The Indonesian Journal of Geography Vol. 18, No. 56,
December 1988. pp. 29 - 42

GEOMORPHOLOGICAL APPROACH TO SURFICIAL MATERIAL EVALUATION IN THE SERANG RIVER BASIN KULONPROGO, YOGYAKARTA, INDONESIA

by
Sutikno*

ABSTRACT

This study deals with the evaluation of surficial material characteristics, based on landform units in the Serang River Basin. The approach concentrates on the use of geomorphological mapping by using aerial photo interpretation and field investigations. The landform units, as defined by geomorphological mapping, was used as sample areas to determine the surficial material characteristics. These characteristics include grain size, sphericity and roundness coefficient. The measurement of the material characteristics in the river bed was based on 100 gravel pebbles systematically sampled along the length profile of the river. During the survey, 14 cross sections were chosen. The potential of the alluvial material resources was estimated by their areal distribution, thickness sedimentary and characteristics.

Among landform units in the studied area which contains a large amount of the materials are: natural levees, river terraces, river bed and hill foot slopes. Generally, the river bed materials decrease in grain size downstreams and increase in sphericity and roundness coefficient. In some cross sections a reversal was found to the general tendency. This situation might be due to human activities for getting material for construction. Due to human activities some environmental impacts occur.

INTRODUCTION

Surficial materials are important as building materials in the construction of highways, rail roads, airports, bridges, and housing. The term surficial materials refers to the materials above bedrocks whether they have arrived there by transport or have developed in situ (Townshend, 1979).

The need for building materials such as sand and gravel increases rapidly in Indonesia due to the national development, especially in physical construction. The

* **Dr. Sutikno is lecturer at Faculty of Geography, Gadjah Mada University, Yogyakarta, Indonesia.**

need for those materials in Indonesia is very large, but the quantity cannot be determined easily. The demand for materials for construction purposes can be estimated from the length of roads and bridges that were constructed and rehabilitated for two years, from 1984 to 1986. During these two years 258 km of new roads and 399 m of new bridges were constructed, and 11,010 m of bridges were rehabilitated, it can be imagined how large the volume of needed materials was.

In Indonesia, the resources of surficial materials for constructional purposes are abundant, but the distribution is uneven. Due to their uneven distribution and the large demand, the exploitation of the surficial materials sometimes causes environmental problems. The surficial materials are commonly found in fertile agricultural land or in settlement areas both in rural and urban areas. Land utilization conflicts arise between the use of the land as sources for surficial materials and other uses. To eliminate those conflicts it is necessary to have information about the location, the quantity, and the character of the surficial materials. Such information can be used in planning the utilization of the surficial materials as optimal and rational as possible and without negative impacts on the environment.

In the Serang River Basin the potential of surficial materials and their characteristics are still unknown, while exploitation of the materials increases rapidly. Some river bank erosion has occurred and caused agricultural land damages.

Objectives of this study are (a) to determine the characteristics and distribution of the surficial material by landform unit approach, and (b) to evaluate the potential of the surficial materials in the study area.

THEORICAL BACKGROUND

Surficial materials for construction purposes generally consist of sand and gravels. Sands and gravels have certain diameter ranges; according to Cook (1974), sands fall within the diameter in interval 0.06 - 2 mm and gravels within 2 - 6 mm. McLean (1979) states that the surficial materials, from engineering point of view are all materials on the surface that can be dug without being drilled and blasted.

The materials for constructional purposes are derived historically from sedimentary rock formations and depositional materials near the surface. Geomorphologically, those surficial materials are found in four locations, namely: (1) in the rivers or stream courses, flood plain and river terraces; (2) in fluvioglacial environments; (3) in marine environments, and (4) in slope and foot slopes (Cook, 1974).

The surficial materials have certain characteristics covering grain size, sphericity coefficient, roundness and sorting coefficients (King, 1966; Sutikno and Suseno, 1979). The differences in characteristics of surficial materials are caused by different geomorphological processes and the property of the parent materials. Theoretically, a landform unit is the otcome of geomorphological processes reshaping a particular landscape. It means that each landform unit is composed of surficial materials with specific characteristics, and formed by specific geomorphological processes. Because landform units are distintive features in the field and discernible on the aerial photographs or on other remote sensing images, their areal distribution and their characteristics are easily identified, classified and mapped. The areal distribution and characteristics of the landform units can be used as a basic evaluation of surficial materials. The landform units are the main elements of a geomorphological study.

