



SOUTH SUDAN CIVIL AVIATION AIRPORTS

PREVENTIVE MAINTENANCE PROGRAMME

JUBA INTERNATIONAL AIRPORT

*Managed and Operated by
South Sudan Civil Aviation
Airports Directorate
(SSCAAD)*

Engineering and Maintenance Department

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February 2026



***Preventive Maintenance Programme
Juba International Airport***

PREVENTIVE MAINTENANCE PROGRAMME

PART 0 - PREFACE

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0.1 Foreword

The goal of the preventive maintenance program is to provide a safe and operable airport infrastructure such as pavement, Visual Aids, and Electrical Systems at the least feasible cost. An effective maintenance program will provide us with sufficient information to allow us to assess how to obtain the greatest return for funds we spend.

The preventive maintenance program details the procedures we will implement to assure proper pavement, visual aids and electrical systems maintenance activities as with all endeavours in order to succeed, we will commit to providing sufficient resources to their maintenance program. The preventive maintenance program has been developed in compliance with SSCAA regulations stipulated in Manual of Standards Aerodromes of 2023 requiring aerodrome operators to establish a maintenance programme, including preventive maintenance to maintain a facility in a condition that does not impair the safety, regularity and efficiency of air Navigation.

The preventive maintenance program forms part of the aerodrome manual for Juba International Airport.

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0.2 Approval Page

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0.5 Abbreviations

A	
AASHTO	American Association of State Highway and Transportation Officials
AGA	Aerodromes and Ground Aids
AGL	Aeronautical Ground Lighting
AIP	Aeronautical Information Publication
ASTM	The American Society for Testing and Materials
C	
CCRs	Constant Current Regulators
CNS	Communication Navigation and Surveillance
H	
HPWB	High Pressure Water Blasting
I	
ICAO	International Civil Aviation Organization
J	
JMF	Job Mix Formula
JSL	Jetting System Limited
K	
KIA	Juba International Airport
L	
LHS	The left side of the vehicle from the driver's position, driver looking forward
M	
MSSV	Main Steam Safety Valve
MVS	Medium Voltage Switchgear
N	
NOTAM	Notice to Airmen
P	
PAPI	Precision Approach Path Indicator
PPE	Personal Protective Equipment
PTO	Power take-off
PWL	Percentage of material Within specification Limits



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R	
SSA	South Sudan Airports
SSCAA	South Sudan Civil Aviation Authority
RHS	The right side of the vehicle from the driver's position, driver looking forward
RPM	Revolutions Per Minute
RTLs	Runway Threshold Lights
T	
TDZ	Touchdown Zone
TSR	Tensile Strength Ratio
TWY	Taxiway
U	
UHP	Ultra High Pressure
UPS	Uninterruptable Power Supply
V	
VMA	Voids in the Mineral Aggregate



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JUBA INTERNATIONAL AIRPORT
***Managed and Operated by
Airports Directorate (SSCAA)***

PART 1 - PAVEMENTS

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1. INTRODUCTION

Pavement maintenance is a cyclic process, which is planned in order to extend pavement lifespan and efficiency. It is not performed to increase the pavement load-carrying capacity, but to make the pavement attain its design life. Maintenance is carried out through either delaying failures or by repairing apparent surface deterioration, hence reducing the need for early reconstruction.

Although Maintenance programs involve many activities and substantial costs, waiting until failures occur is not cost-effective either, since the cost of maintenance treatments is directly related to the condition of the pavement. This means the longer maintenance is delayed, the more deteriorated the pavement will be, thus incurring even higher costs. The true benefits of a good pavement are achieved when there is a consistent schedule of preventive maintenance strategies, which have to be performed while the pavement is still in a good condition (with only slight distress). In fact, as distresses grow, they result in structural failures that are not suitable for maintenance treatments, but need major rehabilitation or reconstruction instead.

In this line, conducting regular maintenance on a pavement that is still in a good condition, before the pavement falls into a condition where structural overlays or replacement is necessary, is very effective in extending the pavement lifespan and service efficiency.

1.1 The Airport Facilities

Juba International Airport has a single paved runway of 3100m long x 45m wide (plus 7.5m of paved shoulders on both sides of the runway), which is oriented at 10/28. The declared distances are detailed in the AIP.

The runway is linked to the northern apron by two taxiways and a single taxiway to the two southern aprons (A & B).

1.2 The Pavement Structure

The Juba International Airport was built with a length of 3100m, and width of 45m. The original pavement layers consisted of the natural subgrade (the soil layer that forms the foundation), lateritic gravel sub-base (500mm), stabilized laterite with cement and an asphalt surfacing base (100mm) plus a 70mm of overlaying layer.

For the past quarter century of the airport life, its pavements (runway, taxiway and apron) have gone through two major rehabilitation works. The first time, rehabilitation

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was designed and carried out in the eighties, which involved extending the runway to accommodate Boeing 747 as well as transforming the runway and the apron to comply with SSCAA manual of standards- Aerodrome standards.

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2. OBJECTIVE OF THIS PROGRAMME

Pavement Maintenance Programme is intended to describe maintenance categories and to set the course of actions to be taken for maintaining and improving the service life of the Juba International Airport pavements (runway, taxiway and apron), its access roads and drainage system over a long term; before any defects can affect the safety of aircraft operations.

The current programme, therefore, gives guidance to the maintenance personnel in their assessment and rating of pavement defects as well as their evaluation and selection of materials and treatment procedures. It also enables the airport authority to forecast maintenance needs and allocate adequate maintenance funds based on reliable data.

Although a pavement maintenance programme integrates mixed preservative activities and conventional treatments; generally, the operations carried out in the programme fall under three types as described below:

2.1 Routine Maintenance

Routine maintenance includes activities to be carried out after certain period of time such as; grass cutting at runway shoulders, drain cleaning, maintenance of paved markings and rubber removal. The procedures are as mentioned below. The grass cutting is done every two weeks in clear and graded areas and once per month per the flyover areas during growth season.

During dry season, cutting activities may vary due to growth rate but the required height of 20cm and 35cm should be respected in clear and graded area and flyover area respectively.

Drain cleaning

Every 3 months the drainage system is maintained and unclogged when it's rainy season and every after 6 months in dry season.

Maintenance of paved markings

Re painting of markings is done once the markings are faded and every after 2 years in general

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Rubber removal

Friction test is done every after three times per year depending on the traffic. The rubber removal shall be removed according to the friction test results showing the accumulation of rubber deposit on the runway. *Refer to appendix 4*

2.2 Preventive Maintenance

Preventive maintenance includes activities to be carried out on minor defects to prevent them from growing and becoming a major pavement distress and safety issue, thus affecting airport functions. These activities include, crack sealing, pothole patching, overlays, improving poor drainage etc. Such activities can also be planned and carried out within six months' period and avoiding interrupting aircraft operations.

2.3 Emergency Maintenance

The emergency (or reactive) maintenance includes unplanned activities carried out to restore a pavement section that has failed suddenly (such as blowout, severe pothole or landslide) and needs urgent repair before the section can become an obstacle to aircraft operations or ground moving equipment. This type of maintenance, depending on the location, may involve immediate closure of the affected section, thus the resulting disruption to airfield operations. This may also be coupled with a high cost due to urgent repair works and extra resources required to respond to the situation.

All three categories of maintenance are needed in a pavement maintenance programme in order to extend the pavement life up to its ideal design time and enhance airport performance in a cost-effective way. Nevertheless, preventive maintenance is to be highlighted as the most important type in a maintenance program; as it prevents a pavement from getting serious defects and requiring other sophisticated maintenance treatment.

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3 PAVEMENT MAINTENANCE STRATEGY

Pavement maintenance strategies include systematic and workable ways of assessing and organizing the information necessary to carry out proper distress treatment (repair) before pavement deterioration and the accompanying negative effects that impede the safety of aircraft operations and ground equipment movement.

Some of the operational requirements for airport pavements (e.g., runway, taxiway and apron) to be considered in the maintenance program include:

- 1) Smooth riding quality;
- 2) Good skid resistance;
- 3) Protection against fuel spillage;
- 4) Effective drainage of surface water;
- 5) Clean surface (free of loose particles);
- 6) Proper pavement marking and signage;

An effective maintenance program encompasses a full range of pavement inspections on a regular basis, in order to detect and take necessary action to stop distress propagation, before the pavement falls into a condition where structural replacement is necessary. The occurrence of pavement defects depends on several factors such as: the nature of the materials, workmanship, excessive traffic loading, the environmental factors, and pavement age. For local areas like apron and taxiway, the inspection should be carried out by walking on the pavement segments and assessing the surface conditions, while for long runway, a drive-by method will be used.

3.1 Inspection Procedure

The inspection is accomplished by a drive-by method, at a very low speed while observing and recording visible defects.

The distress identified through these inspections are treated as soon as possible, in order to prolong the pavement life and improve the level of airport services.

A preventive maintenance, involving asphalt overlay, is done after every 10 years of maintenance cycle to improve the ride quality and decrease the level of maintenance activities.

3.2 Inspection Schedule

Airfield pavement inspections are carried out at frequencies noted below by the assigned airfield pavement Engineer, or other qualified personnel assigned to do so. Records of all inspections are performed on checklists, and copies of the completed inspection

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reports are kept on file in Engineering and Maintenance office. (*See the format of inspection report and checklists in the Appendix 1 and Appendix 2 respectively*)

The assigned airfield pavement Engineer documents identify distress and notify the Manager Maintenance and the Director of Engineering and Maintenance department who will make arrangements for repair. Routine repairs are performed as soon as possible or deferred to regular cyclic repair schedules where appropriate. Emergency repairs are performed within 24 hours.

A. Bi-monthly Inspections - These inspections are done twice a month with drive-by inspections to detect unexpected changes in the pavement condition or any situation creating an unsafe condition.

B. Monthly Inspections - Each element of pavement are subdivided into sections. Stagger inspection of sections so that each element is fully inspected every 6 months.

C. 6-Month Inspections - All pavements are inspected for follow-up on required maintenance items. Obvious distresses, not previously identified, should be noted. The 6-month inspection are performed in the dry season (in July or August) after adverse seasonal weather conditions have ended. Preventive maintenance should be identified and recommended for budgeting

D. Annual Inspection - All pavements are to be visually observed for general performance and condition. Review and revise the maintenance programme, as necessary, at this time. Pavements that show increase in deterioration should be identified for inclusion in capital improvement plan.

The inspection frequency and typical defects to be noted are mentioned in table 3 below;

3.3 Data Storage

The physical pavement inventory records (e.g., inspection checklist, distress maps, work measurement sheets, cost information, etc.) for each maintenance cycle are stored in a proper manner that allows ease of retrieval by the maintenance team for performance monitoring. This is through keeping soft copies in computers and hard copies whenever necessary.

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4 PAVEMENT DISTRESS INVENTORY

Before carrying out an assessment and organizing the information for a pavement repair, the airfield pavement engineer has to understand the types of defects that may possibly occur on a paved area and their causes. During an assessment, he/she determines the types of distress that are non-progressive and have minor impact in the pavement life, and the types of distress that are progressive and may lead the pavement to a total failure. The airfield pavement engineer finds out the cause of a failure so that the maintenance is aimed at solving the cause and not just the symptoms.

4.1 Pavement Assessment Procedure

The steps used in assessing and organizing information for pavement maintenance are as follows:

1. Dividing the pavement into sections and assessing the occurrences (visible failures),
2. Rating the extent and severity of each type of pavement failure observed, as well as its location,
3. Analyzing the possible causes, and scheduling the work to be done for repairing the failure or damage;
4. Quantifying the repair units and estimating cost of the scheduled work
5. Implementing the repair work in time, with available funds and monitoring the pavement performance.

During pavement assessment, each distress category and its location are identified and located on a map, to note any unique conditions (severity), and possibly to study the likely causes before making recommendations for treatment.

The forms are well documented, including dates and the name of the inspector. The inspector should record the quantity and severity of the distress as they exist; since, recording distress at a low or higher severity than the actual condition will most likely invalidate the treatment and cost estimation.

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4.2 The Common Asphalt Pavement Distresses

The prominent distresses for asphalt pavements, and the recommended treatments are shown in the following table:

Table 3: Common asphalt pavement distresses and the treatment method

TYPE OF DISTRESS	POSSIBLE CAUSE	4.2.1.1 TREATMENT
Fatigue (Alligator) Cracking 	✓ Excessive loading on asphalt ✓ Weak pavement layers ✓ Thin surfacing layer or base ✓ Poor drainage (wet layers) ✓ Shrinkage/brittle aged bitumen ✓ Exceptionally low temperature	✓ Remove and repair the base before placing new asphalt
1. Block Cracking 	✓ Old mix (aging of bitumen) ✓ Dry mix (during placement) ✓ Fine mix with low penetration bitumen & absorptive aggregates ✓ The reflection of shrinkage cracks from the underlying bound pavement layers.	✓ Surface treatment (overlay)



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2. Edge Cracks 	✓ Lack of lateral support ✓ Shrinkage of the asphalt ✓ Weak base or subgrade layer ✓ Settlement of underlying material ✓ Heavy traffic or vegetation along edge	✓ Improve drainage, ✓ Remove vegetation at edge ✓ Fill cracks with bitumen emulsion or slurry
3. Longitudinal / Transverse Cracking 	• Poorly constructed paving joint crack • Shrinkage of the asphalt layer • Daily temperature cycling • Cracks in an underlying layer that reflect up through the pavement • Longitudinal segregation caused by the improper operation of the paver	• Improve drainage by removing the source that traps the water • Seal crack or fill with asphalt emulsion slurry or light grade of asphalt mixed with fine sand. • Provide side drains • Crack seal/fill
4. Reflection Cracking 	• Differential movement between the asphalt and concrete layers • Can deteriorate further under heavy traffic	• Crack seal/fill



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5. Slippage Cracks 	• Lack of a good bond between surface layer and the course beneath due to dust, oil, dirt, rubber, water and other non-adhesive material • Tack coat has not been used • Mixture has a high sand content • Vehicular turning or stopping movements in pavements with a low-strength surface mix	• Partial or full-depth patch
6. Corrugations & Shoving 	• Mixtures too high in asphalt • Low air voids • Fine aggregate content too high • Excessive moisture or contamination in the base • Smooth or rounded aggregate • Incorrect asphalt grade	• Deep or full-depth patch
7. Rutting 	• Consolidation or lateral movement of any of the pavement layers or the grade under traffic • Insufficient design thickness • Lack of compaction • Weaknesses in the pavement layers due to moisture infiltration • Weak asphalt mixtures	• Mill and overlay • Apply thin surface patch



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8. Depressions 	• Settlement or failure in the lower pavement layers • Improper construction techniques	• Cold mill and overlay • Thin surface patch
9. Upheaval/Swell 	• Expansive soils (which swell in the presence of moisture) • Frost heave (in which ice lenses grow beneath the pavement, causing the pavement to crack)	• Full-depth patch
10. Utility Cuts/Patch Failure 	• A portion of a pavement has been removed and replaced • A portion of a pavement where additional material has been added • Poor installation techniques such as inadequate compaction, inferior or improper materials • Failure of the surrounding or underlying pavement	• Replace patch with deep or full-depth patch



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11. Raveling/Weathering 	• Asphalt binder has hardened excessively • Poor-quality mixture • Usually requires the presence of both traffic and water to occur	• Any surface treatment or thin overlay
12. Bleeding 	• Improperly constructed seal coat • Too much asphalt in a mix • Too heavy prime or bond/tack coat • Excessive sealant in the cracks or joints under an overlay • Over-compaction by traffic	13. Chip Seals, Sandwich Seals, thin overlay
13. Pothole 	• Continued deterioration of another type of distress, such as cracking, raveling, or a failed patch work • Poor surface mixtures • Weak spots in the base or subgrade	• Partial or full-depth patching

4.3 Distress Measurement

Table 4 below summarizes various types of distress and unit of measurement to be used during inspections.

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Table 4: The common pavement distresses and unit of measurement

DISTRESS TYPE	UNIT OF MEASURE
Cracking - Fatigue Cracking - Block Cracking - Edge Cracking - Longitudinal Cracking - Reflection Cracking at Joints - Transverse Cracking	m^2 m^2 m^2 m Not measured Number & m
Patch and Potholes - Patch Deterioration - Potholes	Number & m Number & m^2
Surface Deformation - Rutting - Shoving	mm Number & m^2
Surface Defects - Bleeding - Raveling	m^2 m^2



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5 MAINTENANCE OF UNPAVED AREAS

The maintenance of unpaved areas on an airport is essential for the following major reasons:

- a. safety of aircraft on operating areas (this concerns runways, taxiways, strips and runway end safety areas);
- b. safety of airborne aircraft (this concerns areas on the airport and in its nearby vicinity within the defined flight pattern where trees and bushes may grow);
- c. Reducing bird hazards to aircraft (this concerns grassland within the airport's boundaries).

The maintenance of unpaved areas need not necessarily be carried out by the staff of the airport operator. The airport operator may contract with nearby farmers who will take care of the task upon advice. The farmers can use the grass for cattle feed and can provide their own equipment. Work performed by contractors must be monitored by authorized personnel to safeguard air traffic safety requirements.

5.1 Maintenance of Green Areas within Strip

Requirements as to the quality of surface grading and bearing capacity of strips and shoulders are specified in Chapter 6 of SSCAA manual of Standards-Aerodromes

After construction work in strip areas, attention should be paid to retain the specified surface conditions. Where the bearing capacity has been reduced it must be improved by soil compaction. Humps and depressions should be eliminated. To protect the surface against blast erosion a sound matting of grass should be provided. On normal soil this condition can be achieved by seeding with grass. Poor soils will need fertilizing. Sometimes this can be accomplished by adding arable soil or humus from composted hay.

The use of urea for winter service on runways and taxiways will often kill the grass along the edges of treated pavement areas. If it is not possible to avoid this damage by reducing urea consumption, seeding must be repeated regularly after the winter period.

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In many cases soil replacement will become necessary. A biologically acceptable sealing material may have to be used for fixing the loose soil containing the fresh seed until the grown grass is capable of protecting the soil against blast erosion. Where poor drainage along the edges of pavement increases erosion effects, hard surface shoulders may have to be built to overcome the problem.

Grass in the strips should be the height required in the Wildlife Hazard Management Plan. Regular mowing will be necessary to keep the grass low, the frequency depending on the climate. The cut material should be picked up since otherwise it might be sucked into jet engines, thus creating a potential hazard to aircraft operation. Where applicable, growth retardant can be used to control growth rate. Its application, however, is often limited by national or municipal rules for groundwater protection, since some growth retardant chemicals can detrimentally affect the quality of drinking water. As these chemicals may also be expensive, it is useful to consider their cost effectiveness in comparison to more frequent mowing.

Mowing attracts birds as the freshly mowed areas are rich in bird food. To minimize the ever-present risk of bird strikes, mowing should take place preferably before periods of lowest air traffic. In other cases, bird protection measures may have to be increased after mowing to keep the collision risk low.

5.2 Maintenance of Grass on Unpaved Runways and Taxiways

Grass height should be kept as low as practicable on unpaved runways and taxiways as rolling drag increases markedly with grass height. Take-off distances can increase by some 20 per cent when grass on runways is too high. For treatment refer to Maintenance of green areas within strips section.

5.3 Maintenance of Green Areas outside Strips

The major reason for maintenance of green areas of an airport outside the strips is to control animal life within the airport boundary. While generally it is not too difficult to keep wild animals that might create collision risks out of the area, for instance by means of fencing or

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hunting, the bird population is very difficult to control. The aim of measures concerning grass surface cultivation is to minimize bird population in order to keep the bird strike hazard as low as possible.

5.4 Maintenance of Green Areas outside Strips

Maintenance of grass surfaces should be determined by the individual needs of the site, i.e. the local species of birds and their habits. Most species prefer low grass areas for food searching; conditions for finding food are better and watching out for enemies is facilitated by good visibility in all directions. For keeping large numbers of birds from settling, the optimum grass height has been observed to be 25 cm in clear and graded area and 35cm in the rest party of runway strip. Only the smallest birds of body mass less than 20 g will prefer such meadows for residence. They are, however, less dangerous for aircraft than heavier birds.

Recent research indicates that dry grass land offers more food to birds than wet land. Draining should therefore be restricted to areas such as unpaved runways, taxiways and strips where good bearing capacity of the soil is necessary in the interest of air safety. In other parts of the airport swampy patches can be tolerated as long as ponds are precluded that would attract aquatic birds.

When the grass height is kept to not less than 25 cm, as protection against birds the mowing frequency will be low. One or two cuttings per year will suffice in many climatic areas to meet this grass height requirement. The grass should be mowed down to a height of about 10 cm and the cut grass should be picked up to prevent detrimental "choking" effects to the grass mats under a probably heavy hay coverage. Consequential composting effects on the mat also produce great numbers of microscopic organisms, insects, worms etc., and again, attract birds to the area. Since immediately after mowing the area attracts birds searching for food, the most favorable period for mowing with regard to local birds' habits should be chosen.

Maintenance work on grass lands should include special methods to diminish the number of mice. Where mice population exceeds a "normal" rate, birds of prey may be attracted which,

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due to their flight techniques and body mass, create the most severe bird strike hazard. Mice populations will then have to be controlled by using suitable chemicals.

Trees and bushes need no special maintenance except for controlling their height. When trees penetrate an obstacle limitation surface they should be shortened. One technique is to cut the trees or bushes but leave their roots in the ground so that they may sprout again. To discourage birds from settling, all bushes carrying berries should be eliminated from the airport.

Note: The height of trees in the approach and departure areas outside the airport boundary must be controlled for air traffic safety reasons. To minimize the extent of cutting or shortening of trees, cutting can be done more frequently.

5.5 Equipment for Maintenance of Grass

As there are different type of mowers available the choice should be determined by local conditions, i.e. the size of the area to be maintained and the types of grass and plants on it.

The following types are being used on airports:

- a. Spindle mowers
- b. Cutter bar mowers
- c. Rotary mowers
- d. Flail mowers.

Spindle mowers

Normally spindle mowers are trailing equipment. They are efficient on areas of low grass height, such as unpaved runways, taxiways etc. With the mowers arranged in groups (so-called mounted gangs),

Strips up to 8 m wide can be mowed in one run. Under favorable conditions the capacity can be 7 hectares per hour. Separate loaders are required to pick up the cut grass.

Cutter barmowers

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Cutter bar mowers are appropriate for both high and low grass. The cutter bar is generally a separate piece of equipment attachable to various tractor types, often in combination with a trailed self-picking hay loader. The cutting width is less than 2 m, thus resulting in a low mowing capacity of about 1/2 hectare per hour. A special type of bar mower, the so-called chaff-cutters, cut strips up to 4 m wide and, in combination with hay loaders

Rotary mowers

Rotary mowers are specialized on extremely high grass. They are produced in trailer form and mow a strip up to 5 m wide, thus achieving a mowing capacity of 4 hectares per hour.

Flail mowers

The flail mowers are most effective for meadows with harder types of grass and plants, including low bushes. They are attachable to various types of towing equipment, have a maximum mowing width of 5 m and achieve a capacity of some 2 hectares per hour.

5.6 Treatment of Cut Grass



Since grass should be removed immediately after mowing as a protection against birds and for other safety reasons, considerable quantities of cut grass will be collected on larger airports. If grass cannot be given away to nearby farmers or ranchers, two options exist:

- a. composting at a suitable site and recycling as fertilizer for the airport,
or
- b. for sale to gardeners or farmers

Cut grass needs approximately three months for composting before it is usable;

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6 RUNWAY AND TAXIWAY CONTAMINATION

Runway and taxiway contamination. Objects to be found on runways and taxiways stem from the following sources:

- a. Debris from damaged pavement
- b. Debris from joint sealings
- c. Rubber debris from aircraft tires
- d. Stones from grass mowing
- e. Metal or plastic parts from aircraft
- f. Sand and soil from heavy storms or engine blast of aircraft
- g. Dead birds or other small animals hit by aircraft.

6.1 Visual checks

Visual check of Movement, runway strip drainage system areas is necessary upon advice airport operation officer on duty or pilots on the existence of objects or debris. Special attention should be paid to the cleanness of runways and taxiways, when construction work on or near operational surfaces is going on. When construction machines or trucks use surfaces used also by aircraft, more frequent checking than normal is recommended.

6.2 Frequency of sweeping

Frequency of sweeping. Surfaces intended to be used by aircraft and ground vehicles have to be swept the apron can be taught to watch and visually check the regularly. The interval between sweepings depends on local needs and experience. Certain areas such as aircraft stands or freight handling zones at busy airports may require sweeping at **least once a day**.

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6.3 Sweeping equipment.

To accomplish the task of regularly sweeping all paved portions of the movement area, the use of truck-type cleaning equipment is practicable. The efficiency of the sweeper required depends on the size and traffic volume of the airport.

Integral sweeper-blowers as used for snow removal have the highest efficiency. Truck-type street sweepers are the right equipment for sweeping populated apron areas, service roads, access roads, walkways, parking lots and even hangar

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7 DRAINAGE

7.1 General

Drainage of the airport area is necessary:

- a. to maintain sufficient bearing strength of the soil for the operation of vehicles and/or aircraft at any time during the year
- b. To minimize the attraction of birds and other animals representing a potential hazard to aircraft.

Surface drainage is required to clear all parts of the movement area of standing water and prevent the formation of ponds or puddles. The quick run-off of water is particularly important on runways to minimize the hazard of **aquaplaning**.

7.2 Aquaplaning or Hydroplaning

Aquaplaning or Hydroplaning can occur when landing on a runway surface contaminated with standing water, slush, and/or wet snow. It can seriously affect ground controllability and braking. The three basic types of hydroplaning are:

- a. Dynamic hydroplaning,
- b. Reverted rubber hydroplaning, and
- c. Viscous hydroplaning.

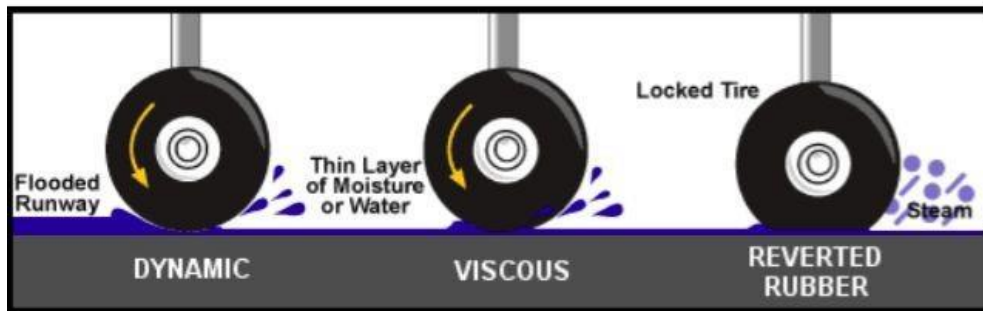
Any one of the three can render an airplane partially or totally uncontrollable any time during the landing roll.

Basic Types of Hydroplaning

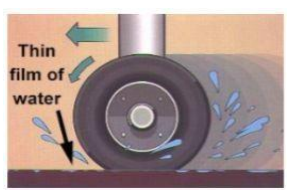
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Dynamic Hydroplaning

Hydroplaning Type	Cause	Occurs when
Dynamic 	The water pressure equals the weight of the Aeroplane, the tire is lifted off the runway surface and stops rotating. Directional control and braking is lost.	High speed of the airplane and the depth of the water increase, resulting in the formation of a wedge of water beneath the tire.
Viscous 	The tire cannot penetrate the fluid and the tire rolls on top of the thin film. Requires a smooth or smooth acting surface such as asphalt or a touchdown area coated with the accumulated rubber of past landings. Such a surface can have the same friction coefficient as wet ice.	Occur at a much lower speed than dynamic hydroplane Viscous hydroplaning is due to the viscous properties of water.
Reverted Rubber	The tire skidding generates enough heat to cause the rubber in contact with the runway to revert to its original uncured state. The reverted rubber acts as a seal between the tire and the runway, and delays water exit from the tire footprint area. The water heats and is	Occurs during heavy braking that results in a prolonged locked wheel skid. Only a thin film of water on the runway is required to facilitate this type of hydroplaning.



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	converted to steam which supports the tire off the runway.	
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7.3 Layout

For practical reasons an airport should have two drainage systems,

- a. one system which drains “clean” areas such as runways, taxiways, aprons, service roads, public roads and parking lots,
- b. and another system which drains areas more likely to be polluted by oil, grease or chemicals such as hangars, aircraft maintenance areas, workshops and tank farms

7.4 Drainage for the clean areas

The drainage system intended to serve the "clean" area may be built in a way to sink the drain water (from precipitation) into the adjacent ground. Where the natural ground is not suitable to drain the surface water it must be collected in slot drains or other artificial sinks which are connected with a drain pipe, culvert or canal ducting the water to nearby creeks, rivers, lakes, etc. To protect these natural water courses from pollution, collector basins with oil separators should be installed.

7.5 Drainage for the areas likely to be polluted

The drainage system intended to serve hangars, workshops, tank farms and other pollutant-generating areas should be connected to a regular sewage system which ducts the water to sewage treatment plants. For pre- treatment the collected drain water should pass through fuel separators before entering the sewage culvert.

7.6 Compliance with national or local regulations

Generally, the airport operator will have to comply with rules on water treatment issued by the national or local authorities responsible for water conservation, water supply and

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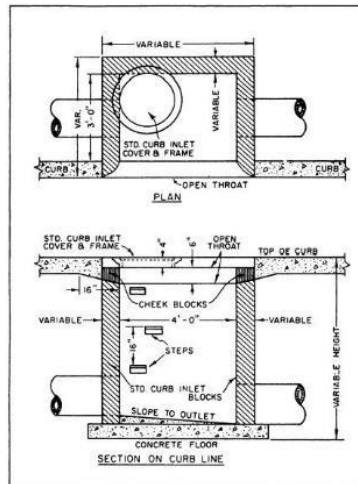
environmental protection. The layout of airport drainage. Systems depends on local conditions and so does the maintenance.

7.7 Time intervals for cleaning slot drains

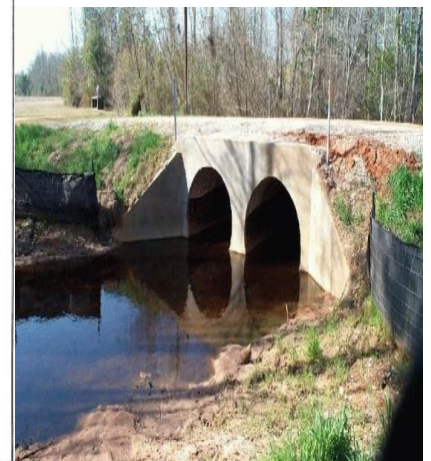
The time intervals for cleaning depend on local experience with drain lines. One cleaning action per year has proved to be the minimum. When sand has been used for winter services a second cleaning right at the end of the winter is recommended. Regular inspections should be carried out to detect the need for additional cleaning. After sandstorms or heavy rain showers which flood unpaved areas near the slot drain, immediate checking of the drain capacity is highly recommended.

7.8 Drain pipes or culverts between surfaces and collector basins

Drain pipes should have manholes at intervals to allow cleaning the pipe of deposits. Sections between consecutive manholes **should not exceed 75 m** and man-holes should have a cross section of at least 1Sq.m. The cleaning can be accomplished by means of flushing with water at high pressure.



Drainage man-hole



Culvert

7.9 Time intervals for cleaning drain pipes or culverts

Time intervals for cleaning depend on local experience. Cleaning **once a year seems to be the operational minimum** to ensure good drainage capacity of pipes and culverts collecting surface water from precipitation. Where the cross section of the pipes is less than 30 cm, cleaning twice a year may be necessary.

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8 RUNWAY FRICTION MEASUREMENTS AT JUBA INTERNATIONAL AIRPORT

Flight safety is the main reason for measuring friction. As the transport airplanes became larger it became also more important to check friction in a better way reasons for friction measurements are as follows:

- a. Determine friction characteristics of runway under winter condition;
- b. Verify friction characteristics of new or resurfaced runways;
- c. Assess periodically the slipperiness of paved runways when wet;
- d. Assess the effect on friction when drainage characteristics are poor;
- e. Assess friction of runways becoming slippery under unusual condition;
- f. The needs of rubber removal

8.1. Measuring the Runway friction coefficient at KIA

a. Type of the equipment

S/N	Juba International Airport	
1	Type of the equipment	ASFT CFME T-5
2	Manufacturer	ASFT industries AB
3	Serial No	SFT030
4	Address	Piledalsvägen 51. 271 73 Köpingbro Sweden www.asft.se/Phone: +46 411 651 00

b. Measurement procedures

- a. Before taking measurements calibration of the equipment is done (load calibration and friction calibration) according to ASFT operating manual to assure accuracy and precision of the machine.
- b. Measurement procedures is well defined into the ASFT operating manual
- c. Measurement can be done under self-watering system or dry system.
- d. Friction values are produced by the computer automatically.
- e. Results are stored automatically into machine and shared to all concerns departments.

8.2. Friction survey frequency

Referring to the article 10.15.2.4 of SCAA Manual of standard- Aerodrome on friction survey frequency and further to SSA Aircraft traffic records of 39 landings per days the measurement should be done once every three months.

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However, the measurement will also be taken at any time depending on the runway conditions, incidents, before and after runway maintenance.

Recommended Friction Survey Frequency (extract from Annex 14 – Attachment A)

Daily turbo-jet aircraft arrivals for runway end	Annual aircraft weight for runway end (million kg)	Minimum Friction Survey Frequency
Less than 15	Less than 447	Once per year
16 to 30	448 to 838	Once every 6 months
31 to 90	839 to 2404	Once every 3 months
91 to 150	2405 to 3969	Once every month
151 to 210	3970 to 5535	Once every 2 months
Greater than 210	Greater than 5535	Once every week

8.3. Analysis of Friction Values

Referring to the Computer Evaluation of Friction Test Data a physical inspection is done to check the reason why the friction value at some points is under the minimum friction value. Once the friction values are under the minimum friction value and after identifying the cause, an alert should be done and corrective measures shall be taken.



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9 RUBBER DEPOSITS ON THE RUNWAY

9.1 Sources of Rubber deposits:

Aircraft wheels contact the runway surface at high speed on touchdown resulting in a build-up of rubber deposits. Due to the friction-induced high temperature in the wheel contact area the rubber melts and is smeared into the surface texture. The rubber film is sticky and with the passage of time increases in depth. Layers of up to 3 mm thick may build up within 12 months in the touchdown zone of a busy runway.

9.2 Effects of Rubber deposits:

The effects of rubber deposits on the runway are as follows: -

- 9.2.1 Ruber deposit on the runway surface blocks the drainage under the wheel in wet conditions by filling the grooves in the pavement.
- 9.2.2 Rubber deposit makes the runway slippery and affects the braking action of aircraft in wet condition.

9.3 Aim of removal of rubber deposits:

The aims of rubber removal from runway surface are the following:

- a. to restore the original macro roughness of the pavement surface;
- b. to provide good drainage under the wheel; and
- c. to restore braking action of aircraft in wet conditions.

9.4 Methods of removal of rubber deposits:

Three methods of removing rubber deposit are described below:

- a. Mechanical grinding,
- b. Chemical method,
- c. High pressure water blast.

The three methods are all effective; however, they are different in terms of speed, cost and erosion of surface material.

Refer to the appendix 4 for detailed procedures for rubber removal

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9.5 Mechanical grinding:

Milling method has proven to be satisfactory. Milling rollers composed of metal discs on a rotating shaft are passed over the surface. The distance between the shaft and the pavement is controlled so that the discs just hit the pavement, but without much pressure. The milling not only removes the rubber layer but, depending on the height control of the roller shaft, also roughens the pavement surface. While this can effectively improve the surface texture, the milled depth should be kept as small as possible.

The mechanical methods must be applied very carefully to avoid severely damaging inset lights and joints between slabs. Sweepers must follow the milling vehicle to clean the strip of dust and rubber debris.

9.6 Chemical method:

In the Chemical method, chemicals dissolve not only rubber but also paint markings and bituminous material, and as such, there is high possibility of erosion of the bituminous pavement, and the markings shall be required to be repainted after each cleaning.

9.7 High pressure water blast method:

Where water supply is not a problem, the high pressure water blast method is most efficient. As opposed to the chemical method, there are no special measures required for environmental protection.

9.8 When the rubber deposits shall be removed:

Rubber deposits shall be removed from runways when friction measurements under wet conditions indicate significant loss of braking quality in critical runway sections.

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10 AIRFIELD PAVEMENT MARKING

10.1 General

1. This item shall consist of the painting of numbers, markings, and stripes on the surface of runways and taxiways applied in accordance with these specifications and at the locations shown on the plans, or as directed by Engineer.
2. The markings shall be continuous or intermitted lines, arrows or symbols and shall be of the color and dimensions shown on the drawings or as directed by Engineer.

Markings on all bituminous surfaces shall be “paint, traffic and airfield marking, waterborne” and on concrete surfaces “Emulsion paint for external use”.

10.2 Materials

Paint shall meet the requirements of Fed. Spec TT-P-1952 (water emulsion base) or British Standard BS (3262) or other equivalent approved international standard, with additional specific requirements stated herein. Regarding the characteristic of paint, the yellow pigmentation shall respect the colorimetric limits defined in chapter 8 of SCAA manual of standards- Aerodrome

10.3 Construction methods

Markings maintenance renovate the pavement for providing perspective information, alignment guidance, and location, runway and threshold identification.

Certain criteria should be evaluated to determine when markings require maintenance because they do not necessarily need to be remarked each year. Some of those criteria are:

1. Faded colors or appearance.
2. Poor nighttime visibility or retro-reflectivity.
3. Existing markings are worn 50 percent or more.
4. Existing markings are covered with contaminants

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10.4 Scope of Work

The airfield pavement work at Juba International Airport is funded by South Sudan Airports and executed by Civil Works and Maintenance Contactor. It is split into following Steps:

- i. **Quantifying surface needs to be painted:** Juba International Airport painted pavement areas are; Threshold, Runway turn pad, Runway designation, Runway centre line, aiming point, Touchdown Zone and Runway side strip, Apron safety line, Equipment staging areas and **are always in white**. There are also Taxiway Centre line, Runway holding position, Aircraft stands, Apron safety line, Road holding position that shall be in **yellow**

- ii. **Preparation of pavement surface**

Immediately before application of the paint, the surface shall be dry and entirely free from dirt, grease, oil, acids, laitance, or other foreign matter, which could reduce the bond between the coat of paint and the pavement.

The area to be painted shall be thoroughly cleaned by sweeping and blowing and scrubbing with water as required to remove all dirt, laitance and loose material.

Areas, which cannot be satisfactorily cleaned by brooming and blowing, shall be scrubbed as directed with a water solution of tri-sodium phosphate (10% Na₃PO₄ by weight) or an approved equal solution. After scrubbing, the solution shall be rinsed off and the surface dried prior to painting.

On new concrete surfaces any laitance and/or curing compound shall be removed by wire brushing or other approved means before applying the markings.

If specified by the paint manufacturer a tack coat shall be provided on old and/or new concrete surfaces.

For cement concrete pavements, no paint shall be applied until the surface in the area to be painted is clean of curing compound.

Sand blasting or high-pressure water shall be used to remove curing compound. When necessary, a special thinner as recommended by the manufacturer shall be applied for concrete surfaces

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iii. Test Section

Contractor to prepare a marking test section of at least 50 m, demonstrating that equipment and procedures for preparing and applying the paint material shall provide a satisfactory pavement marking.

It is not allowed to spray paint on any other surface anywhere else on airside, other than the test section. For testing of the equipment and nozzles, a tray shall be used.

iv. Application

- a. Ensure all pavement closures have all required items in place, such as safety cones, warning tapes, barricades, etc.; and all NOTAMs have been issued for affected areas of the airfield.
- b. Paint shall be applied at the locations and to the dimensions and spacing shown on the drawings.
- c. Paint shall not be applied until the Engineer has approved the layout and condition of the surface.
- d. The paint shall be mixed in accordance with the manufacturer's instructions and applied to the pavement with a marking machine.
- e. Paint shall be applied to clean, dry surfaces, and only when the air and pavement temperatures are at least 5 °C [40 °F] and not more than 35 °C [95 °F], and when the weather is not foggy or windy. A lower temperature based on paint manufacturer's printed recommendations may be permitted when approved by the Engineer. Do not paint when wind displaces paint spray or glass beads or when surface is damp. All emptied containers shall be returned to the paint storage area for checking by the Engineer. The containers shall not be removed from the airport or destroyed until authorized by the Engineer.
- f. When retro-reflective markings are applied, the additional surface application of the glass beads shall be immediately distributed to the surface of the pigmented binder and embedded at the rate as required to provide adhesion and reflection.
- g. A time interval as recommended by the paint manufacturer shall elapse from the laying time of the bituminous surface course and the cement concrete to the time of marking the pavement.
- h. The paint shall not curl or discolour when applied to bituminous surfaces.

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All Markings paint shall be applied at the rate of 2.6 ± 0.1 square meters per liter

If the paint material is applied by brush, the surface shall receive two coats. The first coat shall be thoroughly dry before the second coat is applied.

v. Protection

After application of the paint, all markings shall be protected from damage until the paint is dry.

The fresh paint shall be protected from all traffic, both vehicular and pedestrian, and from injury or damage of any kind.

The Contractor shall be responsible and shall erect or place suitable warning signs, flags, and/or barricades, protective screens, or coverings as required.

All surfaces shall be protected from spatter, splashes, spillage, drippings, etc. of paint or other materials.

