COMPARISON OF VARIOUS COLD MIX ASPHAL T WITH HOT MIX STANDARD

BY

EKWEM PRINCE PASCHAL

PGDICE/OS/040

CIVIL ENGINEERING DEPARTMENT, FEDERA UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE.

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A RESEARCH PROJECT SUBMITTED TO THE CIVIL ENGINEERING DEPARTMENT, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF POST GRADUATE DIPLOMA (PGD) IN CIVIL ENGINEERING

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DECLARATION

I, Ekwem Prince Paschal with registration number *PGD/CE/OS/040* of Civil Engineering Department, School of Engineering and Engineering Technology, Federal university of Technology Minna hereby declare that this project work was carried out by me under the supervision of Engr. Stephen Kolo. All the information utilized and their sources have been fully acknowledged by means of reference.

Ekwem Prince Paschal Date

CERTIFICATION

This is to certify that this project was carried out by Ekwem Prince Paschal and has been examined and approved as meeting the requirement for the award of degree of Post Graduate Diploma in the Department of Civil Engineering, Federal University of Technology Minna, Niger State.

Engr. Stephen Kolo
(Project Supervisor)

Date

Engr. Prof. Sadiku Salawu
(Head of Department)

Date

External Examiner

Date

DEDICATION

This project is dedicated to Almighty God and my entire family members.

~

ACKNOWLEDGEMENT

My profound gratitude goes to Almighty God for sustaining me in every aspect.

I give special thanks to my project supervisor, Engr. Stephen Kolo for his advice, guidance and proper supervision of this project.

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TABLE OF CONTENT

LIST OF FIGURES

ABSTRACT

The study aims to determine the best cold mix asphalt in Nigeria by determining their strength properties. It also compares their strength with hot mix asphalt as provided in General Specifications Volume II of 1997. In carrying out the study, cold mix samples were gotten from Portland Emcor (Lagos State), Carboncor Nigeria (Niger state) and UPM (Akwa Ibom State). These samples were tested using Marshall Test machine and the highest stability value of Portland Emcor was 4.33KN, Carboncor was 9.63KN while UPM was 1.OOKN. On successful completion of this research work it was realized that sample from Carboncor Nigeria seems to be the best and can be used on medium or low traffic roads.

CHAPTER ONE

INTRODUCTION

1.1 General Background

The terms "asphalt (or asphaltic) concrete", "bituminous asphalt concrete" and the abbreviation "AC" are typically used only in engineering and construction document and literature. In British English, the word 'asphalt' refers to a mixture of mineral aggregate and bitumen. In American English, 'asphalt' is equivalent to the British 'bitumen'. However, asphalt concrete pavement are often called just "asphalt" by laypersons who tend to associate the term concrete with Portland cement concrete only. The engineering definition of concrete is any composite material composed of mineral aggregate glued together with a binder, whether that binder is Portland cement, asphalt or even epoxy.

Bituminous pavements are composed of a mixture of bitumen or tar and mineral aggregates commonly used in construction projects such as road surfaces, airports and parking lots (Bindra 2001). Great percentage of roads that exist today are asphaltic concrete. Various types of bituminous pavements having difference thickness have been developed. When properly used and constructed, these pavements have long and economic lives. The serve the serve the following functions:

i. Provide smooth and good riding surface
ii. Provide high resistance to surface wear and deformation
iii. Provide skid resistance surface

iv. Protect the underlying layer and sub grade detrimental actions of water and other natural agencies i.e. it seals the ingress of rain water

v. Distributes the wheel loads in such a way that the layers underneath are not overstressed.

Asphalt concrete is a composite material. It consists of bitumen (used as a binder) and mineral aggregate mixed together, then laid down in layers and compacted.

Asphalt paving mixes are usually prepared at an asphalt mixing plant. There are two types of asphalt mixes: Hot-Mix and Cold-Mix. Hot-Mix asphalt (HMA or HMAC) is more commonly used while Cold-Mix asphalt (generally mixes made with emulsified or cut-back bitumen) is usually used for light to medium traffic secondary roads, or for remote locations or maintenance use. The term "hot-mix" comes from the process of heating the aggregate and bitumen before mixing to remove moisture from the aggregate and to obtain sufficient fluidity of the bitumen for proper mixing and workability.

Hot Mix Asphalt-HMA (also referred to as asphalt concrete, hot mix, blacktop) is composed of aggregates bound together into a mass by bitumen. The aggregates total ninety-three to ninety-seven percent by weight of the total mixture and are mixed with three to seven percent bitumen. HMA is produced in a central mixing plant where aggregates are heated to a temperature of approximately 300 Fahrenheit (149 Celsius) and mixed with bitumen so that all particles are completely coated.

Cold placed asphalt pavement mixtures (or simply cold mixes) are generally mixes made with emulsified or cutback bitumen. Emulsified bitumen may be anionic or cationic. Aggregate material may be anything from a dense-graded crushed aggregate to a granular soil having a relatively high percentage of dust. The aggregate at the time of mixing may be either damp, air-dry or artificially heated and dried. Mixing methods may be performed either in the roadway, along the roadway or in a stationary mixing plant. The resulting mixtures usually are spread and compacted at atmospheric temperature.

There are millions of kilometers of highways and roadways all over the world constructed with Asphalt concrete. It is the preferred road building material especially in those geographical regions where climatic changes are extreme. Asphalt concrete is flexible which allows the pavement to withstand severe freeze/thaw cycles without breaking.

1.2 Aim of the Study

This project is aimed at determining the strength and quality of various cold-mix asphalt samples as compared with hot-mix standard. It also sees which mix type is more suitable and in which construction activity.

1.3 Objective

The following are the objectives of this study:

- ~ To determine the best cold mix product in Nigeria.
- ~ To determine the strength of the various cold mix available in the country
- ~ To check other properties as may be related to hot mix asphalt

1.4 Justification

The development of Cold-Mix Asphalt came so as to overcome some of the flaws associated with Hot-Mix Asphalt which has been in use for a very long time now. Some of the flaws include:

A...

1. High risk of human element exposed to the hazardous emission produced in asphalt factories.
11. Consumes a lot of energy
111. Preparation method heavily depends on machines.
IV. Limited time between production and usage.
(Most of the prepared Cold-Mix Asphalt can last as long as 6 months and more within which it can be used)

1.5 Scope

This scope of this research work is limited to laboratory comparison of the strength properties of the three major cold mix asphalt available in Nigeria for pavement work and relating these strength properties to known asphalt standard as given in General Specifications Vol. II of 1997.

subsoil. First McAdam produced a closely compacted 0.25 to 0.30 metre layer of stone which had been broken to an inch in diameter, and which was raised in the centre to facilitate drainage. This was followed by a carpet of finer grained stone that was cemented by the setting of the powder, a process that was completed in stage. The advantage of McAdam's system was its speed and low cost and was generally adopted throughout Europe.

2.2 Pavement

The term pavement refers to the hard material constituting the structure of a road that are constructed on top of natural soil. The ultimate aim of providing pavement is to ensure that applied wheel load does not exceed the supportinglbearing capacity of the sub grade. Therefore, the pavement is defined as a structure consisting of super-imposed layers of selected, processed and unprocessed materials whose primary function is to distribute the applied vehicle wheel load to the sub grade, aimed at reducing the transmitted stresses from the vehicle wheel-load to the bearable capacity by the sub grade (Opaluwa 2008).

