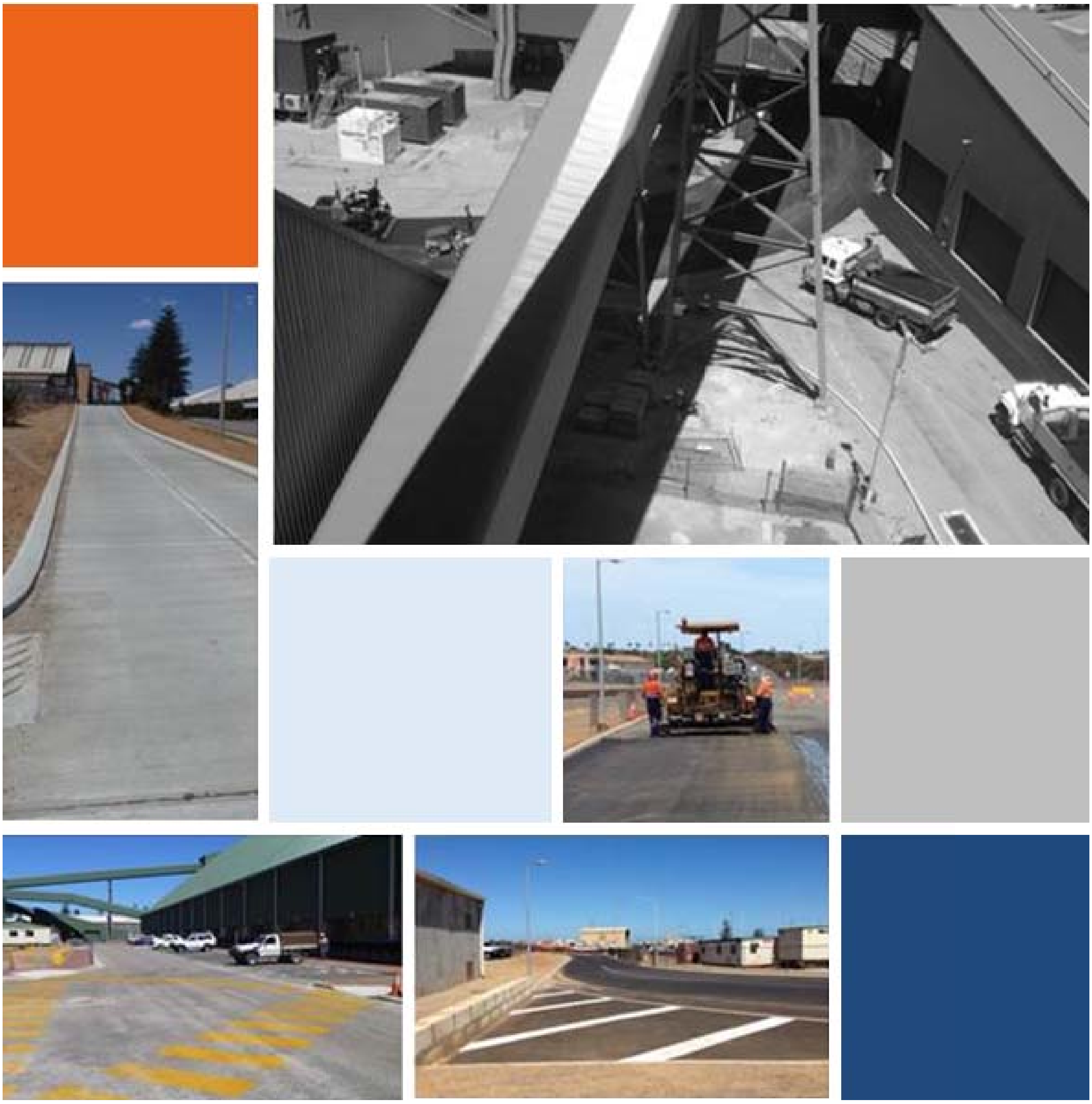
MID WEST PORTS

TECHNICAL GUIDELINE

MWPA503 – Guideline for Roads and Pavements



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1 PREFACE

This document has been compiled on behalf of the Mid West Ports to provide designers and contractors with some guidance for pavement design and construction in the port area. It draws heavily on the Main Roads Western Australia (MRWA) Specifications for Construction Guidance, as these are considered best practice in the area at the time of writing. It also draws on the Austroads Pavement Design Guide (APDG) for design guidance; however, because of the nature of the heavy vehicles in the port area, Austroads is only partly applicable.

The chapters of this guide include methods and guidance for selecting pavement loadings, subgrade considerations, guidelines to contractors on earthworks, pavement material design and behaviour and pavement type selection. Several references have been used in the compilation of this guideline and should be referred to for more detailed information.

This document is not intended to replace bespoke project basis of design, design criteria or specifications, but is intended to provide developers, designers and contractors with a benchmark which their development must meet on a technical basis. This document will be used as a basis for identifying any shortcomings in the technical content and ultimately accepting or rejecting a proposed development.

2 SCOPE

2.1 GENERAL

This document provides design and construction guidelines for light, medium and heavy pavements, and forms part of the MWPA Development Guidelines. This document must be read in conjunction with:

- A Guide to the Structural Design of Road Pavements (Austroads), herein after referred to as Austroads, the Austroads Guide or APDG;
- Engineering Road Note 9 (2012), Main Roads Western Australia, herein referred to as Road Note 9;
- The British Port Authority Pavement Design Manual (British Port Authority), herein referred to as the BPA Manual; and,
- United Nations Conference on Trade and Development Monographs on Port Management, herein referred to as UNCTAD:MPM.

The design of the light and medium type pavements are covered in APDG and Road Note 9 and the design of heavy type pavements are covered in the British Port Authority (BPA) Manual. Light and medium pavements are typically employed for use by road legal vehicles, in port marshalling areas, excess roads and trailer parking areas.

Heavy or industrial pavements are suited for specialised vehicles. Examples of specialised vehicles specific to the Port situation include forklifts, cranes and straddle carriers. These vehicles require heavy duty pavements in both the working and marshalling areas.

This document refers to the MRWA Specifications; these are not repeated in this document. This will ensure that this document will be in line with the most recent developments in material specifications at all times. Where documents are referred to in this part of the MWPA Development Guidelines, the reference shall be taken to mean the most recent revision, unless noted otherwise.

2.2 PRECEDENCE

Where particular aspects are not covered in the MWPA Development Guidelines or where conflict between documents exists, the following precedence for standards shall apply:

1. Statutory Regulations;
2. This Guideline;
3. Standard Specifications;
4. Design Codes and Standards; and
5. Reference Documents.

Where a list is presented and there is a conflict between documents, the reference highest on the list will take precedence, unless noted otherwise.

3 GLOSSARY

For the purposes of this Guideline the following particular definitions apply:

Table 1: Glossary of Terms

Term	Definition
Aggregate	Inert hard rock type material which has been crushed and screened.
Asphalt	A mixture of bituminous binder and aggregate in a prescribed ratio.
Bitumen	A product refined from petroleum crude.
Cemented materials	Material treated with cement to produce a high strength and high modulus.
Design Life	Period of time the structure is designed to be serviceable for subject to fair wear and tear.
Flexible pavement	Pavements constructed of unbound or modified materials.
Modified binder	A standard bituminous binder blended with a polymer to produce a more binder with more desirable properties.
Rigid pavement	Pavements constructed of structural asphalts on a cemented subbase, and concrete pavements.
Modified material	Material mixed with a low percentage of cement and/or lime to enhance the strength of the material.
Unbound granular material	Material consisting of high quality aggregate with a specific grading and processed without any additions.
Engineer	The Engineer is the person or organisation appointed by the MWPA to act in the role as determined by the contract.

