

IMPACT OF THE PISCO-PERU EARTHQUAKE OF AUGUST 15TH 2007 ON HEALTH FACILITIES

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ABSTRACT :

On August 15th 2007, Pisco earthquake with intensity VIII in MM and Magnitude 7.9 Mw on moment scale, affected the cities of Pisco, Ica, Cañete and Lima in the central coast of Peru, South America.

Early reports said that the quake caused almost 600 deaths, more than 1,000 people injured, over 36,000 houses destroyed or with strong damages, 8 hospitals with several damages, and 3 hospitals destroyed.

The most important health facilities of Pisco, Cañete, Chincha and Ica city were affected by the quake. They suffered strong damages on their structures and others on their non structural elements. Most of the health facilities had to attend partially, with emergency resources and some of them collapsed and close their activities. It is assessed that the total population on the affected area is over 863,000 inhabitants.

Most of the strong damages occurred in one-story adobe buildings. The last earthquake of August 15th, demonstrated that this type of material must not be used for essential facilities. According to the last Peruvian seismic code of 2003, adobe bricks are forbidden for hospitals and schools.

But not only the adobe buildings collapsed. There were also significant damage in those buildings of masonry and concrete, whose design, quality materials and construction process was very poor. To this must be added the local soil conditions, often without previous studies leading to an efficient design of the foundation.

To prevent occurrence of similar losses in the future and ensuring the efficient functioning of health facilities, even under the most adverse situations, is important to incorporate guidelines and safety criteria in studies of pre-investment and investment in health, such as designing minimum safety standards for construction of facilities and for the rehabilitation, renovation, expansion and mitigation of existing buildings, and developing mechanisms and means for verifying compliance with minimum standards in pre-investment studies and investment in health.

KEYWORDS: Health Facilities, Impact, Earthquake, Pisco, Chincha, Ica

1. SITUATION OF THE HOSPITAL INFRASTRUCTURE IN PERU

In the Peruvian national territory hospitals from the Ministry of Health, are distributed in the three regions natural distributed: 59 (41%) hospitals in the Coast Region, in the Andean region are located 58 representing 39% and the Forest Region 30 representing 20%. Of all hospitals, 90% (131) are located in urban areas, 3% (5) in rural areas and 7% (11) in marginal urban areas.

The conservation status of environments reported by the census chips allows us to point out that the hospital infrastructure by 69% is in a level of conservation acceptable, 28% introduced a level partially damaged and a 3% requires intervention by the level of that is deteriorating.

Most hospitals have overcome their physical ability - functional and many of them prevails overcrowding in contravention of safety standards in that they were creating a disorderly growth that does not obey a comprehensive development plan for the hospital.

In our country most hospitals have an average that exceeds 40 years of existence and were built under less demanding standards of seismic codes that the infrastructure built more recently. These structures contain sections built over a century ago along with sections built recently as three years ago.

This constructions "Expansions" have resulted in several hospitals that have limited functionality. In addition, these structures were designed for a very different technological standard and are usually obsolete. The lack of maintenance over time has significantly contributed to the deterioration of physical infrastructure and mechanical equipment. The provision of dysfunctional hospitals oldest, combined with the level of obsolete and damaged equipment, presents a latent risk to patients.

Another important item was the investment of the Ministry of Health during the year 2002 -2003, in the presence of "El Niño" phenomenon, performed and executed work of prevention and mitigation in health facilities in 8 departments, aimed at rehabilitation of coverage, ceilings, waterproofing of roofs, gutters and ditches placement for the evacuation of storm water and protective walls with an investment of US\$ 2 '708,728.00. In 2003 and 2004, funds were allocated by the sums of US\$ 996,063.00 and US\$ 472,391.00 respectively for the rehabilitation of health facilities in the departments of Cusco, Puno and Madre de Dios as a result of rains and floods. By the year 2005 was allocated resources for the Rehabilitation Program of the areas affected by the earthquake – 2005 in the department of San Martin.

2. GENERAL INFORMATION OF THE EARTHQUAKE ON AUGUST 15, 2007

The Republic of Peru located on the central western coast of South America shares the seismicity and hazards of the countries located along the Circumpacific belt. A two thousand kilometer long subduction zone resulting from the introduction of the Nazca plate beneath the South American plate makes 80% of Peru's 1'250,000 km² territory, home of 95% of its 28 millions inhabitants highly seismically active. So earthquake hazard is a national problem which hinders sometimes dramatically, the country's social and economical development.