METHODOLOGY

In this study, geomorphological aerial photo interpretation was done, especially for preparing a landform unit map. During the photo interpretation, existing topographical map at a scale of 1:50,000, and geological maps at scales of and 1:50,000 and 1:100,000 of the study area have been used as references. The black and white panchromatic aerial photos, dated from 1981 were used. Based on the landform unit map, field observations, measurement and surficial material samples collection have been carried out. Field observations and measurements were focussed to thicknesses and concentrations of the surficial material, while surficial material samples were used for determining the grain size, sphericity, roundness and sorting coefficients. Due to the fact that the surficial materials are mainly found in the river bed, sample collection was focussed to the river bed. Fourteen river cross sections have been chosen to study the characteris tics of the river bed materials. In each cross section 100 of individual gravels have been collected by systematically random sampling, in case the dominant river bed materials are gravels. From river bed materials consisting mainly of sand, two kilograms of sand have been taken for grain size analysis in the labora tory. From each individual pebble, the length, width, thickness and the radius of corners and edges, have been measured. The parameters were used to calculate average values of grain size, sorting, sphericity and roundness coefficients. The mean grain size was calculated by Dolk and Ward formula (King, 1966).

$$Mz = \frac{\phi 16 + \phi 50 + \phi 84}{3}$$

where Mz = mean grain size
ϕ = conversion of diameter in mm, by using
ϕ = $-\log_2 d$(d = diameter in mm);
$\phi 16$ = the 16th percentiles on ϕ scale.

The sphericity coefficient was calculated by the Wadell concept (Sutikno and Susena, 1979).

$$Sp = \sqrt[3]{c^2/(a.b)}$$

where Sp = sphericity coeffient
a = length of the grain
b = width of the grain
c = thickness of the grain.

The roundness coefficient was determined by the Wadell concept (Krumbein, 1963).

$$Rd = \frac{\text{Average radius of corners and edges}}{\text{Radius of maximum incribed circle}}$$

The sorting coefficient was calculated by the Folk and Ward for mula (King, 1966).

$$r = \frac{\phi 54 - \phi 16}{4} + \frac{\phi 95 - \phi 5}{6.6}$$

where r = sorting coefficient
ϕ 54 = the 54th percentiles on ϕ - scale.

Evaluation of the surficial materials in terms of the quantity aspect was based on the area of the landform unit, the thickness of the layer and the concentration of the surficial materials in a certain cross section.

THE STUDY AREA

The Serang River Basin is located in the Kulonprogo Hilly area, Kulonprogo Regency, Yogyakarta Special Region Province, about 30 km west of Yogyakarta City. The river basin extends from the hilly area in the North to the hilly, low land and coastal area in the South (Figure 1). The highest altitude in mountainous area is 719 m above sea level.

The study area has a tropical monsoonal climate with the average annual rainfall of 2200 mm in the western part and 1600 mm in the eastern part. The mean annual temperature is about 27^{0}C, and the range of the temperature throughout the year is small (Tukidal Yunianto, 1982). The Kulonprogo area is composed of several geological formations:

a. *Nanggulan* Formation (Upper eocene) consisting of sandstone, lignite, claystone, marl, and arkose sandstone.
b. Old Andesites, (Oligocene) as named by Van Bemmelen (1949), Oligocene consisting of andesitic breccia, lapilli tuff, agglomerate, and intercalations of andesitic lava flows. The thickness of this formation amounts to about 650 m (Bemmelen, 1949; Wartono *et al.*, 1977).
c. *Conggrangan* Formation (Lower Miocene) The lower part consists of conglomerates overlain by tuffaceous marls and calcareous sandstones intercalated with seams of lignite. These pass upward into bedded limestone and into coraline limestone, the thickness of this formation is about 250 m (Wartono *et al.*, 1977).
d. *Şentolo* Formation (Middle Miocene) composed of limestones, calcarenites and marly sandstones. The lower part of the formation consists of a basal conglomerate overlain by tuf faceous marl with intercalation of vitric tuffs; the thickness of this formation is about 950 m (Wartono *et al.*, 1977).
e. Colluvial and Alluvial Deposits (Recent): colluvial deposits are mainly composed of unsorted debris from the Old Adesite Formation and andesitic rocks. The alluvial deposits are composed of gravel,, sand, silt and clay.

Besides this formation, in the centre of the Kulonprogo Mountains there are extrusive rocks of andesite. The composition of the andesite ranges from hyper-

