KWAME NKRUMAH UNIVERSIY OF SCIENCE AND TECHNOLOGY, KUMASI, GHANA

INVESTIGATION INTO EARLY DETERIORATION OF SURFACE DRESSINGS IN GHANA

By

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DECLARATION

I hereby declare that this submission is my own work towards the MSc and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

The success of bituminous surface dressing depends primarily on the adhesion of the chippings to the road surface. Premature failure of surface dressing in the country has become prevalent to the extent that some constructions begin to deteriorate soon after being in service. The overall aim of this research was to identify the possible causes of early deterioration of surface dressings in Ghana. The methods adopted for the study were: (i) examination of the existing local specifications for bituminous surface dressing, (ii) data collection through the use of a wellstructured questionnaire to assemble empirical knowledge on surface dressing practices in Ghana, and (iii) visit to surface dressing construction site to assess construction practices. The study revealed that designers of the seal do not take into consideration the road surface temperature when specifying the binder viscosity. Also, not all the recommended tests are performed on the chippings by some of the contractors to ascertain aggregate conformity to the specifications. The study also established that rolling requirements were often ignored during construction and where rolling was carried out, sometimes the equipment used did not conform to specification. Because most of the contractors were not using electronic bitumen distributors and chipping spreaders, the possibility of inaccurate binder and aggregate application exist.

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LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ADT	Average Daily Traffic
ALD	Average Least Dimension
ASTM	American Society for Testing and Materials
DFR	Department of Feeder Roads
DUR	Department of Urban Roads

GHA	Ghana Highway Authority
HGV	Heavy Goods Vehicle
MRH	Ministry of Roads and Highways
MRT	Ministry of Roads and Transportation
PSV	Polished Stone Value
RSTA	Road Surface Treatment Association
TRL	Transport Research Laboratory

CHAPTER 1: INTRODUCTION

1.1 Project Background

Bituminous surface dressing is a simple, effective and inexpensive road surface treatment for preserving the integrity of a road if adequate care is taken in its design and construction. Surface dressing is used in Ghana for both light-trafficked and medium-trafficked roads, and also as a maintenance intervention for trunk and urban roads. Bituminous surface dressing offers several advantages. If properly constructed, it provides an impervious, durable and safe road surface which allows road agencies to maintain a quality road network with a limited budget. As a maintenance technique, it allows the service life of a structurally sound road pavement to be extended if the process is undertaken at the right time using appropriate procedure. Under certain circumstances, surface dressing may also retard the rate of failure of a structurally inadequate road pavement by preventing the ingress of water and thus preserving the inherent strength of the pavement layers and the subgrade (TRL, 2000).

Of the approximately 68,053km of roads in Ghana as of 2010, about 12,332km or 18.12% were surfaced dressed (MRH, 2012). Construction and maintenance work on the road network in the country is generally undertaken by contracts managed by the road agencies, namely, the Ghana Highway Authority (GHA), the Department of Urban Roads (DUR), and the Department of Feeder Roads (DFR).

As surface dressing is very thin, it requires regular maintenance to quickly repair defects. Pavements with surface dressing are normally treated by resealing on a regular basis, usually every 6-10 years as part of a periodic maintenance program (MRT, 2005). Generally, however, some of

the surface dressed roads in Ghana deteriorate earlier than expected making their investment cost ineffective.

1.2 Problem Definition

The success of bituminous surface dressing depends primarily on the adhesion of the chippings to the road surface. Factors such as inappropriate specifications, poor construction materials, and poor workmanship, can drastically reduce the service life of a bituminous surface dressed road. Critical monitoring of most surface dressed roads in Ghana reveals that there is early deterioration of such roads before the end of their design lives, and this must be investigated to establish the causes.

Factors that contribute to the failure of surface dressings are many and varied. These include poor pavement preparation, incorrect cutting back of the binder, wrong size of chipping used, incorrect binder application, delays in covering the binder, over or under spreading of chippings and wrong binder viscosity specified for the ambient temperature. Also, contractors usually abandon many surface dressing projects after the application of the primerseal without the sealing itself (either single or double). This causes the roads to deteriorate within the first few months, thus, having negative impact or effect on transportation and economy. Some of these negative impacts are reduction in ride quality of the road, increase in road user cost, unpleasant environment for those using and living adjacent to the road, and increase in road administration cost. But which of the many factors contribute the major causes of the premature failures of surface dressed roads in Ghana have not yet been documented.

At the moment, the causes of the premature failures are speculative lacking any empirical evidence. Unless the causes of the premature failures are well documented, it would be difficult to design intervention measures to right the problem. This study, therefore, sought to establish the factors which contribute to early deterioration of surface dressings in Ghana

1.3 Research Objective

The overall objective of this research was to investigate the possible causes of early deterioration of surface dressings in Ghana. The specific objectives of the investigation were:

- Examination of the existing local specifications for bituminous surface dressings;
- Evaluation of the conformity of the construction methods employed for surface dressings to the local specifications; and
- Formulation of recommendations to improve surface dressing construction quality.

1.4 Scope of the Study

The scope of study entailed the following:

- Find out the design and specification for surface dressing project from the road agencies in Ghana and how the construction is supervised.
- Enquire from contractors how construction of bituminous surface dressing is carried out.

- Check the type of materials (chippings and bitumen) that are used and how they are applied.

1.5 Justification

- Currently, no studies have been conducted to establish contractor knowledge and practices in the construction of surface dressing in Ghana. This study would provide documented evidence of the causes of the early deterioration.
- The outcome of the investigation would help avoid practices that cause early deterioration of surface dressings in order to achieve the desired service life, so as to minimize the life cycle cost of road construction and maintenance and road user cost.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Surface dressing is the common name given to the method of applying a bituminous film that waterproofs a pavement surface and acts as a binder to hold the stone chips in place. The stone chips then provide the wearing surface for traffic. Surface dressing is also known as sprayed sealing or chip seal (MRT, 2005).

The main objectives of surface dressing are:

- To waterproof the pavement surface thereby protecting the pavement surface from traffic abrasion and water ingress into the pavement structure
- To provide a surface with good riding quality for road users
- To reduce vehicle operating and maintenance cost.

There are many factors that allow the choice of a surface dressing over asphalt; some are operating environment (traffic level) and financial consideration. Surface dressing will always be selected in rural locations unless other factors especially traffic volume indicate the use of a higher class pavement and surface (MRT, 2005). Surface dressing can also be cost effective for the running surface of newly constructed road pavement in addition to its maintenance role. When surface dressing is designed and constructed correctly, it should last at least five years before resealing with another surface dressing becomes necessary (TRL, 2000).

2.2 Types of Surface Dressings

There are many ways to construct surface dressings. The common types of dressings are illustrated in Figure 2.1 (TRL, 2000).

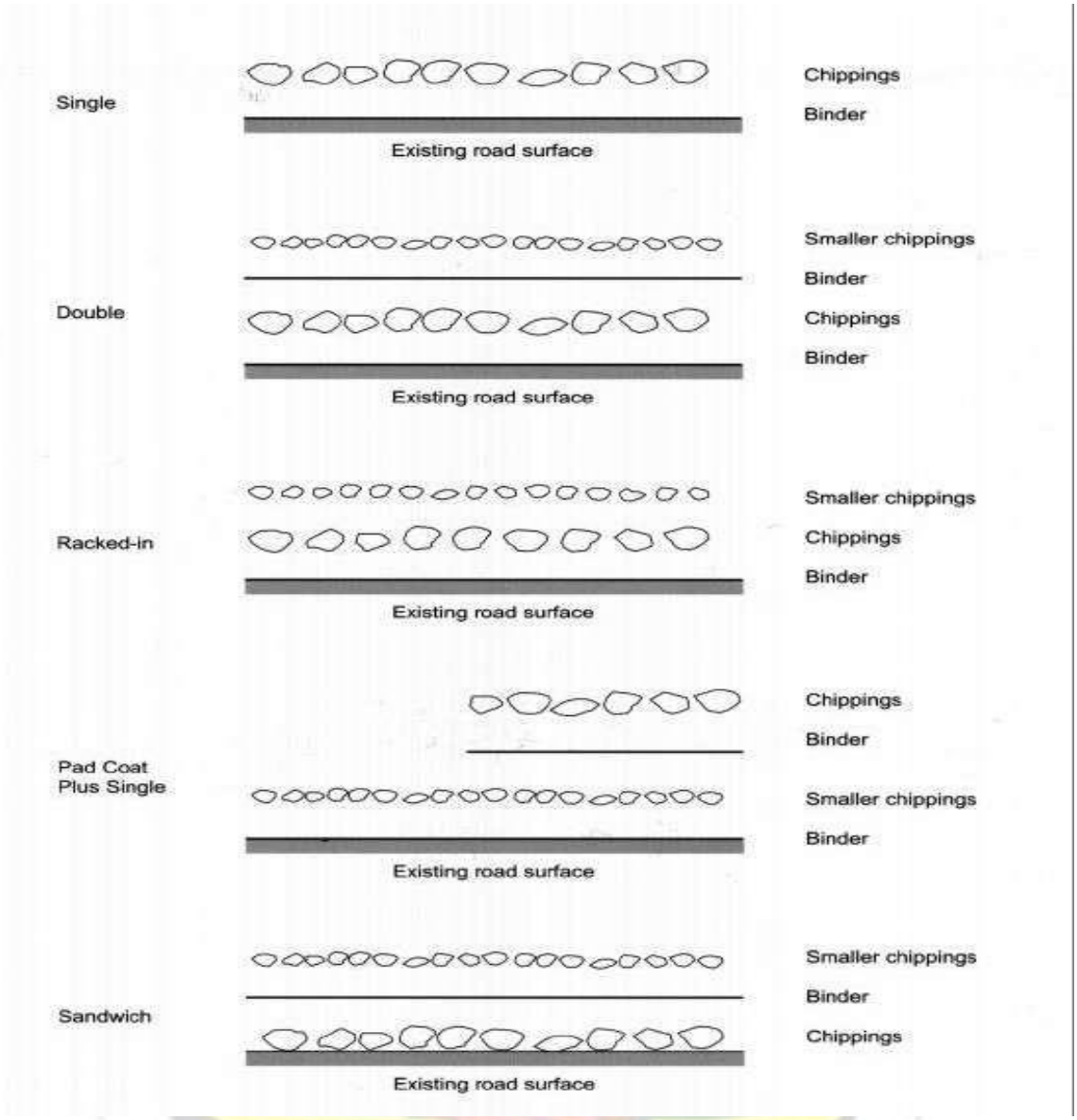

Figure 2.1. Types of surface dressings (TRL, 2000)

2.2.1 Single surface dressing

In the construction of a single surface dressing a thin layer of bitumen is sprayed onto the road surface and a layer of single sized chippings is then spread onto the bitumen, as shown in Figure 2.2. Normally, the chippings should be applied immediately after the bitumen is sprayed (Ethiopian Roads Authority, 2013). Single surface dressing can be applied as a maintenance operation to an existing bituminous road surface to fulfill the functions required of maintenance

re-seal, namely, waterproofing the road surface, arresting deterioration, and restoring skid resistance. It is normally not advisable to use single surface dressing on a new road base because of the danger that the film of bitumen will not give complete coverage (TRL, 2000).

