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PRELIMINARY REPORT ON THE GAZELLE PENINSULA EARTHQUAKES OF 14TH AUGUST 1967, TPNG

by

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1. GENERAL

On Monday 14th August 1967 a series of earthquakes shook the Gazelle Peninsula region of East New Britain. The two largest were of magnitude 6.2 and 6.4 as measured at Port Moresby on the Richter Scale and occurred at 02h. 54m.42s. E.S.T. and 08h.15m. 02s. E.S.T. respectively. Over 150 aftershocks were recorded by the Rabaul Observatory on the 14th and subsequent days. The largest aftershock was of magnitude 5.6.

All the shocks originated at shallow depth, i.e. less than 33 km from the surface, and this contributed to the high felt intensities reported. The area over which the shocks were felt was fairly small and was effectively restricted to the North East Gazelle Peninsula.

The 8.15 am. earthquake caused the most damage rendering uninhabitable the Kabaleo Teachers' Training College and causing damage to the Vunapau Catholic Mission and many buildings in the Bitagalip, Livuan, and Rainau areas. These settlements lie on an approximate east-west line about two miles south of the coast to the east of Kokopo. Maximum intensities of IX on the Modified Mercalli Scale occurred at Kabaleo, Nunapau, and Rainau.

At the first two of these sites most of the wooden frame structures were shifted off their foundations and at Rainau masonry of type D was destroyed.

An aerial inspection of the region revealed no indication of any permanent earth movements apart from the superficial slumping and land-sliding which occurred in areas of steep cut pumice and fill.

It is worthwhile noting that on average since 1958 eleven earthquakes of magnitude six or greater have occurred within the Territory each year. Each of these is as potentially dangerous.

2. ENGINEERING ASSESSMENT OF THE EARTHQUAKE BUILDING DAMAGE

Building designs paid inadequate attention to earthquake forces. Bracing was too light, incorrectly detailed or absent. Little or no attention was paid to relative stiffness. No attempt was made to ensure that a building acted as a whole in resisting horizontal forces.

Foundation systems were usually completely inadequate. Little or no steel was used in non-pile foundations, slabs, and blocks. The little steel used was incorrectly detailed. Concrete was frequently of poor quality, in some cases hardly resembling concrete at all.

The types of construction damaged are all too common throughout the Territory of Papua and New Guinea. However, many inadequate forms of construction, lightly braced tall foundations, unreinforced concrete block construction, etc. were not exposed to attack by this earthquake.

Common forms of bracing for tall foundations are inadequate.

Heavy objects on floors or platforms need constraint against sliding or overturning.

3. RECOMMENDATIONS

Introduction of appropriate building code

These defective buildings can be avoided only by the introduction of codes of building practice. These should be as flexible as possible and should emphasise correct use of materials and principles to be followed in design and detailing. Well trained building inspectors should increase the effectiveness and flexibility of code application.

Examination of earthquake damage

A systematic engineering study should be made of the earthquake damage. Steps should be taken to ensure that damage by future severe earthquakes have rapid and systematic engineering assessment.

Introduction of strong-motion earthquake recorders

Strong-motion earthquake recorders should be installed in the main centres of construction to increase the value of damage studies and provide further information for design engineers and those formulating codes of building practice. The strong-motion records would permit more rational design procedures and hence facilitate the design of new and unusual structures.

Earthquake insurance

The possibility of introducting some form of earthquake damage insurance should be considered. The New Zealand Earthquake and War Damages Insurance could be examined in this regard. A by-product of insurance claim assessment is an accurate knowledge of the extent and type of damage. Engineering studies are however still required to assess mechanisms of damage.

The above measures should increase greatly the efficiency and economy of earthquake-resistant design.

APPENDIX 1

Character of ground motion in epicentral region

Violent accelerations occurred in both N-S and E-W directions. Violent shaking probably persisted for 10 seconds in the E-W direction and 15 seconds in the N-S direction with one particularly large acceleration southward several seconds after the start of severe shaking. The predominant frequencies of acceleration were probably 5 to 7 c/s with considerable acceleration at higher frequencies.

APPENDIX 2

Principles of earthquake-resistant design

It is seldom economically practical to design buildings and other structures, particularly large structures, to withstand the full forces of severe earthquakes within the elastic range of structural members. Materials and design details are chosen to give toughness (strain reserve) and endurance under very brief overloads.

A measure of toughness is the distance which the centre of gravity of the structure can deform horizontally beyond the limit of elastic deformation without losing lateral strength. Permissable overstrains of three to six times provide a large reserve of earthquake resistance.

A measure of endurance is the number of cycles of severe overstrain which a structure can withstand. A building has considerable endurance if it can withstand ten or more cycles of severe overstrain.

Steel frame structures have toughness if the beam and column connections are over designed, usually with the aid of haunches, so that beams and/or columns form plastic hinges near their ends under horizontal overloads. Where possible beam and column ends should be constrained so that plastic hinges form at both ends. These beams and columns should not be excessively slender. Steel frames constructed in this way have a large endurance.

Reinforced concrete frames must have adequate steel bars placed to give moment resistant beam-column connections. Adequate stirruping should be provided through junctions to contain compression concrete within the perimeter surrounded by longitudinal steel. Steel bar laps and particularly steel bar hooks should be avoided at the high moment regions near inter-connections.

The above two forms of construction are relatively flexible and may be designed to withstand, within their elastic range, static horizontal forces of 0.1 to 0.2 times the building weight. The deformations during severe earthquakes will be at least four times the static design deformations and difficulties may be experienced in protecting glazing and non-structural panels.

Comparatively rigid structures are obtained if diagonal bracing or infill block panels are used. This particularly applies to structures of not more than four storeys. Such rigid storeys should be designed for higher horizontal loads. Diagonal bracing by slender members is particularly prone to 'brittle' failure. The large elastic strength available from a small amount of diagonal bracing material may still justify their use in particular situations.

Structures and their foundations should be designed to act as a unit in resisting earthquake forces. Particular attention should be paid to the relative rigidity of components and to the balance of structures. 'L' and 'T' shaped structures should be avoided where possible by separation joints which form rectangular buildings which may move independently. It should be realized that earthquake displacements are four or more times as great as the elastic design displacements.

Adequate foundations call for examination of soil bearing capacity, quality control of concrete and adequate reinforcing steel correctly placed.