FINAL REPORT OF THE COMMISSION OF INQUIRY INTO THE RAINSTORM DISASTERS 1972

GEO REPORT No. 229

T.L. Yang, S. Mackey & E. Cumine

GEOTECHNICAL ENGINEERING OFFICE
CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT
THE GOVERNMENT OF THE HONG KONG
SPECIAL ADMINISTRATIVE REGION

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This report is largely based on the Final Report of the Commission of Inquiry into the Rainstorm Disasters 1972 produced in November 1972

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PREFACE

In keeping with our policy of releasing information which may be of general interest to the geotechnical profession and the public, we make available selected internal reports in a series of publications termed the GEO Report series. The GEO Reports can be downloaded from the website of the Civil Engineering and Development Department (http://www.cedd.gov.hk) on the Internet. Printed copies are also available for some GEO Reports. For printed copies, a charge is made to cover the cost of printing.

The Geotechnical Engineering Office also produces documents specifically for publication. These include guidance documents and results of comprehensive reviews. These publications and the printed GEO Reports may be obtained from the Government's Information Services Department. Information on how to purchase these documents is given on the second last page of this report.

R.K.S. Chan
Head, Geotechnical Engineering Office
July 2008

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FOREWORD

This GEO Report presents the Final Report of the Commission of Inquiry into the Rainstorm Disasters 1972. The Final Report, originally produced in November 1972, covered the disasters at Po Shan Road (Western District), Shiu Fai Terrace (Wan Chai) and at five other places, namely,

(1) Ap Lei Chau,

(2) Belcher's Street (Western District),

(3) Bullock Lane (Wan Chai),

(4) Chai Wan, and

(5) Shau Kei Wan.

H.N. Wong
Deputy Head (Planning & Standards)
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To His Excellency the Governor in Council

Your Excellency,

We, the undersigned Commissioners, now have the honour to submit to Your Excellency our final report which deals, *inter alia*, with the landslips at Po Shan Road (Western District) and Shiu Fai Terrace (Wan Chai), and also the disasters at five other places, namely,

(1) Ap Lei Chau,

(2) Belcher's Street (Western District),

(3) Bullock Lane (Wan Chai),

(4) Chai Wan and

(5) Shau Kei Wan.

This report also includes our final conclusions and recommendations.

CHAPTER I

INTRODUCTION

Since we submitted our Interim Report we have continued to hold public hearings at Victoria District Court on 13 days between August 21 and October 27, 1972. Transcripts of the whole proceedings are now available if required. There was an adjournment from August 24 to October 4, 1972, pending detailed analysis of the structure and steel and concrete samples from Kotewall Court.

2. At the beginning of September 1972 Mr. R. G. PENLINGTON, our legal adviser, wrote to those members of the public who had given evidence in public hearings or who had submitted statements as exhibits on the Po Shan Road disaster, asking them if they had anything further to add to their evidence or statements. They were invited to contact him as soon as possible, and, in any case, not later than a certain date, if they had such additional information. However, no further evidence resulted from these invitations.

3. On September 11, 1972 a press release was issued, in which Mr. PENLINGTON again appealed to any other members of the public who might have information connected with the events before, during or after the landslips at Po Shan Road to contact him. There was no response to the appeal.

4. On October 4, 1972 Government announced that funds had been provided for legal representation of all victims of the June rainstorm disasters at the hearings of the Commission. It was simultaneously announced that Mr. Charles CHING on the instruction of Patrick Chan & Co., Solicitors, had been appointed to represent victims on both sides of the harbour as well as others affected by the rainstorms, except those who had separate interests, thus requiring separate representation.

5. Evidence was received in the same way as previously. There were 31 witnesses and 83 exhibits. Appendix I is a list of witnesses, and Appendix II is a list of exhibits. Appendix III is a list of those members of the public who supplied or offered to supply us with photographs. A list of references is at Appendix IV.

CHAPTER II

BACKGROUND INFORMATION

SECTION 1 GEOGRAPHICAL

(A) INTRODUCTION

6. A comprehensive treatise on the geography and geology of Hong Kong is contained in the report, Hong Kong 1971. To assist ourselves in our deliberations, we have referred to this book for background information and statistics which are relevant to certain aspects of our work. Some of this information is given below.

(B) AREA

7. The total land area of the Colony, including recent reclamations, is 403.7 square miles, of which Hong Kong Island itself, together with a number of small adjacent islands, comprises 29.2 square miles. Kowloon and Stonecutters Island have an area of 4.1 square miles. The New Territories, which consist of part of the mainland and more than 230 islands, have a total area of 370.4 square miles.

8. Owing to the hilly topography, agricultural land is extremely restricted. The most important area is the alluvial plain around Yuen Long in the Deep Bay area. The upland areas are mostly covered with foliage and in places severely eroded. Afforestation has been developed since 1945, but the area covered is still relatively small. The most important function of the uplands is for water catchment areas. To some extent this is now conflicting with the needs of the crowded urban areas for recreational space, and problems of rural conservation in this and other aspects are becoming pressing.

(C) POPULATION

9. The post-war years have brought to Hong Kong a veritable population explosion - from about 600,000 persons in August 1945 to over 4,000,000 at the end of 1971. This latter figure has made Hong Kong one of the most densely populated areas in the world, with an average density of about 9,800 persons per square mile for the whole Colony. The 1971 census revealed that Mongkok, with over 415,280 persons per square mile, was then the most densely populated district. This is about 10 times greater than Tokyo city proper.

SECTION 2 GEOLOGICAL

(A) INTRODUCTION

10. Structurally, Hong Kong is part of the South China Massif and consists of a main peninsula with numerous irregularly shaped islands. It is a partially drowned upland region with a long and deeply indented coastline. Apart from an alluvial plain in the north-western part of the peninsula and close to the China border, which is reserved primarily for agricultural development, and some minor flat areas at the mouths of streams, the land

slopes steeply upwards from the shore-line, reaching peaks ranging in height from 1,500 to 3,130 feet.

11. Distribution of the major rock types is shown in Figure 1. Except for the alluvial plain mentioned above, two acidigneous rocks - an extrusive volcanic rock of a rhyolitic nature and a medium-grained granite - make up the bulk of the land mass. Both types of rocks may be cut by dykes of porphyritic granite, granodiorite porphyry or dolerite, and the boundaries between the two main types show a normal intrusive contact. The main rock formation are deeply weathered and heavily jointed and fissured, the spacing of the joints ranging from around three inches to about five feet and being wider in the granites than in the volcanics. Numerous faults have been discovered and probably many more are present but are masked by the existing soil cover.

12. Geologically, the soils of Hong Kong are either residual or transported: the residual soils can be classified according to the nature of the parent rock from which they have been derived, whereas the transported soils are classified in accordance with the type of transporting agency.

(B) RESIDUAL SOILS

13. The residual soils are produced by the *in situ* decomposition of the underlying rock owing to percolation of water through the rock fissures and into the rock pores, thus breaking down the more unstable rock minerals such as feldspar, biotite and epidote. The chemical breakdown is particularly active in hot humid conditions. It takes place more rapidly beneath a soil cover, as this holds the water and soil acids and thus intensifies attack.

14. In mineral content the granites and volcanics are similar, but in the fresh granite the quartz crystals range in size from about 0.2 to 0.5 millimetres, whereas in the volcanics the size range is from about 0.02 to 0.2 millimetres. Since the size of the rock pores is roughly proportional to the size of the mineral grains, it follows that, even though both rock types have approximately the same volume porosity, the rate of diffusion of water is greater in the coarse-grained, rocks and hence the granites decompose more readily than the volcanics. Observations made indicate depths of decomposition ranging from 20 to 200 feet in the granites, compared with 10 to 50 feet in the volcanics.

15. The nature and variability of the weathered rock have been described by Ruxton and Berry who illustrated the decomposition process diagrammatically as in Figure 2. Decomposition starts in the joints and fissures and works inwards to produce a matrix of decomposed rock around isolated “core-stones” or boulders. In the final stage the rock is completely decomposed, leaving no trace of the original rock structure. For this reason classification of the weathered material into grades becomes necessary for engineering purposes.

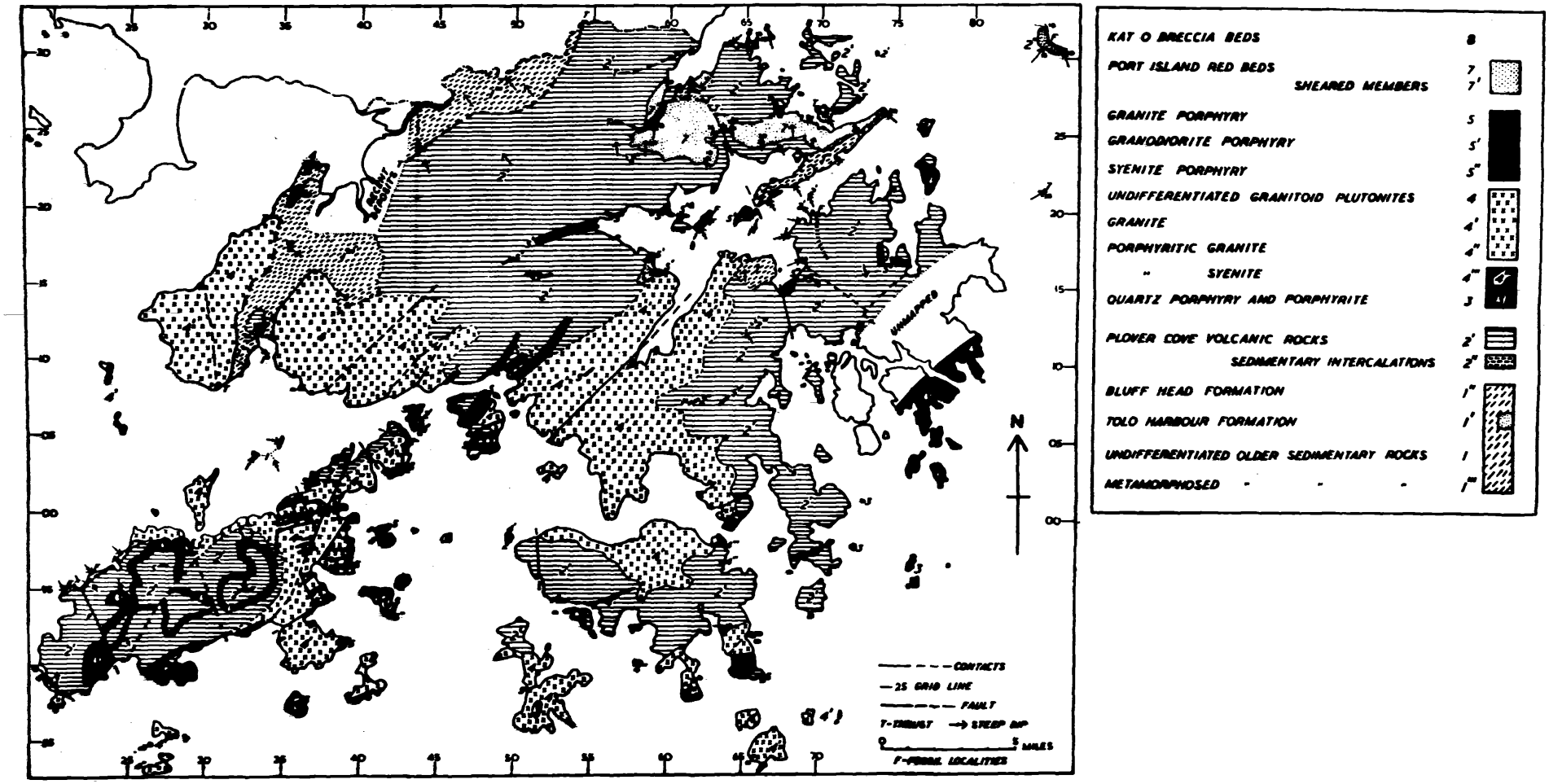
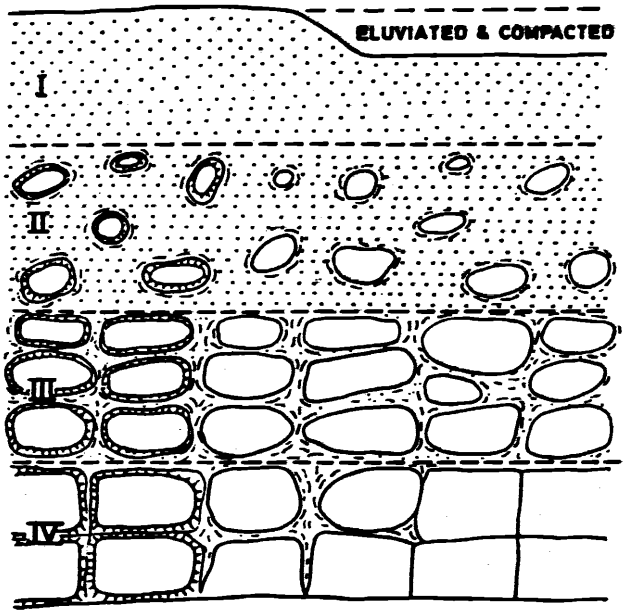


Fig. 1.—GEOLOGICAL MAP OF HONG KONG

(From Ruxton, B. P., 1960 "The Geology of Hong Kong"
Quart. Geol. Soc. London vol. CXV)



ZONES OF A MATURE PROFILE OF WEATHERING ON GRANITE

The iron staining inside the core stones is shown only on the left-hand side.

Figure 2

(From RUXTON, B. P. & BERRY, L. (1957), Weathering of Granite and Associated Erosional Features in Hong Kong, Bulletin of the Geological Society of America, Vol. 68, pp. 1263-1292.)

16. The following broad divisions for granites, after Moye (Reference 1, Appendix IV), form a useful basis for classification: -

(1) *Granitic soil*

This description applies to granite which has been completely decomposed by *in situ* weathering, leaving no trace of the original granitic fabric. The material consists essentially of quartz and kaolin with a clay-content ranging from 20% to 30%. In the aerated zone close to the surface ferric oxide, resulting from the oxidation of minerals containing iron, gives a characteristic red colour to the soil which is known locally as “red earth”.

(2) *Completely weathered granite*

This description covers granite which, although completely decomposed, still possesses recognizable granitic fabric. The original feldspars are completely decomposed and the biotite mica decomposed to varying degrees. When immersed in water the material disintegrates into sandy clay. Generally, it has a brownish colour owing to limonite staining and cannot be sampled by cores using diamond drilling techniques.

(3) *Highly weathered granite*

This material will not disintegrate when immersed in water, and hence can be recovered as cores if care is taken in diamond drilling. But if NX drilling is used the material is often so weak that pieces of the cores can be readily broken and crumbled in the hand. Limonite staining is also present.

(4) *Moderately weathered granite*

This category applies to rock which, although stained reddish-brown and considerably weathered, possesses enough strength so that pieces of NX drill core cannot be broken in the hand.

(5) *Slightly weathered granite*

Distinct evidence of *in situ* weathering occurs throughout the fabric of this category of rock, and slight limonite staining and decomposition of feldspars is evident. But the strength approaches that of fresh granite.

(6) *Fresh granite*

This description applies to the bedrock underlying the weathered zones, and includes that showing a small amount of limonite staining caused by movement of water along the joints.

17. Although the above groupings refer to weathered granite they can also be applied to form broad sub-divisions of the weathered volcanic rocks. In the latter type of rocks, however, the products of weathering are more varied in character than in the granites.

(C) TRANSPORTED SOILS

18. The transported soils are produced from the residual soils either as landslip debris, known as colluvium, or through erosion of the soil surface by rainstorms and streams as alluvium. Other types of transported soil arise from marine deposits, beach sands and man-made fill.

19. Where the slopes are steep the weathered material does not remain *in situ* but migrates downslope. This migration may occur, particle by particle, under the action of wind and rain. But in Hong Kong it is much more evident as a mass movement which is particularly noticeable following periods of heavy rain when large masses break off and slide or roll down the hillsides.

20. The particle size gradings of the colluvium and fill are, of course, the same as those of the residual soils from which they are formed. The main differences between the two groups are that the structure and texture of the residual soils have been destroyed by the sliding and filling processes, and the resulting debris is thoroughly mixed. It is well to remember that undisturbed residual soil can be found underlying colluvium or fill.

21. Additional information on the geology of Hong Kong is given by Mr. D. J. EASTAFF[1] in Appendix V.

(D) SLOPE STABILITY PROBLEMS IN TROPICAL ENVIRONMENTS

22. The heterogeneous nature of rock and soil strata frequently makes realistic analysis of the stability of cut slopes difficult. In these circumstances, analytical design is seldom possible and rarely economically justifiable. The logical alternative is to evolve empirical design methods based on experience gained from systematic collection of slope performance data.

23. In tropical regions there are two additional factors affecting slope stability which are not present to the same extent in temperate climates. These are: -

(1) the rate of softening of weathered rock on exposure to the tropical climate, and
(2) the rate of surface erosion.

Both of these are extremely difficult to predict quantitatively.

24. Erosion and rock softening, which are primarily caused by water, are complementary processes, the former frequently providing the means whereby the latter develops. If the surface of a slope is protected against erosion, softening of the underlying material is greatly retarded. But if the protection against erosion is effected by luxuriant vegetation, requiring a relatively thick soil mantle to support it, the longer retention of rainfall within the soil mantle tends to produce more rapid decomposition of the underlying rock strata. Although some theoretical studies have been carried out relating to the influence of rainstorms on slope stability, which are considered elsewhere in this Chapter (see paragraph 37 *et seq*), the engineer must rely largely on past experience and observation in assessing the rate of softening of any particular slope in a tropical situation.

25. In dealing with cuttings both erosion and softening are important. However, in the case of embankments, the main problem is generally surface erosion, since embankments, if properly constructed, tend to be relatively dense and homogeneous internally and are unlikely to include water-bearing strata.

26. For private building works in Hong Kong it is necessary for all authorized architects[2] to comply with the Building Regulations currently in force at the time when plans are approved for any particular project. The current requirements for cutting and filling are set out, in general, in Circular Letter No. 27, issued by the Buildings Ordinance Office, Public

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(1) Mr. D. J. EASTAFF, B.Sc. (Geol.), M.I.C.E., Chief Geologist of Binnie and Partners, Consulting Engineers for the Public Works Department.

(2) An authorized architect is not necessarily an architect by profession. He can be an engineer, a surveyor or even any person with 15 years practical experience under a practising architect and engineer of 35 years of age or over. The qualifications required are set out in Regulations 3, 4 and 5 of the Building (Administration) Regulations.

Works Department on November 18, 1963 and circulated to authorized architects. The relevant section reads as follows: -

"(7) Site formation. The Hong Kong Society of Architects requested a general statement of requirements for cutting and filling.	(a)	The Building Authority will offer no objections to an angle of slope not greater than 35° for filling and 50° for cutting.
	(b)	Should an angle steeper than the above for cutting or filling be proposed, the authorized architect should confirm in writing to the Building Authority that he has inspected and investigated the nature of the soil and is satisfied that such slope is stable.
	(c)	Adequate protective cover and surface drains should be provided for cutting and filling slopes - chunam and turfing surfaces are generally used for cutting slopes, but for filling slopes, turfing is more suitable.
	(d)	For cuttings exceeding 30 ft. high, provision of berms (minimum 3" wide) with 12" surface channels placed away from edges of berms has been adopted in general practice. 'Herring bone' construction of surface drains should also be considered as an effective means of intercepting the surface water."

27. For the soil and climatic conditions of Hong Kong we consider the above administrative measures to be rational and reasonable and to be in accord with general engineering practice in other countries where soil and climatic conditions of a similar character may be encountered.

28. As a result of a survey of road cuttings carried out in Western Malaysia, Mr. J. N. BULMAN of the Road Research Laboratory, Ministry of Transport, United Kingdom, recommends slope angles of 50-60 degrees for cuttings in coarse-grained weathered igneous rock, and slope angles of 40-45 degrees for fine-grained rock of similar character. (Reference 3, Appendix IV). He defines weathered rock as coarse-grained when 40% or more of its particles are retained on the B.S. 25 sieve, (0.6 millimetre aperture), and fine-grained when less than 40% are retained on this sieve. Based on the investigation of Hong Kong soils carried out by Mr. P. LUMB[3], coarse-grained sub-division corresponds broadly with decomposed granite and fine-grained rock with decomposed volcanics.

29. In considering the risk of landslips in the area the Joint Engineers for the Plover Cove Water Supply Scheme (see Reference 3, Appendix IV) had this to say: -

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(3) Mr. P. LUMB, M.Sc. (Eng.), F.I.C.E., F.G.S., Reader in Civil Engineering, University of Hong Kong.

> "Another common location for slips is the outside of river bends where undercutting is active. It is believed that slips occurring at the latter location are more numerous in the volcanic than the granite areas, presumably because the residual soil of the former has a higher fines content and thus generally a lower shear strength than the latter. In Lead Mine Pass one such slip had occurred on a slope of 26° but usually the slopes on which slips occur are steeper, averaging 30°. In the case of granite, such slopes are generally 5° steeper than for volcanics. If any engineering structures are sited at the foot of steeper slopes than those quoted above, protective measures should be considered. Slopes exposed in reservoirs have been measured and indicate that, for the weathered granite within Jubilee Reservoir and Kowloon Reservoir, 30° slopes and flatter are stable. It is understood that this figure is in accord with the experience of the Snowy Mountains Authority, Australia, in the operation of Guthega Reservoir."

SECTION 3 SEISMOLOGICAL

30. We have considered earthquake risk as a possible cause of landslips in Hong Kong. Evidence submitted to us showed that from September 1921 to December 1969, 69 earthquakes are known to have been felt by residents in Hong Kong. On average, about one earthquake was felt each year between 1921 and 1940 and about three earthquakes were felt annually in the more recent period from 1951 to 1969. Most of the shocks felt were shallow and emanated from the Ho Yuen area of Kwantung, centred about 100 miles north-northeast of Hong Kong. Others came from epicentres in the bed of the China Sea to the south and south-east of Swatow and to the south of the Pratas Shoal. Many originated from the Circum-Pacific Seismic Belt, and a few had epicentres as far north as in the Yangtse Valley.

31. The most severe earthquake shock experienced in Hong Kong occurred on February 13, 1918, and the strongest shock so far recorded since seismographs have been in operation here was of intensity 5 on the Modified Mercalli Scale. It occurred on March, 18th 1962 and caused displacement of small objects, rattling of windows and doors and loosening of plaster.

SECTION 4 METEOROLOGICAL

32. A comprehensive picture of the general rainfall characteristics of Hong Kong together with other relevant meteorological and seismological information was presented to us by Mr. G. J. BELL, Director of the Royal Observatory, Hong Kong. Mr. BELL's general evidence was submitted in the form of four publications (see References 4-6, Appendix IV) prepared by the Royal Observatory. One of these, describing the existing Thunderstorm and Heavy Rain Warning Service, very pertinent to this Inquiry, is reproduced in Appendix VI.

33. Estimates of extreme depth and extreme intensity of rainfall in Hong Kong corresponding to various return periods are shown in Table 1. We appreciate the limitations under which estimates contained in that Table have been made, and we consider the estimates to be as accurate as available data and meteorological knowledge permit.

34. Evidence submitted by Mr. BELL relating to the Royal Observatory rainfall records for the first half of 1972 are considered in the following Section.

SECTION 5 RAINFALL

35. The evidence submitted to us leaves no room for doubt that the heavy rainfall which occurred in May and June 1972 played the dominant role in causing the landslips which resulted in such tragic loss of life and property. One of the tasks facing us has been that of determining whether the rainfall which culminated in the June landslips could have been anticipated with reasonable foreseeability. In examining this aspect of our work we relied principally on the testimony of Mr. G. J. BELL.

36. In evidence, Mr. BELL stated that for each of the periods January-June; April-June; and May-June, 1972 was the second wettest year on record at the Royal Observatory. For the periods in question the rainfall was exceeded only in 1889 during the 82 years of rainfall records available. In a more detailed comparison of the rainfall of 1972 with that of other years, Mr. BELL produced the following records: -

January to June	1.	1889	1899.0 mm	
6 months	2.	*1972*	1658.6 mm	
	3.	1966	1656.8 mm	
April, May, June	1.	1889	1799.0 mm	
3 months	2.	*1972*	1588.3 mm	
	3.	1966	1440.3 mm	
May and June	1.	1889	1487.3 mm	
2 months	2.	*1972*	1453.5 mm	
	3.	1957	1356.5 mm	
June	1.	1966	962.9 mm	
1 month	2.	1959	913.7 mm	
	3.	1892	873.1 mm	
	4.	1916	817.4 mm	
	5.	*1972*	799.0 mm	up to 12 noon on June 27, 1972

TABLE 1(A) EXTREME DEPTH OF RAINFALL CORRESPONDING TO VARIOUS RETURN PERIODS

Time Interval	PARAMETERS		RETURN PERIOD (YEARS)											
	μ	1/α	2	5	10	20	50	100	200	500	1000	2000	5000	10000
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
31 Days	597.8040	155.4216	654.8	830.9	947.6	1059.4	1204.2	1312.8	1420.9	1563.5	1671.3	1779.1	1921.5	2029.3
15 "	417.9600	143.3160	470.5	632.9	740.5	843.6	977.2	1077.2	1176.9	1308.5	1407.9	1507.3	1638.6	1737.9
7 "	305.7600	127.4448	352.5	496.9	592.6	684.3	803.0	892.0	980.7	1097.7	1186.1	1274.4	1391.2	1479.6
5 "	274.9200	120.0000	318.9	454.9	545.0	631.3	743.1	826.9	910.4	1020.6	1103.8	1187.0	1297.0	1380.2
4 "	258.4320	115.3920	300.7	431.5	518.1	601.2	708.7	789.3	869.5	975.4	1055.5	1135.5	1241.2	1321.2
3 "	238.3920	109.0080	278.3	401.9	483.7	562.2	663.7	739.9	815.7	915.7	991.3	1066.9	1166.8	1242.4
2 "	211.9680	99.1200	248.3	360.6	435.0	506.4	598.7	667.9	736.9	827.9	896.6	965.3	1056.2	1124.9
24 Hours	173.8560	85.1520	205.1	301.6	365.5	426.8	506.1	565.6	624.8	703.0	762.0	821.1	899.1	958.1
18 "	158.5800	76.7880	186.7	273.8	331.4	386.7	458.2	511.8	565.2	635.7	689.0	742.2	812.6	865.8
12 "	137.7600	65.1960	161.7	235.5	284.5	331.4	392.1	437.7	483.0	542.9	588.1	633.3	693.0	738.2
8 "	121.1200	56.6320	141.9	206.1	248.6	289.3	342.1	381.6	421.0	473.0	512.3	551.6	603.5	642.7
6 "	109.2000	49.9080	127.5	184.1	221.5	257.4	303.9	338.8	373.5	419.3	453.9	488.5	534.3	568.9
4 "	93.7600	40.4800	108.6	154.5	184.9	214.0	251.7	280.0	308.1	345.3	373.4	401.4	438.5	466.6
2 "	72.6200	26.9800	82.5	113.1	133.3	152.8	177.9	196.7	215.5	240.3	259.0	277.7	302.4	321.1

1(B) EXTREME INTENSITY OF RAINFALL CORRESPONDING TO VARIOUS RETURN PERIODS

Time Interval	PARAMETERS		RETURN PERIOD (YEARS)											
	μ	1/α	2	5	10	20	50	100	200	500	1000	2000	5000	10000
	(mm hr^{-1})	(mm hr^{-1})	(mm hr^{-1})	(mm hr^{-1})	(mm hr^{-1})	(mm hr^{-1})	(mm hr^{-1})	(mm hr^{-1})	(mm hr^{-1})	(mm hr^{-1})	(mm hr^{-1})	(mm hr^{-1})	(mm hr^{-1})	(mm hr^{-1})
60 minutes	54.9500	16.2200	60.9	79.3	91.5	103.1	118.2	129.6	140.8	155.7	167.0	178.2	193.1	204.3
30 "	77.6200	19.5000	84.8	106.9	121.5	135.5	153.7	167.3	180.9	198.8	212.3	225.8	243.7	257.2
15 "	96.6100	23.4400	105.2	131.8	149.4	166.2	188.1	204.4	220.7	242.3	258.5	274.8	296.3	312.5
10 "	107.1996	25.4100	116.5	145.3	164.4	182.7	206.3	224.1	241.8	265.1	282.7	300.3	323.6	341.2
5 "	123.0000	29.8500	133.9	167.8	190.2	211.7	239.5	260.3	281.1	308.5	329.2	349.9	377.2	397.9
2 "	147.9000	36.3090	161.2	202.4	229.6	255.7	289.6	314.9	340.2	373.5	398.7	423.9	457.1	482.3
60 Seconds	167.8980	41.6880	183.2	230.4	261.7	291.7	330.6	359.7	388.7	426.9	455.8	484.8	523.0	551.9
30 "	190.5000	47.8560	208.0	262.3	298.2	332.6	377.2	410.6	443.9	487.9	521.1	554.2	598.1	631.3
15 "	213.8160	54.9600	234.0	296.3	337.5	377.1	428.3	466.6	504.9	555.3	593.4	631.6	681.9	720.0

May	1.	1889	1240.5 mm		
1 month	2.	1957	894.2 mm		
	3.	1921	858.1 mm		
	4.	1891	711.1 mm		
	5.	1902	678.9 mm		
	6.	*1972*	654.5 mm		
15 days	1.	1889	1238.4 mm	May 19 -	June 2
	2.	1959	858.1 mm	June 1 -	15
	3.	1966	840.9 mm	June 4 -	18
	4.	*1972*	793.1 mm	May 19 -	June 2
7 days	1.	1889	924.6 mm	May 25 -	31
	2.	1959	753.8 mm	June 9 -	15
	3.	*1972*	702.9 mm	June 12 -	18
5 days	1.	1889	908.9 mm	May 26 -	30
	2.	1959	753.4 mm	June 11 -	15
	3.	1926	682.6 mm	July 18 -	22
	4.	*1972*	678.2 mm	June 14 -	18
4 days	1.	1889	870.6 mm	May 27 -	30
	2.	1959	724.6 mm	June 12 -	15
	3.	*1972*	677.2 mm	June 15 -	18
3 days[4]	1.	1889	854.9 mm	May 28 -	30
	2.	*1972*	652.3 mm	June 16 -	18
2 days	1.	1899	841.2 mm	May 29 -	30
	2.	1926	561.2 mm	July 19 -	20
	3.	1966	460.4 mm	June 11 -	12
	4.	1959	452.0 mm	June 14 -	15
	5.	*1972*	446.4 mm	June 17 -	18

For periods less than 1 day and more than 2 hours the rainfall in the June 1972 storm does not rank in the top five. The record amounts and the 1972 amounts follow: -

1 day	1.	1926	534.0 mm	July 19
	-	*1972*	232.6 mm	June 18
24 hour	1.	1889	697.1 mm	May 30
	-	*1972*	275.1 mm	June

(4) The first occasion in 82 years when each of three consecutive days received more than 200 mm occurred on June 16, 17, 18, 1972.

12 hour	1.	1926	526.7 mm	July 19
	-	*1972*	219.8 mm	June
8 hour	1.	1926	505.1 mm	July 19
	-	*1972*	199.0 mm	June
6 hour	1.	1926	430.6 mm	July 19
	-	*1972*	193.8 mm	June
4 hour	1.	1889	302.3 mm	May 30
	-	*1972*	185.1 mm	June
2 hour	1.	1926	174.4 mm	July 19
	2.	1889	167.7 mm	May 30
	3.	1966	165.9 mm	June 12
	4.	*1972*	161.6 mm	June 18
1 hour	1.	1966	108.2 mm	June 12
	2.	1926	100.7 mm	July 19
	3.	1968	100.0 mm	June 13
	4.	*1972*	98.7 mm	June 18

37. The influence of rainstorms on slope stability is governed by the infiltration capacity of the soil forming the slope; the intensity/duration curve of continuous rainfall during the storm; and the amount of rainfall that has occurred prior to the storm.

38. Based on his study of the "Effect of Rain Storms on Slope Stability" in Hong Kong (see Reference 7, Appendix IV) Mr. P. LUMB has made the following observations: -

"(1) When landslides do occur they are generally limited to the upper zones of the slope and rarely extend to a depth greater than 10 to 20 feet below the surface.

"(2) Only in exceptionally heavy rainstorms of the order of 15 to 20 ins. per day will any significant effect be produced in decomposed granite, whilst in decomposed volcanics significant effects will be produced every year. Although much further testing is required to determine the range in values of the various parameters it may be tentatively stated that no appreciable wetting can occur in thick decomposed granite mantles, but that in decomposed volcanics the depth of wetting is quite likely to reach 10 to 15 ft. but is very unlikely ever to exceed 20 ft.

"(3) The effect of rainfall on the stability of slopes in thick mantles of residual soil will only be appreciable when the intensity of rainfall is of the same order of magnitude as the permeability of the soil, and moreover the duration of the rainfall must be sufficiently long for the wetting front to reach a significant cepth.

These two conditions are normally satisfied for the decomposed

volcanic soils but not for the decomposed granite soils. Consequently, the stability of slopes in decomposed granite is unaffected except for extremely intense rainstorms, while slopes in decomposed volcanics will be affected every year."

39. Rainstorms are usually rated according to the average interval between their occurrence, the more severe storms having a longer recurrence interval or "return period". Estimates of return periods for various rates of rainfall are shown in Table 1. From this Table it will be seen that the maximum rates achieved in June 1972 over periods of seven to three days would, on average, be equalled or exceeded once in an interval of from 20 to 50 years. Taken individually, the rainfalls of May and June 1972, when averaged over a 31-day period, would be equalled or exceeded, on average, in two to five years and the 15-day and two-day rainfalls have recurrence periods of between 10 and 20 years. The one hour rate of 98.7 millimetres would be equalled or exceeded once in about 20 years. These estimates make no predictions as to how late in the specified period the recurrence is likely to take place.

40. The evidence placed before us, notably the reports prepared by Mr. A. J. VAIL[5] (see Appendix V) and Dr. C. L. SO[6] (see Reference 8, Appendix IV) support, in general, the observations and views of Mr. LUMB, referred to above. Mr. VAIL has stated that "Landslides of varying severity have always been a feature of life in Hong Kong and there is ample evidence of this to be seen from the air". In his report he recommends that studies should be made of inhabited areas in which landslips are likely to occur, with regular inspection of such areas and patrols on a 24-hour basis during periods of prolonged or intense rainfall.

41. In dealing with the geotechnical problems of Hong Kong Mr. VAIL had this to say: -

"The decomposition of the rock, which occurs at the surface and along joint planes, produces silty and clayey material containing many boulders at an earlier stage of decomposition and, near the peaks of the hills, these tend to creep down the face of the parent rock as colluvium (slopewash) to take up more stable slopes in or near the sea.

"The slope of the hillsides formed by the in situ decomposition of the bedrock and the overlying colluvium from the peaks can be as steep as 36° from the exposed fresh rock of the peaks to a level of approximately 500 ft. P.D. and at this level there is a well defined change of slope to about 18°.

"The process of decomposition of the igneous rocks is continuing through geological time as is the migration of the colluvium down the hill slopes towards the sea. By the very nature of the process, colluvium is

(5) Mr. A. J. VAIL, B.Sc., F.I.C.E., F.I.W.E., F.I.E. (M) of Binnie and Partners, Consulting Engineers for the Public Works Department.

(6) Dr. C. L. SO, M.A., B.Sc., Ph.D., Lecturer in Geography, University of Hong Kong.

> potentially unstable and it follows that any disturbance of the slope or any unusually severe conditions will accelerate the process of migration. Evidence of this in the form of slips in the hillsides has been apparent since the Colony was first inhabited."

42. Taking heavy rainfall as an "unusually severe condition", Mr. BELL's evidence, which is readily available to the public in published form, clearly shows the regular frequencies at which such unusually severe conditions are likely to recur in Hong Kong.

SECTION 6 LAND POLICY AND BUILDING DEVELOPMENT

43. Rapid and concentrated urbanization, to meet the needs of an exploding population, are brought into sharper focus in the Colony than in other metropolitan centres, largely as a result of the scarcity of flat land, the high cost of site-forming and the comparative lack of development of new towns. Public utilities have to be made available before any land can be developed, but provision of such primary elements over much of the land area suitable for development has not been within the Colony's capabilities until recently.

44. All the land belongs to the Crown, and, provided there is a continual demand, the sale of land forms a flexible source of revenue. The basic policy of Government is to sell leases at as high a price as the market will bear. This policy provides the guidelines for calculating the premiums to be paid on modifications of existing leases.

45. The great shortage of flat land for building; the rapidly rising demand for living and working space and the growing affluence of the population have had their inevitable influence on the low-lying central urban areas. Spiralling land values gave rise to irresistible pressure for more intensive redevelopment of these areas, where building high became the order of the day. Land suitable for development into high-rise commercial and apartment blocks was made available for such purposes by modifying and/or removing restrictive convenants in existing Crown leases.

46. With displacement of the residential population from many of the central areas to meet the growing needs of commerce, readily accessible locations and, in particular, choice residential areas became the obvious targets for developers. These were to be found at the Mid-levels, wherein were located many of the stately homes of Hong Kong - homes which had lost some of their obvious advantages as a result of high-rise development obliterating their harbour views.

47. Plate 1 shows the type of development in the western part of the Mid-levels prior to 1962, although the photograph was taken considerably later. The character of the neighbourhood had not begun to change. The houses were generally spacious in character and of two or three storeys, with a height not exceeding 35 feet. The height, "design and disposition" of all building developments had to be subject to the "special approval" of the Director of Public Works.

48. The general principle involved in the site formation for these mid-level projects was to cut away as little of the hillside as possible and to have several levels of

cutting to minimize the risk of creating instability of the slope. A series of terraces and retaining walls were often the result.

49. The intensity of redevelopment of the Mid-levels and Pokfulam (1.93 square miles) compared with that of the Peak (3.37 square miles) by the end of the 1950's is reflected in the 1961 census population figures of 43,260 and 5,160 for these respective areas. It is interesting to note that the corresponding figures for the 1971 census were 46,300 and 8,240 respectively.

50. The relatively high density development of the Mid-levels, stemming from the demand for luxury flats, was made possible by the granting of modifications of lease conditions, although almost half the lots in the Mid-levels were without restrictions.

51. The lease modifications included a standard covenant on off-street parking. Besides, there could be only one site entry, and a proper entrance driveway had to be designed. In order to comply with this covenant, developers tended to remove as much of the hillside as possible, and to leave slopes of appreciable height behind the sites. Not, in every case, was proper attention given to the stability of these slopes. Landslips of one size or another were a regular occurrence, particularly where site formation work was being undertaken during the wet season. As a result of this cutting and formation work, almost adjoining one another, some reduction of the hillside stability must have resulted.

52. In the last few years further redevelopment of many sites on the Mid-levels has been taking place. The total revenue from the sale of land in 1971 for the Colony was over HK$214 million; premiums from lease modifications in the same year amounted to only HK$18 million, which is a relatively insignificant sum, particularly in view of the high cost of improving public services to meet development requirements. However, it is an established fact that much of the soil cut from the hillsides is used for land reclamation purposes at sea-level and this reclaimed land becomes available subsequently for sale or for public use.

SECTION 7 LEGAL

53. It is not without significance that of the landslips reported to have arisen from both the 1972 and the 1966 heavy rains, the vast majority occurred in the immediate vicinity of man-made excavations, cuttings and embankments, and were inextricably linked with these operations. To the extent that private development is concerned, Section 37(1) of the Buildings Ordinance provides: -

> "No liability shall rest upon Government or upon any public officer by reason of the fact that any building works are carried out in accordance with the provisions of this Ordinance or that such building works or the plans thereof or materials therefor are subject to inspection or approval by a public officer, nor shall anything in this Ordinance make it obligatory for the Building Authority to inspect any building, building works or materials or the site of any proposed building to ascertain that the provisions of this Ordinance are complied with or that plans, certificates and notices submitted to him are accurate."

It would therefore appear, and in our view it is right and proper, that the authorized architect

and the registered contractor[7] are completely responsible for the proper execution of building works carried out within the Buildings Ordinance. In our opinion such responsibility should be based on what is generally accepted as sound engineering and building practice for the type of operation involved when carried out in the circumstances of Hong Kong and its climate.

54. In the execution of such operations developers, whether they represent the government or private parties, carry at least a moral responsibility to protect the lives and property of all those who may be affected by their operations. Where construction operations which might contribute towards the occurrence of landslips are carried out by the government, its agencies or agents the Buildings Ordinance may not apply by reason of Section 41(1*a*) therein. We hold the view, however, that the degree of culpability which we feel should be carried by the private sector for operations of this nature should be equally carried by the public sector (i.e. government, its agencies and agents), where building works of a similar character are carried out.

