World Conference on Disaster Reduction
18-22 January 2005, Kobe, Hyogo, Japan

**POLICIES FOR SAFER BUILDING/HOUSING**
**Ministry of Land, Infrastructure and Transport (MLIT), Government of Japan**

# Past, Present And Future: What Works In Achieving Safer Buildings


Prof. Javier R. Piqué
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# Policies

- Limiting displacement codes: the Peruvian experience
- Existing non engineered construction: effective inexpensive reinforcing
- Use of land: planning for safe construction

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# Use of damaged buildings (Peru 1971-1980)

| COMMON BUILDIGN USE* | | |
|---|---|---|
| Use or category | Number of buildings | % |
| School buildings | 68 | 47 |
| Office buildings | 18 | 20 |
| Hospitals | 8 | 10 |
| Hotels | 7 | 6 |
| Industrial | 5 | 6 |
| Other uses | 4 | 11 |
| TOTAL | 144 buildings | 100% |

**(*) Kuroiwa, J. “Disaster Reduction”pp.186**

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# Seismic Type damage (Peru, 1971-1980)

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| COMMON DAMAGE TYPES, after Kuroiwa, (2) | | |
|---|---|---|
| Predominant Damage Type | Number of buildings | % |
| Short columns and change in stiffness in plant and height (irregularities) | 100 | 69 |
| Wall shear failure | 18 | 12,5 |
| Beam columns joint failure | 8 | 5,5 |
| Bending in walls | 7 | 5 |
| Poor concrete quality | 5 | 3,5 |
| Beam failure, bending or shear | 4 | 3 |
| Impact between adjacent buildings | 2 | 1,5 |
| TOTAL | 144 buildings | 100% |

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# Evolution of Peruvian Seismic Standards

- 1964: First project of Peruvian Standard, based on SEAOC
- 1970: First Peruvian Standard nationwide
- 1977: Second Peruvian Standard (After quakes of: Chimbote–Huaraz 1970, Lima 1974)
- 1997: Third Peruvian Standard (After Nazca 1996 earthquake, Mexico 1985, Loma Prieta 1989, Northridge 1994, Kobe 1995)
- 2003: Revision of 3rd Standard


HUARÁZ 1970

# School building

**NAZCA**
**1996**

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# Allowable Displacements = Damage

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## LAB BUILDING

### Earthquake in X direction
### Maximum Displacements (RNC-1977)

| FLOOR | Displacements (cm) | | Drift | |
|---|---|---|---|---|
| | x | y | x | y |
| 2do floor | 6.494 | 0.000 | 1/144 | < 1/5000 |
| 1er floor | 4.091 | 0.013 | 1/90 | < 1/5000 |

# ATICO Earthquake, Southern PERU

## 23 June 2001 - Magnitude $M_S$ 8.2, Mw=8,4

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# TIME HISTORY of CORRECTED ACCELERATIONS