10.5 REMOVAL OF EXISTING PAVEMENT MARKINGS

1. General

Existing marking of stripes which are to be abandoned or removed because of changes in the pattern or in the operating procedures, or because the thickness of the layers is excessive, shall be obliterated by the best method suited for the purpose, as decided by the Supervisor.

2. Method of Removal

Obscuring of existing markings will not be applied except as a temporary measure.

Markings removal at Juba International Airport will be done by using water-jetting blasting with rubber removal truck

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11 COST ESTIMATION

Maintenance costs depend on the work location, method of operation (either hand work or machinery), type of materials to be used, quantities, and time allowance. Past maintenance rates could be used roughly, as a baseline for projecting the cost of scheduled work. However, realistic estimates should come from the current construction costs in the local industry. The treatment schedule and work quantities should be ready for the contractors to assess and bid as soon as possible; since, cost-effective maintenance is completing the right repair on a pavement at the right time.

12 TRAINING

The personnel dedicated for airfield pavement inspection shall basically have knowledge of airside safety, and special training in ICAO Annex 14 implementation, Airport Pavements Maintenance and management, etc.

The training programme for pavement Engineer, or other qualified shall be established and submitted to RAC management for approval in annual budget when necessary.

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13 APPENDICES

APPENDIX 1: PREVENTIVE MAINTENANCE PROCEDURES

1. GENERAL REQUIREMENTS FOR WORKS

1.1. Outline description of the works

The hereby preventive maintenance procedure is written as part of preventive maintenance program for Juba International Airport, and define the scope works required of airfield pavement repair such as crack seal repair, potholes repair, milling, resurfacing, asphalt overlay, etc....

1.2. Abbreviation and definitions used in these specifications

1.2.1. Application scope

The preventive maintenance procedure shall apply to all of the airfield works be executed at Juba International Airport, and shall be read in conjunction with all other documents that form the preventive maintenance program.

Any matter not provided in this document shall be determined through consultation between the Engineer and the Contractor.

1. Applicable standards

Generally speaking, all kind of material used for the works shall be in accordance with the current standard in South Sudan or International standards. In the specifications, qualities of materials and equipment to be used and methods of sampling and testing shall be stipulated with the following codes and standards.

- ✓ ASTM: American Society for Testing and Materials.
- ✓ AASHTO: American Association of State Highway and Transportation Officials.
- ✓ Fed Spec: Federal Specifications and Standards and supplements, amendments, and indices thereto are prepared and issued by the General Services Administration of the Federal Government.
- ✓ “BS” and “CP”: British Standard and British Standard code of Practice published or issued by the British Standards Institution, 2 Park Street, London W1A 2BS. All BS and CP’s referred to in the contract shall refer

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to the editions current at the time of tendering, including all amendments published thereto, unless some other edition is specifically referred to in the contract

- ✓ NFP : French Standards AFNOR.

1.3. Obligations work and restrictions

1. The contractor shall:
 - a) Comply with all enactments, regulations and working rules relating to safety, health and welfare;
 - b) Ascertain and comply with the regulations of the civil police affecting the execution of the works;
 - c) Arrange for general purpose industrial safety helmets to BS 5340; 1975 to be provided for use by all persons on site who could be in danger of head injury and endeavor to ensure that helmets are worn when necessary, by all persons;
 - d) Not use the site for any purpose other than carrying out the works;
 - e) Not display or permit advertisements to be displayed on site;
 - f) Prevent trespass on adjoining property by his work people;
 - g) Comply with all Government laws governing the importation licensing, etc. of all plant and machinery whether new or second-hand.
2. a) The site lies within the Security Controlled Area of Juba Airport and unauthorized access is prohibited. The contractor must provide the Engineer at least one week prior to the commencement of works a list of all personnel, machinery and plant that will be entering the site that will make the necessary arrangements for the issuance of "the airport permits". These permits will be used by the contractor's staff only for access to the site and only during the site working hours. If used at places outside the site or outside the working hour's staff are liable for prosecution.
- b) Movements through the airport must be restricted only to the site and staff must follow the pre-arranged and approved routes. They must exercise extra caution when moving near aircraft. They must follow instructions of keeping safe distances from aircraft or stopping when instructed by the airport police or other authorized airport personnel. The speed limit within the airport area is 20Kmph.

1.4. Prevention of nuisance or accident

1. Where the works are to be carried out adjacent to occupied premises, the contractor shall proceed with the works in such a manner as to cause the minimum inconvenience and nuisance to occupants and users. The contractor must take all necessary precautions including regular watering of any service roads and other airport earthed areas as directed to prevent any inconvenience from dust. It is expressly stated that the contractor shall be liable for damages caused by dust resulting from the construction works. Access to properties adjacent to the site shall be maintained at all times.

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2. All Airport pavements must be swept clean from any debris or dust arising from the execution of the works with an approved mechanical brush sweeper.
3. Flying operations and aircraft movements will take place during /throughout the period of the contract. The contractor shall comply at all times with the directions of the Engineer regarding any possible stoppage of work arising from such flying operations and aircraft movements. If such instruction is issued and as a result work has stopped more than one hour, an extension of time will be granted without extra payment to the contractor.
4. All reasonable precautions shall be taken by the contractor to prevent any pollution being caused by the execution of the works.
5. The contractor shall ensure that the risk of infestation is minimized by the adequate arrangements for the disposal of food waste or other matters attractive to pests. Should infestation occur, the Engineer shall be informed immediately

1.5. Complaints and claims by third parties

During the course of the work, complaints and claims may arise from the public or from various authorities. The contractor shall satisfy the Engineer that he is dealing with all such matters without delay until appropriate clearance certificates from any authority concerned are produced by the contractor.

1.6. Setting out

The contractor shall set out the works in accordance with the Drawings supplied by the Engineer or as instructed in writing by the Engineer. The contractor shall construct and maintain any external survey points which are required for the accurate location of the center line of the works.

1.7. Drawings of survey

1. The drawing for the purposes of recording initial, monthly and final surveys shall be prepared by the contractor in Softcopy to the satisfaction of the Engineer, and unless otherwise agreed shall not be larger than A0 size including 10mm margin in around. The scales of the plans and cross sections shall be agreed between the contractor and the engineer.
2. Three copies of each agreed drawing shall be submitted to the Engineer's Representative and transparency of the initial and final surveys shall be submitted to the Engineer on the completion of the works.

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1.8. Working drawing

- (a) Before any part of the work is put in hand, contractor shall prepare and submit for the approval of the Engineer copies of any further detailed working drawings and schedules which may be required for such part of the work, and at the same time call the attention of the Engineer to any alternative detail or modification. Such drawings shall be submitted to one week before approval is required.
- (b) The Engineer will, after any alteration which he may require have been made by the contractor, record on the copies as amended his approval, and will return one copy to the contractor, who shall carry out the work in accordance therewith. The contractor shall forward to the Engineer three additional copies of the working drawings as approval.

1.9. Alteration to drawing

In all cases where drawings are specified or required to be supplied by the contractor for the approval of Engineer for any work included in this contract, any alteration to such drawings which the Engineer may require to have been made, shall be made by the contractor to the Engineer's satisfaction.

1.10. Contractor's facilities

The contractor will propose to the approval of the Engineer the drawing of site installation area within the Airport Security fence. As soon as it was reported by the Engineer, the contractor shall use this area for the setting of all spoil heaps, plant, temporary buildings, works and services.

1.11. Contractor's performance of tests

- (a) The contractor shall perform the tests required by the contract, at the frequencies specified therein, and he shall be responsible for his own quality control of the works. Three copies of the results of each test performed by the contractor in a form approved by the Engineer shall be submitted to him. A fourth copy of the test results of each test shall be retained on site for as long as the Engineer may require.
- (b) Where required by the contract, the contractor shall provide on the site and maintain and remove on issue of the maintenance certificate. The contractor shall have a laboratory including its contents for his own testing of materials.

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- (c) The contractor's site laboratory shall be provided with the minimum equipment. Testing required under the contract that cannot be performed in the contractor's site laboratory shall be carried out in other laboratories which must meet the Engineer's approval.
- (d) The laboratory shall be adequately staffed and equipped so that there shall never occur any interruption to the progress of the works as a result of the need to carry out tests required under the contract. The laboratory staff shall include a qualified English-speaking engineer or engineers, suitably qualified and experienced in the testing of soils, concrete and bituminous materials, and a sufficient number of laboratory assistants and laborers.
- (e) If required by the Engineer the contractor shall perform any or all tests in the presence of authorized representatives of the Engineer.
- (f) Without relieving the contractor of his responsibilities under the contract, the contractor shall perform any additional tests which the Engineer may require, and /or repeat tests the results of which, in the opinion of the Engineer are not representative.

1.12. Access to the site

- (a) The contractor shall make all arrangements for providing safe and expeditious access to the various parts of the site, where necessary, shall construct to an approved standard, maintain, safeguard, and reinstate, all to the satisfaction of the Engineer, all roads and other access works which may be required of that purpose.
- (b) The contractor shall ensure that none of the aforementioned access work (whether of a permanent or temporary nature) shall obstruct or impede services, drainage, or irrigation systems, or have other avoidable effects on surrounding land or property.

1.13. Prevention of mud on the airport pavements

The contractor shall keep all the airport clear of mud and other debris arising from the works and shall avoid mud and debris from being brought on to the airport pavements by construction traffic by washing down vehicles if necessary.

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1.14. Proprietary materials

Reference in this contractor to the names of any films or proprietary articles shall be construed only as an indication of the quality performance and workmanship may be offered to the Engineer for approval.

1.15. Samples

- (a) In addition to any specific provision in the contract for the sampling and testing of materials, the contractor shall submit to the Engineer, as he may require, samples of all materials and goods which he proposes to use or to employ in or for the works. Such samples, if approved, will be retained by the Engineer. No materials or goods of which samples have been approved in writing by the Engineer.
- (b) The engineer may reject any materials and goods which, in his option, are inferior to the samples, thereof previously approved and the contractor shall prompt remove such materials and goods from the sites.

1.16. Tests in general

- (a) The Engineer may examine and may require to be tested any materials or goods required in or for the works such as he may decide from time to time. The contractor shall arrange for the Engineer to have unrestricted access to the contractor's sub- contractors, and suppliers' promise for such purposes at all times.
- (b) The contractor shall afford the Engineer all facilities, assistance, and labor necessary for the convenient examination, testing, or analysis of all such materials or goods.
- (c) notwithstanding any tests which may have been carried out the Engineer shall be empowered to order further tests of any materials or goods should they fail to pass such tests.
- (d) For manufactured materials or goods the contractor shall obtain certificates of tests which are representative of the delivered materials or goods from the suppliers of such materials and shall send four copies of certificates to the Engineer. Such certificates shall certify that the materials or goods concerned have been tested in accordance with the requirements of the contract and shall give the results of all tests carried out. The contractors shall provide adequate means of identifying the materials and goods delivered to the site with the corresponding certificates.
- (e) Various clauses of the specification state the types of test which the contractor shall carry out for the control of the quality of the works, together with the frequencies at which each type of test shall be conducted. The contractor's attention is drawn to the fact that the frequencies of testing specified in the

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relevant clauses are intended to represent only a general guide. The Engineer shall be empowered to vary the frequencies at which tests are conducted should he deem this necessary for the proper control of the quality of the works.

1.17. Materials and workmanship in general

- (a) All materials incorporated in the works shall be new and of the best quality and description of their respective kinds. All materials supplied shall be in accordance with the standards specified in this specification, or equivalent as decided by the Engineer. The workmanship in every case shall be of the best character and the whole shall be subject to the approval of the Engineer.
- (b) The contractor shall provide the Engineer with three copies of all orders for the supply of materials and goods required in connection with the works as the Engineer may require.
- (c) Before entering into any agreement for the supply of any materials or goods, the contractor shall obtain the Engineer's approval in writing of the supplier from whom he proposes to obtain such materials or goods. Should the Engineer, at any time, be dissatisfied with such materials or goods or with the methods of operations carried out at such supplier's works or place of business, he shall be empowered to cancel his previously given approval of such supplier, or to approve another supplier for the supply of such materials and goods from another approved supplier and shall bear any additional cost thereof.

1.18. Sources of materials

QUARRIES

- 1. For the purposes of the contract, quarries shall mean and include all such areas as may be approved in writing by the Engineer as sources from which the contractor may excavator materials for use in the works.
- 2. The contractor shall be wholly responsible for locating quarries and obtaining any necessary consents licenses, permits, royalties etc., from land-owners and relevant authorities for the use of quarries. The contractor shall submit to the Engineer copies of all such consents etc.
- 3. At the commencement of the works, or as soon thereafter as is practicable, the contractor shall submit to the Engineer for approval details of:
 - a) The surfaces from which he proposes to obtain rock; aggregates, and sand;
 - b) The periods during which he proposes to obtain material from each of the several sources;
 - c) The means and routes by which he proposes to obtain and transport these materials;

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- d) Results of his investigations of the materials.
4. No approval by the Engineer of such proposals shall relieve the contractor of his obligations to provide all the materials required for the works, or any other obligation under the contract.

BORROW AREAS

1. For the purposes of the contract, borrow areas shall be provided by the Employer and will be used as a sources from which the contractor may excavate materials for use in the works. These areas mainly concern the Glide Platform.
2. Before commencing the removal of materials from any of the provided borrow areas, the contractor shall carry such investigations as he deems necessary to establish and satisfy himself as to the quality and quantities of material available from the area and the suitability of the plant methods he proposes to use for its removal.
3. The contractor shall work each borrow area in a systematic manner, and, on completion of removal of material from any of the given areas, shall leave the site in a tidy condition, to the satisfaction of the engineer and relevant authority, without unsightly holes or heaps of excavated or inset material. The area shall be left free draining without any features resulting from excavation operations which might result in erosion or instability.

1.19. Removals of condemned materials

The engineer may require the contractor to remove and dispose of any materials employed in the construction of the works, which, in the opinion of the engineer, are unsuitable or have been incorrectly deposited or have suffered damage by exposure to the weather or otherwise are not in accordance with the specified requirements for such materials. The contractor shall be entitled to no payment whatsoever in respect of the removal of such materials.

1.20. Disposals of spoil, rubbish and surplus materials

1. The contractor shall prevent excavated spoils; rubbish and surplus materials arising from the works being dumped on an area other than an area approved by the engineer, and shall comply with legislation governing the controlled tipping of refuse.
2. should any excavated spoil, rubbish or surplus materials be deposited elsewhere than at an approved area, the contractor will be held responsible, cleaning away such deposits and place them in an approved area at his own expense.

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1.21. Existing service installations

1. The contractor shall not use or interfere with the existing service installations without the permission of the engineer and, where applicable, of service and utilities authorities and private owners. He shall take precautions to avoid damage and draw employees' attention to the attendant risks and danger.
2. Should any damage to existing service installations occur, the contractor shall immediately notify in writing the engineer and, where applicable, service and utility authorities and private owners of any damage. He shall make arrangements for the repair at his own expense to the satisfaction of the engineer and, where applicable, or service and utilities authorities and private owners. For urgent repairs shall he shall accept any arrangements made by the engineer. Such arrangements by the engineer will not affect the extent of the contractors' liability.
3. Prior to the beginning of works, underground network system shall be detected in association with the technical services of Juba Airport in order to find all nature of network system that could exist in the perimeter of works. All consequences of damage on the current installation (pipe, cable, lightning...) that could have occurred during the work, shall be supported by the contractor.
4. Prior to the beginning of works, the contractor shall also detect the topographical references that could exist in the perimeter of works. All the displacement of the current reference (stake, stone ...) that could have occurred during the work, shall be overhauled by the contractor.

1.22. Traffic safety measures

1. The contractor shall provide, erect and maintain adequate temporary traffic and warning signs on all access routes and pavements within the site. The size, wording and the locations of the signs shall be approved by the engineer.
2. The contractor shall provide, fix and maintain signs, markings and lights which comply with the requirements on vehicles, plant, stockpiles and at each end of the static plant sites and directed by the engineer.
3. Steps shall be taken by the contractor to ensure at all times the safety of the employer's personnel as well as for the contractor 'employees working along trafficked areas.
4. All details or traffic safety and management measures necessitated by the works shall be submitted to the engineer for his consent 15 days before the contractor intends to commence any work. The contractor shall also furnish any further relevant details and information requested by the engineer.
5. After their erection, the contractor shall not remove or modify in any manner the permanent or temporary traffic signs, without the consent of the engineer. Should the progress of the works necessitate the modification of the permanent or temporary traffic signs arrangement the contractor shall follow the procedure described in sub-clause 6 above.

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2. WORKS ON EXISTING PAVEMENT AND SHOULDER

2.1. Cutting out defluctive surfacing

1. When surfacing is cut out, for any reason, it shall be removed for the full depth of the layer.
2. The area to be cut out shall extend across the full width of the lane between the longitudinal joints.
3. The area of the lane to be cut out shall be defined by straight saw cuts, at least 40 mm deep or for the full thickness of the layer, whichever is the thinner, at right angles to the longitudinal joints.
4. The area shall be cut away carefully by pneumatic spade cutters or approved mechanical scabbing or planning machines. Where spade cutters are used, the cutting tool blades shall overlap the previous cut on each move and each cut shall penetrate the course its full thickness.
5. The surface of the exposed material below shall be thoroughly cleared of all loose fragments and cleaned.
6. Replacement shall not start until the Engineer has approved the condition and cleanliness of the exposed surface.

2.2. Replacement of defluctive or old surfacing

1. Where directed by the Engineer existing bituminous surfaces shall be cold planed by approved milling machines to depths shown on the drawings or directed by the Engineer. The exposed surfaces shall be cleaned with mechanical brush sweeper and compressed air.
2. A tack coat in accordance with clause 10 shall be applied over the exposed surface, care being taken to include all corners, angles and irregularities by vigorous blooming.
3. The exposed vertical faces of the surfacing shall be painted with hot bitumen.
4. Replacement surfacing shall comply with the nominal course thickness shown on the drawings and tolerances and with the standards detailed in this specification.

2.3. Preparation of existing of bituminous surfacing

Before the tack coat is applied, all vegetable growth and loose aggregate or other particles shall be removed from all cracks in the existing bituminous surfacing on which new surfacing is to be laid. Loose laitance and other sapling or deboned

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slurry seal shall be removed from the surface. The surfaces shall be swept until standing water, mud, grit and all other extraneous matter has been removed. Immediately ahead of tack coating, all dust shall be removed by vacuum extraction cleaning, with or without high pressure water at the discretion of the Engineer.

2.4. Milling of bituminous surfaces

Where the surface level of an existing bituminous surface is being reduced by milling, thicknesses shall be removed with an approved planning machine. The machine shall be provided with control devices which enable the rapid adjustment of blades to fine depth-of-cut settings while the machine is operating.

3. GENERAL EXCAVATION AND EMBANKMENT

3.1 Scope of work

1. This work covers excavation, disposal, placement, and compaction of all materials or other purposes in accordance with these specifications and in conformity to the dimensions and typical sections shown on the contract drawings and as specified herein.
2. The contractor shall, before starting the excavation, secure the Engineer's approval on the methods of excavation.

3.2 Classification of works

3.2.1 Top soil excavation

Top soil excavation shall consist of the removal and disposal of deposits of mixture of soils and organic matter not suitable for foundation material or of any other material which will decay.

The Engineering will conduct together with the Contractor, surveys prior to embankment construction and prior to subgrade acceptance in order to locate all the areas where top soil excavation is deemed necessary.

The excavated top soil shall be dumped to earth store close to places submitted to the agreement of the Engineer.

3.2.2 Borrow excavation

Borrow excavation shall consist of approved material required for the construction of embankment or for other portions of the work in the excess of the quantity of usable materials available from required excavation. Borrow material shall be

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always obtained within the Airport property; from the earthworks of the glide platform; or may be within the limits of the Airport at the location of the new taxiway or the new apron.

Borrow area(s) will be indicated by the Engineer, borrow excavation shall be made only at these designated locations and within the horizontal and vertical limits as staked or as directed.

3.2.3 Excavation of unsuitable material

Any material containing vegetable or organic matter, such as muck, peat, organic slit, or sod shall be considered unsuitable for use in embankment construction. Material, when approved by the Engineer as suitable to support vegetation, may be used on the embankment slopes.

Excavation of unsuitable material shall also include the excavation of (the removal and the disposal of deposit) of the areas where the soil in place will produce subsidence in the embankment.

The Engineer will conduct, together with the contractor, surveys prior to embankment construction and prior to subgrade acceptance in order to locate all the areas where excavation of unsuitable material is deemed necessary.

3.2.4 Rock excavation

Rock excavation shall consist of the excavation of boulders 1 cubic meter in volume or greater and all rock or other hard material which, in the opinion of the Engineer, it is not practical to excavate without the use of pneumatic tools or drilling and blasting. It shall not include a material which is in the opinion of the Engineer, can be loosened by a single type hydraulic ripper drawn by a tractor unit with a minimum weight of 15 tones and net horse power rating of 180H.P

3.2.5 Drainage excavation

Drainage excavation shall consist of all excavation made for the primary purpose of drainage ditches, excavation to manholes, inspection and interception chambers, inlets or outlets, grading of the natural ground to re-establish the flow of water or any other type as shown on the plans.

The work shall be performed in the proper sequence with other construction. All satisfactory material shall be placed in fills; unsuitable material shall be placed in waste areas or as directed. All necessary work shall be performed to secure a finish to line, elevation, and cross section.

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3.2.6 Common embankment

Fill classified as common embankment shall consist of excavated earth or rock material, approved by the Engineer as suitable for embankment not used for supporting any aeronautical pavement.

Materials will also be selected preferentially to exclude the use of highly plastic clay soils, classified as A-7-6 by AASHTO specification M145, or CH on the unified cassagrande soil classification system. Where the use of highly plastic soils cannot reasonably be avoided, such material shall be used only in embankment not required to possess good bearing or shear strength. Such highly plastic soil shall never be used in the 30cm of material directly beneath any common pavement or shoulder sub grade or in the 80cm of material beneath aeronautical pavement. In addition, the fill in these zones shall, when tested in accordance with AASHTO T193, have a CBR value of not less than 4% (four percent) after four days soaking when compacted to 95% of the maximum dry density as determined according to AASHTO T180.

3.2.7 Selected embankment

Fill or sub base materials shall only be classified as “selected embankment” when used in locations or for purposes where selected embankment has been specified or otherwise approved in writing by the Engineer. All other fill used shall be regarded as common embankment

Fill classified as selected embankment shall consist of soil or rock material which meets all the above material requirements for common embankment and in addition shall possess certain other required properties, depending on its intended use, as directed or approved by the Engineer. In all cases, all selected embankment shall, when tested in accordance with AASHTO T193 have a CBR value of at least 15% (fifteen percent) after four days soaking when compacted to 95% of the maximum dry density as determined according to AASHTO T180.

3.2.8 Sequences of construction works

3.3 Preliminary Works

Before beginning excavation, grading, and embankment operations in any area, the area shall be completely cleared and grubbed.

The suitability of material to be placed in embankments shall be subject to approval by the Engineer. All unsuitable material shall be disposed of in waste areas within the airport or transported outside as directed by the Engineer. All waste areas inside the airport perimeter shall be graded to allow positive drainage of the area and of

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adjacent area. The surface elevation of waste areas shall not extend above the surface elevation of adjacent usable areas of the airport, unless specified on the plans or approved by the Engineer.

Those areas outside of the pavement areas in which the top layer of soil material has become compacted, by hauling or other activities of the contractor, shall be scarified and disked to a depth of 100mm, in order to loosen and pulverize the soil.

3.3.1. Mobilization Idling Machine

3.3.1.1. Scope

The work does not consist of the mobilization and demobilization of the contractor's forces and equipment necessary for performing the work required under the contract. Mobilization will not be considered as work in fulfilling the contract requirements for commencement of work.

3.3.1.2. Equipment and Material

Mobilization of idling machine; shall be referred to; in case the timeline shall not respect as per the approved work plan which will be mentioning the exactly execution of works in Hrs and the compensation of idling machine will only if the delay is caused by the client occupational.

3.3.2 Excavation

No excavation shall be started until the work has been staked out by the contractor and the Engineer has obtained elevations and measurements of the ground surface. All suitable excavated material shall be used in the formation of embankment, or sub grade, or for other purposes shown on the plans. When the volume of the excavation exceeds that required to construct the embankments to the grades indicated, the excess shall be used to grade the areas of ultimate development or disposed of as directed. When the volume of excavation is not sufficient for constructing the fill to the grades indicated, the deficiency shall be obtained outside from the borrow areas.

The grade shall be maintained so that the surface is well drained at all times. When necessary, temporary drains and drainage ditches shall be installed to intercept or divert surface water which may affect the work.

3.3.2 1 Removal of Top Soil

The removal of topsoil shall be made to a depth of 0.20m below the ground surface, after the clearing and grubbing operations are completed. If any humus is found at depth

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at depths of below 0.20m from the ground surface, it shall also be removed as directed by the Engineer. During and after the removal operation, the ground surface exposed after the topsoil is removed shall be provided with proper drainage to avoid storm water remaining on the surface.

The material produced in the removal of topsoil shall be hauled to the disposal area, and graded evenly.

3.2.2.2 Selective Grading

When selected grading is indicated on the plans, the more suitable material, as designed by the Engineer, shall be used in the constructing of the embankment or in capping the pavement sub-grade. If, at the time of excavation, it is not possible to place this material in its final location, it shall be stockpiled in approved areas so that it can be measured for double-handling as specified.

3.3.2 3 Undercutting

Rock, shale, hardpan, loose rock, boulders, or other materials unsatisfactory for runway safety areas, subgrades, roads, shoulders or any areas intended for turning shall be excavated to a minimum depth of 300mm, or to the depth specified by the Engineer, below the subgrade. Muck, peak, matted roots, or other yielding material, unsatisfactory for subgrade foundation, shall be removed to the depth specified. Unsuitable materials shall be disposed of at locations shown on the plan. This excavated material shall be paid for at the corresponding contract unit price per cubic meter.

The excavated area shall be refilled with suitable material, obtained from the grading operations or borrow areas and thoroughly compacted by rolling. The necessary refilling will constitute a part of the embankment.

3.3.2 4. Over Break

Over break, including slides, is that portion of any material displaced or loosened beyond the finished work as planned or authorized by the Engineer. The Engineer shall determine if the displacement of such material was unavoidable and his decision shall be final. All over breaks shall be graded or removed by the contractor and disposed of as the directed; however, payment will not be made for the removal and disposal of over break which the Engineer determines as avoidable. Unavoidable over break will be classified as: "Common Excavation".

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3.3.2.5. Subgrade Preparation in Cut

3.3.2.5.1 General

Subgrade preparation in cut shall include sloping, compacting and testing of soil in place and maintenance of the surface prepared until the pavement materials are placed on it, all in accordance with the drawings and these specifications or as directed by the Engineer.

The finished grades after compaction shall be not more than one centimeter higher or lower than those specified or approved.

All finished surfaces shall be sufficiently smooth and uniform, and have sufficient grade to ensure the free run-off of surface water.

The contractor shall repair at his own expense any ruts or ridges occasioned by his own workmen or traffic or that of others by reshaping and compacting with rollers of the size and type necessary for such repair.

The contractor shall rectify, in the manner directed by the Engineer, any deterioration of the subgrade that may occur from drying out and cracking, or from flooding or other natural event.

3.3.2.5.2. Compaction Requirements for Sub Grade Under Aeronautical Pavement and Shoulders

The present specification refers to the Advisory Circular AC 150/5320-6 (Chapter 3, section 2 for Flexible Pavement, and section 3 for Rigid Pavement) issued by the department of the Transportation-Federal Aviation Administration-Washington D.C.

The compaction specified in the present Paragraph 3.3.2.5.2 refer to ASTM D 1557 (Modified Compaction).

Compaction requirements under flexible aeronautical pavement (in cohesive soil)

Depth under pavement	Required compaction
From 0 to 22cm	Min.95%
From 22cm to 41cm	Min.90%
From 41cm to 62cm	Min.85%
From 62cm to 83cm	Min. 80%

If deemed necessary, the Engineer will specify the appropriate moisture content. The moisture limitations shall be specified using acceptable moisture ranges as determined by ASTM D 1557.

Payment for suitable materials removed, manipulated and replaced in order to obtain the required depth of density will be paid for as common excavation.

In cut, the top 15cm shall be compacted at 90% of maximum density.

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3.3.2.5.3. Compaction Requirements for Subgrade Under Other Pavements and Shoulders

Layers 30cm or less below subgrade level shall be compacted to 100% of the maximum

3.3.2.6. In Place Field Density Tests and Frequencies in Cut

The in-place field density shall be determined in accordance with ASTM D 1556 or ASTM D 2167.

For subgrade under aeronautical pavement, one density test shall be performed for each 50m³ of material per layer at locations as directed by the Engineer but which shall not be more than 100m apart.

3.3.2.7. Rock and Blasting

Stones or rock fragments larger than 100mm in their greatest dimension will not be permitted in top 150mm of the subgrade.

The finished grading operations, conforming to the typical cross section, shall be completed and maintained at least 300m ahead of the paving operations or as directed by the Engineer.

In cuts, all loose or protruding rocks on the back slopes shall be borne loose or otherwise removed to line of finished grade of slope. All –cut-and –fill slopes shall be uniformly dressed to the slope, cross section, and alignment shown on the plans or as directed by the engineer.

Normal blasting will not be necessary to perform excavation as designed. In case blasting would be unavoidable, it will be permitted only when proper precautions are taken for the safety of all persons, the work, and property. All damage done to the work or property shall be repaired at the contractor's expense. All operations of the contractor in connection with the transportation, storage, and use of explosives shall conform to all state and local regulations and explosive manufacturer's instructions, with applicable approved permits reviewed by the engineer. Any approval given, however, will not relieve the contractor of his responsibility in blasting operations.

In each distinct blasting area, where pertinent factors affecting blast vibrations and their effects in the area remain the same, the contractor shall submit a blasting plan of the initial blasts to the engineer for approval. This plan must consist on hole, size, depth, spacing, burden, and type of explosive, type of delay sequence, maximum amount of explosive on any one delay of period, depth of rock, and depth of overburden if any. The maximum explosive charge weights par delay period included in the plan shall not be increased without the approval of the engineering.

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3.3.3. Preparation of embankment area

Where an embankment is to be constructed, all sod and vegetable matter shall be removed from the surface upon which the embankment is to be placed, and the cleared surface shall be completely broken up by plowing or scarifying to a minimum depth of 150 mm. This area shall then be compacted as indicated in paragraph 3.3.6

Where the embankments are placed on natural slopes steeper than 3 to 1, horizontal benches shall be constructed as directed by the engineer.

No direct payment shall be made for the work performed under this section. The necessary clearing and grubbing and the quantity of excavation removed will be paid for under the respective items of work.

3.3.4 Embankments

Embankments shall be formed in successive horizontal layers of not more than 20 cm in loose depth for the full width of the cross section, unless otherwise approved by the engineer.

The grading operations shall be conducted, and the various soil strata be placed, to produce a soil structure as shown on the typical cross section or as directed.

Materials such as bush, hedge, roots, stumps, grass and other organic matter, shall not be incorporated or buried in the embankment.

Compaction areas shall be kept separate, and no layer shall be covered by another until the proper density is obtained.

Operations on earthwork shall be suspended at any time when satisfactory results cannot be obtained because of rain, or other unsatisfactory conditions of the field. The contractor shall drag, blade, or slope the embankment to provide proper drainage.

The material in the layer shall be within 2% of optimum moisture content before rolling to obtain prescribed compaction. In order to achieve uniform moisture content throughout the layer, wetting or drying of the material and manipulation shall be required when necessary.

Should the material be too wet to permit proper compaction or rolling, all work on all of the affected portions of the embankment shall be delayed until the material has dried to the required moisture content. Sprinkling of dry material to obtain the proper moisture content shall be done with approved equipment that will sufficiently distribute the water. Sufficient equipment to furnish the required water shall be available at all times. Samples of all embankment materials for testing, both before and after placement and compaction, will be taken for each 750 m³ per layer. Based on these tests the contractor shall make the necessary corrections and adjustments in methods, material or moisture content in order to achieve the correct embankment density.

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3.3.4.1 Compaction requirements and sub grade preparation in fill

3.3.4.1.1 General

Subgrade preparation in fill shall include slopping, compacting and testing of soil in place and the maintenance of the surface prepared until the pavement materials are placed on it, all in accordance with the drawings and these specifications or as directed by the engineer.

The finished grades after compaction shall be not more than one centimeter higher or lower than those specified or approved.

All finished surfaces shall be sufficiently smooth and uniform, and have sufficient grade to ensure the free run-off of surface water.

The contractor shall repair at his own expense any ruts or ridges occasioned by his own workmen or traffic or that of others by resolving and compacting with rollers of the size and type necessary for such repair.

The contractor shall rectify, in the manner directed by the engineer, any deterioration of the subgrade that may occur from drying out and cracking, or from flooding or other natural event.

3.3.4.1.2 Compaction requirements of embankments under aeronautical pavement and shoulders

The present specification refers to the advisory circular AC 150/5320-6 (Chapter 3, section 2) issued by the department of Transportation – Federal Aviation Administration – Washington D.C

The compactions specified in the present paragraph 3.3.4.1.2 refer to ASTM D 1557 (Modified compaction)

Compaction requirements under flexible aeronautical pavement are as follow:

The minimum density of soils placed in fill shall be 90%, and for the top 230 mm in fill shall not be less than 95% of the ASTM D 1557 compaction.

The soil in place below the fill shall meet the charted criteria of paragraph 3.3.2.5.2. Before.

3.3.4.1.3 Compaction requirements for other embankments

The embankment shall be constructed and compacted in layers not exceeding 30 cm in thickness. The embankment shall be compacted to 95% of the standard dry density determined according to AASHTO T99.

Layers less than 30 centimeters below subgrade level shall be compacted to 100% of the standard dry density determined according to AASHTO T99.

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No compaction will be required on the top 10 centimeters of embankments constructed outside of the pavement and shoulders areas.

3.3.4.2 In –place field density tests frequencies for embankment

The in- place field density shall be determined in accordance with ASTM D 1556 or ASTM D 2167. The in place field density test frequencies for embankment and embankment subgrade shall be as follow:

- ✓ For embankment under aeronautical pavement one density test shall be performed for each 50 cubic meters of materials placed per layer. The engineer may specify other frequencies as appropriate to the job size.
- ✓ For embankment and subgrade under pavement (other than aeronautical) the density test shall be made per layer at least for every 500 cubic meter at locations as directed by the engineer but which shall not be more than 100 m apart.

3.3.5 Construction method

In the construction of embankments, layer placement shall begin in the deepest portion of the fill, as the placement progresses layers shall be constructed approximately parallel to the finished pavement grade line.

When rock and other embankment material are excavated at approximately the same time, the rock shall be incorporated into the outer portion of the embankment and the other material shall be incorporated under the future paved areas. Stones or fragmentary rock larger than 100 mm in their greatest dimensions will not be allowed in the top 150 mm of the subgrade. Rock fill shall be brought up in layers as specified or as directed and every effort shall be exerted to fill the voids with the finer material forming a dense, compact mass. Rock or boulders shall not be disposed of outside the excavation or embankments areas, except at places and in the manner designated by the engineer.

When the excavated material consists predominantly of rock fragments of such size that the material cannot be placed in layers of prescribed thickness without crushing, pulverizing or further breaking down the pieces, such material may be placed in the embankment as directed in the layers not exceeding 60 cm in thickness. Each layer shall be levelled and smoothed with suitable levelling equipment by distribution of spalls and finer fragments or rock. These types of lifts shall not be constructed above a 120 cm below the finished subgrade. Density requirements will not apply to portions of embankment constructed of materials which cannot be tested in accordance with specified methods.

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3.3.6 *Subgrade acceptance*

When the CBR of the subgrade under aeronautical pavement or shoulders is less than 13, a sub base course shall be formed in successive horizontal layers in cut or fill and in sufficient deep to obtain a CBR value of 13.

Prior using laterite gravel, selected embankment shall be used as sub base materials as much as available.

In any case a minimum, CBR OF 13 is to be obtained on the subgrade under aeronautical pavement or shoulders before constructing the pavement structure.

For other areas, no sub base, or surface course shall be placed on subgrade until the subgrade has been approved by the engineer.

3.3.7 *Haul*

All hauling shall be considered as necessary and incidental part of the work. Its cost shall be considered by the contractor and included in the contract unit price for the pay of items of work involved. No payment will be made separately or directly for hauling on any part of the work.

3.3.8 *Tolerances*

In those areas upon which a foundation, sub base or base course is to be placed, the top of the subgrade shall be of such smoothness that, when tested with a 5 m straight edge applied parallel and at right angles to the centerline, it shall not show any deviation in excess of 15 mm, or shall not be more than 2 cm, from elevation established by the contract drawings. Any deviation in excess of these amounts shall be corrected by loosening, adding, or removing materials, reshaping and re-compacting by sprinkling and rolling.

For other surfaces the tolerances shall be as follow:

- ✓ Excavation and embankments + 5 cm

The frequency of verification of tolerance will be done on all points of the 25×25m grid and on specific points to be determined by the engineer.

3.4 *Method of measurement*

The quantity of excavation to be paid for shall be the number of cubic meters measured in its original position. The quantity of embankments to be paid for shall be the number of cubic meters measured in its final position.

Measurement shall not include the quantity of materials excavated without authorization beyond normal slope lines, or the quantity of materials used for purposes other than those directed. Borrow material shall be paid for on the basis of the number of cubic meters measured in its original position at the borrow pit.

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For payment specified by the cubic meter, measurement for all excavation and embankment shall be computed and the average and area method. The end area is that bound by the original ground line established by field cross sections shown in the plans, subject to verification by the engineer. After completion of all excavation and embankment operations and prior to the placing of base or sub base material the final excavation and the final embankment shall be verified by engineer by means of field cross sections taken randomly at intervals not exceeding 150 linear meters.

Final field cross sections shall be employed if the following changes have been made

- ✓ Plan with of embankments or excavations are changed by more than plus or minus 0.3m
- ✓ Plan elevations of embankments or excavations are changed by more than plus or minus 0.15m

The quantity of subgrade preparation (including additional rolling) to be paid for shall be the number of square meters of pavement and shoulders according to the contract drawings.

3.5 Quantity and work done standards

3.5.1 Quantity standards concerning cutting materials for embankment or subgrade works

All excavated or borrow material to be used as embankment or subgrade material shall be tested as follows:

Work item	Test item	Test method	frequency	Soil classification	notes
Materials to be excavated in common cut and ditch excavation works for use in embankment or subgrade works	Grading Plasticity index of soil Moisture content of soil Moisture Density Relation of soil CBR	AASHTO T88 AASHTO T89/T90 ASTM D2216 AASHTO T99 ASTM D1557 AASHTO T193	At least once every 3000m ³ and or each time when indicated by the engineer	Classified as SM,SP,SC, CL,CH according to the unified soil classification system or material approved by engineer	Analysis findings to be submitted to the engineer for his instructions



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3.5.2 Quantity standards for embankment and subgrade

The quantity standards for embankment and subgrade shall be as follow:

✓ Embankment

Item	Required density	compaction		Density in place	
		Ref.	Frequ.	Ref.	Frequ.
Aeronautical	≥ 90%	ASTM D 1557	See(1) below	ASTM D 1556 or	One per 50 cubic meter per layer
Non aeronautical	≥ 95%	AASHTO T99		ASTM D 2167	One per 500 cubic meter per layer

Item	Required density	compaction		Density in place	
		Ref.	Freq.	Ref.	Freq.
Aeronautical flexible pay. In cut (cohesive soil)	0 to 23 cm ≥ 95% 23 to 42 cm ≥ 90% 41 to 61cm ≥ 85% 61 to 81 cm ≥ 80%	ASTM D 1557	(1) At least once per 10,000m ³ Or more when Deem necessary and as directed by the Engineer	ASTM D 1556 or ASTM D 2167	One per 50 cubic meter per layer
Aeronautical flexible pay. In fill (cohesive soil)	0 to 23 cm ≥ 95% fill ≥ 90%	ASTM D 1557	ditto	Ditto	Ditto
Non Aeronautical pavement areas in cut or fill	0 to 30 cm ≥ 100%	AASHTO T99	ditto	Ditto	Cubic meters per lays not more than 100 m apart



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3.5.3 Work done standards

The work shall be controlled as follows:

Work item	Test item	Test method	frequency	tolerance
Removal of top soil	Work area	By surveying as specified	Area as shown contract drawings	
	Thickness of top soil	ditto	All points of the 25×25 m grid	Remove the top soil entirely
Common excavation	Worked area	ditto	Area as shown on the contract drawings	
	Finish elevation (pavement)	ditto	All points of the 25×25 grid	+0cm 2 cm
	Finish elevation (others)	ditto	ditto	+ 0 cm 5 cm
Surface of ground and slope in cut	Finish elevation and grade at finishing stakes	ditto	Areas as shown on contract drawings	± 5 cm
Ditch excavation	Location width and length	ditto	All points of 25×25 m grid	± 5 cm
Slopes	Finish elevation of top and bottom of slope	ditto	ditto	± 5 cm
Embankment	Embankment area	ditto	Area as shown on the drawing	
	Finish embankment elevation (pavement)	ditto	All points of the 25×25 m grid	± 2 cm
	Finish embankment elevation (others)	ditto	All points of the 25×25 m grid	± 5 cm
Slope of embankment	Finish elevation and grade at finishing stakes	ditto	All points of 25×25 m grid	± 5 cm



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4 LATELITE GRAVEL

4.1 scope of work

This item consists of a sub base or base course composed of gravel and sand mixture with fine laterite module constructed on the prepared underlying subgrade course as defined in section 3 in accordance with these specifications and in conformity to the dimension and typical cross section shown on the plans.

