RUTTING SUSCEPTIBILITY AND MOISTURE DAMAGE OF HOT MIX ASPHALT CONTAINING RECYCLED ASPHALT PAVEMENT

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Certified that the contents and form of thesis titled **"Rutting Susceptibility and Moisture Damage of Hot Mix Asphalt Containing Recycled Asphalt Pavement",** submitted by Waqas Rafiq, have been found satisfactory for the requirement of the degree.

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Assistant Professor (Dr. Arshad Hussain, PhD)

DEDICATED

TO

MY PARENTS, TEACHERS AND COLLEAGUES

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(Waqas Rafiq)

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LIST OF ACRONYMS

AASHTO	- American Association of State Highway and Transportation Officials
AC	- Asphalt Concrete
ASTM	- American Society for Testing and Materials
BS	- British Standard
ESALs	- Equivalent Single Axle Loads
Gsb	- Combined bulk specific gravity of total aggregate
Gmb	- Bulk specific gravity of total aggregate
Gmm	- Theoretical maximum density
HMA	- Hot Mix Asphalt
HWTD	- Hamburg Wheel-tracking Device
NCHRP	- National Corporative Highway Research Program
RAP	- Recycled Asphalt Pavement
SGC	- Superpave Gyratory Compactor
SP	- Supepave
VA	- Air Voids
VFA	- Voids Filled with Asphalt
VMA	- Voids in Mineral Aggregates

ABSTRACT

Recycled Asphalt Pavement (RAP) use in pavement has increased a lot from the last two decades. RAP usage has now become common practice in many countries. Highway agencies around the world are endeavoring to use larger quantities of reclaimed asphalt pavement (RAP) in order to meet not only economical and environmental friendly but also to preserve natural resource and similar or even better performing hot mix asphalt (HMA) mixtures. Comprehensive road networks are a basis for economic development of any country. Overtime damages like rutting, moisture damage and cracking renders the pavement unusable. The use of reclaimed asphalt pavement (RAP) serves a distinct part in achieving the national goal of prosperity. This research work presents an experimental study to evaluate the effect of different percentages of RAP on the volumetric properties of asphalt mixtures. Mix design of one aggregate source and a RAP source using ½-in nominal maximum aggregate size was prepared. RAP material gradation was found and blended in the virgin aggregate gradation to get approximately our desired gradation with in specified limits of NHA. The mix designs included a control mix with 0% RAP and six samples of HMAs with 10%, 20%, 30%, 45%, 60% and 100% RAP to get an optimal percentage on which performance testing to be done after finding out the volumetric, stability and flow of RAP containing mixtures. NHA class-B wearing course gradation, ARL penetration grade of 60-70, aggregate source of Margalla and RAP from Islamabad Lahore Motorway (M-2) were used in this study.This research-study undertakes the rutting susceptibility and moisture damage in RAP incorporated hot mix asphalt (HMA) using Hamburg Wheel-tracking Device. Rutting resistance of Rap containing mixture is increased up to 24.7% for 20% RAP as compared to the controlled mixtures. Moisture damage results at 50°C temperature of water showed 20.7% increased resistance for 20% RAP containing mixture. This research showed that all tested HMAs with RAP performed better than the mixtures prepared with virgin aggregate. Cost comparison of control mix and Rap containing mixture was done on major asphalt production cost categories that how much their impact is on overall cost of any project. Comparison shows that RAP containing mixture can save the cost up-to 13.50%.

Chapter 1

INTRODUCTION

1.1 BACKGROUND

Transportation infrastructure is the corner stone for the prosperity of any country. Roads or pavements are major source of transportation for movement of people and freight. Pavement infrastructure forms a significant part in socioeconomic upbringing of any country. Pavements when designed according to the specification and standards will be durable structure to sever the desire design life. These well designed, properly constructed and maintained roadways sever the needs and satisfy the road users while daily commuting and their long trips as well. In the last few decades, highway agencies around the world are concentrating more on pavement maintenance and rehabilitation than on constructing roads. The demand for and use of reclaimed asphalt pavement (RAP) has frequently increased. The need to recycle old pavement is not only cost effective but also from an increase in environmental awareness. In an era in which every industry desire to adopt more sustainable approaches, asphalt recycling is a step forward in the direction of maintaining pavement systems (Al-Qadi *et al*., 2012).

During the last few decades continuous increase in traffic volume has resulted in premature pavement failures of approximately the whole infrastructure of Pakistan. Premature rutting is one of the major pavement distresses of flexible pavement which is faced by country due to high axle load and high temperatures. Rutting in asphaltic concrete depends on many factors i.e. gradation and quality of aggregate, stability of asphalt mixes, type of binder, percentage of the bituminous binder, air void contents, degree of compaction, environmental conditions including traffic, temperature and humidity, repeated traffic loading cycles, the substructure and the bearing capacity of the sub grade (Khan, 2008).

Economic and environmental considerations have provoked the recycling of steel, aluminum, plastic, and many other materials. One of these recyclable materials is hot mix asphalt (HMA).

In conventional asphaltic mixture design RAP rarely increases 20% to 25% in addition hot-in-place recycling (HIPR) or cold-in-place recycling (CIPR), which can make use of 80% to 100% RAP. Variability in aggregate gradation is one of the causes for RAP's limited use introduces when RAP stockpiles are not correctly managed, separated and processed to reduce variability such as segregation. Due to economic crises coupled with environmental concerns, departments of transportation in United States are being enforced to increase the amount of RAP up to 50% in asphaltic concrete pavements. High amount of RAP usage has the potential to impact durability and structural performance of the pavements. Studies have shown the high amount of RAP impact on the fatigue, fracture and permanent deformation characteristics of HMA (Al-Qadi *et al.*, 2012).

The asphalt paving industry has always suggested recycling. The earliest reclaimed asphalt pavement had been practiced as early as 1915 but major use of RAP in hot mix asphalt (HMA) really started in the mid 1970s because of increase in asphalt binder prices as the result of oil ban. Along with RAP, recycles asphalt shingles (RAS) is being currently used in Texas. The use of RAP/RAS can considerably decrease the cost of HMA paving, Conserve energy, and protect the environment.RAP/RAS binders are stiffer than virgin binders blending stiff material with virgin materials makes the designed mixes causes to cracking and leading to problem i.e. durability, which is one of the major concerns of RAP/RAS mixes. So it is important to address the premature cracking distress in order to efficiently use these recycled materials (Sondag *et al.*, 2002).

1.2 RESEARCH OBJECTIVES

The objectives of the present study are:

1. To evaluate the rutting susceptibility of Hot Mix Asphalt (HMA) mixtures containing RAP content by using Hamburg wheel-tracking device.
2. The effect of RAP content in the mix on Moisture damage of HMA by the use of Hamburg wheel-tracking device.
3. Cost Comparison of Hot Mix Asphalt mixture containing RAP with control Mix.

1.3 SCOPE OF THESIS

To accomplish set objectives above, a comprehensive research plan was organized and the following research tasks were outlined:

- Literature review of the previous research finding on the rutting susceptibility and moisture damage of laboratory fabricated HMA mixtures containing recycled asphalt pavement, the test procedures for rutting susceptibility, moisture damage and interpretation of results.

- Preparation of specimens of HMA mixtures (Controlled and uncontrolled) containing RAP material in laboratory at optimum asphalt content using Superpave Gyratory Compaction method.
- Performing of Wheel tracker test to determine rutting susceptibility and moisture damage of control and uncontrolled HMA mixtures according to AASHTO T-324-04.
- Analysis of experimental data obtained from performance testing using software.

1.4 ORGANIZATION OF THESIS

This study is systematized into five chapters as shown in Figure 1.1. The details of different chapters are as under

Chapter 1 includes a brief introduction to rutting susceptibility, moisture damage and recycled asphalt pavement, their importance in the flexible pavement design, objectives and the scope of the research.

Chapter 2 includes a literature review on outcomes of the preceding studies associated to rutting susceptibility, moisture damage and recycled asphalt pavement.

Chapter 3 explains the collection of materials used for this study, the asphalt mix preparation procedures, rutting susceptibility and moisture damage test procedures using Hamburg Wheel Tracker.

Chapter 4 presents the test results and their analysis

Chapter 5 is concerned with the conclusion and future recommendations.

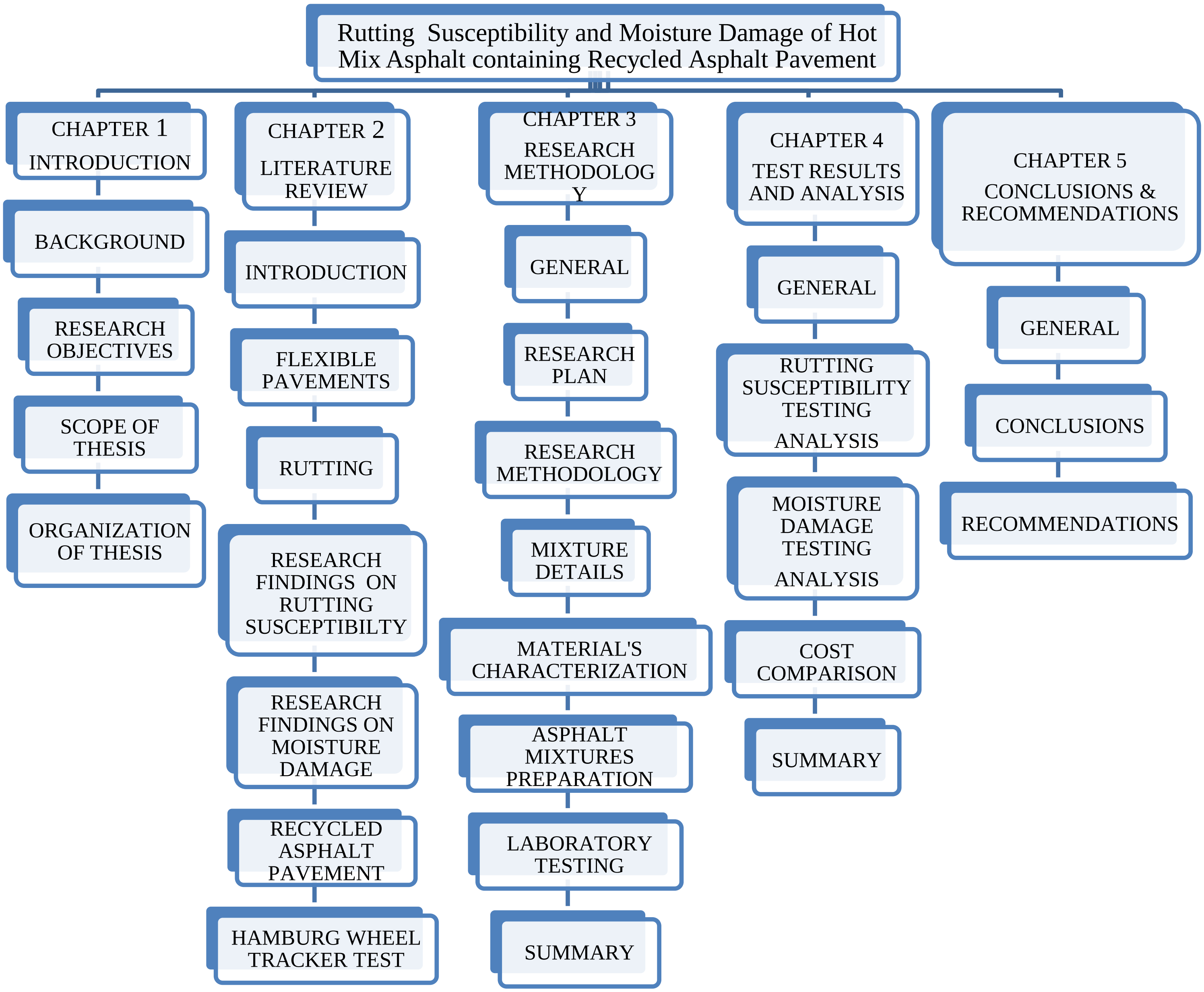


Figure 1.1: Organization of Research Thesis

Chapter 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter contains a brief review of the literature and theory related to the response of hot mix asphalt mixes (HMA) containing Recycled asphalt pavement to the Hamburg wheel tracker tests (for Rutting) and (moisture damage). This chapter deals with hot mix asphalt rutting, types of rutting, recycled asphalt pavement its impact on different performance properties and researches carried out previously to predict HMA rutting and moisture damage using wheel tracker test. The detail of Hamburg Wheel tracker tests on HMA mixtures is also explained.

2.2 FLEXIBLE PAVEMENTS

Flexible pavement yields elastically to traffic loading. It is constructed with asphalt treated surface or a relatively thin surface of hot mix asphalt over one or more unbound base courses resting on a sub grade. Pavement strength is derived from the load distributing characteristics of a layered system designed to protect each underlying layer including the sub grade from compressive shear failure. Better materials are used in the upper structure to increase resistance near surface because of stress conditions caused by traffic wheel loads. These materials include an all weather surface that is resistant to erosion by the environment and traffic action. The bituminous surface layer must also be resistant to fatigue damage and stable under traffic loads and in higher pavement temperatures. The flexible pavements structures should be designed in such a way that it has a good performance and must serve against many functions including load carrying capacity, skid resistance, riding comfort, safety, surface and subsurface drainage throughout its design life (Pavement design guide, 2011).

Pavement layer stimulates different kind of stresses in all the layers on application of traffic loading on the top. These stresses decrease from top layer to bottom layer. Therefore, for an economical design of pavements, material of good quality and higher strength is always placed on the top of the pavement structure to carry the stresses of high magnitude while the material of low strength and inferior quality is always placed at the bottom, due to which the stress or load distributions gets wider and eventually the stress magnitude becomes low. Flexible pavement structure normally consists of the following layers Surface course or wearing surface, Base course, Sub base course and Compacted or treated Sub grade / Natural Sub grade.

Figure 2.1: Pavement Structural Layers

Asphalt concrete consists of asphalt binder, aggregates and air voids. The properties of asphalt concrete depend on the quality of its components, the construction process, and the mix design proportions. In service, asphalt concrete must provide a stable, safe, and durable road surface. Stability of the asphalt concrete depends on strength and flexibility of the mixture and the degree of compaction during placing. The strength must be sufficient to carry the load without shear deformation occurring between particles. Rutting, which is a dominant mode of failure in asphalt pavements, occurs as a result of the accumulation of permanent deformation in pavement layers. Several factors related to the characteristics of the component materials of an asphalt mixture are known to affect the resistance to rutting to a varying degree. In order to be able to produce asphalt mixtures that have adequate resistance to rutting, it is necessary to know the properties of the component materials that influence the resistance to rutting of the mixture. By carefully choosing the types and proportions of component materials that have desirable properties with regard to rutting, it might be possible to minimize rutting in flexible pavements. The effect of the properties of each of the components of asphalt mixture, i.e., binder and aggregates, and their proportions (air void content and binder content) on permanent deformation properties will be reviewed in this chapter after brief discussion on volumetric of asphalt concrete mixtures (Garba, 2002).

2.2.1 Flexible Pavement Analysis and Design Method

The flexible pavements have methods for analysis and design and these methods can broadly be classified into three basic categories which are:

- **Empirical Method**

  This pavement design method is based upon the results derived from experience and experimentation. This design of flexible pavement can be performed with or without soil strength tests. The disadvantage of this method for design is that it can be applied only to the given set of materials, environmental conditions and loading. When above mentioned conditions are changed, the design no longer remains valid and new method must be developed (Huang, 2003).

- **Empirical-Mechanistic Method**

  This method of pavement design is founded upon the mechanics of materials which corresponds input, such as wheel load to the pavement response such as stress and strain (Huang, 2003). In flexible pavement design, the prominent responses are the deflections, stresses and strains inside a pavement structure while the physical reasons are the material properties and the loads of the pavement structure. The relevance amongst all these phenomenon and physical causes, that stand associated to the pavements, are usually described using some mathematical models.

- **Mechanistic Method**

  On assumed mechanism of pavement traffic interaction, mechanistic models are built to calculate the pavement responses i.e. stress, strain and deflection due to traffic loading and environmental changes (Zhao and Arkansas, 2007).

2.3 RUTTING

Rutting is the significant distress mechanisms in asphalt pavements in the form of permanent deformation. Rutting has become the major mode of flexible pavement failure because of increase in truck pressure in last decades. Rutting is principally caused by the accumulation of permanent deformation in different layers in different portion of layers in the pavement structure. Studded tires usage on pavements can also caused rutting. Longitudinal irregularity in the magnitude of rutting causes roughness. Rutting results in a reduced skid resistance increased potential for hydroplaning and spray that reduces visibility because of water trapped. Development of rutting can lead to cracking and eventually to complete disintegration or we can say failure. Highways and secondary roads accounts for a significant portion of maintenance and associated costs.

The average gross weight of trucks has increased and is operating close to legal axle loads limits. Those countries where enforcement of the legal axle load limits is relaxed trucks operate at axle loads, which exceed the legal axle load limit. Due to increase in axle loads and the use of higher tire pressures the contact area between the tire and the pavement results in high stress which contributes to greater deformation in flexible pavements as severe wheel track rutting. The permanent deformation in the asphalt surface layer thus accounts for a major portion of rutting on flexible pavements subjected to heavy axle loads and high tire pressures. Rutting is a longitudinal surface depression in the wheel path direction accompanied by pavement disturbance along the sides of the rut. Major structural failure and hydroplaning can be caused by rutting which is a safety hazard. Rutting can occur in all layers of the pavement structure and results from lateral side distortion and densification. Moreover, rutting represents a nonstop accumulation of small permanent deformations from each load application (Garba, 2002).

Eisemann and Hilmar using wheel tracker device studied phenomenon of asphalt pavement deformation measured the average rut depth and the volume of displaced materials below the tires and in the upheaval zones adjacent to them. They concluded that in the initial stages of traffic loading the increase of irreversible deformation below the tires is noticeably greater than the increase in the upheaval zones. Hence, in the initial phase, traffic compaction is the primary mechanism of rut development. After the initial stage, volume increase in the adjacent upheaval zones is almost equal to the volume decrease below the tires. This indicates that compaction under traffic loading is completed and further rutting is caused essentially by shear deformation, i.e., distortion without volume change. This shows that primary mechanism of rutting for the greater part of lifetime of the pavement is shear deformation (Eisenmann and Hilmar, 1987).

2.3.1 Types of Rutting

In flexible pavements rutting is caused by an asphalt mixture that cannot resist the repeated heavy loads to which that pavement is subjected due to low in shear strength. Rutting from weak asphalt mixture is because of high temperature which mostly occurs in summer when high pavement temperatures are obvious. it most often occurs during the summer when high pavement temperatures are evident. Figure 2.2 illustrates rutting caused by weak asphalt mixture.

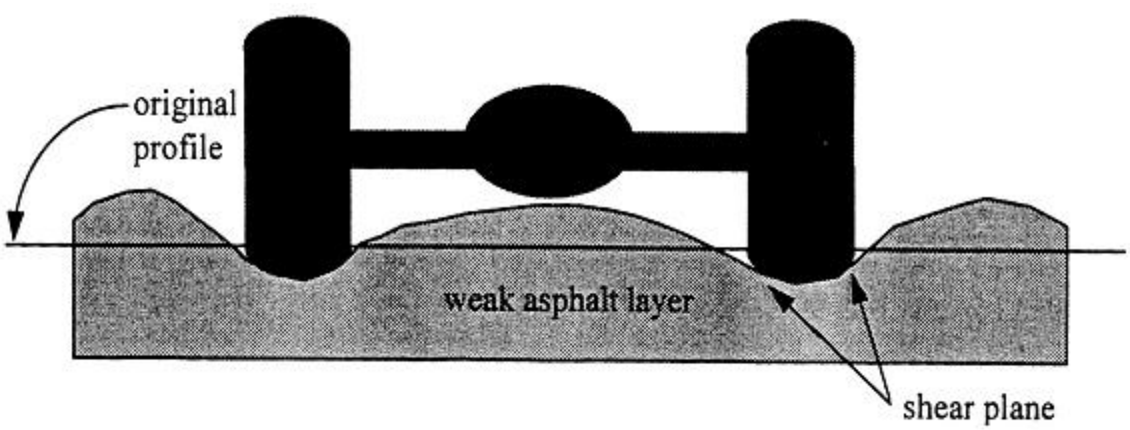


Figure 2.2: Rutting caused by weak asphalt layer

As discussed that the rutting in asphalt concrete consists of densification and shear deformation. With no change in volume shear deformation occurs, i.e., it is distortional. Asphalt concrete may also expand or increase in volume under load. Deformation involving expansion in some literatures is also referred to as shear flow or plastic flow. Such deformation can lead to segregation or disbonding at the binder aggregate interface and deterioration of the pavement. Rutting in asphalt layers is illustrated in Figure 2.3. Thus when mixture are evaluated for their rutting resistance, it is necessary to pay more attention to their shearing and dilatant behaviour in which viscosity increases with the rate of shear strain.

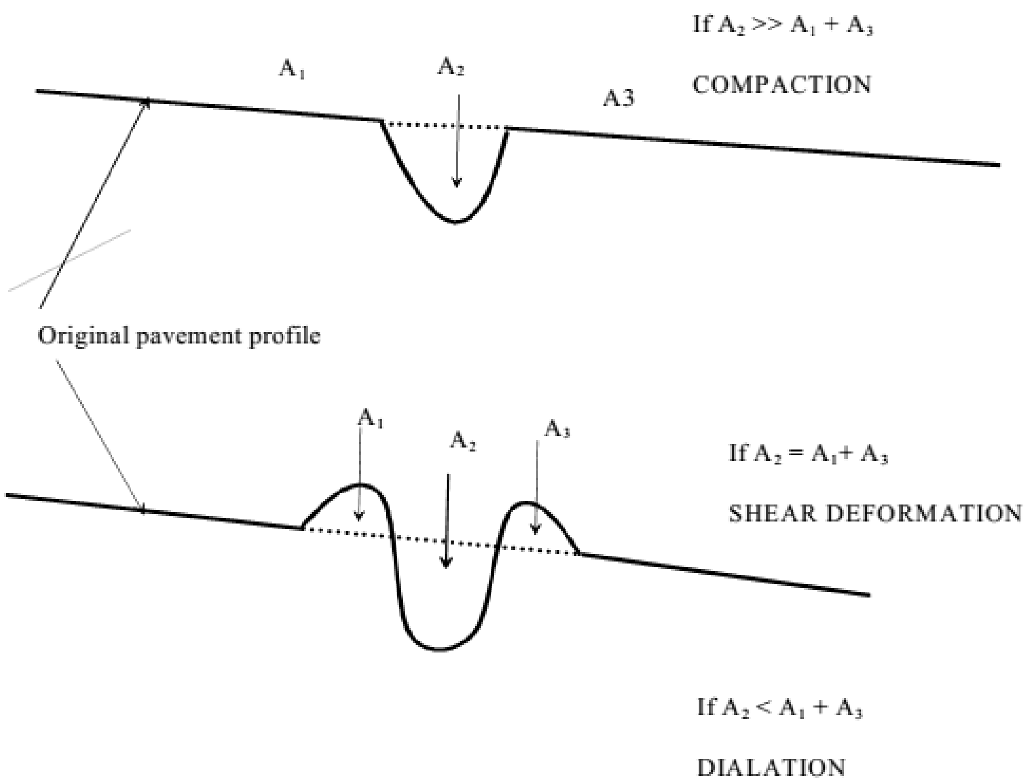


Figure 2.3: Illustration of the rutting mechanism

Another type of rutting can be caused below the asphalt layer to base, subabase or subgrade layer by too much repeated load applied. In various cases due to insufficient depth of cover on the subgrade resulting from too thin an asphalt layer to decrease the stress from applied loads to tolerable level. This type of rutting is often referred to as structural rutting because it is more of a structural problem than a materials problem. Weakening of the subgrade can also be the cause of entering of moisture can also be the cause for weakening of the subgrade. In this type of rutting, the accumulated permanent deformation occurs in the subgrade. Figure 2.4 illustrates rutting from weak subgrade.

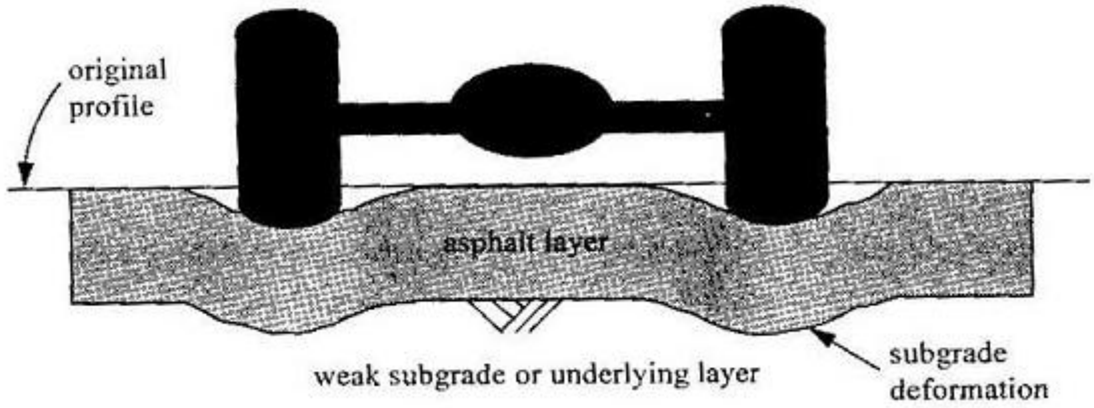


Figure 2.4: Rutting from weak subgrade

2.3.2 Factors Affecting Rutting of Asphalt Mixtures

Permanent deformation in flexible pavements usually depends on several factors which are hot mix asphalt properties which in precise include type of binder its properties, class of gradation, types of aggregates and finally the extent of applied compaction effort. Furthermore factors related to loading pattern includes vehicle types, tire types and their pressure, vehicle speeds and axle load, environmental factors such as climatic conditions and pavement temperature also affect the type and intensity of rutting. Layer thicknesses, material properties of base, sub base layers and bearing capacity of sub grade also play a vital role.

It is therefore essential that quality of material used in pavement layers should be well designed because if the material properties are not properly addressed, it is impossible to reduce rutting susceptibility. To be able to design a mixture that has adequate resistance to rutting, knowledge of the effect of mixture composition and properties of the component materials is of supreme importance (Garba, 2002). For this purpose no matter how much layer thickness is provided and quality controlled construction is carried out it is impossible to reduce rutting. As already discussed that proper structural design of pavement layers, the material properties of individual layers and construction quality control are equally important for a good and satisfactory performance of flexible pavements to minimize the permanent deformation (Miljković and Radenberg, 2011).

2.4 RESEARCH FINDINGS ON ASPHALT MIX DESIGN INCLUDING RECLAIMED ASPHALT PAVEMENT

RAP has been effectively used in HMA since the mid 1970s. Use of RAP in the past has proved to be economical, environmentally sound and effective in increasing the rutting resistance of asphalt mixtures. Advances in HMA plants and processing equipment make it possible to consider mixtures with RAP contents of 50% or more. Experience has shown that, when properly designed and constructed, HMA mixtures with RAP has performed same as the mixtures produced from all new materials.

In view of potential benefits and effects of RAP, researchers studied on various performance measures which include cracking and rutting of mixtures with RAP. Studies reveal that it is not only traffic loading that leads to pavement failing but also the aging of the asphalt binder. When pavement is removed from field, RAP materials during stockpiling may age even more because of exposure to air. Furthermore, when RAP is added to HMA, the aged binder present in RAP mixes to some unknown extends with the virgin binder. Those results in a composite effective binder system with properties that are unknown and hence unpredictable pavement performance achieved. Several studies on RAP have shown that addition of RAP in HMA changes the physical behavior of the mix. RAP binder's increased stiffness is believed to be the cause of increased modulus of HMA. In the same way it also affects the mixture's fatigue behavior and low temperature cracking (Al-Qadi *et al*., 2012).

Purpose of designing hot mix asphalt containing RAP is to optimize the RAP content and achieve a mix with good performance in fatigue, rutting, thermal resistance, and overall durability in addition to stability and compactability requirements. Further, there is the need to meet required volumetric properties including air voids, VMA (Voids in Mineral Aggregates) in final mix (Al-Qadi et al, 2012).

RAP usage in HMA mixtures resulted in a savings of between 18 and 25% in the required virgin asphalt. A clear increase in mixture stiffness with RAP content of 15% was observed. Decrease in 20% asphalt pavement analyzer rut depth was observed when RAP was used. Small change was experienced in tensile strengths because of the addition of RAP fraction. There was a significant increase at intermediate to warm temperatures in mixture stiffness. Low temperature cracking potential is increased by the use of RAP (Gardiner and Wagner, 1999).

European countries have already started using warm mix asphalt (WMA) for many years. Reduction in mixing temperature has raised several concerns about WMA. Moisture damage is one of the primary concerns in asphalt pavement. Moisture absorbed by the aggregate and part of the moisture entrapped in pavement during compaction due to lower mixing temperature, this may not be high enough to vaporize all the moisture. To evaluate the moisture susceptibility of warm mix asphalt laboratory studies were carried out and along with different RAP percentages were used in mixes. To evaluate asphalt mixture Hamburg wheel tracking tests were utilized. Moisture tests results indicated that specimens exhibited lower rut depths with the higher percentages of RAP. The higher percentages of RAP in WMA and HMA in both mixtures showed a reduction to moisture susceptibility (Shurum, 2010).

Since 1980 state of Illinois has been using Reclaimed Asphalt Pavement (RAP) material into hot-mix asphalt (HMA) but questions regarding the correct approach to design HMA with RAP are still there. The Illinois Department of Transportation's provides 100% contribution for the residual asphalt binder from the RAP through solvent extraction process by which virgin asphalt binder is converted into asphalt binder in the RAP for specified percentage. This is usually not reported accurate and can cause dry HMA. Hence durability cracking and premature failure can be resulted. The purpose of this research is to find out the difference between virgin and aged asphalt binder in RAP, which reveals that aged and virgin asphalt binder in RAP will help to understand influence on the performance and durability of the mixture. So based on this research it determines the suitable level of contribution that should be given to the residual asphalt binder in RAP, this interaction will be used to investigate the influence on the performance and the durability of the mixtures as compared to virgin HMA (Al-Qadi et al, 2007).