55. Where, in the opinion of the Building Authority, building works such as cutting and excavation for the purpose of site formation are carried out in contravention of the Buildings Ordinance, or where such works cause or will be likely to cause the collapse of any adjoining or other building, or will render, or will be likely to render, any such building so dangerous that it will collapse, or be likely to collapse, either totally or partially, then the Building Authority may, under Section 23 of the Buildings Ordinance, require that such works cease. But where such building works are carried out not in contravention of this Ordinance or if such works are not likely to cause the collapse of another building or render any such other building dangerous, then the Building Authority does not have any power to intervene. There is obviously a deficiency in the existing Ordinance. We are happy to note that an amendment to the Ordinance, first prepared in January this year, is now being examined in the Legislative Council. The purpose of the proposed amendment is to empower the Building Authority to order a person responsible for the carrying out of building works which are dangerous or potentially dangerous to remedy the situation. If such an order is not complied with the Building Authority is then empowered to cause the necessary work to be carried out and to recover the cost of such work. The power of the Building Authority is therefore enlarged to cover building works which do not contravene the provisions of the Ordinance. The Building Authority may also intervene where no buildings are likely to be endangered by the building works. We consider that this amendment would go a long way towards remedying the present deficiency in the law.

(7) Registered contractors need not be technically qualified, and a statement of particulars countersigned by an authorized architect is adequate for the purpose of registration. The registered contractor keeps all the plans of a construction site, and ensures that the provisions of the Buildings Ordinance are complied with.

CHAPTER III

THE DISASTER AT PO SHAN ROAD

SECTION 1 HISTORY

56. The Mid-levels of Hong Kong Island have been susceptible to earth movement since the area was first extensively developed.

57. On July 18, 1925 a landslip occurred at Po Hing Fong - less than half a mile from the recent Po Shan Road disaster site - destroying houses and causing many deaths.

58. In 1941, and again in 1950, slips occurred along large sections of Bonham Road between Nethersole Hospital and what was then Northcote Training College (9A, Bonham Road).

59. Then, in April 1959, a major landslip occurred at the rear of 92-96, Robinson Road, leading to the temporary closure of several buildings.

60. As a result of the disastrous rainstorms in June 1966, several landslips occurred in the Mid-levels. The two most serious were the landslip from the University of Hong Kong into Lyttelton Road, and that at 41, Conduit Road (I.L. 2479).

SECTION 2 THE REDEVELOPMENT OF INLAND LOT 2260

61. The Linton Investment Co., Ltd., with Mr. Linton CHU as Managing Director, acquired the lease of Inland Lot 2260 (here-inafter referred to as I.L. 2260), 51C and 51D, Conduit Road, on October 1, 1962. It was a property of 30,650 square feet, and consisted of a pair of old-style semi-detached “mansions”. Plate 2 is a photograph of the property in 1961.

62. Mr. NG Chun-man was appointed authorized architect in July 1962, before the completion of the transfer of the lease to Linton Investment Co., Ltd. The demolition of the buildings had been completed by November 21, 1962.

63. The first redevelopment plans, prepared by Mr. NG, were approved by the Buildings Ordinance Office, Public Works Department on October 27, 1962. These plans called for the removal of the existing terraces and general lowering of the site by stepped excavation into the hillside from the level of Conduit Road. The sloping faces of the excavation were, according to the plans, at 50° with the horizontal, with terraces or berms at about 25 feet vertical intervals or less. Horizontal surface-drainage channels were incorporated at each berm and along the front and rear edges of each terrace. The site formation work was on record carried out by Foo Wing Building Construction Company and satisfactorily completed on August 6, 1963. These facts have not been seriously contested other than by Mr. S. L. HO.

64. Mr. Dexter MAN became the Managing Director of Linton Investment Co., Ltd.

on March 16, 1971, and on November 29, 1963 Mr. S. L. HO was appointed authorized architect for the proposed development works vice Mr. NG Chun-man.

65. Plate 3, which is a photograph of the vicinity of I.L. 2260 taken on May 24, 1970, shows the extent of the cutting of the slope behind I.L. 2260. Berms can be seen extending across the inclined surface which was covered with the remains of chunam plastering. It was a slope which apparently had to be bolstered by a small retaining wall or stone-pitching. The slopes did not show any obvious signs of instability, but did appear to be rather steep in places.

66. The standard practice as stated in a rule-of-thumb requirement in a Circular Letter No. 27 from the Buildings Ordinance Office (see Paragraph 26) is sound and conservative. The site formation work of I.L. 2260 was done in accordance with standard practice in Hong Kong.

67. A modification of the lease terms for I.L. 2260 was granted on November 13, 1962. The terms permitted development to nine storeys with 30% site coverage for private residential purposes. The height of the building was not to exceed +595.00 feet P.D. (i.e. Colony Principal Datum). There was to be one carpark per flat . The premium requested was $616,000, but was later reduced to $210,000. The lease modification was, however, not taken up.

68. Following a number of applications a lease modification was granted to Linton Investment Co., Ltd. in December 1970, permitting a maximum development of 12 storeys over carparks on a site coverage of 27½%. The premium was then $367,800.

69. Building plans for this project, submitted by Mr. S. L. HO, were approved on December 4, 1970, and revised site formation plans were approved on January 5, 1971. The consent to commence work was given on February 9, 1971. The Deed of Variation was registered on March 22, 1971.

70. As a result of modifying the lease terms the developer was given an increase of 36 flats - all of which were to have carparks - while the height of the development was still not to exceed the P.D. level of +595.00. In the circumstances, the developer and his authorized architect decided to cut into the site to obtain additional ground floor space for carparks.

71. The revised site formation plans showed an “existing 80½° rock-cutting slope below Po Shan Road”. They also showed a similar cutting, 30 to 40 feet high, which was proposed to be constructed below the “existing” slope in connection with a general reduction in level of the site.

72. The evidence of the Public Works Department was that Mr. S. L. HO’S statement of “existing 80½° of rock” was accepted and the plans were “dealt with on a temporary loose-minute file, the original files being in action elsewhere and which remained untraced until recently”.

73. Evidence submitted to us by Mr. S. L. HO indicated that from the time of his appointment in November 1963 up to May 1971 no work had been done except boring tests

on the site by Zenith Engineering Co., Ltd. in July 1970. However, he did admit under cross-examination that some minor repair work - "trimming" - had been undertaken on the slope following the heavy rains in 1966 by casual workers engaged by the owners, Linton Investment Co., Ltd. Throughout his evidence Mr. HO maintained that the "existing" slope was partially rock, at worst rock and earth, and argued that the 80½° angle of slope was a result of erosion. This was refuted by Mr. VAIL's expert evidence, which we accept.

74. Site formation work commenced on I.L. 2260 in early May 1971 by Tai Shun Construction Company who had been engaged by the owners for this purpose. The contractors ceased work on May 21, 1971, having written to the owners on that same date saying,

> "We are considering that is dangerous to work on this cutting slope, at 80 degrees, of decomposed rocks at it may cause damages (*sic*) to the road above the site. Under the circumstances, we are compelled to slow down the work."

The contractors had virtually withdrawn from the site by June 1, 1971.

75. The residents in the Po Shan Road area were, in fact, becoming more and more apprehensive of the continual encroachment into the hillside at the southern end of I.L. 2260. There were a number of minor slips in that slope during the first seven or eight months in 1971, and mud was washed from the site on to Conduit Road during periods of heavy rain.

76. On August 18, 1971 officers of the Buildings Ordinance Office noticed a rather extensive slip in the cutting at the southern end of I.L. 2260 during a general inspection after Typhoon *Rose*. It was then discovered that the cutting was not of rock composition, and the Buildings Ordinance Office was very concerned about this matter. As a result of the slip, the chunam which had been applied to the surface of the cutting a few months previously fell off *en masse*. Chunam was soon applied to the cutting again, but it also fell off in the following month. Construction work at the site then appeared to be suspended for about five to six months.

77. Meanwhile, in a letter to the Building Authority dated August 27, 1971 Mr. S. L. HO maintained that the slope shown on drawings which he submitted to the Buildings Ordinance Office represented the situation when he first took over as authorized architect. Mr. HO'S statement was accepted by the Buildings Ordinance Office since the original file showing the drawings of Mr. NG Chun-man, the former architect, was not available.

78. Mr. S. L. HO then proposed temporary remedial measures such as cementing the slope and drainage channels, and he also proposed to submit plans for a retaining wall. The pressure from the Buildings Ordinance Office and even from the tenants and owners of nearby property was building up.

79. On November 15, 1971 the Building Authority wrote to Mr. HO asking him about the progress of work on the site. The letter, although dated November 15, 1971 was marked "Forwarded 17th November" - a delay of two days.

80. Meanwhile on November 16, 1971 Mr. HO withdrew from the project, and Mr. D. C. SHUM was appointed authorized architect in his place.

81. On November 20, 1971, four days after his appointment, Mr SHUM submitted new site formation plans, and asked for their early approval as "the present slope at the moment is in a very critical condition".

82. Events then occurred in rapid succession: -

(1) On November 25, 1971 the Buildings Ordinance Office held a site inspection and a meeting.

(2) On November 27, 1971 the Highways Office expressed concern about the situation at I.L. 2260.

(3) On November 29, 1971 Mr. SHUM's proposals were discussed. The Director of Public Works received an anonymous letter forecasting disaster at I.L. 2260.

(4) On December 2, 1971 Mr. SHUM amended his plans following a site meeting with officers of the Buildings Ordinance Office.

(5) On December 16, 1971 there was another anonymous letter to the Director of Public Works with dire predictions.

(6) The Buildings Ordinance Office noticed that on February 21, 1972 there was still no progress at I.L. 2260.

(7) On February 24, 1972 a programme of work was agreed. Amended plans were prepared and these were approved on March 21, 1972.

83. In September 1971 "haircracks" appeared in Po Shan Road opposite No. 21. There was also earth movement in the vicinity of No. 21.

84. In November 1971, the face of the excavation in I.L. 2260 appeared wet and water was seen emerging at formation level.

85. In December 1971, Mr. LI Fook-shu, the owner and occupier of 21, Po Shan Road, noticed that because of the excavation at I.L. 2260 that part of the slope beneath his garage had become steeper. There were now a few cracks on the wall of his garage. Mr. LI's engineering advisers wrote to the authorized architects of the construction site in January 1972 about the matter, but received no reply. In that same month officers from the Public Works Department inspected Mr. LI's premises, and found that the earth under his garden terrace was settling and that there were defective pipes choking the drainage. Repairs to the pipes were subsequently made to the satisfaction of the Public Works Department. There was also "clear evidence" of movement in the slope between the premises and Skyline Mansion (51A and 51B, Conduit Road).

86. Plate 4 is an aerial view of the Mid-levels in March 1972. In that month, the driving of steel sheet piles commenced at I.L. 2260. There was also excavation for the removal of obstructions. By the end of March some 75% of the steel sheet piles had been driven along the eastern half of the base of the slope at the southern face of the site (see Plates

5 and 6).

87. In April 1972 trench excavation for a retaining wall construction began, and by the end of that month a roof made of metal sheeting supported by a bamboo framework had been erected over the whole of the slope. Steel sheet piling and excavation at the site continued throughout May and the first half of June 1972.

88. From April 1972 up to the occurrence of the disaster there were several landslips at another construction site at 8, Po Shan Road, some of which blocked Po Shan Road temporarily. A major slip occurred at that location on May 10, 1972.

89. In April or May 1972, earth was washed down by rain from Po Shan Road into the western end of I.L. 2260.

90. About three weeks before the disaster cracks appeared in Po Shan Road.

91. A few days prior to the disaster heavy rain brought mud and debris on to Conduit Road, particularly that part of the road surface outside I.L. 2260.

92. Figure 3 shows approximate cross sections through the middle of I.L. 2260 to illustrate the extent of the cuttings at various stages of redevelopment and formation of this site.

SECTION 3 EVENTS ON JUNE 16, 1972

93. The heavy rains which commenced on June 15, 1972 continued on June 16. A landslip occurred at about 8.40 a.m. at the construction site at 8, Po Shan Road, and the road was completely blocked by mud, debris and collapsed scaffolding. The affected section of the road was cordoned off while the obstruction was being cleared. Danger signs were put up by the Police, and police officers were posted to warn motorists and pedestrians of the danger.

94. At about 9 a.m. on that day it was still raining heavily, and a large quantity of earth slid from the hill above Po Shan Road, so much so that about four feet of mud was accumulated on the road outside Po Shan Mansions (10-16, Po Shan Road). There was, however, no slip yet at I.L. 2260.

95. At about 10 a.m. a minor slip occurred on the hillside east of Po Shan Mansions and some earth fell on to Po Shan Road.

96. Meanwhile cracks had developed in the middle of the roadway between 8, Po Shan Road and the garage of 21, Po Shan Road. The Public Works Department was unable to seal these cracks.

97. I.L. 2260 was inspected by members of the Public Works Department in the evening and it was found that the blinding layer to the retaining wall foundation had been laid, and no movement of the steel piling was noticed.

SECTION 4 EVENTS ON JUNE 17, 1972

98. It rained heavily on June 17, 1972. I.L. 2260 was again inspected at 8.30 a.m. and it was found that there was no work on the site because of the rain, and that the steel sheet piling was still in order.

99. At about 10 a.m., however, an emergency call was received by the Buildings Ordinance Office that a slip had occurred. At 10.30 a.m. officers of that Office inspected the area in question and found that a slip had occurred over the whole width of the cut slope at the southern face of I.L. 2260, carrying away nearly all the bamboo framing and metal sheet covering. The steel sheet piling tilted northwards and distorted sideways. Half the width of Po Shan Road and the garage and adjoining garden terrace of 21, Po Shan Road had settled some six feet.

100. The residents of 21, Po Shan Road were advised by officers of the Public Works Department to leave the house, which they did, and the section of Po Shan Road above the slip area was cordoned off. Meanwhile, a slip from the south side of Po Shan Road above I.L. 2260 had also occurred and was seen to enlarge.

101. At about 12.45 p.m. officers of the Highways Office noticed signs of break-up in the pitched slope along the access road to Mirror Marina (47, Conduit Road) behind Skyline Mansion (51A & 51B, Conduit Road).

102. At 2 p.m. the Director of Public Works visited the Po Shan Road area with several senior officers of his Department. They noticed that the garage and garden terrace of 21, Po Shan Road appeared to be settling further, and these structures together with the adjoining half-width of Po Shan Road were some 10 to 15 feet below normal level. A minor landslip had occurred on the south side of Po Shan Road to the west of the garage. There were signs of disintegration and damage in the slope below 21, Po Shan Road. Slight cracks occurred in the access road behind Skyline Mansion, and by about midday this access road had been almost completely blocked by earth and rubble fallen from the slope above. There was evidence of movement in the pitched slope along the access road. Nevertheless, the retaining wall behind Skyline Mansion was still intact at the lower level.

103. At that stage it seemed likely that further slipping of the slope below the house of 21, Po Shan Road would occur. On the instruction of the Public Works Department the Police warned the ground floor tenants of the rear block of Skyline Mansion to keep away from rear walls and windows and to prepare for evacuation at short notice. The Highways Office then arranged to build a sandbag wall at the rear of Skyline Mansion to absorb the shock of the expected slip from below 21, Po Shan Road.

104. Meanwhile, in the afternoon there were several small falls of earth at I.L. 2260, and the steel piling there had buckled severely. The piling continued to deflect and distort. By that time the metal sheet covering erected over the slope on the southern end of the site had been largely dislodged. At this stage, all the signs pointed to a possible landslip of a limited nature below 21, Po Shan Road, which might just reach Skyline Mansion and cause further subsidence of the garage and garden terrace.

105. Although there was no water visible on the slip face at I.L. 2260, a

considerable amount of water appeared to seep through the southeast corner of the site and the retaining wall behind Skyline Mansion. In particular, a large quantity of storm-water flowed down from the hillside above Po Shan Road along culverts, one of which ran diagonally below the house at 21, Po Shan Road. In the late afternoon, the Highways Office diverted the drainage and sealed the six inch-diameter sewer which discharged on to the face of the slip. The fresh and salt water supplies for Po Shan Road, Conduit Road (western end) and Kotewall Road were cut off at 4 p.m.

106. In the early evening it was found that the half-width of Po Shan Road adjoining the garage and garden terrace had settled further. At about 8 p.m. lights were set up by the Public Works Department to illuminate the slip area.

SECTION 5 EVENTS BEFORE 5 P.M. ON JUNE 18, 1972

107. There was very heavy rain on June 18, 1972, especially in the morning. By about 9 a.m. the access road behind Skyline Mansion had been completely blocked by mud, rocks and vegetation. The construction of the proposed sandbag wall had not progressed very far and since a landslip was likely to occur the work was stopped. The whole of the slope showed a tendency to creep, and the settlement of the half-width of Po Shan Road as well as the garage and garden terrace continued. Very heavy rain began to fall at 11.30 a.m.

108. In the course of the morning the cracks in Po Shan Road widened considerably. The garage of 21, Po Shan Road sank a little further and moved northwards, and there were also cracks in the garden terrace.

109. Meanwhile, mud and vegetation continued to fall from the slope below the house at 21, Po Shan Road on to the rear and ground floor carpark of Skyline Mansion. At 11 a.m. the mud in Conduit Road was about six inches deep. The main slip face continued to give indications of movement, and by mid-afternoon the steel sheet piling at I.L. 2260 was almost entirely covered with mud and Conduit Road was completely blocked. The road was cordoned off at some time between 4 and 5 p.m.

DIAGRAM OF CROSS SECTIONS TAKEN THROUGH THE MIDDLE OF I.L.2260 (51C & 51D CONDUIT ROAD) TO ILLUSTRATE THE EXTENT OF THE CUTTINGS AT THE VARIOUS STAGES OF THE DEVELOPMENT AND FORMATION OF THIS SITE. ALL SECTIONS ARE APPROXIMATE.

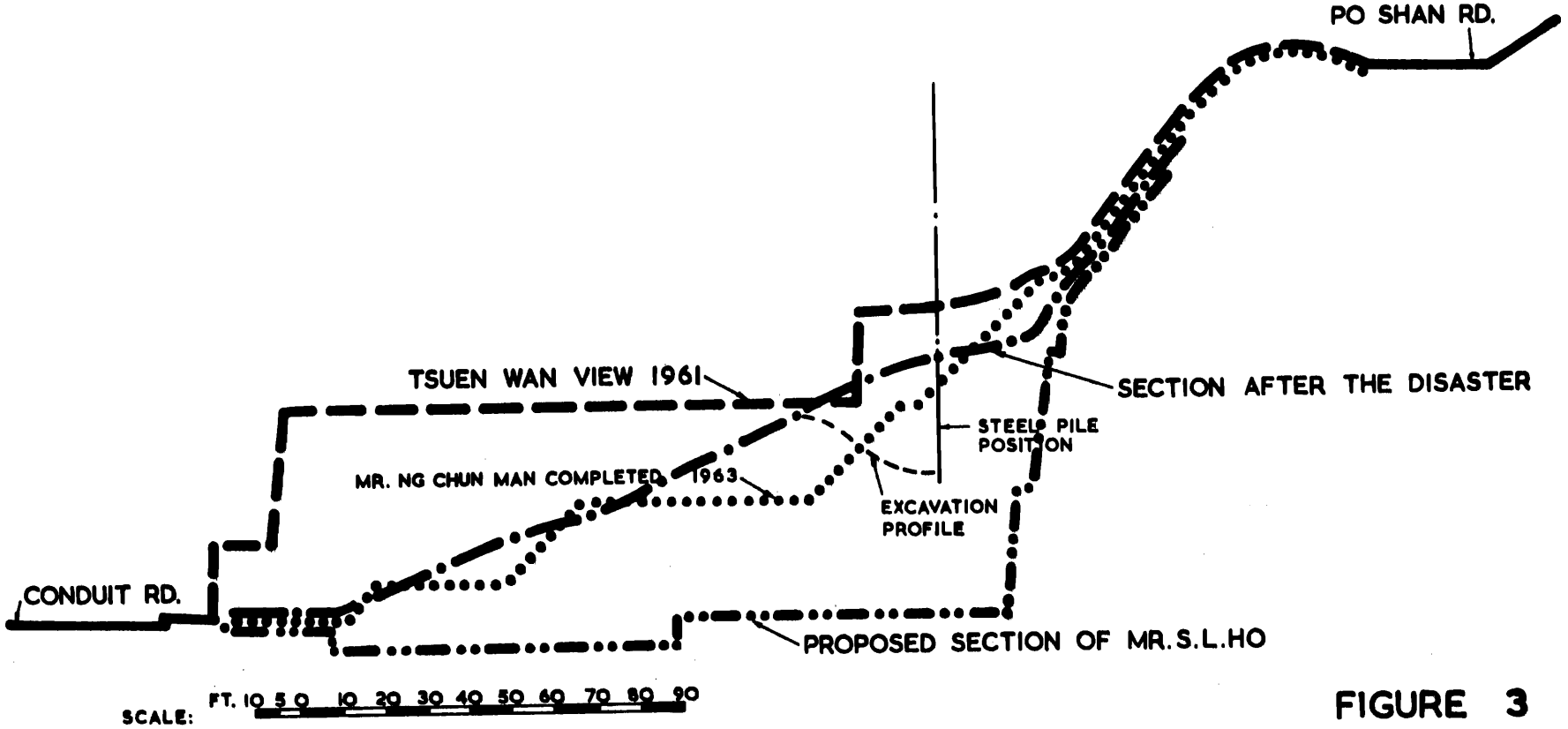

FIGURE 3

110. By early afternoon the retaining wall below 21, Po Shan Road had moved and fractured. The filling behind the retaining wall and the paving had settled fairly extensively. Nevertheless, apart from minor cracks the house itself appeared to be intact. The slope above Mirror Marina was also showing signs of strain. The main slip face continued to give indications of movement. Settlement continued until at one stage the half-width of Po Shan Road was some 20 feet below normal level. The condition of the garage and terrace deteriorated steadily throughout the afternoon. The garage still appeared intact but settling, tilting towards the garden terrace. The terrace was distorted and bowed from end to end, and the supporting beams and columns were fractured. One of the eye-witnesses also noticed a large hole in the garden terrace. The two structures were apparently on the point of imminent collapse and were expected to slip towards the direction of Skyline Mansion (see Plate 8).

111. Some time before 5 p.m. officers of the Buildings Ordinance Office decided that the rear flats of Skyline Mansion should be evacuated, and accordingly made arrangements with the Police towards that end. Some of the residents of the front portion who spoke to the officers were similarly advised. About 30 residents were subsequently evacuated from the 24 flats of the rear block of the building. Other residents had already left probably of their own accord. None of the evacuees requested accommodation from Government.

SECTION 6 THE LANDSLIP AT 5 P.M. ON JUNE 18, 1972

112. At about 5.10 p.m. a huge mass of earth, rocks and vegetation broke loose from the west side of I.L. 2260 and tumbled down "at a terrific speed" across Conduit Road. It broke the retaining wall behind 11, Kotewall Road, a four-storied residence situated between Conduit Road and Kotewall Road, and partially buried that house up to the level of the second floor. Eye-witnesses spoke of a thunderous noise as the slip occurred.

113. The residents of 11, Kotewall Road, Dr. Clifford K.K. SUN and his family, managed to escape from the partially buried house. There was fortunately no casualty from this landslip. As a result of the slip Conduit Road was covered with earth to a depth of about six feet. Plate 9 shows the disaster area after the slip. At that time, Dr. SUN's house was still structurally sound, and Mr. G. F. HOGG, Senior Building Surveyor, was of the view that Dr. SUN and his family would be able to return to their house the following day, as there was still no indication at this stage that any further slipping would endanger Dr. SUN's house.

114. The anxiety of the Public Works Department and the people in the area was mainly focused on the continuing settlement and possible collapse of the garage and garden terrace of 21, Po Shan Road on to Skyline Mansion. Mr. J. G. STEAN, Acting Principal Government Building Surveyor, made the following comments on the possibility of a major landslip in the evening of June 18, 1972: -

> "The evidence of recent slides at No. 8, Po Shan Road seemed to indicate that shallow wash-outs were likely. Nothing in my experience, in this area and elsewhere would have led me to consider as a possibility the magnitude of the slide which took place later that evening nor the possibility that a slide could move so far with such devastating effect. No suggestion that such an event

might happen was made to me by any other officer during my visits to the area."

115. At about 7.30 p.m. the slip area was again illuminated by the Public Works Department. Buildings in the area with the exception of Kotewall Court had no electricity at that time. In fact, some of the residents in the vicinity had left their premises because of the power failure.

116. From about 8 p.m. up to the occurrence of the major landslip shortly before 9 p.m. earth and rocks continued to fall in the slip area.

SECTION 7 THE MAJOR LANDSLIP ON JUNE 18, 1972

117. The evidence indicates that the major landslip took place between 8.50 and 8.55 p.m. According to the evidence of eye-witnesses, this slip appeared to have started from the hillside on the south side of Po Shan Road just above I.L. 2260, crossed the road and hit the garage of 21, Po Shan Road. On being hit the garage broke away from the garden terrace, slid down for a short distance and then toppled over in the direction of the slip. After hitting the garage the slip gathered momentum, swept past the west side of Skyline Mansion, crossed Conduit Road and then completely engulfed and obliterated 11, Kotewall Road - the house which had already been partially buried by the earlier landslip at about 5 p.m. (see paragraph 112). After engulfing 11, Kotewall Road, the slip continued on its path across Kotewall Road and struck Kotewall Court (38-40, Kotewall Road). According to the evidence the landslip itself took only about seven to ten seconds.

118. Kotewall Court - then the only well-lit building in the area - appeared to shudder and come away from its foundation on being struck by the slip, and it moved forward in the direction of the harbour. It then toppled and broke up transversely near the middle, "like a man kneeling, then falling forward". It struck and damaged a portion of the upper storeys of a new block of unoccupied flats in the vicinity (Section H, Block IV of Greenview Gardens, 125, Robinson Road), and then crumbled and disintegrated into rubble. Part of the demolished building fell into the construction site I.L. 8171 at 12, Babington Path. The lights went out as the building collapsed in a cloud of dust. The whole incident took seconds only.

119. One of the eye-witnesses, Mr. David J. ROADS, described the landslip and house collapse in the following terms: -

> "…. At about 20.20 I heard some stones rolling down the hillside from Po Shan Road toward Conduit Road, which were striking some steel stanchions protecting a large crane on Conduit Road. This continued until about 20.45. At about 20.50 I heard a fairly large stone fall down and hit the stanchions. I went to my verandah to see what had happened. I saw about 30 persons standing on Conduit Road, including several children looking up at the hillside where the stones were falling from. Suddenly without warning, the hillside above Po Shan Road gave way and tons of dirt, mud and stones moved very rapidly toward Conduit Road and then on down to Kotewall Road. It struck a small garage and then moved on down to a large apartment house on Kotewall

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> Road. When it hit this building Kotewall Court, the building appeared to move or come away from its foundations, and as it did this it remained upright and moved forward. It began to crumble in the mid-section and as this happened the building began to topple and struck the other block of new buildings adjacent to Kotewall Court. There were candles in various windows of Kotewall Court and there were lights on the crane on Conduit Road. When the building began to crumble all the lights went out. I saw furniture falling from the building and particularly noticed a bed in which people were in and they were thrown out. I went to my telephone and called 999 and told the girl that there was a disaster at Kotewall and Conduit Road junctions and that a large building with many persons in it had collapsed, due to a landslide. I went back to my verandah and heard cries from people trapped in the rubble…."

120. The landslip also demolished a hut adjacent to the construction site I.L. 8171, 12, Babington Path and killed a woman therein.

121. The slip area measured some 900 feet from north to south and some 200 feet from east to west. It was estimated that the weight of earth and rock in the slip was some 50,000 tons.

122. Extracts from some of the accounts of personal experiences are at Appendix VII.

123. In total 67 persons were killed, and, according to reports received, 20 injured. Appendix VIII is a list of the persons killed.

124. Plates 10 and 11, which were taken from the same angle, show the disaster area respectively before and after the major landslip. An aerial view of the disaster area is at Plate 7. Appendix IX is a plan of the disaster area showing the approximate limit of the major landslip (including debris) on June 22, 1972.

SECTION 8 RESCUE WORK

(A) GENERAL INFORMATION

125. The facts stated in paragraphs 23, 24, 26 and 27 of our Interim Report are applicable under this heading, except that the Police District Headquarters concerned in the present case is the Hong Kong Island District Headquarters.

(B) RESCUE WORK ON THE DISASTER SITE

(a) The first hour after the disaster

126. At about 8.55 p.m. on June 18, 1972, the first of over 30 emergency calls of a landslip and building collapses in the area between Po Shan Road and Babington Path were received by the Police at the Radio Control Centre of the Hong Kong Island District Headquarters. (Appendix X is the general information on emergency calls). The calls gave

different locations. The first four of those calls gave the following addresses: (1) 19, Conduit Road, (2) 19, Babington Path, (3) Kotewall Court and (4) 14, Kotewall Road (which according to Police records was reported by Mr. David J. ROADS - see paragraph 119 above). Simultaneously, with the receipt of these first calls, three Police vehicles were despatched. Emergency Unit Car 1 was sent to 14, Kotewall Road, arriving at 9.04 p.m. Emergency Unit Car 3 was sent to 19, Babington Path, arriving at 9.06 p.m. Central Police Station patrol car 19 was sent to Conduit Road, but there is no evidence as to the time of its arrival. Residents in the area agreed in their evidence that the Police arrived within minutes of the collapse of Kotewall Court.

127. By 8.57 p.m. the Assistant Commissioner of Police (Hong Kong Island), the Divisional Superintendent (Central), the Divisional Superintendent (Western), and the Hong Kong Island Police/Military Control Centre (the co-ordinating and operational centre for the Police and the Army in emergencies) had been informed. The Chief Superintendent of Hong Kong Island was informed at 9 p.m.

128. Shortly after 9 p.m. the Chief Inspector in charge of the Emergency Unit, Hong Kong Island, gave instructions for all available personnel in the Unit to prepare for immediate despatch to the scene of the disaster. He also arranged for all emergency equipment held by the Unit to be loaded on to a police lorry in readiness for conveyance to the scene. Such equipment consisted of nine Tilley pressure lamps and one Tilley lamp search-light (powered by kerosene and pressure operated), a Mitralux search-light (powered by a petrol engine generator), two or three dozen flashlights and some big-beam flashlights, blankets, stretchers, first aid boxes, an emergency generator, ropes and such handtools as shovels and pickaxes.

129. The Fire Services Department was informed by the Hong Kong Island Radio Control Centre at 8.58 p.m. of a house collapse at the rear of 17, Babington Path. Accordingly four vehicles under the command of the Rescue Officer 'H' Western responded. These were a light rescue unit, a rescue escape, an escape tender and an ambulance. They arrived at 9.12 p.m.

130. At 9.12 p.m. another report was received by the Fire Services Department from the Hong Kong Island Radio Control Centre of a house collapse at 21, Po Shan Road. A light rescue unit, a rescue escape, and an ambulance under the command of the Rescue Officer 'H' Central were immediately sent. The Senior Divisional Officer (Hong Kong) was informed at the same time and arrived at 9.15 p.m. at the top of the wreckage at Kotewall Road together with the party led by the Rescue Officer 'H' Central.

131. At about this time there were about 10 to 15 Emergency Unit vehicles and at least about 30 fire officers with their fire appliances at Kotewall Road.

132. The Buildings Ordinance Office was informed by the Police at 9.04 p.m., the Social Welfare Department at 10.05 p.m., and the Hongkong Electric Co., Ltd. at 10.22 p.m. The City District Office (Western) was also informed.

133. After being notified of the disaster, officers of the Buildings Ordinance Office were present at the scene on a 24-hour basis to advise the Fire Services on structural problems generally and to assist in other ways as far as possible. They also inspected the two buildings behind Kotewall Court, *viz.*, Blocks I and II, Emerald Gardens, and advised that

both buildings be evacuated completely. They also inspected Block IV of Greenview Gardens and found that there was no immediate danger of even a partial collapse of that building. Buildings at Po Shan Road were also inspected. All these measures were adopted shortly after the collapse of Kotewall Court.

134. According to the evidence of a police inspector there was confusion in the beginning because of darkness and heavy rain and also because the extent of the disaster could not be ascertained at the time. Indeed, a police superintendent remarked that in the initial stages, as the area affected was so vast and the persons there were so shaken with the enormousness of the disaster, the situation appeared to be chaotic. According to him by 10.30 to 11 p.m. the situation had been "very much sorted out".

135. Owing to the different locations given by the emergency calls, police cars were sent to various destinations, and from the boundaries of the scene of the disaster it was difficult for the police officers there at first to appreciate precisely the extent of the collapse. When the first party of fire officers arrived at 9.12 p.m. they also had difficulty in locating and reaching the actual site of the building collapse, and therefore had to make enquiries from bystanders and police officers and search for the site on foot.

136. The lighting in the area at 9.20 p.m. was poor, but each fire and police officer was equipped either with a gas-tight hand-torch or big-beam flashlight with which to beam into cavities in search of persons trapped therein.

137. At this time "a wave of mud and water", and stones and debris came rushing down Kotewall Road with a tremendous noise, covering the whole of the road to a depth of about six inches. On the advice of the Fire Services, police and fire officers were temporarily withdrawn to a safer location in Robinson Road.

138. By 9.24 p.m., the Senior Divisional Officer (Hong Kong) of the Fire Services had ascertained that the landslip had totally demolished a fully occupied building, *viz*., Kotewall Court. He accordingly informed the Fire Services Department's Radio Control Centre of the fact and requested assistance. A major special service call was made accordingly. The call was upgraded to a disaster alarm a little later.

139. At 9.26 p.m. the Emergency Unit Car 1 referred to in paragraph 126 above reported to the Police Radio Control Centre that Kotewall Court had collapsed. This was the first information the Police received of the collapse from a police officer on site.

140. The first two victims were rescued at 9.24 p.m.

141. A strong smell of gas over the whole area was noticed at about 9.30 p.m., and the rescue workers were instructed not to use naked lights nor to smoke.

142. At the same time a large volume of water was flowing over an old retaining wall between Conduit Road and Kotewall Road. This hindered rescue operations.

143. At 9.40 p.m., rescue workers located four persons trapped in that section of the wreckage below Kotewall Road. All of them were extricated and taken to hospital between 10 and 10.40 p.m. The area was combed by rescue workers by means of hand-torches, in

accordance with the normal practice in emergencies of this kind. Parties of fire officers spread out over the whole area of the wreckage, searching for survivors and carrying out rescue work. According to routine practice, rescue workers were ordered in turn to shout, keep silent and listen for calls from trapped survivors. It was understood by all taking part in the search and rescue that these calls might be very weak.

144. In accordance with the normal practice in rescue work of this type, the tools used by fire officers in the initial stages were mainly handtools such as crowbars, bolt croppers and axes, and sometimes they used their bare hands. Requests for more men, ambulances and a medical team were made and instructions as to the most convenient route to the scene of disaster (i.e. through Greenview Gardens, Robinson Road) were given by the fire officers on the spot.

145. At 9.49 p.m. Queen Mary Hospital was warned by the Police Radio Control Centre to standby as many casualties were expected. A medical team was sent by the Hospital to the scene of the disaster. Police parties were sent to the Hospital and the Public Mortuary for identification of casualties. A Missing Persons Bureau was also set up by the Police.

146. There was no lighting at the Kotewall Road level of the wreckage at the time as the street-lighting had failed. The heavy lighting equipment available consisted of a generator and a light connected by a cable only about 30 feet long. The senior fire officer considered that the presence of gas in the area necessitated placing the generator within the danger zone of gas explosion, and it would therefore be unsafe to use this equipment. There was also a shortage of heavy lighting equipment owing to the fact that the main lighting unit of the Hong Kong Command of the Fire Services Department was on loan in Kowloon for the Sau Mau Ping disaster. Most of the Army lighting equipment was similarly engaged.

147. The site of Kotewall Court and the adjoining portion of Kotewall Road was “a mountain of mud”. Water was not only flowing down from Conduit Road into Kotewall Road. There was also water gushing from both upper and lower portions of the wreckage. Kotewall Road had thus “turned itself into river of mud!”

148. The Assistant Chief Fire Officer (Hong Kong) arrived at Kotewall Road at about 9.50 p.m. and assumed command of the whole operation. He was briefed on the general situation as far as it was known at the time. He then surveyed the area. He noticed that the debris across Kotewall Road was about 20 to 25 feet deep. By means of a rope, he descended about 100 feet to the lower level of the wreckage and directed operations there, leaving the Senior Divisional Officer (Hong Kong) in charge at the Kotewall Road level. His descent was made very difficult by the movement of wet and loose earth which trapped his feet.

149. At 9.56 p.m. orders were issued to all off-duty personnel of the Hong Kong Island and Marine Fire Command to be re-called to standby duty at their respective stations.

150. As the approach roads were made impassable by mud, debris, and water, fire appliances were not able to reach the wreckage until shortly before 10 p.m.

151. The general picture of the scene at about this time was described by

Superintendent M. A. TURNER of Western Police Station in these words: -

> "There were many fire appliances, firemen, policemen and civilians in the vicinity and it was raining heavily and a great deal of surplus water was flowing down the hillside on to Kotewall Road….
>
> "There was a very strong smell of gas in the area and there was a lot of crying and shouting probably from persons trapped in the rubble as well as from various bystanders. I spoke to Mr. JACKSON - Acting Assistant Chief Fire Officer - who was directing operations from this point and was the fire officer in charge. He told me that he estimated that at least two hundred people were trapped in the wreckage and that rescue operations were in progress. He went on to say special equipment had been called for and that the services had been requested to assist. He asked me to ensure that all persons not directly involved in the rescue should be kept clear of the area as it was extremely dangerous and they would as well impede the rescue by trained workers. He also asked me to check all four blocks in Emerald Court (*sic*) to ensure no persons were still inside as this building was considered unsafe.
>
> "I checked the site of rescue operations for outsiders with the assistance of Police Tactical Unit and found none and then checked 36, Kotewall Road and brought out one Chinese female and four children who were the only apparent persons remaining in the building."

152. Before leaving this part of the rescue operations, we consider that the rescue work performed by two persons warrant special recognition. One is Mr. Terrence A. BERRECLOTH, an engineer, who arrived at the disaster site of his own accord about 25 minutes after the collapse of Kotewall Court and offered his services. His evidence is reproduced in full in Appendix XI. The second person is Senior Inspector Guy Sanderson SHIRRA, attached to Fanling Magistracy, who was on leave and at home at the time of the landslip. He arrived at the disaster site at about 9.25 p.m. and offered his services. His evidence is reproduced in full in Appendix XII.

(b) From about 10 p.m. until midnight

153. At about 10 p.m. there were some 60 cars parked in Kotewall Road and Robinson Road, causing an obstruction to those vehicles which had to reach the disaster site. Accordingly, the Police made an appeal by loudspeaker, as a result of which some 30 vehicles were removed by their owners. Those remaining were towed away by the Police. Though the area was not cleared of all non-essential vehicles until about 1 a.m., it had already been effectively cordoned off by the Police earlier at 11.10 p.m.

154. At 10.03 p.m., at the request of the Fire Services Department, the Police asked for assistance from the Civil Aid Services and the Army. The Civil Aid Services took part in search and rescue operations from 10.30 p.m. until 4 a.m. the following day, and remained on standby duty on the 19th and 20th.

155. A platoon from the Police Tactical Unit arrived at 10.05 p.m. and a Police Command Post was set up at Kotewall Road at 10.07 p.m.

156. Between 10.05 and 10.10 p.m. the Assistant Chief Fire Officer (Hong Kong) contacted the Fire Services Department Radio Control and again asked for the assistance of Civil Aid Services. Heavy earth-moving equipment and floodlights were also requested. He then gave instructions for portable floodlights to be taken from fire applicances at the scene to be used at the Kotewall Road level of the wreckage.

157. At 10.15 p.m. the Chief Fire Officer (Hong Kong) arrived at the scene and assumed command of the situation. He and the Senior Divisional Officer (Hong Kong) remained at the Kotewall Road level, whilst the Assistant Chief Fire Officer (Hong Kong) was sent to the Babington Path area to take charge of search and rescue operations.

158. A strong smell of gas which appeared to represent dangerous concentrations over the whole area of the wreckage was still evident at this time. Strict precautions were therefore maintained in respect of naked lights. Warnings were issued to all rescue workers against the use of electrical and mechanical equipment, particularly petrol-driven generators, Tilley lamps and propane cutters, lest the sparks or flames produced therefrom might cause a gas explosion. The situation was complicated by the presence of butane gas as well as towngas, which were not readily distinguishable one from the other. As towngas is lighter than air and butane gas is heavier than air, that there might have been both types of gas trapped within the cavities of the wreckage was a very real possibility. Requests were accordingly made by the Police and the Fire Services at about 10.15 p.m. for the attendance of the staff of the Hong Kong and China Gas Co., Ltd. The emergency standby party of the Company arrived at about 10.40 p.m. The Distribution Engineer of the Company arrived shortly before 11 p.m. The standby party reported to a police inspector at the disaster site, but the fire officers in charge of rescue operations were not informed of their arrival, nor did they make any attempt to locate the standby party. Our conclusion on this aspect of the rescue is contained in Chapter VI.

