5. ROADS AND BRIDGES

5.1. Background

5.1.1. Peruvian road network

The Peruvian road network is an extensive system of roads crossing most of the mountain and coastal regions. It consists of 78 318 Km classified in three categories: national highways, regional roads, and rural roads (see Table 5.1). Most of the national highways have two lanes and one safety lane for each travel direction whereas regional roads have one lane and one safety lane.

Table 5.1. Road classification in Peruvian road network. Adapted from [1]

Category	Length [Km]
National Highway	17158
Regional Road	14251
Rural Road	46909

Only 12% of the Peruvian roads, mainly the national highways, are paved. Forty-five percent of the roads do not have surface treatment, mostly in the rural areas, and 23% have base but not pavement. (See Fig. 5.1).

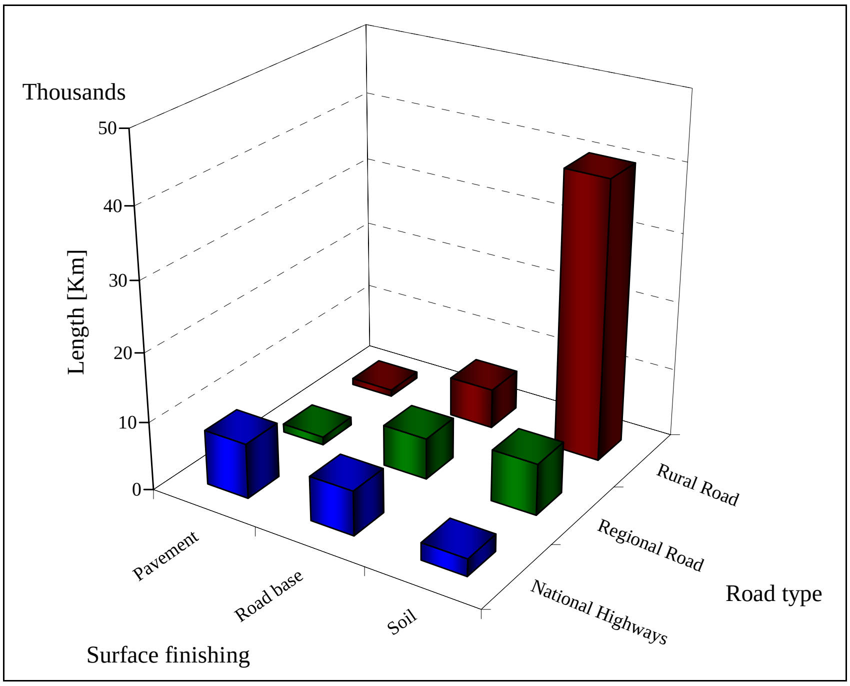

Fig. 5.1 Peruvian road network distribution based on road surface conditions. Adapted from [1]

The main roads are the Pan-American Highway, which runs parallel to the coastline, the Central Highway, which connects the capital, Lima, with the Central Andean highlands, and the Marginal Highway, which penetrates deep into the northeastern Amazon region.

The Ministry of Transportation and Communications (MTC) has developed guidelines for road design and construction as shown below:

- Highway geometric design manual (DG 2001)
- Technical specifications for construction of roads (EG 2000)
- Materials testing manual (EM 2000)
- Bridge design manual (DG 2003)
- Unpaved road design manual (084-2005-MTC)
- Routine and periodic maintenance manual for regional roads (026-2006-MTC)

5.1.2. Concession system of transport infrastructure

The Concession Program was established by the MTC under the Infrastructure Development Plan in order to guarantee infrastructure development and maintenance. The Concession Program promotes the construction, improvement, rehabilitation, operation, and management of infrastructure by private operators in order to resolve investment difficulties that have been affecting the Peruvian road system. The first concession in the Peruvian road system was the Arequipa Matarani Highway given in 1994 to CONCAR S.A. During the team interview surveys, it was found that approximately 10% of the Peruvian road network is currently under concession.

The main access road of the affected region, the South Pan-American Highway, was given in concession under a contract signed on September 20, 2005 on the road stretch between Km 58 and Km 290. The investor COVIPERU (Concesionaria Vial del Perú S.A.), which was given the concession for 30 consecutive years, committed to invest US$157 million in the highway. Furthermore, COVIPERU has the obligation to insure, the entire highway given in concession, against any event, including an earthquake. Table 5.2 shows the length of the concession.