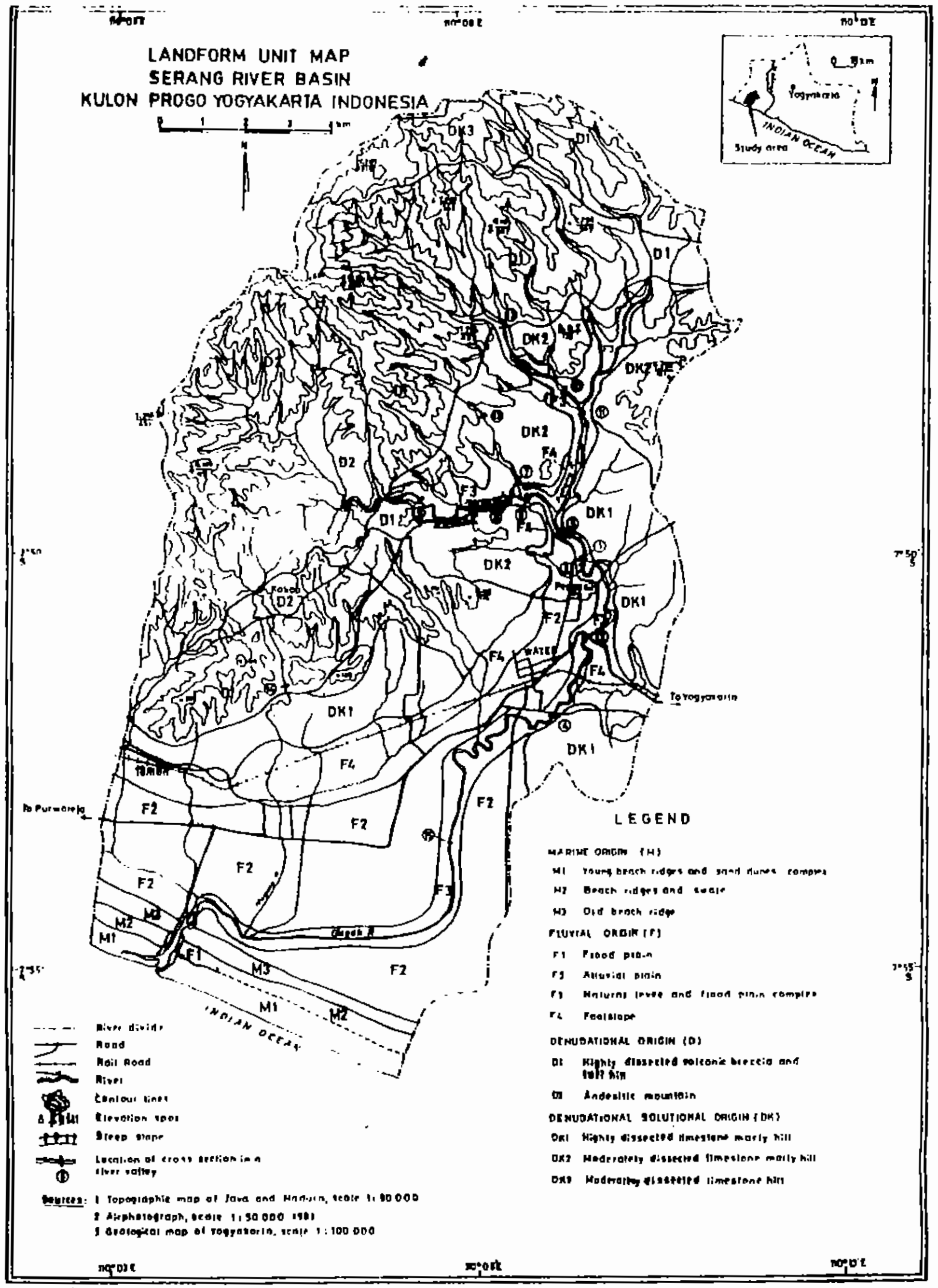

Figure 1. Landform Unit Map of Serang River Basin,

sthene andesite to hornblende- augite andesite and trachyandesite; most of which are prophylitized (Wartono *et al.*, 1977).

The Kulonprogo Mountain as a whole has a dome-like structure, which is characterized by a high topography in the centre of the mountain, layers of the bedrocks in some locations are dipping outward radially with radial patterns of faults. In the block between two adjacent faults sliding and slumping occurred due to gravity tectonics. Joints are found frequently in the study area, even in the Old Andesite Formation and in the andesites. Fault and joint structures in the andesitic breccia and andesites attacked by mechanical and chemical weathering results in debris for surficial materials.

The Serang River Basin covers an area of about 231 square km. The shape of the basin is semi circular, and the stream has a dendritic pattern. Fluctuation in discharges is high, while the maximum discharge occurs in December, January, February and March, respectively 144, 146, 125 and 125 cu.m. The mean minimum discharge occurs in September, amounting to about 5 cu.m (Pujiharto, 1973). When the discharge is high, large amounts of bed materials are transported and deposited along the river bed, when the low discharge is low, the river bed materials are exploited.

Land cover in the study area consists of homestead gardens, rice fields, field crops, mixed gardens, forest plantation, and barren land. The rice field homestead garden and field crops are mostly distributed in the lowland area, while the field crops, mixed garden and forest plantation are distributed in the hilly to mountaneous area. The barren land is found in the beach ridges and sand dunes area.