For the purposes of this Guideline the following particular abbreviations apply:

Table 2: Abbreviations

Abbreviation	Meaning
AADT	Average Annual Daily Traffic
AC	Asphaltic Concrete
BPA	British Port Authority
CBR	California Bearing Ratio
DESA	Design Equivalent Standard Axles (Calculated design loading)
DMS	Dredged Marine Sediments

Abbreviation	Meaning
ESA	Equivalent Standard Axles
FWD	Falling Weight Deflectometer
MWPA	Mid West Ports Authority
HCV	Heavy Commercial Vehicles
ITS	Indirect Tensile Strength
MRWA	Main Roads Western Australia
PAWL	Port Area Wheel Load
SAR	Standard Axle Repetitions
UCS	Unconfined Compressive Strength
UNCTAD:MPM	United Nations Conference on Trade and Development: Monographs on Port Management
WA	Western Australia
WIM	Weigh In-Motion
WMAPT	Weighted Mean Average Pavement Temperature (23° for Geraldton)

4 RELEVANT DOCUMENTATION

4.1 GUIDELINE SERIES

This guideline should be read in conjunction with all other parts of the MWPA Development Guidelines, and these should be followed if relevant:

- MWPA 100 Series – General Guidelines;
- MWPA 200 Series – Drafting and Surveying Guidelines;
- MWPA 300 Series – Mechanical Guidelines;
- MWPA 400 Series – Guidelines for Maritime Structures;
- MWPA 500 Series – Civil Engineering Guidelines;
- MWPA 600 Series – Buildings and Structures Guidelines;
- MWPA 700 Series – Electrical and Instrumentation Guidelines;
- MWPA 800 Series – Guidelines for Rail; and
- MWPA 900 Series – Additional Guidelines.

4.2 STATUTORY REQUIREMENTS

In addition to the requirements of this part of the MWPA Development Guidelines, all designs shall meet the requirements of all current Local, State and Federal Acts and associated Regulations:

- Western Australian Environmental Protection Act
- Western Australian Occupational Safety and Health Act (1984) and Regulations (1996)
- Western Australian Marine (Certificates of Competency and Safety Manning) Regulations (1995)
- Western Australian Mines Safety and Inspection Act 1994
- Western Australian Mines Safety and Inspection Regulations (1995)
- Dangerous Goods Act (2004)
- Port Authorities Act (1999)
- Marine Transport and Offshore Facilities Security Act (MTOFSA) (2003)
- Environmental Protection Act (1986) and Regulations (1987)

4.3 STANDARD SPECIFICATIONS

The following standard specifications and documents shall be adopted for Works covered by this Guideline:

4.3.1 GENERAL DESIGN CODES AND STANDARDS

Table 3: Australian/New Zealand Standards and Design Codes

No.	Title
AS 1141	Methods for sampling and testing aggregates
AS 1160	Bituminous emulsions for the construction and maintenance of pavements

No.	Title
AS 1289.3.6.1	Methods of testing soils for engineering purposes - Soil classification tests - Determination of the particle size distribution of a soil - Standard method of analysis by sieving
AS 1289.5	Methods of testing soils for engineering purposes- Soil compaction and density tests
AS/NZS 4671:2001	Steel reinforcing materials
AS 3972	Portland and blended cements
AS 1379	Specification and supply of concrete
AS 2008	Bitumen for pavements
AS 2758.1	Aggregates and rock for engineering purposes - Concrete aggregates
AS 3600	Concrete Structures
AS 3610	Formwork for concrete
AS 3706	Geotextiles - Methods of test
AS 4058	Precast concrete pipes (pressure and non-pressure)

4.3.2 RELEVANT MRWA SPECIFICATIONS

In addition, the following relevant specifications may be adopted as design guidelines:

Table 4: M RWA Specifications

No.	Title
Specification 201	MRWA – Quality Systems
Specification 302	MRWA – Earthworks
Specification 407	MRWA – Kerbing
Specification 501	MRWA – Pavements
Specification 503	MRWA – Bituminous Surfacing
Specification 504	MRWA – Asphalt Wearing Course
Specification 603	MRWA – Safety and Traffic Barrier Systems
Specification 605	MRWA – Grab Rails and Bollards
Specification 701	MRWA – Roadway Lighting
Specification 803	MRWA – Dismantling and Demolition
Specification 903	MRWA – Fencing

4.3.3 ADDITIONAL REFERENCES

The following references have been used in the production of this guideline:

Table 5: Additional References

No.	Reference
1	*www.transport.wa.gov.au*
2	*www.midwestports.com.au*
3	Guide to Pavement Technology Part 2: Pavement Structural Design. (2010). Austroads Ltd. (NOTE: This has been superced by AGAM05-09: Guide to Asset Management Part 5: Pavement Performance and AGPT02-10: Guide to Pavement Technology Part 2: Pavement Structural Design.)
4	Engineering Road Note 9. (2012). Main Roads Western Australia.
5	Heavy Duty Pavement Design Manual. (n.d.). British Port Authority.
6	Lelarge P, Denel J & Herman P (1993). UNCTAD Monographs on Port Management. New York: United Nations.
7	Limeria J, Agullo L, Etxeberria M, & Levacher D (2011). Dredged marine sand for harbour concrete pavement. Coastal and Maritime Mediterranean Conference. Tangier, Morocco.
8	United Nations Conference on Trade and Development: Monographs on Port Management.
9	Wang D, Abriak N, Zentar R & Xu W (2011). Geotechnical Properties of Cement-Based Dredged Marine Sediments As a New Pavement Material. GeoHunan 2011 Emerging Technologies for Material, Design, Rehabilitation, and Inspection of Roadway Pavements. Hunan, China.

5 DESIGN RELIABILITY

5.1 PROJECT DESIGN RELIABILITY (REFER APDG 2.2.1.2)

Failure criteria can only be meaningfully compared if their degrees of reliability are the same. The design reliability means that the pavement is likely to last for more than the number of design repetitions for the chosen reliability level. Typical reliability levels are 90 to 95% for urban roads and 95 to 97.5% for strategic roads. For MWPA projects minimum design reliabilities of 95% is required, except if the designer can motivate a higher or lower value.

6 ASSESSING PAVEMENT LOADING FOR DESIGN PURPOSES

6.1 DESIGN TRAFFIC LOADING (LIGHT AND MEDIUM PAVEMENTS)

Traffic volumes obtained from traffic counts are available within the port. This data can form the basis for calculation of traffic loading.

MRWA Road Note 9 (Reference No. 4, Section 4.3) also provides methods for calculating traffic loading and adding in a specialised vehicle as follows:

- Heavy vehicle by class (based on Austroads Pavement Design Guide Part 2, Section 7) Vehicle Classification System).
- Axle Equivalency Factors (factors based on Windows Image (Microsoft) (WIM) data).

For granular pavements with thin bituminous surfacing, Austroads provides examples and procedures for including specialised heavy vehicles in terms of Load Equivalence Factors. This method is based on pavement damage which is related to the 4th power of the pavement deflection under a standard wheel. This method allows the inclusion of a specialised vehicle into the normal load spectrum and designers should use this method with care.

6.2 DESIGN TRAFFIC LOADING (HEAVY INDUSTRIAL PAVEMENTS)

The BPA Manual (Reference No. 5, Section 4.3) provides methods for calculating Port Area Wheel Load (PAWL) for use in the design of heavy industrial pavements based on the heavy wheel load, tyre pressures and wheel spacing.

6.3 DESIGN LIFE

Unless specified otherwise by the principal, the permanent deformation of the pavement must have a minimum design life of 40 years.

