GEOTECHNICAL ENGINEERING IN URBAN CONSTRUCTION

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Edited by

Yuzhen Yu
Hirokazu Akagi

Tsinghua University Press

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BRIEF INTRODUCTION

The Sino-Japanese Symposium on Geotechnical Engineering was held in Beijing, China, from 29th to 30th October 2003. This volume contains 70 papers contributed by over 200 authors on the general topic of Geotechnical Engineering in Urban Construction. 10 topics include: *General*, *Pile Foundation*, *Ground Improvement*, *Slope and Excavation*, *Underground Engineering*, *Geoenvironmental Engineering*, *Risk Analysis and Hazard Mitigation*, *Test and Measurement*, *Numerical Analysis* and *Constitutive Model*.

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FOREWORD

The Sino-Japanese Symposium on Geotechnical Engineering was held in Beijing, China, from 29th to 30th October 2003. This volume contains 70 papers contributed by over 200 authors on the general topic of Geotechnical Engineering in Urban Construction.

In China, the economic growth demands the development of urban infrastructure, and there are many projects under construction or planning. Considerable experiences have been accumulated in recent years. In Japan, in the course of extensive urban construction, many useful experiences and advanced techniques have been developed. There is an increased appreciation of innovative ideas and creative technologies for further urban infrastructure development in both countries. Under these perspectives, The Chinese Institution of Soil Mechanics and Geotechnical Engineering - The China Civil Engineering Society (CISMGE-CCES) and The Japanese Geotechnical Society (JGS) organized this joint symposium to provide an opportunity for researchers, engineers and project managers both from China and Japan to exchange information and share experience in the field of urban geo-technology.

We are most grateful to all the authors for their efforts in the preparation of the papers. We also wish to thank all of those who contributed to the success of the symposium and the publication of the proceedings. Special thanks are due to Prof. Zhongyi Chen, Prof. Xiaoming Wu, Dr. Jianhong Zhang, Dr. Liming Hu and Dr. Yuxin Jie for their valuable assistance.

Zaiming Zhang

President of the Chinese Institution of Soil Mechanics and Geotechnical Engineering

Akira Asaoka

Secretary of the Japanese Geotechnical Society

CONTENTS

Part 1 General

Part 2 Pile Foundation

Part 3 Ground Improvement

Part 4 Slope and Excavation

Part 1 General

ENGINEERING PROPERTIES OF COAL MINING REFUSE

SONGYU LIU[1] and YU QIU[2]

Abstract In this paper, results of the investigation on the chemical and mechanical characteristics of coal mine refuse(CMR) in Xuzhou, China, are presented: (1) Coal mine refuse is a mixture of soft rocks and coal, which is well-graded material ranging from 80 millimeter to less than 0.01 millimeter. (2) The coarse grain of CMR is easy to be disintegrated and sloughed. (3) The maximum density and the optimum water content of CMR are related to the coarse grain content. (4) The permeability is relevant to the content of coarse grains, gradation and density. (5) saturating-draining may cause the abrupt increase of compression deformation (6) The strength is sensitive to the water content. (7) when CMR is immersed into water 1 or 4 month, strength parameters decrease no more than 5%. (8) The CBR value is far more than the CBR value of cohesive soil.

Key Words coal mine refuse(CMR), physical properties, mechanical characteristics, water stability

1 INTRODUCTION

Coal mining refuse (CMR) is the waste product from coal mining process. The mining,crushing, and washing process tend to concentrate many impurities in the refuse. Many coal-cleaning methods employ gravity separation to remove impurities,thus the more dense materials such as clays,shales, mudstone and pyrite lense are removed to the refuse dump, which often forms the refuse hills in eastern areas of China. These refuse hills occupy valuable lands and result in air and water pollution problems . Average amount of coal mine refuse produced in China is 150 million tons per year.

The application of CMR in engineering practice becomes a promising way to prevent the pollution . Great Britain has been a forerunner in utilizing CMR as highway fill. Many highways have been successfully built in Great Britain using coal mine refuse as fill material. The chemical and mechanical characteristics of CMR were studied in 1970's in the United States. Federal Highway Administration developed the Manual of coal-mine refuse in highway embankment, thus resulting in the large scale application of CMR in highway construction in the United States during 1980's. With the repaid development of infrastructures in China from 1990's, the construction materials for railways, highways have been getting lacking. The CMR has been found its usefulness in a few highway constructions, but there are no comprehensive researches made for CMR in China.

