Table 3.2-1
SUMMARY PRESENTATION OF DAMAGED BUILDINGS AND INFRASTRUCTURE FACILITIES IN DAGUPAN CITY, DUE TO LUZON EARTHQUAKE OF 16 JULY 1990
(Source: Mayor Office of Dagupan City and AIJ, 1990)

Category of Usage	Damage Category			No. of Bldgs out of Use	Total no. of Bldgs	Comments
	No	Slight to Moderate	Severe			
SB	School Buildings:					Distribution of damaged buildings given in Fig. 3.12.
	47	21	9	3	77	
	61.0%	27.3%	11.7%		100%	
EB	Other Educational Buildings:					
	?	0	4	4	?	
PB	Public Buildings:					Distribution of damaged buildings given in Fig. 3.13.
	?	27	0	?	27	
HB	Hospitals and Other Social Buildings:					
	?	6	0	?	6	
CB	Commercial Buildings:					Estimation based on Tokimatsu, K., 1990, AIJ, field team. ∘ Most of the bldgs. are 3-4 storey r.c. frame structure with infill walls in one direction and shallow foundation. Experienced settlement (20-100cm.) and tilting (1-5 degrees)
	?	102	18	90	120	
	?	85%	15%	75%	100%	
WP	Water Pumping Stations:					
	9	?	?	6	15	
	60%			40%	100%	

Major streets in the Commercial District as bused mainlines were heavily damaged in the length of 3.84 km. as shown in Fig. 3.14, mainly due to liquefaction and lateral spreading of surface soil layers