6.4 HEAVY VEHICLE GROWTH RATE

Heavy commercial vehicle (HCV) growth rates can be based on regional traffic growth rates, but the designer must motivate the growth rate used in terms of the Port's development plans.

6.5 LANE DISTRIBUTION FACTORS

Lane distribution factors must be used to determine the percentage vehicles using the design lane. All lanes of a specific development must be designed to the design lane loading. The lane distribution factors in Road Note 9 must be used.

6.6 DYNAMIC LOADING FOR SPECIALISED VEHICLES

The BPA Manual provides guidance for the dynamic factors that are to be applied to PAWL as a result of braking, cornering, accelerating and uneven surfaces.

6.7 ROUNDABOUTS AND OTHER SMALL RADIUS CURVES

At roundabouts and other small radius curves the design traffic loading in ESA's must be multiplied by a load factor of at least five, or should be based on the 4th power damage factors. This is to mitigate risk of premature failure from cornering forces.

6.8 RATIOS OF SINGLE AXLE REPETITION TO EQUIVALENT STANDARD AXLES (SAR TO ESA)

The SAR/ESA ratios for each damage type are determined from WIM survey data. The SAR/ESA ratios classified by MRWA for the Geraldton area are 1.53 for rutting and shape loss, 4.66 for cemented material fatigue and 1.3 for asphalt fatigue. Designers must consider the function of the road when selecting these values considering that the figures presented above are the lowest in Western Australia and these factors might be higher for the Port area.

MWPA requires that pavement designers consider the function of the road and motivate the method applied in calculating the design loading.

6.9 DESIGN TRAFFIC LOADING (CONCRETE PAVEMENTS)

The percentage distribution and axle group types at WIM sites in WA are published in Road Note 9 and APDG Part 2, 2010. This data can be utilised as a bases for estimating the design load in each heavy vehicle class. Specialised heavy vehicles can be included in the traffic spectrum provided that specialised vehicle widths are of similar dimensions as the other heavy vehicles.

7 GUIDELINES TO DESIGNERS ON SUBGRADES

7.1 GENERAL

The Austroads rutting criterion based on road pavement performance cannot be applied to the design of industrial pavements. This is because the normal Austroads subgrade and material failure criteria might not be applicable to heavy duty pavements and therefore not applicable as design criteria.

This is further emphasised through the fact that the load influence of the heavier vehicle is deeper than that of a road legal vehicle. The consequence of this is that appropriate design models must be used when designing heavy duty pavements. Subgrade conditions must be investigated to deeper depths than normal road pavements and performance of adjacent pavements and structures should form part of the design investigations.

7.2 SUBGRADE STRAIN

When analysing the vertical strain at subgrade level for a road legal axle and a heavy industrial vehicle, it is evident that the vertical strain within the subgrades are generally higher for the heavier load, and the load influence is generally deeper. This influences the depth of subgrade investigations and designers should plan subgrade investigations accordingly.

7.2.1 SOFT SUBGRADES (REFER APDG 3.15.1)

Austroads design procedure does not specifically take into account the improvement in mechanical properties obtained from chemical stabilisation of the subgrade

Evidence to suggest that improvement in subgrade properties achieved by chemical stabilisation is reliable in the long term provided that reactivity of the additive has been verified by laboratory tests.

IN SITU SUBGRADE STABILISATION

CBR values obtained in the laboratory for stabilised subgrade soils are generally much higher than the corresponding values achieved in the field, and the design subgrade CBR adopted should be checked during construction to verify the design value has been achieved (refer Chapter 11, APDG).

The rule of adopting the lesser of the CBR achieved through stabilisation or three times the untreated natural subgrade CBR is considered to be a reasonable guide when modelling stabilised subgrade strength. This prevents assigning too high a subgrade strength to in situ stabilised materials.

7.2.2 REACTIVE SUBGRADES

In the unlikely event reactive subgrades are found in the port precinct, MRWA Engineering Road Note 9 (**Reference No. 4, Section 4.3**) provides guidance regarding the cover over reactive material. It requires that if the swell potential as measured in accordance with Test Method WA141.1 exceeds 7.0%, a specific geotechnical assessment should be conducted and a review of the maintenance history of existing pavements and structures should be conducted.

Following the minimum cover requirements and sourcing advice from a geotechnical engineer is considered best practice in determining the design CBR or stiffness on these materials.

7.2.3 DREDGED MARINE SEDIMENTS (DMS)

Numerous technical publications have been written on the utilisation of DMS as road construction material. These studies range from the manufacture of concrete to the construction of road embankment fill.

In the concrete trials, DMS was used in substitution of the fine sand fraction in a concrete mix as part of an experimental port concrete pavement. The details and analysis of this concrete mechanical behaviour have been reported by Limeira et al. (2011). The study suggested that DMS consisting of a sandy dredged sediment could be successfully used as fine aggregate for concrete production and embankment fill material.

In the studies based on the use of dredged material for road sub layers, researchers found that the use of DMS in these situations is possible by stabilising the material with hydraulic binder mixes such as cement and/or lime. This study, published by Wang et al. (2011) in France, is based on enhancing the mechanical characteristics defined by the Atterberg limits as tested before and after treatment.

The aforementioned processes are not standard practice but have potential for consideration in future Port development.

7.2.4 GENERAL ASSESSMENT OF SUBGRADE STRENGTH

MRWA Road Note 9 (**Reference No. 4, Section 4.3**) provides a comprehensive method in determining the design subgrade CBR. The MWPA site is predominantly low lying, and designers should consider adopting soaked CBR tests with samples compacted to Proctor compaction and at in situ/natural moisture content.

7.2.5 SAFETY

Designers should ensure that designs and documentation are in accordance with current Safety in Design best practice and legislation and that the relevant reviews and audits are carried out during the development phases. Designs should demonstrate and document how safety has been considered in the final product, during construction and ongoing maintenance of the assets.

All current safety legislation is to be followed during construction on site. The MWPA HSEQ policies, procedures and permitting system are to be complied with. All temporary traffic controls should be approved by the Engineer or relevant MWPA Representative prior to its implementation.

8 GUIDELINES TO CONTRACTORS ON EARTHWORKS

8.1 MANAGEMENT OF CONTAMINATED SOILS

Before any construction occurs Contractors are reminded to familiarise themselves with **MWPA Procedure 2.37 – Contaminated Sites Management**, which deals with soils movement, plant/equipment wash-down and stormwater run-off.

8.2 SITE CLEARING

Particular attention should be paid to the clearing of the site to avoid affecting the surrounding landscape unnecessarily. All vegetation cleared from the site should be stockpiled as directed by the MWPA representative for re-use as mulch. Long term and short term environmental effects on the cleared area and its surroundings should be considered and planned for carefully.

8.3 EXCAVATION

Excavation can be defined as any in-situ material which is disturbed or handled during the construction works. The Contractor should satisfy themselves with the properties of the site soils as they may have an impact on the excavation techniques. This may involve testing and inspection.

Coarse materials (rock, gravel, sand) can be identified by inspection. Fine grained material usually requires laboratory testing to determine how it will respond when excavated and/or wetted. Any material that is to be reworked should be tested under the appropriate conditions in the laboratory or in a small field trial to ascertain its suitability and resulting properties.

Areas of excavation where the underlying material is unsuitable for construction generally should be undercut. This is allowed at the discretion of the Engineer or relevant MWPA authority. Unsuitable material should be excavated and replaced with a suitable material.

Where areas of unsuitable material are identified, care should be taken to identify the cause of the unsuitable material. Other factors such as poor drainage may have caused the problem and these should be investigated and mitigated first; fixing the problem may mean the material becomes suitable for construction.

