# THE LUZON EARTHQUAKES OF AUGUST 2, 1968 AND APRIL 7, 1970

by

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## SYNOPSIS

Manila, the commercial and cultural center of the Philippines, was jolted by the Luzon Earthquake of Intensity RF-7.3 on August 2, 1968 causing the collapse of a 6-story building killing 322 persons, injuring about 300 and damaging more than 30 buildings. Another shock with Intensity RF-7.2 on April 7, 1970 caused the collapse of a schoolhouse without any casualty but killed 14 in other places and damaged several buildings including some affected in 1968. Again on April 26 and May 22, 1972 earthquakes of same Intensity RF-6 jolted Manila with negligible damages. The disasters prompted the approval of a National Building Code.

## INTRODUCTION

The Republic of the Philippines lies along the Circum-Pacific Earthquake Belt and is criss-crossed by fault lines (Fig. No.1). Manila, the commercial and cultural center, located at the Manila Bay of Luzon Island, has been the victim of much destruction due to its critical location at the mouth of the Pasig River. Records show that since 1589 to 1899 damaging earthquakes with Intensities RF-6 and above occurred once in 15 years, and since 1900, once every 35 years. The recent Luzon Earthquake of August 2, 1968 with Intensity RF-7.3, epicenter 230 Kms., N 43$^{\circ}$ E from Manila, triggered the collapse of the Ruby Tower killing 322 persons, wounding about 300, and damaged more than 30 buildings. Another shock on April 7, 1970 with Intensity RF-7.2, epicenter 165 Kms., N 42.5$^{\circ}$ E from Manila, damaged also few buildings including some still undergoing repairs. The people have developed such seismic phobia that lighter shocks of Intensity RF-6 on April 26 and May 22, 1972 scared them again running down stairways and away from buildings.

## GEOLOGY OF THE AREA

Manila covers a reclaimed area where the alluvial soil is underlain by volcanic tuff which rises in elevation towards the east. The top stratum of loose sand and silt with a thickness of 5 to 10 meters is underlain by a layer consisting of organic clay and silt with color varying from dark grey to black as the depth increases from 15 to 25 meters. The next layer of grayish stiff clay with silt and good compaction is volcanic tuff (locally called "adobe") with the thickness sometimes extending to more than 100 meters.

## GROUND PREDOMINANT PERIOD

Microtremor measurements conducted by the Team of UNESCO Consultants composed of S. Omote, chairman, and Y. Osawa, I. Skinner and Y. Yoshimi

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as members, at the location of severely damaged buildings with heights ranging from 6 floors to 8 floors with the exception of one (11 floors) showed that where the ground is soft and thick alluvium, the predominant period is 0.46 second, but where adobe is near the surface or the soft layer is thin, and the period varies from 0.20 to 0.30 seconds, the damages are minor.

## OBSERVATIONS ON DAMAGES

Fig. No. 2 shows the location of buildings damaged in 1968 and 1970 - all within the alluvial area, predominantly on the congested area north of the Pasig River. They are generally of reinforced concrete construction with masonry block partitions. The various degrees of damages may be classified into: (1) Total failure or impending collapse due to buckling of columns and shear failure in beams such as the Ruby Tower, the Pedro Guevara Elementary School and the Philippine Bar Association Bldg.; (2) Moderate damages due to cracks in the columns and beams at their intersections, cross-cracks in wall panels, shear cracks along construction joints, cracks in partitions and at corners of doors and windows with planes oriented along the seismic waves in about 60% of the damaged buildings. (3) Light damages, usually architectural, such as plaster cracks, removal of tile and/or marble finishes, breakage of glazing and vision glasses, and hammering of adjacent buildings. It might be mentioned here that there were many other buildings with architectural damages, but never reported officially.

## CAUSES OF FAILURE

An investigation of the structural members of damaged structures and of the Plans and Design Analyses showed that the causes of failures could be attributed to: (1) Inadequacy of design - either failure of design concept of the structure and/or failure to consider the effects of lateral forces and consequential torsion - a responsibility of the Designing Professional. (2) Lack of ductility in the columns and beams due to the absence of adequate ties and spirals of columns at the junction with beams - either due to the Designer's neglect or omission by the Contractor. (3) Poor quality of concrete and improper placement of reinforcing bars, poor workmanship and lack of supervision - the responsibility of the Contractor.