In our world today, various pavement construction method and maintenance equipment and procedures have been developed. Therefore, it is expected that the engineer be able to construct and maintain pavement that are able to carry traffic safely, conveniently and economically with material that are capable of protecting the natural soil from the effect of the traffic and climatic environment (NAPA 2001)

2.2.1 Pavement Types

I. Surface treatment: A surface treatment is a low-cost surface that is constructed by applying of asphalt which is, in turn, covered with aggregate. Thickness may vary between lh and %-inch. Generally, surface treatments are less than 1 inch thick. They may consist of single, double, or triple layers. In case in which the designer wishes to build up a surface which is relatively thick, multiple treatments are used. Surface treatments built up in this manner are used quite often for secondary roads. However, in areas of frost action and, in particular, in states where freezing and thawing is a problem, many surface treatments break up considerably during the spring months. Since the surface is relatively thin, alternate freezing and thawing may cause potholes and chuckholes to develop. Surface treatments are difficult to maintain, because dragging or blading the road will not bring the desired result; it is necessary in many cases to resort to considerable amounts of patching.

Surface treatments are utilized on airports where stage construction is anticipated. For example, landing and taxi way areas on small airports can be built using stabilized base-course materials with a light application of a surface treatment. The area can be built up as traffic on the field increases, much as is done for stage construction for secondary roads (Yoder and Witczak 1975).

II. Road mixes: A road-mix surface is mixed in a place by a travel plant or conventional farm equipment such as discs and harrows. Untreated stabilized gravel surface can be scarified and converted into road-mix surface.

Both open-graded and dense-graded aggregates can be used for this type of construction. The dense-graded variety is used primarily where locally available pit-run materials occur. However, many open-graded road-mix surfaces are constructed in this country, primarily for high-type roads.

The aggregate for bituminous mixtures can be either open graded or dense graded but, in any event should have a loss in the Los Angeles abrasion test of not more than 50 percent. The aggregate can consist of gravel, crushed stone, or crushed slag.
The quantity of bituminous material required for this type of surface depends upon the gradation of the aggregate. Required quantities are most often determined on the basics of experience. The quantity of a bituminous material used ranges between 3 and 6 percent.

In this type of construction, the coarse aggregate is spread over the road surface, usually by means of spreader boxes. If stage construction is adopted, the existing road metal is scarified and bladed for uniformity. The aggregate must be fairly dry, in order to obtain a satisfactory mix. The bituminous material is next spread on the aggregate, and then the mass is mixed by one of several techniques. Rotary mixers are excellent for this purpose. Mixing can also be accomplished by means of a blade grader, by manipulating the material back and forth across the road several times. The material is then bladed to uniform thickness and compacted.

Travel plants of several designs are available in which the material are mixed in plants and spread uniformly for compaction. This technique permits good control.

Road-mix surfaces are well adapted to stage construction. They also can be used for high-type roads if the quality of the aggregate and the quantity of the bituminous binder are carefully controlled. This type of construction permits bituminous surface of varying thickness to be constructed. Most agencies construct pavement between 2 and 3 inches thick by this procedure (Yoder and Witczak 1975).

III. Penetration macadam: Penetration macadam has been used for surface as well as base course. Construction techniques are identical to those of constructing penetration-macadam base courses. Asphalt material most often used for penetration-macadam include RC, RS and hot asphaltic cement, the primary requirement being that the asphaltic material be highly liquid so that it can penetrate between macadam particles.

IV. Asphaltic concrete: High-type asphaltic concrete pavements are used where high loads are anticipated or on highways with high traffic volumes. The paving surface consists of a binder course and a surface course, with the necessary prime, tack and seal coats. In general, the type of bituminous material that is used depends in part on climate. In areas of high air temperature, the heavier grades are used, whereas, for colder climates, the lighter grades are used.

The stability of bituminous-concrete mixtures is made up of both cohesion and internal friction. Cohesion and internal friction in tum depend upon gradation of the aggregate, density of the mix, and quantity of asphalt (Yoder and Witczak 1975).

2.2.2 Asphalt Concrete Mixes

The two major types of asphalt concrete mixes used in construction are hot mix and cold mix but however other types of asphalt do exist.

1. Hot mix asphalt concrete (HMAC): This is produced at high temperature. This high temperature serves to decrease viscosity and moisture during the manufacturing process, resulting in a very durable material. HMAC is most commonly used for high-traffic areas such as busy highways and airports.

11. Cold mix asphalt concrete: This is high quality polymer-modified cold mix asphalt. It involves the coating of aggregate in an emulsion of bitumen. The emulsion is naturally fluid at the ambient temperature. So no heat is required in the mixing; which is a gentle process designed to ensure that emulsion does not break into its constituent elements until it is placed on the pavement. The emulsified asphalt may be anionic or cationic. The cold mix is often soft and sticky out of the bag where it is stored but it quickly hardens after application with similar property to hot mix asphalt. It does not require any special heavy rolling machine or special applicator as it can be shoveled or poured into a roll to be paved and tamped down with hand tools. Aggregate materials may be dense-graded crush aggregate to a granular soil having a relative high percentage of dust. One of the advantages of the cold mix is that the mix can be performed along the roadway or in a stationary mixing facility. Cold mix can be stored for future use and can also be used immediately (Bordeaux 1997).

2.2.3 Requirements of Good Asphaltic Concrete

1. Stability: The ability of the asphalt concrete pavement surface to adjust to load changes without any reduction in performance.

11. Flexibility: The ability of the asphalt concrete to bend repeatedly due to wheel pressure without experiencing breakage or damage.

iii. Durability: The ability of asphalt concrete to last for a long time i.e. to meet the design life without sustaining damage or wear.

iv. Workability: The asphalt concrete must be operated upon easily.

v. Safety: this is when the asphaltic concrete provides good running surface without causing harm or endangering its users.

2.2.4 Types of Pavement Structure

Based upon the structural behavior of the materials used in construction, pavements are generally classified into two categories:

1. Flexible pavements
2. Rigid pavements

2.2.4.1 Flexible Pavement

The pavements which have very low flexural strength and are flexible in their structural behavior under the load are called flexible pavements. The layers of this type of pavement reflect the deformation of the lower layers unto the surface of the layer. Thus if lower layer somehow get deformed, the surface of the pavement also gets deformed. The section of this pavement consists of four layers. Starting from bottom, the progressive layers are in the order of (i) soil sub grade (ii) sub base layer (iii) base layer and (iv) surface layer.

In flexible pavements, vertical load of traffic is transmitted to the lower layer by a grain to grain transfer. A well graded compacted granular structure has very good inter locked aggregate layer and transfer the load to wider area and thus forms a good flexible layer. The load spreading ability of the flexible layer depends on the type of material and the mix design factors. The

CHAPTER TWO

LITERATURE REVIEW

2.1 Historical Development of Roads

The history of development of highway construction is closely linked with the history of human civilization. People would choose the most convenient and the shortest ways of approach to their hunting and fishing grounds, gradually making footpaths. The use of tamed animals for transport required bridle paths of greater width and height. The first artificially constructed tracks were made in mountainous and forested country, where obstacles were encountered. About four to five thousand years B.C. invention of wheeled cart constituted a major technical achievement and greatly accelerated the development of road construction (Bindra 2001).

A road built in Egypt by the pharaoh Cheops around 2500BC is believed to be the earliest paved road on record (Kasen 1992). He constructed road 1000 yards long and 60 feet wide that lead to the site of the great pyramid. However, carrying bulky goods with slow animals over the rough, unpaved roads was a time consuming and expensive preposition. As a general rule, price of goods doubled for every hundred miles they have to travel. Some other ancient rules were established by the rulers and their armies. The Old Testament contains reference to ancient roads like King Highway, dating back to 200BC (Kasen 1992). This was a major route from Damascus in Palestine, and ran south to the gulf of Agande, through Syria to Mesopotamia, and finally on to Egypt. Later it was renamed Trajan's road by the Romans, and was used in the eleventh and twelfth century by the crusader when they attempt to "reclaim" the holy land. Without doubt, the champion road builders of them all were the ancient Romans, who until modem times, built the straightest, best engineered, and most complex network of road in the world. At their height, the Roman Empire maintained 53,000 miles of road, which covered all of England to the north, radiated throughout the Liberian Peninsula, and encircled and crisscrossed the entire Mediterranean area.