RESULTS AND DISCUSSION

Landform Units

Based on the geomorphological mapping by aerial photo interpretation technique, the Serang River Basin can be divided into landform units formed in marine, fluvial, denudational, denudational-solutional environments. Landforms of marine origin consist of three units, namely: young beach ridges and sand dunes complexes; beach ridges and swale complexes; and old beach ridges. Floodplain, alluvial plain, natural levee and river terraces complexes, and footslopes are the landform units of fluvial origin. The landform units of denudational origin consist of strongly dissected volcanic-breccia hills, and dissected old andesitic mountain. The landform units of denudational-solutional origin consist of dissected limestone hills, and moderately dissected limestone-marl hills. The areal distribution of the landform units are presented in the landform unit map (Figure 1).

Among the landform units in the study area, some contain surficial materials with considerable economical value such as the natural levee and river terraces complexes, and footslopes. Those landform units can be described as follows:

Natural levee and River terraces complexes. In fact this unit can be divided into natural levees, river terraces, and flood plains, but on aerial photographs scaled at 1:30,000, it cannot be delineated separately. This unit extends along the main river channel and the larger tributaries. This unit is made up of unconsolidated materials of sands, gravels and boulders. The topography of this unit is

processes in this unit are deposition, especially during flooding periods, and river bank erosion. During one season in 1987, river bank erosion caused agricultural land to be lost as much as 200 m long. This type of erosion can supply materials to the river bed. The river bed in the study area is the main unit of abundant surficial materials that can be exploited direcly by the local people. Hundreds of the local inhabitants along the river make living on digging river bed materials.

In total 14 cross sections (Figure 2) have been chosen to show the characteristics of the river bed materials. Figure 1 shows the result of the cross sections, which are arranged from the upstream to downstream. The position of the cross sections are adjusted to the pattern of the streams. The general shape of the valleys+is U shape with flat bottom. The river channels are wider upstream and narrower downstream, for examples in the cross sections 13,10,11 and 5, the river channels are 74 to 108 m wide; while in the downstream cross sections 5,1,2,3, and 4 they decrease at the minimum of 34.4 m. The decrease in width of the river channel in a downstream direction is controlled by the bedrocks of the river bottom and river bank. The bedrocks in the cross sections 1 to 4 are sandy limestone and marly tuff.

The characteristics of the river bed materials as shown in Figure 2, cover the length (L), width (W), thickness (T), sphericity coefficient (Sp), and roundness (Rd). The values of the characteristics in Figure 2 are taken from the field data, and the average field data are summarized in Table 1 for individual grain of surficial materials and boulders . Table 2 shows the grain size analysis of the bed materials from cross sections 4 and 15 (Figure 2). The average value of the individual pebbles and boulders is 6.0 to 10.5 cm in length with standard deviation ranging from 1.40 to 2.99; 4.2 to 7.4 cm in width with standard deviation ranging from 1.03 to 4.16; 2.9 to 4.9 cm in thickness with standard deviation ranging from 0.99 to 3.35. The decreasing value of the grain size from upstream to downstream followed the transportation principles of running water. In some cross sections, there is a deviation from the general tendency of these transportation principles. This might be due to human activities in exploiting river bed materials for constructional purposes. The materials come from buttom of palaesol and sphereroidal weather up to the bed rocks.

The sphericity coefficient of the river bed materials ranges from 0.6 to 0.7; and the roundness coefficient from 0.5 to 0.7. According to the chart visual estimation of spherecity and roundness (Krumbein *et al.*, 1963), the value of those coefficient is in medium sphere and medium round. The mean value of spherecity and roundness coefficient show that river bed materials have already been transported by rolling and intensively abraded, due to the rugged river bed and relatively high stream gradient. The river gradient ranges between 1^0 to $2^0$10'. Another possibility for the medium value of the sphericity and the mean roundness coefficient is that the shape of the materials before entering to the river may have been already spherical and rounded because of sphereroidal weathering in the lower zones of the (paleo)-soil profiles.