Dump areas should be indicated by the Engineer or relevant MWPA representative. Surplus material can often be used for non-structural applications such as bunding and landscaping.

8.4 FILLING

Material used for fill should be approved by the Engineer prior to being selected and installed. In any case, fill material should be fit for purpose and provide the desired mechanical properties. There is often a trade-off between material selection properties and cost.

Proper compaction is required on any fill material to gain the desired properties. The project specification should provide guidance to the appropriate compactive effort required. The moisture content of the material is also a key aspect in getting the desired compaction. A material that is too wet or too dry will achieve a low density and relatively weak outcome irrespective of the compactive effort.

Moisture content expresses the amount of water present in a moist sample. The optimum moisture content is the moisture content at which compaction will produce the maximum dry density.

In clayey materials the optimum moisture content is slightly less than the plastic limit. Sandy materials, on the other hand, require moisture saturation and vibrational compaction to achieve the optimum compaction.

The nomination of the type of compaction plant is left with the Contractor and the decision can be dependent on the availability of plant. The amount of compactive effort required to achieve the required compaction is determined in the manner prescribed in the project specifications. Once the number of passes of a particular roller has been established for the specified compaction and particular soil type, the amount of compaction testing can be reduced for that soil type.

8.5 SUBGRADE PREPARATION

The subgrade should be prepared in a manner that minimises deterioration from prolonged exposure. This may mean that the subgrade is prepared in a number of sections and overlaid with the next layer in order to minimise exposure as much as practically possible. Precaution should be taken to ensure the subgrade surface remains at the designed profile and to specification. The contractor is to manage traffic routing through the site such that damage to the subgrade is minimised.

8.6 TOPSOIL

Topsoil that is to be reinstated should be carefully excavated to avoid contamination by other material. The material should be stored such that its qualities are preserved and that it is suitable for reinstatement.

Generally, topsoil depths are between 75 mm and 200 mm, however this will vary based on the amount of topsoil recovered. Additional topsoil can be imported to make up any shortfall from excavation. Care must be exercised so as to not impart topsoil contaminated with unwanted vegetation and contaminated material in accordance with **MWPA Procedure 2.37**.

All disturbed areas should be reshaped and reformed upon completion of the main works. Reshaping should be such that the disturbed land marries into the adjoining landscape or required design levels. Landscaping as soon as practicable will assist in ensuring that erosion does not occur.

8.7 SURFACE DRAINAGE

Water can cause many issues in the building of roads and all measures should be taken to minimise water infiltration. Steps should be taken to ensure that water does not runoff neighbouring areas onto the site, but also that overland flow paths are maintained. This may require additional infrastructure such as ponds and temporary piping or channelling.

Conversely, care must be taken to ensure that water gathered onsite, either from weather conditions or site works, does not runoff the site and cause adverse problems on neighbouring land or in waterways. Control of runoff and diversions shall meet the requirements of MWPA Procedures and DEC Guidelines.

8.8 USE OF EXISTING PAVEMENT MATERIALS

Existing pavement materials have the potential to be reworked and then reused in the new pavement structure. The properties of the existing material will determine its suitability for reuse and these should be assessed as required. The costs between treating existing material for reuse and importing new material may not differ greatly, and should form part of the decision on the use of existing material. The degradation of material can best be assessed by constructing a trial section with the recycled material and assessing the breakdown through grading tests.

9 PAVEMENT MATERIALS

9.1 GENERAL

It is common practice in pavement design to use locally available or other readily available materials between the subgrade and the basecourse for economic reasons. These layers can be designated as selected materials or sub-bases, and the thickness of these layers can be designed in accordance with guides such as Austroads. However, it should be noted that the design CBR of the material cannot be assigned to the material unless it also meets the gradation and plasticity requirements as determined in the project specification.

Unbound lateritic materials have performed well on limestone subgrades. However, with the increased wheel loads, higher tire pressures and narrow lane widths, designers should consider the use of other options. These options can include deep cement stabilised pavements.

Concrete or rigid pavements have performed well in the Port. They are, however, expensive to construct and are not user friendly with regards to repair or installation of buried services, but have shown a long term reduction in maintenance costs over other pavement types.

Deciding on a specific pavement type should take note of all other relevant MWPA guidelines.

9.2 UNBOUND GRANULAR MATERIALS

The flexible pavement design procedures set out in Road Note 9 (**Reference No. 4, Section 4.3**) should be followed. If the empirical pavement design procedure is followed, the pavement thickness must not be reduced by any amount to compensate for the thickness of the asphalt wearing course, except where the asphalt nominal thickness is greater than 60mm and the asphalt has a design fatigue life of more than 20 years.

When pavement materials have been cement, bitumen or lime treated, the design of the pavement using these materials must consider that the pavement may fail prematurely in fatigue and that the basecourse thickness may need to exceed 250 mm to manage this risk.

Irrespective of the design procedure followed, the top 250 mm of the pavement must be constructed from basecourse quality material.

9.2.1 DESIGN MODULUS OF GRANULAR MATERIALS

Road Note 9 (**Reference No. 4, Section 4.3**) requires that if the nominal total thickness of the asphalt surfacing is less than 60 mm, the vertical modulus assigned to the granular material in the mechanistic procedure must not exceed the presumptive values in Table 6.3 of APDG Part 2. Higher material parameters are allowed if proven by repeated load triaxial testing.

9.3 MODIFIED GRANULAR MATERIALS

Cement modified granular materials are not typically used. Road Note 9 warns against a premature failure of this type of material and proposes increased thicknesses in order to manage the risk of failure.

9.3.1 MODIFIED GRANULAR MATERIAL DEFINITION

MRWA Road Note 9 defines these materials as material where the unconfined compressive strength does not exceed 1.0 MPa when tested at in-service density as prescribed in Engineering Road Note 9, Section 1.1.12 (**Reference No. 4, Section 4.3**). These materials are described in more detail in the guidance notes of MRWA Specification - 501 Pavements.

9.4 CEMENTED MATERIALS

Cemented materials must not be incorporated in flexible pavement systems. Road Note 9 allows certain exemptions, and designers are encouraged to explore these exempted material types as they include recycling of concrete materials, which may have environmental benefits.

Where cemented materials are used as working platforms below the design subgrade surface, no reduction in the pavement thickness should be allowed. The aim of a working platform is purely to assist construction on substandard subgrades.

If cemented materials are used in pavement layers, the CBR used for design must not exceed the CBR of the unbound granular material used to manufacture the cemented layer. The vertical modulus used in the mechanistic design procedure for crushed rock or recycled concrete subbase must not exceed 500 MPa. In order to limit reflective cracking a nominal thickness of granular pavement material of 230 mm or 175 mm of asphalt must be placed over the top of the cemented material.

9.4.1 DESIGN MODULUS OF CEMENTED MATERIALS

APDG Part 2, Section 6.4.3, defines the design modulus for cemented materials and proposes methods for determining modulus values through Unconfined Compressive Strength correlations. It acknowledges the fact that there are no current standardised tests for determining the flexural modulus for design.

9.5 ASPHALT (REFER APDG 6.5)

9.5.1 INTRODUCTION

Asphalt is a mixture of a bituminous binder and several single-sized aggregate fractions which constitute the skeleton of the mix. There are several types of mixes, which are described by the grading of the aggregate; for example, dense graded mixes, gap graded mixes and open graded mixes. Each of these mixes has their own structural and functional applications. Further details on asphalt mix design and asphalt technology are contained in Austroads Part 4B.

9.5.2 BINDERS

The bituminous binders referred to in the Austroads Guide are classified in accordance with the mid-point of their viscosity range at 60°C, in Pa s.