Table 5.2. Sub-stretches of the South Pan-American Highway, Pucusana Bridge–Cerro Azul–Ica Stretch. Adapted from [2].

Sub - stretch	Department	From	To	Length [Km]
1	Lima	Pucusana Bridge	Cerro Azul	72.700
2	Lima	Cerro Azul	Cerro Calavera	1.600
3	Lima	Cerro Calavera	Pampa Clarita	18.701
4	Lima/Ica	Pampa Clarita	Chincha Alta	33.085
5	Ica	Chincha Alta	San Andres	41.114
6	Ica	San Andres	Guadalupe	54.495

A part of the concession contract includes shifting a portion of the Pan-American Highway towards the west to avoid passing through Canete and Chincha cities, as it presently does. This investment was supposed to be gradually done from 2008 until 2022. The Pisco Earthquake encouraged the MTC to bring forward this schedule, so that the new road is finished by 2011.

5.2. Road Damage

The South Pan-American Highway widespread damage was mainly due to landslides, rock falls, lateral spreading, and liquefaction. The MTC released a preliminary report of the damaged areas shown in Table 5.3.

Table 5.3. Damage in the Pan-American Highway due to Pisco Earthquake
Adapted from [4]

Location Name	Type of failure	Km
San Jeronimo Surco	Slope failure	56 to 57
Mala	Slope failure and pavement cracks	79 to 80
Jahuay - Chincha	Pavement cracks	177 to 178
Jahuay - Chincha	Slope failure	179
Jahuay - Chincha	Embankment failure. L=200m	190 to 191
Jahuay - Chincha	Embankment failure. L=20m	213
	Pavement cracks. L=200m	217 to 218
Huamani	Embankment failure.	222

COVIPERU has among its responsibilities to repair and replace the damaged infrastructure after a disaster to fully restore the service within 15 days. Although traffic was briefly disrupted, 5 hours after the event restricted transit was possible and within 48 hours fully traffic was reestablished. Most of the repair works, except for the reparation of the Huamani Bridge, were finished two weeks after the earthquake. This was a critical fact, considering that South Pan-American Highway is the main access to the affected area, especially for the aid coming from Lima city.

The regional and rural road networks were mainly affected by slope failures and rock falls, which in many cases disrupted the traffic.

Typical road damage induced by the earthquake may be categorized as: slope failure, embankment failure, longitudinal cracking, settlement, shoulder settlement/displacement, road distortion and pot holes. Most of damages are caused by failure of the unstable foundation due to liquefaction. Fig. 5.2 to Fig. 5.7 show typical damage examples.

Fig. 5.2. Slope failure caused by liquefaction induced lateral spreading

Fig. 5.3. Liquefaction induced embankment failure

Fig. 5.4. Cracking along the pavement due to landslide induced movement

Fig. 5.5. Shoulder settlement and displacement

Fig. 5.6. Road distortion due to liquefaction induced lateral spreading

Fig. 5.7 Pot holes caused by rock falls

The South Pan-American Highway was heavily damaged where it turns west to enter Chincha City. This location coincides with the limit where the Canete Formation meets a marine deposit. The Pleistocene Canete formation consists of alternating layers of sand and silt stones, with marine or eolic deposits above it. Widespread liquefaction observed in this area may have caused much of the road damage. At this location, uplifting of the slope side shoulder occurred. This is likely due to loss of the base support of the slope, which then moved towards the road (see Fig. 5.8) lifting it up. Liquefaction /lateral spreading induced loss of base support caused the slope failure damage shown in Fig. 5.9.

Fig. 5.8 Lifted shoulder at Playa Jahuay. South Pan-American Highway

Fig. 5.9 Road failure due to lateral spreading at the foot of the slope. South Pan-American Highway

A massive rock fall occurred along the Canete-Yauyos road, as shown in Fig. 5.10, (S 12º54.778' W 76º05.852'). Debris completely covered the road surface disrupting traffic. The rock formation at this location is constituted by blocks of partially weathered igneous intrusive rock.