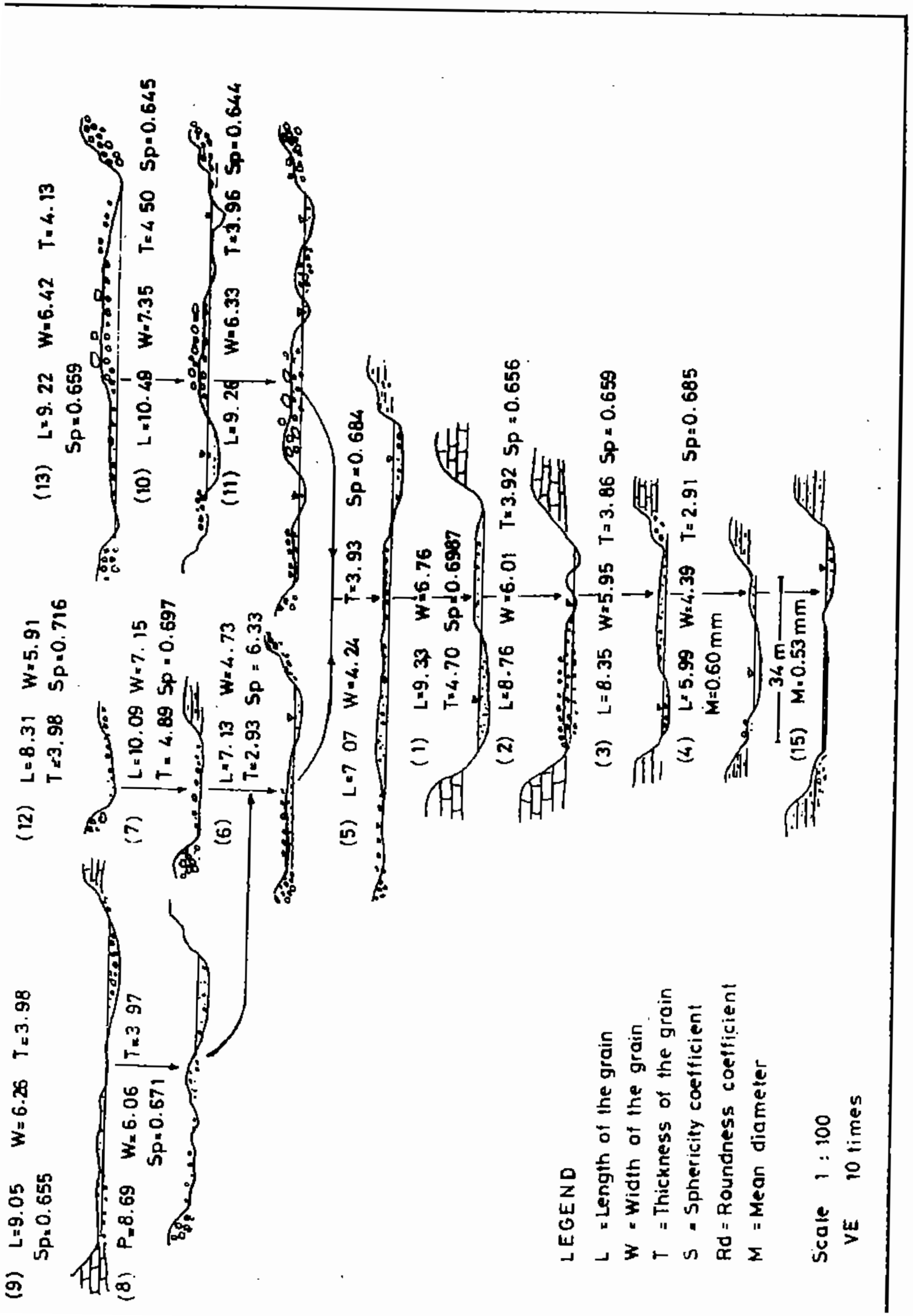

Figure 2. Cross-sections of The River Valley Upstream to Downstream.

TABLE 1.THE CHARACTERISTICS OF THE RIVER BED MATERIALS IN CROSS-SECTION OF THE SERANG RIVER.

No.	Number of Cross section in The Map	Length mean (cm)	Length sd	Width mean (cm)	Width sd	Thickness mean (cm)	Thickness sd	Sphericity mean	Sphericity sd	Roundnees mean	Roundnees sd
1	4	6,5	1,40	4,4	1,03	2,9	0,99	0,72	0,11	0,69	0,12
2	3	8,4	2,51	6,0	4,16	3,9	1,60	0,66	0,11	0,66	0,10
3	2	9,0	2,03	6,0	1,62	3,9	1,54	0,68	0,12	0,66	0,10
4	1	9,3	2,59	6,8	1,74	4,7	1,39	0,69	0,13	0,70	0,12
5	5	7,1	1,98	4,2	1,55	3,9	1,20	0,61	0,12	0,69	0,12
6	6	7,1	1,66	4,7	1,17	2,9	1,06	0,67	0,13	0,63	0,12
7	7	10,1	2,99	7,2	2,55	4,9	1,78	0,65	0,12	0,70	0,10
8	12	8,3	2,33	5,9	1,63	4,2	1,47	0,58	0,09	0,72	0,11
9	9	9,1	2,04	6,3	1,58	4,0	1,33	0,64	0,12	0,66	0,12
10	8	8,7	2,44	6,1	2,01	4,0	1,51	0,64	0,13	0,67	0,11
11	10	10,5	2,44	7,4	2,01	4,5	1,51	0,57	0,13	0,65	0,11
12	11	9,3	2,74	6,3	2,27	4,0	3,35	0,55	0,11	0,64	0,10
13	13	9,2	2,72	6,4	1,75	4,1	1,53	0,58	0,12	0,66	0,12
14	14	8,1	1,96	5,8	1,45	4,0	1,77	0,54	0,13	0,68	0,12

Sd = Standard deviation

The roughness of the river bed is indicated by the number of boulders in the cross-sections. In cross-section 5 the amount of boulders with more than 50 cm in diameter relatively increase. In the cross sections 7,8,9,10,11, and 12 the amount of the boulders are 31, 124, 131, 292, 151, and 132 respectively.

