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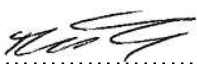
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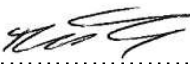
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1. INTRODUCTION

This is a uniform or standard approach in applying the procedures, specifications and guidelines which is needed throughout the life cycle of roads engineering. This manual is supporting the PCM: Perform Roads and Railways Engineering

2. SUPPORTING CLAUSES

2.1 SCOPE

This document covers all procedures, standards and guidelines needed to perform roads engineering.

2.1.1 Purpose

The purpose of the manual is to give guidance to a designer in terms of the specifications and guidelines. This is in terms of the design phase and which specification and/or guideline is to be used for which part of the system or component.

2.1.2 Applicability

This document must be read in conjunction with the EHPUM Process Control Manual for Roads and Railways Engineering and shall apply throughout Eskom Holdings Limited Divisions where road engineering is performed.

2.2 NORMATIVE/INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

- [1] ISO 9001 Quality Management Systems.
- [2] 240-53113685: Design Review Procedure
- [3] 240-53114002: Engineering Change Procedure
- [4] 240-48929482: Tender Evaluation Procedure
- [5] 240-4332798: Engineering Policy

2.2.2 Informative

- [1] Insert informative document references here.
- [2] SANS 1200 – Standards
- [3] SANS 3001: Testing and Sampling
- [4] COLTO : Standard Specification for Road and Bridge work
- [5] UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads
- [6] UTG 2 - Structural Design of Segmental Block Paving
- [7] UTG 3 - Structural Design of Urban Roads
- [8] TMH3 Traffic Axle Load Surveys for Pavement Design
- [9] TMH4 Geometric Design Standards for Rural Two-Lane Two-Way Roads
- [10] TMH8 Traffic counts procedure for Urban Roads
- [11] TMH9 Visual Assessment Manual for Flexible Pavements

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- [12] TMH10 Manual for Completion of Asbuilt Data Sheets
 - [13] TMH12 Visual Assessment Manual for Unsealed Roads
 - [14] Roughness Measurement Guidelines
 - [15] M3-1 Visual Assessment of Concrete Pavements
 - [16] SARTSM Manual
 - [17] TRH1) Prime Coats and Bituminous Curing Membranes
 - [18] TRH3 Design and Construction of Surfacing Seals
 - [19] TRH4 Flexible Pavement Design
 - [20] TRH6 Nomenclature and Methods for describing the Conditions of Asphalt Pavement
 - [21] TRH7 The Use of Bitumen Emulsions in the Construction and Maintenance of Roads
 - [22] TRH8 Design and Use of Hot Mix Asphalts in Pavements
 - [23] TRH9 Construction of Road Embankments
 - [24] TRH10 The Design of Road Embankments
 - [25] TRH11 Guidelines for Conveyance of Abnormal Loads
 - [26] TRH12 Flexible Pavement Rehabilitation Design
 - [27] TRH13 Cementitious Stabilizers in Road Construction
 - [28] TRH14 Guidelines for Road Construction Materials
 - [29] TRH15 Subsurface Drainage for Roads
 - [30] TRH16 Traffic Loading for Pavement and Rehabilitation Design
 - [31] TRH17 Geometric Design of Rural Roads
 - [32] TRH18 Investigation, Design, Construction and Maintenance of Road Cuttings
 - [33] TRH19 Standard Methods and Nomenclature for Describing JCP Pavements
 - [34] TRH20 The Structural Design, Construction and Maintenance of Unpaved Roads
 - [35] TRH21 Hot Mix Recycling
 - [36] TRH22 Pavement Management Systems
 - [37] The South Africa National Road Agency LTD Drainage Manual
 - [38] Standard for Roadworks for Sub-Station and Access Roads (Ref: SCSASABB5 Sept 1998)

2.3 DEFINITIONS

Definition	Description
Angle of Skew	The change of direction to be negotiated by a vehicle turning left off the major road.
Axle load	The maximum gross mass divided by the number of axles of a vehicle.
Bulking factor	The degree that the volume of excavated material in the in situ state increases (or decreases) when measured in the re-compacted state (e.g. in an embankment).
Catchment Area	The area from which rainfall flows into a river, lake, or reservoir, culvert, bridge or area of road.
Critical Length of Grade	The length which causes the speed of the design truck to be reduced by 20km/h
Cut to fill	An expression indicating cutting earth material from an excavation to be used for