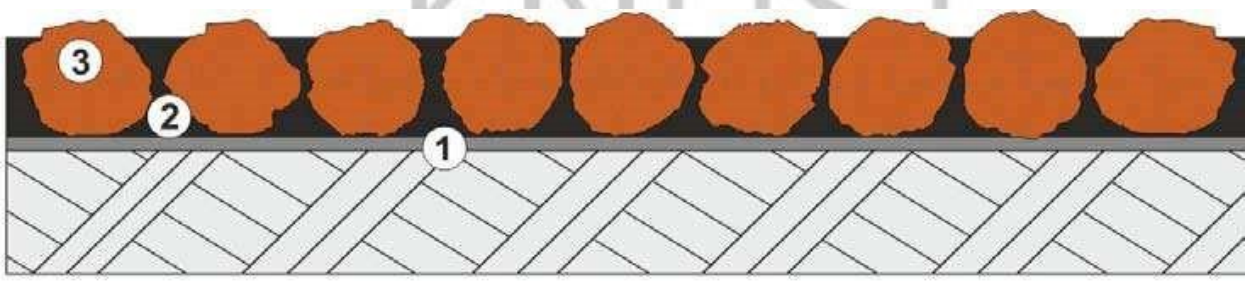

Figure 2.2. **Single surface dressing** (Ethiopian Roads Authority, 2013)

1 Prime coat
2 Binder
3 Aggregate

2.2.2 Double surface dressing

A double surface dressing is constructed with two consecutive applications of both the bituminous binder and uniformly graded aggregate as shown in Figure 2.3 (Ethiopian Roads Authority, 2013). The aggregate in the second application is typically about half the nominal size of the first application. Double surface dressings have less noise from traffic, provide additional waterproofing and are a more robust seal in comparison with a single surface dressing (Sprayed Sealing Guide, 2004 as cited by Gransberg & James, 2005)

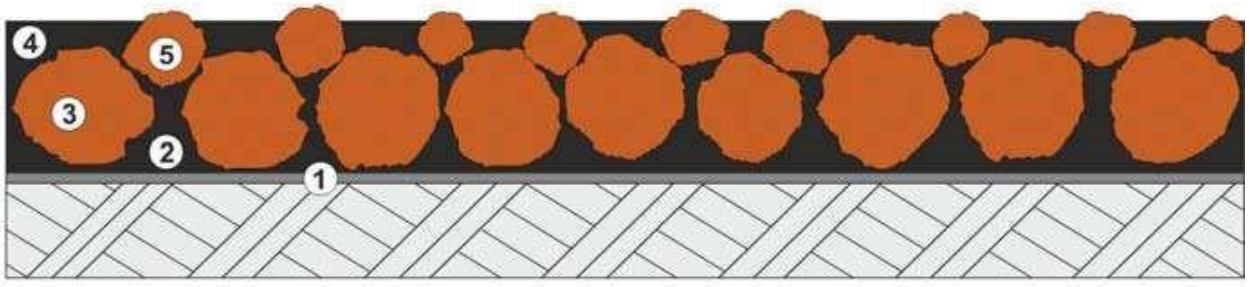

Figure 2.3. **Double surface dressing** (Ethiopian Roads Authority, 2013)

1 Prime coat
2 Binder
3 Larger aggregate
4 Binder (seal coat)
5 Smaller aggregate

Because a double surface dressing is robust, it should be applied when:

- A new road base is surface dressed
- Extra „cover" is required on an existing bituminous road surface because of its condition (e.g. when the surface is slightly cracked or patched)
- There is the need to increase durability and reduce the frequency of maintenance and resealing options (TRL, 2000).

Before the second dressing is applied, it is advisable to allow traffic on the first dressing for a minimum period of two to three weeks (and preferably longer). This will greatly enhance the quality of a double surface dressing. It allows the chippings of the first dressing to properly interlock which provides a firm foundation for the second dressing (TRL, 2000).

2.2.3 Racked-in surface dressing

Racked-in is particularly recommended for heavy or fast traffic areas. A deep single application of binder is made and a layer of large chippings is spread to give approximately 90 per cent coverage. This is followed immediately by the application of smaller chippings which should

„lock-in" the larger aggregate and form a stable mosaic (Figure 2.4.). The amount of bitumen used is more than would be used with a single seal but less than for a double seal (TRL, 2000). A racked-in surface dressing has several advantages over single surface dressings; there is less risk of

chippings being dislodged because of early stability from mechanical interlock and the surface texture is better. However, racked-in surface dressings may be prone to bleeding (Ethiopian Roads Authority, 2013).

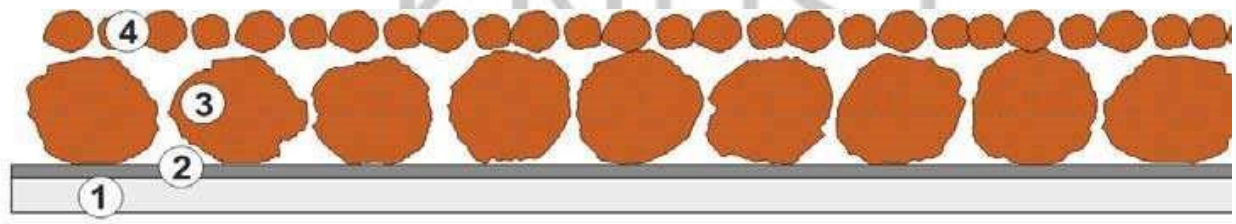

Figure 2.4. **Racked-in surface dressing** (Ethiopian Roads Authority, 2013)

1 Existing base
2 Binder
3 Larger aggregate at 90% application rate
4 Smaller aggregate

2.2.4 Pad coats surface dressing

Pad coats are used where the hardness of the existing road surface allows very little embedment of the first layer of chippings, such as on a newly constructed cement stabilised road base or a dense crushed rock base (TRL, 2000). It is akin to an inverted surface dressing because the larger-sized aggregate goes on top of the smaller-sized aggregate and is, therefore, an inverted double surface dressing as shown in Figure 2.5. These surface dressings are commonly used to repair or correct an existing surface that is bleeding, particularly those that carry a lot of daily traffic (Sprayed Sealing Guide, 2004 as cited by Gransberg & James, 2005).

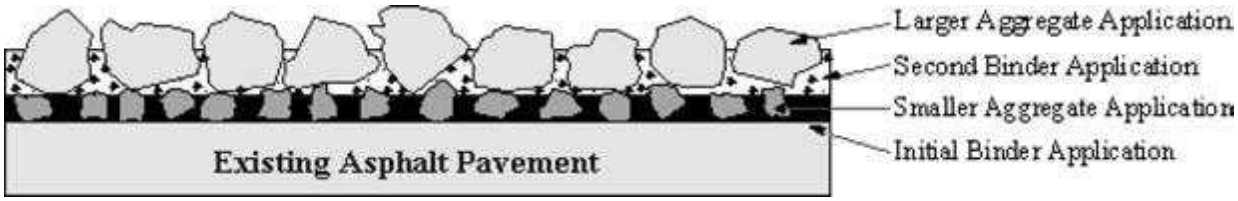

Figure 2.5. **Pad coat surface dressing (Gransberg & James, 2005)**

2.2.5 Sandwich surface dressing

It is a surface dressing technique that involves one binder application sandwiched between two separate aggregate applications (Gransberg and James, 2005). A layer of chippings is placed directly onto the road surface; the first layer of bitumen is then applied, followed by a layer of smaller chippings. Thus, there is one layer of binder „sandwiched" between the two layers of chippings as shown in Figure 2.6 (Ethiopian Roads Authority, 2013). Sandwich surface dressings are particularly useful for restoring surface texture on raveled surfaces (Gransberg & James, 2005). They may also be used on existing binder rich surfaces and sometimes on gradients to reduce the tendency for the binder to flow down the slope (TRL, 2000).

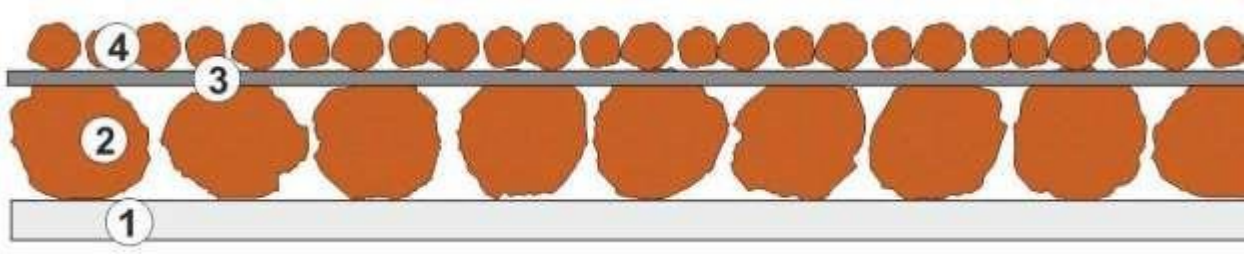

Figure 2.6. **Sandwich surface dressing** (Ethiopian Roads Authority, 2013)

1 Existing base
2 Larger aggregate
3 Binder
4 Smaller chippings

2.3 Material Selection and Design Practices

There are basically only two types of materials used in surface dressing; binder and aggregate.