The thickness of the river bed materials is difficult to measure without excavation or hand drilling. Based on the dug hole made by local people in the valley floor it ranges from 0.5 to 1.5 m. The average thickness in this study is assumed to be at least one m. This thickness value is used for the calculation of the surficial materials in the river bed.

TABLE 2. GRAIN SIZE ANALYSIS OF RIVER BED MATERIALS IN CROSS SECTION 4 AND 15

No.	Unit	1	2	3
Lab. No.		135/G/87	136/G/87	137/G/87
No. of Submission		I	II	III
depth		-	-	-
Date of taking sampler		1-7- '87	1-7- '87	2-7- '87
Location		SWK	SWT	SB
Note		-	-	-
Humidity	(%)	-	-	-
Grain > 25.00 mm	(%)	22.33	0.00	0.00
25.00 mm > grain > 16.00 mm	(%)	14.63	0.00	0.00
16.00 mm > grain > 11.20 mm	(%)	13.38	3.09	0.00
11.20 mm > grain > 8.00 mm	(%)	8.33	0.60	0.00
8.00 mm > grain > 5.60 mm	(%)	7.38	1.27	0.52
5.60 mm > grain > 4.00 mm	(%)	4.66	1.37	0.86
4.00 mm > grain > 2.80 mm	(%)	4.68	1.67	1.64
2.80 mm > grain > 2.00 mm	(%)	1.21	0.70	0.84
2.00 mm > grain > 1.40 mm	(%)	3.30	2.52	4.16
1.40 mm > grain > 0.85 mm	(%)	5.60	9.13	17.85
0.85 mm > grain > 0.60 mm	(%)	3.90	11.57	20.94
0.60 mm > grain > 0.425 mm	(%)	3.12	14.25	22.98
0.425 mm > grain > 0.300 mm	(%)	2.78	23.68	16.17
0.300 mm > grain > 0.212 mm	(%)	2.20	17.87	5.83
0.212 mm > grain > 0.150 mm	(%)	0.91	8.21	2.85
0.150 mm > grain > 0.106 mm	(%)	1.28	2.06	1.34
0.106 mm > grain > 0.075 mm	(%)	0.12	0.39	0.75
0.075 mm > grain > 0.053 mm	(%)	0.05	0.35	0.68
0.053 mm > grain > 0.032 mm	(%)	0.06	0.20	0.27
0.032 mm > grain > 0.016 mm	(%)	0.05	0.10	0.29
0.016 mm > grain > 0.008 mm	(%)	0.02	0.05	0.41
0.008 mm > grain > 0.004 mm	(%)	0.02	0.07	0.47
0.004 mm > grain > 0.002 mm	(%)	0.00	0.18	0.30
0.002 mm > grain > 0.000 mm	(%)	0.00	0.67	0.85
Specific weight	(g/cc)	-	-	-
Organic matter	(%)	-	-	-

Source : Sutikno (1987).

The surficial materials in the natural levee and river terraces appear to be similar to the river bed materials. This is the reason why the characteristics of the materials in the natural levee and in the river terraces have been measured as well.

based on the bedding features, namely: (a) all the materials consisting of river bed materials with variation in grain size, but dominated by coarser materials; (b) at the bottom the materials have heterogeneous textures with irregular patterns, and in the upper part the materials are finer: (c) the bedding of the coarser and finer materials is clear. The materials in the natural levee and river terraces consist of andesitic fragments for about 90 percent and limestone fragments. The thickness of the materials of the river bank or valley varies from 0.5 to 2.5 m. It is estimated that the average thickness of the materials in this unit is 1.5 m.

Footslope Unit. This unit is developed in the transition zone between the hilly areas and the alluvial plains or natural levees and river terraces complexes unit. This unit was formed by accumulation of fragments resulting from weathering processes upon andesitic breccia, limestone and andesites; the fragments have moved down the slope under the influence of gravity. The topography on the footslope unit is generally gentle with a slope of about 8^0; the material is composed mostly of gravel with various shapes and sizes. In the upper part of the vertical profile, the materials have already been weathered and a soil with a finer texture has been formed. The depth of the weathered materials is about 30 to 45 cm. Below the weathered materials, the gravels are still fresh.