Famous for their straightest, Roman roads were composed of graded soil foundation topped by four courses:

1. A bedding of sand or motar

11. Rows of large flat stones

111. A thin layer of gravel mixed with lime.

IV. A thin surfaced of flint-like lava.

Typically, they were 3 to 5 feet thick and varied in width from 8 to 35 feet, although the average width for the main roads was from 12 to 24 feet. The design remained the most sophisticated until the advent of modem-road building technology in the very late 18th and 19th centuries. Many of their original roads are still in use today, although they have been resurfaced numerous times (Gregory 1993).

In 18th century England, the technology of highway construction was getting long overdue boost from two British engineers, namely Thomas Telford and John Loudon McAdam (Gregory 1993).

Telford, originally a stonemason, came up with a system of road building which required digging a trench, installed of a foundation of a heavy rock, and then surfacing with a 6 inch layer of gravel, the center of the road was raised, producing a crown that allowed water to drain off. However, his system was faster and less productive than the Roman method.

On the other hand, McAdam's system was based on the principle that a well drained road does not need the stone foundation unlike the Telford's system but could be built directly on the

iii. Durability: The ability of asphalt concrete to last for a long time i.e. to meet the design life without sustaining damage or wear.

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In flexible pavements, vertical load of traffic is transmitted to the lower layer by a grain to grain transfer. A well graded compacted granular structure has very good inter locked aggregate layer and transfer the load to wider area and thus forms a good flexible layer. The load spreading ability of the flexible layer depends on the type of material and the mix design factors. The materials which fall in the category of flexible pavement layers are, soil-aggregate mix, crushed aggregate, water bound macadam, granular materials with bituminous binder. Bituminous concrete is best flexible pavement layer material (Gurcharan 2004).

Since intensity of traffic is maximum equal to contact pressure, at the surface the surface layer is made from strongest material mix. As the intensity of load goes on decreasing progressively to the lower layers, they may be made from weaker material mix. The top layer has to be the strongest as the highest stresses are to be sustained by this layer. They also have to withstand the wear and tear due to traffic. As the lower layers have to sustain lesser intensity of stresses and there 5nis no direct wearing action, therefore inferior material with lower cost can be used. The lowest layer is the prepared surface of the local soil called the sub grade (Gurcharan 2004).

Surface

Wearing Course

Base Course

Sub base course

Sub grade

,__----- Formation level

Fig. 2.1 Cross section of a flexible pavement (Gupta et al 2003)

1. The surface course: This is the uppermost layer of a flexible pavement. It comes in contact with traffic load and normally contains the highest quality material. It provides characteristic such as friction, smoothness, noise control, routing and shoving resistance and drainage. It serves to prevent the entrance of excessive quantities of surface water into underlying base, sub base and sub grade. The type of material used for surface

course depends largely upon the services expected from the roadway as well as the economic and material availability in the area. In bituminous surfacing, *wearing course* composed of *surface course* and *binder course* are sometimes provided. The binder course is thicker, with more aggregate or larger maximum particle size and less bitumen than the surface course and base course (Summer 2001).

11. The Base course: This is the layer of granular material that lies immediately below the surface course of a flexible pavement. It serves to distribute the applied surface wheel load so that bearing capacity of the sub-grade is not exceeded that will result in excess deformation of the foundation. Hence the material in the base course must be of extremely high quality and of such character that they are not damaged by capillary water (Summer 2001).

111. The sub base course: This layer could be said to be an extension of the road base. It is present between the road base and the sub grade. Both the road base and sub grade are under the surface layer primarily to increase the load bearing capacity of pavement by distributing the load. A sub-base may be used in other to build a relatively thick pavement of a lower cost. It is generally used where the extremely weak sub-grade soil are encountered.

IV. The sub-grade: This is the foundation layer over which the roadway is being constructed and all the loads which come onto the pavement are eventually supported by it. The performance of the pavement largely depends on the characteristics of the sub-grade. The term sub-grade is applied to include compacted soil existing in a cut section or the upper layer of an embankment section (Summer 2001).

2.2.4.2 Rigid Pavement

Rigid pavements possess considerable flexural strength. The rigid pavements are made of cement concrete which may be plains, reinforced or prestressed. The rigid pavements have slab action and are capable of transmitting the wheel loads to wider area. The main difference in the structural behavior is that the critical condition of stress in rigid pavement is the maximum flexural stress occurring in the slab due to wheel load and temperature changes where as in the flexible pavement it is the distribution of compressive stress to lower layers and lastly over the soil sub-grade. The rigid pavements do not get deformed to the shape of the lower surface as it can bridge the minor variations of the lower layer. The cement concrete pavement slab serves as wearing surface as well as an effective base course. Though the cement concrete slab can be laid directly over the soil sub grade, it is not preferred particularly when sub-grade consists of fine grained soil. Providing a good base or sub-base course layer under the cement concrete slab increases the pavement life and proves economical in the long run.

Surface

Concrete

Sub base

Sub grade

Fig. 2.2 Cross section of rigid pavement (Gupta et al 2003)

2.2.S Differences between Flexible Pavement and Rigid Pavement

The major differences between the types of pavement can be tabulated below:

Table 2.1 Differences between flexible pavement and rigid pavement (Bindra 2001).

Flexible Pavement	Rigid Pavement
1. It consists of a series of layers with the highest quality materials at or near the surface.	1. It consists of one course Portland cement concrete slab of relatively high bending resistance.
2. It reflects the deformations of sub grade and subsequent layers on the surface.	2. It is able to bridge over localized failures and areas of inadequate support.
3. Its stability depends upon aggregate interlock particle friction and cohesion.	3. Its structural capacity is supplied by the pavement slab itself by beam action.
4. Pavement design is greatly influenced by the sub grade strength.	4. Flexural strength of concrete is major factor for design.
S. It functions by way of load distribution through the component layers.	S. It distributes load over a wide area of sub-sgrade because of its rigidity and high modulus of elasticity.

2.3 Road Classification

Roads can be classified according to the traffic volume, tonnage, location function they perform. According to traffic volume, they may be classified as heavy, medium and light traffic roads. Classification by the tonnage is done according to the tones a road can safely carry in its daily traffics. Classification according to location and function is more acceptable. In Nigeria, we have

(a) Federal roads (Trunk A), (b) State roads (Trunk B), and (c) Local government roads (Trunk C) (Opaluwa, 2008).

a) Federal roads or national highways are the main highways running through the length and breadth of the country. They connect national capital with state capitals, major port towns and border areas; they are of strategic importance.
b) State Highways are the main roads within the states. They connect important towns and cities in the state. They also connect important cities of the state to the national highway and highways of neighboring states.
c) Local Government Roads may traverse all the local government areas. They serve areas of production, market and establish connection with national or state highways and railways. They carry traffic to the interior rural areas.

2.4 Highway Materials

The need for thorough understanding of soil and aggregate properties which affect pavement stability and durability and also the properties of the binding materials which may be added to improve these pavement features cannot be overemphasized.

2.4.1 Aggregates

These are the basic materials of highway pavement construction. They not only support the main stresses occurring within the pavement but also resist wear due to abrasion by traffic as well as the effects of weathering agencies. The behavior of the pavement structure depends on the inherent properties and qualities of the individual particles and on the means by which they are held together i.e. by interlocking, by cementitious binders, or by both.

2.4.1.1 Classification of Aggregates

1) Natural aggregates: The majority of road aggregates are formed from natural rock. A rock is a geological form of earth's crust composed of aggregates of minerals. A mineral is composed of chemical elements, having a definite composition and structure. Quartz, Felspar, Mica, Calcite, Dolomite etc., are the common mineral constituents of rocks (Bindra 2001). Base on the method of origin, the rocks can be classification into following three main groups.