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Definition	Description
	filling in an embankment.
Daylighting	The construction practice of creating a sloped cut/fill on the edges of a roads alignment in such a manner that allows for drainage as well as stability of embankments
Design Speed	The maximum safe speed under favourable conditions that can be maintained over a specific section of road and is a function of safety and capacity.
Formation	The earth structure supporting the pavement.
Interchange	An intersection at which conflicts between different traffic movements are resolved by introducing a vertical separation between them
Islands	Road marking measures included in an intersection to separate conflicts, control angle of conflicts, reduce pavement area, regulate traffic, and provide arrangement for turning movement.
K-Value	The length of vertical curve required for a 1percent change in grade
Lane Balance	Ensuring the lanes reflect the various options permitted at an interchange by branching off where vehicles diverge.
Level of Service	The qualitative measure describing operational conditions within a traffic stream, and their perception by motorists and/or passenger
Mass Haul Diagram	A graphic representation over the length of a proposed formation showing the volumes of excavated material in cuttings along a line layout that is to be transported over specified distances to the positions of placement in embankments.
Medians	The total area between the inner edges of the inside traffic lanes of a divided road, and includes the inner shoulders and central island
Minor Cross Drainage Structure	Structure which conveys water through or under the road prism, from one side of the road to the other.
Peak Flow	Maximum flow rate expected from a catchment area used to determine the kind/size of drainage needed.
Passing Sight Distance	The distance required for a driver to overtake a slower vehicle travelling in the same direction before meeting an oncoming vehicle.
Shoulder	The usable area alongside the travelled way, and the width allowed does not make provision for the mounting of guardrails, or for edge drains or shoulder rounding.
Shoulder Sight Distance	The un-obscured distance a vehicle entering the road at an intersection has along the shoulder.
Sight Distance / Decision Sight Distance	The distance needed for the driver to be able to perceive hazards on the road, with sufficient time to had to initiate any necessary evasive action safely
Speed Change Lane	An auxiliary lane, including tapered areas, and is intended for the acceleration and deceleration of vehicles ente4ring or leaving the through-traffic lanes, because undue speed changes on the travelled lanes disrupt the flow of through traffic and are often hazardous
Subsurface Drainage	Drainage with the purpose to remove water which may infiltrate into the road structure
Superelevation	The vertical distance between the heights of inner and outer edges of highway pavement
Superelevation Run-off	The length of road need to accomplish the change in cross-slope from a fully superelevated section to a section with the adverse camber removed.

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Definition	Description
Surface Drainage	Measures taken to control the movement of water over the ground, on and adjacent to the road, so that it is directed to suitable disposal points without any detrimental effects to the road.
Topography	The arrangement of the natural and artificial physical features of an area
Traffic Volume / Traffic Flow	The number of vehicles, cyclists or pedestrians passing a given point during a specified period of time
Vertical Alignment	The combination of parabolic vertical curves and tangent sections of a particular slope.
Vertical Curve Sight Distance	Same as Sight Distance but over a vertical curve (crest)
Weaving	The action of two flows of vehicles crossing one another at a flat angle.

2.3.1 Disclosure Classification

Controlled Disclosure: Controlled Disclosure to external parties (either enforced by law, or discretionary).

2.4 ABBREVIATIONS

Abbreviation	Description
COLTO	Committee of Land Transport Officials
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
SANS	South African National Standards
SARTSM	South African Road and Transport Signs Manual
TMH	Technical Methods for Highways
TRH	Technical Recommendations for Highways
UTG	Urban Transport Guidelines
WULA	Water Use License Application

2.5 ROLES AND RESPONSIBILITIES

2.5.1 The Role of a COE

The role of the Engineering Centres of Excellence is provided below:

- Apply its expertise, skill and processes to produce a high quality output of exceptional standards in line with the organizational requirement.
- Assist in providing project activities and man hours for project preplanning
- Provide engineering resources to perform the engineering effort

2.5.2 The Engineering Design Work Lead

- The EDWL has the following reporting lines:

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- Accountable for the strategy and all design related activities to the Plant Engineering General Manager. The Centre of Excellence Engineering Manager will prepare, review, assess and score the performance contract of the EDWL.
- The EDWL is appointed by the Engineering Work Delivery Unit Manager in conjunction with the relevant Centres of Engineering Excellence (CoE's) and Authorised by the Plant Engineering General Manager (GM).
- Reports to the Project Engineering Practitioner for technical delivery achieved to baseline scope, schedule and cost.

