CONSTRUCTION MANAGEMENT ASPECT IN A MASSIVE RECONSTRUCTION PROGRAM OF EARTHQUAKE DEVASTATED AREA: CASE STUDY OF FLORES ISLAND, INDONESIA.

K.S. PRIBADI and B.W. SOEMARDI
Center for Earthquake Engineering Studies
Institut for Research, Institut Teknologi Bandung, Bandung 40132, INDONESIA

11 WCEE
Paper No. 833. (quote when citing this article)
Eleventh World Conference on Earthquake Engineering
ISBN: 0 08 042822 3

ABSTRACT

The December 12, 1992 earthquake in Flores island was one of the strongest and most destructive earthquakes in recent Indonesian history. The 7.5 on the Richter scale earthquake, combined with its tsunami effect, had affected an area of about 10.000 km2 of the island. The earthquake cost the lives of about 2000 peoples and destroyed more than 25.000 houses, 600 schools and 135 health facilities, in addition to the damages to infrastructures (roads, bridge, jetties, airport facilities, irrigation works, water supply systems, etc.), totaling in an estimated damage of about US $ 273.5 Million.

A massive reconstruction and development program have been formulated by the government of Indonesia, focusing on long-term reconstruction and mitigation againts the failure of infrastructure, buildings and services in the future. Several issues related to the construction management aspects of the reconstruction program will be discussed in the paper. The primary objective of the program is to provide building facilities and infrastructure, badly needed by the people in an highly seismic region to continue their normal socioeconomic activities. Various issues related to the construction management aspect i.e. procurement process, contract administration, logistical problems and labor skills and quality assurance are addressed. The experience could be used as a reference when facing similar situation in different countries.

KEYWORDS:

Construction management ; reconstruction; procurement; contract administration; quality assurance.

FLORES EARTHQUAKE

Flores island (120° to123°E / 8° to 9° S) is located in the eastern part of Indonesia, in the Province of Nusa Tenggara Timur (NTT), part of the Smaller Sunda archipelago. With its 1.4 million population and income per capita level of about US $ 170, it is the poorest province in Indonesia. The area is well known as one of most seismically active zones in the region, situated along the boundary between the Eurasian and the Indonesian-Australian tectonic plates. The December 12, 1992 earthquake, with its epicenter located at about 50 kilometers off north coast of the island, was one of the strongest and most destructive earthquakes in recent Indonesian history. The earthquake, which had a magnitude of 7.5 on the Richter scale, combined with its tsunami effect, had affected about 70 % of the 14,200 square kilometers total area of the island.

Earthquake Damages

The earthquake cost the lives of about 2000 peoples out of almost 1.0 million people living in the most seriously affected area, covering 4 districts (East Flores, Ende, Ngada and Sika). About 25.000 houses and public buildings, 600 schools and 135 health facilities were destroyed or severely damaged. Damages were also afflicted to infrastructures and agricultural facilities i.e. 750 kilometers of roads, 700 metros of bridges, 4 seaports, two airports, 42 water resources facilities, 15 surface irrigation scheme serving about 6,000 hectares, 14 ground water irrigation schemes, riverbank protection and flood control works. Farms, livestock and food storage facilities as well as fishing facilities including 2,000 boats were also destroyed. The damage to homes and public infrastructures (commercial and private buildings excluded) is estimated at US $ 273.5 millions, while the damage to the agricultural sector is estimated at US$ 40 millions.

Several factors contributed to the failure of buildings and infrastructures. Masonry buildings, reinforced concrete as well as timbre structures suffered structural failures and totally or partially collapsed after the first shock as they were constructed without respect to the aseimic building design practices. Many construction suffered damage during the earthquake due to the very low quality of the construction material and workmanship. Foundation failure, liquefaction and ground subsidence contributed also to the damage of many infrastructure works. Landslides and rock avalanches during the earthquake destroyed roadways and pavement as well as buildings. Last but not least tsunami contributed to the destruction of many coastal villages and many victims were attributed to those tidal waves just after the first tremor.

Earthquake Recovery Strategy

A three stages program was formulated by the Government of Indonesia as a recovery strategy. The first stage (3 weeks) was focused primarily on the relief of earthquake victims immediately after the disaster. All relief activities were coordinated by the National Coordinating Board for Disaster Relief (BAKORNAS PB). by Government and bilateral as well as multilateral agencies, including the UN and NGOs, in close cooperation with military units and volunteers. The second stage (3 months) consists of initial rehabilitation and recovery works to put vital infrastructure back into service and to provide shelter for the homeless, coordinated by the Ministry of Public Works in cooperation with BAKORNAS PB. During the first and the second stage, the Government was assisted by bilateral and multilateral agencies, private sector organization as well as non-governmental organizations. The third stage implements, for three years, permanent reconstruction works which commence on 1 April 1993, coordinated by the National Development Planning Agency (BAPPENAS) and performed by those agencies that would normally be responsible for the type of work involved.

