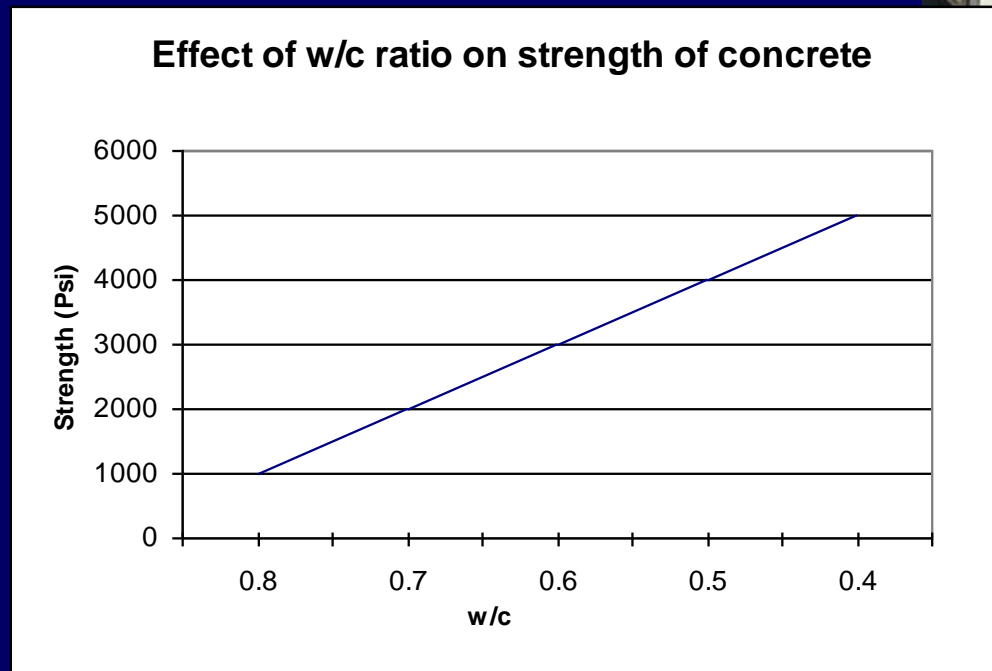
- Reinforced concrete slab
- Pitched light roof is good for heavy snow areas





# Earthquake Safe house (concrete for roof)

- Don't use Bricks inside RC slabs
- Don't use too much water in concrete





# Earthquake Safe house (concrete for roof)

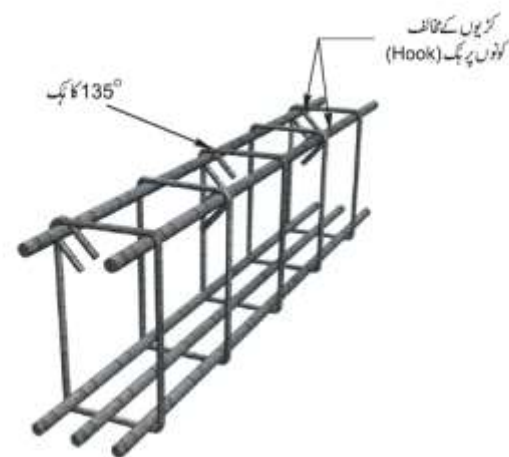
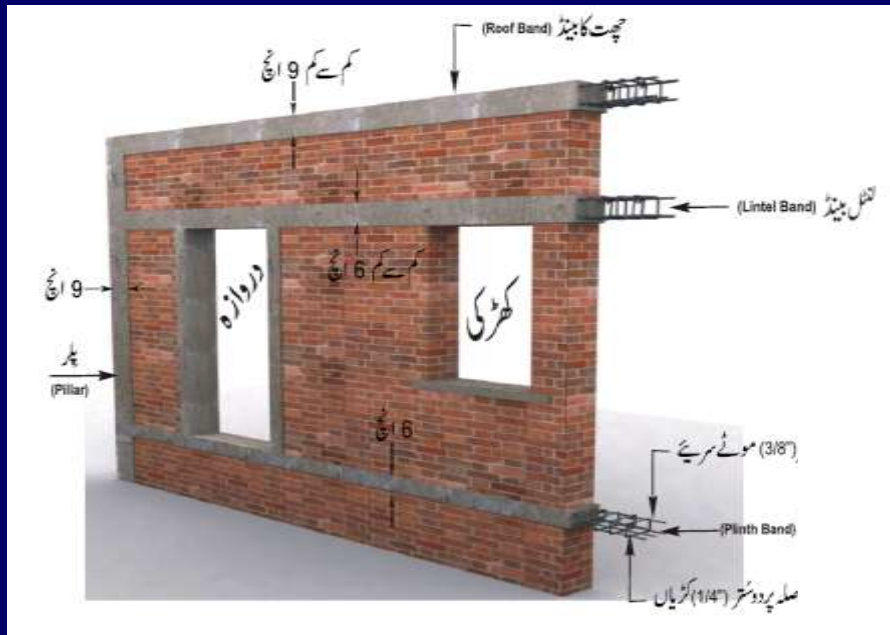