2.5.3 The Project Engineering Manager

The PEM has the following reporting lines:

- Accountable for the schedule, scope and cost of engineering activities. The Project Engineering Area/Portfolio Senior Manager will also prepare, review, assess and score the performance contract of the PEM.
- The PEM is appointed by the Project Engineering Senior Manager and Authorised by the Project Engineering General Manager (GM).
- Reports to the PDD or CMD Manager for engineering delivery achieved to baseline scope, schedule and cost.

2.5.4 The Project Engineering Controls

- The Project Engineering Controls should know the functionality and requirements associated with developing a proper basis of estimate, Cost breakdown structure, level II scheduling, direct and indirect costing, Parametric and factoring approaches. Must be able to produce and communicate the methodology used to arrive at the man hours and costs associated with the estimates. The candidates must have knowledge and hands-on experience with Cost Breakdown Systems (CBS), cost reporting, trend/change management, budget control, forecasting (multiple methods).

2.5.5 The Lead Discipline Engineer

- The LDE has the following reporting lines:
- Accountable for all design related activities to the Centre of Excellence Engineering Manager. The Centre of Excellence Engineering Manager will also prepare, review, assess and score the performance contract of the LDE.
- Reports to the Engineering Design Work Lead (EDWL) for day to day activities, service delivery and logistics. However leave requests will be addressed with the Centre of Excellence Engineering Manager.

2.6 PROCESS FOR MONITORING

Monitoring and Maintenance is to be done by the owner of the road.

2.7 RELATED/SUPPORTING DOCUMENTS

SAICE: Education and Training Department, Practical Geometric Design Course Manual.

3. ROADS DESIGN PROCEDURE

This is to inform the reader which procedures, specifications and/or guidelines to be used to perform Roads Engineering during the various stages of design.

3.1 ROUTE SELECTION

3.1.1 Considerations

A proper route selection is done to obtain the optimum route and the following important parameters must be considered, namely;

Topography (Flat, rolling or mountains)

Hydrology (Flow of water, streams and/or rivers)

Existing facilities / Road Reserve

Geotechnical conditions of the in-situ material.

Preference should be taken over an existing alignment in order to mitigate the environmental impact.

3.1.1.1 Visual Assessment

If rehabilitation is required of an existing road a visual assessment must be done in accordance with TMH12 (2000) Visual Assessment Manual for Unsealed Road or TMH9 (1992) Visual Assessment Manual for Flexible Pavements or TRH6 (1985) Nomenclature and Methods for describing the Conditions of Asphalt Pavement.

It is the Engineers discretion to decide whether further assessments are done on the selected route although it is recommended. All tests should be done in accordance with SANS 3001: Testing and Sampling. It is recommended that a Geotechnical Investigation be done to determine the quality and usability of underlying material in accordance with TRH2 (1978): Geotechnical and Soil Engineering Mapping for Roads and the Storage of Materials Data.

3.1.1.2 Survey

A survey of the area for the proposed access road must be done by a qualified surveyor taking into consideration the fact that the actual road may be situated anywhere within the road servitude. The Surveyor must ensure that there are a sufficient number of benchmarks as well as surveyed points to establish a detailed contoured surface in order to complete design. The survey should also identify position of existing servitudes. This shall include but not be limited to Culverts, Kerbs, Manholes, Railway Servitudes, Telephone Servitudes, Sewer Servitudes, Potable Water Servitudes, Electrical lines, Fences, Gates, Watercourses, existing infrastructure, road reserve boundary, etc. The completed survey drawings should then be handed over to a Professional Civil Engineer for geometric design.

3.2 GEOMETRIC PRELIMINARY STUDIES AND CONSIDERATIONS

3.2.1 Traffic Volume

Traffic Volume patterns and future patterns must be done in accordance with UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads, TMH4 (1978) Geometric Design Standards for Rural Two-Land Two-Way Roads, and TRH17 (1988) Geometric Design of Rural Roads depending of applicability.

Typical road usage patterns including Hourly Traffic Volume Patterns, Daily Traffic Volume Patters, and Seasonal Patterns need to be examined. More finite data should be collected either from existing data or new study including Annual Average Daily Traffic Design Hourly Volume, 30th Highest Hour Volume, Traffic Composition, and Traffic Directional Split. Engineer's discretion should be used as to what information holds relevance and importance.