This study is conducted for utilizing CMR as a road base material and fills of road embankment. The chemical ,physical, and mechanical characteristics of CMR in Xuzhou, China, are focused in this paper, which provides guidelines for the design and construction of highway embankments and bases with the use of CMR in Xuzhou.

2 PHYSICAL CHARACTERISTICS

2.1 Mineralogy

CMR is a mixture of surrounding rocks ,coal seam, coal itself. The surrounding rocks are typically composed of shale ,claystone with minor amounts of silty material. Table 1 presents the mineralogy of coal mine refuse in Xuzhou.

Table 1 Mineralogy of Coal Mine Refuse in Xuzhou (Wt %)

CMR Location	Clay mineral			Quartz	Calcite	Feldspar	Siderite	Allophane	Dolomite
	Kaolinite	Illite	Chlorite						
Quantai[1]	20	10	10	20	10	15	10	<3	
Quantai[2]	25	10	<3	25	5	10	<3	<3	<3
Hanqiao	15	5	5	20	20	<3	<3	<3	<3
Dahuangshan	20	5	<3	25	10	5	<3	<3	<3
Qingshanquan	15	5	10	20	25	10	5	<3	<3

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The clay mineral and quartz are the major components.

2.2 Grain size distribution

The gradation of CMR is controlled by the mining techniques and the degree of weathering. Generally, refuse is well-graded material ranging from 80 millimeter to less than 0.01 millimeter, with a maximum of 20 percent passing 200 mesh sieve. This corresponds to an AASHTO classification of A-1 and A-2. The typical ranges of coal mine refuse in Xuzhou are shown in Fig1.

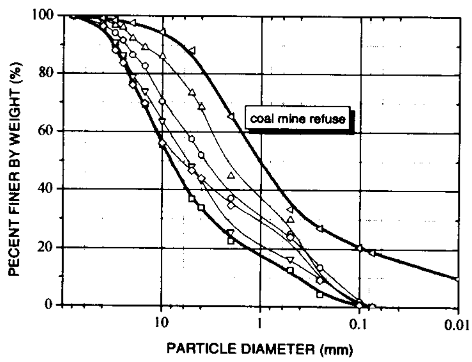

Fig.1 Typical grain size distribution of coal mine refuse in Xuzhou

2.3 Disintegration and sloughing of coarse grain

Coarse grains in CMR are typically rock fragments.The saturated uniaxial compression strength of these rocks is often low and the rocks belong to soft rocks. If immersed, the rock fragments tend to be disintegrated and sloughed.

In order to understand the disintegration and slough of refuse, the repeated freeze-thaw test is done. The grain size distributions of freeze-thaw 7 times and 14 times are shown in Fig2. The results show that the freeze-thaw times increase with coarse grains disintegration and an increase in the amount of fines. After 7 times and 14 times freeze-thaw, the ratio of disintegration can reaches to 19.6% and 24.1% respectively.

3 MECHANICAL CHARACTERISTICS

3.1 The maximum density and the optimum water content

Appropriate compaction during filling highway embankments with CMR will prevent spontaneous combustion and acid leaching by decreasing air voids and permeability. Appropriate compaction is also needed to insure the maximum bearing capacity.

The compaction tests for different coarse grain contents(>5mm) in CMR are done in laboratory. The results generally shows good moisture-density relationships with well-defined peaks, although the peak values will vary from the content of coarse grain to another. The maximum dry densities and the optimum water contents are shown in Fig3, when the coarse grain content of refuse varies from 0% to 100%.

It can be seen that the maximum density and the optimum water content vary from 2.03 g/cm^3 to 2.14 g/cm^3 and from 8.7% to 5.5% respectively, when the coarse grain content of refuse varies from 0% to 100%.

3.2 Degradation during compaction

The moisture-density tests under different compaction energy are conducted on three samples, in which coarse grain contents equal 100%, 80% and 50% respectively. subsequent grading analysis of samples after each test are done to determine the amount of particle breakdown resulting from hammer impact The degradations of CMR with 100% and 80% coarse grain content are shown in Fig.4, and Fig.5 respectively.