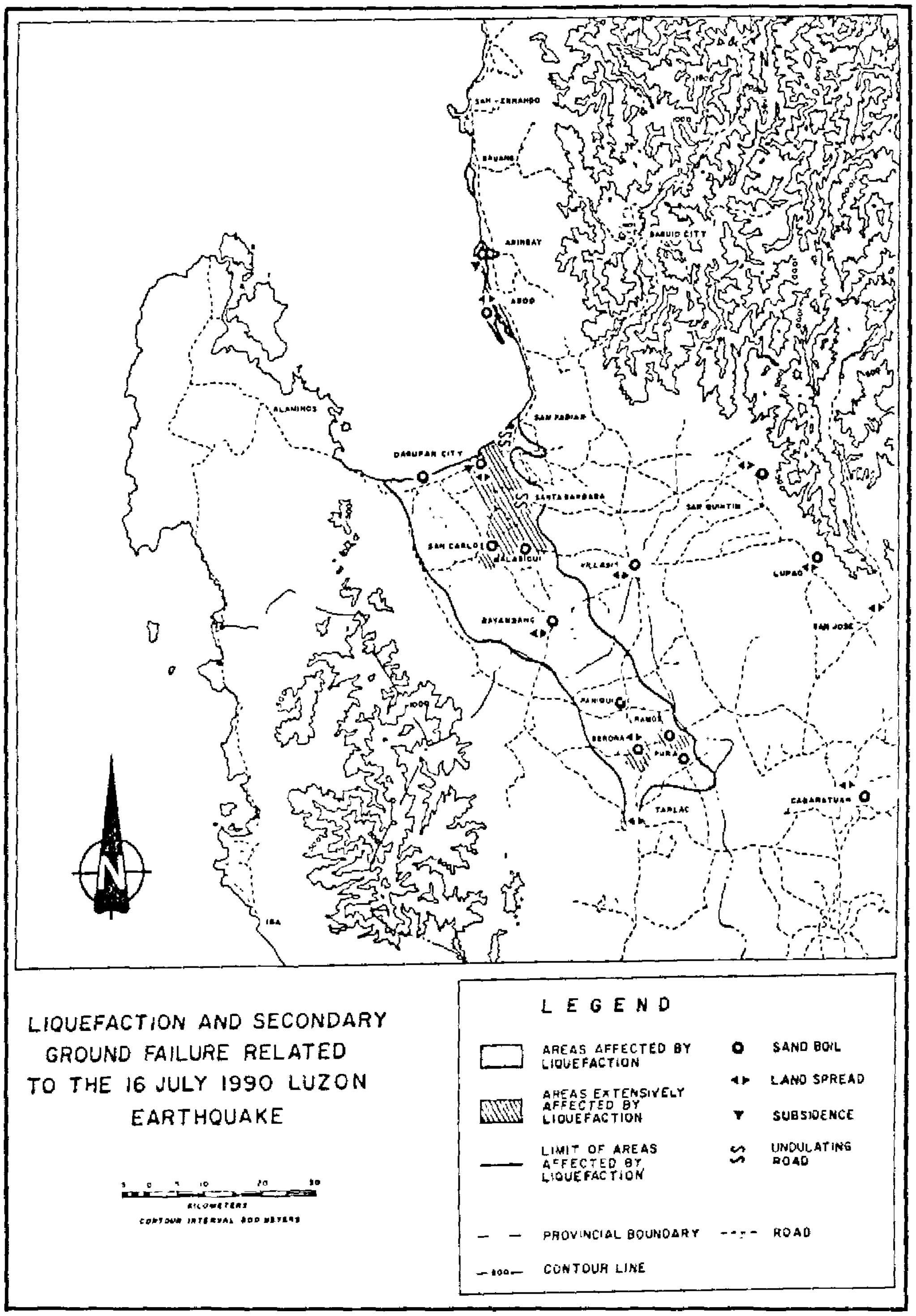


Fig. 3.6 Liquefaction and ground deformations related to the 16 July 1990 Luzon Earthquake in the wider area of Dagupan City (from PHIVOLCS, 1990).

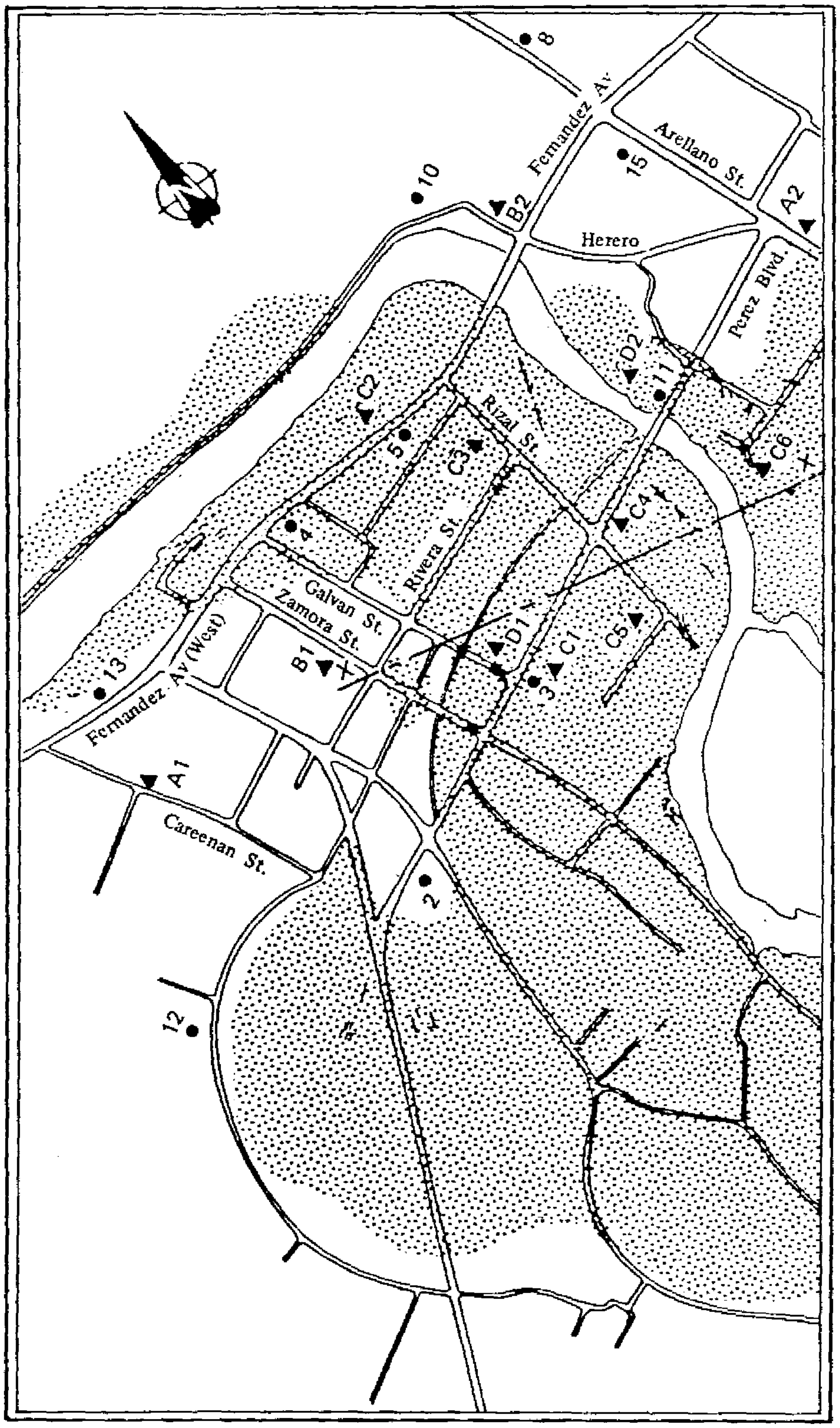


Fig. 3.7 Zones with observed intensive liquefaction and lateral spreading in the central commercial district of Dagupan City, with the locations of SPT test sites (2 - 16), microtremors (A,B,C), and Rayleigh wave field measurements (from PHIVOLCS, 1990, and Tokimatsu, K., 1990).

