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The 2nd Japan-Peru Workshop on
Enhancement of Earthquake and Tsunami Disaster Mitigation Technology

THE INFLUENCE OF CONSTRUCTION PROCEDURES IN THE SEISMIC VULNERABILITY OF NON ENGINEERING HOUSINGS IN TACNA CITY

By: Dina COTRADO FLORES
March, 2011

TACNA:



Geographical coordinates:

- 16 ° 18 ' and 18 ° 20' south latitude
- 69 ° 28 ' and 71 ° 02' west longitude
- Tacna City: 558 m.s.n.m.



Tectonic Plates in the world



Buildings in Tokyo, Japan



Buildings in Lima Perú



Buildings in Tacna, Perú

80% are non engineering structures



WHY???

Damage to masonry buildings
(Earthquake 23/06/2001,
Magnitude $m_v = 6.9$ (igp)
Magnitude $m_s = 7.9$ (igp)
Epicenter: Front Ocoña)



Concrete blocks
"BLOQUETA"
Hand made

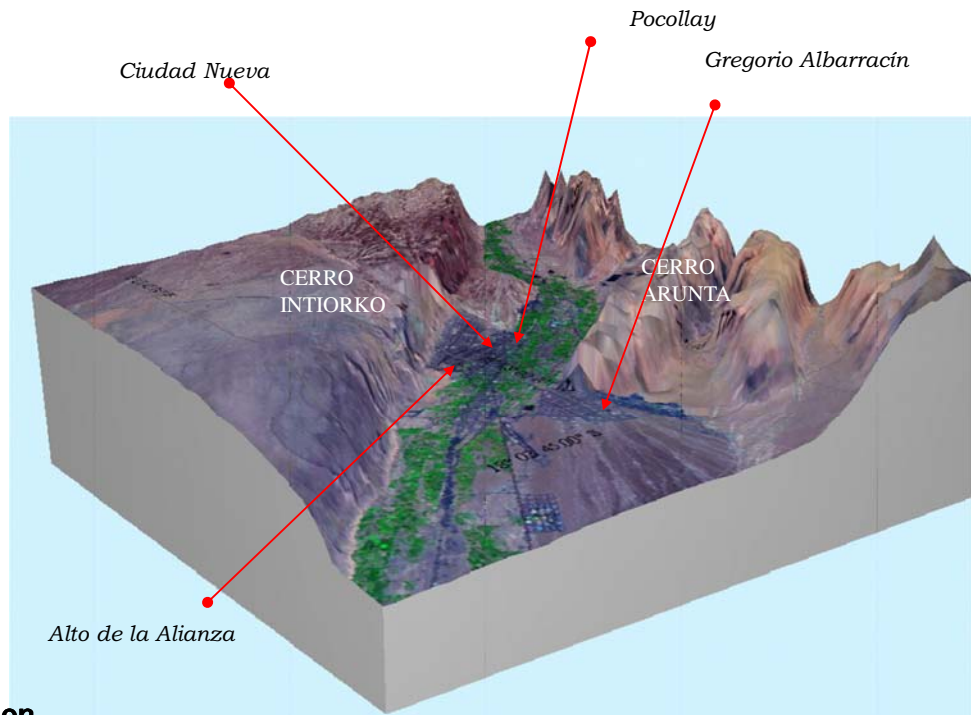
THE PRINCIPAL INFLUENCE IS THE TYPE OF
MASONRY UNIT.



