CHAPTER VII

HYDROLOGICAL INVESTIGATION

Hydrological investigation was done by means of air-photographic interpretation for the drainage pattern and seepage locations, visual observation of the surface water, meteorological study and subsurface investigation of ground water condition and permeability of soil samples. The knowledge from these studies was employed in slope stability analysis.

7.1 Meteorological Study.

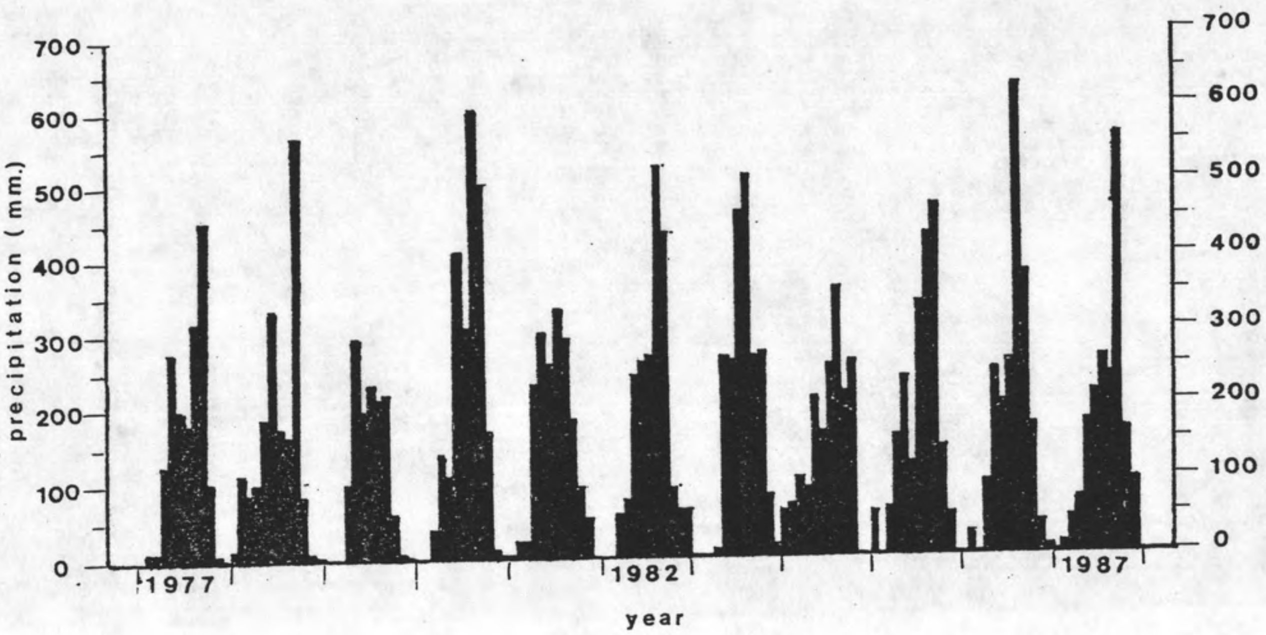
A record of ten years of rainfall in Prachinburi from the Meteorological Department was illustrated as the histograms as shown in Figure 7.1a. The data indicate that the rainy season normally lasts from May to October. The heaviest rainfall generally comes during July to September with an average monthly rainfall of 350 mm., while the average annual precipitation is 1,900 mm. In August, 1983 and 1986 when the landslides occurred, the precipitations were highest, almost twice as much of the normal value (Figure 7.1b).

Thus, these failures are directly related to the heavy rainfall.

7.2 Surface Water Investigation.

The study of the original detailed topography and topographic profiles of the study area reveals that there is a small natural drainage channel jointing the main stream at KM.12.695 (Figure 7.2).

a)



b)