Recycling of asphalt pavement material can result in reduction of cost but concerns are there about the HMA containing RAP, especially in asphalt pavements major load carrying and surface layers. One of the major concerns is of durability and long term fatigue resistance of HMA mixtures containing RAP materials. HMA mixtures containing RAP, the long term aged asphalt cement in Rap is partially blended into new asphalt binder. That result in stiffer asphalt cement which is not prone to rutting. The concern is about mixture resistance to cracking. A typical surface mixture that mostly used in the state of Tennessee was evaluated at 0, 10, 20 and 30% RAP contents. Laboratory studies were carried out on hot mix asphalt (HMA) mixtures containing No. 4 sieve screened reclaimed asphalt pavement for performance testing on cracking resistance. Super pave indirect tension (IDT), beam fatigue and semicircular bending (SCB) tests were conducted to evaluate mixture cracking resistance. Results of above tests indicated that the due to RAP increased in stiffness and indirect tensile strength were observed, mixture cracking resistance was compromised which were under studies. 10% and 20% RAP have no significant effect on properties as compared to 30% RAP (Huang *et al*., 2011).

2.5 LABORATORY EVALUATION AND PERFORMANCE TESTING OF RAP MIXTURES

Recycled asphalt pavement (RAP) mixes performance depends upon their design if they are designed well they can even give better or similar performance than virgin mixes. RAP mixes combined with HMA mixes, if well designed balancing rutting susceptibility, moisture damage and cracking requirement can perform well. Many factors such as traffic in terms of axle loading, environmental conditions, existing pavement conditions for asphalt overlays, pavement structural condition and thickness of layers these factor influence the cracking performance of recycled asphalt pavement.

A study was conducted to establish relationship between Overlay Test cycles and fracture properties, because requirement of single cracking does not apply to all asphalt overlay applications. For this purpose project specific service condition based mix design system should be developed. Balanced mix design procedure and performance evaluation system in which Hamburg wheel tracking test and criteria associated for performance evaluation are used to control rutting susceptibility and moisture damage.

Furthermore investigation on the impact of soft binder on engineering properties of recycled asphalt pavement in terms of dynamic modulus, Hamburg Wheel tracker rutting test and OT cycles. Test results clearly showed that the use of soft as well as modified binder can significantly improve cracking resistance of RAP mixes without much increase in rutting susceptibility and moisture damage (Sondag *et al*., 2002).

2.6 ASPHALT MIXTURE HAMBERG WHEEL TRACKER TEST

2.6.1 Rutting Susceptibility

In Hot Mix Asphalt (HMA) pavements rutting is identified as major cause of distress by Strategic Highway Research Program (SHRP). Permanent deformation in hot mix asphalt pavements results in a loss of serviceability of HMA pavement which can create safety concerns as well. Rutting susceptibility of asphalt pavements is mostly dependent on binder and aggregate characteristics.

2.6.2 Research Findings on rutting behavior of HMA

HMA mixtures having a strong interlocking aggregate structure combined with suitable stiffer binder can significantly reduce pavements rutting susceptibility. Studies have shown that large aggregates with stiffer binder are more resistant than mixes containing fine aggregates and higher binder contents. With increasing number of load applications it gradually develops rutting in HMA roads (Kandhal *et al*., 2001).

Researches shown that proper aggregate gradations are sutible to minimize the effect of rutting in aphalt concrete layers. Mixture with a dense and continuos aggregate gradation has less voids and have more contact points between aggregates than open or gap graded mixtures when properly compacted. Angular aggragtes mixtures are more likely to be stable than mixtures made from rounded aggregates and also lower viscosity asphalt make the mixture less stiff therefore more susceptible to rutting. Studies result shows that binder content influences the mixtures ability to resist the permanenet deformation, increase in binder content increases rutting potential (Sousa *et al*., 1991).

Premature rutting chances are more if in place air voids contents are less than 3%. So value of 3% or slightly more than this is needed to decrease the possibility of premature rutting. HMA mixtures must be having air void content of above 3% and high compactive effort is required to assure that the air voids in mix must stay above 3% later on. Rutting can also be stopped if proper angular coarse and fine aggregates are used (Brown and Cross 1992).

Permanent deformation in asphalt pavement is studied using wheel tracking device. Average rut depth as well as the volume of material displaced is measured. They concluded that in initial phase due to traffic compaction or we can say densification is primary mechanisms of rut development. The volume decreases below the tires is approximately equal to the volume increase in the adjacent upheaval zones after the initial stage. The most compaction under traffic is completed and further rutting is caused essentially by shear deformation. Thus shear deformation is considered to be the primary mechanism of rutting for the greater part of the lifetime of the pavement (Eisemann and Hilmar 1987).

2.6.3 Wheel Tracker Device for Rutting Propensity

Laboratory test methods have been developed to determine the rutting behavior in HMA pavements. Most of the methods have been in use for many years, while others are still in stage of development. Over the last thirty years Hamburg Wheel Tracker Device (HMTD) has been in use to evaluate the performance of flexible pavements (Aschenbrener and Currier, 1993). This machine is used to evaluate the design mixes for their performance under serve load and environmental conditions.

Samples are subjected to repeated loading by moving wheel in order to estimate the permanent deformation characteristics of the pavement. Relationship between mixture properties and rutting potential could provide good information to pavements designers in choosing optimum mixture properties. Some highway agencies have some concerns using the HWTD as a performance testing of rut due to its lack of repeatability in its results. The problem is the lack of consistency in the procedures used for preparation of the samples. Standard procedure for testing is there but consistency cannot be maintained for preparing the specimens. The testing procedures are being addressed in AASHTO T324. Standard Method of Test for Hamburg Wheel Track Testing of Compacted Hot Mix Asphalt (HMA) addresses, but it does not address the preparation of the specimen.

2.6.2 Wheel Tracker Device for Moisture Damage

From past many years effect of moisture on physical properties and mechanical behavior of asphalt paving mixtures has been known. Many empirical, semi empirical test methods such as Boiling water Test and different devices such as Wheel Tracking Device have been developed to predict moisture damage on asphalt mixtures. The purpose of these test methods is to simulate the damage done by moisture in field (Hunter and Ksaibati, 2002). Moisture susceptibility in HMA mixtures is cause of stripping. To overcome this moisture susceptibility issue proper asphalt pavement design is needed. However proper compaction also play role to combat moisture susceptibility if not done pavement may susceptible to moisture damage. Therefore testing of HMA design should be done on those conditions where moisture does infiltrate in air voids of the mixtures (Roberts et al. 1996).

Hamburg Wheel Tacking Device was developed in Germany to predict rutting potential of HMA, since then this device is being in by U.S departments to check the rutting potential of HMA (Mogawer and Stuart, 1995). Texas Department of Transportation (TxDOT) Construction Division indicated that this device can be used to predict the moisture damage susceptibility of HMA. Testing and observations shows that mixture containing soft limestone undergoes severe abrasion and aggregate segregation when tested in the Hamburg wheel tracking device.

Wheel tracker history is described by cooley that in city of Hamburg Germany, based on similar British device that had ribber tire, in 1970s Hamburg Wheel-Tracking was developed. Helmut wind incorporated of Hamburg finalized the test method and developed the specification that are required to measure the rutting and stripping susceptibility.The HWTD measures the combined effect of rutting susceptibility and moisture damage in terms of stripping, steel wheel of HTWD moves across the surface of asphalt concrete specimen that is immersed in hot water that generally is 40 ºC to 50 ºC but this can vary from 25 ºC to 70 ºC. This criterion is used for pass or fail of rutting and moisture susceptibilities (Cooley, 2000).

HWTD wheel load consists of 158lb (705N) force and average contact stress is nearly 0.73Mpa with contact area around 38 in. (970mm^2). This contact pressure simulates the effect produced by the rear tire of a double-axle truck on pavements. The contact area of wheel increases with rut depth, and thus the contact stress is variable (Yetkin et al. 2007).

A regression model is developed to investigate the effect on rut depth due to aggregate size determines the relative importance of each independent variable, resultant rut value of the asphalt mixtures under the cycling loading. Independent variables were interacted individually and then variables in groups to investigate the rut depth relationship measured from the HWTD. Entire data analysis was run using Microsoft Excel Solver tool and least square regression and linear regression coefficients were obtained. Model was statistically evaluated on the basis of goodness of fit i.e. coefficient of determination R^2, standard error of estimate and relative accuracy (Rahman and Hossain, 2014).

2.6.2.1 Stripping

Loss of the integrity of HMA mix through weakening of adhesive bonding between aggregate and asphalt cement is known as stripping. HMA loss in strength can be sudden because of weakening in bond. Stripping generally begins in bottom of HMA layer, and then moves upward. Gradual loss of strength over a period of years causes rutting and shoving to develop in the wheel path. Identification of stripping is sometimes difficult because surface indicators may take years, surface indicators include rutting, shoving, corrugations, raveling and cracking (Izzo and Tahmoressi, 1998).

Identification of stripping can be done by looking at the cross section of HMA mix. Some cases have arisen in which it is difficult to remove core in one piece due to lost in so much adhesion between aggregate and asphalt. Many causes of stripping are possible, inadequate drainage or subsurface drainage is primary contributor for that. Moisture can enter the HMA pavement layers through capillary action from the water table, run off from the road surface and sometimes seepage from the surrounding areas are few cases. If suitable drainage is not given air voids in

HMA may become saturated with moisture increases the internal pressure and weakens the aggregate and asphalt bond (Kennedy, McGennis, and Roberts 1983).

2.7 SUMMARY

This chapter includes brief introduction on hot mix asphalt pavement design methods and analysis. Furthermore it includes the role of binder, aggregate and aggregate gradation in behavior of HMA. Over view on rut distress in flexible pavement, its types and factors affecting the pavements. Review of researches carried out on asphalt mix design including reclaimed asphalt pavement, Laboratory evaluation of recycled asphalt pavements mixtures and their performance testing. Studies carried on Hamburg wheel tracker device and calculation of rutting susceptibility and moisture damage using HWTD. Brief discussion on stripping that is a serious and costly problem for many DOTs. Over the years many testing procedures have been developed to predict moisture susceptibility of an HMA mixture.

RESEARCH MEDOTHOLOGY AND TESTING

3.1 GENERAL

This chapter enlightens the research methodology adopted to achieve the study objectives, which includes acquisition of materials, specimen preparation, testing and analyzing the significance of various factors. The Superpave mix design procedure for the determination of optimum asphalt content was used and will be discussed in detail in this chapter. After the determination of optimum asphalt content the specimens for Hamburg Wheel Tracker test were prepared. This study was carried out on different RAP prepared asphalt concrete specimens and control asphalt concrete specimen for comparison using Marshall Mix design procedure. These laboratory prepared specimens contained NHA-B wearing course gradation and RAP gradation detail of this is presented in this chapter. The equipment used for testing, the procedure for fabrication of test specimens and laboratory tests, that were to be conducted on prepared specimens, along with input parameters to be used during those tests will be discussed in this chapter.

3.2 RESEARCH PLAN

To access the rutting susceptibility and moisture damage of hot mix asphalt containing recycled asphalt pavement, RAP percentage and control sample were selected. Research plan included following points:

- Literature review that provided the guidelines for this research already discussed in Chapter 2
- Laboratory investigation that includes Rutting Susceptibility and Moisture damage testing
- Analysis of results
- Conclusions
- Recommendations

3.3 RESEARCH METHODOLOGY

To achieve the objectives, RAP percentage and control sample were selected. RAP material collected from Islamabad-Lahore Motorway was brought to laboratory of National Institute of Transportation (NIT), NUST for testing and then for analysis of results (results were obtained from Hamburg Wheel Tracker Tests) and specimens were prepared in laboratory under controlled conditions for wearing course mixtures. These specimens were prepared after finding out optimum contents in the laboratory. Specimens were tested for rutting susceptibility and moisture damage of Asphalt Mixture Performance test. Afterwards, analysis of result was done and later conclusions and recommendations were made that will be described in next chapters. Figure 3.1, explains the test methodology adopted for this study.

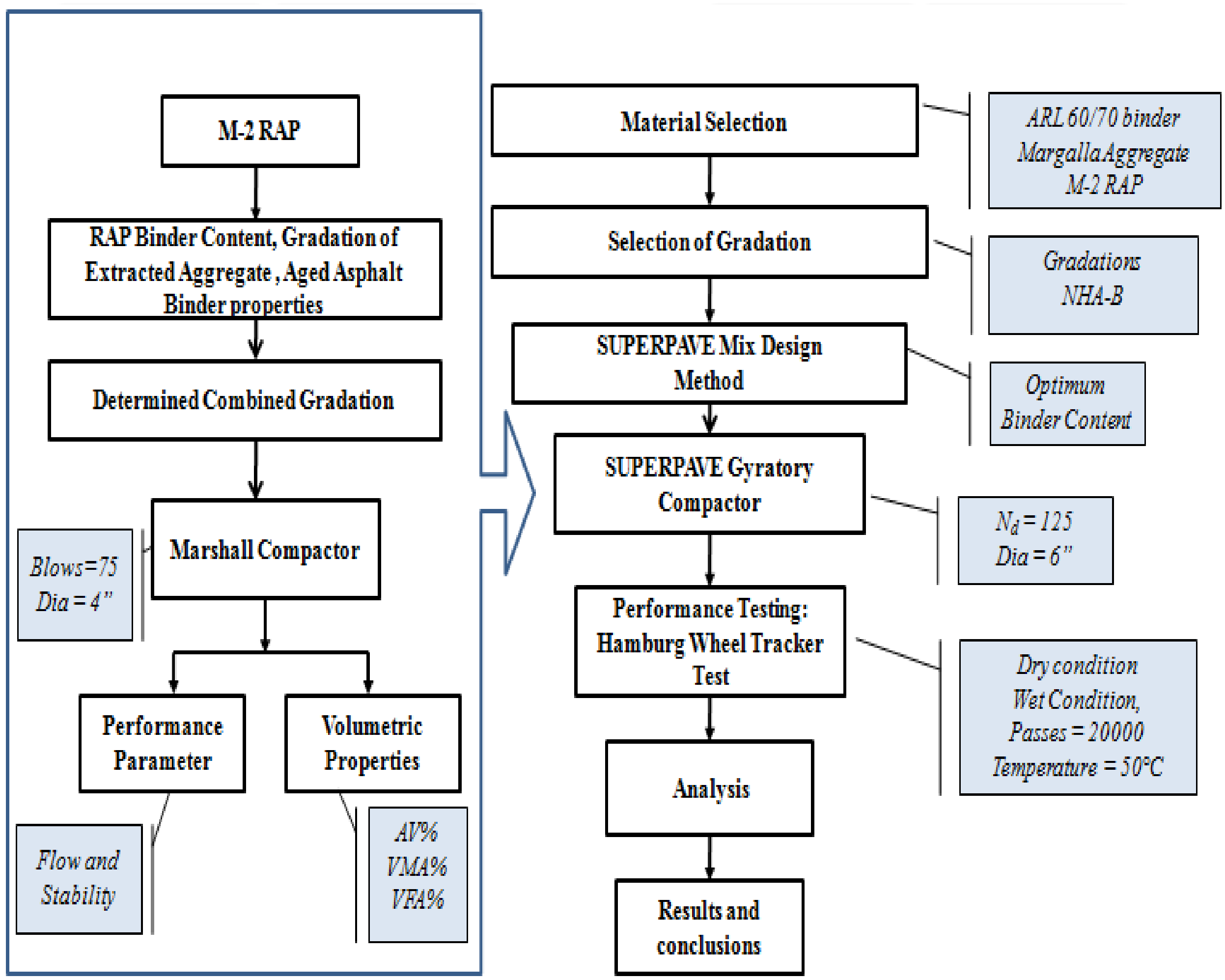


Figure 3.1: Research Methodology

3.4 SELECTION OF MATERIALS AND LABORATORY PREPARED MIXTURES

In this research aggregate i.e., coarse and fine was brought from Margalla quarry and penetration grade of 60/70 bitumen was used, which was collected from Attock Refinery Limited (ARL), Rawalpindi. The reason for selection of grade 60/70 is that it is normally used in practice in Pakistan and is suitable for colder to moderate temperature regions. RAP material was collected from Islamabad-Lahore Motorway in form of milled material. The laboratory-prepared samples were made after calculation of optimum asphalt binder content. Aggregate gradation used in testing was NHA class B according to NHA (1998) specifications for dense graded surface course mixtures. The nominal maximum aggregate size selected for class B wearing coarse gradation was 12.5 mm. The selected gradation is shown in Table 3.1 and Figure 3.2 shows gradation which is plotted with percentage passing verses sieve sizes.

Table 3.1: Class-B Gradation Selected for Testing

S.NO	Sieve Size (Passing mm)	NHA Specification Range (% Passing)	Our Selection	Retained (%)
1	19	100	100	0
2	12.5	75-90	82.5	17.50%
3	9.5	60-80	70	12.50%
4	4.75	40-60	50	20%
5	2.38	20-40	30	20%
6	1.18	5-15.	10	20%
7	0.075	3-8.	5.5	4.50%
8	Pan	-	-	5.50%

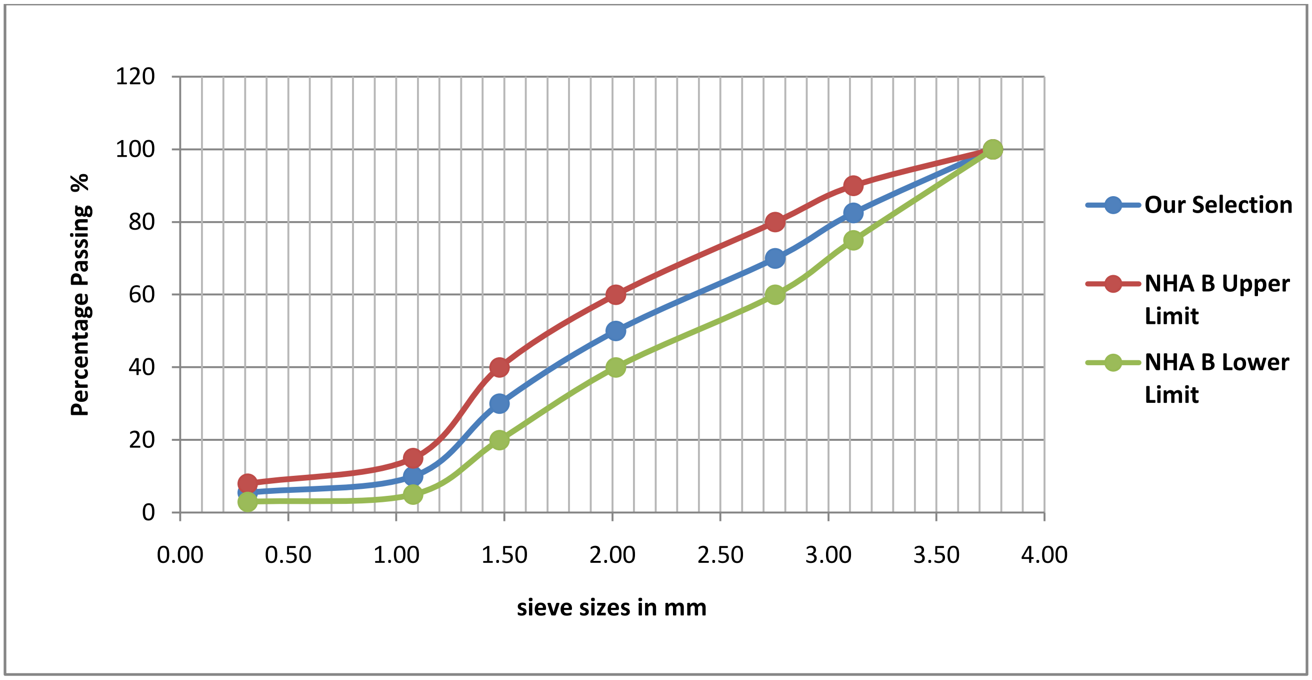


Figure 3.2: Class-B Gradation plot with NHA Specified limit

3.4.1 Gradation for varying proportions of RAP

As the objective of this research was to investigate the effect of proportion of RAP in the mix on rutting susceptibility and moisture damage of hot mix asphalt pavement containing RAP, So for this purpose the amount of Rap was varied by 0%, 10%, 20%, 30%, 45%, 60% and 100% in HMA mix, stability and flow values and volumetric were calculated using Marshall Mix design procedure. Therefore seven different Rap percentages and corresponding aggregate on different sieves were found which are shown by Table 3.2, Table 3.3 and Figure 3.3 shows gradation which is plotted with percentage passing verses sieve sizes.

Table 3.2: Weight of Aggregate as per Gradation

S.NO	Sieve Size (Passing mm)	Percentages of RAP					
		0%		10%		20%	
		Aggregate	RAP	Aggregate	RAP	Aggregate	RAP
1	19	0	0	0	0	0	0
2	12.5	201	0	180.9	20.1	160.8	40.2
3	9.5	143	0	12.7	14.3	114.4	28.6
4	4.75	230	0	207	23	184	46
5	2.38	230	0	207	23	184	46
6	1.18	230	0	207	23	184	46
7	0.075	51	0	45.9	5.1	40.8	10.2
8	Pan	63	0	56.7	6.3	50.4	12.6
Total			0	1033.2	114.8	918.4	229.6
Cross Check		1148		1148		1148	

Table 3.3: Weight of Aggregate as per Gradation

S.NO	Sieve Size (Passing mm)	Percentages of RAP							
		30%		45%		60%		100%	
		Aggregate	RAP	Aggregate	RAP	Aggregate	RAP	Aggregate	RAP
1	19	0	0	0	0	0	0	0	0
2	12.5	140.7	60.3	110.55	90.45	80.4	120.6	0	201
3	9.5	100.1	42.9	78.65	64.35	57.2	85.8	0	143
4	4.75	161	69	126.5	103.5	92	138	0	230
5	2.38	161	69	126.5	103.5	92	138	0	230
6	1.18	161	69	126.5	103.5	92	138	0	230
7	0.075	35.7	15.3	28.05	22.95	20.4	30.6	0	51
8	Pan	44.1	18.9	34.65	28.35	25.4	37.8	0	63
Total		83.6	344.4	631.4	516.6	459.2	688.8	0	1148
Cross Check		1148		1148		1148		1148	

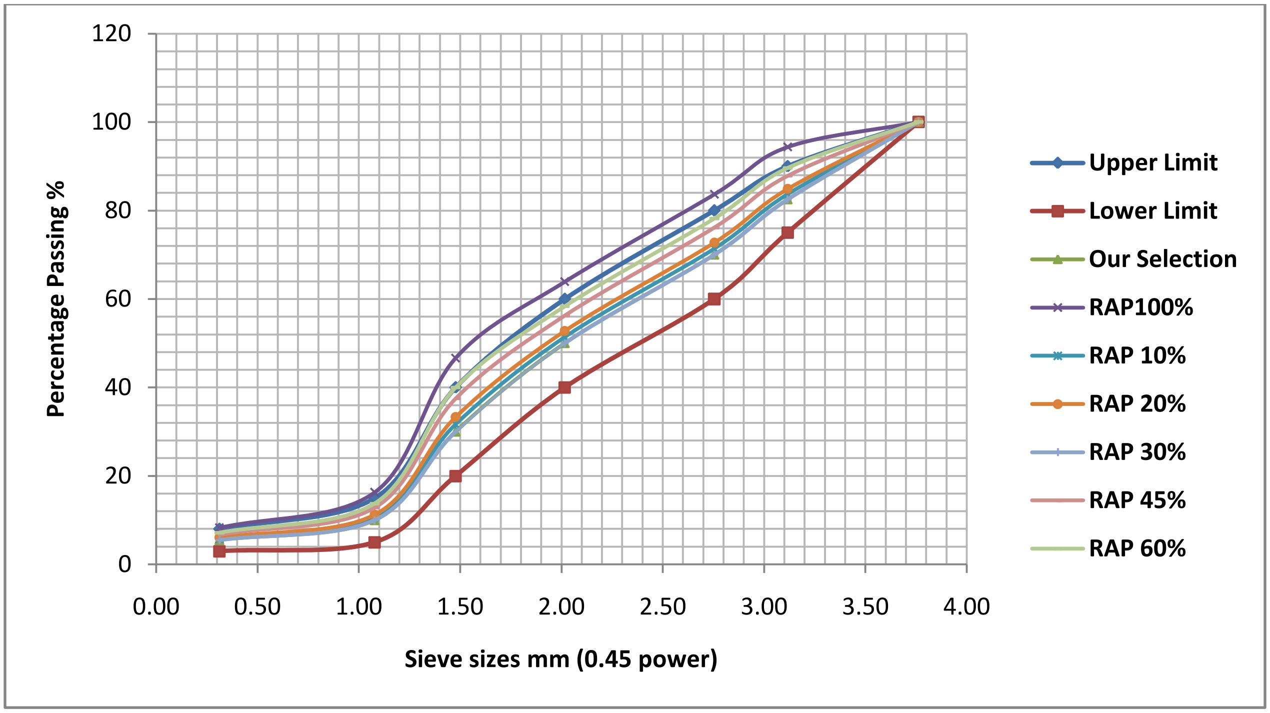


Figure 3.3: Gradation plot of RAP percentages with NHA Specified limit

3.5 LABORATORY CHARACTERIZATION OF MATERIALS

The main portion of the resistance to permanent deformation of the mixture is provided by the aggregate structure makes up about 95% of the mixture and remaining 5% is the asphalt binder. Aggregate is likely to provide a strong stone skeleton to resist repeated load applications. Gradation, shape, and surface texture have a great influence on HMA properties. Angular, rough-textured aggregates provide more shear strength than rounded, smooth-textured aggregates

In the light of ASTM and BS standards and specifications for material characterization, required tests were performed on aggregate and asphalt binder.

3.5.1 Selection of Materials

In this study the aggregates were obtained from Margalla quarry. Aggregates consist of coarse aggregates; fine aggregates and filler material and it was obtained in form of three stockpiles i.e. 0-5, 5-10 and 10-20 mm. The bitumen source used in sample preparation was Attock Refinery Limited (ARL) having pen grade 60/70 that is suitable for colder to modest temperature regions and is mostly used in Pakistan for road construction and Rap in milled form is brought from Lahore Islamabad Motorway (M-2).

3.5.2 Aggregate Testing

The main portion of the resistance to permanent deformation of the mixture is provided by the aggregate skeleton. They are anticipated to offer a well-built stone skeleton to resist repetitive loads. To find out the fundamental aggregate properties such as specific gravity and gradation detailed laboratory assessment procedures of individual stockpiles were performed. Tests performed in the laboratory include:

1. Shape Test

2. Specific Gravity and Water Absorption Test

All of above tests were performed using three samples and then average is taken which were used in further process.

Shape Test Results: Particle shape has a significant role to participate in workability, strength of the asphalt mix. It also influences the compactive effort crucial to gain the required density. Therefore the quantity of flat and elongated aggregate particles was determined using Shape test. Flakiness of aggregate particles is classified as flaky, when they have smaller dimension of less than 0.6 of their mean sieve size, whereas elongated a when they have a length of more than 1.8 of their mean sieve size (ASTM D4791) shown in Table 3.4.

Aggregate Specific Gravity: Weight volume characteristics of aggregate material are represented by its specific gravity. Coarse and fine aggregate specific gravities were determined independently. According to definition coarse aggregate is the aggregate that are retained on the No. 4 sieve whereas those passing No. sieve are fine aggregates.

- Coarse Aggregate Specific Gravity

Three types of specific gravities were determined: saturated surface dry (SSD), bulk and specific gravity by applying the specific gravity test on coarse aggregate. Specific gravity and water absorption were calculated using the equipment and procedures mentioned in ASTM C 127. The test is performed for both of the coarse graded stock piles i.e. 10-20 mm and 5-10 mm and results shown in Table 3.4.

- Fine aggregate specific gravity

Specific gravity test was performed on fine aggregate to find out the value of bulk, SSD and apparent specific gravities. ASTM C128 was adopted for determining the specific gravity and water absorption for fine aggregate result shown in Table 3.4.

3.5.3 Asphalt Binder Testing

According to Asphalt Institute MS-4 manual three properties of asphalt are important for engineering and construction purposes, i.e. consistency, purity and safety. Change in temperature also affects the consistency of asphalt cement binder. Therefore, in order to compare the consistency of one asphalt binder to another the use of standard temperature is necessary. Viscosity test or a penetration test commonly used to find out the consistency of bitumen binder (Asphalt Institute MS-4, 2003). Additional information and confidence toward consistency is provided some other tests like ductility and softening point. So following tests were performed in laboratory to characterize the asphalt binder.

1. Bitumen Penetration Test

2. Bitumen Softening Point Test

3. Bitumen Ductility Test

Penetration Test: Penetration test determines the penetration of asphaltic materials. The method includes needles and containers having specimen. Higher values of penetration indicate softer binder. According to AASHTO T 49-03 temperature, load, and time for the test are 25°C, 100 g, and 5s, respectively until unless the conditions are not specifically mentioned. Penetration tests were conducted by using two specimens of ARL 60/70 and taken five values from each specimen. All penetration values satisfied the necessary criteria of penetration test as per specifications. Penetration test result is presented in Table 3.5.

Softening Point Test: Bitumen is visco-elastic material as the temperature incraese it gradually becomes softer and less viscous. Softening point is the temperature at which a bitumen standard size sample cannot uphold the weight of 3.5 gm steel ball. Softening point of bitumen is the average temperature at which the two disks of bitumen soften enough to let the balls to fall a distance of 25 mm. Ring and ball apparatus were used to determine the softening point of asphalt as per AASHTO T 53 specifications. Table 3.5 shows the outcome of softening point test.