The figures illustrate that the ratio of disintegration is relevant to the content of coarse grain and the energy of compaction. As the compaction energy and the content of coarse grain increase, the ratio of disintegration increases. This breakdown during compaction will influence other mechanical properties.

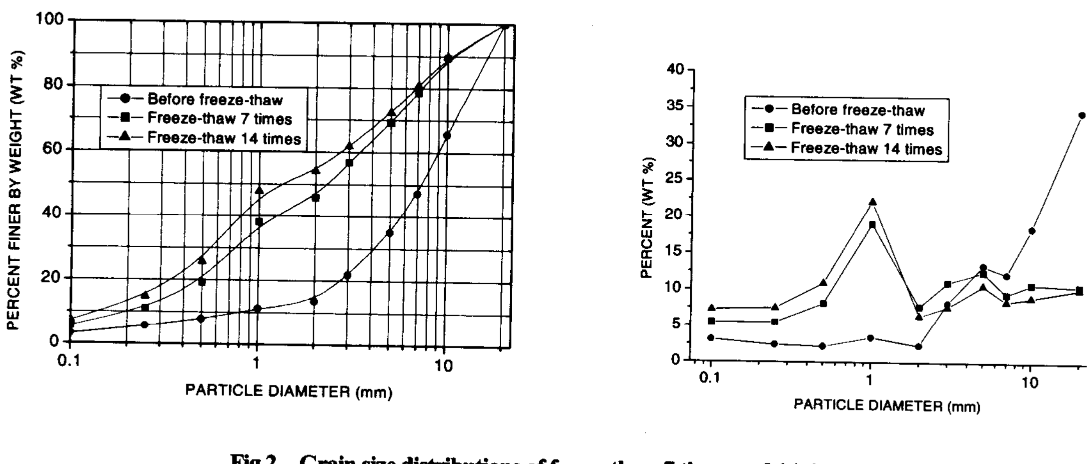

Fig.2 Grain size distributions of freeze-thaw 7 times and 14 times

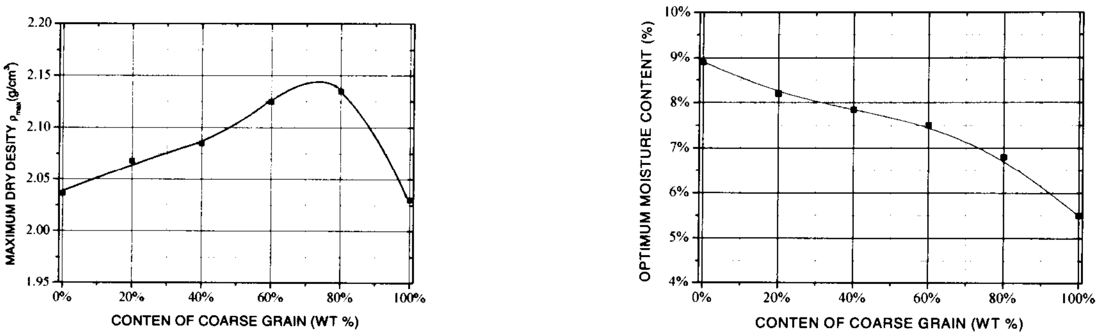

Fig.3 Maximum dry densities and optimum moisture contents of different coarse grain contents