The country has a long history of destructive earthquakes. The two most destructive earthquakes during five centuries of documented historical data were: the October 28, 1746, earthquake when Lima city was completely destroyed, and Callao the nearby sea port city was destroyed by the seismic vibration and then razed by tsunami waves which killed 97% of its 5,000 inhabitants; and the May 31st, 1970, Ancash earthquake, when according to official data the death toll was 67,000, of which about 40,000 were killed under the debris of their own adobe homes. The direct losses were set at more than US\$ 500 million.

On August 15, 2007, at 18:41 hrs (23:41 hrs GMT) a very strong earthquake hit the central coast of Peru. The epicenter was located at 60 kms, on the Pacific Ocean, west of Pisco city, 260 km south from Lima. Its

magnitude was 7.0 ML (on Richter Scale), and 7.9 Mw. The epicenter was 30.2 km depth. The intensity were VII MM on Pisco, Chincha and Ica cities, VI MM on Lima, and V MM on Huancavelica. The quake caused the interruption of both power and telephone services, within Peru and in the capital city of Lima.

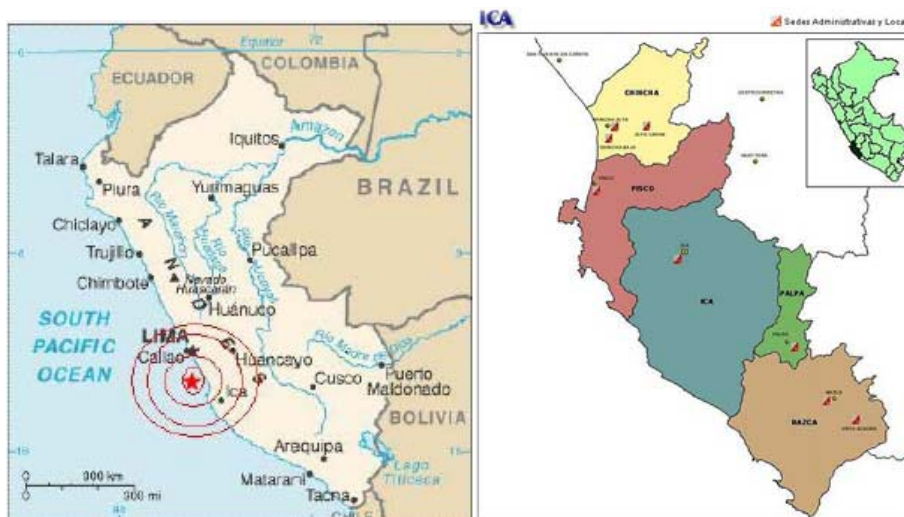


Figure 1: Location of the epicenter and main cities affected by the earthquake of August 15, 2007

As consequence due the earthquake it were important damages on housing, public buildings, and public services such as water supply, sewerage and transport facilities. Almost 600 inhabitants were killed by the quake and more than 266,000 people were affected.

The National Institute of Civil Defense-INDECI reported that more than 58,000 houses were totally destroyed by the quake, and 13,585 houses were affected in different levels on Lima, Ica and Huancavelica Regions. Table-1 shows the totally population affected by the earthquake.

Table-1: Population Affected by Earthquake of August 15, 2007

| Province | Total Population | Families affected | Population affected | % Population affected |
|----------|------------------|-------------------|---------------------|-----------------------|
| Chincha | 184,349 | 15,730 | 78,650 | 42.7 |
| Ica | 319,511 | 13,813 | 69,065 | 21.6 |
| Pisco | 132,505 | 17,697 | 88,485 | 66.8 |
| Palpa | 19,819 | 138 | 690 | 3.5 |
| Cañete | 177,925 | 3,429 | 17,145 | 9.6 |
| Yauyos | 29,488 | 2,580 | 12,950 | 43.9 |
| Total | 863,597 | 53,397 | 266,985 | 30.9 |

Source: Plan for Health Recuperation; Ministry of Public Health

3. DETAILS OF THE DAMAGE CAUSED BY THE EARTHQUAKE IN THE INFRASTRUCTURE OF HEALTH FACILITIES

A mixed team composed by CISMID staff and an expert designed from the Pan-American Health Organization-PAHO evaluated the main health facilities of Ica Region, including hospitals in Pisco and Chincha that suffered physical damage and were operating on a limited basis. This assessment was made possible thanks to financial support from PAHO.

3.1 Hospitals

Chincha Hospital “San Jose”:

This hospital has capacity for 110 beds, with services of emergency, hospitalization, radiology and surgery centre. The last one not regularly works because it does not have specialized medical personnel. It has no ICU.

This hospital presents its main structure in severe damage and the collapse impeding normal operation. The old structures (approximately 80 years) and also the new structure (finished in 2007), which is located hyperbaric camera and central gas, are faced with severe damage and partial collapse. These can not be used. The collapsed sectors are built with adobe blocks 50 cm wide and walls of 5 metres high, without any reinforcement vertically or horizontally. Fortunately work in these blocks administrative services and file clinical history. All rooms built with adobe are unused to 100%.

