



An-Najah National University
Faculty of Graduate Studies

**FEASIBILITY OF USING RECYCLED
ASPHALT MATERIAL AS SUBBASE
MATERIAL IN PALESTINE**

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Declaration

I, the undersigned, declare that I submitted the thesis entitled:

FEASIBILITY OF USING RECYCLED ASPHALT MATERIAL AS SUBBASE MATERIAL IN PALESTINE

I declare that the work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

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Feasibility of Using Recycled Asphalt Pavement Materials as Subbase Material for Road Construction in Palestine

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Abstract

Background: Road construction material is generally limited worldwide, including developing countries, in addition to their high prices and transportation cost. Previous studies on the use of recycled asphalt pavement (RAP) showed different percentages of the optimum RAP in the aggregate mix, which confirms the need for additional research in this field.

Problem Definition & Objectives: The lack of natural resources significantly impacts the construction sector. The need for aggregates will grow as pavement development increases and the aggregate requirements need to be met. To produce better materials that are consistent with the requirements for subbase material, the study aims to determine whether it is possible to use RAP materials in the subbase by examining the viability of reusing milling material and combining RAP with natural materials in specific proportions.

Methodology: The methodology included collecting three samples of milling material from each of three study streets in Ramallah and Al-Bireh Governorate, then mixing them with subbase materials in specific proportions. A mixture of the two materials was made in varying proportions (10-60%) and the number of mixed samples was a total of 11 samples; each sample was lab tested three times.

Results: The study's findings demonstrated that the quality of subbase materials can be improved by combining RAP materials with natural materials. It is also possible to improve these materials and address their deficiencies by blending them with RAP materials in proportions of (20–50%), resulting in a mixture with excellent properties and a cost reduction of more than a one third (33%). An optimum mixing ratio of 32.5% was attained in terms of the proctor test, sand equivalent, and California Bearing Ratio.

Conclusions: At the optimum mix percentage, the mechanical properties of the mixture significantly improve. It was also possible to obtain materials with better properties so that its specifications are met up to 50% mix proportion.

By using these materials, it is possible to save a one third of the cost as compared to the traditional cost when mixing by 30%, and to reduce the thickness of the subbase from 20 cm to 15 cm while maintaining the same efficiency.

Keywords: RAP, subbase, mixture, Palestine.

Chapter One

Introduction

1.1 Theoretical Basis

The Recycled (or more commonly referred to as Reclaimed) Asphalt Pavement (RAP) is a good quality material that can take the place of costly natural aggregates (NA). These materials, which results from milling existing asphalt, could be used as a base or subbase aggregate material during road construction and rehabilitation processes, and could also be used in asphalt mixture. The use of RAP might be an effective and attractive approach for some areas in Palestine, where the necessary natural subbase materials are not available, or have weak rock strength. The use of RAP, which is usually considered as a wasted material, can be economically and environmentally feasible, which could be a competitive alternative for natural aggregates, and can reduce the construction costs even in areas where the suitable materials are available for use as subbase materials.

The recycling process of materials resulting from milling asphalt is not new, as it has been receiving global attention. Many countries around the world have worked on this through the use of modern equipment, such as hot in-place recycling (HIR), by utilizing a mobile asphalt plant configured to operate in a continuous train alongside a regular paver and compaction tools, Full Depth Reclamation (FDR) to recycle asphalt layers and the subbase in full depth, and Cold In-Place Recycling (CIR) machines to recycle cold asphalt layers, in addition to the use of many agencies around the world of these materials to prepare asphalt mixtures. This is due to the impact of using recycled material on raising the efficiency of road maintenance work, speeding up the completion, preserving the environment, and reducing costs (1).

1.2 Problem Definition

Material recycling is receiving a serious global attention due to the limited natural resources. Recycling of construction materials in particular is one of the main concerns in this regard for many reasons. This includes the lack of natural materials Compatible with the required Jordanian's technical specifications for road construction specially in some areas in Palestine such as Jericho, the relatively high material cost, the high transporting costs, the lack of necessary landfills in most Palestinian areas, as a result of

the Israeli control on most lands outside the Palestinian urban areas, and the environmental considerations.

Large amounts of milling material are produced in Egypt, particularly as a result of the country's booming economy, population, and consumerism. Due to ongoing pavement milling operations, the Egyptian market generates about 4 million tons of RAP annually (2).

This means that the exploitation of these materials will greatly affect the costs of maintaining the road network around the world and preserve the environment.

1.3 Importance of the Study

Every year large amounts of milling material are produced from roads in Palestine, which are disposed without realizing any real benefit. This is in addition to significant increase in the prices of fuel, transportation, and labor in Palestine during the past period, which caused a significant increase in the prices of road construction materials. All of these reasons, in addition to limited licensed landfills with the need to take advantage from milling material make a justifiable reason for conducting this study.

The following table shows the projects implemented by the Ministry of Public Works and Housing (MPWH) during the last four years (2018 - 2022) (3), which produced large amounts of milling material.

As seen in Table 1.1, MPWH alone carries out around half of million square meters of asphalt milling material every three years with thickness around 2.5 cm, and dry density for RAP material 1.6 ton/m^3 (4). This produces around 19,100 tons of milling material; this material was dumped into landfills without achieving any significant benefits.

On the other hand, there are few studies conducted in this field in Palestine; particularly in Gaza Strip. These studies addressed the use of crushed waste glass (5), using recycled aggregate in hot asphalt mixtures in Gaza Strip (6), and reusing waste plastic bags in asphalt mixtures (7). Another study was conducted in the West Bank regarding the impact of using rubber in asphalt mixes (8).

Table 1.1*Projects Implemented by the Ministry of Public Works and Housing during (2018-2022)*

No	Project Title	Governorate	Milling Area (m ²)
1	Rehabilitation of Sabastia Entrance	Nablus	11,520
2	Rehabilitation of Anabta-Tulkarm Street	Tulkarem	50,826
3	Reconstruction of Al-Seka– Ktaba Main Road	Tulkarem	25,430
4	Rehabilitation of Al-Seka- Ktaba Road	Tulkarem	13,579
5	Rehabilitation of Jenin– Hiafa Main Road	Jenin	42,595
6	Rehabilitation of Beitunai Ein-Erek Deir Ibzi Main Road	Ramallah	55,000
7	Rehabilitation of Ein-Yabroad– Dora Alqara Main Road	Ramallah	21,672
8	Rehabilitation of Ezaria– Abu Dees Main Road	Jerusalem	80,242
9	Rehabilitation of Qalndia Main Street	Jerusalem	56,311
10	Rehabilitation of Hebron Tarqomia Road (Wad Alqof)	Hebron	35,575
11	Rehabilitation of Beit Awa Deir Samet Main Road	Hebron	12,000
12	Rehabilitation of Bethlehem– Jerusalem Main Road 1st stage	Bethlehem	65,300
13	Rehabilitation of Bethlehem– Jerusalem Main Road 2st stage	Bethlehem	7,553
Total Area (m ²)			477,603

Note: Saadeh T. Quantity of Milling Material Produced by the Ministry of Public Work and Housing. Ramallah: Ministry of Public Work and Housing, Road Supervision Department

The importance of the study is exemplified by its potential to reduce the cost of construction of roads in the Palestinian territories by using less expensive RAP as foundation materials in combination with natural materials rather than throwing them into landfills and exposing institutions to additional costs as well as the negative impacts on the environment.

1.4 Objectives

This research aims to study the feasibility of using RAP as a sub-surface layer (particularly subbase material) by knowing the mechanical properties of materials resulting from mixing NA (Natural Aggregates) with (RAP) material in different proportions.

Numerous studies worldwide addressed the use of RAP in asphalt mixes. Furthermore, the properties of asphalt mix would significantly vary with any slight variation in any of its components (aggregate gradation and properties, asphalt type and content, mechanical processing, etc.); therefore, this would be difficult to control. With the large amounts of asphalt milling product in Palestine that are mostly dumped in landfills, the main objective of this research is to investigate the feasibility of using materials resulting from asphalt milling as an alternative to natural subbase materials.

The study will verify the need to add other materials with certain gradation and proportions to be determined through laboratory experiments, to obtain new materials with characteristics that correspond to the requirements for subbase material. This will also include a comparison between the cost of natural materials and new materials (economic feasibility study).

Specific objectives of this study include:

1. Study and understand the main properties of materials resulting from milling asphalt and intended to be used for recycling.
2. Evaluate the mechanical properties of milling materials such as (Atterberg limits, California Bearing Ratio (CBR), sieve analysis, specific gravity, sand equivalent, absorption, Los Angeles abrasion) According to ASTM, AASHTO.
3. Identify the extent to which material properties comply with the required specifications.
4. Conduct economic feasibility study for the new mixture as compared with the natural materials.
5. Provide recommendations regarding the use of RAP for subbase materials in Palestine.

1.5 Previous Relevant Studies

Numerous studies have been carried out to assess the viability of blending milling material (RAP) with virgin material. The performance and characteristics of RAP/virgin aggregate mixes have been the subject of several research, some of which are summarized in this section.

1.5.1 Developing Countries

Dalloul (5) made a study to determine the impact of using crushed waste glass as coarse sand and filler in the asphalt binder course. The study concluded that crushed waste glass can be used up to a maximum size of 4.75mm and with an optimum replacement of 7.5% of aggregate, and all test results met the requirements with the exception of flow, the study findings are solely applicable to the particular grade and glass type that were employed. Different outcomes might be obtained using different grades of glass or resources.

Alfaqawi (6) investigated using recycled concrete aggregates in place of HMA aggregates. In this investigation, two distinct RCA combinations were used: one with 30% RCA and the other with 60% RCA. When the amount of asphalt in a mixture rises and the specific gravity of the mixture decreases, it was observed that RCA-30% met all of the tested parameters for HMA mixtures while RCA-60% met the majority of the tested Marshall properties but failed when the amount of air voids in the mixture was very high.

El-Saikaly (7) showed that waste plastic bags (WPB) might easily be added to asphalt mixes as a modifier for increased performance of the asphalt mix as well as sustainable management of plastic waste. 9.0% WPB by weight of Optimum Bitumen Content (OBC) was advised as the ideal WPB concentration for enhancing the performance of asphalt mix. When compared to a standard asphalt mix, an asphalt mix amended with 9.0% WPB by OBC weight had a stability rating that was 24% greater. Higher WPB content in the modified asphalt mix resulted in higher air voids, higher flow, and lower bulk density.

Al-Badawy (9) noted that there are linear relationships between the amount of RAP in RAP aggregate mixture and the optimum moisture content, and with maximum dry density. The author also observed that when adding RAP to an aggregate of base quality produces a mixture with lower dry density and strength, and there is an inverse relationship between the percentage of RAP material in RAP aggregates and CBR for the mixture. To take a benefit for adding recycled asphalt pavement to RAP with minimum CBR of 25%, it should not use recycled asphalt for more than 50% in the mixture.

El-Maaty (10) made a study showing that the bituminous mixes containing RAP, particularly at 50 to 100% of RAP, performed better than the new blends. With increasing RAP percentages, mechanical qualities, durability performance, and stripping resistance also improved. The indirect tensile strength was significantly increased by using RAP, with 50% RAP content displaying the highest values.

Ansori and Radam (11) noted that up to 10% RAP can be utilized for the subbase and base courses, for the base course beneath the asphalted course (Class A). For the subbase course (Class B), the maximum limit of the RAP materials was not more than 9 percent. The RAP materials should be employed by no more than 3 percent. Furthermore, no more than 10% of the Class S shoulder of the road should be made up of RAP materials as course materials.

Alamier (12) noted that few research papers have been conducted to describe and analyze the robustness, appropriateness, and efficacy of recycling methods employing regional materials in Iraq. In order to determine the life cycle costs of flexible pavement with an unbounded granular subbase layer made of mixed virgin aggregate materials and RAP, a computer design and management study was conducted. In comparison to traditional flexible pavement in Iraq, the study indicated savings of up to 40% of the overall cost of the pavement and up to 50% of the maintenance cost.

Mousa and Mousa (2) examined the use of RAP percentages of 0%, 20%, 60%, 80%, and 100% by the combined mass of the samples. Index qualities such as gradation, modified proctor compaction, California Bearing Ratio, and hydraulic conductivity were tested in the lab. According to the study, the CBR and hydraulic conductivity dropped as the RAP percentage increased. However, for samples compacted at the optimum moisture content (OMC) and maximum dry density (MDD), a significant rise in the resilient modulus values was seen with an increase in the RAP replacement in the mix. According to CBR data, RAP up to 60% can be used in Egypt for building road subbase.

Alfaqawi (6) made a study for using recycled aggregate (RAP) in hot asphalt mixture in Gaza Strip where large quantities of the building waste for destroyed buildings resulted after the Israeli offensive on Gaza. The study prepared two mixtures; the first consisted of 30% Recycled Coarse Aggregate (RCA) and the other consisted of 60% RCA. It was observed that the use of RCA made the mixture highly absorptive and the porous structure led to low specific gravity. The RCA-30% met all requirements for HMA mixture; however, RCA-60% met most of the required Marshal properties, but it failed in the air void percentages in the mixture. There was an inverse relationship between the percentage of RCA and air voids in the mixture and so with asphalt content due to the high absorption of RCA. The optimum bitumen content for natural aggregate was 5.5% and increased to 5.85% for RCA-30%, and it was more than 6% for RCA-60%, which is higher than the specifications. There's a positive side for RCA mixture observed while using 30% of RCA, which significantly increased the stiffness modules and sustained more fatigue life than natural aggregates (NA). On the contrary, using of 60% RCA in the mixture reduced the stiffness and fatigue life

Hasan (13) conducted laboratory tests to evaluate the modulus of subgrade while taking the effects of RAP and moisture content into consideration at various stress levels. According to the study's findings, RAP concentration enhances the modulus of subgrade (MR) of RAP-mixed soil. Consequently, RAP may be applied to subgrade soil to improve its resilience. According to the study, in order to obtain accurate results from these tests, more tests must be conducted using other sample collections. These studies were designed for one sample of soil and one sample of recycled asphalt.

Mousa and Mousa (14) showed that incorporating RAP material may save up to 48.1%, and the savings increased up to 60% when the cost of disposing of RAP is deducted from the cost of the mix as a unit. The use of the RAP-sand mix (50/50) in the subgrade and subbase layers was recommended, and this was done in accordance with a general technique that was carried out to undertake cost-benefit evaluations.

Tanveer & Niloy (15) noted that a combination of mechanical and bituminous stabilization techniques can be employed for stabilization of subbase and base layers. The addition of virgin aggregate or recycled materials such as RAP is required to ensure the proper gradation while adding asphalt emulsion or foamed asphalt ensures proper binding and results in reduced depth of base/subbase layer. However, cold recycling cannot be recommended for surface layers as hot recycling provides the structural integrity required to handle the loading and climatic adversities of this region.

Abdel-Jaber (16) compiled 15 asphalt mixtures consisting of RAP and NA. An improvement in the stability values was observed with the increase of the RAP content up to 75%, and then it decreased significantly.

1.5.2 Developed Countries

Montepara (17) used two mixtures, one of which consisted of 100% natural aggregates and the other is a mixture of 50% natural aggregates and 50% RAP. Light Weight Deflector Test (LWD), Failing Weight Deflector Test (FWD), and Ground Penetrating Radar (GPR) tests were carried out in order to verify the performance in the short and long term and compare the results between the two mixtures. The tests showed homogeneous results for the two mixtures so that they cannot be distinguished.

Seferoğlu (18) indicated that when used alone, RAP is a weak material in terms of carrying capacity. Cement may be a good way to increase base course performance by increasing bearing capacity and permeability, hence it should be used with it. The amount of cement in the mixture might be capped at 3%. The amount of fine content (below No200 sieve) increases when more than 3% of cement is added to RAP material. With an increase in RAP and cement proportion in blends, MDD and OMC were reduced.

Alwetaishi (19) assessed the effects of various RAP percentages on asphalt mixtures. The researchers concluded that adding RAP to asphalt mixes affects their mechanical properties, but all of these properties were within the allowable specifications. As the RAP content rises, the air voids expand while the bulk-specific gravity decreases. RAP applications in asphalt mixes for low-volume roads appeared to be best suited for a RAP content of 60%, as the stability of asphalt mixes declined as RAP content increased up to 60%.

Montañez (20) evaluated RAP prosperities produced by six distinct road projects. The study found that the size distribution of the smallest range particles from RAP sources exhibits substantial heterogeneity. In order to create novel HMA combinations, the study advised either using RAP from a single source or homogenization procedures among many RAP sources.

Pomoni (21) concluded through a number of experiments on mixtures including (RAP) that these materials often provide less skid resistance since they were used for extended periods of time before being subjected to significant loads.

Maicelo (22) indicated that recycled asphalt is frequently used as an aggregate on pavements; however, it is also used as a granular base or subbase, infill material, or fillers and stabilized base aggregates. Given the higher grade of the original aggregates utilized, the best RAP quality may be extracted from the surface. Because it has been subjected to oxidation, recycled asphalt ages. As a result, since this has an impact on its long-term performance, its usage must be carried out using various treatments. It's crucial to keep in mind that rejuvenators must be applied when using recycled binder in place of virgin one to prevent the final pavement from becoming too hard and breaking. The study found that the compression resistance of the RAP aggregates is lower. Additionally, since substituting greater volumes of binder results in a hardening in the slurry, adding more

RAP would reduce the pavement fatigue life. The stiffness that the RAP exhibits as a result of this hardening; however, results in more resistance to the rutting. It should be taken into account that the less aged the RAP is when it is extracted, the greater yield it will have due to the reduced effects of aging. Mild binders must be used in order to improve the adherence of the binder to the aggregates since moisture has a direct impact on RAP's performance in mixes. The use of oils also increases workability and makes it possible to employ RAP more effectively.

Dughaishi (23) made a study for the Use of RAP Materials for Pavement Construction in Oman for roads, airport runways, shoulders, engineered fill, and culvert backfill. The RAP application serves as a valuable granular base material. Because RAP is less complicated and doesn't require additional asphalt binder, the study suggested that it can be used with a mixing rate of less than 20%. As a result, it will be a positive step toward enhancing Oman's environmentally sustainable constructions.

Pradhan & Biswal (24) tested the CBR and dry density properties using a mixture of different percentages of RAP (0%, 25%, 35%, 45%, 55%, 65%, and 75%) before comparing the findings to those of a mixture made up entirely of natural aggregates. The performance of the subbase layer mixture was examined and found to be better, but mixture with 22% of RAP produced better results regarding density and CBR. Note that using RAP in the mixture increases hardness of the mixture. RAP had more stiffness than nature aggregate, and RAP had more permeability.

Masi (25) presented that the hydrophobic property of RAP is caused by the presence of the bituminous layer. Furthermore, it was shown that RAP had wider pores and a higher open porosity than natural aggregate. When it comes to dimensional stability and frost resistance, the majority of the tested RAP exhibit encouraging results, indicating that it may be appropriate for use as recycled aggregate in concrete mixes.

1.5.3 Summary of Previous Studies

- Al-Badawi (9) suggested an inverse relationship between the proportion of RAP in the mixture and the CBR, while Mousa and Mousa (2) found a linear relationship, whereas Pradhan & Biswal (24) suggested that the mixture produces the best results at a ratio of 22%.

- Al-Badawi indicated “a linear relationship between the percentage of RAP in the mixture and (MDD)” (9) in contrast, while Pradhan & Biswal indicated that “it increases up to a certain percentage and then starts to decline” (24).
- Al-Badawy indicated that it should not use recycled asphalt for more than 50% in the mixture (9), while El-Maaty indicated that the optimal RAP percentage is 50% (10). On the other hand, Ansori and Radam noted that up to 10% RAP can be utilized for the subbase and base courses (11), while Mousa and Mousa noted that according to CBR data, RAP up to 60% can be used in Egypt for building road subbase (14).

Alamier indicated savings of up to 40% of the overall cost of the pavement and up to 50% of the maintenance cost (12), while Mousa and Mousa showed that incorporating RAP material may save up to 48.1% and the savings would increase up to 60% when the cost of disposing of RAP is deducted from the cost of the mix as a unit (14).

1.6 Thesis Structure

There are five chapters in this thesis; Chapter one includes the Introduction along with relevant literature on using recycled asphalt material as a subbase material. Chapter two demonstrates the Methodology used for this study. Data Collection is presented in Chapter three, while Chapter four shows Aggregate Tests, Result Analysis, and Economic Visibility Study and finally chapter five shows that the Conclusions & Recommendations and Limitations and Future Research

Chapter Two

Methodology

2.1 Introduction

The resulting materials from asphalt milling are lab tested, and their mechanical properties and performance are evaluated. In addition, the possibility of using these materials without treatment as a subbase layer are evaluated, and the effect of bitumen coating on the materials properties are considered. Moreover, in this study, several proportions of Recycled Coarse Aggregate (RCA) mixtures are considered in an attempt to reach the most appropriate mixture to be used as a subbase layer. Finally, economic feasibility studies are conducted, considering the cost of the RAP as compared with the natural materials.

The components needed for accomplishing this thesis in order to reach the desired objectives include five main steps, which are Subbase and RAP Material Collection, Sampling, Aggregate Samples Preparations, Aggregate Tests, and lastly Economic Feasibility Study.

2.2 Data Collection

The average annual product of asphalt milling material along with the average annual quantities needed as a subbase material for road construction and rehabilitation projects are collected. The collected data are dedicated for Ramallah and Al-Bireh Governorate, which are collected from relevant institutions including the Ministry of Public Works and Housing, Ministry of Local Government, Municipal Development and Lending Fund, and Ramallah, Al-Bireh, and Beitunia Municipalities.

2.3 Testing and Analysis

- **Subbase Material Collection:** The required samples for natural aggregates usually used as subbase materials are collected from several roads and projects that are currently conducted within the study area. The material was collected from four locations, namely:
 - Beitunia crusher.
 - Ramallah- Jerusalem Main Road.

- Kofor Nemeh Road.
- Beitunia Ein Erech Road.
- **Sampling:** The required number of samples of asphalt milling material, which corresponds with the required significance level (95%) are collected from the relevant institutions in the governorates.
- **Aggregate Samples Preparations:** A number of samples are made to contain different percentages of asphalt milling material (10% - 60%). The percentage was chosen after reviewing the results of previous studies, and then the necessary tests are conducted for each percentage to make a conclusion about the most suitable percentage of RAP needed to make the mixture with the required specifications.
- **Aggregate Tests:** A series of experimental tests are conducted at the Construction and Transportation Research Unit's laboratories of An-Najah National University to determine the mechanical and physical properties for both the natural subbase materials currently available, and the produced asphalt milling material. Several tests are conducted for the collected samples to determine their properties (Atterberg limits, California Bearing Ratio (CBR), sieve analysis, specific gravities, sand equivalent, absorption, Los Angeles abrasion), which are used later for comparison between the natural subbase and new mixture of natural aggregate and milling material. Different mixes of both natural subbase and asphalt milling material are tested and evaluated. The test results are compared with the subbase properties adopted by the Jordanian standards and requirements, which is adopted by the relevant Palestinian institutions. The best mix of asphalt milling material and the natural subbase material that satisfy the specifications are recommended.

To guarantee that the findings are accurate and representative, three samples will be taken from each source and all the aforementioned checks will be made. In addition, odd results won't be taken into account.

- **Economic Feasibility Study:** it is conducted by comparing the annual cost of producing and disposing the asphalt milling material, with the possibility of using this material as replacement for partial quantities needed as a subbase material. This will take into consideration the various cost elements including the transporting cost, which could be critical for some Palestinian areas that lack natural subbase material.

According to the amounts of RAP and subbase that are collected with the aforementioned institutions, the economic feasibility will be calculated. Additionally, since milling materials incurs additional costs for government institutions to send them to landfills, more than one scenario will be developed. In exchange, the materials are then sold in the market at various prices.

We will eventually be able to quantify the savings and advantages of using these materials as opposed to dumping them in landfills.

2.4 Study Area

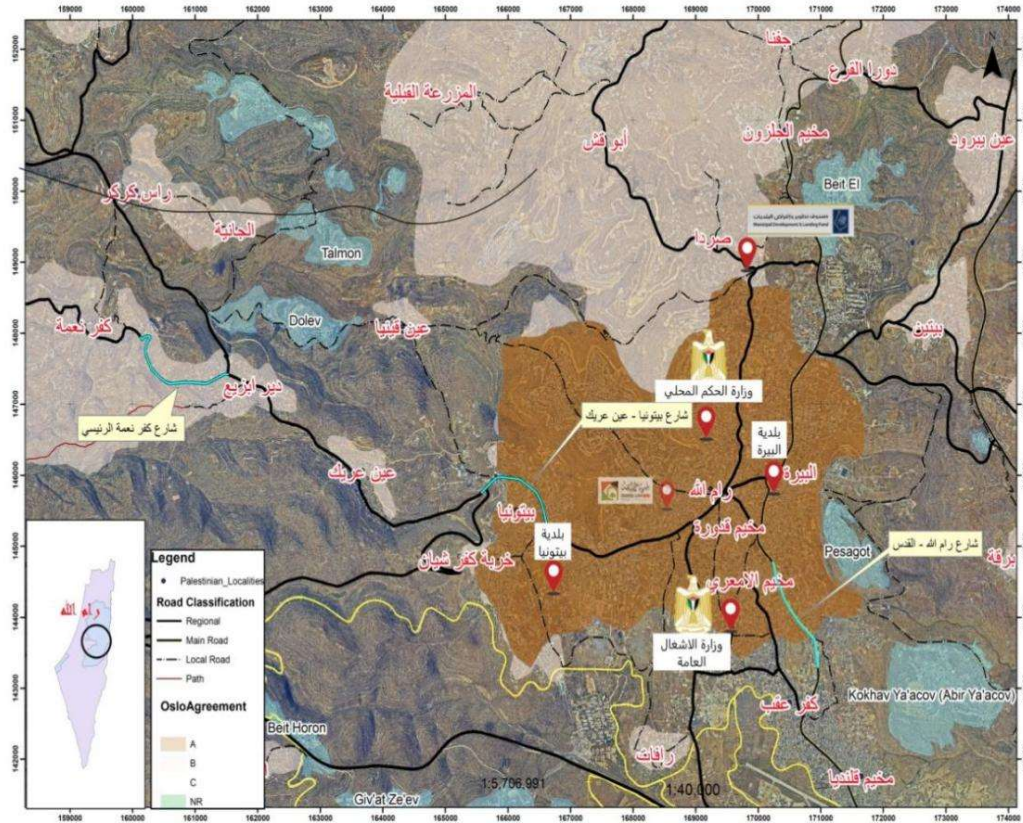
Ramallah and Al-Bireh Governorate is considered for this study. This governorate is chosen due to the presence of a number of projects at the current period under construction these projects are Ramallah- Jerusalem Main Road, Kofor Nemeh Road, and Beitunia Ein Ereik Road as shown in (Figure 2.1).

In addition to the availability of necessary information and sufficient material for the study, and so the presence of all relevant government institutions (MPWH, Ministry of Local Government, Municipal Development and Lending Fund, and Ramallah, Al-Bireh, and Beitunia Municipalities) in the governorate.

Figure 2.1

Ramallah and Al-Bireh Governorate with Project Location and Relevant Government Institutions

(26)



2.5 Conclusion and Recommendations

After reviewing the results and comparison, conclusions and recommendations from this study will be based on this thesis content. Furthermore, the study indicates the limitations that restrain some of the study outputs, leading to think of some future research to cover the shortfalls.

Chapter Three

Data Collection and Results

3.1 Data Collection

In order to determine the necessity of mixing milling materials with subbase or base course materials, data on the quantities of these materials were gathered of all relevant institutions (MPWH, Ministry of Local Government (MOLG), Municipal Development and Lending Fund (MDLF), and Ramallah, Al-Bireh, and Beitunia Municipalities). It was discovered that all institutions incur additional costs as a result of not using these materials and their disposal in permitted landfills. The governorate of Ramallah and Al-Bireh suffers from the scarcity of licensed landfills and the high cost of those that do exist, which results in significant milling and losses for these institutions, in addition to the significant harm that these materials cause to the groundwater and environment.

The amounts of milling differ from one institution to another according to the nature of the institution's work and the streets it specializes in. Quantity data were collected and the results are presented in Table 3.1.

Table 3.1

Milling Material Produced and Subbase and Base Course Produced by Institutions in Ramallah and Al-Bireh Governorate in years (2018-2022)

NO	Government Institutions	Milling Material Produced (2019-2022) m ²	Subbase Material Needed (2019-2022) m ²	Base Course Material Needed (2019-2022) m ²	Reference
1	MPWH	477,603	23,000	218,900	Appendix G.III
2	MOLG	35,230	735,000	2,365,000	Appendix G.IV.
3	MDLF	210,000	33,000	651,000	Appendix G.I
4	Ramallah Municipality	90,760	572	37,329	Appendix G.VIII
5	Al-Bireh Municipality	88,968	3,000	65,000	Appendix G.IX
6	Beitunia Municipality	10,000	————	75,000	Appendix G.X
Total Quantities (m ²)		912,561	794,572	3,412,229	

Note. See Appendix G

3.1 Milling Material Quantities

As seen in Table 3.1, all institutions in Ramallah and Al-Bireh Governorate carry out (912,561) square meters of asphalt milling material every three years with a thickness around 2.5 cm, and dry density for RAP material of 1.6 ton/m³ (4). This produces around 36,502.44 tons of milling material, which constitutes 2% of the total materials as shown in Appendix G; this material is usually dumped into landfills without achieving any significant benefits.

3.2 Subbase Material Quantities

As seen in Table 3.1, all institutions in Ramallah and Al-Bireh Governorate used (794,572) square meters of subbase in the last three years with a thickness around 20 cm, and dry density for subbase material of 2.05 ton/m³ (27). This means that all these institutions used 325,774.52 tons of subbase material, which constitutes 19% of the total materials as shown in Appendix H.

3.2 Base Course Material Quantities

The institutions in Ramallah and Al-Bireh Governorate used (3,412,229) square meters of base course in the last three years with thickness around 20 cm, and dry density for base material of 2.1 ton/m³ (27). This means that these institutions used 1,433,136.18 tons of base course material, which constitutes 81% of the total materials, as presented in Appendix H.

Referring to the previous data, the usage of subbase material by institutions was (19 %) of the total materials used in the foundation, and base course material was (81%) in the last three years.

It has become necessary to look for alternatives to using natural materials, which are weak in Ramallah and Al-Bireh Governorate due to the lack of natural resources in the Palestinian territories and the constrained lands as a result of Israeli occupation measures to control lands designated as "C".

3.3 Base Course or Subbase Materials Used and Street Type

The amount of base course used in the streets in the past three years, which accounts for 81% of the total materials used, while the amount of subbase materials used accounts only for 19%, as shown in the figures in (Appendix G).

The explanation for this is due to the fact that subbase materials are used in streets that are exposed to large traffic loads, such as arterial and regional streets, which constitute (5%) of the total streets according to (Appendix I). On the other hand, local and agricultural streets constitute 81% of the total streets, which are streets usually implemented using a 20 cm thick base course layer and a 5-6 cm thick asphalt layer only, due to the low traffic loads they are exposed to.

Based on that, it is expected that the need for additional base course materials will increase during the coming years, with the limited crushers and the high costs of transportation, in addition to the restrictions imposed by the occupation authorities on lands classified as "C". For these reasons, it is necessary to look for synthetic materials that can replace natural ones.

3.4 Base Course Test Results in Ramallah and Al-Bireh Governorate

According to (Appendix J), comprehensive base course tests for Ramallah and Al-Bireh Governorate were made by a local testing lab over the past year; 33 tests resulted in 54.5% of these tests were according to specifications and the remaining failed in Atterberg limits, sieve analysis (passing sieve 200mm), and sand equivalent.

According to (Appendix K) comprehensive base course tests for Ramallah and Al-Bireh Governorate was made by another local testing lab in the last three years. Results showed that out of 250 tests, 78% were according to specifications whereas 22% of these tests' results failed in Atterberg limits, sieve analysis (passing sieve 200mm), and sand equivalent.

The cause of this is the use of mobile crushers in the Ramallah and Al-Bireh Governorate to produce base course using rocks extracted from building excavations in order to lower construction costs, transportation costs, and landfill fees. Additionally, excavation is carried out using conventional excavators to somewhat shallow depths because of the restrictions put in place by the authorities to using blasting in excavations.

In addition to the clay layers between the rock layers shown in the photo (appendix B), the formation of rocks in the Ramallah and Al-Bireh Governorate (marlstone) contains a high percentage of clay materials, making it impossible to separate them and causing them to be mixed with the base course. As a result, there is an increase in the proportion of clay materials in the mixture, which affects the amount of material that passes through sieve No. 200, the value of (PI) that is above the allowable limits.

In contrast to the Nablus Governorate, which relies on fixed crushers in Jama'in, in addition to that the rock layers are characterized by strength and the absence of mud layers between the rock layers, as shown in (Appendix B).

Also, the governorate of Jericho and the Jordan Valley suffers from a decrease in the value of the sand equivalent of the base course materials, which causes the need to supply base course from the other governorates such as Ramallah and Al-Bireh, and thus greatly raises the cost of road projects compared to other regions, as presented in Appendix G.II.

Based on the prior information, Chapter 4 investigates the possibility of improving these materials by incorporating RAP material products into the mixture in order to supply natural materials, protect the environment, and lower the cost of road projects.

Chapter Four

Test Results and Analysis & Economic Visibility Study

4.1 Introduction

After collecting samples from 3 streets, where the samples included subbase materials and milling materials, three samples were taken from each street, and then all the necessary tests were conducted, which included the following tests for the collected samples to determine their properties (Atterberg limits, California Bearing Ratio (CBR), sieve analysis, specific gravities, sand equivalent, absorption, and Los Angeles abrasion).

4.2 Aggregate Tests

4.2.1 Milling Material Test

After collecting samples from the three streets, 3 samples of milling material (RAP) and subbase material were taken from each street. Several tests were conducted for the collected samples to determine their properties (Atterberg limits, California Bearing Ratio (CBR), sieve analysis, specific gravities, sand equivalent, absorption, and Los Angeles abrasion). The average results are as shown in Table 4.1.

As shown in Table 4.1, (PI) of (RAP) is almost zero, which is a violation of the Jordanian specifications (28) and the American code of foundation materials “(PI) shall neither be less than 2 nor greater than 8” according to AASHTO (27) and so it couldn’t be used as a foundation material. That’s means there’s no cohesive between the aggregates. The reason of this due to presence of the binder around (RAP) aggregate, which causes poor water absorption and they act as insulating materials that prevent water from penetrating inside and reduce the bonds between the granules. This is consistent with what was indicated by Pradhan (24). Therefore, the low value of (PI) results in the difficulty of mixing and compacting these materials separately and the inability to use them as a foundation material except by adding fine materials to become as specification.

Table 4.1*Milling Material (RAP) Test Results (See Appendices C.I, C.II, C.III)*

Test	Beitunia Street	Kofor Neme Road	Ramallah-Jerusalem Main Road	Average Result	Spec's (1)
Plasticity Index (P.I)	0	0	0	0	2-8
Sand Equivalent (%)	88	89.4	87	88.13	25 (Min.)
Percent Passing Sieve No. 200 (%)	1.1	1.3	4.61	2.34	(5-12 Subbase A)
Los Angeles at No500 (%)	22.8	26	23.6	24.13	40 (Max.)
Optimum Moisture Content (%)	6.05	4.98	4.61	5.21	--
Maximum Dry Density (M.D.D) (gm/cm ³)	1.961	1.907	1.897	1.92	2.05 (Min.)
California Bearing Ratio (CBR @ 0.1")	21	19.7	15.73	18.81	40 (Min.)

Regarding the Sand Equivalent, this test technique gives the relative amount, fineness, and kind of clay-like material contained in the test specimen. The average value of sand equivalent is 88.13, which agrees with the Jordanian specifications (28) and the American code of foundation materials;” the material shall contain minimum of 25% sand equivalent at any stage of construction” according to AASHTO (27). On the other hand, it’s a high value and indicates the presence of a large percentage of sandy materials compared to clay materials. This is consistent with the behavior of these materials, which was classified non-plastic materials. This helps in improving the properties of the subbase material when mixed with the (RAP) materials.

As for the granular gradient, a sharp decrease was observed in the percentage of fine materials passing through sieve No.4 and less as shown in Appendices A.III and A.I, which is not consistent with the Jordanian specifications (28) and AASHTO (27). The reason for this is that these materials are the result of milling the asphalt, and because of the presence of bituminous materials, the materials are produced in large sizes with very low percentages of fine materials. As the percentage of fine materials passing through sieve No. 200 is (2.34%), which is a very low percentage as shown in Appendix A.III, however, the existence of this percentage helps in improving the base materials that suffer from an increase in fine materials resulting from mobile crushers that are widespread in the Palestinian territories. This is one of the most important problems that the foundation materials suffer from in the Palestinian territories, which is reflected positively when the mixture is made with natural materials in specific proportions.

This material is generally a good material and has the following characteristics:

- A variety of sizes.
- Grain-to-grain contact.
- High void content.
- High permeability.
- Low stability.
- Difficult to compact.

The average results of Los Angeles test with 500 revolutions was (24.13), which is less than 45%, as shown in Table 4-1; this agrees with the Jordanian specifications (26) and according to AASHTO (T 96) (27). The explanation for this is that the materials used in asphalt mixtures are good materials with high hardness, in addition to the presence of the binder around (RAP) aggregates, which provides additional protection from corrosion.

The modified proctor tests were conducted to determine the maximum dry density (MDD) at the corresponding optimum moisture content (OMC), where the average (OMC) for RAP material was 5.2%, as shown in Table 4.1. It was noticed when carrying out the proctor test on (RAP) materials that the absorption of these granules of water is very low and limited for fine aggregates, which exist with low ratios; so that water remains outside the mixture. The reason for this is due to the coating of the granules with bituminous materials, which forms an insulating layer; therefore, where the water is absorbed by the very fine granules and the mixture reaches the highest density at a low moisture content. Another reason is the density of RAP is affected by the specific gravity of the binder and the specific gravity of the aggregates. “So, the presence of the aged binder reduces the RAP density (25).

As indicated before, there was a very weak cohesion between the RAP granules as a result of the poor gradation and the lack of fine materials in the mixture, which caused high air voids and a low density, and; therefore, the average (MDD) for RAP material was 1.92 g/cm³, as shown in Table 4.1 which less than 2.05 gm/cm³. Therefore, it does not fit the specifications for the subbase material, but it can be used as filling material (topping material) where MDD should be more than 1.7 gm/cm³ according to AASHTO (27). During compaction of the samples large granules are crushed and more water is absorbed; therefore, reduces the effect of bituminous materials covering the surface of the particles.

Since the RAP aggregates are highly permeable, water was draining from the bottom of the mold when the fifth layer was compacted.

As for the CBR test, the average for RAP material was 18.8, as shown in Table 4.1. This result is low and does not match the subbase specifications (≥ 40) (27); however, it could be used as filling material (topping material) as it is higher than 8. The reason behind the low CBR value of the RAP material is due to the poor cohesion between the granules and the difficulty of absorbing water, as mentioned previously, in addition to the poor granular gradation with few fine materials, which results in difficulty in mixing the materials to reach a homogeneous mixture, lower density, and lower bearing capacity. As indicated by Pradhan (24).