## DAMAGED BUILDINGS

(1) The RUBY TOWER - Collapsed on August 2, 1968 - Design and Construction Failure. This 6-story reinforced concrete building is 30 M. wide by 45.5 M. long by 20.5 M. high. The framework is of the beam and slab type with a party line (shear) wall at the rear. Every other interior row of beams is cut by skylights or stairs along every other span in both orthogonic directions. Long columns along the two front rows of columns led to buckling. Ground floor columns were subjected to moments due to torsion of framework and the eccentricity with peripheral foundations without tie beams. Poor concrete materials and workmanship complemented design errors which finally led to collapse like a deck of cards, killing 322 persons and injuring more than 300. As of today, there is a court litigation on the "criminal liability" aspect, the "civil liability" aspect of which has been settled amicably out of court.

(2) The PHILIPPINE BAR ASSOCIATION (PBA) - Damaged on August 2, 1968 and April 7, 1970 - Construction Failure. This building is presently the subject of a judicial case - the Owner versus the Contractor and the Contractor versus both the Owner and the Architect. It is 17.8 M. wide by 39.2 M. long by 22.8 M. high. The framework is of the beam and slab type with a party line (shear) wall at the rear, causing torsion when subjected to lateral forces. Failure was due to buckling of ten (10) exterior and two (2) interior columns for to lack of spirals and ties at the ground floor and below the second floor and the construction deficiencies as indicated by fractures at construction joints and hollow or voids in columns and improper placement of bars causing the building to lurch forward and rotate in 1968. Because no repairs were made due to court litigation, it was further damaged in 1970. The Owner, fearful of any momentary failure and the corresponding liability, decided to demolish the building without prejudice to the prosecution of the court case. The Court penalized jointly and solidarily the Architect and Contractor in the amount of ₱900,000 representing the cost of repairs plus interest. The decision is presently under appeal.

(3) The TUASON REALTY BUILDING - Damaged August 2, 1968. This 5-story office building had four of its columns badly cracked at the ground level, one at the second floor, and one at the third floor, which is a continuation of one damaged at the ground floor at the center of the building. Exterior walls, mullions, stair walls, ceramic and glass block walls and glass panels were so badly cracked obviously due to torsion. The Owner, after having collected ₱235,000 from the Insurance, decided to demolish the structure to give way to a newer and taller building, but the area is presently used as a parking space.

(4) The FILIPINAS INSURANCE (FI) and (5) The TRADERS COMMERCIAL BANK (TCB) are contiguous buildings in one block. FI, a 40-year old building, suffered cracks in exterior, stair and elevator walls. Wooden trusses which sagged dangerously due to hammering of its party line walls against that of the TCB were removed. Up to now, the building is not repaired. The TCB, a 50-year old, 7-story reinforced concrete building suffered in 1968 serious cross-cracks in exterior wall panels, stair and elevator walls; columns and beams around a skylight were badly cracked due to the discontinuity of four (4) columns at the basement which was used as a parking area. The reinforced concrete rigid frames of the Mansard Roof were cracked and demolished. Repairs and remodelling were being undertaken only to be hit again in 1970, increasing crack formation in the walls. Then in July, 1972 shortly after the April and May shocks, a fire at the third floor allegedly started by some short-circuit burned falsework, steel window panes, and spalled all newly plastered ceilings and walls leaving a black surface where the epoxy bonding compound was used. The reconstruction is still underway, but stringent financing may see its completion by June, 1973.

(5) ARANETA - TUASON BUILDING. This is an 8-story reinforced concrete building on pile foundation adjacent to an older 5-story reinforced concrete structure with a mat foundation. Damages consisted of wall cracks at corners of windows at the ground, mezzanine, second floor, from the 4th to the 8th floors, and at the junction of the two structures. The taller building leaned 4 cm. to the east while the other one leaned

5 cm. in the opposite direction. Again, the front of the taller unit is lower by 9 cm. than the rear. No damages were reported in 1970 and 1972.

(7) OLD PHILIPPINE NATIONAL BANK (OLD PNB). This is a 55-year old 7-story building facing Escolta St. with the rear at the street along the Pasig River bank. Built over an old foundation allegedly inadequate for 7 floors, it received serious damages in columns and beams, cracked partitions and walls especially at the front and rear as well as junction of wings. The building was finally demolished. Along Escolta St., a one ~~4-story~~ building of light materials has been erected at the site for business rental.