Ductility Test: Ductility is a substantial property of bitumen which is considered an important factor in case of performance of HMA mix. It is a sign of behavior of bitumen under various temperatures. By definition it can be explained as the “distance to which it will lengthen prior to breaking when two ends of specimen of the material, are pulled away from each other at a particular speed i.e. 5 cm/min and at a particular temperature of 25 ± 0.5 °C (AASHTO T 51-00). Standard specifications and lab results for ductility tests for asphalt binder is shown in Table 3.5. All samples had seen fulfilling the minimum criteria of ductility as 100cm.

So for the preparation of HMA mixtures, it is necessary to check the suitability of both aggregates and asphalt in the light of ASTM and BS standards and specifications for material characterization. These tests were performed on aggregate of Margalla quarry and mention tests were performed in laboratory to characterize the asphalt binder asphalt ARL 60/70. Table 3.4, Table 3.5 and Table 3.6 show the tests performed on the aggregates, bitumen and extracted bitumen of RAP respectively.

Table 3.4: Laboratory Tests performed on the Aggregate

Test Description	**Specification Reference**		**Results**
Flakiness Index (FI)	ASTM D4791		12.9%
Elongation Index (EI)	ASTM D4791		3.578
Aggregate Absorption	(10-20)mm	ASTM C127	0.73%
	(5-10)mm		2.45%
Loss Angles Abrasion	AASHTO T96 ASTM C131		22%
Impact Value	BS 812		24%
Specific Gravity	Coarse Agg	ASTM C127	2.60
	Fine Agg	ASTM C128	2.57

Table 3.5: Laboratory Tests Performed on the Bitumen

Test Type	Designation	Results
Penetration @ 25°C , (mm)	ASTM D 5	64
Flash Point (°C)	ASTM D 92	232
Fire Point (°C)	ASTM D 92	241
Specific gravity	ASTM D 70	1.03
Ductility (cm)	ASTM D 113	104
Softening Point (°C)	ASTM D36	48.2

Table 3.6: Laboratory Tests Performed on the Extracted Bitumen

RAP (%)	Asphalt Source & Grade	Type of Test	
		Penetration Test (6 0-70) ASTM D5/ AASHTO T49	Ductility Test (≥100 cm) ASTM D113/ AASHTO T51
0	ARL 60/70	63	120
10		59	106
20		56	97
30		48	88
45		41	74
60		28	65
100		20	15

3.6 ASPHALT MIXTURES PREPARATION

As stated earlier, there are two categories of mixtures one is laboratory prepared HMA mixture and other is RAP. The procedure of preparation of laboratory prepared HMA is described in the following headings;

3.6.1 Laboratory-Prepared Asphalt Mixtures

Laboratory prepared mixtures were designed through the determination of optimum asphalt content using Superpave Mix design procedure. Afterwards, samples were compacted to their optimum asphalt content at designed air voids.

***Determination of Optimum Asphalt Content*:** Asphalt Institute's Superpave mix design manual (SP-2) was used for the determination of Optimum Asphalt Content (OAC) for asphalt wearing course mixture, (Conditioning, mixing, compaction and fabrication of samples will be explained in following sections). In this research, a design criterion of heavy traffic or design EASL> 10^6 was adopted. Therefore, to simulate heavy traffic and field condition, 125 no. of gyrations were given to the specimens.

After determining Optimum Asphalt Content (OAC) for laboratory prepared mixture, samples were prepared at that optimum asphalt content for the calculation of actual volumetric properties of the samples. Maximum theoretical specific gravity according to AASHTO T209 and the bulk specific gravity of the compacted mix according to AASHTO T 166 were consulted and the values of these parameters were determined in order to find out optimum asphalt content of laboratory prepared mixtures.

3.6.2 Preparation of Bituminous Mixes for Superpave Mix Design

The bituminous mixes prepared for the determination of optimum asphalt contents were according to the method explained in Asphalt Institute's Superpave mix design manual (SP-2). The volumetric parameters theoretical maximum specific gravity $G_{mm,}$ effective specific gravity $G_{se,}$ Bulk specific gravity G_{mb} and %G_{mm} of prepared specimens were measured, verified in light of Superpave Mix design criterion and finally optimum asphalt contents were determined.

Number of Specimens: As there was only one gradation i.e. NHA class B and one binder so three number of specimens were prepared. A total of 12 specimens were prepared for determining the optimum binder content at four different binder contents (4%, 4.5%, 5%, and

5.5%). The reason four trial blends was the selection of the mix that performs optimal at minimum bitumen content at 4% air voids.

Preparation of Aggregates and Bitumen: After performing sieve analysis aggregates were dried to constant temperature of 105°C to 110°C. The Quantity of aggregate used for preparing the compacted 6 inch diameter each specimen by Superpave mix design method was 6000gms. The amount of bitumen to be added in laboratory designed specimen was determined according to Equation 3.1, which yields a bit higher weight of amount of asphalt than calculating it by direct percentage method.

$$W_{asp} = \frac{Pasp\ \ X\ W_{agg}}{(1-P_{asp}\ )} \qquad (3.1)$$

Where,

W_{asp} = Weight of Asphalt

P_{asp} = Optimum percentage of asphalt

W_{agg} = Weight of aggregate

For wearing course, Equation 3.1 yields weight of asphalt to be 260gms for weight of aggregate being 6000gms and optimum asphalt content of wearing course being 4.15%.

Mixing of Aggregate and Asphalt: Mechanical Mixer for mixing purpose of aggregate and bitumen is recommended by the Asphalt institute's Superpave mix design manual (SP-2) is shown in Figure 3.4. Heated dry aggregates and bitumen were put together into mechanical mixer and mixed thoroughly for 10 to 15 minutes at a temperature ranging from 160°C to 165°C respectively. Mechanical mixer ensures the proper mixing of aggregate and bitumen. This mixing temperature corresponds to the temperature during manufacturing hot mix asphalt mixes in Pakistan as specified by NHA. Asphalt institute's Superpave mix design (SP-2) recommends viscosity range of 0.17±0.02 Pa-s at mixing temperature.

Figure 3.4: Asphalt Mixing Machine

Conditioning of Mixtures: The Superpave mix design manual (SP-2) recommends to place the mix and pan in the conditioning oven for 2 hours ± 5minutes at a temperature equal to the mixture's specified compaction ± 3ºC. Therefore, each bituminous mix obtained from mixer was placed in steel tray and placed in oven for about 2 hours at 135ºC as shown in Figure 3.5 respectively.

Figure 3.5: Loose Mix Placed in Tray for Conditioning

Compaction of Mixes: Superpave Gyratory Compactor (SGC) was used for compaction of prepared mixes at 135 ºC. Gyratory compactor mold was cleaned and placed in oven at 100 ºC for 30 minutes after that compaction of specimen was done. The SGC mold is in cylindrical shape (having 150 mm inside diameter) with a base plate at the bottom to provide confinement during compaction. Once the packed mold is placed in the SGC its base rotates at a constant speed of 30 revolutions per minute during compaction, while the mold is positioned at an angle of 1.25 degrees. A loading system applies a load to the loading ram, which imparts a 600 KPa compaction pressure to the specimen. Filter paper was placed on both sides of mold on top and at bottom in which batch of mix was transferred.

The design criteria of heavy traffic or design ESAL(millions) ≥ 30 was adopted. Therefore, to simulate the effect of heavy traffic the design number of gyrations required was 125 as specified by SP-2 manual. For compaction, the mold was placed in the Superpave gyratory compactor and the required number of gyrations was provided to the specimen. After the required gyrations and compaction was achieved, the mold was removed from compactor and the specimen was extracted from mold by means of mechanical sample extruder. The complete procedure adopted for compaction of specimens is shown through Figure 3.6 to 3.9.

Figure 3.6: Transferring Conditioned Mixture in Preheated Gyratory Mold

Figure 3.7: SUPERPAVE Gyratory Compactor

Figure 3.8: Gyratory Mold Placed in SGC

Figure 3.9: Extraction of Compacted Specimen

3.6.3 Determination of Volumetrics

The volumetric properties of mix included, air voids (V_a), voids in mineral aggregate (VMA) and voids filled with asphalt (VFA) were determined using their respective formulae after determination of theoretical maximum specific gravity (G_{mm}) and bulk specific gravity (G_{mb}). AASHTO T209 and AASHTO T166 were used to determine Theoretical maximum specific gravity (G_{mm}) and bulk specific gravity (G_{mb}) respectively. Figure 3.10 and Figure 3.11 shows the equipment used for determining G_{mb} and $G_{mm.}$ The design criteria of Superpave mix for nominal maximum aggregate size used in this research is shown below in Table 3.7.

Figure 3.10: Theoretical Maximum Specific gravity Apparatus

Figure 3.11: Bulk Specific gravity Apparatus

Table 3.7 Superpave Mix Design Criteria

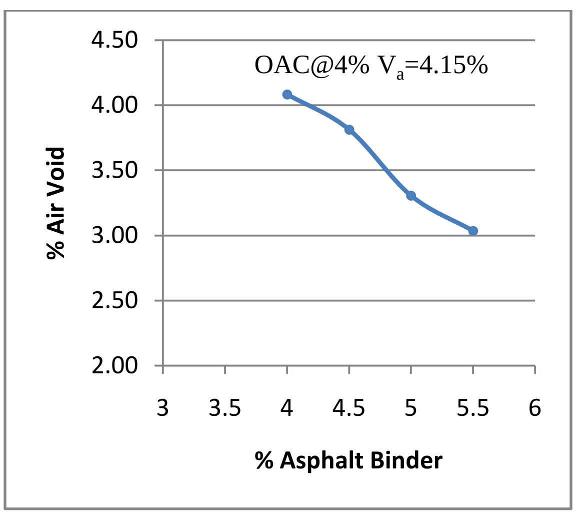
Design EASLs (million)	**Required Density (% of Theoretical Maximum Specify Gravity)**			**Voids-in-the Mineral Aggregate (Percent), minimum** **Nominal Maximum Aggregate Size, mm**					**Voids Filled With Asphalt (Percent)**	**Dust-to-Binder Ratio**
	$N_{initial}$	N_{design}	N_{max}	37.5	25.0	19.0	**12.5**	9.5		
<0.3	≤91.5								70-80	
0.3 to <3	≤90.5								65-78	
3 to <10		96.0	≤98.0	11.0	12.0	13.0	**14.0**	15.0		**0.6-1.2**
10 to<30	≤89.0								**65-75**	
≥30										

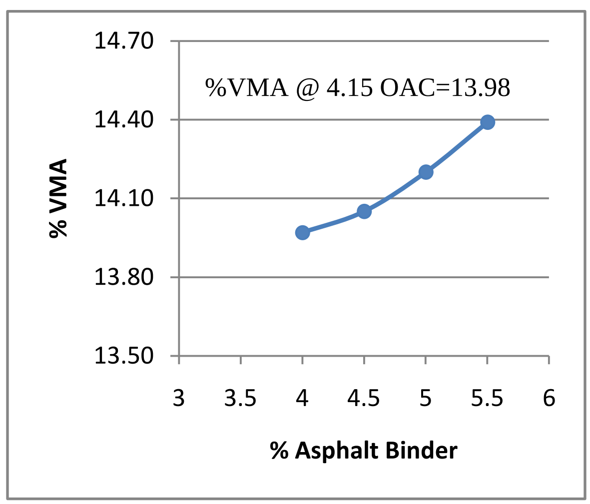
Volumetric properties of NHA class B specimens: The volumetric properties of specimens corresponding to NHA class B gradation without RAP are shown in Table 3.8 given below and plots to determine OBC are shown in Figure 3.12. The asphalt content corresponding to 4% air voids are known as the optimum asphalt contents. Therefore, for class B gradation mix without RAP the optimum asphalt content is 4.15%. The values of volumetric properties according to optimum asphalt content were then found out from the graphs and by using formula.

Table 3.8: Volumetric Properties of Class B Specimen

%AC	G_{mb}	G_{mm}	G_{se}	$\%G_{mm}$	VMA (%)	VFA (%)	V_a (%)	Dust to binder ratio
4	2.377	2.478	2.637	95.91	13.97	70.05	4.08	1.19
4.5	2.379	2.474	2.649	96.18	14.05	71.24	3.81	1.16
5	2.388	2.469	2.665	96.66	14.20	71.79	3.30	1.11
5.5	2.393	2.467	2.686	96.97	14.39	72.30	3.03	1.09

Table 3.9 shows the job mix formula of mixture prepared using class B gradation. The table clearly shows that all of the volumetric properties are meeting criteria. The minimum values of VMA at 4% design air voids for 12.0 NMAS should be 14% and in this case its value is 14%. VFA should be in between 65-75, its value calculated from the graph was 70.74, which was within the specific criteria. The dust to binder ratio value according to criteria should be within 0.6-1.2 and in this case it was 1.17. The measured value of required density (% G_{mm}) at $N_{initial}$ Should be ≤ 89.0 and in this case it was 82.314 which lies in the range of criteria.





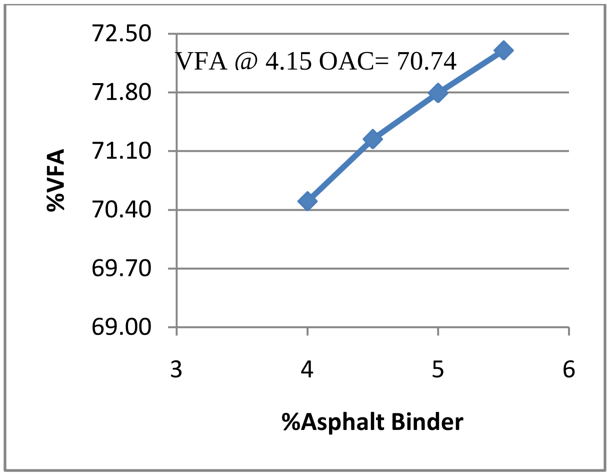


Figure 3.12: Plots to Determine Optimum Bitumen Content at 4% Air Voids

Table 3.9: Job Mix Formula of Class B Specimen

Parameters	**Class B**	**Criteria**	**Remarks**
Optimum Asphalt Content (%)	4.15	NA	
VMA (%)	14.0	Min 14	Pass
VFA (%)	70.74	65-75	Pass
Dust to Binder Ratio	1.17	0.6-1.2	Pass
$\%G_{mm}$ @ $N_{initial}$	82.314	≤89	Pass

Determination of RAP Optimum Content: For quantitative extraction of asphalt binder from asphalt mixtures solvent extractions is done using trichloroethylene or other solvents. From many decades this method and solvents have been in use to determine asphalt contents of asphalt mixtures and as a method of recovering aggregates for additional tests. Normal-propylene bromide and some non-halogenated (terpene or d-limonene based) solvents were found to be acceptable alternative solvents and are permitted in AASHTO T 164, because of some of the concerns related to fumes of that chlorinated solvents.

Due to highly variable ignition correction furnace aggregate correction factors or with the breakdown of certain aggregate types some agencies and contractors are continuing to use solvent extractions. Centrifuge extraction method is applicable for HMA & RAP sampled from pavement or stockpile. The recovered aggregate from any one above samples are further used for sieve analysis

Centrifuge Extraction Method Using Chlorinated Solvent: Weigh the laboratory size sample for extraction. Then that weighed sample of asphaltic concrete is transferred into the extractor bowl. Material is put into bowl with good care. Chlorinated solvent is used to cover the sample. Solvent is poured into airflow of the ventilation system. A small amount of solvent is used to wash any material remaining in the pan into the bowl.

Weigh a clean, dry, filter paper if necessary dry the filter paper in an oven. Place filter paper on top of extractor bowl and screw on funnel-clamp until tight. Place the bowl containing the sample and solvent into the machine, tighten the lock nut, and secure the extractor lid. Place a container under the drain to catch liquid extracted from the sample and start the machine. Stop the centrifuge and collect the discharged liquid in a bowl. This procedure will continue until the extract is reasonably clear and is approximately the same color as clean solvent. Stop the motor every time before pouring solvent into the funnel. Collect and measure the total amount of discharged liquid. Carefully remove the top and filter paper from extractor bowl and brush all clinging aggregate particles back into the bowl. Dry the filter paper to constant weight.
Subtract the original weight of filter paper from the weight recorded to obtain the weight of the fine mineral matter that may contain passing 200 sieve .Transfer the aggregate in the extraction bowl to a pan and dry to constant weight. Weigh and record the net weight of aggregate. By this weight difference before and after extraction we can calculate the RAP bitumen content that after doing comes out to be 4.46%.

3.7 DETERMINATION OF VOLUMETRIC OF RAP CONTAINING MIXTURE

After the gradation is selected and set next step is to calculate the volumetric of RAP containing mixtures which vary from 0% to 100%. Standard practice for mixture preparation was carried out using Marshall Apparatus. The whole procedure is described in following paragraphs.

3.7.1 Specimen Preparation

According to the standard procedure to determine volumetric properties, stability and flow of HMA at optimum asphalt content (OBC) is to be calculated before preparation of specimens for performance testing using SGC which is already being calculated. Therefore standard practice for the preparation of HMA samples as per ASTM D6926 was followed using

Marshall Apparatus. For each RAP percentage, 3 numbers of samples of 4 inch diameter were prepared and using average values volumetric were determined.

According to ASTM D 6926 the amount of aggregates required for 4 inch diameter sample is 1200 gm. So for this purpose amount of aggregates against each sieve size was calculated and was dried in oven at temperature 105 C^o to 110 C^o. The quantity of bitumen required for each sample was obtained from Equations 3-1 and 3-2.

$$W_A + W_B = W_T \quad (3\text{-}1)$$

$$W_B = p/100 \times W_T \quad (3\text{-}2)$$

Where,

p = Percentage of Binder

W_A = Aggregate Weight

W_B = Bitumen Weight

W_T = Total Mix Weight

After calculating the aggregate for each sieve and bitumen the mixing of aggregates and bitumen, is carried out in mechanical mixing machine (ASTM D 6926). The mixing was performed at temperature between 160 °C to 165 °C. Now to avoid honey combing aggregate and bitumen mix was putted in the Marshall 4 inch mold in two equal increments. Compaction was done with design criteria of heavy traffic 75 numbers of blows on each end of specimen using mechanical hammer. The mold was detached from the holder after completion of blows. Specimen was then extracted using extraction jack. The samples were then allowed to cool by placing it on the flat surface.

3.7.2 Testing of Specimen

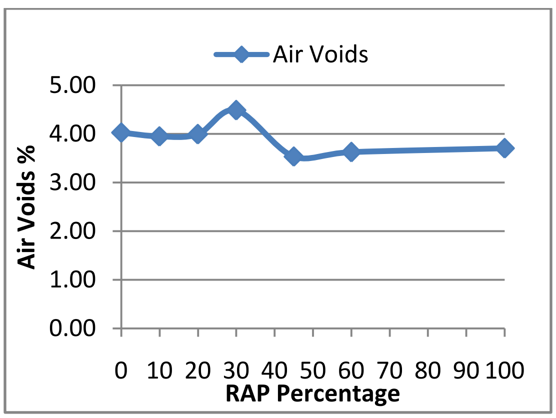
Marshall Test is mainly engaged to find the optimum mix design for hot mix asphalt that best fits the criteria of stability, flow, density .So following tests and analysis were performed on each compacted specimen.

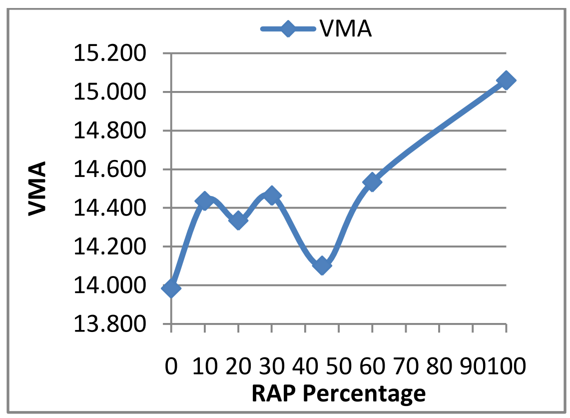
- Bulk Specific Gravity
- Voids Analysis
- Stability and Flow Test

ASTM D6927-06 is followed to determine the Stability and flow test values. While ASTM D2041 and ASTM D2726 standards were followed to determine theoretical maximum specific gravity (Gmm) and Bulk specific gravity respectively. After determination of above mentioned tests and performing analysis, separate graphical plots for all values were drawn. Subsequent graphs were used to find out the optimum RAP value to be used for performance testing.

- RAP % vs. Stability.
- RAP % vs. Flow
- RAP % vs. VA
- RAP % vs. VFA
- RAP % vs. VMA

The ultimate mix design for optimum value of RAP to be used is obtained normally the most rational that will accomplish all the guidelines for Marshall Mix Design. Usually, the standards of mix design produce a narrow range of sufficient asphalt contents that accomplishes all the requirements. Figure 3.13 shows the plots which were obtained for Rap containing mixtures.





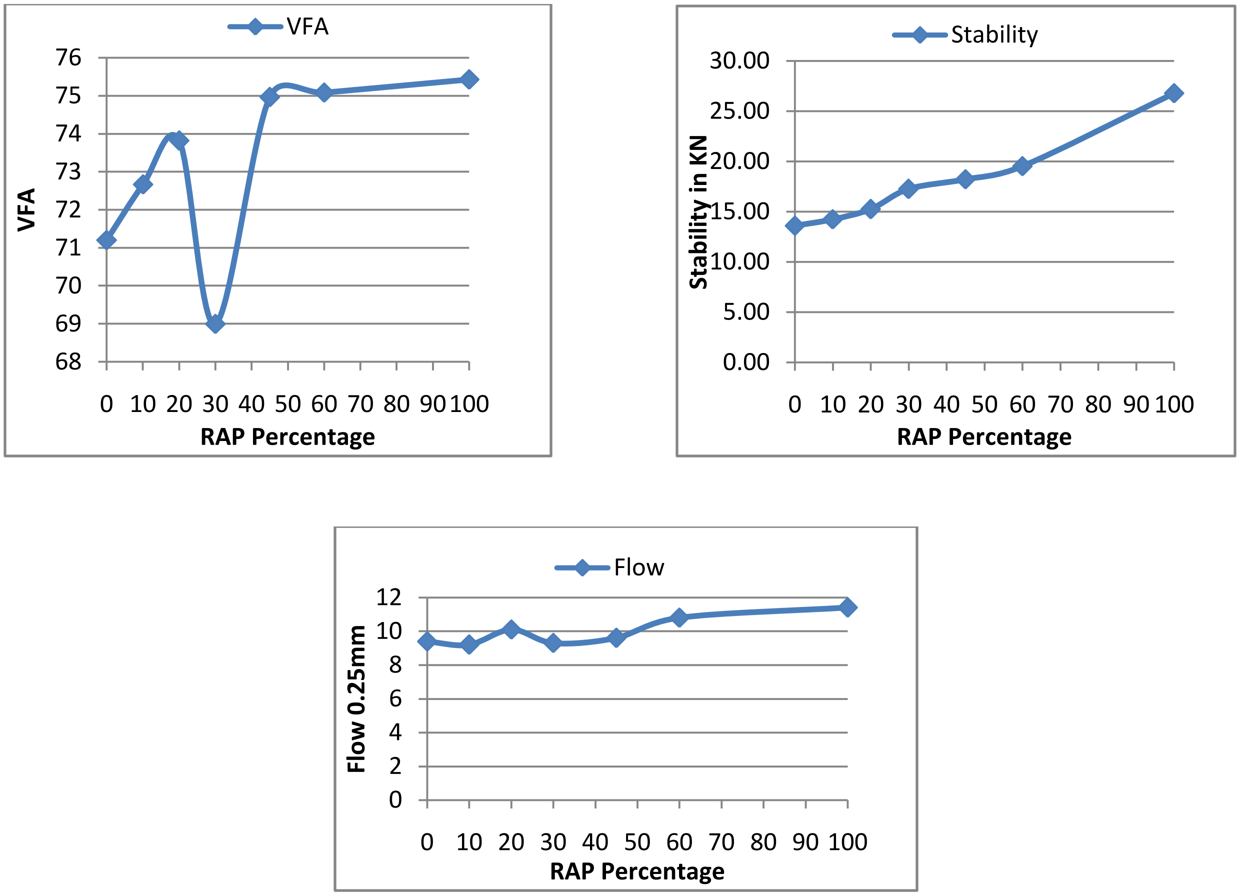


Figure 3.13: Plots of Volumetric Properties of RAP containing Mixtures

For all the selected mix gradation for RAP volumetric properties were calculated for determination of optimum Rap content to be used for performance testing. By using the optimum calculated for virgin aggregate and optimum bitumen calculated from Rap all volumetric properties graphs were draws above and shown in Figure 3.13. The volumetric properties, Stability and Flow Test for wearing course mixes for control gradations and RAP containing gradations are illustrated in Table 3.14.

Table 3.14 Volumetric Properties Results

RAP %	Air Void	VFA	VMA	Stability	Flow	Gmb	Gmm
0	4.03	71.202	13.984	13.60	9.4	2.363	2.462
10	3.95	72.668	14.436	14.23	9.2	2.350	2.447
20	3.99	72.172	14.335	15.23	1.1	2.535	2.451
30	4.48	68.997	14.463	17.24	9.3	2.350	2.460
45	3.53	74.961	14.101	18.21	9.6	2.360	2.446
60	3.62	75.083	14.532	19.52	10.8	2.348	2.436
100	3.70	75.425	15.059	26.78	11.4	2.333	2.423

3.8 SAMPLE PREPARATION FOR PERFORMANCE TESTS

The job mix formula obtained from Superpave mix design was used to prepare specimens for wheel tracker tests. After sieving the aggregates were dried to constant weight at 105°C to 110°C. The required quantity of aggregates for preparing 6 inch diameter gyratory compacted specimens was 6000gm. Compaction of specimens was done by providing 125 gyrations. As RAP is incorporated in specimen's preparation so required amount of RAP is used. Three replicates were prepared for every RAP percentage using 60/70 grade asphalt for both wet and dry condition of Hamburg wheel tracker test. Figure 3.14 shows the compacted samples extracted from mold. Specimens were saw cut from top and bottom of each specimen to obtain a standard specimen of 1.5 inch height and 6 inch diameter. Saw cut specimens for wheel tracker test are shown in Figure 3.15.

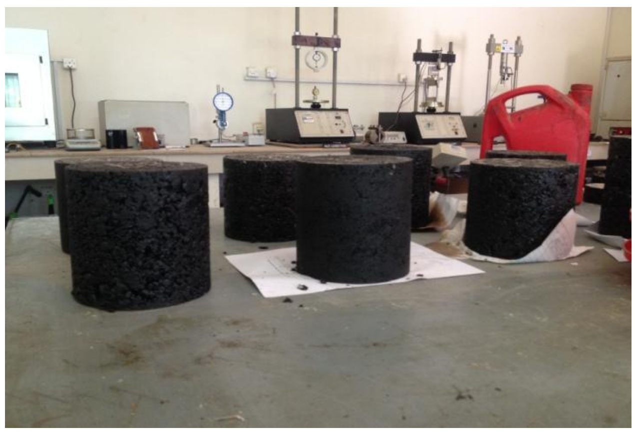


Figure 3.14: Gyratory Compacted HMA Specimens

Figure 3.15: Saw cut specimens for wheel tracker test

3.9 INVESTIGATION OF SAMPLE POTENTIAL FOR RUTTING

Rutting is one of the most common pavement permanent deformations due to repetitive traffic loads which accumulate small deformations of pavement materials appearing as longitudinal depressions in the wheel paths of the roadways. For the investigation of rutting propensity the specimens were tested to determine their resistance to permanent deformation using Hamburg wheel tracker. This machine measures the effects of rutting and moisture damage by rolling a steel wheel across the surface of an asphalt concrete specimen that is immersed in hot water.

Wheel tracker is an electrically powered device, which is capable of moving a 203.2mm diameter, 47-mm wide steel wheel over a test specimen. The load on the steel wheel is 158±1.0 lb. and the average contact stress produced by the contact of wheel is approximately 0.73 MPa with a contact area around 970 mm^2. The contact pressure induced by the steel wheel produces the same effect as produced by the rear tire of a double-axle truck. With increase in rut depth the contact area increase as result of which the contact stress becomes variable. The steel wheel moves over the specimen in forward and backward direction. The steel wheel should complete approximately 50 passes over the specimen per minute. Its maximum speed is approximately 1 ft. /sec, which is reached at the midpoint of the specimen.

Using this device rutting test can be performed on Air, Wet and Dry modes. In this research dry mode and wet mode was used to determine the rutting susceptibility and moisture damage of HMA mixes. These modes can be used by adjusting the device at desired test conditions. Figure 3.16 shows the PMW wheel-tracking device used for conducting rutting tests. Before conducting the test, the sample were saw cut from the top and bottom surface so that two 1.5-inch thick specimens could be obtained. These specimens were cut according to the silicon mold of the wheel tracker tray.

Figure 3.16: PMW Wheel-Tracking Device

After insertion of specimen in the mold, extra spaces were adjusted with pieces of wood so that the specimen does not move with the movement of wheel. The steel tray with the specimen mounted in it was placed under the wheel and fixed. The wheel tracker device was switched on. Then, the details of specimen were entered in the software. The speed of the wheel was adjusted to 50 ppm (passes per minute). The number of passes was fixed to 20,000.

First wheel tracker was used by selecting Dry mode for determination of rutting susceptibility under room temperature. Secondly wheel tracker was used by selecting Wet mode for determination of moisture damage at 50°C temperature of water. Finally the test was run and wheel started moving to and fro on the mounted specimen. The number of passes was shown on the LCD of the system attached with machine. One complete to and fro movement of the wheel was taken as 2 passes. The LVDT measures the rut impression in millimeters of unit at the same time with the motion of wheel. The machine automatically stopped when required number of passes achieved. Results were saved for the further use.

3.9.1 Output of Test

The software gives two types of results as output.

- Graph: which shows number of passes verses rut depth in mm.
- Excel Sheet data: This displays numerical information of the rut depth at 11 points of the wheel path.

Wheel Tracker (WT) Graph is an application that will display graphs and header information for the Wheel Tracking Machine. It has the ability to select a database upon startup so that archived data can be viewed and graphed. The application has the ability to save the graphs and header information to a file.