A. Igneous Rocks: They are formed by gradual cooling and solidification of molten or semi-molten matter erupted from the interior of the earth. Examples of igneous rocks are: Granite, Gabbros, Basalt, Diorites and traps.

B. Sedimentary Rocks: These are secondary rocks formed by mechanical and chemical disintegration of weathering agencies to form layer upon layer in somewhat horizontal positions. Examples of sedimentary rocks are: sand stone, lime stones, shales, dolomites and flint.

C. Metamorphic Rocks: These are basically either sedimentary or igneous rocks that have undergone considerable changes in their constitutions under influence of pressure, temperature, earth movement and shearing stress. Gneiss from granite, Quartzite from sand stone, slate from shale and marble from limestone are typical examples of metamorphic rocks. (Bindra 2001).

The following can be formed from any ofthe above parent rocks:

1. Gravels: These are small stones of irregular shape and size usually water worn. They are generally obtained from river beds or open beaches. Gravel being round in shape has no interlocking of its own. Since they have more workability

than broken stones, therefore, they are preferred in cement concrete mix (Bindra 2001).

11. Sand: It is a fine aggregate formed by weathering of rock. It is obtained from river beds, sea shores, and quarries. It is inert, inorganic material that will pass a 6mm mesh sieve. A good quality sand should be (i) sharp (ii) well-graded (iii) free from organic matter, clay, grit, etc., (iv) Hard, tough and durable.

111. Laterite: It is metamorphic rock composed of porous and cellular sandy stones. It is deep brown and red in colour due to the presence of high percentage of iron oxide. It contains moisture when freshly quarried and is thus easily workable. On exposure for a few months it becomes harder.

IV. Kankar: It is a grey porous impure lime stone containing about 35% clay and sand. It exists in both hard and soft form. The hard kanker occurs in form whereas soft variety occurs in layers.

v. Moorums: They are iron stone gravels mixed with red clay. They are obtained from disintegration of rocks by weathering agencies.

The broken stone natural aggregate are divided into two categories: the hard aggregates and the soft aggregates. The hard aggregates are used for the surfacing course of pavements. They can withstand effectively the abrasion and crushing affects due to heavy traffic loads. They can also resist the affect of weathering agencies.

Aggregates like moorum, kankar, laterite shale etc. are known as Soft aggregate. They are used for low cost construction and also for lower layers, e.g., sub base and base of pavement structure (Bindra 2001).

2.4.2.1 Cutback Bitumen

The cutback bitumen is a liquid binder. It is obtained by blending a bituminous binder with a volatile solvent. It is suitable for direct application and manipulation in road construction. The solvent used in cutback bitumen not only serves as a substitute for heat but also helps in increasing the liquidifying effect over a longer period of time. Soon after the application of cutback bitumen in construction work, the solvent gets evaporated and dissipate by photo-oxidation and leave behind the bitumen to tie the particles together. The behavior of a cutback bitumen in any particular situation depends upon the characteristics and amount of solvent present. Depending upon the type of solvent used to dilute the bitumen, the cutback bitumen can be divided into following three types:

a) Slow Curing Cutback: They are manufactured by either blending bitumen with boiling point gas oil, or by controlling the rate of flow and temperature of crude during the first cycle of refining.

   Since the slow curing cutback contain slowly volatile oils, therefore, they are liable to remain liquid in or on the road way, for a relatively long time after being applied. Thus the binding strength is developed at a comparatively slow rate. It is because of this reason that the slow curing cutback are best used with dense graded aggregates which provide a strong interlocking framework and do not require immediate, strong cementing action from the binder. They should never be used as a binder for open graded road surfacing. They are also used on the surface of soil aggregate road in warm climate to prevent dust nuisance.

Slow curing cutbacks are available in six grades *viz.* 0 to 5 depending upon their consistency. They are designated as S.C- 0, S.C - 1, S.C - 2, S.C - 3, S.C - 4, S.C - 5 (Bindra 2001).

b) Medium curing cutback: These are manufactured by fluxing *100/300* penetration grade bitumen with a petroleum distillate e.g. kerosene or with a cold tar creosote oil or Anthracene oil, or with a mixture of these. They are generally considered the most practical for use in bituminous stabilization of soil. It is possible to effectively coat the fine graded aggregate and sandy soils with medium curing cutback (Bindra 2001).

c) Rapid curing cutback: They are prepared by diluting a suitable penetration grade bitumen with a very volatile petroleum distillate e.g. Gasoline or Naptha. They are used when a quick change back to the residual semi-solid binding agent is desired.

   They have relatively low flash points which renders their use hazardous, particularly when the very viscous grades which may have to be heated before admixing are used in road construction (Bindra 2001).

2.4.2.2 Bitumen Emulsion

An emulsion is a mixture of two immiscible liquids. The liquid which is dispersed is often called the internal phase while the surrounding liquid is known as the external phase. The mixing is done in the presence of an emulsifying agent such as resin or soap which helps in mixing the two liquids. Generally bitumen emulsions are of two types. In the first type minute globules of bitumen are dispersed in water. The second type consist of a bitumen water mixture in which up to about 10% water forms the dispersed phase and cutback and cutback bitumen is the continuous phase. This type is known as inverted emulsion.

Emulsifiers used in the preparation of bitumen emulsions can be either anionic or cationic emulsifiers. Emulsions are manufactured by mixing water, bitumen and the emulsifying agent in either colloid mill or a high speed mixer. Anionic road emulsions can be classified as

a) Liable Emulsions: These emulsions contain only a rmnimum amount of emulsifiers, therefore, they break down rapidly on application. They are not suitable for mixing with aggregates but are used for surface dressing, tack coating, grouting and concrete curing purposes. These emulsions cannot be stored in cold weather because they break on freezing and do not redisperse on thawing.
b) Semi-stable Emulsions: This type of emulsions contain sufficient amount of emulsifiers to permit mixing with certain grades of aggregate before breakdown occurs. They are used for retreading of old road surfaces.
c) Fully stable Emulsions: This type of emulsion has sufficient mechanical and chemical stability for all purposes involving mixing with aggregates. They are particularly useful for winter road works because they can be frozen and thawed without any appreciable breakdown.

Cationic emulsions are used in the following instances:

1. Tack coating purposes
2. Coating wet aggregates
3. To seal gravel surfaces before applying surface dressing

The following factors influence the breakdown in case of bitumen emulsions.

1. Rate of evaporation of water
2. The physico-chemical reaction between the aggregate and the emulsion.

3. The absorption qualities of the surface being covered.

4. The amount of mechanical disturbance applied during compaction.

2.4.2.3 Road Tar

It is a viscous liquid, black in colour with adhesive properties obtained by destructive distillation or organic matters such as wood, coal, shale, etc. In the destructive distillation process the material is subjected to heat alone in the absence of air. The first step for the production of tar is the carbonization of coal to produce crude tar. In the second stage crude tar is refined by distillation process. This involves first collection of benzene, toluene and xylene and then the middle and heavy oils containing creosote oils and Naphthalene. The residue material called pitch is then fluxed back with necessary amounts oftar to give the desired road tar.

The different grades of road tar along with their uses are listed below:

Gradefor Road Tar	*Uses*
1. R.T-l	Surface painting under exceptionally cold weather.
2. R.T-2	Surface paintings under tropical climatic conditions.
3. R.T-3	Surface paintings, renewal coats and premixing chips.
4. R.T-4	Premixing tar macadam in base course
5. R.T-5	Grouting (Gurcharan 2004).