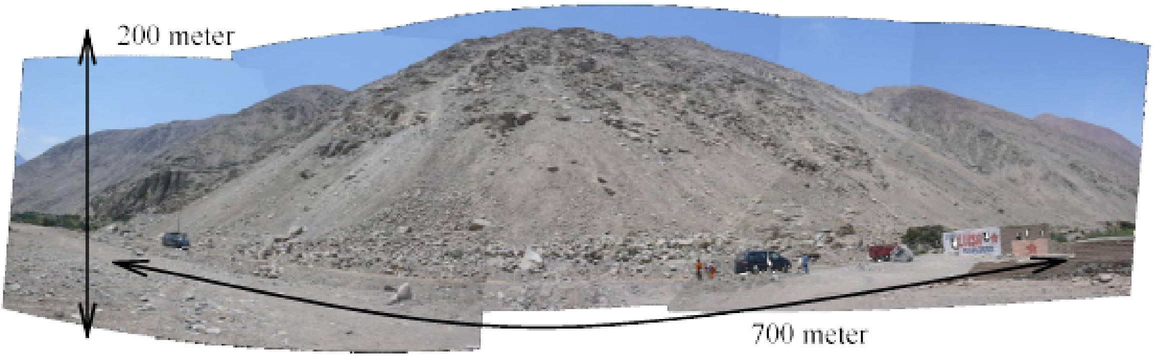

Fig. 5.10. Rock Fall. Canete-Yauyos Road, 60km from epicenter.

A slope failure was observed at the Km.23 of the Canete-Yauyos road. This is the exact point where the road and an irrigation channel meet. Although there was no evidence suggesting channel damage or water leakage, the possibility that its presence may have somehow affected the slope stability needs further assessment.

Fig. 5.11. Google earth view with black arrow indicating the slope failure at Canete-Yauyos road (Km. 23) (13° 3'3.08"S, 76°13'32.85"W).

Fig. 5.12. Slope failure at Canete-Yauyos road (Km. 23)

Fig. 5.13. Slope failure at Canete-Yauyos road (Km. 23)

5.3. Bridge Damage

A few bridges were surveyed in the affected areas along the Pan-American Highway, Los Libertadores Highway, and the Canete-Yauyos Road. Most of the visited sites had little damage, mostly in the form of settlement of the fill behind the abutments. At one of the bridges, a rock impacted on the sub-structure, causing a spalling damage.

Fig. 5.14 Mild settlement of the fill behind abutment (La Quinga Bridge, Los Libertadores Highway)

Fig. 5.15 Rock impacted on bridge sub-structure (Tsej Tji Bridge, Los Libertadores Highway, close to Huaytara)

The most affected bridge was by far the Huamani Bridge, which crosses the Pisco River. This reinforced concrete bridge, designed for a HS-15 truck load, was built in the 50's. At that time, bridge seismic design was quite primitive in Peru. These structures were designed to withstand 0.04, 0.06, and 0.08g base shear force for hard, medium, and soft soils [5].

The 136-m long Huamani bridge follows the configuration of a typical Gerber bridge. Two rather slender abutments (typical Base/Height = 0.3) and four intermediate pillars are supported on 5.4m-deep and 7.3m-deep caissons, respectively. According to the bridge drawings, there is no connection between the abutments/pillars and the caissons, i.e. the pillars could slide/rock upon the caisson top. Fig. 5.16 shows the layout of the bridge. The superstructure consists of five sections.

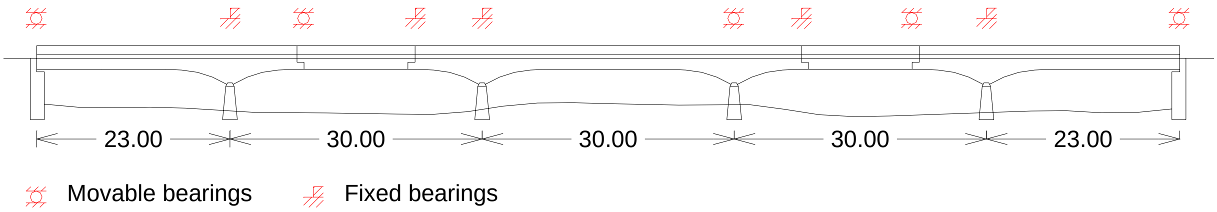

Fig. 5.16 Layout of the Huamani bridge (downstream direction)

Fig. 5.17 Overview of the bridge (downstream direction)

Liquefaction induced lateral spreading was observed in the northern upstream bank of the Pisco River and also south of the south embankment. Evidence of liquefaction was also found around the bridge pillars.