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3.2.2 Design Speed

Design speed is defined as the maximum safe speed under favourable conditions that can be maintained over a specific section of road and is a function of safety and capacity. Capacity being the volume of vehicles accommodated per hour. Factors influencing design speed include;

Road Classification

Speed Limits

Topography

Economics

Sight Distance, Vertical Curve Sight Distance (sag and crest), Stopping Sight Distance, Passing Sight Distance, Barrier Sight Distance Decision Sight Distance and Shoulder Sight Distance are outlined in UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads as well as TRH17 - Geometric Design of Rural Roads. Friction Factor Values and Brake Force Coefficients are incorporated into some of these sight distances.

3.2.3 Level of Service

Level of service can be describes as a qualitative measure of a motorists perception of the operational conditions within a traffic stream. Broken down the levels of service range from A to F described in TRH4 (1996): Structural design of Flexible Pavements for Interurban and Rural Roads. Further reference is also made in UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads, TMH4 (1978) Geometric Design Standards for Rural Two-Lane Two-Way Roads, and TRH17 (1988) Geometric Design of Rural Roads.

3.2.4 Design Vehicle

The design vehicle has more of a role in pavement design but is used in geometric design in the layout of intersections and curve radius. See UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads.

3.3 HORIZONTAL ALIGNMENT

3.3.1 Horizontal and Vertical Co-ordination Considerations

Keeping a generous flowing alignment keeping in one plane as much as possible

Vertical and Horizontal curves should coincide both in term of position and length

Vertical curve lengths should be less than that of horizontal curve lengths if possible

Compound curves of long followed by short curves should be avoided

Loss of sight of road due to a series of vertical curves should be avoided

Horizontal curves should not begin just after a crest

A sag on a long straight appears to be a break in profile to the driver

3.3.2 Curve Radius

Curve radius are given by UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads, TMH4 (1978) Geometric Design Standards for Rural Two-Lane Two-Way Roads, and TRH17 (1988) Geometric Design of Rural Roads. Tables are given for the respective speeds as well as including superelevation.

3.3.3 Curve Length

Minimum and maximum curve lengths are found in UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads, TMH4 (1978) Geometric Design Standards for Rural Two-Lane Two-Way Roads, and TRH17 (1988) Geometric Design of Rural Roads.

3.3.4 Superelevation

Superelevation, Rates of Superelevation, Superelevation Run-off, and Superelevation in Transition Curves are calculated using the guidance of UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads, TMH4 (1978) Geometric Design Standards for Rural Two-Lane Two-Way Roads, and TRH17 (1988) Geometric Design of Rural Roads.

3.4 VERTICAL ALIGNMENT

3.4.1 General

Earthworks should be kept to a minimum with a balance between cut and fill if possible

Co-ordination with horizontal alignment as mentioned in 3.3.1

All sight distances and grade requirements to be met

Consideration on existing controls for vertical alignment such as railway crossings, existing roads, intersections, properties and existing infrastructure

Consideration into drainage requirements.

3.4.2 Curvature

Minimum rates of curvature are given in UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads, TMH4 (1978) Geometric Design Standards for Rural Two-Lane Two-Way Roads, and TRH17 (1988) Geometric Design of Rural Roads for the respective relevant roads. Rates of curvature are based upon sight distances but consideration must also be given to comfort and aesthetics. Note that there is no upper limit on the length of a vertical curve, unlike horizontal curves. Vertical curvature is calculated through a parabolic function in order to determine all the control levels along the curve. It is best to not exceed a level cut or fill of 2 metres. Entrance and exit levels of curves to straights should also be checked. It is preferable to determine vertical alignments of curves with the assistance of computer programs.

3.4.3 Gradients

Maximum gradients along with the critical length of the gradients are also specified in UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads, TMH4 (1978) Geometric Design Standards for Rural Two-Land Two-Way Roads, and TRH17 (1988) Geometric Design of Rural Roads which are dependent on the relevant topography. Gradients are designed in order to not significantly affect the speed of heavy vehicles in order to not create unfavourable conditions for all motorists.