(8) BOTICA BOIE (Presently Peoples Bank and Trust Co.). This 7-story reinforced concrete building east of and adjacent to the preceding building used to house the biggest drug store in the Philippines. In 1968, party line walls at the SW side and SE end caused torsional stresses that cracked walls along the two other faces, elevator and stair walls, breaking floor tiles, vision glasses and several hundreds of glass hollow blocks. Cracks were repaired, but more appeared in 1970 especially along the NW-SE oriented walls. No damage was reported in 1972.

(9) OLD DEVELOPMENT BANK OF THE PHILIPPINES (OLD DBP). This 20-year old, 8-story reinforced concrete building on pile foundation beside the Pasig River was cracked in 1968 in interior walls, stairwalls and in few beams and columns, especially the exterior walls with media aguas from the fifth to the eighth floor. The media aguas were removed to lighten the load and no consequential damages were incurred in 1970 and 1972.

(10) MANILA BANKING CORPORATION. This 8-story office building is located at the back of the OLD DBP, using the same foundation of a building (the former Heacock) damaged in 1937 due to construction defects that resulted in buckling of columns. Damages were similar to the OLD DBP above, including removal of marble finish and shattered glazing. There were few cracks in 1970, but none reported in 1972.

(11) ALOHA THEATER AND PREMIER HOTEL. This 8-story building tapers in plan to the south. Failure started with the collapse of a few short columns near the south end at the fourth floor due to torsion and spread out to the narrow southern end which tilted so badly that it looked it would collapse anytime. Demolition was started immediately after the damage and reconstruction executed with the height of the south end reduced to four (4) floors. The 1970 and 1972 earthquakes caused no structural damage.

(12) LIWAYWAY HOTEL. This 9-story reinforced concrete building was built in 1935 before the City Council of Manila passed the regulations requiring aseismic design for buildings with heights above 30 M. Damages in 1968 were the split columns at the arcade revealing poor concrete and cracked beams due to shear from the second to the fifth floor. The west wall and the beams, more or less parallel to the primary waves, suffered very severe damages due to shear. Partitions and floors were cracked, while ceiling lighting fixtures were destroyed. The 1970 earthquake caused cracks along the south and north walls, but none in 1972.

(13) LA TONDEÑA BUILDING. This is an 8-story reinforced concrete building supported by prestressed concrete piles 33 M. to 35 M. long. The framework has a one-bay width of 18.0 M. with a total length of 32.5 M. (5 bays at 6.50 M.), and the height of 30.40 M. The north-west end has solid shear walls enclosing a stairwell while the southeast end wall is separated into two by a stair window opening 4.50 M. wide. The transverse girder spanning the window and the next two supporting the vault were badly cracked and the effect spread to adjacent walls.

The transverse bents are oriented more or less in the direction NE-SW to the epicenter of the earthquake shock in 1968 and, surprisingly, in the 1970 shock, the cracks produced in 1968 were not materially enlarged, but instead the longitudinal side walls were the ones cracked giving proof that the direction of the waves in 1970 was NW-SE, as was also indicated in the Botica Boie and other buildings.

The structure is situated in a peninsular area where the alluvium soil is so deep that the length of piles exceeded the building height. There were no batter piles so that sway reached damaging proportions. It was reinforced by placing new shear walls with batter piles at the ends designed to absorb all lateral shears at a cost that reached almost ₱1,000,000 including architectural remodelling. It remains to be proven whether the remedial measures adopted are effective.

(14) FAR EASTERN UNIVERSITY (FEU) ARTS BUILDING. This Z-shaped 7-story reinforced concrete building is near the Claro M. Recto Underpass with the north end of the east flange occupying an area beside an estero with a drain pipe that was partly filled up towards the Underpass.

Damages were in the form of cracks in the transverse beams at the junction with columns, shear cracks in interior reinforced concrete walls elevator and end walls along dirty construction joints, and the falling down of concrete hollow block walls which served as partitions between classrooms due to lack of anchorage to the beams above and the toppling down of the ceramic block parapet for lack of anchorage to the roof slab. On top of the above damages, fire ensued at the laboratory area. The side of the building parallel to the estero settled down 15 cms., probably due to the outflow of fines through the estero during pumping operations when the Underpass was being constructed. The framework was designed for seismic forces according to the local Building Ordinance of Manila and the U.S. Uniform Building Code. Failure was obviously due to the poor concrete, dirty construction joints, poor workmanship and lack of supervision. The Owners removed the upper two (2) floors and completely demolished the east wing used as the stair hallway. The Owners were claiming a ₱2,000,000 total damage, but the Insurance Company was only willing to pay less than ₱500,000, the estimated cost of repairs. As of today, the building is not yet repaired.