Directions for Graph display

a) Double-click on the WT Graph icon on the Desktop

b) Select the database to be used.

- To open a current database: double-click either "PMW5.MDB" or "PMW6.MDB" (depending on the Wheel Tracker version)
- To open an archived database: double-click the "Archive" folder, and select the database from the dialog
- Select the test number.
- Select the report type.
- Select the wheel.
- Select the test point.
- Select the graph scaling.
- Click "Display Graph".
- Repeat steps 3 through 8 to display a different graph.

The graph will be displayed in the form of image and the rut depth at every number of passes can be obtained by generating report and then importing the report in the MS excel file.

3.10 SUMMARY

This chapter explains the laboratory characterization of aggregates and bitumen for the preparation of bituminous paving mixes. Those materials that satisfied the standard specifications were used for bituminous mix preparation. The volumetric properties of bituminous mix have been calculated and optimum asphalt contents were determined. The testing procedure adopted for the permanent deformation testing of bituminous mix specimens has been explained.

RESULTS AND ANALYSIS OF EXPERIMENTAL DATA

4.1 INTRODUCTION

In Pakistan the most common type of distress found on HMA pavements is rutting and it mainly occurs due to higher temperatures coupled with heavier axle loads. Therefore, employing the Hamburg Wheel tracker tests are technically as well as practically reasonable as to investigate rutting susceptibility and moisture damage.

This study is based upon utilizing RAP content in HMA mixtures, to see the effect of RAP content on rutting propensity and moisture susceptibility of HMA mixtures. Optimum RAP percentage and one control percentage is used to investigate behavior of the above mention distress, RAP is collected from M-2 Lahore Islamabad Motorway and control samples are prepared in laboratory after calculation of optimum asphalt content. It is important to mention here that all mixtures used in this study have the aggregate gradation of NHA class-B.

The details of rutting susceptibility and moisture damage have already been explained in Chapter 2 (Literature Review), while procedures and test parameters adopted for tests are explained in Chapter 3 (Research Methodology and Testing). This chapter includes the detailed analysis of data obtained from experimental results, along with detailed test results. The analysis of obtained results was done by statistical software packages of Microsoft Excel 2013.

4.2 RUTTING PROPENSITY AND MOISTURE DAMAGE

Permanent deformation is evaluated by comparing the control specimen’s resistance to rutting with optimum RAP percentage modified HMA mixtures. Gyratory compacted specimens were prepared for control and Optimum RAP content by using NHA class B wearing course. Wheel tracker tests were conducted on controlled specimens and then specimens with RAP contents for dry state and wet state. A total of 12 samples were prepared with and without RAP percentage for both states. All the controlled specimens showed good resistance to rutting whereas the specimens with RAP percentages resistance to rutting were greater than the controlled samples. All of the specimens passed the wheel tracker test.

4.3 WHEEL TRACKER TEST RESULTS

For determination of resistance to rutting Permanent deformation is use as performance measure. Rutting is evaluated by comparing the specimen’s resistance to rutting with control mix and with RAP containing mixtures. Hamburg Wheel tracking (HWT) is used to calculate the permanent deformation for controlled specimens first and then for RAP containing specimens for NHA- B wearing course gradation separately. Controlled and RAP specimens of NHA-B were tested against rutting in dry mode of wheel tracker at room temperature. Controlled and RAP specimens of NHA-B were tested against moisture damage in wet mode of wheel tracker at 50˚C. A total of 12 specimens were tested for control and RAP containing HMA mixtures. For both control and RAP containing HMA mixtures the test temperature in dry and wet mode were same and numbers of passes were 20,000. Triplicate wheel tracker samples were tested for every mix type. All the controlled and RAP containing HMA mixtures specimens passed the wheel tracker test but the RAP containing HMA mixtures were resistance to rutting was greater than the controlled specimens.

4.3.1 Definition of Hamburg Wheel Tracking Device

Hamburg Wheel Tracking Device test outputs include different points which are post compaction consolidation, creep slope, stripping slope and stripping inflection point these are shown in Figure 4.1 below. A curve between rut depth and wheel passes is used to obtain these parameters. At first 1000 wheel passes post compaction consolidation deformation in (mm) is obtained. It is assumed that the mixture is densified with in first 1000 wheel passes and therefore is called post compaction consolidation.

Creep Slope is in the linear region of plot in between post compaction and stripping inflection point if stripping occurs, creep slope can also be described as inverse rate of deformation. Creep slopes have been used to evaluate rutting susceptibility primarily due to plastic flow. Creep slope is to assess rutting susceptibility instead of rut depths because the number of wheel passes at which moisture damage starts to influence performance of mixtures which varies widely from mixture to mixture (Yildirim and Kennedy, 2001).

Stripping inflection point and stripping slope are linked with moisture resistance of hot mix asphalt. Stripping inflection point is the intersection point of creep slope and stripping slope, in actual is number of passes at that point. Stripping slope is after stripping inflection point and is inverse rate of deformation and continues till end of the test. The stripping slope measures the accumulation of permanent deformation primarily due to moisture damage This slope is showing rutting primarily due to moisture damage and is the number of wheel passes required to create 1mm depth after stripping inflection point (Rahman and Hossain, 2014)).

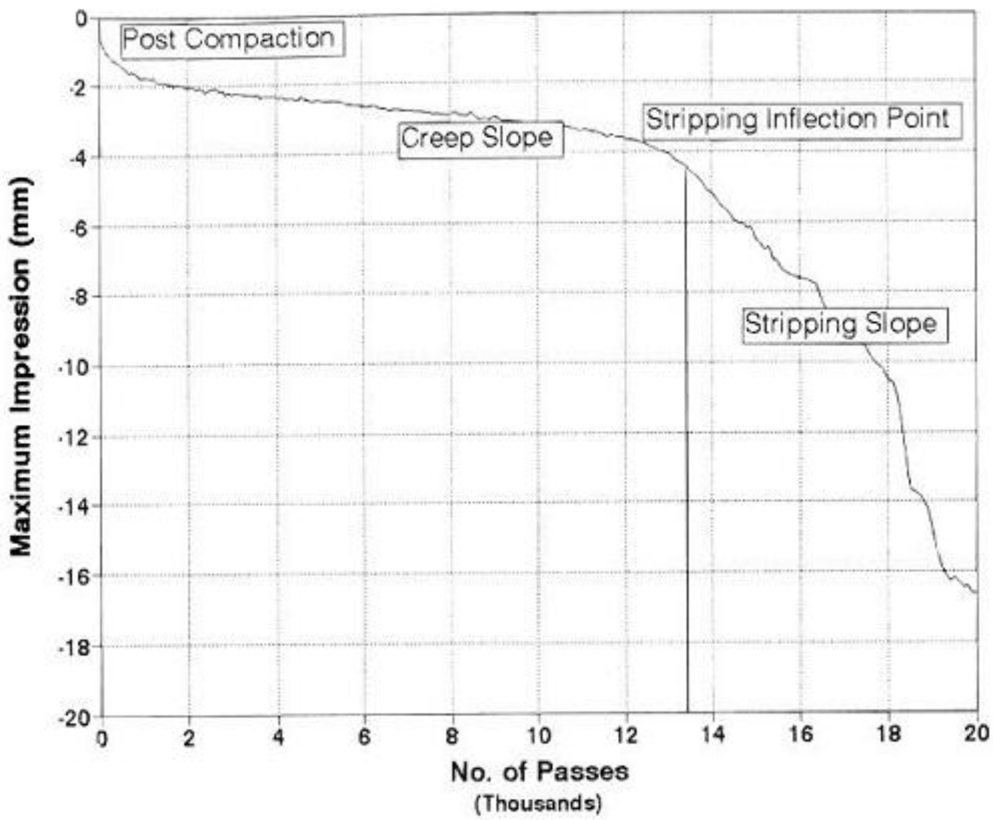


Figure 4.1: Hamburg Wheel Tracking Device test outputs

4.4 WHEEL TRACKER RUTTING SUSCEPTIBILITY RESULTS

Controlled and RAP modified specimens of class B gradation (NMAS 12.5mm) were tested against rutting at room temperature in dry mode of wheel tracker. Figure 4.2 shows the rut depth plotted against 20,000 numbers of passes (approx.). It is clear from figure that the rut depth obtained after 20,000 numbers of passes for controlled mixtures is greater than the rut depth obtained with specimens having RAP content. The maximum rut depth obtained for class-B controlled specimens is -1.174 mm whereas the maximum rut depths obtained for 20% RAP percentage specimens is -0.884 mm respectively and in shown in Figure 4.3. So the improvement in results due to use of 20% RAP percentage is 24.7%.The rut depths obtained for controlled and RAP containing mixtures were well in acceptable range as the failure depth was set at 12.5 mm.

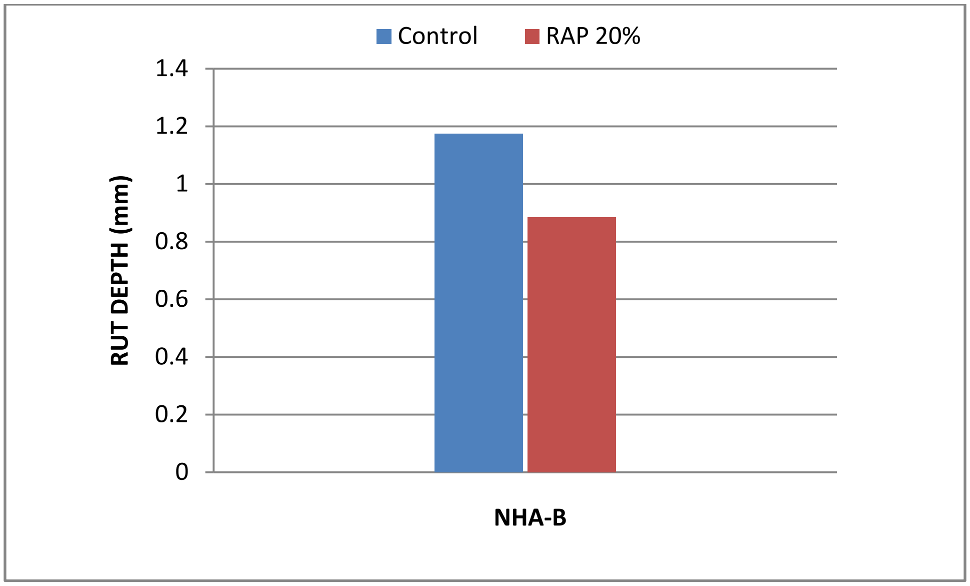


Figure 4.2: Average Rut depth for Control and RAP containing mixture

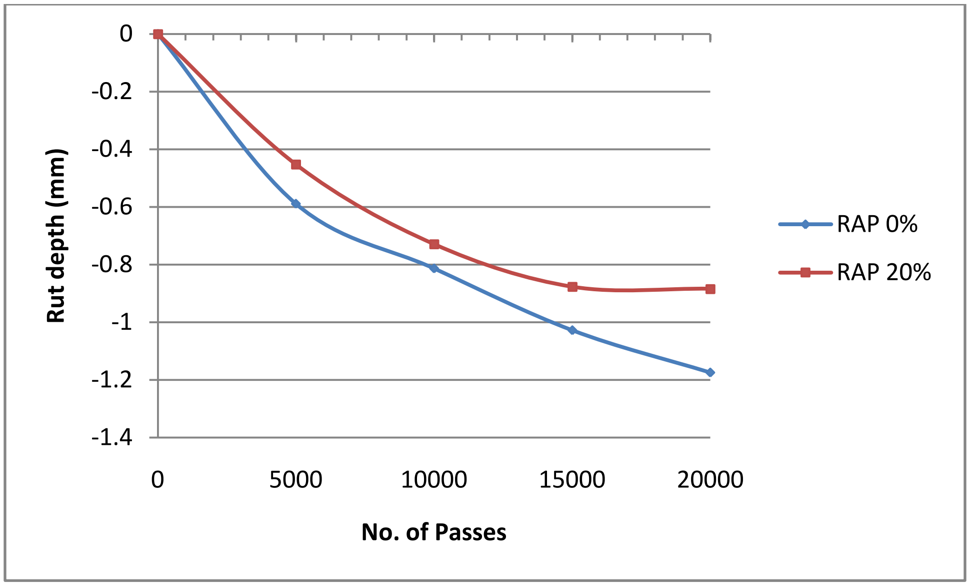


Figure 4.3: Rut Depth versus Number of Passes

4.5 WHEEL TRACKER MOISTURE DAMAGE RESULTS

Controlled and RAP modified specimens of class B gradation (NMAS 12.5mm) were tested against moisture damage at temperature of 50°C under water in wet mode of wheel tracker, Figure 4.4 shows the rut depth due to moisture plotted against 20,000 number of passes (approx.). It is clear from figure that the rut depth obtained after 20,000 numbers of passes for controlled mixtures is greater than the rut depth obtained with specimens having RAP content. The maximum rut depth due to moisture obtained for class-B controlled specimens is -13.277 mm whereas the maximum rut depths obtained for 20% RAP percentage specimens is -10.525 mm respectively. So the improvement in results due to use of 20% RAP percentage is 20.7%.The rut depths obtained for controlled and RAP containing mixtures were well in acceptable range as the failure depth was set at 20 mm.

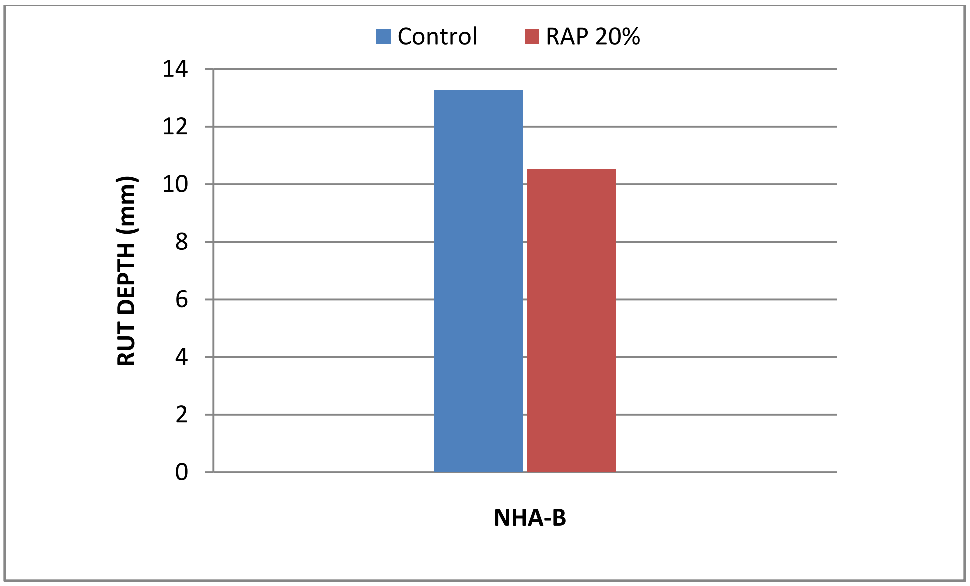


Figure 4.4: Average Rut depth for Control and RAP containing mixtures

The Colorado Department of Transportation (CDOT) reports that stripping Inflection point and the stripping slope did clearly distinguish between the stripping performances. The stripping inflection point correlated with the various levels of expected pavement performance. As a thumb rule stripping point greater than 14000 passes may indicate good performance pavement that has expected life of 10 to 15 years. A stripping point above 10000 passes indicates the routine maintenance before the design life is reached. Moisture damage results shows that HMA with control mix is having stripping inflection point above 10000 passes that is 12000 passes so only routine maintenance is required before the design life Figure 4.5. HMA mixture containing

RAP percentage is having SIP above 14000 passes which indicate good performance pavement Figure 4.6. This is because of stiffness of RAP material which increases SIP value.

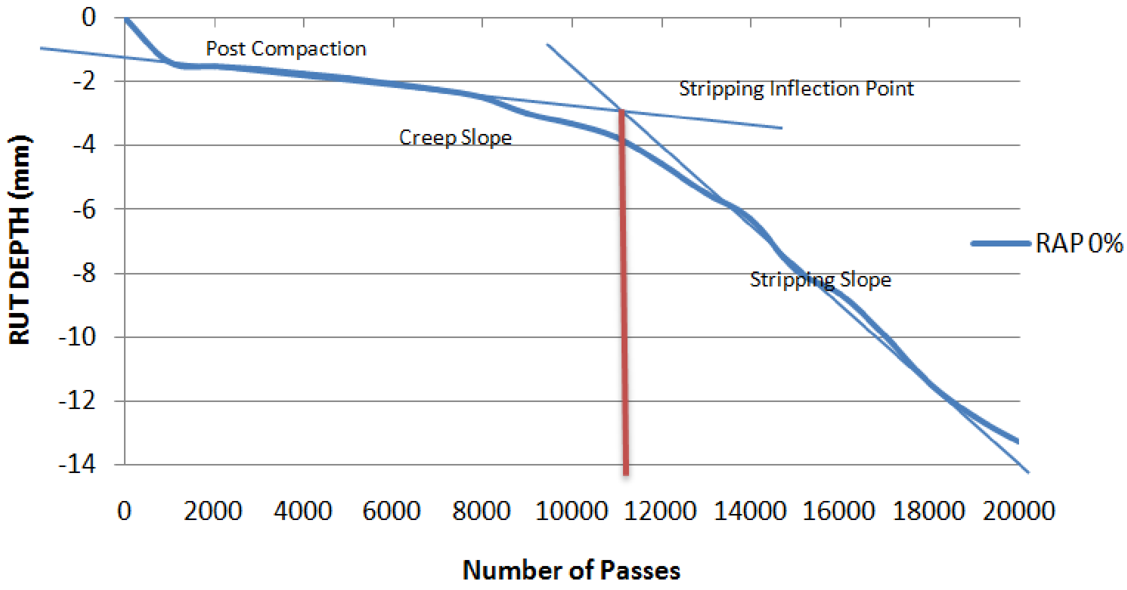


Figure 4.5: Results from Testing with the HWTD for Control Sample

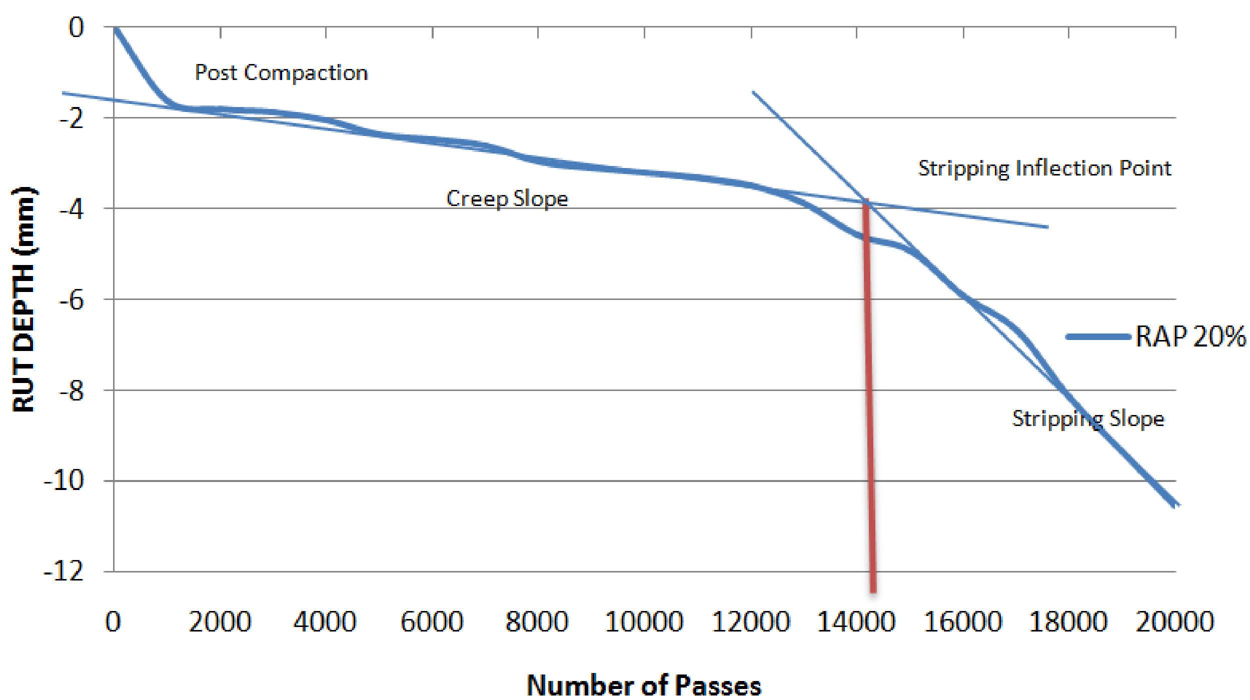


Figure 4.6: Results from Testing with the HWTD for 20% RAP Containing Sample

4.6 COST COMPARISON OF HMA CONTAINING RECYCLED ASPHALT PAVEMENT

Major asphalt production cost categories include materials, Transport/ plant operation and manpower (i.e., construction or lay down). Materials are the most expensive production cost category among others. Asphalt binder is the most expensive and economically variable material. So the most economical use of RAP in surface or intermediate layers of flexible pavements where the less expensive binder from RAP can replace a portion of the more expensive virgin binder.

For this research study cost comparison of control HMA and HMA containing recycled asphalt pavement is done in which all of the major cost dominant factors are included. Asphalt concrete wearing course rate assessment as per actual expenditure occurring is done on per cum of ACWC. Following Table 4.1 shows the Cost summary of ACWC Control Mix. Assessment is done on average daily progress of Asphalt laying by two Asphalt plants installed which produce 1800 tons of ACWC i.e., 762.71cum of asphalt. Comparison shows that by using RAP in HMA we can save cost of 13.50% in ACWC.

Table 4.1: Cost summary of ACWC Control Mix

Ser	Description	Amount (Rs)	Remarks
1	Manpower Civ	139,467.38	Anx A
2	Manpower Army (60% of Held / Posted Str)	249,866.24	Anx B
3	Material	6,709,795.08	Anx C
4	MT/Plt being oper for ACWC (100%)	1,955,100.13	Anx D
5	MT/Plt Less ser 4 (60%)	784,136.36	Anx E
Sub Total Amount		**9,838,365.19**	
Exp based on ratio of ACWC and total W.D (58.35 % = 60 % Approx)			
6	Ration	71,829.87	Anx F
7	Lub	41,185.45	"
8	Utilities	7,241.31	"
9	Repair & Maint	9,638.70	"
10	Aluminium Frame	166,380.23	"
11	Containers	12,690.00	"
12	NJ Barrier	114,750.00	"
13	Proj Store	55,256.08	"
14	Estb of Material Testing Lab, Asphalt Plant	270,684.62	"
15	Other- Exp (Misc Exp)	6,812.58	"
Sub Total Amount		**756,468.84**	
G.Total Amount		**10,594,834.04**	
Direct Cost For 762.71 Cum (Less O/H & Profit)		**10,594,834.04**	
Direct Cost For 1 x Cum		13,891.00	
Overhead & Profit (10 + 15) Percent		**3,472.75**	
Net Cost Per Cum (Incl Overhead & Profit)		**17,363.76**	

Figure 4.7 shows the cost per day in millions on ACWC control Mix which include major cost governing factors that are Manpower, Materials, Transports and Plant operation. Above each bar percentage is shown that represents the percentage of that factor on total amount of producing the above specified tons of ACWC of control mix.

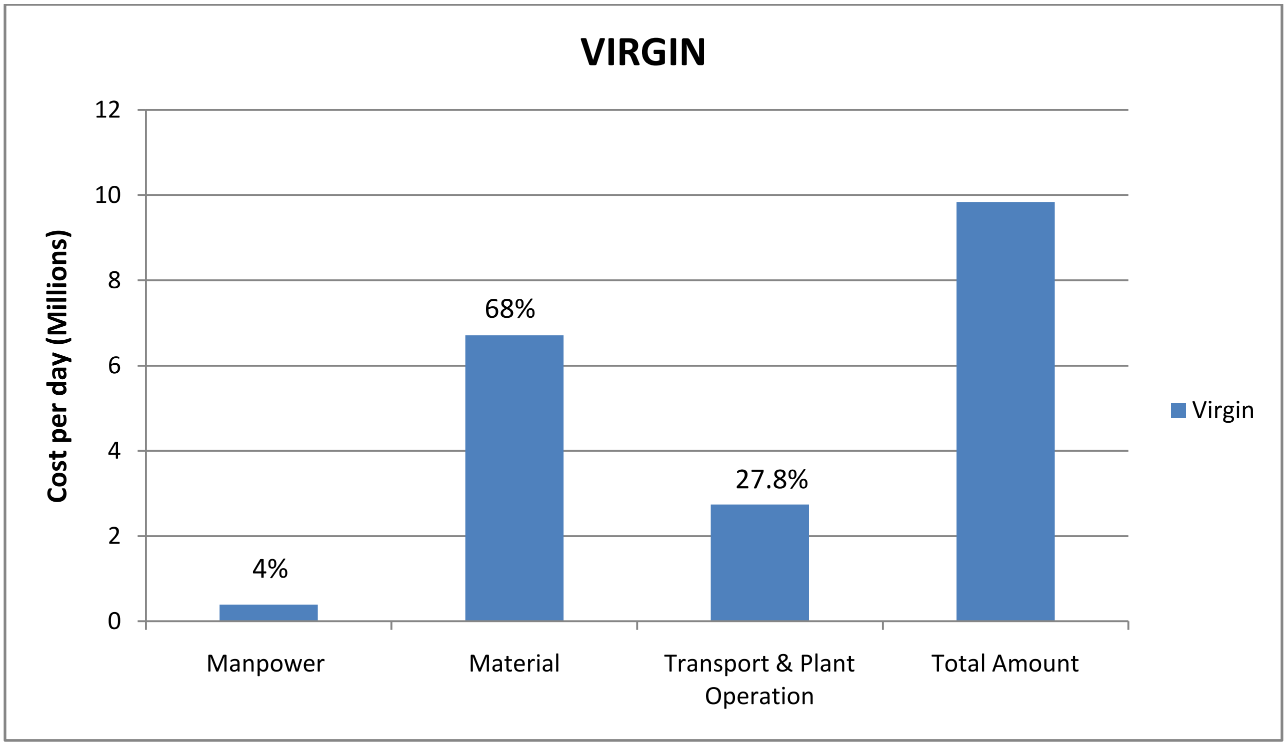


Figure 4.7: Graphical Representation of cost on ACWC Control Mix

Following Table 4.2 shows the Cost summary of ACWC containing RAP. Assessment is done on average daily progress of Asphalt laying by two Asphalt plants installed which produce 1800 tons of ACWC i.e., 762.71cum of asphalt.

Table 4.2: Cost summary of ACWC containing RAP

Ser	Description	Amount (Rs)	Remarks
1	Manpower Civ	139,467.38	Anx A
2	Manpower Army (60% of Held / Posted Str)	249,866.24	Anx B
3	Material	5,430,054.51	Anx G
4	MT/Plt oper for ACWC containing RAP (100%)	1,803,557.02	Anx H
5	MT/Plt Less sr. 4 (60%)	784,136.36	Anx E
Sub Total Amount		**8,407,081.51**	
Exp based on ratio of ACWC and total W.D (58.35 % = 60 % Approx)			
6	Ration	71,829.87	Anx F
7	Lub	41,185.45	"
8	Utilities	7,241.31	"
9	Repair & Maint	9,638.70	"
10	Aluminium Frame	166,380.23	"
11	Containers	12,690.00	"
12	NJ Barrier	114,750.00	"
13	Proj Store	55,256.08	"
14	Estb of Material Testing Lab, Asphalt Plant	270,684.62	"
15	Other- Exp (Misc Exp)	6,812.58	"
Sub Total Amount		**756,468.84**	
G.Total Amount		**9,163,550.36**	
Direct Cost For 762.71 Cum (Less O/H & Profit)		**9,163,550.36**	
Direct Cost For 1 x Cum		12,014.43	
Overhead & Profit (10 + 15) Percent		**3,003.61**	
Net Cost Per Cum (Incl Overhead & Profit)		**15018.04**	

Figure 4.8 shows the cost per day in millions of RAP containing ACWC which include major cost governing factors that are Manpower, Materials, Transports and Plant operation. Above each bar percentage is shown that represents the percentage of that factor on total amount of producing the above specified tons of RAP containing ACWC.

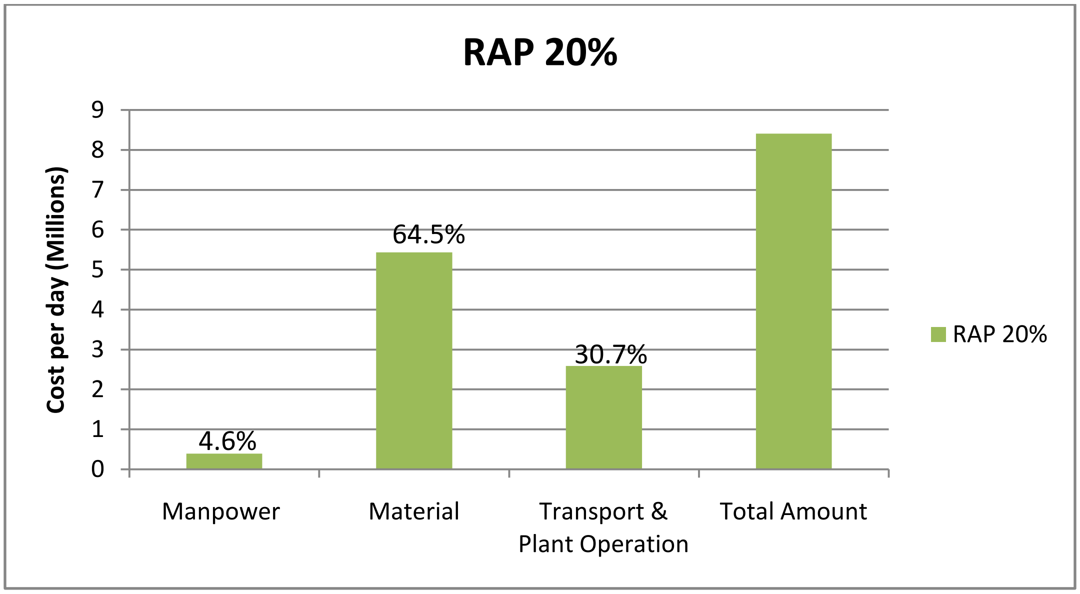


Figure 4.8: Graphical Representation of cost of RAP containing ACWC

Following Figure 4.9 shows the percentage decrease in cost of ACWC and RAP containing ACWC the decrease in material is making impact on the overall cost. This shows that if only 20% RAP is used in project the cost decreases to 15% of the project cost.