2.3.1 Aggregate Selection

The selection of aggregate is very important in determining the type of surface dressing to use, the type of binder to design for, and the type of construction procedures to use. The overall success of surface dressing depends on the quality of aggregate, that is, the aggregates should be clean, durable, and abrasion resistant. The function of the aggregates is to transfer the load to the underlying surface. The aim is to provide adequate skid resistance and hence the aggregate should be durable to withstand climatic effects and traffic wear (Gransberg and James, 2005). Aggregate selection is a function of seeking right gradation and selecting the most appropriate surface dressing for the project (Moulthrop, 2003 as cited by Gransberg et al., 1998).

The aggregate size is selected based on traffic, surface condition, and type of surface dressing. Generally, larger aggregate particle sizes are more durable and less sensitive to variations in binder application rate (Gransberg et al., 1998). A uniformly graded aggregate provides a more consistent embedment that result in improved aggregate retention, surface friction, and drainage capabilities of the dressing (McHattie, 2001). The most frequently used sizes are 14mm and 10mm. The former size is preferable for roads carrying large numbers of heavy commercial vehicles and the latter for lightly-trafficked roads often used by fast-moving vehicles. Some authorities specify different stone sizes for the first and second layers of double surface dressings, e.g. 14 mm for the first layer and 10 mm for the second; other users occasionally reverse the order (Hitch and Russell, 1977).

A number of factors influence the bond between the aggregate and binder, but aggregate type is the most important, and it is a function of mechanical, chemical, and electrostatic properties (Yazgan and Senadheera, 2003 as cited by Gransberg and James, 2005). Binder-aggregate compatibility is also affected by porosity and the presence of water on the surface of the road. Porous aggregate will actually lead to excessive absorption of the binder. Poor adhesion between the binder and aggregate will lead to loss of aggregate shortly after construction (Gransberg and James, 2005).

The shape of cover aggregate plays an important role in the successful performance of surface dressings. As the orientation of the embedded aggregate is important, cubical aggregate shapes are preferred because traffic does not have a significant effect on the final orientation of aggregate (Janisch and Galliard, 1998). Cubical aggregates tend to interlock and provide better long-term retention and stability. Under traffic, elongated and flat particles will lie on their flattest side and submerge within the binder. As a result, dressings with flatter aggregate are more susceptible to bleeding in the wheel-paths. Because the orientation of cubical aggregate is not susceptible to displacement by traffic, the opportunity for bleeding is reduced (Gransberg and James, 2005).

Pre-coating improves binding properties of aggregate, reduces dust in the aggregate, and results in better distinction between the pavement and its markings (Gransberg and James, 2005). Pre-coating the aggregate chips with bitumen before placement has been found to decrease the initial amount of chip loss (Kandhal and Motter, 1991).

2.3.2 Binder Selection

The selection of binder depends on many factors which ncludes; some include: the pavement‟s surface, size and gradation of aggregate, compatibility with local aggregate, and local climatic

considerations (Gransberg et al., 1998). The Asphalt Institute (1988) outlines the following requirements for surface dressing binders:

- The binder should not bleed when applied at the appropriate rate.
- At the time of application, the binder needs to be fluid enough to uniformly cover the surface, yet viscous enough to not puddle or run off the pavement.
- The binder should develop adhesion quickly and hold the aggregate tightly to the roadway surface.

Factors that should influence binder selection are surface temperature, aggregate, and climate of the region during construction operations (McLeod, 1969 as cited by Gransberg and James, 2005). Ambient temperature is an important environmental factor to consider when using any bituminous binder since it closely affects the quality of surface dressing (Gransberg et al., 1998).

2.3.3 Design Practices

Although the most important feature of surface dressing is the provision of a continuous impervious film of binder, the success in the design of the dressing begins with selection of the appropriate sizes for the stone chippings, which protect the film from damage by vehicle tyres. Selection depends upon the weight and nature of traffic and penetrability (softness) of the existing surface. That choice having been made, an appropriate thickness of sprayed binder can be selected (Hitch and Russell, 1977). There are two main categories of surface dressing design method; empirical design based on past experience and design based on some form of engineering algorithm. With the formal method, the engineer must first determine the input characteristics for project design. The following are the issues involved in the design (Gransberg and James, 2005):

- Surface texture evaluation;
- Traffic conditions: volume, speed, percentage of trucks, etc.;
- Climatic and seasonal characteristics evaluation;
- Type of surface dressing selection;
- Aggregate selection;
- Binder application rate determination; and
- Determination of the hours per day available for construction operations.

Advice on the parameters used in the design of dressings is given in the TRL Road Note 39 (TRL, 2000). The design parameters that should be considered are:

- Type of dressing
- Type and spread rate of binder
- Type, size and spread rate of the aggregate/s to be used.

It is also important that the dressing is designed to give maximum performance under the site operating conditions. This will ensure that maximum life is gained from the work (RSTA, 2001)

2.4 Common Surface Dressing Defects and Failures

Some of the common defects and failures associated with surface dressings are:

- Streaking
- Potholes
- Bleeding
- Loss of cover aggregate
- Polished aggregate
- Raveling

It is necessary, therefore, to determine, understand and appreciate the specification, design, and construction practice governing surface dressings in Ghana to avoid bad practice that will lead to premature pavement failures.

2.5 Factors Contributing to Deterioration of Surface Dressings

Surface dressings fail for many reasons, and it must be said, most of the causes can be controlled and avoided. The following are some of the factors which when not addressed properly will contribute to early deterioration of surface dressing (Summers, 2000):

1. Hardness / Softness of surface to be dressed.
2. Traffic; numbers and type of vehicles.
3. Location of the surfaces to be dressed.
4. Choice of binder; cut-back bitumen or bitumen emulsion.
5. Properties of aggregate
6. Workmanship.
7. Carriageway preparation.
8. Application of chippings.
9. Application of binder

2.5.1 Hardness / Softness of surface to be dressed

It is necessary to carry out hardness tests on the road surface correctly and in sufficient numbers to accurately determine the road hardness in order to select the correct size of chipping for the hardness of the surface (Summers, 2000).

2.5.2 Traffic level and type of vehicles

A successful surface dressing will last forever if it does not have any traffic on it. Therefore, it is necessary to know the numbers and types of vehicles for a particular site in order to design the surface dressing correctly (Summers, 2000).

2.5.3 Location of surface to be dressed

Areas to avoid when using surface dressings are:

a. Approaches to busy junctions, and the junction itself
b. Tight bends that take heavy traffic, especially Heavy Goods Vehicle (HGV) „trailers" that have three back axles with "supersingle" tyres on the axles (Figure 2.7).

Figure 2.7. HGV trailer with three back axles (Summers, 2000)

c. Entrance to industrial premises/HGV depot, etc. where commercial vehicles "screw" across the surface dressing, tear the dressing and expose fresh binder for other traffic on the road to pick up on their wheels (Summers, 2000)

2.5.4 Choice of binder

The choice of the binder will help to produce the required spraying viscosity. It is the spraying viscosity that determines the ability of the binder to “wet” the road surface and applied chippings to achieve initial bond of chippings to the road (Summers, 2000).

2.5.5 Aggregate Characteristics

Chippings have different characteristics, some will have resistance to polishing, some will have a lower "flaky" value, and some will just have a more suitable shape for surface dressing, i.e. angular rather than cubical or rounded. Choosing a particular site for particular chippings will overcome these problems. For hard surfaces, angular chippings are better as these will orientate to be in contact with the road and provide better chipping retention with little embedment than cubical and rounded chippings. Cubical and rounded chippings will achieve good embedment into normal and soft surfaces and provide excellent dressings.

2.5.6 Workmanship

Good quality workmanship is one of the most important factors in producing good quality surface dressing. The surface dressing gang, at all levels and in all positions, should have the ability and experience to perform their required tasks (Summers, 2000).

2.5.7 Carriageway preparation

It is important that the road surface is prepared prior to receiving the surface dressing. This will ensure a successful dressing. Removal of all contamination on the road surface must take place well ahead of the dressing (Summers, 2000).

2.5.8 Application of chippings

Chippings are deposited on the road surface that has already received the binder application by a self propelled chipping spreader (Figure 2.8.). This equipment spreads the chippings on the road in advance of its own wheels so that it always travels on newly laid chippings.

Figure 2.8. Chipping spreader (Summers, 2000)

2.5.9 Application of binder

Binder application is of the utmost importance in establishing successful dressings. Too little binder will lead to loss of chippings and too much binder will result in “fatted-up” dressing. Also with an excessive amount of binder there will be the danger of the pick-up of free binder on traffic

wheels with all the associated problems of dramatic failure when binder and chippings wrap around traffic wheels (Summers, 2000).

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the methods for data collection and techniques applied in analyzing the data collected. It includes the research design, sampling technique, data requirement and sources, data collection instrument, data processing and analysis.

3.2 Data Requirement and Sources

The study employed mainly primary data in the analysis. The target population for this research was practicing Civil Engineers and Technicians in the road agencies namely the Ghana Highway Authority (GHA), the Department of Urban Roads (DUR) and the Department of Feeder Roads (DFR). It also included Class A1 to A3 Road Contractors since they are mainly responsible for surface dressing projects.

Respondents for the study were selected using purposive sampling. In all, the study involved 50 respondents made up of 30 Civil Engineers from the road agencies and 20 Class A1 to A3 Road Contractors.