3.4.4 Climbing Lanes

Climbing lanes must be introduced into design if it is deemed necessary to maintain level of service over a particular section. Traffic warrant for climbing lanes are specified in UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads, TMH4 (1978) Geometric Design Standards for Rural Two-Land Two-Way Roads, and TRH17 (1988) Geometric Design of Rural Roads. The relevant information including lane width, taper, length and gradient are also given in the abovementioned specifications.

3.4.5 Shoulders, Guardrails, Medians and Verges

Shoulders, Guardrails, Medians and Verges are specified within UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads, TMH4 (1978) Geometric Design Standards for Rural Two-Land Two-Way Roads, and TRH17 (1988) Geometric Design of Rural Roads giving recommendations and respective widths. Conditions requiring Shoulders, Medians and Verges are listed.

3.5 ACCESS DESIGN

3.5.1 General

Safety considerations are the main restraint on intersection location. The location must be in a position such that the decision sight distance and shoulder sight distance described in TRH17 (1988) Geometric Design of Rural Roads is on the major and minor roads respectively.

Intersections upon heavy earthworks are not advised, especially high fill.

Intersections on a superelevation of greater than 6% are also discouraged.

Intersections on a grade steeper than 3% are not advisable.

Private accesses may prove to be an exception to the above guidelines.

It is suggested that a minimum of 500m between intersections be applied where possible.

The recommended angle of skew is 15 degrees.

3.5.2 Bell Mouth Radii

Most intersections can be accommodated by a 15m radii unchannelised bell mouth. Private property radii can be 10m and unsurfaced private access at 7m.

3.5.3 Surfacing and Delineation

All intersections other than private intersections should be paved unless the major road itself is unpaved. Semi-mountable curbs are also recommended on intersections to reduce wearing on shoulders, a common problem.

3.5.4 Speed Change Lanes / Deceleration Lanes / Acceleration Lanes

Deceleration lanes and acceleration lanes are recommended on high speed roads. Length and curve radii of these lanes are given in UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads, TMH4 (1978) Geometric Design Standards for Rural Two-Land Two-Way Roads, and TRH17 (1988) Geometric Design of Rural Roads

3.5.5 Right Turn Lanes

Right turn lanes must consider the level of service required and if need be an additional lane be added, a right turn lane. This is dependent on the traffic volumes and traffic speed. It is recommended that the storage of vehicles in the turning lane be at least two. The use of a painted island is encouraged where necessary. TRH17 (1988) Geometric Design of Rural Roads provides specifications into Right Turn Lanes.

3.5.6 Channelized Intersections

Refer to UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads and TRH17 (1988) Geometric Design of Rural Roads for specifications on channelized intersections.

3.5.7 Islands

Refer to UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads, TMH4 (1978) Geometric Design Standards for Rural Two-Lane Two-Way Roads, and TRH17 (1988) Geometric Design of Rural Roads for design and conditions for Islands.

3.5.8 Median Openings

Median Openings are covered in UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads TRH17 (1988) Geometric Design of Rural Roads with the general rule of them not being shorter than 12.4m or the surface width of road plus shoulders.

3.5.9 Interchanges

Interchanges are covered in UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads, TMH4 (1978) Geometric Design Standards for Rural Two-Lane Two-Way Roads, and TRH17 (1988) Geometric Design of Rural Roads. Interchanges often require specialised design with the aid of computer programs.

3.5.10 Ramp Terminal

Ramp terminals can be classified into free flowing or stop condition. Free flowing terminals are recommended. The ramp types and specifications are listed in UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads and TRH17 (1988) Geometric Design of Rural Roads.

3.5.11 Interchanges

There are fundamentally two different types of interchanges. Major interchanges are from freeway to freeway whilst minor/service interchanges are from local areas providing access to freeways. Both are covered in UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads and TRH17 (1988) Geometric Design of Rural Roads.

3.5.12 Lane Balance and Weaving

Lane Balance requires the proper continuity of lanes as well as branching off of lanes with the appropriate signalling. Weaving requires the crossing of vehicles in a marked section, specifically at intersections. Both practices are specified in UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads and TRH17 (1988) Geometric Design of Rural Roads.

3.5.13 Pedestrians and Pedal Cyclists

Provisions for pedestrians and Pedal Cyclists and an access is covered in UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads and TRH17 (1988) Geometric Design of Rural Roads it terms of footways, bridges, bus stops, refuse island, footbridges, subways, cycle lanes, lighting and speed zones.