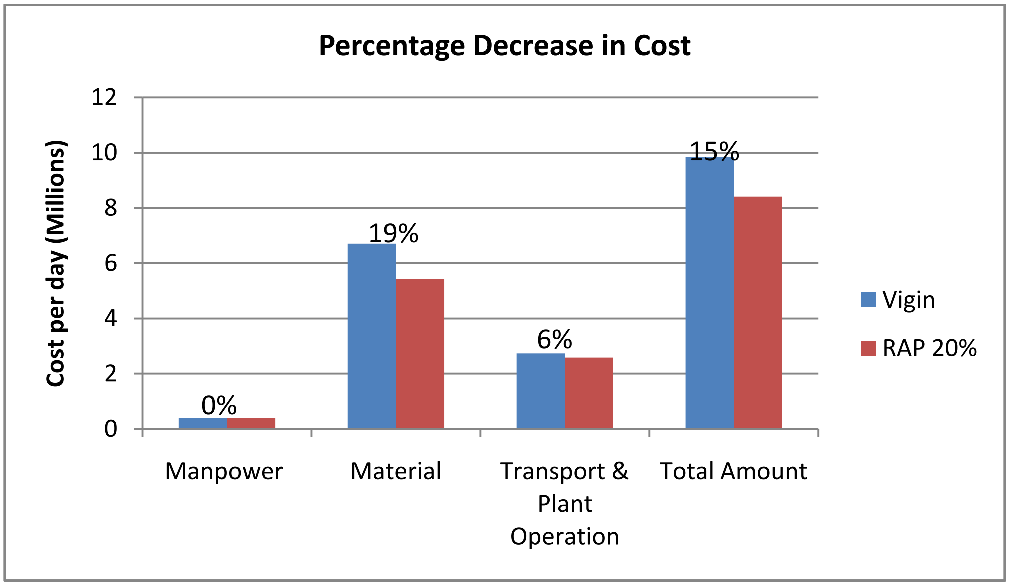


Figure 4.9: Percentage Decrease in cost

4.7 SUMMARY

In this chapter the detailed analysis of the results obtained after laboratory testing has been discussed. The results obtained from the HWTD are discussed in reference of post compaction consolidation, creep slope, stripping slope, and stripping inflection point. The data analysis carried out was presented in the form of tables and graphs. The results of wheel tracker tests for controlled specimens and results of optimum Rap containing specimen i.e., 20% were presented in the form of bar charts. Comparison of both states of HWTD i.e., Dry state and Wet state is done and discussed in detail, which showed that specimens containing Rap both in dry and wet state have greater resistance to rutting as compared to the controlled specimens. Afterwards cost comparison is done on actual rate assessment of control HMA wearing asphalt and Rap containing HMA.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY

This research work was primarily aimed to determine the effectiveness of Recycled asphalt pavement with HMA mixtures. Rutting and moisture damage are one of the serious problems observed in flexible pavements. Hamburg wheel tracker is one of the test equipment used for performance evaluation of hot mix asphalt. NHA class-B wearing course gradation, ARL 60/70 bitumen penetration grade and Aggregate acquired from Margalla were used for testing. RAP material was brought from Lahore Islamabad Motorway (M-2) for testing in Laboratory. Different percentages for RAP are used in testing with virgin aggregate to evaluate the optimum value of RAP percentage to be used for performance testing of rutting susceptibility and moisture damage. Super pave Mix design procedure was used to determine the optimum asphalt contents for NHA class-B gradation. The specimens were prepared using optimum percentage of RAP in super pave gyratory compactor. The parameters selected for study of rutting susceptibility and moisture damage are dry, wet conditions in HWTD and temperature of 50ºC for moisture damage. The key findings for Super pave Mix design, Wheel Tracker testing and analysis of experimental results are concluded as follows

5.2 CONCLUSIONS

The conclusions drawn from the analysis of tests, as conducted in previous chapter are presented as following;

5.2.1 Wheel Tracker Test

- The Marshall stability generally increases with increase in RAP content with good linearity. The stability of the 100% RAP mixtures is two times the stability of the virgin mixtures.
- Using RAP in design even up to 20% will help in conserving the natural resources, reducing the HMA price and improve the performance.
- The recovered binder and its blends with virgin binder were tested for penetration and ductility and the results shows that up to 30% RAP the penetration and ductility show

that the aged binder still has enough life. Since the virgin binder ARL 60/70 selected is soft binder so this will serve as rejuvenating agent in the mixture.

- The rutting resistance of HMA mixture containing RAP increased up to 24.7% with respect to control mixture
- The resistance against moisture damage of HMA containing RAP was increased up to 20.7% as compared to control mixture.
- The number of wheel passes for stripping inflection point for control is less as compared to RAP containing mixture which is 12000 and 14000 respectively which shows that due to addition of RAP material mixture stiffness increases as of control mix.
- Cost comparison of control mix with HMA containing RAP shows that by using RAP even up to 20% can save cost of 13.50%

5.2.2 Recommendations

- In this study only one of the performance testing is utilized i.e. the rutting susceptibility and moisture damage using Hamburg wheel tracker, other performance tests like dynamic modulus, indirect tensile strength and flow number & flow time etc should also be carried out to completely characterize the behavior of RAP containing mixture.
- It is suggested that to evaluate the performance of HMA with RAP content in the field trail section to be constructed to verify that RAP blends is suitable to the country climate condition and more important traffic loadings.
- Further study is recommended to use modified binder and different nominal maximum size aggregate gradation to see the RAP mixture performance.
- Based on the results of this study, it is recommended with confidence that HMA containing Rap content mixtures are possible to design that meets the required volumetric and desired performance criteria. The HMA with RAP performed equal to or better than the mixtures produced with virgin aggregate.

REFERENCES

AASHTO R 30-02. (2010). *Standard Procedure for Mixture Conditioning of Hot-Mix Asphalt (HMA)*. American Association of State and Highway Transportation Officials.

AASHTO T 166. (2007). *Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface dry Specimens.* American Association of State and Highway Transportation Officials.

AASHTO T 312. (2004). *Standard Method of Test for Preparing and Determining the Density of Hot-Mix Asphalt (HMA).*American Association of State Highway and Transportation Officials.

AASHTO T 324-04. (2007). *Standard Test Method for Hamburg Wheel Track testing of Compacted Hot-Mix Asphalt (HMA).* American Association of State Highway and Transportation Officials.

Asphalt Institute SP-2. (2001). *Superpave Mix Design*. Asphalt Institute Superpave Series No. 2 (SP-2), Third Edition, 2001.

ASTM C127. (2007). *Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate.* ASTM International, West Conshohocken, PA.

ASTM C128. (2007). *Standard Test Method for Density*, *Relative Density (Specific Gravity), and Absorption of Fine Aggregate.* ASTM International, West Conshohocken, PA.

ASTM C131. (2009). *Standard Test Method for Resistance to Degradation of Small-size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.* ASTM International, West Conshohocken, PA.

ASTM C535. (2007). *Standard Test Method for Resistance to Degradation of Large-size Coarse Aggregate by Abrasion and Impact in Los Angeles Machine.* ASTM International, West Conshohocken, PA.

ASTM D113. (2007). *Standard Test Method for Ductility of Bituminous Materials.* ASTM International, West Conshohocken, PA.

ASTM D2041. (2000). *Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures*. ASTM International, West Conshohocken, PA.

ASTM D2726. (2008). *Standard Test Method for Bulk Specific Gravity and density of Non Absorptive Compacted Bituminous Mixtures*. ASTM International, West Conshohocken, PA.

ASTM D5. (2006). *Standard Test Method for Penetration of Bituminous Materials*. ASTM International, West Conshohocken, PA.

Al-Qadi I.L., Elseifi, M. and Carpenter, S.H., 2007, "*Reclaimed Asphalt Pavement- A Literature Review*", Research Report FHWA-ICT-07-001, Illinois Center for Transportation

Al-Qadi I.L., Aurangzeb Q. and Carpenter, S.H., (2012), "*Impact of High RAP Content on Structural and performance Properties of Asphalt Mixtures*", Research Report FHWA-ICT-12-002, Illinois Center for Transportation.

Aschenbrener, T. and G. Currier. *Influence of Testing Variables on the Results from the Hamburg Wheel-Tracking Device.* Report CDOT-DTD-R-93-22, Colorado Department of Transportation, Denver, Colo., Dec. 1993

Antrim, J. D. and Busching, H. W., "*Asphalt content determination by the ignition method*," Bituminous Materials and Mixes, Highway Research Record, No. 273, 1969.

Brown, E. R. and Mager, S., "*Round- Robin Study of Asphalt- Concrete Content by Ignition*," Transportation Research Record 1543, 1996, pp. 132- 138.

Brown, E.R. and Cross, S.A. (1992). *A National Study of Rutting in Hot mix (HMA) Pavements.* NCAT Report 92-05 National Center for Asphalt Technology Auburn University, Alabama

Cooley, L. A., Kandhal, P.S., Buchanan, M. S., Fee, F. and Epps, A. (2000). *Loaded Wheel Testers in the United States: State of the practice.* Transportation research E-circle E-C106 National Research council, Washington DC.

Eisenmann, J. and Hilmar, A. (1987). *Influence of wheel load and inflation pressure on the rutting effect of asphalt pavements - Experiments and theoretical investigations.* Proceedings of the Sixth International conference on structural design of asphalt Pavements, Vol. 1, Ann Arbor, Michigan

Garba, R. (2002).*Permanent Deformation Properties of Asphalt Concrete Mixtures.* Dr.Ing thesis, Norwegian University of Science and Technology.

Gardiner, M.S. and Wagner, C. (1999). *Use of Reclaimed Asphalt Pavement in SuperPave Hot-Mix Asphalt Applications.* Presented in journal of the Transportation Research Board1681:1–9.

Huang, Y.H.(2003). *Pavement Analysis and Design*, Second Edition. Pearson Education Inc.

Hunter, E. R. and Ksaibati, K., (2002). *Evaluating Moisture Susceptibility of Asphalt Mixes*. Final Report WY 82071-3295, University of Wyoming Laramie, Wyoming

Huang, B., Shu, X., and Vukosavljevic, D. (2011).*Laboratory Investigation of Cracking Resistance of Hot-Mix Asphalt Field Mixtures Containing Screened Reclaimed Asphalt Pavement*., 23 (11): 1535 –1543.

Izzo, R. and Tahmoressi, M. (1998).*Evaluation of the Use of the Hamburg Wheel-Tracking Device for Moisture Susceptibility of Hot Mix Asphalt*. Final Report, Texas Department of Transportation Report, DHT-45.

Kandhal, P.S., and Mallick. R.B., *"Effect of Mix Gradation on Rutting Potential of Dense-Graded Asphalt Mixtures"*, Transportation Research Record #1767, TRB, National Research Council, Washington, D.C., 2001.

Kennedy, T., R. McGennis, and F. Roberts (1983). *Investigation of Moisture Damage to Asphalt Concrete and the Effect of Field Performance -A Case Study*. Transportation Research Record 911. Washington D.C.: National Academy Press.

Khan, K.R. (2008).*Impact of Superpave Mix Design Method on Rutting Behavior of Flexible Pavements.* Ph.D. Thesis, UET Taxila.

Miljković, M. and Radenberg, M. (2011). *Rutting Mechanisms and Advanced Laboratory Testing of Asphalt Mixtures Resistance Against Permanent Deformation*. Facta Universitatis, Series: Architecture and Civil Engineering. 9(3): 407-417

Mogawer, W. S., and K. D. Stuart. (1995) *Effect of Coarse Aggregate Content on Stone Matrix Asphalt*, Transportation Research Record 1492, TRB, National Research Council, Washington, D.C., Pages 1-11.

Roberts, F., P. Kandhal, E. Brown, D. Lee, and T. Kennedy (1996). *Hot Mix Asphalt Materials, Mixture Design, and Construction.* 2nd edition. Lanham, Maryland: NAPA Education Foundation.

Rahman F. and Hossain M. (2014). *Review and Analysis of Hamburg Wheel Tracking Device Test Data.* Final Report, Kansas State University Transportation Center Report No. KS-14-1.

Solaimanian, M., J. Harvey, M. Tahmoressi, and V. Tandon., *"Test Methods to Predict Moisture Sensitivity of Hot-Mix Asphalt Pavements,"* Transportation Research Board, National Research Council, Washington, D.C., pp. 77-110, 2004.

Shrum, E. D., (2010). *Evaluation of Moisture Damage in Warm Mix Asphalt Containing Recycled Asphalt pavement*. Master's Thesis, University of Tennessee.

Sousa, Jorge B., Craus, J., Monismith, Carl L. (1991). *"Summary Report on Permanent Deformation in Asphalt Concrete."* SHRP-A/IR-91-104 Institute of Transportation Studies University of California Berkeley, California Strategic Highway Research Program National Research Council, Washington, D.C.

Sondag M. S., Chadbourn B. A. and Drescher A. (2002). *Investigation of Recycled Asphalt Pavement (Rap) Mixtures.* Final Report, Department of Civil Engineering University of Minnesota Report No. MN/RC – 2002-15.

VanFrank, K. M. and Romero, P. (2013).*On the Variability of Results from the Hamburg Wheel Tracker Device.* Proceedings of the 49th Annual International Conference, ASC.

VanFrank, K. M. and Romero, P. (2013). *On the Variability of Results from the Hamburg Wheel Tracker Device*. Proceedings of the 49th Annual International Conference, ASC.

Yetkin, Y. et al. (2007) *Hamburg Wheel Tracking Database Analysis* FHWA/TX-05/0-1707-7 Federal Highway Administration.

Yildirim Y. and Kennedy T. W (2001). *Correlation of Field Performance to Hamburg Wheel Tracking Device Results*. Research Report, Texas Department of Transportation Research Report 0-4185-1

Yu, L., "*Determination of Asphalt Content and Aggregate Gradation of HMA by Ignition Heating*," Thesis for the Degree of Master of Science, Auburn University, AL, March 1992.

Zhao, Y. ,and Arkansas, U.O. (2007). *Development of a Simplified M-E Design Procedure for Low-volume Flexible Roads*. University of Arkansas.

Zhou, F., Hu, S., and Scullion, T. (2013).*Balanced Rap/Ras Mix Design and Performance Evaluation System for Project-Specific Service Conditions*. SWUTC/13/0-6092-3, Texas A&M Transportation Institute, Project 0-6092.

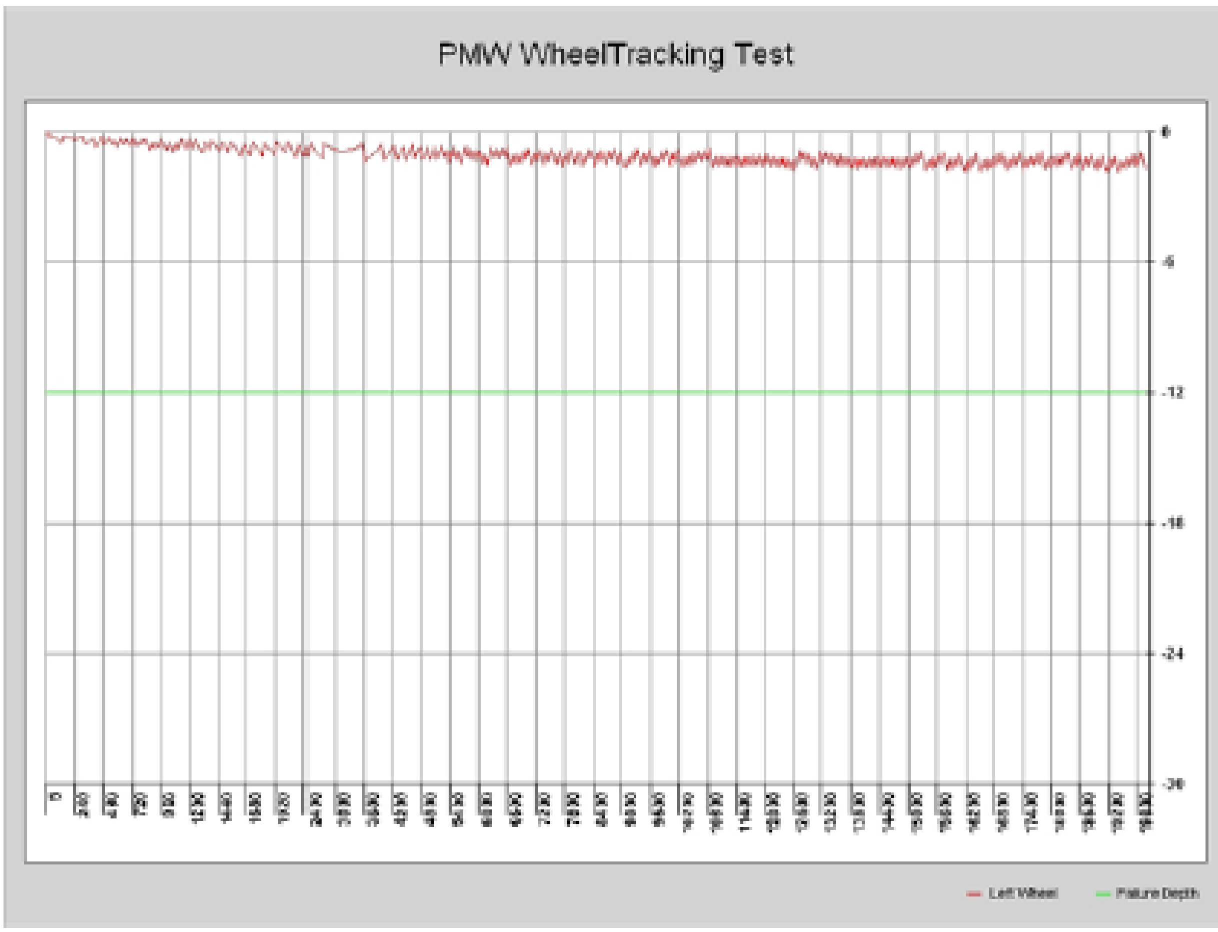
APPENDICES

APPENDIX I: WHEEL TRACKER SOFTWARE RESULT

WheelTracker Report

Project Name:	MS THESIS	Date:	2/16/2006
Project Number:	1	Date Sampled:	2/16/2006
Job Number:	W3 0%	Lab Number:	1
Project Engineer:	WAQAS	Mix Type:	HMA
Submitted By:	NIT	Asphalt Grade:	60/70
Temperature:	29	Pit Source:	LAB
Comments:	Comments		

	Left
Max Impression:	-1.87 mm Pass #: 19400 / Pt: 10
Fail Depth: 12.5mm	PASSED



PASS #	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	Avg
5	0	0	0	0	0	0	0	0	0	0	0	0
20	-0.08128	-0.09144	-0.10668	-0.1524	-0.13716	-0.1524	-0.11176	-0.13208	-0.254	-0.29972	-0.0508	0.052311
40	-0.12192	-0.15748	-0.19304	-0.2032	-0.18288	-0.29464	-0.3048	-0.33528	-0.3556	-0.1016	-0.10668	0.078761
60	-0.14732	-0.1778	-0.21336	-0.21844	-0.29972	-0.32512	-0.3048	-0.36576	-0.37592	-0.2286	-0.09652	0.076326
80	-0.16256	-0.19304	-0.2286	-0.28448	-0.29464	-0.33528	-0.30988	-0.37084	-0.41148	-0.35052	-0.11684	0.074731
100	-0.1778	-0.24384	-0.24384	-0.28956	-0.29464	-0.34036	-0.49276	-0.5842	-0.508	-0.46228	-0.13208	0.123012
120	-0.18796	-0.24892	-0.254	-0.28956	-0.28956	-0.34036	-0.48768	-0.58928	-0.57404	-0.54864	-0.1524	0.137958
140	-0.19812	-0.254	-0.29464	-0.29972	-0.41148	-0.44704	-0.47752	-0.59436	-0.60452	-0.1778	-0.17272	0.135942
160	-0.2032	-0.25908	-0.3048	-0.3048	-0.4064	-0.44704	-0.47244	-0.59436	-0.62992	-0.2286	-0.19304	0.129477
180	-0.21336	-0.26416	-0.31496	-0.3048	-0.41148	-0.46228	-0.47752	-0.59944	-0.64516	-0.26924	-0.19812	0.128134
200	-0.22352	-0.27432	-0.32004	-0.31496	-0.41148	-0.46736	-0.47752	-0.60452	-0.65532	-0.29972	-0.16764	0.12721
220	-0.2286	-0.27432	-0.3302	-0.32512	-0.42164	-0.47244	-0.48768	-0.61468	-0.66548	-0.32004	-0.22352	0.123347
240	-0.23876	-0.29464	-0.33528	-0.3302	-0.4318	-0.48768	-0.49784	-0.635	-0.6858	-0.31496	-0.22352	0.127966
260	-0.24384	-0.29972	-0.34544	-0.34036	-0.44704	-0.50292	-0.52324	-0.66548	-0.70612	-0.28956	-0.21844	0.138545
280	-0.24892	-0.31496	-0.3556	-0.35052	-0.34036	-0.51816	-0.54864	-0.69596	-0.73152	-0.24892	-0.21336	0.15156
300	-0.24892	-0.32512	-0.36576	-0.36068	-0.36068	-0.54356	-0.59436	-0.74676	-0.74168	-0.19812	-0.20828	0.167178
320	-0.25908	-0.34036	-0.34544	-0.37592	-0.39116	-0.46228	-0.45212	-0.80772	-0.72136	-0.59944	-0.19812	0.143919
340	-0.25908	-0.35052	-0.36068	-0.40132	-0.41656	-0.48768	-0.47752	-0.57404	-0.65532	-0.51308	-0.19812	0.104371
360	-0.26924	-0.31496	-0.37084	-0.42672	-0.4572	-0.51816	-0.52324	-0.65532	-0.72644	-0.41148	-0.2032	0.120661
380	-0.27432	-0.3302	-0.381	-0.37084	-0.49276	-0.54356	-0.56896	-0.72644	-0.77724	-0.29972	-0.23368	0.152148
400	-0.27432	-0.3556	-0.38608	-0.38608	-0.39116	-0.46228	-0.635	-0.80264	-0.77724	-0.69088	-0.21844	0.172636
420	-0.2794	-0.37084	-0.37592	-0.41148	-0.4318	-0.508	-0.49784	-0.59436	-0.70612	-0.54864	-0.21336	0.111004
440	-0.28448	-0.34036	-0.39116	-0.381	-0.47752	-0.54356	-0.54864	-0.69596	-0.77724	-0.40132	-0.21844	0.135103
460	-0.28448	-0.36576	-0.40132	-0.39624	-0.39116	-0.57912	-0.62484	-0.79248	-0.8128	-0.254	-0.23368	0.171209
480	-0.28956	-0.381	-0.39116	-0.41656	-0.43688	-0.51308	-0.50292	-0.59436	-0.74168	-0.58928	-0.21844	0.115371
500	-0.29972	-0.35052	-0.40132	-0.39116	-0.49276	-0.5588	-0.5588	-0.70104	-0.79756	-0.41656	-0.2286	0.135775
520	-0.29464	-0.37084	-0.41148	-0.41148	-0.4064	-0.59944	-0.64516	-0.81788	-0.8382	-0.26416	-0.24384	0.17675
540	-0.29972	-0.39116	-0.39624	-0.4318	-0.45212	-0.5334	-0.52324	-0.62484	-0.75184	-0.59944	-0.22352	0.119401
560	-0.3048	-0.36576	-0.41656	-0.40132	-0.51308	-0.57912	-0.57912	-0.74676	-0.83312	-0.39116	-0.27432	0.144423
580	-0.29972	-0.38608	-0.39624	-0.42672	-0.4318	-0.508	-0.6858	-0.86868	-0.84328	-0.72644	-0.23876	0.183804
600	-0.31496	-0.3556	-0.41656	-0.4572	-0.49276	-0.56388	-0.5588	-0.69596	-0.67564	-0.50292	-0.23876	0.111592
620	-0.31496	-0.39116	-0.4318	-0.42164	-0.5588	-0.61468	-0.64516	-0.82804	-0.86868	-0.29464	-0.254	0.174399
640	-0.31496	-0.41148	-0.41656	-0.45212	-0.47752	-0.5588	-0.54864	-0.65532	-0.75692	-0.57912	-0.23876	0.116294
660	-0.31496	-0.38608	-0.4318	-0.42672	-0.55372	-0.61468	-0.635	-0.8128	-0.87376	-0.34544	-0.26924	0.166422
680	-0.32512	-0.37084	-0.42164	-0.4572	-0.47752	-0.5588	-0.54864	-0.64516	-0.79756	-0.62484	-0.24892	0.124691
700	-0.32512	-0.39624	-0.44196	-0.4318	-0.5588	-0.61976	-0.62992	-0.8128	-0.89408	-0.36068	-0.27432	0.164323
720	-0.3302	-0.42164	-0.4318	-0.46228	-0.48768	-0.56388	-0.5588	-0.6604	-0.81788	-0.64008	-0.24892	0.124523
740	-0.33528	-0.40132	-0.44704	-0.43688	-0.56388	-0.62992	-0.65024	-0.83312	-0.89916	-0.3556	-0.2794	0.16827
760	-0.33528	-0.4318	-0.44196	-0.46736	-0.49276	-0.57404	-0.5588	-0.67056	-0.80264	-0.62484	-0.24892	0.120577
780	-0.33528	-0.4064	-0.4572	-0.44704	-0.57404	-0.635	-0.65024	-0.84836	-0.91948	-0.34544	-0.2794	0.172048
800	-0.33528	-0.38608	-0.44196	-0.4826	-0.508	-0.58928	-0.57912	-0.69596	-0.79756	-0.60452	-0.254	0.124943
820	-0.34544	-0.42164	-0.46228	-0.45212	-0.44196	-0.64516	-0.68072	-0.88392	-0.92964	-0.32512	-0.27432	0.183216
840	-0.34544	-0.40132	-0.4572	-0.48768	-0.51816	-0.60452	-0.5842	-0.72136	-0.75692	-0.56896	-0.26416	0.116462
860	-0.34544	-0.42672	-0.46736	-0.46228	-0.4572	-0.6604	-0.70612	-0.91948	-0.9398	-0.82804	-0.27432	0.200933
880	-0.35052	-0.4064	-0.46228	-0.508	-0.54356	-0.61976	-0.61976	-0.77724	-0.889	-0.50292	-0.27432	0.135103
900	-0.35052	-0.44196	-0.45212	-0.47244	-0.4826	-0.57404	-0.56388	-0.97028	-0.9144	-0.762	-0.26924	0.172132
920	-0.3556	-0.42164	-0.47244	-0.4572	-0.56896	-0.64516	-0.64516	-0.82296	-0.9398	-0.43688	-0.3048	0.15685
940	-0.35052	-0.45212	-0.4572	-0.48768	-0.508	-0.58928	-0.57912	-1.03124	-0.86868	-0.67564	-0.26924	0.162644
960	-0.36068	-0.44196	-0.47752	-0.46736	-0.6096	-0.6604	-0.6858	-0.889	-0.95504	-0.35052	-0.28956	0.179521
980	-0.36068	-0.42164	-0.47244	-0.50292	-0.53848	-0.62484	-0.60452	-0.74676	-0.78232	-0.57912	-0.27432	0.118813