A typical asphalt grade binder is a Class 320. The use of polymer modified binder and multi-grade bitumen in heavy duty asphalt wearing course applications has progressed over the past two decades to become common practice. Further details on bitumen binders are contained in Austroads Part 4F.

9.5.3 MINIMUM SURFACING REQUIREMENTS

As a pavement surfacing, MWPA requires a minimum of 40 mm of AC14 with properties in accordance with MRWA Specification 504. In areas of high turning manoeuvres and intersections, a modified intersection type mix must be used.

9.5.4 FACTORS AFFECTING STIFFNESS OF ASPHALT

Besides the physical properties of the asphalt, the binder type, binder content, air voids, temperature at which the surfacing operates, the rate of loading and age of the surfacing are important factors in determining the design stiffness of the asphalt.

BINDER TYPE

In general, stiffer binders produce a stiffer asphalt mix. The characteristics of the binder are defined by the source of the bitumen, the refining process and the type and amount of any binder additives. Shell has produced a set of nomographs (Shell, 1978) to determine the asphalt modulus based on the binder stiffness. These methods, however, are only applicable to conventional binders.

BINDER CONTENT

A low percentage of binder increases the cohesion and strength of an asphalt mix. Beyond a certain value, an increase in binder content reduces the frictional content between aggregate, causing a reduction in the overall stiffness of the asphalt mix.

AIR VOIDS

The relationship between the percentage of air voids and the stiffness of an asphalt mix is dependent on the binder content.

OPERATING TEMPERATURE

The most important factor in determining the asphalt modulus is the temperature at which the asphalt will operate. The modulus can vary up to an order in magnitude in the range of temperature applicable to pavement surfaces.

The Weighted Mean Average Pavement Temperature (WMAPT) is used to calculate the asphalt stiffness for a specific region. Refer to APDG Part 2 for WMAPT values (Austroads 2010 states a WMAPT for Geraldton of 31°C).

RATE OF LOADING

The stiffness of asphalt is dependent on the rate at which it is loaded. A faster vehicle speed gives a quicker rate of loading, and thus higher asphalt stiffness.

AGE

The stiffness of asphalt generally increases with age. For asphalt thickness design, the effect of age on modulus is taken into account in the asphalt fatigue relationship.

9.5.5 DETERMINATION OF DESIGN ASPHALT MODULUS

Road Note 9 (**Reference No. 4, Section 4.3**) requires that the asphalt modulus is calculated from the indirect tensile test asphalt modulus in accordance with APDG Part 2. Designer's attention should be drawn to the additional requirements for Perth Dense Asphalt Mixes for intersection mix designs.

For asphalt nominal thicknesses more than 60 mm at roundabouts and intersections controlled by traffic signals, the rate of loading must be calculated on a maximum speed of 10 km/h.

For all other locations and asphalt thicknesses, the rate of loading must be calculated on a speed not less than 10 km/h below the posted speed limit. Forty kilometres/hour is the maximum speed in the Port precinct.

Road Note 9, Table 9, gives guidance of typical air void and binder content volumetric properties for typical Western Australian asphalt mixes.

9.5.6 ASPHALTIC CONCRETE FATIGUE CRITERIA

Asphalt fatigue criteria should be calculated in accordance with APDG Guide to Pavement Technology Part 2, Section 6.5.6. This relationship is for conventional binders under moderate to heavily trafficked pavements. The desired project reliability factor for asphalt fatigue is 95%.

9.6 CONCRETE PAVEMENTS

Concrete pavements should be designed using the procedures set out in APDG Part 2 for rigid pavements. The design should satisfy the requirements and standards set out the relevant section of Road Note 9.

The 28-day concrete flexural strength is a key parameter for design. Typical values are in the range of 4.0 to 5.0 MPa. APDG Part 2 provides the relationship between flexural and compressive strengths for typical concrete mixes. For surface durability of the concrete wearing surface, 28-day characteristic compressive strength of not less than 32 MPa is required.

Concrete pavements must incorporate a lean mix concrete sub-base and fatigue as well as erosion damage parameters must be satisfied.

Road shoulder widths are to be as per MWPA requirements. Designs are to allow for and demonstrate that sufficient shoulder and lateral support (outside of lanes) to accommodate the loadings.

10 PAVEMENT TYPE COMPARISONS

The final selection of a pavement type may be governed by financial constraints. For high risk profile pavements, the level of risk must be noted in the selection of the pavement type.

Table 1 provides the risk profile for some pavement types.

Table 6: Pavement Type – Risk and Cost Comparison

Pavement Type	Risk	Cost
Concrete Pavement	**Lower**	**Higher**
Structural Asphalt Pavement	↓	↑
Modified Base on Stabilised Subbase	↓	↑
Modified Base on Granular Subbase	↓	↑
Unbound Granular Pavement	**Higher**	**Lower**

Table 7 provides guidance for the selection of pavement type based on 20-year design traffic volume.

Table 7: Pavement Type Guidance based on Design Traffic

	< $5x10^6$ DESA (Light)	$5x10^6$ to $10x10^6$ DESA (Medium)	$10x10^6$ to $50x10^6$ DESA (Heavy)	> $50x10^6$ DESA (Heavy)
Concrete Pavement	↔	↔	↔	↔
Structural Asphalt Pavement	↔	↔	↔	↔ (partial)
Modified Base on Stabilised Subbase	↔	↔	↔	
Modified Base on Granular Subbase	↔	↔	↔ (partial)	
Unbound Granular Pavement	↔ (partial)			

The above tables are guidelines only and the final choice should be evaluated based on whole of life evaluation techniques (refer to APDG, Part 2, Section 10).

11 SELECTION OF SUITABLE PAVEMENT FOR SPECIALISED VEHICLES (HEAVY PAVEMENTS)

The BPA Manual provides guidance for the selection of pavements for specialised vehicles for port areas.

11.1 TRADITIONAL PAVEMENT SELECTION APPROACH

The traditional approach has been to firstly select the specialised equipment and then to design a pavement system to withstand the damage inflicted by the selected equipment.

11.2 MODERN PAVEMENT SELECTION APPROACH

A more modern approach is to consider the selection of the specialised equipment in parallel with the design of the pavement system. This approach requires comprehensive knowledge of both the operational and engineering aspects involved in the selection process.

A guideline for the selection of pavement types for various equipment and operation types can be found in UNCTAD:MPM.

11.3 PAVEMENT DESIGN APPROACH FOR HEAVY PORT EQUIPMENT

11.3.1 DESIGN CHARTS

The BPA Manual contains a large selection of design charts which allow the user to compare alternative pavement solutions.

The design charts are based on:

- Material types and properties;
- Subgrade strength (defined in terms of CBR);
- Assessment of pavement loading:
  - Wide areas of operations;
  - Concentrated areas of operation;
  - Dynamic loading.

These design charts have the advantage of a greater confidence in the overall design process but requires interpretation by an experiences pavement designer.

11.3.2 DESIGN SOFTWARE

Software packages are available for the design of heavy duty pavements. These design packages are mostly designed for airport pavements but lend themselves to other applications, such as port pavements. The software can solve complex pavement systems but should be checked against design charts, and designs should be verified by experienced designers.

12 EARTHWORKS

12.1 CLEARING

12.1.1 EXTENT OF CLEARING

Clearing shall be carried out in the following areas:

1. Over areas affected by cut and fill operations,
2. Within the total area of road reserves, and
3. Where necessary for the construction of drains outside road reserve but limited to three metres either side of the centreline of any pipe.

12.1.2 TYPE OF CLEARING

Clearing shall consist of clearing areas of all trees, standing or fallen, brush, shrubs and other vegetation, loose rocks and boulders and rubbish.