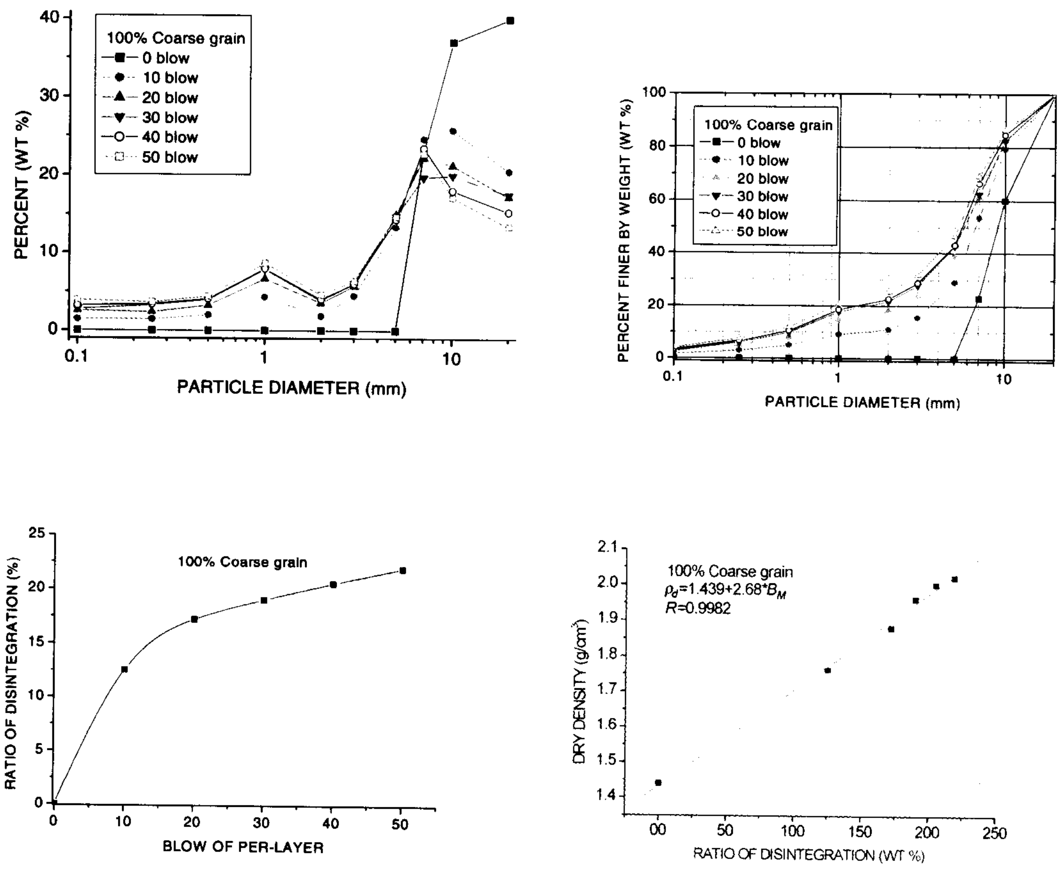

Fig.4 Degradation of refuses of 100% coarse grain mixture

3.3 Permeability

The permeability of CMR is relevant to the content of coarse grain, gradation and density. Generally, the CMR shows poor drainage characteristics when CMR is properly compacted, this is contributed by the well-graded characteristic and coarse grain disintegrations.

(1) Permeability-immersed time relationship

The relationship between the permeability and the immersed time80% is shown in Fig.6(CMR with 80% coarse grain). As the immersed time increases from 0 day to 10 day, the permeability decreases from 7.5×10^{-4}cm/s to 0.5×10^{-4} cm/s.

(2) Permeability-coarse grain content relationship

Fig.7 shows the relationship between the coarse grain content and permeability. As the content of coarse grain varies from 20% to 60%, the permeability of refuse increases from 2.0×10^{-6} cm/s to 6.0×10^{-4} cm/s. when the content of coarse grain is less than 20% and more than 60%, the

