Schools

UN/DESA PROJECT-INT/98/X70 (UNCRD)

CONSULTANT REPORT ON FIELD SURVEY OF NATURAL DISASTERS

Based on Visits to

INDONESIA : Bengkulu, Bandung
NEPAL : Kathmandu
INDIA : Chamoli

by

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PREFACE

United Nations DESA, in consultation with United Nations Centre for Regional Development, Disaster Management Office, Kobe, offered a consultant mission for Field Survey of Natural Disasters by undertaking visits to INDONESIA; Jakarta, Bandung and Bengkulu; NEPAL; Kathmandu, and INDIA; Chamoli. A mission report was to be submitted to UNCRD Kobe after completing the mission visits. The consultant had started preparing the report and planned a detailed technical report on many issues involved in regard to safety of communities from Earthquake Hazards. This was taking time. Then before the report could be completed, the massive earthquake in Kachchh area of Gujarat, India occurred on Jan. 26, 2001, which engaged practically the whole time of the Consultant in providing post-earthquake rehabilitation advise to the State of Gujarat. Now, the consultant has been able to complete the report and submit to the United Nations. The consultant very much regrets the delay in the submission of this report. He has the fond hope that the Report will be well received and made use of by the concerned communities.

The consultant takes this opportunity of conveying his hearty thanks to the various organisations and persons met in Bengkulu and Bendung; Kathmandu and Chamoli, who extended all the courtesies to the Consultant and provided the various types of information included in the project report. Special thanks are due to Dr. M. Kobayashi and Dr. Rajib K. Shaw and the office staff of UNCRD Kobe for providing guidance and timely assistance in successfull completion of the survey visits.

August, 2002

A.S. Arya
Consultant

LIST OF CONTENTS

LIST OF PLATES

(from Page 49 to 75, pages not marked)

Plate 11a-*Top.* Typical stone house with slate roof in Chamoli area
Bot. Complete collapse and damage of stone houses in Chamoli Earthquake

Plate 11- *Top.* Training programs by Building Centre, Ukhimath, installing vertical steel at corner
Mid. Masons training program at Birahri Building Centre
Bot. Demonstrative construction of walls with Seismic Bands at Plinth and Lintel level and Vertical bars at corner and junction of walls

Plate 12- *Top.* Demonstration of Earthquake Resistant Technology in Solid CC Blocks walls
Mid. Reinforcement Preparation for Precast RC Joists
Bot. Dr. Arya explaining provision of top steel for cantilever action.

Plate 13- *Top.* Solid concrete block making yard at Building Centre
Mid. Special concrete block with hole and slit for installing vertical bars at corners
Bot. Preparation of Precast RC Joists for roofing and flooring

Plate 14- *Top.* Construction of house using RR masonry, Seismic bands and Vertical steel bars.
Mid. Stone house at Village Kansali getting ready, Roofing yet to be done, long Stones at corners and `through' stones.
Bot. Pre Cast RCC Planks laid with Steel mesh to be in top in concrete screed and Bond Beam on walls alround

Plate 15- Demonstration Houses
Top. Stone walls with Earthquake Resisting Features, Flat roof with Precast RC Units
Mid. CC Block walls, Precast Units floor, sloping roof with Precast Units
Bot. Built as Mid. house except roofing with CGI Sheets held to gable bands

Plate 16- Demonstration Houses with CGI Sheet Roofing
Top. CC Block and Random stone masonry wall construction with Precast Unit floor
Mid. Stone masonry wall construction throughout with Precast Units Floor
Bot. CC Block wall construction throughout with Precast Units Floor

Plate 17a- *Top.* Entry to Adarsh Basti, Gopeshwar, Reconstructed houses in side (HUDCO)
Mid. Right. Reconstructed School at village Ghingrana
Mid. Left. Reconstructed houses in village Kansali (Rudrapraga district), see the use of flat roof by villagers
Bot. Training of masons in proper installation of vertical bars Earthquake

Plate 17- Community based Reconstruction and Retrofitting, Adarsh Basti, Gopeshwar
Top & Mid. Reconstructed House
Top Left. Retrofitted House
Bot. Commemorative Plaque

Plate 18- Some School Buildings in District Chamoli
Top. Primary School at Village Bairagna
Mid. One of the High School Buildings at Chamoli showing damage
Bot. Another Primary School in district Chamoli

LIST OF TABLES

(Pages within the text)

CONSULTANCY REPORT ON FIELD SURVEY OF NATURAL DISASTER (RES/578/94)*

1. INTRODUCTION

With reference to Consultancy under Project INT/98/X70, the Consultant was assigned to visit Bandung and Bengkulu in Indonesia, Kathmandu in Nepal and Chamoli in India, with the following Terms of Reference :

1) To provide advisory services to communities vulnerable to disasters in cooperation with governmental agencies. NGOs and academic institutions.