1000	-0.36068	-0.45212	-0.46228	-0.4826	-0.48768	-0.57404	-0.74676	-0.96012	-0.95504	-0.81788	-0.2794	0.197742
1020	-0.37084	-0.4318	-0.4826	-0.47244	-0.57912	-0.65024	-0.65024	-0.83312	-0.94488	-0.46228	-0.31496	0.15324
1040	-0.37084	-0.47244	-0.47752	-0.49784	-0.52324	-0.61468	-0.59436	-0.69596	-0.88392	-0.68072	-0.27432	0.127882
1060	-0.37084	-0.45212	-0.49784	-0.4826	-0.46736	-0.68072	-0.70612	-0.92456	-0.98552	-0.9144	-0.29464	0.205635
1080	-0.37592	-0.4318	-0.48768	-0.52832	-0.56896	-0.64516	-0.635	-0.79756	-0.92964	-0.53848	-0.28956	0.135523
1100	-0.37084	-0.46736	-0.47752	-0.49784	-0.51308	-0.6096	-0.58928	-1.03124	-0.92456	-0.74168	-0.2794	0.171377
1120	-0.37084	-0.45212	-0.50292	-0.48768	-0.46736	-0.68072	-0.70104	-0.9144	-0.99568	-0.36576	-0.29972	0.186071
1140	-0.381	-0.43688	-0.49276	-0.4826	-0.56896	-0.65532	-0.635	-0.79756	-0.75692	-0.54864	-0.28956	0.12108
1160	-0.381	-0.47752	-0.4826	-0.50292	-0.51816	-0.61468	-0.59436	-1.0414	-0.94488	-0.75184	-0.28956	0.173308
1180	-0.381	-0.46228	-0.508	-0.48768	-0.635	-0.69088	-0.70612	-0.92456	-1.00584	-0.37084	-0.3048	0.185147
1200	-0.38608	-0.44196	-0.50292	-0.53848	-0.57912	-0.6604	-0.64516	-0.80264	-0.94996	-0.55372	-0.29464	0.13611
1220	-0.38608	-0.4826	-0.48768	-0.508	-0.52832	-0.61976	-0.60452	-1.05156	-0.94488	-0.74676	-0.28956	0.171796
1240	-0.38608	-0.47244	-0.51308	-0.49784	-0.64516	-0.69596	-0.71628	-0.9398	-1.016	-0.36068	-0.3048	0.188506
1260	-0.38608	-0.45212	-0.508	-0.49784	-0.58928	-0.67056	-0.65024	-0.82804	-0.97028	-0.53848	-0.29972	0.146102
1280	-0.38608	-0.49276	-0.49784	-0.51308	-0.53848	-0.635	-0.60452	-1.07696	-0.9398	-0.7366	-0.28956	0.172384
1300	-0.38608	-0.47752	-0.51816	-0.50292	-0.49784	-0.70612	-0.7366	-0.97028	-1.02616	-0.91948	-0.3048	0.210169
1320	-0.38608	-0.46228	-0.51308	-0.49784	-0.61468	-0.6858	-0.67564	-0.86868	-1.00584	-0.48768	-0.3302	0.160629
1340	-0.39624	-0.45212	-0.50292	-0.5334	-0.56388	-0.6604	-0.62992	-0.762	-0.889	-0.6604	-0.29464	0.130485
1360	-0.39624	-0.49276	-0.50292	-0.51308	-0.52832	-0.61976	-0.79756	-1.0414	-1.01092	-0.82296	-0.29972	0.203284
1380	-0.39624	-0.47752	-0.52832	-0.508	-0.49276	-0.70612	-0.71628	-0.9398	-1.05156	-0.40132	-0.32004	0.188422
1400	-0.40132	-0.46736	-0.51816	-0.50292	-0.60452	-0.68072	-0.6604	-0.8382	-0.98552	-0.56388	-0.35052	0.142072
1420	-0.40132	-0.45212	-0.51308	-0.52832	-0.5588	-0.65024	-0.62484	-0.72644	-0.95504	-0.7366	-0.29464	0.139133
1440	-0.39624	-0.49276	-0.5334	-0.52324	-0.51816	-0.61468	-0.77216	-1.016	-1.05156	-0.89916	-0.3048	0.20891
1460	-0.40132	-0.47752	-0.52832	-0.51308	-0.64516	-0.70612	-0.70612	-0.91948	-1.05156	-0.44704	-0.3302	0.176582
1480	-0.41148	-0.46736	-0.51816	-0.55372	-0.59436	-0.6858	-0.65024	-0.82296	-0.84836	-0.59944	-0.3048	0.123515
1500	-0.4064	-0.51308	-0.51816	-0.5334	-0.5588	-0.65532	-0.62992	-0.72136	-1.00076	-0.76708	-0.3048	0.140057
1520	-0.40132	-0.49784	-0.5334	-0.52832	-0.52324	-0.73152	-0.77216	-1.02108	-1.07188	-0.9398	-0.31496	0.218566
1540	-0.4064	-0.4826	-0.5334	-0.52324	-0.65024	-0.71628	-0.71628	-0.93472	-1.0668	-0.45212	-0.3302	0.179605
1560	-0.41656	-0.47752	-0.5334	-0.56388	-0.61468	-0.69596	-0.67056	-0.84328	-1.00584	-0.59944	-0.32004	0.139301
1580	-0.41148	-0.51816	-0.52832	-0.54356	-0.57404	-0.67056	-0.635	-0.74168	-0.99568	-0.75184	-0.30988	0.137874
1600	-0.41148	-0.508	-0.51816	-0.5334	-0.53848	-0.635	-0.79756	-1.05156	-1.08204	-0.91948	-0.31496	0.216803
1620	-0.41148	-0.49784	-0.54356	-0.52832	-0.67056	-0.72644	-0.73152	-0.9652	-1.08712	-1.08204	-0.3302	0.208994
1640	-0.42164	-0.48768	-0.5334	-0.52324	-0.62992	-0.70612	-0.68072	-0.87376	-1.03632	-0.56388	-0.36068	0.150553
1660	-0.41656	-0.47752	-0.5334	-0.55372	-0.58928	-0.6858	-0.65024	-0.77724	-0.97028	-0.7112	-0.31496	0.137874
1680	-0.41148	-0.51816	-0.52832	-0.54356	-0.5588	-0.6604	-0.635	-1.10744	-1.0668	-0.8636	-0.32004	0.195475
1700	-0.41656	-0.51308	-0.55372	-0.53848	-0.5334	-0.74168	-0.77216	-1.02108	-1.10744	-1.02108	-0.32512	0.224444
1720	-0.42164	-0.49784	-0.54356	-0.52832	-0.66548	-0.72644	-0.71628	-0.9398	-1.09728	-0.47752	-0.34544	0.178514
1740	-0.42672	-0.49276	-0.54356	-0.57912	-0.62992	-0.71628	-0.6858	-0.8636	-1.0414	-0.61468	-0.37592	0.140477
1760	-0.42164	-0.47752	-0.53848	-0.5588	-0.59436	-0.69088	-0.65532	-0.77724	-1.02616	-0.76708	-0.32512	0.147446
1780	-0.42164	-0.52324	-0.5334	-0.55372	-0.56388	-0.66548	-0.82804	-1.09728	-1.10744	-0.92456	-0.32512	0.220749
1800	-0.42672	-0.51816	-0.5588	-0.53848	-0.5334	-0.74168	-0.762	-1.016	-1.12268	-1.08204	-0.33528	0.22797
1820	-0.42672	-0.50292	-0.55372	-0.53848	-0.66548	-0.73152	-0.71628	-0.93472	-1.09728	-0.51816	-0.3556	0.171796
1840	-0.42672	-0.49276	-0.55372	-0.5842	-0.635	-0.71628	-0.6858	-0.8636	-1.05156	-0.62992	-0.3302	0.142576
1860	-0.42672	-0.48768	-0.54356	-0.56896	-0.60452	-0.70104	-0.6604	-0.79248	-1.03632	-0.76708	-0.32512	0.148118
1880	-0.42672	-0.5334	-0.54356	-0.55372	-0.57912	-0.67564	-0.65024	-1.13284	-1.10236	-0.89408	-0.32512	0.201437
1900	-0.42672	-0.52324	-0.56388	-0.55372	-0.54864	-0.65024	-0.79756	-1.06172	-1.143	-1.03124	-0.3302	0.228894
1920	-0.42672	-0.51816	-0.56388	-0.54864	-0.69088	-0.74676	-0.74676	-0.9906	-1.13792	-0.4572	-0.35052	0.190941
1940	-0.43688	-0.508	-0.56388	-0.54864	-0.66548	-0.7366	-0.71628	-0.92456	-1.10236	-0.56896	-0.37084	0.1634
1960	-0.43688	-0.49784	-0.5588	-0.59436	-0.64008	-0.72644	-0.69088	-0.8636	-1.05156	-0.68072	-0.34036	0.144423
1980	-0.43688	-0.55372	-0.5588	-0.57912	-0.61468	-0.70612	-0.67056	-0.79248	-1.07188	-0.80772	-0.3302	0.14753
2000	-0.43688	-0.54864	-0.5588	-0.56388	-0.58928	-0.69088	-0.6604	-1.14808	-1.12268	-0.91948	-0.33528	0.204879

2050	-0.43688	-0.52324	-0.56896	-0.55372	-0.70104	-0.75692	-0.75184	-0.99568	-1.14808	-0.46736	-0.35052	0.192032
2100	-0.45212	-0.51308	-0.56896	-0.59436	-0.65024	-0.73152	-0.69596	-0.86868	-1.07188	-0.69088	-0.34544	0.144339
2150	-0.44196	-0.55372	-0.5588	-0.57404	-0.59436	-0.70104	-0.67056	-1.16332	-1.143	-0.92456	-0.34036	0.20807
2200	-0.44704	-0.54356	-0.5842	-0.5588	-0.5588	-0.76708	-0.78232	-1.04648	-1.17856	-1.14808	-0.35052	0.236703
2250	-0.45212	-0.5334	-0.5842	-0.5588	-0.6858	-0.75692	-0.72644	-0.9398	-1.12776	-0.59944	-0.38608	0.162812
2300	-0.45212	-0.51816	-0.57404	-0.59944	-0.64516	-0.73152	-0.69088	-0.84328	-1.07696	-0.77724	-0.34544	0.149545
2350	-0.45212	-0.56388	-0.56896	-0.5842	-0.6096	-0.70612	-0.67564	-1.17348	-1.17348	-0.9652	-0.34544	0.214536
2400	-0.4572	-0.55372	-0.59436	-0.57912	-0.57912	-0.6858	-0.81788	-1.0922	-1.19888	-1.13284	-0.3556	0.239222
2450	-0.46228	-0.54864	-0.58928	-0.57912	-0.72136	-0.77216	-0.76708	-1.016	-1.18364	-0.52832	-0.37592	0.187498
2500	-0.46736	-0.53848	-0.58928	-0.57912	-0.6858	-0.762	-0.72644	-0.91948	-1.12268	-0.69596	-0.41656	0.149041
2550	-0.46736	-0.5334	-0.58928	-0.6096	-0.65024	-0.74168	-0.70104	-0.8382	-1.143	-0.85852	-0.35052	0.160209
2600	-0.46736	-0.57912	-0.5842	-0.59944	-0.61976	-0.73152	-0.6858	-1.19888	-1.19888	-0.9906	-0.35052	0.219742
2650	-0.46736	-0.57404	-0.5842	-0.59436	-0.60452	-0.71628	-0.85852	-1.14808	-1.22428	-1.0922	-0.3556	0.24258
2700	-0.47244	-0.56896	-0.6096	-0.58928	-0.58928	-0.79756	-0.81788	-1.0922	-1.22936	-1.21412	-0.36576	0.246779
2750	-0.47244	-0.56388	-0.6096	-0.5842	-0.74168	-0.7874	-0.77724	-1.03632	-1.21412	-0.54356	-0.381	0.191193
2800	-0.47752	-0.56388	-0.6096	-0.58928	-0.72644	-0.7874	-0.762	-0.99568	-1.1938	-0.61468	-0.40132	0.173728
2850	-0.4826	-0.56388	-0.6096	-0.59436	-0.7112	-0.7874	-0.74676	-0.9652	-1.1684	-0.69088	-0.41656	0.156766
2900	-0.48768	-0.56388	-0.6096	-0.64008	-0.70104	-0.78232	-0.73152	-0.93472	-1.143	-0.74676	-0.37592	0.151057
2950	-0.49276	-0.56388	-0.61468	-0.64008	-0.69596	-0.78232	-0.73152	-0.90932	-1.12776	-0.79248	-0.37084	0.15156
3000	-0.48768	-0.55372	-0.61468	-0.635	-0.6858	-0.77216	-0.72644	-0.889	-1.17856	-0.84328	-0.37084	0.160629
3050	-0.48768	-0.56388	-0.61468	-0.635	-0.6858	-0.78232	-0.72644	-0.88392	-1.1938	-0.86868	-0.37084	0.164323
3100	-0.48768	-0.55372	-0.61468	-0.64008	-0.6858	-0.78232	-0.72644	-0.87884	-1.19888	-0.889	-0.37592	0.166339
3150	-0.49276	-0.56388	-0.61468	-0.64008	-0.6858	-0.78232	-0.72644	-0.88392	-1.19888	-0.88392	-0.37592	0.165079
3200	-0.50292	-0.56896	-0.62484	-0.65024	-0.70104	-0.7874	-0.73152	-0.89916	-1.19888	-0.86868	-0.381	0.161468
3250	-0.50292	-0.56896	-0.62992	-0.65024	-0.70612	-0.79248	-0.74168	-0.9144	-1.18872	-0.84328	-0.381	0.160125
3300	-0.50292	-0.57404	-0.62992	-0.65532	-0.71628	-0.79756	-0.74676	-0.93472	-1.15316	-0.80264	-0.38608	0.153492
3350	-0.508	-0.57912	-0.62992	-0.65532	-0.71628	-0.79756	-0.74676	-0.93472	-1.15316	-0.82296	-0.38608	0.154667
3400	-0.508	-0.58928	-0.64008	-0.61976	-0.73152	-0.80772	-0.762	-0.97028	-1.1938	-0.762	-0.39116	0.159453
3450	-0.508	-0.59436	-0.64008	-0.61976	-0.75692	-0.81788	-0.78232	-1.02108	-1.23444	-0.67564	-0.42672	0.171125
3500	-0.50292	-0.59944	-0.64008	-0.62484	-0.77216	-0.82296	-0.80264	-1.06172	-1.26492	-0.61976	-0.41656	0.187246
3550	-0.508	-0.60452	-0.65024	-0.62484	-0.61468	-0.83312	-0.82804	-1.10236	-1.29032	-0.56388	-0.4064	0.206391
3600	-0.508	-0.61976	-0.65532	-0.62992	-0.635	-0.8382	-0.85852	-1.15824	-1.31064	-1.31572	-0.40132	0.258534
3650	-0.508	-0.62484	-0.635	-0.635	-0.65024	-0.762	-0.89916	-1.20396	-1.3208	-1.2192	-0.39116	0.259122
3700	-0.508	-0.635	-0.64008	-0.64516	-0.67056	-0.78232	-0.73152	-1.25476	-1.31064	-1.13792	-0.39116	0.241573
3750	-0.508	-0.64516	-0.64516	-0.65532	-0.69088	-0.79756	-0.74168	-0.85344	-1.2954	-1.0414	-0.39116	0.178598
3800	-0.51816	-0.59436	-0.65532	-0.67056	-0.71628	-0.8128	-0.75184	-0.9144	-1.25984	-0.92456	-0.39624	0.169025
3850	-0.52324	-0.60452	-0.65532	-0.62992	-0.75184	-0.82804	-0.77216	-0.98044	-1.2192	-0.80772	-0.4064	0.163316
3900	-0.51816	-0.61468	-0.6604	-0.635	-0.77724	-0.8382	-0.80264	-1.05156	-1.27508	-0.6858	-0.43688	0.177086
3950	-0.52324	-0.62484	-0.66548	-0.64008	-0.62992	-0.84328	-0.83312	-1.1176	-1.31064	-0.5842	-0.42164	0.204543
4000	-0.52324	-0.64008	-0.65024	-0.65024	-0.6604	-0.76708	-0.89408	-1.20396	-1.34112	-1.27508	-0.4064	0.261305
4050	-0.52324	-0.65024	-0.65532	-0.65532	-0.69088	-0.79756	-0.74676	-1.29032	-1.32588	-1.1176	-0.40132	0.23981
4100	-0.52324	-0.59944	-0.6604	-0.67564	-0.72644	-0.81788	-0.762	-0.9144	-1.29032	-0.9652	-0.4064	0.174231
4150	-0.52832	-0.61976	-0.67056	-0.64516	-0.76708	-0.84328	-0.7874	-1.016	-1.24968	-0.78232	-0.46736	0.159369
4200	-0.52832	-0.62484	-0.67056	-0.65024	-0.80772	-0.85852	-0.83312	-1.10744	-1.31572	-0.62484	-0.43688	0.195979
4250	-0.52324	-0.65024	-0.68072	-0.65532	-0.67056	-0.7874	-0.90932	-1.22428	-1.35128	-1.27508	-0.41656	0.260885
4300	-0.52832	-0.6604	-0.6604	-0.67056	-0.70612	-0.8128	-0.75692	-0.85344	-1.34112	-1.1176	-0.4064	0.187078
4350	-0.53848	-0.61976	-0.67564	-0.69596	-0.75692	-0.8382	-0.77724	-0.97028	-1.21412	-0.88392	-0.41656	0.158446
4400	-0.52832	-0.62992	-0.68072	-0.65024	-0.80264	-0.85852	-0.82804	-1.0922	-1.31064	-0.67056	-0.44704	0.187078
4450	-0.52832	-0.65024	-0.68072	-0.6604	-0.67056	-0.86868	-0.89408	-1.19888	-1.36144	-1.3462	-0.42164	0.26374
4500	-0.5334	-0.67056	-0.67564	-0.68072	-0.71628	-0.81788	-0.762	-0.87884	-1.34112	-1.08204	-0.41148	0.18246
4550	-0.53848	-0.62484	-0.68072	-0.65532	-0.77724	-0.85344	-0.79756	-1.02616	-1.26492	-0.79756	-0.47244	0.161217

4600	-0.5334	-0.64516	-0.6858	-0.6604	-0.65532	-0.86868	-0.85852	-1.14808	-1.3462	-0.59436	-0.43688	0.210001
4650	-0.53848	-0.66548	-0.67564	-0.67564	-0.70104	-0.8128	-0.762	-1.29032	-1.36652	-1.21412	-0.41656	0.251649
4700	-0.54864	-0.62484	-0.68072	-0.69596	-0.75692	-0.84328	-0.78232	-0.94996	-1.30556	-0.95504	-0.42164	0.17146
4750	-0.54356	-0.64516	-0.6858	-0.66548	-0.81788	-0.86868	-0.83312	-1.10744	-1.33096	-0.68072	-0.45212	0.18817
4800	-0.54356	-0.66548	-0.68072	-0.67564	-0.69596	-0.80772	-0.77216	-1.26492	-1.38176	-1.29032	-0.42164	0.259626
4850	-0.54356	-0.62484	-0.6858	-0.70104	-0.75692	-0.84328	-0.78232	-0.94996	-1.3208	-0.98552	-0.41656	0.176079
4900	-0.54356	-0.65024	-0.69088	-0.67056	-0.81788	-0.87376	-0.83312	-1.09728	-1.3208	-0.71628	-0.46228	0.181621
4950	-0.54356	-0.67056	-0.68072	-0.68072	-0.69596	-0.80772	-0.93472	-1.25984	-1.39192	-1.31064	-0.42672	0.268694
5000	-0.55372	-0.62992	-0.69088	-0.70612	-0.762	-0.85852	-0.79248	-0.9652	-1.32588	-0.98044	-0.42164	0.177086
5050	-0.54864	-0.65024	-0.69596	-0.67056	-0.81788	-0.87884	-0.83312	-1.10744	-1.33096	-0.7112	-0.46228	0.18372
5100	-0.54356	-0.67564	-0.6858	-0.6858	-0.70612	-0.8128	-0.77216	-1.28524	-1.39192	-1.28524	-0.42672	0.260717
5150	-0.55372	-0.64008	-0.69596	-0.72136	-0.77724	-0.85852	-0.79756	-0.99568	-1.2446	-0.91948	-0.42672	0.162308
5200	-0.54864	-0.6604	-0.70104	-0.67564	-0.84328	-0.88392	-0.87376	-1.16332	-1.3716	-0.62484	-0.44704	0.207062
5250	-0.55372	-0.69088	-0.69088	-0.69596	-0.73152	-0.8382	-0.77724	-1.3462	-1.39192	-1.17348	-0.42672	0.249214
5300	-0.55372	-0.65024	-0.70104	-0.67564	-0.80772	-0.87376	-0.81788	-1.05664	-1.2954	-0.81788	-0.49276	0.163736
5350	-0.54864	-0.67564	-0.70104	-0.6858	-0.69596	-0.80772	-0.92456	-1.23952	-1.40208	-1.39192	-0.43688	0.272725
5400	-0.55372	-0.635	-0.69596	-0.70612	-0.75692	-0.85852	-0.79248	-0.9398	-1.36652	-1.06172	-0.42672	0.187078
5450	-0.55372	-0.6604	-0.70612	-0.68072	-0.83312	-0.889	-0.84836	-1.12268	-1.3462	-0.71628	-0.47244	0.186575
5500	-0.55372	-0.6858	-0.69596	-0.69596	-0.71628	-0.82804	-0.78232	-1.30048	-1.41732	-1.2954	-0.43688	0.263152
5550	-0.56388	-0.65024	-0.70104	-0.68072	-0.79756	-0.87884	-0.8128	-1.02616	-1.28016	-0.89916	-0.51816	0.162392
5600	-0.5588	-0.68072	-0.7112	-0.6858	-0.69088	-0.89408	-0.90932	-1.2192	-1.40208	-1.45796	-0.44704	0.271465
5650	-0.56388	-0.64516	-0.70612	-0.7112	-0.76708	-0.8636	-0.79756	-0.9398	-1.38176	-1.08204	-0.43688	0.18775
5700	-0.56388	-0.67056	-0.7112	-0.6858	-0.84328	-0.89408	-0.85852	-1.143	-1.3716	-0.7112	-0.47244	0.191529
5750	-0.56388	-0.69596	-0.70612	-0.70612	-0.74168	-0.84836	-0.79248	-1.3462	-1.41732	-1.22936	-0.43688	0.255679
5800	-0.56896	-0.67056	-0.7112	-0.6858	-0.83312	-0.89408	-0.84328	-1.10744	-1.3462	-0.78232	-0.48768	0.175407
5850	-0.56388	-0.69596	-0.70612	-0.70612	-0.73152	-0.84328	-0.79248	-1.33096	-1.4224	-1.28524	-0.43688	0.262481
5900	-0.56896	-0.66548	-0.71628	-0.6858	-0.82804	-0.889	-0.83312	-1.08204	-1.33096	-0.82296	-0.49784	0.167346
5950	-0.56896	-0.69596	-0.70612	-0.70612	-0.73152	-0.8382	-0.97536	-1.31064	-1.43256	-1.3208	-0.44704	0.272725
6000	-0.57404	-0.66548	-0.71628	-0.69596	-0.8128	-0.889	-0.82804	-1.04648	-1.30556	-0.89916	-0.52324	0.163148
6050	-0.56896	-0.69596	-0.72644	-0.70104	-0.70612	-0.90932	-0.92964	-1.25476	-1.4224	-1.44272	-0.4572	0.272305
6100	-0.57912	-0.6604	-0.71628	-0.73152	-0.7874	-0.88392	-0.8128	-0.9906	-1.37668	-1.02616	-0.44704	0.181872
6150	-0.56896	-0.69088	-0.72644	-0.70104	-0.69596	-0.90932	-0.89916	-1.20904	-1.41224	-1.53416	-0.46736	0.273228
6200	-0.57404	-0.65532	-0.71628	-0.72644	-0.77724	-0.87376	-0.80264	-0.94996	-1.41732	-1.13284	-0.44704	0.195391
6250	-0.57404	-0.6858	-0.72644	-0.70104	-0.8636	-0.90932	-0.87884	-1.17348	-1.397	-0.70104	-0.47752	0.198414
6300	-0.57404	-0.72136	-0.71628	-0.72644	-0.76708	-0.86868	-0.80264	-0.91948	-1.42748	-1.18364	-0.44704	0.194635
6350	-0.57912	-0.69088	-0.72644	-0.70104	-0.85852	-0.90932	-0.87376	-1.14808	-1.38684	-0.74168	-0.48768	0.188842
6400	-0.57404	-0.71628	-0.71628	-0.72644	-0.76708	-0.86868	-0.80264	-0.91948	-1.43764	-1.20396	-0.44704	0.198498
6450	-0.57912	-0.69088	-0.72644	-0.70612	-0.8636	-0.90932	-0.87376	-1.15824	-1.39192	-0.74168	-0.48768	0.190437
6500	-0.57912	-0.6604	-0.72644	-0.72644	-0.77724	-0.87376	-0.80264	-1.41224	-1.43256	-1.1938	-0.44704	0.256687
6550	-0.57912	-0.69088	-0.73152	-0.7112	-0.86868	-0.90932	-0.88392	-1.17348	-1.40208	-0.71628	-0.48768	0.195727
6600	-0.5842	-0.66548	-0.72644	-0.7366	-0.7874	-0.88392	-0.8128	-0.94996	-1.4224	-1.14808	-0.44704	0.194887
6650	-0.57912	-0.69596	-0.7366	-0.7112	-0.7112	-0.9144	-0.90932	-1.21412	-1.4224	-1.55956	-0.47244	0.274152
6700	-0.59436	-0.67564	-0.73152	-0.75184	-0.8128	-0.89408	-0.82296	-1.00584	-1.40208	-1.04648	-0.45212	0.183048
6750	-0.5842	-0.70612	-0.7366	-0.72136	-0.73152	-0.91948	-0.94488	-1.26492	-1.4478	-1.48844	-0.46736	0.275328
6800	-0.59436	-0.6858	-0.7366	-0.75692	-0.82804	-0.90424	-0.82804	-1.04648	-1.36652	-0.9652	-0.46228	0.172048
6850	-0.5842	-0.72136	-0.7366	-0.72644	-0.74676	-0.85852	-0.98044	-1.31572	-1.46304	-1.41224	-0.46228	0.278602
6900	-0.59436	-0.69088	-0.7366	-0.77724	-0.85344	-0.9144	-0.85344	-1.09728	-1.36144	-0.88392	-0.52832	0.162896
6950	-0.5842	-0.72644	-0.73152	-0.7366	-0.76708	-0.87376	-0.81788	-1.38176	-1.46812	-1.30556	-0.46228	0.266847
7000	-0.5842	-0.69596	-0.74168	-0.72136	-0.87376	-0.91948	-0.889	-1.17348	-1.41224	-0.76708	-0.49784	0.191193
7050	-0.59436	-0.7366	-0.7366	-0.75184	-0.80264	-0.889	-0.82296	-0.97028	-1.4478	-1.16332	-0.46228	0.192788
7100	-0.59436	-0.71628	-0.74168	-0.72136	-0.73152	-0.92964	-0.9398	-1.26492	-1.45796	-1.52908	-0.47752	0.277931

7150	-0.59944	-0.69596	-0.74168	-0.76708	-0.83312	-0.9144	-0.84328	-1.06172	-1.32588	-0.98044	-0.47244	0.16869
7200	-0.59436	-0.73152	-0.7366	-0.7366	-0.762	-0.87376	-0.81788	-1.36144	-1.48336	-1.36144	-0.46736	0.272557
7250	-0.59436	-0.70104	-0.74168	-0.72136	-0.87884	-0.92456	-0.88392	-1.16332	-1.41224	-0.79248	-0.51308	0.186071
7300	-0.59436	-0.67564	-0.7366	-0.75184	-0.80264	-0.89408	-0.82804	-0.9652	-1.45796	-1.18364	-0.46228	0.200009
7350	-0.59436	-0.72136	-0.75184	-0.73152	-0.7366	-0.92964	-0.94488	-1.26492	-1.46304	-1.54432	-0.48768	0.277091
7400	-0.59944	-0.69596	-0.74168	-0.72136	-0.85344	-0.91948	-0.85852	-1.0922	-1.35128	-0.9398	-0.54864	0.169109
7450	-0.59944	-0.74168	-0.74168	-0.74168	-0.78232	-0.889	-0.82296	-0.90932	-1.47828	-1.31572	-0.46736	0.207566
7500	-0.59944	-0.71628	-0.75184	-0.72644	-0.72136	-0.9398	-0.90932	-1.21412	-1.4478	-0.7366	-0.49784	0.207902
7550	-0.6096	-0.69596	-0.75184	-0.762	-0.82804	-0.9144	-0.83312	-1.02108	-1.4224	-1.07696	-0.46736	0.185987
7600	-0.59436	-0.73152	-0.7366	-0.7366	-0.75692	-0.86868	-0.82804	-1.32588	-1.48844	-1.4478	-0.47244	0.279694
7650	-0.59944	-0.70612	-0.75184	-0.72644	-0.8636	-0.92456	-0.87376	-1.12268	-1.38176	-0.89408	-0.53848	0.171377
7700	-0.59944	-0.74676	-0.74168	-0.762	-0.80264	-0.89916	-0.83312	-0.94996	-1.47828	-1.25476	-0.47244	0.20236
7750	-0.59944	-0.72136	-0.75692	-0.7366	-0.74168	-0.9398	-0.92964	-1.24968	-1.46812	-1.59004	-0.49784	0.277679
7800	-0.6096	-0.70104	-0.75184	-0.78232	-0.85344	-0.91948	-0.85344	-1.0668	-1.33096	-1.02108	-0.47752	0.170117
7850	-0.60452	-0.74676	-0.74168	-0.74676	-0.77724	-0.88392	-0.82804	-1.3716	-1.48844	-1.37668	-0.47244	0.272557
7900	-0.60452	-0.72136	-0.75692	-0.73152	-0.89916	-0.9398	-0.89916	-1.19888	-1.43764	-0.76708	-0.51308	0.194635
7950	-0.60452	-0.69596	-0.75184	-0.77724	-0.83312	-0.91948	-0.84328	-1.01092	-1.4478	-1.1176	-0.47244	0.191025
8000	-0.60452	-0.7366	-0.762	-0.75184	-0.76708	-0.87376	-0.9906	-1.33096	-1.48844	-1.4732	-0.48768	0.281793
8050	-0.6096	-0.72136	-0.75692	-0.73152	-0.87884	-0.9398	-0.87884	-1.143	-1.40208	-0.87376	-0.53848	0.172468
8100	-0.6096	-0.75184	-0.75692	-0.762	-0.8128	-0.90932	-0.83312	-0.94996	-1.47828	-1.25476	-0.47244	0.200849
8150	-0.6096	-0.7366	-0.762	-0.74676	-0.74676	-0.9398	-0.93472	-1.25984	-1.4732	-1.6002	-0.49784	0.277259
8200	-0.61976	-0.71628	-0.762	-0.78232	-0.85344	-0.92964	-0.85344	-1.06172	-1.4224	-1.04648	-0.47752	0.181201
8250	-0.6096	-0.75184	-0.75692	-0.75692	-0.7874	-0.889	-0.84328	-1.3716	-1.4986	-1.41224	-0.48768	0.274572
8300	-0.61976	-0.73152	-0.76708	-0.74168	-0.89916	-0.94488	-0.89916	-1.18364	-1.43256	-0.81788	-0.52832	0.183888
8350	-0.61976	-0.69596	-0.75692	-0.77724	-0.82804	-0.9144	-0.84328	-0.9906	-1.47828	-1.1938	-0.47752	0.199086
8400	-0.6096	-0.74676	-0.76708	-0.75184	-0.762	-0.86868	-0.9652	-1.30048	-1.49352	-1.55448	-0.49276	0.284312
8450	-0.61976	-0.72136	-0.76708	-0.7366	-0.86868	-0.9398	-0.86868	-1.10744	-1.37668	-0.9652	-0.56388	0.16827
8500	-0.61976	-0.762	-0.75692	-0.76708	-0.80264	-0.90424	-0.84328	-1.40208	-1.50876	-1.36652	-0.48768	0.270877
8550	-0.61976	-0.7366	-0.76708	-0.74676	-0.9144	-0.95504	-0.90932	-1.20904	-1.4478	-0.79248	-0.51816	0.193544
8600	-0.61976	-0.71628	-0.76708	-0.78232	-0.84328	-0.92964	-0.85344	-1.02108	-1.4732	-1.14808	-0.47752	0.194467
8650	-0.61976	-0.75184	-0.77216	-0.75692	-0.77724	-0.889	-0.9906	-1.34112	-1.51384	-1.50368	-0.49276	0.284396
8700	-0.62484	-0.73152	-0.77216	-0.75184	-0.889	-0.95504	-0.88392	-1.15824	-1.4224	-0.89916	-0.54864	0.172972
8750	-0.61976	-0.70612	-0.76708	-0.77724	-0.82804	-0.91948	-0.85344	-0.96012	-1.51384	-1.28524	-0.48768	0.208154
8800	-0.61976	-0.74676	-0.77724	-0.75692	-0.92964	-0.9652	-0.9398	-1.25984	-1.48844	-0.7366	-0.51308	0.210673
8850	-0.62992	-0.72136	-0.77216	-0.79248	-0.85852	-0.9398	-0.85852	-1.05664	-1.45288	-1.0922	-0.48768	0.18691
8900	-0.61976	-0.762	-0.77724	-0.762	-0.7874	-0.889	-1.00076	-1.3462	-1.51384	-1.48844	-0.49276	0.282381
8950	-0.62484	-0.7366	-0.77724	-0.75184	-0.89916	-0.95504	-0.89916	-1.15824	-1.4224	-0.90932	-0.54864	0.174903
9000	-0.61976	-0.77216	-0.76708	-0.77724	-0.81788	-0.9144	-0.85344	-0.94996	-1.51384	-1.3208	-0.48768	0.206811
9050	-0.61976	-0.74676	-0.78232	-0.762	-0.75692	-0.9652	-0.9398	-1.25476	-1.48844	-1.65608	-0.51816	0.281793
9100	-0.635	-0.72136	-0.77724	-0.80264	-0.8636	-0.9398	-0.86868	-1.06172	-1.46304	-1.09728	-0.49276	0.186575
9150	-0.62484	-0.76708	-0.76708	-0.77216	-0.79248	-0.90424	-0.85344	-1.36652	-1.52908	-1.48844	-0.49276	0.283472
9200	-0.62992	-0.74168	-0.78232	-0.75692	-0.90424	-0.9652	-0.89916	-1.16332	-1.43256	-0.91948	-0.5588	0.175239
9250	-0.62992	-0.77724	-0.77724	-0.78232	-0.82804	-0.92964	-0.85852	-0.94488	-1.524	-1.34112	-0.49276	0.208154
9300	-0.62992	-0.75184	-0.7874	-0.762	-0.93472	-0.97028	-0.92964	-1.23952	-1.48336	-0.78232	-0.52832	0.200597
9350	-0.635	-0.72136	-0.78232	-0.79756	-0.85852	-0.94488	-0.85852	-1.02616	-1.49352	-1.18872	-0.49276	0.198162
9400	-0.62484	-0.76708	-0.7874	-0.76708	-0.7874	-0.97028	-0.9906	-1.33604	-1.51892	-1.55956	-0.50292	0.282129
9450	-0.635	-0.74168	-0.7874	-0.82296	-0.89408	-0.9652	-0.88392	-1.12268	-1.397	-0.99568	-0.50292	0.171544
9500	-0.635	-0.7874	-0.78232	-0.78232	-0.81788	-0.92456	-0.85852	-1.4224	-1.52908	-1.40716	-0.49276	0.274824
9550	-0.635	-0.75184	-0.79248	-0.762	-0.92964	-0.97028	-0.92456	-1.2192	-1.46304	-0.83312	-0.54356	0.189261
9600	-0.635	-0.79248	-0.78232	-0.79756	-0.85344	-0.9398	-0.86868	-1.01092	-1.51384	-1.2446	-0.49276	0.199589
9650	-0.635	-0.76708	-0.79248	-0.77724	-0.78232	-0.97028	-0.97536	-1.30556	-1.51384	-1.61544	-0.51816	0.279694