4.2 Materials

4.2.1 Laterite gravel

The laterite gravel materials shall be obtained from sources approved by Engineer prior to use of the materials.

4.2.2 Grading

The grading of the laterite material shall meet the requirements of the following grading when tested in accordance with ASTM C117 and 136.

Requirements for grading of laterite gravel

Sieve designation square openings	Percentage by weight passing sieves
Standard (mm)	
40	90-100
20	70-100
10	50-100
5	30-55
2	20-40
0,7	15-50
0,08	5-30

The gradings in the table represent the limits which shall determine suitability of materials for use from the sources of supply.

In case the grading of the materials shall not permit an optimum compaction, the Engineer could demand to the contractor a modification of the grading.

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4.2.3 Plasticity index

The portion of the laterite filler shall not exceed a percentage between 15% and 20%. The laterite gravel shall have a plasticity index not more than 10 when tested in accordance with ASTM D 4318.

4.2.4 CBR index

The CBR (on sample compacted to 95% of the maximum dry density and obtained after 4 days of immersion) of the material shall be not less than 30%).

4.3 Construction methods

4.3.1 General condition

Work on the foundation course shall not be accomplished when the subgrade is wet. In case of storms during the spreading operation without finishing the compaction, the materials shall be, according to the agreement of the Engineer.

- ✓ Either kept in position standing for the drying out; the compaction shall be continued as soon as the materials will have a normal content,
- ✓ Or cleared at the contractor's own expense and replaced by new materials which will be placed in normal condition.

The Engineer shall demand the wetting of the foundation layer immediately before the placing of the base layer.

The contractor shall have a permanent water tank consequently and appropriated to the rate of the worksite.

4.3.2 Equipment

The machines to be used for proper performance of this work shall be those having obtained Engineer's approval prior to commencement of the works.

4.3.3 Operations in Pits and Quarries

All work involved in clearing and stripping pits and quarries, including handling of unsuitable material, shall be performed by the contractor. The pits shall be operated such a manner that a clean and uniform material will be secured. The material shall be obtained from approved sources.

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4.3.4 Preparing underlying course

The underlying shall be checked and accepted by the Engineer before placing and spreading operations are started. Any ruts or soft, yielding places due to improper drainage condition, hauling, or any other cause, shall be corrected and rolled to the required density before the course is placed thereon. The underlying course shall be slightly scarified before the laterite gravel is placed thereon.

To protect the underlying course and to ensure proper drainage, the spreading of the material shall begin along the centerline of the pavement on a crowned section or on the high side of the pavement with a one-way slope.

4.3.5 Placing

The laterite gravel shall be placed on the prepared underlying course and compacted in layers of uniform thickness with a mechanical spreader as shown on the plans.

The maximum depth of a compacted layer shall be 150mm. If the total depth of the compacted material is more, then it shall be constructed in two or more layers.

4.3.6 Compaction

Immediately upon completion of the spreading operations, the laterite gravel shall be thoroughly compacted. The number, type and rollers shall be sufficient to compact the material to the required density.

The field density of the compacted material shall be at least 100 percent of the maximum density of laboratory specimens prepared from samples of the material delivered to the jobsite. The in-place field density shall be determined in accordance with ASTM D 1556 or ASTM 2167.

The moisture content of the material at the start of compaction shall not be below nor more than 1-1/2 percentage points above the optimum moisture content (Proctor test according to ASTM D 1557).

The course shall not be rolled when the underlying course is soft or yielding or when the rolling causes undulation in the base course. When the rolling develops irregularities that exceed 3/8 inch (9mm) when tested with a 16- foot (4.8m) straightedge, the irregular surface shall be loosened, then refilled with the same kind of material as that used in constructing the course, and again rolled as required above.

4.3.7 Finishing

The surface of this course shall be finished by balding or with automated equipment especially designed for this purpose.

In no case will the addition of thin layers of materials be added to the top layer of base course to meet grade. If the elevation of the top layer is ½ inch (12mm) or more grades,

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the top layer of base shall be scarified to a depth of at least 3 inches (75mm), new material added, and the layer shall be blended and re- compacted to bring it to grade. If the finished surface is above plan grade, it shall be cut back to grade and rerolled.

4.3.8 Surface test

After the course has been completely compacted, the surface shall be tested for smoothness and accuracy of grade and crown. Any portion lacking the required smoothness or failing in accuracy of grade or crown shall be scarified, reshaped, re compacted, and otherwise manipulated as Engineer may direct until the required smoothness and accuracy are obtained. The finished surface shall not vary more than 20mm from a 5.0m straightedge when applied to the surface parallel width and at right angles to, the centerline or shall not be more than 20mm from true elevation according to contract drawings.

4.3.9 Thickness

The thickness of the base course shall be determined by depth tests or cores taken at intervals in such manner that each test shall represent no more than 300 square yards (250 square meters). Where the thickness is deficient by more than 20mm, the contractor shall correct such areas at no additional cost by excavating to the required depth and replacing with new material. Additional test holes may be required to identify the limits of deficient areas. The contractor shall replace, at his/ her expense, the base material where borings have been taken for test purposes.

4.3.10 Protection

Hauling equipment may be routed over completed portions of the foundation course, provided no damage results and provided such that equipment is routed over the full width of the foundation course to avoid rutting or uneven compaction.

However, the Engineer in charge shall have full and specific authority to stop all hauling over completed or partially completed foundation course when, in his opinion, such hauling is causing damage. Any damage resulting to the foundation course from routing equipment over the foundation course shall be repaired by the contractor at his own expense.

4.3.11 Maintenance

Following the completion of the foundation course, the contractor shall perform all maintenance work necessary to keep the foundation course in a condition satisfactory for priming. After priming, the surface shall be kept clean and free from foreign material. The foundation course shall be properly drained at all times. If cleaning is necessary, or if the prime coat becomes disturbed, any work or restitution necessary shall be performed at the expense of the contractor.

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4.4 Quality and work done standards

4.4.1 Quality standards laterite gravel course

Quality standards laterite gravel course shall satisfy the following values:

Work item	Test method	frequency	Standard value	Notes
Grading	ASTM C 117 C 136	Once for every 500 m ³ as designed by the Engineer	According to grading requirements	
Moisture content	ASTM B2216	ditto	-	
Plasticity index	ASTM D 4318	ditto	15% to 20%	
CBR (modified)		ditto	More than 30%	
Percent compaction	ASTM D 1556 or 2167	1000 m ² as designed by the engineer	Not less than 100% of max dry density determined by ASTM 1557 for specimen density	

4.4.2 Work done standards

The work shall be controlled as follows:

Test item	Test method	Frequency	Standard value	notes
Thickness	ASTM D 3665	Four tests for every lot (2000 or 4000 m ²)	+ not specified - 2 cm	
Elevation	by surveying as specified in section 2	At point designated by the engineer	+ 1.5 cm - 1.5 cm	

5. ASPHALT TREATED BASE COURSE: BITUMINOUS GRAVEL

5.1 Description

This item shall consist of a asphalt treated base course composed of mineral aggregate and bituminous material mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and shall conform to the lines, grades, thickness

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and typical cross sections shown on the plans. Each course shall be constructed to the depth, typical section, or elevation required by the plans and shall be rolled, finished, and approved before the placement of the next course.

5.2 *Materials*

5.2.1 *Aggregate*

Aggregates shall consist of crushed stone or crushed gravel with or without sand or other inert finely divided mineral aggregate. The portion of materials retained on the no. 8 sieve is coarse aggregate. The portion passing No.8 (2.36 mm) sieve and retained on the No. 200 (0.075 mm) sieve is fine aggregate, and the portion passing the No.200 (0.075 mm) sieve is mineral filler. Aggregate shall be provided from a quarry in accordance with the agreement of the engineer.

5.2.1.1 *Coarse aggregate*

Coarse aggregate shall consist of sound, tough, durable particles, free from adherent films of matter that would prevent thorough coating and bonding with the bituminous material and be free from organic matter and other deleterious substances. The percentage of wear shall not be greater than 25% for the asphalt treated base when tested in accordance with ASTM C 131. The sodium sulphate soundness loss shall not exceed 13 percent, after five cycles, when tested in accordance with ASTM C 88.

Aggregate shall contain at least 70 percent by weight of individual pieces having two or more fractured faces and 85 percent by weight having at least one fractured face. The area of each face shall be equal to at least 75 percent of the smallest midsection area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces. Fractured faces shall be obtained by crushing.

The aggregate shall not contain more than 8 percent, by weight, of flat or elongated pieces, when tested in accordance with ASTM D 4791.

5.2.1.2 *Fine aggregate*

Fine aggregate shall consist of clean, sound, durable, angular shaped, particles produced by crushing stone or gravel that meet the requirements for wear and soundness specified for coarse aggregate. The aggregate particles shall be free from coating of clay, slit, or other objectionable matter and shall contain no clay balls.

The fine aggregate, including any blended material for the fine aggregate, shall have a plasticity index of not more than 6 and a liquid limit not more than 25 when tested in accordance with ASTM D 4318.

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Natural (no manufactured) sand may be used to obtain the grading of the aggregate blend or to improve the workability of the mix. The amount of sand to be added will be adjusted to produce mixtures conforming to requirements of this specification.

The aggregates shall have sand equivalent values of 45 or greater when tested in accordance with ASTM D 2419.

5.2.1.3 Sampling

ASTM D 75 shall be used in sampling coarse and fine aggregate, and ASTM C 183 shall be used in sampling mineral filler.

5.2.2 Mineral filler

If filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D 242.

5.2.3 Bituminous material

Bituminous material shall conform to the following requirements:

Penetration grade: 60-70 as specified ASTM D 946.

The contractor shall furnish vendor's certified test reports for each lot of bituminous material shipped to the project. The vendor's certified test report for bituminous material can be used for acceptance or the material can be tested independently by the Engineer at contractor's expense.

5.2.4 Preliminary material acceptance

Prior to delivery of materials to the job site, the contractor shall submit certified test reports to the Engineer for the following materials:

- a. Coarse aggregate
 - i. Percentage of wear
 - ii. Soundness
- b. Fine aggregate
 - i. Liquid limit
 - ii. Plastic index
 - iii. Sand equivalent
- c. Mineral
- d. Bituminous material.

The certification(s) shall show the appropriate ASTM test(s) for each material, the test results, and a statement that the material meets the specification requirements.

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The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

5.3 *Composition*

5.3.1 *Composition of mixture*

The bituminous plant mix shall be composed of a mixture of well- graded aggregate, filler and bituminous material. The several aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading equipment's of the job Mix formula (JMF).

5.3.2 *Job Mix Formula*

No bituminous mixture for pavements shall be produced until a job mix formula has been approved by the Engineer. The bituminous mixture shall be designed using procedures contained in chapter III, MARSHALL METHOD OF MIX DESIGN, of the Asphalt Institute's Manual Series No.2 (MS-2), Mix Design Methods for Asphalt Concrete, and shall meet the requirements of table 1.

The design criteria in table 1 are target values necessary to meet the acceptance requirements contained in paragraph 5.5.2.2. The criteria are based on a production process which has a material variability with the following standard deviations:

Stability (Newton) = 1200

Flow (mm) = 0.4

Air voids (%) = 0.65

If material variability exceeds the standard deviations indicated, the job mix formula and subsequent production targets should be based on stability greater than shown in Table 1, and the flow and air voids should be targeted close to the mid-range of the criteria in order meet the acceptance requirements.

If the Tensile Strength Ratio (TSR) of the composite mixture, as determined by ASTM D 4867, is less than 75, the aggregate shall be rejected or the asphalt treated with an approved ant- stripping agent. The amount of ant- stripping agent added to the asphalt shall be sufficient to produce a TSR of not less than 75. If an anti-strip agent is required, it will be provided by the contractor at no additional cost.

The job mix formula shall be sub mitted in writing by the contractor to the Engineer at least 30 days prior to the start of paving operations and shall include as minimum:

- i. Percent passing each sieve size.
- ii. Percent of asphalt cement.
- iii. Asphalt viscosity or penetration grade.
- iv. Number of blows of hammer compaction per side of molded specimen.

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- v. Mixing temperature.
- vi. Compaction temperature.
- vii. Temperature of mix when discharged from the mixer.
- viii. Temperature –viscosity relationship of the asphalt cement.
- ix. Plot of the combined grading.
- x. Graphical plots of stability, flow, air voids, voids in the mineral aggregate, and unit weight verses asphalt content.
- xi. Percent natural sand.
- xii. Percent fractured faces.
- xiii. Percent elongated particles.
- xiv. Tensile Strength Ratio.
- xv. Anti-strip agent (if required).

The contractor shall submit samples to the Engineer, upon request, for job mix formula verification testing.

The job mix formula for each mixture shall be in effect until modified in writing by the Engineer should a change in sources of materials be made, a new job mix formula must be approved by the Engineer before the new material is used.

TABLE1. MARSHALL DESIGN CRITERIA

Test property	0/20
Number of blows	75
Stability, (Newton) minimum	9500
Flow(mm)	2.5-3.6
Air voids (percent)	3-5
Percent voids in mineral aggregate,(minimum)	15

The mineral aggregate shall be of such size that the percentage composition by weight, as determined by laboratory screens, will conform to the grading or grading specified in table 2 when tested in accordance with ASTM standard C 136 and C 117.

The grading in table 2 represents the limits which shall determine the suitability of aggregate for use from the sources of supply. The aggregate, as selected (and used in JMF), shall have a grading within the limits designated in table 2 and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa, but shall be well graded from coarse to fine.

Deviations from the final approved mix design for bitumen content and grading of aggregates shall be within the action limits for individual measurements as specified in

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paragraph 5.6.5.1. The limits still will apply if they fall outside the master grading band in Table 2.

TABLE 2. AGGREGATE- BITUMINOUS PAVEMENTS

Sieve	Percentage by weight passing sieves
	0/20
1 ^{1/4} in. (31.25mm)	-
1 in. (25.0mm)	-
3/4 in. (19.0mm)	100
1/2 in. (12.5mm)	79-99
3/8 in. (9.5mm)	68-88
No.4 (4.75mm)	48-68
No.8 (2.36mm)	33-53
No.16 (1.18mm)	20-40
No.30 (0.60mm)	14-30
No.50 (0.30mm)	9-21
No.100 (0.15mm)	6-16
No.200 (0.075mm)	3-6
Asphalt percent	5,0-6.5

The aggregate grading shown as based on aggregates of uniform specific gravity. The percentages passing the various sieves shall be corrected when aggregates of varying specific gravities are used, as indicated in the asphalt Institute Manual Series No.2 (MS-2), appendix A.

5.3.3 Test section

Prior to full production, the contractor shall prepare and place a quantity of bituminous mixture according to the job mix formula. The amount of mixture should be sufficient to construct a test section the surface of which is 800 squares meter at least, in two lanes, with a longitudinal cold joint, and shall be of the same depth specified for the

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construction of the course which it represents. The underlying grade or pavement structure upon which the test section is to be constructed shall be in the same as the remainder of the course represented by test section. The equipment used in construction of the test section shall be the same type and weight to be used on the remainder of the course represented by the test section.

Three random samples shall be taken at the plant and test for stability, flow and air voids in accordance with paragraph 5.5.1.1.2. Two random samples of mixture shall be taken at the plant and tested for aggregate grading and asphalt content in accordance with paragraphs 5.6.3.1 and 3.2 and evaluated in accordance with paragraphs 5.6.5.1 and 5.2. Three randomly selected cores shall be taken from the finished pavement mat, and three from the longitudinal joint, and tested in accordance with paragraph 5.5.1.2.4. Random sampling shall be in accordance with procedures contained in ASTM D 3665. Mat density and air voids shall be evaluated in accordance with paragraph 5.5.2.6.1. Stability and flow shall be evaluated in accordance with paragraph 5.5.6.2. Joint density shall be evaluated in accordance with paragraph 5.5.2.6.3.

Voids in the mineral aggregate (VMA), for each plant sample, shall be computed in accordance with procedures contained in chapter III, MARSHALL METHOD OF MIX DESIGN, of the Asphalt Institute's Manual Series No 2.(MS-2), Mix Design Methods for Asphalt Concrete.

The test section shall be considered acceptable if:

- i. Stability, flow, mat density, air voids, and joint density are 90 percent or more within limits.
- ii. Grading and asphalt content are within the action limits specified in paragraphs 5.6.5.1 and 5.2 and 3.
- iii. The void in the mineral aggregate is within the limits of Table 1.

If the initial test section should prove to be unacceptable, the necessary adjustments to the job mix formula, plant operation, placing procedures, and/or rolling procedures shall be made. A second test section shall then be placed. If the second test section also does not meet specification requirements, both sections shall be removed at the contractor's expense. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Any additional sections that are not acceptable shall be removed at the contractor's expense. Full production shall not begin until acceptable section has been constructed and accepted by the Engineer.

Job mix control testing shall be performed by the contractor at the start of plant production and in conjunction with the calibration of the plant for the job mix formula. It should be recognized that the aggregates produced by the plant may not satisfy the grading requirements or produce a mix that exactly meets the JMF. In those instances, it will be necessary to re- evaluate and redesign the mix using plant- produced

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aggregates. Specimens should be prepared and the optimum bitumen content determined in the same manner as for the original design tests.

5.3.4 Testing Laboratory

A certification signed by the manager of the laboratory shall be submitted to the Engineer prior to the start of construction. The certification shall contain as a minimum:

- i. Qualifications of personnel; laboratory manager, supervisor technician, and testing technicians.
- ii. A listing of equipment to be used in developing the job mix.

5.4 Construction methods

5.4.1 Weather limitations

The bituminous mixture shall not be placed upon a wet surface.

5.4.2 Bituminous Mixing Plant

Plant used for the preparation of bituminous mixtures shall conform to the requirements of ASTM D 995 with the following challenges:

5.4.2.1. Requirements for all plant

5.4.2.1.1 Truck scales

The bituminous mixture shall be weighed on approved scales furnished by the contractor. Scales shall be inspected and sealed as often as the Engineer deems necessary to assure their accuracy.

5.4.2.1.2 Testing facilities

The contractor shall provide laboratory facilities at the plant for the use of the Engineer's acceptance testing and the contractor's quality control testing, in accordance with paragraph 5.6.2.4.

5.4.2.1.3 Inspection of plant

The engineer or engineer's authorized representative, shall have access, at all times, to all areas of the plant for checking adequacy of equipment, inspection operation of the

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plant, verifying weights, proportions, and material properties, and checking the temperatures maintained in the preparation of the mixtures.

5.4.2.1.4 Storage bins and surge bins

Paragraph 3.9. of ASTM D 995 is deleted. Instead, the following applies. Use of surge bins or storage bins for temporary storage of hot bituminous mixtures will be permitted as follows:

- ✓ The bituminous mixture may be stored in surge bins for period of time not to exceed 3 hours.
- ✓ The bituminous mixture may be stored in insulated storage bins for a period of time not to exceed 24 hours.

The bins shall be such that mix drawn from them meets the same requirements as mix loaded directly into trucks.

If the engineer determines that there is an excessive amount of heat loss, segregation or oxidation of the mixture due to temporary storage, no overnight storage will be allowed.

5.4.2.1.5 Radio connection

The plant shall be radio connected to the bituminous pavers.

5.4.3 Hauling equipment

Trucks used for hauling bituminous mixtures shall have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall lightly have coated with a minimum amount of paraffin oil, lime solution, or other approved material. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary, to ensure that the mixture will be delivered to the site at specified temperature, truck beds shall be insulated or heated and covers shall be securely fastened.

5.4.4 Bituminous Pavers

Bituminous pavers shall be self-propelled, with an activated screed, heated as necessary, and shall be capable spreading and finishing courses of bituminous plant mix material which will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

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The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

The pavers used for airside road construction shall be equipped with an automatic grade control device. The paver shall be equipped with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/ or through a system of mechanical sensors or sensor- directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. The controls shall be capable of working in conjunction with any of the following attachments:

- ✓ Ski-type device of not less than 30 feet (9.14m) in length.
- ✓ Taut string line (wire) set to grade.
- ✓ Short ski or shoe.
- ✓ Laser control.

5.4.5 Rollers

Rollers of the steel wheel, and pneumatic-typed shall be used. They shall be in good condition, capable of operating at slow speeds to avoid displacement of the bituminous mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition.

The use of equipment which causes excessive crushing of the aggregate will not be permitted.

5.4.6 Preparation of Bituminous Materials

The bituminous material shall be heated in a manner that will avoid local overheating and provide a continuous supply of the bituminous material to the mixer at uniform temperature. The temperature of the bituminous material delivered to the mixer shall be sufficient to provide a suitable viscosity for adequate coating of the aggregate particles, but shall not exceed 160°C.

5.4.7 Preparation of Mineral Aggregate

The aggregate mixture shall be heated and dried prior to introduction into the mixer. The maximum temperature and the rate of heating shall be such that no damage occurs to the aggregates. The temperature of aggregate and mineral filler shall not exceed 170°C when the asphalt is added. Particular care shall be taken that aggregates high in calcium or magnesium content are not damaged by overheating. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

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5.4.8 Preparation of Bituminous Mixture

The aggregates and bituminous material shall be weighed or metered and introduced into the mixer in the amount specified by the job mix formula.

The combined materials shall be mixed until the aggregate obtains a uniform coating of bitumen and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but not less than 25 seconds for batch plants. The wet mixing time for all plants shall be established by the contractor, based on the procedure for determining the percentage of coated particles described in ASTM D 2489, for each individual plant and for each type of aggregate used. The wet mixing time will be set to achieve 95% of coated particles. For continuous mix plants, the minimum mixing time shall be determined by driving the weight of its content at operating level by weight of the mixture delivered per second by the mixer. The moisture content of all bituminous mix upon discharge shall not exceed 0.5%.

For all plants, wet mixing time begins with the introduction of bituminous material into the mixer and ends with the opening of the mixer discharge gate.

5.4.9 Preparation of the Underlying surface

Immediately before placing the bituminous mixture, the underlying course shall be cleaned of all dust and debris. A prime coat or tack coat shall be applied as required by the contractor specifications.

5.4.10 Transporting, Placing, and Finishing

The bituminous mixture shall be transported from the mixing plant to the site in vehicles conforming to the requirements of paragraph 9.4.3. Deliveries shall be scheduled so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Adequate artificial lighting shall be provided for night placements as stipulated in general requirements. Hauling over freshly placed material shall not be permitted until the material has been compacted, as specified, and allowed to cool to atmospheric temperature.

The contractor may elect to use a material transfer vehicle to deliver mix to the paver.

The mix shall be placed and compacted at a temperature suitable for obtaining density, surface smoothness, and other specified requirements but not less than 135°C.

Upon arrival, the mixture shall be placed by a bituminous paver. It shall be struck off in uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the bituminous mat. Unless otherwise permitted, placement of the mixture shall begin on the high side of areas with a one-way slope.

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The mixture shall be placed in consecutive adjacent strips except where edge lanes require less width to complete the area. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 30cm; however, the joint in the surface top course shall be at the centerline of the pavement. Transverse joints in one course shall be offset by at least 3m from transverse joints in the previous course.

Transverse joints in adjacent lanes shall be offset a minimum of 3m.

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and lusted by hand tools.

5.4.11 Compaction of Mixture

After placing, the mixture shall be thoroughly and uniformly compacted by rolling. The surface shall be compacted as soon as possible when the mixture has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the contractor.

The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing of the direction of the roller, or from any other cause, shall be corrected at once.

Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained.

In areas not accessible to roller, the mixture shall be thoroughly compacted with hand tampers.

Any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the contractor's expense. Skin patching shall not be allowed.

5.4.12 Joints

The formation of all joints shall be made in such a manner as to ensure a continuous bond between the courses and obtain the required density. All joints shall have the same texture as other sections of the courses and meet the requirements of smoothness and grade.

The roller shall not pass over the unprotected end of the freshly laid mixture except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face.

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prior to placing the adjacent line. In both methods all contact surfaces shall be given a tack coat of bituminous material before any fresh mixture against the joint.

Longitudinal joints which are irregular, damaged, un-compacted, or otherwise defective shall be cut back to expose a clean, sound surface for the full depth of the course. All contact surfaces shall be given a tack coat of bituminous material prior to placing any fresh mixture against the joint.

5.5 Material acceptance

5.5.1 Acceptance sampling and testing

All acceptance sampling and testing necessary to determine conformance with the requirements specified in this section shall be performed by the contractor at his own expense and under supervision of the Engineer or of his authorized representative. All equipment in contractor-furnished laboratories shall be calibrated prior to the start of operations.

5.5.1.1 Plant –produced material

Plant –produced material shall be tested for stability, flow, and air voids on a lot basis. Sampling shall be from material deposited into trucks at the plant or from trucks at the job site. A lot will consist of:

- ✓ One day's production not to exceed 2,000 tones.
- ✓ A half day's production where a day's production is expected to consist of between 2,000 and 4,000 tones, or
- ✓ Similar subdivisions for tonnages over 4,000 tones.

Where more than one plant is simultaneously producing material for the job, the hot sizes shall apply separately for each plant.

5.5.1.1.1 Sampling

Each of lot will consist of four equal sub lots. Sufficient material for preparation of test specimens will be sampled under the Engineer supervision on a random basis, in accordance with the procedures contained in ASTM D 3665. One set of laboratory compacted specimens will be prepared for each sub lot in accordance with ASTM D1559, paragraph at the number of blows required by paragraph 5.3.2 Table 1.

Each set of laboratory compacted specimens will consist of three test portions prepared from the same sample increment.

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The sample of bituminous mixture may be put in covered metal tin and placed in an oven for not more than 30 minutes to maintain the heat. The compaction temperature of the specimens should be as specified in the job mix formula.

5.5.1.1.2 Testing

Sample specimens shall be tested for stability and flow in accordance with ASTM D 1559, paragraph 5. Air voids will be determined in accordance with ASTM D 3203. Prior to testing, the bulk specific gravity of each test specimen shall be measured in accordance with ASTM D 2726 or D 1188, whichever is applicable, for use in computing air voids and pavement density.

For air voids determination, the theoretical maximum specific gravity of the mixture shall be measured twice for each lot in accordance with ASTM D 2041, Type C or D container. Samples shall be taken on a random basis in accordance with ASTM D 3665. The value used in the voids computation for each sub lot shall be the average of the two maximum specific gravity measurements for the lot.

The stability, flow, and air voids for each sub lot shall be computed by averaging the results of the three test specimen's representing that sub lot.

5.5.1.1.3 Acceptance

Acceptance of plant produced material for stability, flow, and air voids shall be determined by the Engineer in accordance with the requirements of paragraph 5.5.2.2.

5.5.1.2. Field placed material

Material placed in the field shall be tested for mat and joint density on a lot basis.

5.5.1.2.1 Mat density

The lot size shall be the same as that indicated in paragraph 5.5.1.1 and shall be divided into four equal sub lots. One core of finished, compacted materials shall be taken by the contractor from each sub lot. Core location will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D 3665. Cores shall not be taken closer than one foot from a transverse or longitudinal joint.

5.5.1.2.2 Joint density

The lot size shall be the total length of longitudinal joint constructed by a lot of material as defined in paragraph 5.5.1.1. The lot shall be divided into four equal sub lots.

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One core of finished, compacted materials shall be taken by the contractor from each sub lot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D 3665.

5.5.1.2.3 Sampling

Samples shall be neatly cut with a core drill. The cutting edge of the core drill bit shall be of hardened steel or other suitable material with diamond chips embedded in the metal cutting edge. The minimum diameter of the sample shall be 75mm. samples that are clearly defective, as a result of sampling, shall be discarded and another sample taken. The contractor shall furnish all tools, labor, and material for cutting samples and filling the cored pavement. Cored holes shall be filled in a manner acceptable to the Engineer and within one day after sampling.

5.5.1.2.4 Testing

The bulk specific gravity of each cored sample will be measured in accordance with ASTM D 2726 or D 1188, whichever is applicable. The percent compaction (density) of each sample will be determined by dividing the bulk specific gravity of each sub lot sample by the average bulk specific gravity of all laboratory prepared specimens for the lot, as determined in paragraph 5.5.1.1.2.

5.5.1.2.5 Acceptance

Acceptance of field placed material for mat density will be determined by the Engineer in accordance with the requirements of paragraph 5.5.2.3. Acceptance for joint density will be determined in accordance with the requirements of paragraph 5.5.2.4.

5.5.1.2 Partial lots-plant-produced material

When operational conditions cause a lot to be terminated before the specified numbers of tests have been made for the lot, the following procedure will be used to adjust the lot size and the number of tests for the lot.

The last batch produced where production is expectedly halted will be sampled and its properties shall be considered as representative of the particular sub lot from which it has taken. Where three sub lots are produced, they shall constitute a lot. Where one or two sub lots are produced, they shall be incorporated into the next lot and the total number of sub lots shall be used in the acceptance plan calculation, i.e., $n=5$ or $n=6$ for example.

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5.5.1.3 Partial lots-Field Placed Material

The lot size for field placed material shall correspond to that of plant material, except that in no cases less than (3) cored samples shall be obtained, i.e., $n=3$.

5.5.2 Acceptance criteria

5.5.2.1 General

Acceptance will be based on the following characteristics of the bituminous mixture and completed pavement as well as the implementation of the contractor's quality control plan and tests results:

- i.** Stability
- ii.** Flow
- iii.** Air voids
- iv.** Mat density
- v.** Joint density
- vi.** Thickness
- vii.** Smoothness
- viii.** Grade

Stability, flow and air voids will be evaluated for acceptance in accordance with the paragraph 5.5.2.2. mat density will be evaluated for acceptance in accordance with paragraph 5.5.2.3. joint density will be evaluated for acceptance in accordance with paragraph 5.5.2.4.

Acceptance for mat density and air voids will be based on the criteria contained in paragraph 5.5.2.6.1. acceptance for stability and flow will be based on the criteria contained in paragraph 5.5.2.6.2. acceptance for joint density will be based on the criteria contained on paragraph 5.5.2.6.3. thickness will be evaluated by the engineer for compliance in accordance with paragraph 5.5.2.6.4. acceptance for smoothness will be based on the criteria contained in paragraph 5.5.2.6.5. acceptance for grade will be based on the criteria contained in paragraph 5.5.2.6.6.

The engineer may at any time, notwithstanding previous plant acceptance, reject and require the contractor to dispose of any batch of bituminous mixture which is rendered unfit for use due to contamination, segregation, incomplete coating for aggregate, or improper mix temperature. Such rejection may be based on only visual inspection or temperature measurements.

5.5.2.2 Stability, Flow, Air voids

Acceptance of each lot plant produced material for stability, flow, and air voids shall be based on the percentage of material within specification limits (PWL). the PWL plan

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considers the variability (standard deviation) of the material and the testing procedures, as well as the average (mean) value of the test results. If a material with high variability is produced, the production target must be adjusted as outlined in paragraph 5.3.2 to achieve a PWL of 90 or more.

5.5.2.3 Mat Density

Acceptance of each lot of in-place pavement for mat density shall be based on the percentage of material within specification limits (PWL). If material with high variability is produced, then a higher target density must be maintained in order to achieve a PWL of 90 or more.

5.5.2.4 Joint Density

Acceptance of each lot of in-place pavement for joint density shall be based on the percentage of material within specification limits (PWL) if a material with high variability is produced, then a higher target density must be maintained in order to achieve a PWL of 90 or more.

5.5.2.5 Percentage of material within specification limits (PWL)

The percentage of material within specification limits (PWL) shall be determined in accordance with procedures specified in annex 1 section 10.

The specification tolerance limits (L) and (U) are contained in table 3.

5.5.2.6 Acceptance Criteria

5.5.2.6.1 Mat density and air voids

If the (PWL) of the lot equals or exceeds 90 percent, the lot shall be acceptable. If the PWL is less than 90 percent, payment shall be made in accordance with paragraph 5.8.1.1.

5.5.2.6.2 Stability and Flow

If the (PWL) of the lot equals or exceeds 90 percent, the lot shall be acceptable. If the PWL is less than 90 percent, the contractor shall determine the reason and take corrective action. If the (PWL) is below 80 percent, the contractor must stop production and make adjustment to the mix.

5.5.2.6.3 Joint density

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If the (PWL) of the lot equals or exceeds 90 percent, the lot shall be acceptable. If the PWL is less than 90 percent, the contractor shall evaluate the method of compacting joints. If the (PWL) is below 80 percent, the contractor shall stop production until the reason for poor compaction can be determined.

5.5.2.6.4 Thickness

Thickness shall be evaluated for compliance by the engineer to the requirements shown on the plans. Measurements of thickness shall be made by the engineer using the cores extracted for each sub lot for density measurement.

5.5.2.6.5 Smoothness

The finished surface of the pavement shall not vary more than 10 mm for the base course. Each lot shall be evaluated with a 3.6 m straightedge. The lot size shall be 1600 square meters. Measurements will be made perpendicular and parallel to the centerline at distances not exceed 15 m. when more than 15 percent of all measurements within a lot exceed the specified tolerance, the contractor shall remove the deficient area and replace with new material. Sufficient material shall be removed to allow at least one inch of asphalt concrete to be placed. Skin patching shall not be permitted. High points may be ground off.

5.5.2.6.6 Grade

The finished surface of the pavement shall not vary from the grade line elevations and cross sections shown on the plans by more than 15 mm. The finished grade of each lot will be determined by running levels at intervals of 15 m or less longitudinally and transversely to determine the elevation of the completed pavement. The lot size shall be 1600 square meters. When more than 15 percent of all the measurements within a lot are outside the specified tolerance, the contractor shall remove the deficient area and replace with new material. Sufficient material shall be removed to allow at least one inch of asphalt concrete to be placed. Skin patching for correcting low areas shall not be permitted. High points may be ground off.

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TABLE 3 ACCEPTANCE LIMITS STABILITY, FLOW, AIR VOIDS, AND DENSITY (75 BLOWS)

	Specification tolerance	
	0/20	
	L	U
Stability, minimum, (Newtons)	8.100	-
Flow, mm	2	4
Air voids total mix (percent)	2.0	5.0
Density, (percent)	96.3	-
Joint density (percent)	93.3	-

5.5.3 *Resampling Pavement*

5.5.3.1 *General*

Resampling of a lot pavement for mat density will be allowed if the contractor request in writing, within 48 hours after receiving the written test results from the engineer. A retest will consist of all the sampling and testing procedures contained in paragraphs 5.5.1.1 and 5.5.2.3. Only one resampling per lot will be permitted.

- a. A redefined PWL shall be calculated for the resampled lot. The number of tests used to calculate the redefined PWL shall include the initial tests made for that lot plus the retests.
- b. The cost for resampling and retesting shall be borne by the contractor.

5.5.3.2 *Payment for resampled lots*

The redefined PWL for a resampled lot shall be used to calculate the payment for that lot in accordance with Table 4.

5.5.3.3 *Outliers*

If the tests within a lot include a very large or a very small value which appears to be outside the normal limits of variation, check for an outlier in accordance with ASTM E 178, at a significance level of 5 percent, to determine if this value should be discarded when computing the PWL.



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5.5.4 *Leveling Course*

Any course used for truing and leveling shall meet the requirements of paragraph 5.3.2 and 5.2.2, but shall not be subject to the density requirements of paragraph 5.5.2.3 and 4. The leveling course shall be compacted with the same effort used to achieve density of the test section. The truing and leveling course shall not exceed a nominal thickness of 37.5 mm.

5.6 *Contractor quality control*

5.6.1 *General*

The contractor quality control shall address all elements which affect the quality of the pavement including, but not limited to:

- i. Mix design
- ii. Aggregate grading
- iii. Quality of materials
- iv. Stockpile management
- v. Proportioning
- vi. Mixing and transportation
- vii. Placing and finishing
- viii. Joints
- ix. Compaction
- x. Surface smoothness

5.6.2 *Testing Laboratory*

The field laboratory shall be equipped with all the necessary apparatus for carrying out all the tests related to asphalt treated base. It shall be available for joint use by the contractor for quality control testing and by the engineer for acceptance testing and must have adequate equipment for the performance of the tests required by these specifications. The engineer shall have priority in use of the equipment necessary for acceptance testing.

Laboratory facilities shall be kept clean and all equipment shall be maintained in proper working condition. The engineer shall be permitted unrestricted access to inspect the contractor's laboratory facility and witness quality control activities. The engineer will advise the contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to be adversely affecting test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are satisfactorily corrected.

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5.6.3 Quality Control Testing

The contractor shall perform all quality control test necessary to control the production and construction processes applicable to these specifications. The testing program shall include, but not necessarily limited to, tests for the control of asphalt content, aggregate grading, temperatures, aggregate moisture, field compaction, and surface smoothness.

5.6.3.1 Asphalt content

A minimum of two extraction tests shall be performed per lot in accordance with ASTM D 2172 for determination of asphalt content. The weight of ash portion of the extraction test, as described in ASTM D 2172, shall be determined as part of the first extraction test performed at the beginning of plant production; and as part of every tenth extraction test performed thereafter, for the duration of plant production. The last weight of ash value obtained shall be used in the calculation of the asphalt content of the mixture.

The use of the nuclear method for determining asphalt content in accordance with ASTM D 4125 is permitted, provided that it is calibrated for the specific mix being used.

5.6.3.2 Grading

Aggregate grading shall be determined a minimum of twice per lot from mechanical analysis of extracted aggregate in accordance with AASHTO T 30 and ASTM C 136 (dry sieve). When asphalt content is determined by the nuclear method, aggregate grading shall be determined from hot bin samples on batch plants, or from the cold feed on drum mix or continuous mix plants, and tested in accordance with ASTM C 136 (dry sieve) using actual batch weight to the combined aggregate grading of the mixture.

5.6.3.3 Moisture content of aggregate

The moisture content of aggregate used for production shall be determined a minimum of once per lot in accordance with ASTM C 566.

5.6.3.4 Moisture content of mixture

The moisture content of the mixture shall be determined once per lot in accordance with ASTM D 1461.

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5.6.3.5 *Temperatures*

Temperatures shall be checked; at least four time per lot, at necessary locations to determine the Temperatures of the dryer, the bitumen in the storage tank the mixture at the plant, and the mixture at the job site.

5.6.3.6 *In-place density monitoring*

The contractor shall conduct any necessary testing to ensure that the specified density is being achieved. A nuclear gauge may be used to monitor the pavement density in accordance with ASTM D 2950.

5.6.3.7 *Additional testing*

Any additional testing that the contractor deems necessary to control the process may be performed at the contractor's option.

5.6.3.8 *Monitoring*

The engineer reserves the right to monitor any or all of the above testing.

5.6.4 *Sampling*

When directed by the engineer, the contractor shall sample and test any material which appears inconsistent with similar material being sampled, unless such material is voluntarily removed and replaced or deficiencies corrected by the contractor. All sampling shall be in accordance with standard procedures specified.

5.6.5 *Control Charts*

The contractor shall maintain linear control charts both for individual measurements and range (i.e., difference between highest and lowest measurements) for aggregate grading and asphalt content.

Control charts shall be posted in a location satisfactory to the engineer and shall be kept current. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the action and suspension limits applicable to each test parameter, and the contractor's test results. The contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the contractor's projected data

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during production indicates a problem and the contractor is not taking satisfactory corrective action, the engineer may suspend production or acceptance of the material.

5.6.5.1 Individual measurements

Control charts for individual measurements shall be established to maintain the process control within tolerance for aggregate grading and asphalt content. The control charts shall use the job mix formula target values as indicators of central tendency for the following test parameters with associated action and suspension limits:

CONTROL CHARTS LIMITS FOR INDIVIDUAL MEASUREMENTS (0/20)

Sieve	Action limit	Suspension limit
3/4 inch(19.0 mm)	±0%	±0%
1/2 inch(12.5 mm)	±6%	±9%
3/8 inch (9.5 mm)	±6%	±9%
No. 4 (4.75 mm)	±6%	±9%
No. 16 (1.18 mm)	±5%	±7.5%
No.50 (0.30 mm)	±3%	±4.5%
No. 200 (0.075 mm)	±2%	±3%
Asphalt content	±0.45%	±0.70%

5.6.5.2 Range

Control charts for range shall be established to control process variability for the test parameters and suspension limits listed below. The range shall be computed for each lot as the difference between the two test results for each control parameters. The suspension limits specified below are based on a sample size of n=2. Should the contractor elect to perform more than two tests per lot, the suspension limits shall be adjusted by multiplying the suspension limit by 1.18 for n=3 and by 1.27 for n=4.

CONTROL CHARTS LIMITS BASED ON RANGE (0/20)

(Based on n=2)

Sieve	Suspension limit
1/2 inch (12.5 mm)	11%
3/8 inch (9.5 mm)	11%
No. 4 (4.75 mm)	11%
No. 16 (1.18 mm)	9%
No.50 (0.30 mm)	6%
No. 200 (0.075 mm)	3.5%
Asphalt content	0.8%

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5.6.5.3 Corrective action

The quality control plan shall indicate that appropriate action shall be taken when the process is believed to be out of tolerance. The plan shall contain sets of rules to when a process is out of control and detail what action will be taken to bring the process into control and production stopped and corrective action taken, if:

- ✓ One point falls outside the suspension limit line for individual measurements or range; or
- ✓ Two points in a row fall outside the action limit line for individual measurements.