12.1.3 DISPOSAL OF MATERIAL

No burning of cleared material shall be allowed on site. All vegetation cleared from the site shall be stockpiled as directed by the MWPA representative for re-use as mulch. All material and debris resulting from the clearing operation which is deemed unsuitable for mulch as directed by the MWPA representative shall be removed from the Site to a suitable tip. The Contractor shall pay all charges in connection with the disposal of clearing material and debris.

12.2 EXCAVATION AND FILL

12.2.1 GENERAL

Earthworks shall include all excavation, filling, compaction and trimming required to complete the bulk earthworks, batters and road embankments to the shapes specified or as shown on the Drawings.

Within road reserves the Contractor shall excavate or fill to the level required. The excavation or fill shall be extended into the land abutting the road reserve to the batter slopes as shown on the Drawings. Clean surplus fill shall be placed on areas designated on the Drawings as fill areas.

Fill shall be placed, levelled and compacted so that the mean of the maximum dry density (MDD) results is not less than 95% and no result is less than 92% when tested in accordance with MRWA Specification 201 - Quality Systems and Specification 302 - Earthworks.

Fill shall be evenly placed and compacted in lifts not exceeding 200 mm. The edges of the fill shall be graded to the slope shown on the Drawings and blend evenly and smoothly into the natural surface. Finished surface shall be graded to the shape indicated by the finished contours.

12.2.2 ROCK

Rock shall be defined as material that can only be excavated using impact tools (e.g. rock hammer).

Hard or difficult material in open excavation that cannot be ripped with the equivalent of a Caterpillar 'D8' with a single tine ripper shall be considered as rock.

Hard or difficult material in trench excavation that cannot be excavated with the equivalent of a 30T excavator with a rock/ripper bucket shall be considered as rock.

13 PAVEMENT CONSTRUCTION

13.1 GENERAL

The pavement shall be constructed to the cross-sections, lines and grades shown on the Drawings. The pavement shall consist of lateritic gravel basecourse. The Contractor is to allow for the removal of all unsuitable material removed during box-out of road.

13.2 QUALITY ASSURANCE

The Contractor shall undertake all testing and measurement required below in accordance with MRWA Specification 201 - Quality Systems and the Project Specifications to demonstrate that the specified materials have been supplied and standards of construction have been achieved. The quality assurance certificates attached in Appendix A may be used for record keeping.

13.3 SUBGRADE PREPARATION

13.3.1 GENERAL

Subgrade preparation shall be carried out in all areas where a pavement is to be constructed. After filling, including refill of trenches, trimming and boxing out, the finished surface of the subgrade shall conform to the lines, grades, shape and dimensions shown on the Drawings.

13.3.2 COMPACTION

The subgrade shall be compacted to not less than 95% of the Maximum Dry Density when tested in accordance with MRWA Specification 201 - Quality Systems and Specification 302 - Earthworks to a minimum depth below the surface of 300 mm. The subgrade shall be worked to provide a layer uniform in all its characteristics.

13.3.3 TOLERANCES

The finished levels of subgrade shall be within -20 mm and +5 mm of the design levels. The subgrade surface shall be tested to ensure accuracy and any irregularities shall be corrected prior to the placement of any sub-base material.

13.4 BASE COURSE

13.4.1 GRAVEL BASE COURSE MATERIAL

GENERAL REQUIREMENTS

A gravel base course shall consist of a combination of soil binder, sand and gravel be selected in accordance with the **MWPA Guidelines for Roads and Pavements** as well as *MRWA: A Guide to the Selection and Use of Naturally Occurring Materials as Base and Subbase in Roads in Western Australia.*

Notwithstanding the Project Specification, any sample which in the opinion of the MWPA's Representative is composed of unsuitable material or is composed of material which would break down with ageing or weathering to such an extent that it would then fall outside the limits of the specification, shall be rejected. Any material thus rejected shall immediately be removed and no liability for payment in any manner whatsoever will be accepted by the MWPA for such rejected consignment.

13.4.2 APPROVAL

Prior to the placement of any base course material the subgrade shall be checked and approved by the MWPA's Representative.

13.4.3 TRANSPORTATION

Base course material shall be transported to the Site in trucks with wheel and axle loadings not exceeding those legally permitted on public roads. Trucks shall not be moved over prepared compacted subgrade and shall be reversed into the point of dumping over sub-base material previously placed.

13.4.4 SPREADING AND COMPACTION

Base course material shall be spread in one layer with pneumatic tyred equipment and the surface shall be graded to the general final required shape and watered if necessary before compaction is commenced.

Compaction shall be carried out in a uniform pattern with approved compaction plant. During grading and compaction the material shall be maintained at a moisture content sufficient to obtain the required compaction.

Base course material shall be compacted to a minimum of 98% Maximum Dry Density when tested in accordance with MRWA Specification 201 - Quality Systems.

13.4.5 TOLERANCES – SURFACE SHAPE

SUBBASE

The shape of the subbase shall be judged to be acceptable when the maximum deviation from a three metre straight edge placed in any position on the surface does not exceed 10 mm.

Additionally, for pavement widening work, the crossfall at any position on the new surface measured at right angles to the centreline shall be within 0.5% of the existing crossfall on the outer two metres of the adjacent traffic lane at that location.

BASECOURSE

The shape of the basecourse shall be judged to be acceptable when the maximum deviation from a three metre straight edge placed in any position on the surface does not exceed 6 mm.

Additionally, for widening work, the crossfall measured at any position on the new surface at right angles to the centreline shall be within 0.5% of the existing crossfall or of the crossfall on the outer two metres of the adjacent traffic lane at that location.

13.4.6 TOLERANCES – SURFACE LEVELS

SUBBASE

a) Construction or Reconstruction Sections

   The level of the completed subbase surface shall be deemed to be conforming when the level measured at any point on the surface is within +5mm, -25mm of the subbase level at that point as determined from the drawings.

b) Pavement Widening Sections

   The level of the completed subbase surface shall be deemed to be conforming when the levels of the subbase at its junction with the existing pavement are within +5mm, -25mm of the levels as determined from the basecourse depth, making due allowances for the effect of the existing crossfall of the pavement.

BASECOURSE

a) Construction or Reconstruction Sections

The level of the completed basecourse surface shall be judged to be acceptable when the level measured at any point on the surface is within the following tolerances for the basecourse level for that point as determined from the drawings:

- Where final surface is asphalt: - 5mm, + 10mm
- Elsewhere: - 5mm, + 20mm

b) Pavement Widening Sections

The level of the completed basecourse surface shall be judged to be acceptable when the levels of the basecourse at its junction with the existing seal are within 0mm, +5mm of the top cut edge level of the existing seal.

13.4.7 SURFACE FINISH

Completed pavement layers shall be in a homogeneous, uniformly bonded condition with no evidence of layering, cracking, disintegration or surface tearing. The finished surface should appear as a stone mosaic interlocked with fine material and shall be dense, even textured and tightly bonded. The basecourse must retain those characteristics after rotary brooming and be suitable to receive bituminous surfacing. Prior to the application of bituminous surfacing, the surface of the basecourse shall be uniformly dry.

13.4.8 PRIME AND SEAL

A prime and seal coat consisting of a bituminous emulsion binder and 7mm sealing aggregate shall be applied to all completed basecourse surfaces which are to be asphalted.

PRE SEAL INSPECTION

The Contractor shall give the MWPA Representative 24 hours notice of his intention to seal to allow the Representative to inspect and approve all areas to be sealed. No sealing shall take place until areas to be sealed have been inspected and accepted by the MWPA Representative.