159. Shortly after 10.15 p.m. the Acting Colonial Secretary and the Director of Fire Services arrived at the scene from the disaster site at Sau Mau Ping. The Acting Deputy Director of Fire Services arrived at about 10.30 p.m.

160. During this time, there was intermittent rain, and water was running down the west side of the slip.

161. By 10.30 p.m. an emergency tender from the Fire Services Department was already in position near the Kotewall Road level of the wreckage, and the generator on the appliance was used to provide lighting at this location. There was another emergency tender at the Babington Path level. Access to the bottom of the wreckage was only possible through the ground floor of Block IV, Greenview Gardens, where the headroom was limited to seven feet six inches. For this reason the appliance could not get within about 500 feet of the bottom of the wreckage. Also, the road leading there was rendered impassable because of heavy rain and roadworks.

162. Generators were now supplied by the Public Works Departments, in addition to the lighting equipment provided by the Police Emergency Unit.

163. Whilst the Kotewall Road level was well-lit at this time the wreckage itself was not. Search and rescue workers were still relying mainly on hand-torches or big-beam

flashlights as it was considered that the danger of gas explosion was still very real. For the same reason, oxy-acetylene cutting equipment and petrol-driven saws were not used.

164. It was not as yet possible at this stage to use large and heavy earth-moving equipment as the ground was still soft and slippery and responsive even to slight vibrations. The whole wreckage was liable to slip and the hazard was aggravated by the many loose articles such as heavy furniture inside the wreckage. In the opinion of the Senior Divisional Officer (Hong Kong) large and heavy machinery would have been dangerous because rescue work in the prevailing circumstances required slow and careful digging by hand and with small equipment. It was unsafe to lift portions of the collapsed structure as it might cause the other parts of the wreckage to move. Consequently, the only practical and safe way of extracting trapped persons was to burrow laboriously into the wreckage.

165. In the words of the Acting Chief Fire Officer (Hong Kong): -

> "First of all the slip on Kotewall Road, some thousands of tons had to be cleared in order to make a working platform, low enough for the working cranes to get into position. The cranes were then mounted on a slab which was all the time subsiding; it was giving a little but firm enough to work on. The whole building, and it comprised not less than 2,000 tons, was still held together in one integral mass and after the initial rescue operations had been concluded and we were trying to get into the building further, it was a case of having to cut it up into little pieces which we could manage with the cranes or with a mechanical shovel and cut it literally apart piece by piece. It was still fastened together as one integral building even though it had collapsed. The equipment at first was controlled by the 7′6" headroom and afterwards the contractors brought in a portable crane in collapsible sections which he constructed on the site and which takes a long time to do this sort of thing. And even then this crane's lifting capacity could have been no more than one ton."

166. The Acting Deputy Director of Fire Services also felt it would be wrong to disturb the debris and that heavy work should not commence until all the known casualties were extricated.

167. Army personnel arrived at about 11.25 p.m. and were placed under the direction of the Fire Services Department. They stayed until 6 p.m. of June 23. There were about 100 men on the site each day, with half of the number working and the other half on standby at any one period. Equipment was provided by the Army at dawn on the following day and this included earth-moving plant and oxy-acetylene cutting equipment. The Army units which rendered assistance were the Royal Engineers, the Gurkha Field Squadron, the Irish Guards and the Royal Army Medical Corps.

(c) From midnight to dawn on June 19, 1972

168. Owing to the difficulties described above, it was not until after midnight that the whole disaster site was fully illuminated. The Fire Services considered that the danger of gas explosion had by this time diminished. The Mitralux searchlight and generator supplied by the Police Emergency Unit were set up on the third floor of Block IV, Greenview

Gardens, 50 to 60 feet away from the bottom of the wreckage. The loud noise emanating from the working generator at that distance was not considered loud enough to drown any possible cries for help. The Fire Services Department was also informed that certain commercial contractors were prepared to supply lighting equipment, and arrangements were being made to convey the equipment to the scene.

169. By this time (i.e., shortly after midnight) the rescue workers had completely explored the debris, calling, tapping and listening, but heard no one.

170. It was decided by the fire officers that though the danger of gas explosion had diminished by this time the presence of residual gas still prevented oxy-acetylene cutting.

171. At about 12.40 p.m., thorough searches for survivors continued. In the meantime, additional power and lighting equipment and a further 50 Army personnel arrived at the Kotewall Road level of the wreckage. Members of the Auxiliary Medical Service also arrived at this time. Workers were again warned to exercise extreme care because of falling debris and the instability of the wreckage.

172. At 1.19 a.m. representatives of the Royal Engineers arrived and made arrangements for the provision of winches and heavy lifting gear. Army personnel also arrived to help in the removal of debris.

173. At 2 a.m. it was decided by fire officers that the residual gas had dispersed sufficiently to allow oxy-acetylene cutting at least at the lower level of the wreckage. The staff of the Gas Company, having worked in the wreckage under difficult circumstances for about three hours, came independently to the conclusion that there was no further gas in the area and accordingly informed the Police of it. They remained on the site until 8 a.m. More Army personnel arrived to relieve the fire officers. The Army and the Public Works Department had by now provided lighting and heavy earth-moving equipment, especially for the removal of the debris of the upper storeys of Kotewall Court, the remains of which now lay in Babington Path. Air-bags for lifting heavy objects and cutting sets were now used by fire officers.

174. More heavy and lighting equipment was brought in at different periods throughout the night.

175. Up to about 3.30 a.m. 19 persons had been extracted from the wreckage alive and six dead.

(d) From 6 a.m. to 6 p.m. on June 19, 1972

176. At about 6.40 a.m. two streams of water were flowing down the hillside above Kotewall Road, one on to the Road itself and the other on to the lower level of the wreckage. Fire officers dug a ditch to divert the second stream of water towards Kotewall Road. This task was completed at about 8.30 a.m.

177. At 8.30 a.m. a Mr. Henry LITTON's calls for help were heard. Mr. LITTON, an occupant of Kotewall Court, was found trapped in a cavity in the mid-section of the wreckage. To reach him, a vertical shaft of some six to seven feet in depth and a horizontal tunnel of

some 20 to 25 feet in length were excavated. The rescue was carried out by members of the Fire Services together with personnel from the First Battalion of the Irish Guards and from the Royal Engineers. The rescue operation continued until 3.30 p.m. when a further major slip occurred in the Po Shan Road area, which necessitated an emergency evacuation of the tunnel area. Once the slip had come to rest and conditions became less hazardous rescue workers again entered the tunnel. From then onwards lookouts were posted to give warnings of further landslips. Relief workers took over at 7.30 p.m. This survivor was finally extricated at 9 p.m. and taken to hospital.

178. To illustrate the difficulties encountered by the rescue workers, a more detailed account of this aspect of the rescue work is at Appendix XIII.

179. With the exception of this survivor, none of the other victims could be rescued as they were unfortunately either already dead or, being in inaccessible cavities, could not be located or reached in time.

180. Throughout the morning search and rescue and the removal of the dead continued. Particular attention was paid to openings in the wreckage. Shouting and listening continued, but no signs of further survivors were detected.

181. These operations were divided into four fields, carried out simultaneously: -

(1) Tunnelling to reach Mr. LITTON.

(2) Clearing of debris by the Army from the lower level of the wreckage so as to create working space for the removal of further debris when this became possible.

(3) Further excavation and continued search of all accessible cavities and crevices within the wreckage.

(4) Careful removal by hand of all surface materials such as clothing, bedding, etc. from the wreckage to uncover, if possible, further rescue openings.

182. Rescue work having continued throughout the night and the following morning, it was clear by 11 a.m. that all survivors who could be seen or heard had been rescued with the exception of Mr. LITTON. Nevertheless, shouting and listening still continued.

183. Arrangements were made for an army bulldozer to work at the disaster site that evening.

184. As the gas mains were buried within the wreckage it was not until about noon that the staff of the Gas Company was able to disconnect them.

185. Throughout the 19th, rescue workers searched for victims and removed debris. Bodies were located but as they were trapped beneath the collapsed structure and the condition of the wreckage was still unstable and dangerous they could not be removed before the 21st.

186. A mobile crane was now being operated from a platform erected by the Army. Pneumatic tools and oxy-acetylene cutting equipment were also in use. Work on the site was of necessity slow and laborious owing to the dangerous state of the wreckage and the possibility of earth movements.

187. The work of the Army and Fire Services at both levels of the wreckage continued throughout the 19th, 20th and the 21st.

(e) From June 20 to June 22, 1972

188. At dawn on the 20th fire officers started to search the disaster site, looking into cavities and shouting and listening as before. On that day pneumatic drills, K-12 cutting sets, bolt croppers, pickaxes, crowbars, etc., were in use, and a 20-ton mobile crane with a jib-length of 125 feet was provided by the Public Works Department. In the evening of that day further movement of the fractured retaining wall below 21, Po Shan Road occurred and in view of the possibility of a further slip rescue work was suspended for the night.

189. On the 21st fire officers, assisted by the Army, continued to search for bodies and this continued throughout the 22nd.

190. On the 22nd, they were also engaged in removing the loose rubble and in breaking up the concrete structure to a size which could be handled by the available crane. In this they were assisted by a construction company. A pump crew and other fire officers were at the upper level of the wreckage, digging and shovelling mud and debris. During the day there were two alarms owing to movement of sand and mud.

191. Between the 21st and the 22nd, apart from the six bodies mentioned in paragraph 175 six further bodies were extracted.

192. On that day the Director of Fire Services, the Director of Public Works and the Director of Medical and Health Services visited the disaster scene.

(f) On June 23, 1972

193. On the 23rd, search and lookout duties continued.

194. On that day a meeting was held by representatives of the Fire Services Department, the Public Works Department, the Medical and Health Department, the Royal Hong Kong Police Force and the Army, under the chairmanship of the Director of Fire Services. As a result of this meeting it was decided that the rescue phase of the operations was by then complete and that it should enter a demolition/recovery phase of operations. Accordingly, arrangements were made to hand over operations to the Public Works Department. The Director of Fire Services subsequently handed over control to Mr. J. G. STEAN, the Acting Principal Government Building Surveyor.

195. Disinfecting teams were now at the scene spraying at least twice daily. The Army was still busy working with heavy equipment. Construction firms engaged by the Public Works Department moved in.

196. At 4.37 p.m., the Chief Fire Officer (Hong Kong) ordered his personnel to cease work, but retained a full crew with a Station Officer in charge to assist in body recovery.

197. Up to this time, 20 survivors and 12 bodies referred to above had been extricated. Seven more bodies had been located in the wreckage but extrication was impossible.

198. At 5.47 p.m. it was estimated that a further 66 bodies might still be trapped within the wreckage.

SECTION 9 RECOVERY OF BODIES BY DEMOLITION WORK

199. Recovery of bodies by demolition work was carried out by the Public Works Department from June 23 to August 28, 1972.

200. The construction firms engaged by the Public Works Department continued the work of demolition and body recovery. These were extremely complicated and dangerous operations. Demolition normally consists of taking a structure apart in a systematic manner. In the case of Kotewall Court, not a single part of the super-structure was in its original position after the collapse. Because of the nature of the collapse, most of the debris was a tangled mass of reinforced concrete members, pipes, timberwork and building fittings spread over a sloping area between Kotewall Road and 125/7, Robinson Road, the difference in level being some 80 to 100 feet (See Plate 12). The operation of breaking up concrete and cutting through nets of tangled steel reinforcement was from the start a tedious undertaking. The number of larger pieces which could be removed *en bloc* was very limited. Except for the work done by compressed-air machines and cranes, all demolition and excavation were performed by hand to avoid possible mutilation of bodies.

201. From June 29 work proceeded round the clock from both the Kotewall Road and Robinson Road levels. To lift debris from the latter level a demountable winch-derrick - the only type of lifting device possible because of restricted access through adjacent building - was installed. A second 20-ton crane was installed at a later date on the construction site of I.L. 8171, 12, Babington Path to serve the centre of the debris pile, as it became necessary to withdraw the crane at the upper level.

202. Accessible cavities having been so thoroughly searched during the rescue operations, it was not until June 27 that the next body was recovered. Since June 23, when the Public Works Department took over operations, a total of 55 bodies have been recovered from the wreckage. Records show: -

1 body on June 27

1 body on June 28

44 bodies between July 4 and 29

4 bodies between August 7 and 9

3 bodies on August 16

1 body on August 17

1 body on August 28.

SECTION 10 REMEDIAL WORKS DONE BY THE PUBLIC WORKS DEPARTMENT AFTER THE DISASTER

203. A written report prepared by Mr. J. G. STEAN dated August 2, 1972 showed the remedial work done to date by the Public Works Department. This evidence is reproduced in Appendix XIV. We approve of the measures described therein.

204. We understand that permanent remedial measures for the restoration of the slip area are under consideration by the Department.

CHAPTER IV

THE DISASTER AT SHIU FAI TERRACE (WAN CHAI)

SECTION 1 INTRODUCTION

205. By comparison with the disasters at Sau Mau Ping and Po Shan Road, in terms of loss of life and damage to property, the landslips at Shiu Fai Terrace were relatively minor in character. But some of the considerations involved in analysis of these landslips are matters of principle, having wider application than to the Shiu Fai Terrace area, and it is for this reason that they have received detailed attention by us.

206. Evidence submitted showed that the rains which fell over the period June 16-18, 1972 caused six major landslips affecting buildings in the Shiu Fai Terrace area, together with a number of other minor slips which were mainly on Crown Land abutting Stubbs Road. Two major slips occurred on the sites of buildings under construction, and in one of these a watchman was killed. It was to the latter of these two landslips that we directed our attention particularly, but the prevalence of landslips in the area was a factor which we could not ignore.

207. Written evidence indicates that the Shiu Fai Terrace area appears to consist almost wholly of highly weathered granite, decomposed *in situ* to a silty sand with granite boulders of varying sizes interspersed throughout the soil mass.

208. There are a number of natural stream courses on the high ground to the south of the developed land, of which the major streams discharge into culverts to traverse the built-up area. Surface water from the buildings and paved areas is discharged through a system of storm-water drains and culverts either to natural stream courses or to the main storm-water drainage system. It has been submitted, and we concur with this view, that the existing storm-water drainage system seems generally adequate for its purpose and that it would not be practicable to attempt to drain all the area above the cutting slopes to the south.

209. The area, now known as Shiu Fai Terrace, was leased for 75 years on October 4, 1920, as I.L. 2302, totalling 310,610 square feet. Included in the lease conditions were the requirements that not more than 20 European-type houses were to be erected not over 35 feet high except with the consent of the Governor in Council. By the end of 1948 four buildings, each two-storey high, had been constructed on the Lot.

210. The question of modifying the original lease conditions was considered by Government on November 19, 1959, and after initial deferment to investigate the possibilities of improving the Stubbs Road/Shiu Fai Terrace junction, it was agreed on November 26, 1959 that modification could be given to allow 12-storey development at suburban coverage. Following the splitting-up of I.L. 2302 into sections, further lease modifications were given in 1963/64 with the result that from 1965 onwards the general pattern of development over the area comprised 12-storey domestic blocks over one or two storeys of carparks.

SECTION 2 THE LANDSLIPS

211. At 1.30 p.m. and 4.00 p.m. on June 16, 1972 two landslips occurred on the hillside cutting at the rear of Sections S and T of I.L. 2302, which were the building site immediately adjoining Sections N, O, P and W of I.L. 2302. Later on that same day, at about 11.30 p.m., a third landslip occurred on the hillside cutting behind Sections N, O, P and W where building construction work was going on. This last landslip dislodged a greater quantity of rocks and soil than either of the earlier ones and buried a building contractor's watchman who had been in a first floor room at the rear of the building on Section P of the Lot at that time. The Fire Services Department was notified by Police Island Radio Control Centre at 11.51 p.m. and fire officers arrived at 11.55 p.m. The watchman was found at 12.40 a.m. on the 17th and was given oxygen. He was dug out from the mud alive at 3.15 a.m., but unfortunately died from his injuries on arrival at the hospital at 3.23 a.m.

212. Although, in fact, three separate landslips occurred on the same day, the areas of the individual slips merged into one another, leaving a continuous scar on the hillside cutting faces as if a single landslip had occurred (see Plate 13).

SECTION 3 HISTORICAL AND TECHNICAL CONSIDERATIONS

213. Approval of plans for construction of a 12-storey domestic building over two storeys of carparks on Sections N, O, P and W with extensions of I.L. 2302 was first given on January 30, 1965. Application for consent to commence site formation work was made on November 25, 1969, but this was refused on the grounds that the approved plans were no longer valid. Consent was granted on April 17, 1970, following approval of amended building plans on December 30, 1969.

214. Amended site formation plans were submitted on March 11, 1971, but were disapproved on May 4, 1971 on the grounds that the actual cutting slope was steeper than the 50^{o} shown by the authorized architect, Mr. Wallace CHIU, on his plans. At the same time, Mr. CHIU was advised that were his slope to be steeper than 50^{o} he would be required to undertake that it would be stable. In resubmitting his plans on May 19, 1971, he gave this undertaking in an accompanying letter.

215. The plans were again disapproved on June 17, 1971, because it was considered, *inter alia*, that the upper cutting slopes were excessively steep.

216. Mr. CHIU resubmitted the plans on September 2, 1971, enclosing a second undertaking as to the stability of the slopes, followed by a further letter dated October 6, 1971, enclosing copies of letters from Inter Pacific Ltd., site investigation contractors (dated October 5, 1971), and from Mr. P. LUMB (dated September 29, 1971) containing the results of soil test and averring that a safe slope for a cutting 64 feet high would be 75^{o}.

217. Accordingly, on October 28, 1971, the amended site formation plans were approved.

218. An application to erect two blocks of apartments on Sections S and T and their extensions was made by Mr. E. Y. WU, authorized architect, on March 12, 1969. These

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buildings were to be of 12 storeys over two storeys of carparks and the plans thereof were subsequently approved on June 16, 1969. On October 9, 1969 the authorized architect submitted the site formation plans. While no structural objections to these plans were raised at that time by the Buildings Ordinance Office, the Chief Engineer, Highways (Hong Kong) Division suggested that site investigation should be carried out to prove that the cutting slope at the rear was of solid compact rock. He also recommended that, were the slope not of rock, the angle of slope should be ten feet vertical to six feet horizontal with a five-foot wide berm with nine-inch surface channels at every 25 feet of height. This was transmitted to Mr. WU who withdrew the site formation plans on November 7, 1969.

219. On November 10, he resubmitted his plans and at the same time confirmed that the cutting slope would be of solid rock, but undertook to reduce the angle of cutting if the sub-soil was found to be other than of rock. The Chief Engineer, Highways (Hong Kong) Division, commented on these plans to the effect that if the cutting was not of rock the width of the access at the rear of the building would be reduced to eight feet.

220. The plans were accordingly approved on January 14, 1970, and consent to commence work was given on January 24, 1970.

221. Amended site formation plans were submitted on August 11, 1970 to the Building Authority, on which the Chief Engineer, Highways (Hong Kong) Division, commented to the effect that the levels were incorrectly shown, that the maximum height between berms was 30 feet and that the minimum width thereof should be five feet.

222. The plans were subsequently amended to the satisfaction of The Chief Engineer, Highways (Hong Kong) Division and were approved on October 27, 1970 with a covering letter containing a warning about unauthorized cutting into Crown Land.

223. Following an investigation into the strength of the concrete being used in the structural frame of the buildings the Government Building Surveyor, on May 26, 1971, instructed the Chief Structural Engineer to have the cutting at the rear of the buildings examined; to report on whether the work had been carried out according to approved plans and to prepare a sketch showing the actual cutting with angles of slope, position of retaining walls, etc. He also requested advice as to whether the existing cutting could be considered safe or, if not, what additional precautionary measures would be required to render it safe. A structural engineer subsequently reported on June 4, 1971 that although the cutting differed from that shown on the authorized architect's plans, having an actual angle between 53^{o} and 56^{o}, there was no apparent structural danger.

224. At a meeting with the then Acting Chief Structural Engineer on June 9, 1971 the authorized architect stated that the rear slope had actually been cut in accordance with plans approved on January 14, 1970, but he undertook to investigate its stability further since it was not in fact rock. No further report was received.

225. On November 1, 1971, Mr. NG Chi-chai, authorized architect, assumed responsibility for the project vice Mr. E. Y. WU.

226. While differing appreciably in detail the development proposals submitted by the respective authorized architects for the above building projects had certain points of

similarity, sufficient to justify them being considered collectively by us. Both projects were for 12-storey domestic building over two floors of carparks, necessitating access through the rear of the buildings and cutting into the hillside slope. To achieve their respective development proposals both authorized architects adopted unusually steep slopes for their cutting faces, which they justified by assuming that the bulk of the cutting was to be made in solid rock. When it was pointed out to each architect by the Public Works Department authorities that the hillside slope might not be solid rock and that further investigation was necessary to determine its nature, one of the architects had such an investigation carried out, which indicated that for the material in question the safe heights for slope angles of 90^{o}, 75^{o} and 60^{o} with the horizontal were 43 feet, 64 feet and 103 feet respectively, adopting a safety factor of 1.5 against collapse. Mr. NG, on the other hand, apparently did not investigate the stability of the rear slope to his site, as mentioned earlier, but maintained that the cutting was carried out in accordance with the plans approved on January 14, 1970.

CHAPTER V

INCIDENTS IN OTHER AREAS

227. We have also examined the circumstances in which deaths occurred at the following places: -

(1) Ap Lei Chau,
(2) Belcher's Street (Western District),
(3) Bullock Lane (Wan Chai),
(4) Chai Wan and
(5) Shau Kei Wan.

SECTION 1 AP LEI CHAU

228. Sometime after 1.00 p.m. on June 16, 1972, a landslip occurred at 8 Pak Sha Wan, Ap Lei Chau, burying the pigsties owned by a pig-breeder there. It was suspected at the time that the pig-breeder's wife was trapped in the mud and rocks fallen from the hillside. Fire officers were requested at 2.13 p.m.; and they went to the scene by launch. Rescue operations had been in progress by 2.46 p.m. They spent nine hours in a vain attempt to locate the victim. Her body was eventually dug out from the mud by fire officers on the following day. The pig-breeder's employee had been living in the area for over ten years. His evidence (which we accept) was that there had not been any landslips there during the exceptionally heavy rainfall in Aberdeen in 1966, nor had there been any other landslips in the area during the period of his residence there.

SECTION 2 BELCHER'S STREET (WESTERN DISTRICT)

229. On June 17, 1972 there was a minor incident of rockfall from the hillside behind 44, Belcher's Street, but no report of this was made to the Police or the Fire Services Department. Sometime in the morning of June 18, 1972 a more serious landslip occurred at the hillside behind 42, 44 and 46, Belcher's Street (see Appendix XV), killing a workman who was in a wooden shed situated between 46, Belcher's Street and the hillside. The Fire Services Department was notified by the workman's employer at 11.10 a.m. and fire officers arrived at 11.13 a.m. With considerable danger to their personal safety Assistant Divisional Officer KWAN Sai-yiu and Fireman LAM Kwok-hung supplied oxygen to the workman, and then extricated him from the boulders, rock, mud and debris. Unfortunately, he soon died from his injuries. During the rescue operation another landslip occurred at the same location and, as soon as the fire officers and the victim had left that spot, a much larger landslip took place, engulfing completely the rescue area.

SECTION 3 BULLOCK LANE (WAN CHAI)

230. Sometime after 12 noon on June 17, 1972 a landslip occurred at the slope just below the tennis court of the Ruttonjee Sanatorium, totally demolishing 4, Bullock Lane and partially demolishing 2, Bullock Lane, the adjoining building (see Appendix XVI). Two

residents of 4, Bullock Lane, a youth and a girl, and a woman residing in 2, Bullock Lane were killed. Thirteen persons were injured.

231. Fire officers were summoned at 12.23 p.m. and arrived at 12.25 p.m. Police arrived at the scene at about 12.30 p.m. Divisional Officer S. M. ELCOCK of the Fire Services Department was in charge of operations. Rescue work was carried out under the threat of imminent further collapse of 2 Bullock Lane, and was hampered by the congested traffic and onlookers in Wan Chai Road, the main road leading to Bullock Lane. By about 8.30 p.m. all known trapped survivors had been rescued. Shortly after 8.30 p.m. a further collapse of 2, Bullock Lane occurred, temporarily interrupting search and rescue operations.

232. The woman was dug out on June 26, the youth on the 27th and the girl on the 28th.

SECTION 4 CHAI WAN

233. At about 9.30 a.m. on June 16, 1972 there was a heavy downpour at Wan Tsui Road, Chai Wan, and the streets were flooded. The body of a youth, apparently drowned, was discovered beneath a military vehicle.

234. It is clear from the evidence that the flood-water formed a swift current flowing down Wan Tsui Road which was fairly steep. It would have been quite unsafe to stand or walk in the water, although the evidence showed that the water was no more than two feet deep.

SECTION 5 SHAU KEI WAN

235. Three separate areas in Shau Kei Wan were examined by us, namely: -

(1) Ma Shan Village,
(2) Nam On Fong Village and
(3) Tsin Shui Ma Tau Village.

Appendix XVII is a plan of these areas.

236. The huts in the Ma Shan, Nam On Fong and Tsin Shui Ma Tau Villages, erected without lawful authority on Crown land, are in clusters perched on the hillsides or in the valley. Squatter huts in the Colony are unlawful, but they are tolerated if they have been included in the Resettlement Department's squatter surveys made from time to time. The latest survey was carried out in 1964. When the land on which they stand is required for permanent development, the huts would be cleared and their occupants resettled. The Resettlement Department is primarily responsible for ensuring that the existing surveyed squatter huts are not enlarged and no new structures are erected. The Department is also responsible for resettling the squatters on planned clearances.

237. The Resettlement Department is not, however, responsible for the physical condition and safety of the tolerated squatter areas nor is the Public Works Department

consulted as to the question of safety before toleration of these huts is decided. These areas are visited by officers of the Resettlement Department on routine patrol to prevent the erection of new squatter huts. It is not part of their duty to ensure that the tolerated area or the squatter huts there are safe for occupation. If an officer on his patrol should notice any danger, or receive any complaint of a danger, he would inform the Public Works Department. After a joint inspection of the spot in question by officers of both Departments concerned, the Public Works Department would then take the necessary action to remedy the situation, or alternatively, the squatters may be resettled. In bad weather conditions, e.g. storms, heavy rains and floods, the officers of the Resettlement Department patrol their respective areas once a day and would, if necessary, advise the residents to evacuate the area and move to temporary shelters.

(A) MA SHAN VILLAGE

238. At about 10.30 a.m. on June 16, 1972 a landslip occurred at a cliff behind an unnumbered hut at the end of Hoi On Street, Ma Shan Village. The hut was completely buried in the earth and two men in the hut were killed. The bodies were dug out by fire officers in the afternoon of that day. There were no eye-witnesses of the incident.

239. A few days before the incident, no sign of possible landslip was observed nor was any complaint received during routine patrol by officers of the Resettlement Department.

(B) NAM ON FONG VILLAGE

240. At about 6.30 a.m. on June 16, 1972 a landslip occurred at a cliff at the Village and several boulders fell on to a newlybuilt hut there. A child of four, probably in his attempt to escape from the hut, fell on to the cement floor of the hut, receiving head injuries from which he later died. There was one person injured.

241. Report of the incident was first received by the Police at about 7.11 a.m. and a party was immediately sent to the scene.

242. When the area was visited by a Resettlement Department officer on his routine patrol a few days prior to the incident, there was no sign of a possible landslip, nor did he receive any complaints.

(C) TSIN SHUI MA TAU VILLAGE

243. There were a number of unauthorized huts in the Village. At about 1.00 p.m. on June 18, 1972 a female resident of one of these huts was washed away by the flood and drowned, presumably while trying to reach her home. The flood was probably caused by the choking of drainage-outlets in the rainstorm. There were no eye-witnesses of the incident.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

244. The evidence which we have heard has led us to the following conclusions. Some of these are of a general nature, whereas others are specifically related to particular incidents. For ease of reference we have classified them under these two headings. The order in which they are listed does not imply any order of significance or preference. We also submit our final recommendations.

SECTION 1 CONCLUSIONS

(A) SPECIFIC CONCLUSIONS

(a) Sau Mau Ping

245. This landslip, which occurred in a highway embankment constructed under the supervision of the Public Works Department, forms the subject matter of our Interim Report. The Interim Report was submitted to Your Excellency before the appointment of Mr. Charles CHING as counsel, representing the interests of the victims, at the Inquiry. Mr. CHING asked for the recall of one witness to give further evidence on the Sau Mau Ping disaster, and, in his final submission, he made several references to this disaster. Mr. CHING questioned whether the Sau Mau Ping embankment was constructed in accordance with the specification laid down for its construction; whether the fact that the existing drainage did not allow for rising ground-water was a fault in design; and whether the manner of inspection adopted for such embankments was adequate.

246. Our conclusion with respect to this landslip is contained in the Interim Report. In view of Mr. CHING'S comments it is repeated below for the sake of completeness: -

> "The burst water main, discovered on 22nd May, 1972, could certainly have contributed to the saturation of the underlying soil to a considerable depth and it is likely that the effects of such saturation would not have been fully dissipated before the onset of the rainstorm on 16th June, 1972. However, because of the time interval between these events, and the amount of rain - over 700 mm. - which fell on the area during the period 16th-19th June, 1972 inclusive, the burst water main cannot be considered as a major factor in causing the landslip. The shallow nature of the landslip itself and the absence of any positive evidence to indicate infiltration from utility services, other than that mentioned above, lead us to conclude that the landslip was due primarily to softening of the fill material caused by infiltration of rain-water mainly through the sloping face, as a result of an exceptionally long and intense rainstorm."

247. The Sau Mau Ping embankment was designed in accordance with well-accepted engineering principles for work of this nature when carried out in the tropics. Some of these principles are outlined in Chapter II Section 2(D) of this Report. The

drawings, photographs and the model of the site show that the configuration of the embankment complied with the design particulars. The surface drainage of the embankment slope was done in accordance with normally accepted good engineering practice based on the knowledge available at the time of construction. It was later improved because of its inadequacy to cope fully with the unusually heavy rainstorms of 1966.

248. No formal evidence was presented to us relating to the supervision of construction of this embankment, nor did we ask for such evidence to be produced. In engineering construction work of this nature it is an established fact that any major deficiencies in the construction materials and methods will normally become evident within a relatively short time after completion. It is specifically to allow for any such undetected deficiencies that all good engineering and building construction contracts include provision for a maintenance period following completion, during which period the contractor must make good all defects at his own cost. The contract for Sau Mau Ping complied with this practice.

249. We questioned Mr. G. A. G. SAPSTEAD, the Acting Principal Government Highway Engineer, as to whether any undue road maintenance had to be carried out on Hiu Kwong Street above the embankment during the intervening years following completion of the embankment. He said that there was no record of anything more than normal maintenance. This certainly removed any suspicion of inadequate compaction of the embankment material or noticeable settlement of the embankment itself. Furthermore, as the embankment was subjected to intense rainfall in 1966, it is reasonable to suppose that construction deficiencies would then have become noticeable.

250. Rising ground-water results from saturation of the underlying soil owing to percolation of water through its pores and fissures. The water may percolate through the ground surface in the vicinity of the area in question. But in hillside slopes the source of entry may lie at a considerable distance up the hillside from the area where its presence constitutes a danger. It then flows down by gravity to the lower levels where it may seep through the surface under particular conditions. Further-more, the natural direction of flow of such water may be changed considerably as a result of road and building development along the hillside slopes and the continuing development of the area above the Sau Mau Ping landslip is certainly conducive to such directional changes.

251. While safety must be the dominant consideration in the execution of engineering design, it is universally accepted that in catering for designs to resist the forces of nature, it is impracticable and, indeed, often impossible to cater for all possible contingent forces, if such designs are to remain practicable and economical. We subscribe to this view and in the case of the Sau Mau Ping embankment we have no fault to find with the manner in which the design and construction of the embankment was carried out.

252. Mr. CHING's remaining suggestion on the mode of inspection of slopes of this nature has been dealt with in our recommendations in the Interim Report.

(b) Po Shan Road

(i) *Technical Considerations*

253. "A Report on the Po Shan Landslide" prepared for the Acting Director of Public Works by Mr. A. J. VAIL, which was submitted in evidence before us, is reproduced in Appendix V.

254. As the cause of the landslip, Mr. VAIL has suggested the following combination of circumstances: -

> "(1) The slope and nature of the material in the hillside.
>
> (2) The almost unprecedented rainfall that occurred in May and June of 1972 culminating in the storm of 16th, 17th and 18th June.
>
> (3) The deep cutting in I.L. 2260."

255. This combination of circumstances has been established as "jointly sufficient causes" for the landslip; that is to say, that without any one of them the slip may not have happened or may not have been so disastrous.

256. In our examination of the evidence, we have directed our attention to each of these three circumstances separately and in combination with one another.

257. The evidence submitted both by Mr. VAIL and Mr. EASTAFF indicates that many of the hillside slopes in Hong Kong, particularly those formed of colluvial soil, are in a state of limiting equilibrium. This is evident from the regular recurrence of landslips of varying severity which have always been a feature of life in Hong Kong. To quote Mr. VAIL's statement: -

> "Since the geological processes of decomposition, transportation and deposition will continue, the stability of the hillsides will continue to decrease and further slips will occur whenever there are periods of prolonged or intense rainfall.
>
> "The deterioration of the hillsides can be retarded in selected areas by civil engineering means:
>
> "Slopes can be protected from increased saturation by the provision of surface drainage and of relatively impermeable surface membranes."

258. We do not wish to consider any of Mr. VAIL's statements out of the context in which they were made. Neither do we consider the above statement by Mr. VAIL to represent or to imply any recommendation for whole-sale removal of Hong Kong's existing hillside vegetation in favour of chunam or similar types of impermeable surface membranes. Indeed, were such choice to become a matter for serious consideration, we would have no hesitation in recommending complete restriction of projects requiring large scale earth-works in the areas concerned. In such circumstances reliance should be placed upon well-designed surface-drainage systems aided by internal drainage of the soil mantles forming the slopes. This would minimize the existing risk to life and property at lower levels arising from future landslips which would undoubtedly take place from time to time. It would also preserve the existing natural foliage.

259. The circumstances relating to rainfall have been dealt with, generally, in Chapter II of this Report. No evidence was given in the rainfall records which pin-pointed the Po Shan Road area as one of especially intense rainfall, when compared with other areas of Hong Kong. Hence, no further consideration of rainfall is necessary in this Section of the Report.

260. With regard to the deep cutting in I.L. 2260 Mr. VAIL had this to say in his report: -

> " …. - the excavation in I.L. 2260 was responsible for the location and magnitude of the 9 p.m. landslide and for its catastrophic mode of failure since the excavation effectively removed the toe of this section of the hillside."

261. Because of possible implications arising from this statement, both Mr. VAIL and Mr. S. L. HO were examined at considerable length on this important aspect of the hearings.

262. The history of redevelopment of I.L. 2260 as presented to us is set out in Chapter III of this Report. However, in spite of much testimony and cross-examination the detailed happenings which occurred on this site over the ten-year period extending from 1962 to 1972 remain something of a mystery. Plate 1 shows the approximate nature and character of the site as it existed prior to 1962 when redevelopment work commenced.

263. When questioned on what he meant by "the deep cutting on I.L. 2260", Mr. VAIL explained that this meant the work carried out on the site during 1963. On being asked for an opinion on the photograph shown in Plate 3, which depicted the site as it was in May 1970, Mr. VAIL said that the upper part of the slope was very steep and could be at an angle of between 65^{o} and 85^{o} with the horizontal. On the assumption that the excavation and cutting carried out in 1963 was done in accordance with the approved plans prepared by Mr. NG Chun-man, the authorized architect, he did not believe that gradual erosion caused by weathering over the ensuing seven or eight years could have led to a change of slope angle from 50^{o} to 80^{o} unless landslips of a particular type and location had taken place on the slope itself. He also stated that any steepening and any increase in depth of a given cutting would not only increase the probability of slipping but would also cause a landslip to occur sooner. In his opinion, this would make the landslip, if anything, larger than it would have been if the cutting had not been steepened or deepened. In the Po Shan Road area, where the whole hillside is at an angle of 36^{o} Mr. VAIL's view was that any cutting steeper than 36^{o}, would in fact decrease the stability of the hillside in that area.

264. Apart from the evidence of Mr. VAIL, there was submitted in evidence a technical report on the Po Shan Road landslip prepared by Mr. J. J. SCHOUSTRA, President of Fugro, Inc., Consulting Engineers and Geologists, of Long Beach, California, at the request of Mr. K. K. CHU, of Messrs. Lau, Chan & Ko, Solicitors. The conclusions drawn by Mr. SCHOUSTRA are as follows: -

> "(1) The development of the slide can be attributed to three principal causes:
>
> (*a*) Record rains at the time of and prior to sliding;

(*b*) Removal of support from the toe of the slide at the time of site formation for the original 'Tsuen Won View' homes, many years prior to 1961.

(*c*) Presence of a remarkably thick (70 feet and more) soil mantle over the existing natural slope. This soil would have very little shear strength upon saturation.

"(2) Two secondary causes can be listed:

(*a*) Failure of a block of soil from the toe of the main slide during Typhoon "*Rose*" in 1971.

(*b*) Concentration of large quantities of surface and subsurface water in and around the slide mass.

"(3) None of the site formation activities since 1961 appear to have contributed in any manner to the development of the slide."

265. Further technical evidence requested by us was submitted in the form of comments on Mr. VAIL's report by Mr. P. LUMB, and Dr. C. L. SO. Neither Mr. LUMB nor Dr. SO disagreed significantly with the combination of the circumstances relating to the cause of the Po Shan Road landslip, as set out in Mr. VAIL's report (see paragraph 254).

266. Consideration of all the evidence submitted to us, aided by our own expertise, has led us to conclude that the primary cause of the Po Shan Road landslip is to be found in the combination of the three circumstances enunciated by Mr. VAIL.

267. The first of the three circumstances refers to the slope and nature of the material in the hillside. These are both natural phenomena dictated by time and the elements. But the evidence shows that these phenomena are each undergoing a continuous process of change by reason of decomposition, transportation and migration. Furthermore, it is accepted that the existing natural hillside slopes, where made up of colluvial material, are in a state of limiting equilibrium, since they are not the final slopes of these hillsides. Excavation or cutting of those slopes automatically increases the slope angle and this increases the risk of landslips, however small that increase in risk may be. It is an established fact of engineering knowledge that the greater the area of cutting and the steeper the slopes of the cutting face, the greater will be the risk of a landslip.

268. This raises the question as to whether Government should permit intensive development of those mid-level areas where the soil is of colluvial origin and the hillside slopes are in excess of 35^{o}. We are well aware of the intense pressures brought to bear in Hong Kong for increasing building development to meet the rapid growth in population. We have also noted the evidence submitted to us that the deterioration of the hillsides can be retarded in selected areas by civil engineering means and that retaining walls, if properly designed and constructed to withstand the forces involved, can be used effectively to replace existing earth supports.

269. The second of the three circumstances refers to rainfall. This again is a

natural phenomenon. Probabilistic estimates of recurrence periods for extreme rainfalls of different durations in Hong Kong have been made by the Royal Observatory, Hong Kong, since 1965. They have been available in published form as R.O. Technical Memoir No. 10 since 1968. Irrespective of the availability of such estimates in published form it is a known fact of life that Hong Kong is an area subjected to very heavy and prolonged rainstorms at relatively frequent intervals and that landslips of varying sizes arising from this cause occur almost annually.

270. The third of the three circumstances refers to the deep cutting. To have left a major cutting on I.L. 2260 unsupported and virtually unmaintained over a period of more than seven years has, in our view, been courting disaster. While it is true that this excavation and cutting was planned and directed by Mr. NG Chun-man in 1963 for the Linton Investment Co., Ltd., responsibility for its deterioration and lack of support during the ensuing years must rest on the shoulders of Mr. S. L. HO and on the owners of the site.

271. In this connection, apart from that of Mr. VAIL, expert evidence was also received from Mr. J. J. SCHOUSTRA and Mr. K. A. PHILLIPS.