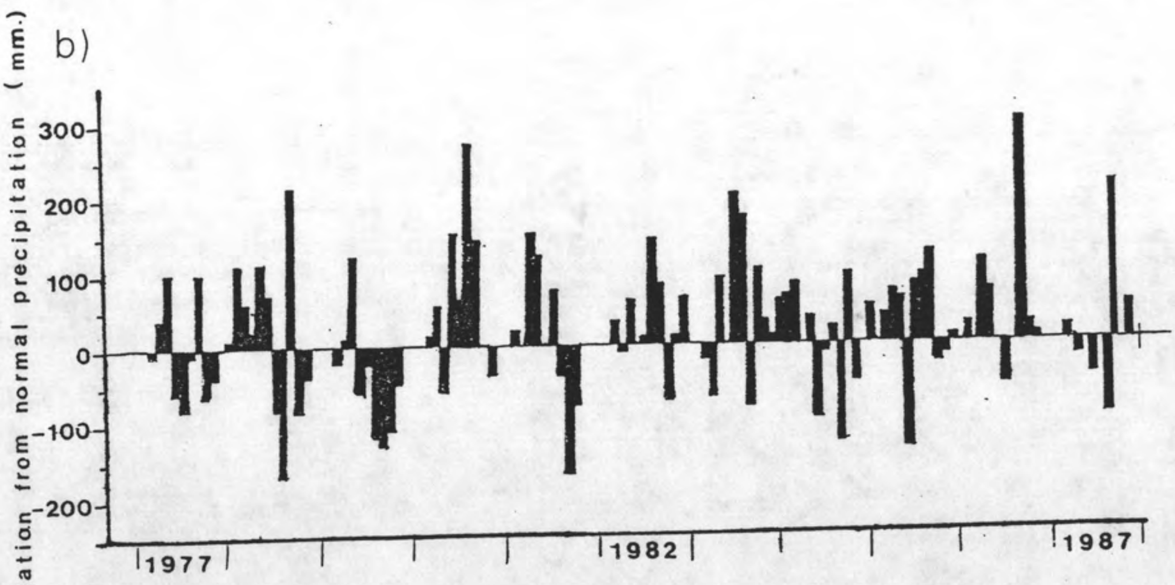


Figure 7.1 Record of rainfall in Prachinburi.

a) Monthly rainfall intensity recorded from 1977 - 1987.

b) Monthly deviation from normal precipitation.

