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Faculty of Engineering

A LABORATORY INVESTIGATION OF ENGINEERING PROPERTIES OF CRUSHED ASPHALT AND CONCRETE WASTES AS UNBOUND ROAD MATERIALS

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Faculty of Engineering
UNIVERSITI MALAYSIA SARAWAK
2004

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BORANG PENGESAHAN STATUS TESIS

Judul: A Laboratory Investigation of Engineering Properties of Crushed Asphalt and Concrete Wastes as Unbound Road Materials

SESI PENGAJIAN: 2004 / 2005

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A LABORATORY INVESTIGATION OF ENGINEERING PROPERTIES OF CRUSHED ASPHALT AND CONCRETE WASTES AS UNBOUND ROAD MATERIALS

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This project is submitted in partial fulfilment of
the requirements for the degree of Bachelor of Engineering with Honours
(Civil Engineering)

Faculty of Engineering
UNIVERSITI MALAYSIA SARAWAK
2004

Dedicated to my beloved families, cousins and friends

ACKNOWLEDGMENT

I would like to send my frank appreciation and gratitude to my supervisor, Ir. Resdiansyah Mansyur for his continuously guidance and advice all through the project until the end of the project.

The author would like to acknowledge all who have contributed towards the completion of this project.

The author deepest appreciation is extended to Universiti Malaysia Sarawak, particularly the laboratory of Civil engineering, Faculty of Engineering for providing the environment and facilities to complete this project successfully.

ABSTRACT

This study was conceded out to test the appropriateness of crushed asphalt and crushed concrete waste as unbound road material. Crushed concrete and crushed asphalt were collected, for laboratory tests, from road and building demolition in Kuching and Kota Samarahan. Both crushed concrete and asphalt samples were tested for design parameter, CBR. Some physical tests as aggregate crushing value and the Los Angeles abrasion were also made. In the meantime, test results were compared on its physical properties between crushed asphalt, crushed concrete and mixed crushed asphalt/crushed concrete with 60/40, 50/50 and 40/60 ratios regarding to the existing specifications for base and subbase materials of Public Works Department (JKR) of Malaysia and British Standard Institution (BSI). The laboratory test results discovered the both crushed concrete and asphalt samples as collected from some area in Kuching and Kota Samarahan require to be graded to meet the criteria of unbound materials as specified. All collected crushed aggregates were found to meet the specifications of subbase set by JKR and BSI. However, only 60/40, 50/50 and 40/60 mix crushed asphalt/crushed concrete could be suitable for road base regarding to the specifications.

ABSTRAK

Kajian ini telah dijalankan untuk menentukan kesesuaian penggunaan bahan terbuang seperti pecahan konkrit dan asphalt sebagai alternatif bahan material bagi lapisan bawah *pavement*. Pecahan konkrit dan asphalt yang telah diambil untuk terlibat dalam ujian makmal adalah daripada jalan di korek dan bangunan yang telah di runtuhkan di sekitar kawasan Kuching dan Kota Samarahan. Kedua-dua pecahan konkrit dan asphalt yang di gunakan di uji dalam makmal, iaitu *CBR*. Sebahagian fizikal batuan yang di uji dalam makmal yang turut terlibat adalah *aggregate crushing value* dan *Los Angeles abrasion*. Keputusan yang diperolehi untuk pecahan konkrit, asphalt dan/atau kedua-dua pecahan untuk 60/40, 50/50 dan 40/60 akan dibandingkan dengan nilai yang telah ditetapkan untuk *road base* dan *subbase*, iaitu Jabatan Kerja Raya Malaysia (JKR) dan *British standard* (BS). Keputusan dari ujian makmal menunjukkan bahawa sampel yang diambil di sekitar kawasan Kuching dan Kota Samarahan memenuhi kriteria bahan untuk *road base*. Kesemua sampel yang telah diambil adalah mengikut nilai *subbase*, iaitu nilai yang telah ditetapkan oleh JKR dan BS. Walaubagaimanapun, hanya pecahan untuk nisbah 60/40, 50/50 dan 40/60, konkrit dan asphalt sesuai digunakan sebagai *road base* tertakluk kepada spefikasi-spefikasi yang telah di tentukan.