- Use **mixer** for mixing
- Use **vibrator** for good compaction.
- This can tremendously increase strength of concrete without adding cement



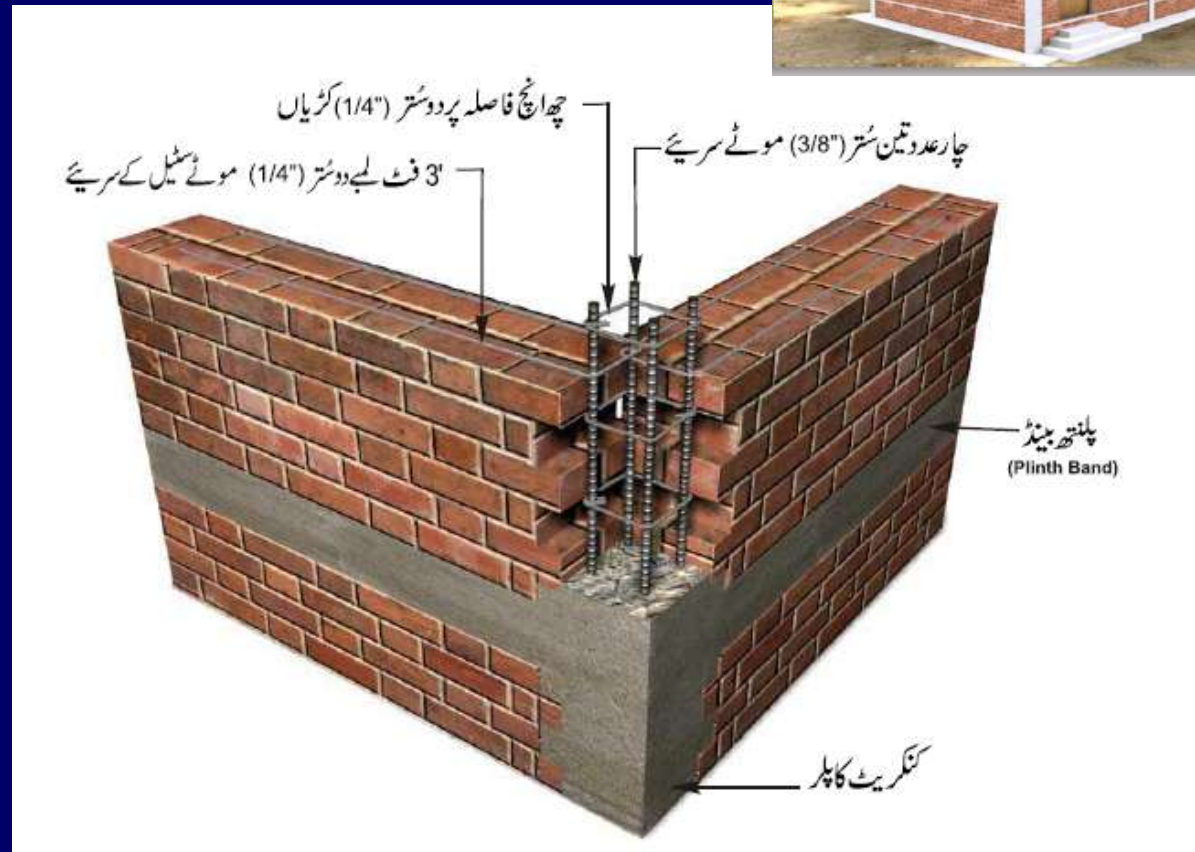


# Earthquake Safe house (Life Saving Bands)



# Earthquake Safe house (Columns)

- At all corners and junction





# Earthquake Safe house

## Shake table test at UET Peshawar





# Lessons learned from Earthquake 2005







# Lessons learned from Earthquake 2005



**DHQ Garhi Habibullah (NWFP, Pakistan):** collapsed buildings constructed with stone Masonry. Note a stone masonry building in the back ground having a bond beam at roof level is still standing

# Shake table test on Stone Masonry UET Peshawar





# Conclusions

1. Cement sand mortar 1 bag : 3 wheel barrow (maximum) and use within two hours.
2. Thickness of wall at least 9 inch
3. Concrete beams at plinth, lintel, and roof level
4. Columns at all corners and junctions
5. Less water in concrete



**The End**