2) To improve the safety of some of the core communities like schools.

3) To suggest and promote community based disaster management schemes in the earthquake hit areas.

4) To suggest retrofit design of some of the selected building types using traditional technologies

5) To submit a mission report to UNCRD and UNDESA on completion of the assignment.

The visits to the various places were schedule and undertaken in consultation with the sponsors of the Project viz, United Nations Centre for Regional Development, Nagoya in general and Dr. Kobayashi and Dr. Rajib Shaw of the UNCRD Kobe Office in particular. The schedule of visits is given in Annexure-1 and the names of places/organisation visited and the persons met are given in Annexure-2.

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2. BACKGROUNDS OF THE PROJECT

2.1 From the terms of reference, it is seen that the focus of this assignment is on *core communities like schools*. Schools form a critical component in the life of the communities for various reasons (Ref. 16, 5) such as the following:

(i) Schools play a vital role in every community. Children take a very strong message back to their homes, and through them, it is possible to address a wide range of population.

(ii) When schools are closed because of earthquake damage, the education is delayed and community life is disrupted.

(iii) Repair and construction of school buildings are difficult after an earthquake, when government resources are strained.

(iv) It is one of the moral obligations of society to provide a safe study and work environment for children and teachers.

(v) Earthquake-threatened communities need earthquake-resistant schools to protect their children and teachers.

(vi) An earthquake-resistant school can be used as the relief and rehabilitation shelter immediately after an earthquake.

(vii) Depending on the active role of the teacher, schools can play an important role in the community training, and building partnership among different sectors of the community.

It has been observed from many earthquakes, especially the Hanshin Awaji Earthquake of Kobe 1995, that the schools can be used as a temporary shelter for many people immediately after the earthquake. Not only an earthquake resistant school, but a strong leadership of the teachers has proven very useful in dealing with the emergency situation. This is important not only during the emergency situation, but also before and after the events.

(viii) Through a recent survey, it has been found that more than 40% of the population in the developing countries lie in the age group of 6 to 18. By addressing this important community (and the future citizens), *it is possible to establish the culture of prevention and mitigation.*

(ix) The United Nations IDNDR (International Decade for Natural Disaster Reduction) has been able to make a significant progress in raising awareness among diverse communities regarding the risk and effects of natural disasters. A strong shift has been observed from post-disaster rehabilitation and reconstruction to pre-disaster mitigation and preparedness policy. As a part of the prevention and preparedness process, it has been emphasized that we need to strengthen the school buildings and make proper disaster education.

(x) When an earthquake occurs during daytime (school hours), the disaster will be significant. For example, in Bali (1976), more than 60 students died when the quake occurred in mid afternoon causing the collapse of one classroom.

(xi) As is well known, school buildings should be made stronger for the following reasons:

- The collapse of school buildings may cause high toll of human lives.
- Most of the occupants are children, who are society's precious resources.
- Closure of school for a long time may result in community problems, and major school damage may pose long term economic problems,
- The additional cost for new buildings to be earthquake resistant is small, about 2. to 6 percent (depending on various types of construction and Intensity Zone) of the cost of construction.
- When designed and built properly, the school building pays off.

3. EARTHQUAKE DAMAGE IN BENGKULU, INDONESIA

3.1 DISCUSSIONS WITH MAYOR OF BENGKULU MUNICIPALITY AND STAFF

During the discussions, the Mayor and the Municipal Engineers explained about the School buildings damages as well as the rehabilitation of schools already taken in hand. Two types of primary schools exist which are termed as (i) *permanent* consisting of R.C.C. columns and brick walls, having one or two storied height; the roofs are invariably sloping consisting of wooden trusses with CGI sheet roofing; and others termed as semi-permanent, of one storey height, consisting of wooden columns and in-fill masonry with sloping roofs as the permanent ones. In the Municipal area, it was mentioned that 13 schools have already been rehabilitated. Many of these schools were visited by the visiting team and some of them are shown in Plates numbered 2, 3 and 4.

In the rural district, there were about 100 elementary schools, mostly of the semi permanent type, out of which 89 were found damaged with 74 usable after some repairs and 15 of them found unusable needing reconstruction.

3.2 DISCUSSIONS IN BENGKULU UNIVERSITY

The team had discussion with the Rector, Vice Rector of the University and Dr. Mrs. Mucharromah, Prof. Bengkulu University who was incharge of the Community Based Rehabilitation program with funding from INDOSIAR. An amount of 5.3 million Indonesian Rupia equivalent to about 1 million US$ was made available which was to be spent, about half and half, on the reconstruction of houses and reconstruction of school/community buildings. An area of 21 sq.m was to be provided to each house holder. In the first round totally damage houses were to be taken up for reconstruction and in the second round houses with heavy damage with less financial aid were to be taken up. 600 students of the University were employed to collect the damage data in Bangkulu province. The effort was being made for socializing the materials and technology with the communities as well as the rural people with some engineering supervision. In consultation with Mrs. Mucharromah visit was planned to village Sukaraja where house construction in this program was under progress. Plate nos. 5 and 6 show the example of the new house constructions in the village alongwith some deficiencies observed in the construction and also an example where such defects have been taken care off.