Fig. 5.18 Liquefaction induced lateral spreading (Pisco River north upstream bank)

Fig. 5.19 Liquefaction at the bridge pillar

The southern abutment tilted towards the north some 7% due to the Pisco earthquake [5] and settlement and cracking of the embankment also occurred. The intermediate pillars also rotated. Although the north abutment was not as damaged as the southern, settlement of the backfill was observed there. The geological formation at the bridge north access belongs to the Miocene/early Pliocene age whereas alluvial deposits are found in the south.

Fig. 5.20 South abutment, upstream

Fig. 5.21 South abutment, downstream

The bridge superstructure is supported on fixed and movable bearings as shown in Fig. 5.16. The movable bearings are made of steel rollers as shown in Fig. 5.22 and Fig. 5.23. Note the steel stoppers installed to prevent the movement in the bridge transverse direction. The steel bearings were quite corroded.

Fig. 5.22 Movable bearings on the pillars

Fig. 5.23 Movable bearing at the southern abutment

The bridge superstructure permanently moved upstream as shown in Fig. 5.24. The blue dots represent the superstructure sections and the measurements indicate relative displacements between adjacent sections or between superstructure and abutments. At the movable bearings on the abutment, the steel fittings separated from the concrete structure (Fig. 5.23). The stoppers on the pillar movable support, bottom, were not found. The lateral movement of the bridge caused damage to the concrete wings of the pillars, especially that with the movable bearing. These wings had very little steel reinforcement.

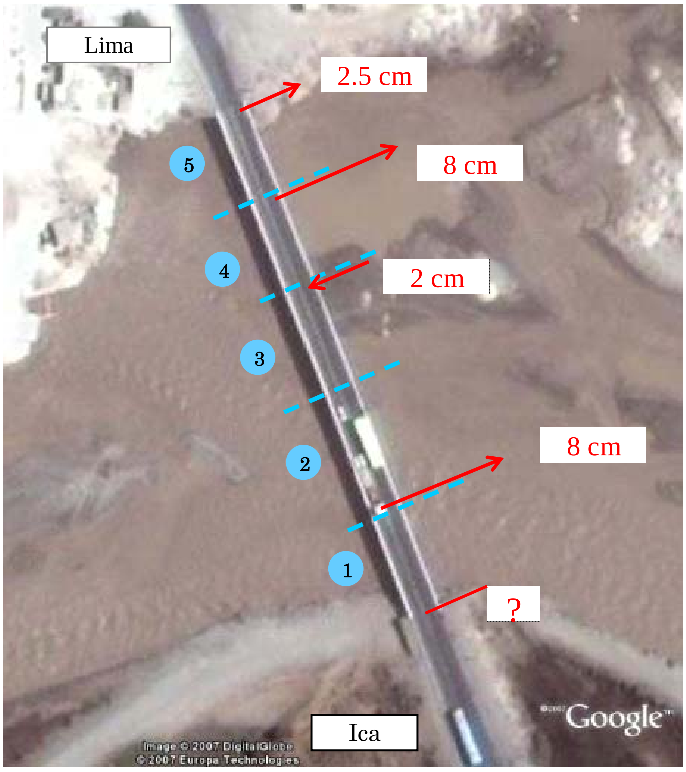

Fig. 5.24 Google earth view of the displacement of the bridge superstructure.

Fig. 5.25 Bridge slab displacement (picture taken towards the north). Arrow indicates the gap corresponding to the southern 8 cm gap shown in Fig. 5.24

Fig. 5.26 No bottom steel stoppers were found at the pillar movable bearing.

Fig. 5.27 Failed wing with poor reinforcement (pillar with movable bearing)

Fig. 5.28 Failed wing with poor reinforcement (pillar with movable bearing)

The displacements and rotations of the bridge segments concentrated stresses on the superstructure transverse beams which suffered cracking.

