ジュムナ河川堤防材料の性質及び土嚢の利用について
(Characteristics of Jamuna river embankment material and the use of sandbag)

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Introduction

In Bangladesh, nearly 4,600 km of embankments along the bank of big rivers are flowing across the country. JAMUNA, one of the big rivers is flowing alongside of Sirajganj district of Bangladesh (Fig.1). At 41 locations of its bank, the length of failure occurring is about 160.62km[1]. This is because of the fluctuation of water levels, siltation, scouring and severe wave actions of the river. In addition, devastating flood in almost every year and excessive rainfall are stepping up the early failure of embankments which results immense damage to agriculture and infrastructures. To minimize the impact of natural disasters as well as to achieve the goal of agricultural production, sustainable and cost-effective protection measures of those river embankments are now crucial for Bangladesh. Some of the major causes of these embankment failures are due to the use of geotechnically unstable materials, improper method of construction and insufficient post operative maintenance. So, prior to construction of a stable embankment it is important to evaluate the inherent properties of the construction materials for its safe design as well as to select appropriate protection system. Hence, the present article paid attention to investigate the physical as well as mechanical properties of the failed Jamuna river embankment materials at Sirajganj in Bangladesh. Consequently, an appropriate and sustainable method was sought as well to protect the bank of big river embankment like Jamuna (Fig.2) in Bangladesh.

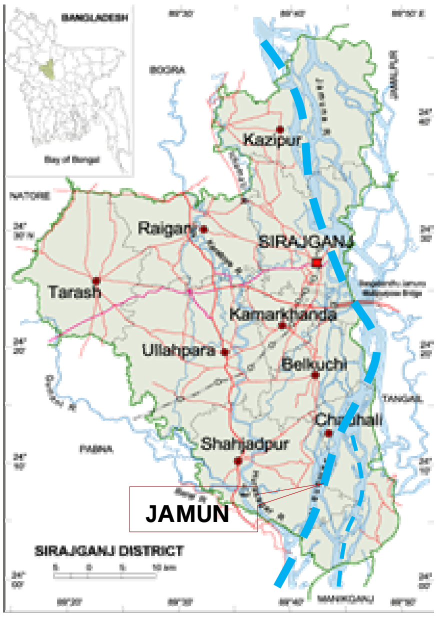

Fig.1 Sirajganj district and Jamuna

Fig.2 Failed Embankment of Jamuna

Methodology

The soil samples were brought directly from the broken part of the right bank of Jamuna river embankment at Shirajganj in Bangladesh. All experiments have been accomplished in the Laboratory of Mie University. Basic physical properties like particle density, liquid limit, plastic limit and particle size analysis were determined according to Japanese Industrial Standard (JIS).

Particle density of the soil sample which passed through 9.5mm seive was determined by JIS A 1202 using 100ml pycnometer. Liquid limit and plastic limit test were done according to JIS A 1205 standard where naturally dried soil screened by 425µm seive were used. Since all samples were passed through 2mm sieve, the Hydrometer analysis (JIS A 1204) was carried out to know the particle size distribution characteristics. On the basis of the test results, the soil was also classified by Japanese Geotechnical Society (JGS) engineering classification.

Mechanical properties like compaction, permeability and uniaxial compressive strength were also determined according to JIS. The compaction test was followed by JIS A 1210 (A method) where the dry unit weight was measured at different water content level below the liquid limit. The falling head method (JIS A 1218) was followed to determine the coefficient of permeability where the compaction of the test samples was made according to JIS A1210 standard. The unconfined compressive strength was determined by applying an axial stress to cylindrical soil specimen according to JIS A 1216.

