Visakhapatnam Chapter

Proceedings of Indian Geotechnical Conference 2020
December 17-19, 2020, Andhra University, Visakhapatnam

Geotechnical Investigations for the Afflux Bunds of a Barrage Project in Eastern India

Vikas Kumar Jain [1], Satyajit Roy [2] and Chitra R. [3]

[1] Central Soil & Materials Research Station, Ministry of Jal Shakti
Deptt of Water Recourses, RD & GR, New Delhi-110016
vikasjain1964@gmail.com

Abstract. A barrage is proposed to be constructed across the river Kharkai in Jharkhand. The proposed barrage has 2849 sq. km catchment area .The axis of barrage is fixed on d/s of confluence point of 2 rivers. The total catchment area of the river up to barrage site is 5814 sq. km. The right main canal having a length of 29.83 km from the Barrage will supplement water of 18.1 cumecs to irrigate CCA of 15,440 ha. It irrigates land of one of the state of eastern part of India. It has many distributaries. It also supplies 1.12 cumecs water to industrial uranium complex. The left canal (through pipe line and pumping) will supplement water to a Dam for Drinking purpose during lean period and also supply water to industries of a city as per requirement. Since the barrage is proposed to be constructed at the confluence of two rivers where water flow is very high, afflux bund needs to be constructed on either side of the proposed barrage to be constructed. For the construction of afflux bund, CSMRS has carried out the geotechnical investigations. The investigations include the foundation investigations along the axis of the afflux bunds and the borrow area investigations, The foundation investigation include collection of undisturbed soil samples from the trail pits excavated along the bund axis besides carrying out insitu permeability tests. The borrow area investigations include collection of disturbed soil samples from 8 different potential borrow areas. The paper presents the geotechnical investigations carried out for ascertaining the suitability of the borrow area materials for the construction of the proposed afflux bunds at the a Barrage Project, in Eastern India.

Keywords: Barrage, Afflux, Borrow Area, Geotechnical Investigations

1 Introduction

The Subarnarekha multipurpose project envisaged the construction of two dams & two barrages and a network of canals. One of the barrages discussed in this paper is across the Kharkai at Ganjia near Adityapur. The Kharkai Barrage Project is proposed across Kharkai River, a major tributary of Subarnarekha River in Mahanadi basin near village Ganjia in Jharkhand state. The construction of Kharkai Barrage is part of Subarnarekha Multipurpose Project. The Subarnarekha River (also called the Swarnarekha River) flows through the Indian states of Jharkhand, West Bengal and Odisha.

1.1 About the project

The Kharkai Barrage is located at latitude and longitude of respectively 22˚ 45‘15” N and 86˚ 00’ 60” E. The proposed barrage is situated at 40 km d/s of proposed Icha Dam on River Kharkai which is having 2849 sq. km catchment area. The axis of barrage is fixed on d/s of confluence point of Kharkai and Sanjay River. The total catchment area of the Kharkai river up to Barrage site is 5814 sq. km. The right main canal having a length of 29.83 km from the Barrage will supplement water of 18.1 cumecs to irrigate CCA of 15,440 ha. It irrigates land of Jharkhand state mostly in East Singhbhum district up to Jadugora U.C.I.L Mines. It also supplies 1.12 cumecs water to industrial uranium complex. Kharkai Left Canal will be about 2.5 km. long canal with a head discharge of 2.5 cumec. It shall supply 49 hm^3 of water to Sitarampur reservoir for irrigation, industrial and municipal purpose of Adityapur town. It is proposed that Kharkai Barrage and its canal system will supply water to municipal and agricultural purpose.

2 Borrow Area Investigations

The geotechnical investigation for the proposed afflux bund of Kharkai Project was carried out by CSMRS. The geotechnical investigation includes the foundation investigations along the axis of barrage and the borrow area investigations. The borrow area investigations were carried out for ascertaining their suitability as borrow area materials to be used for the construction of the proposed afflux bund collected from the borrow areas located near the project site. A total of 20 borrow area materials were collected from eight different borrow areas namely Bosco Kochhcha, Bosco Kochhcha Pond, Udaipur (big pond), Ganjia, Udaipur (small pond), Ganjia near intake well on left bank of Sanjay river, Pradhandih Village and Rani band Pradhandih Village. The collected borrow area materials were subjected to various soil laboratory tests such as Grain Size Analysis, Atterberg Limits, Standard Proctor Compaction, Laboratory Permeability, Shrinkage Limit, Differential Free Swell Index, Triaxial Shear, One Dimensional Consolidation and Chemical Analysis of soils. In addition, the selected borrow area materials were subjected to soil dispersivity identification tests for ascertaining their dispersive characteristics. All the tests were carried out in accordance with the relevant BIS standards and other standard procedures.