9700	-0.635	-0.7366	-0.79248	-0.81788	-0.88392	-0.95504	-0.88392	-1.08712	-1.46812	-1.08204	-0.50292	0.184056
9750	-0.635	-0.77724	-0.78232	-0.78232	-0.8128	-0.9144	-1.02616	-1.38176	-1.53416	-1.48844	-0.50292	0.28406
9800	-0.635	-0.75184	-0.79248	-0.77216	-0.9144	-0.97028	-0.90932	-1.18364	-1.4478	-0.90932	-0.56388	0.174903
9850	-0.635	-0.79248	-0.7874	-0.79756	-0.84328	-0.9398	-0.86868	-0.97536	-1.53416	-1.31572	-0.49784	0.206055
9900	-0.635	-0.762	-0.79756	-0.77724	-0.9398	-0.98044	-0.94488	-1.25984	-1.4986	-0.7874	-0.5334	0.202948
9950	-0.64008	-0.7366	-0.79248	-0.80772	-0.86868	-0.95504	-0.87376	-1.04648	-1.4986	-1.17348	-0.49784	0.195811
10000	-0.635	-0.77724	-0.79756	-0.78232	-0.79756	-0.90932	-0.99568	-1.34112	-1.52908	-1.57988	-0.51816	0.285152
10050	-0.65024	-0.75184	-0.79756	-0.83312	-0.90932	-0.97028	-0.89916	-1.143	-1.41224	-1.01092	-0.58928	0.166422
10100	-0.64008	-0.79248	-0.79248	-0.79756	-0.83312	-0.93472	-0.87376	-1.43764	-1.54432	-1.41732	-0.50292	0.275915
10150	-0.64008	-0.762	-0.80264	-0.78232	-0.9398	-0.98044	-0.93472	-1.22936	-1.48844	-0.84328	-0.54864	0.190773
10200	-0.64516	-0.7366	-0.79248	-0.80772	-0.8636	-0.95504	-0.87376	-1.01092	-1.52908	-1.27	-0.50292	0.206055
10250	-0.64008	-0.77724	-0.80772	-0.78232	-0.79248	-0.98552	-0.98044	-1.3208	-1.53416	-1.64084	-0.52832	0.28322
10300	-0.65024	-0.74676	-0.80264	-0.82296	-0.889	-0.97028	-0.889	-1.0922	-1.37668	-1.1176	-0.50292	0.176582
10350	-0.64516	-0.79248	-0.80772	-0.79248	-0.81788	-0.92456	-0.87376	-1.38684	-1.5494	-1.53924	-0.51816	0.285739
10400	-0.65532	-0.762	-0.80772	-0.8382	-0.90932	-0.98044	-0.89916	-1.13284	-1.41732	-1.05156	-0.6096	0.167766
10450	-0.65024	-0.79248	-0.79756	-0.79756	-0.82804	-0.93472	-1.04648	-1.41224	-1.55956	-1.50368	-0.51816	0.287251
10500	-0.65532	-0.76708	-0.80772	-0.78232	-0.92964	-0.98552	-0.91948	-1.18364	-1.45288	-0.96012	-0.5842	0.174819
10550	-0.65024	-0.80264	-0.80264	-0.80772	-0.84328	-0.94488	-0.87884	-1.45796	-1.55956	-1.43256	-0.51308	0.278854
10600	-0.65024	-0.77724	-0.80772	-0.7874	-0.94996	-0.9906	-0.9398	-1.23444	-1.48844	-0.87884	-0.56388	0.186659
10650	-0.65024	-0.80772	-0.80772	-0.81788	-0.86868	-0.9652	-0.88392	-1.00584	-1.54432	-1.3208	-0.51308	0.205887
10700	-0.65024	-0.77724	-0.8128	-0.79248	-0.96012	-0.99568	-0.95504	-1.27	-1.51384	-0.81788	-0.54864	0.201185
10750	-0.65532	-0.75184	-0.80772	-0.82296	-0.87884	-0.9652	-0.88392	-1.03124	-1.53924	-1.27	-0.51308	0.204711
10800	-0.65024	-0.7874	-0.8128	-0.79756	-0.97536	-1.00076	-0.97028	-1.2954	-1.52908	-0.78232	-0.54864	0.210421
10850	-0.66548	-0.75184	-0.80772	-0.82804	-0.889	-0.97028	-0.89408	-1.06172	-1.524	-1.21412	-0.51308	0.198246
10900	-0.65024	-0.79248	-0.81788	-0.80264	-0.8128	-1.00076	-1.00076	-1.3462	-1.55956	-1.63068	-0.5334	0.283976
10950	-0.67056	-0.762	-0.8128	-0.84328	-0.90932	-0.98552	-0.89916	-1.10236	-1.50368	-1.13792	-0.51816	0.189178
11000	-0.65532	-0.79756	-0.81788	-0.80264	-0.81788	-0.92964	-1.016	-1.36652	-1.55956	-1.59512	-0.5334	0.286663
11050	-0.6604	-0.762	-0.8128	-0.84328	-0.90932	-0.98552	-0.90424	-1.10744	-1.40208	-1.13284	-0.51816	0.177758
11100	-0.65532	-0.79756	-0.82296	-0.80772	-0.82804	-1.00076	-1.02108	-1.38176	-1.56972	-1.59512	-0.52832	0.28448
11150	-0.66548	-0.76708	-0.81788	-0.85344	-0.9144	-0.98552	-0.90932	-1.12268	-1.49352	-1.10744	-0.635	0.177086
11200	-0.65532	-0.80264	-0.82804	-0.8128	-0.82804	-0.93472	-1.03124	-1.38684	-1.56972	-1.57988	-0.52832	0.287839
11250	-0.66548	-0.77216	-0.81788	-0.85344	-0.91948	-0.9906	-0.90932	-1.12268	-1.4224	-1.10744	-0.52324	0.176331
11300	-0.65532	-0.80264	-0.80772	-0.80772	-0.82804	-0.93472	-1.02616	-1.38684	-1.56972	-1.57988	-0.52832	0.28893
11350	-0.67056	-0.77216	-0.81788	-0.84836	-0.9144	-0.98552	-0.90424	-1.1176	-1.40208	-1.13284	-0.51816	0.176582
11400	-0.65532	-0.80264	-0.82804	-0.80772	-0.82804	-0.93472	-1.02616	-1.38176	-1.56464	-1.60528	-0.5334	0.289014
11450	-0.67056	-0.77216	-0.81788	-0.85344	-0.91948	-0.9906	-0.90932	-1.1176	-1.40208	-1.13792	-0.52324	0.176415
11500	-0.6604	-0.80264	-0.82804	-0.81788	-0.83312	-1.01092	-1.03632	-1.38176	-1.56972	-1.60528	-0.53848	0.284648
11550	-0.66548	-0.77216	-0.82296	-0.85852	-0.92456	-0.99568	-0.91948	-1.13284	-1.4224	-1.10744	-0.52832	0.176247
11600	-0.65532	-0.80772	-0.82804	-0.81788	-0.83312	-0.9398	-1.0414	-1.397	-1.5748	-1.58496	-0.5334	0.289686
11650	-0.67056	-0.77216	-0.82296	-0.85852	-0.92964	-0.99568	-0.91948	-1.13792	-1.43256	-1.09728	-0.52832	0.176834
11700	-0.66548	-0.8128	-0.82804	-0.81788	-0.84328	-0.94488	-1.05156	-1.41224	-1.5748	-1.55956	-0.5334	0.287671
11750	-0.67564	-0.7874	-0.82804	-0.86868	-0.9398	-1.00584	-0.92456	-1.17348	-1.45288	-1.05156	-0.52832	0.176499
11800	-0.66548	-0.81788	-0.81788	-0.82296	-0.85852	-0.96012	-0.89916	-1.43764	-1.5748	-1.52908	-0.52832	0.284648
11850	-0.67564	-0.7874	-0.82804	-0.80772	-0.94488	-1.00584	-0.92964	-1.17856	-1.45796	-1.0414	-0.61976	0.174063
11900	-0.66548	-0.81788	-0.82296	-0.83312	-0.85344	-0.95504	-0.90424	-1.42748	-1.58496	-1.55448	-0.53848	0.286999
11950	-0.67564	-0.7874	-0.82804	-0.87376	-0.9398	-1.00584	-0.92964	-1.16332	-1.4478	-1.07696	-0.5334	0.176247
12000	-0.67056	-0.82296	-0.8382	-0.82804	-0.85344	-0.95504	-1.05664	-1.4224	-1.58496	-1.55956	-0.53848	0.286579
12050	-0.67564	-0.7874	-0.83312	-0.8128	-0.94488	-1.01092	-0.92964	-1.17348	-1.46304	-1.05664	-0.61976	0.175239
12100	-0.67056	-0.82296	-0.82804	-0.82804	-0.85344	-0.95504	-1.05664	-1.43256	-1.59004	-1.55956	-0.53848	0.289014
12150	-0.68072	-0.7874	-0.83312	-0.86868	-0.9398	-1.00584	-0.92456	-1.15824	-1.4986	-1.10236	-0.64008	0.176163
12200	-0.67564	-0.82296	-0.8382	-0.83312	-0.85344	-1.02108	-1.05156	-1.41224	-1.58496	-1.59512	-0.54356	0.283556

12250	-0.68072	-0.7874	-0.83312	-0.86868	-0.93472	-1.00584	-0.92456	-1.13792	-1.4224	-1.143	-0.5334	0.177254
12300	-0.67564	-0.82296	-0.84328	-0.83312	-0.84328	-0.95504	-1.0414	-1.397	-1.58496	-1.6256	-0.54864	0.28851
12350	-0.68072	-0.7874	-0.8382	-0.86868	-0.92964	-1.00584	-0.92456	-1.12268	-1.53416	-1.17348	-0.5334	0.19178
12400	-0.67564	-0.81788	-0.8382	-0.82296	-0.8382	-1.02108	-1.02616	-1.38176	-1.58496	-1.65608	-0.54864	0.286159
12450	-0.69088	-0.7874	-0.8382	-0.86868	-0.92964	-1.00584	-0.92456	-1.10744	-1.5494	-1.20904	-0.5334	0.195223
12500	-0.67564	-0.81788	-0.84328	-0.82804	-0.83312	-1.02616	-1.016	-1.3462	-1.5748	-1.7018	-0.56388	0.284816
12550	-0.68072	-0.77724	-0.8382	-0.85344	-0.9144	-1.00584	-0.91948	-1.08712	-1.55956	-1.25984	-0.5334	0.20362
12600	-0.68072	-0.81788	-0.84328	-0.82804	-0.83312	-1.02616	-1.00076	-1.33604	-1.56972	-1.73736	-0.56896	0.287503
12650	-0.67564	-0.77724	-0.8382	-0.8636	-0.9144	-1.00076	-0.92456	-1.07188	-1.5748	-1.30048	-0.53848	0.206727
12700	-0.68072	-0.81788	-0.84836	-0.82804	-1.00076	-1.03124	-0.99568	-1.31572	-1.55956	-0.84328	-0.57404	0.205887
12750	-0.68072	-0.84836	-0.8382	-0.85344	-0.90424	-0.99568	-0.91948	-1.03632	-1.59004	-1.38176	-0.53848	0.209833
12800	-0.68072	-0.80772	-0.84836	-0.83312	-0.9906	-1.03632	-0.98044	-1.28016	-1.53924	-0.92456	-0.59436	0.190353
12850	-0.67564	-0.84328	-0.8382	-0.85344	-0.889	-0.98552	-0.91948	-1.50876	-1.60528	-1.45796	-0.54356	0.279862
12900	-0.68072	-0.80264	-0.84836	-0.82804	-0.97028	-1.02616	-0.95504	-1.2192	-1.51384	-1.01092	-0.61976	0.178514
12950	-0.68072	-0.8382	-0.8382	-0.84328	-0.86868	-0.98044	-1.08204	-1.45796	-1.60528	-1.56464	-0.54864	0.290526
13000	-0.69596	-0.79756	-0.84836	-0.87884	-0.95504	-1.02108	-0.9398	-1.15824	-1.53924	-1.14808	-0.54356	0.188926
13050	-0.67564	-0.82804	-0.85344	-0.8382	-0.85344	-1.03632	-1.0414	-1.38684	-1.59512	-1.68148	-0.56388	0.287335
13100	-0.68072	-0.7874	-0.84836	-0.86868	-0.92456	-1.01092	-0.92456	-1.08204	-1.58496	-1.2954	-0.54356	0.206643
13150	-0.6858	-0.82296	-0.85344	-0.83312	-1.01092	-1.03632	-0.99568	-1.31572	-1.56464	-0.87884	-0.58928	0.202024
13200	-0.6858	-0.84836	-0.84836	-0.85344	-0.90424	-0.99568	-0.91948	-1.53924	-1.60528	-1.43256	-0.54356	0.278015
13250	-0.69088	-0.81788	-0.85344	-0.83312	-0.98552	-1.03632	-0.97536	-1.26492	-1.53416	-0.96012	-0.6096	0.181033
13300	-0.68072	-0.84836	-0.84836	-0.85852	-0.89408	-0.99568	-0.92456	-1.51892	-1.61544	-1.46812	-0.54864	0.281373
13350	-0.69088	-0.81788	-0.85344	-0.8382	-0.98552	-1.0414	-0.97028	-1.25476	-1.53924	-0.9906	-0.61976	0.181621
13400	-0.6858	-0.84836	-0.85344	-0.85344	-0.889	-0.9906	-0.92456	-1.4986	-1.61544	-1.51384	-0.54864	0.284984
13450	-0.69596	-0.81788	-0.85852	-0.83312	-0.98044	-1.03632	-0.95504	-1.2192	-1.50368	-1.06172	-0.64008	0.178598
13500	-0.69088	-0.84836	-0.85344	-0.85344	-0.88392	-0.9906	-0.92964	-1.48336	-1.62052	-1.55448	-0.55372	0.28851
13550	-0.69596	-0.81788	-0.85852	-0.83312	-0.98044	-1.03632	-0.95504	-1.2192	-1.50876	-1.06172	-0.64008	0.179102
13600	-0.69596	-0.84836	-0.85344	-0.85852	-0.889	-0.99568	-0.92964	-1.47828	-1.62052	-1.56972	-0.5588	0.288594
13650	-0.69596	-0.8128	-0.85852	-0.8382	-0.97536	-1.03632	-0.96012	-1.21412	-1.4986	-1.08204	-0.64516	0.178262
13700	-0.6858	-0.84328	-0.8636	-0.85344	-0.87884	-0.98552	-0.92964	-1.45796	-1.6256	-1.59512	-0.56388	0.291197
13750	-0.70104	-0.8128	-0.8636	-0.83312	-0.97028	-1.03632	-0.94996	-1.17856	-1.4732	-1.143	-0.55372	0.185735
13800	-0.69596	-0.84328	-0.8636	-0.85344	-0.87376	-0.98044	-1.07188	-1.43764	-1.62052	-1.64592	-0.56896	0.292793
13850	-0.70104	-0.80772	-0.8636	-0.89408	-0.96012	-1.03632	-0.94996	-1.15824	-1.45796	-1.18872	-0.5588	0.180949
13900	-0.69088	-0.84328	-0.86868	-0.85344	-0.86868	-1.05156	-1.05664	-1.41732	-1.62052	-1.6764	-0.57404	0.288259
13950	-0.70104	-0.8128	-0.8636	-0.89408	-0.95504	-1.03632	-0.94488	-1.14808	-1.56972	-1.20904	-0.55372	0.195727
14000	-0.69596	-0.84836	-0.86868	-0.85344	-0.87376	-0.98552	-1.0668	-1.43256	-1.62052	-1.66624	-0.57404	0.292625
14050	-0.70612	-0.81788	-0.8636	-0.90424	-0.97028	-1.03632	-0.95504	-1.17856	-1.48336	-1.15824	-0.67056	0.172636
14100	-0.69596	-0.84836	-0.87376	-0.85852	-0.88392	-0.98552	-1.08204	-1.44272	-1.63068	-1.65608	-0.57404	0.29422
14150	-0.70104	-0.8128	-0.86868	-0.90424	-0.9652	-1.03632	-0.95504	-1.17348	-1.4732	-1.17348	-0.56388	0.180361
14200	-0.69596	-0.84836	-0.87376	-0.85852	-0.87884	-1.05156	-1.07188	-1.44272	-1.63068	-1.64592	-0.57404	0.287839
14250	-0.70612	-0.81788	-0.86868	-0.90424	-0.97028	-1.0414	-0.95504	-1.17348	-1.4732	-1.17348	-0.56388	0.180361
14300	-0.70104	-0.85852	-0.87376	-0.8636	-0.889	-0.99568	-1.0922	-1.46812	-1.63068	-1.61544	-0.57404	0.291281
14350	-0.70612	-0.82804	-0.87376	-0.84836	-0.98552	-1.05156	-0.9652	-1.20904	-1.50876	-1.1176	-0.66548	0.178514
14400	-0.70104	-0.8636	-0.87884	-0.86868	-0.89408	-1.00076	-1.10236	-1.48336	-1.64084	-1.60528	-0.56896	0.292877
14450	-0.70612	-0.82804	-0.87376	-0.90932	-0.98552	-1.05156	-0.97028	-1.2192	-1.51384	-1.11252	-0.6604	0.174483
14500	-0.70104	-0.85852	-0.8636	-0.86868	-0.89408	-1.00076	-0.94488	-1.4732	-1.63576	-1.61544	-0.57404	0.292205
14550	-0.7112	-0.82804	-0.86868	-0.90932	-0.98552	-1.05156	-0.9652	-1.19888	-1.49352	-1.15824	-0.56896	0.182964
14600	-0.70612	-0.85852	-0.87884	-0.8636	-0.88392	-0.99568	-1.07696	-1.44272	-1.63576	-1.66624	-0.57912	0.292373
14650	-0.7112	-0.82296	-0.87376	-0.90424	-0.98044	-1.04648	-0.96012	-1.18364	-1.56972	-1.18872	-0.56388	0.19262
14700	-0.70612	-0.8636	-0.87884	-0.86868	-0.88392	-0.99568	-1.07696	-1.45288	-1.63576	-1.66116	-0.57912	0.292289
14750	-0.71628	-0.82804	-0.87884	-0.90932	-0.98044	-1.05156	-0.96012	-1.18364	-1.56972	-1.18364	-0.56896	0.190941

14800	-0.70612	-0.8636	-0.87884	-0.86868	-0.889	-1.06172	-1.07696	-1.44272	-1.63576	-1.6764	-0.5842	0.287839
14850	-0.71628	-0.82804	-0.87884	-0.90932	-0.98044	-1.05156	-0.96012	-1.18872	-1.5748	-1.18364	-0.56896	0.192116
14900	-0.70612	-0.8636	-0.86868	-0.87376	-0.89408	-1.00076	-1.0922	-1.45796	-1.64592	-1.65608	-0.57912	0.294556
14950	-0.71628	-0.82804	-0.87884	-0.85344	-0.98552	-1.05664	-0.97028	-1.20904	-1.50368	-1.14808	-0.56896	0.187414
15000	-0.70612	-0.8636	-0.86868	-0.87884	-0.90932	-1.00584	-0.94996	-1.48844	-1.64592	-1.61036	-0.57912	0.292121
15050	-0.7112	-0.8382	-0.88392	-0.85852	-1.00076	-1.06172	-0.98044	-1.23444	-1.54432	-1.0922	-0.66548	0.180361
15100	-0.70612	-0.87376	-0.87884	-0.88392	-0.91948	-1.02108	-0.94996	-1.53416	-1.66116	-1.53924	-0.57404	0.28851
15150	-0.7112	-0.84328	-0.88392	-0.8636	-1.016	-1.0668	-1.00076	-1.30556	-1.58496	-0.97536	-0.635	0.186491
15200	-0.7112	-0.88392	-0.87884	-0.89408	-0.94488	-1.03632	-0.95504	-1.07188	-1.64592	-1.41224	-0.56896	0.211849
15250	-0.7112	-0.85344	-0.88392	-0.86868	-1.0414	-1.07188	-1.02616	-1.36144	-1.62052	-0.889	-0.61468	0.208658
15300	-0.72136	-0.82296	-0.88392	-0.90424	-0.96012	-1.05156	-0.95504	-1.1176	-1.6256	-1.33096	-0.56896	0.20849
15350	-0.71628	-0.8636	-0.889	-0.86868	-0.88392	-1.07188	-1.05156	-1.41224	-1.64084	-1.7526	-0.59944	0.291785
15400	-0.72136	-0.82804	-0.88392	-0.90932	-0.98044	-1.05664	-0.9652	-1.15824	-1.61036	-1.26492	-0.57404	0.201353
15450	-0.71628	-0.87376	-0.889	-0.87884	-0.89916	-1.01092	-1.08204	-1.45796	-1.651	-1.68656	-0.58928	0.292793
15500	-0.72136	-0.84328	-0.88392	-0.8636	-1.00076	-1.0668	-0.97536	-1.22428	-1.53416	-1.13792	-0.6858	0.180445
15550	-0.71628	-0.87884	-0.88392	-0.88392	-0.91948	-1.02108	-0.95504	-1.524	-1.66116	-1.57988	-0.57912	0.291029
15600	-0.72136	-0.84836	-0.889	-0.86868	-1.02616	-1.07188	-0.99568	-1.28016	-1.56972	-1.04648	-0.65532	0.183048
15650	-0.71628	-0.88392	-0.88392	-0.89916	-0.9398	-1.03632	-0.95504	-1.57988	-1.66116	-1.48844	-0.57404	0.283808
15700	-0.72136	-0.8636	-0.89408	-0.87376	-1.0414	-1.07188	-1.02616	-1.3462	-1.61036	-0.93472	-0.62484	0.198582
15750	-0.72136	-0.89916	-0.88392	-0.90932	-0.9652	-1.05156	-0.96012	-1.11252	-1.64592	-1.3716	-0.57404	0.208574
15800	-0.72136	-0.86868	-0.89408	-0.87884	-0.889	-1.07696	-1.05664	-1.41224	-1.64084	-1.778	-0.6096	0.292289
15850	-0.72644	-0.8382	-0.889	-0.92456	-0.98552	-1.06172	-0.97028	-1.17856	-1.49352	-1.22936	-0.57404	0.183636
15900	-0.72136	-0.87376	-0.89408	-0.889	-0.90932	-1.016	-1.09728	-1.4732	-1.66116	-1.68148	-0.59436	0.29422
15950	-0.72644	-0.84836	-0.889	-0.86868	-1.00584	-1.0668	-0.98044	-1.2192	-1.51892	-1.16332	-0.69088	0.178934
16000	-0.72136	-0.889	-0.889	-0.89408	-0.92964	-1.03124	-1.13792	-1.52908	-1.66116	-1.59512	-0.58928	0.292373
16050	-0.72136	-0.84836	-0.89916	-0.87884	-1.03124	-1.07696	-1.01092	-1.30556	-1.59004	-1.016	-0.65024	0.184559
16100	-0.72136	-0.82296	-0.889	-0.90932	-0.95504	-1.0414	-0.96012	-1.08712	-1.65608	-1.42748	-0.57912	0.217139
16150	-0.72136	-0.86868	-0.89916	-0.88392	-1.05664	-1.08204	-1.05156	-1.38684	-1.63068	-1.81864	-0.61976	0.283304
16200	-0.72644	-0.8382	-0.89408	-0.91948	-0.98044	-1.06172	-0.97028	-1.143	-1.64084	-1.33096	-0.57912	0.208322
16250	-0.72136	-0.87884	-0.89916	-0.889	-0.90424	-1.08204	-1.08204	-1.44272	-1.66116	-1.73736	-0.60452	0.290022
16300	-0.73152	-0.84836	-0.89408	-0.93472	-1.00584	-1.0668	-0.98044	-1.22428	-1.52908	-1.1684	-0.69596	0.174483
16350	-0.72136	-0.889	-0.89408	-0.89408	-0.93472	-1.03632	-0.9652	-1.53924	-1.67132	-1.58496	-0.58928	0.290778
16400	-0.72644	-0.8636	-0.89916	-0.87884	-1.03632	-1.08204	-1.016	-1.31572	-1.6002	-1.01092	-0.65532	0.184559
16450	-0.72644	-0.89916	-0.89408	-0.90932	-0.95504	-1.05156	-0.9652	-1.08204	-1.66116	-1.4478	-0.5842	0.214284
16500	-0.72644	-0.87376	-0.89916	-0.87884	-1.06172	-1.08204	-1.04648	-1.39192	-1.64084	-1.81864	-0.61976	0.285068
16550	-0.7366	-0.84328	-0.89916	-0.92456	-0.9906	-1.0668	-0.97536	-1.16332	-1.63068	-1.28524	-0.5842	0.201773
16600	-0.72136	-0.87884	-0.90424	-0.89408	-0.90932	-1.08204	-1.0922	-1.45796	-1.66624	-1.73228	-0.6096	0.291617
16650	-0.7366	-0.84836	-0.89916	-0.93472	-1.00584	-1.07696	-0.98044	-1.20396	-1.51384	-1.22428	-0.71628	0.175995
16700	-0.72644	-0.889	-0.90424	-0.89408	-0.92456	-1.03124	-1.12268	-1.50876	-1.6764	-1.65608	-0.59944	0.295396
16750	-0.7366	-0.85344	-0.89916	-0.87884	-1.016	-1.08204	-0.99568	-1.2446	-1.5494	-1.13792	-0.69088	0.180277
16800	-0.72644	-0.89916	-0.89916	-0.90424	-0.9398	-1.0414	-0.97028	-1.56464	-1.68656	-1.56972	-0.59436	0.291617
16850	-0.72644	-0.8636	-0.90424	-0.889	-1.0414	-1.08712	-1.02108	-1.3208	-1.60528	-1.01092	-0.65532	0.185231
16900	-0.72644	-0.82804	-0.89916	-0.91948	-0.96012	-1.05664	-0.97028	-1.08204	-1.6764	-1.48844	-0.58928	0.224024
16950	-0.73152	-0.87376	-0.90932	-0.89408	-1.0668	-1.0922	-1.0414	-1.3716	-1.63576	-0.93472	-0.64008	0.203788
17000	-0.7366	-0.84328	-0.89916	-0.92964	-0.98552	-1.0668	-0.97536	-1.13284	-1.66116	-1.3716	-0.58928	0.211429
17050	-0.73152	-0.889	-0.90932	-0.89916	-0.90932	-1.016	-1.07696	-1.44272	-1.66624	-1.778	-0.61468	0.296823
17100	-0.74676	-0.85852	-0.90932	-0.88392	-1.01092	-1.08204	-0.98552	-1.21412	-1.524	-1.2192	-0.58928	0.18901
17150	-0.72644	-0.89916	-0.89916	-0.90932	-0.9398	-1.0414	-0.97536	-1.53924	-1.69164	-1.63068	-0.59944	0.296235
17200	-0.7366	-0.8636	-0.90932	-0.89408	-1.03632	-1.08712	-1.01092	-1.29032	-1.59004	-1.07696	-0.67056	0.182796
17250	-0.7366	-0.9144	-0.90424	-0.91948	-0.96012	-1.05664	-0.97536	-1.0668	-1.6764	-1.51384	-0.58928	0.218146
17300	-0.7366	-0.88392	-0.9144	-0.89408	-1.0668	-1.0922	-1.03632	-1.36652	-1.63068	-0.95504	-0.64516	0.198498