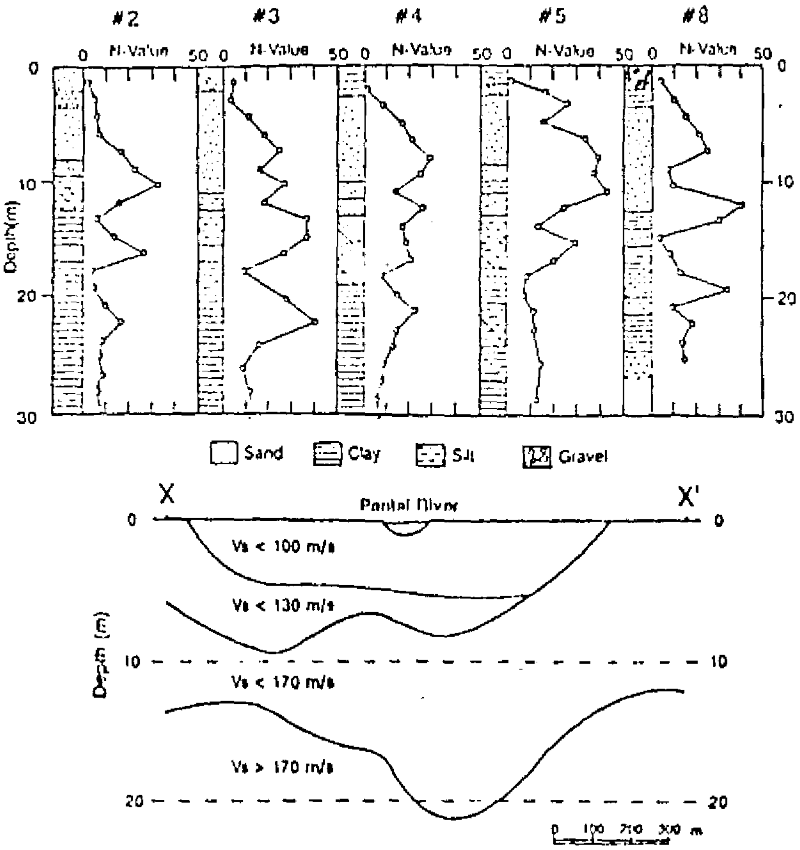


Fig. 3.8 Boring logs along Perez Blvd. (#2 and #3), Fernandez Avenue (#4 and #5) and at Arellano St. (#8), with cross-section of shear wave velocity profile along x-x line. (from Tokimatsu, K., 1990).

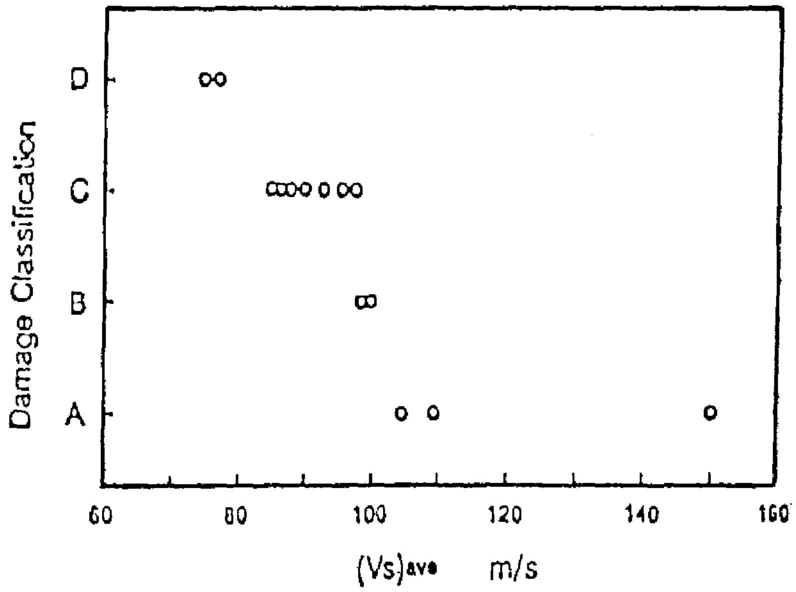


Fig. 3.9 Relation between average shear wave velocity and buildings earthquake damage category (A - no or slight damage, II - small, III - medium, IV - severe damage, V and VI - partial or complete collapse) as classified r.c. buildings, in Dagupan City central area (from Tokimatsu, K., 1990).