3.3 Data Collection Instrument

Data was collected through the use of questionnaires. The items in the questionnaire were a combination of close-ended and open-ended questions. The close-ended questions consisted of a list of items with answer options for respondents to choose. With the open-ended items, respondents were required to supply answers themselves (as briefly as possible). The questions focused on eight areas, namely:

1. Background of the respondent
2. Surface dressing design
3. Materials for surface dressing
4. Equipment
5. Production and storage of aggregates

6. Surface dressing construction
7. Quality control
8. Surface dressing performance

Two sets of questionnaires were prepared; one set was developed for Civil Engineers and Technicians in the road agencies and the other set was prepared for surface dressing Contractors. The selection of Civil Engineers and Technicians for the study was based on knowledge and experience in surface dressing design and pavement construction practices in Ghana, and that of Road Contractors was based on their Class and experience in surface dressing construction. Samples of the questionnaires are provided in Appendix A.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Background Experience of Respondents in Surface Dressing

Respondents from the road agencies consisted of 53% Technician Engineers and 47% Civil Engineers while those working with Contractors were made up of equal numbers of Civil Engineers and Technician Engineers. Of the total respondents, 66.7% indicated they were involved in surface dressing construction and supervision whilst the remaining indicated they were involved

in the design only. Figure 4.1 shows the years of experience of the respondents in surface dressing operation.

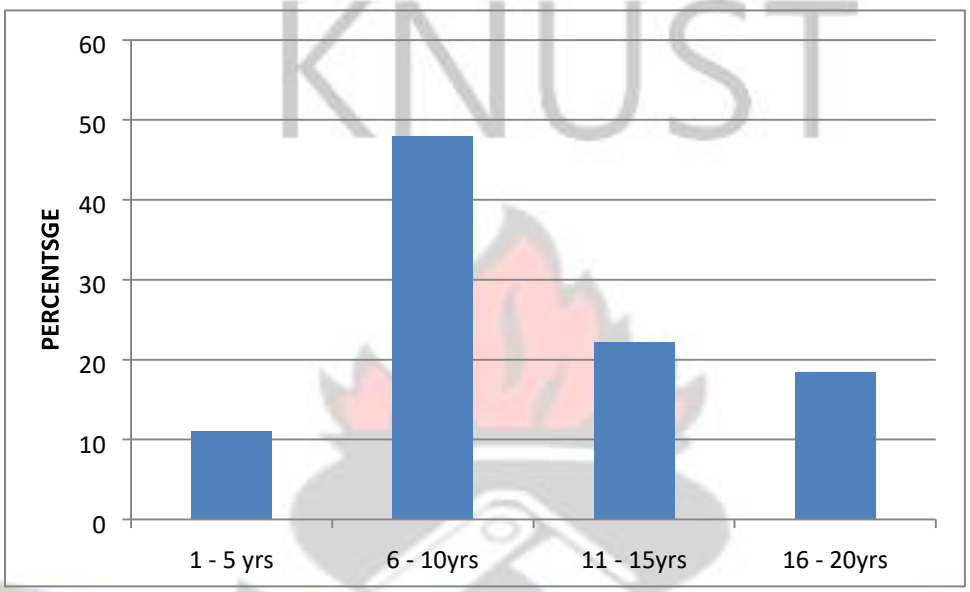

Figure 4.1. Respondents‟ years of Experience in Surface Dressing

4.2 Existing Specification

Most of the personnel contacted at the road agencies (about 90%) indicated that the Ministry of Roads and Transport (MRT) Surface Dressing Design Manual was the most consulted Manual for design of surface dressing. The Manual provides specification for selection of type of binder, required viscosity, chipping requirement, design procedure, etc. They admitted that the Manual should serve as a guide only since the relevant specifications and actual application rates should be determined by onsite trial.

Majority of the respondents from the Contractors‟ side (about 60%) had little or no knowledge of the existing specification. They indicated that they based their activities on experience. The

respondents from the road agencies (about 65%) were able to outline some of the procedures followed in surface dressing as:

1. Determination of number of vehicles applying the road
2. Selection of the type of seal to design for
3. Determination of the road surface hardness
4. Selection of chipping size(s)
5. Determination of ALD
6. Establishment of bitumen spread rate
7. Estimation of road temperature
8. Selection of grade of binder

4.3. Conformity of Design to Specification

4.3.1 Surface Dressing Design

The responses of the survey revealed that not all of the tests that are to be performed on the chippings for surface dressings are done by some contractors; only about 55% of the tests are conducted by some contractors. The tests that are usually performed are those for the evaluation of Flakiness Index, Los Angeles Abrasion, Aggregate Crushing Value, Aggregate Least Dimension and Grading. Some contractors do not even perform any test on the aggregates; this was noticed during the site visit. An important test that must be performed on the coarse aggregates is the soundness test which is intended to study the resistance of aggregates to weathering action due to alternate dry-wet cycle, but unfortunately the survey revealed that this test is not performed by the Contractors.

One of the most important specifications in surface dressing design and construction is the viscosity of the binder and yet about 40% of the contractor respondents did not know the viscosity specification of binder for surface dressing works. The responses gathered from most of the road agency personnel and Contractors indicated that the viscosity is specified without considering the nature of the road surface, although according to Ministry of Roads and Transport (MRT) Design Manual (2005), the viscosity of the binder should be specified depending on the type and nature of the surface of the road.

.

4.3.2 Materials for Surface Dressing

From the literature review, it was noted that the grade of cutback bitumen specified for primerseal is AMC4 which contains 16% cutter (kerosene) by volume. All the respondents clearly indicated these as contained in the Design Manual. In terms of selection of chipping size, about 82% of the respondents correctly stated that sizes 10mm and 14mm are to be used for surface dressing project. The respondents generally indicated that, the 14mm chipping is selected for sealing over 10mm chipping primerseal. However, the order in which chippings are applied primarily depends on the type of seal to design for and the surface texture.

Table 4.1. details response gathered from the Civil Engineers contacted in the survey. The respondents from the road agencies (about 73%) indicated that the chipping application rate must be based on the ALD of the chippings and the traffic volume as stipulated in the Design Manual while the rest indicated that selection of the chippings application rate is based on chipping size only. The latter response is not what is specified in the Design Manual.

Table 4.1. Basis for selecting chippings application rate

Basis for chipping application rate	Frequency	Percentage

Selected based on ALD, traffic volume and basic spread design rate	11	73.3
Selected based on size of chippings	4	26.7
Total	15	100

4.3.3 Equipment used for surface dressing

The main equipment for sealing works are: (a) Bitumen Distributor – for spraying the binder; (b) Chipping Spreader – for spreading the chippings; and (c) Rollers – for rolling the spread chippings. The use of electronic bitumen distributors is becoming more common in Ghana. It is a requirement in surface dressing works as indicated by the respondents from the road agencies, but unfortunately not all contractors in Ghana have access to the equipment. According to the Ministry of Roads and Transport (MRT) Design Manual (2005), it is advisable to use electronic controls on bitumen distributors to achieve a uniform application of binder at a predetermined rate.

Figure 4.2 shows an electronic bitumen distributor for achieving a uniform application of binder at a predetermined rate.

Figure 4.2. Electronic Bitumen Distributor (www.speedcraft.net/bitumen-distributors)

When it came to spreading of chippings, the respondent from the road agencies stated that electronic chipping spreaders were required in surface dressing works but, only 20% of the contractor respondents said they use them. Figure 4.3 shows an example of an electronic chipping spreader for achieving more accurate and uniform spreading. It must however be emphasized that chipping spreaders without electronic gate control give reasonable control for most applications when operators and truck drivers are experienced. However, chipping spreaders with electronic control achieve more accurate and uniform spreading, often resulting in significant reduction in overspreading of chippings.

Figure 4.3. A typical electronic Chipping Spreader (www.speedcraft.net/chippings-distributor)

Rolling in surface dressing work is usually carried out by pneumatic-tyred self propelled multiwheel rollers as shown in Figure 4.4. During the site visit, it was observed that rolling requirements are often ignored during construction. At some construction sites, there was no rolling after the application of binder and aggregates. Some sites too were not using pneumatic

Figure 4.4. Pneumatic-tyred roller (www.speedcraft.net/roller)

rollers as required but were using smooth wheeled rollers which tend to crash the aggregates.

4.3.4 Production and Storage of Aggregate

Chippings which have been precoated should be stockpiled for at least one week before use (MRT, 2005). About 55% of the responses conformed to the specifications stipulated in the Design Manual [i.e. 8days minimum (23%) and 7days (32%)]. The rest of the respondents (45%) indicated durations that are less than the time required by the specification. All of the respondents indicated that if stockpiled precoated chippings are not to be used immediately, it should be covered with heavy plastic sheeting or similar material to prevent contamination. This is exactly what is specified in the Ministry of Roads and Transport (MRT) Design Manual (2005). Also, if precoated chippings have not been used within six (6) months or have dried out, light precoating may be required. Only 58% of the contractors indicated correctly what should be done.

4.3.5 Surface Dressing Construction

The surface temperature of the existing roadway is a critical factor, because energy transfer between the binder and the pavement surface greatly affects the resultant viscosity of the binder and the speed at which the binder will break (Gransberg and James, 2005). This means that it is important to determine the road surface temperature before commencement of the spray work.

In regard to surface temperature, the responses from the road agency respondents showed that 73% did not see surface temperature as a requirement. This is a concern because low surface temperatures can lead to poor adhesion of the surface dressing to the existing pavement surface (*Asphalt Surface Treatments—Specifications* undated). The general consensus from the survey was that the ambient air temperature to do surface dressing work is between 26 to 30^{o}C. Because the

adhesion process is closely related to the viscosity of the binder, warmer ambient air temperatures result in better adhesion obtained between not only the aggregate and binder but also between the surface dressing and pavement surface. Ambient air temperature at the time of application should be a minimum of 21°C and a maximum of 43°C when using asphalt cements (Gransberg & James, 2005). Only 50% of the respondents correctly stated this.