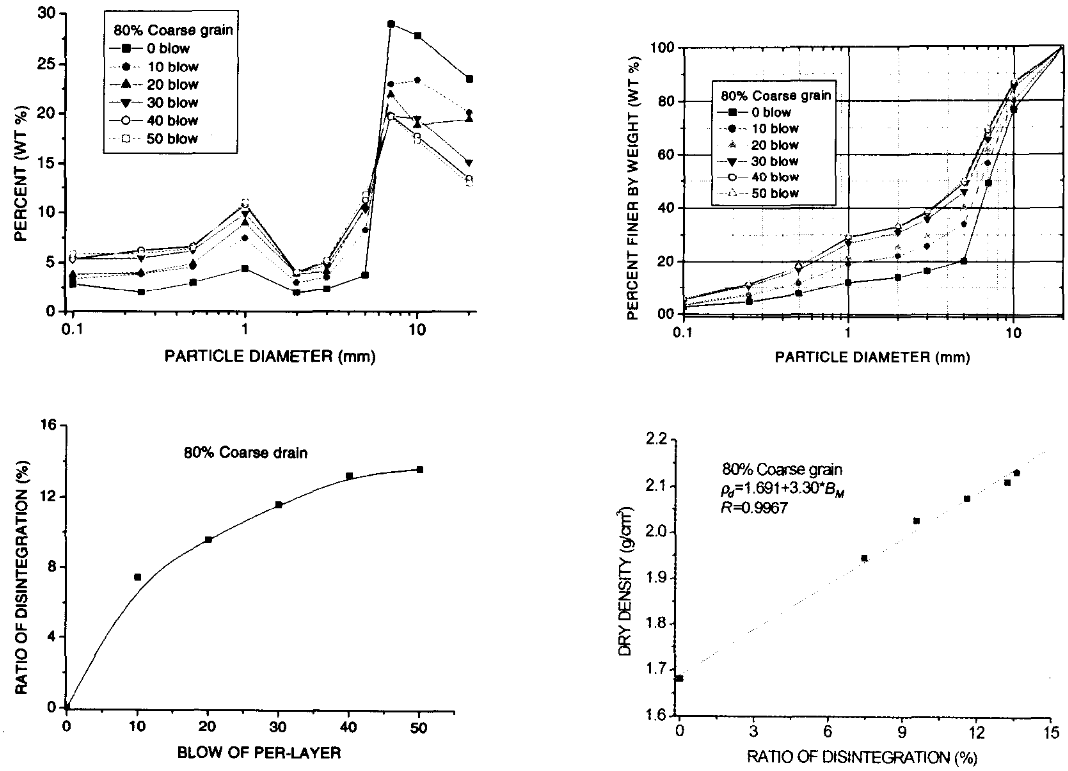

Fig.5 Degradation of refuses of 80% coarse grain mixture

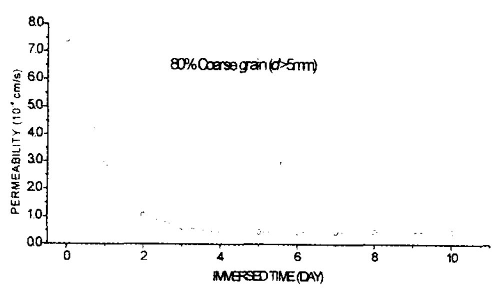

Fig.6 Relationship between permeability and immersed time

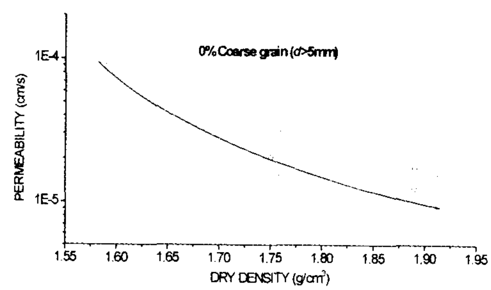

Fig.8 Relationships between permeability and density, of fine aggregate

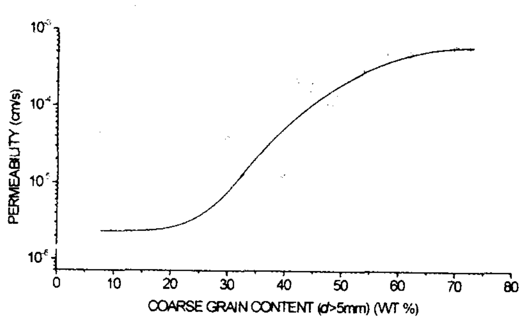

Fig.7 Relationship between coarse grain content and permeability

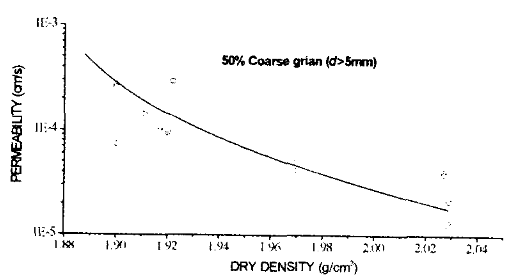

Fig.9 Relationships between permeability and density, of 50% coarse grain