(15) IGLESIA NI CRISTO, Tondo. This landmark near the northern part of Manila's coastline is a Chapel with reinforced concrete rigid frames (40.0 M. span x 51.5 M. high and 28.0 M. span x 38.5 M. high) supported by prestressed concrete pile foundation, and covered with wooden purlins and G.I. roofing. It has a seating capacity of 5,000, the biggest of its kind in the Philippines. There are four (4) 70.0 M. high towers, one at each corner of the Auditorium 35.0 M. x 55.0 M. on centers. The southwest tower broke at a height of 35 M. where the base of the tower has a

hexagonal shape near its junction with the rigid frames. One man was killed by a splinter. The fractures revealed that the construction joints at the place of failure were not cleaned, the grout was as thick as 30 cms in the tower legs, and concrete did not look sound. An examination of the towers showed fine cracks at about the same elevation, so instructions were given to demolish the three remaining towers. A detailed examination of the rigid frames showed cracks at connections of horizontal ties and at the joints of the vertical struts and horizontal ties. Major cracks were sealed with epoxy bonding compound. To strengthen the joints and prevent further fractures, steel plates were cut and welded to fit the joints like a jacket, bolted thereto and interconnected to act as an integrated assembly at a cost of about P500,000.

(16) PEDRO GUEVARA ELEMENTARY SCHOOL. The E-W wing of this L-shaped 3-story reinforced concrete building was almost finished when the August 2, 1968 inflicted some structural damage. It was allegedly repaired and the N-S wing was completed in 1969. When the April 7, 1970 earthquake came it collapsed completely. Fortunately, there was a strike of jeepney drivers so there were no classes on that day - otherwise many children would have lost their lives. An investigation of the structural design showed that there was no consideration for seismic forces; concrete was very poor. Reinforced concrete specifications were not followed. The structure has been redesigned using prestressed concrete elements - columns, beams, floors and walls - and is presently being used.

(17) GOCHECO BUILDING. This apartment is a 6-story reinforced concrete building with four wings that form an almost closed polygon around a yard at the center. Damage to frames and panels were caused by NE-SW shocks in 1968. These were repaired with epoxy bonding materials together with the appropriate placement of four (4) shear walls. In addition, the walls around stairwells were reinforced to act as shear elements. Because of the shape of the building, there were many CHB partitions which were damaged. A solution by separating the wall panels from the columns by a 5 cm. gap and sealed with an elastic filler has been implemented, and performed satisfactorily against in 1970 and 1972 shocks.

(18) PEARL TOWER. This is a reinforced concrete residence condominium with two blocks: the ALPHA, a 7-story with 7 x 5 bays and the BETA a 5-story with 19 x 2 bays connected by beams at the first and second floor levels.

In 1968, the framework received structural damage along the transverse direction where there were no stiff elements in addition to poor construction joints, poor workmanship and faulty details. This weakness was remedied by the introduction of a couple of shear walls in each building with their own foundations independent of the existing column foundation. The 1970 earthquake produced no cracks. However, it must be pointed out that along the direction of the 1970 motion (NW-SE) there are strong party line walls. It was not damaged in 1972.

(19) UNITED (FIRST HOTEL). This 5-story reinforced concrete commercial building has a length of 8-bays and a width of 4 to 5 bays with the long axis oriented about N 51° E. It received minor damages from the August 2, 1968 earthquake, probably due to the existence of the party

line wall along the direction of the motion. However, with the apparent change of direction of the shock waves in 1970 to the NW-SE, major damages due to shear and diagonal tension in the exterior columns along the north and east sides, in addition to cracked walls, produced such an image that the building might collapse any time. This was due to torsional effects. No damages were reported in 1972.

(20) *DIAMOND TOWER*. This narrow and long building with a NW-SE axis is an 11-story residential condominium. Its slender cross-section due to side-sway resulted in cracked beams and columns in the transverse direction. All damaged concrete was chipped off and replaced with dry-pack concrete. A reinforcing cage of No. 4 bars was placed, while wide cracks were filled up by epoxy under pressure. Some cantilevers which deflected were repaired without correcting the sag. But the most important aspect of the rehabilitation was the placement of a couple of shear walls at the third bent from the ends in a symmetrical pattern. The new wall reinforcements were welded to the column and beam bars, resulting in an integrated panel between the two outer rows of columns. The performance of the new transverse walls, however, was not tested by the NW-SE motion of 1970. Damages incurred along the longitudinal direction were only cracked vertical sun-baffles.