17350	-0.73152	-0.84328	-0.90932	-0.93472	-0.98552	-1.0668	-0.98044	-1.13284	-1.66116	-1.38176	-0.58928	0.211597
17400	-0.73152	-0.889	-0.9144	-0.90932	-0.92456	-1.0922	-1.09728	-1.46304	-1.6764	-1.7526	-0.61468	0.291281
17450	-0.74676	-0.85852	-0.90932	-0.94996	-1.016	-1.08204	-0.9906	-1.21412	-1.61544	-1.23444	-0.58928	0.194719
17500	-0.7366	-0.89916	-0.90424	-0.90932	-0.9398	-1.0414	-0.98044	-1.53416	-1.68656	-1.64592	-0.60452	0.295648
17550	-0.74676	-0.87376	-0.9144	-0.89408	-1.0414	-1.0922	-1.016	-1.29032	-1.59004	-1.10744	-0.6858	0.183048
17600	-0.74168	-0.9144	-0.90932	-0.91948	-0.96012	-1.05664	-0.98044	-1.06172	-1.68656	-1.53416	-0.59944	0.219406
17650	-0.74168	-0.87884	-0.9144	-0.90424	-1.06172	-1.09728	-1.03632	-1.35636	-1.6256	-0.9906	-0.65532	0.192368
17700	-0.74676	-0.91948	-0.90932	-0.92964	-0.98552	-1.07188	-0.98044	-1.11252	-1.6764	-1.44272	-0.59436	0.212604
17750	-0.7366	-0.889	-0.92456	-0.90424	-0.90932	-1.09728	-1.0668	-1.41732	-1.66624	-0.89408	-0.64008	0.217222
17800	-0.75184	-0.8636	-0.9144	-0.94488	-1.01092	-1.08712	-0.9906	-1.18872	-1.50876	-1.2954	-0.59944	0.186071
17850	-0.7366	-0.89916	-0.90932	-0.90932	-0.93472	-1.03632	-1.12268	-1.50368	-1.69164	-1.71196	-0.61468	0.298335
17900	-0.75184	-0.87376	-0.91948	-0.96012	-1.03632	-1.0922	-1.00076	-1.25476	-1.55956	-1.18364	-0.59944	0.185651
17950	-0.74676	-0.90932	-0.90932	-0.91948	-0.95504	-1.05156	-1.15316	-1.5494	-1.69672	-1.64592	-0.6096	0.296067
18000	-0.74676	-0.87376	-0.91948	-0.89916	-1.0414	-1.09728	-1.016	-1.28524	-1.58496	-1.13284	-0.69596	0.183384
18050	-0.74676	-0.90932	-0.90932	-0.92456	-0.95504	-1.05664	-0.98552	-1.56464	-1.69672	-1.61036	-0.6096	0.292289
18100	-0.74676	-0.87884	-0.92456	-0.90424	-1.05156	-1.10236	-1.02616	-1.31572	-1.61544	-1.07188	-0.6858	0.183636
18150	-0.74676	-0.91948	-0.9144	-0.92456	-0.97536	-1.0668	-0.98044	-1.61036	-1.69672	-1.54432	-0.59944	0.288091
18200	-0.74676	-0.889	-0.92456	-0.90424	-1.0668	-1.10744	-1.03632	-1.3462	-1.63576	-1.02108	-0.67056	0.188002
18250	-0.74676	-0.91948	-0.9144	-0.93472	-0.98552	-1.07696	-0.98552	-1.10236	-1.69672	-1.48844	-0.59944	0.218314
18300	-0.74676	-0.89916	-0.92456	-0.90424	-1.08204	-1.10744	-1.05664	-1.41224	-1.66624	-0.92456	-0.64516	0.210337
18350	-0.75184	-0.8636	-0.92456	-0.94996	-1.01092	-1.0922	-0.99568	-1.18364	-1.66116	-1.33604	-0.59944	0.207062
18400	-0.74676	-0.90932	-0.92456	-0.91948	-0.9398	-1.0414	-1.1176	-1.50368	-1.69672	-1.7272	-0.61976	0.296067
18450	-0.75184	-0.87884	-0.92456	-0.90424	-1.0414	-1.10236	-1.01092	-1.28524	-1.58496	-1.14808	-0.70104	0.18372
18500	-0.75184	-0.92456	-0.92456	-0.92964	-0.97536	-1.07696	-0.9906	-1.61036	-1.69672	-1.55448	-0.60452	0.286915
18550	-0.74676	-0.89916	-0.92964	-0.90932	-0.90932	-1.11252	-1.05156	-1.39192	-1.651	-0.9652	-0.6604	0.204459
18600	-0.762	-0.8636	-0.92456	-0.94996	-1.00584	-1.0922	-0.99568	-1.16332	-1.66116	-1.3716	-0.59944	0.20849
18650	-0.74676	-0.90932	-0.92964	-0.91948	-0.9398	-1.0414	-1.10744	-1.49352	-1.68656	-1.7526	-0.62484	0.294808
18700	-0.75184	-0.87884	-0.92964	-0.90424	-1.0414	-1.10744	-1.01092	-1.27	-1.5748	-1.1684	-0.7112	0.18246
18750	-0.75184	-0.91948	-0.92456	-0.92456	-0.9652	-1.0668	-0.9906	-1.58496	-1.7018	-1.60528	-0.61468	0.291953
18800	-0.75184	-0.89408	-0.93472	-0.90932	-1.07188	-1.11252	-1.0414	-1.36144	-1.64084	-1.02108	-0.67056	0.189429
18850	-0.75184	-0.93472	-0.92456	-0.94996	-1.00584	-1.0922	-0.99568	-1.143	-1.68148	-1.41732	-0.60452	0.209414
18900	-0.75184	-0.9144	-0.93472	-0.91948	-0.92964	-1.03632	-1.09728	-1.4732	-1.68656	-1.78308	-0.635	0.295648
18950	-0.762	-0.87884	-0.92964	-0.97028	-1.0414	-1.10744	-1.01092	-1.25984	-1.56972	-1.19888	-0.72644	0.176415
19000	-0.75184	-0.91948	-0.92456	-0.93472	-0.9652	-1.0668	-0.99568	-1.56972	-1.71196	-1.63576	-0.61468	0.294556
19050	-0.75692	-0.89408	-0.93472	-0.91948	-1.07188	-1.11252	-1.0414	-1.35636	-1.63576	-1.0414	-0.67564	0.185315
19100	-0.75692	-0.93472	-0.92456	-0.95504	-1.00584	-1.0922	-0.99568	-1.13792	-1.69672	-1.4478	-0.6096	0.213108
19150	-0.75184	-0.9144	-0.93472	-0.92456	-0.9398	-1.0414	-1.10236	-1.4732	-1.69164	-1.79832	-0.64008	0.296823
19200	-0.76708	-0.87884	-0.92964	-0.97536	-1.03632	-1.10236	-1.01092	-1.23952	-1.5494	-1.24968	-0.6096	0.185231
19250	-0.75692	-0.91948	-0.92456	-0.93472	-0.96012	-1.06172	-0.99568	-1.55956	-1.71196	-1.66116	-0.61976	0.296571
19300	-0.762	-0.89408	-0.93472	-0.91948	-1.0668	-1.11252	-1.03124	-1.3208	-1.61544	-1.0922	-0.69088	0.183216
19350	-0.75692	-0.93472	-0.92964	-0.94996	-0.9906	-1.08204	-0.99568	-1.64084	-1.70688	-1.524	-0.6096	0.284732
19400	-0.75692	-0.90932	-0.9398	-0.92456	-1.09728	-1.11252	-1.07188	-1.41732	-1.67132	-1.87452	-0.65532	0.285991
19450	-0.76708	-0.87884	-0.93472	-0.9652	-1.02616	-1.09728	-1.00076	-1.19888	-1.66624	-1.33096	-0.6096	0.203704
19500	-0.75692	-0.91948	-0.9398	-0.93472	-0.95504	-1.11252	-1.13284	-1.524	-1.70688	-1.7272	-0.62484	0.291953
19550	-0.76708	-0.889	-0.93472	-0.91948	-1.05664	-1.11252	-1.02616	-1.30048	-1.6002	-1.143	-0.70104	0.1833
19600	-0.75692	-0.93472	-0.93472	-0.94996	-0.98552	-1.08204	-0.99568	-1.07696	-1.71196	-1.56972	-0.61468	0.221421
19650	-0.762	-0.89916	-0.9398	-0.92456	-1.08204	-1.11252	-1.04648	-1.36144	-1.64084	-1.0414	-0.67564	0.185903
19700	-0.762	-0.93472	-0.92964	-0.94996	-0.9906	-1.08204	-0.99568	-1.6256	-1.71196	-1.55956	-0.61468	0.287587
19750	-0.76708	-0.89916	-0.93472	-0.92456	-1.07696	-1.11252	-1.0414	-1.3462	-1.63576	-1.06172	-0.6858	0.184056
19800	-0.76708	-0.9398	-0.93472	-0.95504	-1.00076	-1.08712	-0.99568	-1.10744	-1.70688	-1.51384	-0.61468	0.216131
19850	-0.762	-0.9144	-0.9398	-0.92964	-1.10236	-1.11252	-1.07188	-1.41732	-1.67132	-0.94488	-0.65532	0.206979

19900	-0.762	-0.87376	-0.93472	-0.97028	-1.02616	-1.10236	-1.00076	-1.17856	-1.6764	-1.3716	-0.6096	0.208154
19950	-0.762	-0.91948	-0.94996	-0.93472	-0.95504	-1.05664	-1.12268	-1.4986	-1.7018	-1.76784	-0.635	0.293968
20000	-0.77216	-0.889	-0.9398	-0.98044	-1.0414	-1.10744	-1.01092	-1.23952	-1.64592	-1.26492	-0.61468	0.195223

APPENDIX II: COST AS PER ACTUAL EXPENDITURE

Manpower Civil

Ser	Description	Salary Per Month	Salary Per Day	%age	Total Amount
1	Snr Tn Engr	90,000	3,462	60%	2,077
2	Dy Manager	90,000	3,462	60%	2,077
3	QS	39,050	1,502	60%	901
4	QS	35,000	1,346	60%	808
5	AQS	28,400	1,092	60%	655
6	AQS	28,400	1,092	60%	655
7	AQS (FS-8)	30,000	1,154	60%	692
8	ePMS	22,500	865	60%	519
9	Engr	25,000	962	60%	577
10	Engr	30,000	1,154	60%	692
11	Asst Mngr (MS-5)	51,750	1,990	60%	1,194
12	Asst Mngr (MS-5)	50,750	1,952	60%	1,171
13	Site Engr	35,000	1,346	100%	1,346
14	Site Engr	35,000	1,346	100%	1,346
15	Site Engr	35,000	1,346	100%	1,346
16	Traniee Engr - Civ	35,000	1,346	60%	808
17	Mech Engr	25,000	962	60%	577
18	Mechatronics	25,000	962	60%	577
19	Mechatronics	25,000	962	60%	577
20	Acct (NMS-6)	36,660	1,410	60%	846
21	Acct (NMS-7)	36,550	1,406	60%	843
22	Acct (NMS-8)	22,500	865	60%	519
23	Auto Cad Op (FS-9)	24,850	956	60%	573
24	Auto Cad Op	25,000	962	60%	577
25	Auto Cad Op	18,000	692	60%	415
26	Auto Cad Op	28,400	1,092	60%	655
27	Cptr Op (NMS-9)	22,890	880	60%	528
28	DAE Civ	15,000	577	60%	346
29	DAE Civ	15,000	577	60%	346
30	DAE Civ	15,000	577	60%	346
31	DAE Civ	15,000	577	60%	346
32	DAE Elec	15,000	577	60%	346
33	DAE Mech	15,000	577	60%	346
34	DAE Mech	15,000	577	60%	346
35	DAE QS	15,000	577	60%	346
36	CME	49,700	1,912	60%	1,147
37	AME	39,050	1,502	60%	901
38	AME	39,050	1,502	60%	901

39	SLT	36,000	1,385	100%	1,385
40	LT Gd I	30,000	1,154	100%	1,154
41	LT Gd I	30,000	1,154	100%	1,154
42	LT Gd I	30,000	1,154	60%	692
43	LT Gd I	30,000	1,154	60%	692
44	LT Gd I	30,000	1,154	60%	692
45	LT Gd II	25,000	962	60%	577
46	LT Gd II	25,000	962	60%	577
47	LT Gd III	22,000	846	60%	508
48	LT Gd III	22,000	846	60%	508
49	LT Gd III	22,000	846	60%	508
50	LT Gd III	22,000	846	60%	508
51	LT Gd III	22,000	846	60%	508
52	LT Gd III	22,000	846	60%	508
53	LT Gd III	22,000	846	60%	508
54	LT Gd III	22,000	846	60%	508
55	LT Gd III	22,000	846	60%	508
56	LT Gd III	22,000	846	60%	508
57	LT Gd III	22,000	846	60%	508
58	LT Gd III	22,000	846	60%	508
59	Svy Gd I	36,300	1,396	100%	1,396
60	Svy Gd I	36,300	1,396	100%	1,396
61	Svy Gd I	36,300	1,396	60%	838
62	Svy Gd II	28,000	1,077	100%	1,077
63	Svy Gd II	28,000	1,077	100%	1,077
64	Svy Gd II	28,000	1,077	100%	1,077
65	Svy Gd II	28,000	1,077	100%	1,077
66	Svy Gd II	28,000	1,077	60%	646
67	Svy Gd II	28,000	1,077	60%	646
68	Svy Gd II	28,000	1,077	60%	646
69	Svy Gd II (FS-11)	19,800	762	60%	457
70	Elec (NMS-9)	20,000	769	60%	462
71	Elec (NMS-13)	13,440	517	60%	310
72	Paver Op	35,000	1,346	100%	1,346
73	Paver Op	35,000	1,346	100%	1,346
74	Paver Op	35,000	1,346	100%	1,346
75	PTR Op	30,000	1,154	100%	1,154
76	PTR Op	30,000	1,154	100%	1,154
77	PTR Op	20,000	769	100%	769
78	PTR Op	20,000	769	100%	769
79	PTR Op	20,000	769	100%	769
80	PTR Op	20,000	769	100%	769
81	PTR Op	20,000	769	100%	769
82	PTR Op	20,000	769	100%	769
83	VM B&C Gde-1	15,300	588	60%	353

84	Dumper Dvr	18,225	701	100%	701
85	Dumper Dvr	18,225	701	100%	701
86	Dumper Dvr	18,225	701	100%	701
87	Dumper Dvr	18,225	701	100%	701
88	Dumper Dvr	18,225	701	100%	701
89	Dumper Dvr	18,225	701	100%	701
90	Dumper Dvr	18,225	701	100%	701
91	Dumper Dvr	18,225	701	100%	701
92	Dumper Dvr	18,225	701	100%	701
93	Dumper Dvr	18,225	701	100%	701
94	Dumper Dvr	18,225	701	100%	701
95	Dumper Dvr	18,225	701	100%	701
96	Dumper Dvr	18,225	701	100%	701
97	Dumper Dvr	18,225	701	100%	701
98	Dumper Dvr	18,225	701	100%	701
99	Dumper Dvr	18,225	701	100%	701
100	Dumper Dvr	18,225	701	100%	701
101	Dumper Dvr	18,225	701	100%	701
102	Dumper Dvr	18,225	701	100%	701
103	Dumper Dvr	18,225	701	100%	701
104	Dumper Dvr	18,225	701	100%	701
105	Dumper Dvr	18,225	701	100%	701
106	Dumper Dvr	18,225	701	100%	701
107	Dumper Dvr	18,225	701	100%	701
108	Dumper Dvr	18,225	701	100%	701
109	Dumper Dvr	18,225	701	100%	701
110	Dumper Dvr	18,225	701	100%	701
111	Dumper Dvr	18,225	701	100%	701
112	Dumper Dvr	18,225	701	100%	701
113	Dvr (LTV)	18,225	701	100%	701
114	Dvr (LTV)	18,225	701	100%	701
115	Dvr (LTV)	18,225	701	100%	701
116	Dvr (LTV)	18,225	701	100%	701
117	Dvr (LTV)	18,225	701	100%	701
118	Dvr (LTV)	18,225	701	100%	701
119	FM Asphalt	40,000	1,538	100%	1,538
120	FM Asphalt	40,000	1,538	100%	1,538
121	FM Asphalt / Labour	40,000	1,538	100%	1,538
122	Labour Asphalt	13,000	500	100%	500
123	Labour Asphalt	13,000	500	100%	500
124	Labour Asphalt	13,000	500	100%	500
125	Labour Asphalt	13,000	500	100%	500
126	Labour Asphalt	13,000	500	100%	500
127	Labour Asphalt	13,000	500	100%	500

128	Labour Asphalt	13,000	500	100%	500
129	Labour Asphalt	13,000	500	100%	500
130	Labour Asphalt	13,000	500	100%	500
131	Labour Asphalt	13,000	500	100%	500
132	Labour Asphalt	13,000	500	100%	500
133	Labour Asphalt	13,000	500	100%	500
134	Labour Asphalt	13,000	500	100%	500
135	Labour Asphalt	13,000	500	100%	500
136	Labour Asphalt	13,000	500	100%	500
137	Labour Asphalt	13,000	500	100%	500
138	Labour Asphalt	15,000	577	100%	577
139	Labour Asphalt	13,000	500	100%	500
140	Labour Asphalt	13,000	500	100%	500
141	Labour Asphalt	13,000	500	100%	500
142	Labour Asphalt	13,000	500	100%	500
143	Labour Asphalt	13,000	500	100%	500
144	Labour Asphalt	13,000	500	100%	500
145	Labour Asphalt	13,000	500	100%	500
146	Labour Asphalt	13,000	500	100%	500
147	Labour Asphalt	13,000	500	100%	500
148	Labour Asphalt	13,000	500	100%	500
149	Labour Asphalt	13,000	500	100%	500
150	Labour Asphalt	13,000	500	100%	500
151	Labour Asphalt	13,000	500	100%	500
152	Labour Asphalt	13,000	500	100%	500
153	Labour Asphalt	13,000	500	100%	500
154	Labour Asphalt	13,000	500	100%	500
155	Racker Man	18,000	692	100%	692
156	Racker Man	18,000	692	100%	692
157	Recker Man	18,000	692	100%	692
158	Recker Man	18,000	692	100%	692
159	Recker Man	18,000	692	100%	692
160	Recker Man	18,000	692	100%	692
161	Racker Man	18,000	692	100%	692
162	Recker Man	18,000	692	100%	692
163	Screw Man	18,000	692	100%	692
164	Screw Man	18,000	692	100%	692
165	Screw Man	18,000	692	100%	692
166	Screw Man	18,000	692	100%	692
167	Screw Man	18,000	692	100%	692
168	Screw Man	18,000	692	100%	692
169	Tandom Op	20,000	769	100%	769
170	Tandom Op	20,000	769	100%	769
171	Tandom Op	20,000	769	100%	769
172	Tandom Op	20,000	769	100%	769

173	Tandom Op	20,000	769	100%	769
174	Tandom Op	20,000	769	100%	769
175	Cook (M)	18,465	710	60%	426
176	Cook (U)	18,465	710	60%	426
177	Mess Staff	18,465	710	60%	426
178	Mess Staff (Waiter)	18,465	710	60%	426
179	Mess Staff (Waiter)	18,465	710	60%	426
180	Asphalt Plt Op	39,050	1,502	100%	1,502
181	Asphalt Plt Op	39,050	1,502	100%	1,502
182	Mech	19,965	768	60%	461
183	Loader Op	21,600	831	60%	498
184	Gen Op	21,600	831	60%	498
185	Burner Op	21,600	831	60%	498
186	Welder	21,600	831	60%	498
187	Welder	21,600	831	60%	498
188	Asphalt Plt Op	39,050	1,502	100%	1,502
189	Asphalt Plt Op	39,050	1,502	100%	1,502
190	Mech	19,965	768	60%	461
191	Burner Op	21,600	831	60%	498
192	Loader Op	21,600	831	60%	498
193	Gen Op	21,600	831	100%	831
194	Paver Op	35,000	1,346	100%	1,346
Total					**139,467**

Anx-B

Manpower Army

Ser	Description	Nos	Salary per Mnth	Salary per Day	Amount 60%
1	Offrs	6	424811	14,160.37	8,496.22
2	JCOs/Sldrs of HQ Coy	106	2548463	84,948.77	50,969.26
3	JCOs/Sldrs of 136 FCE	146	2961565	98,718.83	59,231.30
4	JCOs/Sldrs of 137 FCE	136	2777848	92,594.93	55,556.96
5	JCOs/Sldrs of 347 ESC	150	3044442	101,481.40	60,888.84
6	JCO/Sldrs of 308 Engr Bn LAD	19	457735	15,257.83	9,154.70
7	NCB	8	105753	3,525.10	2,115.06
8	SDO/Waiters	7	172695	5,756.50	3,453.90
	Total	**578**			**249,866.24**

REQ MATERIAL FOR 1800 TONS

Ser	Description	Length (Mtr)	Width (Mtr)	Thickness (Mtr)	Qty (Cum)	Density	Asphalt Qty (Ton)	Bitumen (4.3%)	Total Crush	Crush 10 - 20 mm (38%)	Crush 5 - 10mm (20 %)	Crush 0 - 5 mm (42 %)	LDO
								Ton	Ton	Ton	Ton	Ton	Ltr
1	Full Width	1304	11.7	0.050	762.84	2.36	1,800	77.413	1,722.889	654.6980	344.5779	723.6135	14,402.4192
Total Ton							**1,800**	**77.41**	**1,722.89**	**654.70**	**344.58**	**723.61**	
Total Cft									**41,894.29**	**17,544.70**	**8,812.73**	**15,536.86**	**14,402.42**
Rate Avg (Balkasar + Thallian)								57,330.00		41.97	41.97	21.62	57.60
Cost Rs								4,438,087.47		736,351.00	369,870.42	335,906.83	829,579.35
Total Cost Rs								**6,709,795.08**					

Anx- D

MT/PLT

Ser	Make & Type	Nos	Dep/Hiring Amount			POL Consumed Per Day (11Hrs)	POL Rate	POL Amount	Total Amount (Dep/Hiring + POL)
			Per Month	Per Day	Total				
1	Asphalr Plant	2	4400000	169,230.77	338,461.54	-	-	-	338,461.54
2	PTR	6	185000	7,115.38	42,692.31	55.00	83.38	27,515.40	70,207.71
3	Tendom Roller	3	225000	8,653.85	25,961.54	66.00	83.38	16,509.24	42,470.78
4	Paver	2	750000	28,846.15	57,692.31	220.00	83.38	36,687.20	94,379.51
5	Loader	2	250000	9,615.38	19,230.77	209.00	83.38	34,852.84	54,083.61
6	Fuel Bowzer	1	175000	6,730.77	6,730.77	15.00	83.38	1,250.70	7,981.47
7	Generator (400 KVA)	2	425000	16,346.15	32,692.31	550.00	83.38	91,718.00	124,410.31
8	MTV	2	1410000	54,230.77	108,461.54	88.00	83.38	14,674.88	123,136.42
9	Dumper	32	350000	13,461.54	430,769.23	180.00	83.38	480,268.80	911,038.03
10	Air Comproser	4	160000	6,153.85	24,615.38	154.00	83.38	51,362.08	75,977.46
11	Tractor (With Broomer)	5	55000	2,115.38	10,576.92	55.00	83.38	22,929.50	33,506.42
12	Water Bowzer	2	130000	5,000.00	10,000.00	80.00	83.38	13,340.80	23,340.80
13	S/Cabin	5	65000	2,500.00	12,500.00	30.00	83.38	12,507.00	25,007.00
14	D/C	5	75000	2,884.62	14,423.08	40.00	83.38	16,676.00	31,099.08
Total		**73**			**1,134,807.69**			**820,292.44**	**1,955,100.13**

Anx-E

OTHER EXP				
Ser	**Description**	**Per Month**	**Per Day**	**Amount (60%)**
1	Hirring / Dep	32,859,000.00	1,263,807.69	758,284.62
2	POL (for Other Veh)	1,120,242.35	43,086.24	25,851.75
Total		**33,979,242.35**	**1,306,893.94**	**784,136.36**

Exp based on ratio of ACWC with total W.D (58.35 % ≥ 60 %)

Ser	Description	Per Month	Per Day	%Age	Amount
1	Ration	3,112,627.90	119,716.46	60%	71,829.87
2	Lub	1,784,703.00	68,642.42	60%	41,185.45
3	Utilities	313,790.00	12,068.85	60%	7,241.31
4	Repair & Maint	417,677.00	16,064.50	60%	9,638.70
5	Aluminium Frame	7,209,810.00	277,300.38	60%	166,380.23
6	Containers	549,900.00	21,150.00	60%	12,690.00
7	NJ Barrier	4,972,500.00	191,250.00	60%	114,750.00
8	Proj Store	2,394,430.00	92,093.46	60%	55,256.08
9	Estb of Material Testing Lab, Asphalt Plant & Const Party	10,054,000.00	386,692.31	70%	270,684.62
10	Other- Exp (Misc Exp)	295,212.00	11,354.31	60%	6,812.58
Total		**31,104,649.90**	**1,196,332.69**		**756,468.84**

Anx-G

REQ MATERIAL FOR 1800 TONS FOR RAP

Ser	Des	Length (Mtr)	Width (Mtr)	Thickness (Mtr)	Qty (Cum)	Density	Asphalt Qty (Ton)	Bitumen (4.3%)		Total Crush		Crush 10 - 20 mm (38%)	Crush 5 - 10mm (20 %)	Crush 0 - 5 mm (42 %)	LDO
								Virgin (80%)	Rap (20%)	Virgin (80%)	Rap (20%)				RAP (20%)
								Ton	Ton	Ton	Ton	Ton	Ton	Ton	Ltr
1	Full Width	1304	11.7	0.050	762.84	2.36	1,800	62	0	1,378.312	344.58	523.7584	275.6623	578.8908	12,602.1168
						Total Ton	**1,800**	**61.93**	**0**	**1,378.31**	**344.58**	**523.76**	**275.66**	**578.89**	
						Total Cft				**33,515.43**		**14,035.76**	**7,050.19**	**12,429.49**	**12,602.12**
							Rate Avg	57,330.00	57,330.00			41.97	41.97	21.62	57.60
							Cost Rs	3,550,469.98	0		0	589,080.80	295,896.34	268,725.47	725,881.93
							Total Cost Rs	**5,430,054.51**							

MT/ Plt

Ser	Make & Type	Nos	Dep/Hiring Amount			POL Consumed Per Day (11Hrs)	POL Rate	POL Amount	Total Amount (Dep/Hiring + POL)
			Per Month	Per Day	Total				
1	Double Barrel Asphalt Plant	1	4859879	186,918.42	186,918.42	-	-	-	186,918.42
2	PTR	6	185000	7,115.38	42,692.31	55.00	83.38	27,515.40	70,207.71
3	Tendom Roller	3	225000	8,653.85	25,961.54	66.00	83.38	16,509.24	42,470.78
4	Paver	2	750000	28,846.15	57,692.31	220.00	83.38	36,687.20	94,379.51
5	Loader	2	250000	9,615.38	19,230.77	209.00	83.38	34,852.84	54,083.61
6	Fuel Bowzer	1	175000	6,730.77	6,730.77	15.00	83.38	1,250.70	7,981.47
7	Generator (400 KVA)	2	425000	16,346.15	32,692.31	550.00	83.38	91,718.00	124,410.31
8	MTV	2	1410000	54,230.77	108,461.54	88.00	83.38	14,674.88	123,136.42
9	Dumper	32	350000	13,461.54	430,769.23	180.00	83.38	480,268.80	911,038.03
10	Air Comproser	4	160000	6,153.85	24,615.38	154.00	83.38	51,362.08	75,977.46
11	Tractor (With Broomer)	5	55000	2,115.38	10,576.92	55.00	83.38	22,929.50	33,506.42
12	Water Bowzer	2	130000	5,000.00	10,000.00	80.00	83.38	13,340.80	23,340.80
13	S/Cabin	5	65000	2,500.00	12,500.00	30.00	83.38	12,507.00	25,007.00
14	D/C	5	75000	2,884.62	14,423.08	40.00	83.38	16,676.00	31,099.08
Total		**72**			**983,264.58**			**820,292.44**	**1,803,557.02**