2.1 Laboratory investigations

The grain size analysis of the tested borrow area material indicates that the borrow area materials collected from all 8 potential borrow areas in general possess predominately silt sizes followed by clay sizes. The Atterberg limits of samples from all borrow areas indicate that the tested soil samples possess intermediate to high compressibility characteristics and exhibit medium to high plasticity characteristics. Based on the results of grain size distribution and Atterberg limits tests, the tested soil samples fall under CH, CI, CL, CI-CL groups as per Bureau of Indian Standard soil classifica-

tion system. The graphical representation of the grain sizes distribution of selected borrow area materials are presented in Fig. 1.

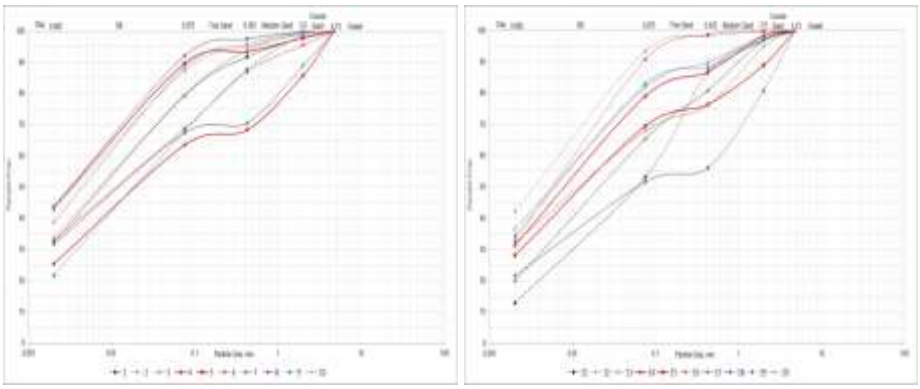

Fig. 1. Grain Size Distribution Curves of Borrow area Material

A total of eight selected soil samples collected from the eight different borrow areas were subjected to Standard Proctor Compaction Test and the Specific Gravity test and the results are presented in Table-1. The values of Maximum Dry Density and the Optimum Moisture Content of the tested borrow area materials vary from 1.72 g/cc to 1.89 g/cc and 12.5 % to 15.5 respectively. From these values, it is inferred that the tested borrow area materials from all the different borrow areas are capable of achieving good/very good compaction densities. The graphical representation of the compaction test of selected borrow area materials are presented in Fig. 2. The values of specific gravity of all the tested borrow area materials vary from 2.67 to 2.78.

Table 1. Results of Standard Proctor Compaction Test

Borrow Area	Soil No.	Maximum Dry Density g/cc	Optimum Moisture Content %	Specific Gravity
Bosci	Soil 1	1.84	15.5	2.67
Bosci Pond	Soil 6	1.88	12.5	2.72
Udaipur Small Pond	Soil 7	1.72	15.0	2.70
Udaipur Big Pond	Soil 11	1.79	13.5	2.73
Ganjia	Soil 13	1.81	15.2	2.78
Ganjia Well	Soil 15	1.78	14.0	2.76
Pradhandih	Soil 18	1.89	14.2	2.78
Rani Band	Soil 20	1.86	13.0	2.76