## PEAK GROUND ACCELERATION : 295.3 cm/seg$^2$

## (300 km from epicenter)

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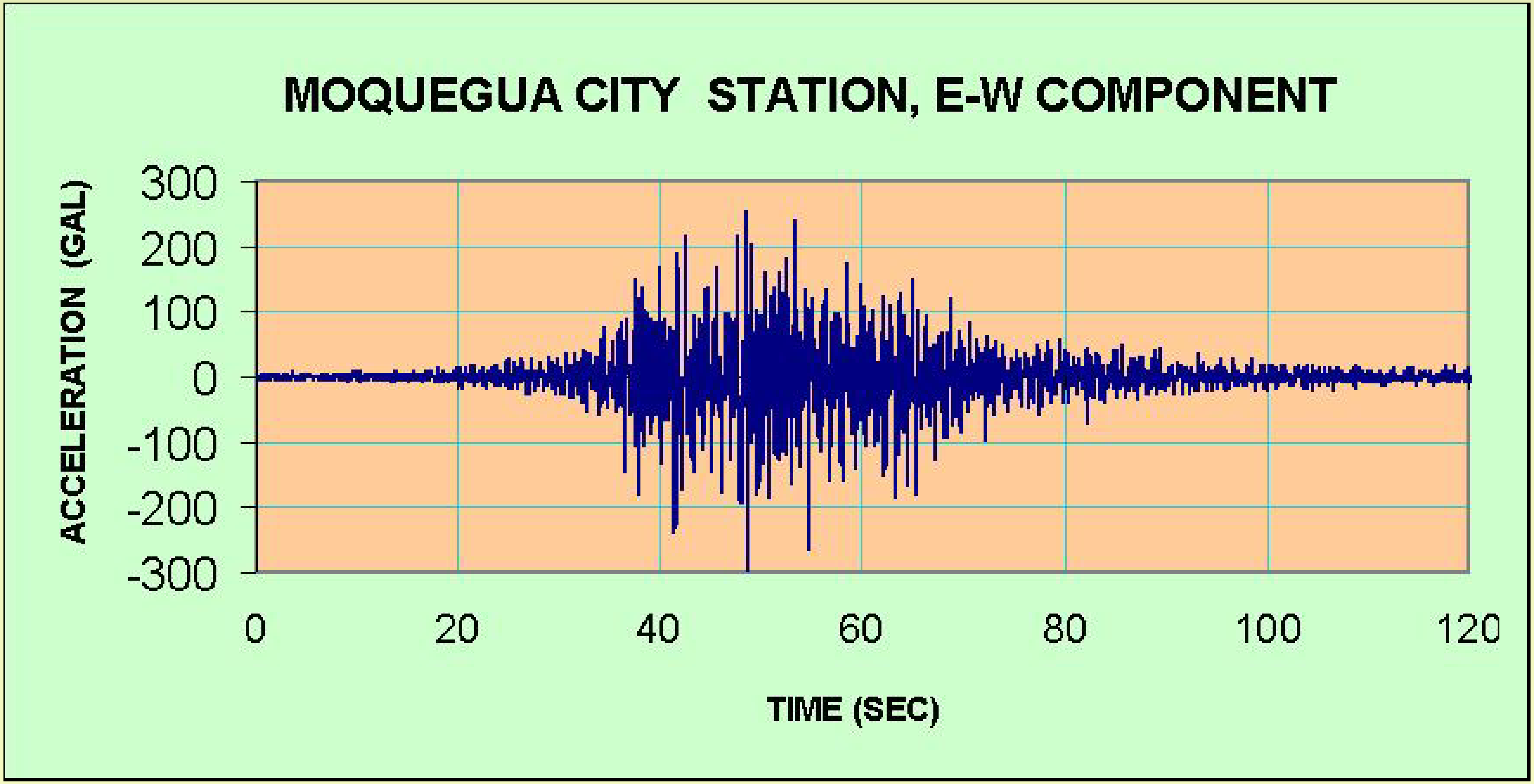


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# 1977 Standard: Allowable Displacements = damage

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Photo: E. Fierro

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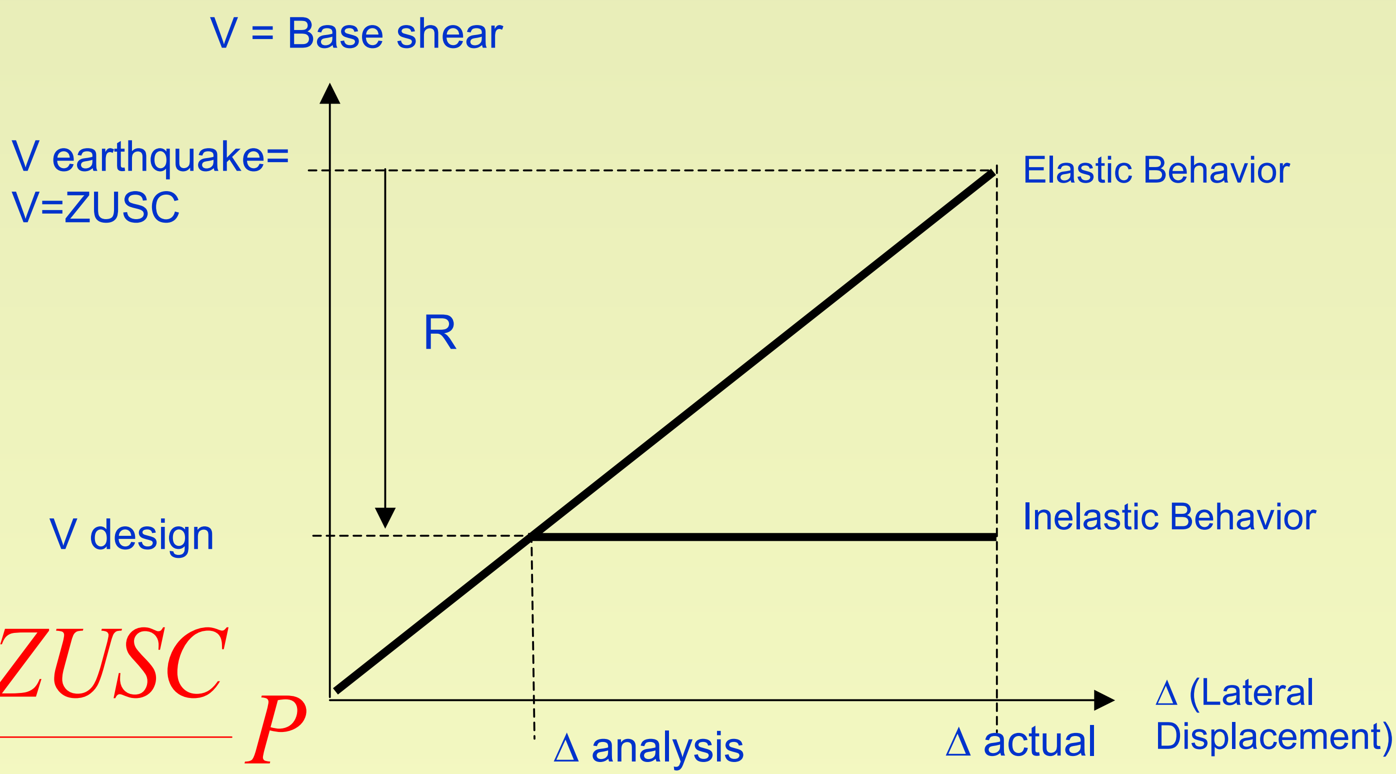
# 1997 = Change of Standars