The aggregate control chart parameters and suspension and action limits contained in the above paragraphs are based on 19.0 mm maximum size aggregate grading. When 31.5 mm maximum size aggregate is specified, the individual measurements chart requirements should be amended as follows:

Sieve	Action limit	Suspension limit
1 or 1 ¼ inch	0%	0%
¾ inch	6%	11%

5.7 Testing requirements

ASTM C 29	Unit Weight of aggregate.
ASTM C 88	Soundness of aggregates by use of sodium sulphate or Magnesium sulphate.
ASTM C 117	Test Method for Materials finer than 75-um (No.200) sieve in Mineral aggregates by washing.
ASTM C 131	Resistance to abrasion of small size coarse aggregates by use of the Los Angeles machine.
ASTM C 136	Sieve or screen analysis of fine and coarse aggregates.
ASTM C 183	Sampling hydraulic cement.
ASTM C 566	Total moisture content of aggregates by drying.
ASTM D 75	Sampling aggregates.
ASTM D 995	Requirements for mixing plant for hot-mixed hot-laid bituminous paving mixtures.
ASTM D 118	Bulk specific gravity of compacted bituminous mixtures using paraffin-coated specimens.
ASTM D 1461	Moisture or volatile distillates in bituminous paving mixtures.
ASTM D 1559	Resistance to plastic flow of bituminous mixtures using Marshall apparatus.

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ASTM D 2041	Theoretical maximum specific gravity and density of bituminous paving mixtures.
ASTM D 2172	Quantitative extraction of bitumen from bituminous paving mixtures.
ASTM D 2419	Sand equivalent value of soils and fine aggregate.
ASTM D 2489	Degree of particle coating of bituminous – aggregate mixtures.
ASTM D 2726	Bulk specific gravity of compacted bituminous mixtures using saturated surface- dry specimens.
ASTM D 3203	Percent air voids in compacted dense and open bituminous paving mixtures.
ASTM D 2950	Density of bituminous concrete in place by nuclear method.
ASTM D 3665	Random sampling of paving materials.
ASTM D 3666	Inspection and testing agencies of bituminous paving material
ASTM D 4125	Asphalt content of bituminous mixtures by the nuclear method.
ASTM D 4318	Liquid limit, plastic limit, and plasticity index of soils.
ASTM D 4791	Flat or elongated particles in coarse aggregate.
ASTM D 4867	Effect of moisture on asphalt concrete paving mixtures.
ASTM E 178	Practice for dealing with outlying observations.
AASHTO T 30	Mechanical analysis of extracted aggregate.
The asphalt Institute's Manual No. 2 (MS-2)	Mix design methods for asphalt concrete.
The asphalt Institute's Manual No. 20 (MS-20)	Hot- mix recycling.

5.8 Material requirements

ASTM D 242	Mineral filler for bituminous paving mixtures.
ASTM D 946	Asphalt cement for use in pavement construction.
ASTM D 3381	Viscosity –Graded asphalt cement for use in pavement construction.
ASTM D 4552	Classifying Hot-Mix Recycling Agents.



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6. ASPHALT CONCRETE SURFACE COURSES: BITUMINOUS CONCRETE

6.1 Description

This item shall consist of a surface course composed of mineral aggregate and bituminous material mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and shall conform to lines, grades, thickness, and typical cross sections shown on the plans. Each course shall be constructed to the depth, typical section, or elevation required by the plans and shall be rolled, finished, and approved before the placement of the next course.

6.2 Materials

6.2.1 Aggregate

Aggregates shall consist of crushed stone or crushed gravel with or without sand or other inert finely divided mineral aggregate. The portion of materials retained on the No. 8 sieve is coarse aggregate. The portion passing the No.8 (2.36mm) sieve and retained on the No.200 (0.075mm) sieve is mineral filler.

6.2.1.1 Coarse aggregate

Coarse aggregate shall consist of sound, tough, durable particles, free from adherent films of mater that would prevent thorough coating and bonding with the bituminous material and be free from organic matter and other deleterious substances. The percentage of wear shall not be greater than 25 percent when tested in accordance with AASTM C131. The sodium sulphate soundness loss shall not exceed 10 percent, or the magnesium sulphate soundness loss shall not exceed 13 percent, after five cycles, when tested in accordance with ASTM C 88.

Aggregate shall contain at least 70 percent by weight of individual pieces having two or more fractured faces and 85 percent by weight having at least one fractured face. The area of each face shall be equal to at least 75 percent of the smallest mid-sectional area of piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces. Fractured faces shall be obtained by crushing.

The aggregate shall not contain more than 8 percent, by weight, of flat or elongated pieces, when tested in accordance with ASTM D 4791.

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6.2.1.2 *Fine aggregate*

Fine aggregate shall consist of clean, sound, durable, angular shaped particles produced by crushing stone or gravel that meets the requirements for wear and soundness specified for coarse aggregate. The aggregate particles shall be free from coatings of clays, silt, or other objectionable matter and shall contain no clay balls. The fine aggregate, including any blended material for the fine aggregate, shall have a plasticity index of not more than 6 and a liquid of not more than 25 when tested in accordance with ASTM D 4318.

Natural (non-manufactured) sand may be used to obtain the grading of the aggregate blend or to improve the workability of the mix. The amount of sand to be added will be adjusted to produce mixtures conforming to requirements of this specification. The fine aggregate shall not contain more than 20 percent natural sand by weight of total aggregates.

The aggregates shall have sand equivalent values of 45 or greater when tested in accordance with ASTM D 2419.

6.2.1.3 *Sampling*

ASTM D 75 shall be used in sampling coarse and fine aggregate, AND ASTM C 183 shall be used in sampling mineral filler.

6.2.2 *Mineral Filler*

If, filler in addition to the naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D242.

6.2.3 *Bituminous Material*

Bituminous material shall conform to the following requirements:

Penetration grade: 60-70 as specified ASTM D 946.

The contractor shall furnish vendor's certified test reports for each lot of bituminous material shipped to the project. The vendor's certified test report for the bituminous material can be used for acceptance of the material can be tested independently by the Engineer at contractor's expense.

6.2.4 *Preliminary Material Acceptance*

Prior to delivery of materials to the job site, the contractor shall submit certified test reports to the Engineer for the following materials:

- ✓ Coarse aggregate
 - Percent of wear

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- Soundness
- ✓ Fine aggregate
 - Liquid limit
 - Plastic index
 - Sand equivalent
- ✓ Mineral filler
- ✓ Bituminous material

The certification(s) shall show the appropriate ASTM test(s) for each material, the test results, and a statement that the material meets the specification requirements.

The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

6.3 *Composition*

6.3.1 *Composition of mixture*

The bituminous plant mix shall be composed of a mixture of well- graded aggregate, filler and bituminous material. The several aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading equipment of the job Mix formula (JMF).

6.3.2 *Job Mix Formula*

No bituminous mixture for pavements shall be produced until a job mix formula has been approved by the Engineer. The bituminous mixture shall be designed using procedures contained in chapter III, MARSHALL METHOD OF MIX DESIGN, of the Asphalt Institute's Manual Series No.2 (MS-2), Mix Design Methods for Asphalt Concrete, and shall meet the requirements of table 1.

The design criteria in table 1 are target values necessary to meet the acceptance requirements contained in paragraph 5.5.2.2. The criteria are based on a production process which has a material variability with the following standard deviations:

Stability (Newton) = 1200

Flow (mm) = 0.4

Air voids (%) = 0.65

If material variability exceeds the standard deviations indicated, the job mix formula and subsequent production targets should be based on stability greater than shown in Table 1, and the flow and air voids should be targeted close to the mid-range of the criteria in order meet the acceptance requirements.

If the Tensile Strength Ratio (TSR) of the composite mixture, as determined by ASTM D 4867, is less than 75, the aggregate shall be rejected or the asphalt treated with an

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approved ant- stripping agent. The amount of ant- stripping agent added to the asphalt shall be sufficient to produce a TSR of not less than 75. If an anti-strip agent is required, it will be provided by the contractor at no additional cost.

The job mix formula shall be submitted in writing by the contractor to the Engineer at least 30 days prior to the start of paving operations and shall include as minimum:

- i. Percent passing each sieve size.
- ii. Percent of asphalt cement.
- iii. Asphalt viscosity or penetration grade.
- iv. Number of blows of hammer compaction per side of molded specimen.
- v. Mixing temperature.
- vi. Compaction temperature.
- vii. Temperature of mix when discharged from the mixer.
- viii. Temperature –viscosity relationship of the asphalt cement.
- ix. Plot of the combined grading.
- x. Graphical plots of stability, flow, air voids, voids in the mineral aggregate, and unit weight verses asphalt content.
- xi. Percent natural sand.
- xii. Percent fractured faces.
- xiii. Percent elongated particles.
- xiv. Tensile Strength Ratio.
- xv. Anti-strip agent (if required).

The contractor shall submit samples to the Engineer, upon request, for job mix formula verification testing.

The job mix formula for each mixture shall be in effect until modified in writing by the Engineer should a change in sources of materials be made, a new job mix formula must be approved by the Engineer before the new material is used.

TABLE 1. MARSHALL DESIGN CRITERIA

Test property	
Number of blows	75
Stability, (Newton) minimum	11.000
Flow(mm)	2.5-3.6
Air voids (percent)	3-5
Percent voids in mineral aggregate (minimum)	16



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The mineral aggregate shall be of such size that the percentage composition by weight, as determined by laboratory screens, will conform to the grading or grading specified in table 2 when tested in accordance with ASTM standard C 136 and C 117.

The grading in table 2 represents the limits which shall determine the suitability of aggregate for use from the sources of supply. The aggregate, as selected (and used in JMF), shall have a grading within the limits designated in table 2 and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa, but shall be well graded from coarse to fine.

Deviations from the final approved mix design for bitumen content and grading of aggregates shall be within the action limits for individual measurements as specified in paragraph 6.6.5.1. The limits still will apply if they fall outside the master grading band in Table 2.

TABLE 2. AGGREGATE- BITUMINOUS PAVEMENTS

Sieve	Percentage by weight passing sieves 0/14 bituminous concrete
½ in. (12.5mm)	100
3/8 in. (9.5mm)	79-99
No.4 (4.75mm)	58-78
No.8 (2.36mm)	39-59
No.16 (1.18mm)	26-46
No.30 (0.60mm)	19-35
No.50 (0.30mm)	12-24
No.100 (0.15mm)	7-17
No.200 (0.075mm)	3-6
Asphalt percent	5.5-7.0

The aggregate grading shown as based on aggregates of uniform specific gravity. The percentages passing the various sieves shall be corrected when aggregates of varying specific gravities are used, as indicated in the asphalt Institute Manual Series No.2 (MS-2), appendix A.

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6.3.3 Test section

Prior to full production, the contractor shall prepare and place a quantity of bituminous mixture according to the job mix formula. The amount of mixture should be sufficient to construct a test section the surface of which is 800 squares meter at least, in two lanes, with a longitudinal cold joint, and shall be of the same depth specified for the construction of the course which it represents. The underlying grade or pavement structure upon which the test section is to be constructed shall be in the same as the remainder of the course represented by test section. The equipment used in construction of the test section shall be the same type and weight to be used on the remainder of the course represented by the test section.

Three random samples shall be taken at the plant and test for stability, flow and air voids in accordance with paragraph 6.5.1.1.2. Two random samples of mixture shall be taken at the plant and tested for aggregate grading and asphalt content in accordance with paragraphs 6.6.3.1 and 3.2 and evaluated in accordance with paragraphs 6.6.5.1 and 5.2. Three randomly selected cores shall be taken from the finished pavement mat, and three from the longitudinal joint, and tested in accordance with paragraph 6.5.1.2.4. Random sampling shall be in accordance with procedures contained in ASTM D 3665. Mat density and air voids shall be evaluated in accordance with paragraph 5.5.2.6.1. Stability and flow shall be evaluated in accordance with paragraph 5.5.6.2. Joint density shall be evaluated in accordance with paragraph 6.5.2.6.3.

Voids in the mineral aggregate (VMA), for each plant sample, shall be computed in accordance with procedures contained in chapter III, MARSHALL METHOD OF MIX DESIGN, of the Asphalt Institute's Manual Series No 2. (MS-2), Mix Design Methods for Asphalt Concrete.

The test section shall be considered acceptable if:

- i. Stability, flow, mat density, air voids, and joint density are 90 percent or more within limits.
- ii. Grading and asphalt content are within the action limits specified in paragraphs 6.6.5.1 and 5.2 and 3.
- iii. The void in the mineral aggregate is within the limits of Table 1.

If the initial test section should prove to be unacceptable, the necessary adjustments to the job mix formula, plant operation, placing procedures, and/or rolling procedures shall be made. A second test section shall then be placed. If the second test section also does not meet specification requirements, both sections shall be removed at the contractor's expense. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Any additional sections that are not acceptable shall be removed at the contractor's expense. Full production shall not begin until acceptable section has been constructed and accepted by the Engineer.

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Job mix control testing shall be performed by the contractor at the start of plant production and in conjunction with the calibration of the plant for the job mix formula. It should be recognized that the aggregates produced by the plant may not satisfy the grading requirements or produce a mix that exactly meets the JMF. In those instances, it will be necessary to re-evaluate and redesign the mix using plant-produced aggregates. Specimens should be prepared and the optimum bitumen content determined in the same manner as for the original design tests.

6.3.4 Testing Laboratory

A certification signed by the manager of the laboratory shall be submitted to the Engineer prior to the start of construction. The certification shall contain as a minimum:

- i. Qualifications of personnel; laboratory manager, supervisor technician, and testing technicians.
- ii. A listing of equipment to be used in developing the job mix.

6.4 Construction methods

6.4.1 Weather Limitations

The bituminous mixture shall not be placed upon a wet surface.

6.4.2 Preparation of pavement before reinforcement

6.4.2.1 Erasing of the old paint

The contractor shall erase all the existing paint and eventually the most important rubber deposit.

6.4.2.2 Reparation of the depression, scrapping and crack sealing

The corresponded plans a precise the areas which require, prior to the placing of the surface course, reparation of depressions or a scrapping of the existing pavement.

All areas, where the thickness of reinforcement is less than 5 cm, shall be scrapped in order to place a minimum thickness of bituminous concrete of 5cm.

The areas, where it is necessary to repair the depression, shall receive a tack coat which consists of a dosage at 400g of bitumen per square meter without sanding. This operation shall be done after the cleaning and the sucking up of the areas to be treated.

The sealing of cracks shall concern the most important cracks according to the Engineer's assessment.

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6.4.3 Bituminous Mixing Plant

Plant used for the preparation of bituminous mixtures shall conform to the requirements of ASTM D 995 with the following challenges:

6.4.3.1. Requirements for all plant

6.4.3.1.1 Truck scales

The bituminous mixture shall be weighed on approved scales furnished by the contractor. Scales shall be inspected and sealed as often as the Engineer deems necessary to assure their accuracy.

6.4.3.1.2 Testing facilities

The contractor shall provide laboratory facilities at the plant for the use of the Engineer's acceptance testing and the contractor's quality control testing, in accordance with paragraph 6.6.2.4.

6.4.3.1.3 Inspection of plant

The engineer or engineer's authorized representative, shall have access, at all times, to all areas of the plant for checking adequacy of equipment, inspection operation of the plant, verifying weights, proportions, and material properties, and checking the temperatures maintained in the preparation of the mixtures.

6.4.3.1.4 Storage bins and surge bins

Paragraph 3.9. of ASTM D 995 is deleted. Instead, the following applies. Use of surge bins or storage bins for temporary storage of hot bituminous mixtures will be permitted as follows:

- ✓ The bituminous mixture may be stored in surge bins for period of time not to exceed 3 hours.
- ✓ The bituminous mixture may be stored in insulated storage bins for a period of time not to exceed 24 hours.

The bins shall be such that mix drawn from them meets the same requirements as mix loaded directly into trucks.

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If the engineer determines that there is an excessive amount of heat loss, segregation or oxidation of the mixture due to temporary storage, no overnight storage will be allowed.

6.4.3.1.5 Radio connection

The plant shall be radio connected to the bituminous pavers.

6.4.4 Hauling equipment

Trucks used for hauling bituminous mixtures shall have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall lightly be coated with a minimum amount of paraffin oil, lime solution, or other approved material. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary, to ensure that the mixture will be delivered to the site at specified temperature, truck beds shall be insulated or heated and covers shall be securely fastened.

6.4.5 Bituminous Pavers

Bituminous pavers shall be self-propelled, with an activated screed, heated as necessary, and shall be capable spreading and finishing courses of bituminous plant mix material which will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

The pavers used for airside road construction shall be equipped with an automatic grade control device. The paver shall be equipped with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/ or through a system of mechanical sensors or sensor- directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent.

The controls shall be capable of working in conjunction with any of the following attachments:

- ✓ Ski-type device of not less than 30 feet (9.14m) in length.

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- ✓ Taut string line (wire) set to grade.
- ✓ Short ski or shoe.
- ✓ Laser control.

6.4.6 Rollers

Rollers of the steel wheel, and pneumatic-typed shall be used. They shall be in good condition, capable of operating at slow speeds to avoid displacement of the bituminous mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition.

The use of equipment which causes excessive crushing of the aggregate will not be permitted.

6.4.7 Preparation of Bituminous Materials

The bituminous material shall be heated in a manner that will avoid local overheating and provide a continuous supply of the bituminous material to the mixer at uniform temperature. The temperature of the bituminous material delivered to the mixer shall be sufficient to provide a suitable viscosity for adequate coating of the aggregate particles, but shall not exceed 160°C.

6.4.8 Preparation of Mineral Aggregate

The aggregate mixture shall be heated and dried prior to introduction into the mixer. The maximum temperature and the rate of heating shall be such that no damage occurs to the aggregates. The temperature of aggregate and mineral filler shall not exceed 170°C when the asphalt is added. Particular care shall be taken that aggregates high in calcium or magnesium content are not damaged by overheating. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

6.4.9 Preparation of Bituminous Mixture

The aggregates and bituminous material shall be weighed or metered and introduced into the mixer in the amount specified by the job mix formula.

The combined materials shall be mixed until the aggregate obtains a uniform coating of bitumen and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but not less than 25 seconds for batch plants. The wet mixing time for all plants shall be established by the contractor, based on the procedure for determining the percentage of coated particles described in ASTM D 2489, for each individual plant and for each type of aggregate used. The wet

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mixing time will be set to achieve 95% of coated particles. For continuous mix plants, the minimum mixing time shall be determined by driving the weight of its content at operating level by weight of the mixture delivered per second by the mixer. The moisture content of all bituminous mix upon discharge shall not exceed 0.5%.

For all plants, wet mixing time begins with the introduction of bituminous material into the mixer and ends with the opening of the mixer discharge gate.

6.4.10 Preparation of the Underlying surface

Immediately before placing the bituminous mixture, the underlying course shall be cleaned of all dust and debris. A prime coat or tack coat shall be applied as required by the contractor specifications.

6.4.11 Transporting, Placing, and Finishing

The bituminous mixture shall be transported from the mixing plant to the site in vehicles conforming to the requirements of paragraph 9.4.3. Deliveries shall be scheduled so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Adequate artificial lighting shall be provided for night placements as stipulated in general requirements. Hauling over freshly placed material shall not be permitted until the material has been compacted, as specified, and allowed to cool to atmospheric temperature.

The contract may elect to use a material transfer vehicle to deliver mix to the paver.

The mix shall be placed and compacted at a temperature suitable for obtaining density, surface smoothness, and other specified requirements but not less than 135°C.

Upon arrival, the mixture shall be placed by a bituminous paver. It shall be struck off in uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the bituminous mat. Unless other permitted, placement of the mixture shall begin on the high side of areas with a one-way slope. The mixture shall be placed in consecutive adjacent strips except where edge lanes require less width to complete the area. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 30cm; however, the joint in the surface top course shall be at the centerline of the pavement. Transverse joints in one course shall be offset by at least 3m from transverse joints in the previous course.

Transverse joints in adjacent lanes shall be offset a minimum of 3m.

On areas where irregularities or unavoidable obstacles make the use mechanical spreading and finishing equipment impractical, the mixture may be spread and lusted by hand tools.

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6.4.12 Compaction of Mixture

After placing, the mixture shall be thoroughly and uniformly compacted by rolling. The surface shall be compacted as soon as possible when the mixture has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the contractor.

The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing of the direction of the roller, or from any other cause, shall be corrected at once.

Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained.

In areas not accessible to roller, the mixture shall be thoroughly compacted with hand tampers.

Any mixture that becomes loose and broken, mixed with dirt, contains check- cracking, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the contractor's expense. Skin patching shall not be allowed.

6.4.13 Joints

The formation of all joints shall be made in such a manner as to ensure a continuous bond between the courses and obtain the required density. All joints shall have the same texture as other sections of the courses and meet the requirements of smoothness and grade.

The roller shall not pass over the unprotected end of the freshly laid mixture except when necessary to form transverse joint. When necessary to form a transverse joint, it shall be made means of placing a bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing the adjacent line. In both methods all contact surfaces shall be given a tack coat of bituminous material before any fresh mixture against the joint.

Longitudinal joints which are irregular, damaged, un-compacted, or otherwise defective shall be cut back to expose a clean, sound surface for the full depth of the course. All contact surfaces shall be given a tack coat of bituminous material prior to placing any fresh mixture against the joint.

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6.5 Material Acceptance

6.5.1 Acceptance Sampling and Testing

All acceptance sampling and testing necessary to determine conformance with the requirements specified in this section shall be performed by the contractor at his own expense and under supervision of the Engineer or of his authorized representative. All equipment in contractor-furnished laboratories shall be calibrated prior to the start of operations.

6.5.1.1 Plant –produced material

Plant –produced material shall be tested for stability, flow, and air voids on a lot basis. Sampling shall be from material deposited into trucks at the plant or from trucks at the job site. A lot will consist of:

- ✓ One day's production not to exceed 2,000 tones.
- ✓ A half day's production where a day's production is expected to consist of between 2,000 and 4,000 tones, or
- ✓ Similar subdivisions for tonnages over 4,000 tones.

Where more than one plant is simultaneously producing material for the job, the lot sizes shall apply separately for each plant.

6.5.1.1.1 Sampling

Each of lot will consist of four equal sub lots. Sufficient material for preparation of test specimens will be sampled under the Engineer supervision on a random basis, in accordance with the procedures contained in ASTM D 3665. One set of laboratory compacted specimens will be prepared for each sub lot in accordance with ASTM D1559, paragraph at the number of blows required by paragraph 6.3.2 Table 1.

Each set of laboratory compacted specimens will consist of three test portions prepared from the same sample increment.

The sample of bituminous mixture may be put in covered metal tin and placed in an oven for not more than 30 minutes to maintain the heat. The compaction temperature of the specimens should be as specified in the job mix formula.

6.5.1.1.2 Testing

Sample specimens shall be tested for stability and flow in accordance with ASTM D 1559, paragraph 5. Air voids will be determined in accordance with ASTM D 3203. Prior to testing, the bulk specific gravity of each test specimen shall be measured in accordance with ASTM D2726 or D 1188, whichever is applicable, for use in computing air voids and pavement density.

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For air voids determination, the theoretical maximum specific gravity of the mixture shall be measured twice for each lot in accordance with ASTM D 2041, Type C or D container. Samples shall be taken on a random basis in accordance with ASTM D 3665. The value used in the voids computation for each sub lot shall be the average of the two maximum specific gravity measurements for the lot.

The stability, flow, and air voids for each sub lot shall be computed by averaging the results of the three-test specimen's representing that sub lot.

6.5.1.1.3 Acceptance

Acceptance of plant produced material for stability, flow, and air voids shall be determined by the Engineer in accordance with the requirements of paragraph 6.5.2.2.

6.5.1.2 Field placed material

Material placed in the field shall be tested for mat and joint density on a lot basis.

6.5.1.2.1 Mat density

The lot size shall be the same as that indicated in paragraph 6.5.1.1 and shall be divided into four equal sub lots. One core of finished, compacted materials shall be taken by the contractor from each sub lot. Core location will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D 3665. Cores shall not be taken closer than one foot from a transverse or longitudinal joint.

6.5.1.2.2 Joint density

The lot size shall be the total length of longitudinal joint constructed by a lot of material as defined in paragraph 6.5.1.1. The lot shall be divided into four equal sub lots.

One core of finished, compacted materials shall be taken by the contractor from each sub lot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D 3665.

6.5.1.2.3 Sampling

Samples shall be neatly cut with a core drill. The cutting edge of the core drill bit shall be of hardened steel or other suitable material with diamond chips embedded in the metal cutting edge. The minimum diameter of the sample shall be 75mm. samples that are clearly defective, as a result of sampling, shall be discarded and another sample taken. The contractor shall furnish all tools, labor, and material for cutting samples and

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filling the cored pavement. Cored holes shall be filled in a manner acceptable to the Engineer and within one day after sampling.

6.5.1.2.4 Testing

The bulk specific gravity of each cored sample will be measured in accordance with ASTM D 2726 or D 1188, whichever is applicable. The percent compaction (density) of each sample will be determined by dividing the bulk-specific gravity of each sub lot sample by the average bulk specific gravity of all laboratory prepared specimens for the lot, as determined in paragraph 6.5.1.1.2.

6.5.1.2.5 Acceptance

Acceptance of field placed material for mat density will be determined by the Engineer in accordance with the requirements of paragraph 6.5.2.3. Acceptance for joint density will be determined in accordance with the requirements of paragraph 6.5.2.4.

6.5.1.3 Partial lots-Plant-Produced Material

When operational conditions cause a lot to be terminated before the specified numbers of tests have been made for the lot, the following procedure will be used to adjust the lot size and the number of tests for the lot.

The last batch produced where production is expectedly halted will be sampled and its properties shall be considered as representative of the particular sub lot from which it has taken. Where three sub lots are produced, they shall constitute a lot. Where one or two sub lots are produced, they shall be incorporated into the next lot and the total number of sub lots shall be used in the acceptance plan calculation, i.e., $n=5$ or $n=6$ for example.

6.5.1.4 Partial lots-Field Placed Material

The lot size for field placed material shall correspond to that of plant material, except that in no cases less than (3) cored samples shall be obtained, i.e., $n=3$.

6.5.2 Acceptance Criteria

6.5.2.1 General

Acceptance will be based on the following characteristics of the bituminous mixture and completed pavement as well as the implementation of the contractor's quality control plan and tests results:

- i. Stability

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- ii. Flow
- iii. Air voids
- iv. Mat density
- v. Joint density
- vi. Thickness
- vii. Smoothness
- viii. Grade

Stability, flow and air voids will be evaluated for acceptance in accordance with the paragraph 6.5.2.2. mat density will be evaluated for acceptance in accordance with paragraph 6.5.2.3. joint density will be evaluated for acceptance in accordance with paragraph 6.5.2.4.

Acceptance for mat density and air voids will be based on the criteria contained in paragraph 6.5.2.6.1. acceptance for stability and flow will be based on the criteria contained in paragraph 6.5.2.6.2. acceptance for joint density will be based on the criteria contained on paragraph 6.5.2.6.3. thickness will be evaluated by the engineer for compliance in accordance with paragraph 6.5.2.6.4. acceptance for smoothness will be based on the criteria contained in paragraph 6.5.2.6.5. acceptance for grade will be based on the criteria contained in paragraph 6.5.2.6.6.

The engineer may at any time, notwithstanding previous plant acceptance, reject and require the contractor to dispose of any batch of bituminous mixture which is rendered unfit for use due to contamination, segregation, incomplete coating for aggregate, or improper mix temperature. Such rejection may be based on only visual inspection or temperature measurements.

6.5.2.2 Stability, Flow, Air voids

Acceptance of each lot plant produced material for stability, flow, and air voids shall be based on the percentage of material within specification limits (PWL). The PWL plan considers the variability (standard deviation) of the material and the testing procedures, as well as the average(mean) value of the test results. If a material with high variability is produced, the production target must be adjusted as outlined in paragraph 6.3.2 to achieve a PWL of 90 or more.

6.5.2.3 Mat Density

Acceptance of each lot of in-place pavement for mat density shall be based on the percentage of material within specification limits (PWL). If material with high variability is produced, then a higher target density must be maintained in order to achieve a PWL of 90 or more.

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6.5.2.4 Joint Density

Acceptance of each lot of in-place pavement for joint density shall be based on the percentage of material within specification limits (PWL) if a material with high variability is produced, then a higher target density must be maintained in order to achieve a PWL of 90 or more.

6.5.2.5 Percentage of material within specification limits (PWL)

The percentage of material within specification limits (PWL) shall be determined in accordance with procedures specified in annex 1 section 10.

The specification tolerance limits (L) and (U) are contained in table 3.

6.5.2.6 Acceptance Criteria

6.5.2.6.1 Mat density and Air voids

If the (PWL) of the lot equals or exceeds 90 percent, the lot shall be acceptable. If the PWL is less than 90 percent, payment shall be made in accordance with paragraph 10.8.1.1.

6.5.2.6.2 Stability and Flow

If the (PWL) of the lot equals or exceeds 90 percent, the lot shall be acceptable. If the PWL is less than 90 percent, the contractor shall determine the reason and take corrective action. If the (PWL) is below 80 percent, the contractor must stop production and make adjustment to the mix.

6.5.2.6.3 Joint density

If the (PWL) of the lot equals or exceeds 90 percent, the lot shall be acceptable. If the PWL is less than 90 percent, the contractor shall evaluate the method of compacting joints. If the (PWL) is below 80 percent, the contractor shall stop production until the reason for poor compaction can be determined.

6.5.2.6.4 Thickness

Thickness shall be evaluated for compliance by the engineer to the requirements shown on the plans. Measurements of thickness shall be made by the engineer using the cores extracted for each sub lot for density measurement.

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6.5.2.6.5 Smoothness

The finished surface of the pavement shall not vary more than 10 mm for the base course. Each lot shall be evaluated with a 3.6 m straightedge. The lot size shall be 1600 square meters. Measurements will be made perpendicular and parallel to the centerline at distances not exceed 15 m. when more than 15 percent of all measurements within a lot exceed the specified tolerance, the contractor shall remove the deficient area and replace with new material. Sufficient material shall be removed to allow at least one inch of asphalt concrete to be placed. Skin patching shall not be permitted. High points may be ground off.

6.5.2.6.6 Grade

The finished surface of the pavement shall not vary from the grade line elevations and cross sections shown on the plans by more than 15 mm. The finished grade of each lot will be determined by running levels at intervals of 15 m or less longitudinally and transversely to determine the elevation of the completed pavement. The lot size shall be 1600 square meters. When more than 15 percent of all the measurements within a lot are outside the specified tolerance, the contractor shall remove the deficient area and replace with new material. Sufficient material shall be removed to allow at least one inch of asphalt concrete to be placed. Skin patching for correcting low areas shall not be permitted. High points may be ground off.

**TABLE 3 ACCEPTANCE LIMITS STABILITY, FLOW, AIR VOIDS,
AND DENSITY (75 BLOWS)**

	Specification tolerance	
	L	U
Stability, minimum, (Newton)	9.350	-
Flow, mm	2	4
Air voids total mix (percent)	2.0	5.0
Density, (percent)	96.3	-
Joint density (percent)	93.3	-

6.5.3 Re-sampling Pavement

6.5.3.1 General

Re-sampling of a lot pavement for mat density will be allowed if the contractor request in writing, within 48 hours after receiving the written test results from the engineer.

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A retest will consist of all the sampling and testing procedures contained in paragraphs 6.5.1.1 and 6.5.2.3. Only one re-sampling per lot will be permitted.

- a. A redefined PWL shall be calculated for the re-sampled lot. The number of tests used to calculate the redefined PWL shall include the initial tests made for that lot plus the retests.
- b. The cost for re-sampling and retesting shall be borne by the contractor.

6.5.3.2 Payment for re-sampled lots

The redefined PWL for a re-sampled lot shall be used to calculate the payment for that lot in accordance with Table 4.

6.5.3.3 Outliers

If the tests within a lot include a very large or a very small value which appears to be outside the normal limits of variation, check for an outlier in accordance with ASTM E 178, at a significance level of 5 percent, to determine if this value should be discarded when computing the PWL.

6.5.4 Leveling Course

Any course used for truing and leveling shall meet the requirements of paragraph 6.3.2 and 6.2.2, but shall not be subject to the density requirements of paragraph 6.5.2.3 and 4. The leveling course shall be compacted with the same effort used to achieve density of the test section. The truing and leveling course shall not exceed a nominal thickness of 37.5 mm.

6.6 Contractor quality control

6.6.1 General

The contractor quality control shall address all elements which affect the quality of the pavement including, but not limited to:

- xi. Mix design
- xii. Aggregate grading
- xiii. Quality of materials
- xiv. Stockpile management
- xv. Proportioning
- xvi. Mixing and transportation
- xvii. Placing and finishing
- xviii. Joints
- xix. Compaction
- xx. Surface smoothness

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6.6.2 Testing Laboratory

The field laboratory shall be equipped with all the necessary apparatus for carrying out all the tests related to asphalt treated base. It shall be available for joint use by the contractor for quality control testing and by the engineer for acceptance testing and must have adequate equipment for the performance of the tests required by these specifications. The engineer shall have priority in use of the equipment necessary for acceptance testing.

Laboratory facilities shall be kept clean and all equipment shall be maintained in proper working condition. The engineer shall be permitted unrestricted access to inspect the contractor's laboratory facility and witness quality control activities. The engineer will advise the contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to be adversely affecting test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are satisfactorily corrected.

6.6.3 Quality Control Testing

The contractor shall perform all quality control test necessary to control the production and construction processes applicable to these specifications. The testing program shall include, but not necessarily limited to, tests for the control of asphalt content, aggregate grading, temperatures, aggregate moisture, field compaction, and surface smoothness.

6.6.3.1 Asphalt content

A minimum of two extraction tests shall be performed per lot in accordance with ASTM D 2172 for determination of asphalt content. The weight of ash portion of the extraction test, as described in ASTM D 2172, shall be determined as part of the first extraction test performed at the beginning of plant production; and as part of every tenth extraction test performed thereafter, for the duration of plant production. The last weight of ash value obtained shall be used in the calculation of the asphalt content of the mixture.

The use of the nuclear method for determining asphalt content in accordance with ASTM D 4125 is permitted, provided that it is calibrated for the specific mix being used.

6.6.3.2 Grading

Aggregate grading shall be determined a minimum of twice per lot from mechanical analysis of extracted aggregate in accordance with AASHTO T 30 and ASTM C 136 (dry sieve). When asphalt content is determined by the nuclear method, aggregate grading shall be determined from hot bin samples on batch plants, or from the cold feed

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on drum mix or continuous mix plants, and tested in accordance with ASTM C 136 (dry sieve) using actual batch weight to the combined aggregate grading of the mixture.

6.6.3.3 Moisture content of aggregate

The moisture content of aggregate used for production shall be determined a minimum of once per lot in accordance with ASTM C 566.

6.6.3.4 Moisture content of mixture

The moisture content of the mixture shall be determined once per lot in accordance with ASTM D 1461.

6.6.3.5 Temperatures

Temperatures shall be checked; at least four time per lot, at necessary locations to determine the Temperatures of the dryer, the bitumen in the storage tank the mixture at the plant, and the mixture at the job site.

6.6.3.6 In-place density monitoring

The contractor shall conduct any necessary testing to ensure that the specified density is being achieved. A nuclear gauge may be used to monitor the pavement density in accordance with ASTM D 2950.

6.6.3.7 Additional testing

Any additional testing that the contractor deems necessary to control the process may be performed at the contractor's option.

6.6.3.8 Monitoring

The engineer reserves the right to monitor any or all of the above testing.

6.6.4 Sampling

When directed by the engineer, the contractor shall sample and test any material which appears inconsistent with similar material being sampled, unless such material is voluntarily removed and replaced or deficiencies corrected by the contractor. All sampling shall be in accordance with standard procedures specified.

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6.6.5 Control Charts

The contractor shall maintain linear control charts both for individual measurements and range (i.e., difference between highest and lowest measurements) for aggregate grading and asphalt content.

Control charts shall be posted in a location satisfactory to the engineer and shall be kept current. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the action and suspension limits applicable to each test parameter, and the contractor's test results. The contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the contractor's projected data during production indicates a problem and the contractor is not taking satisfactory corrective action, the engineer may suspend production or acceptance of the material.

6.6.5.1 Individual measurements

Control charts for individual measurements shall be established to maintain the process control within tolerance for aggregate grading and asphalt content. The control charts shall use the job mix formula target values as indicators of central tendency for the following test parameters with associated action and suspension limits:

CONTROL CHARTS LIMITS FOR INDIVIDUAL MEASUREMENTS (0/20)

sieve	Action limit	Suspension limit
1/2 inch (12.5 mm)	±0%	±0%
3/8 inch (9.5 mm)	±6%	±9%
No. 4 (4.75 mm)	±6%	±9%
No. 16 (1.18 mm)	±5%	±7.5%
No. 50 (0.30 mm)	±3%	±4.5%
No. 200 (0.075 mm)	±2%	±3%
Asphalt content	±0.45%	±0.70%

6.6.5.2 Range

Control charts for range shall be established to control process variability for the test parameters and suspension limits listed below. The range shall be computed for each lot as the difference between the two test results for each control parameter. The suspension limits specified below are based on a sample size of n=2. Should the contractor elect to perform more than two tests per lot, the suspension limits shall be adjusted by multiplying the suspension limit by 1.18 for n=3 and by 1.27 for n=4.

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CONTROL CHARTS LIMITS BASED ON RANGE (Based on n=2)

sieve	Suspension limit
3/8 inch (9.5 mm)	11%
No. 4 (4.75 mm)	11%
No. 16 (1.18 mm)	9%
No.50 (0.30 mm)	6%
No. 200 (0.075 mm)	3.5%
Asphalt content	0.8%

6.7 Corrective action

The quality control plan shall indicate that appropriate action shall be taken when the process is believed to be out of tolerance. The plan shall contain sets of rules to when a process is out of Control and detail what action will be taken to bring the process into control. As a minimum, a process shall be deemed out of control and production control stopped and corrective action taken, if:

- ✓ One point falls outside the suspension limit line for individual measurements or range; or
- ✓ Two points in a row fall outside the action limit line for individual measurements.

6.8 Testing measurements

ASTM C 29	Unit Weight of Aggregate.
ASTM C 88	Soundness of aggregates by use of sodium sulfate or magnesium sulfate.
ASTM C 117	Test method for materials finer than 75-µm (No.200)
ASTM C 131	Resistance to Abrasion of Small Size Coarse Aggregate by Use of Los Angeles Machine.
ASTM C 183	Sampling Hydraulic Cement.
ASTM C 566	Total Moisture Aggregate by Drying.
ASTM D 75	Sampling Aggregates.
ASTM D 995	Requirements for mixing Plants for Hot-Mixed Hot Laid Bituminous Paving Mixtures.
ASTM D 118	Bulk Specific Gravity of Compacted of Compacted Bituminous Mixtures Using Paraffin-coated Specimens.
ASTM D 1461	Moisture or Volatile Distillates in Bituminous Paving Mixtures.
ASTM D 1559	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus.
ASTM D 2041	Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.

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ASTM D 2172	Quantitative Extraction of Bitumen from Bitumen from bituminous Paving Mixtures.
ASTM D 2419	Sand Equivalent Value of Soils and Fine Aggregate.
ASTM D 2489	Degree of Particle Coating of Bituminous –Aggregate Mixtures.
ASTM D 2726	Bulk specific Gravity of Compacted Bituminous Mixtures using Saturated Surface-Dry specimens.
ASTM D 3203	Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures.
ASTM D 2950	Density of Bituminous Concrete in Place by Nuclear Method.
ASTM D 3665	Random Sampling of Paving Materials.
ASTM D 3666	Inspection and Testing Agencies of Bituminous Paving Material.
ASTM D 4125	Asphalt Content of Bituminous Mixtures by Nuclear Method.
ASTM D 4318	Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
ASTM D 4791	Flat or Elongated Particles in Coarse Aggregate.
ASTM D 4867	Effect of Moisture on Asphalt Concrete Paving Mixtures.
ASTM E 178	Practices for Dealing with Outlying Observations.
AASHTO T 30	Mechanical Analysis of Extracted Aggregate.
The Asphalt Institute's Manual No.2 (MS-2)	Mix Design Methods for Asphalt Concrete.
The Asphalt Institute's Manual No.20 (MS.20)	Hot- Mix Recycling

6.9 Material Requirements

ASTM D 242	Mineral Filler for Bituminous Paving Mixtures
ASTM D 946	Asphalt Cement for Use in Paving Construction
ASTM D 3381	Viscosity-Graded Asphalt Cement for Use in Paving Construction
ASTM D 4552	Classifying Hot-Mix Recycling Agents.

7. EMULSIFIED ASPHALT SLURRY SEAL SURFACE TREATMENT

7.1 Scope of works

The work shall consist of a mixture of emulsified asphalt, mineral aggregate, and water; properly proportioned, mixed, and spread on the existing wearing course of the runway shoulders or service roads in accordance with these specifications and shall conform to the dimensions shown on the plans or as directed by the engineer.

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The emulsified asphalt slurry seal surface treatment shall be used for the runway overlay shoulders as much as for the separation coat between a concrete pavement and a flexible overlay course.

If the contractor wishes to resurface the runway shoulders pavement by a method other than the one specified in this item, he is allowed to propose his method to the agreement of the engineer at the time of tendering.

7.2 Materials

7.2.1 Aggregate.

The aggregate shall consist of sound and durable natural and manufactured sand, slag crusher fines, crushed stone, or crushed stone and rock dust, or a combination thereof. Smooth-textured sand of less than 1.25 percent water absorption, as tested by ASTM C 128, shall not exceed 50 percent of the total combined aggregate. The aggregate shall be clean and free from vegetable matter, dirt, dust, and other deleterious substances. The aggregate blend shall have a sand equivalent of not less than 45 when tested in accordance with ASTM D2419. The aggregate shall show a loss of not more than 25 percent when tested in accordance with ASTM C 131. The sodium sulfate soundness loss shall not exceed 9 percent, or the magnesium soundness loss shall not exceed 12 percent after 5 cycles when tested in accordance with ASTM C88.