The survey response on whether the number of passes of rollers is specified for surface dressing indicated that most of the respondents from the road agencies (73%) often ignored rolling requirement whilst 27% indicated that number of passes of rollers required is six. None of the contractors responded to this. According to the Ministry of Roads and Transport (MRT) Design Manual (2005), rolling should be continuous during the day and should continue for at least one hour after the last chipping has been spread.

4.3.6 Quality Control

The respondents from the road agencies (90%) were of the view that field inspection responsibilities include ensuring that construction operations are conducive to high-quality workmanship specified in the contract. The client or the private consultant must therefore ensure that the specifications and guidelines enshrined in the contract are adhered to during the construction period. But during the site visit, it was noticed that supervision at some sites were very poor leaving the contractors to do their own thing with no regard to the specifications.

Table 4.2 and Table 4.3 respectively are the survey responses from the personnel from the road agencies on how the application rates of binder and aggregate are certified. According to the

responses, 73% indicated the use of tray test with 27% checking on the design calculation sheet, surface condition and aggregate absorption rate. It is always important to certify the rate of application of binder and aggregate to ensure that the application rates are within the tolerances of the project"s design standard.

Table 4.2. Method of certifying the rate of binder application

Method	Frequency	Percentage
Tray test	6	40
Tray test and difference between initial and final litres per area sprayed	5	33.3
Check on design calculation information sheet, surface condition and aggregate absorption rate	4	26.7
Total	15	100

Table 4.3. Method of certifying the rate of aggregate application

Method	Frequency	Percentage
Tray test	4	26.7
Check on design calculation information sheet, ALD and traffic volume data	4	26.7
Check volume of aggregate against the area spread	7	46.7
	15	100

In response to calibration of the bitumen sprayers, all the contractor respondents indicated that the calibration is always performed whilst 73% of the respondents from the road agencies indicated that calibration is a requirement. According to the Ministry of Roads and Transport (MRT) Design

Manual, to maintain accuracy, several calibration procedures and checks should be regularly performed on the binder distributor. Calibrating the binder distributor ensures that the distributor spray bar is delivering the required amount of bitumen from each nozzle.

The frequency of calibration as indicated by the respondents from the road agencies is shown in Table 4.4. The Ministry of Roads and Transport (MRT) Design Manual specifies that calibration is required every year, or whenever the sprayer has been overhauled or the bitumen pump replaced (MRT, 2005).

From the table below it can be seen that calibration was not an issue as it was done more often than required.

Table 4.4. Frequency of binder sprayer equipment calibration

Period	Frequency per year	Percentage
For each spray	2	18.2
For each spray but depends on the frequency of spray	5	45.5
Quarterly	4	36.3
Total	11	100

The calibration of the aggregate spreader is crucial to the satisfactory performance of surface dressing (Janisch and Gaillard, 1998). Calibrating the aggregate spreader ensures that all gates are

applying the required rate of aggregate across the entire spread width. All the respondents agreed that there is the need to calibrate aggregate spreader.

The road agency respondents indicated that other special quality control measures are taken by their agencies to achieve a well constructed surface dressing. The type of controls employed were tray test (36.4%) and rate of spray and tray test (63.6)

4.3.7 Performance of Surface-Dressed Roads

Majority of the road agency respondents (73%) regard quality control as the most important factor to be considered in minimizing defects during surface dressing construction whilst 83% of the contractors view construction procedure as the main factor.

4.4 Assessment of Surface Dressing Practices

About six surface dressing construction sites were visited to assess construction practices. At one of the project site it was discovered that the longitudinal joint at some sections was not properly constructed leaving a gap between the two adjoining sealing. This was detected during the site inspection by the Resident Engineer as shown in Figure 4.5.

Figure 4.5. Gap between two adjoining seals

But in accordance with Ministry of Roads and Transport (MRT) Design Manual (2005), full width spraying should be carried out so that there will be no longitudinal joint in the seal and the overlap at the longitudinal joint of adjacent runs should be 50 mm to 100 mm wide.

The contractor however was using an electronic bitumen distributor and an electronic chipping spreader as indicated in Figure 4.6.

Figure 4.6. Electronic distributor and spreader

This was immediately followed by rolling with pneumatic tyre roller as recommended (Figure 4.7).

Figure 4.7. Rolling with pneumatic tyre roller

Photographs of the surface dressing construction practices are shown in Appendix B

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

This study investigated into early deterioration of surface dressings in Ghana. The main conclusions drawn from the study are:

1. The Ministry of Roads Transport Surface Dressing Manual (2005) was identified as the most consulted local manual for surface dressing works. It provides reliable guidelines for all aspects of surface dressing including design and construction. However, some of the contractors did not know most of the specification requirements contained in the Manual.
2. In the conformity of the construction method employed to local specification, the following were identified;
   - Some of the designers of the seal do not take into consideration the road surface temperature when specifying the binder viscosity.
   - Majority of contractors do not take the specification for testing of chipping to ascertain it durability seriously, an important requirement such as soundness test is not performed on the chippings by the contractors to determine their resistance to weathering due to alternate dry-wet cycle.
   - Rolling requirements are often ignored in the field and sometimes the specified rolling equipment is not used.
   - Also because most of the contractors do not use electronic bitumen sprayers and chipping spreaders, it is difficult to achieve uniform application rate for both binder and chippings which will lead to over spraying to cause bleeding or under spraying to cause loss of cover aggregates.

5.2 Recommendation

Base on the findings from the study, the following recommendations are proposed:

1. The area that apparently has the greatest potential for improvement is surface dressing design. The Ministry of Roads and Transport (MRT) surface dressing manual should be used only as a guideline; the actual design must be verified in the field.

2. The supervision team must ensure that all the relevant tests that are required on both the binder and the coarse aggregates are carried out by the contractors.

3. Performance-based contracts for surface dressing must be considered. In this way all design and construction liabilities are assumed by the contractor, with the agency‟s only responsibility being to specify outcome.

4. Contractors must also be encouraged to use electronic bitumen sprayers and chipping spreaders to achieve uniform application rate for both binders and chippings.

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APPENDICES

APPENDIX A

SAMPLE OF QUESTIONNAIRE

(*ROAD AGENCIES AND CONTACTORS*)

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

SURFACE DRESSING CONSTRUCTION PRACTICES IN GHANA

QUESTIONNAIRE [CIVIL ENGINEERS AND CONSTRUCTION TECHNICIANS]

Please answer the questions based on your experience in surface dressing works in Ghana. All the information which will be provided will be kept confidential and anonymous and will be used only for academic purpose. You are respectfully asked to tick in your opinion one of the responses or tick the one that is nearest to your opinion and suits the real event or situation

---

SECTION A: RESPONDENT'S BACKGROUND

1. Please, indicate your profession by ticking (√) in the brackets.

[ ] Civil Engineer

[ ] Construction Technician

2. Which specific aspects of surface dressing works have you been involved in?

☐ Design of the seal

☐ Construction and Supervision

3. How many years have you been involved in chip seal construction projects in Ghana?

……..…….……..……

SECTION B: GENERAL INFORMATION

4. From your experience what is the typical life span (age) of surface dressing your agency undertake?

Approximately …… years

5. How often do you do resealing of existing surface dressed road?

…….

6. How do you rate the performance of surface dressing construction using in-house crew? (Check one box only.)

☐ Excellent ☐ Poor

☐ Good ☐ Unacceptable

☐ Fair ☐ Not applicable

7. How do you rate the performance of contract surface dressing construction?
(Check one box only.)

☐ Excellent ☐ Poor

☐ Good ☐ Unacceptable

☐ Fair ☐ Not applicable

8. Which approach seems to yield a better final surface dressing product?

☐ Agency constructed ☐ Contractor constructed ☐ No difference

9. What are the primary problems associated with surface dressing works?

☐ Early loss of aggregate

☐ Premature flushing/bleeding ☐ Potholes

☐ Flushing/bleeding at intersections and turning areas

☐ Streaking

☐ Other, please specify:

SECTION C: SURFACE DRESSING DESIGN

10. Who does the design of surface dressing?

☐ In-house

☐ Consultant

11. How do you determine the binder application rates?

☐ Based on design manual ☐ Based on past experience

☐ Other, please specify:

12. How do you determine the aggregate application rates?

☐ Based on design manual ☐ Based on past experience

☐ Other, please specify:

13. What type of bitumen binder do you specify for surface dressing?

……...

14. Do you specify the viscosity required of the binder?

[ ] YES [ ] NO

15. Do you conduct any test on the chippings before their use?

[ ] YES [ ] NO

If YES, please list the tests that are conducted

i. ……

ii. …… iii.

…… iv.

…… v.

…… vi.

…… vii.

…… viii.

……

16. What type of binder do you specify for the precoating of the aggregates?

.....

17. Do you specify the viscosity of the precoating binder?

[ ] YES [ ] NO

18. Do you specify the application rate of the precoating binder?

[ ] YES [ ] NO

19. What type of binder do you specify for the construction of primer seal?

…… ……

20. Do you specify the viscosity of the binder for primer seal?

[ ] YES [ ] NO

21. Do you specify the application rate of the primer seal binder?

[ ] YES [ ] NO

22. How is the chipping application rate selected?

…….

……..

……

SECTION D: MATERIALS

23. What aggregate size do you use for your surface dressing projects? (Check all that apply.)

☐ 16.0 mm

☐ 12.5 mm

☐ 14 mm

☐ 10 mm

☐ Other, please specify:

Which size is most commonly used?

24. Do you use more than one aggregate size if doing a double surface dressing?

☐ Yes ☐ No

If Yes, please specify the sizes:

……

SECTION E: EQUIPMENT

25. Do you require electronic controls on your bitumen distributors? ☐ Yes ☐ No

26. Do you require electronic gate controls on your chip spreaders?

☐ Yes ☐ No

27. What roller types do you specify for use on surface dressing projects?

☐ Static steel ☐ Vibratory steel ☐ Pneumatic-tired ☐

Combination pneumatic/steel ☐ Combination vibratory/pneumatic

☐ Other, please specify:

SECTION F: PRODUCTION AND STORAGE

28. How long do you specify for precoated chippings to be stockpiled before use?

……

29. What do you do when stockpiled precoated chippings are not to be used immediately?

……

A6

A7

SECTION G: CONSTRUCTION

30. Do you determine the road surface temperature before the commencement of the spray work?

[ ] YES [ ] NO

31. If YES at what temperature of the road surface will you avoid spraying the bitumen?

……

32. What are your specifications for ambient air temperature to do surface dressing work?

……degrees ☐ No specification

33. Do you specify the number of roller passes for surface dressing?

[ ] YES [ ] NO

If YES, what is the number? ……..