Fig. 5.29 Damaged transverse beams

Fig. 5.30 Cracks in the wing of the pillar with fixed bearing

In spite of the damage observed in the bridge, it performed very well. Immediately after the earthquake, traffic continued, but was restrained to one truck at a time. To improve the traffic conditions, a temporary passage along the riverbed was later prepared and was still in use while the bridge was been repaired when we passed this location on several occasions from September 8 to 18.

Because it is expected that in the near future the stretch of the Pan-American Highway to which the Huamani bridge belongs will be shifted towards the west, the reparation works done were aimed at restoring its original capacity, not improving it.

5.4. Summary

Road damage due to the 2007 Pisco Earthquake extended over a wide area. The South Pan-American Highway which was the most affected and also pivotal for the response actions was recovered in a relatively short time. Because this portion of the highway has been given in concession, revisions of the investment schedules and contract terms are currently under discussion.

Regional and rural roads were affected mainly by rock falls and landslides, problems which afflict them on a regular basis.

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6. DISASTER RESPONSE AND RECOVERY/RECONSTRUCTION

6.1. Response

Disaster response is a function that belongs to the National Institute of Civil Defense and the local governments. Therefore, coordination among these entities is fundamental for a successful response. Incidentally, in January 2007, the authorities at local governments changed and therefore, most of them, except for those who were re-elected, had less than eight months in office. In addition, there are few disaster management career officials at the local governments. These two factors hindered the response capacity of local governments. In this section, some of the disaster response aspects will be discussed.

Debris removal

Debris removal proceeded swiftly with heavy machinery in Pisco immediately after the earthquake. After this, there was a period in which removal was carried out by crews, approximately 1 800 people, hired by the Ministry of the Presidency in the framework of the Building Peru Program. No heavy machinery was observed in Pisco by our team in this period. Eventually, almost a month after the earthquake, heavy machinery re-started cleaning Pisco. Table 6.1 shows a summary of debris removal as of October 24, more than 2 months after the earthquake.

Table 6.1 Progress in debris removal [2]

Province	Volume to remove [m^3]	Progress as of Oct. 24 [m^3]	Progress as of Oct. 24 [%]
Chincha	2 858 000	382 895	13.3
Ica	2 023 645	284 058	14.0
Pisco	2 120 000	441 927	20.8
Canete	791 820	113 514	14.3
Yauyos	440 000	6 624	1.5
Total	8 233 465	1 229 019	14.9

Residents who had their houses collapsed could request assistance from the municipality to remove the debris from their lots by submitting a form. In addition, many people were cleaning their properties by themselves. This was observed by the reconnaissance team especially at Tambo de Mora and Guadalupe, Ica. It is worth noticing that the cleaning progressed faster due to self support in towns where tourism is the main economic activity, such as Lunahuana, in the region of Lima.

Fig. 6.1 Cleaning crew hired in the framework of the Building Peru Program

Fig. 6.2 People removing debris from their homes by themselves

Temporary facilities

A few temporary houses were observed in downtown Pisco as shown in Fig. 6.3 and 6.4. To be eligible for this, the beneficiary should first clean his/her lot from debris. Many people, who could not benefit from these facilities, build their own temporary houses with the material they could recover from their roofs, mainly straw mats.

Fig. 6.3 A temporary house provided by BANMAT or Materials Bank a governmental agency under the Ministry of Housing.

Fig. 6.4 Wooden temporary house

Fig. 6.5 A temporary house built by a resident (Guadalupe, Ica)

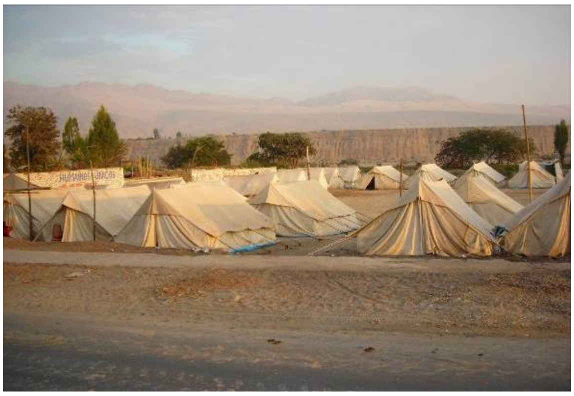

Fig. 6.6 Tents were used to cover the housing shortage in most of the places visited (Humay, Ica)

Temporary houses were not observed outside Pisco. At the other visited locations housing requirements were mostly covered by tents as shown in the table below or self constructed shelters.