Aggregate retained on the no.50 sieve (300 micro m) shall be 100 percent Crushed.

The combined aggregate shall conform to the grading shown in table 1 when tested in accordance with ASTM C 136.

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TABLE 1 AGGREGATE-

Sieve Size	Percentage by Weight Passing Sieves
No.4 (4.75 mm)	100
No.8 (2.36 mm)	90-100
No. 16 (1.18 mm)	65-90
No.30 (600 µm)	40-60
No. 50 (300µm)	25-42
No. 100 (150µm)	15-30
No. 200 (75µm)	10-20
Residual asphalt content ercent dry aggregate	10-16
Pounds of aggregate Per square yard	6-10
Kilograms of aggregate Per square meter	3.2-5.2

The aggregate, as finally selected, shall have a grading within the limits designated in table 1, and should not vary from the low limit on one sieve to the high-limit on the adjacent sieve and vice versa.

Precautions shall be taken to prevent segregation of the aggregate in storing and handling. The stockpile shall be kept in areas that drain readily.

7.2.2 Filler

If filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D 242 and shall be used in the minimum amounts required. Mineral filler shall only be used if needed to improve the workability of the mix or to improve the grading of the aggregate. The filler shall be considered as part of the blended aggregate.

7.2.3 Emulsified asphalt

The emulsified asphalt shall be conform to the requirements of ASTM D2397 for type CSS-1 or CSS-1h for type Cationic emulsion (used for hot moderate or climates).

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7.2.4 Water

All water used in making the slurry shall be portable and free from- harmful soluble salts.

7.2.5 Tack coat

The tack coat shall be a diluted asphalt emulsion of the same type specified for the slurry mix. The ratio of asphalt emulsion to water shall be 1 to 3.

7.3 Construction methods

7.3.1 Weather limitations

The slurry seal, shall not be applied if either the pavement or the air temperature is 55 F (13°C) or below or when rain is imminent.

7.3.2 Equipment and Tools

All equipment, tools, and machines used in the performance of this work shall be maintained in satisfactory working order at all times. Descriptive information on the slurry mixing and applying to be used shall be submitted to the Engineer for approval not less than 10 days before work starts.

a. Slurry mixing Equipment

Pressure distributors used for application of diluted asphalt emulsion tack coat shall be self-propelled, equipped with pneumatic tires, and capable of uniformly applying 0.3 and 0.4 kg per square meter of diluted emulsion over the required width of application distributors shall be equipped with tachometers, pressure gages, and volume- measuring devices.

b. Slurry Mixing Equipment

The slurry mixing machine shall be a continuous flow mixing unit capable of accurately delivering a predetermined proportion of aggregate, water, and asphalt emulsion to the mixing chamber and of discharging the thoroughly mixed product on a continuous basis. The aggregate shall be prevented immediately prior to mixing with the emulsion. The mixing unit of the mixing chamber shall be capable of thoroughly blending all ingredients together. No excessive mixing shall be permitted. The mixing machine shall be equipped with an approved fines feeder that provides an accurate metering device or method to introduce a predetermined proportion of mineral filler into the mixer at the

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same time and location that the aggregate is fed into the mixer. The fines feeder shall be used whenever added mineral filler is part of the aggregate blend.

The mixing machine shall be equipped with a water pressure system and fog-type spray bar adequate for complete fogging of the surface with an application of 0.3 and 0.4 kg per square meter preceding the spreading equipment.

Sufficient machine storage capacity to mix properly and apply a minimum of 5 tones (4500 kg) of the slurry shall be provided. Proportioning devices shall be calibrated prior to placing the slurry seal.

c. Slurry spreading Equipment

Attached to the mixing machine shall be a mechanical-type squeegee distributor equipped within flexible material in contact with the surface to prevent loss of slurry from the distributor. It shall be maintained to prevent loss of slurry on varying grades and crown by adjustments to assure uniform spread. There shall be a lateral control device and a flexible strike-off capable of being adjusted to lay the slurry at the specified rate of application. The spreader box shall have an adjustable width. The box shall be kept clean, and built-up asphalt and aggregate on the box shall not be permitted. The user of burlap drags or other drags shall be approved by the Engineer.

d. Roller

The roller shall be a pneumatic-tired roller capable of exerting a contact pressure during rolling of 50 pounds per square inch (350000newtons per square meter).

e. Auxiliary Equipment

Other tools or equipment such as brushes, hand squeegees, hose equipment, tank trucks, water distributors and flushes, power blowers, barricades, etc., shall be provided as required.

7.3.3 Equipment calibration

Each slurry mixing unit to be used on the project shall be calibrated in the presence of the Engineer prior to construction. Previous calibration documentation covering the exact materials to be used may be accepted by the Engineer provided they were made during the calendar year. The documentation shall include an individual calibration of each material at various settings, which can be related to the machines metering devices. No machine will be allowed to work on the project until the calibration has been completed and / or accepted.

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7.3.4 Cleaning existing surface

Prior to placing the tack coat, unsatisfactory areas shall be repaired and the surface shall be cleaned of dust, dirt or other loose foreign matter, grease, oil, or any type of objectionable surface film. Any standard cleaning method will be accepted except that water flushing will not be permitted in areas where considerable cracks are present in the pavement surface.

Any painted stripes or markers on the surface to be treated shall be removed before applying the tack coat.

When the surface of the existing pavement or base is irregular or broken, it shall be repaired or brought to uniform grade and cross section as directed by the engineer. Cracks wider than 3/8 inch (9 mm) shall be sealed with compatible joint sealer prior to applying the slurry seal.

7.3.5 Application of bituminous tack coat

Following the preparation for sealing, application of the diluted emulsion tack coat shall be made by means of a pressure distributor in amounts between 0.3 and 0.4 kg per square meter as directed by the Engineer. The tack coat shall be applied, at least 2 hours before slurry seal, but within the same day.

7.3.6 Composition of slurry mix.

No slurry seal for payment shall be placed until a mix design has been approved by the Engineer. The mix design shall be developed by a laboratory with experience in designing slurry seal mixes and a signed copy submitted in writing by the contractor to the Engineer at least 10 days prior to the start operations.

The laboratory report must indicate the proportions of aggregates, mineral filler (min and max), water (min and max), and asphalt based on the dry aggregate weight. It shall also report the quantitative effects of moisture content on the unit weight of the aggregate (bulking effects). The mix design shall be in effect until modified in writing by the Engineer. Should a change in sources of materials be made, a new mix design shall be established before the new material is used.

The percent of aggregate passing each sieve shall not vary more than +/-14.0 percent from the mix design formula. The residual asphalt content shall not vary more than +/-1.0 percent from the mix design quantity.

7.3.7 Test sections

Test sections shall be placed prior to the start of the slurry seal work in the presence of the Engineer. The test area will be designed by the Engineer and will be located on the existing pavement.

Test strips shall be made by each machine after calibration. Samples of the slurry seal shall be taken and mix consistency and proportions verified. The rate of application will also be verified. If any test does not meet specification requirements, additional tests shall be made at the contractor's cost until an acceptable test strip is place

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7.3.8 Application of slurry

The surface shall be preventing by forging ahead of the slurry spreader box. Water used in preventing the surface shall be applied at such a rate that the entire surface is damp with no apparent flowing water in front of the slurry spreader box. The slurry mixture shall be of the desired consistency when deposited on the surface, and no additional elements shall be added. Total time of mixing shall not exceed 5 minutes. A sufficient amount of slurry shall carry in all parts of the spreader box at all times so that complete coverage of all surface voids and cracks is obtained. Care shall be taken not to overload the spreader box which shall be towed at the slow and uniform rate not to exceed 5 miles per hour (8 kilometers per hour). No lumping, balling, or unmixed aggregate shall be permitted. If the coarse aggregate settles to the bottom of the mix, the slurry will be removed from the pavement surface. A sufficient amount of slurry shall be fed in the box to keep a full supply against the full width of the squeegee. The mixture shall not be permitted to overflow the front sides of the spreader box.

No excessive breaking of the emulsion will be allowed in the spreader box. No streaks such as caused by oversized aggregate will be left in the finished pavement. Adjacent lanes shall be lapped at the edges a minimum of 4 inches (100 mm) to provide complete sealing at the overlap. All edges shall be feathered with hand squeegees. After application of the slurry seal, the surface shall be rolled with a pneumatic-tired roller a minimum of 4 coverage. The roller should be operated at a tire pressure of 50 pounds per square inch (350000Kpa).

The fresh slurry seal application shall be protected by barricades and markers and permitted to dry for 4 to 24 hours, depending on weather conditions. Any damage to uncured slurry will be repaired at the Contractor's expense.

In areas where the spreader box cannot be used, the slurry shall be applied by means of a hand filled by using hand squeegee. Any joints or cracks that are not filled by the slurry mixture shall be filled by using hand squeegee. No excessive buildup or unsightly appearance shall be permitted on longitudinal or transverse joints. Upon completion of the work, the seal coat shall have no holes, bare spots, or cracks through which liquids or foreign matter could penetrate to the underlying pavement. The finished surface shall present a uniform and skid resistant texture satisfactory to the Engineer. All wasted and unused material and all debris shall be removed from the site prior to final acceptance.

7.3.9 Emulsion material (contractor's responsibility).

Samples of the emulsion that the contractor proposes to use, together with a statement as to its source, must be submitted, and approval must be obtained before using such material. The contractor shall furnish the Engineer a manufacturing's certified report for each consignment of the emulsion. The manufacturer's certified report shall not be interpreted as a basis for final acceptance. All such reports shall be subject to verification by testing samples of the emulsion as received for use on the project.

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7.4 Testing requirements

ASTM C88	Soundness of aggregates by use of sodium sulfate or magnesium sulfate
ASTM C128	Specific gravity and absorption of fine aggregate
ASTM C131	Resistance to abrasion of small size coarse aggregate by use of the Los Angeles Machine
ASTM C136	Sieve or screen analysis of fine and coarse aggregates
ASTM D2419	Sand Equivalent Value of soils and fine aggregate

Material requirements

The asphalt	Table IV-3 Temperature-Volume corrections for institute Emulsified Asphalts Manual MS-6
ASTM D 242	Mineral Filler for Bituminous paving mixtures
ASTM D 977	Emulsified Asphalt
ASTM D 2397	Cationic Emulsified Asphalt

8. JOINT SEALERS

8.1 Scope of work

This work shall consist in the supply and installation of resilient and adhesive joint sealing filler.

8.2 Materials

Joint sealing material shall be submitted for the Engineer's approval and will conform to one of the following:

- Cold applied sealing compound two component elastomeric, polymer type (jet fuel resistant) –meeting Fe Spec. SS200.
- Hot poured one component (jets fuel resistant) meeting either ASTM D 1854 or ASTM D 3569.

Pre- formed joint sealer will not be accepted.

Each lot of batch of sealing compound shall be delivered to the job site in the manufacturer's original sealed container, marked with the manufacturer's name, batch or lot number, and the safe heating temperature. They shall be accompanied by the manufacturer's certification stating that the compound meets the requirements of this specification.

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8.3 Construction method

8.3.1 Time Application

Joints shall be sealed as soon as possible after completion of the slab curing period, and the pavement shall not be opened to traffic (including construction equipment) during this period.

If the pavement must be opened to traffic prior to placement of the sealant, the contractor will be required temporarily fill the joint with a jute or nylon rope immediately after the joint is sawn.

The rope should be slightly larger than the joint and should be forced into the joint so that the top rope is 3 mm below the pavement surface. The rope shall be removed immediately prior to cleaning.

8.3.2 Preparation of joints

Immediately before sealing, the joints shall be thoroughly cleaned of all curing compound and other foreign material. Cleaning shall be accomplished by sand blasting or wire brushing. Upon completion of cleaning, the joints shall be blown out with compressed air. The joint faces shall be surface dry when the sealant is to be applied.

8.3.3 Application of sealant

Joints shall be inspected for proper width, depth, alignment, and preparation, and shall be approved by the Engineer before sealing is allowed. Sealants shall be installed in accordance with the following requirements.

8.3.3.1 Hot poured sealants

The joint sealant shall be applied uniformly solid from bottom to top and shall not contain any voids. A backing material shall be placed as shown on the drawings and shall be non- adhesive to the concrete or sealant. For safety reasons, heating of the sealant shall be indirect means. Positive temperature control and mechanical agitation shall be provided. The sealant shall not be heated to more than 10°C below the safe heating temperature as indicated by the manufacturer. A direct connecting pressure type extruding device with nozzles shaped for insertion into the joint shall be provided. Any sealant spilled on the surface of the pavement shall be removed immediately.

8.3.3.2 Cold applied sealants

Cold joint sealing compound shall be applied by means of pressure equipment that will force the sealing material to the bottom of the joint and completely fill the joint without spilling the material on the surface of the pavement. A backing material shall be placed as shown on the plans and shall be non- adhesive to both concrete and sealant. Sealant which fails to bond with the concrete, is porous and does not achieve a tack-free

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condition will be rejected and replaced by the contractor at no additional cost. Before sealing the joints, the contractor shall demonstrate that the equipment and procedures for preparing, mixing, and placing the sealant will produce a satisfactory joint seal. This shall include the previous preparation of two small batches and the application of the resulting material on the trial section executed for slabs.

The use of a backup material should be compatible with the sealant, should not adhere to the sealant, should be compressible without extruding the sealant, and should recover to maintain contact with the joint faces when the joint is open.

8.4 Quality and work- done standards

8.4.1 Quality standards

The quality standards will be as follows:

Test item	Test method	Frequency	Standard value	Notes
Joint sealant	As approved by the Engineer	At every delivery	To meet: -SS-S200 Fed spec for cold applied sealant - ASTM D 1854 D 3569 for hot applied sealant	Manufacturer's data may substitute as directed by Engineer

9. PRIME COAT

9.1 Scope of work

This work shall consist of the prime coat to be applied on the prepared laterite gravel course to be overlaid by a treated bituminous base, in accordance with the requirements designated in the contract drawings, and as specified herein.

The contractor shall, before the work on the prime coat is started, secure the Engineer's approval in the material to be used and the methods of application.

9.2 Material

For the prime coat, a cut back asphalt meeting MC 70 type according to AASHTO M 82 or ASTM D 2028 will be used. The application temperature shall be from 50°C to 70°C.

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9.3 Construction methods

9.3.1 Distribution Quantity of Cut-back Asphalt

The cut-back asphalt shall be uniformly applied by means of a bituminous distributor at the rate of 0, 7 kg/m² to 0, 8 kg/m² depending on the course surface texture.

9.3.2 Weather Limitations

The prime coat may be applied on dry or humid surfaces, but never in foggy or rainy weather conditions.

9.3.3 Equipment

The equipment used by the contractor for the application shall include a self- powered bituminous material distributor and the requirement for heating the bituminous material. The distribution equipment shall have the capacity which allows the bituminous material at even heat to be applied uniformly on the surface at controlled specified rates from 0.5 kg/m² to 3 kg/m² with a maximum variation of specified rate not exceeding 10%. The distribution equipment shall include a tachometer, pressure gauges, volume measuring devices or calibrated tank and a thermometer for measuring temperatures of tank contents. The asphalt distributor shall be provided with a chart showing the relation between the working speeds, the spray bar pressure (or the rev. speed of the pump) and the rate of asphalt application. The distribution shall be self-powered and shall be equipped with a power unit for the pumps and full circulation spray bars adjustable laterally and vertically. The spray bar shall work according to the triple overlap principle.

A power broom shall be provided for cleaning of the surface to be treated.

9.3.4 Application of cut-back Asphalt

Immediately before applying the prime coat, the total surface area shall be swept with a power broom to remove all loose dirt and other objectionable material. The application of the cut- back asphalt shall be made by means of the pressure distributor at the temperature designated, and at a rate of 0.7 kg/m² to 0.8 kg/m².

After the application of cut-back asphalt on the aggregate course, the surface shall be allowed to dry not less than 48 hours without being distributed or for such additional time as may be necessary to permit the drying out of the prime coat. The period shall be determined by the Engineer.

The contractor shall then maintain and protect the prime coated surface from any damage until the hot asphalt treated base or sub base is placed. Where the prime coat is separated from the surface, the application of the cut-back asphalt shall be re- laid on the corresponding surface.

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9.4 Quality and work- done standards

9.4.1 Quality standards

The Engineer will decide if manufacturer test data will be sufficient. Otherwise, he will designate a test method to be performed at every stage of completion. The quality standards shall be as follows:

Test item	Test method	Frequency	Standard value	Notes
Cut back asphalt	To be approved by the Engineer	A every receiving	To meet AASTHO M 82 or ASTM D 2028	Manufacturer's data may substitute as directed by Engineer
Material not to be used 3 months after delivery				

9.4.2 Work done standards

The works shall be controlled as follows:

Test item	Test method	Frequency	Standard value	Notes
Application of cut back asphalt	As approved by the Engineer	As decided by the Engineer	0.7 to 0.8 kg/m ² ±10%	-

10. TACK COAT

10.4 Scope of work

This work shall consist of tack coat to be applied on the asphalt treated base or on the asphalt sub base course, in accordance with the requirements designated in the contract drawings, and as specified herein.

The contractor shall, before the work on the tack coat is started, secure the Engineer's approval in the material to be used and the methods of application.

10.5 Material

For the tack coat, an emulsified asphalt meeting SS1 type according to ASTM D 977 will be used. The application temperature shall be from 25°C to 55°C.

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10.6 Construction methods

10.6.1 Distribution Quantity of emulsified Asphalt

The application of emulsified asphalt shall be uniformly applied by means of a bituminous distributor at the rate of 0.3 to 0.4 kg/m² of residual asphalt.

10.6.2 Weather Limitations

The tack coat may be applied on dry or humid surfaces, but never in foggy or rainy weather conditions.

10.6.3 Equipment

The equipment used for the application shall include a self- powered bituminous material distributor and the requirement for heating the bituminous material.

The distribution equipment shall have the capacity which allows the bituminous material at even heat to be applied uniformly on the surface at controlled specified rates from 0.5 Liter/m² to 1 Liter/m² with a maximum variation of specified rate not exceeding 10%.

The distribution equipment shall include a tachometer, pressure gauges, volume measuring devices or calibrated tank and a thermometer for measuring temperatures of tank contents. The distribution shall be self-powered and shall be equipped with a power unit for the pumps and full circulation spray bars adjustable laterally and vertically.

A power broom shall be provided for cleaning of the surface to be treated.

10.6.4 Application of emulsified Asphalt

Immediately before applying the tack coat, the total surface area shall be swept with a power broom to remove all loose dirt and other objectionable material. The application of the emulsified asphalt shall be made by means of the pressure distributor at the temperature designated, and at a rate of 0.8 liter/m² to 1 liter/m².

After the application of emulsified asphalt on the asphalt treated base or sub base course, the surface shall be allowed to dry as may be necessary until it will not be picked up by traffic or equipment. The period shall be determined by the Engineer.

The contractor shall then maintain and protect the tack coated surface from any damage until the hot asphalt cement mixture is placed. Where the tack coat is separated from the surface, the application of the emulsified asphalt shall be re- laid on the corresponding surface area.

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10.7 Quality and work- done standards

10.7.1 Quality standards

The Engineer will decide if manufacturer test data will be sufficient. Otherwise, he will designate a test method to be performed at every stage of completion of works.

The quality standards shall be as follows:

Test item	Test method	Frequency	Standard value	Notes
Emulsified asphalt	As approved by the Engineer	A every completion of works	To meet ASTM D 977	Manufacturer's data may substitute as directed by Engineer

10.7.2 Work done standards

The works shall be controlled as follows:

Test item	Test method	Frequency	Standard value	Notes
Application of emulsified asphalt	As approved by the Engineer	As decided by the Engineer	0.3 to 0.4 kg/m ² of residual asphalt $\pm 10\%$	-

11 ANTI-KEROSENE PROTECTION

11.1 Scope of work

This work shall consist in applying a cover protection against Kerosene aggression on the bituminous surface of aircraft stand or apron.

It shall be used a binder placed in aqueous solution for surface protection. The concerned areas are shown on the plans.

The anti- kerosene product shall be in accordance with the French standard NFP 98-170 for category C product.

The contractor shall, before the application of the anti- kerosene protection is started, secure the Engineer's approval on the material to be used and the methods of application.

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11.2 Materials

For information, the product to be used could have the following characteristics:

Number of component: 1

Color of the dry thin layer: black

Aspect of the dry film layer: black silk finish emulsion, half- flexible

Relative density at 20⁰: approximately 1.2 g/ml

11.3 Construction methods

The underlying support shall be prepared to be clean without any wet trace when applying the anti-K protection.

It recommended that the covering should be applied in three (3) layers.

For instance, the application could be as follows:

1st layer:

- a. Application of the pure product if the conditioning is 30kg, or diluted between 20% and 30% if the conditioning is 250kg according a consumption of 300 to 500g per square meter.

2nd layer:

- b. Application of the pure product according a consumption of 300 to 500g per square meter.

3rd layer:

- c. Application of the pure product according a consumption of 300 to 500g per square meter.

The average total thickness of the product could be around 500μ.

It shall be necessary to respect the minimum required drying time, but also the time of covering over between the first and the second layer as defined by the manufacturer of the product.

11.3.1 Weather limitations.

The painting shall be performed on when the surface is dry, when the atmospheric temperature is above 45F (7⁰C), and when the weather is not foggy or windy.

11.3.2 Equipment.

All equipment for the work shall be approved by the Engineer and shall include the apparatus necessary to properly clean the existing surface, a mechanical marking machine, and such as auxil.

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12 FENCING

12.1 General

The scope of works to be executed consists of furnishing and erecting fences in accordance with these specifications and the details shown on the plans and in conformity with lines and grades shown on plans or established by the Engineer. In particular, the contractor shall, before work on fences and gates is started, secure the Engineer's approval on the materials to be use and on the methods of execution.

12.2 Material

12.2.1 Wooden fence

The wooden fence shall be made of wood board with length of 150mm and spaced out by 500mm, and shall receive a treatment against weather aggression.

12.2.2 Wooden structure

The structural members shall be wooden posts 120 wide and 80mm thick, fully slotted in a concrete foundation (500mm wide and 750mm deep). Two perpendicular wooden boards shall be also fixed to the wooden posts to support the vertical wooden board. The structural wooden posts shall be spaced every 6m.

12.2.3 Concrete for Foundation

The concrete to be used shall conform to K 175 or K 225 as specified in paragraph 15, in concrete works.

12.3 Construction methods

12.3.1 Clearing fence line

The site shall be sufficiently cleared of obstructions. The fence line shall be cleared to a minimum of 60cm on each side of the centerline of the fence. This clearing shall include the removal of all stumps, brush, rocks, tree, or other obstructions within this area of the fence line. The area shall be grubbed or excavated as necessary and all holes

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remaining after stump removal shall be back- filled with suitable soil, or other materials acceptable to the Engineer and shall be compacted properly with tampers.

12.3.2 Fixing of wooden fence

The wooden fence will be fixed to the posts as shown on contract drawings or as proposed by the contractor and accepted by the Engineer.

12.3.3 Cleaning up

After the work is completed, the contractor shall clear the site of surplus materials, dirt and rubbish and shall restore the site to conditions acceptable by the Engineer.

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12.3.4 Quality and work done standards

12.3.5 Quality standards

The quality standards shall be as follows:

Test item	Test method	frequency	Standard value	Notes
chain link fence or wire fence	As approved by the Engineer	At every delivery of materials	To meet requirements specified in this section	Manufacture's test data may substitute as directed by the Engineer
Welding	Ditto	Ditto	Ditto	
Concrete	As specified in paragraph 15-concrete works			



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13 CONCRETE KERBING

13.1 Scope of work

- a. This shall consist of the concrete kerbs to be constructed in accordance with the requirements of location, dimension, line and grade designated in the contact drawings and as specified herein.
- b. The contractor shall, before work commences, secure the Engineer's approval on the materials to be used and the methods of execution.

13.2 Materials

13.2.1 Prefabricated concrete blocks

The concrete blocks shall be of the shape and dimensions designated in the contract drawings. The concrete to be used shall meet the requirements of K 175 and K225 as specified in paragraph 15-concrete works.

13.2.2 Reinforcing Bars

All reinforcing bars shall meet the requirements specified for steel bars in paragraph 15, -concrete works.

Size and dimension of reinforcing bars shall meet the requirements designated in the contact drawings or those of the Engineer where specifically requested.

13.2.3 Laterite gravel

The laterite gravel shall be in accordance with the requirements as specified in the paragraph 4.

13.2.4 Mortar

The mortar shall be in accordance with the requirements as specified in the paragraph 15-concrete works.

13.3 Construction methods

13.3.1 Foundation

The foundation materials (laterite gravel) shall be placed to the line grades and dimensions shown on the contract drawings and shall be compacted by the tamper.

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13.3.2 Placing concrete

The concrete shall be placed according to the contract drawings which show in particular the quantity of concrete to be placed in order to prevent, any displacement of the concrete kerb.

13.3.3 Placing kerb

The prefabricated concrete kerb shall be set on a concrete foundation and with any necessary additional concrete to give support to the kerb. The top surface and alignment of finished concrete curb shall not show depressions more than 5mm when measured with a3 straightedge.

13.3.4 Cleaning and restoration of the site

After is completed, the contractor shall clear the site of surplus material, dirt and rubbish and shall restore the site to the original conditions.

13.4 Quality and work done standards

13.4.1 Quality standards

The quality standards shall be as follows:

Test item	Test method	Frequency	Standard value	Note
Concrete reinforcing bars mortar	As specified in paragraph 15-concrete works			
Laterite gravel	As specified in paragraph 4			



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13.4.2 Work done standards

The work shall be controlled as follows:

Work item	Test item	Test method	Frequency	tolerance	Notes
Concrete kerbing	Finish elevation	By surveying specified in part 1-section 2	At points designated by the engineer	±1cm	
	width	By the Engineer's instruction	Ditto	±2cm	
	Length	Ditto	Ditto	Not specified -2cm	
	thickness	Ditto	Ditto	±2cm -1cm	
	Flatness and alignment	By 3m straightedge	At lines designated by the Engineer	Irregularities Shall not exceed 5mm	

14 CONCRETE WORKS

14.1 General

14.1.1 Scope of works

The works to be executed by the contractor under this section shall comprise all the concrete works, reinforced or unreinforced, in the civil works.

14.1.2 Codes and standards

The concrete works shall be carried out in accordance with the requirements of the following codes and standards:

- i. ASTM : The American Society for Testing and Materials.
- ii. AASHTO : Standards Specifications for Transportation Materials and Methods of
 1. Sampling and Testing (Part I specifications & Part II Testing).

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- iii. ACI 305 : Hot Weather Concreting, American Concrete Institute.
- iv. ACI 315 : Details and Detailing of Concrete Reinforcement, American Concrete
1. Institute
- v. ACI 318 : Building Code Requirements for Reinforced Concrete, American Concrete
1. Institute
- vi. ASTM C 207 : Hydrated Lime
- vii. ASTM C 227 : Test Method for Potential Alkali Reactivity of Cement Aggregate
1. Combinations (Mortar bar Method)
- viii. ASTM C242 : Terminology of Ceramic White wares and Related Products
- ix. ASTM C 289 : Test Method for Potential Reactivity of Aggregates (Chemical Method)
- x. ASTM C 476 : Mortar and Grout for Reinforcement of Masonry
- xi. ASTM C586 : Test Method for Potential Alkali Reactivity of Carbonate Rocks for Concrete Aggregate (Rock Cylinder Method) and:
- xii. AASHTO M 31: Deformed and Plain Billet- Steel Bars for Concrete Reinforcement.
- xiii. AASHTO M 32: Cold Drawn Steel Wire for Concrete Reinforcement.
- xiv. AASHTO M 45: Aggregate for Masonry Mortar.
- xv. AASHTO M 55: Welded Steel Wire Fabrics for Concrete Reinforcement.
- xvi. AASHTO M 85: Portland cement.
- xvii. AASHTO M 153: Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
- xviii. AASHTO M 173: Concrete Joint Sealer, Hot- Poured Elastic Type.
- xix. AASHTO M 213: Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction.
- xx. AASHTO T11: Amount of Materials Finer than 0.075mm Sieve in Aggregate.
- xxi. AASHTOT 21: Organic Impurities in Fine Aggregate for Concrete.
- xxii. AASHTO T 22: Compressive Strength of Cylindrical Concrete Specimens.
- xxiii. AASHTO T 23: Marking and Curing Concrete Compressive and Flexural Test Specimens in the Field.
- xxiv. AASHTO T 26: Quality of Water to be used in Concrete.
- xxv. AASHTO T 84: Specific Gravity and Absorption of fine Aggregate.
- xxvi. AASHTO T 85: Specific Gravity and Absorption of Coarse Aggregate.
- xxvii. AASHTO T 96: Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine.
- xxviii. AASHTO T 97: Flexural Strength of concrete (Using Simple Beam in the Third-Point Loading).
- xxix. AASHTO T 104: Soundness of Aggregate by use of Sodium Sulphate or Magnesium Sulphate.

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- xxx. AASHTO T 112: Clay Lumps and Friable Particles in Aggregates.
- xxxi. AASHTO T 119: Slump of Hydraulic Cement Concrete.
- xxxii. AASHTO T 126: Making and Curing Concrete Test Specimens in the Laboratory.
- xxxiii. AASHTO T 141: Sampling Fresh Concrete.
- xxxiv. Shop drawings for all works required indicating, in detail, the reinforcement bar

Schedules, the materials list properties, and the construction requirements. Shop drawings shall be submitted not less than two (2) months before construction commences. In addition, the contractor shall submit structural calculations for any work proposed which is at variance with work as shown or specified in the tender documents.

A detailed construction plan indicating the proposed methods, sequences, standards, etc., to be adopted.

Furthermore, the contractor shall submit the mix design for each type of concrete thirty (30) days prior to the intended start of concrete placement, and he shall notify in writing twenty four (24) hours before starting mixing or placing of any concrete.

The results in writing of all specified quality control tests shall be submitted as soon as they are available or requested by the engineer. In the case of compressive or flexural strength tests, this will involve submitting the 3-days strength, 7-days strength and 28-days strength test results 3 days and 28 days respectively following the date of mixing.

14.2 Materials

14.2.1 General

All materials shall be new and of the best quality of the specified type. They shall meet the requirements of the relevant standards.

14.2.2 Source and storage of material

All materials and plant necessary for the construction shall be supplied by the contractor. A statement of the origin of all materials and plant intended to be used on the site shall be submitted by contractor within a period of sixty (60) calendar days from the date of acceptance of the tender. This statement shall include the characteristics of the materials and plant, the standards of performance, test reports, proofs of past performance and the reason for their selection.

Samples shall be submitted to the Engineer for all materials which may be subject to acceptance tests (aggregates, cements, prefabricated components, coatings and renderings, sealing products, mastics, etc...). Acceptance samples shall be kept as reference to be compared with the materials delivered on site as the works proceed.

The contractor shall provide, on request, proof of the origin and quality of the materials. No materials shall be permitted on site which are not specified or specifically approved

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in writing. Any modification of the origin and quality of materials shall not be permitted without the Engineer's authorization. The contractor shall submit proof the proposed material is equal or better than that specified, including detailed description, test reports and past performance data.

The contractor shall provide storage areas, with suitable surfacing, large and resistant enough to preclude any pollution of the materials throughout the duration of the works. The storage of cements and reinforcement steel bars on bare ground is prohibited.

14.2.3 Acceptance Tests

The Engineer may stipulate complementary acceptance tests, as well as test methods, in addition to those performed by the contractor's laboratory.

These tests shall be carried out in this same laboratory under the control of the Engineer or his representative. Rejected lots shall be immediately isolated and labeled to avoid any risk of confusion. They shall be removed from the work site by the contractor within 48 hours following their rejection.

14.2.4 Cements

14.2.4.1 Nature of cements and testing

The cements used for the concrete works shall be any type of Portland cement conforming to AASHTO M 85. However, unless otherwise permitted by the Engineer, air-entraining cements shall not be used.

Supply of cement shall be submitted for approval before use, with respect to origin and quality. Subsequent deliveries shall be also subject to quality control testing as work proceeds.

Approval of origin and quality shall be given on presentation of test results showing that the cement factory proposed is able to supply a product which will consistently meet the physical and chemical qualities specified. Quality control tests shall be made on each cement delivery, in order to determine the following characteristics:

- i. Specific gravity,
- ii. Specific surface by means of air permeability,
- iii. Heat loss,
- iv. Hot and cold expansion properties,
- v. Compressive strength at 3, 7 and 28 days,
- vi. Setting time, and periodic determination of carbonate, alkali and chloride contents.

All these tests shall be carried out in accordance with a procedure agreed by the engineer. When cement is stored for long periods, the Engineer shall be entitled to ask

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for a renewal of quality control tests, restricted to heat loss, setting and chemical resistance.

Manufacturer's test certificates shall be submitted to the Engineer on request.

Unless otherwise permitted by the Engineer, the product of only one mill and one brand shall be used to the project for each type of Portland cement used in the project.

14.2.4.2 Storage

Cement must be stored in a way approved by the Engineer, which will prevent deterioration or contamination. A suitable building or tank shall be provided for this purpose.

No cement which is in any way affected by dampness or aeration shall be used in the work, and any cement which the Engineer considers to be unfit for use shall be rejected without any further testing.

Cement delivered in bags shall be stored under cover, in a weatherproof shed that is airtight and has a raised wooden floor covered with polyethylene sheeting. The stacks of cement bags shall be always kept covered with an envelope of polyethylene sheeting.

14.2.4.3 Aggregates

14.2.4.3.1 General specifications for aggregates

Aggregate for concrete shall be supplied from the most suitable source determined by the contractor in accordance with the Employer's requirements, with the technical requirements there under specified, and with the agreement of the Engineer.

Regular tests shall thence forward be carried out during the entire period of construction works, to ensure that the quality of subsequent supplies is maintained.

Aggregates for concrete (reinforced and non- reinforced) shall originate from stable rock, not subject to deterioration under the influence of water or air.

They shall contain no impurity detrimental to the essential properties of concrete: stress resistance, durability and impermeability.

The documentation required to be submitted to the Engineer to substantiate their origin and quality is as follows:

- a. A document identifying the workings, giving the exact location of the bed being worked and the place of extraction, and describing the technique of preparation of the aggregates (crushing, sieving, washing or dust-freeing) and the production and storage capacity.
- b. The mineralogical identification reports of the natural materials or rock-based prepared materials and the results of qualitative and quantitative analysis carried out by the contractor's laboratory which must thus be equipped with the necessary means. References must be established from a sufficient number of analyses for a valid identification of homogeneity of the bed or geological horizon being worked.

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The contractor's attention is drawn to the particular importance of the mineralogical composition of the aggregates. Tests shall be carried out to ensure that the aggregates do not contain any component liable to affect the durability of the concrete. For this purpose, the following appropriate tests shall be carried out:

- i. Reactivity of aggregates (chemical method-ASTM C.289),
- ii. Sodium sulphate and magnesium sulphate soundness of aggregates (AASHTO 104); the loss after 5 cycles shall be at maximum 10% for fine aggregates and 12% for coarse aggregates; if a loss lower than those specified cannot be obtained, the Engineer may approve the use of material, based on other data and experience,
- iii. Alkali reactivity of the concrete mix (mortar bar-ASTM C.227-C.586),
- iv. Change of volume of the concrete mix (ASTM C.242).

The contractor shall consider that these tests are quite long to carry out. He shall therefore take the necessary measures so that the tests do not delay the regular progress of the works. The contractor shall be responsible for possible delays.

14.2.4.3.2 Fine aggregates

Fine aggregates may be either sand resulting from crushing of the rock used for the fabrication of coarse aggregates with a Loss Angles abrasion coefficient lower than 35% at 500 revolutions (AASHTO T96) or a water absorption capacity lower than 5% (AASHTO T 84), or natural river sand, and shall conform to the requirements specified here above. The use of sea sand is not allowed. Fine aggregates shall not include any excessive quantity of flat and elongated matter such as shells and shall conform to the following grading requirements:

Sieve designation		Percentage of passing material
Standard (mm)	Imperial (inches)	(By weight)
10	3/8	100
4.75	#4	95-100
2.36	#8	80-100
1.18	#16	50-85
0.6		25-60
0.3	#50	5-30
0.15	#100	0-10
0.075	#200	0-3

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The fineness module shall be between 2.3 and 3.1. The granulometric dispersion range shall not allow a variation in the fineness module of more than 0.5.

The cleanliness of the fine aggregates shall be assessed generally by the application of the sand Equivalent Test (AASHTO T 176), the result of which must be above 75%. The material shall be washed or freed of dust, if necessary.

The following shall be considered as impurities and shall not be accepted:

- i. Wood or coal particle, or their residues'
- ii. Organic matter, which may only be accept if present in sufficiently small quantities, as revealed by the coloration tests (AASHTO T 21) to show a lighter colour than the typical colouring.
- iii. Sulphates and sulphides, which shall only be tolerated if the total sulphur content, expressed in SO_3 , does not exceed 1% by weight (the proportions shall be determined by chemical analysis if their presence is detected by qualitative test),
- iv. Chlorides, which shall only be tolerated as trace elements, but the total amounts of chlorine present in concrete due to its constituents (aggregates, cement, mixing water) shall under no circumstances exceed 0.4% in respect of reinforced concrete, calculated in relation to the weight of the cement,
- v. Clay and crumbly particles, which must of represent less than 1% of the weight of the aggregates (AASHTO t 112).

If considered necessary by the Engineer, the sand shall be rewashed at the contractor's expense.

The use of granite fines in lieu of shall be subject to the approval of the Engineer who may require adjustments to the mix proportions as deemed necessary.

14.2.4.3.3 Coarse aggregates

Coarse aggregates shall be rounded natural aggregates or crushed aggregates obtained by crushing a rock which meets the general description specified here above. It shall have a Los Angeles abrasion coefficient after 500 revolutions below 35% (AASHTO T 96) and a water absorption capacity < 5% (AASHTO T 85).

The aggregates shall include as few as possible of flat and elongated particles. The testing for checking the number of particles with an incorrect shape shall be carried out either by determining the average volumetric coefficient of the aggregates, or by any other equivalent method approved by the Engineer.

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The coarse aggregates shall meet the following grading requirements:

Sieve designation		Percentage of passing material
Standard (mm)	Imperial (inches)	(By weight)
25	1	100
20	3/4	90-100
10	3/8	20-55
4.75	#4	0-10
2.36	#8	0-5
1.18	#16	0-2
0.075	#200	Max .1

The coarse aggregates shall be selected so that the maximum particle size is no more than $\frac{3}{4}$ of the minimum clear space:

- i. Between reinforcing bars,
- ii. Or between reinforcing bars and formwork,
- iii. Or between any other restrictions in the space that the concrete must occupy in the work.

The same requirements regarding impurities as those specified for fine aggregates shall be applicable.

14.2.5 Water

Water for concrete mixing shall be clean and free from harmful matters, such as grease, oil, salt, acid, alkali, sugar or organic matters. It shall have a pH approximately neutral. Analyses to be submitted to obtain approval of the water quality must that:

- i. The amount of matter in suspension is less than 2g per litre,
- ii. The amount of dissolved salts does not exceed 15g per litre.

Among salts in solution, chlorides shall only be permitted if the (Cl⁻) ion content in the concrete, included all constituents, calculated in relation to the weight of the cement, and does not exceed a maximum content of 0.4%. The total amount of sulphates shall be less than 1% if cement ASTM type I is used. Otherwise, ASTM cement type V shall be used.

In case of doubt concerning the quality of the water, verification can be made by comparing the influence of the water on the setting time of the cement, and the

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quantities of resistance of the concrete mix, one made with the water submitted for approval and the other with distilled water. Resistance to compression after 28 days using the water proposed shall not be less than 90% of the resistance of the sample mixed with distilled water.

14.2.6 Admixtures

All admixtures shall be conformed to the relevant AASHTO standards and shall be approved by the Engineer. Any delivered of admixtures shall be accompanied with a certificate of origin starting the date of manufacturing and the limit date of use.

14.2.7 Curing products

All curing products are subject to the Engineer's approval.

All requests for approval must be accompanied by a test report, the test having been carried out by a specialised laboratory establishing the efficiency of the product under hazardous conditions: at 40⁰ Celsius and with humidity of 55%, the coefficient of efficiency of the product shall not be less 85% after 6 hours and 80% after 24%.

Furthermore, the curing product shall not adversely affect the bond of neither coatings nor insulation, or the bond of water proofing systems to be applied to the concrete.

A certificate of origin and directions for use shall be submitted with every delivery.

14.2.8 Reinforcement steel

Unless otherwise specified all reinforcement steel shall comply with the requirements of the ACI315, and shall be free of any defect which would affect their strength or ability to be bent, such as faults, cracks, crevices, blow- holes, or material deficiency.

The surface shall be regular without hair- cracks or holes, undulations or incipient oxidation pitting. Sawn or sheared sections shall be clean, uniform and free of defects. Reinforcing steel shall be plain or deformed billet steel bars, conforming to the following requirements:

- i. Plain bars, for diameters less or equal to 12mm (and for dowel bars, even with diameters greater than 12mm):

$$\text{With } f_Y = 2.400 \text{ kg/cm}^2$$

- ii. Deformed bars, for diameters more or equal to 16m:

$$\text{With } f_Y = 3.900 \text{ kg/cm}^2$$

Steel mesh reinforcement shall be welded steel fabric, type BRC or similar, conforming to the following requirements: with $f_Y = 5.000 \text{ kg/cm}^2$.