272. Mr. SCHOUSTRA stated in his written evidence that "none of the site formation activities since 1961 appear to have contributed in any manner to the development of the slide". In support of this contention he put forward as one of three principal causes for the slip the "removal of support from the toe of the slides at the time of site formation for the original 'Tsun Won View' homes" which are shown on Plate 2. Mr. SCHOUSTRA evidence assumed that the initial slip, which took place on June 17, 1972, surfaced at an elevation above 500 feet P.D. and possibly as high as 530 feet P.D. and that the surface of failure for the main slip broke out of the slope at about the same elevation as the initial slip of June 17. His concept of how the failure might have occurred is depicted in Appendix XVIII, extracted from his report. Mr. VAIL's opinion on the possible location of the failure surface is shown diagrammatically in Appendix XIX which is an overlay of the diagram attached to his report. On this overlay he had shown the positions of boreholes B7 and D1 in relation to the slip profile, noting in his evidence that while these holes were not on the actual section depicted in the Figure, their distances from Conduit Road were accurate. According to Mr. VAIL, a piece of asphalt, probably a fragment of the Po Shan Road surfacing, was encountered in borehole B7 at elevation 479 feet P.D., and a piece of uncorroded steel in borehole D1 at elevation 469 feet P.D., indicating slipped material at least to these depths at the locations concerned.

273. Mr. K. A. PHILLIPS, a resident partner of Messrs. Scott Wilson Kirkpatrick & Partners, Consulting Civil and Structural Engineers, Hong Kong, submitted comments on various technical reports, including those of Mr. VAIL and Mr. SCHOUSTRA, at the request of Messrs. Lau, Chan & Ko, Solicitors. Mr. PHILLIPS' concept of the mechanism of failure of the Po Shan Road landslip is given in Appendix XX. In support of his views he advances the following reasons: -

> "It is presumed that the steep face at the rear of I.L. 2260 suffered a rotational failure which, remarkably, did not totally collapse into I.L. 2260 early on 17th June. The toe of the slip is shown at the base of the steep face because to take the toe further north, say at or under the sheet piling, almost certainly would increase the restraining force more than it would increase the overturning force.

> Furthermore it accords with the evidence that the sheet piling rotated northwards due to 'slipped' material pushing it over at the top. It is not clear why the slope did not collapse entirely on the morning of 17th June, but the sector of ground that had moved must have remained delicately poised for the further 36 hours.
>
> "Once the sector north of Po Shan Road had failed vital support to the natural slope south of the road must have been lost. This slope, which like all surrounding ground at 37^{o} would have had a factor of safety decreasing towards unity (i.e. failure) as the rains continued, must have been subject to further strains. By now it must have been just a question of time before the factor of safety of the slope above (i.e., south of) Po Shan Road would arrive at unity. When this occurred at 20.50 hours on 18th June the mass of earth must have slid into the delicately poised sector of ground ahead of it after which they crashed forward together."

274. In his comments on Mr. SCHOUSTRA'S conclusions Mr. PHILLIPS considered that Mr. SCHOUSTRA's third conclusion "appears to be too sweeping".

275. Both Mr. SCHOUSTRA and Mr. PHILLIPS showed the probable failure surface breaking the surface of the ground south of the sheet pile wall. Their arguments for a failure surface emerging in this area hinged primarily on the fact that, prior to collapse, the sheet piling rotated northwards due to pressure from the "slipped" material pushing it over at the top.

276. Mr. VAIL, on the other hand, showed the failure surface as breaking the surface at the toe of the slope which he had diagrammatically shown as extending down almost to the level of Conduit Road in spite of the evidence relating to Mr. NG Chun-man's site formation work and Mr. S. L. HO's written statement that the only general excavation on I.L. 2260 carried out by Tai Shun Construction Company comprised "levelling of the site from Conduit Road to about 60 feet inward".

277. Under cross-examination Mr. VAIL said, "I think the sheet piles wouldn't have influenced where the slip daylighted at all. They are such flimsy things ….".

278. If Mr. HO's evidence on the limit of excavation undertaken is assumed to be correct, that obtained from boreholes D1 and B7 which were located over 75 feet in from Conduit Road supports Mr. VAIL's contention. Furthermore, the excavation carried out immediately to the north of the sheet pile wall for the purposes of constructing the proposed retaining wall would create a local plane of weakness within the soil mass allowing initial tilting of the sheet piles as part of a more general movement. An additional consideration which must also be taken into account is the fact that in the ensuing rescue and remedial works pieces of sheet piling were found in the landslip debris as far north as Kotewall Court and even below this level. One can only infer that these pieces must have formed part of the sheet pile wall at I.L. 2260.

279. Taking into account all the above factors and considerations and using our own expertise, we accept Mr. VAIL's concept of the failure surface.

280. We have considered all the evidence submitted in relation to the structural design and the strength of materials used in Kotewall Court. This evidence indicates that some of the materials used in the structure were of lower strengths than those specified in the design specification. Nevertheless, these deficiencies were relatively minor in character. The structural design was executed in an acceptable manner and was capable of resisting the normal forces which are to be expected on a building of this nature. We have no fault to find with the manner in which Kotewall Court was designed and constructed and we conclude that its collapse was the result of impact of forces which were beyond the bounds of any reasonable expectation. We are of the opinion that even if the building had been satisfactory in every respect it could not have withstood the force of the landslip.

(ii) *Rescue Operations*

281. The rescue operations presented special difficulties: -

(1) The material from the slip was at first in a semi-liquid state and remained very wet and soft for a long period.

(2) There was therefore no prospect in the first instance of reducing the level of this material at Kotewall Road, the only possible point of entry for heavy plant.

(3) In any event, any attempt to do this would necessarily have severely interfered with the rescue operations being conducted from this level.

(4) While the concrete in the building had failed in many places because of the collapse, the reinforcement had remained intact, leaving "pockets" within the wreckage. Large scale dismantling and clearance were therefore impracticable in the initial stages.

(5) Owing to instability of the wreckage and the surrounding area, the number of rescue workers who could work there was limited. To exceed this limit would have endangered the workers as well as the victims.

(6) The presence of gas at the early stages prevented the use of electrical and mechanical equipment.

282. We are satisfied that the tools and equipment used by the Fire Services Department for rescue work were suitable and in sufficient supply. These are listed in Appendix XXI.

283. Heavy equipment could not be used at the Kotewall Road level of the wreckage because of instability of the ground and the possible danger of further slips. They could not be used at the bottom level of the wreckage because of the limited headroom of entry already referred to. With persons still trapped in the wreckage, the danger of injury or mutilation by heavy equipment is obvious. Experience shows that such rescue operations can usually be carried out more effectively by hand and with small tools. It would be highly dangerous to disturb a collapsed building with people trapped inside because of the possible

train of consequences. The building, therefore, must be dismantled in small pieces with the minimum disturbance of the wreckage mass. In the present situation, the combination of adverse circumstances made rescue work well-nigh impossible. We are therefore satisfied that the decision not to use heavy equipment in the early stages was correct.

284. The Army and the Police placed themselves under the command of the fire officer in charge. There were frequent meetings between them to plan operations, and liaison and co-ordination was efficiently maintained between these services throughout the relevant period. We consider that there was at all times close co-operation between the services which took part in rescue operations.

285. We are further satisfied that the decision of the Fire Services not to use electrical and mechanical equipment in the presence of butane gas and towngas was correct. Though there was no leaking gas as such in the area, it was evident that residual gas in the pipes escaped during the night of the disaster. In theory, where the atmosphere is mixed with towngas and air, the possibility of explosion is dependent upon the relative proportions of gas and oxygen present. In the opinion of the Senior Distribution Engineer of the Gas Company, as there was but a small quantity of residual towngas at low pressure within the pipes, the danger of an explosion in an open area was extremely unlikely, despite the strong smell of gas. However, he was of the view that butane gas, being heavier than air, would settle into crevices in the wreckage, thereby causing danger. The fire officers who were obliged to make a spot decision considered that the presence of butane gas and towngas, particularly within the crevices of the wreckage, made it dangerous for electrical and mechanical equipment to be used. It was a difficult decision to make, and one which did not permit the slightest miscalculation. We approve of the decision of the Fire Services.

286. Taking all the circumstances into account, we consider that the lack of liaison between the Fire Services and the Gas Company mentioned earlier, regrettable though it may be, did not affect the result of the rescue operations.

(c) Shiu Fai Terrace (Wan Chai)

287. Leaving aside the question as to what constitutes an acceptable risk for work similar in nature to that at Shiu Fai Terrace, the tragic events of June 16-18, 1972 leave no doubt that the landslips which occurred during this period resulted from excessive cutting into the hillside at slopes steeper than could be sustained by the natural ground when saturated with moisture from the unusually heavy rainstorms which occurred.

288. Based on the evidence submitted to us, we find that for cuttings extending up to 130 feet high, at slope angles of 50^{o} and more, in decomposed granite material, as occurred at Shiu Fai Terrace, the investigations upon which this site formation work was based were insufficient to ensure an adequate margin of safety against collapse, bearing in mind the climatic conditions of Hong Kong.

(d) Incidents in Other Areas

(i) *Ap Lei Chau*

289. This incident, in our view was an unfortunate collapse of a natural slope owing

to natural causes with no construction implications.

(ii) *Belcher's Street (Western District)*

290. We find that this collapse occurred as a typical rockfall which is liable to occur in steeply-sloped cuttings in partly-decomposed rock, following periods of intense rain. It forms one of the natural hazards which have to be accepted by people who dwell or work beneath such cuttings.

(iii) *Bullock Lane (Wan Chai)*

291. The evidence submitted on the engineering aspects of this landslip was incomplete. On balance, we find that the landslip was partly caused by cutting into the existing slope to allow unauthorized extension of the property known as 4, Bullock Lane, combined with the presence of a defective drain higher up the slope. No evidence was submitted to indicate whether the drain had been rendered defective as a result of the building extensions or not.

(iv) *Chai Wan*

292. The evidence submitted on this case showed that it was a drowning fatality owing to flooding arising from the blockage of a catchpit at the end of Sui Man Road. This blockage was due to debris such as baskets washed down from the squatter areas upstream during the heavy downpour. Beyond noting with satisfaction the present campaign by Government to "Keep Hong Kong Clean" we have nothing to say about the construction aspects related to this fatality.

(v) *Shau Kei Wan*

293. Three separate incidents occurred in this area involving demolition of two huts with consequent loss of life, and one drowning fatality. Both huts were built very close to the foot of an abandoned quarry face without due regard to the danger of landslips and falling boulders. With regard to the drowning fatality our comments on the Chai Wan incident also apply here.

(B) GENERAL CONCLUSIONS

(a) Hillside Excavation

294. Based on the evidence before us and on our own expertise, we are in no doubt that any excavation or cutting made into the hillside slopes of Hong Kong carries with it an implied risk of a landslip occurring as a result of these operations, however small that risk may be. Among many factors which tend to aggravate the risk of collapse at any one particular site, mention must be made of the following: -

(1) increasing area of cutting-face;

(2) increasing angle of cutting-face with the horizontal;

(3) increasing height of cutting-face;

(4) inadequate support of cutting-face and

(5) increasing time over which cutting-face is unsupported or inadequately supported.

(b) Consideration of Construction Operations

295. In Chapter II of this Report we pointed to the significance of the association of landslips with man-made excavations, cuttings and embankments. In all but one of the landslips which we have considered, such association was evident. There is no doubt in our mind that in each and every case examined human activities played some part in causing the landslips to occur.

(c) Seismicity

296. Evidence submitted to us showed that there was no significant earthquake tremor in Hong Kong during the period June 16-18, 1972. We find, accordingly, that earthquake shocks had no bearing on the landslips forming the subject matter of this Inquiry. Furthermore, based on the more general evidence on earthquake tremors experienced in Hong Kong, and presented to us, we do not consider that earthquake risk need be included in our general recommendations.

(d) Rescue Operations

297. We are of the view that all those who took part in rescue work, particularly the Fire Services, the Police and the Army merit commendation for the courage, zeal and efficiency with which they discharged their respective duties. We are satisfied that everything that could be done to rescue the victims and recover the dead in the shortest possible time was done by all rescue workers.

SECTION 2 RECOMMENDATIONS

(A) SAFETY OF SQUATTER AREAS

298. With reference to what we have said in paragraphs 236 and 237, we appreciate that because of the nature of the general topography of Hong Kong and the location of many squatter areas in relation to this topography, it would be an impossible task for Government to ensure the complete safety of these areas against the effects of landslips and rockfalls. Nevertheless, we *recommend* that both the Resettlement Department and the Public Works Department should continue to act on complaints about possible dangers in existing squatter areas. In addition, regular inspections of these areas should be made by experienced engineers to watch out for possible danger spots and to take action when necessary to alleviate such danger.

299. We appreciate that the frequency and the degree of thoroughness of such inspection depends on the manpower and other resources available, and we *recommend* that

Government should consider increasing such resources of the relevant departments if necessary.

(B) LIGHTING EQUIPMENT FOR RESCUE WORK

300. In connection with rescue work, and with reference to what we have said in paragraph 146, we recommend that the Fire Services Department, the Public Works Department and the Royal Hong Kong Police Force be provided with connecting cables of adequate length to ensure that generators for heavy lighting equipment may be placed at a safe distance from an area affected by gas. This would also have the advantage of preventing the noise created by such generators from drowning possible victims' cries for help.

(C) BUILDING DEVELOPMENT

301. We are of the opinion that the risk of landslips in Hong Kong arises more from deficiencies in supervision and control of works than from deficiencies in design. Because of this we do not recommend the formation of a special panel of civil engineers who would be authorized to deal specifically with earthworks problems as suggested by Mr. VAIL. Adequate expertise on such matters is already available in Hong Kong even though it may not be utilized to its fullest extent. We consider the control measures recommended below, if implemented properly, will provide adequate safeguards against recurrence of the disasters of June 1972.

(a) Abandoned Quarries, Rock Cuttings and Faces

302. Short of *recommending* that no one should be allowed to live at the foot of abandoned quarries, and, in particular, rock cuttings and faces which are badly fissured and show evident signs of water seeping through these fissures at various times, there is little we wish to say with regard to such hazardous areas.

(b) Underground Pipes

303. In all ground susceptible to settlement or soil creep we *recommend* that water service mains, particularly those carrying water under high pressure, should be constructed of materials which are not of a brittle nature and thus particularly liable to fracture arising from differential movement of the soil.

(c) Soil Engineering

304. We *recommend* the setting up of an appropriate unit of the Public Works Department as enunciated in Mr. VAIL's Recommendation No. 4 (Appendix V), and carrying the following responsibilities and duties: -

(1) to carry out a geological and topographical study of those inhabited parts of the Colony in which landslips are likely to occur;

(2) to conduct a comprehensive soil investigation of the potential landslip areas of the Colony determined from the study in (1);

(3) to inspect regularly all potential landslip areas with particular regard to retaining walls, slope protection and the repair and maintenance of drainage channels and water courses;

(4) to consider and implement any measures to improve the stability of dangerous hillsides overlooking populated areas;

(5) to consider the site investigation and foundation proposals of prospective developers in all potential landslip areas;

(6) to be empowered to ensure that all excavations in sloping areas are fully protected and are completed without delay;

(7) to review the foundation design of all existing structures in potential landslip areas and recommend any improvements necessary;

(8) to patrol on a 24-hour basis all potential landslip areas during periods of prolonged or intense rainfall and to advise the immediate evacuation of areas in danger.

(d) Modifications and New Leases

305. Where new leases or lease modifications, which calls for extensive site formation, are granted by Crown Lands and Survey Office, we *recommend* that, to ensure that site formation proceeds with the minimum of delay, a building covenant be incorporated in the terms and conditions of the lease or its modification which relates specifically to site formation.

(e) Enforcement and Maintenance

306. We accept the information contained in paragraph (7) of Circular Letter No. 27 (see paragraph 26) as a reasonable basis for design of cuttings pending the availability of additional information and techniques. We *recommend* its rigorous enforcement and, furthermore, we *recommend* that all such cutting work should be programmed by the authorized architect and approved by the Building Authority so as not to expose large and dangerous cutting faces during the accepted wet seasons.

(f) Land Policy

307. We *recommend*, irrespective of what has been recommended above, that Government immediately review its current land policy with a view to decentralizing the urban areas and utilizing some of the flat land in the New Territories for this purpose. This is to be preferred to further exploitation of hilly terrain involving large scale cuttings and excavations.

(g) Implementation

308. We appreciate that our recommendations involve an expansion of Government services by way of recruitment and training. We do not wish our recommendations to be

deferred because of difficulties arising from these causes. We *recommend* therefore, that Government engages suitable expertise from outside sources on contract basis to ensure that no undue delays are encountered in implementing our recommendations.

CHAPTER VII

ACKNOWLEDGEMENTS

309. We would like to express our gratitude to all those members of the public who gave or offered to give evidence or statements, or otherwise provided photographs to assist us in our Inquiry. We would also like to thank the Honourable the Chief Justice for providing the place and staff for the public hearings.

310. We are particularly indebted to Mr. J. G. STEAN and his staff for the technical and historical evidence presented on Po Shan Road and Shiu Fai Terrace. This evidence was prepared comprehensively and systematically, and with admirable dispatch. Without it our work would have been greatly prolonged and made more arduous.

311. We cannot conclude our report without also paying tribute to our legal adviser, Mr. R. G. PENLINGTON, assisted by Mr. P. NGUYEN, and to all counsel and solicitors who appeared before us, for the care and thoroughness with which they presented and tested the evidence. Thank are also due to our secretary, Mr. Y. C. MO, who has ably discharged his onerous duties with considerable conscientiousness and celerity.

T. L. YANG
Chairman

SEAN MACKEY

ERIC CUMINE

Y. C. MO
Secretary

November 28, 1972

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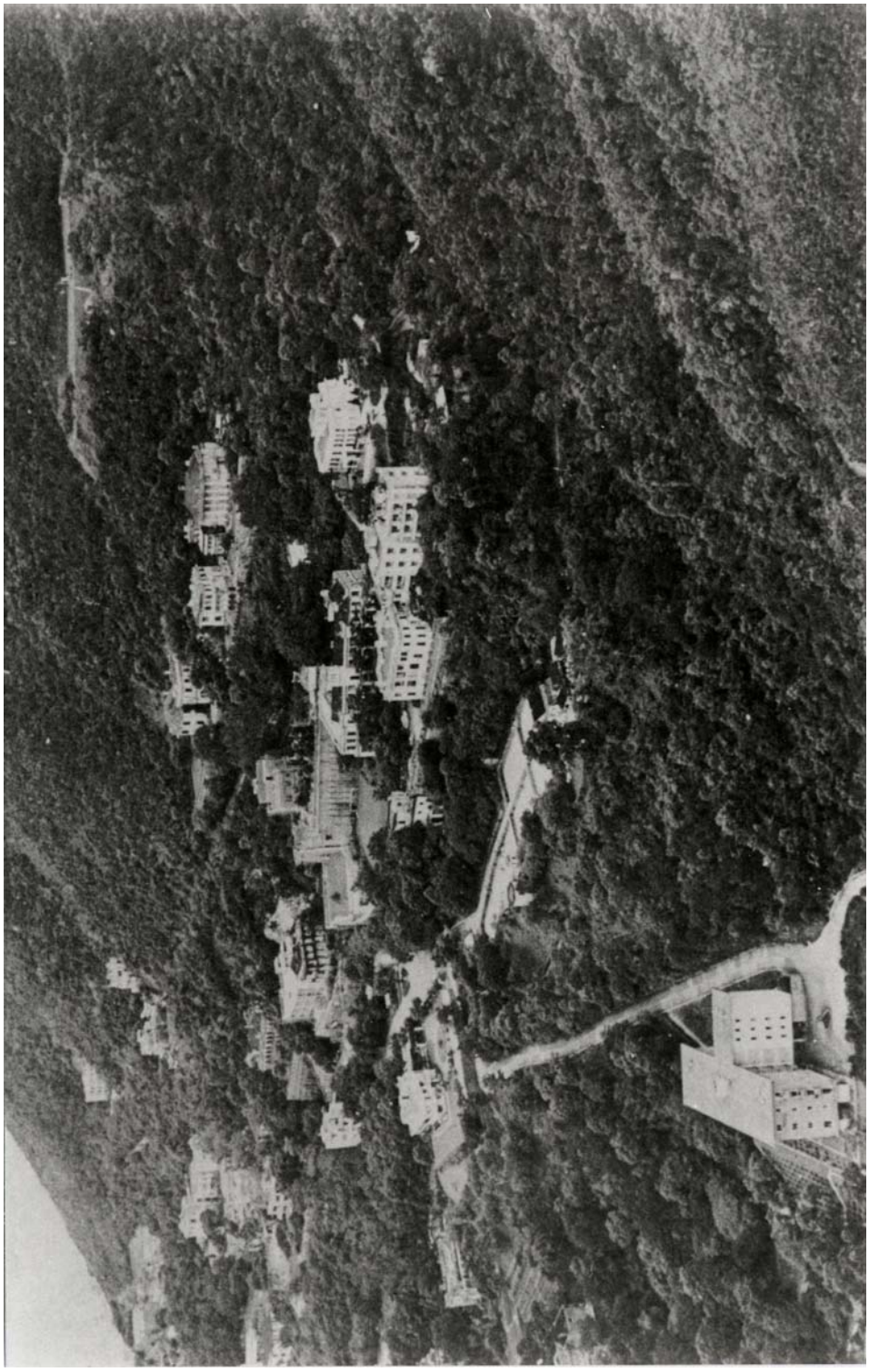

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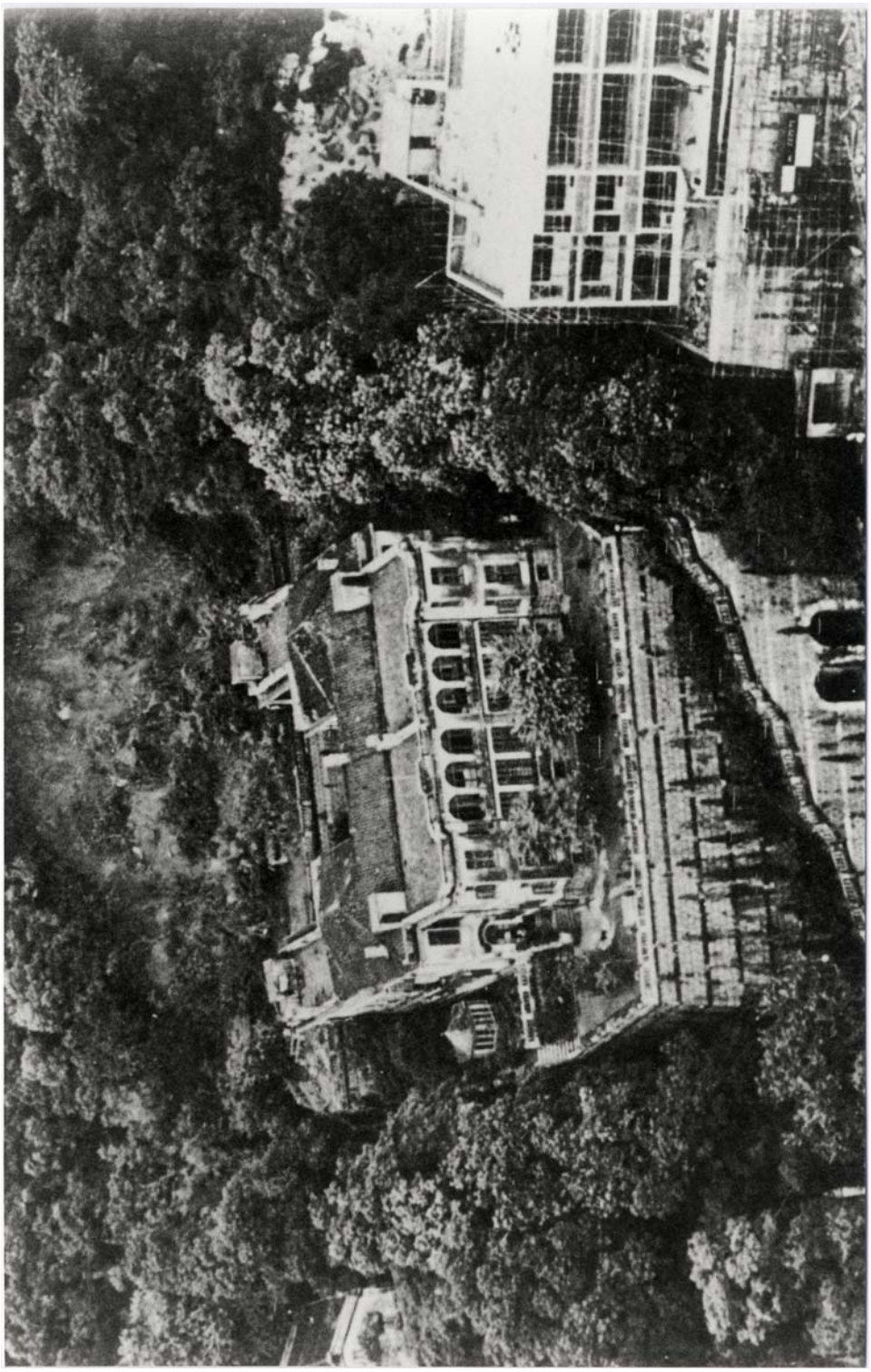

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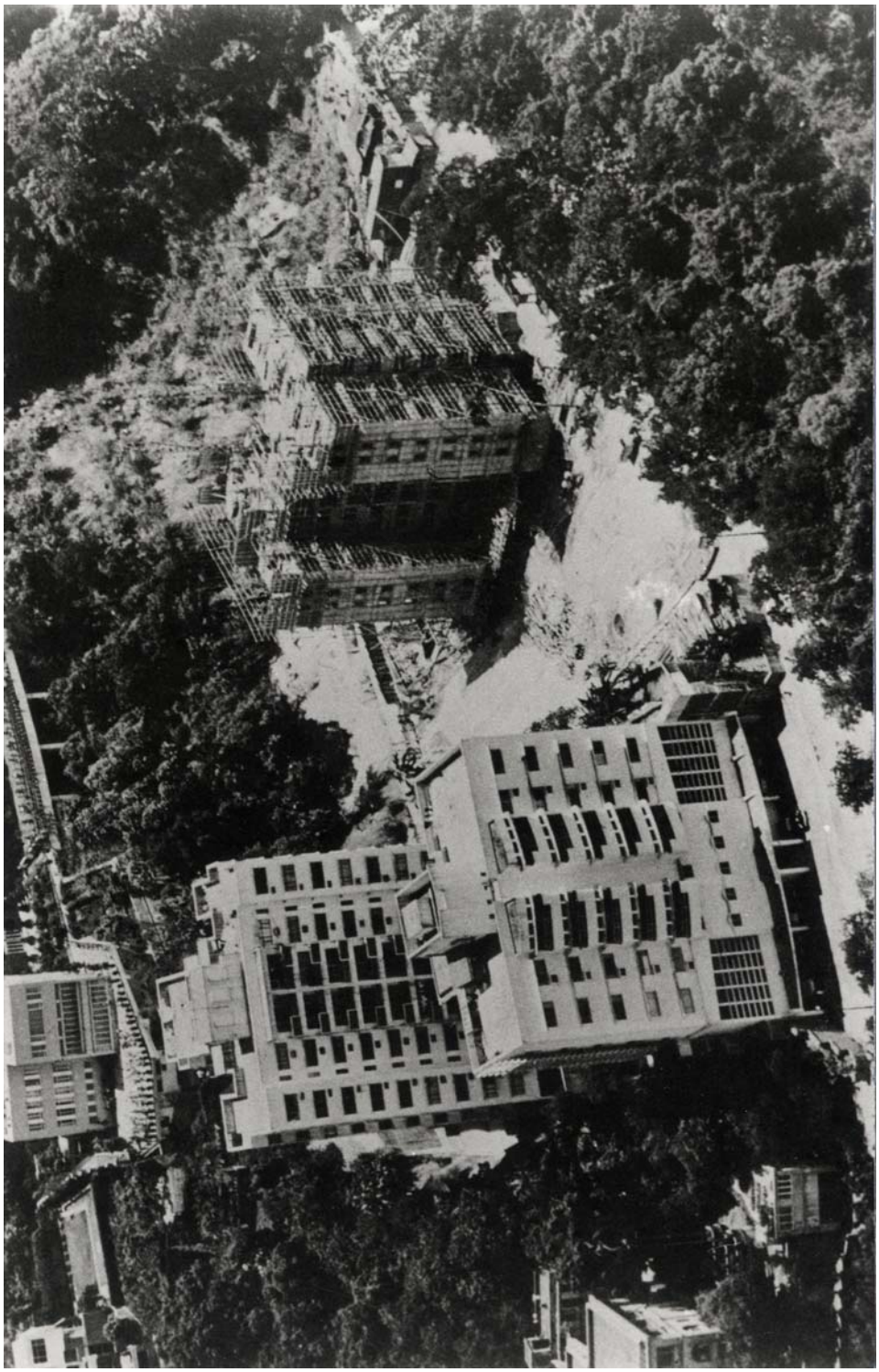

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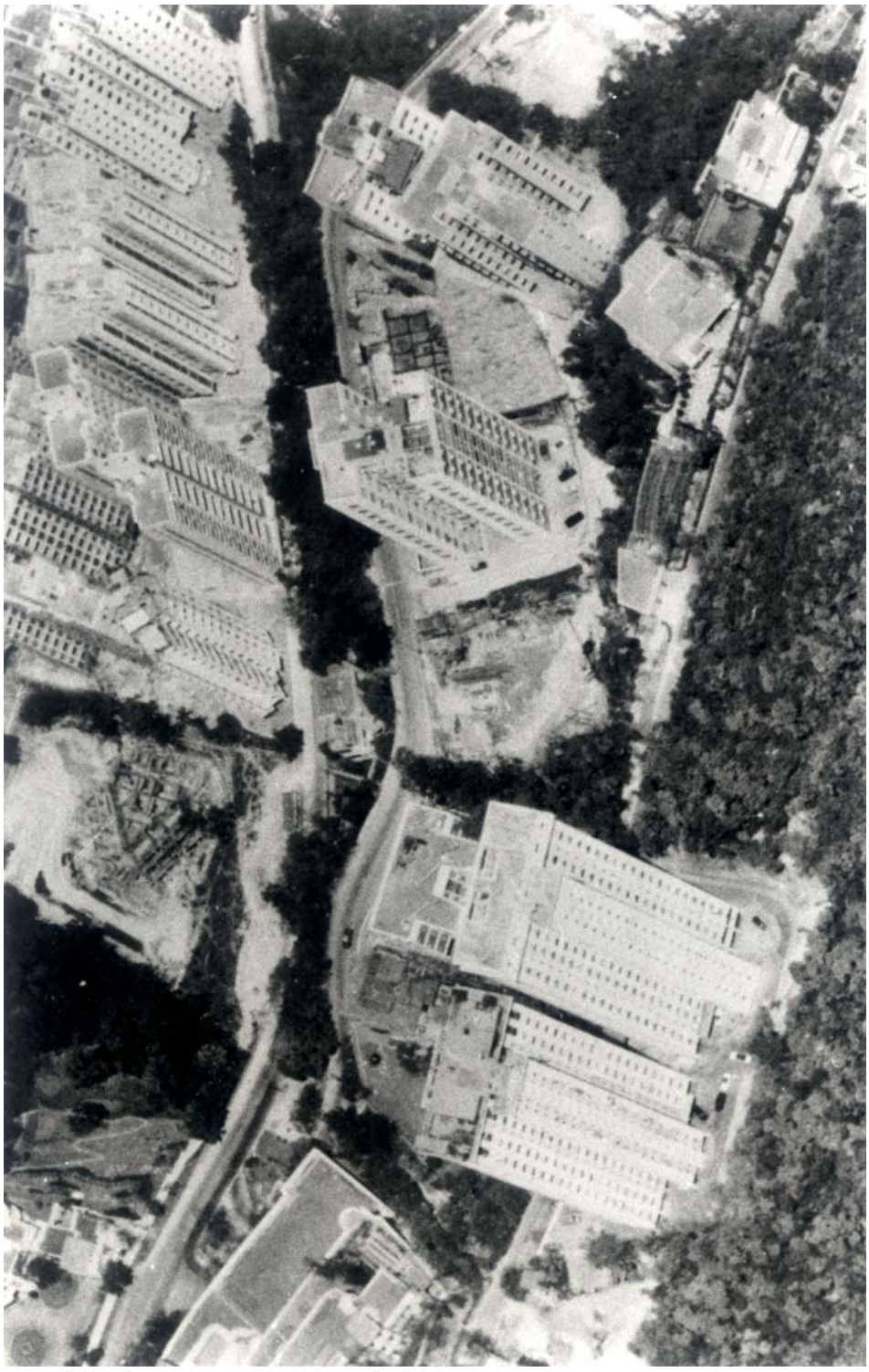

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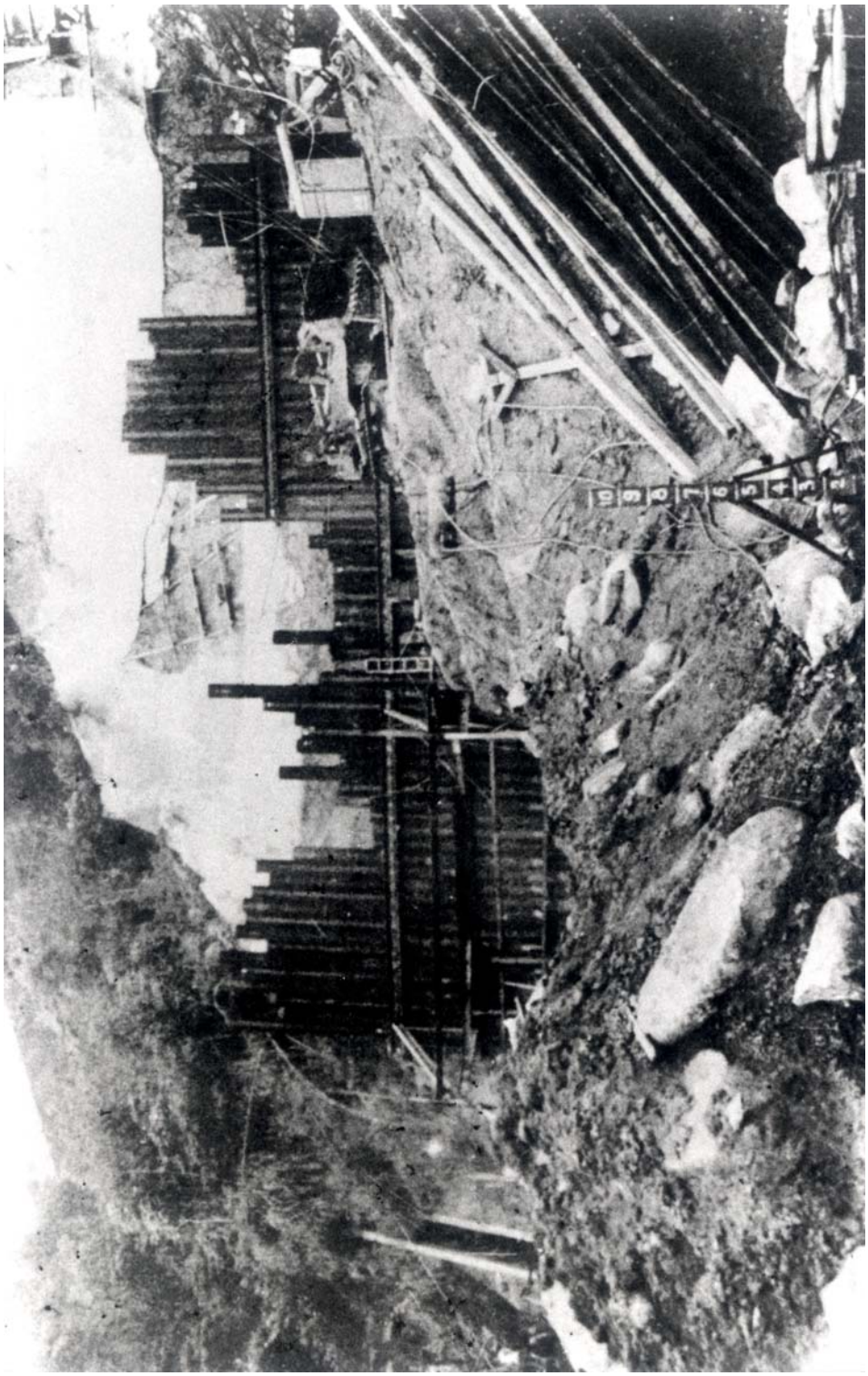

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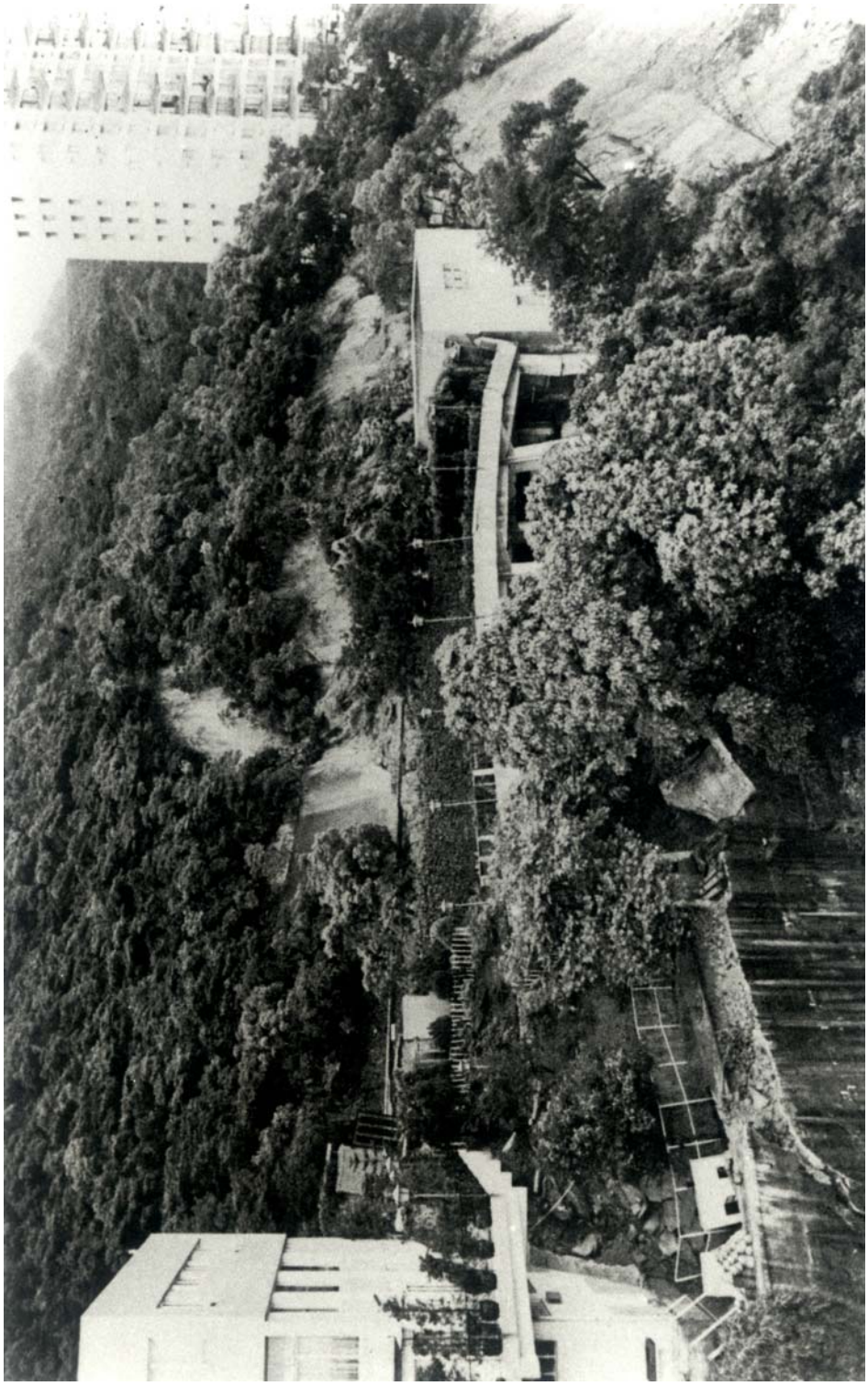