$$V = \frac{ZUSC}{R} P$$

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# Comparison between base shear coefficients

| Seismic Standard | 1977 | 1997 |
|---|---|---|
| factor Z | 1 | 0.4 |
| factor U | 1 | 1 |
| factor S | 1 | 1 |
| factor C (short periods) | 0.4 | 2.5 |
| ZUCS | 0.4 | 1 |

*To obtain similar base shear, R factors had to be increased: 2,5 times*

# Drift Limits were also reduced

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| Standard | 1977 | 1997 | Increment of demand |
| --- | --- | --- | --- |
| PREDOMINANT MATERIAL | $\left(\Delta_I / he_i\right)$ | $\left(\Delta_I / he_i\right)$ | $\left(\dfrac{\Delta_{77}}{\Delta_{97}} - 1\right) \cdot 100$ |
| Reinforced Concrete | 0.010 | 0.007 | 43% |
| Steel (*) | 0.015 | 0.010 | 50% |
| Masonry | 0.010 | 0.005 | 100% |
| Timber | 0.015 | 0.010 | 50% |

# Same strengh larger displacements

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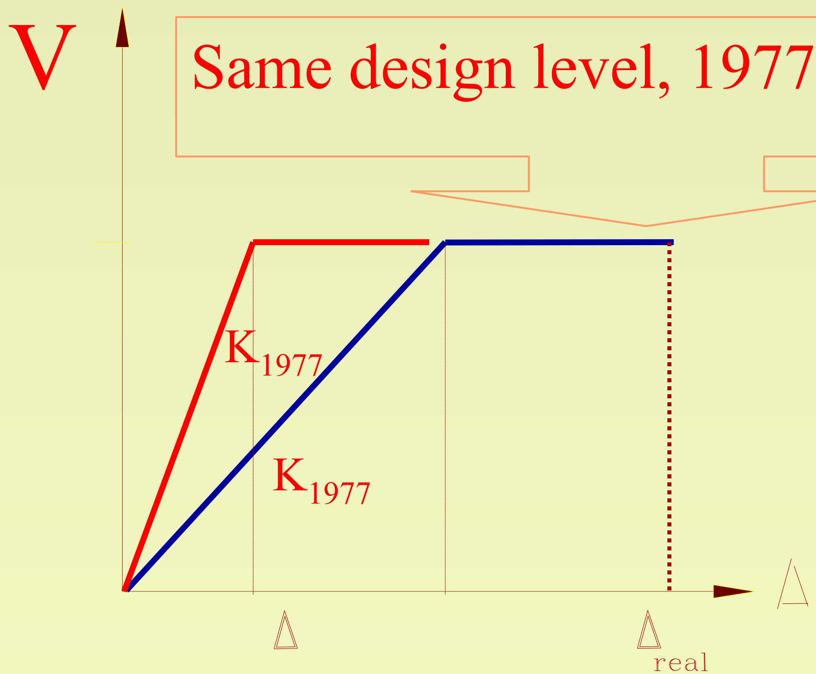


Displacements 1997 = 2.5 x 4/3= 3.33 times larger and compared against a stringent drift

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# 1997 Standard = Stiffer structures. Regular structural system mandatory = No damage

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Photos
E. Fierro


# CONCLUSIONS 1

- All school buildings in Southern Peru designed with 1977 Standard experienced structural and nonstructural damage. None of the schools designed and built under the 1997 Standard suffered damage.
- Change in Peruvian Seismic Standards resulted in higher computed lateral displacements. Structures designed using 1997 new Standard have to be much more rigid than before.