SECTION H: QUALITY CONTROL

34. Who performs the final inspection?

☐ Client ☐ Private consultant ☐ Contractor

How many people perform the inspection? ☐ Individual ☐ Team

35. How do you certify the rate of binder application?

.....

.....

.....

36. How do you certify the rate of aggregate application?

.....

.....

.....

37. Do you require calibration of binder spray equipment?

☐ Yes ☐ No

If Yes, how often? .....

38. Do you require calibration of aggregate spreading equipment?

☐ Yes ☐ No

If Yes, how often? .....

39. What tolerances are allowed for binder spray and aggregate spread rates?

Binder spray ± ……L/sm

Aggregate spread ± ……kg/sm

40. Are any special quality control tests employed by your agency?

☐ Yes ☐ No

If Yes, please specify: ……..

SECTION I: PERFORMANCE

41. Which of the following in your opinion will minimize defects in surface dressing project?

☐ Construction procedure ☐ Design method ☐ Better binder ☐

Better aggregates ☐ Quality control ☐ Double seal

☐ Other, please specify:

A8

42. What is the most common public/user complaint about surface dressing, if any?

☐ Loose stone ☐ Road noise ☐ Vehicle ride

☐ Appearance ☐ Other, please specify: ☐ None

If there is anything you would like to add that was not covered in this questionnaire but you feel would benefit this study, please write your comments below:

THANK YOU FOR SUPPORTING THIS IMPORTANT EFFORT

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

SURFACE DRESSING CONSTRUCTION PRACTICES IN GHANA

QUESTIONNAIRE [CIVIL ENGINEERS AND CONSTRUCTION TECHNICIANS]

Please answer the questions based on your experience in surface dressing works in Ghana. All the information which will be provided will be kept confidential and anonymous and will be used only for academic purpose. You are respectfully asked to tick in your opinion one of the responses or tick the one that is nearest to your opinion and suits the real event or situation

---

SECTION A: RESPONDENT'S BACKGROUND

1. Please, indicate your profession by ticking (√) in the brackets.

[ ] Civil Engineer

[ ] Construction Technician

2. Which specific aspects of surface dressing works have you been involved in?

☐ Design of the seal

☐ Construction

3. How many years have you been involved in surface dressing construction projects in Ghana?

……..…….……..……

SECTION B: SURFACE DRESSING DESIGN

4 Who does the design of surface dressing?

☐ In-house

☐ Consultant

If In-house:

5. For how long has the current design procedure been used? ……. Years.

6. How do you determine the binder rates?

☐ Based on design manual ☐ Based on past experience

☐ Other, please specify:

7. How do you determine the aggregate rates?

☐ Based on design manual ☐ Based on past experience

☐ Other, please specify:

8. What type of bitumen binder do you prepare and use for surface dressing?

……

9. Do you determine the viscosity required of the binder?

[ ] YES [ ] NO

10. Do you conduct any test on the chippings before their use?

[ ] YES [ ] NO

If YES, please list the tests that are conducted and their requirements

i. …… ii.

…… iii.

…… iv.

…… v.

…… vi.

…… vii.

……

viii.

…… ix.

……

11. What type of binder do you use for the precoating of the aggregates?

.....

12. Do you determine the viscosity of the precoating binder?

[ ] YES [ ] NO

13. Do you determine the application rate of the precoating binder?

[ ] YES [ ] NO

14. What type of binder do you use for the construction of primer seal?

……

15. Do you determine the viscosity of the binder for primer seal?

[ ] YES [ ] NO

16. Do you determine the application rate of the primer seal binder?

[ ] YES [ ] NO

17. Have you been doing single or double sealing?

……

SECTION C: MATERIALS

18. What aggregate size do you use for your surface dressing projects? (Check all that apply.)

☐ 16.0 mm

☐ 12.5 mm

☐ 14 mm

☐ 10 mm

☐ Other, please specify:

Which size is most commonly used?

19. Do you use more than one aggregate size if doing a double surface dressing?

☐ Yes ☐ No

If Yes, please specify the sizes:

……

20. Do you use quartzite aggregate for surface dressing projects?

[ ] YES [ ] NO

SECTION D: EQUIPMENT

21. Do you use electronic controls on your bitumen distributors? ☐

Yes ☐ No

22. Do you use electronic gate controls on your chip spreaders? ☐

Yes ☐ No

23. What roller types do you use on surface dressing projects?

☐ Static steel ☐ Vibratory steel ☐ Pneumatic-tired ☐

Combination pneumatic/steel ☐ Combination vibratory/pneumatic

☐ Other, please specify:

SECTION E: PRODUCTION AND STORAGE

24. How long do you stockpile precoated chippings before use?

……

25. What do you do when stockpiled precoated chippings are not to be used immediately?

……

26. What happen to precoated chippings which have dried out while stockpiled (before use)?

……..

27. At what temperature do you heat bituminous material before use?

……..

28. Do you spray the bitumen to the road surface at any temperature? [ ] YES [ ]

NO

29. If NO at what temperature of the road surface will you avoid spraying the bitumen?

……

SECTION F: CONSTRUCTION

30. What are the specifications for ambient air temperature to do surface dressing work?

……degrees ☐ No specification

31. What are the specifications for pavement temperature to do surface dressing work?

…….degrees ☐ No specification

32. How soon after the binder spray operation is aggregate spread? ……. minutes

33. What is the typical time span between aggregate spread and initial rolling?

……

34. What number of passes of roller is required? ……..

SECTION G: QUALITY CONTROL

35. Who performs the final inspection?

☐ Client ☐ Private consultant ☐ Contractor

How many people perform the inspection? ☐ Individual ☐ Team

36. Do you perform calibration of binder spray equipment?

☐ Yes ☐ No

If Yes, how often? .....

37. Do you perform calibration of aggregate spreading equipment?

☐ Yes ☐ No

If Yes, how often? .....

38. What tolerances are allowed for binder spray and aggregate spread rates?

Binder spray ± ……L/sm

Aggregate spread ± ……kg/sm

39. Are any special quality control tests employed by your agency?

☐ Yes ☐ No

If Yes, please specify: ……..

SECTION H: PERFORMANCE

40. Which of the following in your opinion will minimize defects in surface dressing project?

☐ Construction procedure ☐ Design method ☐ Better binder ☐

Better aggregates ☐ Quality control ☐ Double seal

☐ Other, please specify:

41. What is the most common public/user complaint about a surface dressing, if any?

☐ Loose stone ☐ Road noise ☐ Vehicle ride

☐ Appearance ☐ Other, please specify: ☐ None

If there is anything you would like to add that was not covered in this questionnaire but you feel would benefit this study, please write your comments below:

THANK YOU FOR SUPPORTING THIS IMPORTANT EFFORT

A16

APPENDIX B

SPSS RESULTS

ROAD AGENCIES RESPONDENTS FREQUENCY TABLE

Respondent profession

Profession	Frequency	Percent	Cumulative Percent
Civil Engineer	7	46.7	46.7
Construction Technician	8	53.3	100.0
Total	15	100.0	

Surface dressing works involved in

Surface dressing works	Frequency	Percent	Cumulative Percent
Design of the seal	7	46.7	46.7
Construction and supervision	8	53.3	100.0
Total	15	100.0	

Experience in surface dressing construction projects in Ghana (years)

Experience	Frequency	Percent	Cumulative Percent
4	1	6.7	6.7
6	1	6.7	13.3
7	1	6.7	20.0
8	2	13.3	33.3
10	2	13.3	46.7
12	2	13.3	60.0
15	3	20.0	80.0
18	2	13.3	93.3
20	1	6.7	100.0
Total	15	100.0	

Typical life span (age) of surface dressing

Life span (years)	Frequency	Percent	Cumulative Percent
8	6	40.0	40.0
10	9	60.0	100.0
Total	15	100.0	

Amount of surface dressing work done by agency in a year (km/year)

Amount of work done (km/year)	Frequency	Percent	Cumulative Percent
30	6	54.5	54.5
50	5	45.5	100.0
Total	11	100.0	

Frequency of resealing of existing surface dressed roads

Frequency of resealing works	Frequency	Percent	Cumulative Percent
8-10 years	4	26.7	26.7
Nil	4	26.7	53.3
Not often	7	46.7	100.0
Total	15	100.0	

Performance rating of surface dressing construction using in-house crew

Performance rating	Frequency	Percent	Cumulative Percent
Excellent	0	0	0
Good	10	100.0	100.0
Fair	0	0	100.0
Poor	0	0	100.0
Unacceptable	0	0	100.0
Not applicable	0	0	100.0
Total	10	100.0	

Performance rating of contract surface dressing construction

Performance rating	Frequency	Percent	Cumulative Percent
Excellent	0	0	0
Good	11	100.0	100.0
Fair	0	0	.100.0
Poor	0	0	.100.0
Unacceptable	0	0	.100.0
Not applicable	0	0	.100.0

	11		
Total		100.0	

Approach that seem to yield a better final surface dressing product

Approach	Frequency	Percent	Cumulative Percent
Agency constructed	0	0	0
Contractor constructed	8	53.3	53.3
No difference	7	46.7	100.0
Total	15	100.0	

B2

Primary problems associated with surface dressing works

Primary problems	Frequency	Percent	Cumulative Percent
Early loss of aggregate	1	6.7	6.7
Premature flushing/bleeding Potholes	0	0	6.7
	9	60.0	66.7
Flushing/bleeding at intersections and turning areas	5	33.3	100.0
Streaking	0	0	100.0
Total	15	100.0	

Designer of surface dressing

Designer	Frequency	Percent	Cumulative Percent
In-house	9	60.0	60.0
Consultant	6	40.0	100.0
Total	15	100.0	

Method of determining the binder application rates

Method	Frequency	Percent	Cumulative Percent
Based on design manual	13	100.0	100.0
Based on past experience	0	0	100.0
Other	0	0	100.0
Total	13	100.0	

Method of determining the aggregate application rates

Method	Frequency	Percent	Cumulative Percent
Based on design manual	15	100.0	100.0
Based on past experience	0	0	100.0
Other	0	0	100.0
Total	15	100.0	

Type of bitumen binder specified for surface dressing

Type of binder	Frequency	Percent	Cumulative Percent
AC10	11	73.3	73.3
AC10 (80/100)	4	26.7	100.0
Total	15	100.0	

B3

Is the viscosity required of the binder specified?