In general, the results of all previous tests are consistent with similar studies, especially the study of Pradhan & Biswal (24) as the results in general indicate that the specifications of RAP materials are not compatible with the specifications of subbase materials, but these materials can be used as filling materials or filtration materials due to the presence of the bituminous, which cover the granules. In addition, most of the mixture consists of coarse materials with little amount of fine aggregates.

4.2.2 Subbase Material Test

After collecting samples from the three streets, 4 samples of subbase material were taken. Several tests were conducted for the collected samples to determine their properties and the average results are presented in Table 4.2.

Table 4.2*Subbase Material Test Results (See Appendices D.I, D.II, D.III, D.IV)*

Test	Beitunia Crusher	Ramallah Jerusalem Street	Kofor Nemeh Street	Beitunia Main Street	Average Result (except Kofor Nemeh)	Specifications (1)
Plasticity Index (P.I)	6.4	2.2	16	2.9	3.8	2-8
Sand Equivalent (%)	25.2	54	20	43.5	40.9	25 (Min.)
Percent Passing Sieve No. 200 (%)	13.4	8.1	14.1	10.4	10.7	(5-12 Subbase A)
Los Angeles at No. 500 (%)	36.2	35.8	38	39.5	37.2	40 (Max.)
Optimum Moisture Content (%)	9.3	7.6	9.4	8.2	8.4	--
Maximum Dry Density (M.D.D) (gm/cm ³)	2.05	2.08	2.00	2.09	2.08	2.05 (Min.)
California Bearing Ratio (CBR @ 0.1")	74.3	127	55.4	65	88.8	40 (Min.)
Notes	OK	OK	Rejected	OK	OK	

Results in Table 4.2 show that all samples are according to the specifications except for Kofor Nemeh sample, which shows high plasticity index, low sand equivalent, and high percentage of passing sieve No200. This is due to the high proportion of soft clay materials in the mixture, as visually observed, in addition to the low MDD because of the poor quality of the rock used. Therefore, these materials were excluded as they do not comply with the specifications of the subbase materials.

A sample from Beitunia Crusher was chosen to be mixed with the RAP materials of Ramallah-Jerusalem Road, as its properties were within acceptable specifications compared to other samples.

4.3 Subbase RAP Mixture Tests

A number of samples were prepared that consisted of a mixture of RAP materials in addition to subbase materials in percentages of (10, 15, 20, 25, 30, 35, 40, 45, 50, 55, and 60%). These percentages were chosen by reference to previous studies, then necessary laboratory tests were conducted, and the results are described in the following sub-sections.

4.3.1 Atterberg Limits Test

Atterberg tests determine the moisture contents in which fine-grained clay or silty clay transfer between hardness, semi-solidity, plastic, and liquid, as these tests are important since they represent an assessment of the shear strength, permeability, and potential expansion of the soil.

- **Liquid Limit**

Table 4.3

Mixing Material Liquid Limit Results (See Appendix N)

Sample No	0	1	3	4	6	8	10	12	13	14	15	16
Milling Material %	0	10	15	20	25	30	35	40	45	50	55	60
LL Test 1	26.4	26	25.9	25.5	25.5	25.3	25.2	25.1	25	24.9	24.5	24.1
LL Test 2	26.4	26.3	25.9	22.5	22.5	25.3	25.2	25.1	25	24.9	24.5	24
LL Test 3	26.4	26.4	25.9	22.5	22.5	25.3	25.2	25.1	25.1	24.9	24.5	24
LL Average	26.4	26.4	25.9	23.5	23.5	25.3	25.2	25.1	25	25	24.5	24

“Liquid Limit (LL) is defined as the water content at which a soil sample is just fluid enough to allow a groove to close when shaken in a certain way” (29).

During the implementation of the experiments, it was observed that the moisture content of the transition from the plastic state to the liquid state decreased from (26.41) to (24.03) after increasing the percentage of RAP to 60%, as shown in Table 4.3.

An increase in the moisture weight relative to the dry weight was observed as the proportion of RAP increases in the mixture, as shown in the photo in Appendix A.II. The reason for this is that the RAP materials are silty, and their capacity to absorb water is constrained by their bitumen coating.

- **Plastic Limit**

Table 4.4

Mixing Material Plastic Limit Test Results (See Appendix N)

Sample No	0	1	3	4	6	8	10	12	13	14	15	16
Milling Material %	0	10	15	20	25	30	35	40	45	50	55	60
PL Test 1	20.0	20.0	19.8	19.7	19.9	19.7	19.7	19.7	21.1	20.4	19.6	19.4
PL Test 2	20.3	20.2	19.7	19.8	19.7	19.8	19.6	19.8	21.0	20.2	19.7	19.5
PL Test 3	19.7	19.8	19.9	19.6	20.0	19.6	19.8	19.5	21.2	20.3	19.7	19.3
PL Average	20.0	20.0	19.8	19.7	19.9	19.7	19.7	19.7	21.1	20.3	19.7	19.4

“Plastic limit is defined as the water content when a plastic material transforms into a semi-solid condition” (29). A soil sample is continuously rolled into a thread for this test until it begins to disintegrate.

The materials' behaviors changed slightly during the experimentation as shown in Table 4.4, with the exception of the mixtures of more than 50% RAP material. This is due to the high percentage of silty materials within the mixture with the increase in the percentage of RAP materials. Thus, the homogeneity of the mixture decreases.

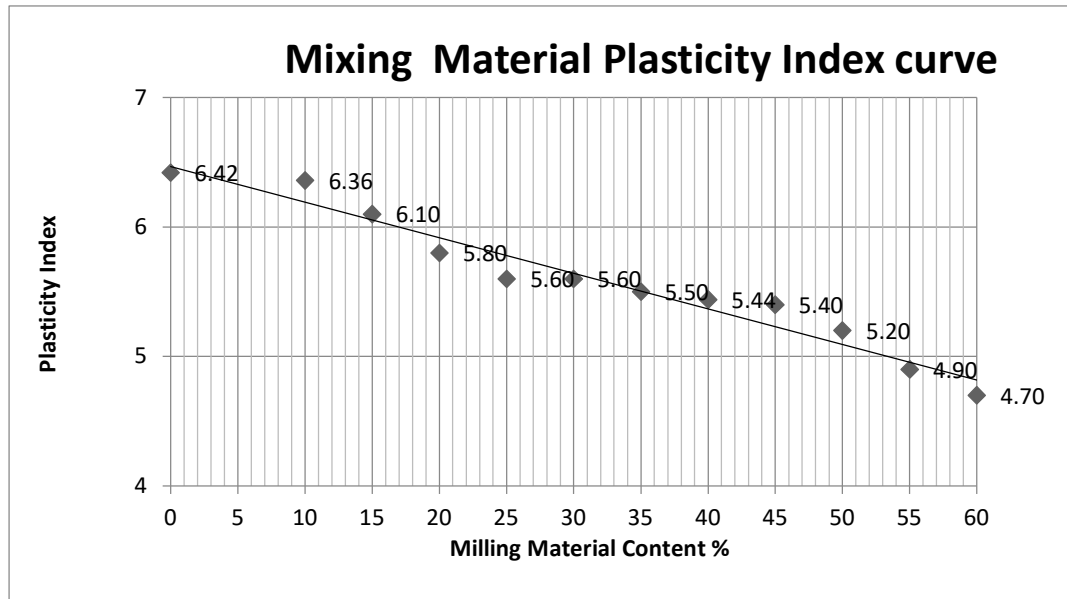
Whereas, during the implementation of the experiment, it was noticed that the bonding between the materials weakened when the percentage of the RAP materials was increased in the mixture, which causes the materials to disintegrate faster as shown in the photo in Appendix A.III.

- **Plasticity Index**

Figure (4.1) shows the relationship between the plasticity index and RAP percentage, which shows an inverse relationship. The value of PI decreases with the increase in the percentage of RAP materials. This is because the RAP materials are non-plastic. When mixed with natural materials, it is normal to decrease the PI value with an increase in the percentage of the RAP material.

Figure 4.1

Mixing Material Plasticity Index Curve (See Appendix N)



Plasticity index demonstrates the breadth of the moisture range at which the soil is still plastic. When blending natural materials with RAP material, the ratio of clay materials inside the combination reduces, which explains why PI is low. In general, the plasticity index simply relies on the amount of clay present.

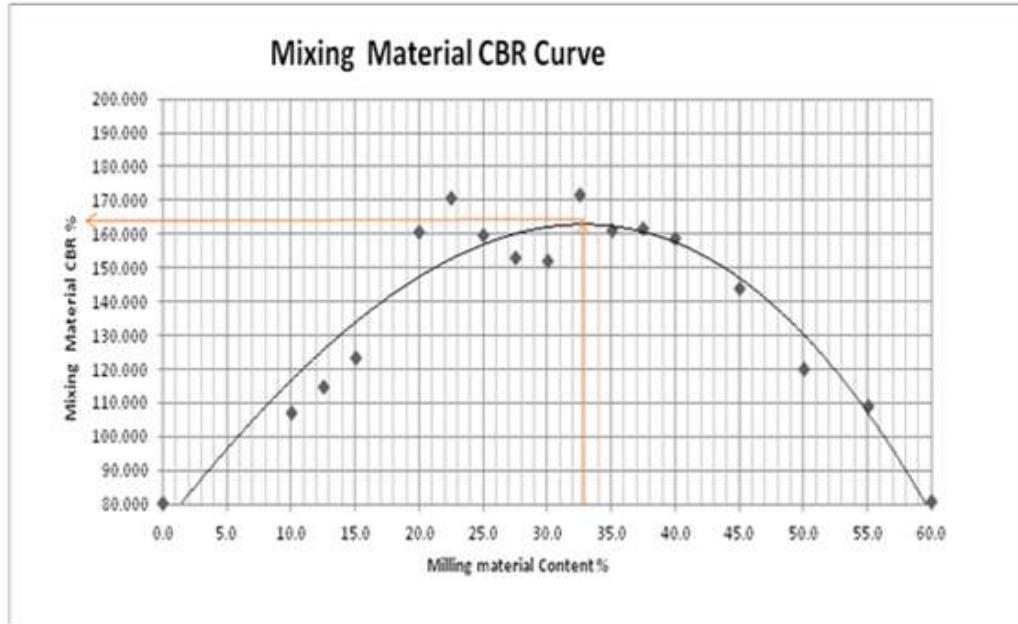
According to these results, all percentages are within the specifications, so that up to 60% of the RAP materials can be added to the mixture.

4.3.2 California Bearing Ratio (CBR) Test

To ascertain the strength characteristic in terms of bearing capacity, the CBR test was conducted. RAP, fresh aggregates, and composite materials including varied percentages of RAP were all put through CBR testing; results are shown in Figure 4.2. It is evident that the CBR values of the combination grow as the proportion of RAP aggregates increase up to 32.5%, before decreasing rapidly as photo in Appendix A.VI shows. The fact that the specific gravity of RAP aggregate is lower than other aggregates may cause the CBR values to decline after a certain proportion of RAP content.

Figure 4.2

Mixing Material California Bearing Ratio (CBR) Curve (See Appendix M)



The higher the CBR percentage, the higher the percentage of water that comes out from the bottom mold due to the particles inability to absorb it with the increase in the percentage of RAP. The large increase in the CBR value is due to the granules used mainly in asphalt mixtures that are good material. However, what reduces the CBR value is the lack of homogeneity in the gradation of these materials after milling and the significant decrease in the proportion of fine materials, as shown in (A.III). The percentage of material passing sieve 2 mm in the mixture does not exceed 19%, while the minimum according to the specifications (of subbase) is 37%. This as compensated when mixing these materials with natural materials up to a specific percentage (32.5%), where this represents the optimal percentage of the mixture to obtain the highest value.

4.3.3 Sieve Analysis

Figure 4.3

Sieve Analysis and %RAP (See Appendix M)

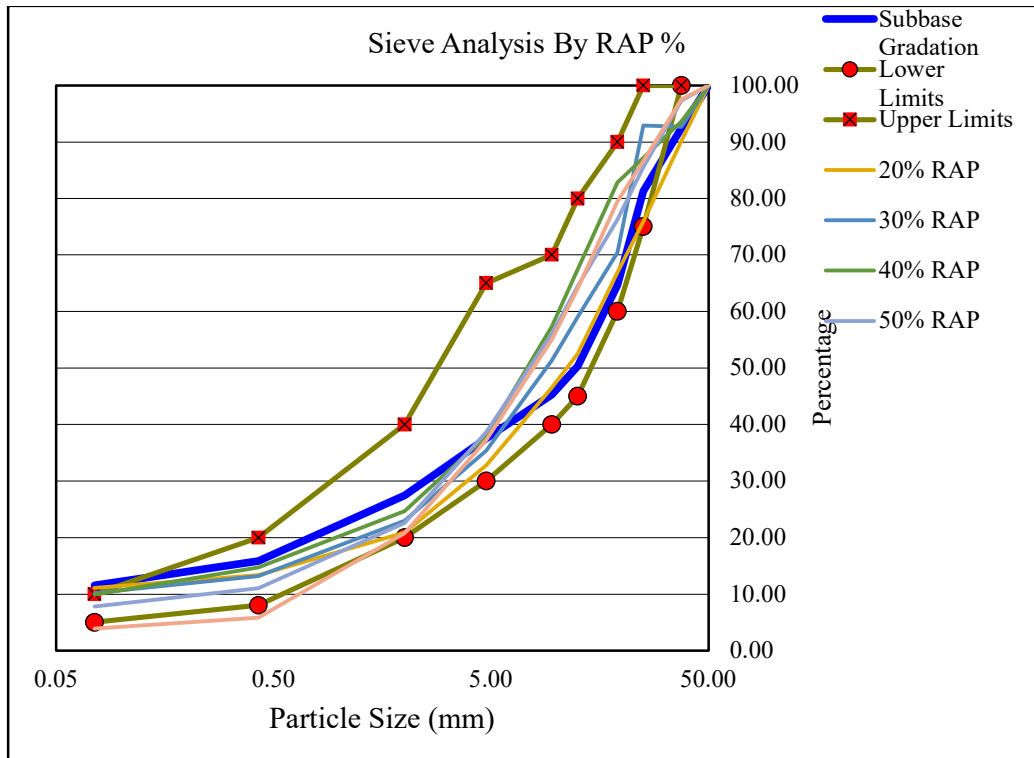


Table 4.5

Mixing Material Passing Sieve No200 Results (See Appendix M)

Sample No	0	1	3	4	6	8	10	12	13	14	15	16
Milling Material %	0	10	15	20	25	30	35	40	45	50	55	60
Test 1 (%)	13.4	11.5	11.2	11.1	10.5	10.1	10	9.9	8.5	7.8	5.9	3.9
Test 2 (%)	13.2	11.6	11.3	11.3	10.6	10	10.1	9.7	8.2	7.9	5.8	4.4
Test 3 (%)	13.4	11.5	11.1	11.2	10.3	10.1	9.9	9.8	8.5	7.6	5.9	3.9
Average	13.3	11.5	11.2	11.2	10.5	10.1	10	9.7	8.4	7.7	5.9	4.1

With reference to (Table 4.1), the average passing through sieve No. (200) of the milling materials was only 2.34%, which is a low percentage and less than the specifications required for subbase materials. The materials resulting from asphalt milling are generally course materials. However, base course and subbase materials in the Palestinian territories contain a significant amount of fine materials, particularly in the governorates of Jericho and Ramallah and Al-Bireh, as shown in Table 4.2, with an average of 11.2%. This is close to the higher limit for subbase material specifications and higher than base course material specifications.

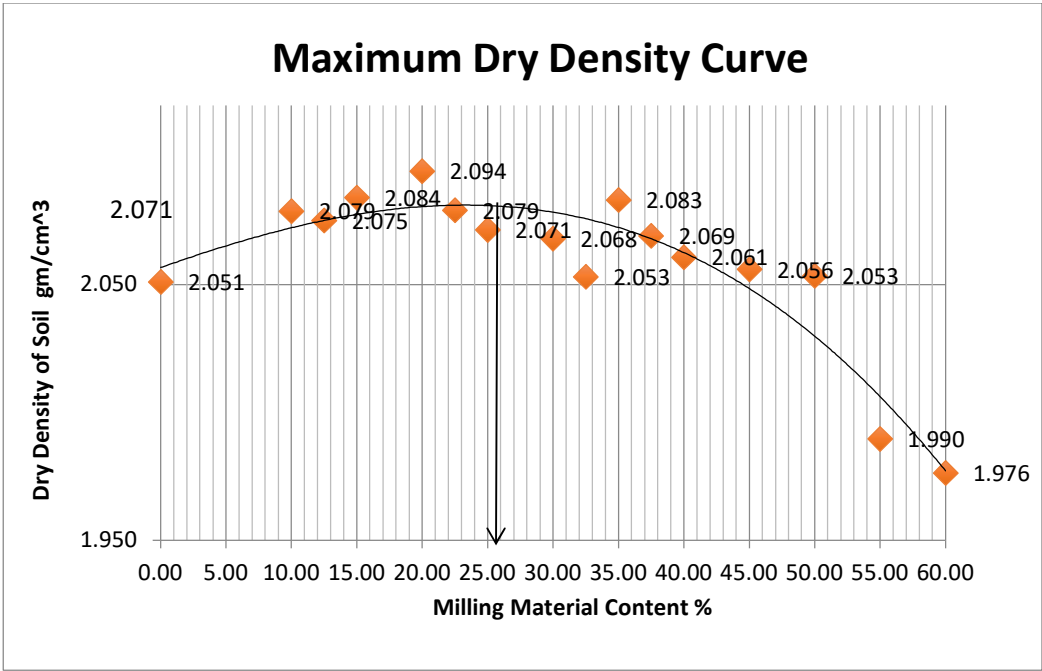
Therefore, it is concluded that mixing the RAP materials with the base course or subbase materials works on reducing the proportion of the materials passing through sieve No. 200 to the acceptable limits. It is also noted the improvement of the gradient of the mixture with the increase in the ratio of the RAP since subbase materials have a high percentage of fine materials (passing sieve No. 4) and low percentage of course materials; this a generally observed problem for base course in the Palestinian territories. As a result, the mixture became more homogeneous and the values are within the acceptable range.

4.3.4 Maximum Dry Density and Optimum Moisture Content

• Maximum Dry Density

Compared to natural aggregates, RAP aggregates have a lower dry density. The density of RAP will be affected by the specific gravities of the aggregates, the binder, and the bitumen. As a result, the RAP density decreases when an old binder is present. Thus, when the amount of RAP material in the mixture rises, the homogeneity increases in the mixture up to 25 % (see Figure 4.4), after which, it increases air voids and decreases MDD. The mixture becomes harder when RAP is added; RAP is more porous and stiffer than natural aggregates.

Figure 4.4
Mixing Material Maximum Dry Density Curve (See Appendix M)

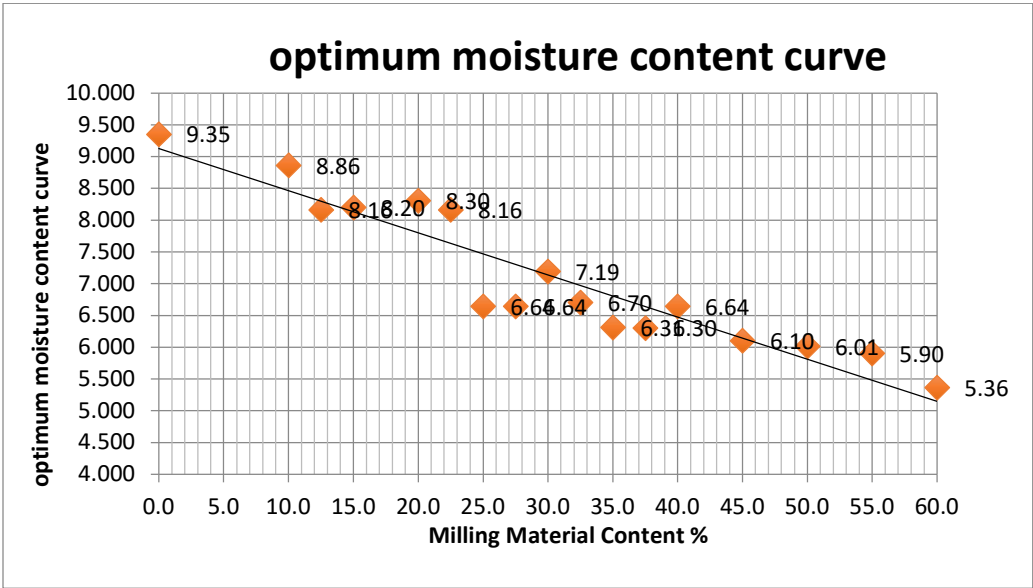


The maximum dry density (MDD) at the corresponding optimum moisture content (OMC) was calculated using a modified proctor test. The results show that raising the RAP quantity for each combination somewhat increases the OMC as the maximum dry density values of the mixture depend on the number of fine particles in the mixture and will climb significantly. MDD will rise to a specific proportion of RAP. It was determined that 32.5% RAP content is the ideal RAP percentage for the combination since it results in the maximum dry density. The larger RAP aggregates were crushed during compaction. Additionally, samples with greater RAP aggregates that were compacted at lower moisture levels might lose their optimum condition after being withdrawn from the mold. Since RAP aggregate is highly porous, water began to stream out of the bottom of the mold while the fifth layer was being crushed. This may be partially attributed to the RAP's open-graded structure. RAP's capacity to store moisture is negligible.

4.3.5 Optimum Moisture Content

Due to their comprehensive encapsulation with bituminous materials, fine materials in RAP are (silty) materials with limited water absorption. As a result, as shown in Figure 4.5, as the proportion of RAP in the mixture increases, the (OMC) decreases. This implies that we require less water to reach (MDD), which would lower the cost of road construction.

Figure 4.5
Mixing Material Optimum Moisture Content Curve (See Appendices E. I to E. XI)



4.3.6 Sand Equivalent

Table 4.6

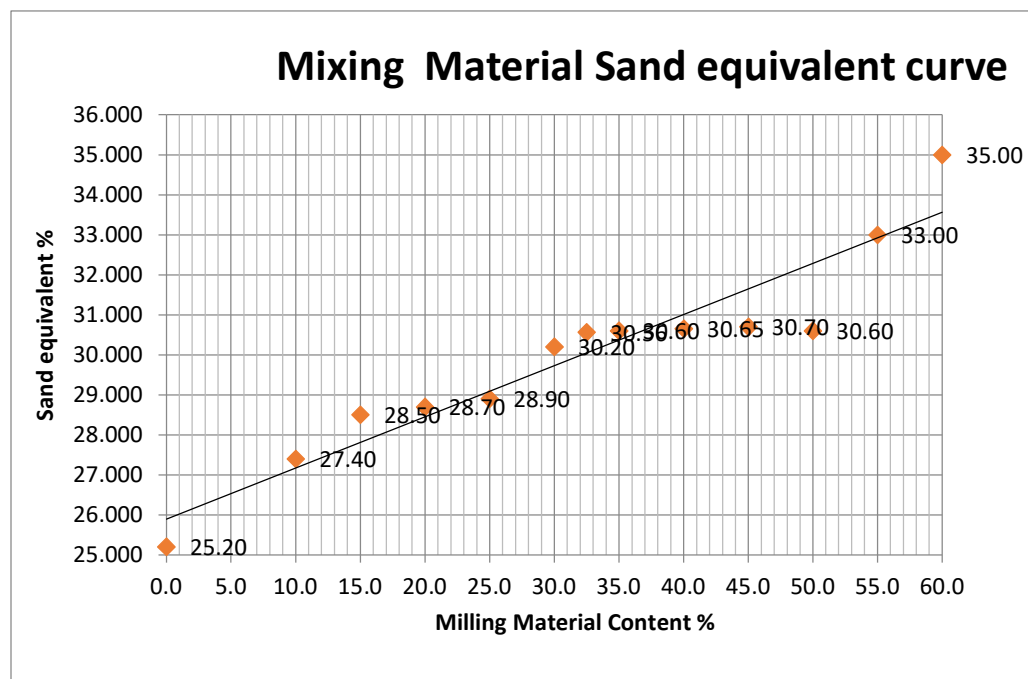
Sand Equivalent Test Results for Different RAP Percentages (See Appendix M)

RAP percentages	Sand Reading (%)	Clay Reading (%)	Sand Equivalent (%)
Subbase Material	2.90	11.5	25.2
10% RAP	3.15	11.5	27.4
15% RAP	3.25	11.4	28.5
20% RAP	3.24	11.3	28.7
25% RAP	3.24	11.2	28.9
30% RAP	3.35	11.1	30.2
35% RAP	3.36	11.0	30.5
40% RAP	3.34	10.9	30.6
45% RAP	3.32	10.8	30.7
50% RAP	3.35	10.9	30.6
55% RAP	3.45	10.5	33.0
60% RAP	3.50	10.0	35.0
100% RAP	4.7	4.2	89.4

As shown in Table 4.2, the proportion of sandy materials decreases as the ratio of RAP materials in the mixture increases, where sand equivalent of the subbase material is 25.2, as per (Appendix D). As a result, increasing the amount of these components in the mixture will also increase the amount of sand reading components, as shown in Figure 4.6.

Figure 4.6

Mixing Material Sand Equivalent Curve



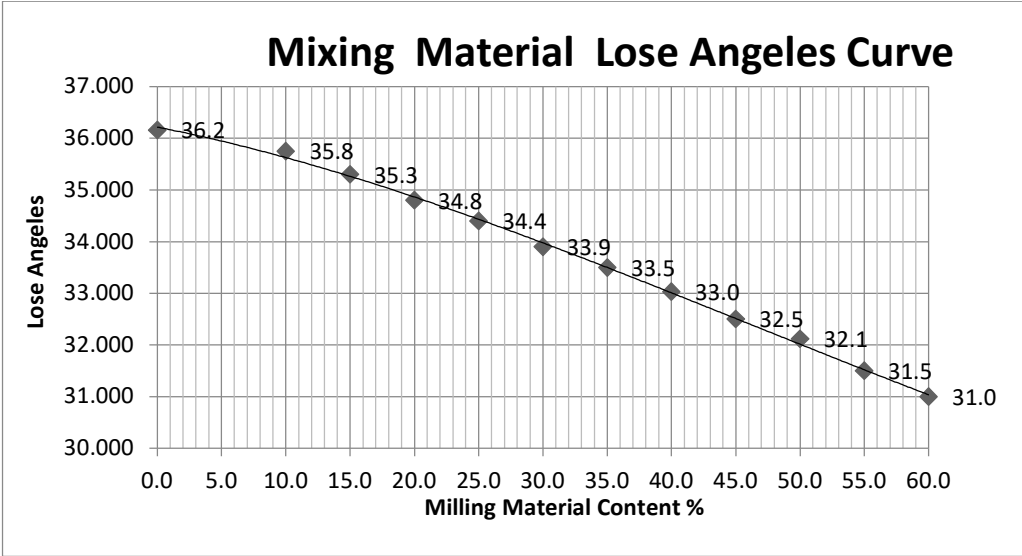
As shown in Figure 4.6, sand equivalent value has considerably increased at 10%, bringing it to compliance with the specifications for base course material, which would enhance the new mixture's overall properties.

This makes sense because the RAP materials are made of silty materials; therefore, increasing their proportion in the mixture will increase the proportion of silty materials and decrease the proportion of clay materials, as shown in photo in Appendix A. VIII, which results in increasing the value of Sand Equivalent.

4.3.7 Los Angeles Abrasion

Figure 4.7

Mixing Material Los Angeles Abrasion Curve (See Appendices E. I to E. XI)



Referring to (Appendix C.II), it is observed that Los Angeles Abrasion is valued at 26, while the subbase materials are valued at 36.16. (Appendix. D). As show in Figure 4.7, Los Angeles Abrasion values decrease as the proportion of RAP materials in the mixture increases, which makes sense given that RAP materials have a high resistance to abrasion. This is due to the bituminous material coating the aggregates that insulates and increases rigidity.

4.4 Validation of Results

For the purpose of verifying the results, especially the (Sand Equivalent, CBR, and Proctor) tests, a number of samples was taken from the major percentages, which are

(12.5, 22.5, 27.5, 32.5, and 37.5). As seen in (Appendix M), the results were close to the main percentages, but these percentages were chosen to obtain greater accuracy in the optimal percentage of the mixture, which is 32.5%.

4.5 Comparison Between this Study and Previous Studies

- When examining the study's findings, we see that they are similar to those of Pradhan & Biswal (24), with the percentage increasing to 32.5% before the CBR starts to decline. Gradually, as the proportion of rap in the mixture increases, which is a logical outcome given that the rap's components are materials of high hardness, and as the gradient increases the homogeneity of the Sub Base mixture until it reaches a certain percentage.
- In this study a rise (MDD) was seen up to a percentage of 25%, followed by a gradual decrease due to an increase in homogeneity until this percentage was reached, before beginning to decline with an increase in the proportion of course materials and declining in homogeneity with an increase in the percentage of mixture in mixture.
- This study showed that it is possible to obtain materials with better properties so that its specifications are met up to 50% mix proportion.

4.5 Economical Feasibility Study

4.5.1 Introduction

Generally, in Palestine using RAP material is limited as a filtration material especially on a local road when traffic loads are very low due to RAP permeability; often institution threw this material into the landfill without achieving any benefits, which costs these institutions additional expenses like transportation and landfill fees.

The use of this material as a subbase material helps to sustain natural resources and preserve the environment and community health. The economic effects of using RAP materials as subbase in different ratios were examined using percentages (30%, 50%) as 30% is considered an optimum mixture percentage and 50% is considered as the maximum acceptable RAP percentage. The price per square meter for each case was calculated and compared with the price per square meter related to the use of subbase and base course materials. There are two different breakdowns of the price for each percentage: one is for private institutions, where the cost is determined by market rates;

the other is for institutions where the materials are owned by the institution and the viability of the project will be assessed.

In Palestine, a lot of RAP material is produced each year; in the last three years, it reached (898,982) square meters as mentioned in Table 3.1. Less than 10% of these materials are used in very specific circumstances, such as temporarily rerouting roads, parking lots, and agricultural roads, as well as occasionally as filter material below the base layer.

Due to the high costs of constructing road projects, especially in the recent years due to the rise in transportation cost after the rise in fuel prices, in addition to the lack of good natural material, the need to use RAP mix in road construction becomes inevitable. Therefore, this study investigates the cost-effectiveness of using RAP-subbase mixture and RAP-base course mixture.

4.5.2 Direct Comparison of Costs Incurred

The cost-effectiveness of this procedure is questioned by the analogy of achieved benefits from the use of the RAP-aggregate blend. An economic analysis must compare all costs associated with producing subbase and base course natural aggregates to costs associated with making a virgin aggregate mixture and discarding the waste material.

4.5.2.1 Unit Cost of RAP-Subbase Blend

Based on the actual unit prices offered for Beitunia Ein Erik Street project to be constructed in Ramallah and Al-Bireh Governorate, the cost of the RAP subbase mixture was evaluated in this study. The existing asphalt layer on the main road was being milled as part of extensive rehabilitation work. Based on information obtained from the cost and estimates section in the MPWH, as shown in in Appendix G. IV, the price of constructing the road using RAP made from crushed asphalt and natural materials was compared with the cost of utilizing natural materials. All costs have been converted to equivalent US dollars.

4.5.2.2 Unit Cost Analysis of RAP-Subbase Blend for Governmental Institutions

The prices of milling materials, subbase, and base course were obtained from the MPWH for the purpose of conducting the economic feasibility study, and the prices were as shown in Table 4.7.

Table 4.7*Prices of Milling Material Subbase and Base Course (see Appendix G.V, Appendix G. VI)*

Material	Material costs (NIS)	Supply, mixing and rolling costs (NIS)	Total cost (NIS)	Note
Milling Material	18	40	58	For institution, price =40
Subbase	26	40	66	
Base course	38	40	78	

According to Table 4.7 and Appendix G.IV, the RAP was cost free for governmental institutions; the only cost incurred was for transportation fees of RAP. The cost of RAP was \$11.43/m³ including the transport cost, mixing, spreading, and compaction. Where the unit cost of subbase material was \$18.86/m³, the cost for base course material was \$22.29/m³, and as shown in Appendix G. VI, the cost of RAP disposal was \$0.71/m².

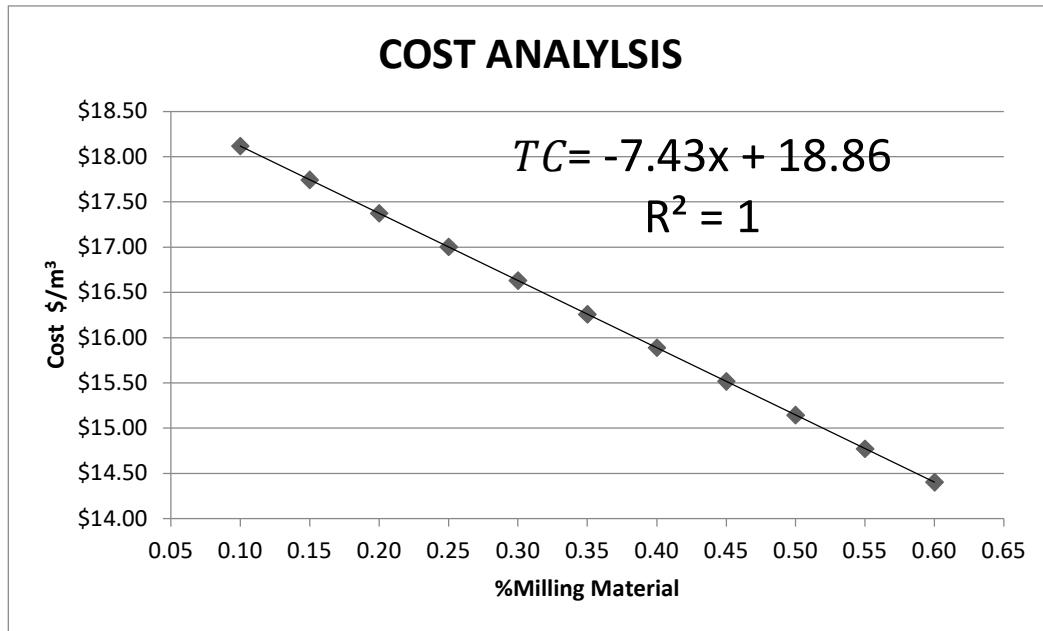
A linear model was developed that represents the relationship between the ratio of the RAP materials in the mixture with subbase material and the cost per cubic meter. In the figure, we notice a decrease in the cost per cubic meter from \$18.12/m³ at 0% of RAP to \$14.14/m³ at a rate of 60% of RAP materials. The model is also given in Eq. (1) as follows:

$$TC = -7.43x + 18.86$$

Where (*TC*) is the Total cost (\$/m³) and (*X*) is RAP percentage.

Figure 4.8

RAP Mixture Cost Relationship



4.5.2.3 RAP-Subbase Blend for Governmental Institutions with 30% of RAP

Due to the superior quality of the RAP-subbase blend with 30% RAP (CBR = 152%) compared to the conventional subbase (CBR = 80%), an equivalent thickness of RAP-sand layer is predicted using the layer coefficient of each material. This process involved two steps. First, using Eq. (4.1), which was reported for being applicable over a broad range of CBR values of more than (30), the resilient modulus (M_r) of each material was calculated:

$$M_r(\text{psi}) = 2555\text{CBR}^{0.64} \quad (4.1)$$

According to Eq. (4.1), the M_r values for RAP-Subbase mix and traditional subbase materials are 438.82 MPa and 291.93 MPa, respectively. The following equation (4.2) was used in the second phase to calculate the layer coefficient for the two types of materials:

$$a_3 = 0.227 * \text{Log}_{10}(M_r) - 0.839 \quad (4.2)$$

According to equation (4.2), a 20 cm conventional subbase layer and a layer of 30% RAP mixing with subbase material were compared, and the unit cost per square meter was then

computed. The layer coefficients for the 30% RAP mixture and the subbase material are 0.21 and 0.25, respectively.

$$\text{RAP cost/m}^2 = 40 \times 0.2 = 8 \text{ NIS/m}^2 = \$2.29/\text{m}^2$$

$$\text{Subbase cost/m}^2 = 66 \times 0.2 = 13.2 \text{ NIS/m}^2 = \$3.77/\text{m}^2$$

Where mixing with 30% RAP material with thickness of 20cm cost equals:

$$\text{Cost}_{30\% \text{ RAP}} = (0.3 \times \text{RAP COST} + 0.70 \times \text{Subbase cost})$$

$$\text{Cost}_{30\% \text{ RAP}} = (0.3 \times 2.29 + 0.70 \times 3.77) =$$

$$\text{Cost}_{30\% \text{ RAP}} = \$3.33/\text{m}^2$$

$$\text{Where Subbase cost/m}^2 = \$3.77/\text{m}^2$$

This results in a 12% cost reduction over the standard material. When taking the cost of disposal into account, it will be reduced to \$2.62 /m²; therefore, the cost reduction over standard material will be 31%.

This large cost savings promotes the use of the suggested RAP blend in place of the traditional subbase material, especially given the additional advantages of resource conservation and a decreased requirement for disposal yards.

RAP-Subbase Blend for Governmental Institutions with 50% of RAP

Due to the superior quality of the RAP-Subbase blend with 50% RAP (CBR = 120%) compared to the conventional subbase (CBR = 80%), an equivalent thickness of RAP-sand layer is predicted using the layer coefficient of each material. Using the previous methodology, the resilient modulus (Mr) of each material was estimated.

According to Eq. (4.1) above, the Mr values for RAP-subbase mix with 50% RAP are 377.2 MPa. The following equation (4.3) was used in the second phase to calculate the layer coefficient for the two types of materials:

$$a_3 = 0.227 * \text{Log}_{10}(\text{Mr}) - 0.839 \quad (4.3)$$

According to equation (4.3), a 20 cm conventional subbase layer and a layer of 50% RAP mixing with subbase material were compared, and the unit cost per square meter was then computed. The layer coefficient for the 50% RAP mixture is 0.24.

The corresponding layer coefficients for 50% RAP mixing from Eq. (3) are 0.24 and 0.21.

Subbase layer with 20cm thickness costs \$3.77/m² where mixing with 50% RAP material with thickness of 20 cm cost equals:

$$\text{Cost}_{50\% \text{ RAP}} = (0.5 \times \text{RAP COST} + 0.50 \times \text{Subbase cost})$$

$$\text{Cost}_{50\% \text{ RAP}} = (0.5 \times 2.29 + 0.5 \times 3.77) = \$3.03/\text{m}^2$$

$$\text{Where subbase cost}/\text{m}^2 = \$3.77/\text{m}^2$$

This results in a 19.6% cost reduction over the standard material. When taking costs of disposal into account the cost will be reduced to \$2.32/m²; therefore, the cost reduction over standard material will be 38.5%.

In addition to reducing road construction costs, using a mixture of RAP material and natural materials will reduce the use of natural materials and the duration of the project, as transporting materials from outside the project takes more time than skimming. Also, there is no additional work required for mixing and implementing on site because the grader performs the mixing in the same manner as when using a subbase.