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NOTATION

C.B.R	-	California Bearing Ratio
A.C.V	-	Aggregate Crushing value
cm^2	-	Centimeter square
cm^3	-	Centimeter cubic
kg	-	Kilogram
kg/m^3	-	Kilogram per meter cubic
hr	-	Hour
in	-	Inch
in^2	-	Inch square
kg	-	Kilogram
kN	-	kilo Newton
lb/ft^3	-	Pounds per feet cubic
MPa	-	Mega pascal
M_3	-	Mass of retained specimen at 2.36 mm test sieve
M_2	-	Mass of passing specimen at 2.36 mm test sieve
M_1	-	Mass of the test specimen
Min	-	Minute
mm	-	Millimeter
No.	-	Number
rpm	-	revolution per minute
S.O	-	Superintendent officer
^oC	-	Degress celcius
%Loss	-	Percentage loss
%	-	Percentage
μm	-	Micrometer

ABBREVIATIONS

AASHTO	-	American Association of State Highway & Transportation Officials
ASTM	-	American Society for Testing Materials
B.S	-	British Specification
JKR	-	Jabatan Kerja Raya
n.d	-	No date
S.O	-	Superintendent Officer
M.S	-	Material standard
Vs.	-	Versus

CHAPTER 1

INTRODUCTION

The aims of this chapter is to establish a general thought that consists of road pavement, unbound granular materials, base course, sub-base course and the aim of this project is also included.

1.1 Background

The movement of people and goods throughout the world is primarily dependant upon transportation networks especially the roadways. Roads are an essential part of everyday life since they provide a platform for freight haulage, in addition to satisfying the diverse range of business and recreational commuting needs of one country.

Although it would be naïve to compare the roads constructed by the Romans more than 1800 years ago with modern highways, the sheer scale of their operations throughout the whole of Europe seems incredible even by today's standard. Throughout Europe from medieval times, stone setts were the most widely used form of pavement construction. After 1850, wood block pavements were introduced into many European cities as a less noisy alternative to stone setts. While in between 1870 and 1890, ceramic brick or block pavements were widely used in New York and other American cities. The blocks were of brick size, but only 2-3 in thick. Fracture, probably due to in adequate quality control, appears to have been the main problem with these. The use of wood blocks in London continued until the nineteen-fifties. In later years, their life was extended by tar spraying and chipping. This also ensured an adequate resistance skidding. [Croney D.etl, 1977]

In 1854, asphalt was first used as a paving material in Paris. The material used was natural rock asphalt, i.e., limestone rock impregnated with asphalt. The material provided a quiet, easily cleaned surfacing but the skid resistance was very low in wet weather. By 1870, this type of surfacing was being widely used also in Britain, Germany, Switzerland and in the United States, and it continued to be used until the nineteen thirties in the city of London. Concrete roads almost certainly started in the USA in the first decade of the twentieth century, and spread to Europe in the twenties. Concrete was widely used over a century ago as a base for stone setts, wood blocks and asphalt, but it was not used as running surface. [Croney D.etl, 1977]

According to Wai Y.C [1994], the road pavement in Malaysia itself was constructed from Sungai Ujong to Malacca and Seremban in 1818. The road

pavement was getting important in Malaysia accordance with the growth of using lorries, cars and from Kuala Lumpur to Kuantan (1899), from Johore Bahru to Perai (1911), from Singapore to Padang Besar (1928) and the main road that was linking all east-course divisions was constructed after the year of 1945. Meanwhile the road constructions in Sarawak have started earlier during the British governance. The purpose is to transport antimony and rubber for economic purposes [Jong Kiam Leong, JKR Kuching].

Most of the roadway in Sarawak either in town or rural area are using asphalt or bitumen road pavement. Basically, natural aggregates were used for the pavement construction. In order to get natural aggregate, the cost of expanses is high and it included lots of money spent on transportation to carry the natural aggregates from the quarries to the construction site. Nevertheless, our economic situation is still unstable which is why waste material usage as an alternative is a perfect solution to these problems.

Because of topography factors of Sarawak, it is much accurate to use waste material such as demolished concrete from old buildings or old culverts disused and asphalt from old waste road pavement materials as an alternative to natural aggregate. In Sarawak, the usage of old waste road pavement materials as unbound material was only widely used after the 1980s [Jong Kiam Leong, JKR Kuching].

Based on the Recycling resource [2003], Malaysia itself produced 17 tonnes of waste materials everyday, other than to waste those materials especially the old

concrete and asphalt, there still is an alternative on how to use those materials wisely by recycling it as unbound road materials.