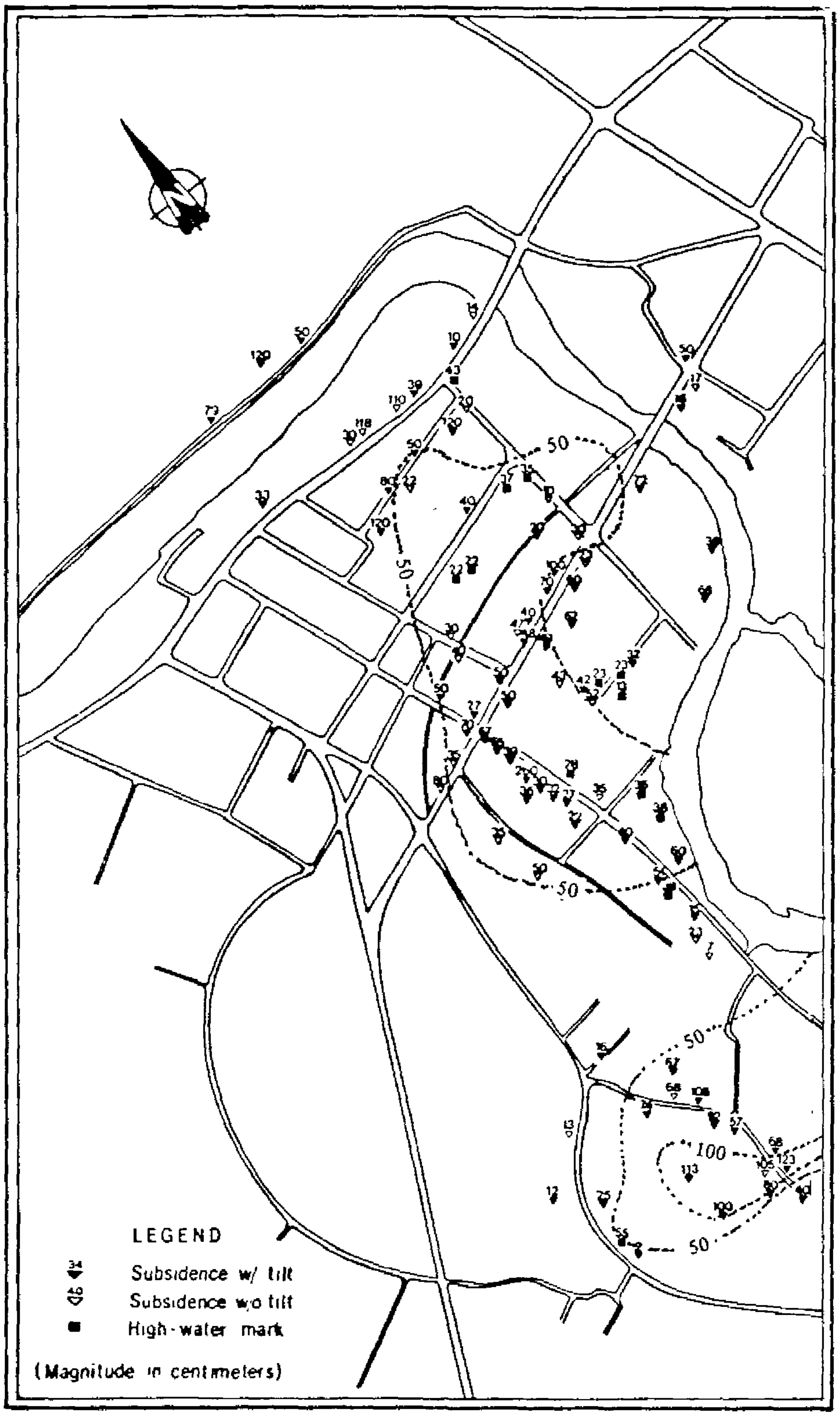
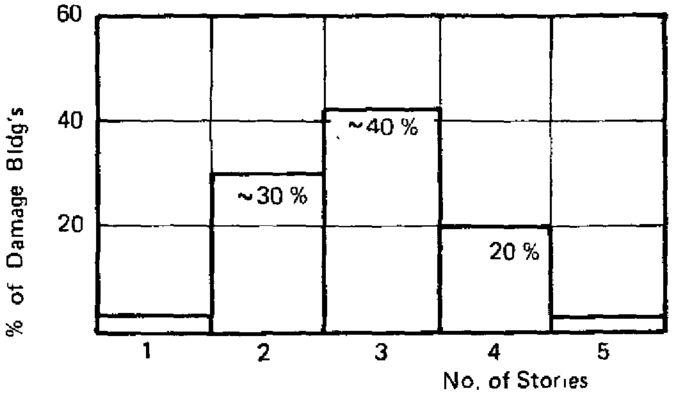
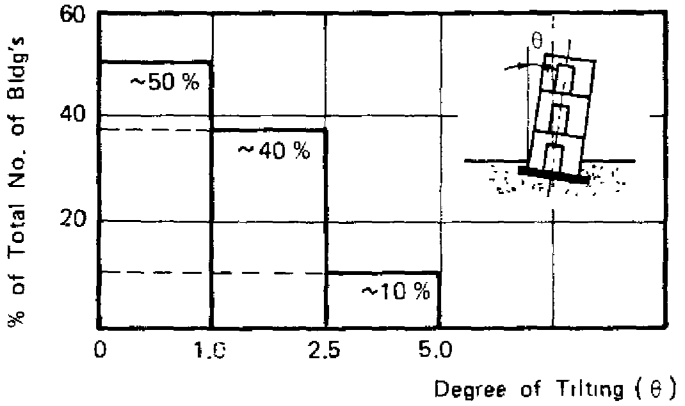