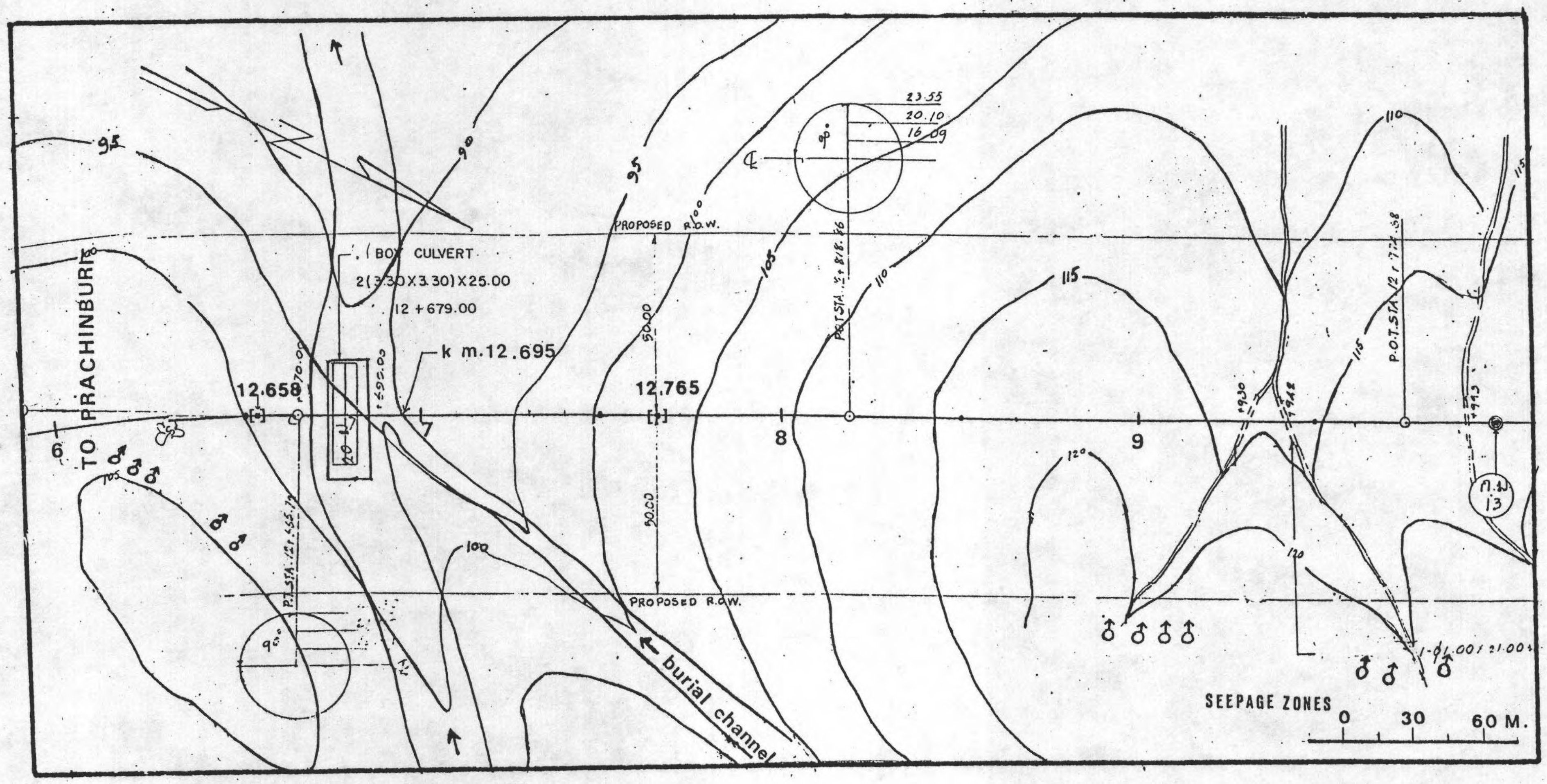


Figure 7.2 Original topographic detailed of study area of embankment failure.

This natural drainage was blocked by the embankment fill and no discharge allowance was prepared for this drainage channel. The blockade of the running water may be the additional cause of slope failures here.

7.3 Spring and Seepage Investigation.

Springs and seepage are the common distinctive features of the colluvium. Colluvium is often more permeable at the base and may result in a spring line at the basal contact where exposed. The permeability contrast is especially clear near stream courses or below rock scarps where the colluvium may have had much of its fine matrix washed out by surface water flow or, near the base of the colluvium, by the backsapping of sub-surface springs (Huntley and Randall, 1981).

Many seepages were discovered in the colluvium mass of the present study area, especially at the location of embankment failures near the stream course. The location of seepage zones and seepages are shown in Figures 4.1, 6.1 and Plate 6.2.

7.4 Groundwater Investigation.

Colluvium is generally more permeable than the underlying basement layer, and perched water table is likely in the colluvial mass (Deere and Patton, 1971; Tien and Sangrey, 1976.). It is also likely that the saturation condition approaches the shallow depth during the life of a slope (Brand, 1984.) and non-uniformity in permeability of colluvium allows artesian aquifer at the base of the colluvium (Deere et al., 1971).

During the investigation in 1985-1986, three open-stand pipes and 2 observation wells were installed. Their locations are shown in Plate 6.2.

A general picture of ground water condition in the study area appears as follows:

1. Because of a high difference in permeability between colluvium and the underlying impervious mudstone and siltstone, perched groundwater was observed.

2. Because of the dip direction of impervious mudstone and siltstone is toward the embankment failure area, groundwater flowage into this area is very likely.

3. The groundwater level is directly related to the amount of rainfall.

4. The natural drainage was blocked by embankment fill and no discharge allowance was prepared for this drainage channel.

5. For the failure in 1983, the groundwater observation was done by the writer in his previous work at the end of November. Unfortunately, the highest groundwater level could not recorded but the groundwater surface was oftenly found beneath the upper layer of filled materials. The confined aquifers were found both in the sliding mass and colluvium.

6. For failure in 1985-1986, the observed groundwater surface was located within the gravel drain layer at the depth of 2

to 3 meters below the ground surface. This groundwater surface was plot in Figures 9.8 and 9.9, corresponding to the profile of the slides.

7.5 Field Permeability Test.

The knowledge of the permeability of soil formations is essential for the planning of drainage systems and interpreting the groundwater regime.

The in-place permeability tests were performed in the soils at the slide area using bore hole test techniques namely open-end test method recommended by United States Bureau of Reclamation (USBR), (1961). The condition in Figure 7.3b was chosen to determine the permeability. The determination procedure is as follows:

1. Casings are inserted into the bore hole to the soil layer whose permeability is needed to be determined.

2. The hole is cleaned out.

3. Clear water is filled into the hole to the top of the casing, then more water is added to maintain gravity flow at a constant head (h).