As observed in various past earthquakes in Peru, usually the adobe wall constructions have light and flexible roofs so the wall's upper borders are free to vibrate. Under horizontal seismic forces perpendicular to the wall it fails by flexure. At the corners, cracks caused by negative moment and shear propagate from the upper border downward; and in the wall center, positive moment opens cracks starting in the upper free border. In long walls usually, the upper central part collapses first.

Sectors that have not been damaged buildings relate to brick and reinforced concrete; only show slight cracks that have not committed to the structure.

As in other hospitals pressure gauges were destroyed because the balls of oxygen are not insured and equipment kitchen and house forces do not have bolts that remain fixed to the ground.

Among the teams affected are: conservative house of corpses, power generator, fire extinguisher, pressure gauge, incubators and equipment phototherapy.

The equipment generally does not present seismic safety. There was significant loss of equipment by earthquake.



Figure 2: View of adobe buildings collapsed

Pisco Hospital “San Juan de Dios”:

The old adobe structures presented with severe damage and partial collapse with greater possibility of collapse under the influence of replicas. These structures could not be used and would most likely be demolished. Additionally no longer be maintained without an underpinning or strengthening.

The block of two new floors presented severe damage to collapse due to the existence of short columns. The structure is not recoverable. It should be demolished.

The body of a new floor is in full function and care including emergency service. With no structural damage or no structural significance.

Units of Pharmacy, Pediatrics, Medicine, Surgery, Admission, Epidemiology and SIS were completely destroyed along with equipment that were inside as: hyperbaric chamber, oxygen balloons, surgical beds, car healing, healing teams, showcases, Ultrasound, fetal monitoring equipment, equipment insertion neck, computer and printer. A total of 22 beds were affected.

The equipment generally does not present seismic safety. There was significant loss of equipment by earthquake. The homes around this hospital are constructed of adobe as a whole collapsed. As for buildings of masonry damage is severe, found some of these buildings collapsed.



Figure 3. Structures of adobe and reinforced concrete with very severe damage and collapse.

Ica Hospital “Santa María del Socorro”:

Hospital located in city of Ica attention with a reference 200,000 people but with a population of 50,000 allocated. It presents a set of buildings 1 and 2 floors. Structures oldest possess more than 100 years, main building is approximately 50 years and a structure relatively recent, 2003.

In general is uneven development of structures and spaces connectivity generating relatively complex. Adobe structures, all of a flat, except for the chapel, are severely damaged and evacuated. The services were located in these structures: Admission, Psychology, archiving, chapel, statistics, social service, deposits, physical medicine and other.

At the beginning of the century structures, a flat, with partial damage, cracking widespread average rate of soil and settlements. The structures are partially used. The services are there: Laboratories, X-Ray, Blood Bank. The damage allowed use of low occupancy.

The structures of the 50 have mostly two stories. They fissure means. They are running all services originals. The fissure presents no serious injury but was strongly suggests evaluating the cracks in the field of obstetrics postpartum which have opened new doors and there is a fault line that may be due to two causes: including lintel beam which would indicate that there is no risk or absence of a beam so that deserves an immediate review.

In sections near the catholic chapel, built in mud, as social service, psychology, statistics and so on were found doors and windows with wooden frames in severe damage and broken glass, roofs mat with slight damage, without light or water, detachment of plastering on the walls and floors in poor condition.

The sections made in masonry, in general, were found cracks in the sky and plastering of false walls, wooden doors and windows in good condition, with light and water, ceramic floors have not been damaged. However, it was noted in the section of the dining room very false sky and figured in the pediatric section, located on the second floor, with cracks on the floor.

It was noted that no team from the House Forces, laundry and kitchen are anchored to the floor to avoid slipping or dump also happens to pressure gauges of oxygen that the balls were broken in all units of the hospital.



Figure 4. Severe Damage in old buildings of the hospital

3.2 Other Health Facilities

Other health facilities, smaller and less technological resources, were also affected by the earthquake of August 15, 2007. These establishments are located in small populations of the provinces of Ica, Chincha and Pisco, and in neighboring provinces on the Andean Region.

Briefly level of damage in health facilities minor is shown in the table below.