PREPARATION

The surface of the basecourse to be primed and sealed shall be swept free from loose stones, dust, dirt and foreign matter.

A mechanically operated rotary broom may be used for sweeping, provided it does not disturb the stones in the surface and any additional sweeping necessary to obtain a satisfactory clean surface shall be done by hand using a stiff bass broom or similar approved brooms. The sweeping shall be completed as far as practical immediately before the application of the binder. All sweeping shall be completely removed off the road.

No binder shall be applied until the surface has been approved by MWPA's Representative and the basecourse layer has dried back such that the moisture content is less than 85% of modified optimum moisture.

Priming of pavement will only be carried out when the air temperature is between 14°C and 30°C and rain is not expected to fall for at least three hours.

Unless MWPA's Representative instructs otherwise, the base course surface shall be lightly watered prior to spraying binder.

BINDER

The binder shall be bitumen emulsion complying with requirements of the MRWA Specification 503 - Bituminous Surfacing.

The binder shall be applied by an approved mechanical sprayer which has been tested in accordance with MRWA Specification 201 - Quality Systems.

The MWPA's Representative may approve spraying using a hand lance fed from a mechanical sprayer if, in the Representative's opinion, the direct use of a mechanical spray is impractical.

COVER MATERIAL

The binder shall, immediately after spraying, be covered with an approved 7mm diorite or granite sealing aggregate. All sprayed areas shall be completely covered within a period of 15 minutes.

The cover material should be spread by means of approved aggregate spreader attached to the body of a motor vehicle transporting the metal. Such equipment shall be capable of spreading a uniform layer of aggregate.

The rate of application shall be at a maximum of 150 square metres per cubic metre of metal controlled so that only sufficient is applied to give a uniform dense mat one stone thick. Additional aggregate shall be added by hand spreading to any insufficiently covered areas as necessary to produce the required uniform layer.

Within 15 minutes of the application of the aggregate rolling shall be commenced with a five to eight tonne self-propelled steel wheel roller. This initial rolling shall preferably consist of at least three complete passes over the area concerned, but should any general crushing occur under the roller such rolling should be stopped regardless of the number of passes completed.

The surface shall then be backrolled with a pneumatic tyred roller until proper interlocking of the chipping and adhesion of the binder to the stone takes place. During this operation the material is to be constantly broomed to ensure that an even layer of material is equally spread and rolled hard.

13.5 HOT-MIXED ASPHALT

13.5.1 GENERAL

Where shown on the Drawings, the material for the wearing course shall be 'Hot-Mixed Asphalt' consisting of a combination of course aggregate, fine aggregate and mineral filler, uniformly coated and mixed with bituminous binder. The mixture shall be composed of the materials as specified in MRWA Specification 504 - Asphalt Wearing Course. All Hot-Mixed Asphalt shall be supplied and placed with a minimum compacted thickness of 40mm, and tolerance +5mm.

14 EXTRUDED CONCRETE KERBING

14.1 GENERAL

Kerbs to roadways shall be constructed of extruded concrete kerbing to the line, level, cross-section and detail shown on the Drawings.

14.2 KERB CONSTRUCTION

The surface to receive kerbing shall normally be a bituminous aggregate seal. The area between the receiving surface and the new kerb shall be cleaned of all loose sand, stones, dust and other foreign matter and the surface shall be wet with water immediately prior to placement of the new kerbing.

All concrete used shall be supplied by an approved firm in a ready mixed state and shall comply with the requirements of AS 2876 Concrete kerbs and channels (gutters) - Manually or machine placed.

All concrete used in the works shall develop a minimum compressive strength of 20 MPa at 28 days with a minimum slump of 100 mm.

A string line or similar shall be pegged on an offset alignment to the kerb at sufficiently frequent intervals to ensure that the accuracy of the finished alignment conforms to the requirements of the Specification and Drawings. Setting out of the kerb shape, profile and alignment shall be carried out on the rear of the kerb. Spikes and nails shall not be driven into the pavement surface.

The first 150mm of any new pour shall be cut away and removed. The gap between the old and new work shall be filled by hand placing, rodding and shaping of the concrete until a satisfactory shape and finish has been obtained.

14.3 TOLERANCES

The finished product shall be true to the dimensions specified and shall be a smooth finish. The top surface of the kerb shall be parallel to the ruling grade of the pavement and shall be free from depressions exceeding 5mm when measured with a three metre long straight edge.

14.4 CONTRACTION JOINTS

CONTRACTION JOINT

Immediately after placing the kerbing, contraction joints shall be formed by grooving the exposed faces of the kerbs. Contraction joints shall be formed at spacings not exceeding four metres.

EXPANSION JOINT

Not less than 24 hours, nor more than 72 hours, after placing of concrete, expansion joints shall be constructed at the mid-point between contraction joints by sawing a 6mm wide gap through the full cross section of the kerb. Kerb cutting shall be carried out with water to minimise dust in the sawing process.

FILLERS AND SEALANTS

An approved joint filler shall then be forced into the sawn joint such that a 12mm deep space remains to the concrete surface. This space shall be completely filled with an approved joint sealant such as Sikaflex construction polyurethane joint sealant or equivalent approved by the MWPA representative and used as per manufacturer's instructions.

Care must be taken to avoid any disturbance of the edges of the joint and any such disturbance must be made good immediately.

14.5 CURING

All exposed faces of the completed kerb shall be kept permanently wet for the curing period of a minimum 72 hours after placing. Concrete maybe cured by spraying with approved curing compounds.

Any water applied shall not cause erosion of the concrete surface.

The concrete shall be protected within 15 minutes after completion of casting the kerb.

The kerb shall be protected from traffic and rain for at least 24 hours following placement.

14.6 PROTECTION

Kerbs shall be protected from bitumen overspray at all times by adequately covering the kerbs with polythene sheeting or similar approved material.

14.7 BACKFILLING

The backfilling to the kerbing shall be placed after the curing of the concrete and acceptance of the kerbing by the Company's Representative.

The backfill material shall be a similar material to the locally occurring topsoil, free from debris and compacted in accordance with MRWA Specification 302 – Earthwork.

15 GUARDRAILING

Guardrailing as shown on the Drawings shall be corrugated W-beam safety barrier and shall comply with MRWA Standard Specification 603 – Safety and Traffic Barrier Systems.

Specification 603 can be downloaded at the Main Roads WA website and shall be used in conjunction with the Drawings.

16 LINE MARKING

Requirements for the supply, installation and maintenance of road pavement markings and raised pavement markers shall comply with MRWA Standard Specification 604 - Pavement Marking.

Specification 604 can be downloaded at the Main Roads WA website and shall be used in conjunction with the Drawings.

AS BUILT/RECORD EXISTING PAVEMENT MARKINGS

Where existing roads or surfaces are being reconstructed, the existing pavement markings shall be photographed and documented accordingly so as to ensure remarking of finished surface are as detailed in records or as shown on the drawings if changes are required.

17 QUALITY ASSURANCE AND TESTING

17.1 GENERAL

The Contractor shall at all times be responsible for achieving the specified standards and demonstrating such achievement through testing and measurement and the provision of documentation which shall cover all work under the Contract, both onsite and offsite, and shall include the activities of all Subcontractors and Suppliers.

17.2 TRACEABILITY

Traceability is required for all materials. The trace shall start at the specified or nominated source point and finish at the location where the material is incorporated into the Works.

17.3 INSPECTION

MWPA's Representative shall at all times be provided access to any facility where work associated with the Contract is being performed, including the facilities of Subcontractors or Suppliers either on-site or off, and any laboratory used for testing.