4. The rate of adding water is recorded.

The coefficient of permeability can be determined by the equation

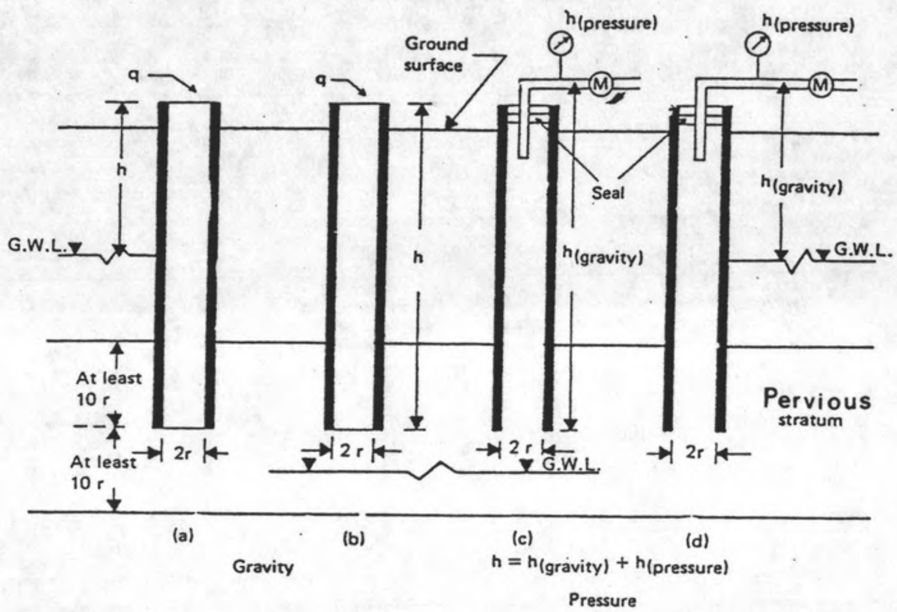


Figure 7.3 Open-end test for soil permeability in the field.(After U.S. Bureau of Reclamation, 1961).

$$k = \frac{q}{5.5rh}$$

where r = inside radius of the casing.

h = differential head of water.

q = rate of supply of water to maintain constant head.

The results of field permeability test are classified according to Hoek and Bray (1974) and summarized in Table 7.1.

The permeability study of the soils and data gathered from the subsurface investigation revealed that the average permeability valve of 1985-1986 filled material is 4.14×10^{-7} cm./sec. The value indicates a practically impervious condition (Hock et al., 1974). Meanwhile, the colluvium is a water bearing stratum that has a low ability to transmit water, with an average permeability of 2.88×10^{-6} cm./sec. This permeability value indicates a poor drainage condition (Hock et at.,1974). This in ability is even accentuated not only by a block of filled material in colluvium, but also by the low gradient of the underlying existing weathering profile or bedrocks. Under this condition, during a period of high rainfall, the groundwater in colluvium is raised up and a high excess pore water pressure is developed. This leads to the change of groundwater situation from unconfined to confined aquifer.

Table 7.1. Summary of the coefficient of permeability test results in filled material and colluvium.

Materials	Coefficient of Permeability (cm./sec.)	Classification
	1.23×10^{-7}	practically impermeable
	1.82×10^{-7}	practically impermeable
	2.23×10^{-7}	practically impermeable
Filled	3.67×10^{-7}	practically impermeable
material	5.02×10^{-7}	practically impermeable
	7.21×10^{-7}	practically impermeable
	7.81×10^{-7}	practically impermeable
	1.09×10^{-6}	low discharge poor drainage
	1.00×10^{-6}	low discharge poor drainage
	1.06×10^{-6}	low discharge poor drainage
	1.09×10^{-6}	low discharge poor drainage
	1.16×10^{-6}	low discharge poor drainage
	1.71×10^{-6}	low discharge poor drainage
	1.90×10^{-6}	low discharge poor drainage
	1.90×10^{-6}	low discharge poor drainage
Colluvium	1.90×10^{-6}	low discharge poor drainage
	2.05×10^{-6}	low discharge poor drainage
	2.23×10^{-6}	low discharge poor drainage
	2.56×10^{-6}	low discharge poor drainage
	2.64×10^{-6}	low discharge poor drainage
	4.61×10^{-6}	low discharge poor drainage
	6.32×10^{-6}	low discharge poor drainage
	6.46×10^{-6}	low discharge poor drainage
	7.55×10^{-6}	low discharge poor drainage