3.3 VISIT TO THE P.W.D. OFFICE AND DISCUSSION WITH ENGINEERS

During this visit the school building design drawings were studied in consultation with Mr. Teddy Boen and the local P.W.D. Engineers. It was seen that the drawings lacked details for enhancing ductility of the reinforced concrete columns, and connections with the infill walls. The building was understood to be safe under a PGA of 0.2 g but the design has to be worked out for a PGA of 0.4g in the Bengkulu Provice in view of the most severe seismic zone of Indonesia.

3.4 VISITS TO DAMAGED SCHOOLS

The following schools were visited to obtained first hand information on the damage situation.

School No. 38. Earlier unusable; semi permanent construction; gable fallen down; rebuilt ring col. (wooden tie-beam and wooden column). One deteriorated semi-permanent block replaced already by permanent one.

School No. 59. Permanent 1 storey;, unusable; columns are shifted (No. diaphragm in the buildings).

School No. 51. Permanent type; minor damage; ceiling damaged, good candidate for retrofitting. Retrofitting will be cheapest when done along with repair and restoration work.

3.5 THE BENGKULU EARTHQUAKE AND SEISMICITY OF BENGKULU (Ref. 17)

Bengkulu Province in Sumatra was shaken by a 7.3 Richter scale earthquake, with its epicenter 100 km south west of Bengkulu City, 33 km under the seabed of the Indian Ocean.

Province of Bengkulu is located at the western coast of Sumatra on 2°61'S - 5°31'S and 101° 01'E - 103° 46' E with 19788.70 km2 surface area, populated by about 1.5 million people (See Plate 1a). Its annual population growth in the last 7 years was about 3.85%. The Province is divided into 4 districts, that is South Bengkulu, North Bengkulu (which includes also the nearby Enggano Island), Rejang-Lebong and Municipality of Bengkulu City. Population of Bengkulu City is approximately 300000.

Basically, the western part of Sumatra is located between two tectonic system, e.g. the Sumatran fault which is found inland along the island from Aceh to Lampung and the Mentawai fault, which runs parallel to Sumatran fault on the sea bed on the Indian Ocean. This fault is the location of the subduction zone at the place where the Indo-Australian plate and the Eurasian plate meet.

The June 4, 2000 Bengkulu Earthquake was recorded by BMG (Bureau of Meterology and Geophysics, Jakarta) to be 7.3 Richter scale, besides the USGS (Ms = 7.9; Mw = 7.7), Harvard and ERI networks (Mw = 7.9). Location of epicenter is approximately 4.73°S - 102°E at the depth of 33 km (BMG), and it was the biggest earthquake in 80 years recorded in the region. The seismic mechanism is reported as reverse fault (USGS) or strike-slip (ERI). The main shock was followed by thousands of after shocks that occurred within a week after the main shock. The orientation of rupture area and CMT (centroid moment tensor) solution of ERI suggests that the Bengkulu earthquake was caused by subduction of Indo Australia plate beneath Eurasia plate. The same subduction activity has caused similar large earthquakes that occurred previously in the region in 1756, 1770, 1818, 1833, 1861, 1908, 1914, and 1979.

Historically Bengkulu is seismically very active. Several major earthquakes have been recorded since the 19th century (1833, 1871, 1902, 1914, 1933, 1938 and 1979) where intensity as high as MMI IX has been recorded. The 1933 earthquake was followed by a tsunami.

3.6 OVERALL DAMAGES REPORTED

The earthquake affected all four districts of the Bengkulu Provice but damages were found in sporadic manner, rather than any large totally damaged area. Upto June 12, 90 human lives were found lost, 803 were severely injured while 1782 were lightly injured.

(i) Schools. Damages were recorded in 639 elementary/primary schools, 36 junior secondary schools and 36 senior secondary schools. Besides, 3 university level institutions were also recorded as damaged. Damage varies from total collapse, heavy damage and light damage. However, only a few cases were found to be totally collapsed, in particular public primary schools built with INPRES fund. Typical damage in Schools may be seen in Plates 2,3 and 4.

(ii) Government Offices and Public Facilities. 324 government offices and public facility buildings were affected. However, most of the damages are of the non-structural types, and many buildings can be quickly used again after proper fixing. Some buildings would need structural retrofit before use again.