Table 6.2 Number of tents distributed [2]

Province	No. of tents
Pisco	3 443
Chincha	2 500
Ica	2 000
Canete	390
Total	8 333

At schools, such as the San Luis Gonzaga high school in Ica, temporary classrooms were being installed while the team was surveying. Also, temporary health centers were installed in Pisco.

Fig. 6.7 Temporary classrooms under construction in San Luis Gonzaga School (Ica)

Fig. 6.8 A day-care center wawa wasi functioning in a tent (San Luis, Canete)

Fig. 6.9 Temporary health center in Pisco (Ica) (courteousy of Shizuko Matsuzaki)

Refugee camps

Table 6.3 summarizes the refugee camp situation as of October 24, 2007. According to a Health Ministry Situational Report [3], in most of the camps, there were insufficient tents for the sheltered population. Other problems include insufficient temporary toilets and cylinders for solid waste collection, which just cover approximately 20% of the demand. Water was distributed by EMAPISCO in cistern trucks and food was distributed by PRONAA and SODEXHO (a private company) and when necessary cooked in the camp.

Table 6.3 Refugee camps [2]

Province	Installed camps	No. of families	No. of people
Pisco	22	2 628	9 282
Chincha	49	1 872	8 621
Ica	1	29	98
Canete	19	5 170	5 170
Total	91	5 563	23 171

Response issues

Through the interviews and data collection carried out during our survey, the team could identify some disaster response issues as summarized below:

- Information disclosure to the general public: People were not well informed about the situation and this generated unrest.
- Looting: Immediately after the earthquake there was social turmoil which was resolved with the arrival of the Army.
- People did not know how to behave during the earthquake. Reportedly, two people died because they stood under the door entrance of their adobe house and the concrete lintel fell on their heads. Standing under the door entrance is a commonly recommended action to take when an earthquake hits. People believed that running into the churches would safe them when actually these structures were heavily damaged.
- Difficulties faced by the province municipalities to gather information from their districts. At Huaytara Province the lack of a system that effectively connected the

capital with all the districts, either physically, roads, or virtually, telephones/INTERNET, delayed the response actions.
- Corruption: A few cases were reported and investigated by the relevant authorities.

6.2. Recovery/Reconstruction

FORSUR

There seems to be no governmental agency in Peru which is responsible for the integral disaster management of the country including mitigation, preparedness, response, and recovery/reconstruction. Although, INDECI is the leading agency in the first three, i.e. mitigation, preparedness, and response, it is not specifically given the responsibility for reconstruction, although, in a sense, reconstruction is mitigation for the next event.

To coordinate all the reconstruction efforts in this occasion, the executive proposed to the congress the creation of the Fund for the Reconstruction of the South (FORSUR), which the latter accepted almost two weeks after the earthquake [4]. It was conceived following the model of the Fund for the Reconstruction of the Eje Cafetalero, in Colombia, which took over the reconstruction of the region hit by the 1999 Armenia Earthquake. FORSUR is under the Presidency of the Ministry Council (PCM) and its board is constituted by: a president, who represents the Peruvian President, the Presidents of Ica, Lima, and Huancavelica Regions, the Majors of Ica, Chincha, Pisco, Canete and Yauyos, the Ministers of Transportation and Communications, Health, Housing, Construction and Sanitation, Education, Energy and Mining, and Economy and Finance, or its representatives, and four representatives from the private sector. All of them work *ad honorem*.

FORSUR has been in office for almost two months and has reportedly made progress in the reconstruction planning [5]. However, this is not perceived at the affected provinces. As a result, the population is taking reconstruction steps on their own.

Financial support for house reconstruction

Shortly after the 2007 Pisco Earthquake, the government announced that it will provide S/. 6 000 to the people who lost their houses. This money will come from the Contingency Fund that the Ministry of Economy and Trade prepares every year, S/.30 million for 2007. However, one of the requirements to be eligible for this assistance was to submit among others a land property certificate. As mentioned in Chapter 4, informality, in this case, lack of property certificate, is one of the main issues in Peru.