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Approval given by the Engineer to any source of steel under the above conditions does not in any way relieve the contractor from his contractual liability to supply materials which comply with the specifications. Any material which in opinion of the Engineer, is unsatisfactory or does not comply with the requirements of the ACI 315 shall be rejected.

Any delivery of steel in which satisfactory material has been mixed unsatisfactory material shall be rejected and shall be removed from the site. Bars in very long reinforcement shall be supplied in such lengths that laps are at least 11.50m apart.

14.2.9 Coal tar Base Products

Rendering on concrete surfaces below ground shall be generally a de-acidified coal tar base product submitted to the Engineer for approval, except, as otherwise specified.

14.2.10 Supports and Ties

Supports for reinforcement shall be formed from lightweight steel bars or precast concrete blocks of class K275 concrete, unless otherwise directed by the Engineer. Wood, bricks, stone or other materials shall not be permitted as supports.

Ties fastening reinforcement shall be annealed steel wire conforming to AASHITO M 32.

14.2.11 Mild Steel Sections and Tubes

Steel tubes and profiles for minor works included in the concrete works, such as sleeves, will not be subject to acceptance tests. They shall however meet the size characteristics shown on the drawings, or the equivalent.

They shall be free from deformation or incipient oxidation pitting.

14.2.12 PVC Pipes

PVC pipes embedded in the concrete works shall be of standard type and shall be approved by the Engineer.

They must be of sufficient strength to withstand pressures created by freshly pounced concrete or forces set up during fixing of reinforcement, or any other stresses to which they may be subjected. All joints must perfectly seal.

14.3 Workmanship

14.3.1 General

The workmanship shall be of first-class quality and shall follow the normally accepted methods defined by the applicable codes of practice. In the absence of special mention in these specifications, the instructions included in standard international regulations and, especially, in the Indonesian code of practice for reinforced concrete construction, ACI135 shall apply.

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The concrete works shall be carried out in such a manner as to ensure a satisfactory co-ordination with the works of the other trades.

14.3.2 Equipment, Plants and Construction Methods

Within a period of thirty (30) days from the date of award, the contractor shall submit the list of heavy equipment and plants he intends to use, to the Engineer's approval. This list must include, as a minimum, the following items:

- i. Bulldozers, graders, tire rollers, vibrating cylinders,
- ii. Excavators,
- iii. A shop for bending reinforcement steel bars, and for each separate construction site:
- iv. One automatic-weighing concrete mixer, and a separate facility for weighing cement with a tolerance of 0.5%,
- v. One or more cement containers equipped with thermometers, permitting the storage of a minimum quantity of cement corresponding to 2-day consumption when concreting in continuous,
- vi. The trucks necessary for resupplying aggregate stockpiles and other socks necessary for the jobsite,
- vii. Cranes providing service to all parts of the jobsite, if deemed necessary by the Engineer,
- viii. Props, joints and platforms,
- ix. Formwork in sufficient quantity to ensure that the specified striking is strictly maintained,
- x. Provision for safety rails,
- xi. Compressors and concrete vibrators, vibration tables, poker vibrators,
- xii. Mats or and tarpaulins for protection of freshly pounced concrete.

The contractor shall join to the equipment list a memorandum specifying the construction methods and the equipment planned for each work.

14.3.3 On Site Laboratory and Controls

The contractor shall install an onsite laboratory staffed and equipped before the beginning of stockpiling materials.

This laboratory shall be used by the contractor, at his cost, to perform all permanent control tests of production and working quality required by the Engineer under the present contract, and any others which it shall deem necessary to perform on the site.

In particular, the contractor shall be able to control the quality of the constituents of pounced and precast concrete, and of other materials intending for masonry works.

Here shall provide the minimum following equipment:

- i. Complete sieve analysis equipment: sets of sieves from 80 microns to 50 mm, scales, oven etc.

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- ii. Equipment for measuring and equivalent and CaCO_3 content,
- iii. A series of metal moulds for making concrete test cylinders,
- iv. Two Abram's cones for concrete slump testes,
- v. A concrete press (minimum force 1.200kN),
- vi. A flexural strength testing machine,
- vii. Equipment for smoothing concrete test specimens,
- viii. Equipment for normal and modified Proctor compaction test,
- ix. A diagram dens meter for compaction control,
- x. Precision scales suitable for the various tests,
- xi. Cement testing equipment: setting test, fast identification, specific area,
- xii. Various necessary chemicals,
- xiii. An accelerometer or a concrete hammer for non- destructive testing of concrete in- situ.

This laboratory shall also be able to perform the acceptance tests started in the present contract specifications, other than those within the competence of the surveyors. All the test results shall be noted in test reports, to submitted to the Engineer's within tree (3) days following the tests.

14.3.4 Composition of Mortars and Concretes

The material proportions and batch weights for mortars and concretes shall be determined in accordance with the limits given in the following table.

Reference or class	Designation	Composition	Purpose
K125	Lean concrete	Estimated cement content: 250kg/m^3 Maximum water content: 130kg/m^3	Blinding beds under concrete slabs in contact with the ground, and under foundations
K175	Structural unreinforced concrete	Estimated cement: 300kg/m^3 Maximum water content: 150kg/m^3	Unreinforced plain concrete structures, such as sidewalks, curbs, cable ducts
K225	Structural reinforced concrete	Estimated cement content: 350kg/m^3 Maximum water content: 160kg/m^3	All reinforced concrete drainage and civil works structures

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Reference or class	Designation	Composition	Purpose
M1	Masonry mortar	400kg of cement per m ³ of dry sand	Laying the masonry blocks
M2	Mortar for capping and coatings	450kg of cement per m ³ of dry sand	Standard facings and capping, anchoring, filling, grouting
M3	Mortar for vertical facings	250kg of cement & 250kg of lime per m ³ of dry sand	Renderings on walls
M4	Waterproofing mortar	600kg of class 5 cement per m ³ of dry sand	Facings of conduits, underground structures & basis damp-proofed courses

Within thirty (30) days from the date of acceptance of the contract, the contractor shall propose to the Engineer, for each of the mortars and concrete listed in the table here above:

- i. The origin and grading of the aggregates,
- ii. The mix designs (contents of sand, coarse aggregates, cement and water) for the concretes.

The contractor shall support his proposals for the mix designs of the structural concretes, by making and testing trial mixes, in the presence of the Engineer, using the same type of plant and equipment as will be used for the works, and shall submit the test reports to the Engineer.

The Engineer, within five (5) working days, shall make his comments on those proposals, or approve them. However, even after his approval the contractor shall still be entirely responsible for achieving the results required by the concrete quality control testing specified there under.

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14.3.5 Structural Concrete Design Tests**14.3.5.1 Nature of the tests**

For each class of structural concrete, K175, K225, the design tests shall consist of:

Type of tests	Age	Number of specimens tested
Compressive strength	3 days	20
	7 days	20
	28 days	20
Flexural strength	3 days	20
	7 days	20
	28 days	20

And plasticity control tests by measurement of the slump.

All these tests shall be carried out in accordance with the requirements of AASHITO T22, T97, T126 and T119.

The trial mix designs shall be deemed acceptable provided they meet all the mix property requirements specified here after.

14.3.5.2 Mix property requirements

All structural concretes used in the work shall meet the compressive strength, flexural strength and slump requirements specified in the following tables, or approved by the Engineer, when sampled, cured and tested in accordance with AASHITO T22, T23, T97, T119, T126 and T141.

Concrete Class	Minimum compressive strength (kg/cm ³)					
	15 cm cube specimen σ_{bK}			15cm x30cm cylinder specimen $0.83\sigma_{bK}$		
	3-day	7-day	28-day	3-day	7-day	28-day
K 175	70	115	175	55	95	145
K 225	90	145	225	75	120	185

Concrete class	Minimum flexural strength = modulus of rupture MR (kg/cm ²)		
	3-day	7-day	28-day
K 175	16	21	26
K 225	18	23	29

Note: MR from= $K \sqrt{f'_c}$, with K=8 to 10, and $f'_c = 0.83\sigma_{bK}$, in psi.

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concrete	Slump (mm)	
class	Vibrated	Non- vibrated
K 175	20-60	50-80
K 225	20-60	50-100

14.3.6 Structural concrete quality control Tests

14.3.6.1 Nature of the tests

Systematic quality control tests of the structural concretes K175, K225, shall be carried out throughout the works execution.

These tests consist of:

Type of tests	Number of specimens	Age
Compressive strength	2cylinders	3days
	2cylinders	7days
	2cylinders	28days
Flexural strength	2 prisms	3days
	2 prisms	7days
	2 prisms	28days

The compressive strength tests shall be normally carried out on cylinder specimens. However, the contractor may use cube specimens with the approval of the engineer. Plasticity control tests by measurement of the slump of fresh concrete, shall be carried out using the Abrams cone, and completed, if necessary, by the compacting factor test described in ACL 315. One slump test, or more as directed by the engineer, shall be called out on every batch of concrete produced, and the test shall not be deemed to have been carried out unless witnessed by the engineer or his representative. All these tests shall be carried out according to the methods specified there under.

14.3.6.2 Sampling of specimens for quality control testing

The sampling of the concrete specimens for the quality control testing shall be carried out as directed by the Engineer, either from the concrete mixer, or when placed. Each test series shall comprise 6 cylinders and 6 prisms for each grade of concrete poured. The following shall apply every day:

- ✓ 1 test series if the quantity poured is less than 60 m³,
- ✓ 2 test series if the quantity poured is more than 60 m³,

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- ✓ 1 test series for any isolated structure, regardless of its volume,
- ✓ 1 test series every day.

However, the Engineer may reduce the test frequency as soon as production and strength consistency of the various grades of concrete has been achieved. The test frequency shall not however, ever be less than at one week interval.

The specimens for the 3-day and 7-day tests shall always be stored near the structure, adequately protected and maintained by the contractor, so that their thermal and hygrometric history is comparable to that of the structure.

The specimens intended for the 28-day tests shall be kept in their molds at a temperature as close as possible to 20°C during the first 24 hours. They shall be removed from the molds after 24 hours, placed into sealed casings and transported to the laboratory as quickly as possible. They shall be kept under water until are tested. They shall be wiped, but not dried, just before testing.

14.3.6.3 Test results

The results of the quality control tests shall be in accordance with the mix property requirements, as specified here above.

They shall be submitted to the Engineer as soon as they are available.

14.3.6.4 Consequences of unsatisfactory test results

14.3.6.4.1 Plasticity

Concrete not meeting the slump requirements shall generally not be placed in the work, except that the Engineer may in some instances approve the limited use of small quantities of such concrete in lowly-stressed parts of certain works. The workability and texture of the mix shall be such that it can be replaced in the works without the formation of hollow spaces or gaps or retention of air or water bubbles, and such that on removal of formwork as smooth, uniform, dense surface is presented.

If it appears impossible to get the specified workability with the original mix design approved by the engineer, the contractor shall submit to the Engineer's approval mix adjustments. Admixtures for increasing the workability will be permitted only when specifically approved by the Engineer.

14.3.6.4.2 Compressive strength

When the results of 7-day tests give strengths below those specified, the contractor shall not place any further concrete until the cause of low results has been ascertained and until he has taken such steps to ensure that the production of concrete complies with the specifications.

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The Engineer may also suspend the work and/ or direct the contractor to take corrective action to improve the mix quality on the basis of the 3-day compressive strength test results. In a such case the contractor shall immediately cease placing the concrete in question but may elect to wait until the results of the 7-day test are available before implementing corrective measures, at which time the Engineer will review both 3-day and 7-day test results, and may direct immediate implementation of whatever corrective measures he judges are necessary.

Rectification of unsatisfactory concrete work involving the complete removal and replacement of the concrete shall not be based on the results of 3-day compressive strength tests alone unless the contractor and Engineer mutually agree on the rectification.

If 28-day results are not satisfactory, the structure or part of the structure shall be subject to additional quality control testing including dynamic non-destructive testing, as loading tests, sclerometer or concrete hammer testing, and compressive strength testing on core drilled samples, according to schedule approved by the Engineer.

The final decision of acceptance, rectification of the structure or part of the structure shall be under the Engineer 's responsibility, who will be entitled to order the demolition of the deficient part of the structure, if the results of additional testing are not satisfactory.

The cost of the 28-day strength tests, core drilling and testing, dynamic non-destructive testing and load test, including all supplies and use of specialized staff, shall be supported by the contractor.

14.3.7 Concrete information Tests

Concrete information testing shall be carried out at time periods chosen by the contractor. The purpose of this testing is to assess the strength actually met in the structure after a certain time, and to assess the possibility for skirting forms and scaffolding.

The specimens prepared for information testing shall be kept near the structure, so that their thermal and hygrometric history is similar to that of structure.

14.3.8 Concrete Testing Methods

The concrete mix design tests, the systematic concrete quality control tests and the concrete information tests shall be carried out according to the following methods.

14.3.8.1 Plasticity control

The concrete plasticity measured with the Abrams cone shall be kept between eight and twelve tenths of the specified slump. The slump to be taken into account is the arithmetical mean of the results of six tests, measured after removal of the cone.

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14.3.8.2 Compressive tests

The compressive strength of the structural concrete shall be normally measured on cylinder specimens, diameter 15cm x height 30cm, which shall be crushed. The tests shall be carried out in accordance with AASHTO T 22.

The definition of the characteristics strength and standard deviation shall be conforming to the ACI 315.

14.3.8.3 Flexural tests

The flexural tests shall be carried out on prismatic specimens, 15cm x 15cm x 50cm, in accordance with AASHTO T 97.

14.3.8.4 Preparation of molds

The mold shall be of metal, capable of disassembly, and shall include a bottom and walls. They shall be equipped with a cover. The maximum tolerance on each of their dimensions shall be ± 0.3 mm for a new mold and 0.6mm for a mold in service. The bottom and the walls shall be adjusted with sufficient accuracy so that a satisfactory sealing is ensured. They shall be thick enough not to be significantly deformed during concrete pouring.

The moulds shall be thoroughly cleaned after the specimens are removed from the moulds and shall be greased immediately afterwards.

The Engineer may refuse to use unsatisfactory moulds, or those, which, because of their wear, no longer meet the above requirements. The rejected moulds, shall remove from the site.

The moulds shall be in sufficient quantity on the site for the execution of all the tests and controls specified here above or those specified by the Engineer.

14.3.8.5 Test specimen marking

The specimens shall be marked when removed from the moulds. The marks shall be affixed by paint or by any other process approved by the Engineer.

14.3.9 Formwork

14.3.9.1 General

The materials selected for formwork shall be approved by the Engineer as to strength reliability and impact on the finished appearance concrete.

All timber shall be stored above the ground in an adequate position to prevent warping. Formwork unemployed for the next 7 days shall be cleaned, oiled and stored flat and protected against humidity by a tarpaulin or similar waterproof cover.

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14.3.9.2 *Types of formwork*

15.3.9.2.1 *Ordinary (or wrought) formwork*

All the formwork used below ground or for unexposed surfaces shall be of the ordinary type. They shall consist either of aligned parallel wood boards with sharp edges, simply juxtaposed, or of compressed particle or plywood panels. The joints shall be closed enough to eliminate any loss of grout when the concrete is poured. If necessary, this sealing may be obtained by use of adhesive tape. The level difference between two juxtaposed panels or boards, measured normal to the face plane, shall not exceed 3.

15.3.9.2.2 *Prepared (or sawn) formwork*

Formwork for all exposed faces shall be prepared or sawn forms. These forms shall consist of aligned parallel boards with sharp edges, planed on their four faces, juxtaposed, butted and suitably leveled, or of compressed wood fiber or plywood panels with a finish equivalent to that of plywood. If these panels are to be used repeatedly their edges shall be protected against wear and water penetration by means of linings or special paints. These forms may consist also of steel panels. The sealing of joints between formwork constituents shall be such that only slight water seepage occurs when a concrete is poured. The use of adhesive tape to obtain this sealing is not authorized. The level difference between two adjacent boards or panels, measured perpendicularly to the plane, shall not exceed 1mm.

14.3.9.3 *Design, construction and erection*

Formwork for exposed surfaces shall be (if they are made of wood) of the same kind of wood and of the same thickness, without knots and with parallel grain. Without prior agreement of the engineer, it cannot be painted or provided with a plasticized lining. Formwork shall be so designed and constructed and constructed that concrete can be properly placed and thoroughly compacted without loss of water. Formwork shall be adequately strutted, braced, and tied. It shall be capable of adjustment to the lines and the dimensions of the finished concrete and be sufficiently strong to withstand the pressure resulting from placing the fresh concrete, whatever method of compaction is employed, without undue deflection or loss of alignment. The contractor shall submit to the engineer the design calculation for the formwork.

Forms shall be constructed so that they can be removed without damaging the concrete. Formworks shall provide chamfering of all sharp edges.

The rigidity of forms shall be such that the surfaces do not deviate by more than five (5) mm from the theoretical surfaces and that the cross-sections of parts of the structure are never less than those specified on the working drawings. The contractor shall conciliate this requirement with possible formwork deformation due to internal vibration of the concretes. The 5mm tolerance shall not be required for concrete below ground.

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The permissible tolerance for the verticality of upright forms shall be 10mm for a height of 3m.

The components of prefabricated forms shall be designed to withstand, without deformation, the various stresses which they undergo during their transport, assembly and disassembly, as well as during concrete pouring.

Whenever permitted by the desired appearance of the surfaces of the structure, the engineer may authorize that the holes reserved for formwork fastening be left exposed. In this case, their locations, dimensions and shapes will be carefully studied as to appearance and pattern, and shall be submitted to the engineer.

The contractor is required to make allowance for any settlement or deflection of formwork which might occur during construction so that the hardened concrete shall conform accurately to the specified line and level.

All the horizontal forms shall be leveled, taking into account cambers necessary to compensate the elastic deformation under dead loads and the deformation due to shrinkage and possibly to creep.

Furthermore, all arrangements shall be made to prevent deformation of forms at construction joints. In the case of pouring in several stages within the same formwork, this formwork shall be retightened and rebounded to the faces of the part already hardened before the beginning of a new concreting stage.

Ties shall be provided where necessary. They shall be of a variety acceptable to the engineer and spaced to a regular pattern to the architect's approval. All ties anchored against timber shall pass through a plate washer at least 50mm*50mm and of sufficient thickness to transfer the load into the timber without visible deflection or penetration into the timber.

All holes left after the removal of the ties shall be filled with mortar of approved color and composition and finished to the architect's approval.

Forms shall not be spotted by hydrocarbon products, such as grease, oil sludge, etc. nor by rust. Any accidental spots which might appear before pouring shall be removed as quickly as possible.

Immediately before concrete pouring, the forms shall be cleaned and free of dust and waste of any kind. Opening with removable hatches shall be made in the forms, if necessary to facilitate cleaning and inspection of areas where access is difficult. Final cleaning shall be by blasting with compressed air.

Then, just after cleaning and before concrete pouring, the forms shall be saturated with water or coated internally with a form-removal oil (non-staining mineral oil) applied in two coats, the excess of which, accumulated at the bottom of the moulds shall be removed before concreting by sponging. The form-removal oils or chemicals shall be submitted for approval by the engineer together with the direction for use. Preliminary moulding tests shall be performed to control the quality of the oils.

Forms and scaffolding components which have projecting nails or spikes after use shall be immediately cleaned of nails or spikes, if they are intended to be reused. Otherwise, they shall be burned immediately or stored away from the site in closed premises.

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14.3.9.4 Compliance with the scheduled and formwork striking times

The contractor shall supply a sufficient number of formwork components to meet the work execution deadlines and to comply with the various requirements in particular with that of form work striking times.

14.3.10 Shaping and placing reinforcement

14.3.10.1 Bending reinforcing bars

Reinforcing bars shall be bent to the length and shapes specified in the working drawings. The bars shall be cold cut and bent. The bending devices shall be equipped with full sets of mandrels permitting to achieve all specified curvatures. Mandrels shall be permanently available in the bending shops. No minus tolerance shall be allowed on mandrel diameters. Plus, tolerances may be allowed if agreed by the engineer, and if no disadvantage results for the structural quality of the reinforced concrete and if there is no regulation transgression.

Shaping of the reinforcing bars shall be in accordance with the type of steel. The minimum diameters for bending shall be as specified in the certificates.

14.3.10.2 Placing reinforcement

14.3.10.2.1 Fastening and wedging

Bars shall be placed into the moulds in the exact positions given in the shop drawings and shall be fastened by ties and wedges by blocks, sufficiently solid and in a sufficient number (about 2 blocks per square meter) so that the bars cannot be displaced during pouring, in particular during vibration, or by accident by the workmen.

No part of the placed reinforcement shall be used to support concrete conveying equipment, access ways, working platforms or any other construction loads.

Ties shall be in annealed mild steel wire. They shall be well tightened with pliers. They shall be located at all bar intersections unless otherwise directed by the engineer. The twisted ends of the tie wires shall be directed away from concrete exposed surfaces.

Wedges keeping the bars away from the formwork surfaces may be metal, concrete, mortar or plastic.

The concrete or mortar blocks shall be of a composition similar to that of the concrete in the structure, and of the same color if exposed.

Plastic blocks and metal blocks insulated by plastic linings resting on the formwork shall be approved by the engineer as to their shape and constitution. The use of these blocks shall not prejudice the reinforced concrete as far as its mechanical strength and corrosion resistance are concerned.

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Unless they are perfectly stable because of their shape, blocks of all kinds shall be provided with devices permitting their fastening to the reinforcing bars, so that they are not displaced during pouring concrete.

14.3.10.2.2 Reinforcement continuity

All reinforcement shall be furnished in the full length, as indicated on the drawings. Splicing of bars, except shown on the drawings, will not be permitted without the written approval of the engineer. Any splices that may be approved shall be staggered as far as possible and shall be located at points of minimum tensile stress.

The continuity of continuous reinforcing bars shall be ensured by overlapping of a minimum of forty (40) diameters or more, as required by ACI 318.

When reinforced consists of several bars or bundles of bars, the joints shall be distributed over a length such that every section has at least two thirds of continuous bars.

Welded wire fabric shall be installed in as long length as practicable, with adjoining pieces lapped at least one full mesh. The fabric shall be cut to fit at curbs and openings, and shall be discontinuous at construction/contraction and expansion joints between slabs.

Welding of reinforcing steel shall not be permitted unless detailed on the drawings or specifically authorized by the engineer in writing. If the engineer approves splices welding, the welds shall be full penetration butt welds conform the requirements of AWS D 2.0. Water quenching of welds shall not be permitted.

14.3.10.2.3 Reinforcement cleanliness

When ready for pouring concrete, bars in place shall be perfectly clean, without dirt or loose rust, paint, grease oil, mortar, concrete or soil.

When fixed reinforcement is to be left exposed for a delayed period of time, it shall be thoroughly cleaned and painted with a cement grout.

14.3.10.2.4 concrete production, transport and pouring

14.3.10.2.4.1 Mixing

The mixing shall be placed in the skip in the following order: coarse aggregates, cement, sand, and water, each of them having been weighed separately from the others. The mixing duration shall be at least two (2) minutes.

The contractor shall display, in the site office, for each type of concrete, the certified theoretical composition (according to the approved mix design), and at the batching plant, the practical composition which shall take into account the actual moisture contents of the aggregates.

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For each component the tolerance shall be:

- a. +/- 3% (three percent) for each category of aggregates,
- b. +/- 2% (two percent) for the total amount of aggregates and sand,
- c. +/- 2% (two percent) for the total amount of water,
- d. +/- 2% (two percent) for the cement.

Sampling of aggregates and checking of cement and water may be performed, at the Engineer's request, at the discharge point of the batching equipment.

14.3.10.2.4.2 Transport

All plant and tools for transporting concrete shall always be kept clean and free from concrete accumulation. Concrete shall be transported under conditions which do not give rise to segregation of the components or setting before pouring.

All precautions shall be taken to avoid excessive evaporation or intrusion of foreign matter during transport. The transport methods shall be approved by the Engineer.

The conditions of transport and use of dry mixes shall be approved by the Engineer.

Details of any proposed pumping, conveyor belt or shutting plant must be approved by the Engineer before such plant is delivered to the site. When concrete pump is used, the end of the pipe shall be placed as close as possible to the surface of the concrete already in place.

If the contractor uses concrete pumps, pneumatic conveyors or belt conveyors, the pipes or belts shall be thoroughly cleaned after every shutdown. When the Engineer so specifies, pipes exposed to the sun shall be suitably protected, for instance by periodically watered straw matting or tarpaulins.

14.3.10.2.4.3 Arrangements for pouring

The arrangements made by the contractor for pouring concrete into forms shall be submitted to the Engineer's approval. These arrangements shall prevent segregation. In particular, for heavily reinforced members, the Engineer may require concrete pouring through spouts or chutes.

14.3.10.2.4.4 Concreting schedule

The concreting program shall be prepared by the contractor taking into account the following points:

- i. The restrictions imposed by the program planned for the construction works,
- ii. The methods of construction which must be selected in order to stay within the limits of the bearing capacity of all structural members during all phases of the construction works.

The overall program may require several mixing stations operating simultaneously so that the structure of the various buildings be completed in time.

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The concreting schedule shall define, for all concretes, the stages of concrete pouring, which shall be sequenced without interruption, as well as the succession of the stages. This schedule shall be presented by the contractor to the approval of the Engineer before any concrete is poured.

This program shall define the position and configuration of the construction joints, taking into account the indications shown on the working drawings. It shall be prepared so as to reduce interruptions as much as possible and to arrange the construction joints satisfactory, with regard to mechanical correctness and appearance.

For the structural concretes, the concreting schedule shall specify the type, the characteristics and the number of vibration devices to be used during each concreting stage. It shall also specify the number of vibrators to be held in stand-by to replace those out of order.

The concreting schedule shall give the arrangements and maximum distances of the points where the vibrators shall be used. The time of action at each point shall be set for each of them when clamp on vibrators is used.

14.3.10.2.4.5 Placing concrete

No concrete shall be placed until the forms and the steel reinforcement (dimensions and position) have been checked and approved by the Engineer.

Concrete shall be placed in its final position as soon as possible after mixing in such a manner as to avoid segregation of the concrete and displacement of the reinforcement from the framework. Placing shall be continuous between specified or approved construction joints.

Suspended gangways for the work men placing and vibrating the concrete are to be provided wherever possible to avoid damaging and displacing the reinforcement. Steel fixers shall be constantly in attendance while pouring concrete is in process to maintain the reinforcement in correct position.

Concrete shall not be dropped from a height likely to cause segregation.

Any concrete unused for more than fifteen (15) minutes after mixing, or any concrete dropped during transportation shall be rejected.

14.3.10.2.4.6 Concrete vibration

14.3.10.2.4.6.1 General

Concrete shall be thoroughly compacted by means of mechanical vibration during placing, and carefully worked around the reinforcement and embedded fixtures (if any) and into corners of the formwork.

The vibration shall be thorough and at least equal to six thousand (6000) vibrations per minute. It shall be stopped as soon as grout rises to the surface.

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14.3.10.2.4.6.2 Internal vibration

The contractor shall supply enough vibrators of each type to ensure that vibration is carried out efficiently without delay and without breaks in continuity throughout the operation of concrete placing. Hand compacting shall not be allowed without prior approval of the Engineer.

The vibrators shall be of such sizes as to penetrate within the form walls wherever specified, so as to act on all the concrete, taking into account their radius of action. A vibrator shall never use to spread the concrete or to push it into the corners of the formwork. Unless otherwise specified by the Engineer, the depth of action of an immersion vibrator shall be at most equal to forty five (45) centimeters.

Concrete shall be placed in layers not thicker than forty five (45) centimeters until vibration of each layer is completed. Care must be taken to ensure that successive layers are well worked together.

When the thickness of the concrete to be poured is at most equal to thirty (30) centimeters, this concrete shall be poured in a single layer.

If the positions and vibration time of vibrators are not specified in concreting schedule, suitable ones shall be assessed during the work by observing the mortar reflux circle at the surface of the concrete. The radius of this circle may be considered as the radius of action of vibrator.

A layer of fresh concrete over a layer already poured shall not be considered as a construction joint if the first layer can be vibrated. This may be assessed if the immersion vibrator penetrates easily into this layer and if the hole closes up when the vibrator is removed. In that case, when vibrating a new layer, the vibrators shall have to penetrate into the underlying layer. If the concrete already placed cannot be vibrated, the superposition of a layer of fresh concrete over the first one shall be considered as a construction joint on hardened concrete.

The thickness of the layers consolidated by the surface vibration using vibrating tampers or screeds shall be limited to 20 cm for non-structural concretes and 15cm for structural concretes, unless tests performed by the contractor have shown the possibility of accepting greater thickness. The vibration shall be carried out at each position of the vibrating device until device a reflux of mortar occurs on the edges. The successive location the device shall overlap.

14.3.10.2.4.7 Construction joints

Concreting shall be carried out continuously up to construction joints, the position and arrangement of which shall be as shown on the drawings or as approved by the Engineer. The contractor may be required to submit a drawing showing the intended sequence of pouring, location and details of proposed construction joints. No casting shall commence until approval has been given.

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Where practical, construction joints shall be either vertical or horizontal; vertical joints shall be formed against a rigid stop board and rebated, horizontal joints shall be leveled and formed with a suitable key, if required. Whenever possible, the position of construction joints shall be settled before concreting begins. As a general rule, joints in column are to be made as near as possible to the underside of the deepest beam. Vertical joints in walls shall be kept to a minimum.

Before placing new concrete, the surface of the old concrete shall be thoroughly roughened and cleaned; in the case of horizontal surface, any grout or scum on the surface shall be removed by spraying water into the surface and brushing to expose the coarse aggregates. The final cleaning shall be with compressed air. The surface of the construction joint shall be wetted abundantly, so that the old concrete is moisture-saturated before the fresh concrete is placed. However, its surface should have no free water when concrete is internally vibrated, the vibrator action duration shall be increased by one-half with respect to those which would be used if the old concrete were able to be vibrated.

Construction joints due to unplanned cessation of concreting shall be performed according to the above specifications, but only after approval of the configuration of the construction joint surface by the Engineer. The Engineer may specify to provide a surface suitable for mechanical strength and appearance, and small diameter dowels into the fresh concrete to ensure continuity.

14.3.10.2.4.8 Concreting without the use of formwork

The surfaces shall have the shapes and positions specified in the working drawings. They shall be made flush and finish during the operation of concreting, without addition of concrete after the initial set and without addition for mortar at any time whatsoever. Any concrete added to correct the surface finish shall be vibrated in the same ways the underlying concrete, if the latter has been vibrated.

Necessary arrangements, such as use of templates, installation of reference marks, guide straightedges for templates or for vibrating screeds, etc, shall be made for correct adjustment of surfaces. These arrangements shall be approved by the Engineer.

The finishing of surfaces shall be uniform finish matching that of adjacent faces poured inside forms.

For construction joints of vertical facings, the contractor may use wire meshing to retain the concrete in the required position.

14.3.10.2.4.9 Fixtures, indentations and miscellaneous

Anchor holes, grooves, openings, etc, shall be part of the forms. Unless they are made of Styrofoam, the boxes for anchor holes shall be made of several parts, to permit their removal without damaging the concrete.

Angle sections, cover frames, anchor rails, etc, shall be screwed to the forms to prevent their displacement during vibration. Flanges of pipes shall be screwed to the forms and adjusted perpendicularly to the formwork faces.

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No opening, chases, holes or other voids shall be formed in the concrete without the Engineer's approval. Details of any fixture intended to remain in the concrete shall be submitted to the Engineer's approval. All fixtures must comply with the requirements of the Engineer and must be of character and size to avoid any weakening or contamination of the concrete.

14.3.10.2.4.10 Concrete foundation

The foundation shall be of lean concrete K125, thickness according to drawings.

14.3.10.2.4.11 Concreting in hot weather

Batching, mixing and delivery of concrete in hot weather shall comply with ACI305. The contractor shall provide, on each work area, the equipment for measuring the following parameters required for the calculation of the quantity of water evaporated per hour and per square meter of concrete placed:

- i. Air velocity,
- ii. Relative humidity of the atmosphere,
- iii. Air temperature,
- iv. Concrete temperature.

If special measures have to be taken, all methods and equipment shall be submitted to the Engineer, either for reducing the temperature of fresh concrete, or for increasing the air humidity above the placed concrete, or for using both measures.

The procedures of cooling concrete shall be one or more of the following method:

- i. Shading the aggregates,
- ii. Sprinkling the coarse aggregates with water,
- iii. Using chilled water in the mix,
- iv. Replacing some, or all, of the mix water with ice but with no unmelted ice left in concrete after mixing,
- v. Placing concrete during night.

If necessary, an artificial fog shall be kept above the concrete before placing the curing compound so that no drop of water can condense on top of the concrete slab.

Nevertheless, the concrete work shall be stopped when any one of the following conditions occurs:

- i. Temperature of concrete above 35°C;
- ii. Temperature of cement above 70°C;
- iii. Water evaporation measured according to ACI 305 above 1kg/m²/h

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iv. Time between mixing and beginning of curing above the following values:

Time in minutes	Temperature of fresh concrete (°C)
90	Less than 25°C
60	25°C to 30°C
45	30°C to 35°C

14.3.11 concrete curing

Concrete shall be kept in the moist state necessary for satisfactory hardening, taking into account the climatic conditions.

The Engineer will decide or approve the curing procedures applicable to each part of the structure. The curing should involve both final surfaces and construction.

Curing shall be performed by spraying a film of a curing compound approved by the Engineer. This product should allow a perfect bonding of finishing layers or of thermal insulating panels. The directions for use of the product shall be provided by the supplier. The compound shall be colored, so that it is possible to check visually the continuity and uniformity of the film. However, its color should disappear with time or be easily wiped off the finished surface.

To the concrete curing shall be added, as needed, formwork watering, thorough placing of straw matting, other mats or materials kept permanently moist, day and night, by repeated or permanent sprinkling. The use of waterproof forms, such as metal forms, will save the watering of the forms.

The arrangements adopted for concrete curing shall be submitted to the approval of the Engineer together with the concreting schedule.

14.3.12 Coal Tar coating

The faces of concrete structures which will remain permanently in contact with the ground shall be covered with three (3) coats of deacidified coal tar, except as otherwise specified.

14.3.13 Striking of props and Forms

The forms striking schedule shall be submitted to the Engineer for approval, together with detailed work schedule and calculations based on the required strength of concrete. Formwork shall be kept in position fully, supported, until the concrete has hardened and gained enough strength for supporting its own dead load and any load likely to be imposed upon it.

The forms shall be removed without shock or vibration which could damage the concrete.

14.3.14 Expansion joints

Expansion joints shall be installed in accordance with the manufacturer requirements, and not less than 28 days **after pouring the concrete**.

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14.3.15 Checking and Acceptance Tests

TYPE OF WORK	TYPE OF CONTROL	FREQUENCY	RESULTS REQUIRED	TOLERANCE	PENALTIES IF OUT OF TOLERANCE
Formwork	Rigidity Quality	Control of complete form; tolerance as specified Qualities as specified			Rejection; do again Rejection; do again
Concretes for reinforced concrete	Cement temperature in containers	Constantly	70°C	No tolerance	Stop using this cement
	Water content of mixes	Twice daily	As in mix design	+/- 5 L	Stop concrete mixing until new water proportion adjustment
	Slump test	As specified	As specified	+/- 2 cm	
	Compression and flexural strengths	As specified	As specified	As specified	Correct water proportion As specified



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TYPE OF WORK	TYPE OF CONTROL	FREQUENCY	RESULTS REQUIRED	TOLERANCE	PENALTIES IF OUT OF TOLERANCE
Concrete structures	Checks for levels, height, dimensions, verticality	All structures	As specified		Rejection. Contractor must check and propose adjustments. Engineer may require demolition
Anchoring	Layout Leveling	Each anchoring	Theoretical dimensions	+/- 2 cm +/- 1 cm	Rejection. Do again adjustments of anchorages
Sleeves and opening in structures	Layout Contour regularity	Each sleeve or opening	Theoretical dimensions. Contour set	+/- 2 cm None	Rejection. Changes to be made.

14.4 Design

14.4.1 Design loads

All concrete works under aeronautical pavement shall comply with the load of an aircraft type B-747-400 t (maximum take-off weight) to be increased by 50 t.

14.4.2 Structure analysis and shop drawings

The contractor shall have to develop, from the information provided in the tender documents, all the calculations and the shop drawings necessary for the implementation of the concrete works. In particular, the contractor shall have to develop, as required, the design of the reinforced concrete foundations of all structures, including calculations, reinforcement bar schedules and detailed shop drawings.

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He shall submit these documents to the Engineer for approval before starting the construction of any part of the structure.

The shop drawings shall include the complete schedule of reinforcement bars. The amount of reinforcement to be included in the contract shall be the weight shown on the shop drawings, as approved by the Engineer.

He shall submit the details of the construction, and fixing of all precast elements.

15. PIPE CULVERTS

15.1 Scope of work

The work shall consist of the construction of pipe culverts in accordance with the following specifications and close conformity with the lines and grades shown on the contract drawings.

Before work on pipe culverts is started, the contractor shall secure the Engineer's approval on the materials to be used and the methods of execution.

15.2 Materials

15.2.1 General

General materials shall meet the requirements shown on the contract drawings and as follows.

15.2.2 Pipe

In general, the pipes to be used for drainage network will be reinforced D load pipe meeting the requirements of ASTM 655. They will be chosen to ensure a 0.01 inch crack for D load (allowable load in ponds per linear foot per foot of internal diameter) equal to 3,000 according to US standards.

Diameter	0.01"crack D load in da N/m
400	4,800
500	6,000
600	7,500
800	10,500
1000	13,500
1200	17,100

These pipes shall include spigot or groove joints with rubber joint seals. The mechanical characteristics and source of supply will be submitted to the Engineer's approval.

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15.2.3 Concrete

Concrete used in this section shall meet the following requirements:
K175 for structural unreinforced concrete,
K175 for structural reinforced concrete,
Paragraph 15 of specification-concrete works.

15.2.4 Reinforcement steel

The reinforcing bars shall meet the requirements specified in paragraph 15- concrete works.

15.2.5 Laterite gravel

The laterite gravel will be in accordance with the requirements specified in paragraph 4- of this part (civil works).

15.2.6 Joint materials

The joint materials shall meet the requirements specified in specifications paragraph 15- concrete works.

15.2.7 Rubber gaskets

Rubber gaskets for concrete pipe shall be conformed the requirements of ASTM C443.

15.2.8 Joint mortar

Pipe joint mortar shall consist of one part of Portland cement and two parts of sand.

- Portland cement shall conform to ASTM C 150 requirements'
- Sand shall conform to ASTM C 144 requirements.

Water shall be clean and free from alkaline, acid, organic substances or other deleterious materials.

15.3 Construction method

15.3.1 Excavation

The width of the pipe trench shall be sufficient to permit satisfactory jointing of the pipe and thorough tamping of the bedding material under and around the pipe, but it shall be less than the external diameter of the pipe plus 15 cm (150mm) on each side. The trench walls shall be approximately vertical.

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Where rock, hardpan, or other unyielding material is encountered, the contractor shall remove it from below the foundation grade for a depth of at least 30 cm but for no more than three-quarters of the nominal diameter of the pipe. The width of the excavation shall be at least 30 cm greater than the horizontal outside diameter of the pipe.

The foundation bed shall be compacted to not less than 95% of the maximum dry density as determined by AASHTO T 99.

Nevertheless, if the pipe or the box culvert is to be constructed under aeronautical pavement, the foundation bed shall be compacted:

- i. Either to the compaction level requested, in paragraph 2 “General Excavation and Embankment” of the present specifications, at the elevation of the foundation bed.
- ii. Or to not less than 95% of the maximum dry density as determined by AASHTO T 99; whichever is greater.

Where a firm foundation is not encountered at the grade established, due to soft, spongy, or other unstable soil, the unstable soil shall be removed and replaced with approved granular material for the full trench width.

The Engineer shall determine the depth of removal necessary. The granular material shall be compacted to not less than 90% of the maximum dry density as determined by AASHTO T 180.

The excavation for pipes that are placed in embankment fill shall not be made until the embankment has been completed to the height above the top of the pipe as shown on the plans.

15.3.2 Bedding

The pipe bedding shall conform to the class specified on the plans. When no bedding class is specified or detailed on the plans, the requirements for class C bedding shall apply.

15.3.2.1 Class A bedding

Class A bedding shall consist of a continuous concrete cradle conforming to the plan details.

15.3.2.2 Class B bedding

Class B bedding shall consist of a bed of granular material having a thickness of at least 6 inches (150 mm) below the bottom of the pipe and extending up around the pipe for a depth of not less than 30 percent of the pipe’s vertical outside diameter. The layer of bedding material shall be shaped to fit the pipe for at least 10 percent of the pipe’s vertical diameter and shall have recesses shaped to receive the bell of bell and spigot pipe. The bedding material shall be sand or selected sandy soil, all of which passes a 3/8-inch (9mm) sieve and not more than 10 percent of which passes a No.200 (0.075mm) sieve.

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15.3.2.3 Class C bedding

Class C bedding shall consist of bedding the pipe in its natural foundation to a depth of not less than 10 percent of the pipe's vertical outside diameter. The bed shall be shaped to fit the pipe and shall have recesses shaped to receive the bell of bell and spigot pipe.

15.3.3 Laterite gravel for foundation

The laterite gravel shall be placed in accordance with the location grade elevation and thickness as designed on contract drawings, or as directed by the Engineer. The laterite gravel shall be compacted to not less than 90 % of the maximum dry density as determined by AASHTO T 180.