(iii) Mosques, Churches and Temples. 357 worshipping places were affected.

(iv) Residential. 42, 342 houses were reported as affected (1,386 total damage, 15, 512 heavily damaged, 25, 424 lightly damaged).

(v) *Airport.* Airport Padang is the only air gate to the province. During the earthquake, the control tower and the terminal buildings suffered some non structural damages, while the runway and apron remained intact. The airport was fully operational.

(vi) Road and Bridges. Land transportation was disrupted slightly by damages in 56 locations and damaged bridges (light and heavy) recorded in 17 bridge locations, almost all operating normally.

(vii) Power. Power line was reestablished within 3 days of the main shock. Some damages were observed at the power plant (shifted engine foundation). Some distribution lines were cut off when a series of power line poles tumbled down (along the road to the Padang Baai harbour).

(viii) Piped Water. Water supply system in the city suffered from damages in the powerhouse and chemical mixing building and some damages (about 1000 meters) of transmission and distribution lines including a 12 m pipe bridge. Two small sub-district water treatment plants suffered heavy damage.

(ix) Irrigation System. Several damages have been induced to the irrigation system in the province. Damages were recorded in 22 locations, consisting of damages to dikes and embankment, channel linings, water regulating structures, bridges etc.

(x) Liquefaction. Liquefaction due to the earthquake was identified at some areas at harbours and some residential housing. The soil conditions in this areas mainly consists of loose saturated sand. The liquefaction has caused severe damage to the harbours and foundations of the residential housings. The damage of the harbour was caused by lateral spread in combination with liquefaction. Damage to a building in Bangkulu city due to liquefaction is shown in Plate 9.

(xi) Landslides. Many landslides due to earthquake occurred at the slopes of rural roads northward of Bengkulu. The landslides occurred due to insufficient safety factor of the slopes under the earthquake loading.

General Remark on Building Damage.

From general observation, it can be seen that most of the collapsed or heavily damaged buildings and houses belonged to non-engineered, masonry constructions, with or without practical reinforced concrete columns, in particular those built by low-income community or low-cost housing. In most cases non-structural damages were observed (cracked walls, collapsed interior ceilings, falling roof tiles, falling fixed furniture and equipment etc.). Cases of structural damage mostly due to improper detailing in the reinforcement (beam and column connection), improper concreting and inadequate steel stirrup/reinforcement and also from soft story effect on first floor columns.

Some liquefaction phenomena were also observed, causing building subsidence. In many cases, collapsed structures in low-cost residential areas were caused by inadequate foundation built on poor soil condition (improper fill over swamp area or solid waste dump area).

Surprisingly, in spite of the extraordinary magnitude of the main tremor, many government offices and public buildings survived the shock, suffering only from non-structural damages, which can be repaired quickly without demolishing the buildings. No fire incidence was reported during the disaster.

3.7 SCHOOL TYPES AND MANAGEMENT (Ref. 5,9)

Indonesia has a population of more than 200 million with a total area of about 1.9 million km^2. The human resource development is taken as priority area. A program of compulsory education suggested a minimum of 9 years education: 6 years of elementary school and 3 years of junior high school. With such a large number of population, school buildings are in great demand. Some of these buildings are built with foreign loans from Asian Development Bank (ADB), World Bank, etc. To meet the compulsory requirements, almost all school buildings are built by the government, only a small and insignificant number is held by private sector.

Prior to 1997, the Department of Education and Culture, Government of Indonesia, provides *standard or prototype designs of school buildings* for basic education at all levels, from kindergarten till upper secondary schools for the whole country.

Class rooms size and other facilities for the various grade of school buildings is shown in Table 1.

Table 1 Class Room Sizes for Various Grade Schools

	Elementary School	Junior High School	Senior High School
Classroom	54 sqm	63 sqm	72 sqm
Office	100 sqm	150 sqm	184 sqm
Toilet	3 sqm/class room	3 sqm/class room	3 sqm/class room
Laboratory	-	120 sqm	144 sqm
Multi Function Room	-	144 sqm	288 sqm
Library	90 sqm	105 sqm	144 sqm

Most school buildings are single storeyed (more than 85%), few two storeyed (about 10%) and just about 5% are three storeyed. The storey height is generally 3 m for primary schools and 3.0 - 3.50 m for others. The classroom blocks usually consist of single row of rooms with a narrow covered veranda in front, the blocks being connected through a passage of light open construction.

To fulfill the lack of elementary school buildings in Indonesia, through President Instruction more than twenty years ago, thousands of elementary school building were constructed all over the country. The fund directly came from the Central Government along with the standard of construction. The task of local government was to find the area/space for those constructions. Although there was *the standard* of construction, but it was frequently found that the quality of the school building was very poor. Some of them were damaged before being used. The procedure of contractor procurement was also inadequate. Recently, it was fund that the standard design was not yet perfect. This design is lacking in details. So during implementation phase, some schools were not constructed properly.