According to Sherwood [1995], the crushed concrete arising from the demolition of disused airfield runways was widely available after World War II. However the materials, crushed concrete and asphalt, has been used in road pavements as road-base or sub-base, and in some cases as both. This unbound road materials is usually appropriate for rural road pavement, parking areas and other areas that having low traffic load.

Before World War II, the first pavement constructed in Malaysia was the flexible pavement or bituminous pavement that using block stone pitching on sand or laterite subbase covered with a layer of tar or bitumen stabilized aggregates. Since that, the road pavements had been constructed using crushed stones road base and subbase with dense bituminous surfing and still being practiced until now.

1.2 Objective

The objective of this study is to investigate the appropriateness of crushed asphalt and crushed concrete for unbound road materials, especially as alternative materials for road base or sub-base. Crushed asphalt and crushed concrete samples are taken from Bt. Kawa area in Kuching.

1.3 Scope of Works

In details, the following tasks shall be carried out:

a) to investigate the use of crushed asphalt pavements and crushed concrete as sub-base courses and/or base courses based on BS (British Standard) standard or ASTM and JKR (Jabatan Kerja Raya) standard and;

b) to compare physical properties between crushed asphalt, crushed concrete, and/or both 60/40 or 50/50 or 40/60 mix crushed asphalt/crushed concrete by using field measurement and laboratory.

CHAPTER 2

LITERATURE REVIEW

The principle of this second chapter is to give detail explanations and understanding on the physical and chemical properties of crushed asphalt and crushed concrete. The road construction specifications shall be adhered to be drawn up and discussed in details in this chapter.

2.1 Background

According to Ontario Construction Industry resource [n.d], paving asphalt is a mixture of 5 percent asphalt cement and 95 percent aggregate. It can be used as a "cold mix" as crushed asphalt, aggregate, stone, compacted to form a road-base. Road asphalt is not deeming suitable for recycling; it should be used as road-base. This paving asphalt is crushed to the required size, usually 38 mm or less. [Atkins, H.N.,1997].

According to COST 337 resources, [1998], besides using the asphalt as a road base or subbase, concrete waste too is widely used as unbound road materials. Generally concrete is made of a hardened mixture of cement, sand, stone and water. Concrete waste is produce in the construction, renovation and demolition of bridges, roads, sidewalks, buildings, foundations and structural elements. However, concrete can be crushed and used as an aggregate for road beds. It is also minimize the need for virgin aggregates by using crushed demolition materials wherever possible and this will help to preserve natural environments where aggregates are mined. According to Mullehorn, [1990], reported that crushed concrete had lower compacted densities than limestone, but the density of the crushed concrete proved to be more consistent.

2.2 Road Pavement

The road pavement is the actual surface on which the vehicles will travel, in other words it means the structural element which supports traffic. Road pavement can be defined as a structure constructed to facilitate the movement of persons and materials from one place to another. In addition, road pavement is also a path specially prepared for movement of the transport vehicles. Its purpose is two fold, to provide friction for the vehicles and to transfer normal stresses to the underlying soils.

As commonly known, pavement can be classified as "Flexible" or "Rigid". Those types of pavements can be differentiated depending on how they distribute surface loads. Flexible pavement can be classified as pavements with a bitumen bonded surfacing and road base. Thus, rigid pavement is a high quality concrete of its top layer

with a concrete surface slab which can be un-reinforced, joint reinforced or continuously reinforced.

The functions of the pavement structure are to distribute imposed wheel loads over a large area of the natural soil and reduce the high unit stresses imposed by vehicles on the surface to stresses on the sub-grade which are low enough to be carried without failure due to rutting, excessive settlement, or other types of distress. Furthermore, shear failure would occur in the wheel path in most soils if vehicles were to travel on the natural soil itself and forming ruts. The shear strength of the soil is commonly not high enough to support the load. Regarding to its load distribution purpose, the surface course of pavement structure shall provide a level with safe traveling surface.

Generally, the major layers of the pavement structure can be divided into four parts that are surface, base, sub-base and sub-grade. The most expensive layer is the surface layer and it depends on bearing capacity of base and sub-base layer.

Besides, both base and sub-base are usually granular materials. Sub-base, there are various types such as gravel, sand, recycled asphalt and concrete pavements and slag. The sub-base does not require high quality materials as the base does because loads are reduced considerably.