Table-2: Minor Health Facilities affected

| PROVINCE | HEALTH FACILITIES | HEALTH FACILITIES WITH DAMAGES | No Structural damages | Partially Structural damages | Uninhabitable | Collapsed | % HEALTH FACILITIES WITH DAMAGES |
|----------------|-------------------|--------------------------------|-----------------------|------------------------------|---------------|-----------|----------------------------------|
| Ica | 55 | 5 | - | 4 | 1 | | 9.09 |
| Pisco | 23 | 5 | - | 5 | | | 21.7 |
| Chincha | 30 | 22 | - | 20 | 2 | | 73.3 |
| Castrovirreyña | 32 | 13 | - | 10 | 1 | 2 | 40.62 |
| Huaytará | 40 | 12 | - | 7 | 1 | 4 | 30 |
| Yauyos | 34 | 10 | - | 10 | | | 29.41 |
| Cañete | 43 | 17 | - | 17 | | | 39.53 |
| Total | 257 | 84 | - | 73 | 5 | 6 | |

Source: Ministry of Public Health

As the table above shows, the establishments in the province of Chincha were the hardest hit, that due to the poor quality of material used in construction, mostly adobe, and the poorly maintained buildings. Two of them were uninhabitable.

The physical damage to buildings caused the functions of the establishments were affected in whole or in part as shown in Table-3. This led to health facilities become a problem rather than providing assistance in the most adverse situations.

Table-3. Situation on the operational capability of health centers

| PROVINCE | Totally Operative | Partially Operative | No Operative |
|----------------|-------------------|---------------------|--------------|
| Ica | 1 | 4 | |
| Pisco | 3 | 2 | |
| Chincha | | 22 | |
| Castrovirreyna | 10 | 1 | 2 |
| Huaytará | 3 | 5 | 4 |
| Yauyos | 10 | | |
| Cañete | 17 | | |
| Total | 44 | 34 | 6 |

Source: Ministry of Public Health

Table-4: Health Workers affected

| NAME OF HEALTH FACILITY | NUMBER OF WORKERS | NUMBER OF WORKERS AFFECTED |
|--|-----------------------------------|----------------------------|
| HOSPITAL REGIONAL ICA | 574 | 38 |
| HOSPITAL SANTA MARIA DE SOCORRO ICA | 312 | 59 |
| DIRESA | 184 | 28 |
| RED DE SALUD 1 ICA PALPA NAZCA | 500 | 114 |
| RED DE SALUD 2 CHINCHA PISCO | 463 | 463 |
| HOSPITAL SAN JOSE-CHINCHA | 307 | 194 |
| HOSPITAL SAN JUAN DE DIOS PISCO AND HEALTH FACILITIES OF PISCO | 463 | 463 |
| TOTAL | 2803 | 1359 |
| ESSALUD: 150 WORKERS AND 80% AFFECTED DECEASED | 01 FROM MINSA 01 FROM ESSALUD | |
| SERIOUSLY INJURED | 02 WORKERS FROM HOSPITAL SAN JOSE | |

Source: Ministry of Public Health

As shown in Table 4, the quake caused nearly 1360 employees of health facilities were directly affected by the damage to their homes and by the collapse of its central tasks. Two of them died fulfilling his duties.

4. CONCLUDING REMARKS

The health facilities are essential buildings that should continue to function during and after seismic movement occurred.

Under this concept, health and medical service support that occurred after an adverse event of natural or technological should continue running in the same physical infrastructure, should maintain an operational capability to meet normal demand additional wounded, should remain in permanent communication with the external environment, and should remains accessible for the community. Even the Peruvian earthquake resistant design code classifies hospitals as Category A-essential buildings, whose role should not be discontinued immediately after the occurrence of an earthquake.

However, the earthquake of August 15, 2007 revealed the fragility and the high degree of vulnerability of some buildings hospital in Peru, which not resisted the seismic movement. Almost all of adobe buildings that were operating within health facilities, suffered major structural or collapsed. To this must be added that these buildings are very old and were built without any building code.

But not only the adobe buildings collapsed. There were also significant damage in those buildings of masonry and concrete, whose design, quality materials and construction process was very poor. To this must be added the local soil conditions, often without previous studies leading to an efficient design of the foundation.

In order to prevent occurrence of similar losses in the future and ensuring the efficient functioning of health facilities, even under the most adverse situations, experts in the field suggest to incorporate guidelines and safety criteria in studies of pre-investment and investment in health, such as designing minimum safety standards for construction of facilities and for the rehabilitation, renovation, expansion and mitigation of existing buildings, and developing mechanisms and means for verifying compliance with minimum standards in pre-investment studies and investment in health.

Also to ensure compliance with safety standards disaster in the construction of new health services and the operation of existing ones, to devise mechanisms and means for tracking and monitoring of security conditions in health services, and to develop intervention actions to reduce vulnerability in health services. In this last item it is very important to have a preliminary diagnosis of conditions of vulnerability of health facilities for strategic disaster response and prioritizing the allocation of resources for reducing vulnerability of health services evaluated.

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