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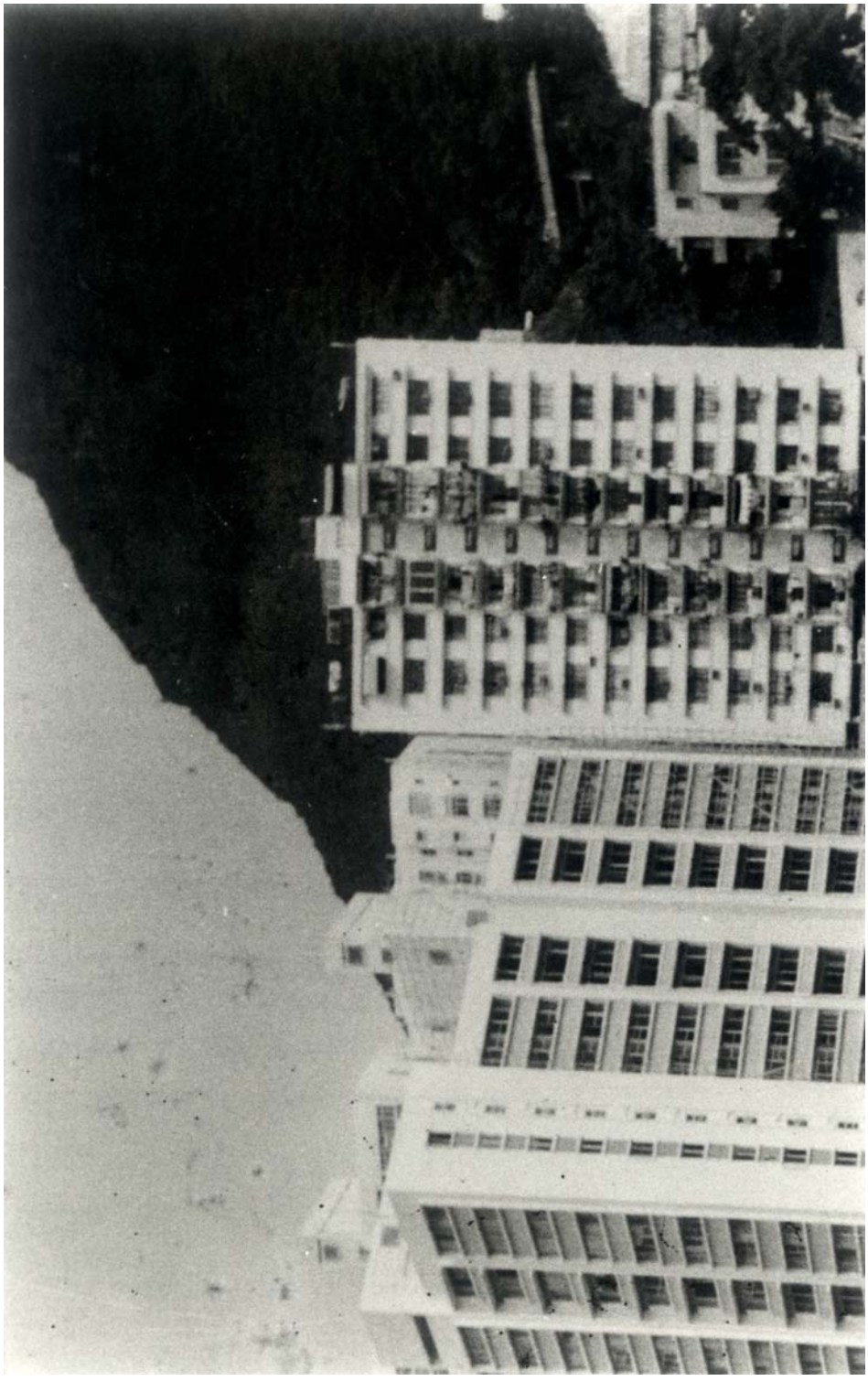

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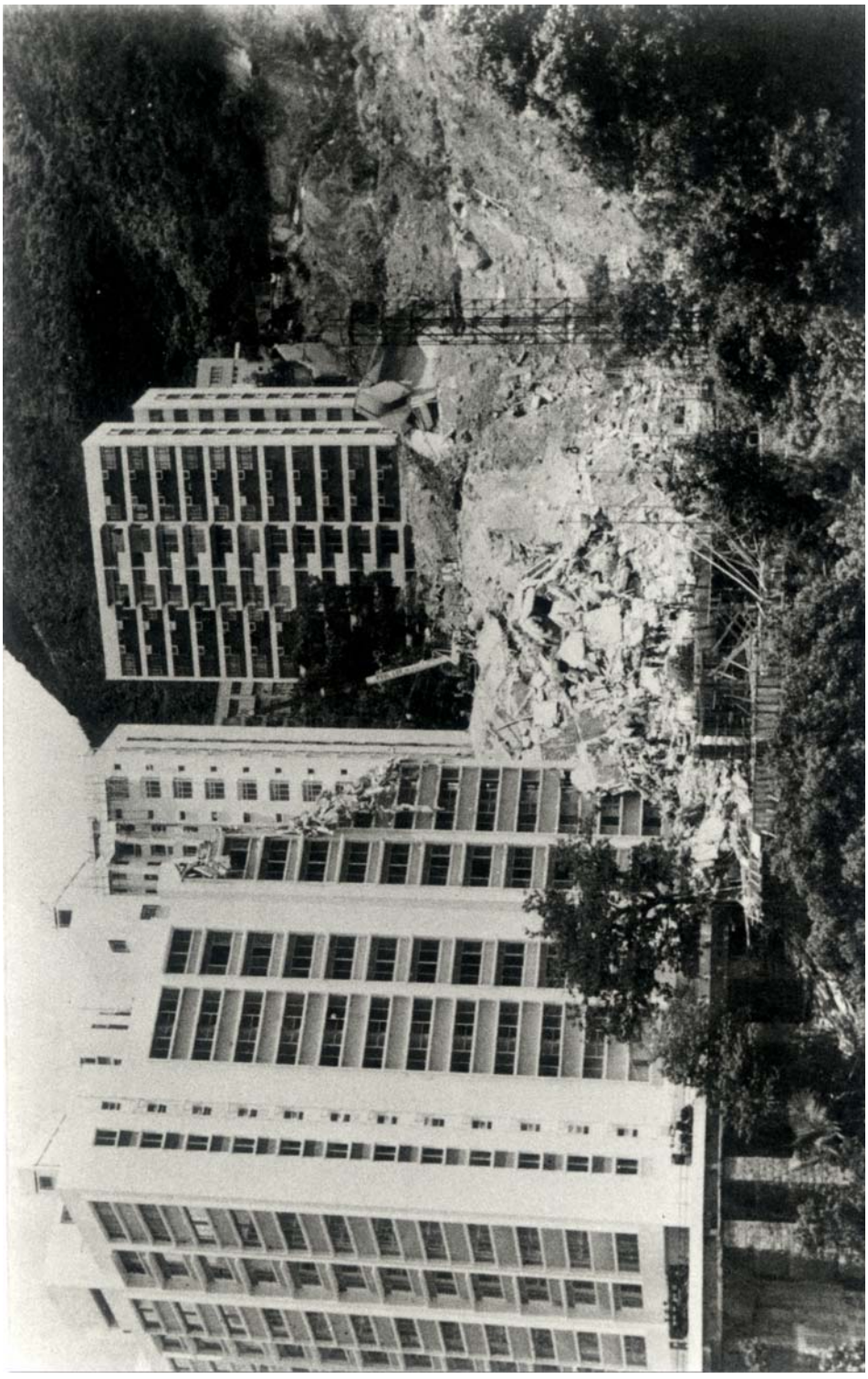

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LIST OF WITNESSES

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76	A. STEVENSON-HAMILTON
77	Rab NAWAZ
78	LEUNG Fong-chee
79	YUEN Yu-choi
80	J. G. MANSELL
81	D. M. HOLDROYD
82	R. A. PORTER
83	K. P. CLARK
84	L. POWER
85	M. A. TURNER
86	G. S. SHIRRA
87	H. L. ELSWORTH
88	L. WORRALLO
89	F. JACKSON
90	M. K. LANE
53	KWAN Sai-yiu (recalled)
91	LO Hing-cheung
92	A. S. CONWAY
93	CHEUNG Shu-shing
48	S. M. ELCOCK (recalled)
94	LO Shiu-kuen
95	J. A. HIGGINS
96	A. T. W. DUNCAN
97	CHAN Chun-ying
98	G. FAIRHURST
99	A. J. VAIL
100	HO Shiu-lai
101	SHUM Dai-chung

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103	LEUNG Man-kwong
104	David AKERS-JONES
105	CHAN Yan-wing

ON THE INCIDENTS AT SHAU KEI WAN

46	CHENG Wu-chow (recalled)

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158.2 Photostat copy of photograph of light projector used by the Police
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ON METEOROLOGICAL DATA

229. Further statement from G. J. BELL (1)

APPENDIX III

LIST OF THE PERSONS/PARTY WHO SUPPLIED OR OFFERED TO SUPPLY PHOTOGRAPHS TO THE COMMISSION

1. CHAN Tak-shun
2. E. M. CRAWFORD
3. P. A. DAVIES
4. Alex K. Y. LEE
5. Kenneth LOO Pok-wing
6. Miguel de MARTINI
7. F. C. MERRILL
8. Fernie PEREIRA
9. Gerhard F. SIMMEL
10. Michael SMITHIES
11. South China Morning Post Ltd.
12. Henry STEINER
13. Clifford K. K. SUN
14. J. M. TABERNACLE
15. Mrs. Joan TEMPLEMAN
16. S. C. THOMPSON
17. Edward VISSER
18. Conway C. W. WONG
19. Walter C. S. YEN

APPENDIX IV

LIST OF REFERENCES

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APPENDIX V

A REPORT ON THE PO SHAN LANDSLIDE

BY

A. J. VAIL

THE COMMISSION OF ENQUIRY

INTO

THE RAINSTORM DISASTERS OF JUNE 1972

*** * ***

A REPORT ON THE PO SHAN LANDSLIDE

BY

A. J. VAIL, B.Sc., F.I.C.E., F.I.W.E., F.I.E.(M).
of Binnie & Partners, Consulting Engineers

for and on behalf of

THE PUBLIC WORKS DEPARTMENT

GOVERNMENT OF HONG KONG

SEPTEMBER 1972

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INTRODUCTION

On 24th July 1972 Binnie & Partners (Hong Kong) were asked by the Acting Director of Public Works to provide specialists to advise on the technical aspects of the Po Shan Road landslide.

On 26th July I arrived in the Colony and was joined on 27th by Mr. D. J. EASTAFF, Chief Geologist of Binnie & Partners, Westminster.

We flew over the area of the landslide by helicopter with representatives of the Public Works Department and later toured the site on foot.

On the following days we had discussions with the P.W.D. and I prepared a Preliminary Report for the Director of Public Works, recommending certain short term and long term remedial measures.

Mr. EASTAFF left the Colony on 29th July but before his departure he prepared a brief description of the geology of Hong Kong for the preliminary report and this is attached as Appendix A to this present report. Following further discussions at P.W.D. Headquarters I was asked to prepare for the Commission of Enquiry into the Rainstorm Disasters of June 1972, a report on the causes of the Po Shan landslide and the measures necessary to prevent similar disasters.

In order to prepare this report I have read the relevant sections of the transcript of evidence presented so far to the Commission and have studied the borehole logs, samples collected and the results of soil tests carried out by the P.W.D. in the area of the slide and the hillside above.

THE GEOTECHNICAL PROBLEMS OF HONG KONG

In order to understand the geotechnical problems of Hong Kong it is necessary to study the geology of the Colony and the manner in which the igneous rocks of which it consists are decomposing.

The Geology of Hong Kong has been discussed by P. LUMB (1965)* and a further brief description by D. J. EASTAFF is appended to this report. Figure 1 shows diagrammatically a section typical of many parts of Hong Kong Island and the New Territories.

The decomposition of the rock, which occurs at the surface and along joint planes, produces silty and clayey material containing many boulders at an earlier stage of decomposition and, near the peaks of the hills, these tend to creep down the face of the parent rock as colluvium (slopewash) to take up more stable slopes in or near the sea.

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* "The Residual Soils of Hong Kong" P. LUMB Geotechnique June 1965.

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The slope of the hillsides formed by the insitu decomposition of the bedrock and the overlying colluvium from the peaks can be as steep as 36° from the exposed fresh rock of the peaks to a level of approximately 500 ft P.D. and at this level there is a well defined change of slope to about 18°.

The process of decomposition of the igneous rocks is continuing through geological time as is the migration of the colluvium down the hill slopes towards the sea. By the very nature of the process, colluvium is potentially unstable and it follows that any disturbance of the slope or any unusually severe conditions will accelerate the process of migration. Evidence of this in the form of slips in the hillsides has been apparent since the Colony was first inhabited.

THE STABILITY OF NATURAL EARTH SLOPES

The stability of any natural slope in soil is affected by three main factors:

(1) The angle of the slope.

(2) The degree of saturation of the soil.

(3) The pore water pressure within the slope.

The effect of these factors can perhaps best be illustrated by examining the stability of an idealized slope as shown in figure 2.

The mode of failure of a homogeneous slope approximates to a rotational slip which is three dimensional in nature but which is illustrated here for simplicity in two dimensions.

If we consider an element of soil of unit weight W distant x from the centre of the potential slip circle being examined we can say that the disturbing moment of that element is being resisted by the shear strength of the soil along the base of the element multiplied by the distance R of that surface from the centre of the circle.

Neglecting the forces between the elements of soil making up the slice, which are secondary, one can also state that the factor of safety of the slope against failure *along this particular circle* will be

$$F = \frac{\sum SR}{\sum Wx}$$

Where S is the Shear Strength of the soil in the Coulomb equation:

$$S = C + W (1 - r) \tan \varnothing$$

and:

C = Cohesion of the soil

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r = Pore pressure ratio at the failure surface

∅ = Angle of internal friction of the soil.

Examining this equation, we can see that, in a cohesionless material such as a clean sand where C = 0, the shear strength S depends entirely upon W and as this increases linearly with depth the factor of safety depends only upon the angle ∅ or, in other words, the radius of the circle becomes infinite and the stability of the slope is independent of height. This is demonstrated by a pile of sand which fails by surface sloughing and has constant side slopes regardless of the height of the pile.

In a cohesive material where ∅ = 0, the shear strength depends entirely upon the cohesion and as this is independent of depth, the failure circle will have a very small radius and the stability of the slope will depend upon its height. This explains why a 20 feet high slope in clay might be stable where a 40-foot slope in the same material would not.

In nature, most soils have both cohesion and internal friction and this is certainly true of the residual soils of Hong Kong which are variable. Soils derived from the volcanics have rather less shear strength than those derived from the granites.

The actual shape of natural slip surfaces will rarely be circular but will be affected by the fact that no soils are in fact homogeneous and will fail along weaker planes and in weaker zones.

The effect on the stability of a slope of the three factors, slope, saturation and pore pressure can be readily seen from figure 2: -

As the angle of the slope increases, so the summation of the disturbing moments Wx increases and the factor of safety is reduced.

An excavation at the foot of a slope will not only effectively increase the slope by altering the inclination of the incipient failure surface but will reduce the distance over which S can act, again reducing the factor of safety.

The residual soils in Hong Kong are, for the most part of the year unsaturated to great depth and, as their porosity can be as high as 50% (LUMB 1965), the degree of saturation is markedly affected by rainfall and especially by continuous or heavy rain which may eventually saturate the entire soil mass.

The degree of saturation of the soil increases W but since water induces a neutral stress there is no corresponding increase in S. Therefore, again F decreases.

In addition to this effect, LUMB (1965) has shown that the cohesion of the residual soils of Hong Kong, particularly those derived from the Rhyolites, drop rapidly with increase in the degree of saturation to zero or a very small value when saturation is reached and this again leads to a decrease in shear strength.

The pore pressure within a slope can be increased by water emerging from the bedrock

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beneath the slope or by finding its way into relatively previous strata or zones within the overburden from points of entry at higher levels. Such water can exert very high pressures and unless this pressure is relieved it can lift the entire slope.

The pore water pressure (r) induced in the soil along the incipient failure plane, effectively reduces the W term in COULOMB'S equation once again reducing the factor of safety.

THE EVENTS LEADING TO THE PO SHAN LANDSLIDE

The events leading up to the catastrophic landslide of the 18th June are well known to the Commission but it would be convenient to summarise them here giving the sequence reported in the evidence of the witnesses to date and referring to figure 3:

1971	An unspecified number of slips in the southern face of the excavation in I.L. 2260 above Conduit Road.
August 1971	An extensive slip along the south slope of I.L. 2260 noted immediately after typhoon "*Rose*".
September 1971	Haircracks in the Po Shan Road opposite No. 21. "Earth movement" in the vicinity of 21, Po Shan Road.
November 1971	The face of the excavation in I.L. 2260 appeared wet and water was seen emerging at formation level.
January 1972	"Clear evidence" of movement in the slope between 21, Po Shan Road and Skyline Mansion.
March 1972	Excavation and driving of steel sheet piles commenced in I.L. 2260.
April 1972	Excavation and sheet piling continued and trench excavation for a retaining wall foundation began. The Contractor erected a rain cover over the works.
May 1972	Excavation and steel sheet piling continued.
June 1972	Excavation and steel sheet piling continued.
15th June 1972	Intermittent heavy rain commenced.
16th June 1972	Cracks were noted in Po Shan Road between No. 21 and No. 8.
17th June 1972 a.m.	A slip occurred over the width of the cut slope at the south face of I.L. 2260 carrying away most of the rain cover and distorting the sheet piling. The northern half of Po Shan Road and the

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garden terrace and garage of No. 21 settled some 6 feet.

A fall occurred onto the Po Shan Road from the hillside above, which increased during the morning.

The slope above Skyline Mansion began to break up and water was seen emerging from it.

17th June 1972 p.m. At 12.45 a heavy rainstorm began and flow from the slope above Skyline Mansion increased considerably.

The garden terrace and garage of No. 21, together with the northern half of Po Shan Road continued to sink to 10 to 15 feet below original level.

The access road leading to No. 47, Conduit Road below Skyline Mansion exhibited signs of pressure from the overlying slope.

Operations commenced to divert existing water courses from the area between 21, Po Shan Road and 53, Conduit Road to the west of I.L. 2260.

The water supply mains serving the area were closed at 4.00 p.m.

Large quantities of water were flowing along Po Shan Road and down the slope into I.L. 2260 from the nullah to the east of No. 21 and directly from the hillside.

The retaining wall below 21, Po Shan Road fractured and sank overnight and the fill under the house settled considerably.

18th June 1972 a.m. Sheet piling in I.L. 2260 continued to distort.

The northern part of Po Shan Road, the terrace and garden of No. 21 continued to settle.

The access road to No. 47 Conduit Road was blocked by rocks and soil and the slope above continued to creep.

18th June 1972 p.m. Po Shan Road terrace and garden continued to sink and to tilt.

The parapet of the retaining wall under No. 21 collapsed. At about 5 p.m. a large slip occurred at the junction of the south and west faces of the excavation in I.L. 2260 and flowed across Conduit Road demolishing the rear wall of 11, Kotewall Road.

At about 9 p.m. the hillside above I.L. 2260 failed catastrophically.

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THE NATURE OF THE SLIP

Within 36 hours of the landslide, the Public Works Department began short term remedial measures by cutting and lining two catchwater drains in the hillside above the slip to divert surface water from the face. They later began excavating and removing slipped material from Conduit Road and the adjacent area and demolished those boulders brought down by the landslide which offered further immediate danger.

They also continued to divert all surface water drainage from the affected area, an operation they had begun on 17th June.

On 1st July the Department began work on a programme of percussion boring and rotary drilling through the material that had slid into the excavation and into the undisturbed ground beneath in I.L. 2260 and along Po Shan Road on both sides of the slip. They commissioned an aerial survey of the affected area and prepared sections through the area showing the profile of the ground both before and after the landslide.

Samples taken from the boreholes driven into the material from the slip lying in the excavated area of I.L. 2260 show clearly the texture of the volcanic rock and this has led me to the conclusion that the major slide from above came down as a comparatively undisturbed wedge.

Examination of the sections through the hillside taken both before and after the slide and reproduced in figure 4, indicates a slip of an average thickness, on this particular section, of about 30 feet and a maximum thickness as yet unknown but which in all probability is in excess of 60 feet assuming a failure surface passing through the base of the deep cutting in I.L. 2260. The volume of material involved in the landslide based on this assumption would be of the order of 50,000 cubic yards.

The approximate length of the slipped area is 360 feet and it can therefore be described as relatively shallow rather than deep seated and is the type of slip normally associated with a silty rather than a clayey material.

As the whole area into which this wedge of earth slid was saturated and in a loose condition and as the material in the wedge itself must have been near saturation point the contact zone between the hillside material and the lower slopes must have been liquefied or at least in the form of a slurry and this would have increased considerably the distance which the slipped material travelled before coming to rest.

I understand that a considerable quantity of water was seen emerging from the face of the slipped hillside for some days after the landslide occurred and this strongly suggests a build up of water pressure in deep relatively pervious strata in the colluvium.

THE CAUSE OF THE PO SHAN LANDSLIDE

It is evident from the record of events that a number of unfavourable circumstances combined to produce a condition of instability in the area:

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(1) The slope and nature of the material in the hillside.

(2) The almost unprecedented rainfall that occurred in May and June of 1972 culminating in the storm of 16th, 17th and 18th June.

(3) The deep cutting in I.L. 2260.

Other factors which may or may not have had an effect are:

(4) The design and construction of 21, Po Shan Road.

(5) The design and construction of the terrace garden and garage adjoining 21, Po Shan Road.

The hillside above Po Shan Road is derived from volcanic rock and is covered by a mantle of colluvium. It is typical of slopes in this part of Hong Kong Island under Victoria Peak, is among the steepest of these and forms a marked ridge clearly discernible from the air. A topographical survey has indicated that below a level of 900 feet PD it has an overall slope of 36° and that this slope meets the less steep 18° coastal slope on or near the centre of I.L. 2260.

Three boreholes sunk in the hillside immediately above the slipped area have revealed clayey material about six feet in thickness in some places overlying clayey silt containing boulders and overlying, in turn, volcanic rock at depths between 60 and 90 feet. There are also a number of boulders on the surface of the hillside which, it appears from their size, have broken off from the summit.

The logs of these boreholes, shown at Appendix B, indicate that the weathered material in the hillside is very silty with sand near decomposing boulders and bedrock. Grading curves of material taken from boreholes in the slipped material lying in I.L. 2260 and probably similar to that in the remaining hillside are shown in Figure 5 to this report. They reveal only 10% of clay and a further 30% of silt and lie within the zones of grading published for decomposed volcanics by LUMB (1965).

It is significant to note that the sandier layers at depth in the hillside being relatively permeable could provide seepage paths for water to percolate to the lower levels and that these could, in times of prolonged rainfall, be under considerable pressure.

The commission has heard evidence of unusually heavy and prolonged rainfall from 1st May 1972 until the date of the landslide.

It has also heard that “the first occasion in 82 years when each of three consecutive days received more than 200 mm occurred on June 16th , 17th and 18th 1972”.

These three days of intense and prolonged rainfall, together with the exceptionally high long term figures preceding them and the peak intensities reported on 17th and 18th June were without doubt the main factor contributing to all the slips that occurred during this period.

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The effect on the moisture content of the hillsides of both direct precipitation and of water overflowing from the permanent drainage channels and nullahs is self evident but just as significant is the strong possibility of a build up in pore pressure in the material forming the hillsides by the increased quantity of water percolating from the bedrock into the decomposed overburden at higher levels.

Eye witnesses have reported seeing water emerging from the southern slope of the excavation in I.L. 2260 in drier times and from the slope above Skyline Mansion on 17th June. These reports confirm that there were underground sources of water and it is reasonable to assume that these sources would be increased in yield in such conditions of prolonged and heavy rainfall and, if relief was limited, they could have built up pressure within the overburden. The effect of saturation on the cohesion and density of decomposed volcanics has already been discussed.

There appear to have been a number of slips in I.L. 2260 following the excavation which started in May 1971. There is no doubt that the southern face of this excavation immediately below Po Shan Road having been left unprotected for nearly eight years until April 1972 would have softened progressively by exposure and by the emergence of water from its face. The latest operation commenced in March 1972 and never completed, which involved further excavation of the southern face, could only have reduced the stability of the slope still further and it is not surprising that it did not survive the 1972 saturation with its consequent reduction in cohesion. I understand that the purpose of this additional excavation was to construct a retaining wall and to protect this high face with masonry. Had this work been completed as was scheduled, by the end of April 1972, the stability of the face would have been improved since it would have been, in some measure, supported.

I have read no evidence of slips into the excavation in I.L. 2260 from the access road into Mirror Marina or the adjacent covered channel, both lying to the east and I therefore find no evidence to suggest that the deterioration of the slope between house No. 21, Po Shan Road and Skyline Mansion was caused by the excavation in I.L. 2260.

It is my opinion that, while the hillside above Po Shan Road was already in an unstable condition - demonstrated by the falls onto Po Shan Road on 17th June - the excavation in I.L. 2260 was responsible for the location and magnitude of the 9 p.m. landslide and for its catastrophic mode of failure since the excavation effectively removed the toe of this section of the hillside.

No. 21, Po Shan Road was constructed in 1964 at the level of Po Shan Road on a framework of reinforced columns and beams supported by insitu bored piles driven to an average depth of 70 feet below ground floor level, not to bedrock but to what is described in a piling drawing as “hardpan”.

In order to create access and a parking area between the house and Po Shan Road, fill was placed to the south of and under the house and this was contained to the north and west of the house by a mass concrete retaining wall.

During the prolonged rainfall which commenced on 15th June a considerable quantity of surface water flowed along Po Shan Road from the east and this may well have saturated

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the fill beneath No. 21. On the night of the 17th/18th June the retaining wall fractured and sank and the fill under the house settled appreciably. This did not occur however until after the hillside between No. 21, Po Shan Road and Skyline Mansion had begun to slip and I am therefore led to the conclusion that the retaining wall failed because it was located within a slip failure occurring at a lower level below the house and was not simply pushed over by the fill under the house. The wall was massive in construction and retained behind it an appreciable depth of fill which, when weakened by saturation, would have increased the disturbing moment created by its own weight and that of the wall and could have caused the slip.

The upper limit of the slip failure appears to be just north of the northern face of the house, which remains apparently undamaged, and the slip cannot be said to have triggered off the major landslide above Po Shan Road.

It has been suggested that the terrace garden and garage in the extension of 21, Po Shan Road contributed to the landslide. While these may appear to be massive structures, the terrace garden was piled to depths of about 50 feet and the garage was on spread footings. I am advised that the total weight of the garage was 224 tons and that the footings covered an area of 331 square feet. The bearing pressure on these footings was therefore almost exactly two thirds of a ton per square foot. The plan area of the building was about 1,200 square feet so that its total load on the ground can be said to have been equivalent to a little under three and a half feet of earth. I consider therefore that the contribution of these structures to the instability of the area they were constructed on was not significant.

To Summarize: I am of the opinion that:

(1) The slope between 21, Po Shan Road and Skyline Mansion slipped progressively due to saturation by rainfall and surface water and to an increase in pore pressure in the slope.

(2) The southern face of the excavation in I.L. 2260 slipped progressively and later rather more drastically due to softening of the slope by long term exposure and by water emerging from within the slope.

(3) The hillside above Po Shan Road slipped catastrophically due to softening by saturation and to an increase in pore pressure in the hillside combined with the effect of the removal of the major portion of the supporting toe below Po Shan Road and a reduction in strength of the remainder.

(4) There is no obvious connection between the progressive slip below 21, Po Shan Road and above Skyline Mansion and the major landslide.

(5) The effect of the construction of the garden terrace and garage adjoining 21, Po Shan Road on the stability of the hillside cannot be regarded as being of major significance.

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THE PREVENTION AND CONTROL OF LANDSLIDES

Landslides of varying severity have always been a feature of life in Hong Kong and there is ample evidence of this to be seen from the air.

In the past, when intense development was confined to the coastal slopes and buildings were of a very limited height, these landslides were, for the most part, little more than a nuisance but today, as the availability of land becomes more restricted, landslides are becoming more and more a serious problem not only because development of the Mid Levels increases the probability of creating landslides but also because the greatly increased population and density of development can render the consequences of any such landslides extremely grave.

Since the geological processes of decomposition, transportation and deposition will continue, the stability of the hillsides will continue to decrease and further slips will occur whenever there are periods of prolonged or intense rainfall.

The deterioration of the hillsides can be retarded in selected areas by civil engineering means:

Slopes can be protected from increased saturation by the provision of surface drainage and of relatively impermeable surface membranes.

The build up of pore pressure within the slopes can be prevented, or at least alleviated, by the provision of internal drainage from bores or adits and the gradients of the hillsides can be effectively reduced, in some places, by the construction of retaining walls, toe weights or tie-back structures.

These remedies require not only direct expenditure in civil engineering works but also in some cases, the purchase of land or the denial of its use for other purposes and it would be for the developers concerned and their technical advisers to determine the economics of the remedial measures in each case.

Many future slips would be prevented and others controlled if developers and their technical advisers were made aware of the nature of the geotechnical problems of Hong Kong and of the dangers inherent in developing in the Mid Levels and other steep areas of the Colony.

I understand that, under the present building regulations, prospective developers are required to engage an Authorized Architect to design their structures and no approval can be given unless such an architect has signed the drawings.

There is however, no requirement for an Authorized Engineer to investigate or design the foundations for these structures or to consider the short and long term stability of the construction sites.

It is a regrettable fact that developers, the world over, are reluctant to spend their money on foundation exploration or design because they receive no visible asset for such

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expenditure which can be utilized to generate income. In some cases these developers place their architects under considerable pressure to reduce expenditure on foundations, occasionally with tragic results.

Hong Kong with its geotechnical problems, restricted space and high population density presents civil engineering problems of unusual severity and I am of the opinion that all prospective developers should have the advice of engineers as well as of architects, and that they should be required to obtain such advice as a prerequisite to approval of their proposals.

A knowledge of soil mechanics and foundation engineering is not within the field of all civil engineers and if legislation requiring developers to engage authorized engineers is to be of practical value, it will be necessary for the Government to select, from the private sector, certain engineers qualified and experienced in this field for authorization and to afford the opportunity for others to acquire sufficient knowledge and experience to be considered for authorization in the future.

To this end, it might be of considerable benefit to run a part time post graduate course or series of lectures on soil mechanics and its particular application in Hong Kong and this could, perhaps, be done by the University of Hong Kong who have all the necessary expertise and facilities.

The Government itself can combat the problem of landslides by conducting further investigation of the nature of the geotechnical processes involved so that they can anticipate when and where future slips are likely to occur.

The geology of the Colony has been well defined by RUXTON* and others and it should be quite feasible for an appropriate Government Office to determine the limits of the decomposed granitic and volcanic rocks and, by relating them to existing or fresh land surveys, to decide which areas in the Colony are potential landslide areas, which of these pose the most severe risk and in which of them can preventive measures be economically implemented.

To complete this study, it would be necessary to carry out site investigation in the potentially unstable areas by boring, drilling, sampling and laboratory testing thereby building up a reservoir of information on the physical characteristics of each area and its response to rainfall. This work together with the programme outlined below would throw a very heavy additional burden on the present Offices in the Public Works Department and the Government might like to consider enlarging the appropriate Office or creating a new Specialist Office within the Department.

Armed with the information obtained from the study the Office would be in a position to monitor the dangerous areas on a year-round basis to detect at an early date any evidence of deterioration in the hillsides or in the natural or man-made drainage systems and to arrange

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* B.P. RUXTON 1960 “The Geology of Hong Kong” Quart. Geol. Soc. London.

for the construction of new drainage systems where those existing were inadequate or in a state of disrepair.

The Office would be in a position to study and comment on the foundation design proposals of any developer and to require of him not only an adequate site investigation prior to the commencement of construction but also a detailed programme of works. By this means the Office would ensure that nowhere were slips encouraged by unsupported and imprudent excavation or construction.

Where a proposed development is to be on a steep slope, the developer should be required to design a foundation for his structure which would impose no additional load on the ground below, e.g. by providing end bearing piles to rock.

There are a number of structures formed in the hillsides of the Colony which do appear to impose additional loads on the slopes below them and the Office should carry out a study of the foundations of all such structures and make recommendations for their improvement wherever necessary.

To function efficiently the Office should have powers to order the immediate cessation of construction where this is creating a hazard and the proper protection of construction sites against exposure. They should also be empowered to require all developers to satisfy them that their proposals would, at no time, increase the danger of a slip.

This last function of the Office would require of its officers a thorough understanding of soil mechanics and foundation engineering and to this end the staff should include at a high level, engineers experienced in this field*.

The Office should also be empowered to advise, without the delays necessitated by the present legislation, the evacuation of areas they consider in immediate danger and, while this

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* This point is made because of the apparent misconceptions of many developers (not only in Hong Kong but elsewhere) about the support and protection of slopes:

The function of a protective facing to an earth slope, such as the "chunam" used extensively in Hong Kong is to prevent rainwater from entering the face and softening it. It is, of course, essential at the same time to permit the drainage of water from the face and where water drains from well defined fissures in a rocky face this can be achieved by setting in weepholes at the points of emergence. Where the slope is of a soil at an advanced state of decomposition however, weepholes alone can be ineffective as pressure can build up between them and in this case it is necessary to provide a filtered protective face.

The function of a retaining wall in a natural slope is to support a slope by replacing the earth wedge that has been excavated. The common practice of building a wall away from the face and placing fill behind is not sufficient unless the wall is designed for and the backfill is compacted to, the "earth pressure at rest" condition as otherwise some movement of the slope behind the wall will occur until this condition is reached. This movement, especially in silty soils, may be sufficient to shear the soil which would not only increase the pressure on the retaining wall but would also create deep surface cracks into which water could percolate and soften the failure surface.

Again, some developers appear to have an incomplete appreciation of the necessity for drainage behind retaining walls and of the capacity of the foundations of these walls to withstand the forces involved.

sounds a formidable power, it should be remembered that in practice it would only have to be exercised during periods of prolonged or intense rainfall when the public, with the memory of the Po Shan disaster, would be conditioned to such precautions.

To summarize, I recommend that:

1. Prospective developers are required in future to submit to the Government site investigation data, foundation designs and construction proposals prepared by an Authorized Engineer.

2. A panel be formed of Civil Engineers with sufficient knowledge and experience to be authorized to prepare proposals for developers.

3. A post graduate course be instituted, possibly at the University of Hong Kong, to improve the knowledge of engineers on soil mechanics and foundation engineering and of the geotechncial problems of Hong Kong.

4. The appropriate Office of the Public Works Department:

   (a) Carries out a geological and topographical study of those inhabited parts of the Colony in which landslides are likely to occur.

   (b) Conducts a comprehensive soils investigation of the potential landslide areas of the Colony determined from the study in (*a*).

   (c) Regularly inspects all potential landslide areas with particular regard to retaining walls, slope protection and the repair and maintenance of drainage channels and water courses.

   (d) Considers and implements any measures to improve the stability of dangerous hillsides overlooking populated areas.

   (e) Considers the site investigation and foundation proposals of prospective developers in all potential landslide areas.

   (f) Is empowered to ensure that all excavations in sloping areas are fully protected and are completed without delay.

   (g) Reviews the foundation design of all existing structures in potential landslide areas and recommends any improvements necessary.

   (h) Patrols on a 24 hour basis all potential landslide areas during periods of prolonged or intense rainfall and advises the immediate evacuation of areas in danger.

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I appreciate that many of the functions mentioned above were carried out by the Building Ordinance Office and the Highways Office of the Public Works Department with extreme efficiency during the intense rainfall between 15th and 18th June. I feel, however, that the Public Works Department should be given increased powers and the engineers with special qualifications and experience in soil mechanics to enable them to implement these recommendations.

A. J. VAIL
27th September, 1972

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APPENDIX A

A BRIEF DESCRIPTION OF THE GEOLOGY OF HONG KONG

BY D. J. EASTAFF, B.Sc. (GEOL). M.I.C.E.

There are two major rock types in Hong Kong and both of them are of igneous origin:

(i) Granite

(ii) Volcanics.

In addition, there are some metamorphosed sedimentary rocks but they cover only a small area of the Colony and they have no bearing on the present study.

The granitic rocks are younger than the volcanic rocks and they have been intruded into them in the form of a batholith or stock which has an irregular outline. The granites are generally widely jointed with joint spacing varying from 1 foot to 10 feet. Close to faults they may be comminuted or very closely jointed. The granites have a variable composition and colour but they are normally composed of feldspar, quartz and hornblende. Towards the contact with the volcanic rocks the granites are finer grained. The contact is usually sharp and well defined.

The volcanic rocks are variable in composition and consist of recrystallized and metamorphosed volcanic ashes (ignimbrites), and basalt and rhyolite lava flows which are probably metamorphosed. The ignimbrites are the commonest rock type. The rocks are generally closely to very closely jointed, with a spacing of the order of 3 inches to 1 foot, but in the coarser grained varieties the joint spacing may be very wide, of the order of 5 feet to 10 feet.

The granite rock underlies the area of Kowloon and the lower levels of Victoria whilst the volcanic rocks underlie the middle and upper levels of Victoria and much of the New Territories.

THE SOILS

The soils on the slopes of the hills of Hong Kong are derived from the weathering of the granites and the volcanic rocks. The soil may consist of weathered in situ rock or it may be of colluvial origin (slopewash) being derived from material that moves down the slope either by surface creep or mass movement as a result of torrential rainstorms.

The soils can be classified in the following manner:

(A) Residual in situ granite soil

(B) Residual in situ volcanic soil

Appendix V - *Contd.*

(C) Colluvial soil derived from the weathering of granitic rocks

(D) Colluvial soil derived from the weathering of volcanic rocks.

The soils derived from the granitic rocks are usually more clayey than the soils derived from the volcanic rocks whether they are formed by in situ weathering or by colluvial processes. In Hong Kong, hill slopes composed of soil derived from the weathering of granitic rocks usually have a slope angle of 30° whereas those in volcanic soils usually have an angle of 25°. This might be taken to indicate that the granitic soils are stronger than the volcanic soils. Many of the slopes in areas of both the granite and the volcanic rocks show signs of instability of weathered soil mantle.

The soil cover over the rock can vary from a few feet to at least 100 feet depending upon the position of the water table, the slope angle, the soil type, the stability of the slope and the direction that the slope is facing.

The weathered in situ soil can be recognized as such by the presence of relics of joint planes and the original crystal fabric of the rock. Where the rock is widely jointed the passage from completely weathered material (soil) to fresh rock is extremely variable and this is probably related to the joint pattern, the spacing of the joints and the position of the water table. During the dry season the water table is usually located within the underlying rock and not within the soil. There is normally a gradation from completely weathered rock to fresh rock. In the zone where the rock may be described as being moderately weathered (the feldspars have been altered to kaolin but the rock cannot be crumbled in the hand), the joints are usually open and this represents a zone which is frequently more permeable than either the overlying soil or the underlying fresh rock. (In countries such as South Africa this zone is sometimes developed as an aquifer).

In the more closely jointed rock the passage from soil to almost fresh rock can occur over a depth of 1 or 2 feet. The joint planes in the volcanic rocks are often coated with a clay-type mineral which frequently remains along the lines of relict joints in the soil.

The weathering of granite usually produces kaolin-type clay minerals but the weathering of volcanic rocks can produce montmorillonitic (bentonite) and halloysite clay.

The colluvial soils usually consist of angular and sub-angular blocks of rock (varying in size from a few inches to several feet) in a matrix of clayey silty soil derived from the weathering of rock from above the area being considered. In Hong Kong many of the natural slopes composed of colluvium become unstable as a result of torrential storms. The most unstable areas appear to be those where the colluvial material is derived from the volcanic rocks.

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APPENDIX B

LOGS OF BOREHOLES IN THE PO SHAN HILLSIDE

MALAYAN DRILLERS (H.K.) LTD.