3.6 EARTHWORKS DESIGN

Earthwork Design is separate from pavement design as it deals with the insitu material or selected material to be shaped in order to place the pavement to the correct levels and gradients. It is ideal for the material used in cutting to be placed in the form of embankments.

3.6.1 Mass Haul Diagram

A mass haul diagram is a useful tool to represent the economical and material balance of the project. It gives a good idea into the magnitude of the project. The mass haul diagram is drawn from the adjusted cut and fills volumes. Factors such as the 'bulking factor' are used depending on the material. This

factor can range from 0.7 to 1.2 depending on the material density. Mass Haul Diagrams are a recommended tool for design.

3.6.2 Daylighting

Often when an area is in cut there will be some daylighting required. Particulars to this information are given in UTG 1 - Guidelines for the Geometric Design of Urban Arterial Roads and TRH17 (1988) Geometric Design of Rural Roads

3.6.3 Embankments

Design of embankments are covered in TRH10 (1994) The Design of Road Embankments yet the quality of material and its suitability in construction needs to be determined through a Geotechnical investigation. The width of the embankment is a function of the width of the road and its services. The slopes of the embankment depend on the material, most notably whether it is in hard rock or soft material.

3.7 DRAINAGE

Adequate drainage is of fundamental importance to road design both in terms of safety and the longevity of the road.

3.7.1 Design Criteria

Surface drainage takes place in two ways, displacing the rain that falls onto the road surface itself and displacing the water that flows to the road by means of a watercourse through a catchment area. The first is solved by the use of cross-slope into a drainage system. The second requires the involved process of developing the drainage the drainage system for the specific catchment area.

3.7.2 Peak Flows

Peak flows are generally calculated using the 'Rational Formula' although other methods are available. The flows are measured in terms of the probability of a flood reoccurring in a time period. For example the probability of a flow in 1:2yrs, 1:5yrs, 1:10yrs, 1:50yrs, 1:100yrs, etc. Standards will refer to these peak flows for design specifications.

Finding the catchment area is done using a topographical map, defining the watercourses and contours to determine the catchment area. Areas can range from less than a hectare in the case of a culvert to thousands of hectares for the case of a Bridge Catchment. This can be checked using areas generated by computer programs. During this process the longest watercourse is identified as well as the average catchment slope. The mean annual rainfall and runoff coefficient are also required.

The South Africa National Road Agency LTD Drainage Manual clearly identifies the procedure for calculating peak flow with the relevant information. To briefly outline the steps are as follows:

Calculate the time of Concentration (T_c)

Calculate the rainfall intensity (I)

Find the runoff coefficient (C) using the topography of the land

Adjust the runoff coefficient

Use the rational formula to determine the Peak Flow

Use the rational formula to determine the require follows return period i.e.) 1:2yrs, 1:5yrs, 1:10yrs etc.

This process was also followed for the Upgrading of Bridge structures on WP8.

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3.7.3 Culvert Design

Culvert design uses the Peak Flows to determine the shape and size of culvert, having already decided on the positioning of the culverts. The location of culverts should be established using the guidelines of lowpoints and natural channels for positioning taking into consideration erosion or siltation. For lesser culverts they should preferably be not more than 100m apart. The South Africa National Road Agency LTD Drainage Manual outlines the procedure of culvert selection but the following steps are outlined following the calculation of peak flow for the culverts catchment.

Check sizing of the culvert according the principle of dividing peak flow by three (generally accepted practice)

Check whether a box culvert or pipe culvert is preferable using a HW/D nomograph.

Calculated HW from HW/D for Inlet Control

Calculate d_c (critical depth) from chart and check the outlet control.

Calculate h_o

Calculate H from nomograph, adjust according to Manning value

Calculate HW for Outlet Control

Compare HW for inlet and outlet control using the larger value as the critical value.

Check sufficient cover for headwater depth

3.7.4 Subsurface Drainage

If overland drainage is not sufficient or the Engineer expects there to be subsurface water then subsurface drainage may be required. This can be done in conjunction with overland drainage. Subsurface drainage is covered in The South Africa National Road Agency LTD Drainage Manual and TRH15 (1994) Subsurface Drainage for Roads

3.8 PAVEMENT DESIGN

Pavement design requires specialist studies and expertise in order to establish the current condition of the road, the future requirements and the materials needed to satisfy those requirements. This is done taking into consideration the material available within the site or region and construction limitations (budget, time, resources etc.). Use Standards TMH3 (1988) Traffic Axle Load Surveys for Pavement Design, TMH8 (1987) Traffic counts procedure for Urban Roads, TMH9 (1992) Visual Assessment Manual for Flexible Pavements, TMH12 (2000) Visual Assessment Manual for Unsealed Roads, Roughness Measurement Guidelines, M3-1 Visual Assessment of Concrete Pavements in the relevant area for investigation on condition of the road.