2.4.3 Comparison of Bitumen and Tar

1. Both bitumen and tar appear blackish in colour when viewed in large mass but appear brown in colour when viewed in thin films.
2. Tar coated aggregates exhibit lower stripping action as compared to bitumen coated aggregates.
3. Tar is more temperature susceptible i.e. it becomes liquid at lower temperatures and solidifies at comparatively higher ones.
4. Tar takes more time to set, therefore, central mixing plant can be used for efficient road construction work.
5. Tar is not susceptible to dissolving action of petroleum solvents. Hence in parking areas where petrol and oil are likely to drip from vehicles, a tar surfacing may have a longer life than a bitumen one.
6. Tar contains a higher percentage of free carbon. Therefore, it is more brittle at low temperature.
7. Tars may be overheated and spoiled more easily than bitumen.
8. Tar takes more time to set. Therefore, tar roads take more time before they are opened to traffic.
9. Tar contains more phenolic content, so get oxidized easily.
10. Tar gets crystallized and forms an internal structure.

2.4.4 Rubber Bitumen

It contains a mixture of bitumen and rubber latex of different forms. They have got more cohesion and stability. They are more resilient than one without. They also serve better to cushion vibrations and traffic shocks. The addition of rubber also increases the softening point, viscosity of the bituminous mixture. Rubber bitumen mixture is less temperature susceptible. In cold areas, the addition of 5.5 to 7% rubber by weight of bitumen reduces surface cracking (Bindra 2001).

CHAPTER THREE

METHODOLOGY

3.1 Preamble

This chapter enumerates the laboratory works carried out in the comparison of the strength properties of the three different cold mix asphalt samples. It also shows the procedures by which the tests were carried out.

3.2 Material Use

The under listed apparatus were used for this research work and can be found in Civil Engineering Department, Federal University of Technology Minna, Niger State, Nigeria.

I. Weighing balance

11. Mould

111. Sample tray

IV. Spatula

v. Marshall Stability and flow machine

VI. Set of sieves

V11. Extruder

V11I. Water Basin set for 40 degrees Celsius

IX. Engine Oil

x. Filter paper

3.3 Material Characteristics

Table 3.1 presents materials used as samples for this research work. Also presented in the table are the source and physical properties of the materials.

Table 3.1 Material description

SINo	Sample	Description/Characteristic	Sources
1	Carboncor cold-mix asphalt	Black in colour. A mixture of aggregates and binder	Carboncor Nigeria, Sauka Kahuta, Niger State, Nigeria
2	Portland Emcor Cold-mix Asphalt	Black in colour. A mixture of aggregates and binder	Portland Paints and Products, Lagos, Nigeria.
3	UPM Cold-mix asphalt	Black in colour. A mixture of aggregates and binder	UPM Company, Uyo, Akwa Ibom State, Nigeria

3.4 Method of study

The under listed are the procedures and steps that were followed in order to obtain a systematic and objective result:

i. Material sourcing

ii. Determination of strength properties of samples

iii. Determination of specific gravity

iv. Sieve analysis

v. Comparison of the various cold mixes

vi. Comparison with the standard of Hot Mix Asphalt.

3.4.1 Sieve Analysis

In sieve analysis, a sample of a dry aggregate of known weight is separated through a series of sieves with progressively small openings. Once separated, the weight of the particles retained on each sieve is measured and compared to the total sample weight.

Particle size distribution is then expressed as percentage retained by weight on each sieve size. The results are usually in tabular or graphical format

$$\text{Percentage retained on any sieve} = \frac{\text{Weight of aggregate retained}}{\text{Total aggregate weight}} \times 100$$

Cumulative percentage retained on any sieve = sum of percentage retained on all coarser Sieves.

3.4.2 Marshall Test

.. This was used to determine the strength properties of the various test samples. In this test, some amount not less than 1000g is placed in the Marshall mould and the round end of the rammer is rested on the material inside the mould. Each sample is compacted with the 75 blows on each side of the specimen with 4.54kg compacting rammer falling through 457mm unto the top and bottom of each specimen. The weight on the rammer is lifted up and allowed to fall freely until the required amount of blows is given. The same is done to the other side of the specimen. The mould containing the material is removed and then labeled. The material is extruded out of the mould. The density of the compacted material is achieved by weighing in air and suspended in water. The numerical differences in the two weights are the volume. The density is calculated by dividing the weight in air by the volume. Three samples of each material are placed in water heated to 40°C for the duration of 30 minutes that the sample continues to be in it. Three samples of each material are air-dried for 3 days. Other 3 samples of each material are placed in cold water for 3 days. The samples are then placed in the stability machine and the load applied. The highest load is taken and calculated as stability while the rate of deformation which is the flow is read directly from flow gauge. The figure obtained from the stability gauge is used to multiply the proofing ring factor of the machine. This is used in multiplying the correction factor to achieve stability. While the stability stands for the highest load the specimen can withstand, the flow stands for the rate of deformation caused at highest load.

In summary the following steps were taken to obtain the result in table ... to determine the properties of the various cold mix asphalts especially their bearing capability (ability to withstand imposed load):

1. Weigh 1200 gram of sample (9 samples of each type cold mix)
2. Place filter in the molds
3. Put asphalt in the moulds, poke it with spatula, and then compact 75 blows on each side
4. Extrude it out of the molds
5. Get weight of sample in air
6. Get weight of sample in water
7. Place 3 samples of each in water basin for 30 min at 60 degrees Celsius
8. Crush sample in the stability machine to determine stability and flow
9. Air-dry 3 samples of each for 3 days and then crush sample in the stability machine to determine stability and flow
10. Place 3 samples of each in water for 3 days and then crush sample in the stability machine to determine stability and flow.

P8 = 1201.9 - 574.6 = 627.3cm^3

P9 = 1226.0 - 585.9 = 640.1cm^3

Carboncor

Cl = 1037.2 - 403.3 = 633.9cm^3

C2 = 1025.9 - 460.1 = 565.8cm^3

C3 = 1135.8 - 479.4 = 656.4cm^3

C4 = 1125.9 - 456.3 = 669.6cm^3

C5 = 1126.0 - 477.4 = 648.6cm^3

C6 = 1136.4 - 484.0 = 652.4cm^3

C7 = 1132.3 - 505.8 = 626.5cm^3

C8 = 1146.4 - 502.0 = 644.4cm^3

C9 = 1074.5 - 468.8 = 605.7cm^3

UPM

Ul = 1083.1 - 440.0 = 643.1cm^3

U2 = 1079.5 - 400.6 = 678.9cm^3

U3 = 1096.0 - 383.3 = 713.3cm^3

U4 = 1087.6 - 502.0 = 583.6cm^3

U5 = 1083.8 - 440.7 = 643.1cm^3

U6 = 1047.5 - 390.0 = 657.5cm^3

of each material are air-dried for 3 days. Other 3 samples of each material are placed in cold water for 3 days. The samples are then placed in the stability machine and the load applied. The highest load is taken and calculated as stability while the rate of deformation which is the flow is read directly from flow gauge. The figure obtained from the stability gauge is used to multiply the proofing ring factor of the machine. This is used in multiplying the correction factor to achieve stability. While the stability stands for the highest load the specimen can withstand, the flow stands for the rate of deformation caused at highest load.

In summary the following steps were taken to obtain the result in table ... to determine the properties of the various cold mix asphalts especially their bearing capability (ability to withstand imposed load):

1. Weigh 1200 gram of sample (9 samples of each type cold mix)
2. Place filter in the molds
3. Put asphalt in the moulds, poke it with spatula, and then compact 75 blows on each side
4. Extrude it out of the molds
5. Get weight of sample in air
6. Get weight of sample in water
7. Place 3 samples of each in water basin for 30 min at 60 degrees Celsius
8. Crush sample in the stability machine to determine stability and flow
9. Air-dry 3 samples of each for 3 days and then crush sample in the stability machine to determine stability and flow
10. Place 3 samples of each in water for 3 days and then crush sample in the stability machine to determine stability and flow.