CONTRACT No. 502/71 SITE INVESTIGATION : REPORT ON DRILL/BORE HOLE No. E-1 Page 1

CLIENT :HIGHWAY (H) OFFICE
JOB No. :
JOB NAME :KOTEWALL ROAD /PO SHAN ROAD LANDSLIDE
DRAWING No. :

G. L. :EX. G.L.
ORIENTATION :VERTICAL
METHOD :ROTARY DRILL
MACHINE :LONGYEAR 34
CORE BARREL & BIT DESIGN: NX DIAMOND BIT

Sample No. Depth and Type	Progress	Water Recov. % & Level	Core Recov. % & Size	DESCRIPTION OF STRATA	Depth (ft.)	Symbolic Log
				GREY & BROWN SILTY CLAY WITH SAND & ORGANIC MATERIALS	0.67	
				BROWN SILTY CLAY WITH SAND & PARTICLES OF GRAVELS		
U1½"1 4'-8"						
U1½"2 5'-4"						
U1½"3 6'-0"						
U1½"4 9'-2"	16/8/72			RED, LIGHT GREY & YELLOW CLAYEY SILT WITH SAND PARTICLES	8.50	
					9.17	
	17/8/72			WEATHERED VOLCANIC ROCK (BOULDER)	10.33	
U1½"5 11'-0"				RED, LIGHT GREY & YELLOW SANDY SILT WITH CLAY		
		18/8 ▽				
	17/8/72					
U1½"6 14'-8"	18/8/72				14.67	
	18/8/72			GREY FRACTURED VOLCANIC ROCK (BOULDER)		
	19/8/72					
	20/8/72					
	22/8/72				21.42	
U1½"7 22'-1"				RED, LIGHT GREY & YELLOW SANDY SILT WITH CLAY (DECOMPOSED VOLCANIC ROCK)		
U1½"8 22'-9"						
					25.17	
				GREYISH WHITE & BROWN HIGHLY WEATHERED & FRACTURED VOLCANIC ROCK (BOULDER)	27.50	
				RED CLAYEY SILT WITH SAND PARTICLES	28.25	
	23/8/72			GREYISH BROWN SANDY CLAY	29.33	
				BOULDER	29.75	
U1½"9 31'-11"				RED, LIGHT GREY & YELLOW CLAYEY SILT WITH PARTICLES IF GRAVELS		
U1½"10 32'-5"					32.50	
				RED, LIGHT GREY SANDY SILT WITH PARTICLES OF GRAVELS	34.33	
				RED & LIGHT GREY SANDY CLAY	34.75	
	23/8/72			RED & LIGHT GREY CLAYEY SILT WITH SAND PARTICLES	35.67	
				WEATHERED VOLCANIC ROCK (BOULDER)	36.25	
				RED, LIGHT GREY & YELLOW SILTY SAND WITH LITTLE CLAY	36.83	
U1½"11 38'-6"				RED & LIGHT GREY CLAYEY SILT WITH SAND PARTICLES		
U1½"12 39'-4"						
U1½"13 40'-0"						
					41.00	
				RED SILTY CLAY WITH SAND PARTICLES		
					43.00	
				RED CLAYEY SILT WITH SAND PARTICLES		
					45.08	
	24/8/72			GREY & BROWN FRACTURED & WEATHERED VOLCANIC ROCK (BOULDER)		
	24/8/72					

W: water sample
U : undisturbed sample
D : disturbed sample
L : liner sample
( ): N value
═: casing depth
—: hole depth
▽ : G.W. first encountered
▼ : morning water level

REMARKS

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Appendix V - *Contd.*

APPENDIX B – *Contd.*

MALAYAN DRILLERS (H.K.) LTD.

CONTRACT No. 502/71 SITE INVESTIGATION : REPORT ON DRILL/~~BORE~~ HOLE No. E-1 Page 2

CONTRACTOR:
CLIENT : HIGHWAY (H) OFFICE
JOB No. :
JOB NAME : KOTEWALL RD./PO SHAN RD.
DRAWING No. : LANDSLIDE

G. L. :EX. G.L.
ORIENTATION: VERTICAL
METHOD :ROTARY DRILL
MACHINE :LONGYEAR 34
CORE BARREL & BIT DESIGN: NX DIAMOND BIT

Sample No. Depth and Type	Progress	Water Recov. % & Level	Core Recov. % & Size	DESCRIPTION OF STRATA	Depth (ft.)	Symbolic Log
				GREY & BROWN FRACTURED & WEATHERED VOLCANIC ROCK	51.17	
U1½"14 52'-6"				RED, GREY & BROWN SILTY SAND WITH LITTLE CLAY & ROCK FRAGMENTS	54.00	
U1½"15 54'-8"			55	GREYISH YELLOW & BROWN SILT, WITH LITTLE		
U1½"16 55'-4"				CLAY & FINE GRAVELS		
U1½"17 56'-0"					56.75	
				RED & LIGHT GREY CLAYEY SILT WITH SAND PARTICLES		
U1½"18 59'-8"			60			
U1½"19 60'-4"					61.00	
U1½"20 61'-0"				YELLOWISH BROWN SANDY CLAY	62.25	
				RED & BROWN CLAYEY SILT WITH SAND PARTICLES	63.83	
	25/8/72		65	GREYISH WHITE & BROWN HIGHLY WEATHERED & FRACTURED VOLCANIC ROCK (BOULDER)		
25/	25/8/72				67.17	
				RED & LIGHT GREY CLAYEY SILT WITH SAND PARTICLES	69.42	
			70	GREY VOLCANIC ROCK	71.17	
				GREYISH WHITE & BROWN HIGHLY WEATHERED VOLCANIC ROCK		
			75		75.00	
				RED & LIGHT GREY CLAYEY SILT WITH SAND PARTICLES	76.42	
				RED & LIGHT GREY CLAYEY SILT WITH PARTICLES OF GRAVELS	77.00	
	26/8/72			RED & LIGHT GREY CLAYEY SILT WITH		
			80	SAND PARTICLES		
U1½"21 81'-11"						
U1½"22 82'-7"						
U1½"23 82'-10"						
	27/8/72		85	~~BROWN SILTY CLAY WITH SAND PARTICLES~~	84.92 85.33	
				RED & LIGHT GREY CLAYEY SILT WITH		
U1½"24 87'-	"27/8/72			SAND PARTICLES	87.08	
	28/8/72			~~BROWN SILTY CLAY WITH SAND PARTICLES~~	87.33	
	29/8/72			RED & LIGHT GREY CLAYEY SILT WITH SAND PARTICLES		
			90	~~BROWNISH RED SILTY CLAY WITH SAND PARTICLES~~	89.50 89.67	
				GREY FRACTURED VOLCANIC ROCK (FLESH ROCK) (FISSURED & JOINTED FROM 91'-2" to 91'-9")		
			95			
	28/8/72				98.00	
				GREY & YELLOW FRACTURED VOLCANIC ROCK (SLIGHTLY WEATHERED)		
			100			

W: water sample
U : undisturbed sample
D : disturbed sample
L : liner sample
( ): N value
= : casing depth
— : hole depth
▽ : G.W. first encountered
▼ : morning water level

REMARKS (FISSURED & JOINTED FROM 1) 98'-10"
2) 99'-1" to 99'-4"

SCALE 1" = 5 ft.

500/3/72

Appendix V - *Contd.*

APPENDIX B – *Contd.*

MALAYAN DRILLERS (H.K.) LTD.

CONTRACT No. 502/71 **SITE INVESTIGATION : REPORT ON DRILL/BORE HOLE No.** E-1 Page 3

CLIENT : HIGHWAY (H) OFFICE
JOB No. :
JOB NAME : KOTEWALL RD./PO SHAN RD. LANDSLIDE
DRAWING No. :

G. L. : EX. G.L.
ORIENTATION : VERTICAL
METHOD : ROTARY DRILL
MACHINE : LONGYEAR 34
CORE BARREL & BIT DESIGN : NX DIAMOND BIT

Sample No. Depth and Type	Progress	Water Recov. % & Level	Core Recov. % & Size	DESCRIPTION OF STRATA	Depth (ft.)	Symbolic Log
				GREY & YELLOW FRACTURED VOLCANIC ROCK (SLIGHTLY WEATHERED) (FISSURED FROM 100'-5" to 100'-10")	100.83	
				GREY FRACTURED VOLCANIC ROCK (FLESH ROCK) FISSURED FROM : 1) 101'-1" to 101'-3" 2) 101'-7" 3) 102'-10" 4) 103'-4" to 105'-8" 5) 110'-5" 6) 111'-0" to 111'-3" 7) 115'-5" 8) 116'-10" to 117'-0" 9) 119'-0" to 119'-2"		
	29/8/72					
	30/8/72					
	31/8/72				121.67	
				OPERATION STOPPED AT 121'-8"		
				DRY DRILLING IN "COMMON GROUND" WITH 'NX' CORE BARREL START FROM 0'-0" to 89'-8"		

DATE	TIME	WATER LEVEL (BELOW G.L.)
18/8	08:30	14'-0"
"	19:00	1'-9"
19/8	08:30	3'-8"
"	18:00	3'-1"
21/8	08:35	11'-2"
"	12:00	9'-8"
22/8	08:45	11'-7"
"	20:00	4'-2"
23/8	08:40	12'-1"
24/8	20:05	45'-6"
25/8	08:15	46'-9"
25/8	20:00	23'-4"
26/8	08:20	32'-10"
"	20:00	13'-9"
27/8	08:30	34'-2"
"	18:00	26'-1"
28/8	08:30	31'-3"
"	20:00	29'-1"
29/8	08:30	60'-3"
"	20:00	33'-6"
30/8	08:20	66'-2"
"	20:00	29'-6"
31/8	08:20	67'-5"
"	19:00	44'-6"

W : water sample
U : undisturbed sample
D : disturbed sample
L : liner sample
( ) : N value
=: casing depth
—: hole depth
▽ : G.W. first encountered
▼ : morning water level

REMARKS

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Appendix V - *Contd.*

APPENDIX B – *Contd.*

MALAYAN DRILLERS (H.K.) LTD.

CONTRACT No. 502/71 SITE INVESTIGATION : REPORT ON DRILL/BORE HOLE No. E-3 Page 1.

CLIENT : HIGHWAY (H) OFFICE
JOB No. :
JOB NAME : KOTEWALL RD. LANSLIDE – PO SHAN RD.
DRAWING No. :

G. L. : EX. G.L.
ORIENTATION : VERTICAL
METHOD : ROTARY DRILL
MACHINE : LONGYEAR 34
CORE BARREL & BIT DESIGN : NX DIAMOND BIT

Sample No. Depth and Type	Progress	Water Recov. % & Level	Core Recov. % & Size	DESCRIPTION OF STRATA	Depth (ft.)	Symbolic Log
				BROWNISH RED SILTY CLAY WITH SAND PARTICLES		
				GREYISH YELLOW SILTY SAND WITH SOME CLAY & SAND PARTICLES	2.17 2.58	
				BROWNISH RED CLAYEY SILT WITH SAND PARTICLES	4.00	
U1½"1 4'–8" U1½"2 5'–4" U1½"3 6'–0"				BROWNISH RED SILTY CLAY WITH SAND PARTICLES		
				BROWNISH RED SANDY CLAY	7.00 7.50	
U1½"4 9'–8"				RED & YELLOW CLAYEY SILT WITH SAND PARTICLES		
U1½"5 10'–4" U1½"6 10'–8"	5/9/72			RED & YELLOW CLAYEY SILT WITH SAND & PARTICLE OF GRAVELS	10.67 11.75	
				GREYISH YELLOW & RED WEATHERED VOLCANIC ROCK (BOULDER)	12.83	
U1½"7 14'–3" U1½"8 14'–11" U1½"9 15'–4"				RED & YELLOW CLAYEY SILT WITH SAND PARTICLES	16.58	
				RED SANDY CLAY	17.91	
				RED & YELLOW CLAYEY SILT WITH SAND PARTICLES	19.00	
U1½"10 19'–8"		7/9 ▽		RED SANDY CLAY	19.58	
				RED & YELLOW CLAYEY SILT WITH SAND PARTICLES		
U1½"11 23'–4"					23.67	
	6/9/72			GREYISH WHITE & RED FRACTURED & WEATHERED VOLCANIC ROCK	24.67	
				GREYISH WHITE FRACTURED & WEATHERED VOLCANIC ROCK (HIGHLY WEATHERED ROCK, JOINTED FROM 25'–4" TO 25'–10")	27.00	
	7/9/72			GREYISH WHITE FRACTURED VOLCANIC ROCK	29.67	
	8/9/72			GREYISH YELLOW & RED HIGHLY WEATHERED & FRACTURED VOLCANIC ROCK	30.91	
				RED, LIGHT GREY & YELLOW CLAYEY SILT WITH PARTICLE GRAVELS	31.58	
				GREYISH WHITE FRACTURED VOLCANCI ROCK	32.83	
				LIGHT GREY, YELLOW & RED FRACTURED VOLCANIC ROCK (HIGHLY WEATHERED)	34.08	
				RED, WHITE & YELLOW SILTY CLAY WITH SAND	35.00	
	9/9/72			RED & YELLOW CLAYEY SILT WITH SAND PARTICLES	36.00	
				GREY VOLCANIC ROCK (FLESH ROCK)		
	9/9/72				38.92	
				GREY FRACTURED VOLCANIC ROCK (SLIGHTLY WEATHERED ROCK JOINTED FROM 29'–11" to 40'–4"	42.08	
				GREYISH WHITE & YELLOW FRACTURED VOLCANIC ROCK (HIGHLY WEATHERED ROCK JOINTED FROM 41'–7" to 41'–11" & 42'–10" to 44'–6")	44.50	
				GREYISH WHITE & YELLOW HIGHLY WEATHERED & FRACTURED VOLCANIC ROCK		

W : water sample
U : undisturbed sample
D : disturbed sample
L : liner sample
( ) : N value
= : casing depth
— : hole depth
▽ : G.W. first encountered
▼ : morning water level

REMARKS

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MALAYAN DRILLERS (H.K.) LTD.

CONTRACT No. 502/71 SITE INVESTIGATION : REPORT ON DRILL/BORE HOLE No. E-3 Page 2.

CONTRACTOR:
CLIENT : HIGHWAY (H) OFFICE
JOB No. :
JOB NAME : KOTEWALL RD. LANDSLIDE – PO SHAN RD.
DRAWING No. :

G. L. : EX. G.L.
ORIENTATION: VERTICAL
METHOD : ROTARY DRILL
MACHINE : LONGYEAR 34
CORE BARREL & BIT DESIGN: NX DIAMOND BIT

Sample No. Depth and Type	Progress	Water Recov. % & Level	Core Recov. % & Size	DESCRIPTION OF STRATA	Depth (ft.)	Symbolic Log
	10/9/72			GREYISH WHITE & YELLOW HIGHLY WEATHERED & FRACTURED VOLCANIC ROCK	51.25	
				GREYISH WHITE & YELLOW FRACTURED VOLCANIC ROCK (WEATHERED ROCK JOINTED FROM : 1) 55'-3" TO 55'-11" 2) 56'-2" 3) 57'-0" TO 61'-4")	61.33	
	11/9/72			GREY FRACTURED VOLCANIC ROCK (FLESH ROCK) FISSURED FROM: 1) 61'-8" TO 62'-2" 2) 63'-5" TO 63'-10" 3) 67'-4" TO 67'-8"	70.17	
	12/9/72			GREY VOLCANIC ROCK (FLESH ROCK)	83.17	
	13/9/72			GREY FRACTURED VOLCANIC ROCK (FLESH ROCK) FISSURED AT: 1) 83'-2" 2) 84'-6" TO 84'-10" 3) 88'-3" TO 88'-6" 4) 89'-3" TO 90'-7"		
	14/9/72			OPERATION STOPPED AT 90'-7" DRY DRILLING IN "COMMON GROUND" WITH 'NX' CORE BARREL START FROM 0'-0" to 36'-0"	90.58	

W: water sample
U : undisturbed sample
D : disturbed sample
L : liner sample
( ): N value
=: casing depth
—: hole depth
▽ : G.W. first encountered
▼ : morning water level

REMARKS

SCALE 1" = 5 ft.

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Appendix V - *Contd.*

APPENDIX B – *Contd.*

MALAYAN DRILLERS (H.K.) LTD.

CONTRACT No. 502/71 SITE INVESTIGATION : REPORT ON DRILL/BORE HOLE No. E-3 Page 3

CLIENT :HIGHWAY (H) OFFICE
JOB No. :
JOB NAME :KOTEWALL ROAD LANDSLIDE - PO SHAN ROAD
DRAWING No. :

G. L. :EX. G.L.
ORIENTATION : VERTICAL
METHOD : ROTARY DRILL
MACHINE : LONGYEAR 34
CORE BARREL & BIT DESIGN: NX DIAMOND BIT

Sample No. Depth and Type	Progress	Water Recov. % & Level	Core Recov. % & Size	DESCRIPTION OF STRATA	Depth (ft.)	Symbolic Log

DATE	TIME	WATER LEVEL (BELOW G.L.)
6/9	08:20	Nil
"	20:00	9'-1"
7/9	08:20	21'-3"
"	20:00	24'-4"
8/9	08:30	27'-11"
"	20:00	25'-8"
9/9	08:15	28'-4"
"	20:00	33'-7"
10/9	08:15	35'-5"
"	20:00	30'-1"
11/9	08:15	51'-0"
"	20:00	50'-8"
12/9	08:00	57'-2"
"	20:00	76'-9"
13/9	08:00	60'-2"
"	20:00	50'-7"
14/9	08:00	64'-9"
"	18:00	58'-9"

No water return at :

1. 37'-7" to 70'-2"
2. 87'-5" to 90'-7"

W: water sample
U : undisturbed sample
D : disturbed sample
L : liner sample
( ): N value
═: casing depth
---: hole depth
▽ : G.W. first encountered
▼ : morning water level

REMARKS

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Appendix V - *Contd.*

APPENDIX B – *Contd.*

MALAYAN DRILLERS (H.K.) LTD.

CONTRACT No. 502/71 **SITE INVESTIGATION : REPORT ON DRILL/BORE HOLE No.** E-5 Page 1

CLIENT : HIGHWAY (H) OFFICE
JOB No. :
JOB NAME : KOTEWALL RD. LANDSLIDE-PO SHAN RD.
DRAWING No. :

G. L. : EX. G.L.
ORIENTATION : VERTICAL
METHOD : ROTARY DRILL
MACHINE : LONGYEAR 34
CORE BARREL & BIT DESIGN : NX DIAMOND BIT

Sample No. Depth and Type	Progress	Water Recov. % & Level	Core Recov. % & Size	DESCRIPTION OF STRATA	Depth (ft.)	Symbolic Log
				BROWNSIH GREY SILTY CLAY WITH SAND & ORGANIC MATERIALS	1.08	
				BROWN SILTY CLAY WITH SAND & ROOTS OF TREE	2.33	
U1½"1 4'-8"				BROWN SILTY CLAY WITH PARTICLES OF GRAVELS		
U1½"2 5'-4"				5		
U1½"3 6'-0"					6.00	
				RED & YELLOW CLAYEY SILT WITH SAND PARTICLES		
U1½"4 9'-8"				10		
U1½"5 10'-2"					10.67	
				YELLOW SILTY CLAY WITH SAND PARTICLES	11.25	
				RED & YELLOW CLAYEY SILT WITH SAND PARTICLES	12.42	
		27/8 ▽		RED SILTY CLAY WITH SAND PARTICLES	12.92	
				RED & YELLOW CLAYEY SILT WITH SAND		
U1½"6 14'-8"				15 PARTICLES	15.42	
U1½"7 15'-1"				BROWN SILTY CLAY WITH SAND PARTICLES	16.00	
U1½"8 15'-5"				BROWN CLAYEY SILT WITH SAND PARTICLES	16.50	
	25/8/72			BROWN SILTY CLAY WITH SAND PARTICLES	16.75	
				BROWN & WHITE CLAYEY SILT WITH SAND PARTICLES	17.50	
				BROWN & WHITE SILTY CLAY WITH SAND PARTICLES	18.25	
U1½"9 19'-8"				RED & LIGHT GREY CLAYEY SILT WITH SAND		
U1½"10 20'-3"				20 PARTICLES		
U1½"11 24'-8"				25		
U1½"12 25'-4"					25.75	
U1½"13 25'-9"				BROWN & GREY SILTY CLAY WITH SAND PARTICLES	26.50	
				RED & LIGHT GREY CLAYEY SILT WITH SAND PARTICLES	29.00	
U1½"14 29'-8"				LIGHT RED CLAYEY SILT WITH SAND PARTICLES		
U1½"15 30'-0"	26/8/72			30	31.50	
				BROWNISH RED SILTY CLAY WITH SAND PARTICLES	33.17	
				LIGHT RED CLAYEY SILT WITH SAND PARTICLES	34.58	
U1½"16 34'-7"				35 GREYISH BROWN CLAYEY SILT WITH SAND		
U1½"17 34'-11"	27/8/72			PARTICLRS	36.42	
				GREYISH BROWN SANDY SILT WITH LITTLE CLAY	37.75	
U1½"18 39'-8"				GREYISH BROWN CLAYEY SILT WITH SAND		
U1½"19 40'-2"				40 PARTICLES		
U1½"20 44'-0"					43.58	
U1½"21 44'-7"				GREY & BROWN SANDY CLAY		
				45	45.00	
				GREYISH BROWN CLAYEY SILT WITH SAND PARTICLES	46.33	
				GREYISH BROWN SANDY CLAY	47.50	
				GREYISH BROWN SANDY SILT WITH THIN LAYER OF CLAY		
U1½"22 49'-8"	28/8/72					
U1½"23 50'-1"				50		

W : water sample
U : undisturbed sample
D : disturbed sample
L : liner sample
( ) : N value

= : casing depth
— : hole depth
▽ : G.W. first encountered
▼ : morning water level

REMARKS

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Appendix V - *Contd.*

APPENDIX B – *Contd.*

MALAYAN DRILLERS (H.K.) LTD.

CONTRACT No. 502/71 SITE INVESTIGATION : REPORT ON DRILL/~~BORE~~ HOLE No. E-5 Page 2

CONTRACTOR:
CLIENT : HIGHWAY (H) OFFICE
JOB No. :
JOB NAME : KOTEWALL RD. LANDSLIDE - PO SHAN RD.
DRAWING No. :

G. L. : EX. G.L.
ORIENTATION: VERTICAL
METHOD : ROTARY DRILL
MACHINE : LONGYEAR 34
CORE BARREL & BIT DESIGN: NX DIAMOND BIT

Sample No. Depth and Type	Progress	Water Recov. % & Level	Core Recov. % & Size	DESCRIPTION OF STRATA	Depth (ft.)	Symbolic Log
	28/8/72				50.08	
				GREY SILTY SAND	50.75	
				GREYISH BROWN SANDY SILT WITH LITTLE CLAY		
U1½"24 54'-5"						
U1½"25 54'-9"	29/8/72				55.42	
				GREYISH WHITE & YELLOW FRACTURED VOLCANIC ROCK (BOULDER)	57.00	
	29/8/72			GREY, WHITE & YELLOW CLAYEY SILT WITH SAND PARTICLES	58.33	
				GREY SANDY CLAY	59.50	
U1½"26 59'-3"						
U1½"27 59'-6"				GREY, WHITE & YELLOW SILTY SAND WITH LITTLE CLAY	61.17	
				LIGHT GREY & BROWN FRACTURED VOLCANIC ROCK (SLIGHTLY WEATHERED)(FISSURED & JOINTED FROM 61'-2" to 64'-0"	64.00	
	30/8/72			LIGHT GREY & BROWN FRACTURED VOLCANIC ROCK (HIGHLY WEATHERED)(FISSURED & JOINTED FROM 65'-2" to 67'-1")	68.00	
				LIGHT GREY & BROWN FRACTURED VOLCANIC ROCK (SLIGHTLY WEATHERED)(FISSURED & JOINTED FROM 68'-8" to 70'-0" & 70'-9" to 71'-5")	71.42	
	30/8/72			LIGHT GREY & BROWN FRACTURED VOLCANIC ROCK (HIGHLY WEATHERED)	73.83	
				SLIGHTLY WEATHERED & FRACTURED VOLCANIC ROCK	74.67	
				GREY FRACTURED VOLCANIC ROCK (FLESH ROCK) (FISSURED & JOINTED FROM 73'-10" to 76'-2")		
	31/8/72					
	1/9/72					

55 60 65 70 75 80 85 90 95 100

W: water sample
U : undisturbed sample
D : disturbed sample
L : liner sample
( ): N value
═ : casing depth
— : hole depth
▽ : G.W. first encountered
▼ : morning water level

REMARKS

SCALE 1" = 5 ft.

500/3/72

Appendix V - *Contd.*

APPENDIX B – *Contd.*

MALAYAN DRILLERS (H.K.) LTD.

CONTRACT No. 502/71 SITE INVESTIGATION : REPORT ON DRILL/BORE HOLE No. E-5 Page 3

CLIENT : HIGHWAY (H) OFFICE
JOB No. :
JOB NAME : KOTEWALL RD. LANDSLIDE - PO SHAN RD.
DRAWING No. :

G. L. : EX. G.L.
ORIENTATION : VERTICAL
METHOD : ROTARY DRILL
MACHINE : LONGYEAR 34
CORE BARREL & BIT DESIGN : NX DIAMOND BIT

Sample No. Depth and Type	Progress	Water Recov. % & Level	Core Recov. % & Size	DESCRIPTION OF STRATA	Depth (ft.)	Symbolic Log
				GREY FRACTURED VOLCANIC ROCK (FLESH ROCK)		
	2/9/72				105.75	

OPERATION STOPPED AT 105'-9"

DRY DRILLING IN "COMMON GROUND" WITH 'NX' CORE BARREL START FROM 0'-0" TO 61'-2"

DATE	TIME	WATER LEVEL (BELOW G.L.)
25/8		Nil
26/8		Nil
27/8	08:00	Nil
"	13:00	13'-6"
28/8	08:00	18'-2"
29/8	08:00	28'-4"
30/8	08:00	47'-7"
"	20:00	47'-1"
31/8	08:00	53'-3"
"	20:00	39'-6"
1/9	08:00	77'-4"
"	20:00	43'-6"
2/9	08:00	54'-2"
"	20:00	43'-1"

105 110 115 120 125 130 135 140 145 150

W : water sample
U : undisturbed sample
D : disturbed sample
L : liner sample
( ) : N value

=: casing depth
—: hole depth
▽ : G.W. first encountered
▼ : morning water level

REMARKS

500 - 6 - 72

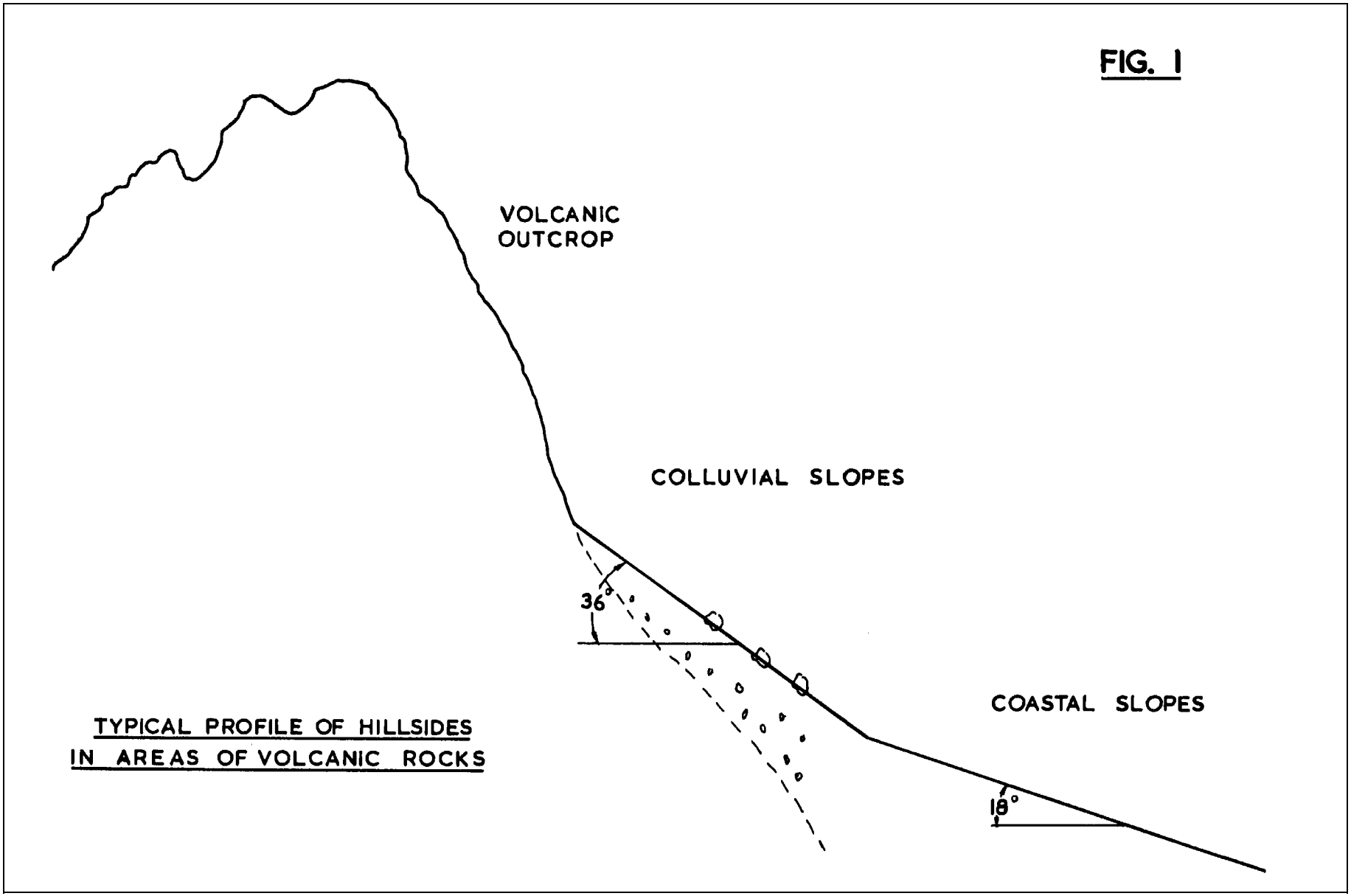
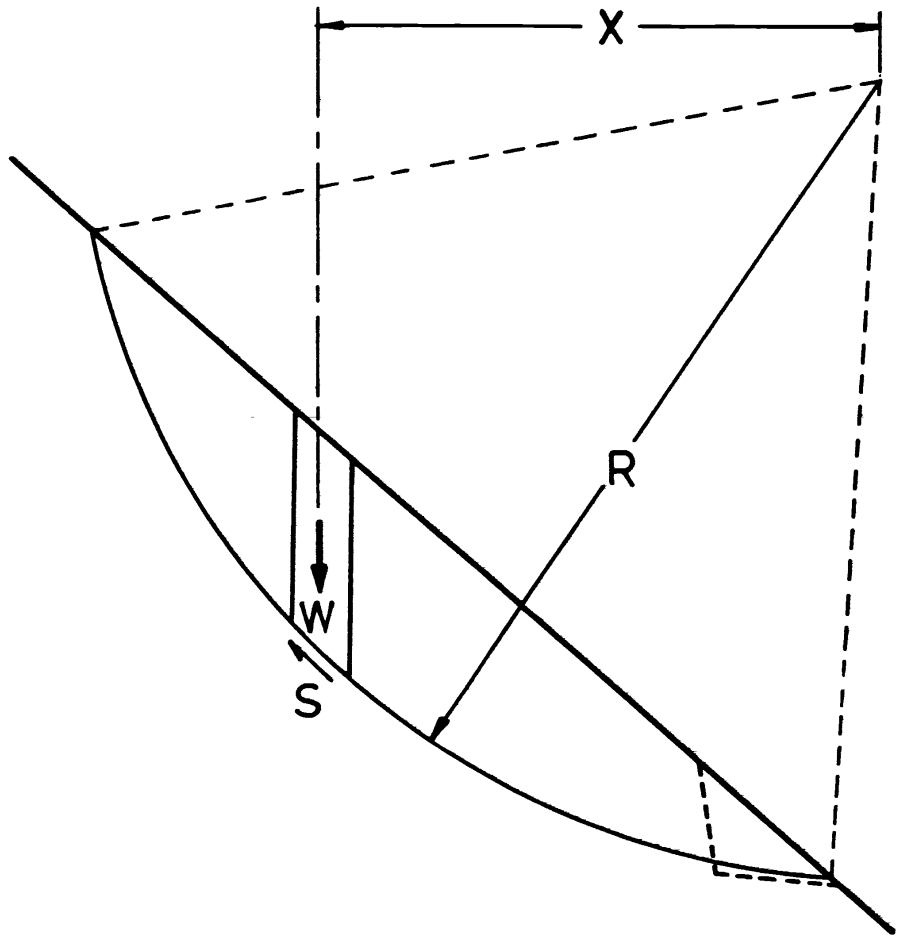


FIG. 1
VOLCANIC
OUTCROP
COLLUVIAL SLOPES
36°
COASTAL SLOPES
18°
TYPICAL PROFILE OF HILLSIDES
IN AREAS OF VOLCANIC ROCKS

FIG. 2



$$WX = S\,R \quad \text{(AT FAILURE)}$$

$$F = \frac{\Sigma S R}{\Sigma W X}$$

$$S = C + W(1 - r)\,\text{TAN}\,\phi$$

C = COHESION

ϕ = ANGLE OF INTERNAL FRICTION

r = PORE PRESSURE RATIO

THE STABILITY ANALYSIS OF SLOPES (AFTER FELLENIUS)

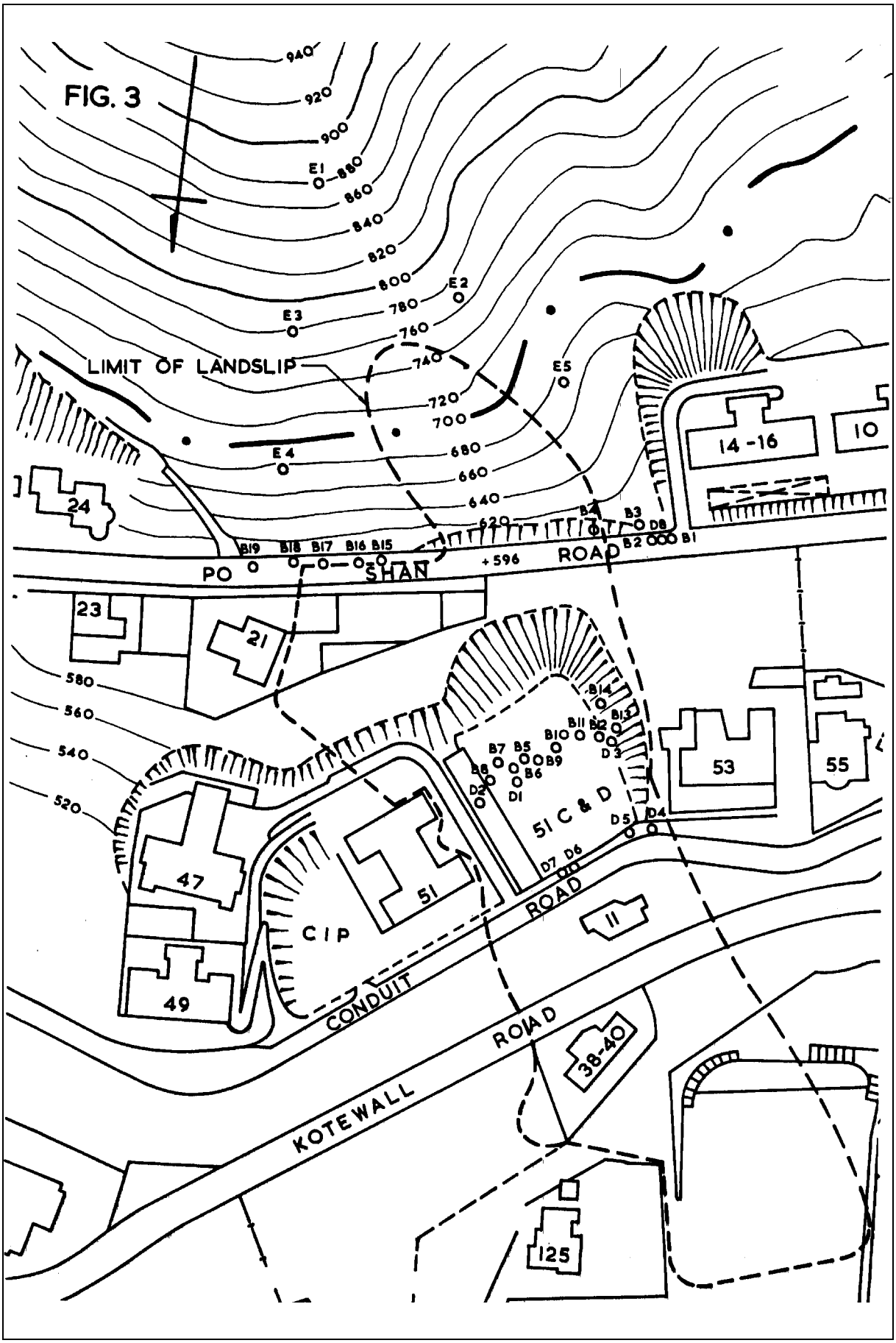


FIG. 4

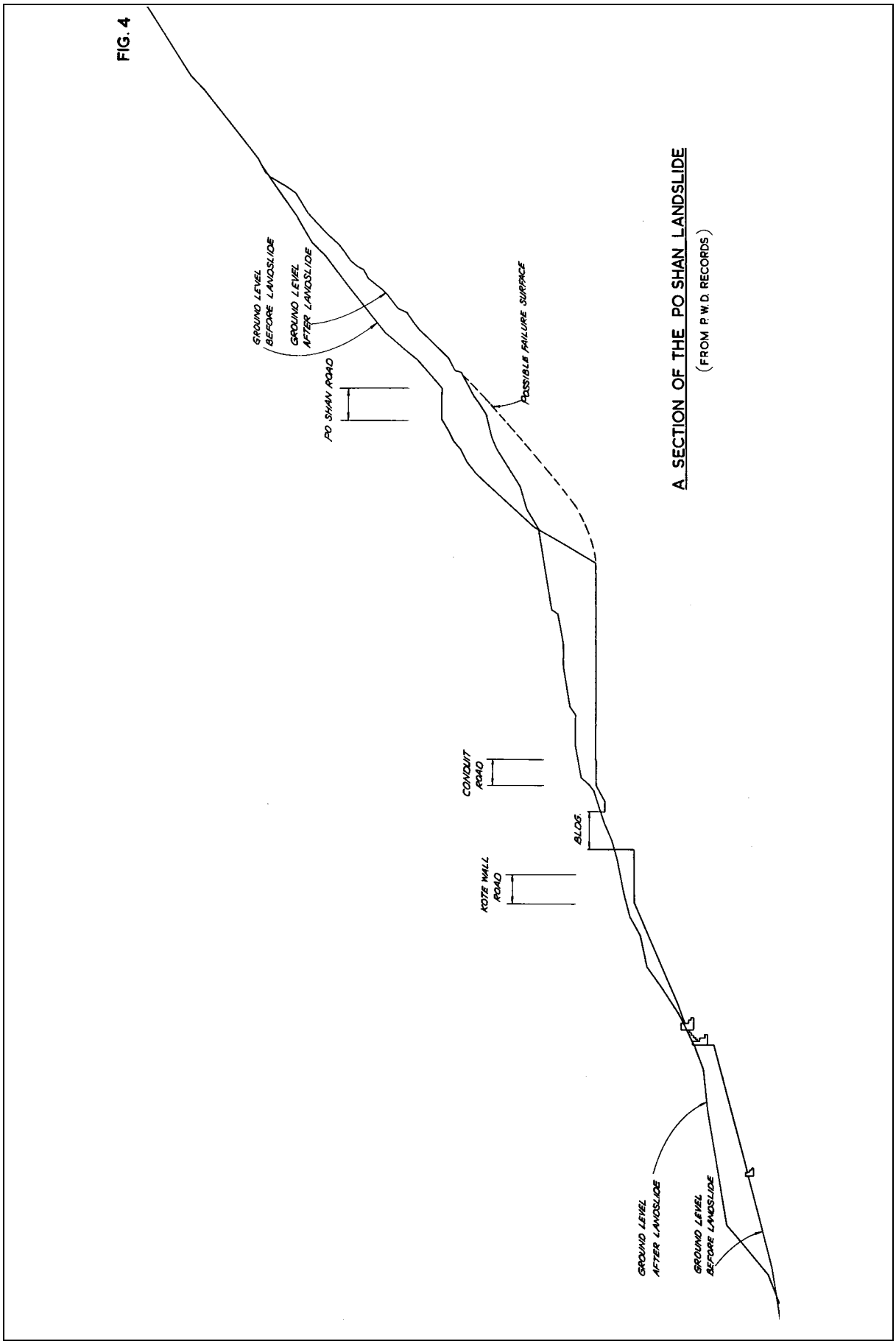
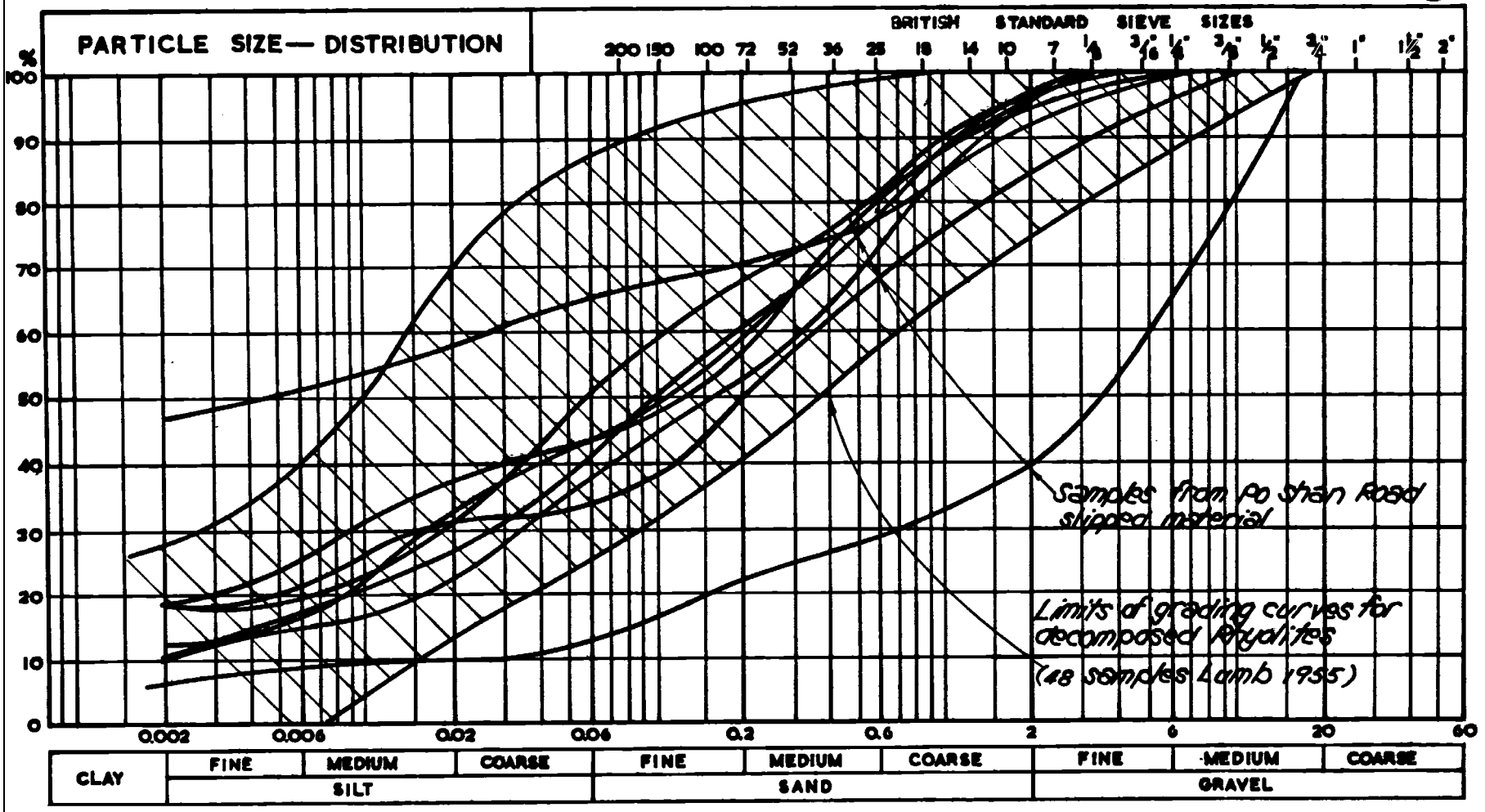

A SECTION OF THE PO SHAN LANDSLIDE
(FROM P.W.D. RECORDS)
GROUND LEVEL BEFORE LANDSLIDE
GROUND LEVEL AFTER LANDSLIDE
PO SHAN ROAD
POSSIBLE FAILURE SURFACE
CONDUIT ROAD
BLDG.
KOTE WALL ROAD
GROUND LEVEL AFTER LANDSLIDE
GROUND LEVEL BEFORE LANDSLIDE

FIG. 5



GRADING CURVES OF DECOMPOSED VOLCANIC ROCK

(TAKEN FROM P. W. D. TEST RESULTS FROM THE PO SHAN ROAD AREA)

APPENDIX VI

THE THUNDERSTORM AND HEAVY RAIN WARNING SERVICE

1. INTRODUCTION

The most intense rainfall in the world occurs in thunderstorms in the tropics; lightning associated with these storms causes damage to electrical installations and is a danger to people working with explosives. In 1966, three separate storms affecting Hong Kong caused a total loss of 86 lives and extensive damage to property. To reduce such looses, warnings of thunderstorms and heavy rain must reach, in good time, those persons responsible for taking the necessary precautions. The Royal Observatory has therefore introduced the Thunderstorm and Heavy Rain Warning Service in an attempt to minimize damage and loss of life caused by these meteorological hazards.