Bloquer II

Clay blocks
"BLOQUETA ROJA"
Machine made

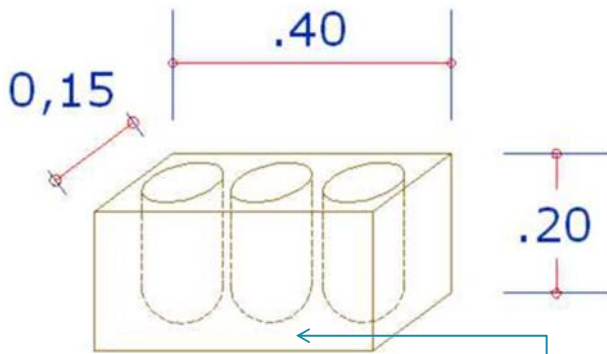




Cheap construction

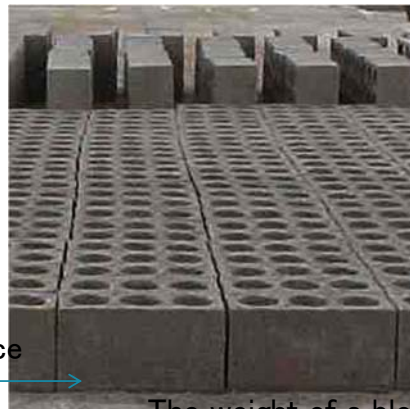
Actividad	Recurso	Costo	
		S/.	\$
Construcción de muro con ladrillos de arcilla m ²	Ladrillo de 24x14x9 (39 unidades)	13.65	3.88
	Mortero (arena , cemento)	4.81	1.37
	Mano de obra	18.9	5.4
	Sub. Total	37.36	10.65
Construcción de muro con bloques de concreto m ²	Bloquetas de Concreto (12 unidades)	10.8	3.08
	Mortero (arena fina, cemento)	2.14	0.61
	Mano de obra	18.9	5.4
	Sub. Total	31.84	9.09

.....very used in new and old buildings



do not cross the seating surface

CONCRETE BLOCKS
"BLOQUETA"



The weight of a block ranges from 18 to 20 kg



it is easy to spread the mortar on the full side



CONCRETE BLOCKS
"BLOQUETA"



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$f'm = 23.04 \text{ Kg/cm}^2$
 $f'b = 18.48 \text{ Kg/cm}^2$

values below the peruvian standard

TABLA 9 ()**
RESISTENCIAS CARACTERÍSTICAS DE LA ALBAÑILERÍA Mpa (kg / cm²)

Materia Prima	Denominación	UNIDAD f_b	PILAS f_m	MURETES v_m
Arcilla	King Kong Artesanal	5,4 (55)	3,4 (35)	0,5 (5,1)
	King Kong Industrial	14,2 (145)	6,4 (65)	0,8 (8,1)
	Rejilla Industrial	21,1 (215)	8,3 (85)	0,9 (9,2)
Silice-cal	King Kong Normal	15,7 (160)	10,8 (110)	1,0 (9,7)
	Dédalo	14,2 (145)	9,3 (95)	1,0 (9,7)
	Estándar y mecano (*)	14,2 (145)	10,8 (110)	0,9 (9,2)
Concreto	Bloque Tipo P (*)	4,9 (50)	7,3 (74)	0,8 (8,6)
		6,4 (65)	8,3 (85)	0,9 (9,2)
		7,4 (75)	9,3 (95)	1,0 (9,7)
		8,3 (85)	11,8 (120)	1,1 (10,9)

CONCRETE BLOCKS
"BLOQUETA"



P máx. (kN)	Área Diagonal (cm ²)	vm		Gm	
		MPa	kg/cm ²	MPa	kg/cm ²
50.00	1790.10	0.28	2.85	346.3	3533
52.51	1790.10	0.29	2.99	163.3	1665
47.25	1790.10	0.26	2.69	206.2	2103
44.92	1790.10	0.25	2.56	202.2	2062
50.38	1790.10	0.28	2.87	165.6	1689
	X	0.27	2.78	184.3	1880
	σ_{stan}	0.02	0.19	23.0	235
	CV	7%		12%	
	v'm	0.25	2.59	161.3	1645

values below the peruvian standard

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RESISTENCIAS CARACTERÍSTICAS DE LA ALBAÑILERÍA Mpa (kg / cm²)

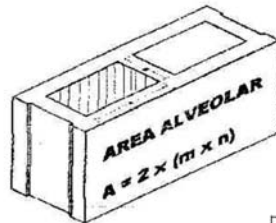
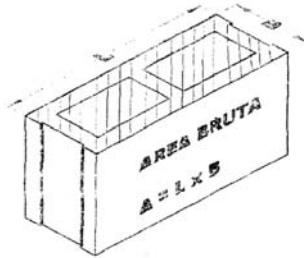
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what happens with the vulnerability of a house...