## NATIONAL CONSCIOUSNESS

The repeated occurrence of earthquakes and the heavy losses incurred thereby has awakened the people to their lack of technical and scientific preparation to meet the effects of disasters. The government sector headed by no other than Senate President Gil Puyat and Senator Helena Z. Benitez led the move to formulate regulations for the design and construction of buildings in order to minimize the tragic effects of earthquake failures. A group of selected Professionals worked untiringly to prepare the draft of the National Building Code which was finally "Approved into Law" on August 26, 1972. However, a National Building Code is not enough remedy for Nature's unpredictable devastations. Man has to act intelligently for his survival and to that end, the following Recommendations are presented.

## RECOMMENDATIONS

(1) There is need for local SUB-SOIL zoning maps for metropolitan areas to show the dynamic response of soil structures to earthquake motions. To complement the above, the dynamic response of tall buildings must also be known. There must be available microtremor equipment to measure the period and amplitude of ground vibration and accelerographs to be installed in tall buildings at strategic places to gather similar data as provided for in the National Building Code.

(2) To complement the above equipment, there must be electronic computers and trained personnel to operate and maintain such special instruments.

(3) A Building Research Institute similar to that in Japan is necessary to take care of the above recommendations and prosecute relevant studies. It should maintain close collaboration with local research organizations and allied institutions in other countries.

(4) The IAEE should adopt an International Scale for Magnitude and

Intensity of Earthquakes, and the Metric System for measurements to achieve a better coordination of all scientific researches and technological development.

**ACKNOWLEDGEMENT**

(1) The pertinent data regarding Gecheco, Pearl Tower, United (First Hotel) and Diamond Building were kindly furnished by Dr. Fiorello Estuar, a Consulting Engineer, who designed and supervised their repair and reconstruction.

(2) Map shewing "Major Structural (Fault) Lines" was furnished by Engr. Wellington A. Miñesa, Weather Specialist of the Weather Bureau of the Republic of the Philippines.

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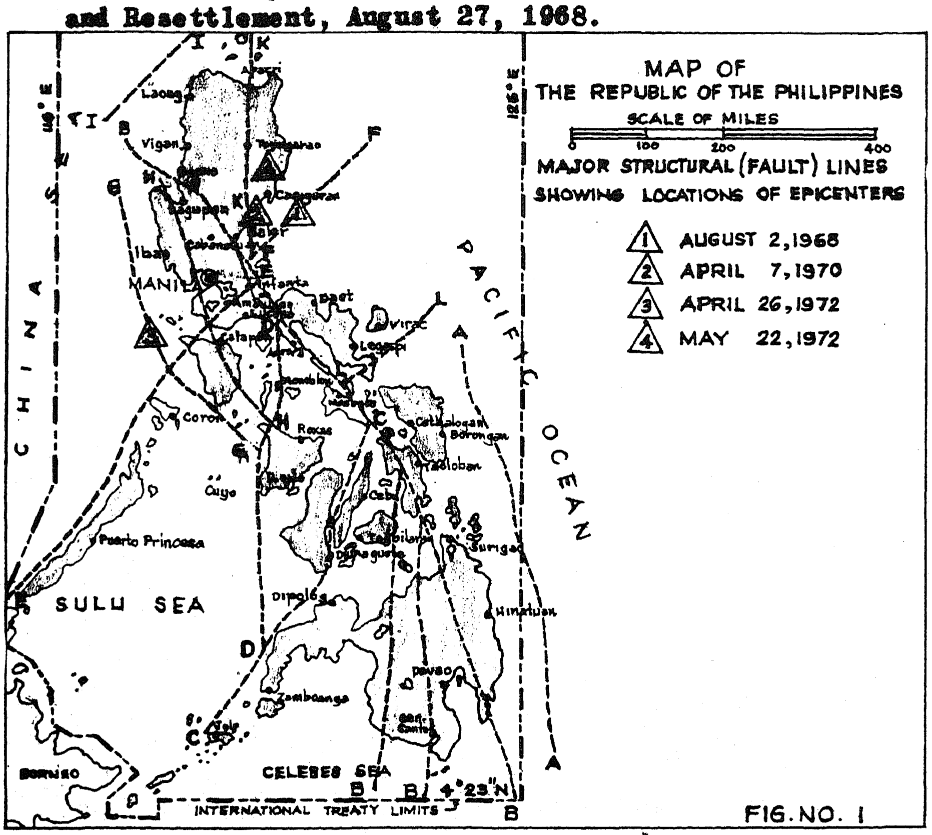