Because irregularities in the land property in Peru are the rule, not the exception, the Commission for the Formalization of the Informal Property (COFOPRI) was created to deal with this problem before the earthquake. COFOPRI's main mission is to give land property titles to those that do not have it and who are eligible according to COFOPRI standards. After the earthquake, COFOPRI started working in the affected areas to try to solve the problems of land property. It estimated that approximately 30% of all the lots in Pisco were not registered [6]. Furthermore, of the more than 75,000 houses that are estimated will be reconstructed, 50% do not have property title [5].

Because the S/.6 000 will be insufficient to reconstruct a house, the government is planning to use the program TECHO PROPIO to provide additional money. This program, sponsored by the Ministry of Housing, was already in place before the earthquake to help low income people procure themselves with adequate housing. It consists of a grant of US$3 800. According to FORSUR, these two grants will cover almost 70% of the reconstruction cost and the 30% left will be obtained in the form of soft 20-year long loans. For receiving both grants, property title is a requirement and because of the irregular situation of most of the affected, the reconstruction process is not proceeding swiftly.

Fig. 6.10 The only way left to establish property rights is writing the resident name and address on the walls left standing (Tambo de Mora, Ica)

Recurrent deficient construction practices

During the survey it was observed that at many places, adobe blocks from the collapsed houses were neatly piled next to the lots suggesting that they may soon be used for reconstruction. In other places, people were trying to reuse the few walls that were left standing as the first walls of their new constructions.

The National Service for Training for the Construction Industry (SENCICO) has signed agreements with some municipalities, such as San Antonio, Cerro Azul and Lunahuana, to assist them with mason training. Unfortunately, these courses do not include guidance on adobe construction, which in our view is indispensable.

INDECI has also signed a MOU with SENCICO for the same purpose and reportedly FORSUR has approached it for advice.

Fig. 6.11 Front adobe wall, which did not collapse during the earthquake, is reused in the new structure with some "reinforcement"

Fig. 6.12 Adobes from collapsed walls are kept to be used as construction material

Fig. 6.13 Units from collapsed walls piled up ready to start the reconstruction

Other issues

Other reconstruction issues that were identified during our survey and interviews are summarized below:

- Material construction prices have increased affecting reconstruction process.
- People did not accept to be relocated unless they were given a land property title at another location. Many of these people do not have property titles for the places were they used to live and therefore there is no evidence of ownership other than their presence next to the debris.
- It seemed that there was no government coordination/ supervision of the activities of some NGO's.

6.3. Summary

In spite of the great efforts of the organizations in charge of disaster response, the magnitude of the disaster has overwhelmed them. This has translated in delays in the debris removal, insufficient temporary houses and tents, and poor conditions at the refugee camps. The affected people are trying to fill these need gaps by themselves.

An independent agency has been created to coordinate the reconstruction efforts. Although reconstruction plans seem to have progressed, works have not started yet and the public is growing increasingly impatient. It is of great concern that people have started reconstructing their houses with the same poor construction practices and bad quality materials. Some courses to train masons on good construction practices have been organized. However, the benefits of these efforts are yet to be seen.

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7. RECOMMENDATIONS

Based on the field survey findings and the numerous interviews held, the team's recommendations are summarized below. These are aimed at providing ideas on how to improve the disaster resilience capacity of the areas affected by the earthquake in particular, and the country as a whole. We have tentatively ordered the recommendations based on their impact to reduce human and property losses in future earthquakes, the most impacting being presented first. However, it is our understanding that this ordering is just tentative and the final one should be a result of discussion among relevant parties.