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# CONCLUSIONS 2

- Schools continue to operate unharmed, even when peak ground acceleration must have been higher than design acceleration (0.3g was registered 100km south, even further from epicenter)
- Changes in structural element dimensions to achieve additional stiffness increase structural costs by 30%. No cost was involved after the earthquake because of absence of damage.

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# CONCLUSIONS 3

- Structures designed with 1977 Standards had to be repaired, they could not be used for several months and cost of retrofitting and stiffening reach up to 40% of initial cost
- It is recommended Codes should incorporate:
  - Restrict displacements
  - Limit irregularities severely.  Essential buildings should be regular
  - Either assure safe collapse mechanisms or limit use of frame systems alone

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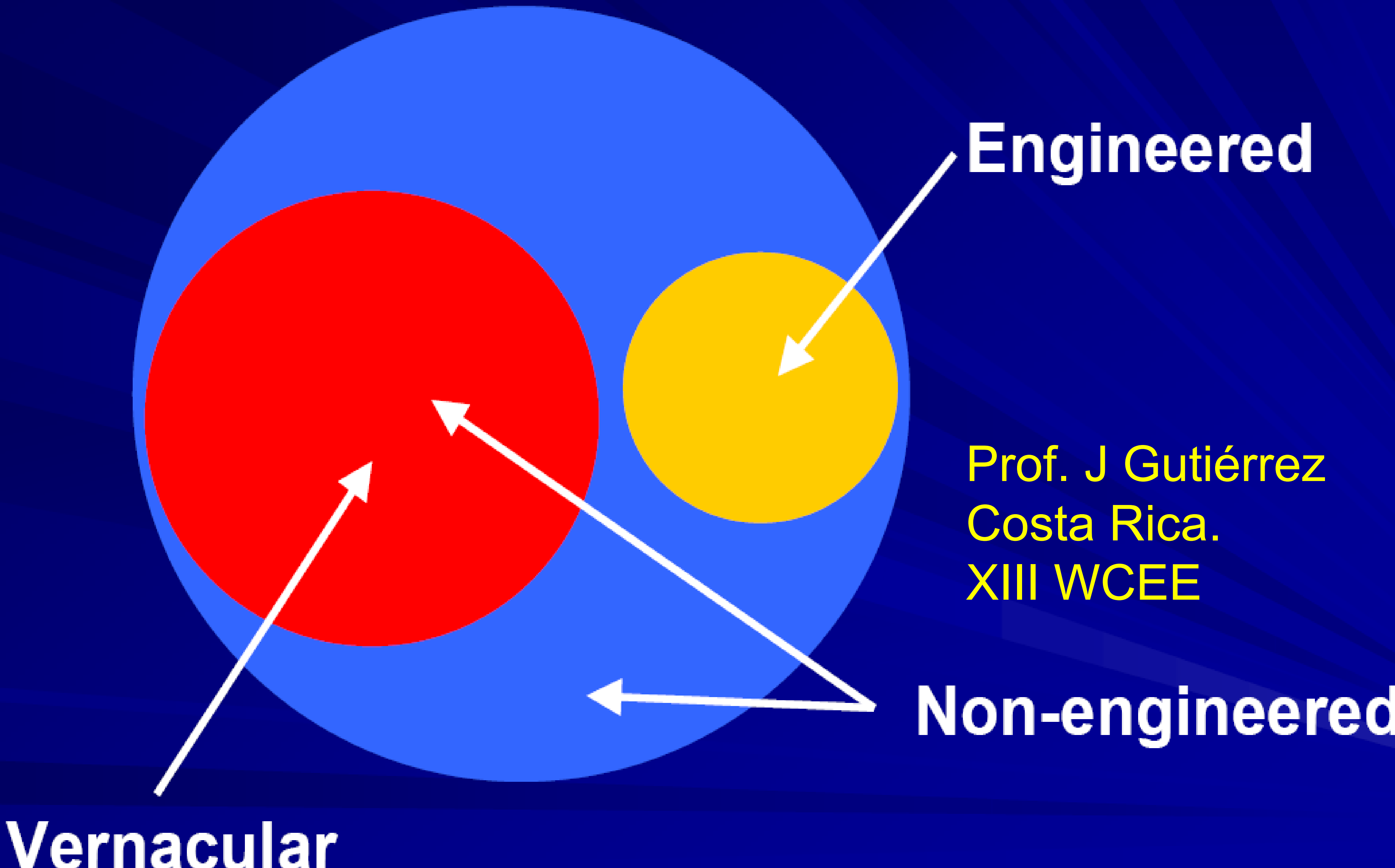
# Existing non engineered buildings: improvement in adobe housing