Since the materials of the footslope unit are generally coarse, and the upper part has already been weathered, the physical condition of this unit is suitable for agriculture activities and for settlement as well. However, it does not mean that the unit as a whole is suitable for agriculture and settlement, because this unit is subject to mass movement processes, such as slumping and landslides. Some mass movements occur in the study area, especially in footslopes that are composed of limestone fragments.

The surficial materials in the footslope unit are derived mainly from andesitic breccias, andesites and limestones, resulting from physical weathering. The physical weathering is active here, because of joints, fractures, and even faults. Sphereroidal weathering is a common feature in the andesites and andesitic breccias. The steep slopes on the mountains and hills, and land uncovered by vegetation are favourable factors for mass movement from the mountains and hills and the resulting colluvial debris are deposited on the footslope.

Characteristics of The Surficial Materials

The surficial materials are abundantly found on the landform unit of natural levee and river terraces complexes, and on the footslopes. At present the surficial materials in the river bed have been exploited for a long time. The deposits in the natural levee and in the river terraces are abundant too, but these units are used already for settlement and agricultural land. Hence, the description of the surficial materials characteristics concerns mainly the river bed materials.

Due to the sand-sized bed materials downstream, the size parameters of length, width etc. cannot be measured anymore, hence sieving methods are used. The river bed materials downstream cannot be measured individually. Three samples are taken for laboratory analysis. The results are presented in Table 2. Grain size data in Table 2 are plotted in a cumulative graph to arrive at a mean river course and 7.48 in the sand bar. In the cross sections 15, the location is lower downstream than the cross sections 4, the mean diameter of the river bed materials is 0.53 mm and the sorting coefficient is 0.43. Based on the result of the grain size analysis the bed materials in the cross sections 4 and 15 downstreams are finer-grained and better sorted. According to the Folk and Wars scale (King, 1966), the sorting coefficient in these cross-sections can be classified as extremely poorly sorted to well sorted.

The surficial materials in the footslope unit have diameters varying from sand, gravel to boulder. The thickness of the surficial materials in the footslopes is difficult to be determined. In some locations the thickness is about one metre and in other locations is very thick. In the footslope of the limestone hills the thickness varies from 0.5 to 2 m. To simplify calculations the thickness of the surficial materials is taken to be at least 1 metre.

Surficial Materials Potential

The potential of the surficial materials is estimated by the volume of the deposits. The volume of the deposits can be estimated by the areal of distribution, the thickness and the concentration. The areal distribution data are based on the area of the landform unit that contains surficial materials, e.g. river bed, natural levee and river terraces, and footslope.

The area of the river bed based on Figure 1 is 89,000 sq.m in upstream of the cross sections number 5, and 541,000 sq.m between cross sections 5 to 4. The estimated thickness of the naturals of considerable value is 1 m., and the concentration in one metre wide in the vertical section is estimated about 80 percent. Based on the parameters the amount of the deposits in the river bed is estimated at 1,325,000 cu.m.

The area of the natural levee and river terraces based on the Map 1 is 5879500 sq.m. The estimated thickness in considerable value is 1.5 m, and the concentration of the surficial in the natural levee and river terracess is 5,291,550.

The area of the footslope unit is 993,750 sq.m, the thickness is 1 m and the concentration is about 40 percen. Based on those data the amount of surficial materials in the footslope unit is 397,500 cu.m.

The natural levee and river terrace, based on the Map 1, cover an area of 5,879,500 sq.m. The estimated thickness of the materials of considerable value is 1.5 m and the concentration of the materials is 60 percen. The amount of deposits of the surficial materials in natural levee and river terrace is 5,291,550 cu.m.

The area of the footslope unit is 993750 sq.m, the thickness is 1 m and concentration is about 40 percent. The valume on the footslope unit is 397,500 cu.m.

The total amount of the surficial materials in the Serang River Basin is ca. 13,630,000 cu.m. The deposits are large enough, but not all of the materials can be exploited, because some of them are located in the agricultural land and settlements. In some segments of the river the exploitation of the river bed materials caused erosion river bank. To avoid the adverse impact of river bed exploitation, it is recommended that the local people should not be allowed to take river bed materials from the water course to prevent increasing river gradients.

CONCLUSION

Geomorphological mapping using airphoto interpretation with emphasis on the landform unit classification is advantagous for evaluation of the surficial materials. Among the landform units in the study area, the natural levee and river terraces complexes, river bed and footslope unit are the main landform units which contain surficial materials of economical value. The main characteristics of the materials are: grain size length 6.0 to 10.5 cm; width 4.2 to 7.3 cm and thickness 2.9 to 4.9 cm; the spherecity coefficient 0.54 to 0.72. Generally, the river bed materials decrease in diameter downstream and increase in the sphericity and roundness. The surficial materials in the natural levees, river terraces and footslope are similar to those in the river bed.