■ Structural and construction issues

- Strengthen the system of code enforcement not only at the design but also at the construction stage. Three components are necessary for this purpose: a) municipalities, which should have an adequate, in number and expertise, team of specialists to assess the projects' design and supervise that the construction follows the design; b) Association of Civil Engineers, which licenses the engineers responsible for the projects, to ensure that engineers manage projects according to their expertise level; c) an independent entity, which investigates and establish responsibilities when there are construction irregularities.
- Although the above mentioned system should, ideally, be also applicable for house construction, in practice, it will take time for this to become a reality in Peru. In the case of house construction, training masons in good construction practices (also for Adobe structures) may be a more feasible way to improve the construction quality. An agency like the National Service for Training for the Construction Industry (SENCICO) could be a very important component for this purpose.
- Require that all public buildings, governmental and private, are upgraded to the latest revision of the codes. It is practically impossible to retrofit all public buildings, it may even be impossible to assess the vulnerability of all of them. Therefore, a methodology to establish the order in which structures should be assessed and retrofitted is desirable.
- Promote retrofitting of seismically weak houses.
- Establish the mechanisms to effectively close the facilities which are deemed unsafe by the National Institute of Civil Defense (INDECI).
- Continue with pilot projects to introduce to the population earthquake resistant construction techniques, including a follow-up component to estimate the impact of these projects and the archiving of these experiences to serve as reference material for future initiatives.
- Explore cheaper construction technologies to retrofit adobe houses, for instance with plastic meshes. Solutions that may be suitable for one situation may not be for another. Reinforced and retrofitted adobe houses performed well, demonstrating that adobe can be made earthquake safe.

- Emphasize the retrofitting of public structures which have a special significance to the population, for instance churches, and use these opportunities to create disaster awareness among the population.

■ Disaster awareness issues

- Carry out activities to increase the public disaster awareness. Mass media can be a very useful tool for this. Outreach to the young generation at elementary and high schools through imagination exercises in which they explore the possible consequences of a disaster and drills. Promoting disaster awareness among young people has a multiplying effect and also creates a conscious next generation.

■ Issues related to future earthquake affecting Lima

- Study the possible impact, direct (human and property losses) and indirect losses, for an expected earthquake in Lima. The Peruvian Capital concentrates more than 30% of the country population, the central government, and also an important share of the country economy. Although every people we met agreed that an earthquake in Lima would be a tragedy, nobody could give specific numbers regarding the potential losses. Such an assessment can have a huge leverage for promoting mitigation.
- Extend the Sustainable City Program, which is being carried out by INDECI, to cover all the major cities in the country especially Metropolitan Lima.

■ Land use issues

- While it may take time, it is very important to base the land use plans on existing hazard maps. The damages in Tambo de Mora and Pisco coincide very well with these maps, showing their importance and necessity. When such maps are updated, land use laws should also be updated if deemed necessary.
- Accelerate the process of formalization of property rights.

■ Foundations and geotechnical issues

- Liquefaction induced large soil cracks and displacements were observed in Tambo de Mora and Pisco. The only way to reduce the damages induced by such soil deformations is with reinforced, strong, and expensive foundations. The good performance of such foundations was clearly shown by a newer school house in Tambo de Mora and a Hotel in Pisco.
- The strong foundations are especially important for public buildings like schools and hospitals. Weak foundations, similar to the one of the health center in Huaytara, needs to be retrofitted or reconstructed.
- Foundations preventing moisture from entering the adobe walls from the surrounding ground are necessary. In addition to reducing the earthquake resistance of an already earthquake vulnerable building type, moisture also constitutes a general health problem.
- It is not easy to reduce the effects of large soil cracks, such as the ones observed in Nuevo Monterrico. With strong reinforced foundation slabs, the houses may have withstood some of the deformations.

- Disaster response and reconstruction issues
  - Create a digital and interactive disaster management manual, effectively a database, in which the roles and duties of each stakeholder are included. With this type of system strengths and weaknesses can be pinpointed helping to improve it. It can be enhanced with the experiences collected in drills and during disaster events.
  - It should be desirable that the experiences of the Fund for the Reconstruction of the South (FORSUR), which has been created just to address the reconstruction of the areas affected by the 2007 Pisco Earthquake, are archived for future reference as well as all disaster management experiences.
  - Encourage disaster management related officials at all government levels, central, regional, and local to stay at their positions for longer periods. In this way, disaster management policies can have continuity even under different administrations and also, people experienced in disaster response are available when a disaster hits.
  - Establish procedures to release accurate and timely information to the population in order to avoid rumors and tensions.

- Seismic network
  - Strengthen the system for sharing strong ground motion recorded information, through, for instance a common INTERNET platform from where the information of all relevant institutions can be downloaded as soon as it is available. E.g. instrumental intensity maps based on all records could be provided.
  - Adding more seismographs to the networks, especially to the bigger cities, and converting analog instruments to digital, would e.g. allow for quicker estimation of affected areas.