Fig. 3.10 Relative settlement of the buildings in the Commercial district of Dagupan City with probable contour lines of equal settlements (based on the data from PHIVOLCS, 1990).

a. Damage Buildings, No. of Stories



b. Tilting of Buildings



c. Settlement of Buildings

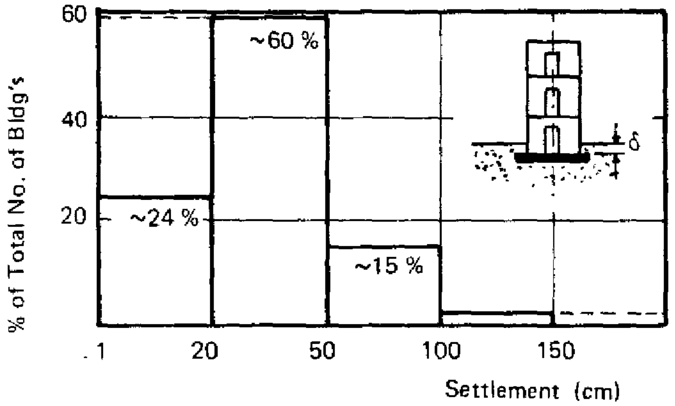


Fig. 3.11 Presentation of the dominant modes of earthquake - damage of r.c. 1 to 5-storey r.c. buildings in Dagupan City. a. number of storeys; b. intensity of tilting; c. intensity of settlement (based on the statistics presented in AIJ, 1990).