The river bed materials are derived from the natural levees, river terraces and footslopes due to erosion and mass movement processes. The surficial materials in the river bed can be exploited continuously without conflicting with other utilizations. The river bed material are recovered seasonally.

REFFERENCES

Bemmelen, R.W. Van. 1949. *The Geology of Indonesia I. General Geology Adjacant Archipelago.* The Hague: Goverment Printing Office.

Cooke R.U. and J.R. *Doornkamp. 1974. Geomorphology in Environmental Management.* Oxford: George Allen and Unwin.

Dackombe, R.V. and V. Gardiner. 1983. *Geomorphological Field Manual.* London: George Allen and Unwin.

Djoko Sutjahjono. 1983. *Penyebaran Sedimen Klastik Sungai Gandong,* Magetan, Jawa Timur. Skripsi Sarjana. Yogyakarta: Fakultas Geografi Universitas Gadjah Mada.

King A.M. Cuchlaine. 1966. *Technique in Geomorphology.* London: Edward Arnold.

Mclean and CN. Gribble. 1979. *Geology for Arit Engineer.* London: George Allen and Unwin.

Pannekoek. A.J. 1949. *Outline of the Geomorphology of Java.* Haarlem: Geological Survey.

Pujiharto. 1973. *Pengelolaan Daerah Aliran Sungai Serang, Kulonprogo.* Skripsi Sarjana. Yogyakarta: Fakultas Geografi Universitas Gadjah Mada.

Sartono, S. 1964. *Stratigraphy and Sedimentation of Eastern Most of Gunungsewu (East Java).* Publikasi Teknik Seroi Geologi Umum (1). Bandung: Jawatan Geologi.

Suharto. 1985. *Pidato Kenegaraan Presiden Republik Indonesia.* Jakarta.

Sutikno. 1987. *Studi Geomorfologi untuk Evaluasi Potensi Sumberdaya Material Bahan Bangunan di DAS Serang, Kulonprogo. Yogyakarta:* Fakultas Geografi UGM

Townshed J.R.G. and Poter T. Han Cock. 1981. The Role of Remote Sensing in Mapping Surficial Deposit. *In Terrain Analysis and Remote Sen-sing.* London: George Allen and Unwin

Wartono Rahardjo, Sukandarrummidi Rusidi. 1977. *Geological Report to Accompany Geological Map of the Yogyakarta Quadrangle, Java.* Bandung: Geological Survey of Indonesia.

Verstappen H. 1983. Applied Geomorphology. *Geomorphological Surveys for Environmental Development.* Amsterdam: Elsevier.

Zuidam, R.A. Van and Zuidam Cancelado. 1979. *Terrain Analysis and Classification Using Aerial Photographs.* Enshcede: ITC, Netherland.

The Indonesian Journal of Geography, Vol. 18, No. 56,
December 1988, pp. 43 - 54

GEOMORPHOLOGICAL ANALYSIS FOR ASSESSMENT OF COASTAL RECREATION SITES IN THE COASTAL AREA OF TRISIK, KULON PROGO REGENCY, YOGYAKARTA PROVINCE*

by
Suratman Woro and Tukidal Yunianto**

ABSTRACT

The sand dunes and beach ridges area along the south coast of Yogyakarta Special Region are partly potential for a recreation site. The development of the Trisik Coast in Kulon Progo as a recreational area, is feasible for its natural landscape condition and its location, close to the outlet of Progo River. For this purpose, a basic survey should be carried out, in which case, a geomorphological survey may be a part of the survey that contributes to the study of landforms and their processes. Relevant geomorphological aspects, such as morphodynamics of the tidal zone, wind-erosion and flood hazard in the assessment of physical potential of the Trisik coast for recreation have been analysed. Aerial-and ortho-photo interpretation proved to be a useful tool in delineating landforms.

INTRODUCTION

Geomorphological reconnaissance are essential prequisites for almost any kind of applied geomorphological work. The field of geomorphology encompasses landforms, processes, genesis in their environmental context (Verstappen, 1960). By analysing these geomorphological data, the geomorphologist may contribute the solution of current development problems.

To develop the coastal area of Trisik as a recreational area, a physical survey should be carried out evaluate its potential. Geomorphological surveying can applied to delineate landforms, because landforms are more recognizable features in the field and on aerospace imagery. By interpreting ortho-photos (1981) and aerial

* **The former version of this paper was submitted to the "Symposium IGU Working group on Geomorpholgical Survey and Mapping", Yogyakarta, August 14 - 19th 1988.**

** **Lecturers at the Department of Physical Geography, Faculty of Geography, Gadjah Mada University, Yogyakarta, Indonesia.**