4.5.2.4 RAP-Base Course Blend for Governmental Institutions with 30% of RAP

The study's experiments revealed a notable improvement in the materials' properties, particularly with regard to CBR, sand equivalent, and proctor. Here, mixing can be used by RAP to enhance the properties of the foundation materials that have weak properties. According to the following, using base course in the mixture is economically feasible:

Since the CBR is greater than 80%, the study can be applied to base course materials and the previous results are still valid.

$$\text{RAP cost}/\text{m}^2 = \$2.29/\text{m}^2$$

$$\text{Base course cost}/\text{m}^2 = 78 \times 0.2 = 15.6 \text{ NIS}/\text{m}^2 = \$4.46/\text{m}^2$$

Where mixing with 30% RAP material with thickness 20cm cost equals:

$$\text{Cost}_{30\% \text{ RAP}} = (0.3 \times \text{RAP COST} + 0.70 \times \text{Base Course cost})$$

$$\text{Cost}_{30\% \text{ RAP}} = (0.3 \times 2.29 + 0.70 \times 4.46)$$

$$\text{Cost}_{30\% \text{ RAP}} = \$3.81/\text{m}^2$$

$$\text{Where base course cost}/\text{m}^2 = \$4.46/\text{m}^2$$

This results in a 14.6% cost reduction over the standard material. When taking the cost of disposal into account, the cost will be reduced to \$3.1 /m²; therefore, the cost reduction over standard material will be 30.5%.

4.5.2.5 RAP-Base Course Blend for Governmental Institutions with 50% of RAP

$$\text{RAP cost/m}^2 = \$2.29/\text{m}^2$$

$$\text{Base course cost/m}^2 = \$4.46/\text{m}^2$$

Where mixing with 50% RAP material with thickness 20cm cost equals:

$$\text{Cost}_{50\% \text{ RAP}} = (0.5 \times \text{RAP COST} + 0.5 \times \text{Base Course cost})$$

$$\text{Cost}_{50\% \text{ RAP}} = (0.5 \times 2.29 + 0.5 \times 4.46)$$

$$\text{Cost}_{50\% \text{ RAP}} = \$3.38/\text{m}^2$$

$$\text{Where base course cost/m}^2 = \$4.46/\text{m}^2$$

This results in a 24.2% cost reduction over the standard material. When taking costs of disposal into account the cost will be reduced to \$2.67/m²; therefore, the cost reduction over standard material will be 40%.

4.5.2.6 Unit Cost Analysis of RAP-Subbase Blend for Private Sector

According to Table 4.2, the unit price of milling material for the private sector will go up to 58 NIS/m³. Consequently, since the institutions do not incur any costs as a result of these materials, the economic feasibility will decrease due to the additional cost of milling materials.

4.5.2.7 RAP-Subbase Blend for Private Institutions with 30% of RAP

$$\text{According to Table 4.2 RAP cost/m}^2 = 58 \times 0.2 = 11.6 \text{ NIS/m}^2 = \$3.31/\text{m}^2$$

$$\text{Subbase cost/m}^2 = 66 \times 0.2 = 13.2 \text{ NIS/m}^2 = \$3.77/\text{m}^2$$

Where mixing with 30% RAP material with thickness 20cm cost equals:

$$\text{Cost}_{30\% \text{ RAP}} = (0.3 \times \text{RAP COST} + 0.70 \times \text{Subbase cost})$$

$$\text{Cost}_{30\% \text{ RAP}} = (0.3 \times 3.31 + 0.70 \times 3.77) =$$

$$\text{Cost}_{30\% \text{ RAP}} = \$3.63/\text{m}^2$$

$$\text{Where Subbase cost/m}^2 = \$3.77/\text{m}^2$$

This results in a 4% cost reduction over the standard material. When taking the cost of disposal into account, the cost will be reduced to \$2.92/m²; therefore, the cost reduction over standard material will be 22.5%.

4.5.2.8 RAP-Subbase Blend for Private Institutions with 50% of RAP

According to Table 4.2 RAP cost/m² = 58 × 0.2=11.6 NIS/m² = \$3.31/m²

Subbase cost/m² = 66 × 0.2=13.2 nis/m²=\$3.77/m²

Where mixing with 50% RAP material with thickness 20cm cost equals:

$$\text{Cost}_{50\% \text{ RAP}} = (0.5 \times \text{RAP COST} + 0.5 \times \text{Subbase cost})$$

$$\text{Cost}_{50\% \text{ RAP}} = (0.5 \times 3.31 + 0.50 \times 3.77) =$$

$$\text{Cost}_{50\% \text{ RAP}} = \$3.54/ \text{m}^2$$

Where Subbase cost/m² =\$3.77/m²

This results in a 6.1% cost reduction over the standard material. When taking the cost of disposal into account, the cost will be reduced to \$2.83/m²; therefore, the cost reduction over standard material will be 25%.

4.5.2.9RAP-Base Course Blend for Private Institutions with 30% of RAP

RAP cost/m² = \$3.31 /m²

Base Course cost/m² = 78 × 0.2=15.6 NIS/m²=\$4.46/m²

where mixing with 30% RAP material with thickness 20cm cost equals:

$$\text{Cost}_{30\% \text{ RAP}} = (0.3 \times \text{RAP COST} + 0.70 \times \text{Base Course cost})$$

$$\text{Cost}_{30\% \text{ RAP}} = (0.3 \times 3.31 + 0.70 \times 4.46)$$

$$\text{Cost}_{30\% \text{ RAP}} = \$4.12/ \text{m}^2$$

Where Base Course cost/m² = \$4.46 /m²

This results in an 8% cost reduction over the standard material. When taking the cost of disposal into account, the cost will be reduced to \$3.41/m²; therefore, the cost reduction over standard material will be 23.5%.

4.5.2.10 RAP-Base Course Blend for Private Institutions with 50% of RAP

$$\text{RAP cost/m}^2 = \$3.31 / \text{m}^2$$

$$\text{Base Course cost/m}^2 = 78 \times 0.2 = 15.6 \text{ NIS/m}^2 = \$ 4.46 / \text{m}^2$$

Where mixing with 50% RAP material with thickness 20cm cost equals:

$$\text{Cost}_{50\% \text{ RAP}} = (0.5 \times \text{RAP COST} + 0.5 \times \text{Base Course cost})$$

$$\text{Cost}_{50\% \text{ RAP}} = (0.5 \times 3.31 + 0.5 \times 4.46)$$

$$\text{Cost}_{50\% \text{ RAP}} = \$3.88 / \text{m}^2$$

$$\text{Where Base Course cost/m}^2 = \$4.46/\text{m}^2$$

This results in a 13% cost reduction over the standard material. When taking the cost of disposal into account, the cost will be reduced to \$3.17/m²; therefore, the cost reduction over standard material will be 29%.

4.6 Discussion of Results

Table 4.8 and Figure 4.9 provide a summary and comparison between the costs of mixing the RAP with different percentages for the governmental and private sectors.

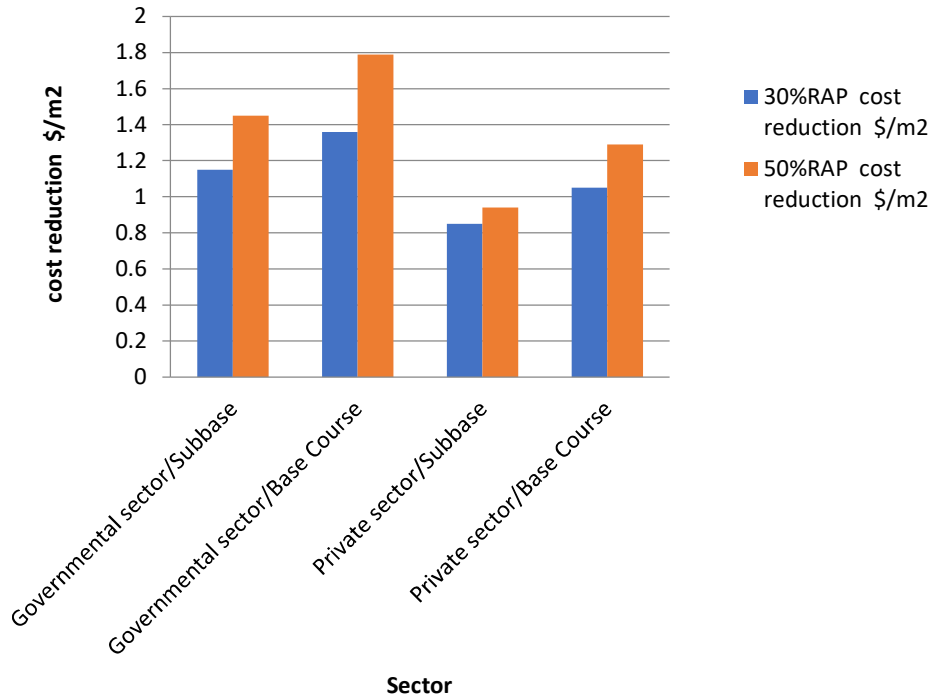
Table 4.8

Subbase and Base Course Cost via Mixing Cost for Governmental Institutions and Private Sector

Sector	Material Type	Material Cost (\$/m ²)	30% RAP Cost (\$/m ²)	50% RAP Cost (\$/m ²)	30% RAP Cost Reduction (%)	50% RAP Cost Reduction (%)
Governmental sector	Subbase	3.77	2.62	2.32	31%	38%
	Base Course	4.46	3.10	2.67	30%	40%
Private sector	Subbase	3.77	2.92	2.83	23%	25%
	Base Course	4.46	3.41	3.17	24%	29%
Average Value					27%	33%

Figure 4.9

Economic Comparison of Subbase and Base Courses for Governmental and Private Sectors



The summary of results of the cost study are as follows:

- In the Palestinian territories, RAP materials are accessible and extremely cost effective when compared to natural materials.
- This is especially true for governmental and non-governmental institutions that own the RAP material since these materials are free and they only incur transportation, spreading, and rolling costs. The cost is significantly reduced in direct proportion to the amount of RAP in the mixture.
- Regarding Table (4.8), in the government sector, a decrease in the cost is noticed when using a mixture of 30% RAP and 70% subbase materials by 31% and up to 38% when increasing the proportion of RAP up to 50%. However, when using RAP mixture with base course materials by 30% in the governmental sector, the decrease percentage reaches 30%, and it increases when the percentage of RAP materials in the mixture increased up to 50%, to reach 40%.
- Regarding Table (4.8), in the private sector, a decrease in the cost is noticed when using a mixture of 30% RAP and 70% base-course materials by 23% and up to 25%

when increasing the proportion of RAP up to 50%. However, when using RAP mixture with base course materials by 30% in the private sector, the decrease percentage reaches 24%, and it increases when the percentage of RAP materials in the mixture increased up to 50%, to reach 29%.

- Looking at the previous results, we see the convergence of prices between the percentages of 30% and 50%, but the 30% rate achieves a significant improvement in the properties of the materials, particularly (sand equivalent, CBR, MDD), and a reduction in the cost was achieved for a range of (18-27)% of the cost of natural materials. Therefore, it is economically feasible, in addition to shortening project duration and maintaining the environment.
- Approximately 900 thousand square meters have been scraped over the past three years by various institutions in Ramallah and the Al-Bireh Governorate. The cost of transporting to landfills is \$0.71/m² per square meter (Appendix G.II), and the losses incurred by institutions from the transfer of these materials alone amount to \$639,000.

Chapter Five

Conclusions and Recommendations

5.1 General

The world in general and the Palestinian territories in particular suffer from the lack of natural materials suitable for use as foundation materials in the streets. This is due to the poor properties of raw materials at times, and, for the Palestinian case, the control of the Israeli occupation over areas classified "C" where quarries exist, in addition to the high transportation prices.

On the other hand, since RAP materials are usually disposed in landfills without achieving any benefit from them, and they cost the institutions additional costs related to transportation and landfill fees, this thesis aims to study the possibility of using the RAP materials as foundation materials in specific proportions to reduce the costs of road projects and preserve the environment and natural resources.

5.2 Conclusions

The following points illustrate the main conclusions of the research:

- Base course constitutes 81% of the total materials used by institutions in Ramallah and the Al-Bireh Governorate, while subbase materials constitute only 19%.
- In Ramallah and Al-Bireh Governorate, 35,955.68 tons of RAP materials are produced without achieving any benefits from them, so they are thrown into landfills, which costs these institutions an estimated amount of \$639,000 during the last three years.
- One third of the base course samples' comprehensive test results in Ramallah and Al-Bireh Governorate in the last year 3 failed. The reason for this is due to the use of mobile crushers to produce base course using rocks extracted from building excavations in order to lower construction costs, transportation costs, and landfill fees. Additionally, excavation is carried out using conventional excavators to somewhat shallow depths because of the restrictions put in place by the authorities to using blasting in excavations in addition to the clay layers between the rock layers.

- RAP materials are difficult to mix and compact separately due to their low (PI) values, and cannot be used as a foundation material without the addition of fine materials to produce well-graded material.
- Due to the presence of a high proportion of sandy materials compared to clay materials, RAP material has a high sand equivalent.
- CBR for RAP material was very low and did not match the subbase specifications, but can use as filling material. The RAP material's poor granular cohesion, difficulty in absorbing water, poor gradation, and other factors all contribute to its low durability.
- The PI of RAP is almost zero. The presence of the binder around the (RAP) aggregate leads to poor water absorption, serves as an insulator to stop water from entering the material from the outside, and weakens the bonds between the granules, such as sand. It also explains low value of MDD and OMC.
- Contrary to subbase materials in Ramallah and Al-Bireh Governorate, which suffer from a high percentage of fine materials, RAP material suffers from a very low percentage of fine materials, especially passing through sieve No. 200. However, when mixing the materials together, we obtain a mixture with a good homogeneous gradation, and the percentage of fine materials becomes within the acceptable limits, which enhances the effectiveness of the mixture.
- In comparison to fresh aggregate, RAP aggregate has a lower specific gravity. This is because old binder is trapped inside the pores of RAP aggregate, and RAP aggregates have already been subjected to a repetitive loading and wear and tear.
- The use of RAP materials as foundation materials is possible, as it was found that the mechanical properties of the mixture improve remarkably until reaching a percentage of 32.5%, after which the properties of the mixture decrease in some characteristic such as (MDD and CBR). This ratio represents the optimal value of the mixture. Other characteristics continue to improve with the increase in the rate of RAP and here it is possible to obtain materials with better properties so that its specifications match the required specifications up to 50%. The reason for this is that when the binder materials are added to the subbase materials, the proportion of sandy materials increases and the gradient's consistency rises, improving the mixture's performance up to a certain percentage (32.5%). After which, the proportion of fine materials in the mixture decreases, resulting in the loss of required bonding, and the consistency falls.

- Using a combination of equal amount of natural material and RAP materials can reduce the cost per square meter of base course by 34.5% and the cost per square meter of subbase materials by 31.5%. Using a combination of 30% of the RAP materials can also result in savings of 27% of the base course and subbase materials' original cost.

5.3 Recommendations

Based on the results of the thesis, it is recommended to use the premix materials in a mixture with subbase materials or base course materials in ratio between (20-50) % to improve the properties of these materials to become within the required specifications. It is also possible to obtain base course (grade A) when mixing subbase materials with RAP by 30%.

In order to reduce the cost of road projects and preserve the environment and natural resources, relevant Palestinian institutions are encouraged to put the results of this study into practice and amend the Palestinian specifications to permit the use of RAP materials and their mixing with natural materials.

5.4 Limitations and Future Research

In order to obtain more accurate results that are representative of all the Palestinian territories, this research must be conducted similarly in other governorates. This will assist in developing a guide for the use of RAP materials. It is necessary to conduct this study across all of the governorates because the nature of the rocks varies from one governorate to another.

The final recommendation of this thesis is to apply the study to all the governorates of the Palestinian territories, especially those that suffer from the weakness and scarcity of foundation materials, especially the governorate of Jericho and the Jordan Valley.

List of Abbreviations

Abbreviation	Meaning
CBR	California Bearing Ratio
CIR	Cold In-Place Recycling
ECES	Emar Center for Engineering Studies
FDR	Full Depth Reclamation
FWD	Failing Weight Deflector Test
GMT	Geotechnical Material Testing Center
GPR	Ground Penetrating Radar
HIR	Hot in-place recycling
HMA	Hot Mix Asphalt
LWD	Light Weight Deflector Test
MDD	Maximum Dry Density
MOPWH	Ministry of Public Work & Housing
MR	Modulus of Sub Grade
NA	Natural Aggregate
OMC	Optimum Moisture Content
RA	Recycled Aggregate
RAP	Recycled Asphalt Pavement
RCA	Recycled Coarse Aggregate
VDOT	Virginia Department of Transportation
WPB	waste plastic bags
OBC	Optimum Bitumen Content

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Appendices

Appendix A

Photos for the Tested for RAP and Subbase and mixture material

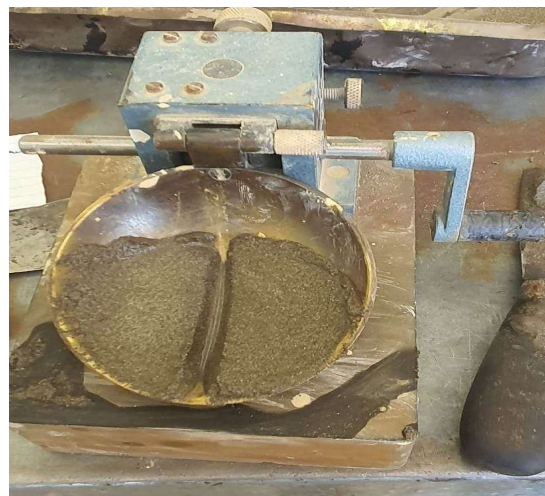
Appendix A.I

Photos for sieve analysis of subbase and



Appendix A.II

Photos taken for Waterberg's limits for RAP material



Appendix A.III

Photos taken for sieve analysis for RAP material



Appendix A. IV

Photos taken for passing sieveNo200 of RAP material



Appendix A.V

Photos taken for sand equivalent of RAP material and for CBR test for mixing material



Appendix A.VI

Photos taken for Waterberg's limits and for CBR test for mixing material



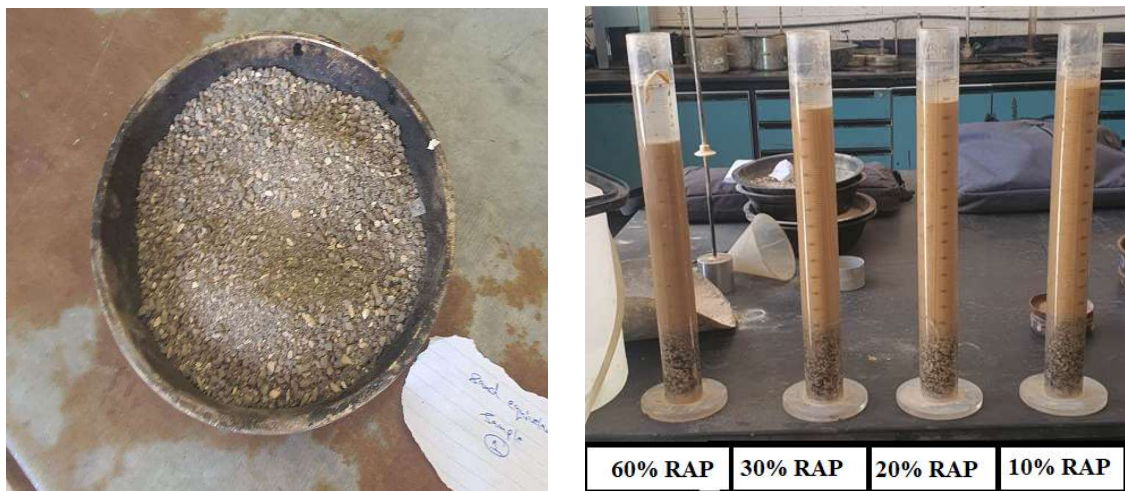
Appendix A. VII

Photos taken for Sieve analysis test for mixing material



Appendix A. VIII

Photos taken for sand equivalent test for mixing material



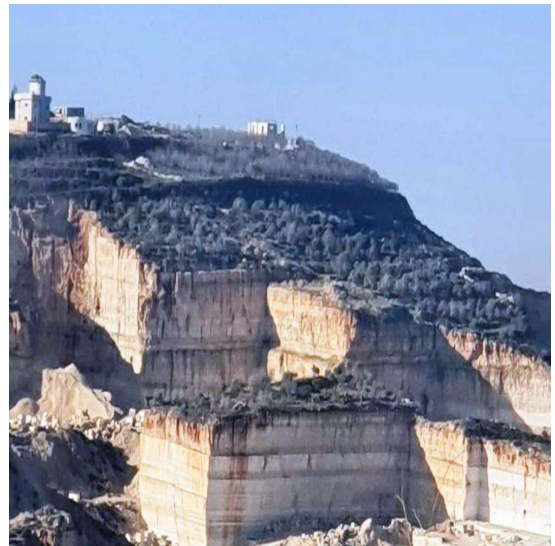
Appendix A. X

Photos taken for Los Angeles abrasion test for mixing material



Appendix B

Photo of mobile crushers in Ramallah and Al-Bireh, and stationary crushers in Jama'in Nablus



Appendix C

RAP material test

Appendix C.I

Comprehensive Milling Material Test Reports For milling material

An Najah National
University



جامعة النجاح الوطنية

التاريخ: 16/07/2022
الرقم: 01

الى : الدكتور خالد الساحلي المحترم
بواسطة : م.علاء غنيمات

الموضوع: نتائج فحص عينة (Milling Material 01)

الموقع : شارع بيتونيا

تحية طيبة وبعد ,,,,,,

بالاشارة الى الموضوع اعلاه ، وكجزء من رسالة الماجستير بعنوان " جدوى استخدام مخلفات الاسفلت المعاد تدويره كمواد تحت طبقة الأساس في أعمال الطرق في فلسطين " بإشراف الدكتور خالد الساحلي تم إجراء فحوصات مادة (Milling Material) والتي تم أخذها من الموقع من قبل الطالب (م.علاء غنيمات) بتاريخ 06-1-2022 في شارع بيتونيا وتم إجراء كافة الفحوصات اللازمة بإشراف قسم الدراسات والبحوث في جامعة النجاح الوطنية وكانت النتائج كما يلي :

• **Comprehensive Milling Material-Reports: 2022/06/01 (Non compacted)**

Test	Result	Specification	note
Plasticity Index (P.I)	0	2-8	Not .Approved
Sand Equivalent	88	25 (Min.)	Approved
Percent Passing Sieve No.200	1.1	(5-12 Subbase A) (5-15 Subbase B)	Not .Approved
Los Angeles after a#500	22.8	40 (Max.)	Approved
Optimum Moisture Content	6.05	--	Approved
Maximum Dry Density (M.D.D) gm/cm ³	1.961	2.05 (Min.)	Approved
California Bearing Ratio (CBR @ 0.1")	21	40 (Min.)	Not .Approved

ملاحظة : مرفق لحضرتكم نتائج الفحوصات والمواصفات الخاصة لفحص مواد ناتج قشط الاسفلت

مع التقدير والاحترام

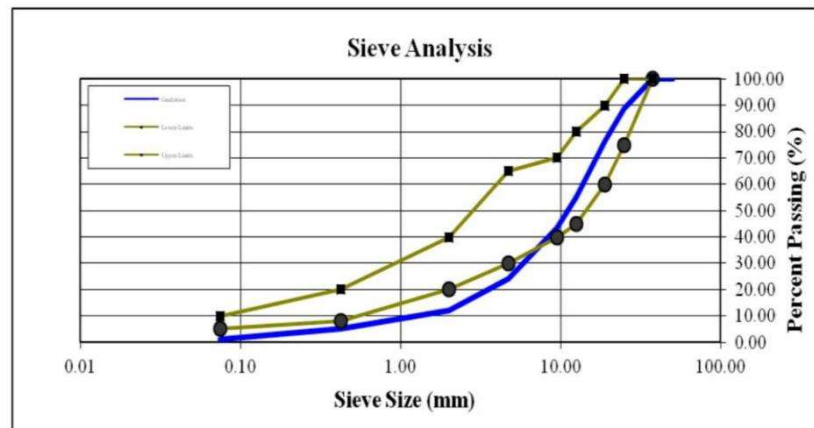
م .علاء غنيمات



Test Result

1. Sieve analysis according to ASTM C 136-06" standard test method for sieve analysis of fine and coarse aggregate".

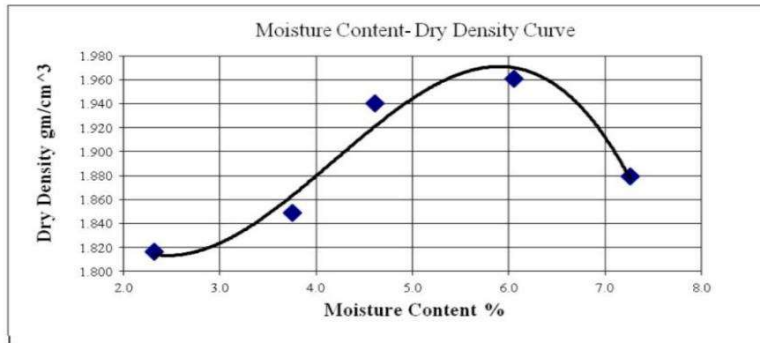
Sieve Size (in)	Wt. Retained (g)	Cumulative % Passing	Specification subbase B		Specification Base course B	
			80-100	ok	100	ok
2.0	0.0	100.00	80-100	ok	100	ok
1.5	0.0	100.00	70-95	Not ok	70-100	ok
1.0	737.6	88.91	60-95	ok	55-85	ok
3/4	846.3	76.18		ok	50-80	ok
1/2	1386.2	55.34	47-80	ok	45-80	ok
3/8	786.0	43.52		ok	40-70	ok
4.0	1289.0	24.13	30-60	Not ok	30-60	Not ok
10.0	800.0	12.10	22-45	Not ok	20-50	Not ok
40.0	471.8	5.01	10-30	Not ok	10-30	Not ok
200.0	260.7	1.09	5-15	Not ok	5-12	Not ok
Pan	72.4	0.00	-		-	





2. Proctor For Milling Material sample NO 1

Proctor For Milling Material sample NO 1					
Proctor Mould Volume (Cm ³):	2109	Reference Standard: AASHTO (T180-93)			
No. of Layers : 5	Total Blows : 280		Weight of Hammer : 4.5kg		
Compaction Trial No.	A	B	C	D	E
Weight of Mould + Wet Soil (W2) gm.	8760	8886	9120	9225	9091
Weight of Mould (W1) gm.	4840	4840	4840	4840	4840
Weight of Wet Soil (W2)-(W1) gm.	3920	4046	4280	4385	4251
Density of Wet Soil gm/cm ³	1.859	1.918	2.029	2.079	2.016
Moisture Content Can #	1	2	3	4	5
Weight of Can + Wet Soil (Ww) gm.	309.6	337.9	329.1	422.2	420
Weight of Can + Dry Soil (Wd) gm.	303.3	326.6	315.6	398.8	392.4
Weight of Can (Wc) gm.	38.4	37.0	36.1	35.6	40.1
Weight of Moisture (Ww) - (Wd) gm.	6.3	11.3	13.5	23.4	27.6
Weight of Dry Soil (Wd) - (Wc) gm.	264.9	289.6	279.5	363.2	352.3
Moisture Content %	2.32	3.76	4.61	6.05	7.27
Dry Density of Soil gm/cm ³	1.817	1.849	1.940	1.961	1.879



Max. Dry Density gm/cm ³	1.961
Optimum Moisture Content %	6.1

3. Sand Equivalent Test: according to ASTM D24 I 9-02

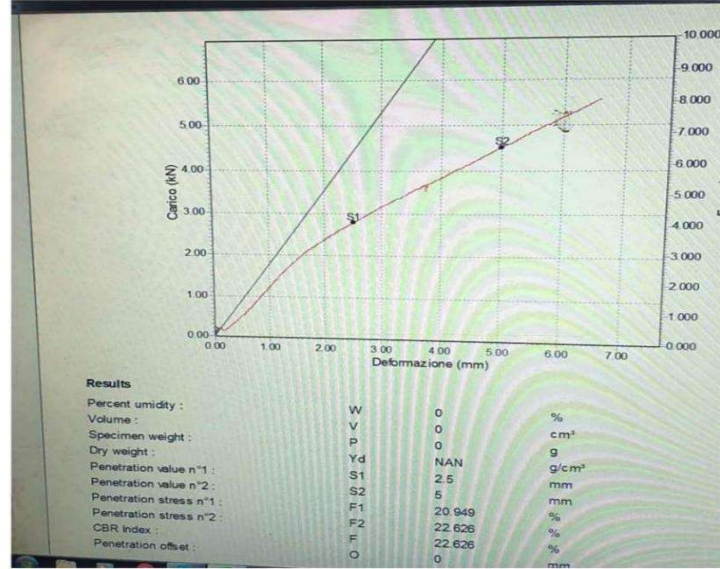
Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification	NOTE
1	4.9	4.3	88	88	25(Min.)	Approved

4. Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"

Plasticity Index = 0 (Non plastic material)

5. California Bearing Ratio

CBR= 21%



6. Report of Los Angeles Abrasion Test for Aggregate Used in Milling Material

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) Abrasion after 500 Rev.	Loss in Weight (gm)	Abrasion Ratio (%)
1	5000	3860	1140	22.8

م. علاء غنيمات ، م. سمير حلاوة

Appendix C.II

Comprehensive Milling Material Test Reports For kofor nemeh Road

An Najah National
University



جامعة النجاح الوطنية

التاريخ: 16/07/2022
الرقم: 02

الى : الدكتور خالد الساحلي المحترم
بواسطة : م. علاء غنيمات

الموضوع: نتائج فحص عينة (Milling Material 02)

الموقع : شارع كفر نعمة

تحية طيبة وبعد ,,,,,,,,,,

بالإشارة الى الموضوع أعلاه ، وكجزء من رسالة الماجستير بعنوان " جدوى استخدام مخلفات الاسفلت المعاد تدويره كمواد تحت طبقة الأساس في أعمال الطرق في فلسطين " بإشراف الدكتور خالد الساحلي تم إجراء فحوصات مادة (Milling Material) والتي تم أخذها من الموقع من قبل الطالب (م.علاء غنيمات) بتاريخ 06-2022 في شارع كفر نعمة وتم إجراء كافة الفحوصات اللازمة بإشراف قسم الدراسات والابحاث في جامعة النجاح الوطنية وكانت النتائج كما يلي :

• ***Comprehensive Milling Material-Reports: 2022/06/06 (Non compacted)***

Test	Result	Specification	note
Plasticity Index (P.I)	0	2-8	Not Approved
Sand Equivalent	89.4	25 (Min.)	Approved
Percent Passing Sieve No.200	1.3	(5-12 Subbase A) (5-15 Subbase B)	Not Approved
Los Angeles after a#500	26	40 (Max.)	Approved
Optimum Moisture Content	4.98	--	Approved
Maximum Dry Density (M.D.D) gm/cm ³	1.907	2.05 (Min.)	Not Approved
California Bearing Ratio (CBR @ 0.1")	19.70	40 (Min.)	Not Approved

ملاحظة : مرفق لحضرتكم نتائج الفحوصات والمواصفات الخاصة لفحص مواد ناتج قشط الاسفلت

مع التقدير والاحترام

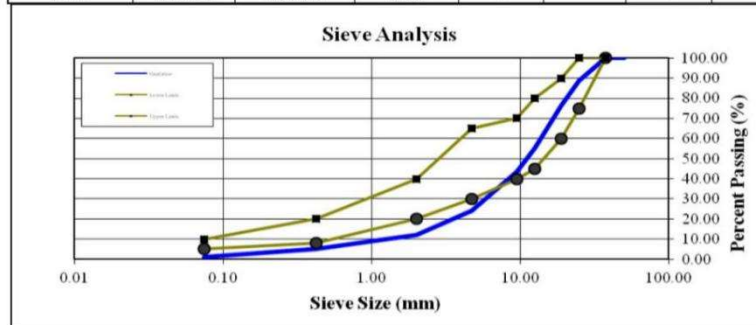
م. علاء غنيمات



Test Result

1. Sieve analysis according to ASTM C 136-06" standard test method for sieve analysis of fine and coarse aggregate".

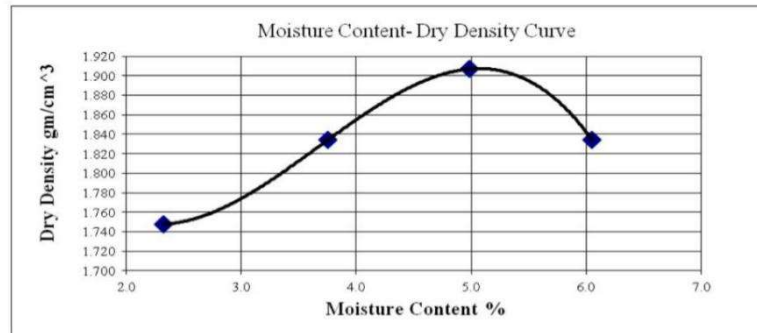
Sieve Size (mm)	% Retained	Cumulative % Retained	% Passing	Specification	
				subbase B	Base course B
50.00	0.00	0.00	100.00	80-100 ok	100 ok
37.50	0.00	0.00	100.00	70-95 Not ok	70-100 ok
25.00	11.09	11.09	88.91	60-95 ok	55-85 ok
19.00	12.73	23.82	76.18	ok	50-80 ok
12.50	20.85	44.66	55.34	47-80 ok	45-80 ok
9.50	11.82	56.48	43.52	ok	40-70 ok
4.75	19.38	75.87	24.13	30-60 Not ok	30-60 Not ok
2.00	12.03	87.90	12.10	22-45 Not ok	20-50 Not ok
0.43	7.09	94.99	5.01	10-30 Not ok	10-30 Not ok
0.075	3.92	98.91	1.09	5-15 Not ok	5-12 Not ok
Pan	100.00	100.00	0.00	-	-





2. Proctor For Milling Material sample NO 2

Proctor Mould Volume (Cm ³):	2109	Reference Standard: AASHTO (T180-93)			
No. of Layers : 5	Total Blows : 280	Weight of Hammer : 4.5kg			
Compaction Trial No.		A	B	C	D
Weight of Mould + Wet Soil (W2) gm.	8612	8854	9062	8942	
Weight of Mould (W1) gm.	4840	4840	4840	4840	
Weight of Wet Soil (W2)-(W1) gm.	3772	4014	4222	4102	
Density of Wet Soil gm/cm ³	1.789	1.903	2.002	1.945	
Moisture Content Can #		1	2	3	4
Weight of Can + Wet Soil (Ww) gm.	309.6	337.9	329.1	422.2	
Weight of Can + Dry Soil (Wd) gm.	303.3	326.6	314.5	398.8	
Weight of Can (Wc) gm.	38.4	37.0	36.1	35.6	
Weight of Moisture (Ww) - (Wd) gm.	6.3	11.3	14.6	23.4	
Weight of Dry Soil (Wd) - (Wc) gm.	264.9	289.6	278.4	363.2	
Moisture Content %	2.32	3.76	4.98	6.05	
Dry Density of Soil gm/cm ³	1.748	1.834	1.907	1.834	



Max. Dry Density gm/cm ³	1.907
Optimum Moisture Content %	4.98

3. Sand Equivalent Test: according to ASTM D24 I 9-02

Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification	Note



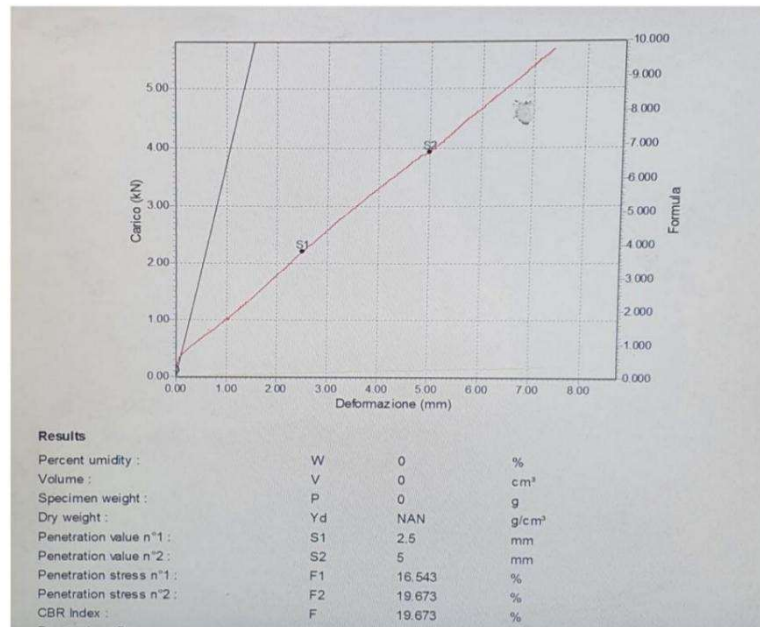
1	4.7	4.2	89.4	89.4	30.0 (Min.)	Approved
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4. Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"

$$\text{Plasticity Index} = 0 \quad (\text{Non plastic material})$$

5. California Bearing Ratio

$$\text{CBR} = 19.7\%$$



6. Report of Los Angeles Abrasion Test for Aggregate Used in
Milling Material NO 2

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) <u>Abrasion after 500 Rev.</u>	Loss in Weight (gm)	Abrasion Ratio (%)
1	5000	3700	1300	26

Appendix C.III

Comprehensive Milling Material Test Reports for Ramallah –Jerusalem Road

An Najah National
University



جامعة النجاح الوطنية

التاريخ: 16/07/2022
الرقم: 03

الى : الدكتور خالد الساحلي المحترم
بواسطة : م.علاء غنيمات

الموضوع: نتائج فحص عينة (Milling Material 03)

الموقع : شارع رام الله القدس

تحية طيبة وبعد ,,,,,,

بالإشارة الى الموضوع أعلاه ، وكجزء من رسالة الماجستير بعنوان " جدوى استخدام مخلفات الاسفلت المعاد تدويره كمواد تحت طبقة الأساس في أعمال الطرق في فلسطين " بإشراف الدكتور خالد الساحلي تم إجراء فحوصات مادة (Milling Material) والتي تم أخذها من الموقع من قبل الطالب (م.علاء غنيمات) بتاريخ 29-06-2022 في شارع رام الله القدس وتم إجراء كافة الفحوصات اللازمة بإشراف قسم الدراسات والأبحاث في جامعة النجاح الوطنية وكانت النتائج كما يلي :

• ***Comprehensive Milling Material-Reports: 2022/06/01 (Non compacted)***

Test	Result	Specification	note
Plasticity Index (P.I)	0	2-8	Not Approved
Sand Equivalent	87	25 (Min.)	Approved
Percent Passing Sieve No.200	4.61	(5-12 Subbase A) (5-15 Subbase B)	Not Approved
Los Angeles after a#500	23.6	40 (Max.)	Approved
Optimum Moisture Content	4.61	--	Approved
Maximum Dry Density (M.D.D) gm/cm ³	1.897	2.05 (Min.)	Approved
California Bearing Ratio (CBR @ 0.1")	15.73	40 (Min.)	Approved

ملاحظة : مرفق لحضرتكم نتائج الفحوصات والمواصفات الخاصة لفحص مواد ناتج قشط الاسفلت

مع التقدير والاحترام

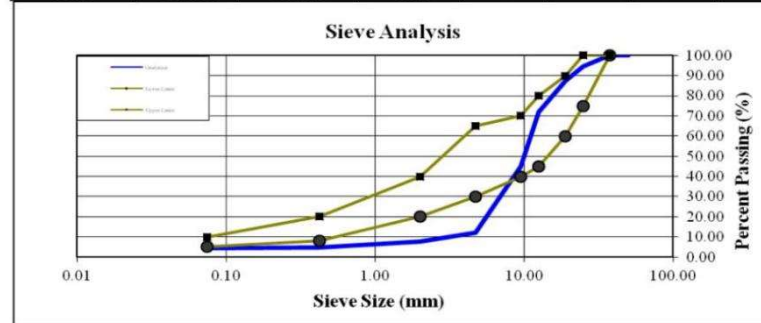
م .علاء غنيمات



Test Result

1. Sieve analysis according to ASTM C 136-06" standard test
method for sieve analysis of fine and coarse aggregate".

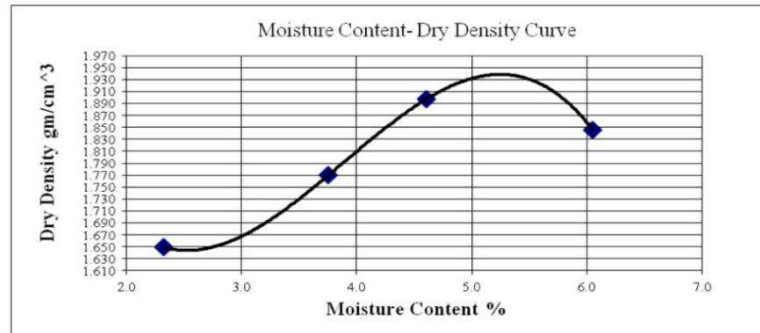
Sieve Size (mm)	% Retained	Cumulative % Retained	% Passing	Specification subbase B	Specification Base course B
50.00	0.00	0.00	100.00	80-100 ok	100 ok
37.50	0.00	0.00	100.00	70-95 ok	70-100 ok
25.00	5.46	5.46	94.54	60-95 ok	55-85 ok
19.00	7.17	12.64	87.36	ok	50-80 ok
12.50	15.36	28.00	72.00	47-80 ok	45-80 ok
9.50	27.16	55.16	44.84	ok	40-70 ok
4.75	32.74	87.90	12.10	30-60 Not ok	30-60 Not ok
2.00	4.25	92.15	7.85	22-45 Not ok	20-50 Not ok
0.43	3.12	95.27	4.73	10-30 Not ok	10-30 Not ok
0.075	0.12	95.39	4.61	5-15 Not ok	5-12 Not ok
Pan	100.00	100.00	0.00	-	-





2. Proctor For Milling Material sample NO 2

Proctor Mould Volume (Cm ³):	2109	Reference Standard: AASHTO (T180-93)			
No. of Layers : 5		Total Blows : 280		Weight of Hammer : 4.5kg	
Compaction Trial No.		A	B	C	D
Weight of Mould + Wet Soil (W2) gm.		9851	10165	10478	10420
Weight of Mould (W1) gm.		6292	6292	6292	6292
Weight of Wet Soil (W2)-(W1) gm.		3559	3873	4186	4128
Density of Wet Soil gm/cm ³		1.688	1.836	1.985	1.957
Moisture Content Can #		1	2	3	4
Weight of Can + Wet Soil (Ww) gm.		309.6	337.9	329.1	422.2
Weight of Can + Dry Soil (Wd) gm.		303.3	326.6	315.6	398.8
Weight of Can (Wc) gm.		38.4	37.0	36.1	35.6
Weight of Moisture (Ww) - (Wd) gm.		6.3	11.3	13.5	23.4
Weight of Dry Soil (Wd) - (Wc) gm.		264.9	289.6	279.5	363.2
Moisture Content %		2.32	3.76	4.61	6.05
Dry Density of Soil gm/cm ³		1.649	1.770	1.897	1.846



Max. Dry Density gm/cm ³	1.897
Optimum Moisture Content %	4.61

3. Sand Equivalent Test: according to ASTM D24 I 9-02

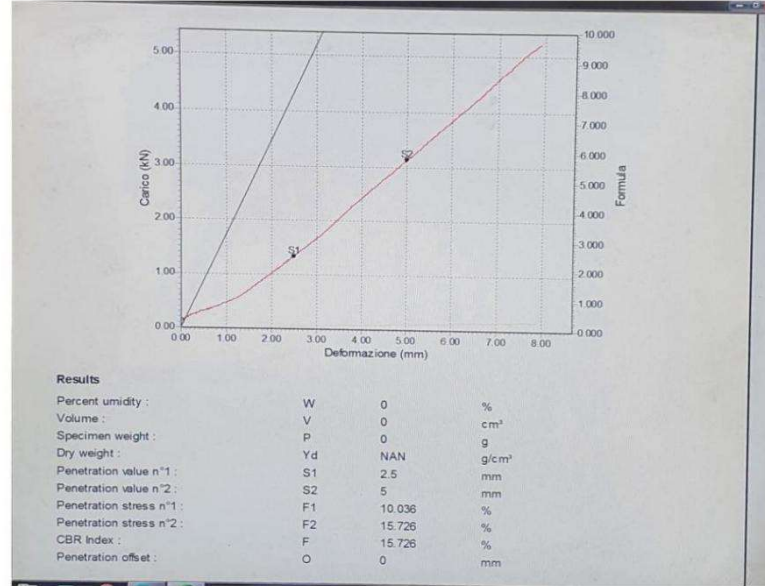
Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification
1	4.9	4.3	87	87	25 (Min.)

4. Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"

Plasticity Index = 0 (Non plastic material)

5. California Bearing Ratio

CBR= 15.73%



6. Report of Los Angeles Abrasion Test for Aggregate Used in Milling Material NO 2

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) Abrasion after 500 Rev.	Loss in Weight (gm)	Abrasion Ratio (%)
1	5000	3820	1180	23.6

م.علام غنيمات ، م.سمير ابو الحلاوة

Appendix D: Subbase material test

Appendix D.I

Comprehensive Subbase Material Test Reports for betunia Road

An Najah National
University



جامعة النجاح الوطنية

التاريخ: 2022/07/16
الرقم: 04

الى : الدكتور خالد الساحلي المحترم
بواسطة : م.علاء غنيمات

الموضوع: نتائج فحص عينة (Subbase Materail No.01)

الموقع : كسارة بيتونيا

تحية طيبة وبعد

بالإشارة الى الموضوع أعلاه ، وكجزء من رسالة الماجستير بعنوان " جدوى استخدام مخلفات الاسفلت المعاد تدويره كمواد تحت طبقة الأساس في أعمال الطرق في فلسطين " بإشراف الدكتور خالد الساحلي تم إجراء فحوصات مادة (Subbase Material No.01) والتي تم أخذها من الموقع من قبل الطالب (م.علاء غنيمات) بتاريخ 2022-07-04 في شارع بيتونيا وتم إجراء كافة الفحوصات اللازمة بإشراف قسم الدراسات والابحاث في جامعة النجاح الوطنية وكانت النتائج كما يلي :

• Comprehensive Subbase Material-Reports: 2022/06/01 (Non compacted)

Test	Result	Specification	Note
Liquid Limit (L.L)	26.42	30 (Max.)	OK
Plastic Limit (P.L)	20	--	OK
Plasticity Index (P.I)	6.42	2-8	OK
Sand Equivalent	25.2	25 (Min.)	OK
Percent Passing Sieve No.200	13.43	(5-12 Class A Not Compacted) (5-15 Class B Not Compacted)	OK class B
Los Angeles after a#500	36.16	40 (Max.)	OK
Optimum Moisture Content	9.3	--	OK
Maximum Dry Density (M.D.D) gm/	2.05	2.05 (Min.)	OK
California Bearing Ratio (CBR @ 0.1")	74.27	40 (Min.)	OK

ملاحظة : مرفق لحضرتكم نتائج الفحوصات والمواصفات الخاصة لفحص مواد (Subbase NO.01)

مع التقدير والاحترام

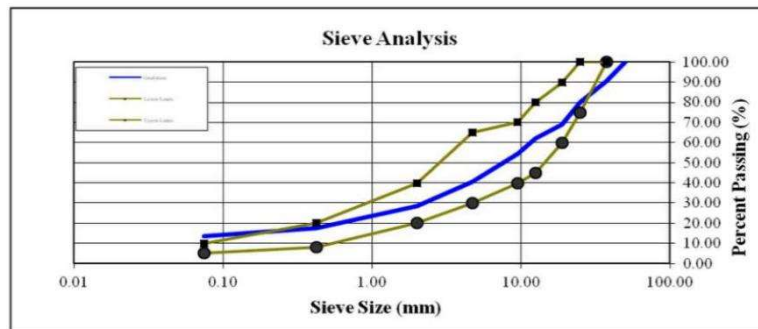
م.علاء غنيمات



Test Result

1. Sieve analysis according to ASTM C 136-06" standard test method for sieve analysis of fine and coarse aggregate".

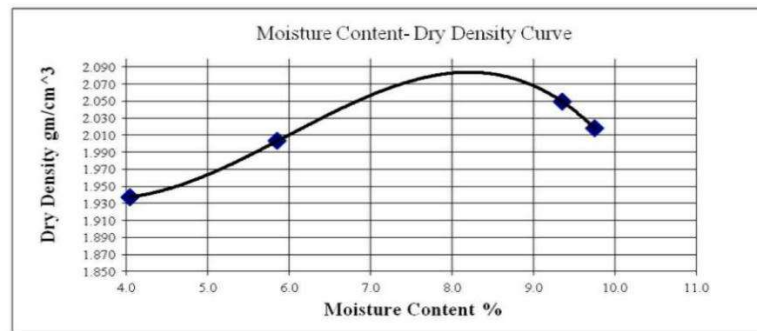
Sieve Size (mm)	Cumulative % Passing	Specification subbase B		Specification Base course A	
		Min	Max	Min	Max
50.00	100.00	80-100	ok	100	ok
37.50	90.44	70-95	ok	70-100	ok
25.00	80.05	60-95	ok	55-85	ok
19.00	68.95		ok	50-80	ok
12.50	62.14	47-80	ok	45-80	ok
9.50	54.62		ok	40-70	ok
4.75	40.71	30-60	ok	30-60	ok
2.00	28.53	22-45	ok	20-50	ok
0.43	17.61	10-30	ok	10-30	ok
0.075	13.43	5-15	ok	5-10	Not ok
Pan	0.00	-		-	





2. Proctor For Subbase Material sample NO 1

Subbase Material NO.01				
Proctor Mould Volume (Cm ³):	2109	Reference Standard: AASHTO (T180-93)		
No. of Layers : 5	Total Blows : 280	Weight of Hammer : 4.5kg		
Compaction Trial No.	A	B	C	D
Weight of Mould + Wet Soil (W2) gm.	10530	10750	11005	10950
Weight of Mould (W1) gm.	6278	6278	6278	6278
Weight of Wet Soil (W2)-(W1) gm.	4252	4472	4727	4672
Density of Wet Soil gm/cm ³	2.016	2.120	2.241	2.215
Moisture Content Can #	1	2	3	4
Weight of Can + Wet Soil (Ww) gm.	1360	1350.0	1416	1440.0
Weight of Can + Dry Soil (Wd) gm.	1325.0	1300.0	1330.0	1348.0
Weight of Can (Wc) gm.	496.0	496.0	496.0	496.0
Weight of Moisture (Ww) - (Wd) gm.	35.0	50.0	86.0	92.0
Weight of Dry Soil (Wd) - (Wc) gm.	829.0	804.0	834.0	852.0
Moisture Content %	4.05	5.85	9.35	9.75
Dry Density of Soil gm/cm ³	1.938	2.003	2.050	2.019



Max. Dry Density gm/cm ³	2.050
Optimum Moisture Content %	9.3

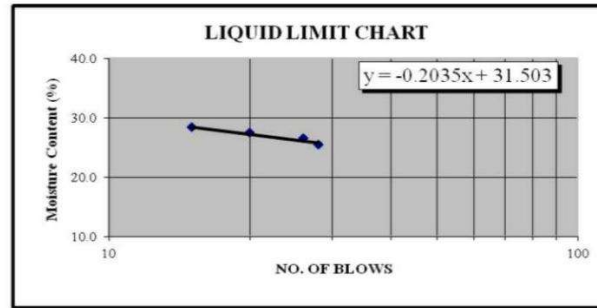
3. Sand Equivalent Test: according to ASTM D24 I 9-02

Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification
1	11.5	2.9	25.2	25.2	25.0(Min.)



4. Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"

Sample No.	Can No.	Can Weight (gm)	Can Wt. + Wt. Wet (gm)	Can Wt. + Wt. Dry (gm)	Moisture Weight (gm)	Dry Weight (gm)	No. of Blows	Moisture Content %
Liquid Limit Test								
1	A	12.12	34.80	30.20	4.6	18.08	28	25.44
2	B	12.14	22.60	20.40	2.2	8.26	26	26.63
3	C	12.35	36.50	31.30	5.2	19.0	20	27.44
4	D	12.36	24.80	22.05	2.75	9.7	15	28.38
Plastic Limit Test								
5	E	12.64	35.10	31.35	3.75	18.71	-	20.04

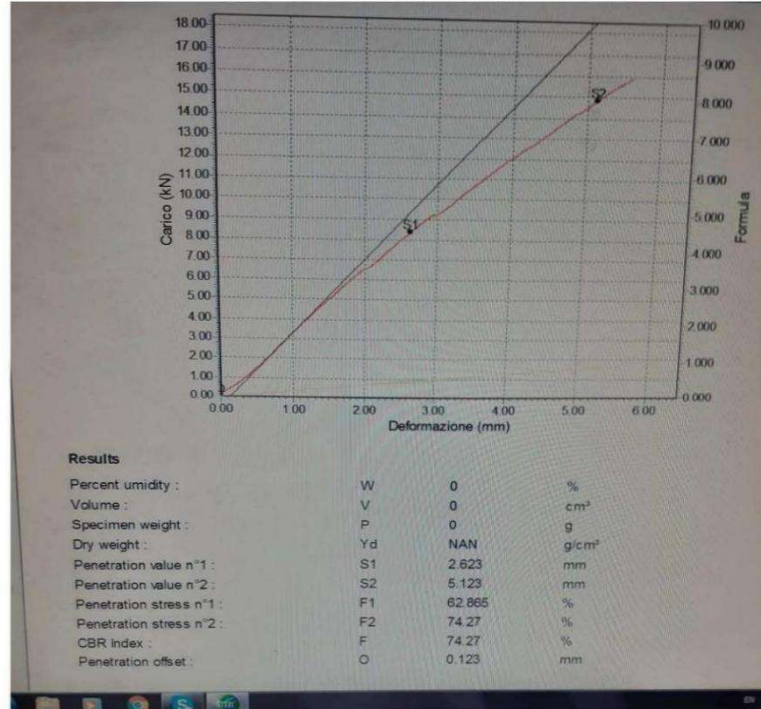


LL =	26.42
PL =	20.0
PI = LL - PL =	6.4

5. California Bearing Ratio



6.CBR= 74.27%



7. Report of Los Angeles Abrasion Test for Aggregate Used in
Subbase material NO. 1

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) <u>Abrasion after 500 Rev.</u>	Loss in Weight (gm)	Abrasion Ratio (%)
<u>1</u>	5000	3192	1808	36.16

م.علاء غنيمات ، م.سمير حلاوة

Appendix D.II

Comprehensive Subbase Material Test Reports for Ramallah –Jerusalem Road

An Najah National
University



جامعة النجاح الوطنية

التاريخ: 25/07/2022
الرقم: 05

الى : الدكتور خالد الساحلي المحترم
بواسطة : م. علاء غنيمات

الموضوع: نتائج فحص عينة (Subbase Materail NO.2)

الموقع : شارع رام الله القدس

تحية طيبة وبعد ,,,,,,,,,,

بالإشارة الى الموضوع أعلاه ، وكجزء من رسالة الماجستير بعنوان " جذوى استخدام مخلفات الاسفلت المعاد تدويره كمواد تحت طبقة الأساس في أعمال الطرق في فلسطين " بإشراف الدكتور خالد الساحلي تم إجراء فحوصات مادة(02 Subbase Material) والتي تم أخذها من الموقع من قبل الطالب (م.علاء غنيمات) بتاريخ 18-07-2022 في شارع رام القدس وتم إجراء كافة الفحوصات اللازمة بإشراف قسم الدراسات والأبحاث في جامعة النجاح الوطنية وكانت النتائج كما يلي :

• ***Comprehensive Subbase Material-Reports: 2022/06/01 (Non compacted)***

Test	Result	Specification	Note
Liquid Limit (L.L)	% 21.1	30 (Max.)	Ok
Plastic Limit (P.L)	% 18.9	--	Ok
Plasticity Index (P.I)	2.2	2-8	Ok
Sand Equivalent	% 54	25 (Min.)	Ok
Percent Passing Sieve No.200	% 9.17	(5-12 Class A Not Compacted) (5-15 Class B Not Compacted)	Ok
Los Angeles after a#500	% 35.8	40 (Max.)	Ok
Optimum Moisture Content	% 7.6	--	Ok
Maximum Dry Density (M.D.D) gm/cm ³	2.083	2.05 (Min.)	Ok
California Bearing Ratio (CBR @ 0.1")	127	40 (Min.)	Ok

ملاحظة : مرفق لحضرتكم نتائج الفحوصات والمواصفات الخاصة لفحص مواد (Subbase 02)

مع التقدير والاحترام

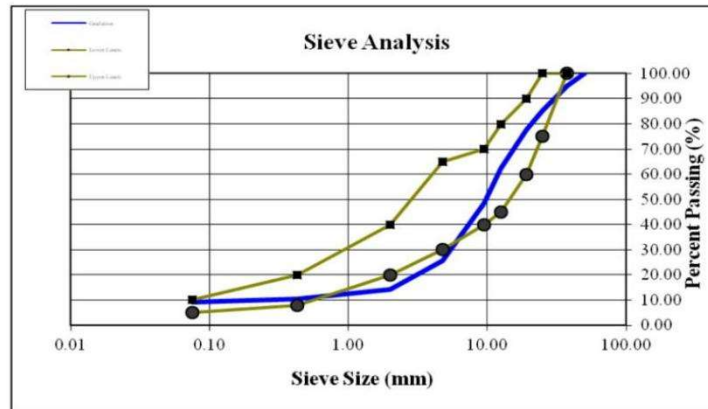
م. علاء غنيمات



Test Result

1. Sieve analysis according to ASTM C 136-06" standard test method for sieve analysis of fine and coarse aggregate".

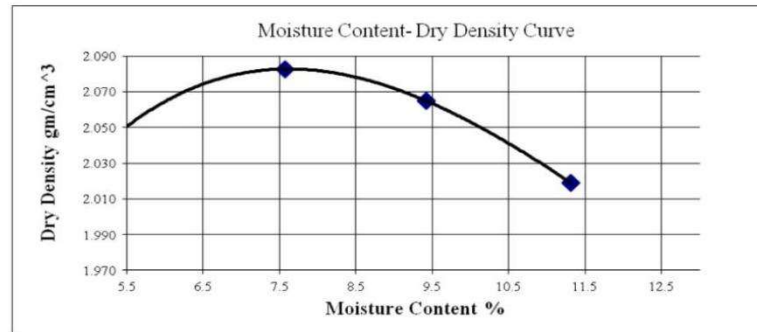
Material Type: & Base Course		(Approved)						
Total Sample	5000.00 gm							
Reference Standard (AASHTO - T27-14)								
Sieve Size (mm)	Wt. Retained (g)	% Retained	Cumulative % Retained	% Passing	Specification subbase B	Specification Base course B		
50.00	0.0	0.00	0.00	100.00	80-100	ok	100	ok
37.50	241.9	4.84	4.84	95.16	70-95	ok	70-100	ok
25.00	501.6	10.03	14.87	85.13	60-95	ok	55-85	ok
19.00	382.0	7.64	22.51	77.49		ok	50-80	ok
12.50	761.0	15.22	37.73	62.27	47-80	ok	45-80	ok
9.50	683.0	13.66	51.39	48.61		ok	40-70	ok
4.75	1150.0	23.00	74.39	25.61	30-60	Not ok	30-60	Not ok
2.00	572.0	11.44	85.83	14.17	22-45	Not ok	20-50	Not ok
0.43	180.0	3.60	89.43	10.57	10-30	ok	10-30	ok
0.075	70.2	1.40	90.83	9.17	5-15	ok	5-12	ok
Pan	458.3	100.00	100.00	0.00	-		-	





2.Proctor For Subbase Material sample NO 2

Subbase Material				
Proctor Mould Volume (Cm ³):	2109	Reference Standard: AASHTO (T180-93)		
No. of Layers : 5	Total Blows : 280		Weight of Hammer : 4.5kg	
Compaction Trial No.	A	B	C	D
Weight of Mould + Wet Soil (W2) gm.	9270	9560	9600	9575
Weight of Mould (W1) gm.	4835	4835	4835	4835
Weight of Wet Soil (W2)-(W1) gm.	4435	4725	4765	4740
Density of Wet Soil gm/cm ³	2.103	2.240	2.259	2.248
Moisture Content Can #	1	2	3	4
Weight of Can + Wet Soil (Ww) gm.	388	263.0	426.4	607.5
Weight of Can + Dry Soil (Wd) gm.	372.0	246.0	390.0	543.0
Weight of Can (Wc) gm.	36.5	38.5	39.9	37.2
Weight of Moisture (Ww) - (Wd) gm.	16.0	17.0	36.4	64.5
Weight of Dry Soil (Wd) - (Wc) gm.	335.5	207.5	350.1	505.8
Moisture Content %	4.55	7.57	9.42	11.31
Dry Density of Soil gm/cm ³	2.011	2.083	2.065	2.019



Max. Dry Density gm/cm ³	2.083
Optimum Moisture Content %	7.6

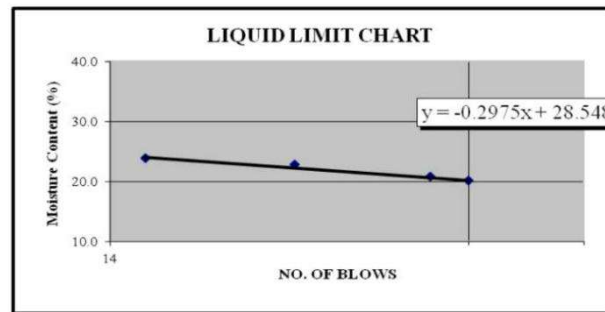
3.Sand Equivalent Test: according to ASTM D24 I 9-02

Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification
1	6.2	3.4	54	54	25.0(Min.)



4. Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"

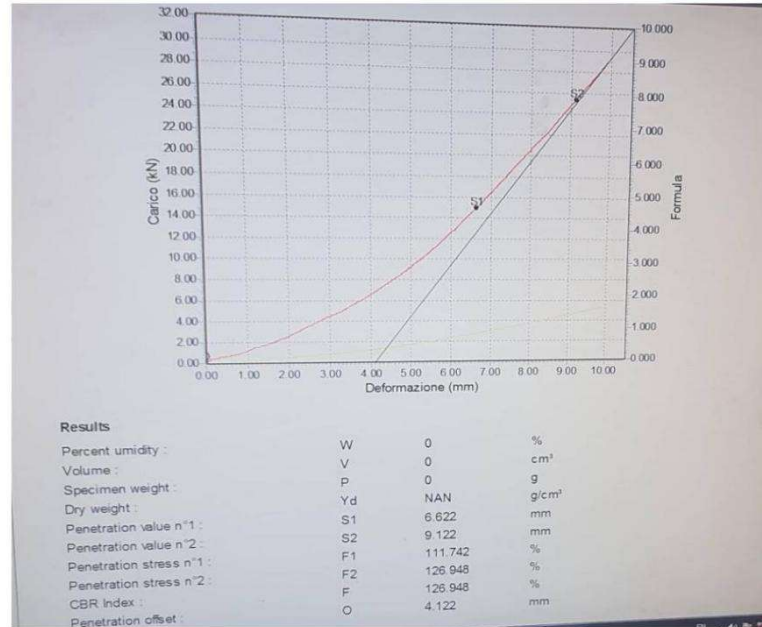
Sample No.	Can No.	Can Weight (gm)	Can Wt. + Wt. Wet (gm)	Can Wt. + Wt. Dry (gm)	Moisture Weight (gm)	Dry Weight (gm)	No. of Blows	Moisture Content %
Liquid Limit Test								
1	A	12.12	51.00	45.00	6	32.88	15	18.25
2	B	12.14	52.50	46.00	6.5	33.86	26	19.20
3	I	12.90	52.70	46.10	6.6	33.2	15	19.88
4	D	12.36	52.00	45.60	6.4	33.2	26	19.25
Plastic Limit Test								
5	5	13.00	28.10	25.70	2.4	12.7	-	18.90



LL =	21.1
PL =	18.9
PI = LL - PL =	2.2

5. California Bearing Ratio

CBR= 127%



6. Report of Los Angeles Abrasion Test for Aggregate Used in
Subbase material NO. 1

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) Abrasion after 500 Rev.	Loss in Weight (gm)	Abrasion Ratio (%)
1	5000	3210	1808	35.8

م. علاء غنيمات ، م. سمير الحلاوة

Appendix D.II

Comprehensive Subbase Material Test Reports for kofor-nemeh Road

An Najah National
University



جامعة النجاح الوطنية

التاريخ: 25/07/2022
الرقم: 06

الى: الدكتور خالد الساحلي المحترم
بواسطة: م. علاء غنيمات

الموضوع: نتائج فحص عينة (Subbase Material NO.3)

الموقع: شارع كفر نعمة

تحية طيبة وبعد

بالإشارة الى الموضوع أعلاه ، وكجزء من رسالة الماجستير بعنوان " جدوى استخدام مخلفات الاسفلت المعاد تدويره كمواد تحت طبقة الأساس في أعمال الطرق في فلسطين " بإشراف الدكتور خالد الساحلي تم إجراء فحوصات مادة (Subbase Material 03) والتي تم أخذها من الموقع من قبل الطالب (م.علاء غنيمات) بتاريخ 2022-07-20 في شارع كفر نعمة وتم إجراء كافة الفحوصات اللازمة بإشراف قسم الدراسات والابحاث في جامعة النجاح الوطنية وكانت النتائج كما يلي :

• Comprehensive Subbase Material-Reports: 2022/06/01 (Non compacted)

Test	Result	Specification	Note
Liquid Limit (L.L)	% 38	30 (Max.)	Ok
Plastic Limit (P.L)	% 22	--	Ok
Plasticity Index (P.I)	16	2-8	Not Ok
Sand Equivalent	% 20	25 (Min.)	Not Ok
Percent Passing Sieve No.200	% 14.05	(5-12 Class A Not Compacted) (5-15 Class B Not Compacted)	Ok class B
Los Angeles after a#500	% 38	40 (Max.)	Ok
Optimum Moisture Content	% 9.4	--	Ok
Maximum Dry Density (M.D.D) gm/cm ³	2.00	2.05 (Min.)	Not Ok
California Bearing Ratio (CBR @ 0.1")	55.4	40 (Min.)	Ok

ملاحظة: مرفق لحضرتكم نتائج الفحوصات والمواصفات الخاصة لفحص مواد (Subbase)

مع التقدير والاحترام

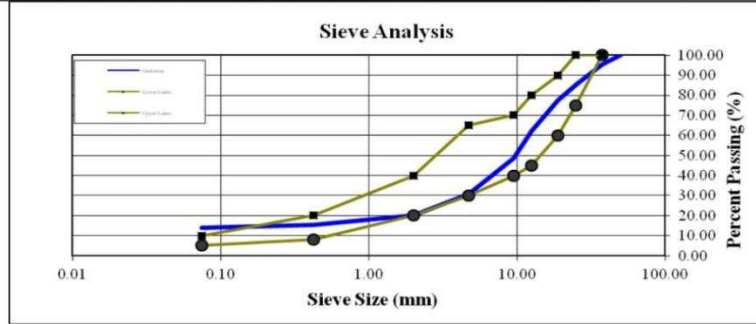
م. علاء غنيمات



Test Result

1. Sieve analysis according to ASTM C 136-06" standard test method for sieve analysis of fine and coarse aggregate".

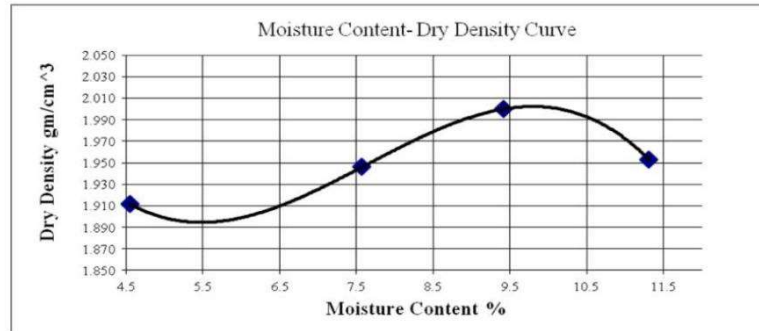
Sieve Size (mm)	Wt. Retained (g)	% Retained	% Passing	Specification			
				subbase B	Base course A		
50.00	0.0	0.00	100.00	80-100	ok	100	ok
37.50	241.9	4.84	95.16	70-95	ok	70-100	ok
25.00	501.6	10.03	85.13	60-95	ok	55-85	ok
19.00	382.0	7.64	77.49		ok	50-80	ok
12.50	761.0	15.22	62.27	47-80	ok	45-80	ok
9.50	683.0	13.66	48.61		ok	40-70	ok
4.75	900.0	18.00	30.61	30-60	ok	30-60	ok
2.00	520.0	10.40	20.21	22-45	ok	20-50	ok
0.43	238.0	4.76	15.45	10-30	ok	10-30	ok
0.075	70.2	1.40	14.05	5-15	ok	5-10	Not ok
Pan	702.3	100.00	0.00	-		-	



2. Proctor For subbase No.03



Proctor Mould Volume (Cm ³): 2109		Reference Standard: AASHTO (T180-93)			
No. of Layers : 5		Total Blows : 280		Weight of Hammer : 4.5kg	
Compaction Trial No.		A	B	C	D
Weight of Mould + Wet Soil (W2)	gm.	9050	9250	9450	9420
Weight of Mould (W1)	gm.	4835	4835	4835	4835
Weight of Wet Soil (W2)-(W1)	gm.	4215	4415	4615	4585
Density of Wet Soil	gm/cm ³	1.999	2.093	2.188	2.174
Moisture Content Can #		1	2	3	4
Weight of Can + Wet Soil (Ww)	gm.	388	263.0	426.4	607.5
Weight of Can + Dry Soil (Wd)	gm.	372.0	246.0	390.0	543.0
Weight of Can (Wc)	gm.	36.5	38.5	39.9	37.2
Weight of Moisture (Ww) - (Wd)	gm.	16.0	17.0	36.4	64.5
Weight of Dry Soil (Wd) - (Wc)	gm.	335.5	207.5	350.1	505.8
Moisture Content	%	4.55	7.57	9.42	11.31
Dry Density of Soil	gm/cm ³	1.912	1.946	2.000	1.953



Max. Dry Density gm/cm ³	2.000
Optimum Moisture Content %	9.4

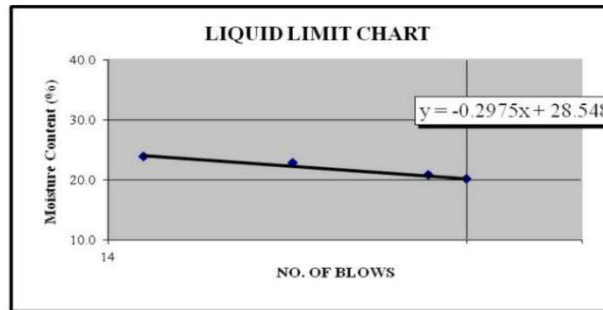
Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification	Note
1	13.5	2.6	29	20	25.0(Min.)	Not Ok



3.Sand Equivalent Test: according to ASTM D24 I 9-02

4.Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"

Sample No.	Can No.	Can Weight (gm)	Can Wt. + Wt. Wet (gm)	Can Wt. + Wt. Dry (gm)	Moisture Weight (gm)	Dry Weight (gm)	No. of Blows	Moisture Content %
Liquid Limit Test								
1	1	12.80	49.80	39.60	10.2	26.8	15	38.06
2	2	13.00	50.00	40.00	10	27	30	37.04
3	3	12.90	49.50	39.50	10	26.6	15	37.59
4	4	12.36	51.00	40.20	10.8	27.8	26	38.79
Plastic Limit Test								
5	2	13.00	27.80	24.60	3.2	11.6	-	27.59



LL =	37
PL =	22.0
PI = LL - PL =	15



5. California Bearing Ratio

CBR= 55.4 %

6. Report of Los Angeles Abrasion Test for Aggregate Used in
Subbase material NO. 3

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) Abrasion after 500 Rev.	Loss in Weight (gm)	Abrasion Ratio (%)
1	5000	3100	1900	38

م. علاء غنيمات ، م. سمير حلاوة

Appendix D.IV

Comprehensive Subbase Material Test Reports for Betunia Road

An Najah National
University



جامعة النجاح الوطنية

التاريخ: 28/07/2022
الرقم : 07

الى : الدكتور خالد الساحلي المحترم
بواسطة : م.علاء غنيمات

الموضوع: نتائج فحص عينة (Subbase Material NO.4)

الموقع : شارع بيتونيا

تحية طيبة وبعد ,,,,,,

بالاشارة الى الموضوع اعلاه ، وكجزء من رسالة الماجستير بعنوان " جدوى استخدام مخلفات الاسفلت المعاد تدويره كمواد تحت طبقة الأساس في أعمال الطرق في فلسطين " بإشراف الدكتور خالد الساحلي تم إجراء فحوصات مادة (Subbase Material NO.4) والتي تم أخذها من الموقع من قبل الطالب (م.علاء غنيمات) بتاريخ 2022-07-24 في شارع بيتونيا وتم إجراء كافة الفحوصات اللازمة بإشراف قسم الدراسات والابحاث في جامعة النجاح الوطنية وكانت النتائج كما يلي :

- **Comprehensive Subbase Material NO.04-Reports: 2022/07/24 (Non compacted)**

Test	Result	Specification	Note
Liquid Limit (L.L)	% 21.1	30 (Max.)	Ok
Plastic Limit (P.L)	% 18.2	--	Ok
Plasticity Index (P.I)	2.9	2-8	Ok
Sand Equivalent	% 43.5	25 (Min.)	Ok
Percent Passing Sieve No.200	% 10.39	(5-12 Class A Not Compacted) (5-15 Class B Not Compacted)	Ok class A
Los Angeles after a#500	% 39.5	40 (Max.)	Ok
Optimum Moisture Content	% 8.16	--	Ok
Maximum Dry Density (M.D.D) gm/cm ³	2.093	2.05 (Min.)	Ok
California Bearing Ratio (CBR @ 0.1")	65	40 (Min.)	Ok

ملاحظة : مرفق لحضرتكم نتائج الفحوصات والمواصفات الخاصة لفحص مواد (Subbase NO.04)

مع التقدير والاحترام

م.علاء غنيمات

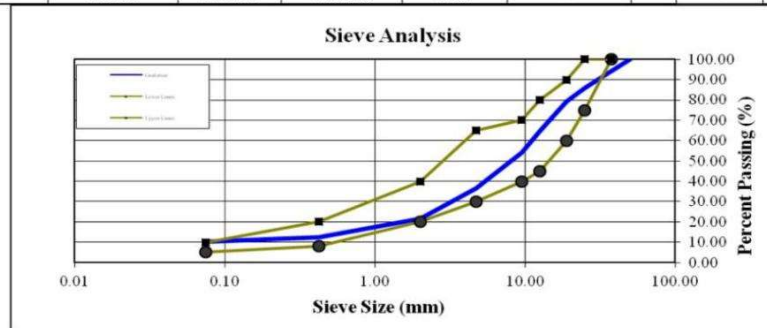
Page 1 of 5



Test Result

I. Sieve analysis according to ASTM C 136-06" standard test method for sieve analysis of fine and coarse aggregate".

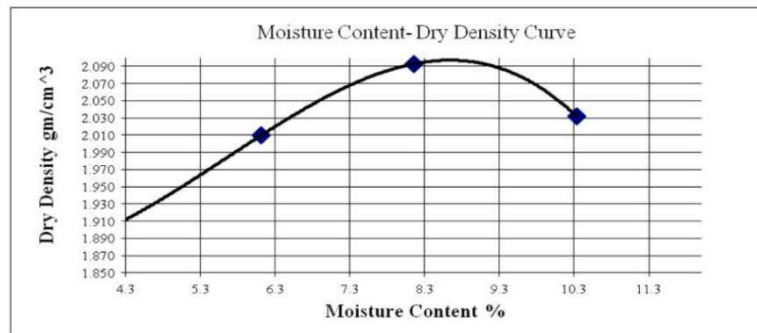
Sieve Size (mm)	Wt. Retained (g)	% Retained	Cumulative % Retained	% Passing	Specification			
					subbase B	Base course A		
50.00	0.0	0.00	0.00	100.00	80-100	ok	100	ok
37.50	336.0	5.70	5.70	94.30	70-95	ok	70-100	ok
25.00	504.0	8.56	14.26	85.74	60-95	ok	55-85	ok
19.00	376.0	6.38	20.65	79.35		ok	50-80	ok
12.50	862.0	14.63	35.28	64.72	47-80	ok	45-80	ok
9.50	624.0	10.59	45.87	54.13		ok	40-70	ok
4.75	1040.0	17.66	63.53	36.47	30-60	ok	30-60	ok
2.00	876.0	14.87	78.40	21.60	22-45	ok	20-50	ok
0.43	540.0	9.17	87.57	12.43	10-30	ok	10-30	ok
0.075	120.0	2.04	89.61	10.39	5-15	ok	5-10	Not ok
Pan	612.0	100.00	100.00	0.00	-		-	





2. Proctor For subbase No.04

Proctor Mould Volume (Cm ³):	2109	Reference Standard: AASHTO (T180-93)			
No. of Layers : 5		Total Blows : 280		Weight of Hammer : 4.5kg	
Compaction Trial No.		A	B	C	D
Weight of Mould + Wet Soil (W2) gm.		10450	10750	11026	10980
Weight of Mould (W1) gm.		6252	6252	6252	6252
Weight of Wet Soil (W2)-(W1) gm.		4198	4498	4774	4728
Density of Wet Soil gm/cm ³		1.991	2.133	2.264	2.242
Moisture Content Can #		1	2	3	4
Weight of Can + Wet Soil (Ww) gm.		390	382.0	420	463.0
Weight of Can + Dry Soil (Wd) gm.		375.0	361.0	389.0	419.0
Weight of Can (Wc) gm.		36.5	38.5	39.9	37.2
Weight of Moisture (Ww) - (Wd) gm.		15.0	21.0	31.0	44.0
Weight of Dry Soil (Wd) - (Wc) gm.		338.5	322.5	349.1	381.8
Moisture Content %		4.24	6.11	8.16	10.33
Dry Density of Soil gm/cm ³		1.909	2.010	2.093	2.032



Max. Dry Density gm/cm ³	2.093
Optimum Moisture Content %	8.16

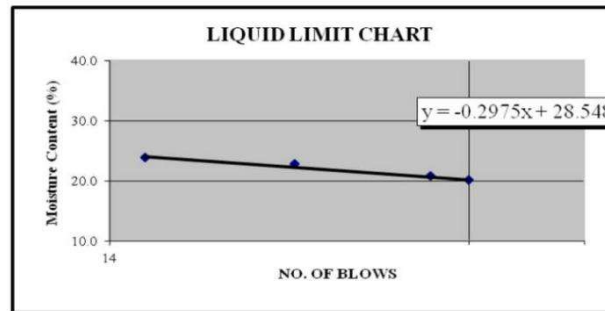
3. Sand Equivalent Test: according to ASTM D24 I 9-02

Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification
1	8.1	3.5	43.5	43.5	25.0(Min.)



4. Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"

Sample No.	Can No.	Can Weight (gm)	Can Wt. + Wt. Wet (gm)	Can Wt. + Wt. Dry (gm)	Moisture Weight (gm)	Dry Weight (gm)	No. of Blows	Moisture Content %
Liquid Limit Test								
1	1	12.80	60.50	52.50	8	39.7	20	20.15
2	2	13.00	61.60	53.30	8.3	40.3	25	20.60
3	3	12.80	60.60	52.30	8.3	39.5	20	21.01
4	4	13.00	61.00	53.00	8	40.0	25	20.00
Plastic Limit Test								
5	1	12.90	38.20	34.30	3.9	21.4	-	18.22



LL =	21.1
PL =	18.2
PI = LL - PL =	2.9



5. California Bearing Ratio

CBR= 65 %

6. Report of Los Angeles Abrasion Test for Aggregate Used in
Subbase material NO. 4

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) Abrasion after 500 Rev.	Loss in Weight (gm)	Abrasion Ratio (%)
1	5000	3025	1975	39.5

م. علاء غنيمات ، م. سمير حلاوة

Appendix E: Mixing material test

Appendix E.I

Comprehensive Mixing Material with 10% RAP material Test Reports

An Najah National
University



جامعة النجاح الوطنية

التاريخ: 2022/09/10
الرقم: 08

الى : الدكتور خالد الساحلي المحترم
بواسطة : م. علاء غنيمات

الموضوع: نتائج فحص عينة (Mixing Material NO.01)

الموقع : شارع بيتونيا

تحية طيبة وبعد

بالإشارة الى الموضوع أعلاه ، وكجزء من رسالة الماجستير بعنوان " جدوى استخدام مخلفات الاسفلت المعاد تدويره كمواد تحت طبقة الأساس في أعمال الطرق في فلسطين " بإشراف الدكتور خالد الساحلي تم إجراء فحوصات مادة (Mixing Material NO.01) بنسبة 10% من مواد القحط والتي تم خلطها وتحضيرها في مختبر جامعة النجاح من قبل الطالب (م.علاء غنيمات) وبمساعدة المهندس سمير حلوة بتاريخ 2022-08-03 وتم إجراء كافة الفحوصات اللازمة بإشراف مختبر المواصفات في جامعة النجاح الوطنية وكانت النتائج كما يلي :

- **Comprehensive Mixing Material NO.01-Reports: 2022/09/10 (Non compacted)**

Test	Result	Specification	Note
Liquid Limit (L.L)	% 26.36	30 (Max.)	Ok
Plastic Limit (P.L)	% 20	--	Ok
Plasticity Index (P.I)	6.36	2-8	Ok
Sand Equivalent	% 27.4	25 (Min.)	Ok
Percent Passing Sieve No.200	% 11.53	(5-12 Class A Not Compacted) (5-15 Class B Not Compacted)	Ok class A
Los Angeles after a#500	% 35.8	40 (Max.)	Ok
Optimum Moisture Content	% 7.3	--	Ok
Maximum Dry Density (M.D.D) gm/cm ³	2.17	2.05 (Min.)	Ok
California Bearing Ratio (CBR @ 0.1")	108.08	40 (Min.)	Ok

ملاحظة : مرفق لحضر تكم نتائج الفحوصات والمواصفات الخاصة لفحص مواد (Mixing Material NO.01)

مع التقدير والاحترام

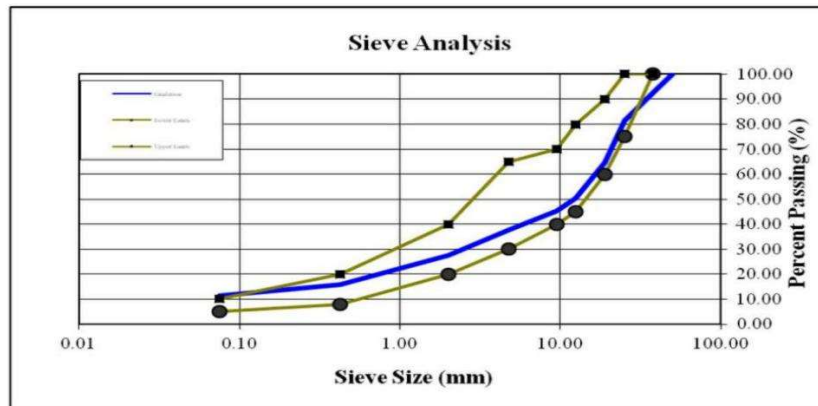
م. علاء غنيمات ، م.سمير حلوة



Test Result

1. Sieve analysis according to ASTM C 136-06" standard test method for sieve analysis of fine and coarse aggregate".

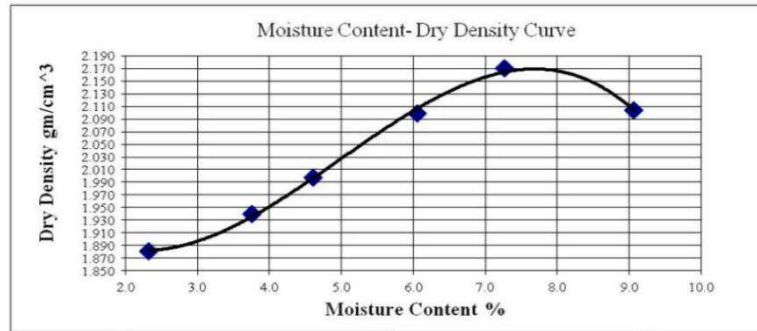
Sieve Size (mm)	Wt. Retained (g)	% Retained	Cumulative % Retained	% Passing	Specification			
					subbase B	Base course A		
50.00	0.0	0.00	0.00	100.00	80-100	ok	100	ok
37.50	240.0	7.58	7.58	92.42	70-95	ok	70-100	ok
25.00	352.0	11.12	18.70	81.30	60-95	ok	55-85	ok
19.00	527.0	16.65	35.36	64.64		ok	50-80	ok
12.50	453.0	14.31	49.67	50.33	47-80	ok	45-80	ok
9.50	161.0	5.09	54.76	45.24		ok	40-70	ok
4.75	243.0	7.68	62.43	37.57	30-60	ok	30-60	ok
2.00	320.0	10.11	72.54	27.46	22-45	ok	20-50	ok
0.43	368.0	11.63	84.17	15.83	10-30	ok	10-30	ok
0.075	136.0	4.30	88.47	11.53	5-15	ok	5-10	Not ok
Pan	365.0	100.00	100.00	0.00	-		-	





2.Proctor For Mixing No.01

Proctor For Milling Material sample NO 1						
Proctor Mould Volume (Cm ³):	2109	Reference Standard: AASHTO (T180-93)				
No. of Layers : 5	Total Blows : 280	Weight of Hammer : 4.5kg				
Compaction Trial No.	A	B	C	D	E	F
Weight of Mould + Wet Soil (W2) gm.	8900	9084	9246	9534	9750	9678
Weight of Mould (W1) gm.	4840	4840	4840	4840	4840	4840
Weight of Wet Soil (W2)-(W1) gm.	4060	4244	4406	4694	4910	4838
Density of Wet Soil gm/cm ³	1.925	2.012	2.089	2.226	2.328	2.294
Moisture Content Can #	1	2	3	4	5	6
Weight of Can + Wet Soil (Ww) gm.	309.6	337.9	329.1	422.2	420	315.0
Weight of Can + Dry Soil (Wd) gm.	303.3	326.6	315.6	398.8	392.4	290.0
Weight of Can (Wc) gm.	38.4	37.0	36.1	35.6	40.1	39.0
Weight of Moisture (Ww)-(Wd) gm.	6.3	11.3	13.5	23.4	27.6	25.0
Weight of Dry Soil (Wd)-(Wc) gm.	264.9	289.6	279.5	363.2	352.3	251.0
Moisture Content %	2.32	3.76	4.61	6.05	7.27	9.06
Dry Density of Soil gm/cm ³	1.881	1.939	1.997	2.099	2.170	2.103



Max. Dry Density gm/cm ³	2.170
Optimum Moisture Content %	7.3

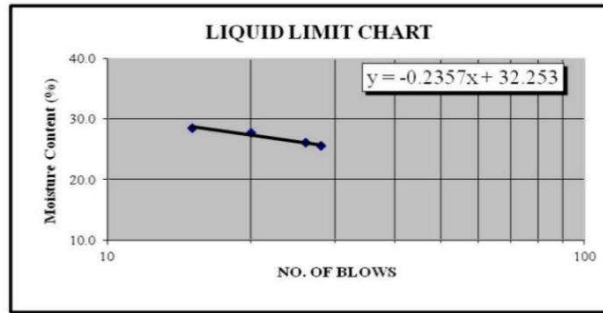
3. Sand Equivalent Test: according to ASTM D24 I 9-02

Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification
1	11.5	3.15	27.4	27.4	25.0(Min.)



4. Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"

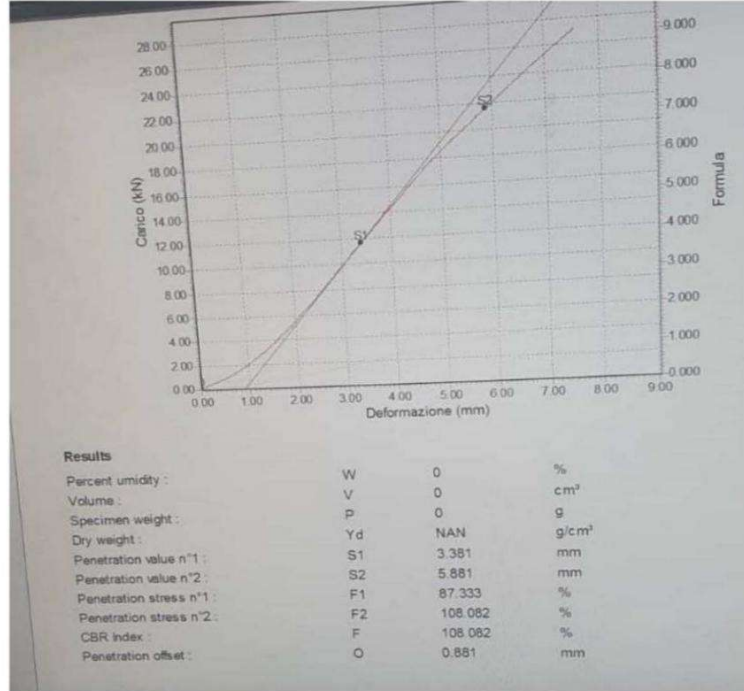
Report of Atterberg Limits Test sample #1 (10%)								
Sample No.	Can No.	Can Weight (gm)	Can Wt. + Wt. Wet (gm)	Can Wt. + Wt. Dry (gm)	Moisture Weight (gm)	Dry Weight (gm)	No. of Blows	Moisture Content %
Liquid Limit Test								
1	1	20.40	55.50	48.35	7.15	27.95	28	25.58
2	5	20.20	54.00	47.00	7	26.8	26	26.12
3	3	20.30	56.00	48.25	7.75	28.0	20	27.73
4	6	20.80	53.40	46.15	7.25	25.4	15	28.60
Plastic Limit Test								
5	6	20.80	38.20	35.30	2.9	14.5	-	20.00



LL =	26.36
PL =	20.0
PI = LL - PL =	6.36

5. California Bearing Ratio

CBR= 108 %



6. Report of Los Angeles Abrasion Test for Aggregate Used in
Mixing material NO. 01

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) <u>Abrasion after 500 Rev.</u>	Loss in Weight (gm)	Abrasion Ratio (%)
<u>1</u>	5000	3210	1808	35.8

م. علاء غنيمات ، م. سمير حلاوة

Appendix E.II

Comprehensive Mixing Material with 15% RAP material Test Reports

An Najah National
University



جامعة النجاح الوطنية

التاريخ: 10/09/2022
الرقم: 09

الى : الدكتور خالد الساحلي المحترم
بواسطة : م.علاء غنيمات

الموضوع: نتائج فحص عينة (Mixing Material NO.03)

الموقع : شارع بيتونيا

تحية طيبة وبعد ,,,,,,,,,,

بالاشارة الى الموضوع اعلاه ، وكجزء من رسالة الماجستير بعنوان " جدوى استخدام مخلفات الاسفلت المعاد تدويره كمواد تحت طبقة الأساس في أعمال الطرق في فلسطين " بإشراف الدكتور خالد الساحلي تم إجراء فحوصات مادة (Mixing Material NO.03) بنسبة 15% من مواد القحط والتي تم خلطها وتحضيرها في مختبر جامعة النجاح من قبل الطالب (م.علاء غنيمات) وبمساعدة المهندس سمير حلاوة بتاريخ 04-08-2022 وتم إجراء كافة الفحوصات اللازمة بإشراف مختبر المواصلات في جامعة النجاح الوطنية وكانت النتائج كما يلي :

- Comprehensive Mixing Material NO.01-Reports: 2022/09/10 (Non compacted)

Test	Result	Specification	Note
Liquid Limit (L.L)	% 25.9	30 (Max.)	Ok
Plastic Limit (P.L)	% 19.8	--	Ok
Plasticity Index (P.I)	6.1	2-8	Ok
Sand Equivalent	% 28.5	25 (Min.)	Ok
Percent Passing Sieve No.200	% 11.18	(5-12 Class A Not Compacted) (5-15 Class B Not Compacted)	Ok class A
Los Angeles after a#500	% 35.3	40 (Max.)	Ok
Optimum Moisture Content	% 6.98	--	Ok
Maximum Dry Density (M.D.D) gm/cm ³	2.089	2.05 (Min.)	Ok
California Bearing Ratio (CBR @ 0.1")	126.95	40 (Min.)	Ok

ملاحظة : مرفق لحضرتكم نتائج الفحوصات والمواصفات الخاصة لفحص مواد (Mixing Material NO.03)

مع التقدير والاحترام

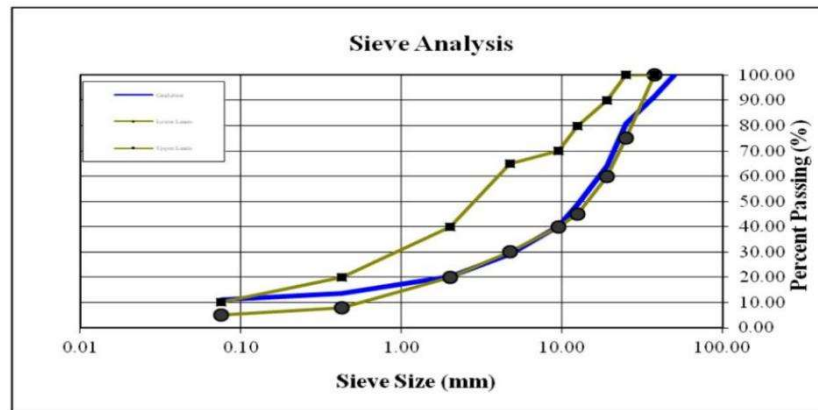
م.علاء غنيمات ، م.سمير حلاوة



Test Result

1. Sieve analysis according to ASTM C 136-06" standard test
method for sieve analysis of fine and coarse aggregate".

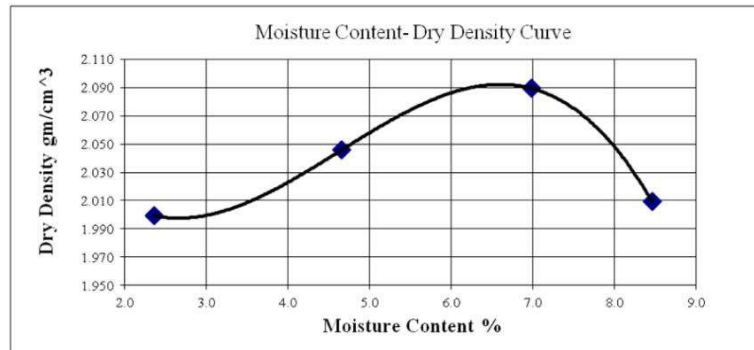
Sieve Size (mm)	Wt. Retained (g)	% Retained	Cumulative % Retained	% Passing	Specification	
					subbase B	Base course A
50.00	0.0	0.00	0.00	100.00	80-100 ok	100 ok
37.50	340.0	8.28	8.28	91.72	70-95 ok	70-100 ok
25.00	442.0	10.77	19.05	80.95	60-95 ok	55-85 ok
19.00	700.0	17.06	36.11	63.89	ok	50-80 ok
12.50	624.0	15.20	51.32	48.68	47-80 ok	45-80 ok
9.50	350.0	8.53	59.84	40.16	ok	40-70 ok
4.75	450.0	10.96	70.81	29.19	30-60 ok	30-60 ok
2.00	365.0	8.89	79.70	20.30	22-45 ok	20-50 ok
0.43	268.0	6.53	86.23	13.77	10-30 ok	10-30 ok
0.075	106.0	2.58	88.82	11.18	5-15 ok	5-10 Not ok
Pan	459.0	100.00	100.00	0.00	-	-





2. Proctor For Mixing No.03

Mixing Material No.03(15%)				
Proctor Mould Volume (Cm ³):	2109	Reference Standard: AASHTO (T180-93)		
No. of Layers : 5	Total Blows : 280	Weight of Hammer : 4.5kg		
Compaction Trial No.	A	B	C	D
Weight of Mould + Wet Soil (W2) gm.	10620	10820	11018	10900
Weight of Mould (W1) gm.	6304	6304	6304	6304
Weight of Wet Soil (W2)-(W1) gm.	4316	4516	4714	4596
Density of Wet Soil gm/cm ³	2.046	2.141	2.235	2.179
Moisture Content Can #	1	2	3	4
Weight of Can + Wet Soil (Ww) gm.	1300	1310.0	1254	1220.0
Weight of Can + Dry Soil (Wd) gm.	1280.0	1270.0	1198.0	1155.0
Weight of Can (Wc) gm.	452.0	452.0	452.0	452.0
Weight of Moisture (Ww) - (Wd) gm.	20.0	40.0	56.0	65.0
Weight of Dry Soil (Wd) - (Wc) gm.	828.0	818.0	746.0	703.0
Moisture Content %	2.36	4.66	6.98	8.46
Dry Density of Soil gm/cm ³	1.999	2.046	2.089	2.009



Max. Dry Density gm/cm ³	2.089
Optimum Moisture Content %	6.98

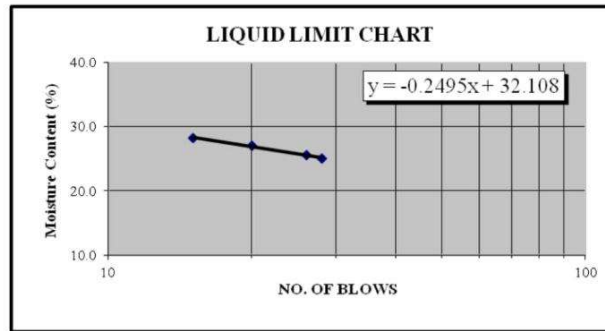
3. Sand Equivalent Test: according to ASTM D24 I 9-02

Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification
1	11.4	3.25	28.9	28.5	25.0(Min.)



4. Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"

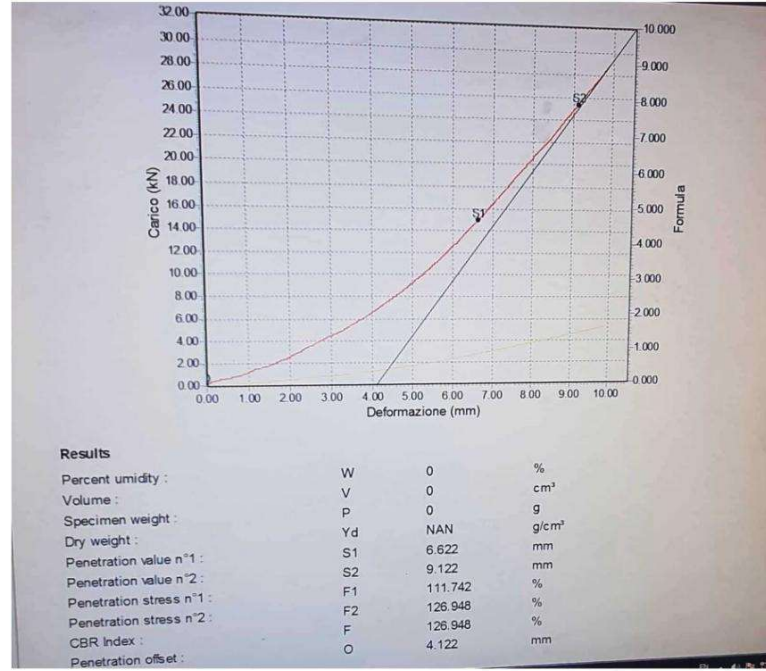
Report of Atterberg Limits Test sample #3 (15%)								
Sample No.	Can No.	Can Weight (gm)	Can Wt. + Wt. Wet (gm)	Can Wt. + Wt. Dry (gm)	Moisture Weight (gm)	Dry Weight (gm)	No. of Blows	Moisture Content %
Liquid Limit Test								
1	1	20.40	54.80	47.90	6.9	27.5	28	25.09
2	8	23.40	55.00	48.55	6.45	25.15	26	25.65
3	1	20.40	56.00	48.40	7.6	28.0	20	27.14
4	6	20.80	53.40	46.20	7.2	25.4	15	28.35
Plastic Limit Test								
5	8	23.40	39.45	36.80	2.65	13.4	-	19.78



LL =	25.9
PL =	19.8
PI = LL - PL =	6.1

5. California Bearing Ratio

CBR= 126.95 %



6. Report of Los Angeles Abrasion Test for Aggregate Used in Mixing material NO. 03

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) Abrasion after 500 Rev.	Loss in Weight (gm)	Abrasion Ratio (%)
<u>1</u>	5000	3235	1765	35.3

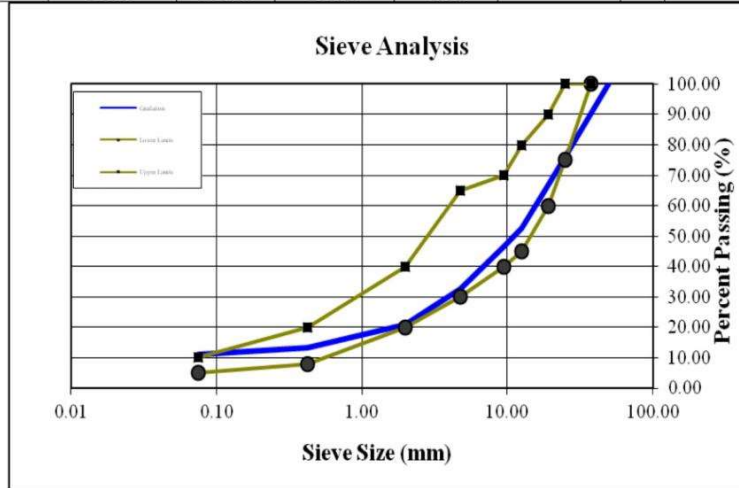
م. علاء غنيمات ، م. سمير حلاوة



Test Result

1. Sieve analysis according to ASTM C 136-06" standard test
method for sieve analysis of fine and coarse aggregate".

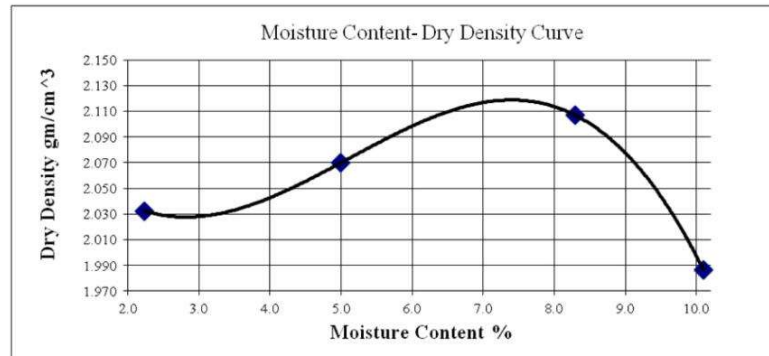
Sieve Size (mm)	Wt. Retained (g)	% Retained	Cumulative % Retained	% Passing	Specification		Specification	
					subbase B	ok	Base course A	ok
50.00	0.0	0.00	0.00	100.00	80-100	ok	100	ok
37.50	338.0	9.80	9.80	90.20	70-95	ok	70-100	ok
25.00	492.0	14.26	24.06	75.94	60-95	ok	55-85	ok
19.00	310.0	8.99	33.04	66.96		ok	50-80	ok
12.50	498.0	14.43	47.48	52.52	47-80	ok	45-80	ok
9.50	206.0	5.97	53.45	46.55		ok	40-70	ok
4.75	476.0	13.80	67.25	32.75	30-60	ok	30-60	ok
2.00	410.0	11.88	79.13	20.87	22-45	ok	20-50	ok
0.43	260.0	7.54	86.67	13.33	10-30	ok	10-30	ok
0.075	78.0	2.26	88.93	11.07	5-15	ok	5-10	Not ok
Pan	382.0	100.00	100.00	0.00	-		-	





2. Proctor For Mixing No.04

Mixing Material No.04(20%)				
Proctor Mould Volume (Cm ³):	2109	Reference Standard: AASHTO (T180-93)		
No. of Layers : 5	Total Blows : 280		Weight of Hammer : 4.5kg	
Compaction Trial No.				
	A	B	C	D
Weight of Mould + Wet Soil (W2) gm.	10650	10852	11080	10880
Weight of Mould (W1) gm.	6268	6268	6268	6268
Weight of Wet Soil (W2)-(W1) gm.	4382	4584	4812	4612
Density of Wet Soil gm/cm ³	2.078	2.174	2.282	2.187
Moisture Content Can #				
	1	2	3	4
Weight of Can + Wet Soil (Ww) gm.	1268	1260.0	1352	1450.0
Weight of Can + Dry Soil (Wd) gm.	1250.0	1220.0	1278.0	1350.0
Weight of Can (Wc) gm.	460.0	460.0	460.0	460.0
Weight of Moisture (Ww) - (Wd) gm.	18.0	40.0	74.0	100.0
Weight of Dry Soil (Wd) - (Wc) gm.	790.0	760.0	818.0	890.0
Moisture Content %	2.23	5.00	8.30	10.10
Dry Density of Soil gm/cm ³	2.032	2.070	2.107	1.986



Max. Dry Density gm/cm ³	2.107
Optimum Moisture Content %	8.30

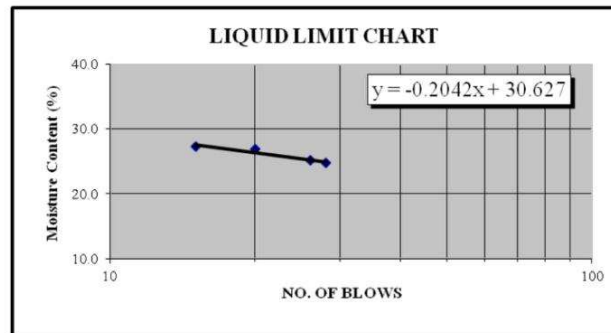
3. Sand Equivalent Test: according to ASTM D24 I 9-02

Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification
1	11.3	3.24	28.7	28.7	25.0(Min.)



4. Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"

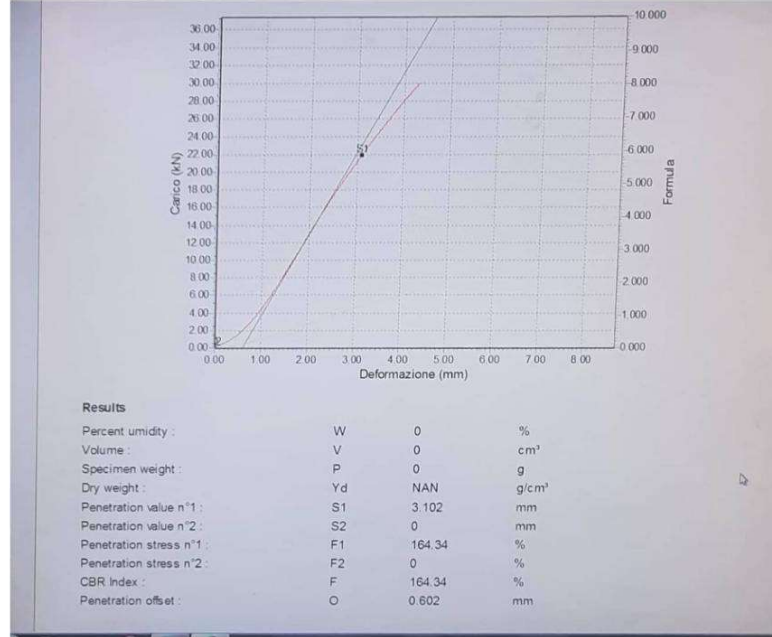
Report of Atterberg Limits Test sample #4 (20%)								
Sample No.	Can No.	Can Weight (gm)	Can Wt. + Wt. Wet (gm)	Can Wt. + Wt. Dry (gm)	Moisture Weight (gm)	Dry Weight (gm)	No. of Blows	Moisture Content %
Liquid Limit Test								
1	3	20.30	55.50	48.50	7	28.2	28	24.82
2	8	23.40	54.90	48.55	6.35	25.15	26	25.25
3	1'	20.40	56.00	48.45	7.55	28.1	20	26.92
4	6	20.80	53.40	46.40	7	25.6	15	27.34
Plastic Limit Test								
5	1	23.40	39.50	36.85	2.65	13.45	-	19.70



LL =	25.5
PL =	19.7
PI = LL - PL =	5.8

5. California Bearing Ratio

CBR= 165 %



6. Report of Los Angeles Abrasion Test for Aggregate Used in
Mixing material NO. 04

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) <u>Abrasion after 500 Rev.</u>	Loss in Weight (gm)	Abrasion Ratio (%)
1	5000	3260	1740	34.8

م. علاء غنيمات ، م. سمير حلاوة

Appendix E.IV

Comprehensive Mixing Material with 25% RAP material Test Reports

An Najah National
University



جامعة النجاح الوطنية

التاريخ: 26/09/2022
الرقم : 11

الى : الدكتور خالد الساحلي المحترم
بواسطة : م. علاء غنيمات

الموضوع: نتائج فحص عينة (Mixing Material NO.06)

الموقع : شارع بيتونيا

تحية طيبة وبعد ,,,,,,

بالاشارة الى الموضوع اعلاه ، وكجزء من رسالة الماجستير بعنوان " جدوى استخدام مخلفات الاسفلت المعاد تدويره كمواد تحت طبقة الأساس في أعمال الطرق في فلسطين " بإشراف الدكتور خالد الساحلي تم إجراء فحوصات مادة (Mixing Material NO.06) بنسبة 25% من مواد القحط والتي تم خلطها وتحضيرها في مختبر جامعة النجاح من قبل الطالب (م. علاء غنيمات) وبمساعدة المهندس سمير حلاوة بتاريخ 09-08-2022 وتم إجراء كافة الفحوصات اللازمة بإشراف مختبر المواصلات في جامعة النجاح الوطنية وكانت النتائج كما يلي :

- **Comprehensive Mixing Material NO.06-Reports: 2022/09/26 (Non compacted)**

Test	Result	Specification	Note
Liquid Limit (L.L)	% 25.5	30 (Max.)	Ok
Plastic Limit (P.L)	% 19.4	--	Ok
Plasticity Index (P.I)	5.8	2-8	Ok
Sand Equivalent	% 28.9	25 (Min.)	Ok
Percent Passing Sieve No.200	% 10.47	(5-12 Class A Not Compacted) (5-15 Class B Not Compacted)	Ok class A
Los Angeles after a#500	% 34.4	40 (Max.)	Ok
Optimum Moisture Content	% 6.64	--	Ok
Maximum Dry Density (M.D.D) gm/cm ³	2.077	2.05 (Min.)	Ok
California Bearing Ratio (CBR @ 0.1")	167.5	40 (Min.)	Ok

ملاحظة : مرفق لحضرتكم نتائج الفحوصات والمواصفات الخاصة لفحص مواد (Mixing Material NO.06)

مع التقدير والاحترام

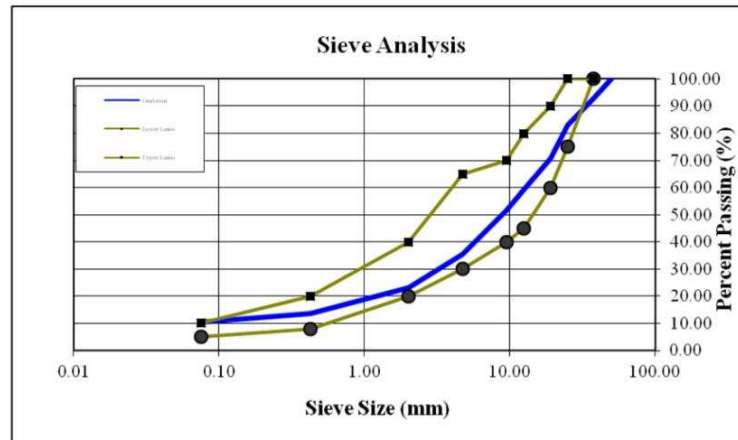
م. علاء غنيمات ، م. سمير حلاوة



Test Result

1. Sieve analysis according to ASTM C 136-06" standard test method for sieve analysis of fine and coarse aggregate".

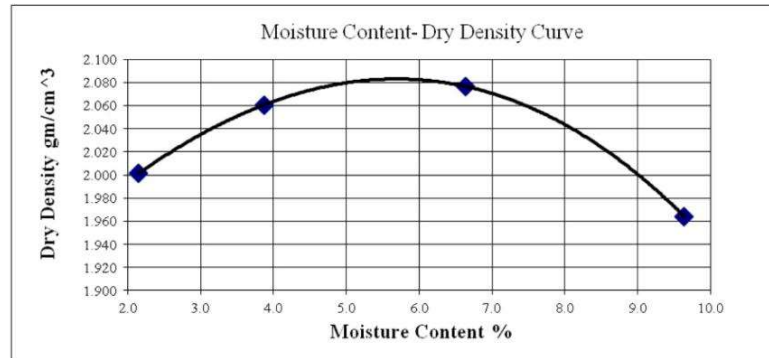
Material Type: mixture subbase & milling material #6 (25%)								
Total Sample		3840.00	gm					
Reference Standard: (AASHTO - T27-14) - (Approved)								
Sieve Size (mm)	Wt. Retained (g)	% Retained	Cumulative % Retained	% Passing	Specification subbase B	Specification Base course A		
50.00	0.0	0.00	0.00	100.00	80-100	ok	100	ok
37.50	278.0	7.24	7.24	92.76	70-95	ok	70-100	ok
25.00	372.0	9.69	16.93	83.07	60-95	ok	55-85	ok
19.00	472.0	12.29	29.22	70.78		ok	50-80	ok
12.50	440.0	11.46	40.68	59.32	47-80	ok	45-80	ok
9.50	296.0	7.71	48.39	51.61		ok	40-70	ok
4.75	618.0	16.09	64.48	35.52	30-60	ok	30-60	ok
2.00	474.0	12.34	76.82	23.18	22-45	ok	20-50	ok
0.43	372.0	9.69	86.51	13.49	10-30	ok	10-30	ok
0.075	116.0	3.02	89.53	10.47	5-15	ok	5-10	Not ok
Pan	402.0	100.00	100.00	0.00	-		-	



2. Proctor For Mixing No.04



Mixing Material No.06(25%)				
Proctor Mould Volume (Cm ³):	2109	Reference Standard: AASHTO (T180-93)		
No. of Layers : 5	Total Blows : 280	Weight of Hammer : 4.5kg		
Compaction Trial No.	A	B	C	D
Weight of Mould + Wet Soil (W2) gm.	10650	10852	10970	10880
Weight of Mould (W1) gm.	6338	6338	6300	6338
Weight of Wet Soil (W2)-(W1) gm.	4312	4514	4670	4542
Density of Wet Soil gm/cm ³	2.045	2.140	2.214	2.154
Moisture Content Can #	1	2	3	4
Weight of Can + Wet Soil (Ww) gm.	1620	1750.0	1724	1340.0
Weight of Can + Dry Soil (Wd) gm.	1595.0	1700.0	1640.0	1255.0
Weight of Can (Wc) gm.	458.0	458.0	458.0	458.0
Weight of Moisture (Ww) - (Wd) gm.	25.0	50.0	84.0	85.0
Weight of Dry Soil (Wd) - (Wc) gm.	1137.0	1242.0	1182.0	797.0
Moisture Content %	2.15	3.87	6.64	9.64
Dry Density of Soil gm/cm ³	2.002	2.061	2.077	1.964



Max. Dry Density gm/cm ³	2.077
Optimum Moisture Content %	6.64

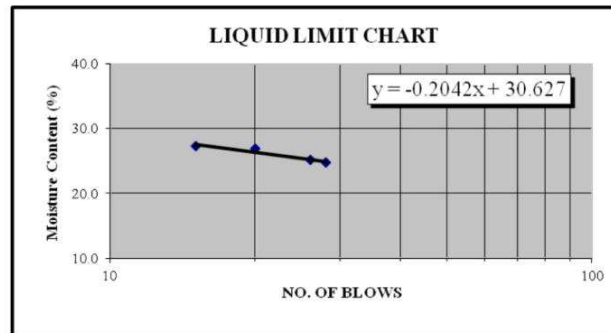
3.Sand Equivalent Test: according to ASTM D24 I 9-02

Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification
1	11.2	3.237	28.9	28.9	25.0(Min.)



4. Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"

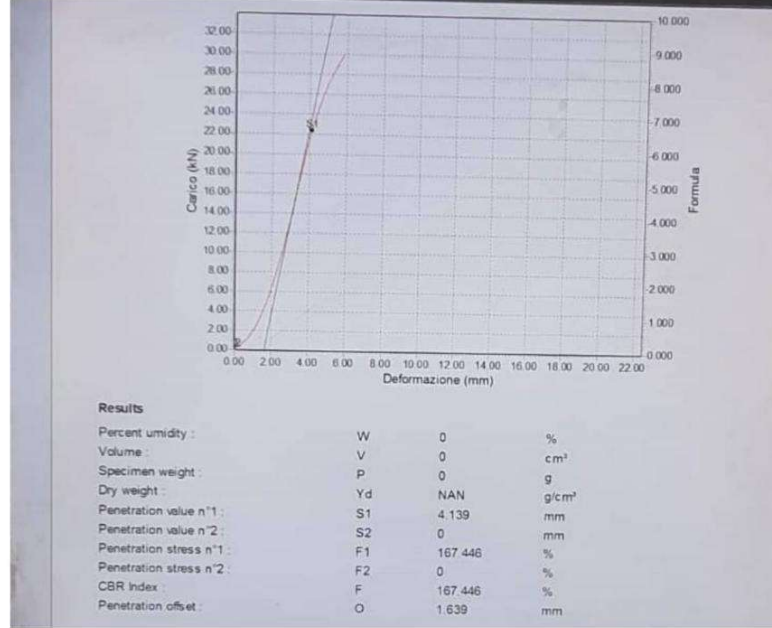
Report of Atterberg Limits Test sample #6 (25%)								
Sample No.	Can No.	Can Weight (gm)	Can Wt. + Wt. Wet (gm)	Can Wt. + Wt. Dry (gm)	Moisture Weight (gm)	Dry Weight (gm)	No. of Blows	Moisture Content %
Liquid Limit Test								
1	3	20.30	55.50	48.50	7	28.2	28	24.82
2	8	23.40	54.90	48.55	6.35	25.15	26	25.25
3	1	20.40	56.00	48.45	7.55	28.1	20	26.92
4	6	20.80	53.40	46.40	7	25.6	15	27.34
Plastic Limit Test								
5	3	20.30	42.18	38.55	3.63	18.25	-	19.89



LL =	25.5
PL =	19.9
PI = LL - PL =	5.6

5. California Bearing Ratio

CBR= 167.5 %



6. Report of Los Angeles Abrasion Test for Aggregate Used in Mixing material NO. 06

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) <u>Abrasion after 500 Rev.</u>	Loss in Weight (gm)	Abrasion Ratio (%)
<u>1</u>	5000	3280	1720	34.4

م.علاء غنيمات ، م.سمير حلاوة

Appendix E.V

Comprehensive Mixing Material with 30% RAP material Test Reports

An Najah National
University



جامعة النجاح الوطنية

التاريخ: 26/09/2022
الرقم : 12

الى : الدكتور خالد الساحلي المحترم
بواسطة : م. علاء غنيمات

الموضوع: نتائج فحص عينة (Mixing Material NO.08)

الموقع : شارع بيتونيا

تحية طيبة وبعد ,,,,,,,,,,

بالإشارة الى الموضوع أعلاه ، وكجزء من رسالة الماجستير بعنوان " جدوى استخدام مخلفات الاسفلت المعاد تدويره كمواد تحت طبقة الأساس في أعمال الطرق في فلسطين " بإشراف الدكتور خالد الساحلي تم إجراء فحوصات مادة (Mixing Material NO.08) بنسبة 30% من مواد القحط والتي تم خلطها وتحضيرها في مختبر جامعة النجاح من قبل الطالب (م.علاء غنيمات) وبمساعدة المهندس سمير حلوة بتاريخ 10-08-2022 وتم إجراء كافة الفحوصات اللازمة بإشراف مختبر المواصلات في جامعة النجاح الوطنية وكانت النتائج كما يلي :

- **Comprehensive Mixing Material NO.08-Reports: 2022/09/26 (Non compacted)**

Test	Result	Specification	Note
Liquid Limit (L.L)	% 25.3	30 (Max.)	Ok
Plastic Limit (P.L)	% 19.7	--	Ok
Plasticity Index (P.I)	5.6	2-8	Ok
Sand Equivalent	% 30.2	25 (Min.)	Ok
Percent Passing Sieve No.200	% 10.13	(5-12 Class A Not Compacted) (5-15 Class B Not Compacted)	Ok class A
Los Angeles after a#500	% 33.9	40 (Max.)	Ok
Optimum Moisture Content	% 7.19	--	Ok
Maximum Dry Density (M.D.D) gm/cm ³	2.039	2.05 (Min.)	Ok
California Bearing Ratio (CBR @ 0.1")	151	40 (Min.)	Ok

ملاحظة : مرفق لحضرتكم نتائج الفحوصات والمواصفات الخاصة لفحص مواد (Mixing Material NO.08)

مع التقدير والاحترام

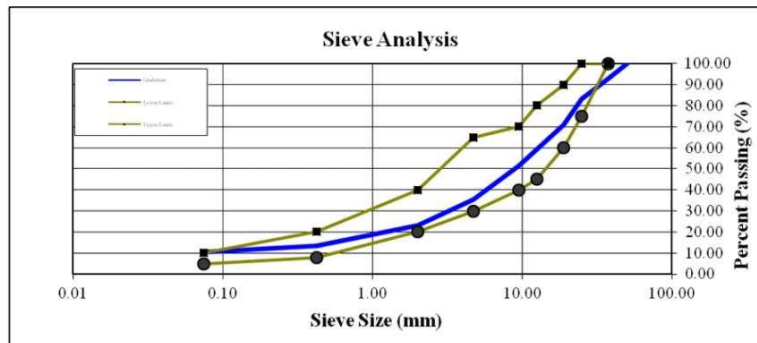
م. علاء غنيمات ، م.سمير حلوة



Test Result

1.Sieve analysis according to ASTM C 136-06" standard test method for sieve analysis of fine and coarse aggregate".

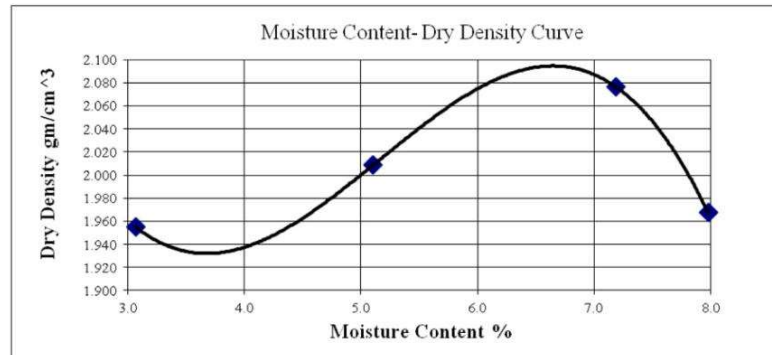
Material Type:	mixture subbase & milling material #8 (30%)							
Total Sample	3140.00	gm						
Reference Standard: (AASHTO - T27-14) - (Approved)								
Sieve Size (mm)	Wt. Retained (g)	% Retained	Cumulative % Retained	% Passing	Specification subbase B	Specification Base course A		
50.00	0.0	0.00	0.00	100.00	80-100	ok	100	ok
37.50	230.0	7.32	7.32	92.68	70-95	ok	70-100	ok
25.00	307.0	9.78	17.10	82.90	60-95	ok	55-85	ok
19.00	391.0	12.45	29.55	70.45		ok	50-80	ok
12.50	358.0	11.40	40.96	59.04	47-80	ok	45-80	ok
9.50	242.5	7.72	48.68	51.32		ok	40-70	ok
4.75	501.0	15.96	64.63	35.37	30-60	ok	30-60	ok
2.00	390.0	12.42	77.05	22.95	22-45	ok	20-50	ok
0.43	307.0	9.78	86.83	13.17	10-30	ok	10-30	ok
0.075	94.0	2.99	89.82	10.18	5-15	ok	5-10	Not ok
Pan	319.5	100.00	100.00	0.00	-		-	





2. Proctor For Mixing No.08

Mixing Material No.08(30%)				
Proctor Mould Volume (Cm^3):	2109	Reference Standard: AASHTO (T180-93)		
No. of Layers : 5	Total Blows : 280		Weight of Hammer : 4.5kg	
Compaction Trial No.	A	B	C	D
Weight of Mould + Wet Soil (W2) gm.	10650	10852	11094	10880
Weight of Mould (W1) gm.	6400	6400	6400	6400
Weight of Wet Soil (W2)-(W1) gm.	4250	4452	4694	4480
Density of Wet Soil gm/cm^3	2.015	2.111	2.226	2.124
Moisture Content Can #	1	2	3	4
Weight of Can + Wet Soil (Ww) gm.	1200	1300.0	1196	1350.0
Weight of Can + Dry Soil (Wd) gm.	1170.0	1245.0	1126.0	1260.0
Weight of Can (Wc) gm.	222.0	222.0	222.0	222.0
Weight of Moisture (Ww) - (Wd) gm.	30.0	55.0	70.0	90.0
Weight of Dry Soil (Wd) - (Wc) gm.	948.0	1023.0	904.0	1038.0
Moisture Content %	3.07	5.10	7.19	7.98
Dry Density of Soil gm/cm^3	1.955	2.008	2.076	1.967



Max. Dry Density gm/cm^3	2.076
Optimum Moisture Content %	7.19

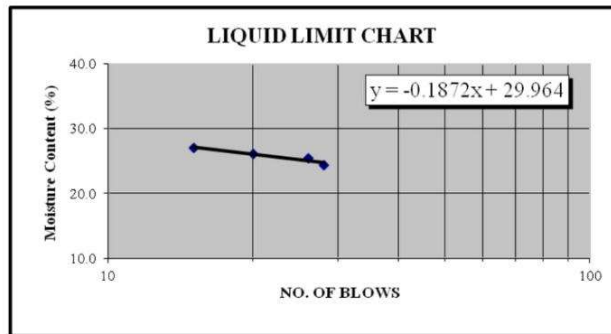
3. Sand Equivalent Test: according to ASTM D24 I 9-02



Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification
1	11.1	3.35	30.2	30.2	25.0(Min.)

4. Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"

Report of Atterberg Limits Test sample #8 (30 %)								
Sample No.	Can No.	Can Weight (gm)	Can Wt. + Wt. Wet (gm)	Can Wt. + Wt. Dry (gm)	Moisture Weight (gm)	Dry Weight (gm)	No. of Blows	Moisture Content %
Liquid Limit Test								
1	3	20.30	56.00	49.00	7	28.7	28	24.39
2	8	23.40	55.40	48.90	6.5	25.5	26	25.49
3	1	20.40	55.30	48.05	7.25	27.7	20	26.22
4	6	20.80	53.40	46.45	6.95	25.7	15	27.10
Plastic Limit Test								
5	3	20.30	43.10	39.35	3.75	19.05	-	19.69

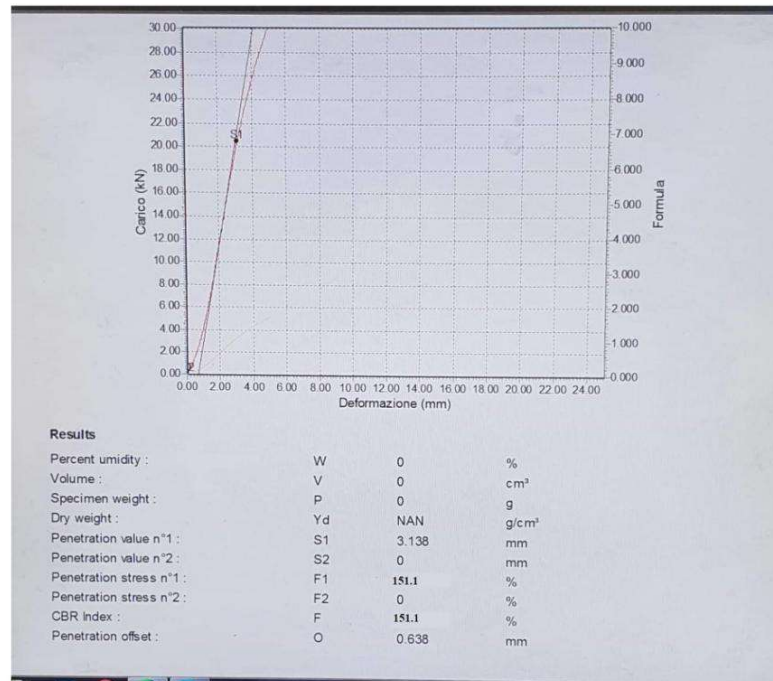


LL =	25.3
PL =	19.7
PI = LL - PL =	5.6



5. California Bearing Ratio

CBR= 151 %



6. Report of Los Angeles Abrasion Test for Aggregate Used in
Mixing material NO. 08

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) Abrasion after 500 Rev.	Loss in Weight (gm)	Abrasion Ratio (%)
1	5000	3305	1695	33.9

Appendix E.VI

Comprehensive Mixing Material with 35% RAP material Test Reports

An Najah National
University



جامعة النجاح الوطنية

التاريخ: 10/10/2022
الرقم : 13

الى : الدكتور خالد الساحلي المحترم
بواسطة : م. علاء غنيمات

الموضوع: نتائج فحص عينة (Mixing Material NO.10)

الموقع : شارع بيتونيا

تحية طيبة وبعد ,,,,,,,,,,

بالإشارة الى الموضوع أعلاه ، وكجزء من رسالة الماجستير بعنوان " جدوى استخدام مخلفات الاسفلت المعاد تدويره كمواد تحت طبقة الأساس في أعمال الطرق في فلسطين " بإشراف الدكتور خالد الساحلي تم إجراء فحوصات مادة (Mixing Material NO.10) بنسبة 35% من مواد القحط والتي تم خلطها وتحضيرها في مختبر جامعة النجاح من قبل الطالب (م. علاء غنيمات) وبمساعدة المهندس سمير حلاوة بتاريخ 15-08-2022 وتم إجراء كافة الفحوصات اللازمة بإشراف مختبر المواصلات في جامعة النجاح الوطنية وكانت النتائج كما يلي :

- **Comprehensive Mixing Material NO.10-Reports: 2022/10/10 (Non compacted)**

Test	Result	Specification	Note
Liquid Limit (L.L)	% 25.2	30 (Max.)	Ok
Plastic Limit (P.L)	% 19.7	--	Ok
Plasticity Index (P.I)	5.5	2-8	Ok
Sand Equivalent	% 30.54	25 (Min.)	Ok
Percent Passing Sieve No.200	% 10.04	(5-12 Class A Not Compacted) (5-15 Class B Not Compacted)	Ok class A
Los Angeles after a#500	% 33.5	40 (Max.)	Ok
Optimum Moisture Content	% 6.31	--	Ok
Maximum Dry Density (M.D.D) gm/cm ³	2.081	2.05 (Min.)	Ok
California Bearing Ratio (CBR @ 0.1")	164.34	40 (Min.)	Ok

ملاحظة : مرفق لحضرتكم نتائج الفحوصات والموصفات الخاصة لفحص مواد (Mixing Material NO.10)

مع التقدير والاحترام

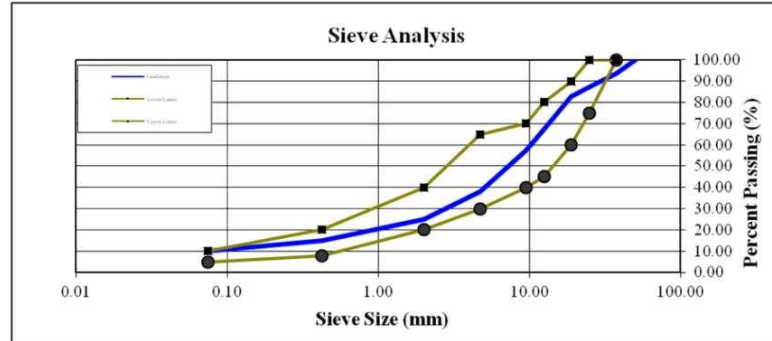
م. علاء غنيمات ، م.سمير حلاوة



Test Result

1. Sieve analysis according to ASTM C 136-06" standard test method for sieve analysis of fine and coarse aggregate".

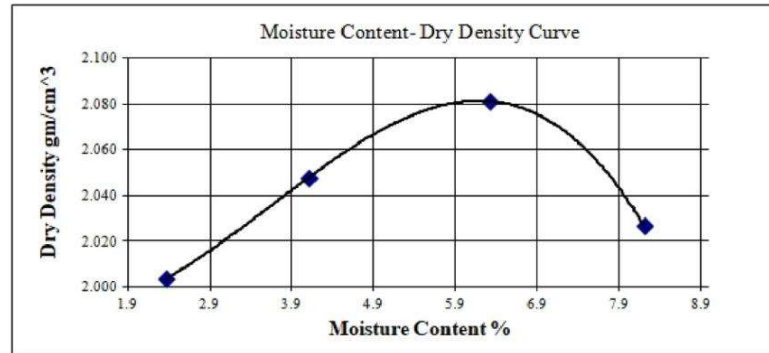
Material Type:		mixture subbase & milling material #10 (35%)					
Total Sample		2650.00	gm				
Reference Standard: (AASHTO - T27-14) - (Approved)							
Sieve Size (mm)	Wt. Retained (g)	% Retained	Cumulative % Retained	% Passing	Specification subbase B		Specification Base course A
50.00	0.0	0.00	0.00	100.00	80-100	ok	100 ok
37.50	168.0	6.34	6.34	93.66	70-95	ok	70-100 ok
25.00	170.0	6.42	12.75	87.25	60-95	ok	55-85 ok
19.00	116.0	4.38	17.13	82.87		ok	50-80 ok
12.50	406.0	15.32	32.45	67.55	47-80	ok	45-80 ok
9.50	268.0	10.11	42.57	57.43		ok	40-70 ok
4.75	514.0	19.40	61.96	38.04	30-60	ok	30-60 ok
2.00	350.0	13.21	75.17	24.83	22-45	ok	20-50 ok
0.43	264.0	9.96	85.13	14.87	10-30	ok	10-30 ok
0.075	128.0	4.83	89.96	10.04	5-15	ok	5-10 Not ok
Pan	266.0	100.00	100.00	0.00	-		-





2. Proctor For Mixing No.10

Mixing Material No.10(35%)				
Proctor Mould Volume (Cm ³):	2109	Reference Standard: AASHTO (T180-93)		
No. of Layers : 5	Total Blows : 280	Weight of Hammer : 4.5kg		
Compaction Trial No.	A	B	C	D
Weight of Mould + Wet Soil (W2) gm.	10580	10750	10920	10880
Weight of Mould (W1) gm.	6254	6254	6254	6254
Weight of Wet Soil (W2)-(W1) gm.	4326	4496	4666	4626
Density of Wet Soil gm/cm ³	2.051	2.132	2.212	2.193
Moisture Content Can #	1	2	3	4
Weight of Can + Wet Soil (Ww) gm.	1400	1350.0	1210	1230.0
Weight of Can + Dry Soil (Wd) gm.	1370.0	1300.0	1142.0	1140.0
Weight of Can (Wc) gm.	132.0	132.0	132.0	132.0
Weight of Moisture (Ww) - (Wd) gm.	30.0	50.0	68.0	90.0
Weight of Dry Soil (Wd) - (Wc) gm.	1238.0	1168.0	1010.0	1008.0
Moisture Content %	2.37	4.11	6.31	8.20
Dry Density of Soil gm/cm ³	2.004	2.048	2.081	2.027



Max. Dry Density gm/cm ³	2.081
Optimum Moisture Content %	6.31

3. Sand Equivalent Test: according to ASTM D24 I 9-02

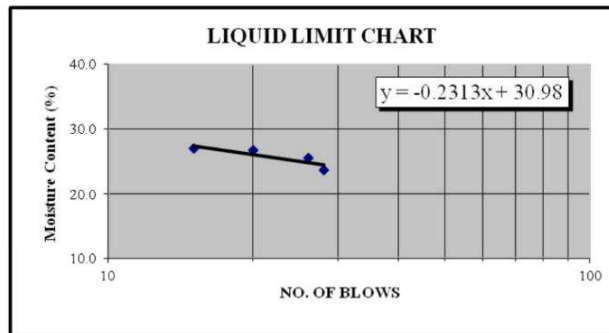
Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification
1	11	3.36	30.60	30.54	25.0(Min.)

4. Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"



Report of Atterberg Limits Test sample #10 (35%)

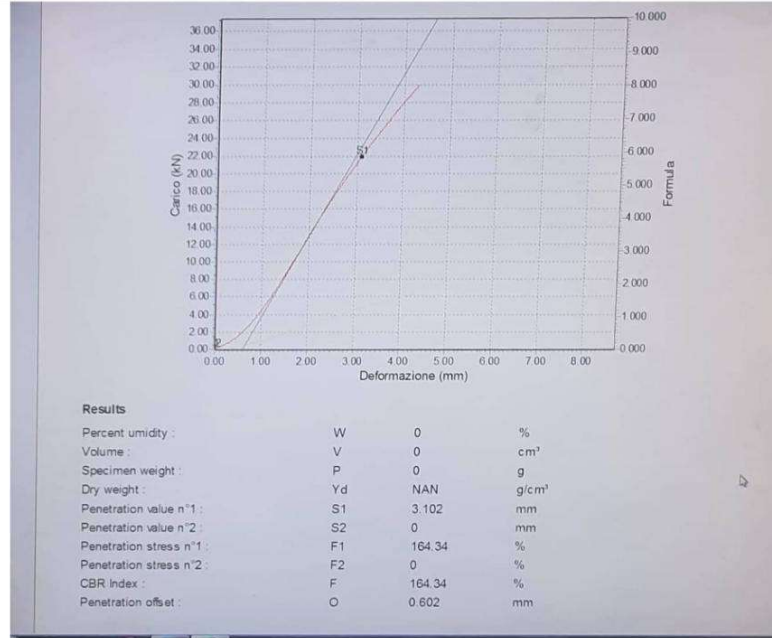
Sample No.	Can No.	Can Weight (gm)	Can Wt. + Wt. Wet (gm)	Can Wt. + Wt. Dry (gm)	Moisture Weight (gm)	Dry Weight (gm)	No. of Blows	Moisture Content %
Liquid Limit Test								
1	3	20.30	56.50	49.55	6.95	29.25	28	23.76
2	8	23.40	54.30	48.00	6.3	24.6	26	25.61
3	1	20.40	54.40	47.20	7.2	26.8	20	26.87
4	6	20.80	53.40	46.45	6.95	25.7	15	27.10
Plastic Limit Test								
5	3	20.30	43.10	39.35	3.75	19.05	-	19.69



LL =	25.2
PL =	19.7
PI = LL - PL =	5.5

5. California Bearing Ratio

CBR= 164.34 %



**6. Report of Los Angeles Abrasion Test for Aggregate Used in
Mixing material NO. 10**

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) Abrasion after 500 Rev.	Loss in Weight (gm)	Abrasion Ratio (%)
1	5000	3325	1675	33.5

م. علاء غنيمات ، م. سمير حلاوة

Appendix E.V11 Comprehensive Mixing Material with 40% RAP material Test

Reports

An Najah National
University



جامعة النجاح الوطنية

التاريخ: 10/10/2022

الرقم : 14

الى : الدكتور خالد الساحلي المحترم
بواسطة : م. علاء غنيمات

الموضوع: نتائج فحص عينة (Mixing Material NO.12)

الموقع : شارع بيتونيا

تحية طيبة وبعد ,,,,,,,,,,

بالاشارة الى الموضوع اعلاه ، وكجزء من رسالة الماجستير بعنوان " جدوى استخدام مخلفات الاسفلت المعاد تدويره كمواد تحت طبقة الأساس في أعمال الطرق في فلسطين " بإشراف الدكتور خالد الساحلي تم إجراء فحوصات مادة (Mixing Material NO.12) بنسبة 40% من مواد القحط والتي تم خلطها وتحضيرها في مختبر جامعة النجاح من قبل الطالب (م. علاء غنيمات) وبمساعدة المهندس سمير حلاوة بتاريخ 17-08-2022 وتم إجراء كافة الفحوصات اللازمة بإشراف قسم الدراسات والابحاث في جامعة النجاح الوطنية وكانت النتائج كما يلي :

- **Comprehensive Mixing Material NO.10-Reports: 2022/10/10 (Non compacted)**

Test	Result	Specification	Note
Liquid Limit (L.L)	% 25.13	30 (Max.)	Ok
Plastic Limit (P.L)	% 19.69	--	Ok
Plasticity Index (P.I)	5.44	2-8	Ok
Sand Equivalent	% 30.64	25 (Min.)	Ok
Percent Passing Sieve No.200	% 9.87	(5-12 Class A Not Compacted) (5-15 Class B Not Compacted)	Ok class A
Los Angeles after a#500	% 33.02	40 (Max.)	Ok
Optimum Moisture Content	% 6.64	--	Ok
Maximum Dry Density (M.D.D) gm/cm ³	2.061	2.05 (Min.)	Ok
California Bearing Ratio (CBR @ 0.1")	162.23	40 (Min.)	Ok

ملاحظة : مرفق لحضرتكم نتائج الفحوصات والموصفات الخاصة لفحص مواد (Mixing Material NO.12)

مع التقدير والاحترام

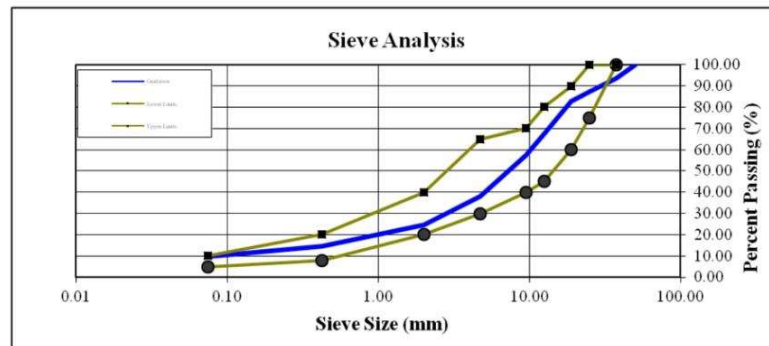
م. علاء غنيمات ، م.سمير حلاوة



Test Result

1. Sieve analysis according to ASTM C 136-06" standard test method for sieve analysis of fine and coarse aggregate".

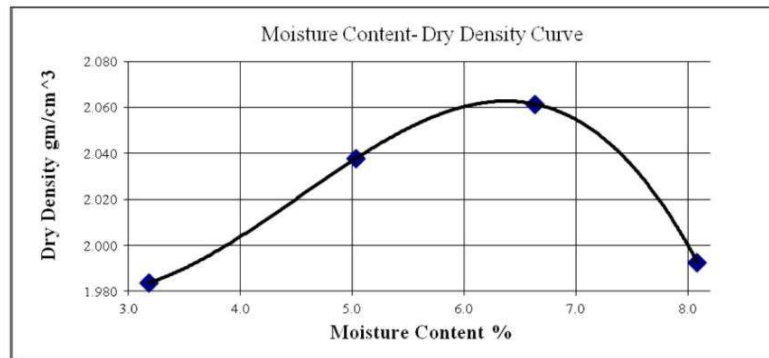
Sieve Size (mm)	Wt. Retained (g)	% Retained	Cumulative % Retained	% Passing	Specification subbase B	Specification Base course A
50.00	0.0	0.00	0.00	100.00	80-100 ok	100 ok
37.50	168.0	6.35	6.35	93.65	70-95 ok	70-100 ok
25.00	170.0	6.43	12.78	87.22	60-95 ok	55-85 ok
19.00	116.0	4.39	17.16	82.84	ok	50-80 ok
12.50	406.0	15.35	32.51	67.49	47-80 ok	45-80 ok
9.50	268.0	10.13	42.65	57.35	ok	40-70 ok
4.75	514.0	19.43	62.08	37.92	30-60 ok	30-60 ok
2.00	350.0	13.23	75.31	24.69	22-45 ok	20-50 ok
0.43	264.0	9.98	85.29	14.71	10-30 ok	10-30 ok
0.075	128.0	4.84	90.13	9.87	5-15 ok	5-10 ok
Pan	261.0	100.00	100.00	0.00	-	-





2. Proctor For Mixing No.12

Mixing Material No.12(40%)				
Proctor Mould Volume (Cm ³):	2109	Reference Standard: AASHTO (T180-93)		
No. of Layers : 5	Total Blows : 280	Weight of Hammer : 4.5kg		
Compaction Trial No.	A	B	C	D
Weight of Mould + Wet Soil (W2) gm.	10655	10852	11074	10880
Weight of Mould (W1) gm.	6338	6338	6438	6338
Weight of Wet Soil (W2)-(W1) gm.	4317	4514	4636	4542
Density of Wet Soil gm/cm ³	2.047	2.140	2.198	2.154
Moisture Content Can #	1	2	3	4
Weight of Can + Wet Soil (Ww) gm.	1400	1650.0	1724	1200.0
Weight of Can + Dry Soil (Wd) gm.	1370.0	1590.0	1640.0	1140.0
Weight of Can (Wc) gm.	458.0	458.0	458.0	458.0
Weight of Moisture (Ww) - (Wd) gm.	30.0	60.0	84.0	60.0
Weight of Dry Soil (Wd) - (Wc) gm.	912.0	1132.0	1182.0	682.0
Moisture Content %	3.18	5.03	6.64	8.09
Dry Density of Soil gm/cm ³	1.984	2.038	2.061	1.993



Max. Dry Density gm/cm ³	2.061
Optimum Moisture Content %	6.64

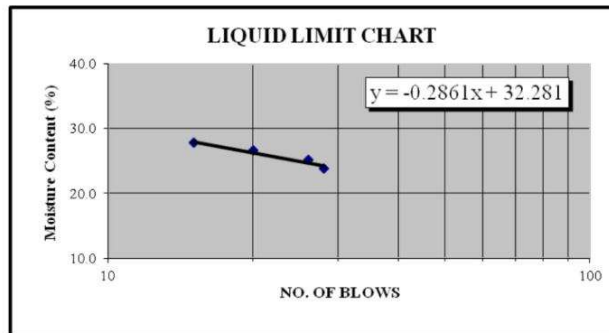
3. Sand Equivalent Test: according to ASTM D24 I 9-02

Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification
1	10.9	3.34	30.60	30.64	25.0(Min.)



4. Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"

Report of Waterberg Limits Test sample #12 (40%)								
Sample No.	Can No.	Can Weight (gm)	Can Wt. + Wt. Wet (gm)	Can Wt. + Wt. Dry (gm)	Moisture Weight (gm)	Dry Weight (gm)	No. of Blows	Moisture Content %
Liquid Limit Test								
1	1	20.40	55.10	48.40	6.7	28	28	23.93
2	8	23.40	54.20	48.00	6.2	24.6	26	25.20
3	1	20.40	55.80	48.35	7.45	28.0	20	26.65
4	6	20.80	53.60	46.45	7.15	25.7	15	27.88
Plastic Limit Test								
5	2	20.40	43.56	39.75	3.81	19.35	-	19.69

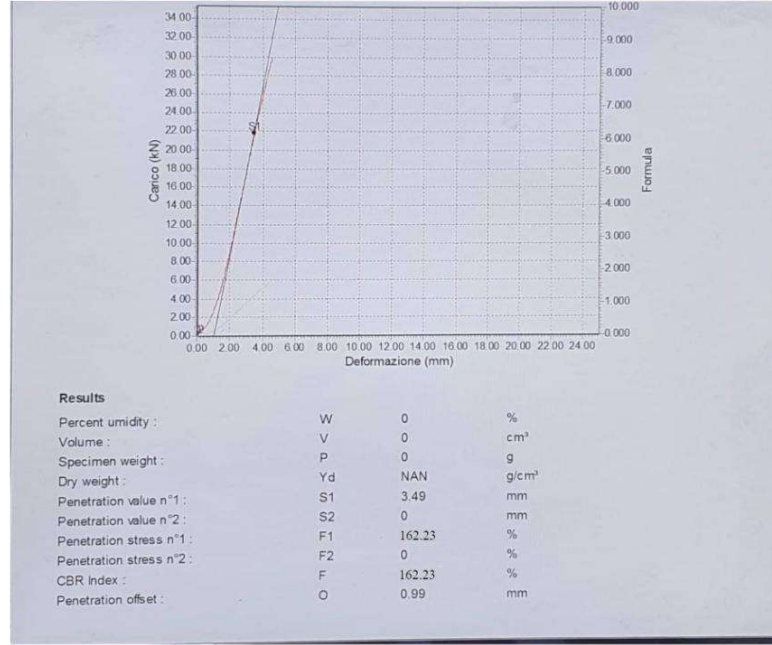


LL =	25.13
PL =	19.69
PI = LL - PL =	5.44

5. California Bearing Ratio



CBR= 162.23%



6. Report of Los Angeles Abrasion Test for Aggregate Used in Mixing material NO. 10

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) <u>Abrasion after 500 Rev.</u>	Loss in Weight (gm)	Abrasion Ratio (%)
<u>1</u>	5000	3349	1651	33.02

م.علام غنيمات ، م.سمير حلاوة

Appendix E.VIII Comprehensive Mixing Material with 45% RAP material Test

Reports

An Najah National
University



جامعة النجاح الوطنية

التاريخ: 10/10/2022
الرقم : 15

الى : الدكتور خالد الساحلي المحترم
بواسطة : م.علاء غنيمات

الموضوع: نتائج فحص عينة (Mixing Material NO.13)

الموقع : شارع بيتونيا

تحية طيبة وبعد ,,,,,,

بالاشارة الى الموضوع أعلاه ، وكجزء من رسالة الماجستير بعنوان " جدوى استخدام مخلفات الاسفلت المعاد تدويره كمواد تحت طبقة الأساس في أعمال الطرق في فلسطين " بإشراف الدكتور خالد الساحلي تم إجراء فحوصات مادة (Mixing Material NO.13) بنسبة 45% من مواد القحط والتي تم خلطها وتحضيرها في مختبر جامعة النجاح من قبل الطالب (م.علاء غنيمات) وبمساعدة المهندس سمير حلاوة بتاريخ 2022-08-23 وتم إجراء كافة الفحوصات اللازمة بإشراف قسم الدراسات والابحاث في جامعة النجاح الوطنية وكانت النتائج كما يلي :

- **Comprehensive Mixing Material NO.10-Reports: 2022/10/10 (Non compacted)**

Test	Result	Specification	Note
Liquid Limit (L.L)	% 25.13	30 (Max.)	Ok
Plastic Limit (P.L)	% 19.69	--	Ok
Plasticity Index (P.I)	5.44	2-8	Ok
Sand Equivalent	% 30.7	25 (Min.)	Ok
Percent Passing Sieve No.200	% 8.45	(5-12 Class A Not Compacted) (5-15 Class B Not Compacted)	Ok class A
Los Angeles after a#500	% 32.5	40 (Max.)	Ok
Optimum Moisture Content	% 6.10	--	Ok
Maximum Dry Density (M.D.D) gm/cm ³	2.058	2.05 (Min.)	Ok
California Bearing Ratio (CBR @ 0.1")	145	40 (Min.)	Ok

ملاحظة : مرفق لحضرتكم نتائج الفحوصات والمواصفات الخاصة لفحص مواد (Mixing Material NO.13)

مع التقدير والاحترام

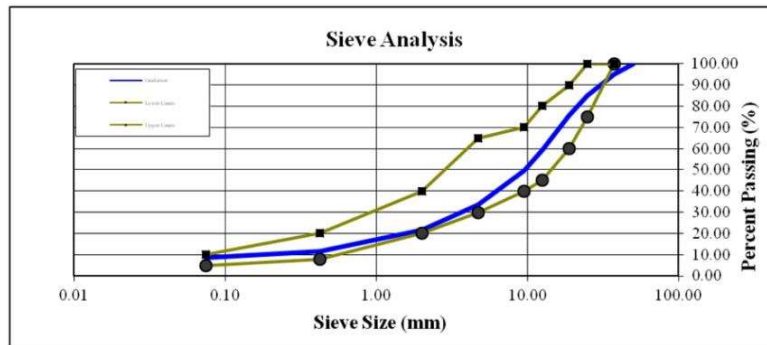
م .علاء غنيمات ، م.سمير حلاوة



Test Result

1. Sieve analysis according to ASTM C 136-06" standard test method for sieve analysis of fine and coarse aggregate".

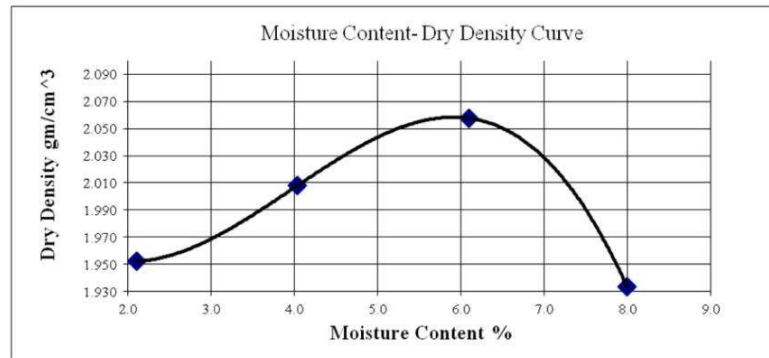
Material Type:	mixture subbase & milling material #13 (45%)							
Total Sample	4700.00	gm						
Reference Standard: (AASHTO - T27-14) - (Approved)								
Sieve Size (mm)	Wt. Retained (g)	% Retained	Cumulative % Retained	% Passing	Specification subbase B	Specification Base course A		
50.00	0.0	0.00	0.00	100.00	80-100	ok	100	ok
37.50	224.0	4.77	4.77	95.23	70-95	ok	70-100	ok
25.00	480.0	10.21	14.98	85.02	60-95	ok	55-85	ok
19.00	434.0	9.23	24.21	75.79		ok	50-80	ok
12.50	772.0	16.43	40.64	59.36	47-80	ok	45-80	ok
9.50	468.0	9.96	50.60	49.40		ok	40-70	ok
4.75	746.0	15.87	66.47	33.53	30-60	ok	30-60	ok
2.00	564.0	12.00	78.47	21.53	22-45	ok	20-50	ok
0.43	464.0	9.87	88.34	11.66	10-30	ok	10-30	ok
0.075	151.0	3.21	91.55	8.45	5-15	ok	5-10	Not ok
Pan	397.0	100.00	100.00	0.00	-		-	



2. Proctor For Mixing No.13



Mixing Material No.13(45%)				
Proctor Mould Volume (Cm ³):	2109	Reference Standard: AASHTO (T180-93)		
No. of Layers : 5	Total Blows : 280	Weight of Hammer : 4.5kg		
Compaction Trial No.	A	B	C	D
Weight of Mould + Wet Soil (W2) gm.	10650	10852	11050	10850
Weight of Mould (W1) gm.	6446	6446	6446	6446
Weight of Wet Soil (W2)-(W1) gm.	4204	4406	4604	4404
Density of Wet Soil gm/cm ³	1.993	2.089	2.183	2.088
Moisture Content Can #	1	2	3	4
Weight of Can + Wet Soil (Ww) gm.	1300	1400.0	1260	1300.0
Weight of Can + Dry Soil (Wd) gm.	1275.0	1348.0	1190.0	1205.0
Weight of Can (Wc) gm.	112.0	112.0	112.0	112.0
Weight of Moisture (Ww) - (Wd) gm.	25.0	52.0	70.0	95.0
Weight of Dry Soil (Wd) - (Wc) gm.	1163.0	1236.0	1078.0	1093.0
Moisture Content %	2.10	4.04	6.10	8.00
Dry Density of Soil gm/cm ³	1.952	2.008	2.058	1.934



Max. Dry Density gm/cm ³	2.058
Optimum Moisture Content %	6.10

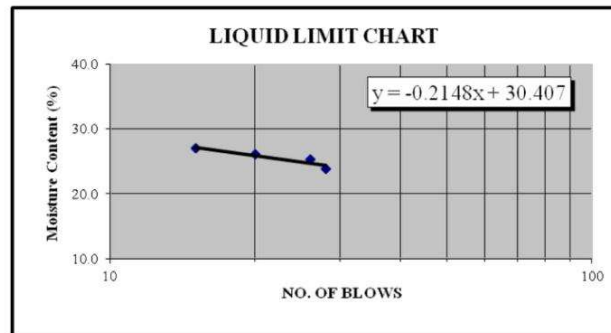
3. Sand Equivalent Test: according to ASTM D24 I 9-02

Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification
1	10.8	3.32	30.70	30.70	25.0(Min.)



4. Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"

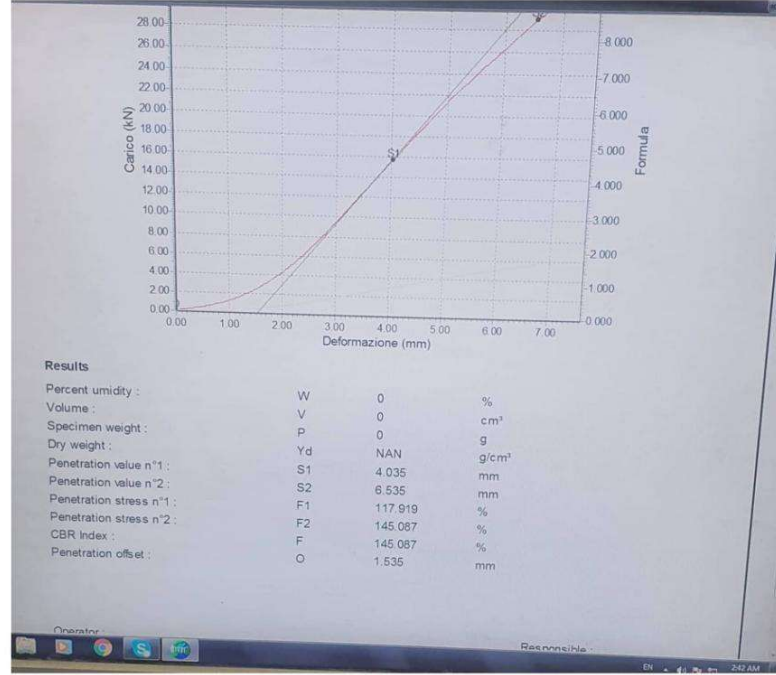
Report of Atterberg Limits Test sample #13 (45%)								
Sample No.	Can No.	Can Weight (gm)	Can Wt. + Wt. Wet (gm)	Can Wt. + Wt. Dry (gm)	Moisture Weight (gm)	Dry Weight (gm)	No. of Blows	Moisture Content %
Liquid Limit Test								
1	6	20.80	54.50	48.00	6.5	27.2	28	23.90
2	1	20.40	53.00	46.40	6.6	26	26	25.38
3	8	23.40	53.30	47.10	6.2	23.7	20	26.16
4	1	20.40	54.20	47.00	7.2	26.6	15	27.07
Plastic Limit Test								
5	2	20.40	44.45	40.50	3.95	20.1	-	19.65



LL =	25.04
PL =	19.7
PI = LL - PL =	5.4

5. California Bearing Ratio

CBR= 145%



6. Report of Los Angeles Abrasion Test for Aggregate Used in
Mixing material NO. 10

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) <u>Abrasion after 500 Rev.</u>	Loss in Weight (gm)	Abrasion Ratio (%)
1	5000	3375	1625	32.5

م. علاء غنيمات ، م. سمير حلاوة

Appendix E.IX Comprehensive Mixing Material with 50% RAP material Test Reports

An Najah National
University



جامعة النجاح الوطنية

التاريخ: 10/10/2022
الرقم : 16

الى : الدكتور خالد الساحلي المحترم
بواسطة : م. علاء غنيمات

الموضوع: نتائج فحص عينة (Mixing Material NO.14)

الموقع : شارع بيتونيا

تحية طيبة وبعد ,,,,,,

بالإشارة الى الموضوع اعلاه ، وكجزء من رسالة الماجستير بعنوان " جدوى استخدام مخلفات الاسفلت المعاد تدويره كمواد تحت طبقة الأساس في أعمال الطرق في فلسطين " بإشراف الدكتور خالد الساحلي تم إجراء فحوصات مادة (Mixing Material NO.14) بنسبة 50% من مواد القحط والتي تم خلطها وتحضيرها في مختبر جامعة النجاح من قبل الطالب (م.علاء غنيمات) وبمساعدة المهندس سمير حلاوة بتاريخ 2022-08-28 وتم إجراء كافة الفحوصات اللازمة بإشراف مختبر المواصلات في جامعة النجاح الوطنية وكانت النتائج كما يلي :

- **Comprehensive Mixing Material NO.10-Reports: 2022/10/10 (Non compacted)**

Test	Result	Specification	Note
Liquid Limit (L.L)	% 24.9	30 (Max.)	Ok
Plastic Limit (P.L)	% 19.7	--	Ok
Plasticity Index (P.I)	5.2	2-8	Ok
Sand Equivalent	% 30.6	25 (Min.)	Ok
Percent Passing Sieve No.200	% 7.79	(5-12 Class A Not Compacted) (5-15 Class B Not Compacted)	Ok class A
Los Angeles after a#500	% 32.1	40 (Max.)	Ok
Optimum Moisture Content	% 6.01	--	Ok
Maximum Dry Density (M.D.D) gm/cm ³	2.056	2.05 (Min.)	Ok
California Bearing Ratio (CBR @ 0.1")	136.6	40 (Min.)	Ok

ملاحظة : مرفق لحضرتكم نتائج الفحوصات والمواصفات الخاصة لفحص مواد (Mixing Material NO.14)

مع التقدير والاحترام

م. علاء غنيمات ، م.سمير حلاوة

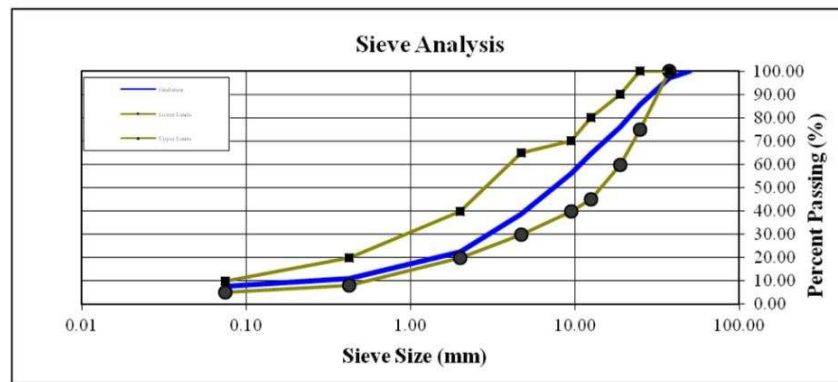
Test Result

Page 1 of 5



1. Sieve analysis according to ASTM C 136-06" standard test
method for sieve analysis of fine and coarse aggregate".

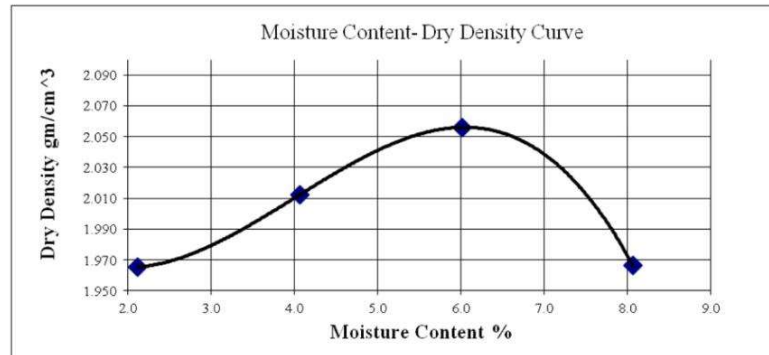
Material Type:	mixture subbase & milling material #14 (50%)							
Total Sample	5134.00	gm						
Reference Standard: (AASHTO - T27-14) - (Approved)								
Sieve Size (mm)	Wt. Retained (g)	% Retained	Cumulative % Retained	% Passing	Specification		Specification	
					subbase B	Base course A		
50.00	0.0	0.00	0.00	100.00	80-100	ok	100	ok
37.50	138.0	2.69	2.69	97.31	70-95	ok	70-100	ok
25.00	602.0	11.73	14.41	85.59	60-95	ok	55-85	ok
19.00	480.0	9.35	23.76	76.24		ok	50-80	ok
12.50	604.0	11.76	35.53	64.47	47-80	ok	45-80	ok
9.50	436.0	8.49	44.02	55.98		ok	40-70	ok
4.75	888.0	17.30	61.32	38.68	30-60	ok	30-60	ok
2.00	826.0	16.09	77.41	22.59	22-45	ok	20-50	ok
0.43	592.0	11.53	88.94	11.06	10-30	ok	10-30	ok
0.075	168.0	3.27	92.21	7.79	5-15	ok	5-10	Not ok
Pan	400.0	100.00	100.00	0.00	-		-	



2. Proctor For Mixing No.14



Mixing Material No.14(50%)				
Proctor Mould Volume (Cm ³):	2109	Reference Standard: AASHTO (T180-93)		
No. of Layers : 5	Total Blows : 280	Weight of Hammer : 4.5kg		
Compaction Trial No.	A	B	C	D
Weight of Mould + Wet Soil (W2) gm.	10501	10685	10865	10750
Weight of Mould (W1) gm.	6268	6268	6268	6268
Weight of Wet Soil (W2)-(W1) gm.	4233	4417	4597	4482
Density of Wet Soil gm/cm ³	2.007	2.094	2.180	2.125
Moisture Content Can #	1	2	3	4
Weight of Can + Wet Soil (Ww) gm.	1300	1400.0	1552	1300.0
Weight of Can + Dry Soil (Wd) gm.	1275.0	1348.0	1466.0	1205.0
Weight of Can (Wc) gm.	122.0	122.0	122.0	122.0
Weight of Moisture (Ww) - (Wd) gm.	25.0	52.0	86.0	95.0
Weight of Dry Soil (Wd) - (Wc) gm.	1153.0	1226.0	1344.0	1083.0
Moisture Content %	2.12	4.07	6.01	8.06
Dry Density of Soil gm/cm ³	1.965	2.012	2.056	1.967



Max. Dry Density gm/cm ³	2.056
Optimum Moisture Content %	6.01

3.Sand Equivalent Test: according to ASTM D24 I 9-02

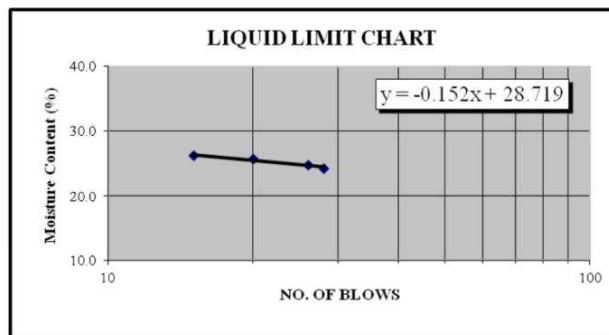
Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification
1	10.8	3.31	30.6	30.6	25.0(Min.)

4.Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"



Report of Atterberg Limits Test sample #14 (50%)

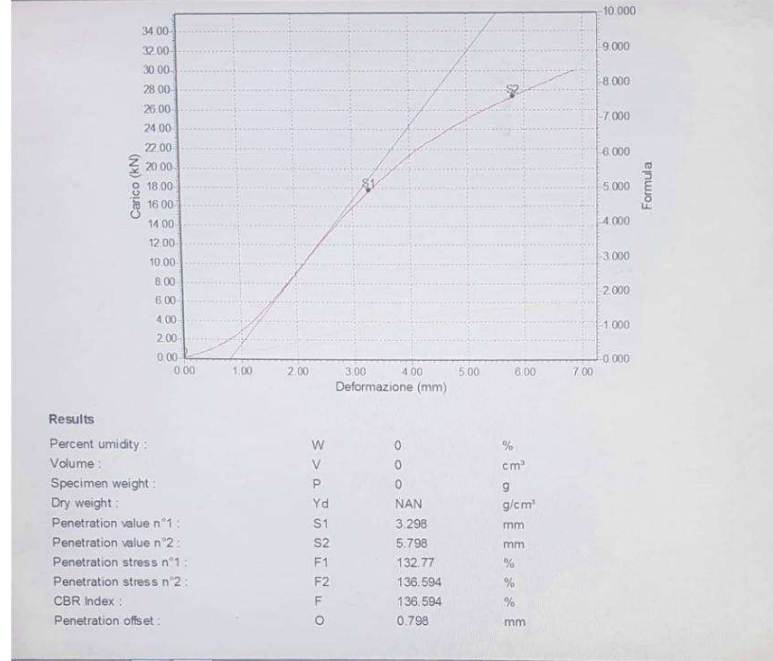
Sample No.	Can No.	Can Weight (gm)	Can Wt. + Wt. Wet (gm)	Can Wt. + Wt. Dry (gm)	Moisture Weight (gm)	Dry Weight (gm)	No. of Blows	Moisture Content %
Liquid Limit Test								
1	8	23.40	54.80	48.65	6.15	25.25	28	24.36
2	1	20.40	49.80	43.95	5.85	23.55	26	24.84
3	1	20.40	56.00	48.70	7.3	28.3	20	25.80
4	6	20.80	53.40	46.60	6.8	25.8	15	26.36
Plastic Limit Test								
5	7	20.30	42.69	39.00	3.69	18.7	-	19.73



LL =	24.9
PL =	19.7
PI = LL - PL =	5.2

5. California Bearing Ratio

CBR= 136.6%



**6. Report of Los Angeles Abrasion Test for Aggregate Used in
Mixing material NO. 10**

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) <u>Abrasion after 500 Rev.</u>	Loss in Weight (gm)	Abrasion Ratio (%)
1	5000	3395	1605	32.1

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Appendix E.X

Comprehensive Mixing Material with 55% RAP material Test Reports

An Najah National
University



جامعة النجاح الوطنية

التاريخ: 2022/10/10
الرقم : 17

الى : الدكتور خالد الساحلي المحترم
بواسطة : م. علاء غنيمات

الموضوع: نتائج فحص عينة (Mixing Material NO.15)

الموقع : شارع بيتونيا

تحية طيبة وبعد ,,,,,,

بالإشارة الى الموضوع أعلاه ، وكجزء من رسالة الماجستير بعنوان " جدوى استخدام مخلفات الاسفلت المعاد تدويره كمواد تحت طبقة الأساس في أعمال الطرق في فلسطين " بإشراف الدكتور خالد الساحلي تم إجراء فحوصات مادة (Mixing Material NO.15) بنسبة 55% من مواد القحط والتي تم خلطها وتحضيرها في مختبر جامعة النجاح من قبل الطالب (م. علاء غنيمات) وبمساعدة المهندس سمير حلاوة بتاريخ 2022-08-30 وتم إجراء كافة الفحوصات اللازمة بإشراف مختبر المواصفات في جامعة النجاح الوطنية وكانت النتائج كما يلي :

- **Comprehensive Mixing Material NO.10-Reports: 2022/10/10 (Non compacted)**

Test	Result	Specification	Note
Liquid Limit (L.L)	% 24.5	30 (Max.)	Ok
Plastic Limit (P.L)	% 19.6	--	Ok
Plasticity Index (P.I)	4.9	2-8	Ok
Sand Equivalent	% 33	25 (Min.)	Ok
Percent Passing Sieve No.200	% 5.94	(5-12 Class A Not Compacted) (5-15 Class B Not Compacted)	Ok class A
Los Angeles after a#500	% 31.5	40 (Max.)	Ok
Optimum Moisture Content	% 5.90	--	Ok
Maximum Dry Density (M.D.D) gm/cm ³	1.992	2.05 (Min.)	Not Ok
California Bearing Ratio (CBR @ 0.1")	108	40 (Min.)	Ok

ملاحظة : مرفق لحضرتكم نتائج الفحوصات والمواصفات الخاصة لفحص مواد (Mixing Material NO.15)

مع التقدير والاحترام

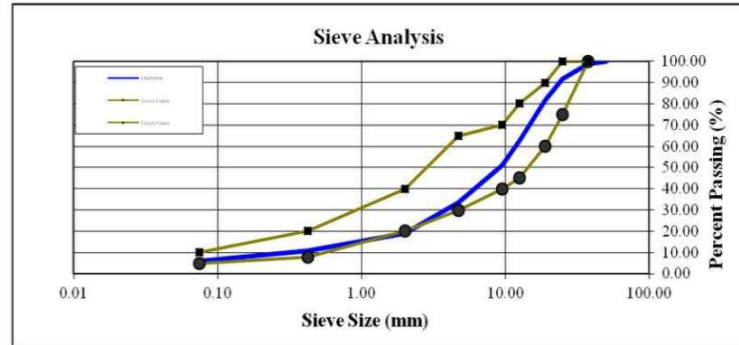
م. علاء غنيمات ، م.سمير حلاوة



Test Result

1. Sieve analysis according to ASTM C 136-06" standard test method for sieve analysis of fine and coarse aggregate".

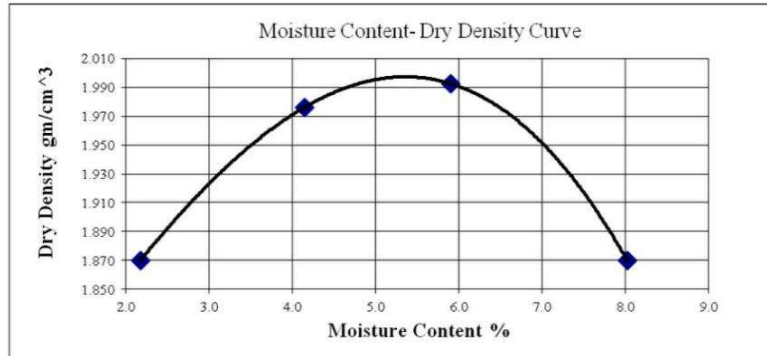
Material Type:	mixture subbase & milling material #15 (55%)					
Total Sample	4178.00	gm				
Reference Standard: (AASHTO - T27-14) - (Approved)						
Sieve Size (mm)	Wt. Retained (g)	% Retained	Cumulative % Retained	% Passing	Specification	
					subbase B	Base course A
50.00	0.0	0.00	0.00	100.00	80-100 ok	100 ok
37.50	58.0	1.39	1.39	98.61	70-95 ok	70-100 ok
25.00	296.0	7.08	8.47	91.53	60-95 ok	55-85 ok
19.00	410.0	9.81	18.29	81.71	ok	50-80 ok
12.50	792.0	18.96	37.24	62.76	47-80 ok	45-80 ok
9.50	488.0	11.68	48.92	51.08	ok	40-70 ok
4.75	730.0	17.47	66.40	33.60	30-60 ok	30-60 ok
2.00	604.0	14.46	80.85	19.15	22-45 ok	20-50 ok
0.43	352.0	8.43	89.28	10.72	10-30 ok	10-30 ok
0.075	200.0	4.79	94.06	5.94	5-15 ok	5-10 Not ok
Pan	248.0	100.00	100.00	0.00	-	-





2. Proctor For Mixing No.15

Mixing Material No.15(55%)				
Proctor Mould Volume (Cm ³):	2109	Reference Standard: AASHTO (T180-93)		
No. of Layers : 5	Total Blows : 280	Weight of Hammer : 4.5kg		
Compaction Trial No.	A	B	C	D
Weight of Mould + Wet Soil (W2) gm.	10310	10620	10830	10540
Weight of Mould (W1) gm.	6280	6280	6380	6280
Weight of Wet Soil (W2)-(W1) gm.	4030	4340	4450	4260
Density of Wet Soil gm/cm ³	1.911	2.058	2.110	2.020
Moisture Content Can #	1	2	3	4
Weight of Can + Wet Soil (Ww) gm.	1321	1381.0	1752	1285.0
Weight of Can + Dry Soil (Wd) gm.	1295.0	1329.0	1656.0	1192.0
Weight of Can (Wc) gm.	126.0	126.0	126.0	126.0
Weight of Moisture (Ww) - (Wd) gm.	26.0	52.0	96.0	93.0
Weight of Dry Soil (Wd) - (Wc) gm.	1169.0	1203.0	1530.0	1066.0
Moisture Content %	2.18	4.14	5.90	8.02
Dry Density of Soil gm/cm ³	1.870	1.976	1.992	1.870



Max. Dry Density gm/cm ³	1.992
Optimum Moisture Content %	5.90

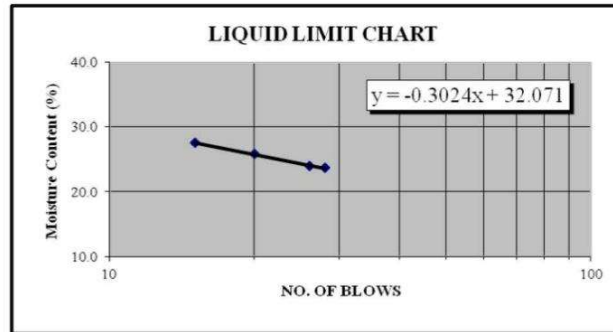
3. Sand Equivalent Test: according to ASTM D24 I 9-02

Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification
1	10.5	3.45	33	33	25.0(Min.)



4. Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"

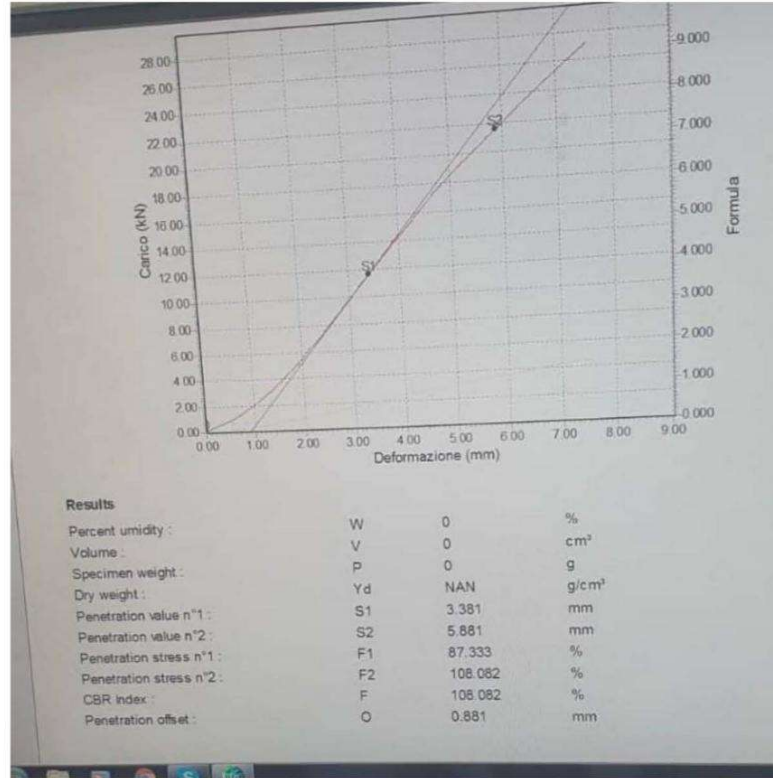
Report of Atterberg Limits Test sample #15 (55%)								
Sample No.	Can No.	Can Weight (gm)	Can Wt. + Wt. Wet (gm)	Can Wt. + Wt. Dry (gm)	Moisture Weight (gm)	Dry Weight (gm)	No. of Blows	Moisture Content %
Liquid Limit Test								
1	6	20.30	55.20	48.50	6.7	28.2	28	23.76
2	1	20.40	50.30	44.50	5.8	24.1	26	24.07
3	8	23.40	54.00	47.70	6.3	24.3	20	25.93
4	2	23.10	53.60	47.00	6.6	23.9	15	27.62
Plastic Limit Test								
5	5	20.30	43.50	39.70	3.8	19.4	-	19.59



LL =	24.5
PL =	19.6
PI = LL - PL =	4.9

5. California Bearing Ratio

CBR= 108%



6. Report of Los Angeles Abrasion Test for Aggregate Used in
Mixing material NO. 15

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) <u>Abrasion after 500 Rev.</u>	Loss in Weight (gm)	Abrasion Ratio (%)
<u>1</u>	5000	3425	1575	31.5

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Appendix E.XI

Comprehensive Mixing Material with 60% RAP material Test Reports

An Najah National
University



جامعة النجاح الوطنية

التاريخ: 10/10/2022
الرقم : 18

الى : الدكتور خالد الساحلي المحترم
بواسطة : م.علاء غنيمات

الموضوع: نتائج فحص عينة (Mixing Material NO.16)

الموقع : شارع بيتونيا

تحية طيبة وبعد ,,,,,,,,,,

بالاشارة الى الموضوع اعلاه ، وكجزء من رسالة الماجستير بعنوان " جدوى استخدام مخلفات الاسفلت المعاد تدويره كمواد تحت طبقة الأساس في أعمال الطرق في فلسطين " بإشراف الدكتور خالد الساحلي تم إجراء فحوصات مادة (Mixing Material NO.16) بنسبة 55% من مواد القحط والتي تم خلطها وتحضيرها في مختبر جامعة النجاح من قبل الطالب (م.علاء غنيمات) وبمساعدة المهندس سمير حلاوة بتاريخ 2022-09-13 وتم إجراء كافة الفحوصات اللازمة بإشراف مختبر المواصلات في جامعة النجاح الوطنية وكانت النتائج كما يلي :

- **Comprehensive Mixing Material NO.10-Reports: 2022/10/10 (Non compacted)**

Test	Result	Specification	Note
Liquid Limit (L.L)	% 24.05	30 (Max.)	Ok
Plastic Limit (P.L)	% 19.4	--	Ok
Plasticity Index (P.I)	4.7	2-8	Ok
Sand Equivalent	% 35	25 (Min.)	Ok
Percent Passing Sieve No.200	% 3.92	(5-12 Class A Not Compacted) (5-15 Class B Not Compacted)	Not Ok
Los Angeles after a#500	% 31	40 (Max.)	Ok
Optimum Moisture Content	% 5.36	--	Ok
Maximum Dry Density (M.D.D) gm/cm ³	1.976	2.05 (Min.)	Not Ok
California Bearing Ratio (CBR @ 0.1")	85	40 (Min.)	Ok

ملاحظة : مرفق لحضرتكم نتائج الفحوصات والمواصفات الخاصة لفحص مواد (Mixing Material NO.16)

مع التقدير والاحترام

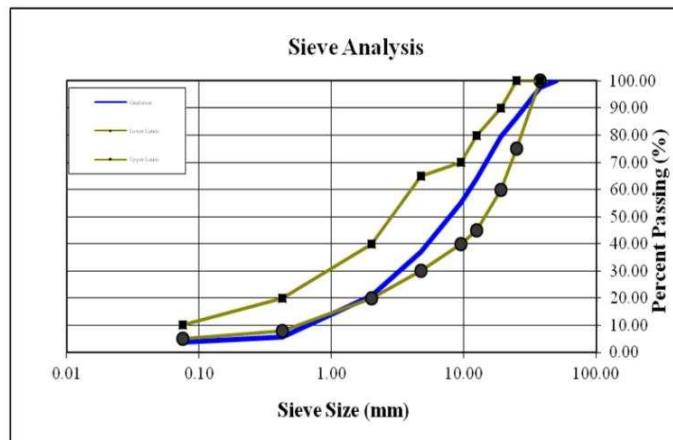
م.علاء غنيمات ، م.سمير حلاوة



Test Result

1.Sieve analysis according to ASTM C 136-06" standard test method for sieve analysis of fine and coarse aggregate".

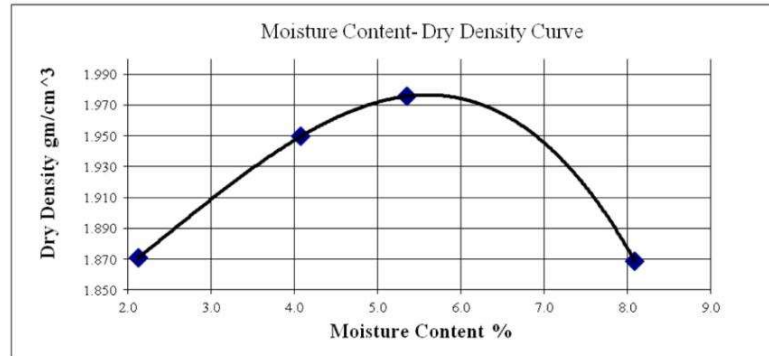
Material Type:		mixture subbase & milling material #16 (60%)						
Total Sample	4180.00	gm						
Reference Standard: (AASHTO - T27-14) - (Approved)								
Sieve Size (mm)	Wt. Retained (g)	% Retained	Cumulative % Retained	% Passing	Specification subbase B	Specification Base course A		
50.00	0.0	0.00	0.00	100.00	80-100	ok	100	ok
37.50	102.0	2.44	2.44	97.56	70-95	ok	70-100	ok
25.00	456.0	10.91	13.35	86.65	60-95	ok	55-85	ok
19.00	300.0	7.18	20.53	79.47		ok	50-80	ok
12.50	642.0	15.36	35.89	64.11	47-80	ok	45-80	ok
9.50	380.0	9.09	44.98	55.02		ok	40-70	ok
4.75	744.0	17.80	62.78	37.22	30-60	ok	30-60	ok
2.00	688.0	16.46	79.23	20.77	22-45	ok	20-50	ok
0.43	624.0	14.93	94.16	5.84	10-30	ok	10-30	ok
0.075	80.0	1.91	96.08	3.92	5-15	ok	5-10	Not ok
Pan	164.0	100.00	100.00	0.00	-		-	



2.Proctor For Mixing No.16



Mixing Material No.16(60%)				
Proctor Mould Volume (Cm ³):	2109	Reference Standard: AASHTO (T180-93)		
No. of Layers : 5	Total Blows : 280	Weight of Hammer : 4.5kg		
Compaction Trial No.	A	B	C	D
Weight of Mould + Wet Soil (W2) gm.	10310	10560	10670	10540
Weight of Mould (W1) gm.	6280	6280	6280	6280
Weight of Wet Soil (W2)-(W1) gm.	4030	4280	4390	4260
Density of Wet Soil gm/cm ³	1.911	2.029	2.082	2.020
Moisture Content Can #	1	2	3	4
Weight of Can + Wet Soil (Ww) gm.	1300	1400.0	686	1300.0
Weight of Can + Dry Soil (Wd) gm.	1275.0	1348.0	656.0	1205.0
Weight of Can (Wc) gm.	126.0	126.0	126.0	126.0
Weight of Moisture (Ww) - (Wd) gm.	25.0	52.0	30.0	95.0
Weight of Dry Soil (Wd) - (Wc) gm.	1149.0	1222.0	530.0	1079.0
Moisture Content %	2.13	4.08	5.36	8.09
Dry Density of Soil gm/cm ³	1.871	1.950	1.976	1.869



Max. Dry Density gm/cm ³	1.976
Optimum Moisture Content %	5.36

3.Sand Equivalent Test: according to ASTM D24 I 9-02

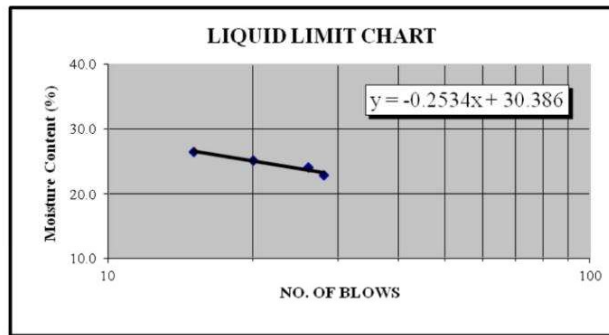
Sample No.	Clay Reading (mm)	Sand Reading (mm)	Sand Equivalent (%)	Average Sand Equivalent (%)	Specification
1	10	3.5	35	35	25.0(Min.)

4.Plasticity index, according to ASTM D 4318-10 "standard test method for liquid limit, plastic limit, and plasticity index of soil"



Report of Atterberg Limits Test sample #16 (60%)

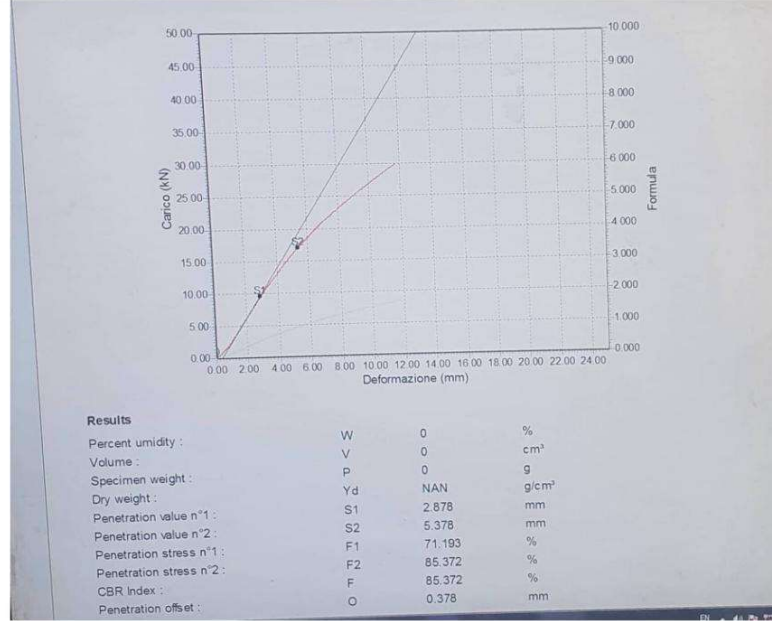
Sample No.	Can No.	Can Weight (gm)	Can Wt. + Wt. Wet (gm)	Can Wt. + Wt. Dry (gm)	Moisture Weight (gm)	Dry Weight (gm)	No. of Blows	Moisture Content %
Liquid Limit Test								
1	1	20.40	55.20	48.70	6.5	28.3	28	22.97
2	2	23.10	50.30	45.00	5.3	21.9	26	24.20
3	3	24.00	54.00	47.95	6.05	24.0	20	25.26
4	2	23.10	53.60	47.20	6.4	24.1	15	26.56
Plastic Limit Test								
5	5A	2.80	33.60	28.60	5	25.8	-	19.38



LL =	24.1
PL =	19.4
PI = LL - PL =	4.7

5. California Bearing Ratio

CBR= 85%



**6. Report of Los Angeles Abrasion Test for Aggregate Used in
Mixing material NO. 15**

Sample No.	Original Oven Dry Wt. (gm)	Wt. Retained on Sieve #12 (gm) <u>Abrasion after 500 Rev.</u>	Loss in Weight (gm)	Abrasion Ratio (%)
<u>1</u>	5000	3450	1550	31

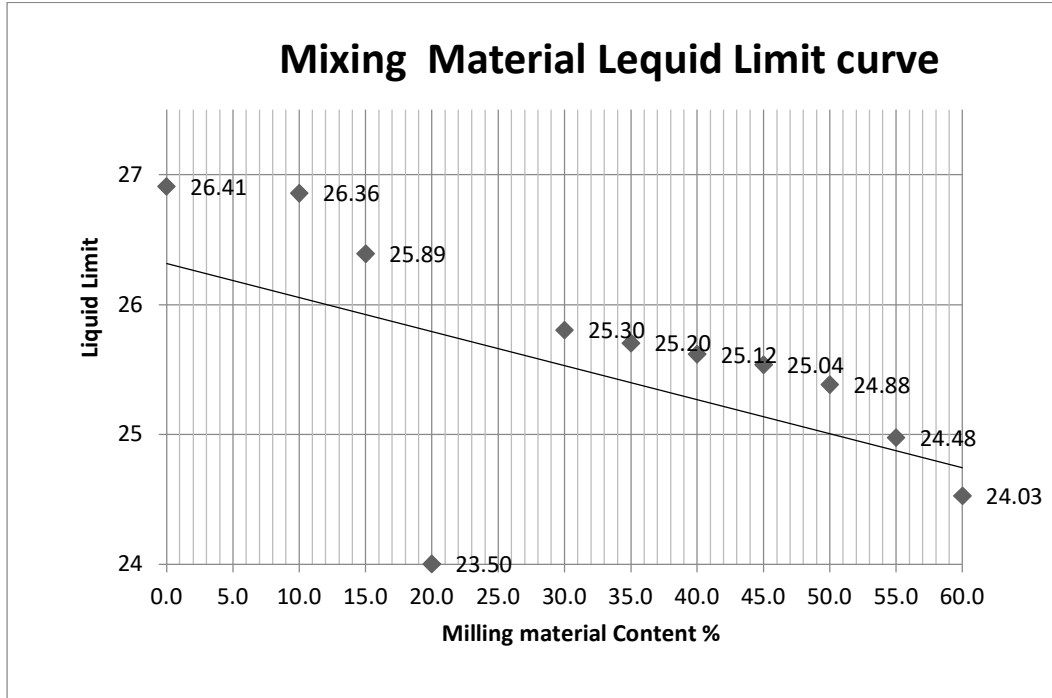
م. علاء غنيمات ، م. سمير حلاوة

Appendix F

Mixing Material test result graph

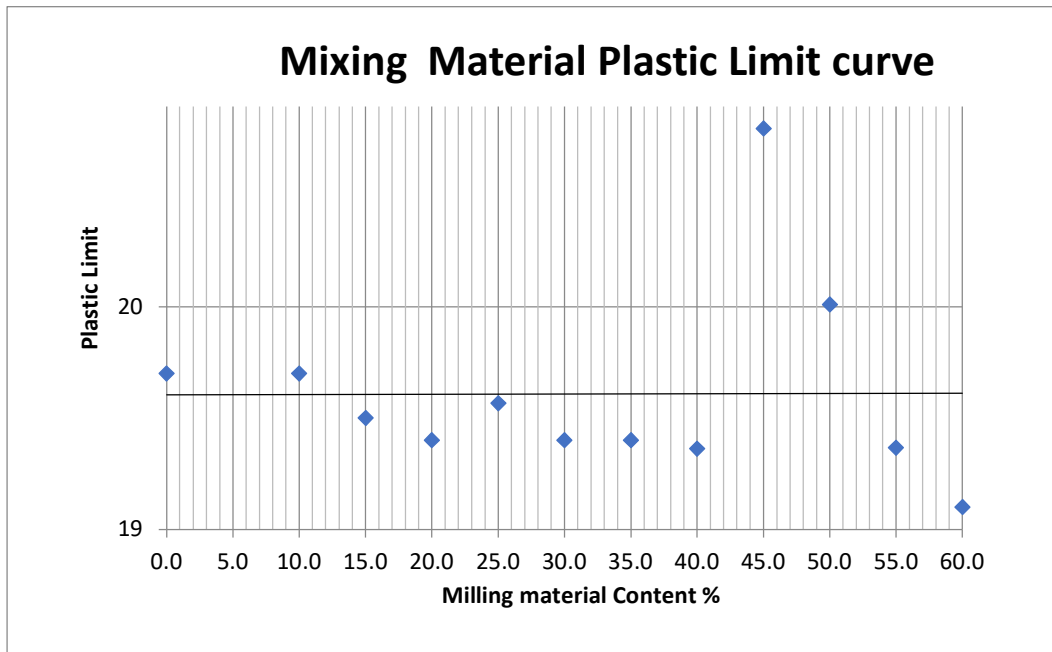
Appendix F.I

Mixing Material liquid limit result



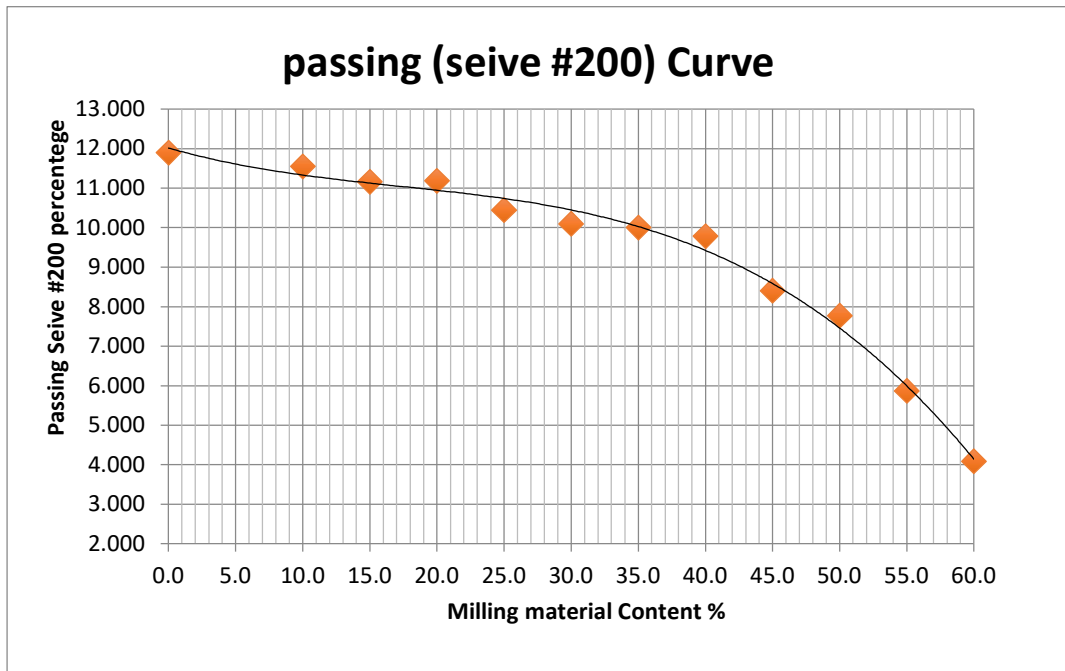
Appendix F.II

Mixing Material plastic limit result



Appendix F.III

Mixing Material passing (sieve No200) result



Appendix G

Milling material produced and subbase and base course produced by institutions at Ramallah and Al-Bireh governorates

Appendix G.I

Milling material and subbase and base course produced by Ministry of Local Government (30)

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



State of Palestine
Ministry of Local Government

دولة فلسطين
وزارة الحكم المحلي

Date: التاريخ: No. الرقم:

Date: 28/6/2022

Dear An-Najah National University

Subject: Projects Implemented by the Ministry of Local Government during (2020-2022)

which contain milling works.