FIG. NO. I

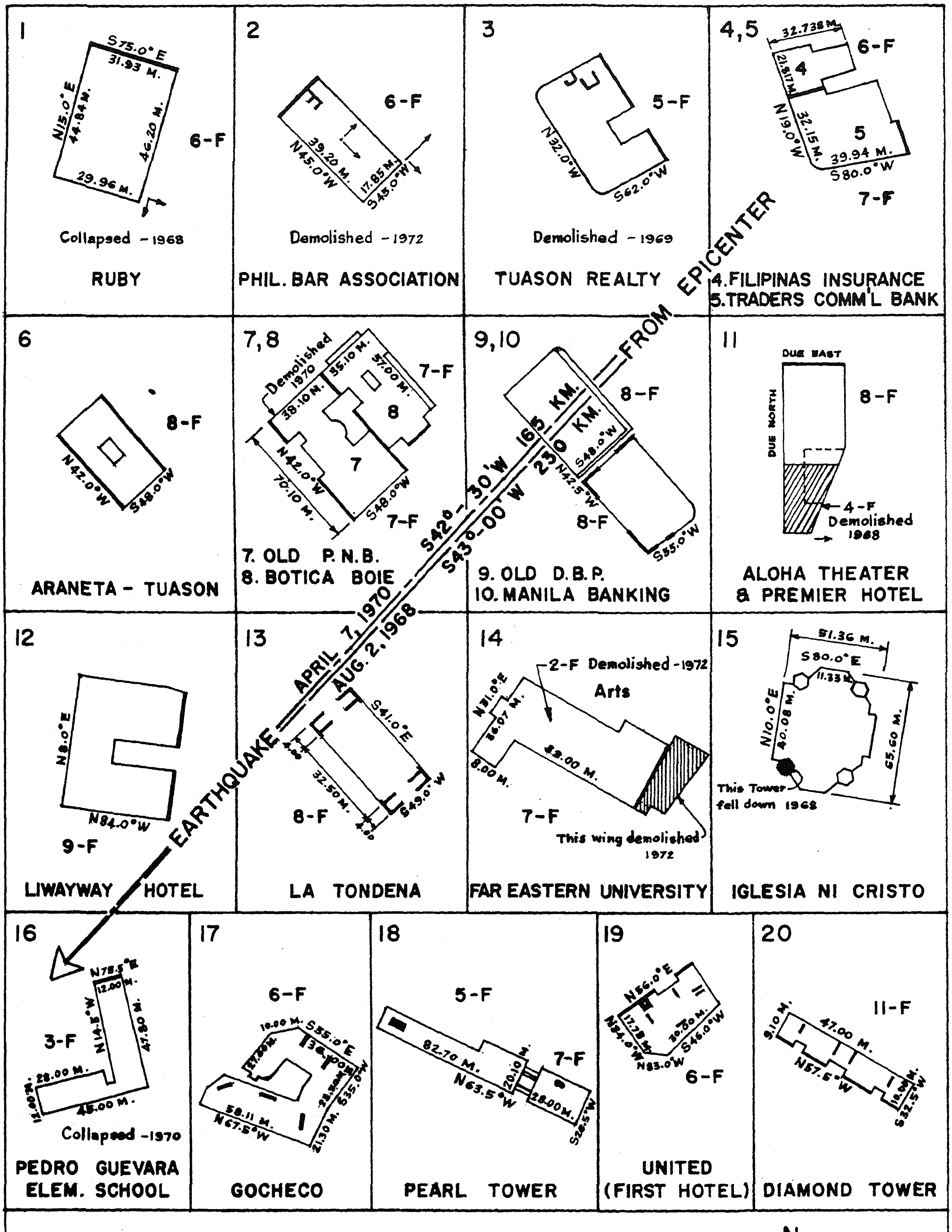


FIGURE No. 3

BUILDING ORIENTATION

Legend: 6-F = 6 Floors