3.4.3 Percentage Bitumen Content

The percentage bitumen content of the various samples was determined as follows:

% bitumen by weight of total mix =

$$\frac{\text{Wt of sample before extraction} - \text{Wt of sample after extraction}}{\text{Wt of sample before extraction}} \times 100$$

% bitumen by weight of aggregate =

$$\frac{\text{Wt of sample before extraction} - \text{Wt of sample after extraction}}{\text{Wt of sample after extraction}} \times 100$$

3.4.4 The specific gravity for aggregate and bitumen

The specific gravity of the aggregate and bitumen were not done separately. This is because the bitumen used for the various cold mixes could not be gotten from the producers of the cold asphalt. So for this test, the specific gravity of bitumen is taken as 1 for all samples. However, the specific gravity of the aggregate was determined.

The sample is soaked in distilled water. Later, it is surface dried and weighed in air and then oven dried for 24 hours at 100 - 110°C, weighed in air again. The specific gravity is calculated by dividing the weight of the oven-dry sample in air by the difference between the saturated sample weights in air and water.

The specific gravity was calculated as follows:

If weight of cylinder	$= A$
Weight of cylinder + Sample	$= B$
Weight of cylinder + Sample + Water	$= C$
Weight of cylinder + Water only	$= D$

Therefore, Specific Gravity g/cm^3

$$\frac{B-A}{(D-A)-(C-B)}$$

CHAPTER FOUR

PRESENTING RESULT AND DISCUSSION

The following are the results of the tests carried out on the cold mix samples:

4.1 Marshall Test

Each of the three various cold mixes were tested for Marshall Stability and flow for different conditions (curing) namely:

1. After being placed in a water basin at 40°C for 30 mins. (Samples 1 - 3)

11. After being air-dried for 3 days (Samples 4 - 6)

111. After being placed in a cold water basin for 3 days (Samples 7 - 9)

4.1.1 Bulk volume = weight in air - weight in water

Portland Emcor

PI = 1208.2 - 575.2 = 633cm ^{3}

P2 = 1199.1 - 550 = 649.1cm ^{3}

P3 = 1208.0 - 561.4 = 646.6cm ^{3}

P4 = 1223.3 - 575.9 = 647.4cm ^{3}

P5 = 1203.6 - 559.1 = 644.5cm ^{3}

P6 = 1198.1 - 569 = 629.1cm ^{3}

P7 = 1212.1 - 568.1 = 644.0cm ^{3}

P8 = 1201.9 - 574.6 = 627.3cm^3

P9 = 1226.0 - 585.9 = 640.1cm^3

Carboncor

C1 = 1037.2 - 403.3 = 633.9cm^3

C2 = 1025.9 - 460.1 = 565.8cm^3

C3 = 1135.8 - 479.4 = 656.4cm^3

C4 = 1125.9 - 456.3 = 669.6cm^3

C5 = 1126.0 - 477.4 = 648.6cm^3

C6 = 1136.4 - 484.0 = 652.4cm^3

C7 = 1132.3 - 505.8 = 626.5cm^3

C8 = 1146.4 - 502.0 = 644.4cm^3

C9 = 1074.5 - 468.8 = 605.7cm^3

UPM

U1 = 1083.1 - 440.0 = 643.1cm^3

U2 = 1079.5 - 400.6 = 678.9cm^3

U3 = 1096.0 - 383.3 = 713.3cm^3

U4 = 1087.6 - 502.0 = 583.6cm^3

U5 = 1083.8 - 440.7 = 643.1cm^3

U6 = 1047.5 - 390.0 = 657.5cm^3

U7 = 1078.8 - 427.6 = 651.2cm3

U8 = 1081.2 - 439.5 = 641.7cm3

U9 = 1080.0 - 385.7 = 694.3cm3

Table 4.1 Sampl e weight and volume

sample	Weight in air (g)	Weight in water (g)	Bulk
Porland Emcor			
PI	1208.2	575.2	633
P2	1199.1	550	649.1
P3	1208	561.4	646.6
P4	1223.3	575.9	647.4
P5	1203.6	559	644.6
P6	1198.1	569	629.1
P7	1212.1	568.1	644
P8	1201.9	574.6	627.3
P9	1226	585.9	640.1
Carboncor			
Cl	1037.2	403.3	633.9
C2	1025.9	460.1	565.8
C3	1135.8	479.4	656.4
C4	1125.9	456.3	669.6
C5	1126	447.4	678.6
C6	1136.4	484	652.4
C7	1132.3	505.8	626.5
C8	1146.4	502	644.4
C9	1074.5	468.8	605.7
UPM			
Ul	1083.1	440	643.1
U2	1079.5	400.6	678.9
U3	1096.6	383	713.6
U4	1087.6	502	585.6
U5	1083.8	440.7	643.1
U6	1047.5	390	657.5
U7	1078.8	427.6	651.2
U8	1081.2	439.5	641.7
U9	1080	385.7	694.3

$$C2= \frac{1025.9}{565.8} = 1.81$$

$$C3 = \frac{1025.9}{565.8} = 1.73$$

$$\text{Average, } C_{nomlal} = \frac{1.64 + 1.81 + 1.73}{3} = 1.73$$

$$C4= \frac{1125.9}{669.6} = 1.68$$

$$C5 = \frac{1126.0}{648.6} = 1.74$$

$$C6= \frac{1136.4}{652.4} = 1.74$$

$$\text{Average, } C_{air} = \frac{1.68 + 1.74 + 1.74}{3} = 1.72$$

$$C7= \frac{1132.3}{626.5} = 1.81$$

$$C8= \frac{1140.4.}{644.4} = 1.78$$

$$C9= \frac{1174.5.}{605.7} = 1.77$$

$$\text{Average, } C_{water}= \frac{1.81 + 1.78 + 1.77}{3} = 1.79$$

4.3.3 UPM

$$Ul= \frac{1083.1.}{643.1} = 1.68$$

$$U2= \frac{1079.5.}{678.9} = 1.59$$

$$U3= \frac{1096.6}{713.3} = 1.54$$

$$\text{Average, } U_{normal} \quad \frac{1.68 + 1\ 59 + 1.54}{3} = 1.6$$

$$U4= \frac{1087.6}{583.6} = 1.87$$

$U5 = \frac{1087.6}{583.6} = 1.66$

$U6 = \frac{1047.5}{657.5} = 1.59$

Average, $U_{air} = \frac{1.87 + 1.66 + 1.59}{3} = 1.7$

$U7 = \frac{1078.8}{651.2} = 1.66$

$U8 = \frac{1081.2}{641.7} = 1.68$

$U9 = \frac{1080.0}{694.3} = 1.56$

Average, $U_{water} = \frac{1.66 + 1\ 68 + 1.56}{3} = 1.63$

4.3 Specific Gravity

The table below shows the specific gravity of the various cold mix asphalt samples

Table 4.2 Specific gravity of the various samples

Material	Portland (g)	Carboncor (g)	UPM (g)
Wt of cylinder (A)	114.10	126.90	97.50
Wt of Cylinder + Sample (B)	208.40	217.8	161.7
Wt of cylinder + Sample + Water (C)	421.80	428.30	386.20
Wt of cylinder + water only (D)	362.4	374.9	346.0
Specific Gravity $\frac{B-A}{(D-A) - (C-B)}$ g/rrr'	2.59	2.42	2.68

4.4 The maximum theoretical density

Maximum theoretical density, mtd= $\frac{100}{\frac{\%bitumen}{s.g\ of\ bitumen}+\frac{\%Agg}{s.g\ of\ agg}}$

For Portland Emcor

Specific gravity of bitumen = 1.0

Specific gravity of aggregate = 2.59

$$\frac{100}{\frac{9.4}{1}+\frac{90.6}{2.59}} = 2.25$$

For Corboncor

Specific gravity of bitumen = 1

Specific gravity of aggregate = 2.42

$$\frac{100}{\frac{10.1}{1}+\frac{89.9}{2.42}} = 2.16$$

ForUPM

Specific gravity of bitumen = 1.0

Specific gravity of aggregate = 2.68

$$\frac{100}{\frac{8.8}{1}+\frac{91.2}{2.68}} = 2.33$$

4.5 Bitumen Content

The bitumen contents of the samples were calculated as follows:

4.2 Bulk Density

$$\text{Bulk density} = \frac{\text{Weight in air}}{\text{Bulk volume}}$$

4.3.1 Portland

$$PI = \frac{1208.2}{\sim} = 1.91$$

$$P2 = \frac{1199.1}{649.1} = 1.85$$

$$P3 = \frac{1208.0}{646.6} = 1.87$$

$$\text{Average, } P_{normal} = \frac{1.91 + 1.85 + 1.87}{3} = 1.88$$

$$P4 = \frac{1223.3}{647.4} = 1.89$$

$$P5 = \frac{1203.6}{644.5} = 1.87$$

$$P6 = \frac{1198.1}{629.1} = 2.11$$

$$\text{Average, } P_{air} = \frac{1.89 + 1.87 + 2.11}{3} = 1.96$$

$$P7 = \frac{1212.1}{644} = 1.88$$

$$P8 = \frac{1201.9}{627.3} = 1.92$$

$$P9 = \frac{1226.0}{640.1} = 1.92$$

$$\text{Average, } P_{water} = \frac{1.88 + 1.92 + 1.92}{3} = 1.91$$

4.2.1 Carboncor

$$C1 = \frac{1037.2}{633.9} = 1.64$$

Table 4.3 Determination of Bitumen content

Samples	Portland	carboncor	UPM
weight of sample before extraction, g, (A)	1178.7	1008.8	1063.3
weight of sample after extraction, g, (B)	1067	906.7	969.6
weight of bitumen, g, (C) = A - B	110.8	102.1	93.7
% bitumen by weight of total mix = Cj A X 100	9.4	10.1	8.8
% bitumen by weight of aggregate = CjB X 100	10.4	11.3	9.7

4.6 Comparison of strength properties

The table below shows the stability and flow values for the various cold mix asphalts and the standard specification. Some tests could not be done on some samplesofUPM due to the poor nature of the sample.

Table 4.4Comparison of test results for normal asphalt method of testing

	Cold mix samples			
Property	Portland	Carboncor	UPM	Standard specification for hot mix wearing course
Optimum bitumen content	9.40%	10.10%	8.80%	5.0% - 8.0%
Stability (KN)	2.25	4.19	-	~ 3.5KN
Flow(mm)	3.9	6.4	-	2mm-4mm
Voids in total mixture (%)	16.4	12.96	-	3%-5%
Voids filled with bitumen (%)	51.6	30.61	-	75% - 82%

Table 4.5 Comparison of test results for air-dried asphalt method of testing

	Cold mix samples			
Property	Portland	Carboncor	UPM	Standard specification for hot mix wearing course
Optimum bitumen content	9.40%	10.10%	8.80%	5.0%- 8.0%
Stability (KN)	4.33	9.63	1.00	~ 3.5KN
Flow(mm)	4.86	5.2	6.8	2mm -4mm
Voids in total mixture (%)	12.80	20.30	-	3%-5%
Voids filled with bitumen (%)	58.59	48.12	35.49	75% - 82%

Table 4.6 Comparison of test results for soaked asphalt method of testing

	Cold mix samples			
Property	Portland	Carboncor	UPM	Standard specification for hot mix wearing course
Optimum bitumen content	9.40%	10.10%	8.80%	5.0%- 8.0%
Stability (KN)	3.42	7.03	-	~ 3.5KN
Flow(mm)	4.20	5.4	-	2mm -4mm
Voids in total mixture (%)	15.11	17.12	-	3%-5%
Voids filled with bitumen (%)	54.08	53.97	-	75% - 82%

4.7 Sieve Analysis

a) Portland Emcor

Presented below is the sieve analysis result for Portland Emcor sample:

Description of sample	PORTLAND EMCOR
Weight of sample plus bitumen	l,178.70g
Weight of sample	l,067.90g
Date	18/03/2011

Table 4 7 Extraction Analysis of Asphalt

SIEVESIZE	WEIGHT RETAINED (grm)	% WEIGHT RETAINED	%PASSING
20.10mm	-	-	100.00
14.00mm	-	-	100.00
10.00mm	-	-	100.00
6.30mm	42.70	4.00	96.00
5.00mm			
3.35mm			
2.36mm	511.90	47.94	48.07
1.18mm	147.70	13.83	34.24
600llm	116.50	10.91	23.33
4251lm			
300llm	108.80	10.19	13.14
2121lm			
150llm	69.30	6.49	6.65
751lm	43.10	4.04	2.61
Passing 751lm	27.90	2.61	

Weight of sample before extraction	1,178.70	
Weight of sample after extraction	1,067.90	
Weight of bitumen	110.80	
% Bitumen by weight of Total mix	9.40	%
% Bitumen by weight of aggregate	10.38	%

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Extraction Chart

Fig 4. Extraction Chart

b) Carboncor

Presented below is the sieve analysis result for Carboncor sample:

Description of sample	CABONCOR
Weight of sample plus bitumen	I,008.80g
Weight of sample	906.70g
Date	18/03/2011

Table 4.8 Extraction Analysis of Asphalt

SIEVESIZE	WEIGHTRETAINED (grm)	% WEIGHT RETAINED	%PASSING
20.10mm	-	-	100.00
14.00mm	30.10	3.32	96.68
10.00mm	59.60	6.57	90.11
6.30mm	92.70	10.22	79.88
5.00mm			
3.35mm			
2.36mm	203.00	22.39	57.49
1.18mm	98.30	10.89	46.65
600llm	87.10	9.61	37.05
4251lm			
300llm	110.10	12.14	24.9
2121lm			
isoum	87.20	9.62	15.29
751lm	74.70	8.24	7.05
Passing751lm	63.90	7.05	

Weight of sample before extraction	1,008.80	
Weight of sample after extraction	906.70	
Weight of bitumen	102.10	
% Bitumen by weight of Total mix	10.12	%
% Bitumen by weight of aggregate	11.26	%

.A..