In general we can classify three model of school building construction: (i) *funded by government*, (ii) funded by private and, (iii) lastly funded by community (religion schools, poor association). Except for building constructed by rich private school, the rest *had lack of control during construction.*

3.8 DAMAGE OBSERVED IN SCHOOLS (Ref.5)

3.8.1 Materials and Techniques of Construction

The common building materials used for school buildings in Indonesia are wood, burnt clay bricks, reinforced concrete, occasionally steel and cement mortar. Wood is very commonly used for structural as well as non structural purposes. Most school buildings have sloping roofs made of timber roof trusses, rafters and purlins and carrying galvanized iron or asbestos sheet roofing. The most common structural type for one story school buildings is a wall bearing

construction. Where load bearing walls are used, there is a wooden or reinforced concrete wall plate on which the trusses rest and are anchored to it through nails. The walls are commonly constructed of burnt clay bricks with a wall thickness of 15 cm. Some very old building walls are in random rubble 40 cm thick. The mortar in rural areas is cement and sand ranging from 1:5 to 1:10 ratio. New construction, particularly in cities use cement-sand mortar in 1:3 to 1:5 ratio and walls are 15-16 cm thick with or without any frame. Alternatively reinforced concrete "practical" columns (size 15 x 15 cm and size 12 x 12 cm) are used under the trusses and brick walls are used as tight infills. See Plates 7 where damage to such constructions can be observed. In such cases a reinforced concrete foundation ring beam and collar beam (size 15 x 20 cm) at roof level are used. Many school buildings using timber posts and timber ring beams and trusses with plywood/or timber planks side covering and GI roofing have also been adopted as light construction. Plate 8 shows a traditional house with hipped roof which suffered only minor damage. Temporary strengthening by wooden cross bracings and repair of cracks by grouting can also be seen. In very remote areas, bamboo matting is also used as wall cladding in rural areas.

For single storied school buildings, river (boulder) stone footings are used for bearing and non-bearing walls and isolated footing for columns.

3.8.2 Damage to School Buildings in the past.

Damage to school buildings has occurred in almost all earthquakes in various islands of Indonesia in the past. Besides thousands of residential buildings, a large number of schools and associated buildings were damaged and collapsed during those earthquakes. Teaching activities were dislocated for a period of several months. The main reasons of damage were *weak masonry walls, inadequate connections in wooden members, lack of ring beams and lack of vertical reinforcement in the form of columns,* particularly *poor detailing at members connections* etc. Overturning of walls was a common feature.

3.9 STUDY OF SCHOOL DESIGN AND DRAWINGS (Ref. 5)

The design and drawings were discussed with Mr. Teddy Boen along with P.W.D. engineers (see Plate 10). In 1997, the Directorate General for Buildings, Department of Public Works issued a decree No 295/KPTS/CK/1997 about "Technical Guidelines for the Construction of Government Buildings". School buildings are included in those Technical Guidelines. Those Guidelines contain among others the technical specifications, and the administration procedures. In each area where the buildings are to be built, a project manager is appointed. Prototypes of school buildings are provided by the Directorate General for Buildings, Dept. of Public Works and subsequently consultants may be appointed for the design, to adjust the design in accordance with the seismic zones where the schools are to be built. Consultants for the supervision during construction may also be appointed and a contractor for the construction will be selected based on open tender. Theoretically, the consultants are expected to take into consideration the seismicity of each different area throughout Indonesia in the design and provide the necessary supervision to warrant that the construction details follow the prevailing asseismic design. In actuality, most of the design for school buildings are replications of the existing prototypes and the design consultants hardly checked the structural design. The same happens with the supervisor consultants, most of the time they never perform as assigned. Such practice is common, particularly with regard to one story wall bearing construction type of school buildings, wherein the consultants and contractors usually follow prevailing practice and leave everything to the foreman to complete the school building. This is a fact in big cities and urban as well as rural areas.

Typical schools and the damages are shown in Plate Nos. 2,3,4. The results of the structural analysis based on a 3-D model of a "typical" elementary school building (one story, masonry bearing wall construction with R.C. *practical* columns, timber roof trusses, and galvanized iron sheet roofing) showed that, provided it is constructed appropriately, with good materials, good workmanship and appropriate structural detailings in accordance with the

prototype drawings, the structure can withstand a PGA of 0.22 g. The seismic design was based on *UBC 97/IBC-2000 with a* $C_A = 0.22$, $C_v = 0.32$ *and an importance factor of 1.25.* The typical material which is used in the model: K-175 reinforced concrete for columns and beams, for brick masonry walls with 1:6 mortar mix (the typical strengths of masonry: compressive stress 21 kg/cm^2, shearing stress 3.9 kg/cm^2, bending tensile stress 2.5 kg/cm^2), U-24 reinforcing steel (f_y = 2400 kg/cm^2), wooden roof truss (2nd class, allowable stresses of wood: compressive stress // gain = 81 kg/cm^2, shear stress // grain = 10.8 kg/cm^2, bending tensile stress = 91.8 kg/cm^2) and roof material is light galvanized iron roof sheet.