17.4 TESTING

17.4.1 TESTING PERSONNEL

All quality control testing, unless specified otherwise, shall be carried out by a laboratory holding current National Association of Testing Authorities (NATA) registration for all test methods referred to in the Specifications. NATA registration for all test methods shall be held at the time of tendering and be maintained until completion of the Contract. All test reports shall be NATA endorsed by a current NATA signatory approved for the laboratory conducting the testing.

Surveying processes to verify conformance shall be conducted by personnel with a minimum qualification for acceptance to the Institution of Engineering and Mining Surveyors, Australia, or equivalent.

17.4.2 SAMPLING AND TEST FREQUENCY

Sampling methods shall be unbiased and either random or systematic in concept or as specified. For testing of road pavement particular regard shall be required for compaction around and over structures such as culverts, manholes and gullies. The frequency of tests shall at all times be adequate to demonstrate the work's conformance with the Specification. The minimum frequency of tests are listed below

MINIMUM TESTING FREQUENCY

The minimum frequency of testing to determine the conformance of works processes with specified requirements shall be as shown in Table 8.

Table 8: Minimum Testing Frequency

Process	Quality Verification Requirement	Minimum Testing Frequency
Bulk Earthworks	Compaction Standard Geometrics	1 test per 500m^2 for each 350 mm layer
Subgrade	Compaction Standard Geometrics	1 test per 500 m^2 1 cross section per 20 metres
Basecourse	Material Compaction Standard Geometrics	1 supplier's certificate per contract 1 test per 500 m^2 1 cross section per 20 metres
Bituminous Prime and Seal	Material Bitumen Application Cover Material	1 supplier's certificate 1 spray record per day 1 application record per day
Bituminous Concrete	Material Geometrics Thickness of Layer Compaction	1 supplier's certificate per day 1 cross section per 20 metres 1 check 20 metres Verify specified rolling procedure
Kerbing	Material Geometrics	1 supplier's certificate per delivery Shape and width between kerbs Checked every 20 metres
Block Paving	Material - Blocks - Bedding Sand - Jointing Sand Geometrics	 1 supplier's certificate for contract Verify grading Verify grading Ensure free draining surface and location
Sewers and Stormwater	Materials "As constructed" Survey	1 supplier's certificate per delivery 1 per sewer/drainage line
Trench Backfill (General)	Compaction Standard	1 test full depth per 30m (linear) of trench
Trench Backfill (Over Concrete Encasement)	Compaction Standard	1 test full depth per 10m (linear) of trench with encased sewer

17.5 MEASUREMENT AND TEST EQUIPMENT

Measurement and test equipment shall include all equipment necessary for the proper setting out and for production and conformance testing of the Works. Calibration and certification of test equipment shall comply with NATA stipulations.

17.5.1 NUCLEAR MOISTURE DENSITY METERS

Nuclear Moisture Density Meters (NDM) shall be calibrated in accordance with Main Roads Test Method WA 135.1 on standard blocks for the range of densities specified in the Contract. A current NATA endorsed calibration certificate shall be supplied to the Company's Representative for approval prior to the NDM being used for conformance testing of the Works. The NDM shall have current density calibrations for the 50 mm, 65 mm, 100 mm, 150 mm, 200 mm and 300 mm direct transmission (DT) modes. The NDM shall be compatible with the normal operating procedures and test methods of Main Roads Western Australia.

The direct transmission mode (depth of probe) to be used for each in situ density test undertaken shall be stated in the appropriate quality assurance certificates. The depth of probe shall be the maximum depth of the six calibrations listed above that can be accommodated by the layer to be tested, taking tolerances into account (e.g. 65 mm for a 75 mm base course layer).

17.6 RECORDS AND REPORTING

The Contractor shall provide all "as constructed" and quality verification certificates, including Manufacturer's certificates, to the MWPA's Representative at regular intervals during the Contract Period as agreed with the MWPA's Representative.

Quality verification pro forma shall be in a format acceptable to the Company's Representative. Manufacturer's and supplier's certificates shall enable a clear trace of items from source to the location within the Works. Example proforma are provided in Appendix A.

APPENDIX A

SAMPLE QUALITY VERIFICATION PROFORMA

ITEM A1 - QUALITY ASSURANCE CERTIFICATE: EARTHWORKS

Principal: ______________________ Contract No. : _______________________________

Project: ______________________ Contractor: _______________________________

Section/Lot: ______________________

1. Topsoil Stripping

Clearing Completed ☐

Topsoil Stripped and Stockpiled ☐ Depth ___________ Approx. Volume_____________

Date Topsoil Stockpiling Completed ___________________

2. Earthworks Compaction

Test Method:

Nuclear Density Meter ☐

Test Results

Date Tested ____________

Test No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Result										

Testing Authority ________

Signed ________________

Signed laboratory result sheets to be appended to this certificate.

3. Geometrics

Marked up plan of surveyed levels to be submitted to Superintendent:

Date Surveyed: ____

Surveyor: ____*(Print Name)*

Signed: ____

4. Verification

Section conforms Yes ☐ No ☐

Date Results Submitted to Superintendent ______________ Signed ___________________ *(Contractor)*

ITEM A2 - QUALITY ASSURANCE CERTIFICATE: ROAD CONSTRUCTION

Principal: ______________________________ Contract No:______________________

Project: ______________________________ Contractor:______________________

Process: **SUBGRADE**

Section/Lot: ____

1. Compaction

Test Method: Nuclear Density Meter ☐

Test Locations
(Diagram to be Drawn)

Test Results

Date Tested ____________

Test No.	1	2	3	4	5	6	7	8	9	10
Result										

Testing Authority _________

Signed ________________

Signed laboratory result sheets to be appended to this certificate.

2. Geometrics

Marked up plan of surveyed levels to be submitted to Superintendent:

Date Surveyed:____

Surveyor: ____ *(Print Name)*

Signed: ____

3. Verification

Section conforms Yes ☐ No ☐

Date Results Submitted to Superintendent ______________Signed ____________________ *(Contractor*

ITEM A3 - QUALITY ASSURANCE CERTIFICATE: ROAD CONSTRUCTION

Principal: ________________________________ Contract No:____________________

Project: ________________________________ Contractor:____________________

Process: **BASECOURSE**

Section/Lot:____

1. Compactión

Test Method: Nuclear Density Meter ☐

Test Locations
(Diagram to be Drawn)

Test Results

Date Tested ____________

Test No.	1	2	3	4	5	6	7	8	9	10
Result										

Testing Authority __________

Signed ________________

Signed laboratory result sheets to be appended to this certificate.

2. Geometrics

Marked up plan of surveyed levels to be submitted to Superintendent:

Date Surveyed: ____

Surveyor: ____ *(Print Name)*

Signed: ____

3. Verification

Section conforms Yes ☐ No ☐

Date Results Submitted to Superintendent ______________Signed ______________ *(Contractor)*

ITEM A4 - QUALITY ASSURANCE CERTIFICATE: ROAD CONSTRUCTION

Principal: ______________________________ Contract No: __________

Project: ______________________________ Contractor: __________

Process: **BITUMINOUS SURFACING**

Section/Lot: ______________________________

1. Prime and Seal

Specified Application Rates	**Actual Application Rates**
Binder ____________ l/m^2	Binder ____________ l/m^2
Cover material ____________ m^2/m^3	Cover material ____________ m^2/m^3

Verification

Section conforms Yes ☐ No ☐

Date Results Submitted to Superintendent ____________ Signed ____________ *(Contractor)*

2. Hot-Mixed Asphalt

Supplier's Certificate

Contractor to attach documentation from the Supplier to certify material conforms to Specification.

Verification

Section conforms Yes ☐ No ☐

Date Results Submitted to Superintendent ____________ Signed
(Contractor)