2. OBJECT OF THE THUNDERSTORM AND HEAVY RAIN WARNING SERVICE

The object of the Thunderstorm and Heavy Rain Warning Service provided by the Royal Observatory is to give short term notice of the likelihood of thunderstorms and heavy rain affecting any part of the Colony so that those who are most concerned can take precautionary measures. "Heavy rain" is taken to be a total rainfall of about 2 inches or more in any one hour, and "short term notice" is taken to mean that the warning will be issued 6 hours or less before the expected onset of the heavy rain or thunderstorms. These warnings supplement the routine weather forecasts issued by the Royal Observatory by drawing attention to thunderstorms and heavy rain, and in particular to those thunderstorms which develop suddenly and were not previously expected.

The Service is designed to assist such people as engineers in charge of dams or tunnels, contractors on construction sites, and anyone else who is likely to suffer loss due to heavy rain or thunderstorms.

3. THUNDERSTORMS AND HEAVY RAIN

Thunderstorms, which may or may not be accompanied by periods of heavy rain, are a localized phenomenon. It is possible for intense thunderstorms to pass very close to the borders of Hong Kong without affecting the Colony itself, and thunderstorms observed to be moving towards Hong Kong may die out before reaching here. Similarly, a thunderstorm affecting one part of the Colony may not affect other parts. A thunderstorm warning therefore may appear to be a false alarm on some occasions, the storm either not reaching Hong Kong or affecting only a limited area within the Colony. In order to keep the number of false alarms to a minimum, no attempt will be made to give more than 6 hours notice of these storms. In the case of unexpected thunderstorms that are observed by radar or other means the warning may be as little as 1 hour or even less.

Appendix VI - *Contd.*

Each year a large number of thunderstorms will form which are isolated, have a life of approximately 1 hour, do not cause heavy rain (as defined here) and are local in effect. Also worthy of mention is the fact that lightning at night may be visible in Hong Kong although the associated thunderstorms are located many miles away over China or well out to sea. Neither of these two cases necessitate the implementation of precautions and thus flashes of lightning and isolated thunderstorms do not necessarily mean that a warning of thunderstorms will be issued by the Royal Observatory.

Prolonged heavy rain not accompanied by thunder and lightning is usually more widespread and associated with large-scale meteorological features more easily located and tracked than individual thunderstorms. Hence the arrival or development of heavy rain usually can be timed more precisely than can thunderstorms.

The following tables give statistical information on thunderstorms and rainfall recorded at the Royal Observatory. It will be noticed that in Hong Kong the heaviest rain and most thunderstorms occur in the summer months.

MONTHLY NORMALS OF THUNDERSTORMS FOR THE 20 YEARS 1947-1966

MONTH	No. of days with lightning observed	No. of days with thunderstorms	No. of thunderstorms
Jan.	<0.5	<0.5	<0.5
Feb.	<0.5	<0.5	<0.5
Mar.	1	1	3
Apr.	3	3	5
May	7	5	10
Jun.	9	6	9
Jul.	7	5	7
Aug.	10	6	8
Sep.	7	4	5
Oct.	1	1	1
Nov.	<0.5	<0.5	<0.5
Dec.	<0.5	0	0
YEAR	45	31	48

Note: The above statistics on thunderstorms relate to the Royal Observatory. The incidence of thunderstorms over the Colony as a whole will be higher than shown here.

Appendix VI - *Contd.*

MEAN NUMBER OF HOURS WITH RAINFALL AT THE ROYAL OBSERVATORY OF SPECIFIED INTENSITY

MONTH	NUMBER OF HOURS WITH RAINFALL AT RATE OF	
	10 mm per hour or more	50 mm per hour or more
Jan.	0.23	0.00
Feb.	0.35	0.00
Mar.	1.03	0.00
Apr.	2.91	0.07
May	7.01	0.23
Jun.	9.66	0.34
Jul.	8.82	0.20
Aug.	8.96	0.15
Sep.	7.23	0.07
Oct.	2.45	0.07
Nov.	0.79	0.00
Dec.	0.20	0.01
YEAR	49.64	1.14

MONTHLY NORMALS OF RAINFALL FOR THE 70 YEARS 1884-1939 & 1947-1960 EXTREME VALUES FOR 1884-1939 & 1947-1966

RAINFALL / MONTH	Total		Duration of rain	No. of days with measurable rain	Extreme daily maximum		Extreme hourly maximum	
	mm	in.	hr		mm	in.	mm	in.
Jan.	31.7	1.25	50	6	99.6	3.92	21.8	0.86
Feb.	46.9	1.85	66	8	86.1	3.39	24.6	0.97
Mar.	72.2	2.84	84	11	96.1	3.79	39.9	1.57
Apr.	135.8	5.35	82	12	190.2	7.49	67.6	2.66
May	292.7	11.52	91	16	520.6	20.49	86.4	3.40
Jun.	401.2	15.80	87	21	382.6	15.06	108.2	4.26
Jul.	371.7	14.63	72	19	534.0	21.03	100.7	3.97
Aug.	370.8	14.60	72	17	282.8	11.13	71.1	2.80
Sep.	278.8	10.98	59	15	325.5	12.81	84.0	3.31
Oct.	99.2	3.91	32	8	292.2	11.51	71.6	2.82
Nov.	43.1	1.70	31	5	149.2	5.87	44.2	1.74
Dec.	24.9	0.98	37	5	90.9	3.58	51.7	2.03
YEAR	2168.8	85.39	763*	143	534.0	21.03	108.2	4.26

* Includes unregistered drizzle.

Appendix VI - *Contd.*

4. TIME OF ISSUE OF WARNINGS

A warning will be issued when thunderstorms or heavy rain are expected OR are occurring in any part of Hong Kong and are likely to persist and affect other areas within the Colony.

A warning of thunderstorms or heavy rain will not be issued when Local Storm Signals are hoisted because it may lead to confusion. It should be noted that precautions against heavy rain should always be taken when such Local Storm Signals are in force.

5. CONTENT OF WARNINGS

The warning will specify:

(*a*) Whether it is a warning
of THUNDERSTORMS
or of HEAVY RAIN
or of THUNDERSTORMS and HEAVY RAIN,

(*b*) The time the thunderstorms and/or heavy rain are first expected to affect the Colony,

and (*c*) The period for which the warning is effective.

If thunderstorms and/or heavy rain are likely to persist beyond the time stated in the warning then it will be renewed. Whenever possible the warning will be issued from 3 to 6 hours before the start of the thunderstorms or heavy rain but, as explained above, in the case of thunderstorms which develop unexpectedly, the warning may be as short as 1 hour or even less. Warnings will not be issued for the isolated type of thunderstorm described in para. 3 above.

6. METHOD OF DISSEMINATION OF WARNINGS

A warning issued by the Royal Observatory will be passed to: -

(*a*) the Hong Kong Telephone Company who will contact everyone who subscribes to the telephone calling service,

(*b*) the Government Information Service for issue to radio stations and to the press if the warning period makes it relevant.

7. TELEPHONE CALLING SERVICE

In order to reduce loss of life and damage it is essential that warnings of thunderstorms and heavy rain should reach those persons responsible for taking the necessary precautions without delay. Such people are often at work on construction sites or in offices away from radios and the latest newspapers. Thus special methods are required to ensure the timely receipt of warning messages. This is achieved by the “Telephone Calling Service” whereby

the Telephone Company undertakes to pass all warnings of thunderstorms and/or heavy rain issued by the Royal Observatory directly and with the minimum of delay to those who subscribe to the service.

The charge made by the Telephone Company for this service is HK$20.00 per annum and those who wish to subscribe should apply to the Company, stating whether they require a full 24-hour service or specifying between which hours of the day or night warnings are required.

8. NOTE

The introduction of the Thunderstorm and Heavy Rain Warning Service is one of many attempts by the Royal Observatory to increase the meteorological information available to the public. This particular service has been designed to meet the requirements of those who are likely to suffer loss of life or damage due to thunderstorms or heavy rain, enabling them to take the necessary precautions in good time. This service is new and the Royal Observatory will be pleased to consider any suggestions for improving its usefulness.

Like all forecasts, a warning of thunderstorms or heavy rain represents the most likely development in the weather and is subject to the usual errors of probability. There may be occasions when thunderstorms and associated periods of heavy rain develop suddenly and affect parts of the Colony before a warning is issued. It should be understood that whilst the Royal Observatory staff will do their best to avoid such occurrences, they cannot be held responsible for the result of either unwarned thunderstorms and/or heavy rain, or for the consequences of a false alarm.

ROYAL OBSERVATORY, HONG KONG
June, 1967

APPENDIX VII

EXTRACTS OF STATEMENTS ON THE PO SHAN ROAD DISASTER

(1) MR. ROBERT M. BRIDGE

"At approximately eight twenty I heard a tremendous roar. The programme, 'The Two Ronnies' had just started on T.V.B. I dashed to the amah's quarters to look out at Conduit Road. In the dark I could make out that the garage at 21, Po Shan Road was falling down the hillside. I could see the garage coming down but not the hill. I dashed back into the main room and yelled to my wife to lie on the floor and fell on top of her. Before I was completely on top of my wife the building shook and the lights went off. The building then twisted savagely to the left, towards Po Shan Road - the site (South west) and I knew that it was collapsed.

"I must have been knocked unconscious at some point of time, but when I regained consciousness I found that my body was pinned by rubble with my legs higher than my head but with my head in the fresh air. It seemed to me that I was right on top of the pile. My wife was in my arms and was obviously dead. There was a young Chinese girl, Kitty LEE, and she came and sat with me. I have no idea what time the rescuers arrived but I heard the sirens and quite soon after they arrived they heard the voices of myself and Kitty LEE. It took them, I suppose, 15 minutes to locate us but when they had done so they immediately removed Kitty LEE and attempted to dig me out. They removed my wife's body first and then managed to free me. They were extremely careful and clever in extracting me. I was then carried down to Babington Path, put in an ambulance and driven straight to Queen Mary Hospital."

(2) MR. CHIU CHI-POK

"The noise was not loud at first but became louder and louder - a matter of seconds passed. I ran towards the bedroom in which my wife was. At the same time she ran out of the bedroom and we met in the corridor between the study and the washroom. The building then began to shake just like an earthquake and the lights went out. Everything then started to fall down.

"It was about one minute after the collapse that it became very quiet.

"I found I was trapped but not seriously injured. Also my wife was not seriously injured. Both of us lay trapped. I could move certain parts of my body but could not get up. At the same moment I heard my children shouting and crying. Both my wife and I spoke to the children to calm them.

"On my chest was a door, the toilet door. My wife could feel a hole beneath her which she crawled through and which I also managed to climb through with the assistance of my wife who pulled my legs.

Appendix VII - *Contd.*

"After climbing through the hole I could see light. I crawled down about 10 feet guided by the voices of my children and then saw my daughter. My wife crawled a little further and found our son. I tried to help my wife to get my son out but heard noise of things falling and had to retreat back. There was a hole nearby through which I could see the sky. Through the hole I could see the house of the H.K. University Chancellor - before the collapse I was unable to as 'B' Block obstructed the view.

"The efforts to free my son were fruitless. I climbed through another hole with my daughter while my wife remained with my son. (During this time I heard my amah crying out but she had managed to reach safety before us).

"When I climbed out I met a man in a dark uniform and asked his assistance. This man had no torch or light but he climbed down the hole to assist my wife and son.

"This man was followed by other men in uniform and the first persons they brought out from the hole was a little girl and then a lady whom I know as Mrs. WONG, Dr. WONG's wife.

"From this same hole a boy was brought out, Jules MCNEIL.

"At approximately mid-night I went to Queen Mary Hospital with my wife. My daughter was left with a Mrs. BROWN.

"My son was rescued while I was at the hospital."

(3) MR. HENRY LITTON

"I heard the noise what I thought was a small landslide up at Conduit Road. Myself, Mrs. MCNEIL and the two boys went to the living room window facing Kotewall Road to see what had happened. Shortly thereafter I saw some bushes and trees between Kotewall Road and Conduit Road being flattened as if by a tremendous gust of wind and I realized something enormous was descending from the hillside. I ran together with Mrs. MCNEIL and stood in the corridor and as far as I remember Mrs. MCNEIL dragged Casper with her. I did not see which way Jules ran but I learned from him later that he ran towards the balcony. The next thing that happened was the floor seemed to buckle under me and the walls crumbled and then we were plunged in darkness. I was struck a glancing blow by an object on the forehead but as far as I know I did not lose consciousness. I did not realize that the whole building had collapsed. I myself was pinned down and I was lying on my left side and my right shoulder was pinned by part of a beam. My thigh and pelvis was pinned down by what appeared to be an enormous slab and I was totally immobilized. At this stage there was a very strong smell of gas which I thought was the fractured main leading to the bathroom. I called out to Mrs. MCNEIL and she answered me. She was very concerned about the children and she appeared to be unhurt except she said she had difficulty in breathing. She said that she was pinned down and could not move. I heard a faint cry from Caspar but I did not hear him again and realized he must have been very seriously injured. Mrs. MCNEIL and I both shouted for Jules but there was no answer. From the direction of Mrs. MCNEIL's voice I would estimate she would have been one or two yards away from me and slightly under the level where I was lying. I heard the voice of a Chinese lady shouting for help in Chinese. I

Appendix VII - *Contd.*

told Mrs. MCNEIL to keep very quiet and to breathe gently as the smell of gas was very strong. It was completely pitch dark in the place where I was trapped and I could not see anything and I did not realize how deep I was buried.

"I kept oral contact with Mrs. MCNEIL and she was distressed and asked me several times how long it would take for the rescuers to come. The next clear recollection of these events was that a lot of water started to come in and I presumed it was raining heavily. I can remember telling Mrs. MCNEIL that it was a good sign as we were possibly not too deeply buried. All the time the smell of gas persisted. Shortly after the heavy rain I realized that a considerable amount of mud was being washed down to where we were lying. I could feel the mud gathering around my legs and up towards my body. My right fingers were free and I scratched to try to make a drainage for the water to run away. I was able to raise my head up to a distance of about 6″ and as the level of mud and water rose I raised my head up. The mud and water level kept rising however and when I raised my head more mud would gather behind my head in fact wedging me in even tighter. The muddy water came up to the level of my mouth, then the rain abruptly stopped and quite quickly the muddy water receded.

"I shouted again to Mrs. MCNEIL but there was no answer. I keep on shouting every 15 minutes or so but there was no response. Mrs. MCNEIL at no stage complained to me that she was in pain and never indicated that she was badly injured except for the difficulty she had in breathing. I should state that all this time I myself was in very severe pain and tried to overcome the pain by diverting my thoughts by mental exercise.

"At some stage I heard the noises of the movement of what appeared to be lorries and heavy equipment. I had no idea of time and the intense pain blotted out any time sequence. I purposely did not yell out for help in order to preserve my strength when I knew help was near but about every 15 minutes I called out to Mrs. MCNEIL.

"I did not hear any voices at all and the voice of the Chinese lady whom I mentioned was shouting for help was not repeated. After what appeared to be a long period of time I heard the faint sound of a radio coming from above me. I thought that it belonged to a rescuer so I shouted at the top of my voice for help and my calls were heard by a European who asked me to identify myself which I did and he asked me how many people were below and I told him there were four. He asked me which flat we were in and I told him 2B. We had some difficulty in communicating and his voice was not very clear. The European summoned help because shortly afterwards I could hear some more voices. I asked the person whom I first spoke to what time it was and I was most surprised to hear that it was 8 o'clock in the morning and that I had been buried for about 12 hours.

"The first daylight I saw was at 5 p.m. on 19th June, 1972. I should mention that during the time I was buried I heard the rumblings of further slides and this happened also during the operation to rescue me. I am not clear how the rescuers got to me as I was in total darkness. I am ignorant of the details of the rescue operation because most of the time I was pinned in total darkness. I realized the rescuers were running considerable personal risk because I heard the sound of at least 3 further slides during the course of that day.

"The first glimmer of daylight I saw was about 5 p.m. I was still pinned down by the slab over my thighs and the beam on my right shoulder. Eventually an officer of the Irish

Appendix VII - *Contd.*

Guards, Lt. John GORMAN came into the cavity where I was and by use of an electric hammer broke up the slab over my head and freed my shoulder so that I could half sit up. Then he went to work on the slab pinning down my thighs. At the time I had been given an oxygen mask which Lt. GORMAN and I both made use of. Fire Services were also in the cavity where I was, working in relays to rescue me and Dr. PARK came in also just before I was extricated. At an earlier stage, Fire Services offered me an injection to kill the pain but I declined. I was finally extricated at about 9 p.m. on 19th, June 1972 and escorted to Q.M.H. by ambulance where I have been receiving treatment ever since. I later learned that Mrs. MCNEIL and Caspar died in the disaster and that Jules had survived."

(4) MR. MICHAEL TIN-HTUN

"At approximately 20.45 hours we all heard a noise - just a noise, not too loud, sounding like things falling down - and we all knew it was a landslide. When I heard the noise I got up from the table and made my way to the bedroom as I wanted to look out of the window. Before I got to the window, I only managed to get to the door of the room. When the building started to skake, I knew immediately the building was collapsing. I hung onto the door frame and I heard screams. I was trapped by something slightly on my chest. I heard groans coming from my mother and my niece - the younger niece - screaming. I also heard other members of my family groaning - I cannot identify who. Also I heard other persons screaming. From where I lay I could see some light. I managed to speak with one person trapped below me but was unable to converse with other voices which I could hear. The person to whom I spoke was Miss Joyce YAO of Flat A, 6th floor. I lay trapped for approximately two hours. I had my watch on and when I was rescued it was 23.00 hours. It was a fireman who reached me first, a Mr. TSANG or CHEUNG. I was then taken to Queen Mary Hospital by ambulance.

"I was discharged after having stitches and went back to the scene at approximately 02.00 hours on 19th June, 1972.

"I could recognize the place I came out of and my own furniture and wall paper. I pointed this out to several firemen. The furniture which I identified as mine was practically at the top of the rubble looking from a North East angle. I also noticed my amah's bedsheets, my kitchen cupboard, and my children's play cot. Also in the rubble I identified a water container which we used during water shortage and a filing cabinet which was kept in the bedroom.

"Thinking back I remember seeing a European boy trapped by his legs whom I can recognize by sight, Jules MCNEIL, living on the 2nd floor, Flat B. I also remember a naked woman was rescued before I was brought out and she kept on reporting that she was only visiting.

"When I was pulled out I remember seeing firemen and ambulance men. I do not remember seeing any policemen or military personnel. I did see a car belonging to the Civil Aid Services."

Appendix VII - *Contd.*

(5) MISS JOYCE YAO TSAI-YEE

"I was eating the lollipop and looking out of my window towards F. S. LI's garage and platform in Po Shan Road. The platform was built on stilts. I saw cracks in the platform since Saturday, 17th June, 1972. These cracks were on only two stilts. On Sunday, 18th June, 1972 the last stilt on the west side had bent. While I was looking out of the window there was very light rain, powdery. I then saw the garage near to the bent stilt slowly began to move and slide down the mountain. The time was about 21.00 hours. The garage slid for about five seconds then started to tumble forward and it was at this time that the noise started. Not loud at first then I saw cracks appear in the wall of the amah's washroom which I could see through the window.

"I was then thrown from where I was standing to the other side of the room against a wall to wall wardrobe. While I was thrown there was an enormous bang. A few seconds passed as the world whirled around me.

"When everything settled (in my case) I realized I was lying on my wardrobe. I heard my brother shout for mother and I responded with, 'Anthony, Anthony'. I heard rubble falling but none fell on me.

"In my 'little cubicle' things were still, I was perfectly conscious. I could not move my head which rested on my right arm. There was a wall with wall paper on my right, which I could feel with my left hand. I could feel a Chinese trunk which did not belong to my family. There was a metal handle on the trunk. Except for this, I could see nothing else. There was no light.

"I call out and received an answering call from a Michael NG and we began to converse through a wall which divided us. The first thing we did was to exchange identification. He told me he was in the back room of Flat 5A and could see the sky through a closed window.

"It was a very long time before I heard the fire brigade noise. All the time I lay trapped I continuously heard pitiful yells from all directions. I also heard Michael Ng ask a lady without a dress on to open the window which I think he could see through. I also heard him cry out twice, 'Mr. THOMSON, Mr. THOMSON'.

"When I was rescued and taken to Kotewall Road it was 00.30 hours. I must have been trapped for three and a half hours. I was rescued by fireman. (Before I was rescued I heard an English speaking man tell a Chinese speaking man that he needed more men and a hammer).

"I was sent to Queen Mary Hospital where I was treated and discharged."

APPENDIX VIII

LIST OF FATAL CASUALTIES IN THE RAINSTORM DISASTERS (EXCLUDING THOSE WHICH OCCURRED AT SAU MAU PING)*

Name of deceased	*Sex/Age*	*Cause of death*
		AT PO SHAN ROAD
WONG Sze-kit	M/6	Crushed. Asphyxia.
WONG Kuen-chun	M/40	Crushed. Asphyxia.
Mrs. Angela BRIDGE	F/23	Deep open wounds of head and lower limbs.
LO Woon-yee	F/51	Crushed. Asphyxia with fractured left femur.
LIEU Tung-ching	M/53	Asphyxia.
LO Kum	F/66	Head injury and multiple fractures of right humerus.
LI Kit-lai	F/16	Fractured skull and brain injury.
KOH Jui-hiang	M/40	Crushed. Asphyxia.
YAP Keow	F/61	Asphyxia.
AW Poh-yeok	F/40	Multiple open wounds and fracture of left ankle.
LI Yau-kwong	M/40	Crushed. Asphyxia with laceration of scalp.
LI Kit-mei	F/17	Multiple fractures of shoulder joint and ribs.
LAM Chung-yau	F/41	Multiple injuries.
LEE Kit-wan	F/14	Asphyxia.
Malar WIN	F/14	Multiple injuries.
DAW Kyin-may	F/55	Multiple injuries.
POON Man-to	F/4	Multiple injuries.
POON Wai-man	F/2	Multiple injuries.
LI Yung	F/50	Multiple injuries.
WONG Mui	F/47	Multiple injuries.
LEUNG Wai	F/56	Multiple injuries.
WU Wun-chun	F/44	Multiple injuries.
Milan ONG	F/33	Multiple injuries.
Thida WIN	F/11	Multiple injuries.
Derrick TIN-NYUNT	M/34	Multiple injuries.
YAO Tien-ming	M/60	Multiple injuries.
LAU Hing	F/59	Multiple injuries.
CHIANG Shiao-yang	M/59	Multiple injuries.
CHIANG Chuen-tung	M/27	Multiple injuries.
CHIANG SHUM Yi-pak	F/60	Multiple injuries.
YING Wing-sze	F/30	Multiple injuries.
Caspar Ian MCNEIL	M/7	Multiple injuries.
LI Chik-sang	M/15	Multiple injuries.
TANG Man-chung	M/64	Asphyxia.
Jennie YEN Chung-yee	F/28	Asphyxia.
Mrs. Annemaria MCNEIL	F/28	Asphyxia.

* The names for each disaster area are listed in the order of identification.

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Appendix VIII – *Contd.*

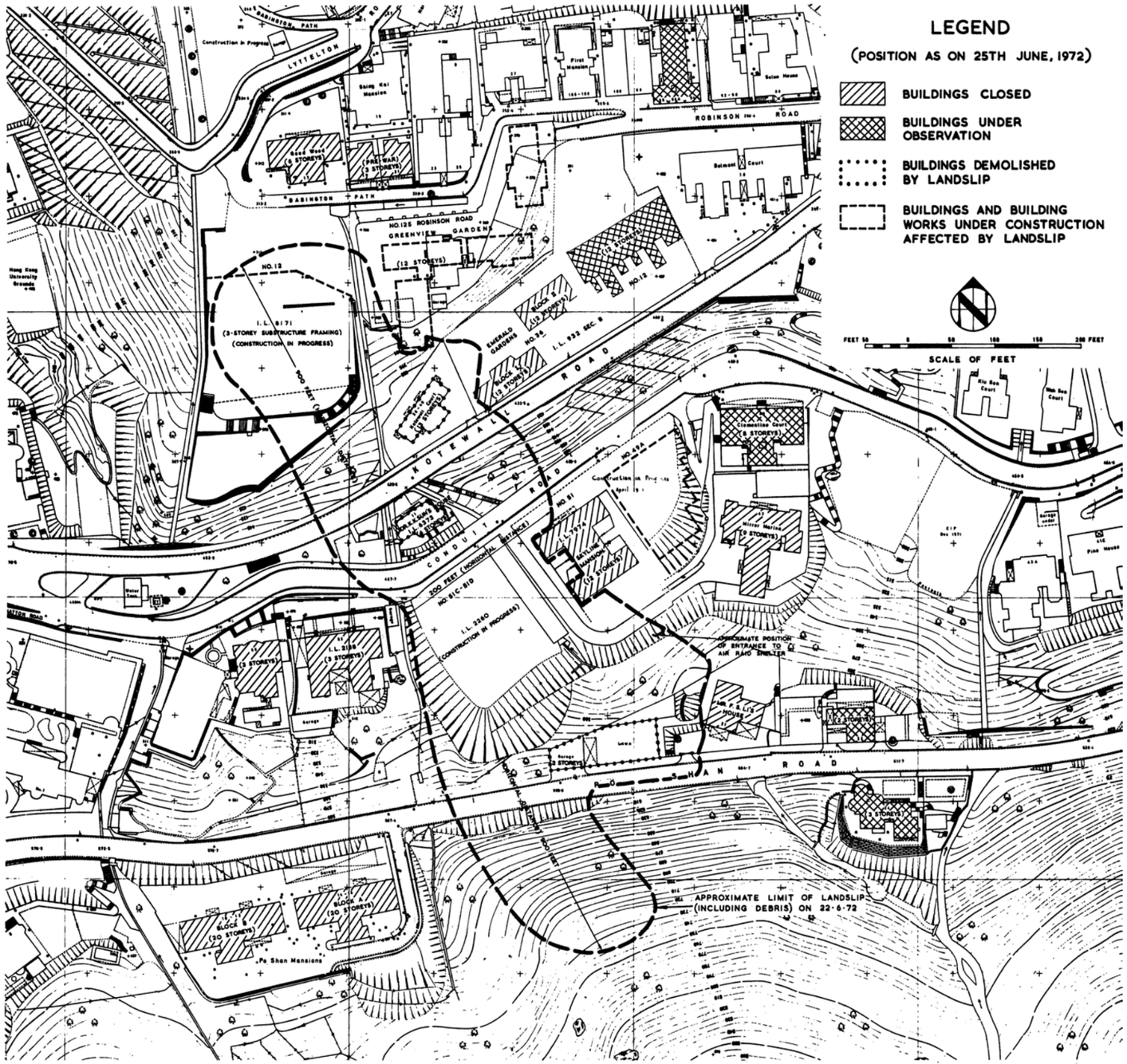
Name of deceased	*Sex/Age*	*Cause of death*
YEN Pei-chi	M/58	Asphyxia.
YEN CHANG Jyn-ling	F/55	Asphyxia.
CHIU Chui-ping	F/47	Asphyxia.
KOO Wei-leung	M/3	Asphyxia.
KOO Teh-cheung	M/48	Asphyxia.
KOO Wai-tong	M/6	Asphyxia.
Satoru HARADA	M/40	Asphyxia.
Mayumi HARADA	F/6	Asphyxia.
Mrs. Teiko HARADA	F/35	Asphyxia.
TANG Yuen-han	F/37	Cerebral laceration.
Helen LOKE	F/60	Cerebral laceration.
LIEU Yuen-ying	F/17	Multiple injuries with decapitation.
CHING Ngan	F/57	Multiple injuries.
Katie YAO CHUI Hui-khiu	F/50	Multiple injuries.
TONG Sau-wan	F/68	Multiple injuries with crushed cranium.
SHEN Chung-sing	M/53	Multiple injuries with crushed chest wall and skull fracture.
LEE Sze-wai	M/61	Multiple injuries and fractured skull.
SHEN Chung	M/16	Multiple injuries.
CHANG Tsek-ming	M/58	Multiple injuries.
LOO Yu-jin	F/60	Multiple injuries.
CHANG KAI-YU	F/16	Multiple injuries.
YEE Pin-nee	F/56	Multiple injuries.
KING Nine-poo	F/44	Multiple injuries.
HOU Shi-kwan	F/15	Multiple injuries.
HOU Chi-hsiung	M/50	Multiple injuries.
Jean-Claude THOMAS	M/39	Multiple injuries.
LO Wai-kiu	F/32	Multiple injuries.
HO But-hung	M/46	Multiple injuries.
POON Shun-sik	F/69	Crushed. Injury of chest.
HO Yin-yee	F/11	Crushed. Injury of skull.
HUI Foon	F/61	Multiple injuries.
		AT SHIU FAI TERRACE
LO Yiu-shing	M/26	Crushed. Asphyxia.
		AT AP LEI CHAU
WOO Choi-mui	F/49	Crushed. Asphyxia.
		IN BELCHER'S STREET (WESTERN DISTRICT)
NG Wing-shing	M/19	Crushed. Asphyxia.

Appendix VIII - *Contd.*

Name of deceased	*Sex/Age*	*Cause of death*
		IN BULLOCK LANE (WAN CHAI)
WONG Choi-king	F/47	Multiple injuries.
WONG Yiu-sing	M/14	Asphyxia.
TONG Yu-chun	F/17	Asphyxia.
		AT CHAI WAN
SIN Yuen-keung	M/17	Asphyxia by drowning.
		AT SHAU KEI WAN
MUI Hoi-man	M/39	Cerebral contusion.
WONG Kam-fong	M/3½ yrs.	Cerebral laceration.
CHAN Hing	M/33	Cerebral laceration.

APPENDIX IX

PO SHAN ROAD DISASTER AREA



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APPENDIX X

GENERAL INFORMATION ON EMERGENCY CALLS

An emergency telephone operator answering an emergency call will, in Cantonese followed by English, say "Police 999, which service do you require - police, fire or ambulance?" If police services only are required the operator obtains particulars of the incident, whilst at the same time another operator is monitoring the call. The monitoring operator, when obtaining details, simultaneously directs by radio the nearest police vehicle to the scene of the incident. Whilst the first operator is obtaining details the police vehicle is on its way to the scene, thus avoiding any delay. In some cases the vehicle may well arrive before the caller has finished the telephone conversation.

2. If fire or ambulance services are required the telephone operator immediately switches the emergency call direct to the appropriate control. As with police services another operator listens to the call and, when obtaining details, simultaneously directs by radio the nearest police vehicle to the scene of the incident. Again it is possible that the police vehicle will arrive before the call is finished and before the fire engines or ambulances arrive. Police vehicles are constantly patrolling the roads and may well be only a few yards from an incident when a call is made. Fire engines and ambulances are stationed in their respective depots and normally will have to travel greater distances than police vehicles.

APPENDIX XI

STATEMENT OF MR. TERRENCE A BERRECLOTH ON THE PO SHAN ROAD DISASTER

I, the above stated, live at apartment 2B, 61, Mount Kellett Road.

2. On the night of the 18th June, 1972, I was at home and heard a radio broadcast mobilizing all auxiliary firemen - the nine o'clock news. I realized that a major disaster had occurred though I am not a member of any disciplined force in the Colony. I have previous experience in rescue work - mountain rescue and plane crash. Also have experience in train disaster and can use a cutting torch which is invaluable in these sort of things. I put my heavy boots on, took a torch, rock pick and then drove down to Po Shan Road.

3. The road was blocked by an overturned police vehicle. A man in the crowd who had just come up the hill from Kotewall Road indicated that a number of occupied buildings had collapsed. I then made my way down to the Conduit, Kotewall Road junction where both Police and Fire Services were in the process of organizing rescue operations along Kotewall Road. I then felt that I couldn't be of much help in this area so I drove back out down to Robinson Road to check how far down the hill the landslip had effected. This led me to Green View Gardens where one senior fire officer and approximately five or six firemen were engaged in searching the rubble - let's say there were five or six torches but within a few minutes this number increased to something like twenty. The time could not have been outside twenty past nine.

4. At about this time or a little later two senior fire officers arrived on the scene to check the situation and then left.

5. I offered my services to the senior officer on sight and was told should I be required he would call on me. I then surveyed the area and made an appraisal as to where I thought the most likely situation for survivors would be.

6. There were some large unbroken floor slabs wedged in the corner against the building that had lost the top and it occurred to me by entering this building it would be possible to view the debris by cross section. I mentioned this to a fire officer and he arranged to obtain the main entrance key.

7. We entered the building, investigated the power supply, find source of light. This was not possible due to the very temporary nature of the wiring. Together with a fire officer we entered the first floor of an apartment and moved into the northern most room facing the rubble.

8. At about this time two fire officers arrived in the Apartment with calor gas lamps. After a short while these were removed possibly due to the fact there was a strong smell of gas in the area. I then called and alternatively listened into the rubble. (At this time there was considerable activity over towards the west and the bottom part of the pile where a number of bodies/victims were discovered).

Appendix XI – *Contd.*

9. After listening quietly I thought I heard a cry or possibly a noise made by a cat. I then called a fire officer back to the scene who waited with me and called several minutes without any response. He left the room to attend to other urgent work. I continued calling, finally getting a response. I then located the same fire officer who on returning to the room also heard the sound. By torch light we identified a woman some six or eight feet inside the rubble and at this time heard a second voice lower down. Almost immediately a rescue party was organized who located and rescued the woman from the lower area.

10. The second rescue party was organized and initially supervised by the senior fire officer. Firstly they attempted to cut the web of concrete and steel that prevented direct access to the victim - an older woman, an amah? who was scantily dressed.

11. Approximately this time or possibly prior to the rescue of the young woman a motor generator was started providing light. The cutting of the concrete was extremely dangerous. This operation took approximately thirty minutes and the firemen involved in the operation showed considerable courage. Throughout this time I was providing some torch light and offering what I thought to be useful suggestions.

12. With considerable skill the woman still alive was removed and placed on a stretcher finally collected by an ambulance.

13. After the woman was removed it was possible to see a Chinese male, twenty to thirty years. I was advised this man was dead by one of the firemen who had rescued the woman. It appeared to me several steel rods either passed through the body or were binding the body to the debris. He was in his pyjamas. The elder woman was rescued very close.

14. At the time the woman was being rescued a number of soldiers started digging at the bottom of the pile with several of their officers climbing the main pile up to Kotewall Road.

15. After the rescue of the woman I suggested to a number of fire officers to break down a door leading to an open area. The top of the open area was covered with a canopy of debris. Shortly after this, I left the scene.

16. The enthusiasm and courage of the firemen working at the scene was hampered by the lack of suitable equipment.

(*Signed*) Terrence A. BERRECLOTH

(*Signed*) F. J. ERASMUS

At 11.25 hours on 5th July, 1972

APPENDIX XII

STATEMENT OF MR. GUY S. SHIRRA ON THE PO SHAN ROAD DISASTER

I am Guy Sanderson SHIRRA. I have been in the R.H.K.P. for 5½ years. I am presently working at Fanling Court, 9 a.m.-5 p.m., and live at Flat B-10, 5th Floor, 25, Park Road, Hong Kong.

2. On the evening of Sunday, 18th June, 1972, I was on weekly leave and at home watching T.V. I did not hear any noise until about 20.55 hours when an ambulance with siren went up Park Road and up the hill via Lyttelton Road. It was followed at closed intervals by several other emergency vehicles and ambulances and I could see people in the flats behind on their balconies looking towards Kotewall Road. This continued until about 21.10 hours and, realizing that something serious had happened, I telephoned Upper Levels Station Report Room. An Inspector on duty informed me briefly that there was a report of "House Collapse" and I rang off. I then dressed fittingly and left home at about 21.15 hours. It was still raining fairly heavily. At first I took my car, drove to Lyttelton Road, but on seeing Traffic Police turning cars back, I returned to park the car at home, and then ran up to Kotewall Road where there were a fair number of emergency vehicles (10-15?). The road was thick with mud, and it was dark. I could see a very large landslide across the road. I entered a block of flats via a garage or entrance hall, went through to the back and climbed up a large bank of mud to where there were several firemen. I think there were about 30 where that I could see.