15.3.4 Laying pipes

The pipe laying shall begin at the lowest point of the trench and precede up-grade. The lower segment of the pipe shall be in contact with the bedding throughout its full length. Bell or grove ends of rigid pipes shall be placed facing up grade.

Paved or partially lined pipe shall be placed so that the longitudinal center line of the paved segment coincides with the flow line. The leveling tolerance shall be ± 1 cm from design drawings and no counter slope admitted.

15.3.5 Joining pipe

Joints shall be made with Portland mortar.

Mortar joints shall be made with an excess of mortar to form a continuous bead around the outside of the pipe and shall be finished smooth on the inside. Rubber ring gaskets shall be installed to form a flexible watertight seal.

Concrete pipe will be either bell and spigot or tongue and groove. The method of joining pipe sections shall be such that the ends are fully entered and the inner surfaces are reasonably flush and even joints shall be thoroughly wetted before mortar is applied.

15.3.6 Placing reinforcement bars and concrete

The reinforcement bars and concrete shall be placed in accordance with the specified requirements, specified in paragraph 15- concrete works.

15.3.7 Backfilling

Pipes shall be inspected by the Engineer before any backfill is placed; any pipes found to be out of alignment, unduly settle, or damaged shall be removed and re- laid or replaced at the contractor's expense.

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Material for backfill shall be fine, readily compatible soil, or granular material selected from the excavation or a source of the contractor's choosing and submitted for the Engineer's approval. It shall not be contained, stones that would be retained on a 2 inch (50mm) sieve, checks of highly plastic clay, or other objectionable material.

When the top of the pipe is even with or below the top of the trench, the backfill shall be compacted in layers not exceeding 150mm on both sides of the pipe and shall be brought up 30cm above the top of the pipe or to natural ground level, whichever is greater. Care shall be exercised to thoroughly compact the backfill material under the haunches of the pipe. Material shall be brought up evenly on both sides of the pipe.

When the top of the pipe is above the top of the trench, the backfill shall be compacted in layers not exceeding 6 inches (150 mm) and shall be brought up evenly on both sides of the pipe to 30 cm above the top of the pipe. The width of backfill on each side of the pipe for the portion above the top of the trench shall be equal to twice the pipe's diameter or 3.5 m whichever less is.

The backfill shall be compacted to not less than 95% of the maximum dry density as determined by AASHTO T 99.

Nevertheless, if the pipe or the box culvert is to be constructed under aeronautical pavement, the backfill shall be compacted:

- iii. Either to the compaction level requested, in paragraph 2 "General Excavation and Embankment" of the present specifications, at the elevation of the foundation bed.
- iv. Or to not less than 95% of the maximum dry density as determined by AASHTO T 99; whichever is greater.

15.3.8 Cleaning and restoration of site

After the backfill is completed the contractor shall dispose of surplus materials dirt and rubbish from the site. The contractor shall restore all disturbed areas to their original conditions.

15.4 Quality standards

The quality standards will be as follows:

Test item	Test method	Frequency	Standard value	Notes
Reinforcing bars	As specified in paragraph 15- concrete works			
Mortar cement	As approved by the Engineer	At every receiving of material		
Mortar sand		One for 500m ³		

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	Ditto			
Laterite gravel	As specified in paragraph 4 of this part (civil works)			
Joint materials	As specified			
Density in place	As determined by AASHTO T 191	Once every 25 m at points designated by the Engineer	Not less than 95% of max dry density by AASHTO T 99	
Pipe	As approved by the Engineer	At every Delivery	ASTM 655 type 3,000	Manufacturer's test data may substitute as directed by the Engineer

15.5 Work done standards

The works shall be controlled as follows:

Test item	Test Method	Frequency	Standard Value	Notes
Finish elevation	As specified	At points designated by the Engineer	±1cm	-
Width	According to Engineer's instruction	Ditto	±2cm	-
Length	Ditto	Ditto	±2cm	-
Thickness	Ditto	Ditto	±2cm -1cm	-

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16. MANHOLES AND COLLECTIONS

16.1 Scope of work

This work shall consist of the manholes and collectors to be constructed in accordance with the requirements of the location, dimension, shape, and elevation designated in the contract drawings or required by the Engineer and as specified herein.

The contractor shall, before the work on the manholes and collectors is started, secure the Engineer's approval on the material to be used and on the methods of the work execution.

16.2 Materials

16.2.1 Concrete

Concrete to be used shall meet the requirements of K175 or K225 structural unreinforced or reinforced concrete specified in specification paragraph 15- concrete works.

16.2.2 Reinforcement steel

The reinforcing bars shall meet the requirements specified in specifications – paragraph 15- concrete works. The dimensions for the reinforcing bars shall meet the requirements shown on the contract drawings.

16.2.3 Laterite gravel

The laterite gravel shall be in accordance with the requirements specified in paragraph 4.

16.2.4 Mortar

The mortar shall consist the mixture of Portland cement, sand and water (cement – sand volume ratio of 1 to 2). The Portland cement shall meet the requirements of AASHTO M-85.

Water shall be clean and free from alkaline, acid or organic substances or other deleterious materials.

16.2.5 Frames, Covers, and Grates

The castings shall conform to one of the following requirements:

- a. Grey iron castings shall meet the requirements of ASTM 48, class 30B and 35 B.
- b. Malleable iron castings shall meet the requirements of ASTM A 47.
- c. Steel castings shall meet the requirements of ASTM A 47.
- d. Structural steel for grates and frames shall conform to the requirements of ASTM A 283, grade D.
- e. Ductile iron castings shall conform to the requirements of ASTM A 536.

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All castings or structural steel units shall conform to the dimensions shown on the plans and shall be designed to support the loadings specified.

Each frame and cover or grate unit shall be provided with fastening members to prevent it from being dislodged by traffic but which will allow easy removal for access to the structure.

All castings shall be thoroughly cleaned and given two coats of approved bituminous paint. After fabrication, structural steel units shall be galvanized to meet the requirements of ASTM A 123.

16.2.6 Steps

The steps or ladder bars shall be gray or malleable cast iron or galvanized steel. The steps shall be the size, length, and shape shown on the plans and those steps that are not galvanized shall be given a coat of bituminous paint, when directed.

16.3 Construction methods

16.3.1 Excavation

- a. The contractor shall do all excavation for structures and structure footings to the lines and grades or elevations, shown on the plans, or as asked by the Engineer. The excavation shall be of sufficient size to permit the placing of full width and length of the structure or structure footings shown. The elevations of the bottoms of footings, as shown on the plans, shall be considered as approximately only; and the Engineer may order, in writing, changes in dimensions or elevations of footings necessary to secure a satisfactory foundation.
- b. Boulders, logs, or any other objectionable material encountered in excavation shall be removed. All rock or other hard foundation material shall be cleaned of all loose material and cut to a firm surface either level, stepped, or serrated, as directed by the Engineer. All seams or crevices shall be cleaned out and grouted. All loose and disintegrated rock and thin strata shall be removed. When concrete is to rest on a surface other than rock, special care shall be taken not to disturb the bottom of the excavation, and excavation to final grade shall not be made until just before the concrete or reinforcing is to be placed.
- c. The contractor shall do all bracing, sheating, or shoring necessary to implement and protect the excavation and the structure as required for safety or conformance to governing laws. The cost of bracing, sheating, or shoring shall be included in the unit price bid for the structure.
- d. Unless otherwise provided, bracing, sheating or shoring involved in the construction of this item shall be removed by the contractor after the completion of the structure. Removal shall be effected in a manner which will not disturb or mar finished masonry. The cost of removal shall be included in the unit price bid for the structure.

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- e. After each excavation is completed, the contractor shall notify the Engineer to that effect; and concrete or reinforcing steel shall be placed after the Engineer has approved the depth of the excavation and the character of the foundation material.

16.3.2 Concrete structure

Concrete structures shall be built on prepared foundations, conforming to the dimensions and form indicated of the contract drawings. The construction shall conform to the specified requirements. Any reinforcement required shall be placed as indicated on the plans and shall be approved by the Engineer before the concrete is poured.

All invert channels shall be constructed and shaped accurately so as to be smooth, uniform, and cause minimum resistance to flowing water. The interior bottom shall be sloped downward toward the outlet.

16.3.2.1 Inlet and outlet pipes

For concrete or brick structures, the mortar shall be placed around these pipes so as to form a tight, neat connection.

16.3.2.2 Placement and Treatment of castings, frames, and Fittings

All castings, frames, and fittings shall be placed in the positions indicated on the contract drawings or as directed by the Engineer, and shall be set true to line and to correct elevation. If frames or fittings are to be set in concrete or cement mortar, all anchors or bolts shall be in place and position before the concrete or mortar is placed. The unit shall not be disturbed until the mortar or concrete has set.

When frames or fittings are to be placed upon previously constructed masonry, the bearing surface or masonry shall be brought true to line and grade and shall present an even bearing surface in order that the entire face or back of the unit will come in contact with the masonry. The unit shall be set in mortar beds and anchored to the masonry as indicated on the plans or as directed and approved by the engineer. All units shall set firm and secure.

16.3.3 Installation of steps

The steps shall be installed as indicated on the contract drawings or as directed by the engineer. When the steps are to be set in concrete, they shall be placed and secured in position before the concrete is poured. The steps shall not be disturbed or used until the concrete or mortar has hardened for at least 7 days. After this period has elapsed, the steps shall be cleaned and painted, unless they have been galvanized.

In case prefabricated ladders may be installed instead of steps, they shall be held in place by grouting the supports in drilled holes.

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16.3.4 Backfilling

- a. After a structure has been completed, the area around it shall be filled with approved material, in horizontal layers not to exceed 20 cm in loose depth, and compacted to the density required in paragraph 2. Each layer shall be deposited all around the structure to approximately the same elevation. The top of the fill shall meet the elevation shown on the plans or as directed by the engineer.
- b. Backfilling shall not be placed against any structure until permission is given by the engineer. In the case of concrete, such permission shall not be given until the concrete has been in place 7 days, or until tests made by the laboratory under supervision of the engineer establish that the concrete has attained sufficient strength to provide a factor of safety against damage or strain in withstanding any pressure created by the backfill or the methods used in placing it.
- c. Backfill shall not be measured for direct payment. Performance of this work shall be considered as a subsidiary obligation of the contractor covered under the contract unit price for the structure involved.

16.3.5 Cleaning and restoration of site

After the backfill is completed, the contractor shall dispose of all surplus material, dirt, and rubbish from the site. Surplus dirt may be deposited in embankments, shoulders, or as ordered by the engineer. The contractor shall restore all disturbed areas to their original condition.

After all work is completed, the contractor shall remove all tools and equipment, leaving the entire site free, clear, and in good condition.

16.4 Quality and work done standards

16.4.1 Quality standards

The quality standard shall be as follows:

Test item	Test method	Frequency	Standard value	Notes
Concrete	As specified in paragraph 15- concrete works			
Reinforcing bars	As specified in paragraph 15- concrete works			
Mortar cement	As approved by engineer	At every receiving of material		
Mortar sand	ditto	One for 500 m ³		
Laterite gravel	As specified in paragraph 4 of this part (civil works)			
Joint materials	As specified			

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Frames covers grates steps	As approved by the engineer	At every delivery	ASTM A 27 A 47 A 48 A 283 A 536 A 123	
Density in place	AASHTO T 191	At points designed by the engineer	Not less than 95% of max dry density by AASHTO T 99	

16.4.2 Work done standards

The works shall be controlled as follows:

Test item	Test method	Frequency	Tolerance	Notes
Finish elevation	By surveying as specified	At points designated by the engineer	± 1 cm	
Width	By engineer's instruction	ditto	± 2 cm	
Depth	ditto	ditto	± 2 cm	
Thickness	ditto	ditto	+ 2 cm 1 cm	

17 BOX CONCRETE CULVERTS

17.1 Scope of work

This work shall consist of plain or reinforced box concrete culverts, head walls and miscellaneous drainage structures (inlet and outlet) constructed in accordance with these specifications at specified locations and conforming to the lines, grades and dimensions shown on contract drawings or required by the Engineer.

Before these works be started, the contractor shall secure the Engineer's approval of the materials to be used and the method of execution.

17.2 Materials

Plain or reinforced concrete shall be in accordance with the specifications of paragraph 15-concrete works. If concrete culverts should be equipped with frames covers or grates, they will conform to specifications in Paragraph 15.

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17.2.1 General

The materials (concrete, reinforcing bars, joint material, crushed aggregates) shall conform to the specifications of paragraph 15-concrete works.

17.2.2 Mortar

The mortar shall consist of a mixture of Portland cement, sand and water (cement/ sand ratio in volume =1 to 2). The materials shall meet the requirements.

17.2.3 Frames and Grates

Frames and Grates if needed shall conform to the requirements of specifications paragraph 17.2.5 in the present specification.

17.3 Construction methods

17.3.1 Excavations

Trenches and foundation pits for structures or structure footings shall be excavated to the lines and grades or elevations shown on the plans. The excavation shall be of sufficient size to permit the placing of the full width and length of the structure or structure footings shown. The elevation of the bottoms of footings, as shown on the plans, shall be considered as approximate only; and the Engineer may order, in writing, changes in dimensions or elevations of footings necessary to secure a satisfactory foundation.

Boulders, logs, or any other objectionable material encountered in excavation shall be removed. All rock or other hard foundation material shall be cleaned of all loose material and cut to a firm surface either level, stepped, or serrated, as directed by the Engineer. All seams or crevices shall be cleaned out and grouted. All loose and disintegrated rock and thin strata shall be removed. When concrete is to rest on a surface other than rock, special care shall be taken not to disturb the bottom of the excavation, and excavation to final grade shall not be made until just before the concrete or reinforcing steel is to be placed.

The contractor shall do all bracing, sheathing, or shoring necessary to perform and protect the excavation and the structure as required for safety or conformance to governing laws. The cost of bracing, sheathing, or shoring shall be included in the unit price bid for excavation.

After each excavation is complete, the contractor shall notify the Engineer to that effect, and concrete or reinforcing steel shall be placed after the Engineer, has approved the depth of the excavation and the character of the foundation material.

17.3.2 Concrete structures

Concrete structures shall be built on prepared foundations conforming to the dimensions and form of the contract drawings. The construction shall conform to the requirements

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specified. Any reinforcement required shall be placed according to contract drawings and shall be approved by the Engineer before the concrete is poured.

17.3.3 Backfilling

After a structure has been completed, backfilling with approved material shall be accomplished by applying the fill in horizontal layers not to exceed 3 inches (200mm) in loose depth, and compacted. The back fill shall be compacted to not less than 90% of the maximum dry density as determined by AASHTO 99.

Nevertheless, if the concrete culvert is to be constructed under aeronautical pavement, the back fill shall be compacted:

- i. Either to the compaction level requested, in paragraph 2 “General excavation and Embankment” of the present specifications, at the elevation of the foundation bed.
- ii. or to not less than 95% of the maximum dry density as determined by AASHTO T 99.

Whichever is greater

The field density shall be determined in accordance with ASTM D 2167.

No backfilling shall be placed against any structure until permission is given by the Engineer. In the case of concrete, such permission shall not be given until the concrete has been in place 7 days, or until

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APPENDIX 2 PAVEMENT INSPECTION REPORT

PAVEMENT INSPECTION REPORT

Pavement Element: [RWY, TWY, APRON&SEVICE ROAD]

Inspected By:

Date Inspected: dd/mm/yyyy

Inspection Record			Maintenance Action		
Location	Distress/Defects	Description/Dimensions/Severity/Features Recommended Action	Description of Repair	Date Performed	Cost (if necessary)
	Cracks				
	Longitudinal and Transverse Cracks,	-It is parallel to the centerline in the direction of the traffic	Improve drainage by removing the source that traps the water	dd/mm/yyyy	

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		-30mm (Medium severity) : has potential for material to become dislodged after further trafficking and create FOD problems -All loose material should be removed from within cracks, the surface should be dried , cleaned	• Seal crack or fill with asphalt emulsion slurry or light grade of asphalt mixed with fine sand. • Provide side drains		
	Block Cracking,			dd/mm/yyyy	
	Reflection Cracking,	-			
	Alligator or fatigue Cracking,				
	slippage Cracks				
	Disintegration				
	Raveling and Weathering				
	Potholes				



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	Asphalt Stripping				
	Jet Blast Erosion				
	Patching and Utility Cut Patch				
	Distortion				
	Rutting				
	Corrugation				
	Shoving				
	Depression Swelling				
	Skid Resistance				
	Polished Aggregate				
	Contaminants Bleeding				
	Fuel/Oil Spillage.				



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APPENDIX 3 INSPECTION CHECKLIST-PAVEMENT

<i>INSPECTION CHECKLIST-PAVEMENT</i>				
Inspector Name : √: Satisfactory Date of Inspection : X: unsatisfactory Pavement Location : N/A: Not applicable				
SR/NO	CONDTION		REMARKS RATINGS (Condition and urgency rating)	AND Resolved by (Date/Initials)
	Cracking			
01	Longitudinal and Transverse Cracks,			
02	Block Cracking,			
03	Reflection Cracking,			



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04	alligator or fatigue Cracking,			
05	slippage Cracks			
	Disintegration			
06	Raveling and Weathering			
07	Potholes			
08	Asphalt Stripping			
09	Jet Blast Erosion			
10	Patching and Utility Cut Patch			
	Distortion			
11	Rutting			
12	Corrugation			
13	Shoving			
14	Depression Swelling			
	Skid resistance			
15	Polished Aggregate			



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16	Contaminants Bleeding			
17	Fuel/Oil Spillage.			
	Friction Surveys			
18	Texture depth			
19	Rubber deposits			
20	Paint marking			
21	Pavement abnormalities, such as rutting, raveling, and depression			
	Drainage Surveys			
22	Ponding of water			
23	Soil buildup at pavement edge preventing runoff			
24	Eroded ditches and spill basins			
25	Broken or displaced inlet grates or manhole covers			
26	Clogged or silted inlet grates and manhole covers			
27	Blocked subsurface drainage outlets			



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28	Broken or deformed pipes			
29	Backfill settlement over pipes			
<i>Name of official</i> 		<i>Signature</i> 	<i>Manager & Maintenance</i> 	<i>Signature</i>

	Needs painting	Does not Need Painting	REMARKS/Condition and Urgency ratings
1. Runway markings			
Runway designation	Needs painting ☐	Does not Need Painting ☐	
Runway-centerline	Needs painting ☐	Does not Need Painting ☐	
Runway-side strip	Needs painting ☐	Does not Need Painting ☐	
Threshold	Needs painting ☐	Does not Need Painting ☐	



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Transverse strip	Needs painting ☐	Does not Need Painting ☐	
Arrows	Needs painting ☐	Does not Need Painting ☐	
Aiming point	Needs painting ☐	Does not Need Painting ☐	
Touchdown zone	Needs painting ☐	Does not Need Painting ☐	
Runway turn pad	Needs painting ☐	Does not Need Painting ☐	
2. Taxiway Alpha			
Taxiway center line	Needs painting ☐	Does not Need Painting ☐	
Taxiway side and transverse stripes	Needs painting ☐	Does not Need Painting ☐	
Apron edge lines	Needs painting ☐	Does not Need Painting ☐	
Taxiway holding position pattern A	Needs painting ☐	Does not Need Painting ☐	
Aircraft stands: Identification, lead-in lines, turning lines, stop lines, lead-out-lines	Needs painting ☐	Does not Need Painting ☐	



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Apron safety lines and passenger safety lines	Needs painting ☐	Does not Need Painting ☐	
Equipment parking lines	Needs painting ☐	Does not Need Painting ☐	
Service roads lines	Needs painting ☐	Does not Need Painting ☐	
Mandatory instruction, information	Needs painting ☐	Does not Need Painting ☐	
3. Taxiway Bravo			
Taxiway center line	Needs painting ☐	Does not Need Painting ☐	
Taxiway side and transverse stripes	Needs painting ☐	Does not Need Painting ☐	
Apron edge lines	Needs painting ☐	Does not Need Painting ☐	
Taxiway holding position pattern A	Needs painting ☐	Does not Need Painting ☐	
Aircraft stands: Identification, lead-in lines, turning lines, stop lines, lead-out-lines	Needs painting ☐	Does not Need Painting ☐	
Apron safety lines and passenger safety lines	Needs painting ☐	Does not Need Painting ☐	

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Equipment parking lines	Needs painting ☐	Does not Need Painting ☐	
Service roads lines and road holding position	Needs painting ☐	Does not Need Painting ☐	
Mandatory instruction, information	Needs painting ☐	Does not Need Painting ☐	
4. Taxiway Charlie			
Taxiway center line	Needs painting ☐	Does not Need Painting ☐	
Taxiway side and transverse stripes	Needs painting ☐	Does not Need Painting ☐	
Apron edge lines	Needs painting ☐	Does not Need Painting ☐	
Taxiway holding position pattern A	Needs painting ☐	Does not Need Painting ☐	
Aircraft stands: Identification, lead-in lines, turning lines, stop lines, lead-out-lines	Needs painting ☐	Does not Need Painting ☐	
Apron safety lines and passenger safety lines	Needs painting ☐	Does not Need Painting ☐	
Equipment parking lines	Needs painting ☐	Does not Need Painting ☐	
Service roads lines	Needs painting ☐	Does not Need Painting ☐	

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Mandatory instruction, information	Needs painting ☐	Does not Need Painting ☐	
5. Taxiway Delta, Echo, Foxtrot, Golfe, Hotel, Juliet			
Taxiway center line	Needs painting ☐	Does not Need Painting ☐	
Taxiway side and transverse stripes	Needs painting ☐	Does not Need Painting ☐	
Taxiway holding position pattern A	Needs painting ☐	Does not Need Painting ☐	
6. North apron			
Apron edge lines	Needs painting ☐	Does not Need Painting ☐	
Aircraft stands: Identification, lead-in lines, turning lines, stop lines, lead-out-lines	Needs painting ☐	Does not Need Painting ☐	
Apron safety lines and passenger safety lines	Needs painting ☐	Does not Need Painting ☐	
Equipment parking lines	Needs painting ☐	Does not Need Painting ☐	
Service roads lines	Needs painting ☐	Does not Need Painting ☐	

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Mandatory instruction, information	Needs painting ☐	Does not Need Painting ☐	
7. South apron Alpha and Bravo			
Apron edge lines	Needs painting ☐	Does not Need Painting ☐	
Aircraft stands: Identification, lead-in lines, turning lines, stop lines, lead-out-lines	Needs painting ☐	Does not Need Painting ☐	
Apron safety lines and passenger safety lines	Needs painting ☐	Does not Need Painting ☐	
Equipment parking lines	Needs painting ☐	Does not Need Painting ☐	
Service roads lines	Needs painting ☐	Does not Need Painting ☐	
Mandatory instruction, information	Needs painting ☐	Does not Need Painting ☐	
<i>Name of official</i>	<i>Signature</i>	<i>Manager Maintenance</i>	<i>Signature</i>
<i>Date (dd/mm/yy):</i>		<i>Time:</i>	

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APPENDIX 4: RUBBER REMOVAL PROCEDURE

0. INTRODUCTION

The rubber removal at Juba International Airport will be performed based on the below compliance:

Standards 2.9.2, 8.4.1 and 10.3.1 of ICAO Annex 14 – Aerodromes refer to the Airport Services Manual, Part 2 — Pavement Surface Conditions (Doc 9137) for further guidance on Runway Rubber Removal. Chapter 8 of Doc 9137 Removal of Rubber deals with means of rubber removal.

The rubber removal technique opted by South Sudan Airport Company is High Pressure Water Blasting (HPWB). Water pressure to be applied will be depending on the rubber deposits.

Upon friction testing in the runway, results are being analyzed and the areas with low friction value will be cleaned in order to keep all the runway within acceptable friction values

0.1 Equipment to be used:

- (a) LI 1000 linear Osprey rubber removal machine mounted on 8*4 Mercedes Arocs chassis;
- (b) Fixed width linear system, two heads;
- (c) Maximum operating with 1000mm;
- (d) Ultra high pressure pumps, Uraca KD724; operating water pressure 2500 bar;
- (e) Inlet water boost pump 1-6 bar (HYPRO);
- (f) Filtration system;
- (g) Safety system;
- (h) Fresh water tank 10,000liters;
- (i) Debris recovery system 53P (KAESER/OMEGA);
- (j) Harrier Debris tank 12,000 liters;

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0.1.1 Overview of the equipment

The Jetting Systems Osprey LI1000 is supplied for the purpose of maintaining friction values by removing rubber deposits from various surfaces.

The Osprey uses Ultra-High-Pressure water jetted onto the surface to break up the deposits of rubber, or when required, paint markings. Removed material is recovered into the debris tank on the Osprey leaving a clean and relatively dry surface.

0.1.1.1 Safety concern

- (a) The Osprey is designed for one-man operation, however for safety reasons it is recommended that two persons shall be present during any ultra-high-pressure water jetting activity.
- (b) All Hazards associated with the equipment and personnel protection measures to be taken by operators.
- (c) Checks on equipment before commencing operations.
- (d) check of the Systems operation.
- (e) Use of the equipment.
- (f) Ultra-high-pressure water will only actuate when the vehicle is moving forward. This may be bypassed by an authorised service technician using the service key and only when the ultra-high-pressure water system is being checked for correct function.



WARNINGS

- (a) Never work on any part of the ultra-high-pressure water system when the vehicle is running.
- (b) Never allow any persons to walk in front of the machine when the vehicle is running.
- (c) Never attempt to clean or touch the nozzles or water stream when the vehicle is running

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- (d) Ensure all four door locks are open before opening the rear door. Damage to the door will occur if all four locks are not fully open.
- (e) Never get under the raised tank unless the safety prop is raised and the tank lowered onto the prop – see section 5.14 for instructions.

Other Safety

- (a) The machine must only be used for the purpose designed and intended by the manufacturer.
- (b) Personnel operating, repairing, or maintaining the machine must have received appropriate safety awareness training and be familiar with the hazards and dangers associated with the equipment.
- (c) The instructions and safety recommendations must be readily available to all those involved in operating and servicing the unit.
- (d) The equipment package includes the normal hazards associated with a vehicle truck chassis, for example, vehicle hydraulic and pneumatic systems. Other hazards that may be new to personnel associated with the Osprey include:



- (i) Ultra-high-pressure water jetting system operating at pressures up to 40,000 psi (250 MPa, 2500 bar, 2548 kgf/cm²) which produces water jet velocities in the order of 1536 mph (2450 km/h).
- (ii) Water weighs 1 kg per litre and at the pressures and velocities generated by the Osprey the impact of a water jet can cause serious injury and even death.
- (iii) In the event that a person is injured by the impact of a water jet, the injury caused may appear insignificant and give little indication of the extent of the injury beneath the skin or the damage to deeper tissues. Large quantities of water may have punctured the skin, flesh and organs through a very small hole and not even bleed.
- (iv) Any injury however small must receive immediate medical attention. The medics must be fully informed of the injury and potential risks as they may not have experience of water jet injuries.



- (v) Tipping tanks. These present a falling object hazard when in the raised position and **must always be propped before working underneath them.**

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- (vi) Caution: Whilst opening rear door the inner ledge will retain debris. Stay clear of the rear tank door when open as the retained debris or door may fall resulting in serious injury or death.

The following personal protective equipment (PPE) is recommended as a minimum for operators.



0.1.1.2 After service

- (a) Actions to be taken by operators to ensure the equipment is cleaned and stored in order to be available for service when next required (for example, anti-corrosion protection or precautions against sub-zero temperatures, if there is any chance of the equipment, especially the ultra-high pressure pump freezing)
- (b) The Osprey must not be stored with water in the clean water tanks. Debris tank must be empty. A corrosion inhibiting solution must be circulated during periods of prolonged shutdown.

1. OPERATING INSTRUCTIONS

1.1 Pre-operation checks

Note: There should be a system in place for reporting defects discovered during the pre-start checks. Ensure the operators know where and who they are to report any defects to, and that the vehicle is not to be used until such defects have been rectified.



Before turning on the vehicle and control panel

- (a) **Inlet hose condition**

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- (i) Ensure all hoses are in good condition, not leaking and do not look perished.

(b) Inspect water filter bags:

To replace water filters bags:

- (i) Close the filter isolator valve.
- (ii) Open the filter bleed valves mounted to the steel uprights.
- (iii) Drain filters using drain valves located at the bottom of each housing.
- (iv) Use filter spanner to remove blue 10-micron filter housing.
- (v) Inspect 10-micron bag and replace if necessary.
- (vi) Do not replace dirty bags into filter housings.
- (vii) Ensure filter housings are clean before refitting.
- (viii) Check filter bowl O-ring is seated in place.
- (ix) Refit filter housing using filter spanner.
- (x) Repeat process for the 1-micron filter housing.
- (xi) Close the bleed and drain valves.
- (xii) Open filter isolator valve.

NB: Always ensure correct micron rating bag is fitted into the correct housing. Do not replace dirty bags into filter housings.



Warning

Ensure filter isolator valve is opened after cleaning the filters. Serious damage will occur to the pump if this valve remains closed.

(c) Jetting head inspection

While Front Rig is in the travel position, visually check nozzles to ensure that they are all present and that there is no debris blocking them.

(d) Wear plates condition and security of attachment

Ensure there is no damage to the wear plates and that they are correctly fixed. Check that fixings are tight with spring washers compressed.

(e) Ultra-high-pressure hose condition

This check must be done prior to pressurising the system. Visually inspect ultra-high-pressure hoses for perishing, cuts, bulging or any other damage or degradation.

(f) Ultra-high-pressure pump oil level

Check oil on ultra-high pressure pump, ensure oil is half-way up the sight-glass. If low, top up slowly allowing oil to settle before checking the level is correct.

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NB: Do not overfill - if overfilled, drain to correct level.

(g) Vacuum pump oil level

Check vacuum oil level, ensure oil is half-way up the sight-glass.

(h) OMSI ATF level check (*Sight glass on side of OMSI*)

Check OMSI ATF level, ensure oil is half-way up sight-glass.

(i) OMSI gearbox oil level check (*Sight glass on rear of OMSI*)

Check OMSI gearbox oil level, ensure oil is half-way up sight-glass.

(j) Hydraulic oil level (*Debris tank must **NOT** be raised*)

Check hydraulic tank oil level, ensure oil level indicator is at the top of the sight-glass.

(k) Drive belt inspection (*Guard fitted*)

Visually check for any signs of deterioration such splits, cracks, or fraying. Ensure all drive belts are fitted and seated fully on the pulleys.

(l) Visual check of all hydraulic rams

Visually check all the hydraulic rams for any signs of leaks or pitting on the pistons. (Do not run hands down hydraulic components) – Tank raise/lower ram will be inspected once controls powered up.

(m) Debris valve operation

Check that both the 100mm dirty water valve and the 150mm sludge valve open and close.

(n) Drain Cyclone

Ensure cyclone is drained by opening the drain valve. Close the valve once empty.

(o) Door lock operation and security

Ensure side doors are operating correctly and are secure when closed.

(p) Check Isolators

Ensure the Truck Battery Isolator and Jetting Isolator are all switched to the ON position.

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Start vehicle and turn ON JSL Control panel

- (a) Status bar should state “System Healthy”.
- (b) If an error message is displayed in the status bar, an acoustic sounder may alarm. This can be silenced from the main page by pressing the *Mute button* on the screen, alternatively the *Reset button* can be pressed once the issue has been resolved (eg. Low freshwater level).
- (c) Ensure the Front Rig travel restraint is removed.
- (d) The Front Rig can be raised and lowered using the up and down arrows on the screen. Check that once the rig has been lowered completely the *Rig Down* green light will illuminate.

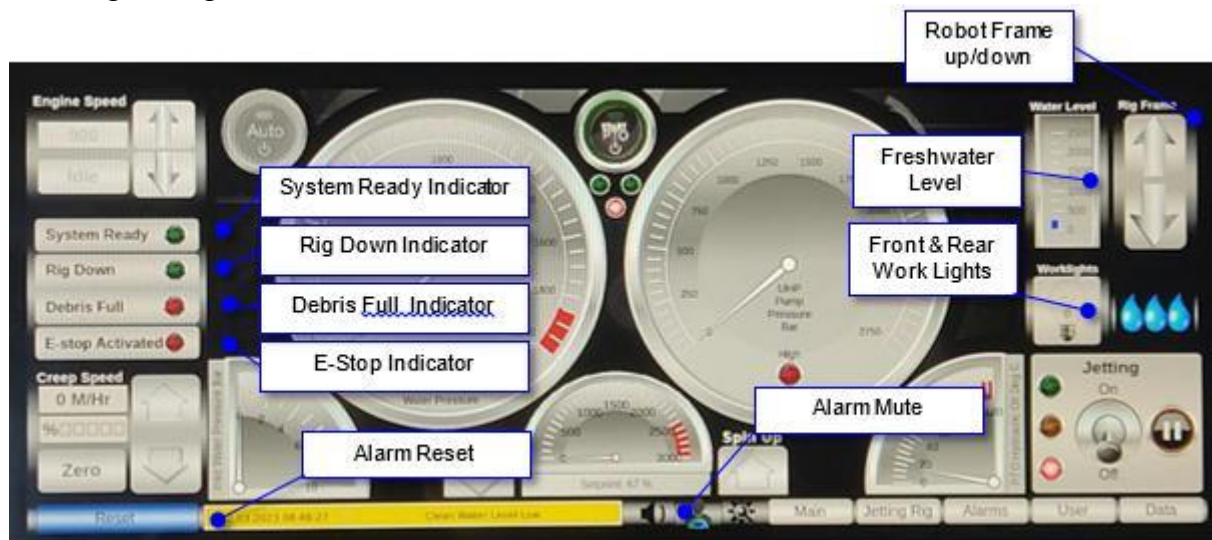


Figure 1.1 - Main Control Page

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Figure 1.2 – Jetting Rig Page

- (e) Navigate to the *Jetting Rig* page. Use the *System Select* toggle to select either *Rubber* mode (2 x 500mm jet bars) or *Paint* mode (single left-hand jet bar).
- (f) If *Paint* mode is selected only the left jet head will rotate. Ensure that the blanking hub is fitted to the right spin motor and the 300mm paint jet head is fitted to the left spin motor. Failure to change jet bars could cause damage to the surface.
- NOTE: A warning will appear asking to confirm that the correct jetting head as been installed. Check the front rig and press OKAY button to confirm your selection. Failure to install the correct head or blanking hub will result in the system either under or over pressuring. Pre-start checks are now complete.*

1.2 Engaging PTO Gearbox

- (a) Drive Mode indicators should have the lower (red) indicator illuminated indicating normal road mode.
- (b) Press *PTO* on JSL control screen
- (c) **Upper two indicators (green) should illuminate, and the lower (red) indicator should go off.**
- (d) If one of the green lights does not illuminate then press *PTO* again, move the vehicle slightly (to realign drive shafts) and repeat above.



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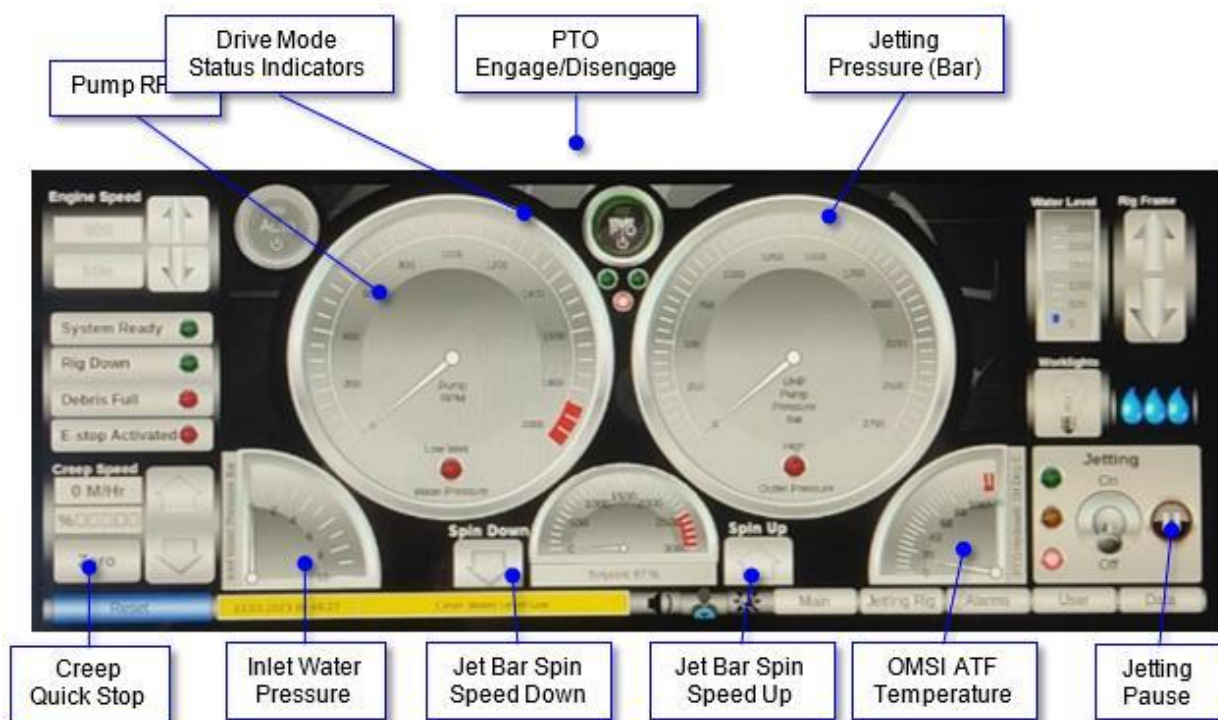


Figure 1.3 Main Control Screen 2

1.3 Driving the PTO gearbox

- (a) With the vehicle **in neutral** and **parking brake ON** press **NA2** button.
- (b) With OMSI correctly engaged as 1.2, *Auto* button will appear “live” as shown here instead of grey as in Figure 1.2. Press *Auto* and 14th gear will select and the clutch engage.
- (c) The vehicle driveshaft will now be powering the PTO gearbox
 - (i) The UHP pump will be driven through the PTO gearbox and low pressure water will be coming from the jet-heads
 - (ii) The PTO gearbox will be driving the hydrosatic drive pump
 - (iii) *At any point the FOOT BRAKE can be depressed hard, this will disconnect PTO drive and stop jetting, drop creep speed to zero and return engine speed to idle.*



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1.4 Checking Jet-Bars and Nozzles

- (a) Low pressure water should now be exiting the nozzles.
- (b) Standing to one side of the Front Rig, not in front, inspect jet-bars and hubs for leaks. Do not touch the water streams.
- (c) Inspect the water streams coming out of each nozzle and check for fanning. The streams should appear as thin laser-like jets.
- (d) If any nozzles leak or are blocked then the system must be shut down and the nozzles or seals replaced before starting up the system again.



1.5 Start Jetting

- (a) Lower the Front Rig to the ground. The *Rig Down* indicator will illuminate.
- (b) Switch Jetting to ON by pressing the *Jetting* toggle switch in the bottom right corner of the main screen (See Figure 1.2).
- (c) **Lightly** depress the foot brake and release the hand-brake
- (d) Press the *Creep Speed Up* arrow. The vehicle will start moving forward. Ultra-high-pressure Jetting will not commence until a minimum Creep Speed of 175m/hr is achieved.
- (e) Increase the pump speed (increasing water flowrate and pressure) by increasing the engine speed using the JSL Control Screen
 - (i) Mercedes engine speed is limited to 1412rpm.
 - (ii) Hydrostatic Creep drive is also powered by the OMSI and is therefore affected by the Mercedes engine RPM. Faster creep speeds will be achieved by faster engine speeds.

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(iii) Jetting can be paused at any time during the cleaning process if necessary eg. to avoid expansion joints in the surface. To pause the jetting simply touch the pause button located next to the Jetting toggle switch. The high pressure will be paused until the operator presses the play button and the high pressure will resume.

(iv) Jet head spin speed can be increased / decreased while cleaning by pressing *Spin Up* / *Spin Down* buttons located at the bottom of the main page. The minimum head spin speed is 500rpm and the maximum speed is 3000rpm. A spin speed alarm is set to sound if the spin speed drops lower than 500rpm and will automatically shut down Jetting if speed drops below 400rpm. This is to ensure no damage occurs to the runway surface.

Variables	Explanation	Alterations available
Pressure	This is controlled by the Mercedes engine RPM. When set up correctly the maximum pressure (2500bar) should be achieved when the engine is approaching the limited 1412RPM.	Under normal conditions, areas with lower rubber deposits can be cleaned with lower engine RPM and lower pressure. This uses less water per square meter and allows longer use of the machine. Where deposits are heavier, full RPM and pressure can be used if required.
Head-Spin	This is the speed at which the jet-bar rotates.	Faster rotation is gentler on the surface than slower rotation as the dwell time over the surface is reduced at high speed. Very slow head-spin can cause damage to the surface as the nozzles start cutting into the surface. The control system has an alarm and automatic shut-down in case this happens
Forward speed	This is the forward speed of the vehicle in hydrostatic creep drive.	Fast forward speeds result in lighter cleaning and are safer for the surface as they lower the dwell time of the nozzles over the runway surface. Slower speeds are used for heavier deposits.

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Only use enough pressure to clean. If 100% of the rubber deposits can be removed at 1000bar then higher pressure is not required. Less water can be used to clean the surface and one full tank of water will clean a greater area of runway. If rubber still remains then increase the pressure until cleaning is satisfactory.