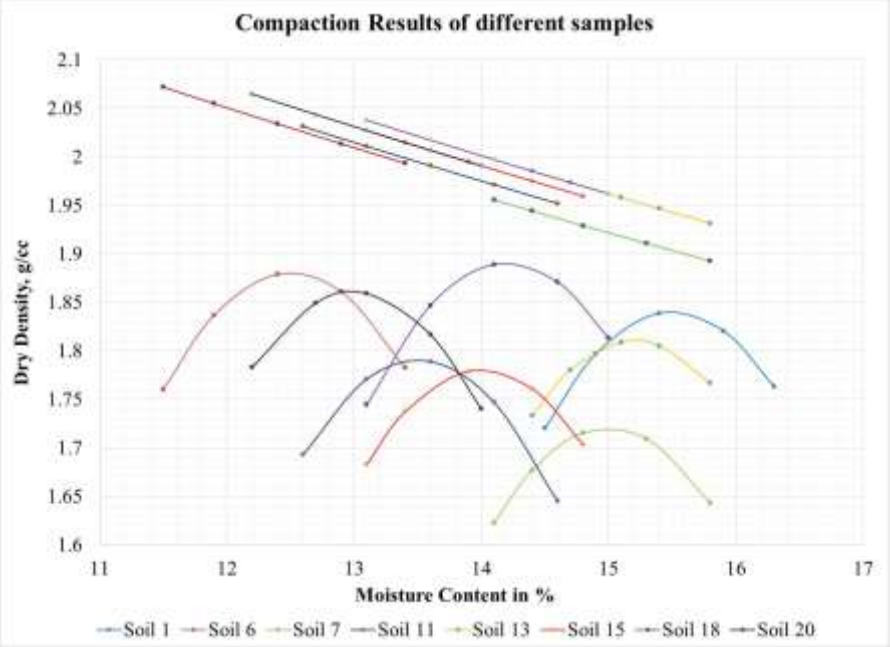

Fig. 2. Moisture Content vs Dry Density Curves of Borrow area Material

Three selected soil samples were subjected to the Consolidated Undrained Triaxial shear tests (CU) with pore water pressure measurement to determine the shear strength parameters. The soil samples were packed at 98 % of MDD and were saturated by using backpressure. All the soil samples were consolidated and sheared under effective confining pressure of 1.0 to 4.0 kg/cm2. The total cohesion (c) and total angle of shearing resistance (ϕ) values of the tested soil samples vary from 0.20 kg/cm^2 to 0.42 kg/cm^2 and 16.1° to 21.20° respectively. The effective cohesion (c') and effective angle of shearing resistance (ϕ') values of the tested soil samples vary from 0.10 kg/cm^2 to 0.27 kg/cm^2 and 21.5° to 29.8° respectively and the results are presented in Table-2. From these values, it is inferred that the tested soil samples are likely to exhibit good shear strength characteristics.

Table 2. Results of Triaxial Shear Test

Sample No.	Total Shear Parameters		Effective Shear Parameters	
	c (kg/cm^2)	ϕ	c' (kg/cm^2)	ϕ'
Soil 7	0.42	16.1°	0.27	21.5°
Soil 13	0.20	21.2°	0.10	29.8°
Soil 18	0.32	18.3°	0.22	25.3°

Based on the results of one dimensional consolidation tests, it is inferred that the soil samples from all borrow areas are likely to exhibit low to medium compressibility

characteristics. The laboratory permeability test conducted on the borrow area materials indicate that the soil samples possess impervious drainage characteristics. The consensus arrived at based on the Soil dispersivity identification tests namely Pin Hole test, Double Hydrometer test, Crumb test and Chemical analysis of Pore Water extract conducted on the selected borrow area material indicate that the tested borrow area material possess non-dispersive characteristics. The Chemical analysis of soils carried out on the borrow area material with particular reference to pH, CaCO3, TSS, organic matter, water soluble sulphates and chlorides indicate the normal behaviour of the tested soil samples.

3 Discussion on Test Results

The grain size analysis of all the borrow area materials indicates that the tested soil samples possess predominantly silt sizes followed by clay sizes with medium to high plasticity characteristics .The results of Standard Proctor tests carried out on soil samples from all the borrow areas shows that all borrow area materials are capable of achieving good / very good compaction densities. The results of triaxial shear on soil sample tested indicate that all borrow area materials are likely to exhibit reasonable shear strength characteristics. The results of one dimensional consolidation tests indicate soil samples from all borrow areas are likely to exhibit low to medium compressibility characteristics. The laboratory permeability test indicates that tested materials from all borrow areas possess impermeable drainage characteristics. On the basis of chemical analysis done on 1soil sample from each borrow area, the conductivity values in terms of total dissolved salts (TSS) are below 1.0 millli mho/cm indicating normal behaviour of soil. The consensus arrived at based on the four soil Dispersivity identifications tests indicate that the tested soil samples possess non-dispersive characteristics.

4 Conclusions

Based on the borrow area investigations carried out on the soil samples collected from the eight different borrow areas, it was recommended that the materials from all the eight borrow areas were found suitable for the construction of impervious core of the afflux bund. However, borrow areas where CH group soil samples are predominant needs to be avoided. The engineering properties of a soil can vary greatly from gravel to clays. In order to build a quality embankment, the specific properties of the soil being used must be understood in order to make proper field judgments.

Acknowledgement

The authors are thankful to Director CSMRS for giving encouragement for writing this paper and permitting the use of CSMRS data. The authors are also thankful to staff of the soil discipline who has contributed in testing of the samples.

References

1. CSMRS: Report on Soil Investigations on Borrow Area Soil Samples for the afflux bunds of Kharkai Barrage Project, Jharkhand, Report No: 04/Soil – II/CSMRS/E/09/2016. September (2016). New Delhi-16.
2. Head, K.H.: Manual of soil laboratory testing. 2nd edn. vol. 2. Pentech Press, UK(1994).
3. Singh Alam: Soil engineering in theory and practice. 2nd edn. vol. 2. C B S Publisher and distributes, New Delhi (2004).
4. Dr. B. C. Punmia: Soil Mechanics and Foundations. 13th edn. Laxmi Publications (P) Ltd., New Delhi (1998).
5. Dr. B. M. Das: Principles of Geotechnical Engineering. 5th edn. Bill Stenquist. Bangalore. (2004).
6. EM 1110-2-2300: Earth manual, United States Bureau of Reclamation (1982).