Response	Frequency	Valid Percent	Cumulative Percent
Yes	12	100.0	100.0
No	0	0	100.0
Total	12	100.0	

Is any test conducted on chippings before use?

Response	Frequency	Percent	Cumulative Percent
Yes	12	100.0	100.0
No	0	0	100.0
Total	12	100.0	

Tests conducted on chippings before use

Test	Frequency	Percent	Cumulative Percent
Flakiness	8	53.3	
10% fines (dry &wet)	5	33.3	
Aggregate impact value & 10% fine	4	26.7	
Grading	5	33.3	
Shape test	5	33.3	
Elongation index	8	53.3	
Aggregate crushing value	13	86.7	
Aggregate least dimension	13	86.7	
Los angeles abrasion	13	86.7	
Stripping test	4	26.7	
Total	15		

Type of binder specified for the precoating of aggregates

Type of binder	Frequency	Percent	Cumulative Percent
10% bitumen and 90% diesel	4	26.7	26.7
AC10	7	46.7	73.3
AC10 (80/100)	4	26.7	100.0
Total	15	100.0	

Is the viscosity of the precoating binder specified?

Response	Frequency	Percent	Cumulative Percent
Yes	6	40.0	40.0
No	9	60.0	100.0
Total	15	100.0	

Is the application rate of the precoating binder specified?

Response	Frequency	Percent	Cumulative Percent
Yes	15	100.0	100.0
No	0	0	100.0
Total	15	100.0	

Type of binder specified for the construction of primer seal

Type of binder	Frequency	Percent	Cumulative Percent
AC10	2	13.3	13.3
AC10 (50/100))	3	20.0	33.3
AC10 (80/100)	1	6.7	40.0
AC10 (cutback with kerosine)	5	33.3	73.3
AC10 (field cutback of 16% kerosene)	4	26.7	100.0
Total	15	100.0	

Is the viscosity of the binder for primer seal specified?

Response	Frequency	Percent	Cumulative Percent
Yes	11	73.3	73.3
No	4	26.7	100.0
Total	15	100.0	

Is the application rate of the primer seal binder specified?

Response	Frequency	Percent	Cumulative Percent
Yes	15	100.0	100.0
No	0	0	100.0
Total	15	100.0	

Method of selecting chipping application rate

Method	Frequency	Percent	Cumulative Percent
Selected based on ALD, traffic volume & basic spread design rate	4	26.7	26.7
Selected based on design manual	7	46.7	73.3
Selected based on size of chippings	4	26.7	100.0
Total	15	100.0	

Aggregate size used for surface dressing projects

Aggregate size	Frequency	Percent	Cumulative Percent
14 mm	4	26.7	26.7
10 &14 mm	11	73.3	100.0
Total	15	100.0	

Most commonly used size

Commonly used size	Frequency	Percent	Cumulative Percent
14 mm	4	100.0	100.0

Total	4		

Are more than one aggregate size used for double surface dressing?

Response	Frequency	Percent	Cumulative Percent
Yes	15	100.0	100.0
No	0	0	100.0
Total	15	100.0	

Sizes used for double surface dressing

Aggregate size	Frequency	Valid Percent	Cumulative Percent
10 and 14 mm	15	100.0	100.0
Total	15	100.0	

Is quartzite aggregate used for surface dressing projects?

Response	Frequency	Percent	Cumulative Percent
Yes	0	0	0
No	15	100.0	100.0
Total	15	100.0	

Are electronic controls required on bitumen distributors?

Response	Frequency	Percent	Cumulative Percent
Yes	15	100.0	100.0
No	0	0	100.0
Total	15	100.0	

Are electronic gate controls required on chip spreader?

Response	Frequency	Percent	Cumulative Percent
	9	64.3	64.3

	Yes	5	35.7	100.0
	No			
Total		14	100.0	

Roller types specified for use on surface dressing projects

Roller type	Frequency	Percent	Cumulative Percent
Static steel	0	0	0
Vibratory steel	0	0	0
Pneumatic-tired	14	100.0	100.0
Combination pneumatic/steel	0	0	100.0
Combination vibratory/pneumatic	0	0	100.0
Other	0	0	100.0
Total	14	100.0	

Period specified for precoated chippings to be stockpiled before use

Period	Frequency	Percent	Cumulative Percent
		26.7	26.7
3 days	4	13.3	40.0
5 days	2	26.7	66.7
5 days minimum 8	4	33.3	100.0
days minimum	5		
Total	15	100.0	

What is done when stockpiled precoated chippings are not to be used immediately?

Action	Frequency	Percent	Cumulative Percent
	7	46.7	46.7
cover from dust & rain	8	53.3	100.0
covered with tarpaulin			
Total	15	100.0	

Is the road surface temperature determined before the commencement of spray work?

Response	Frequency	Percent	Cumulative Percent

Yes	4	26.7	26.7
No	11	73.3	100.0
Total	15	100.0	

Temperature of road surface at which spraying of bitumen will be avoided

Temperature	Frequency	Percent	Cumulative Percent
No temperature determined	11	73.3	73.3
Above room temperature	4	26.7	100.0
Total	15	100.0	

Specifications for ambient air temperature to do surface dressing work

Temperature	Frequency	Percent	Cumulative Percent
10 - 15 degree celcius 26	4	50.0	50
- 30 degree celcius	4	50.0	100.0
Total	8	100.0	

Is the number of roller passes specified for surface dressing?

Response	Frequency	Percent	Cumulative Percent
Yes	4	26.7	26.7
No	11	73.3	100.0
Total	15	100.0	

Number of roller passes specified

Number of passes	Frequency	Percent	Cumulative Percent
Not specified	11	73.3	73.3
6 passes	4	26.7	100.0
Total	15	100.0	

Performer of the final inspection

	Inspection performer	Frequency	Percent	Cumulative Percent
	Client	15	100.0	100.0
	Private consultant	0	0	100.0
	Contractor	0	0	100.0
Total		15	100.0	

Number of people who perform the inspection

Number of inspectors	Frequency	Percent	Cumulative Percent
Individual	0	0	0
Team	12	100.0	100.0
Total	12	100.0	

Method of certifying the rate of binder application

Method	Frequency	Percent	Cumulative Percent
By tray test	6	40.0	40.0
By tray test & diff. between initial and final litres per area sprayed	5	33.3	73.3
Check on design calculation info sheet, surface condition & aggregate absorption rate	4	26.7	100.0
Total	15	100.0	

Method of certifying the rate of aggregate application

	Frequency	Percent	Cumulative Percent
By tray test	4	26.7	26.7
Check on design calculation info sheet, ALD and traffic volume	4	26.7	53.3
date Check volume of aggregate against the area spread Total	7	46.7	100.0
	15	100.0	

Is the calibration of binder spray equipment required?

Response	Frequency	Percent	Cumulative Percent
Yes	11	73.3	73.3
No	4	26.7	100.0
Total	15	100.0	

Frequency of binder spray equipment calibration

Frequency of calibration	Frequency	Percent	Cumulative Percent
For each spray	2	18.2	18.2
For each spray but depends on frequency of spray	5	45.5	63.7
Quarterly	4	36.3	100.0
Total	11	100.0	

Is the calibration of aggregate spreading equipment required?

Response	Frequency	Percent	Cumulative Percent
Yes	15	100.0	100.0
No	0	0	100.0
Total	15	100.0	

Frequency of binder spray equipment calibration

Frequency of calibration	Frequency	Percent	Cumulative Percent
1-2 years	4	26.7	26.7
For each spread	7	46.7	73.3

Quarterly	4	26.7	100.0
Total	15	100.0	

Tolerance allowed for binder spray rate

Tolerance	Frequency	Percent	Cumulative Percent
+ or - 0.1-0.2 L/sm	7	46.7	46.7
+ or - 5% L/sm	8	53.3	100.0
Total	15	100.0	

Tolerance allowed for aggregate spreading rate

Tolerance	Frequency	Percent	Cumulative Percent
+ or - 0.0-1.0 kg/sm	7	46.7	46.7
+ or - 2% kg/sm	4	26.7	73.3
+ or - 5% kg/sm	4	26.7	100.0
Total	15	100.0	

Are any special quality control tests employed by your agency?

Response	Frequency	Percent	Cumulative Percent
Yes	11	73.3	73.3
No	4	26.7	100.0
Total	15	100.0	

Special quality control tests employed

Special quality control test	Frequency	Percent	Cumulative Percent
Rate of spray & spread check	1	9.1	9.1

Rate of spray & spread check (tray test)	6	54.5	63.6
Tray test	4	36.4	100.0
Total	11	100.0	

B11

Which of the following will minimize defects in surface dressing projects?