No	Project Title	Governorate	Milling Area (M ²)
1	Paving Internal Roads in Faqqoua	Jenin	850
2	Paving the Connecting Road between Al-Yammon – Berqeen- Kuferdan and West Jenin Villages	Jenin	2000
3	Paving Internal Roads in Yaabad	Jenin	1500
4	Paving Roads in Beita	Nablus	1800
5	Paving Roads in Boureen	Nablus	900
6	Paving Internal Roads in Kufr-Qallil	Nablus	800
7	Paving Internal Roads in Kufr-Jammal	Tulkarm	1050
8	Paving Internal Roads in Iktaba	Tulkarm	1100
9	Rehabilitation of Infrastructure in Qalqilia	Qalqilia	2400
10	Paving Internal Roads in Kufr-Theleth	Qalqilia	1450
11	Paving Internal Roads in Farata	Qalqilia	950
12	Rehabilitation of AL-Faraa – Yaseed Road	Tubas	700
13	Rehabilitation and Paving Internal Roads in Tubas	Tubas	1100
14	Paving Internal Roads in Dier Ballout	Salffet	960
15	Rehabilitation and Paving Internal Roads in Yassouf	Salffet	1050
16	Rehabilitation and Paving Internal Roads in Jericho	Jericho	2200
17	Paving An-Najma Road in Atara	Rammallah	800
18	Rehabilitation and Paving Internal Roads in Shibteen	Rammallah	1200

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

State of Palestine
Ministry of Local Government



دولة فلسطين
وزارة الحكم المحلي

Date: التاريخ:

No. الرقم:

19	Paving Internal Roads in Silwad	Rammallah	1500
20	Paving Omar Khattab Road in Doha	Bethlehem	1200
21	Paving the Main Road in Beit Fajjar	Bethlehem	2000
22	Paving Al-Khaldia – Yetta Road	Hebron	1800
23	Paving Internal Roads in Surra	Hebron	1800
24	Paving Al-Qbibeh Road in Hebron	Hebron	2500
25	Paving Internal Al-Shawamrah	Hebron	1620
26	Total Area (M ²)		35230

Department of Supervision

Eng. Mahmoud Al-Wanneh

فلسطين، البيرة، البالوع، ص.ب: 731 رام الله - Palestine, Al-Bireh, P.O.Box: 731 Ramallah
Tel.: +970 2 240 1092, Fax: +970 2 240 1091 - Gaza: Tel.: 08 282 0273, Fax: 08 286 7509
www.molg.pna.ps - molg.pal - @molgpalestine - Email: media@molg.pna.ps



Date: 16/1/2023 التاريخ:

No. الرقم:

Dear An-Najah National University

Subject: Projects Implemented by the Ministry of Local Government during (2020-2022) that contain Subbase & Basecourse works.

No	WORKS	Quantities (m ²)
1	BASECOARSE	2365000
2	SUBBASE	735000

Department of Supervision

Eng. Ali Ghneimat

Appendix G.II

Base Course Tests at Jericho and the Jordan Valley ___Governorate (32)

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

Palestine State



دولة فلسطين

Ministry of Public Works & Housing

وزارة الأشغال العامة والإسكان

Date: 18/01/2023

Dear An-Najah National University,,

Subject: Base Course Tests at Jericho and the Jordan Valley Governorate

After conducting many tests of the Base Course materials in the projects, it was found that governorate of Jericho and the Jordan Valley suffers from a decrease in the value of the sand equivalent of the base course materials.

Head Of Road Supervision Departement

Tamer Saadeh



Appendix G.III

Quantity of Milling material produced by Ministry Of Public Work And Housing

(3)

STATE OF PALESTINE
Ministry Of Public Works and Housing



دولة فلسطين
وزارة الأشغال العامة والإسكان



Date : 23/01/2022



Dear An-Najah National University,,,

Subject: Projects Implemented by the Ministry of Public Works and Housing during (2018-2021) witch contain milling work

No	Project Title	Governorate	Milling Area (m ²)
1	Rehabilitation of Sabastia Entrance	Nablus	11,520
2	Rehabilitation of Anabta-Tulkarm Street	Tulkarem	50,826
3	Reconstruction of Al-Seka – Ktaba Main Road	Tulkarem	25,430
4	Rehabilitation of Al-Seka - Ktaba Road	Tulkarem	13,579
5	Rehabilitation of Jenin – Hiafa Main Road	Jenin	42,595
6	Rehabilitation of Beitunai Ein-Erek Deir Ibzi Main Road	Ramallah	55,000
7	Rehabilitation of Ein-Yabroad – Dora Alqara Main Road	Ramallah	21,672
8	Rehabilitation of Ezaria – Abu Dees Main Road	Jerusalem	80,242
9	Rehabilitation of Qalndia Main Street	Jerusalem	56,311
10	Rehabilitation of Hebron Tarqomia Road (Wad Alqof)	Hebron	35,575
11	Rehabilitation of Beit Awa Deir Samet Main Road	Hebron	12,000
12	Rehabilitation of Bethlehem – Jerusalem Main Road 1 st stage	Bethlehem	65,300
13	Rehabilitation of Bethlehem – Jerusalem Main Road 2 st stage	Bethlehem	7,553
Total Area (m ²)			477,603

Head Of Road Supervision Departement

Tamer Saadeh

Ramallah-almasyoun-M.darwish Rotary-Ministries Compound
P.O.Box : Al Bireh (3961)
Ramallah_Tel : 2966006/7 Fax : 2987890
Gaza - Southern Rimal-Arab League St

رام الله - العيصون - دوار محمود درويش - مجمع الوزارات
صندوق بريد: البيرة (3961)
رام الله تليفون: 2966006/7 - فاكس: 2987890
غزة - الرمال الجنوبي - شارع جامعة الدول العربية

Appendix G.IV

Quantity of subbase and base course produced by Ministry Of Public Work And Housing (33)

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

Palestine State



دولة فلسطين

Ministry of Public Works & Housing

وزارة الأشغال العامة والإسكان

Date: 18/01/2023

Dear An-Najah National University,,

Subject: project implementation by MPWH (2020-2022) with contain base course and subbase material

No	Project Title	Governorate	Subbase Area	Base Course
1	Rehabilitation of Sabastia Entrance	Nablus	_____	25,000
2	Rehabilitation of Anabta-Tulkarm Street	Tulkarem	_____	8,000
3	Reconstruction of Al-Seka – Ktaba Main Road	Tulkarem	3,000	22,000
4	Rehabilitation of Jenin – Hiafa Main Road	Jenin	_____	12,00
5	Rehabilitation of Beitunai Ein-Erek Deir Ibzi Main Road	Ramallah	8,000	58,000
6	Rehabilitation of Ein-Yabroad – Dora Alqara Main Road	Ramallah	_____	7,800
7	Rehabilitation of Ezaria – Abu Dees Main Road	Jerusalem	_____	2500
8	Rehabilitation of Qalndia Main Street	Jerusalem	_____	500
9	Rehabilitation of Hebron Tarqomia Road (Wad Alqof)	Hebron	_____	1,500
10	Rehabilitation of Beit Awa Deir Samet Main Road	Hebron	12,000	85,000
11	Rehabilitation of Bethlehem – Jerusalem Main Road 1st stage	Bethlehem	_____	7,500
12	Rehabilitation of Bethlehem – Jerusalem Main Road 2st stage	Bethlehem	_____	1,100
Total Area (m ²)			23,000	218,900

Head Of Road Supervision Departement

Tamer Saadeh



Appendix G.VI

prices of milling material by Ministry Of Public Work And Housing (35)

State Of Palestine
Ministry of Public Works & Housing



دولة فلسطين
وزارة الأشغال العامة والإسكان

التاريخ: 2023/01/03

إلى /م. علاء غنيمات

الموضوع : تحليل تكلفة المتر المربع لأعمال قشط الاسفلت في رام الله والبيرة

بالإشارة الى الموضوع اعلاه ، نعلمكم ان معدل سعر المتر المربع لأعمال قشط الاسفلت في محافظة رام الله والبيرة هو (4.5) شيقل بحيث يشمل السعر قشط الاسفلت ميكانيكا بتكلفة 2 شيقل للمتر المربع وترحيل الطمم الى المكبات بتكلفة 2.5 شيقل /م2 .

مع فائق الاحترام والتقدير

م. عماد أبو بكر
مدير دائرة التكاليف والتقدير

Appendix G.VII

Quantity of subbase and base course produced by Municipal Development and Lending Fund (36)

179 من 14

FW: Delivery Status Notification (Failure)

الأحد، 15 يناير، 9:56 من (قبل 6 أيام)

<kdarawshi@mdlf.org.ps> Khalid G.G. Darawshi

<From: Anas H.K. Abdel Aziz <aabelaziz@mdlf.org.ps>
Sent: Sunday, January 15, 2023 9:47 AM
<To: Khalid G.G. Darawshi <kdarawshi@mdlf.org.ps>
Subject: FW: Delivery Status Notification (Failure)>

تحية طيبة وبعد :
بلغت كميات الفشط والبسكوس والسببيز خلال الثلاث سنوات الاخيرة في محافظة رام الله والبيرة كما يلي :
كمية الفشط : 210,000 متر مربع
كمية السببيز : 33,000 متر مربع
كمية البسكوس : 651,000 متر

تقبلو فائق الاحترام والتقدير

اسم الشارع/المشروع	كمية القحط والاسفلت	طول الشارع
مشاريع عام 2019		
شارع ابو علاء المعري	2350 م ²	315 م.ط
شارع ابراهيم طوقان	1095 م ²	240 م.ط
شارع يحيى حمودة	766 م ²	90 م.ط
شارع عصام عبدالهادي	2107 م ²	285 م.ط
شارع مدريد	2470 م ²	273 م.ط
شارع دمشق	3080 م ²	350 م.ط
شارع الكرك	7060 م ²	650 م.ط
شارع عكا	1670 م ²	210 م.ط
شارع صيدا	2860 م ²	355 م.ط
شارع هائل عبدالحميد	3000 م ²	385 م.ط
شارع سلامة موسى	1315	180 م.ط
مشاريع عام 2020		
شارع سعد بن ابي وقاص	1780 م ²	320 م.ط
شارع جاك شيراك	9280 م ²	950 م.ط
شارع عين الجوز	2580 م ²	230 م.ط
شارع ابراهيم عقل	6030 م ²	470 م.ط
شارع الكرمل	12217 م ²	1130 م.ط
شارع الاثوريين	5500	425 م.ط
مشاريع عام 2021		
شارع الفالوجة	6140 م ²	445 م.ط
شارع البرية	1950 م ²	265 م.ط
شارع الطيرة	1080 م ²	130 م.ط
شارع حنا غانم	2680 م ²	320 م.ط
شارع الكلية الاهلية	4710 م ²	530 م.ط
الشارع الرئيسي	2790 م ²	300 م.ط
نوار المنارة	1700 م ²	-
ميدان ياسر عرفات ومحيطه	3170 م ²	-
شارع جورج الصاع	630 م ²	80 م.ط
شارع يوحنا المعمدان	750 م ²	100 م.ط

دولة فلسطين



Appendix G.IX

Quantity of milling and subbase and base course material produced by Al-Bireh Municipality (38)

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

State of Palestine
Al-Bireh Municipality
Tel: 02-2404737/8/9 - 2406445
Fax: 02-2404431 / P.O.Box:3506



دولة فلسطين
بلدية البيرة

تلفون: ٠٢-٢٤٠٦٤٤٥ - ٢٤٠٤٧٣٧/٨/٩/
فاكس: ٣٥٠٦ / ٠٢-٢٤٠٤٤٣١

Date : التاريخ :

Our Ref : إشارتنا :

رقم الصادر : ١٤٣١٩

٢٠٢٢/٠٧/٠٢

السيد (علاء حجازي سليمان نعيم) المحترم
تحية طيبة وبعد،

الموضوع :- (معلومات عن قشط الشوارع في المدينة)

تهديكم ادارة بلدية البيرة اطيب التحيات وبالاشارة الى الموضوع اعلاه فان مشروع شق وإعادة تأهيل وتعبيد طرق داخلية ٢٠٢٠ = ٤٧,٣٠٠ متر مربع ونفذ خلال عامي ٢٠٢٠ / ٢٠٢١ ومشروع شق وإعادة تأهيل وتعبيد طرق داخلية ٢٠١٩ = ٤٠,٥٦٨ متر مربع خلال عامي ٢٠١٩ / ٢٠٢٠ ومشروع المبنى التربوي بمساحة ٢١١٠٠ تقريبا خلال العام ٢٠٢١

واقبلوا فائق الاحترام
رائد محمد الطويل
مدير خدمات الجمهور

www.Al-bireh.ps

info@al-bireh.ps

[AlBirehMunicipality](https://www.facebook.com/AlBirehMunicipality)

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

State of Palestine
Al-Bireh Municipality

Tel: 02-2404737/8/9 - 2406445
Fax: 02-2404431 / P.O.Box:3506



دولة فلسطين
بلدية البيرة

تلفون: ٠٢-٢٤٠٦٤٤٥ - ٢٤٠٤٧٣٧/٨/٩/
فاكس: ٢٥٠٦ / ٠٢-٢٤٠٤٤٣١

Date: التاريخ

Our Ref: إشارتنا:

رقم الصادر: ١٤٣١٩

٢٠٢٢/٠٧/٠٢

السيد(علاء مجازي سليمان نعيم) المحترم
تحية طيبة وبعد،

الموضوع : معلومات عن كميات البيسكورس والسببيز خلال الثلاثة اعوام الاخيرة

تهديكم بلدية البيرة اطيب التحيات وبالإشارة الى الموضوع اعلاه فأنا كميات
البيسكورس والسببيز خلال الثلاثة اعوام الاخيرة كما يلي :

كمية البيسكورس : 32,000 متر مربع

كمية السببيز : 3000 متر مربع

واقبلوا فائق الاحترام



Appendix G.X

Quantity of subbase and base course produced by Beitunia Municipality (39)



دولة فلسطين
State of Palestine



No. :
Date :

الرقم :
التاريخ: 2022/8/4

حضرة الاخ المهندس علاء غنيمات المحترم

تحية طيبة وبعد،

كميات الاسفلت المقشوط

بالإشارة إلى الموضوع أعلاه ولاحقا لكتابكم بخصوص كميات الاسفلت المقشوط خلال الاعوام
2018-2022 فهي كالتالي:

في عام 2018 كانت كمية القشط 2000 متر مربع تقريبا

في عام 2019 كانت كمية القشط 2000 متر مربع تقريبا

في عام 2020 كانت كمية القشط 5000 متر مربع تقريبا

في عام 2021 كانت كمية القشط 3000 متر مربع تقريبا

في عام 2022 كانت كمية القشط 0 صفر

تحياتي لكم

عطاف الديك

رئيس قسم المشاريع

T:- 02-2900754 , 02-2900533 Fax:- 02-2900534

هاتف:- 2900754 2900533 ، فاكس :- 2900534

E-mail :- Administration@beitunia.ps

E-mail :- Secretary@beitunia.ps

No. :
Date :

الرقم :
التاريخ: 2023/1/16

لمن يهمه الأمر

تحية طيبة وبعد،

الموضوع: كميات البيس كورس في السنوات الاخيرة

بالإشارة الى الموضوع أعلاه وبناء على طلب الطالب المهندس علاء غنيمات بخصوص كميات البيس كورس في مدينة بيتونيا خلال السنوات الثلاث الاخيرة وهي كمايلي:

السنة	كمية البيس كورس
سنة 2020	25,000
سنة 2021	25,000
سنة 2022	25,000

اما بخصوص ال sub base لم تنفذ البلدية طبقات sub base خلال الاعوام الخمسة الاخيرة.

م. عطفان التبرك
رئيس قسم المشاريع

T:- 02-2900754, 02-2900533 Fax:- 02-2900534

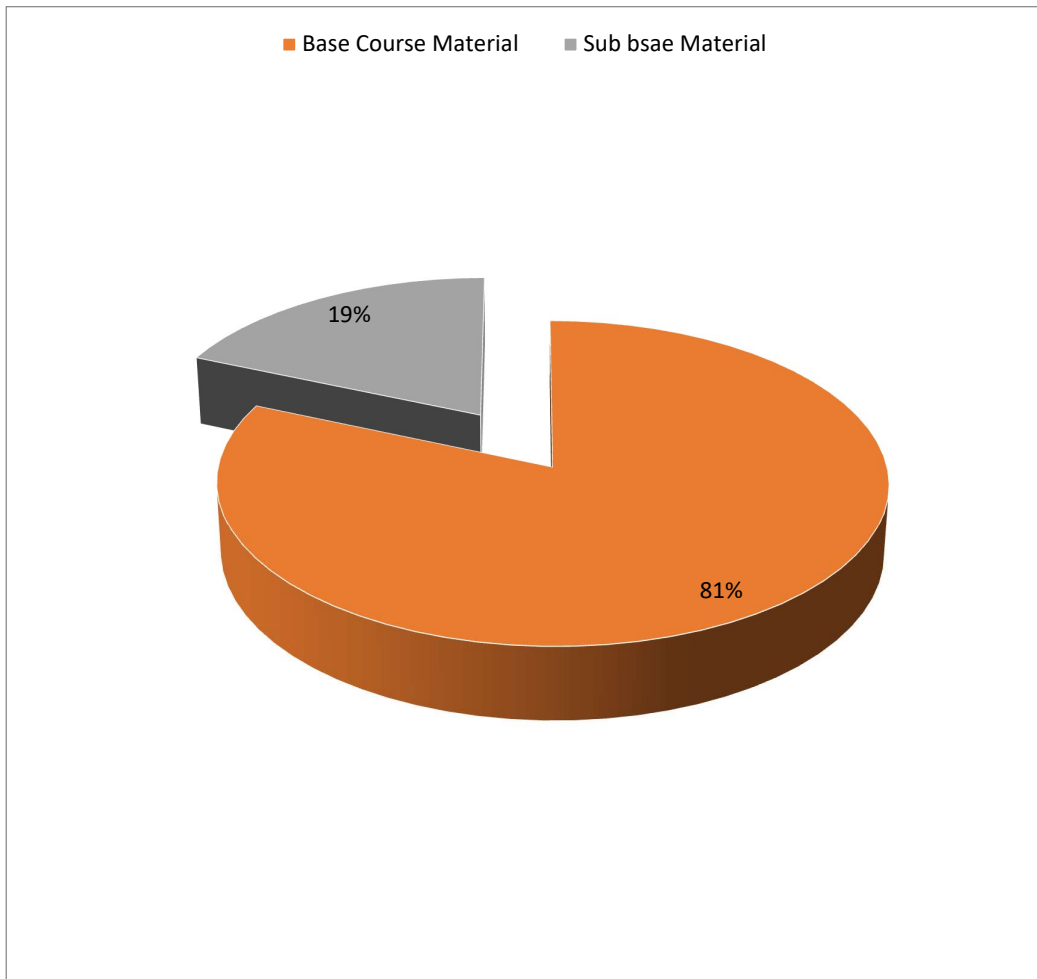
هاتف:- 2900754 2900533 ، فاكس :- 2900534

E-mail :- Administration@beitunia.ps

الرمز البريدي: P6300264 E-mail :- Secretary@beitunia.ps

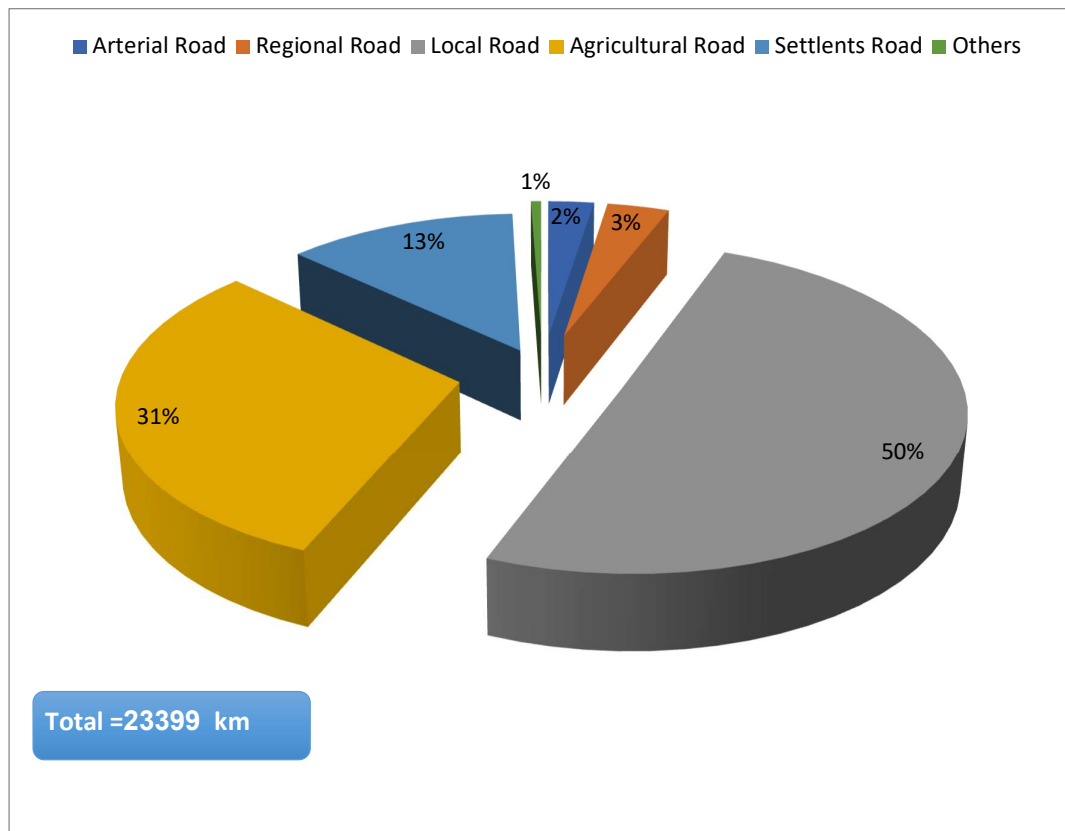
Appendix H

subbase and base course produced by All Institution



Appendix I

Percentage of the road network in the West Bank by type of road (40)



Appendix J

Comprehensive base course tests in Ramallah Governorate made by Geotechnical Material Testing Center (GMT) (41)



التاريخ:- 15/1/2023

الرقم:- GMT-23-384

السادة / جامعة النجاح الوطنية المحترمين

تحية طيبة وبعد

الموضوع : رسالة الماجستير للمهندس علاء حجازي غنيمات

بناءً على الكتاب المرسل من قبلكم بخصوص رسالة الماجستير للمهندس علاء حجازي غنيمات والتي هي بعنوان " جدوى استخدام مخلفات الاسفلت المعاد تدويره كمواد لطبقة ما تحت الاساس في اعمال الطرق في فلسطين " فإته ومن خلال دراستنا للعينات المفحوصة من قبلنا في منطقة رم الله فقط والذي يبلغ عددها 33 عينة، فإن نتيجة 18 عينة حققت متطلبات وزارة الاشغال الفلسطينية ومتطلبات وزارة الحكم المحلي، وهنالك 15 عينة لم تحقق متطلبات المواصفات خاصة فحص حدود اتريبيرغ وفحص المكافء الرملي وفحص التدرج الحبيبي خاصة منخل رقم 200#.

مع الاحترام والتقدير

م. عبد الرحمن الخطيب

مدير المختبر


15/1/2023



Appendix K

Comprehensive base course tests in Ramallah Governorate made by Emar Center for Engineering studies (42)

مركز اعمار للدراسات الهندسية
Emar Center for Engineering Studies (ECES)



التاريخ: 24/1/2023

السادة: جامعة النجاح الوطنية

الموضوع:- عينات طبقة التأسيس للطرق (Base Course)

تحية وبعد،

بالإشارة إلى الموضوع أعلاه، نود أن نوضح ما يلي:

لقد تم فحص ما يقارب مائتان وخمسون عينة BASE COURSE خلال السنوات الثلاث السابقة وكانت ما نسبته 78% من العينات مطابقة للمواصفات الفنية وما تبقى 22% من العينات لم يكن مطابقا للمواصفات وأهم الفحوصات التي لم تتطابق مع المواصفة هي

- 1- التدرج الحبيبي
- 2- المكافئ الرملي
- 3- فحص حد السيولة والانكماش

ويعزى سبب هذه النتائج والنسبة الكبيرة في عدم تحقيق المطابقة للمواصفات هو استخدام الكسارات المتنقلة بشكل كبير.

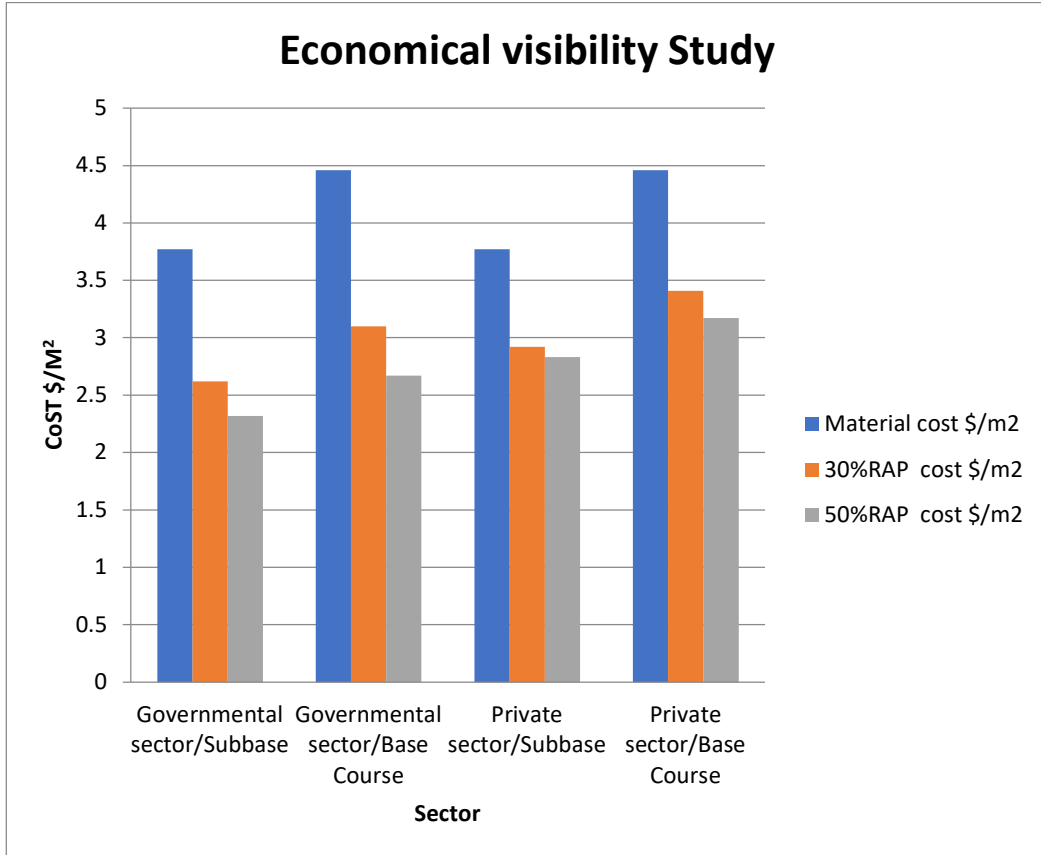
مع الاحترام والتقدير،،،

Emar Center
for
Engineering Studies
مركز اعمار للدراسات
الهندسية
م. خالد شبنوي
E.C.E.S.

فلسطين / البيرة - قرب جوال- تلفاكس 0562-150170 (972) (2) 2420128 + جوال 0562-150170
Palestine / AlBireh – Beside Jawwal Telefax + (972) (2) 2420128, Jawwal 0562-150170

Appendix L

Economical visibility Study for subbase and base course for governmental and private sector



Appendix M

Sand Equivalent, CBR, Proctor, and Passing Sieve NO#200 result for mixing material

Mixing Material Sand equivalent curve																		
sample #		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
milling material	%	0.00	10.00	12.50	15.00	20.00	22.50	25.00	27.50	30.00	32.50	35.00	37.50	40.00	45.00	50.00	55.00	60.00
Sand equivalent 1	%	25.20	27.40	27.90	28.50	28.70	28.75	28.90	29.40	30.20	30.56	30.60	30.62	30.65	30.70	30.60	33.00	35.00
Sand equivalent 2	%	25.4	27.35		28.56	28.72		28.95		30.25		30.62		30.7	30.73	30.55	33.5	35.05
Sand equivalent 3	%	24.99	27.45		28.45	28.7		28.86		30.16		30.56		30.68	30.71	30.63	33.1	34.96
Sand equivalent avg	%	25.20	27.40	27.90	28.50	28.71	28.75	28.90	29.40	30.20	30.56	30.59	30.62	30.68	30.71	30.59	33.20	35.00

Mixing Material CBR curve																		
sample #		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
milling material		0.0	10.0	12.5	15.0	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5	40.0	45.0	50.0	55.0	60.0
Calefornaia Bearing Ratio % TEST 1		74	108	115	127	165	171	167	153	151	172	163	162	162	145	112	108	86
Calefornaia Bearing Ratio % Test 2		82	104		120	160		158		155		160		160	140	120	112	75
Calefornaia Bearing Ratio % TEST 3		85	110		124	158		155		151		161		155	148	128	107	82
AVG Calefornaia Bearing Ratio %		80	107	115	124	161	171	160	153	152	172	161	162	159	144	120	109	81

Mixing Material proctor curve																	
sample #		0	1	2	3	4	5	6	8	9	10	11	12	13	14	15	16
milling material	%	0.00	10.00	12.50	15.00	20.00	22.50	25.00	30.00	32.50	35.00	37.50	40.00	45.00	50.00	55.00	60.00
Dry Density of Soil 1	gm/cm ³	2.050	2.082	2.075	2.089	2.107	2.079	2.077	2.076	2.053	2.081	2.069	2.061	2.058	2.056	1.992	1.976
Dry Density of Soil 2	gm/cm ⁴	2.054	2.075		2.08	2.085		2.065	2.063		2.085		2.063	2.056	2.053	1.982	1.971
Dry Density of Soil 3	gm/cm ⁵	2.049	2.079		2.083	2.091		2.072	2.065		2.083		2.058	2.054	2.051	1.995	1.982
Dry Density of Soil AVG	gm/cm ⁶	2.051	2.079	2.075	2.084	2.094	2.079	2.071	2.068	2.053	2.083	2.069	2.061	2.056	2.053	1.990	1.976

Mixing Material Passing Sieve No#200 Results												
Sample No	0	1	3	4	6	8	10	12	13	14	15	16
Milling Material %	0	10	15	20	25	30	35	40	45	50	55	60
Test 1 (%)	13.4	11.5	11.2	11.1	10.5	10.1	10	9.9	8.5	7.8	5.9	3.9
Test 2 (%)	13.2	11.6	11.3	11.3	10.6	10	10.1	9.7	8.2	7.9	5.8	4.4
Test 3 (%)	13.4	11.5	11.1	11.2	10.3	10.1	9.9	9.8	8.5	7.6	5.9	3.9
Average	13.3	11.5	11.2	11.2	10.5	10.1	10	9.7	8.4	7.7	5.9	4.1

Appendix N

Plastic Limit, Liquid Limit, and Plasticity Index result for mixing material

<i>Mixing Material Plastic Limit Results</i>												
Sample No	0	1	3	4	6	8	10	12	13	14	15	16
Milling Material %	0	10	15	20	25	30	35	40	45	50	55	60
PL Test 1	20	20	19.8	19.7	19.9	19.7	19.7	19.7	21.1	20.4	19.6	19.4
PL Test 2	20.3	20.2	19.7	19.8	19.7	19.8	19.6	19.8	21	20.2	19.7	19.5
PL Test 3	19.7	19.8	19.9	19.6	20	19.6	19.8	19.5	21.2	20.3	19.7	19.3
PL Average	20	20	19.8	19.7	19.9	19.7	19.7	19.7	21.1	20.3	19.7	19.4

<i>Mixing Material Liquid Limit Results</i>												
Sample No	0	1	3	4	6	8	10	12	13	14	15	16
Milling Material %	0	10	15	20	25	30	35	40	45	50	55	60
LL Test 1	26.4	26	25.9	25.5	25.5	25.3	25.2	25.1	25	24.9	24.5	24.1
LL Test 2	26.4	26.3	25.9	22.5	22.5	25.3	25.2	25.1	25	24.9	24.5	24
LL Test 3	26.4	26.4	25.9	22.5	22.5	25.3	25.2	25.1	25.1	24.9	24.5	24
LL Average	26.4	26.4	25.9	23.5	23.5	25.3	25.2	25.1	25	25	24.5	24

<i>Mixing Material Plasticity Index Results</i>												
Sample No	0	1	3	4	6	8	10	12	13	14	15	16
Milling Material %	0	10	15	20	25	30	35	40	45	50	55	60
PI Test 1	6.4	6.0	6.1	5.8	5.6	5.6	5.5	5.4	3.9	4.5	4.9	4.7
PI Test 2	6.1	6.1	6.2	2.7	2.8	5.5	5.6	5.3	4.0	4.7	4.8	4.5
PI Test 3	6.7	6.6	6.0	2.9	2.5	5.7	5.4	5.6	3.9	4.6	4.8	4.7
PI Average	6.4	6.2	6.1	3.8	3.6	5.6	5.5	5.4	3.9	4.6	4.8	4.7



جامعة النجاح الوطنية
كلية الدراسات العليا

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الأساس في أعمال الطرق في فلسطين

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إشراف

د. خالد الساحلي

قدمت هذه الرسالة استكمالاً لمتطلبات الحصول علي درجة الماجستير في هندسة الطرق والمواصلات ، من كلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس -فلسطين.

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الملخص

خلفية: أجريت العديد من الدراسات في مجال إعادة استخدام مخلفات الأسفلت حول العالم في مواد التأسيس؛ مع ندرة الدراسات بهذه الخصوص في الدول النامية على الرغم من محدودية الموارد في هذه الدول وارتفاع أسعار المواد الطبيعية وتكاليف النقل. بحثت الدراسات السابقة كيفية الوصول إلى النسبة المثوية المثلى لمخلفات الأسفلت ضمن خليط مع المواد الطبيعية، وكان هناك اختلاف واضح في التوصيات الخاصة في الدراسات المختلفة، مما يؤكد الحاجة إلى إجراء العديد من الأبحاث في هذا المجال.

المشكلة والهدف: يتأثر قطاع البناء حالياً بشكل كبير بنقص الموارد الطبيعية، هذه قضية رئيسية لأن الحاجة إلى الركام ستزداد مع تطور الرصفات وتطور متطلبات الركام للرصفات.

من أجل إنتاج مواد أفضل تتوافق مع متطلبات مواد التأسيس، تهدف الدراسة إلى معرفة إمكانية استخدام مخلفات الأسفلت كمواد تأسيس ضمن خليط مع المواد الطبيعية بنسب محددة.

المنهجية: تضمنت منهجية البحث جمع ثلاث عينات من مخلفات الأسفلت من ثلاثة شوارع ليصبح العدد الإجمالي لمواد القشط 9 عينات موزعة في محافظة رام الله والبيرة. ثم تم عمل خليط من مخلفات الأسفلت والمواد الطبيعية بنسب محددة، بحيث تم اختيار عينة ممثلة لمواد مخلفات الأسفلت وعينة ممثلة لمواد (Subbase) ذات المواصفات المتوسطة بين مختلف العينات، ثم تم عمل الخليط بنسب متفاوتة (10-60%) وبلغ عدد العينات 12 عينة، وأعيد فحص كل عينة ثلاث مرات.

أوضحت نتائج الدراسة امكانية استخدام مواد (RAP) مع المواد الطبيعية لتحسين مواد التأسيس خصوصا للمواد ذات الجودة الأقل، بحيث انه من الممكن الحصول على خليط بمواصفات أعلى. لوحظ ضعف مواد التأسيس في محافظة رام الله والبيرة بشكل عام خصوصا في المكافئ الرملي ونسبة المواد الناعمة وحدود اتيربيرج. يمكن معالجة هذا الضعف بخلط هذه المواد مع RAP بنسب (30-50%) والحصول على خليط بخصائص ممتازة.

النتائج: اوضحت نتائج الدراسة أن استخدام مواد مخلفات الاسفلت مع المواد الطبيعية تعمل على تحسين نوعية مواد (Subbase) خصوصا تلك المواد التي لا تحقق المواصفات المطلوبة، في هذه الحالة من الممكن الحصول على مواد (بيسكورس) بمواصفات أفضل حيث لوحظ في محافظة رام الله والبيرة وجود ضعف في مواد (البيسكورس) بشكل عام، من الممكن معالجة هذه الضعف وتحسين هذه المواد من خلال خلطها بمواد مخلفات الإسفلت بنسب (20-50%) والحصول على خليط بمواصفات ممتازة بالإضافة الى تخفيض التكلفة بنسبة تتجاوز الثلث خصوصا للقطاع الحكومي ، تم الحصول على نسبة (32.5%) وهي نسبة الخلط المثلى وفقاً لاختبارات نسبة تحمل كاليفورنيا وفحص الدمك (proctor test) والمكافئ الرملي .

الخاتمة: توصي الدراسة بشدة باستخدام المواد الناتجة عن مخلفات الأسفلت مع الركام الطبيعي لتحسين مواصفات مواد التأسيس خاصة تلك المواد ذات المواصفات الأقل.

الكلمات المفتاحية: مخلفات الأسفلت، مواد التأسيس، خليط، فلسطين.