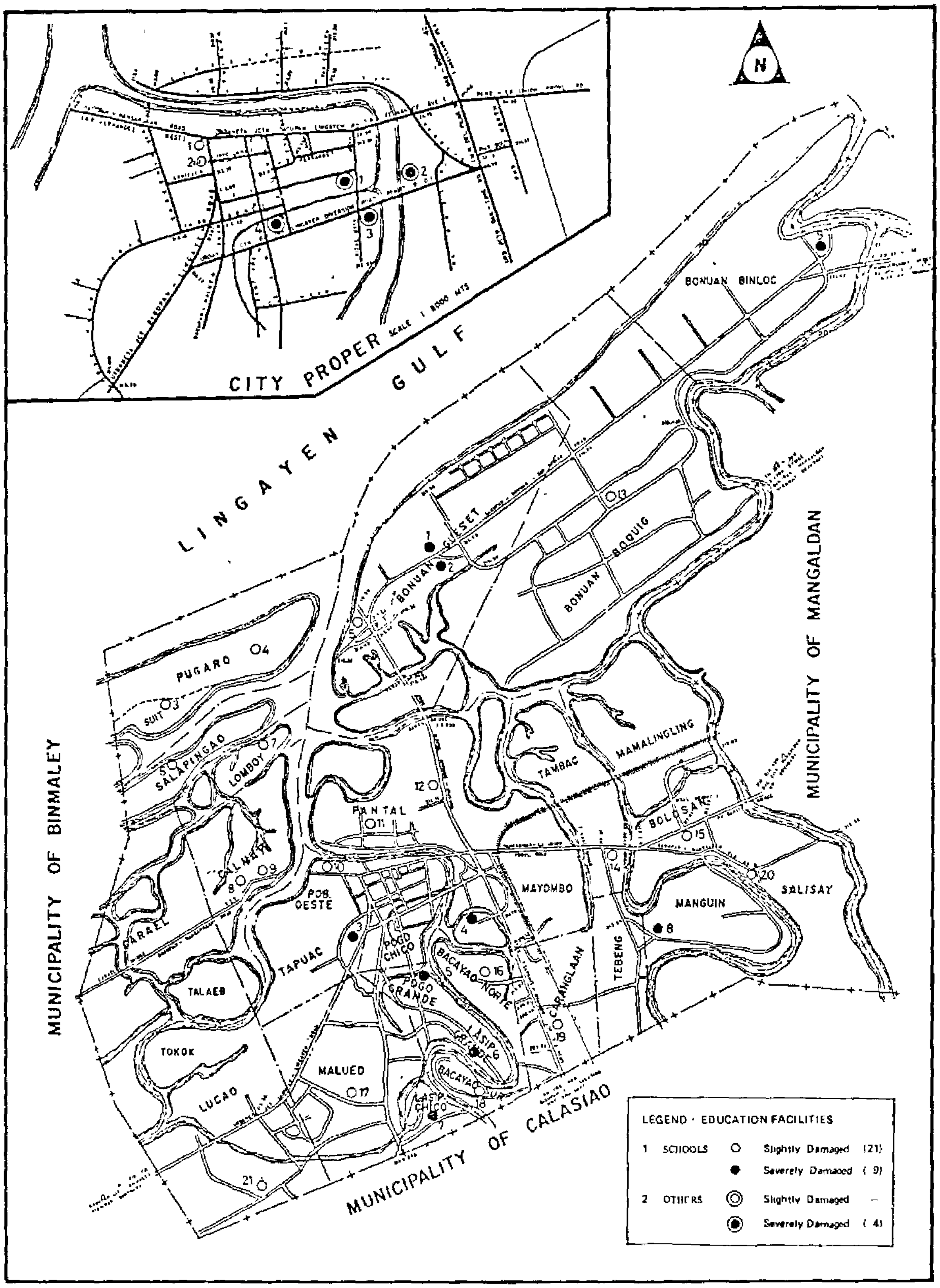


Fig. 3.12 Dagupan City. Distribution of damaged educational buildings due to the Luzon earthquake of 16 July 1990 (source: Mayor Office of Dagupan City)