50% of world housing is non-engineered

# The built environment

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Costa Rica.
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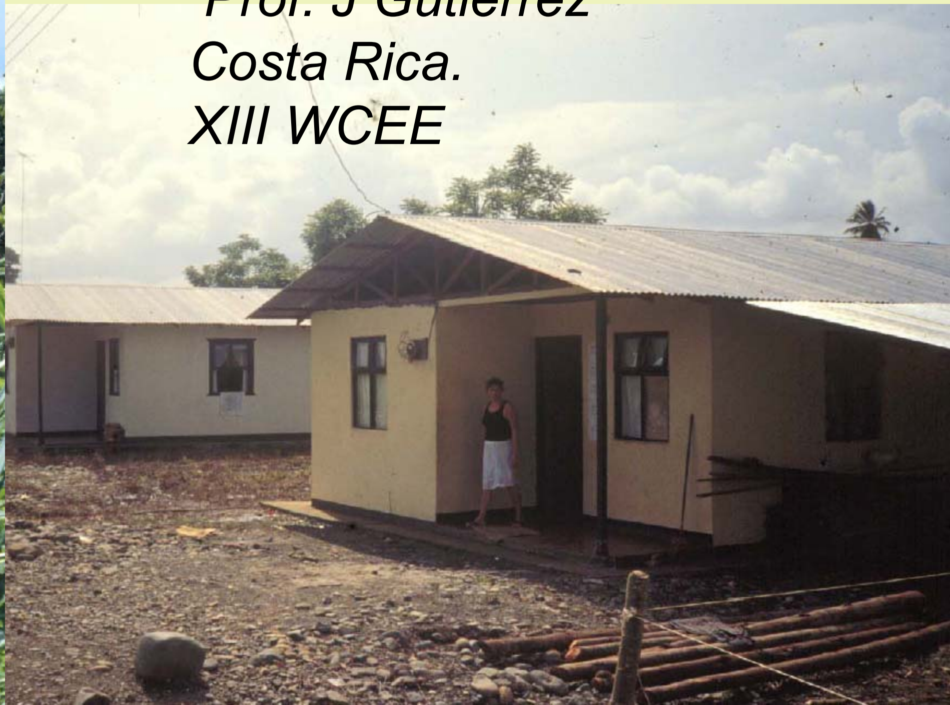
Limón, Costa Rica, Earthquake

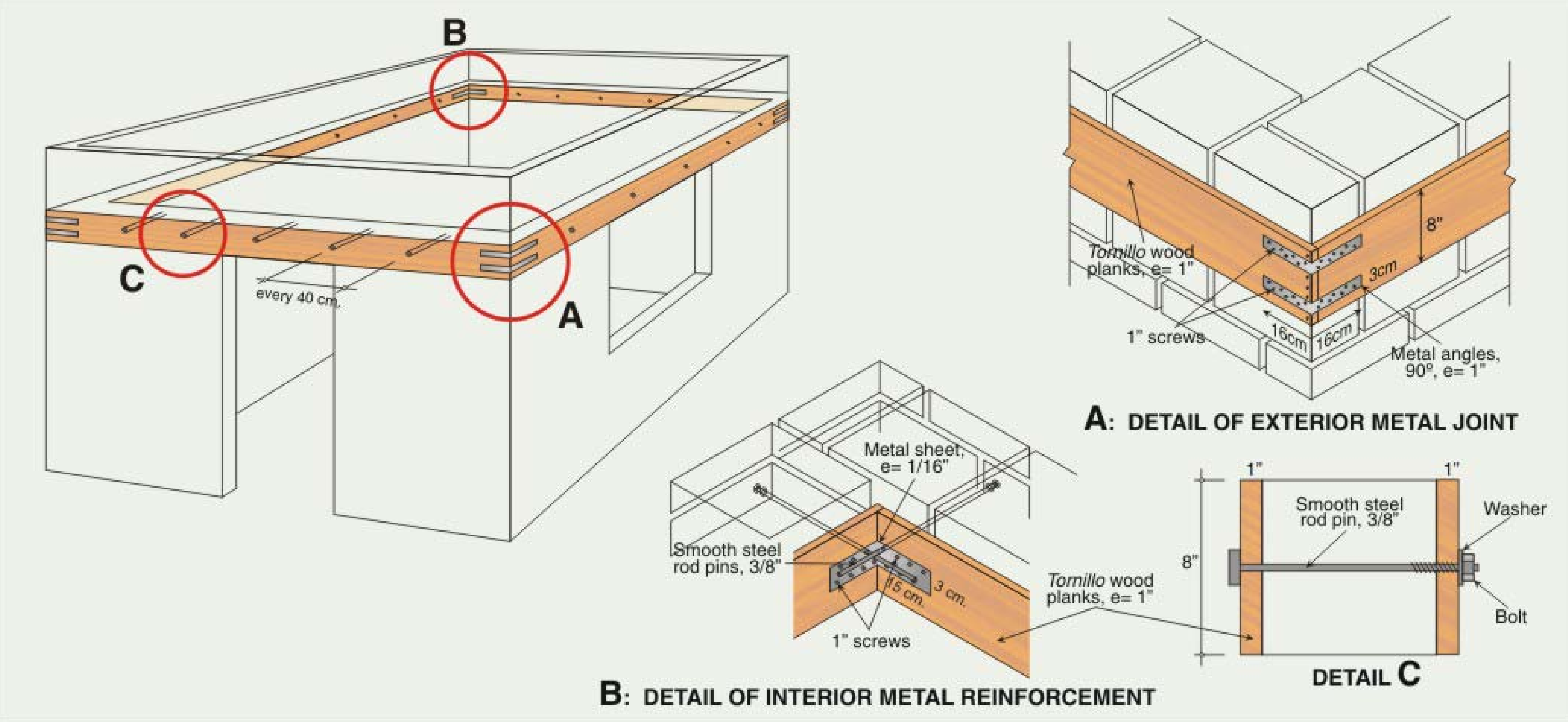
(April, 22, 1991 M**L** = 7.5 MMI = IX)