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Extraction Chart

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~ts· ~,:L Extraction Chart

c) UPM

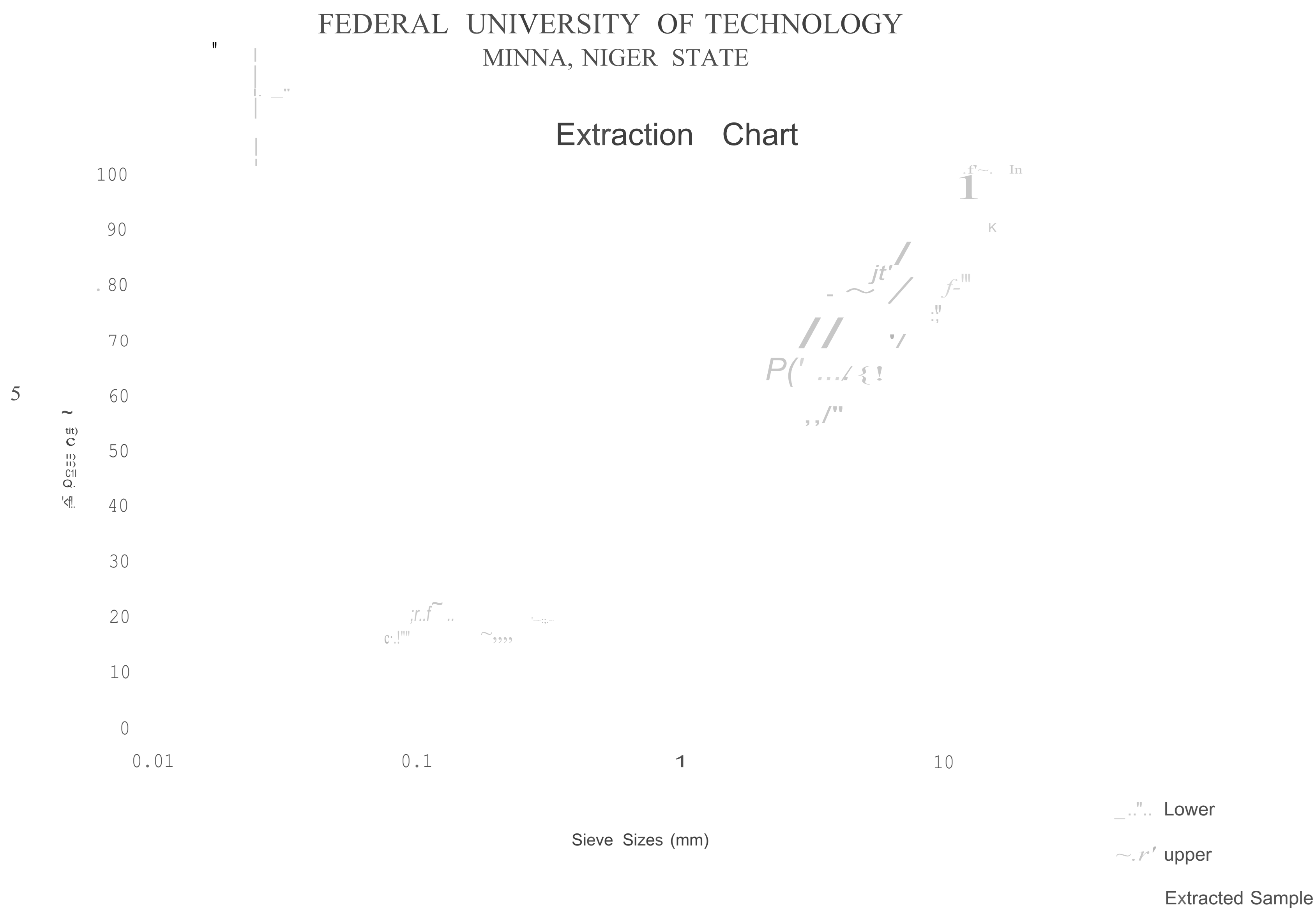
Presented below is the sieve analysis result for UPM sample:

Description of sample	UPM
Weight of sample plus bitumen	1,063.30g
Weight of sample	969,60g
Date	18/03/2011

Table 4 9 Extraction Analysis of Asphalt

SIEVE SIZE	WEIGHT RETAINED (grm)	% WEIGHT RETAINED	% PASSING
20.10mm	-	-	100.00
14.00mm	-	-	100.00
10.00mm	-	-	100.00
6.30mm	6.70	0.69	99.31
5.00mm			
3.35mm			
2.36mm	562.40	58.00	41.31
1.18mm	246.70	25.44	15.86
600~m	73.40	7.57	8.29
425~m			
300~m	30.80	3.18	5.12
212~m			
150~m	20.30	2.09	3.02
75~m	18.70	1.93	1.09
Passing 75~m	10.60	1.09	

Weight of sample before extraction	1,063.30	
Weight of sample after extraction	969.60	
Weight of bitumen	93.70	
% Bitumen by weight of Total mix	8.81	%
% Bitumen by weight of aggregate	9.66	%



~,'~4,6 Extraction Chart

4.8 Discussion of results

4.8.1 Marshall Test

Tables 4.4, 4.5 and 4.6 show the strength properties of the various samples of cold mix asphalts at three different test methods as compared with standard for hot mix asphalts. Table 4.5 shows the strength properties for air-dried asphalt method of testing, which is where the samples exhibited their highest stability values.

i. Optimum Bitumen Content

From table 4.5, the Optimum Bitumen Contents of the three samples were seen to be slightly above the range for the standard specification for hot mix, with UPM having the closest value to the standard range.

ii. Stability

The stability values of the various cold mix samples as seen on table 4.5 shows that Portland and Carboncor samples met the standard specification for hot mix and the UPM sample could not meet the standard specification. While the Carboncor sample had stability value far above the minimum requirement, the UPM sample had stability value far below the minimum requirement.

111. Flow

The flow values of the various cold mix samples as seen on tables 4.4, 4.5 and 4.6 for the three different method of testing (normal asphalt, air-dried asphalt and soaked asphalt methods) show that only Portland sample had flow value in the range of the hot mix standard specification and only in the normal asphalt method of testing. The Carboncor sample had flow values slightly above the range in all the methods of testing while the UPM sample had the highest flow value above the range for hot mix standard in the air-dried method of testing. The flow test could not be carried out on the UPM sample for normal asphalt method and soaked asphalt method of testing due to the poor nature of the sample.

iv. Voids in total mixture (%)

From tables 4.4, 4.5 and 4.6, the percentage voids in total mixture of the samples were seen to be above the range of the hot mix standard specification in all the methods of testing.

v. Voids filled with bitumen (%)

The percentage voids filled with bitumen in all the cold mix samples were seen to be below the range of the standard specification for hot mix asphalt in all the methods of testing.

4.8.2 Sieve Analysis

Figures 4.1, 4.2 and 4.3 show the graph for the sieve analysis carried out on the three cold mix samples. From fig. 4.2, it was seen that the Carboncor sample has the best particle size distribution as it falls within the standard upper and lower limits. Fig. 4.1 shows that the graph for the Portland sample didn't quite fall within the standard upper and lower limits but it was close to the standard limits. The UPM sample showed a graph which is far away from the standard upper and lower limits, showing poor particle size distribution as can be seen in fig. 4.3.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From thetests carried out, the sample from Carboncor Nigeria Limited is the best. Next is sample from Portland Emcor and the least is sample from UPM. Cold mix asphalt gain more strength in air than in hot or cold water. The aggregates in the UPM sample are not well distributed as their sizes are too close to each other. The samples could not meet all the requirements as contained in the standard specifications for hot-mix asphalt. The best method of curing in cold mix asphalt is by air-drying. Surfacing with low flows and high stability will not deform easily but are likely to be brittle, while those with low stabilities and high flows deform easily under traffic. The stability is a function of both the interparticle and the binder frictions.

5.2 Recommendation

Based on the laboratory tests and analysis obtained from the comparison of various cold mix asphalt with hot mix standard, the following recommendations were drawn, aggregates for cold mix asphalt should be well distributed with different aggregate sizes. Air-drying should be used as a method of curing in cold asphalt. Cold mix asphalt is better used on medium and low traffic roads.

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APPENDIX A

STANDARD PROPERTIES OF COMPACTED HOT MIX ALPHALTIC CONCRETE

Property	Base course	Wearing course
Optimum Bitumen Content	4.5%-6.5%	5.0% - 8.0%
Stability, not less than	3.8KN	3.5KN
Flow	2mm-6mm	2mm-4mm
Voids in total mixture	3%-8%	3%- 5%
Voids filled with bitumen	68% -72%	75% - 82%

APPENDIXB

GRADING ENVELOPE FOR BINDER AND WEARING COURSES

SIEVE SIZE	% BY WEIGHT PASSING 40mm - 60mm BINDER COURSE	40mm - SOmm WEARING COURSE
31.Bmm	100	100
25mm	90 -100	100
19.0mm	70 - 90	100
12.5mm	55 - BO	85 - 100
9.5mm	47 -70	75 - 92
6.4mm	40 - 60	65 - 82
2.8mm	27 - 45	50 - 65
1.25mm	20 - 34	36 - 51
600llm	14 - 27	26 - 40
300llm	8 - 20	18 - 30
150llm	5 -15	13 - 24
751lm	2-7	7 -14
Bitumen Content % by weight of aggregate	4.5 - 6.5	5.0 - 8.0