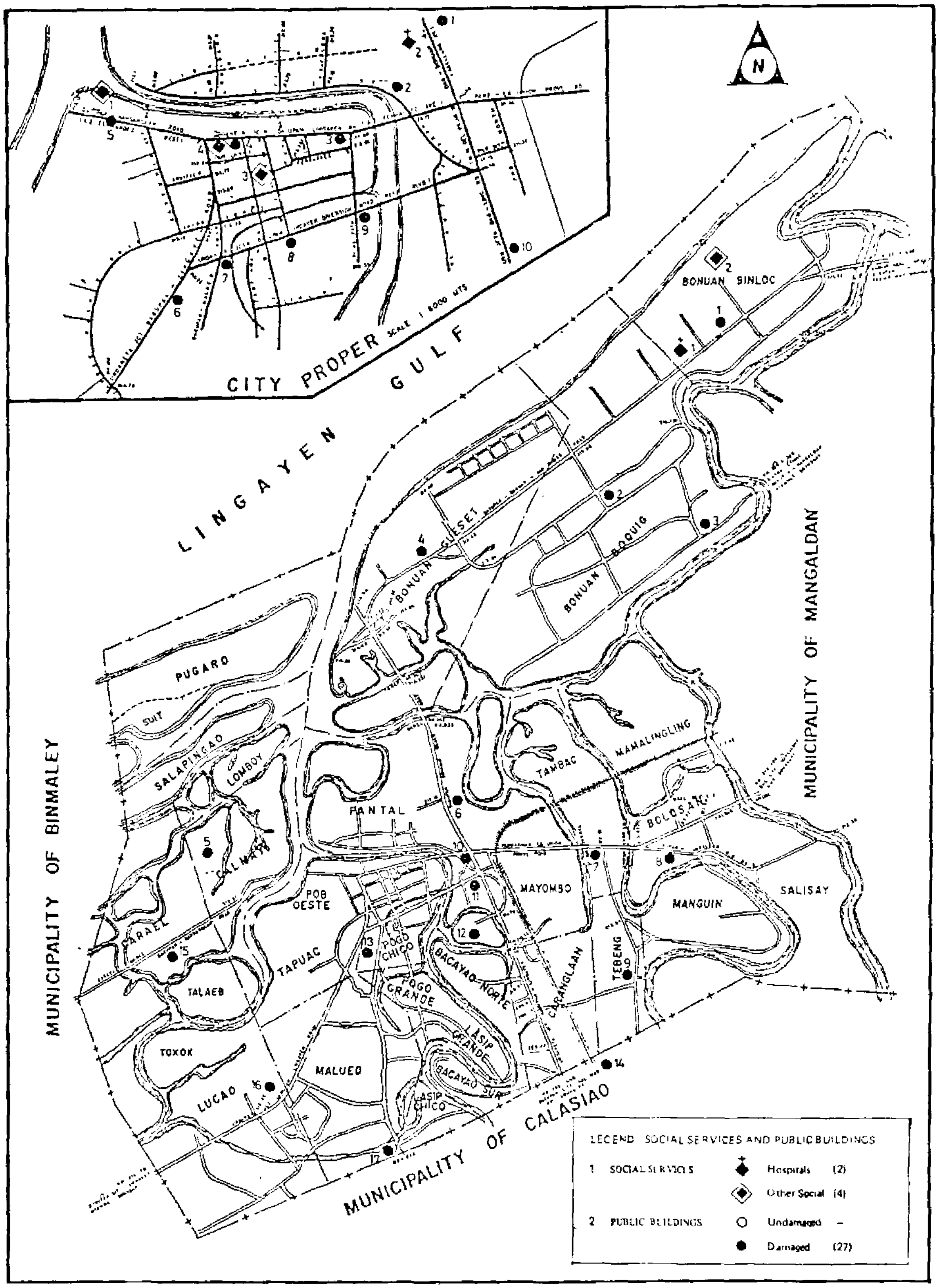


Fig. 3.13 Dagupan City. Distribution of damaged social services and public buildings due to the Luzon earthquake of 16 July 1990 (source: Mayor Office of Dagupan City)