PROGRAM PRIORITY, COMPONENT AND FINANCING PLAN

Program Priorities

The program had given priority to the rehabilitation and reconstruction of roads and bridges, port facilities, water supply, irrigation and river works, social infrastructure which includes homes, health facilities, schools and markets damaged by the 12 December 1992 earthquake. The main objective of the projects is to ensure that buildings and infrastructure are designed, located and built to withstand any seismic events that may occur in the future in Flores

Component

Human Settlements. Consist of reconstruction of public buildings, about 5,000 houses, public sector schools,

hospitals and health centers, urban resettlement, urban water supply and sanitation, earth science facilities, including equipment.
Road and Bridges. To rehabilitate damaged national, provincial and district road links and bridges, including equipment and consulting services for design review and supervision.
Water Resources. Rehabilitation of surface and groundwater irrigation schemes, riverbank protection and flood control works, equipment and consulting services for detailed design, review and construction supervision.
Ports & Airports. Rehabilitation of damaged seaports and airports facilities to put them back in service.
Technical Assistants. Provision for management of overall reconstruction program, design and supervision, training and equipment in earth sciences, engineering/earthquake hazard mitigation and quality assurance technique, socio-economic and geo-technical spatial planning of human settlements.

Financing Plan

The Government of Indonesia is financing about 42 % of the total estimated budget of US $ 155.6 millions required to carry out the program. Several multilateral and bilateral sources co-finance the program in the form of loan (ADB, IBRD, OECF) and grant (AIDAB, UNDP), as shown in Table 1.

Table 1. Financing Plan

Financing	Govt. Projects	ADB Projects	World Bank Projects	OECF Projects	AIDAB Projects	UNDP Projects	TOTAL	PER CENT
Government	26.0	17.7	20.8	-	-	-	65.5	42
Loan	-	26.0	42.1	6.0	-	-	74.1	48
Grant	-	-	-	-	14.0	2.0	16.0	10
Total	26.0	43.7	62.9	6.0	14.0	2.0	155.6	100

EARTHQUAKE MITIGATION MEASURES

As the main objective is to reconstruct in accordance with standards appropriate to the seismic conditions in the region for future earthquake, the design and implementation were to follow the prevailing codes and standard practices for aseismic building and structures, such as (Arya et al., 1986) and (Annon , 1989) and other relevant codes and guidelines published by the Ministry of Public Work under the term of SNI (Indonesian National Standards). A General Reconstruction Guidelines (Annon.,1995) was prepared in order to define rules on the save design and implementation of rehabilitation and reconstruction works, including the rebuilding or resettlement of devastated urban areas.

Microzoning & Resettlement

Micro zone maps for the area were prepared, among others those for ground acceleration, base rock depth, geological condition, correction factors for ground acceleration based on risk to slope stability and liquefaction, risk zone to tidal waves, etc. Resettlements of damaged coastal villages were based on the new zoning maps to avoid future risk of liquefaction, tidal waves and landslides or rock avalanche.

Seismic Resistant Building

New building and structures were designed according to the above guidelines and codes. Special measures were taken to ensure that the detailing of concrete reinforcing is correctly designed and executed (including the proper spacing of column ties and beam stirrups) , large section of brick masonry walls is avoided by using properly placed and designed reinforced concrete columns and tie beams, etc. The main factor contributing to the damage of hundreds of school building was the absence of column and tie beams or collar beams in the typically designed brick masonry structure. To avoid the same mistake and also to speed up the reconstruction process, typical school building design using steel frame and ferrocement or plywood panels were introduced. Defects in the construction quality are to be avoided.

Road and Bridges

Many inland road sections were damaged by landslide and rock avalanche. Road links in the mountainous terrain were cut into steep slopes or laid along hill ridges. Reconstruction works include the cutting of slopes into proper inclination and sometimes slope protection works to avoid future landslide. Bridge foundation and abutment were reconstructed taking into account soil condition and liquefaction hazard. Increase of soil lateral pressure to the abutment during earthquake should be taken into account. Major abutment structures designed using reinforced concrete instead of the usual stone masonry.