30 *'bahareque'* houses with prefabricated panels at epicenter, none was damaged

*Prof. J Gutiérrez*
*Costa Rica.*
*XIII WCEE*



# Proposed reinforcing for less vlnerability (Kuroiwa-CISMID)





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# Laboratory tests show high strength and improved ductility

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Full scale model . 0,8g pga

Full scale model . 1,0g pga. Roff has not fallen

Kuroiwa, J. "Disaster Reduction" pp.143

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# CONCLUSION

- Implement progams to support retroffiting with training and long term credit or subsidies
- Non-engineered heavy housing in high intensitie areas should be relocated

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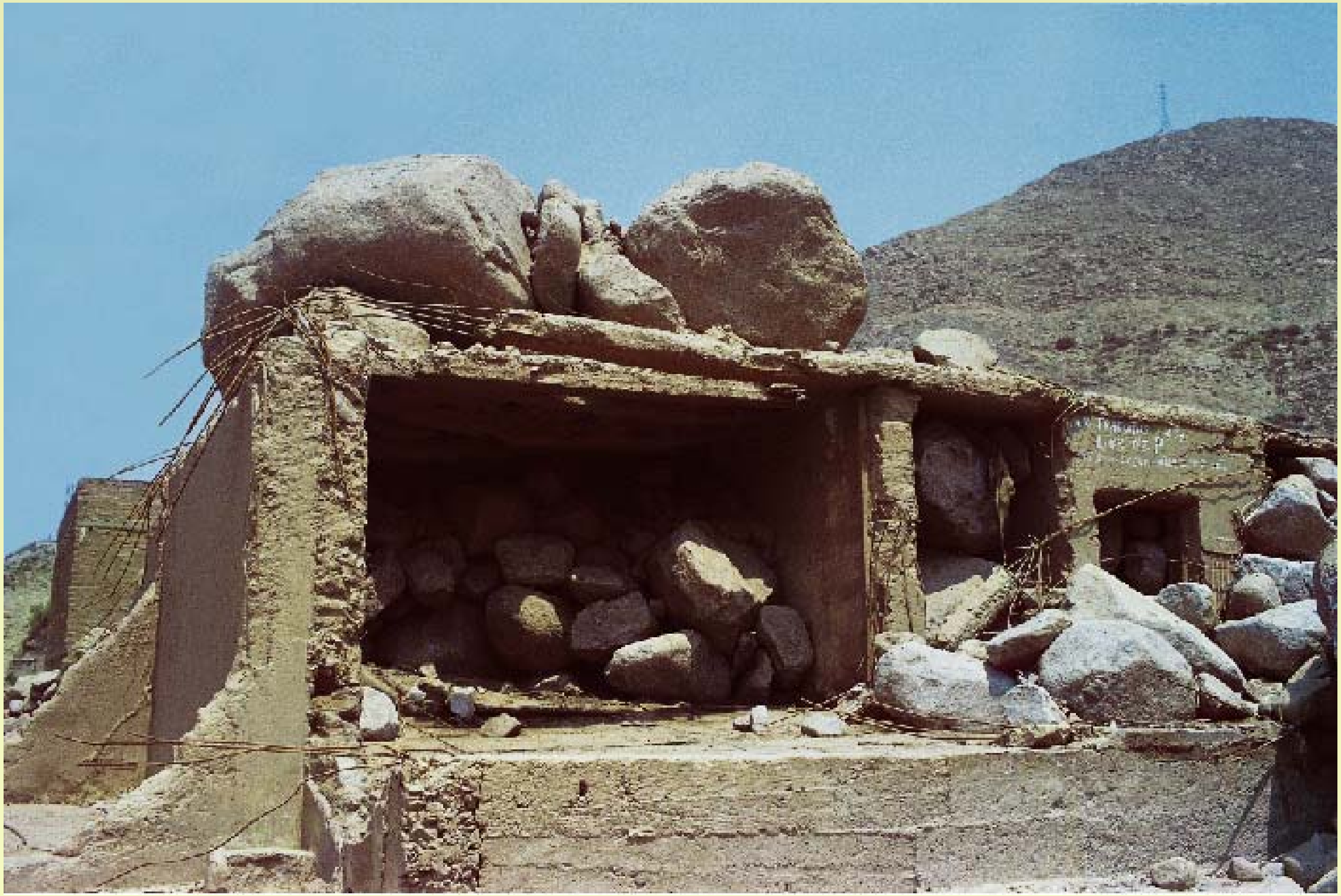
# Planning for future occupation: The importance of location