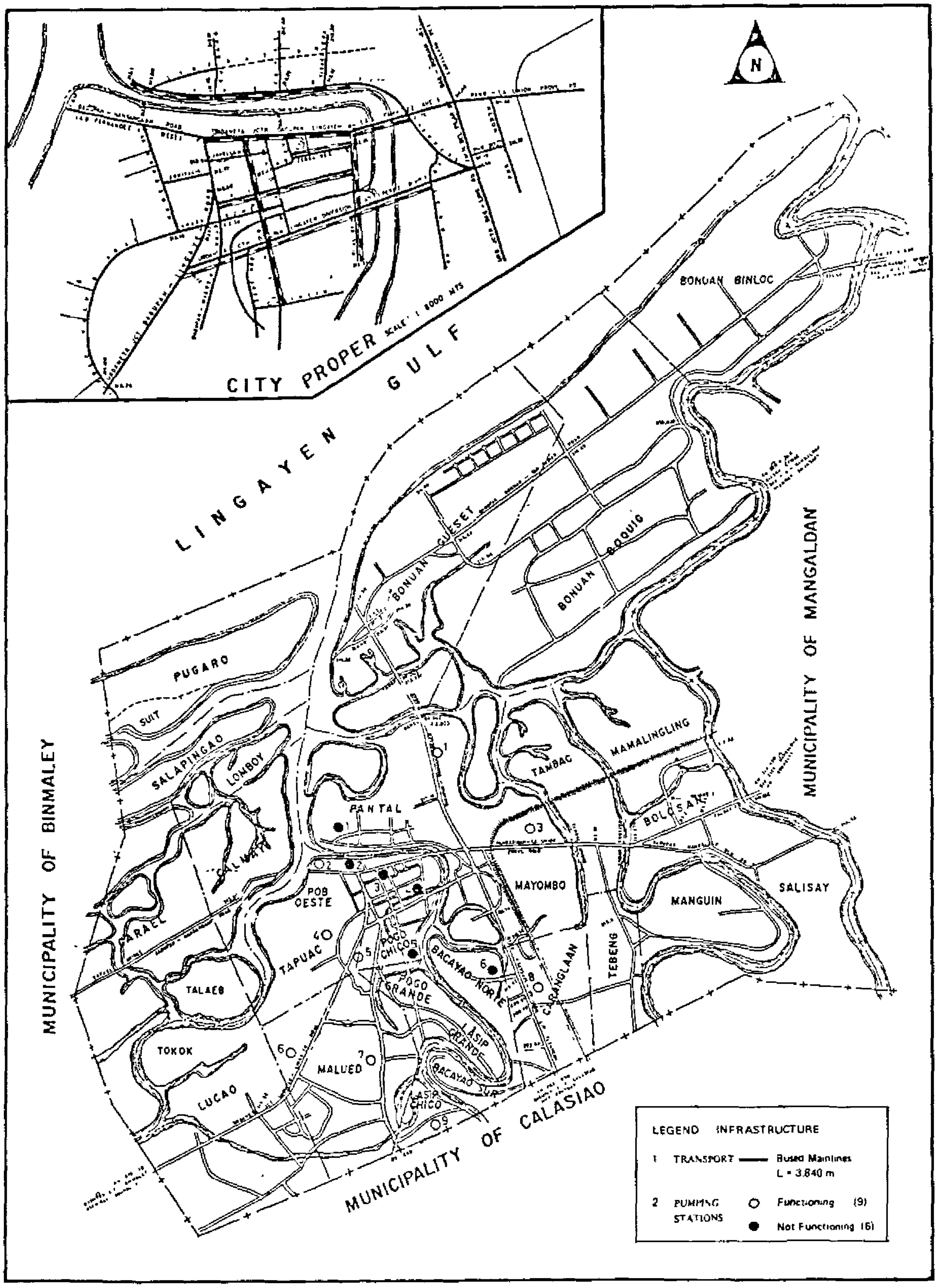


Fig. 3.14 Dagupan City. Distribution of damaged city center bused main lines (transportation system) and water-pumping stations due to the Luzon earthquake of 16 July 1990 (source: Mayor Office of Dagupan City)

3.3. Land Instabilities and Other Earthquake Effects

The effects of land instabilities or ground failure during the Luzon Earthquake of 16 July 1990 have shown in the most dramatic way their dominant influence on earthquake damage of buildings and structures (bridges, ports, etc.), transportation and irrigation systems, lifelines (water supply, sewerage, power supply systems) and communication systems. They have been discussed in detail considering specifically earthquake damage effects in Baguio and Dagupan City in this chapter as well as in Chapter 4, considering land instabilities as a principal cause for an extensive damage to roads and bridges, water supply systems, ports and other facilities. However, for the consistency in presentation and easier reading of this report, major effects of land instabilities will be summarized below.

Liquefaction, the vibration-induced transformation of water-saturated sand to a fluid slurry, occurred locally in Nueva Ecija and Tarlac and extensively in coastal or river delta areas of Pangasinan and La Union. The most dramatic effects of liquefaction were where buildings and bridges subsided and tilted as the ground on which they were built turned into weak slurries. The business district of Dagupan subsided 0.5 - 1.0 meters into a 5-10-meters-thick sand layer, and many buildings are severely tilted. Collapse of the Carmen bridge in Rosario (St. Tomas) was also caused by liquefaction. Many houses, businesses and schools in Aringay, Agoo, Santo Tomas and Gerona were also damaged by liquefaction. Less dramatic but more widespread effects included cracking and subsidence of farmland and roads as liquefied sand spread laterally.

An enormous number of landslides occurred in mountainous areas to the northeast of the Philippine Fault, along the Digdig Fault and in the area from Baguio to the coast from San Fernando to Damortis (Photos 3.15 to 3.22). Relatively few landslides occurred north of the Philippine Fault and east of the Digdig Fault. The greatest concentration of landslides, denuding entire hillsides from crown to base, was along the San Jose-Santa Fe road and in areas surrounding Baguio, particularly along the Kennon and Marcos Highways.

Most landslides were shallow-seated, thin slides of soil from the crest or high on slopes. These deposited huge amounts of sediment and vegetation in river valleys. Monsoon rains subsequently generated additional landslides and viscous debris flows and sediment-laden floods. Deeper-seated rock falls, rock slides and block slides of rock and soil were much less common. Reactivation of pre-existing landslides was rare.

Data base on seismic hazard related vulnerability, direct and indirect losses: The Luzon Earthquake of 16 July 1990 with a magnitude of 7.8 on the Richter's scale was the strongest one in the modern history of the Philippines, affecting large number of urban areas including Metro Manila. Although human casualties are large and material losses are tremendous, the earthquake itself created "national laboratory" for testing buildings and structures, transportation facilities, lifelines and other man-made facilities to the intensive earthquake ground motions and triggered land instabilities. This is probably the best opportunity with systematic earthquake damage data collection to create appropriate data base of seismic hazard related vulnerability for all sectors, and with careful planning to create additional data base on direct and indirect losses during the next 3-5 years of the reconstruction and development period of earthquake stricken areas.

Strong motion instruments and network: Besides very carefully planned and performed surface faulting field studies and seismic investigations, no strong motion instruments have been installed to serve temporary and permanent needs. Existing 14 to 20 strong motion instruments installed in the country before the earthquake of 16 July 1990 were not operational. It will be of utmost importance to bring them into operational conditions as soon as possible and to install carefully planned additional strong motion instruments network with urgent realization in the affected region and urban areas with installation of small-size strong-motion instruments arrays in Baguio, Dagupan, Metro Manila and network in the affected region. Further improvement of existing seismological stations network with implementation of the telemetred and computerized systems, and gradual creation of strong-motion instruments network in the country within the period of 3-5 years is strongly recommended in order to establish better understanding of the earthquake hazards and their effects in the Republic of Philippines.