	Frequency	Percent	Cumulative Percent
	4	26.7	26.7
Construction procedure	0	0	26.7
Design method	0	0	26.7
Better binder	0	0	26.7
Better aggregate	11	73.3	100.0
Quality control			100.0
Double seal	0	0	
Other	0	0	100.0
Total	15	100.0	

The most common public/user complaint about surface dressing

		Frequency	Percent	Cumulative Percent
	Loose stone	15	100.0	100.0
\	Road noise	0	0	100.0
	Vehicle ride	0	0	100.0
	Appearance	0	0	100.0
	Other	0	0	100.0
	None	0	0	100.0
Total		15	100.0	

B12

CONTRACTORS RESPONDENTS FREQUENCY TABLE

Respondent profession

Profession	Frequency	Percent	Cumulative Percent
Civil Engineer	6	50.0	50.0
Construction Technician	6	50.0	100.0
Total	12	100.0	

Surface dressing works involved in

Surface dressing works	Frequency	Percent	Cumulative Percent
Design of the seal	2	16.7	16.7
Construction	10	83.3	100.0
Total	12	100.0	

Experience in surface dressing construction projects in Ghana (years)

Experience	Frequency	Percent	Cumulative Percent
5	2	16.7	16.7
6	1	8.3	25.0
7	1	8.3	33.3

8	1	8.3	41.7
10	4	33.3	75.0
12	1	8.3	83.3
20	2	16.7	100.0
Total	12	100.0	

Designer of surface dressing

Designer	Frequency	Percent	Cumulative Percent
Consultant	12	100.0	100.0
In-house	0	0.0	100.0
Total	12	100.0	

B13

How long has the current design procedure been used (years) (no one answered)

		Frequency	Percent
Missing	System	12	100.0

Method of determining the binder application rates

Method	Frequency	Percent	Cumulative Percent
Based on design manual	9	75.0	75.0
Based on past experience	3	25.0	100.0
Total	12	100.0	

Method of determining the aggregate application rates

Method	Frequency	Percent	Cumulative Percent
Based on design manual	7	70.0	70.0
Based on past experience	3	30.0	100.0

Total	10	100.0	

Type of binder prepared and used for surface dressing

Type of binder	Frequency	Percent	Cumulative Percent
AC-10	12	100.0	100.0
Total	12	100.0	

Is the viscosity required of the binder determined?

Response	Frequency	Percent	Cumulative Percent
Yes	5	100.0	100.0
No	0	0.0	100.0
Total	5		

B14

Is any test conducted on chippings before use?

	Frequency	Percent	Cumulative Percent
Yes	8	100.0	100.0
No	0	0.0	100.0
Total	8		

Tests conducted on chippings before use

Test	Frequency	Percent	Cumulative Percent
Flakiness	11	91.7	
Specific gravity	12	100.0	
Flash point	7	58.3	
Grading	12	100.0	
Aggregate least dimension			

Los angeles abrasion	3	25.0	
Total	10	83.3	
	12		

Type of binder specified for the precoating of aggregates

Type of binder	Frequency	Percent	Cumulative Percent
Bitumen and kerosene	12	100.0	100.0
Total	12	100.0	

Is the viscosity of the precoating binder determined?
(no one answered)

		Frequency	Percent
Missing	System	12	100.0

Is the application rate of the precoating binder determined?

Response	Frequency	Percent	Cumulative Percent
Yes	12	100.0	100.0
No	0	0.0	100.0
Total	12	100.0	

B15

Type of binder used for the construction of primer seal

Type of binder	Frequency	Percent	Cumulative Percent
AC-10	12	100.0	100.0
Total	12	100.0	

Is the viscosity of the binder for primer seal determined?

Response	Frequency	Percent	Cumulative Percent
Yes	12	100.0	100.0

No	0		100.0
	12	0.0	
Total		100.0	

Is the application rate of the primer seal binder determined?

Response	Frequency	Percent	Cumulative Percent
Yes	12	100.0	100.0
No	0	0.0	100.0
Total	12	100.0	

Have you been doing single or double sealing

Type of sealing	Frequency	Percent	Cumulative Percent
Single sealing	12	100.0	100.0
Total	12	100.0	

Aggregate size used for surface dressing projects

Aggregate size	Frequency	Percent	Cumulative Percent
10 mm	1	8.3	8.3
10 &14 mm	11	91.7	100.0
Total	12	100.0	

Most commonly used size

Aggregate size	Frequency	Percent	Cumulative Percent
14 mm	5	41.7	41.7
10 & 14 mm	7	58.3	100.0
Total	12	100.0	

Are more than one aggregate size used for double surface dressing? (no one answered)

		Frequency	Percent
Missing	System	12	100.0

Sizes used for double surface dressing (no one answered)

	Frequency	Percent	Cumulative Percent
Missing	12	100.0	100.0

Is quartzite aggregate used for surface dressing projects?

Response	Frequency	Percent	Cumulative Percent
Yes	0	0.0	0.0
No	11	100.0	100.0
Total	11	100.0	

Are electronic controls used on your bitumen distributors?

Response	Frequency	Percent	Cumulative Percent
Yes	10	83.3	83.3

No	2	16.7	100.0
Total	12	100.0	

Are electronic gate controls used on your chip spreader?

Response	Frequency	Percent	Cumulative Percent
Yes	2	16.7	16.7
No	10	83.3	100.0
Total	12	100.0	

Roller types used on surface dressing projects

Roller type	Frequency	Percent	Cumulative Percent
Static steel	0	0	0
Vibratory steel	0	0	0
Pneumatic-tired	11	100.0	100.0
Combination pneumatic/steel	0	0	100.0
Combination vibratory/pneumatic	0	0	100.0
Other	0	0	100.0
Total	11	100.0	

Period for stockpiling precoated chippings before use

Period	Frequency	Valid Percent	Cumulative Percent
7 days	7	100.0	100.0
Total	7	100.0	

What is done when stockpiled precoated chippings are not to be used immediately?

Action	Frequency	Percent	Cumulative Percent
Covered	12	100.0	100.0
Total	12	100.0	

What happen to precoated chippings which have dried out while stockpiled (before use)?

Action	Frequency	Percent	Cumulative Percent
Apply light precoating	7	100.0	100.0
Total	7	100.0	

Temperature at which bituminous material is heated before use

Temperature	Frequency	Percent	Cumulative Percent
150-200 degrees celcius	5	41.7	41.7
160-190 degrees celcius	7	58.3	100.0
Total	12	100.0	

Is the bitumen sprayed to the road surface at any temperature?

Response	Frequency	Percent	Cumulative Percent
Yes	0	0.0	0.0
No	12	100.0	100.0
Total	12	100.0	

At what temperature of the road surface is bitumen spraying avoided? (no one answered)

		Frequency	Percent
Missing	System	12	100.0

Specifications for ambient air temperature to do surface dressing work (degree celcius) (no one answered)

		Frequency	Percent
Missing	System	12	100.0

Specifications for pavement temperature to do surface dressing work (degree celcius) (no one answered)

		Frequency	Percent
Missing	System	12	100.0

How soon after the binder spray operation is aggregate spread (mins)?

Period	Frequency	Percent	Cumulative Percent
Immediately	12	100.0	100.0
Total	12	100.0	

Typical time span between aggregate spread and initial rolling (no one answered)

		Frequency	Percent
Missing	System	12	100.0

Number of roller passes required (no one answered)

	Frequency	Percent	Cumulative Percent
missing	12	100.0	100.0

Performer of the final inspection

Inspection performer	Frequency	Percent	Cumulative Percent
Client	8	66.7	66.7
Private consultant	4	33.3	100.0
Contractor	0	0	100.0
Total	12	100.0	

Number of people who perform the spection

Number of inspectors	Frequency	Percent	Cumulative Percent
Individual	0	0	0
Team	10	100.0	100.0
Total	10	100.0	

Is the calibration of binder spray equipment performed?

Response	Frequency	Percent	Cumulative Percent
Yes	12	100.0	100.0
No	0	0.0	100.0
Total	12	100.0	

Frequency of binder spray equipment calibration (no one answered)

	Frequency	Percent	Cumulative Percent
missing	12	100.0	100.0

Is the calibration of aggregate spreading equipment performed?

Response	Frequency	Percent	Cumulative Percent
Yes	12	100.0	100.0
No	0	0.0	100.0
Total	12	100.0	

Frequency of aggregate spreading equipment calibration (no one answered)

	Frequency	Percent	Cumulative Percent
missing	12	100.0	100.0

Tolerance allowed for binder spray rate (no one answered)

	Frequency	Percent	Cumulative Percent
Missing	12	100.0	100.0

Tolerance allowed for aggregate spready rate (no one answered)

	Frequency	Percent	Cumulative Percent
Missing	12	100.0	100.0

Are any special quality control tests employed by your agency? (no one answered)

		Frequency	Percent
Missing	System	12	100.0

Special quality control tests employed (no one answered)

	Frequency	Percent	Cumulative Percent
Missing	12	100.0	100.0

Which of the following will minimize defects in surface dressing projects?

Factor	Frequency	Percent	Cumulative Percent
	10	83.3	85.7
Construction procedure	0	0	85.7
Design method	0	0	85.7
Better binder	0	0	85.7
Better aggregate	2	16.7	100.0
Quality control	0	0	100.0
Double seal	0	0	100.0
Other	12	100.0	
Total			

The most common public/user complaint about surface dressing

Complaint	Frequency	Percent	Cumulative Percent
Loose stone	12	100.0	100.0
Road noise	0	0	100.0
Vehicle ride	0	0	100.0
Appearance	0	0	100.0
Other	0	0	100.0
None	0	0	100.0
Total	12	100.0	

APPENDIX C

SURFACE DRESSING CONSTRUCTION PRACTICES ASSESSMENT PHOTOGRAPHS

APPLICATION OF SEAL

C1

APPLICATION OF
SEAL


More
binder
Fewer
chippings

APPLICATION OF
SEAL

ROLLING

C5

APPLICATION OF
SEAL

C4

WASHING OF DUST FROM PRIMERSEAL PROIR TO SEALING

APPLICATION OF SEAL

C6

APPENDIX D

PHOTOGRAPHS OF SUFACE

DRESSING FAILURES

IDENTIFIED ON SOME ROADS

FAILURES: RAVELING

JINIJINI - BABIANEHA ROAD

TEMA TOWN ROADS (COMM. 2)

FAILURES: POTHOLES

BEREKUM – JINIJINI ROAD

D2