Table.1　Basic properties of soil

Particle density	2.747g.cm^{-3}
Liquid limit	25.8%
Plastic limit	NP
Maximum size	425µm
Sand(75µm-2mm)	51%
Silt (5µm -75µm)	41%
Clay < 5µm	8%
Soil type	SF

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Results and discussion

The results of basic physical properties test are shown in Table.1. Particle density of the test sample showed an average value of 2.747g/cm^3. The liquid limit was found to be 25.8% where the plastic limit was NP regarding consistency. From liquid limit analysis, it is seen that the rate of changing consistency level is very small with the change of water content. Fig. 3 shows the patterns of grain size distribution of the experimented soil where the maximum grain size and effective size (D_{10}) are 425μm and 7.6μm respectively. In addition, the uniformity coefficient (C_u) was calculated as 16 and the coefficient of curvature (C_c) was 4.0. The percentage of fine grain (<75μm) in the sample was reported as 49% where the coarse grain (≧75μm) amounted 51% (silt=41%, clay=8%). Accordingly, the soil was classified into SF group using JGS engineering classification. From the compaction test results as shown in Fig.4, the optimum water content (w_{opt}) was found to be 21.2% at maximum dry density of 1.593g/cm^3. The variation of permeability of the soil at different water content level is shown in Fig. 5. The coefficient of permeability showed minimum value of 1.29×10^{-5}cm/s in damper side at w=24% which is beyond the optimum water content (21.2%). The change in the coefficient of permeability was observed almost one order larger value from the smallest coefficient of permeability for unit change of water content on dry side. It is also predicted that the permeability is increased rapidly in submerge condition of the soil. From uniaxial compression test, the maximum value of compressive strength (q_u) was reported as 51.8kN/m^2 at 19.6% wc which is below the optimum water level (Fig. 6). It was also clear that the uniaxial compressive strength of the soil largely varied with the small change in water content.

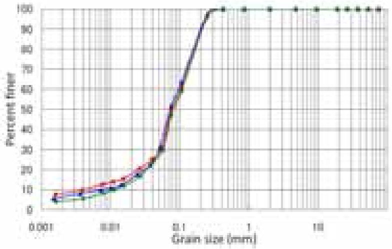

Fig.3 Grain size distribution

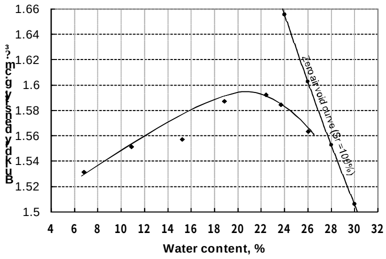

Fig.4 Dry density vs. water content

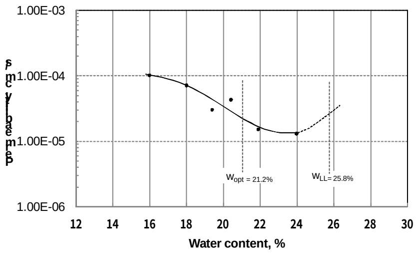

Fig.5 Permeability vs. water content

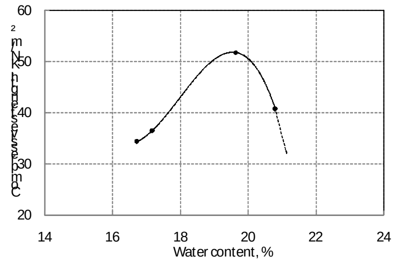

Fig.6 Uniaxial compressive strength

So, the embankment constructed with this material can`t be safe unless the quality of soil is improved by some means like . At present, a number of embankment protection techniques are being practiced in Bangladesh including launching of sandbag to riverbank. But, till now there is no particular specification as well as proper method has been developed for the successful use of sandbags. Consequently, the application of sandbags could not resolve the problem of embankment failure (Fig.7).

Unlike the abundant availability of sand, Bangladesh doesn`t have large quantities of rock such as stone and gravel etc. It is the cheapest and only readily accessible material throughout the construction season. So, the sandbag application could be the practical way of protecting riverbank in Bangladesh if it is done with proper design and specification. Moreover, a comprehensive study of its impact on the slope stability condition of embankment is necessary to make it sustainable.

Fig.7 Sandbags on failed riverbank

Conclusion

The present study found that the properties of Jamuna river embankment material do not satisfy to be used for constructing a safe river embankment. Hence, it can be recommended for further study to find out the appropriate technique to improve soil quality (using additives or reinforcing materials) and a specification with proper design method for the effective use of sandbags in riverbank protection.

Reference

Islam M.N. 2002. Embankment Erosion Control: Towards Cheap and Simple Practical Solutions for. Bangladesh, ICV-2 Proceedings, Thailand. pp 307-321,