3.9.1 Code Provisions

The Indonesian Loading code SNI-03-1727-1989 provides specification for earthquake loads. The earthquake is specified in the form of horizontal and vertical seismic coefficients based on seismic zones (Fig. 1), height of structure, soil stiffness and importance of buildings. *Prior to 1997, small and simple buildings with a total maximum height of 5 m from the foundation and with enough walls that provide sufficient stiffness to the main structure may be exempted from these regulations.* Since the school buildings are generally of almost that height, they become exempt and remain non-engineered from earthquake viewpoint. According to the Technical Guidelines No295/KPTS/CK/1997, school buildings up to 2 (two) storeyes are considered as "simple" buildings, however must comply with the Indonesian aseismic Code. There are no specifications for strengthening laid down for such buildings.

3.10 CAUSES OF DAMAGE (Ref.5)

From twenty years of observations carried out by Mr. T. Boen after visiting many earthquake stricken areas all over Indonesia, it was be concluded that "construction practice in Indonesia is deteriorating (this is also the case with most developing countries) and most of the school building failure are caused by *poor quality of construction, poor workmanship, and improper and inadequate detailing.* Quality of workmanship needs to be emphasised since a building's performance in an earthquake will be affected by how well all the materials are assembled. All walls should be *plumb, square and level. All joints should be strong for all structures: an improved quality of carpentry, masonry, truss connection, ring beam assembly, joints and connections will substantially improve seismic resistance.* Another major contributor to the damage and collapse is lack of maintenance.

To sum up, most of the failures to school buildings during earthquakes are attributed to the lack of consistent professional performance. On top of that, due to lack of accountability, there is also no such thing as cost benefit analysis, giving a false sense of low potential losses.

However, in rural areas, apart from the above mentioned reasons, the main cause for poor quality control is that there is a gap between knowledge and application and that despite our experience from numerous earthquakes, and the growth of our knowledge of aseismic design, the principles are not being communicated to the humble local builders and craftsman.

(i) The damage and collapse of school buildings in past earthquakes in Indonesia are not so much caused by design deficiencies, but primarily cause by poor quality control, resulting in the use of inferior quality of materials, poor workmenship, and improper and inadequate detailing. Another major factor contributing to the damage and or collapse of buildings is the lack of maintenance, resulting in deterioration and reduced structural strength.

(ii) Poor quality control is the result of poor performance of the government officers-in-charge and also because there is a gap between knowledge and application. This is a gap exists between the knowledge of experienced practitioners in big cities and the humble local builders and craftsmen in rural areas.

3.11 IMPROVING DESIGN AND CONSTRUCTION OF SAFER SCHOOLS (Ref.5)

(i) To bridge the knowledge gap, there is an urgent need to train an intermediate group of technicians who would serve as problem solvers at the local level and train local builders and craftsmen in quality control.

(ii) It is necessary to produce ideas which are relevant, appropriate, understandable and acceptable to the small builders in rural areas.

(iii) International institutions and foreign or local donors financing the construction of school buildings before or after a destructive earthquake should adhere to a financing mechanism which encourages the compliance of effective quality control and code enforcement practice.

(iv) In the present practice of school building construction, viz, Government providing prototype school buildings drawings and local authorities approving them, the local communities need to be involved in decision making including options to be exercised. Therefore, participatory approach in building schools needs to be adopted.

3.12 SUGGESTIONS FOR RETROFITTING

Looking to the design and construction of elementary school buildings and study of the main deficiencies, the following suggestions are offered for redesigning the school building for new construction. A PGA of 0.4 g has to be used as per the Seismic Zoning of Indonesia. In working out the retrofitting elements, the same seismic factor has to be used. The following elements will need special attention:

i) Since the walls are quite long as much as 8 to 10 m, it is necessary to stabilise the walls against out-of-plane bending effects of horizontal earthquake forces. This can be done by using intermediate RCC columns and connecting horizontal RCC beams at the door/window lintel level. In retrofitting work these elements could be added externally with proper shear keys to connect with the walls.

ii) Where practical columns of wood or reinforced concrete are used their strength should be checked against out of plane bending and the stirrup ties should be closely spaced to enhance the ductility of the column.

iii) The top beam cast on top of the columns and walls needs to be properly reinforced against the horizontal earthquake forces, and fully attached with the vertical columns. In the case of reinforced concrete columns and beams, enough horizontal ties must be used in the joints to increase the shear resistance at the joints and enhance the ductility.

iv) The roof trusses must have horizontal cross bracing at the ceiling level as well as in the planes of the rafters . Moreover the trusses must be fully anchored into the supporting RCC beams or columns.