Plan land use

# Avalanche: debris flow, 1987. Observe quality materials, wrong location



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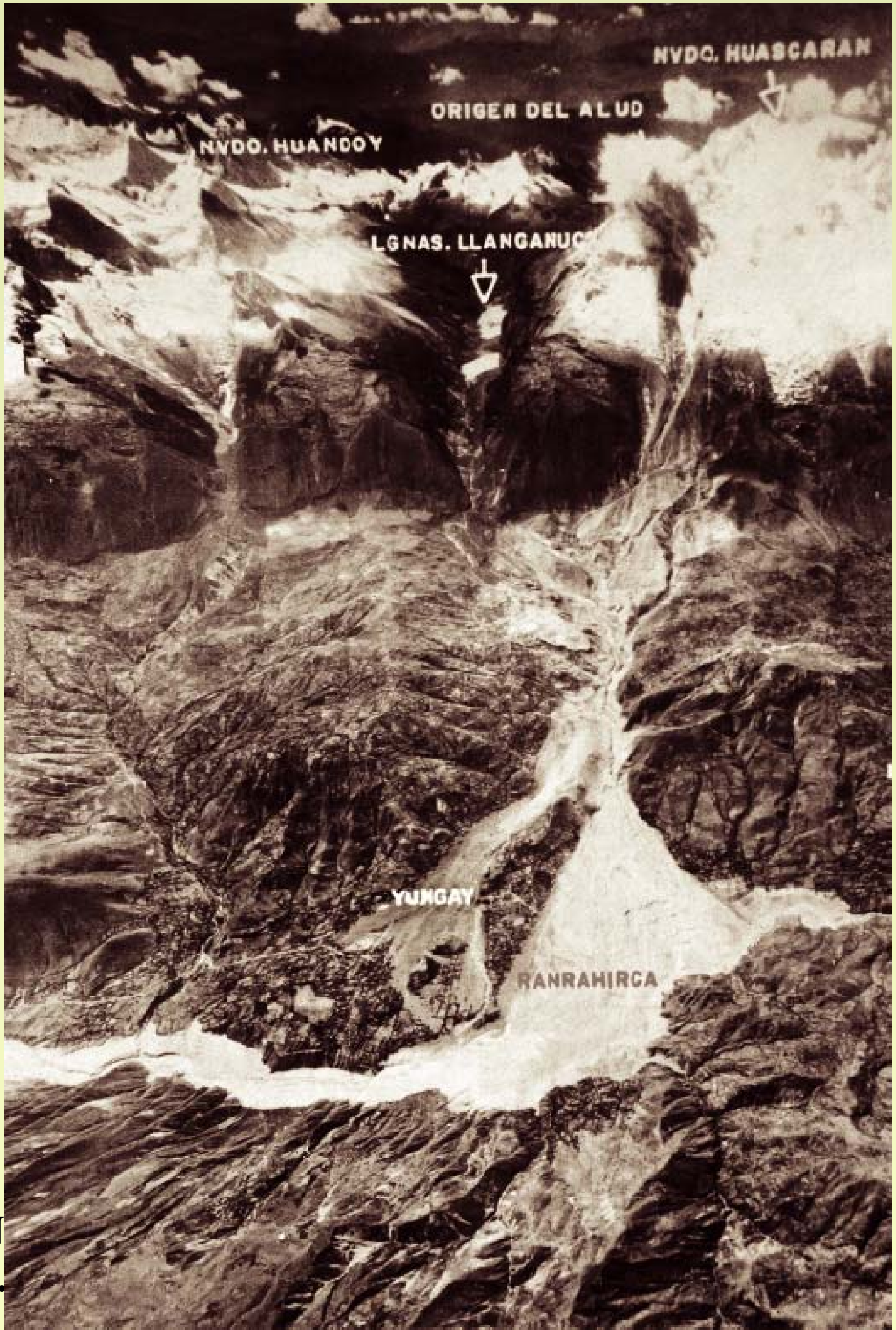
# Avalanche caused by earthquake: Huaraz 1970 67 000 dead