1.6 Stop Jetting and Return to Normal Drive

- (a) To stop jetting press *Jetting Off* and the high pressure will stop
- (b) Press *Idle* to lower engine speed
- (c) Press *Zero* on the creep drive area of the screen and the truck will come to a stop.
- (d) Press the foot brake hard and Press *NA2* button to the OFF position.
- (e) Press *PTO* button to disengage PTO gearbox. The two upper (green) Drive Selector Indicators will go off and the lower (red) indicator will illuminate to show the truck is in normal road mode.
- (f) The front rig can be raised to 40 degrees.
- (g) The vehicle can now be driven away using the normal vehicle drive controls.

1.7 Emergency evacuations

Should you be required to evacuate the cleaning area in a hurry, then follow these steps:

- (a) Stop vehicle by pressing foot brake **hard** (Jetting will stop automatically)
- (b) Press *NA2* button
- (c) Raise the Front Rig to approximately 40 degrees
- (d) Disengage PTO gearbox
- (e) The vehicle can now be driven away using the normal vehicle drive controls.

Entire process should be achieved in 20 to 30 seconds.

1.8 Debris disposal operation

- (a) Ensure the JSL control panel in the cab is switched ON.
- (b) Move to the valve control box at rear of Osprey and pull the dirty water drain valve actuator.
- (c) Once the dirty water stops, the operator can then open the debris drain valve.
- (d) Once the debris stops coming out of the valve then both valves can be closed.
- (e) The operator can then move to the side control box located on the LHS of the vehicle and unlock the debris door. Hold the switch until 4 clicks are heard.

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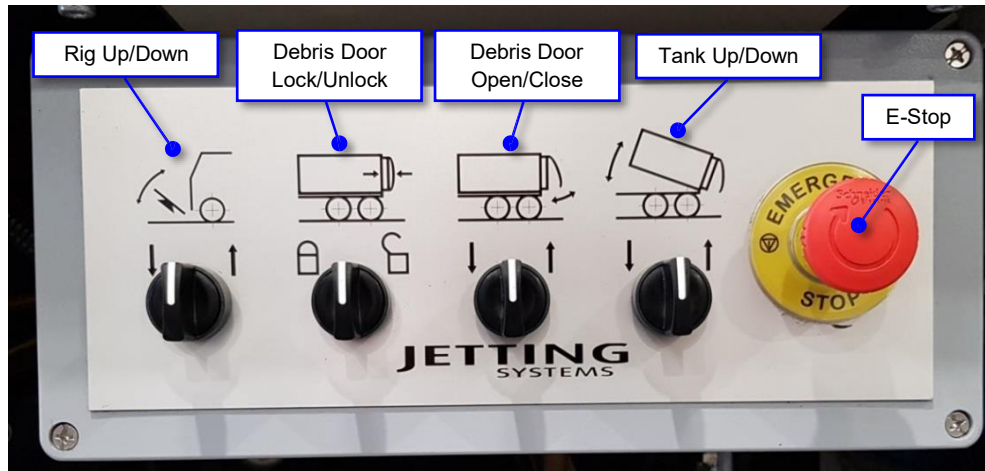
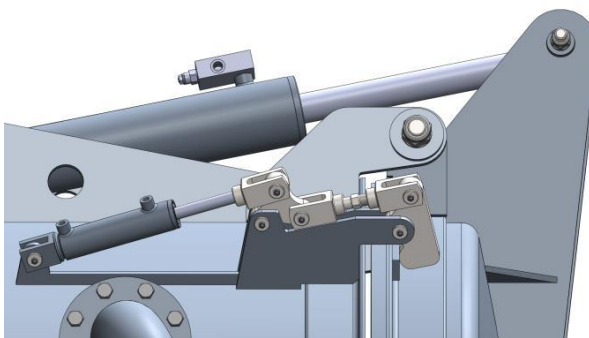
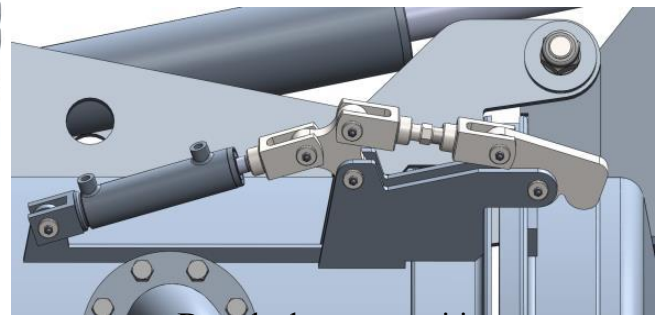


Figure 1.4

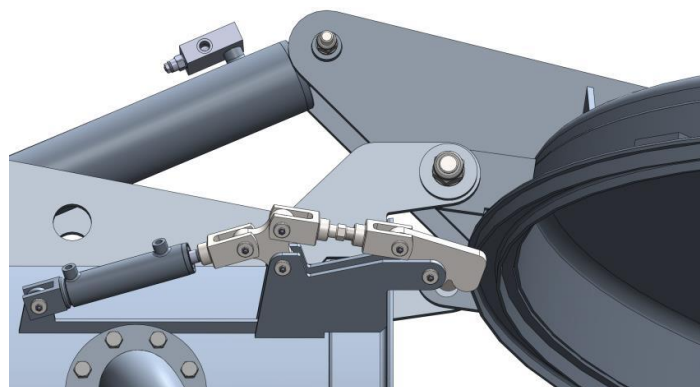


Door locks closed position.



Door locks open position.

NOTE: Move to rear of vehicle and check that all four locks are fully open. Damage will occur to the door if any latches are not fully open. The Clean water level will also need to be reduced to approximately 1/4 full to allow for the operation of the hydraulic ram to tip the tank



Debris door opens safely when door locks are fully open.

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- (f) Once all 4No door locks are open then the rear door can be opened using the Debris Door Open/Close Switch.
- (g) Once the rear door is fully open the Tank can be tipped by using the tank up/down switch



WARNING

NEVER GET UNDER THE RAISED TANK UNLESS THE SAFETY PROP IS RAISED AND THE TANK LOWERED ONTO THE PROP – See section 5.14 for instructions.

- (a) Empty tank of all debris
- (b) Lower tank and clean rear door seal.
- (c) Once the door seal is cleaned the rear door can be closed. **Making sure no personnel are in the crush zone. Visually check the rear door is fully closed before locking the door.**
- (d) Holding the Debris Door Lock switch until 4 clicks are heard indicating all the locks are in the closed position. **Visually check all the locks are closed.**

1.9 Using the Tank Safety Props

(a) Tank Prop

- (i) If any maintenance work is required under the tank, then the tank prop **must be used**. Personnel should not be under the tank without it being supported by the tank prop.
- (ii) **The freshwater tank must be drained, and the Debris tank must be empty before this can take place.**
- (iii) The tank prop is located under the tank.
- (iv) With the truck parked on a flat surface the tank must be raised up enough for the prop to pivot into position. Once in position, lower the tank onto the prop.
- (v) Turn the system off and **turn all isolators OFF**.
- (vi) Work can commence safely under the tank.



(b) Debris Door Prop

- (i) If access into the debris tank is required, ensure the debris door prop is used.

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- (ii) After unlocking the door, open the door until the door prop can be placed into position.
- (iii) Lower the door onto the prop. It is now safe to access the tank internals.

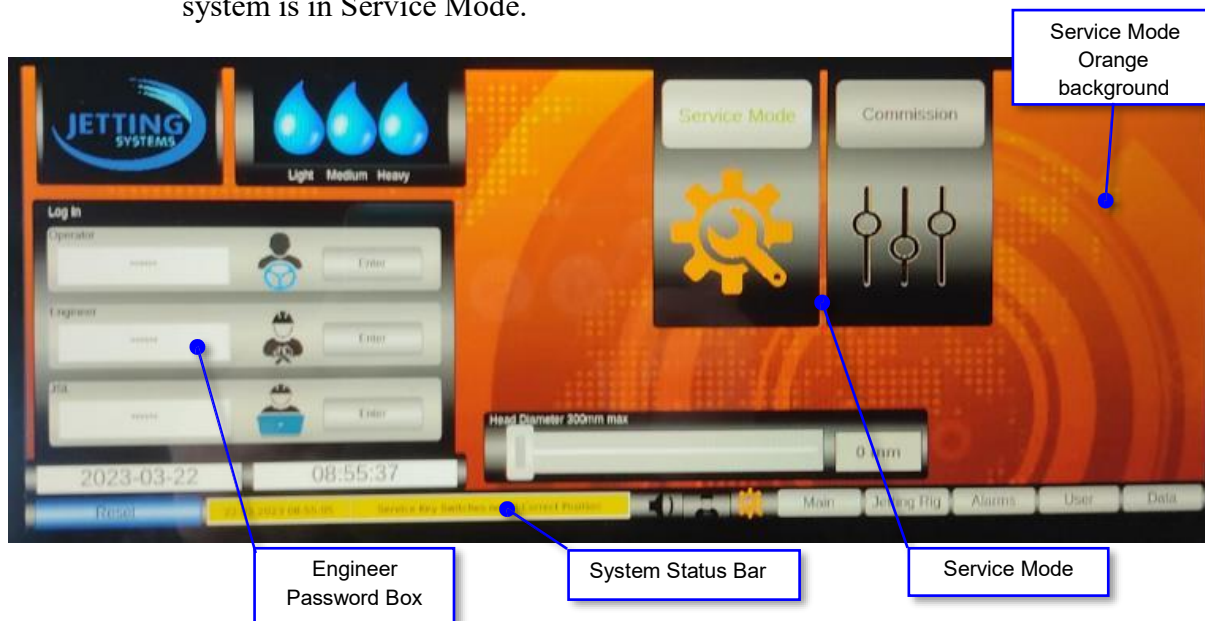


1.10 Service mode

Service mode is used for general checks on the UHP system.

Before operating the system in service mode, the truck must be in a safe working zone and the front and rears ends of the truck must be suitably barricaded to stop any persons approaching the jetting heads.

- (a) Raise the robot frame to 40 degrees.
- (b) Select the *User* screen and select the *Engineer* box. Enter the password which is “engineer” all lower case. Press *Enter*.
- (c) Press *Service Mode* and the background display will turn orange to show the system is in Service Mode.



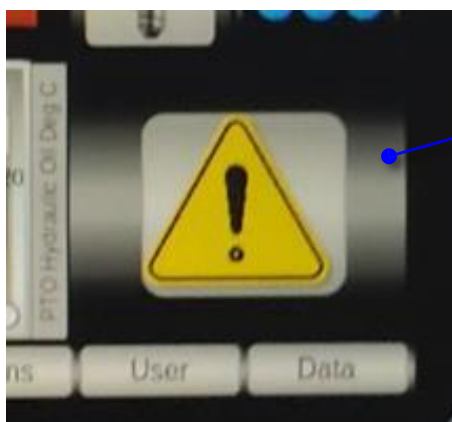
- ✓ A message will appear in the Status Bar instructing the operator to turn on the Service Key located on the side of the control box in the pump house.

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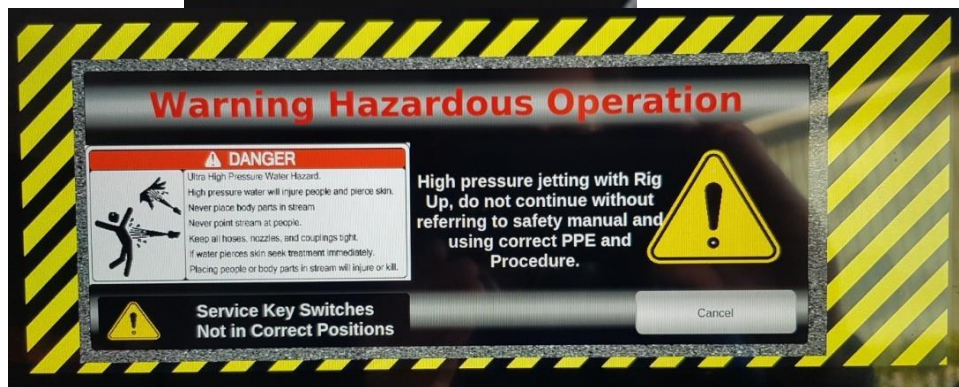
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- (d) Turn the *Normal* switch key to OFF, remove the key and place it in the *Service* switch and turn ON.
- (e) On the main page of the control screen in the cab a warning triangle will appear where “Jetting On/Off” usually is to warn the operator that the service



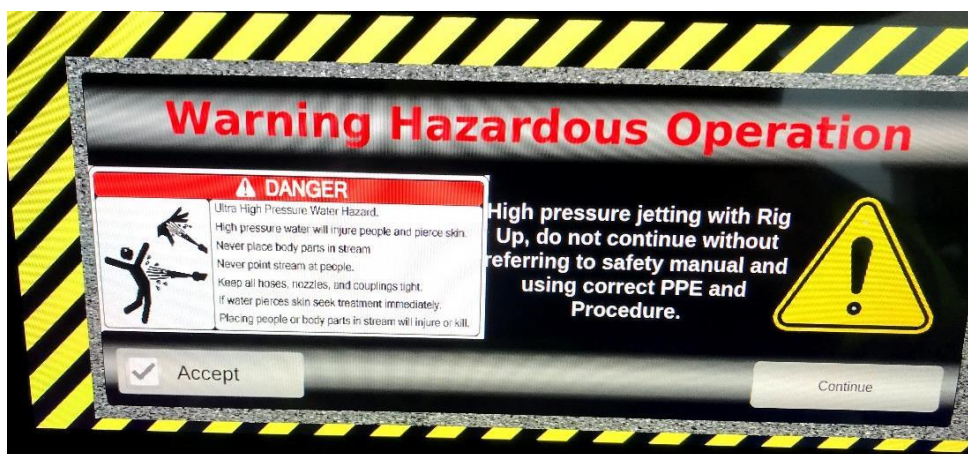
Warning Triangle



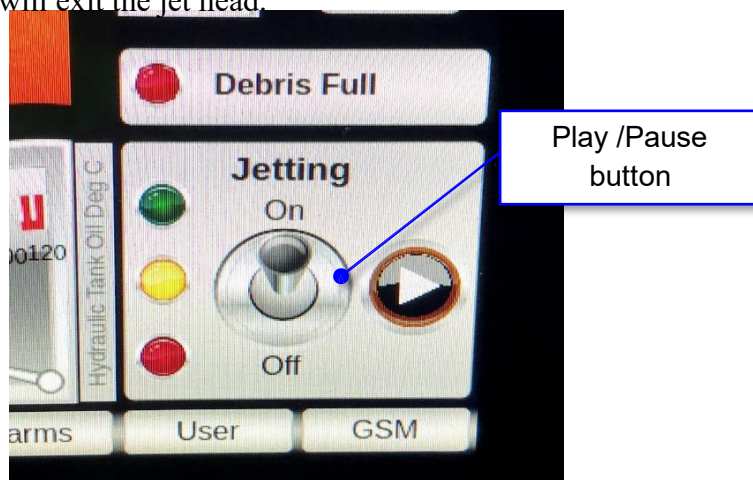
key has been operated.

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- (f) Press the warning triangle and the following warning will appear:
 - (i) If keys are not switched to the correct positions.
 - (ii) If keys are switched to the correct positions.
- (g) Read through the warning page to make sure the information is understood.
- (h) Press accept and a tick will appear in the accept box and then press continue.



- (i) Engage PTO gearbox as section 1.2.
- (k) Start driving PTO gearbox as section 1.3.
- (l) The UHP pump will now be rotating, and low-pressure water will exit the jet head. Jetting is in the "Ready, Paused" state.
- (m) To engage ultra-high pressure, press the *Play* button and UHP water will exit the jet head.



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- (n) To increase the pressure, use the engine RPM up arrow. The pressure can be increased to maximum working pressure of 2500 bar.
- (o) If the system does not achieve the maximum working pressure, then the UHP system either has a leak, worn seals, a worn nozzle/s or the MSSV may be leaking water back to tank.
- (p) If pressures higher than 2500bar are achieved there may be blocked nozzles creating additional pressure. Inspect nozzles as section 1.4.
- (q) With the system working at maximum working pressure, open the MSSV observation valve. Water in the hose will drain out of the valve and then should stop. This will confirm that the MSSV is working correctly, and the pumped water is being pushed to the front jet bars and not returning to tank. If water continues to exit the observation valve hose the MSSV seat is worn and requires replacement.
- (r) The “Plunger Cooling Observation Valve” can be opened – the water flow should be constant. This will confirm that water is passing through the cooling system of the UHP pump. If the flow pulses, remove the 3No quick coupler individual plunger cooling lines (situated beneath the front left corner of the pump-house) and check that each one has equal flow.
- (s) Once inspections are complete, lower engine RPM using the down arrow on the engine speed.
- (t) Switch Jetting Off.
- (u) Press foot brake and disengage PTO gearbox.
- (v) Switch Service key OFF, remove and place back into the normal key lock and turn ON.
- (w) Return to the user screen and press *Service Mode* on the screen and the orange back display will disappear.
- (x) Reboot the whole system by turning off the system and turning it back on. This is done for safety reasons, so all the safety interlocks are reset into normal mode.

1.11 Hand Lance

To aid with cleaning of the vehicle and tank, the LI1000 is equipped with a wash down hose reel and hand lance. Water is supplied by the main UHP pump. The pressure is limited to a maximum 160 bar by a pressure regulating valve. Further over pressure protection is provided by a 275 bar burst disc fitted to the lower port of the pressure regulating valve.

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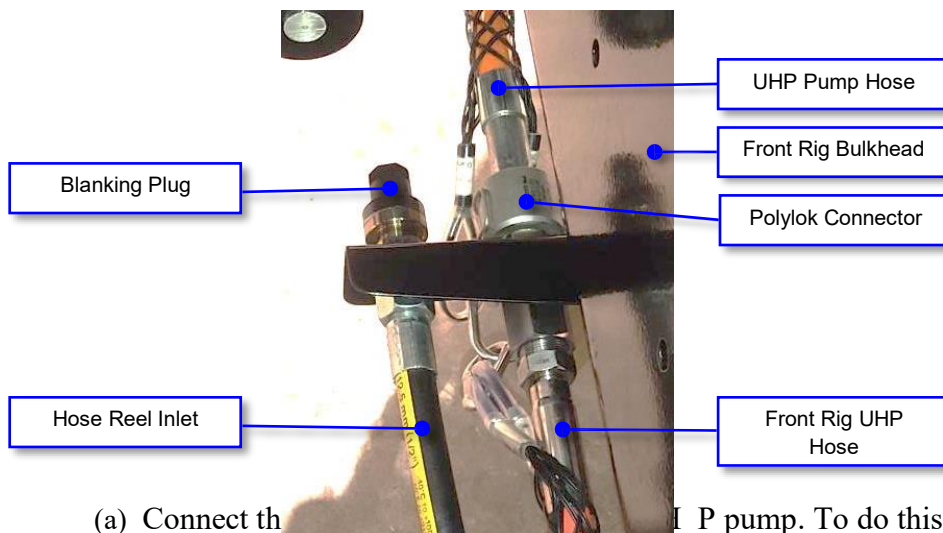


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WARNING!



Attempting to connect or disconnect hoses with the system on and PTO engaged could result in serious harm.



- (a) Connect the UHP pump. To do this the outlet hose from the pump must be disconnected from the front rig and connected to the hose reel inlet hose. The connection points can be found underneath the Front Rig Bulkhead.
- (b) Connect the hand lance to the hose reel.

WARNING!



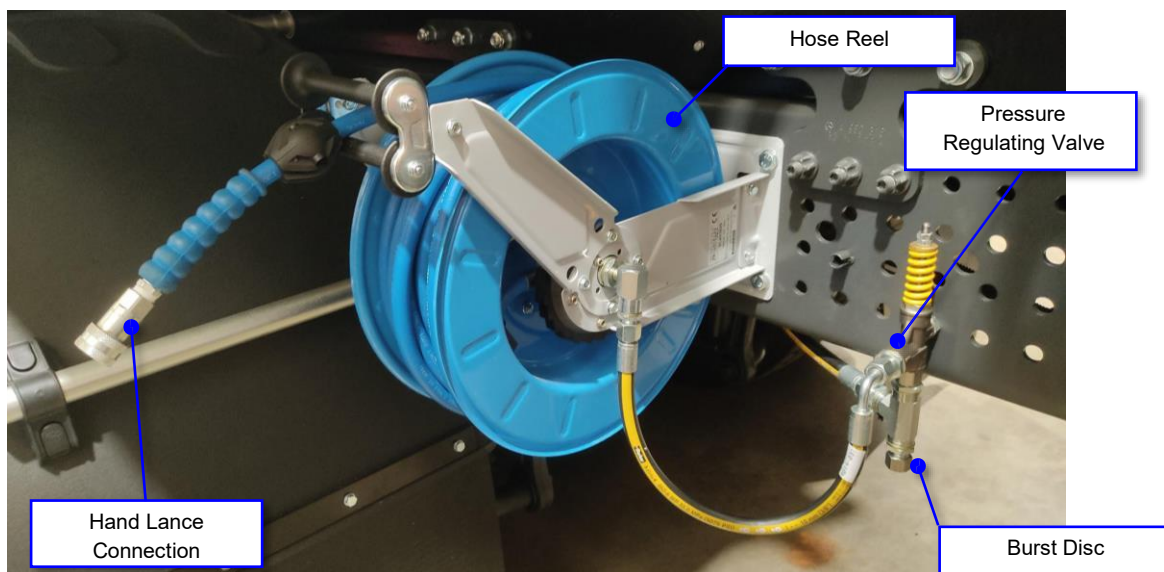
The Blanking Plug must be used to close off the Front Rig UHP Hose when not in use. Any debris that is allowed to enter the hose could block the jet bar nozzles.

- (a) Engage OMSI as sections 1.2 and 1.3. Water will now be available from the hand-lance.

Only use enough engine rpm/flow rate for the task. If a satisfactory clean can be achieved at engine tick over, then higher rpm/flow is not required. This will reduce the amount of water used and reduce the risk to the operator from excess reaction forces.

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The pressure regulating valve will divert all flow back to tank when the hand lance trigger is released. It will also regulate the pressure to 160 bar by bleeding flow back to tank, even with the trigger engaged should too much flow be sent to the wash down system. Increasing the engine rpm/flow past this point will not increase the flow or pressure through the hand lance.

Should the pressure regulating valve malfunction or become blocked causing the pressure to rise past 275 bar, a burst disc will rupture. Should this happen, press the vehicle footbrake to pause jetting and disengage the OMSI PTO. Identify the cause of the blockage, clearing and/or replacing parts as necessary before fitting a new burst disc.



NOTE: Spare burst discs can be found in the JSL toolkit.

WARNING!



Always ensure the burst disc is replaced. Should the pressure regulating valve malfunction or become blocked without a burst disc fitted, pressure will continue to rise until a hose or fitting fails, potentially causing harm to anyone in the vicinity.

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- (b) Once finished, stop pumping as section 1.6. Shut off engine.
- (c) Ensure all pressure is released from the system by pulling the trigger on the hand lance before disconnecting the hand lance or the UHP hose at the manifold.
- (d) Ensure the Front Rig hose is reconnected, all whip restraints are attached, and the blanking plug refitted to the hose reel inlet pipe.

2 Storage Procedure

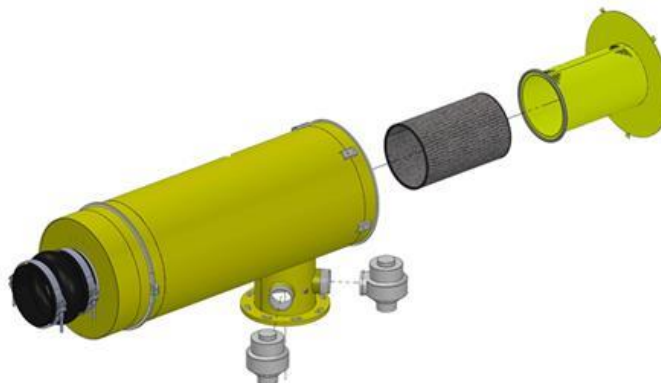


Warning – if the vehicle is going to be layed up for more than 30 days it is imperative that the anti-corrosion / anti-freeze procedure is followed

2.1 Layup Procedure

To be followed if the equipment is not going to be used for more than 30 days.

- (a) Remove blower inlet silencer end plate.
- (b) Remove the filter element.



- (c) Spray corrosion inhibiting oil (fogging oil) into the inlet of the blower while running the pump and blower at idle speed and low pressure – water will be exiting the jet bar.
- (d) Refit the filter element ensuring it is dry and clean.
- (e) Refit blower inlet cover
- (f) Spray corrosion inhibiting oil into the bottom of the vacuum relief valves
- (g) Empty all dirty water and debris from the debris tank and wash the tank.

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- (h) Drain the cyclone using the drain valve located on the RHS of truck and leave open.
- (i) Remove the front suction hoses but leave the UHP hose connected.
- (j) Select the anti-corrosion tank (contains 50/50 standard anti-corrosion/water mix) using the freshwater/anti-corrosion selector valve (see Figure 1.5)
- (k) Drain the freshwater tank by opening the valve attached to the JSL chassis, under the RHS of the tank.
- (l) Remove the freshwater strainer, clean then refit.
- (m) Ensure the anti-corrosion tank is full.



- (n) Raise the Front Rig sufficiently to place a suitably sized container under the jet head to catch the ejected corrosion inhibitor.
- (o) Place suitably sized containers under the MSSV observation valve and plunger cooling observation valve to catch the corrosion inhibitor. Both valves can be opened.
- (p) Start the truck and turn the system on. Engage the PTO gearbox as per section 5.2 and drive the UHP Pump as per section 5.3. The UHP pump will discharge low pressure water out of the jet head and the observation valve hoses. Once the corrosion inhibitor is present at the jet head and both observation valves, close the observation valves and leave the pump to run for 10 seconds before stopping the pump by pressing the foot brake **hard** and pressing NA2.
- (q) If at any point during this process the anti-corrosion tank runs low, then stop the process and refill the tank as per the above instructions.
- (r) Refill anti-corrosion tank.
- (s) Remove the UHP hose, ensuring the spin motor and bulkhead connections are plugged with the nylon plugs supplied.

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- (t) Stow UHP and Suction hoses in pump-house.
- (u) Shut the system down. Turn off the Jetting Isolator and Truck Battery Isolator.
- (v) The truck can now be stored until time of next operation.

2.2 Bringing the Osprey back into service

- (a) Close freshwater tank drain and fill tank with fresh water.
- (b) Close the cyclone drain and switch anti-corrosion selector tap to water supply.
- (c) Perform all Pre-Start Inspections as section 1.1.
- (d) Fit UHP hose and place buckets beneath jetting head and observation valves.
- (e) Run pump until all anti-corrosion fluid is collected in buckets and only clean water exits jet head and observation valves.
- (f) Dispose of anti-corrosion fluid responsibly.
- (g) Osprey is now ready to be used.

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PREVENTIVE MAINTENANCE PROGRAMME

PART 2 – VISUAL AIDS AND ELECTRICAL SYSTEMS

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VISUAL AIDS AND ELECTRICAL SYSTEMS

1.0 Introduction

The serviceability and reliability of air navigation equipment and installations are requirements for safe operation of aircraft in airport area. Apart from visual aids, the air navigation equipment and installations include electronic landing aids, navigation equipment, radar and meteorological equipment. The required serviceability of installations and equipment will only be achieved as long as a constant power supply is maintained. To solve this, a regular maintenance is done for airport electrical equipment and installations distributing primary and secondary power.

1.1 Purpose

The purpose of this programme is to establish a mechanism to maintain Visual Aids and Electrical Systems at JIA and that they are effectively implemented including preventive maintenance programme to ensure highest level of performance of all kinds of electrical installations and appliances at Juba International Airport.

1.2 Compliance of Aeronautical Ground Lighting (AGL) systems at Juba International Airport (JIA)

KIA as a precision approach runway category I/II, its preventive maintenance system has an objective that during any period of category I/II operations, all approach and runway lights comply with ICAO standards, and that, in any event, at least 85 per cent of the lights are serviceable.

S/N	Lighting system	Minimum percentage of serviceability
1	Precision approach lighting system (approach, PAPI, RTLs and sequence flashing lights)	85%
2	Runway threshold lights	85%
3	Runway centerline lights	85%
4	Touchdown zones lights	85%
4	Runway edge lights	85%
5	Runway end lights	85%
6	Runway turn pad lights	85%
7	Guard lights	85%
7	Stop bar lights	85%
8	Intermediate Holding position lights	85%
9	Runway guard lights	85%
10	Taxiway edge lights	85%
11	Guidance Signs	85%
12	Wind cone	85%
13	Beacon	85%
14	Obstacle lights	85%

Note: No two adjacent lights are unserviceable at KIA



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1.3 Elements of Visual Aids in Electrical section at KIA

The visual Aids in electrical include the following lights AGL lights: Obstacle lights, Approach lighting systems (including approach lights, PAPI, RTLs and flashing lights), Threshold lights, Runway centerline, TDZ lights, Runway edge lights, Runway end lights, TWY edge lights, Runway turn pad lights, Stop bar lights, Guard lights, taxiway centerline lights, intermediate holding position lights, Apron flood lights, aerodrome beacon, wind direction indicator lights, PAPI and guidance signs

1.4 PAPI

1. The PAPIs inspection and maintenance carried out by electrical department under Maintenance and they are repaired immediately when there is any default. PAPIs are calibrated by CNS (Communication Navigation and Surveillance) once a year.
2. Approved electrical maintenance contractor is used for some cases that require capabilities/ expertise beyond the electrical section of the airport.

1.5 The alignment of AGL lights

The alignment of AGL lights is carried out once a year this to make sure luminosity is exactly in the same angle as required. When carrying out maintenance the alignment is made and make sure is put into consideration. The service is done by a trained and experienced electrical engineers and technicians at KIA.

1.6 Testing the intensity of lights

The light intensity test is done every once in six months and this service is done by electrical section using an appropriate tool named photometric testing machine to ensure the same brightness of the lighting system is maintained as required.

1.7 Elements of Electrical Power Equipment and Installations

The following are different elements of power system's equipment and installations at KIA.

3. Power cables,
4. Medium voltage Switchgear (MVS)

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5. Control cables, ALCS, PLC cabinets
6. Airport sub-stations (Transformer, Constant Current Regulators (CCRs), Supervision system, MV and LV distribution panels,)
7. Uninterruptable Power supply (UPSs)
8. Generators.

1.8 Training Programme for Electrical Staff

The training programme for Electrical engineers and technicians is done by the Coordinator of powerhouse and regarding on fulfilment for everyone to be well trained to do the maintenance of Electrical systems and Visual Aids. The training plan is submitted to the Manager Maintenance for approval every year. The training program is kept in the powerhouse office.

1.9 Reporting Procedures

Electrical staff on duty does reporting any incident due to any power failure. He/she will immediately communicate to the following:

1. Powerhouse Coordinator
2. Manager Maintenance and Director Engineering and Maintenance
3. Operations officer on duty: He/ She will immediately inform Director Airport Operations, RAC safety office and Managing Director and

After realizing the cause of the incident the report prepared, it is distributed to the Managing Director and a copy to Director Engineering and Maintenance, Director Airport operations and RAC safety office.

2.0 Power Supply at KIA

There are two main Power stations (Powerhouses) at KIA that serve power to all Airports' electrical systems.

2.1 Powerhouse 1

This powerhouse is the main that carries almost 95% of total load of the useful power for KIA.

The above Powerhouse1 has two lines of primary power supply from national grid that supply the main power station (powerhouse) at KIA, in case one line fails the other line switches on automatically.

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Schematic of power distribution systems in Powerhouse1. There are two sections named Technical and commercial sections, where the above powerhouse1 feeds power.

Both technical and commercial sections, in case both lines fail the UPSs respond immediately without any interruption until standby secondary power supply generators respond.

There are two (2) backup generators of 350kVA each to support Airside section (Technical section) and 2 generators of 700kVA each for landside section (commercial section). In case of mains (both lines of grid power) failure, one (1) generator starts at a time whereas the rest remains standby to support in case of any failure.

There are 3 substations which supply air navigation equipment, of which each substation has a backup generator as follows:

- a. Substation 1 & Substation 2, each has a generator of 100kVA
- b. Substation 3 (Technical section) has a generator of 150kVA

2.2 Powerhouse 2

This Power is located in southern area of the Airport and serves only the infrastructures of southern Apron. It has one main power line and one standby generator to intervene in case of main power failure. In this case (failure), the UPSs take over the load immediately without interruption until standby secondary power supply generator starts.

i. In case the existing network fails (Partial failure)

In case of partial failure as mentioned early we have two sections one that serves the Airside (runway, apron and tower) and another section serves Land side (Terminal building and car parking) it will depend on which section that's is blacked out.

- ii. **In case our existing network fails (Total Blackout):** The responsible authorities and operations officer on duty are informed for immediate action while the technical team are finding the fault of the incident and resolving the problem as soon as possible.

3.0 Maintenance Personnel

Electricians to be entrusted with the task of maintenance of Airport Electrical Systems have the following qualifications/ qualities;

1. Skilled electricians,
2. Trained on the safety measures while working with Electrical systems,
3. Fully trained with the work to be done in their field,

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4. Present or on call during the operating hours of the airport to correct any deficiencies that might develop.

The same personnel are utilized for maintenance of both Electrical systems and Visual aids.

Note: The required safety devices are always ready in place to protect the personnel

3.1 As-built wiring/circuit diagram and manufacturer's manual

A set of wiring / circuit diagram is available in the maintenance unit. The wiring /circuit diagram has to be kept in the following manner:

1. A set of wiring / circuit diagram of important and complex electrifications is kept readily available.
2. These wiring/ circuit diagrams are kept up to date and any changes at site is reflected immediately on these drawings.
3. The completeness and the accuracy of all circuit diagrams, drawings and checked at least annually.
4. Manufacturer's Operation and Maintenance Manual and the copies of the circuit diagrams are kept in the office of the Powerhouse Coordinator.

3.2 Spare parts

An adequate stock of spare parts is available. The required level of stock of spare parts depends on the following criteria:

1. Rate of consumption of the item;
2. Time required to re-supply the item, and
3. Shelf life of the item.

4.0 General Procedures for Maintenance

At the time of servicing the electrical installations and Visual Aids, the following general procedures are followed:

1. The instructions of the appropriate authority, based on the recommendations of the manufacturer are followed.
2. Maintenance schedule is prepared and a record of maintenance of each piece of equipment is maintained.
3. These are arranged in a dated reminder file to make sure that all equipment is serviced regularly.
4. This record has space to enter observations, measurements and initials of the servicing individual.

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5. If situation demands, a change in the schedule may be effected with the approval of the Powerhouse coordinator in consultation with the equipment manufacturer, if applicable.

4.1 Regular/Corrective Maintenance

Corrective maintenance is defined as the maintenance, which is required to bring an item back to working order when it has failed or worn out. Corrective maintenance is carried out on items where:

1. The consequences of failure or wearing out are not very significant, and
2. The cost of corrective maintenance is not greater than preventive maintenance.

Corrective Maintenance activity consists of repair, restoration or replacement of equipment/ item. This activity is result of a regular inspection, which identifies the failure in time for corrective maintenance to be planned, scheduled and effected.

4.2 Preventive Maintenance for Visual Aids and Electrical systems

Preventative maintenance is the maintenance, which is carried out to prevent equipment failing or wearing out. Preventive maintenance is implemented by providing systematic inspections, detection and prevention of incipient failures. Preventive maintenance is carried out on all electrical systems. The corrective action is immediately taken into action once every after check or inspections have shown any default to any of the electrical systems inspected. The corrective action can either require to replace, repair or cleaning.

4.3 Basic Components of Maintenance

Maintenance includes measures to keep or restore the operational function as well as measures to check and to evaluate the present function of an element. The basic components of maintenance are:

1. Inspection and Monitoring;
2. Servicing and overhaul; and
3. Repair, and replace
4. Cleaning

4.4 Regular maintenance and Inspection

Inspection is a vital part of maintenance. An inspection programme is prepared and followed strictly. The frequency of inspection varies according to the hours of operation of the airport and flight schedules, Inspections are done 2 times a day morning hours and evening hours. Maintenance personnel regularly inspect the electrical installations

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and equipment to assess the requirement of maintenance and maintenance works are done immediately, the inspection team consisting of at least 2(Two) qualified personnel from the electrical department. The maintenance personnel is included in the inspection team to do the maintenance job instantaneously, whenever more manpower needed a maintenance contractor is engaged to do the work under the supervision of electrical department personnel.

4.5 Recording of Inspection and Maintenance reports:

1. Daily report of the inspection and maintenance work during the last 24 hours is raised by both inspection and maintenance personnel and is given to the concerned Engineer.
2. The Engineer verifies the genuineness of the report and preserve in his office as record.
3. The assigned electrical Engineer will send copy of the report to the Manager Engineering and maintenance. The Manager Maintenance verifies the Inspection and maintenance report and takes necessary action. Reports are preserved as record for future use.

5.0 Preventive Maintenance Schedule and Frequency checks and inspections

Maintenance schedule and frequency of inspection for very different types of electrical installations varies according to the type of installations and equipment regarding their location and usage. A maintenance programme is based on its past experience and with the objective of achieving required service level.

The following schedules are presented as guidance material in establishing a corrective and, at the same time, a preventive maintenance programme for all electrical and visual Aids at KIA.

1. More frequent checks and inspections are required for higher categories of lights / equipment.
2. Each check is followed by appropriate corrective action.
3. All malfunctions and corrective actions are recorded after taking the action.

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5.1 Preventive Maintenance Programme

S/N	ITEM	TYPE OF PREVENTIVE MAINTENANCE	FREQUENCY/ INSPECTION
1	GENERATORS	Refuelling and refilling of cooling water	Within 24hours
		Replacement of fuel, Oil and Air filters	Every one year
		Replacement of Engine Oil Every 250 working hours	
		Overhauling for both Mechanical and Electrical parts	
2	LV AND MV SWITCHBOARDS	Cleaning, Tightens of Bolts and nuts for each connection points	Every 6 month
		Grassing	
		Check the Performance of each individual circuit breaker	
3	POWER TRANSFORMERS	Cleaning, Insulation resistance tests	Every one year
		Verification of Primary/Secondary voltages	
		Short circuit tests and Winding insulation resistance tests	
4	AGL LIGHTS AND FLOOD LIGHTS	Cleaning of lights and inside the transformer pits	Every three months
		Circuits resistance tests	Every 6months
		Continuity resistance tests of each individual circuit	
5	CONSTANT CURRENT REGULATORS	Cleaning and dust removal	Once per week
		Circuit load balance	
6	UPS	Cleaning and Blowing	Once per week



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		Check for UPS input/output	Every three months
		UPS Switchboard harmonics	
		Tightness of Bolted connections	
		Battery Discharge Test	
		Test all UPS diagnostic fault indicators	
7	GENERAL LIGHTNG	Cleaning of the lights	Once per month
		Replacement of faulty light Immediate action	Once per week
8	SUBSTATIONS	Cleaning and Blowing of Dusts	
9	RECTIFIERS	Cleaning and Blowing, Battery inspection and measurements	Every three months
10	POWER FACTOR CAPCITOR BANK	Cleaning and Blowing, Battery inspection and measurements	Every three months

6. ELECTRICAL AND VISUAL AIDS INSPECTION CHECKLIST

a) GENERATOR PREVENTIVE RECORDS

GENERATOR NUMBER NO:

GENERATOR NO.	DATE	SERVICE WORK DONE	CURRENT INDEX READING (Hrs)	NEXT SERVICE READINGS (Hrs)	SERVICED BY	SIGN
1						
2						
3						

COMMENTS:



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b) DAILY SHIFT ELECTRICAL INSPECTION AND WORK DONE REPORT OF (DATE)

PART/EQUIPMENT	SPECIFIC AREA	STATUS	ACTION REQUIRED/COMMENT
1. REG SUPPLY LINES	GASOGI LINE		
	GIKONDO LINE		
2. MV CELLS	PROTECTION TRANSFO (TR01)		
	PROTECTION TRANSFO (TR02)		
	BOUCLE 15KV (C04) (Départ Boucle Vers Bloc Tech)		
	BOUCLE 15KV (C05) (Départ Boucle Vers SST2)		
	MV CELL 15 kV AND PROTECTION TRANSFO (Southern Apron)		
3. CHANGEOVERS	EXISTING CHANGEOVERS FOR TECHNICAL PART (CD9-CD10)		
	CHANGEOVERS OF SOUTHERN APRON POWERHOUSE		
	NEW CHANGEOVERS FOR COMMERCIAL PART		
4. UPSs	POWERHOUSE UPSs TECHNICAL PART (2x300kVA)		
	POWERHOUSE UPSs COMMERCIAL PART (3x300kVA)		
	BASEMENT UPS		
	SOUTH APRON UPS (2x100kVA)		
5. GENERATORS	A. POWERHOUSE		



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	GEN 1 (Technical part)		
	GEN 2 (Technical part)		
	GEN 3 (Technical part)		
	GEN 1 (Commercial Load)		
	GEN 2 (Commercial Load)		
	B. SOUTH APRON GENERATOR		
6. AGL SYSTEMS	A. RUNWAY EDGE LIGHTS		
	Circuit 1		
	Circuit 2		
	B. RUNWAY CENTER LINE		
	Circuit 1		
	Circuit 2		
	C. PAPI		
	PAPI 28		
	PAPI 10		
	D. APPROACH 28		
	E. THRESHOLD LIGHTS		
	F. RUNWAY TURN PAD 10 & 28		
	G. LEAD ON LEAD OFF		
	H. TDZ LIGHTS		
	I. TAXIWAY A		
	J. TAXIWAY B		
	K. TAXIWAY C		
	L. Stop bar A		
	M. Stop bar B		