4. EARTHQUAKE EDUCATION PROJECT AT BANDUNG

4.1 CONDITION OF BASIC EDUCATION BUILDING IN BANDUNG (Ref. 10)

As the third largest Indonesian City, the municipality of Bandung is considered as one of the most densely populated city, with approximately 120 people per hectare. By the year 2010, the population of the municipality itself is forecast to be 7 million.

The management complexity, dense population and geological condition have brought the city of Bandung to be very vulnerable toward any natural disaster such as earthquake, volcanic eruption, floods, and landslides. For about a century, the city of Bandung has not experienced any significant earthquake disaster. How long there will be calm is any body's guess.

Vulnerability of Bandung is worsened by the fact that, due to lack of guidance and control during the planning and the implementation of urban development, most infrastructure and public buildings were constructed without respects to earthquake safe practices and codes. Consequently, special attention needs to be paid to critical facilities such as hospitals, health centers, and public schools, since these are often built with limited budget or less attention towards construction quality.

As stated in Para 2, schools play a vital role in every community, to anticipate the problem faced by the city if an earthquake occurs, the IDNDR (International Decade of Natural Disaster Reduction) Secretariat of the United Nations launched the RADIUS (Risk Assessment Tools for Diagnosis of Urban Areas Against Seismic Disaster) project in Bandung. This project aimed to promote city activities for reduction of seismic disaster in urban areas. As a part of close cooperation between the IDNDR Secretariat and the UNESCO office, two projects were formulated, funded by UNESCO Jakarta office. First, the School Earthquake Safety Project, and the other Earthquake Educational Material Project. These project are expected to be able to assists the Local Government, concerned agencies and the people of Bandung, in mitigating the earthquake risk overtime especially in School areas by improving the strengthening the existing public school building and producing a suitable material for earthquake education program at school. The following earthquake facts were appreciated:

- Earthquake can occur without warning at any time during school hours or after school.
- Rescue personnel would not be able to respond to every school within the affected area for several hours if the earthquake occur during school hours
- The ground shaking itself seldom causes death or injuries. Most death and injuries are caused by falling debris from damaged buildings and accident happening due to the student panic.

4.1.2 School Earthquake Safety Project

Survey on some typical school-buildings in Bandung area was carried out in this Project to identify the structural condition of the buildings, particularly in resisting the earthquake loading. The results show that *most of the masonry and timber structures* lack earthquake resistance. The condition is very vulnerable during an earthquake occurrence. Many of the building were found vulnerable even in a normal condition.

Another important finding was that the layout of many school building complexes was rather poor. The very dense student population using those building worsens this condition, since the accessibility, orientation and circulation of people in those areas are not well provided. The evacuation during the earthquake is expected to be extremely difficult. This study recommended retrofitting several schools by using simple technology and affordable cost, so community can do retrofitting using local resources.

4.2 LEARNING ABOUT EARTHQUAKE (Ref. 7)

Earthquake Education Material Project develops booklets and posters consisting of simple and attractive description for elementary students in order to raise their understanding, preparedness and awareness regarding how to behave properly when earthquake occurs.

A lot of people in Bandung do not know much about what happens in an earthquake, because it rarely happens in Bandung, and a damaging quake has never occurred for almost a 100 years. However, the scientists have found that an earthquake might occur in Bandung. So people should learn to find out what an earthquake is, how it occurs and what they can do to protect themselves against it. The following is an example of the educational material developed under tis project (Ref.7).

4.2.1 Earthquakes and Seismicity

What is an earthquake? We can only see the surface of the earth, but actually the earth has got three main layers. We live on the crust, which is the earth's outermost layer. The outer shell of the earth, on which we live, is not always stable. It moves, and this movement accumulates energy in different parts of it. The sudden release of energy shakes the earth's surface. This is called an earthquake.

How does an earthquake occur? Earthquake is caused by: the movements of earth's surface due to the movements of faults. The movement of the earth's surface can cause a fault. When these faults move, it also can cause an earthquake.

Volcano's eruption. Under ground volcanic forces or volcano eruption can also cause an earthquake.

Time Duration. An earthquake may last from a few seconds to as much as 5 minutes. They could come in a series over a period of several days.

Is An earthquake may happen in Bandung? Bandung is surrounded by faults and mountains. Some of the mountains are active and may cause an earthquake.

What happens to people? We can fall down and have trouble standing up. We can only crawl.