3. I then identified myself to a Senior Fire Officer there (Mr. ELSWORTH) and offered assistance. Just then, the Chief Fire Officer Hong Kong Island, Mr. Fred JACKSON spoke to Mr. ELSWORTH and told him that he would get the C.S. to declare it a disaster. At the time several firemen were pulling 2 or 3 survivors from top of the rubble, and were moving aside a refrigerator with ropes. I had a torch myself and at this time the firemen had only hand torches; more spades were brought together with crowbars and saws. There was quite a strong smell of gas, and Mr. ELSWORTH gave a warning not to smoke. He then instructed 4 men to go down the left side of the rubble to look for survivors. Here, there was a strong stream of mud and water flowing down from above, and the ground was very unstable. At first they misunderstood and only looked around at the top, so I told Mr. ELSWORTH and I then went down on a rope with one other fireman. I went down the left side about 30 feet to where the concrete overhung a flatter gap in the rubble before it continued down the hillside. It was a mass of debris and twisted metal bars and wires there. Immediately we saw in our torch lights a naked Chinese woman who was slightly injured but sitting completely free on the rubble. She was taken up by a third fireman. Just then I heard a young European boy's voice call out "Help me, help me, I'm dying" very close by. I then searched with my torch and saw a hand sticking out and a face just visible. I climbed into the rubble beneath the overhanging concrete and bars to where he was and found that he was completely buried and lying face down jammed under a bookcase with concrete above and squashed against a board and a large piece of concrete below. He was very firmly embedded. I calmed him and asked his name after clearing his head of rubble and he told he was Jules MCNEIL and that he had been on the 2nd floor with his mother (Anna Marie), young brother (Kaspar) and Henry LITTON. I could see no sign of anyone else near him

Appendix XII - *Contd.*

and could hear no one else calling for help. I then told the firemen to tell Mr. ELSWORTH that we would need help in getting the boy out. I lost my torch and was given another by two firemen who assisted me in removing debris from beneath the boy. (KWONG and LEE?) Eventually, it was clear that the boy was mainly pinned by the right elbow and around the waste and hips. He was in some pain, and I therefore asked if a doctor had been called and this was confirmed. The two firemen and myself were then joined by Mr. ELSWORTH and shortly afterwards another fireman arrived with a portable arc lamp and remained holding it until the boy was eventually extracted. Mr. JACKSON also visited the scene. We then commenced sawing at the wooden furniture holding the boy and were able to free him down to the waist.

4. A doctor KAN (Q.M.H. Casualty) arrived and gave the boy an injection of morphine at about 22.30 hours, and at this time I noticed the presence of C.A.S. and it was evident that other survivors had been found lower down. We then continued extricating the boy, who was very drowsy, after the injection, and used saws to cut away the bookcase and rattan furniture around him. Further work revealed that his left leg was doubled back over the wood and his right foot was strongly jammed in the debris.

5. At about 23.30 hours we called for a pneumatic wedge and the first one that arrived (a C.A.S. wedge) did not work. A Fire Service wedge was brought about ten minutes later, and after several attempts at freeing his right foot, we were successful and we were able to slide the boy out about 00.10 hours. We then carried him up the hill, using the ropes, with extreme difficulty and handed him to a fireman near the top. There we were blinded by flashbulbs which didn't help. (The photographers had earlier been warned off for this reason). Jules was then put onto a stretcher and we examined him again and affixed a saline/glucose drip.

6. We then put him into an ambulance outside and Dr. KAN joined me. The ambulance drove to Q.M.H. with a blue light but no siren as there was very little traffic. It arrived at Q.M.H. at about 00.30 hours where he was immediately attended to by doctors. There were also 3 European matrons present, and it was obvious that they were well prepared for the emergency. A splint was fixed to his left arm and he was x-rayed and admitted to the orthopaedic ward and later transferred to the intensive care unit for non-function of kidneys. (He is now recovering well in ward E1).

7. I later returned to the scene at about 02.30 hours, and I found that generators had been set up for arc lamps, thoroughly lighting the whole scene where the Army were involved in the digging. P.T.U., C.A.S. and Fire Services were present with further ambulances. I remained for a time, and observed as further assistance was obviously not required. I left at about 03.00 hours.

8. I have the following observations to make: -

(*a*) all the rescuers, particularly the Fire Services were extremely enthusiastic and efficient in their work;

Appendix XII - *Contd*.

(*b*) the rescue work necessitated slow, careful digging with hands and small implements; large equipment would have been useless and dangerous.

G. S. SHIRRA, S.I.P.
O.C./Fanling Court

APPENDIX XIII

THE RESCUE OF MR. HENRY LITTON

At about 8.15 a.m. on June 19, 1972 Divisional Officer A. S. CONWAY, Fire Services Department, surveyed the upper section of the Kotewall Court wreckage to see if there were signs of life. Suddenly he heard the sound of a radio from inside the debris. He shouted but there was no reply. He was about to leave when he heard a "definite, muffled voice" from beneath the rubble. He shouted in Cantonese and heard a man reply in English, saying that he and three other people were trapped inside. The person identified himself as Henry LITTON. Mr. CONWAY reassured him and went away to obtain assistance and equipment.

2. On returning to the spot Mr. CONWAY cleared the site carefully and, together with a member of the Royal Engineers, began to dig a tunnel to reach Mr. LITTON. At about that time Mr. F. JACKSON, Acting Chief Fire Officer (Hong Kong), arrived and was informed of the situation.

3. Since only one person could work in the tunnel at one time, Mr. CONWAY alternated with the member of the Royal Engineers until the arrival of other Fire Services personnel at about 9 a.m. The debris had by then been tunnelled to about six feet. The tunnel was approximately 18 to 24 inches in diameter and was dug at an incline in the general direction of where Mr. LITTON was thought to be trapped. The debris around the tunnel opening was unstable and susceptible to movement. Working conditions were poor for lack of space and natural light. Hand-torches were the only means of illumination, and the rescuer had to lie prostrate with his head inclined downwards.

4. Tunnelling was done mainly by hand. Earth and concrete lumps were broken up and moved from the tunnel which eventually became long enough to permit two men to enter in single file. The man in front passed the debris to the man behind him, and this was then passed out of the tunnel. Mr. M.K. LANE, Chief Fire Officer (Prevention), the officer then in overall control of operations at the Po Shan Road disaster site, was also kept informed of the progress.

5. During the digging operation the rescuers occasionally spoke with Mr. LITTON in order to ascertain his location, physical condition and state of mind. The rescuers had by then excavated a vertical shaft of some six to seven feet deep and a horizontal tunnel of some 20 to 25 feet long. During the excavation a ceiling fan was encountered, the blades of which were subsequently either broken off or bent to make way for the tunnel. By that time the rescuers had reached Mr. LITTON and his right forearm was exposed. Further excavation revealed that the small of his back was pinned down by a baulk of timber, and the lower part of his body by a gas water-heater, both of these objects being firmly set in the rubble. The rescuers managed to free Mr. LITTON from these objects after much effort. They continued to remove the debris from his back and disposed of it in a plastic container which was subsequently passed out of the tunnel.

6. The rescuers had to work extremely carefully using bare hands and small handtools, as any mishandling of the debris might cause a collapse of the tunnel area.

Appendix XIII - *Contd*.

7. Mr. L. WORRALLO, Assistant Chief Fire Officer (Hong Kong) arrived at the scene at about 1.30 p.m. and assumed command of the rescue work.

8. A Medical Officer who had been summoned arrived at about 3 p.m. Mr. LITTON was offered an injection of morphia, but he declined, asking that it be withheld for the time being. By now he had been supplied with an oxygen/air mixture via a 25-foot extension tube for some time.

9. At about 3.30 p.m. a further landslip occurred some distance away and the rescue site was urgently evacuated. However, the slip did not affect this site and work resumed shortly afterwards. Some rescuers were on the lookout for further slips and those working in the immediate area were reduced to a minimum. Nevertheless, during most of the time three persons were working in the tunnel and at least three others at the mouth feeding in oxygen and equipment. Mr. LANE discussed the situation with the rescue officers and stressed the need for urgent extrication of Mr. LITTON. Various items of power equipment were also ordered. As Mr. LITTON's lower limbs were still firmly trapped by what was thought to be a concrete beam the possibility of the amputation of his lower limbs was discussed. In fact, Mr. LITTON himself agreed that this might well have to be done in order to save his life if the worst should happen.

10. The rescuers broke up a slab above Mr. LITTON's head and shoulder so that he could half sit up. Further excavation revealed that his legs were still trapped by a wash-basin. The rescuers succeeded in cracking this some time after 6 p.m. and gradually broke it up into small pieces, thereby largely freeing Mr. LITTON's legs. Eventual extrication was then only a matter of time. His condition had, however, deteriorated and he was apparently suffering from acute depression.

11. Fresh rescuers took over at about 7.30 p.m. Work having progressed smoothly for some time, it was suspended briefly when a doctor was permitted to enter the tunnel and talk with him. At that time Mr. LITTON had been almost completely freed except for the lower part of his legs. A rope was placed around him ready for subsequent extrication through the tunnel. Rescue work resumed shortly and Mr. LITTON's legs were soon freed. The rescuers then adjusted the rope round his chest and placed him in the correct position for extrication. They made every effort to avoid further injury to him as his limbs were numb. They finally extricated him at about 9 p.m. and took him to Queen Mary Hospital.

12. Those who took part in the rescue comprised members of the Fire Services Department and the Army, specifically the 1st Battalion Irish Guards and Royal Engineers.

13. Whilst all those who were engaged in this rescue work merit commendation for their part in this difficult and dangerous task, several should be especially mentioned, *viz*., Acting Divisional Officer J. A. HIGGINS, Divisional Officers A. S. CONWAY and CHEUNG Shu-shing, Acting Assistant Divisional Officer TSUI Hin-kwing and Station Officers LO Shiu-kuen and LEUNG Shiu-kay, all of them members of the Fire Services Department.

APPENDIX XIV

REMEDIAL WORKS PERFORMED AFTER THE PO SHAN ROAD DISASTER

Since June 19, 1972 the following works have been completed by the Highways Office of the Public Works Department: -

(a) The construction of two catch-waters above the Po Shan Road slip which were designed to divert all surface water run-off into the arterial nullah running to the east of 24, Po Shan Road.

(b) The blasting of dangerous boulders on the slip face.

(c) The clearance of Conduit Road down to its original alignment and level (which was opened to through traffic on July 5, 1972).

(d) The spraying of the slip face with a cement/Bentonite solution to prevent the infiltration of rain-water into the soil.

(e) Dewatering by means of well points.

(f) The construction of temporary cross-road drains and stepped channels in the landslip area.

(g) Diversion of all storm-water drains and sewers away from the landslip area.

(h) Site investigation by percussion bores.

2. The following works are still in progress under the direction of the Highways Office of the Public Works Department: -

(a) Dewatering by means of vertical caissons.

(b) Clearance of a blocked nullah near Babington Path.

(c) Site investigation by drill-holes.

(d) Driving of headings into the slip face to relieve any pore-water pressure.

(e) Detection of surface ground movement by means of slope indicators.

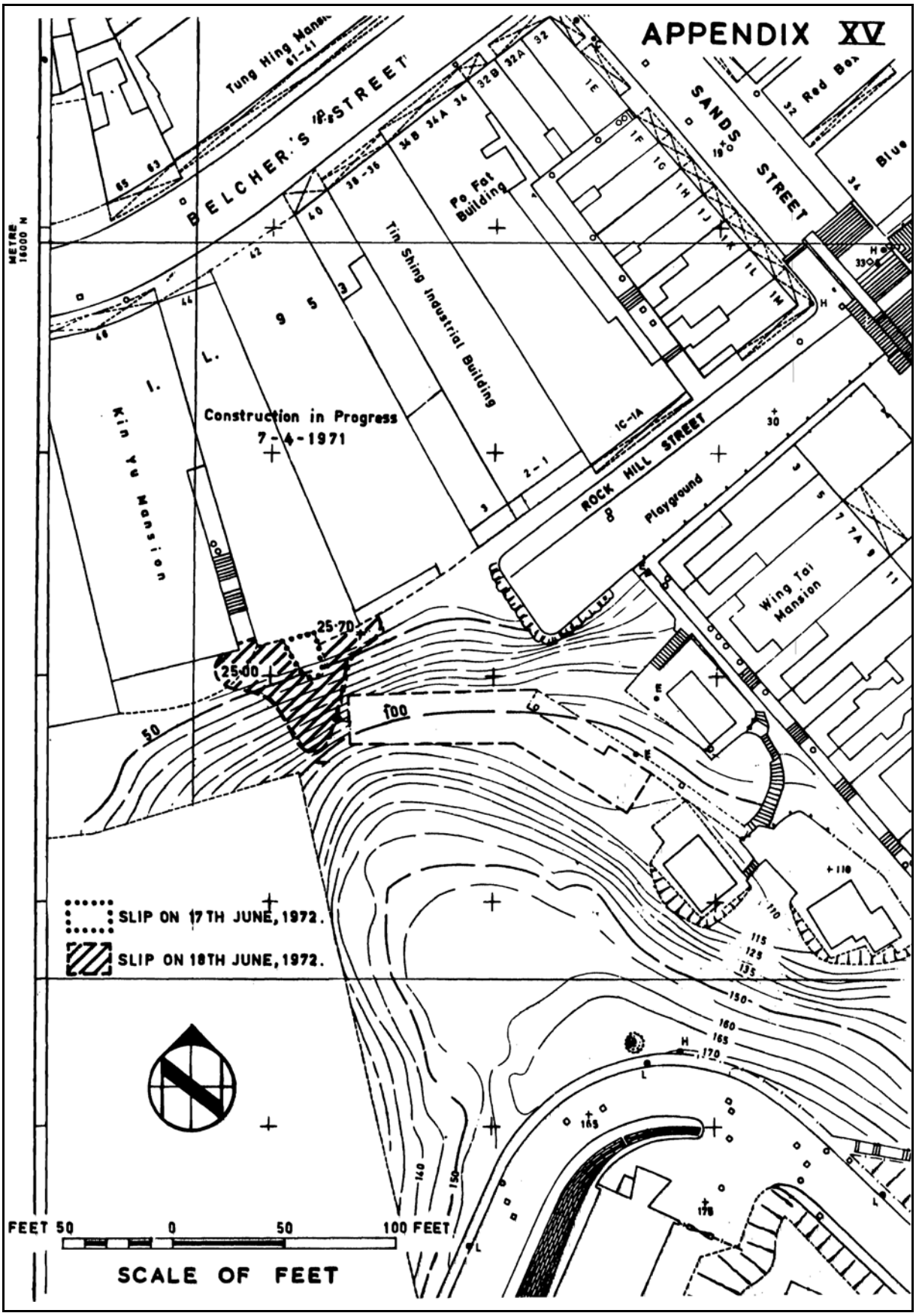
(f) Detection of sub-surface soil movement by means of slope indicators.

(g) Removal of dangerous boulders on the virgin slope above the slip face.

(h) Clearance adjacent to 51, Conduit Road, Skyline Mansion.

(i) Clearance below Conduit Road to locate 11, Conduit Road.

3. Permanent remedial measures for the restoration of the area are under consideration by the Public Works Department.



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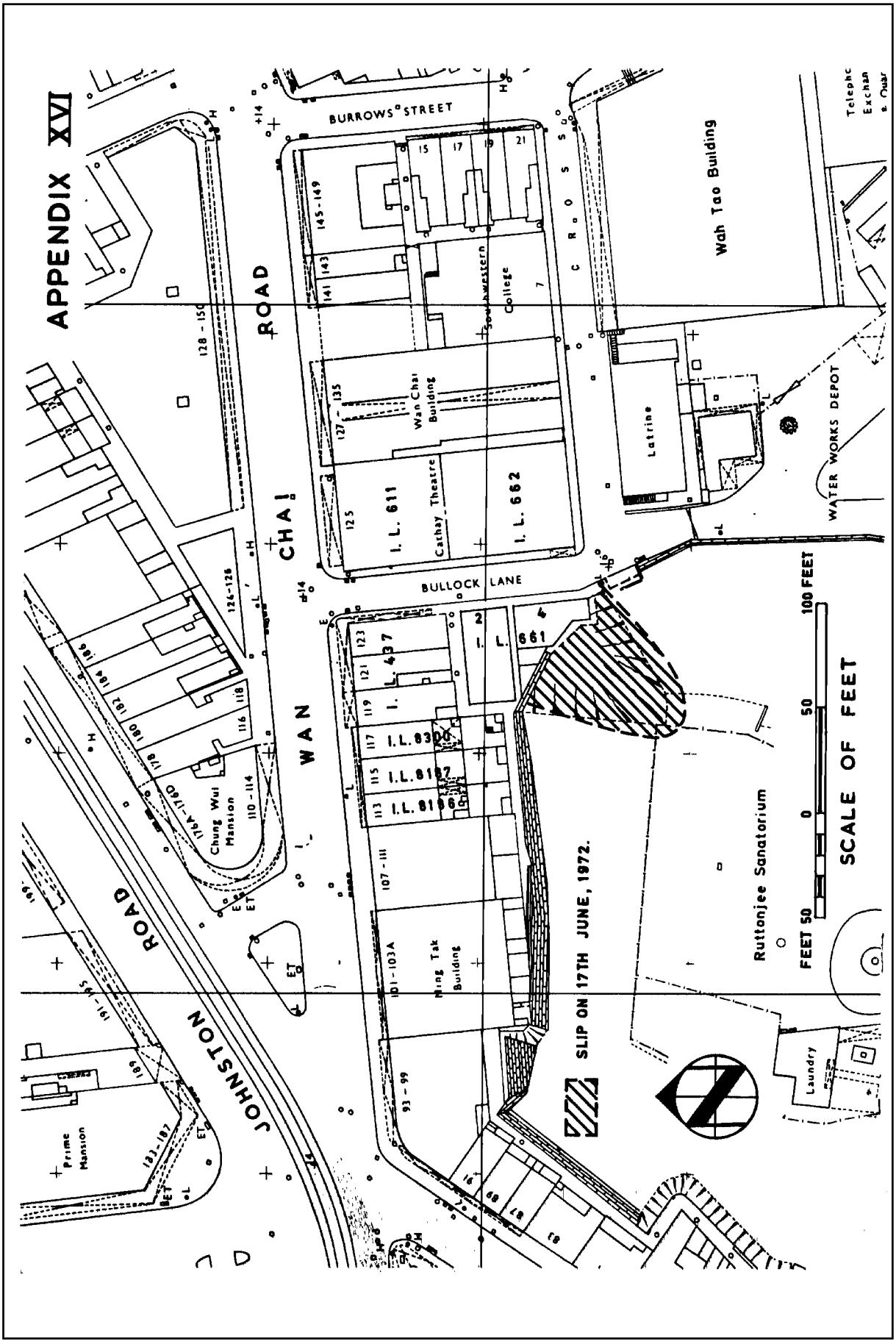
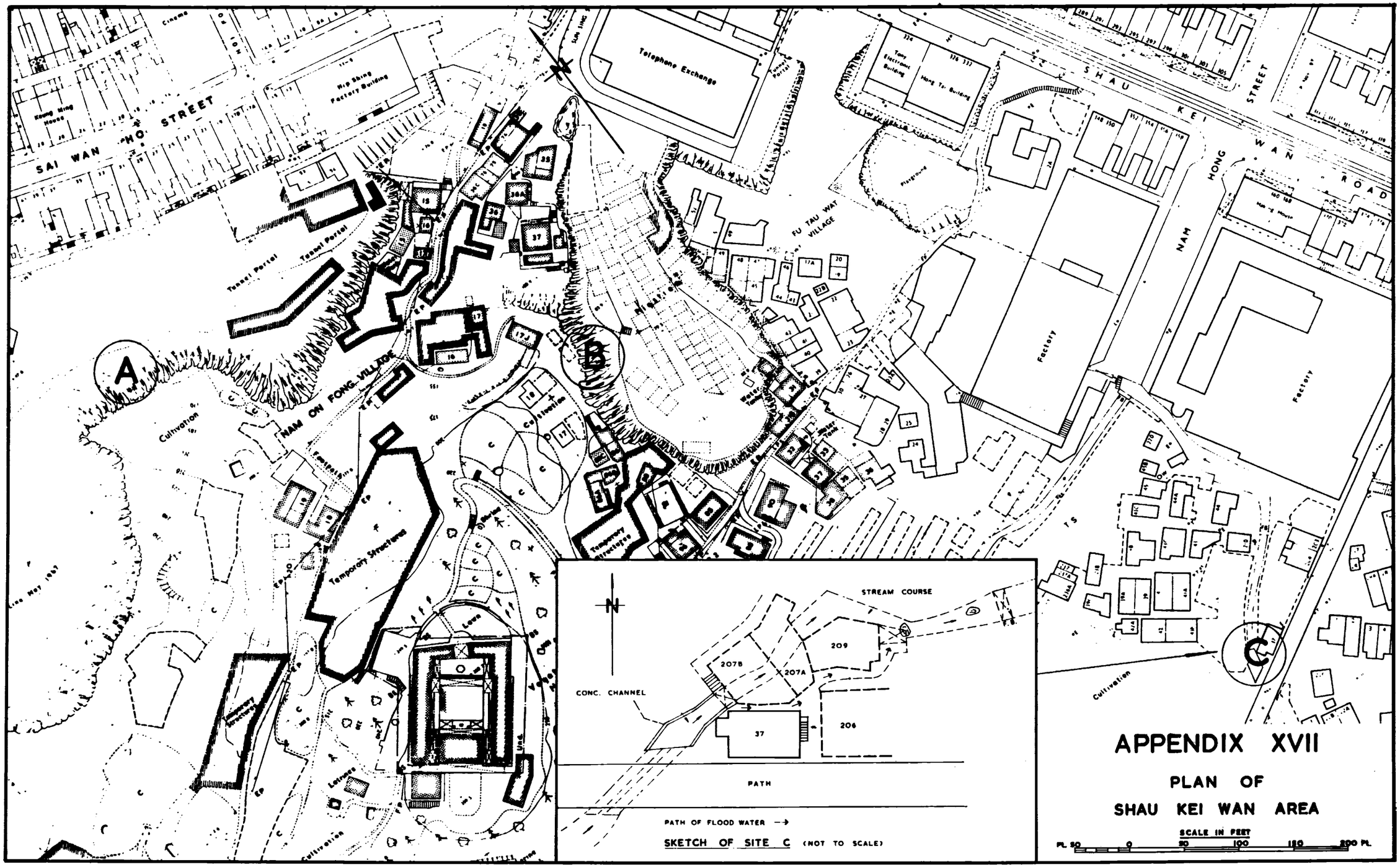
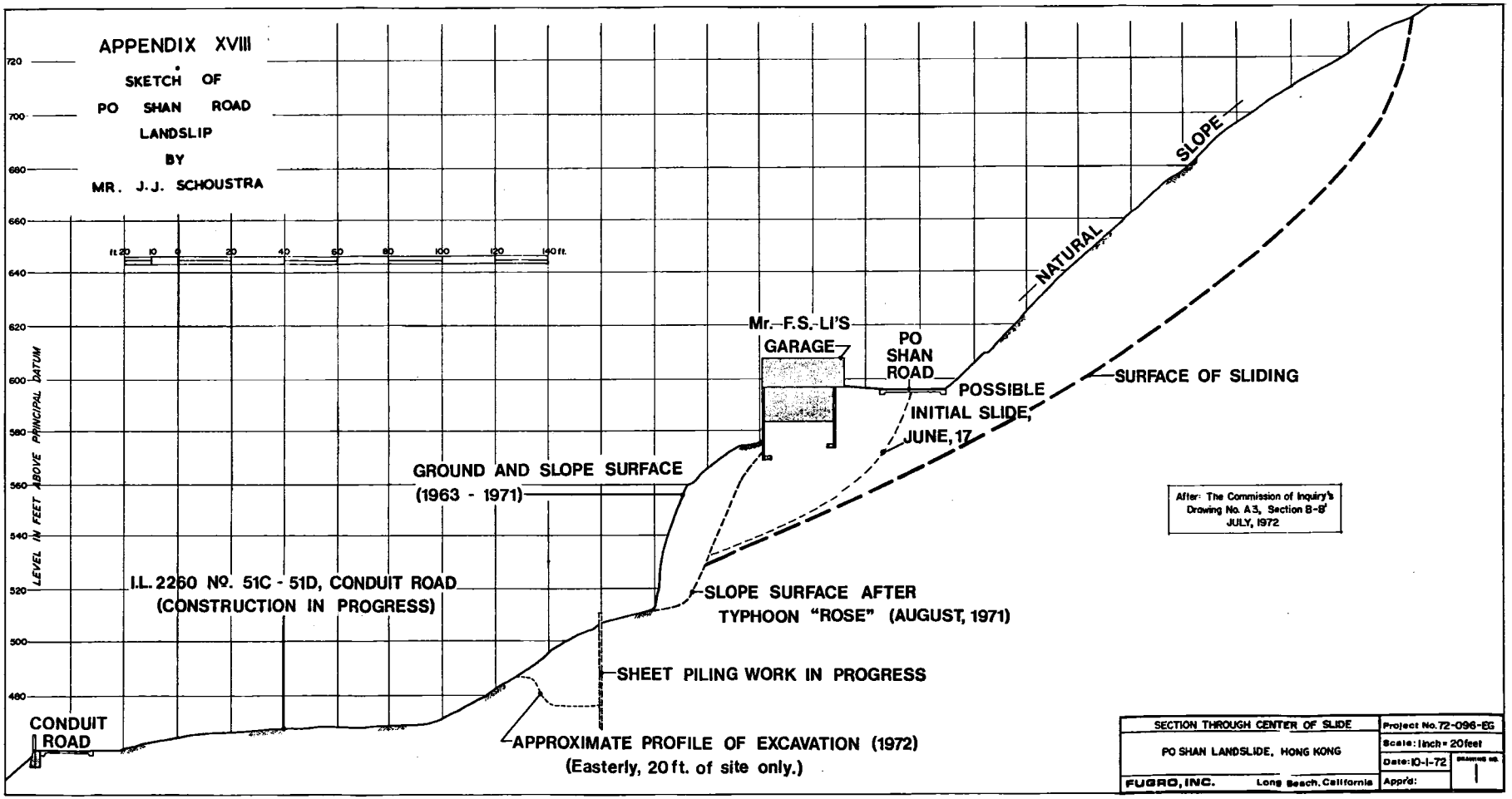

APPENDIX XVI
BURROWS STREET
WAN CHAI ROAD
JOHNSTON ROAD
BULLOCK LANE
Wah Tao Building
Wan Chai Building
Cathay Theatre
I. L. 611
I. L. 662
I. L. 661
I. L. 437
I.L. 8300
I.L. 8187
I.L. 8186
Chung Wui Mansion
Ming Tak Building
Prime Mansion
Ruttonjee Sanatorium
Laundry
Latrine
WATER WORKS DEPOT
SLIP ON 17TH JUNE, 1972.
SCALE OF FEET
FEET 50 0 50 100 FEET




APPENDIX XVIII
SKETCH OF
PO SHAN ROAD
LANDSLIP
BY
MR. J.J. SCHOUSTRA
ft. 20 10 0 20 40 60 80 100 120 140 ft.
720
700
680
660
640
620
600
580
560
540
520
500
480
LEVEL IN FEET ABOVE PRINCIPAL DATUM
NATURAL SLOPE
Mr. F.S. LI'S GARAGE
PO SHAN ROAD
POSSIBLE INITIAL SLIDE, JUNE, 17
SURFACE OF SLIDING
GROUND AND SLOPE SURFACE (1963 - 1971)
After: The Commission of Inquiry's Drawing No. A3, Section B-B' JULY, 1972
I.L. 2260 No. 51C - 51D, CONDUIT ROAD (CONSTRUCTION IN PROGRESS)
SLOPE SURFACE AFTER TYPHOON "ROSE" (AUGUST, 1971)
SHEET PILING WORK IN PROGRESS
CONDUIT ROAD
APPROXIMATE PROFILE OF EXCAVATION (1972)
(Easterly, 20 ft. of site only.)
SECTION THROUGH CENTER OF SLIDE
PO SHAN LANDSLIDE, HONG KONG
FUGRO, INC. Long Beach, California
Project No. 72-096-EG
Scale: 1 inch = 20 feet
Date: 10-1-72
Appr'd:
DRAWING NO.

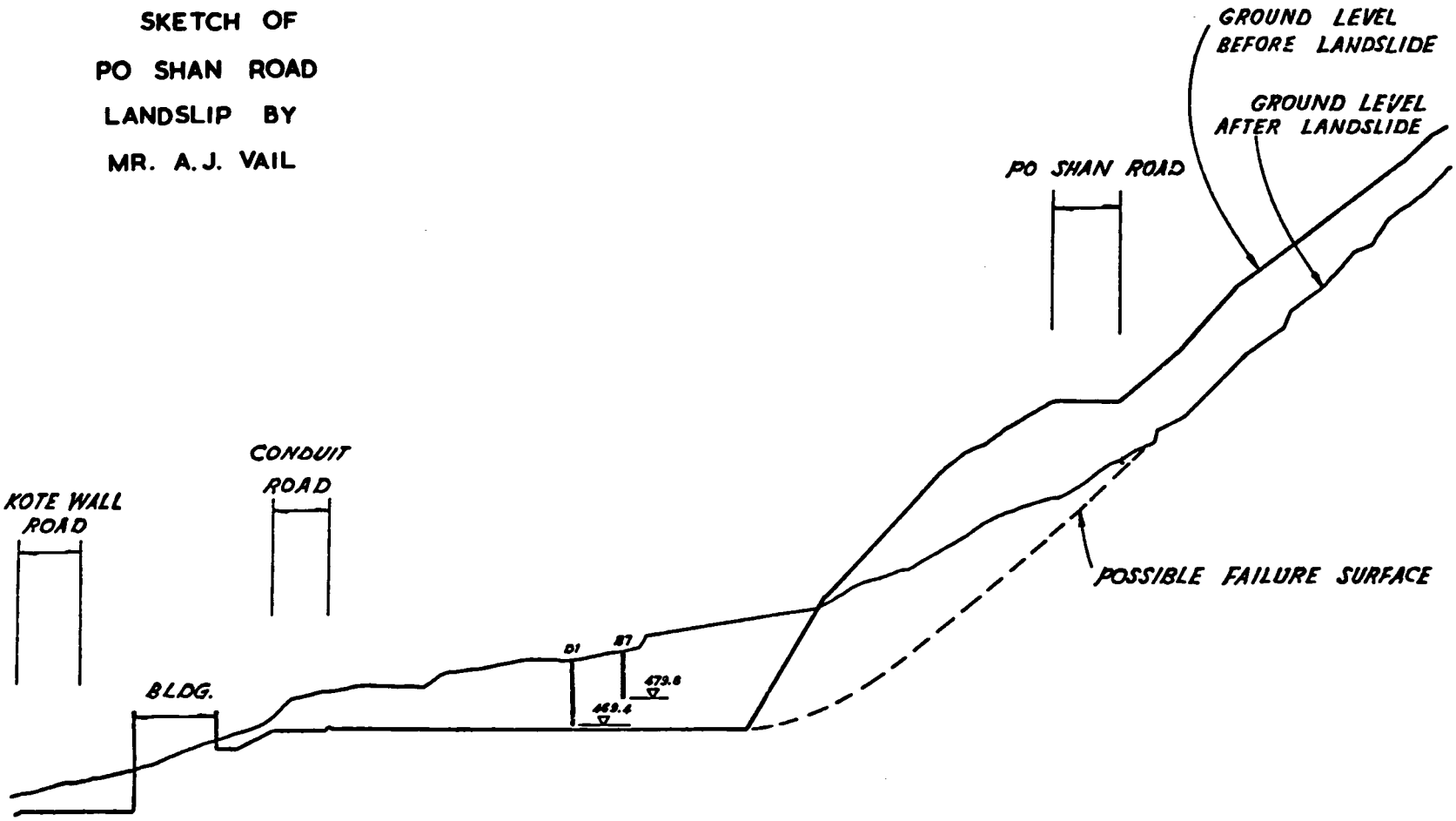
APPENDIX XIX

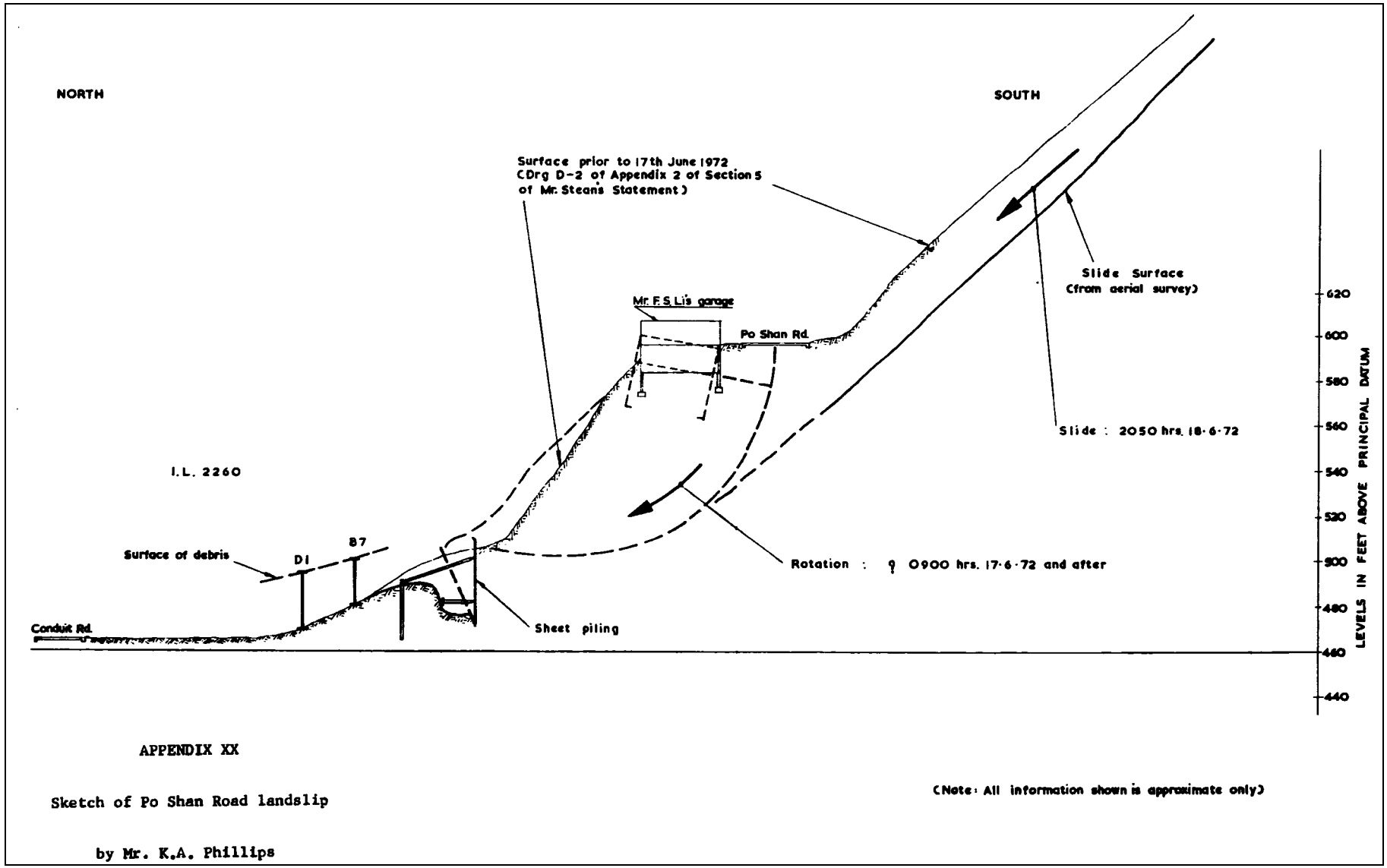
SKETCH OF

PO SHAN ROAD

LANDSLIP BY

MR. A.J. VAIL





APPENDIX XX

Sketch of Po Shan Road landslip

by Mr. K.A. Phillips

(Note: All information shown is approximate only)

APPENDIX XXI

EQUIPEMNT USED BY THE FIRE SERVICES

PNEUMATIC AIR-BAG

1. A pair of pneumatic air-bag connected to an ordinary compressed-air cylinder in operation after inflation, giving a total lifting force of 8,480 lbs. to lift e.g. a vehicle from ground.

TIRFOR - A HAND-OPERATED WINCH

2. A fireman in action to operate a Tirfor for pulling objects by manually operating the handle of this device to shorten the wire. A maximum pulling force of three tons horizontally and one and a half tons vertically can be provided.

PRY-AXE

3. An axe consisting of various components, including an axe blade with serrated teeth, a pike, a claw and a detachable handle for levering, is used for general breaking-in purposes.

LARGE BOLT CROPPER

4. For general cutting of iron wire/rod up to ½ in. diameter.

CHISEL

5. (Self-explanatory).

CROWBAR

6. For general digging and levering purpose.

10-LB. HAMMER

7. (Self-explanatory).

10-TON PORTO-POWER

8. A 10-ton hydraulic porto-power with ancillary equipment can be set up into various combinations for performing clamping, pushing, pulling and spreading duties.

50-TON PORTO-POWER

9. A 50-ton hydraulic porto-power which consists mainly of a manually operated hydraulic hand-pump connected via a high pressure tube to a ram, may be used to perform lifting duties.

Appendix XXI – *Contd.*

RESUSCITATION APPARATUS

10. A resuscitation apparatus is used for applying oxygen/air-mixed oxygen to a person to effect artificial respiration by means of a mouth mask connected up to the set. Oxygen in passed from the connected oxygen cylinder, passes through a pressure-reducing regulator and is delivered to the face mask for application to the casualty to effect artificial respiration. Extention enables resuscitation in confined places.

PORTABLE OXY-PROPANE CUTTING SET

11. A portable flame cutting set can be mounted on the back of the user. It is provided with self-contained propane and oxygen gases to form a high temperature flame for cutting metals of general thickness up to 2 in.

IMPACT CUTTER

12. A compressed-air operated cutter gives impact force for cutting general hard materials of concrete, stone and metal. Compressed-air is supplied from an air-liner set with compressed-air cylinder via extensible high pressure tube.

K-12 CUTTING SETS

13. A petrol-motor driven portable cutting set with variable cutting discs made of special material for all kinds of cutting duties, including concrete, metal and stone.

COMPRESSED-AIR BREATHING APPARATUS

14. This is a self-contained breathing apparatus with compressed-air stored in a cylinder.

GEO PUBLICATIONS AND ORDERING INFORMATION
土力工程處刊物及訂購資料

A selected list of major GEO publications is given in the next page. An up-to-date full list of GEO publications can be found at the CEDD Website http://www.cedd.gov.hk on the Internet under "Publications". Abstracts for the documents can also be found at the same website. Technical Guidance Notes are published on the CEDD Website from time to time to provide updates to GEO publications prior to their next revision.

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土力工程處之主要刊物

GEOTECHNICAL MANUALS

Geotechnical Manual for Slopes, 2nd Edition (1984), 300 p. (English Version), (Reprinted, 2000).

斜坡岩土工程手冊(1998)，308頁(1984年英文版的中文譯本)。

Highway Slope Manual (2000), 114 p.

GEOGUIDES

Geoguide 1	Guide to Retaining Wall Design, 2nd Edition (1993), 258 p. (Reprinted, 2007).
Geoguide 2	Guide to Site Investigation (1987), 359 p. (Reprinted, 2000).
Geoguide 3	Guide to Rock and Soil Descriptions (1988), 186 p. (Reprinted, 2000).
Geoguide 4	Guide to Cavern Engineering (1992), 148 p. (Reprinted, 1998).
Geoguide 5	Guide to Slope Maintenance, 3rd Edition (2003), 132 p. (English Version).
岩土指南第五冊	斜坡維修指南，第三版(2003)，120頁(中文版)。
Geoguide 6	Guide to Reinforced Fill Structure and Slope Design (2002), 236 p.
Geoguide 7	Guide to Soil Nail Design and Construction (2008), 97 p.

GEOSPECS

Geospec 1	Model Specification for Prestressed Ground Anchors, 2nd Edition (1989), 164 p. (Reprinted, 1997).
Geospec 3	Model Specification for Soil Testing (2001), 340 p.

GEO PUBLICATIONS

GCO Publication No. 1/90	Review of Design Methods for Excavations (1990), 187 p. (Reprinted, 2002).
GEO Publication No. 1/93	Review of Granular and Geotextile Filters (1993), 141 p.
GEO Publication No. 1/2000	Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls (2000), 146 p.
GEO Publication No. 1/2006	Foundation Design and Construction (2006), 376 p.
GEO Publication No. 1/2007	Engineering Geological Practice in Hong Kong (2007), 278 p.

GEOLOGICAL PUBLICATIONS

The Quaternary Geology of Hong Kong, by J.A. Fyfe, R. Shaw, S.D.G. Campbell, K.W. Lai & P.A. Kirk (2000), 210 p. plus 6 maps.

The Pre-Quaternary Geology of Hong Kong, by R.J. Sewell, S.D.G. Campbell, C.J.N. Fletcher, K.W. Lai & P.A. Kirk (2000), 181 p. plus 4 maps.

TECHNICAL GUIDANCE NOTES

TGN 1	Technical Guidance Documents