CLAY BLOCKS "BLOQUETA ROJA"



Bloquer II



$$f' m = 77.17 \text{ Kg/cm}^2$$

the hollow area exceeds the peruvian standard



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TABLA 9 (**)
RESISTENCIAS CARACTERÍSTICAS DE LA ALBAÑILERÍA Mpa (kg / cm²)

Materia Prima	Denominación	UNIDAD	PILAS	MURETES
		f'_m	f'_m	f'_m
Arcilla	King Kong Artesanal	5,4 (55)	3,4 (35)	0,6 (6,1)
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CLAY BLOCKS "BLOQUETA ROJA"



Bloquer II

PRODUCTO	CLASE	TIPO	RENDIMIENTO		Módulo de Elasticidad	ALABEO (coeficiente)	ABSORCIÓN (%)	ÁREA DE SACO (%)	PUREZA (%)	DENSIDAD (gr/m ³)
			SOGA	CABEZA						
BLOCKER II 12 x 17 x 29	PERFORADO	V	17	-	115	1.15	13.42	52	98	2.10



WHAT HAPPENS IF WE COMBINE THESE UNITS...

$f'm = 77.17 \text{ Kg/cm}^2$

$f'm = 23.04 \text{ Kg/cm}^2$



.....OR OTHERS NON-REGULATED UNITS



tubular bricks for roof

tubular bricks for wall





Pandereta: $f'm = 23.05 \text{ Kg/cm}^2$



Pirámide 15: $f'm = 50.95 \text{ Kg/cm}^2$

.....increasing vulnerability

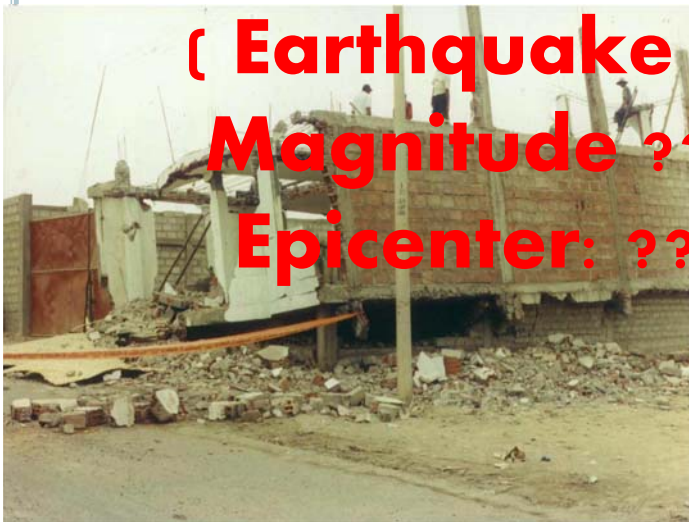
...WHAT HAPPENS IF ANOTHER PROBLEM IS THE PRESENCE OF SALTS IN THE SOIL





Damage to masonry buildings.....AGAIN???.

WHEN???



**(Earthquake ??????????,
Magnitude ??????????,
Epicenter: ??????????)**



CONCLUSIONS

- Tacna city is located in the southern part of Peru, in one of the higher seismicity zones, due to the subduction of Nazca plate into the South American plate. After the earthquake of June 23, 2001, many of the existing buildings, especially, the single-family housings located in the suburbs of Tacna city, remain seriously damaged because they are non engineering structures, where materials of bad quality has been used and not qualified construction work and constructive process were performed. There are more than 9 years that the quake hapen, and the owners of these houses have not learned the lesson, since it keeps on committing the same constructive errors that increase its seismic vulnerability.



GRACIAS