Hydraulic Structures

During the earthquake, many hydraulic structures failed due to liquefaction, slope stability problem, foundation settlement and or increased lateral soil pressure which breaks retaining walls. Defects in the construction quality play an important role in damage of the structures. During the reconstruction, measures were taken to avoid the occurrence of the same mistakes. Soil investigation conducted to get better information on the geotechnical condition of the sites and more proper earthquake acceleration is adopted for the design of the structures.

CONSTRUCTION MANAGEMENT ASPECT

Project Management Organization

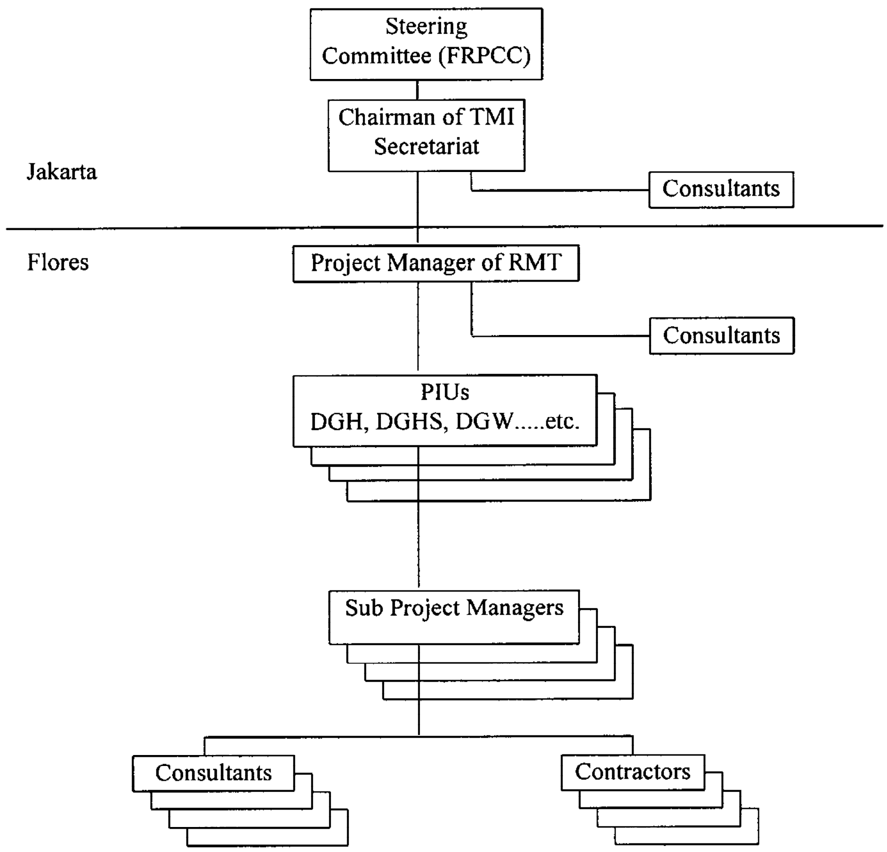
The executing agency of the Reconstruction Program is the Ministry of Public Work, in coordination with BAPPENAS. Under the guidance of a Steering Committee, known as the Flores Reconstruction Programme Coordination Committee (FRPCC), the Core Management Team (TMI) was established in Jakarta and the Reconstruction Management Team was established in Maumere on Flores Island. The Project Manager is located in the RMT and the Head of the whole project is located in the TMI. Project Implementation Units under Directorate General from various involved Ministries as the Implementing Agencies were set up. The structure for the organization of the project management is shown in Figure 1. To assist the TMI Program Management Advisory Service (PMA), Coordination Consultant (CC) and RMT Consultant (RMTC) were attached to the Core Management Team. Chief Design Engineer (CDE), Chief Construction Engineer (CCE) , Chief Quality Assurance Engineer as well as RMTC were attached to RMT and are responsible to the Project Manager. Design and supervision consultants were appointed under each PIU.

Project Schedule

Although for the IBRD loan funded project mobilization commenced in March 1993, the adopted reference point for project start was 1st of July 1993 and work was scheduled to be completed in June 1996. The loan closing date was 31 December 1996. The ADB loan funded project mobilized consultants in December 1993 and first reconstruction contracts were let in March 1994, while works had to be completed by 31 March 1996. At the end of June 1995, it was clear that due to various delays and additional scope of works, an extension of one year to December 1997 was necessary.