**Kuroiwa, J. "Disaster Reduction" pp.143**

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# Hazard map of Ica, Peru


**Kuroiwa, J. "Disaster Reduction" pp.44**

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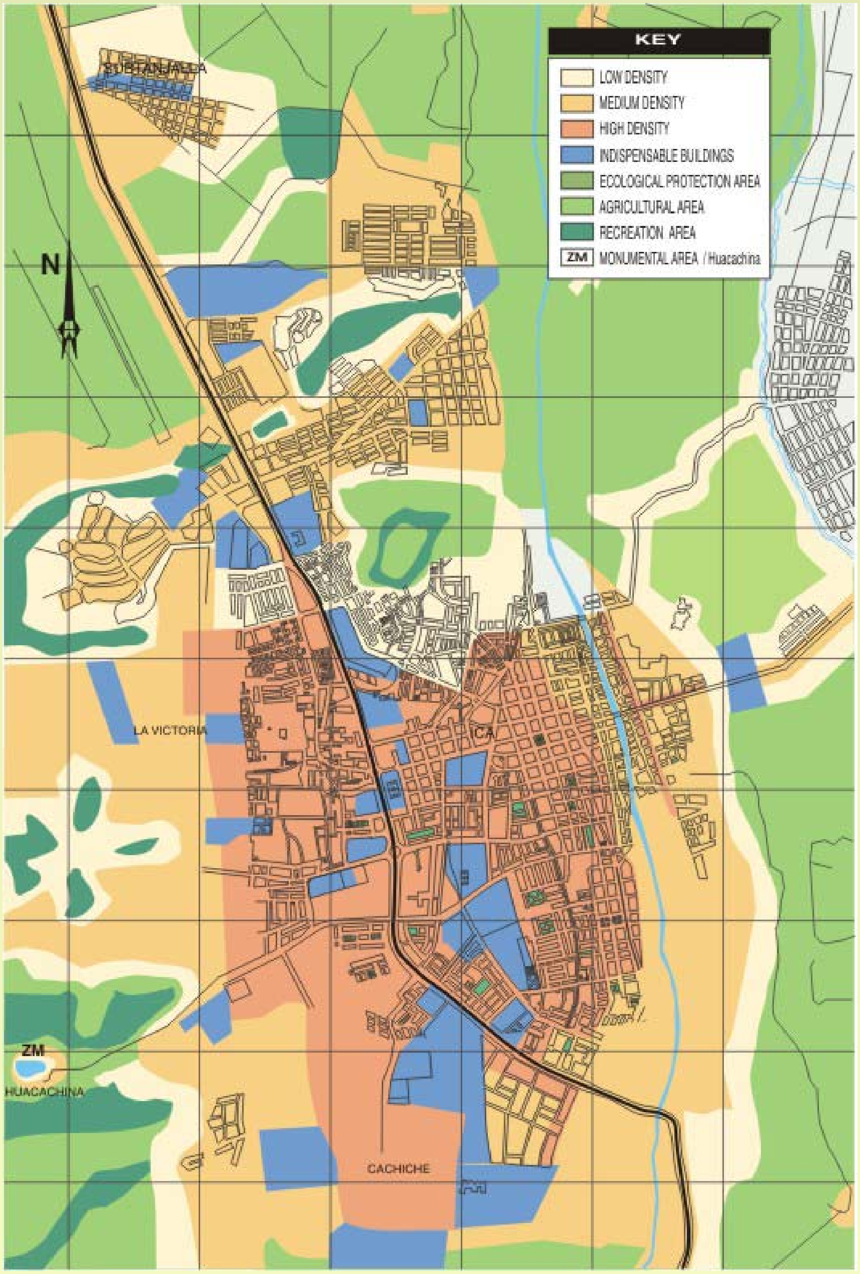
# Land use plan for Ica, Peru




**Kuroiwa, J. "Disaster Reduction" pp.44**

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# CONCLUSIONS

- Good location is essential in reducing vulnerability to all natural hazards
- Once estimated, prepare land-use plan and enforce compliance
- Effective policies should concentrate in:
- Simple Codes, low cost retroffiting , location

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# Thanks for your kind attention