What happens inside a house? Lights, cupboard and anything hanging on the walls fall to the floor. Most furniture and cupboards fall over.

What happens to houses and buildings? Some houses are badly cracked and some large buildings are badly damaged.

What happens outside? Roads, bridges and railroads are badly damaged. Electricity poles fall over. Walls made of stone, brick or cement blocks crack and may collapse.

How big is an earthquake? Earthquake may range in intensity from slight to great shocks. The words seismic Intensity scale and Magnitude are used to describe the how big an earthquake is.

What `seismic intensity' means? Seismic Intensity is the severity of shaking that occurs in a place. It describes the severity caused by an earthquake. One of the seismic intensity that is adopted in Indonesia is Modified Mercalli Intensity (MMI).

What does "magnitude" means? The word Magnitude describes the amount of energy of the earthquake. Magnitude can be measured using Richter scale.

Occurrence of fire. Electricity network can be damaged by an earthquake, which may cause a fire. Gas leaks from pipes or stoves in kitchen may also cause fire. The damage from an earthquake can become much greater if fires break out.

Earthquake and Landslides. Landslides can occur to unstable earth slopes when an earthquake strikes. Earthquake can also cause ground cracking and fissuring.

Earthquake and flood. Earthquake can cause flood if a reservoir dam is damaged. You should know the location of dams around You.

Warning announcements. Earthquake can occur suddenly without warning. If an earthquake occur in Bandung, and the government predicts that aftershocks will happen soon, they will announce a warning through television, radio and other media. If the intensity of the earthquake is bigger than VI, the government will take an immediate action to make city safer.

It's important to know that the warning announced by the government is the most reliable. Do not belief someone who said that a big quake would happens soon without giving the trusted source.

What should you do if an earthquake strikes? The first thing to do in an earthquake is to protect yourself. Look around you and think about the best way to protect yourself.

4.2.2 Protection

When you're at school

- If you are in a classroom, crawl under your desk and hold onto the legs of the desk tightly. Never be in panic or run outside.
- If there is no desk to crawl under, stand on the exit door and hold onto the door or squat down at the corner of the classroom and cover your head with a book, school bag or whatever is handy.
- If you are in a playground or somewhere else outside, stay away from all buildings, squat down in an open space and cover your head.
- After the shaking stops, follow your teacher's direction. If no teacher is nearby, listen for an announcement over the school PA system (if there is), and follow all directions.

When you're outside

- Stay away from buildings, walls, electricity poles and signborads.
- Squat down and cover your head with a school bag or anything handy.
- If you're on the way to or from school, remember that the first thing to do is to protect yourself. Wait until the shaking stops, then go home or go to school whichever is closer.
- If you're in a building, mall or other public facilities, listen for announcement over the PA system or follow the directions of the person in charge. Don't be in panic or run outside in a panic, because it might hurt you.

When you're at home

- If you're near a desk or table, crawl under it.
- If there is nothing to crawl under, squart down and cover your head with a pillow or anything handy.
- Move away from standing furniture and windows.
- After the earthquake, wear your sandals or shoes to protect your feet from any broken glass.
- Follow the direction of older family members.
- After the shaking has stopped, it is important to evacuate.

4.2.3 Evacuation. Evacuation is moving to a safe place

Evacuating from school

- Following the teacher's directions or the announcement given by the school PA system (if there is).
- Cover your head then quickly line up and move to the evacuation area.
- On the way to the evacuation area, do not run, push or talk.
- Follow your teacher's direction at the evacuation area.

Evacuating from home

- Do not run out of the house in a panic. Stay inside until the shaking stops, and then evacuate.
- Follow the direction of your parents or older family members.
- When you are home alone, evacuate to the place that an older family member told you to go in emergency.

Evacuating from a public area

- If you are in a mall, bus station, market or other public areas, follow the evacuation directions given by the person in charge.
- If you are on a road, move to the nearest safe area and protect yourself.

4.2.4 Preparedness

Are you prepared for an earthquake? Is your family prepared for an earthquake? Ask your family to discuss the preparedness toward an earthquake

Talk about earthquake prevention with your family

- Discuss what kind of disaster could happen
- Think about what might happen around your home during a disaster
- Ensure that the lay out of furniture in your house wouldn't block your way out if an earthquake strikes.

Everyone in your family should have a special `disaster assignment'.

- Who will do what in your family if an earthquake happens? Decide what each member of your family should do.
- Think about what to do if someone in your family is not at home during an earthquake.
- If there are elderly in your family, they will need your help.
- If all family member are not at home, how will you reach them?

Remember that sometimes the telephones don't work after an earthquake

- Decide the safe place to meet, i.e. evacuation area
- Decide the evacuation's route
- Could you go to the evacuation area alone, if there is no one in the house?
- If all family member are at a different place, how do you contact them?