The design procedure is covered in TRH4 (1996) Flexible Pavement Design but a simplified version is provided below;

Select the appropriate road category

Select the Structural design period

Select the Design Traffic (based on 80kN axles/lane with a given ES value)

Locate the Available Material

Identify the Climatic Region

Select the Pavement Type (Granular or Cemented)

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Develop Cross-Sections based on all previously mentioned factors and Pavement Class and Design Bearing Capacity

Select the required compaction to each layer

Check economic feasibility

Typically within Pavement design one will also need to establish the shoulder, the drainage in terms of culverts, V-drains, Daylighting, slopes, and cut/fill, and links to the existing ground level either in terms of minimum slopes, lengths or offsets. These designs are covered in sections 3.5 and 3.6.

Specifications that are used in the pavement design and to check the suitability of material include UTG 2 - Structural Design of Segmental Block Paving, UTG 3 - Structural Design of Urban Roads, TRH16 (1991) Traffic Loading for Pavement and Rehabilitation Design, TRH12 (1997) Flexible Pavement Rehabilitation Design TRH13 (1986) Cementitious Stabilizers in Road Construction, and TRH14 (1985) Guidelines for Road Construction Materials.

3.9 ASPHALT, SUFACE SEALS AND BITUMEN

Asphalt, surface seals and bitumen selection and design are covered in TRH7 (1994) The Use of Bitumen Emulsions in the Construction and Maintenance of Roads and TRH8 (1987) Design and Use of Hot Mix Asphalts in Pavements and TRH3 Design and Construction of Surfacing Seals.

3.10 ENVIROMENTAL CONSIDERATIONS

Within every design there are environmental considerations and applications that need to be research, evaluated and approved. This can be quite and extensive process from a full EIA or a Basic Assessment and is all dependent on the works involved in the project.

3.11 APPLICATION FOR WULA AND EIA

The application for the WULA and compilation of the EIA/EMP needs to be completed and is often done with the assistance of specialists, either internal or external who will compile the relevant information to formulate there applications and documentation. Specialist reports may also be required depending on the activity. In due process the relevant documentation this will be submitted to the department of Water Affairs and the Department of Public Works, Roads and Transport. Aspects covered with discussions with DEA could include included amendments to current EMP, Conditions of license, new activities, ecological report upgrade, sensitivity report, Public Employment Service, Environmental Impact Statement, and further studies (Storm water, Rehabilitation Plan, Infrastructure Master Plan)

3.11.1 Basic Assessment

Basic Assessment includes providing the relevant information, drawings, photographs, floodline calculations, and previous studies.

3.11.2 Public Participation Process

Public Participation requires meetings with the relevant parties to answer questions about the design and process. Here, explanations into the environmental impacts are given and concerns registered with the team to draft into the EIA report. The designs and drawings are presented and subsequently explained with comment received by relevant stakeholders.

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4. AUTHORISATION

This document has been seen and accepted by:

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5. REVISIONS

Date	Rev.	Compiler	Remarks
September 2014	0.1	R.M.K Thijs	To support the PCM: Perform Roads and Railways Engineering Document
September 2014	0.2	R.M.K Thijs	Draft Document for Comments Review
October 2014	1	R.M.K Thijs	Final Document for Authorisation and Publication
February 2020	1.1	R.M.K Thijs	Updated Review dates and signatories
April 2020	1.2	R.M.K Thijs	Final Draft after Review Process
April 2020	1.3	R.M.K Thijs	Draft for additional Review Process
May 2020	1.4	R.M.K Thijs	Final Draft after Review Process
May 2020	2	R.M.K Thijs	Final Rev 2 Document for Authorisation and Publication

6. DEVELOPMENT TEAM

The following people were involved in the development of this document:

- Rene Thijs
- Riaan Venter
- Philip Van Heerden
- Michael Were

7. ACKNOWLEDGEMENTS

None

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