Procurement Process

In order to expedite the reconstruction work, a fast track procurement is applied. The World Bank as well as ADB allowed direct appointment by force account to previously internationally competitive bid (ICB) procured contractors working on road sections and irrigation works which receive bilateral or multilateral



DGH Directorate General of Highway (MPW)
DGHS Directorate General of Human Settlement (MPW)
DGW Directorate General of Water Resources (MPW)

Figure 1 : Organization for the Reconstruction Program

loan prior to the 12 December 1992 earthquake. Specific urgent road works not exceeding US$ 4 millions were agreed to be implemented by addenda to existing ICB contracts and this was subsequently extended for certain direct appointments to firm which had very recently completed an ICB contract. Other civil works packages up to US$ 200,000 value could be contracted directly. Otherwise local competitive bid procurement for packages costing less than US$ 1,000,000 value were allowed. Direct appointments for consultancy services, i.e. management consultancy, studies and design and or supervision, have been applied.

Contract Volume and Progress

Until end of September 1995, the total agreed volume and contracted works from IBRD and ADB projects is shown in Table 2. The agreed volume of works has evolved from the original estimation during the progression of works, and development in the field showed that more works were proposed and to be approved by the lending agencies. At the same time, about 64 % of the IBRD loan and 63 % of the ADB had been committed and 52 % of the IBRD loan and 48 % of the ADB loan had been disbursed.

Design, Supervision and Quality Assurance

The design works were carried out by the appointed consultants and checked and approved by the Chief Design Engineer (CDE). The supervision consultants are responsible, on behalf the RMT Project Manager, to oversee the contractor's work from the point of view of technical and administrative aspect of the work.

They give guidance and solutions in case of technical problems and they monitor the progress of each individual contract and to report it to the Project Manager, and to carry out work acceptance and commissioning.

Table 2. Volume of Works (Analyzed from FERP Quarterly Report as of September 1995)

Works	Agreed Volume	Contracted works
Road	576.11 km	442.69 km
Bridges	561 m	423.1 m
Schools	343 units	336 units
Health facilities	124 units	124 units
Hospital	2 units	2 units
Equipment	13 contract	12 contract
	2 package O&M	-
	13 vehicle & 8pumps	13 vehicles & 8 pumps
Consultancy		
Foreign	205.6 mm	193.6 mm
Local	1394.5 mm	1092.5 mm

For the purpose of quality assurance, all design must be approved by CDE and all construction work must be certified by the Chief Construction Engineer (CCE) for the satisfactory completion. The Quality Assurance Engineer (QAE) is active in designing work systems which will help produce finished construction of the appropriate quality.

Due to the difficulties in obtaining quality conforming work during the beginning of the projects, a Quality Assurance Panel was eventually established , comprising the Project Manager, CCE, QAE and engineers from local PIUs as well as from the design consultant.

The main factors contributing to the non achievement of quality varied from the incompleteness of details in the design drawing, misinterpretation of the drawing by the contractors' technicians and workers/ tradesmen., unsuitable local materials, lack of skill from the local tradesmen, difficult terrain and climate. Special emphasis on the execution of concrete mix and formwork preparation, concrete reinforcing details, timber jointing works, concrete pouring and masonry work were necessary for the achievement of the main objective of the project, i.e. producing buildings, structures and infrastructures which will withstand seismic events that may occur in the future in Flores.

The main factors contributing to project delays among others were delays in contract approval, authorizations of local budgets, decision concerning spatial plan for resettlement work, design approval etc., as well as delays on the delivery of portland cement and other materials imported to the island due to the west monsoon, low contractors'absorption capacity, etc. Those problems were addressed accordingly by the RMT and its associated consultants.

Local Authorities and Local Communities Involvement

Toward the end of the project, a growing concern over the involvement of local authorities and local communities was felt. A new mechanism involving a higher responsibility from the local government agencies was implemented. Construction of demonstration school buildings was proposed in which the project construct part of the buildings using bamboo cladding while training the local communities to continue the completion of the building using their own sources.

CONCLUSION

A vast rehabilitation and reconstruction program for the 12 December 1992 Flores earthquake damage has been described. Project description concerning financing, project management and earthquake mitigation measures have been presented and issues on the construction management aspect of the projects have been discussed. The approach for the scheme could be implemented with some adjustments in the other similar situations in other countries and events.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to Mr. Soewono from Flores Earthquake Reconstruction Project and Mr. Aubrey Newman, ADB Coordinating Consultant for FERP Core Management Team, for providing the invaluable information used in this paper.

REFERENCES

Guidelines on the Design of Aseimic Buildings and Houses, SNI -1726-1989-F (1989). Ministry of Public Works, Indonesia.

General Reconstruction Guidelines, FERP Report(1995). Ministry of Public Works, Indonesia.

Arya A.S., *et al.* (1986) Guidelines For Earthquake Resistant Non-Engineered Construction, The International Association For Earthquake Engineering, Tokyo, Japan