
Calculux Road



Version 6.6



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Appendix

A1 Road Reflection Tables

Contains the Road Reflection Tables that are used by Calculux to calculate the Road Luminance.

A2 Requirements Profiles

Contains some examples of the standard requirements profiles that are supplied with Calculux Road.

A3 Index


Chapter 1

Introduction



1 Introduction

This chapter describes the main features of Calculux and explains what you can expect from the package.

-  Some of the Calculux features described in this manual partly only apply for Calculux Area or Calculux Road. If so, this is mentioned.

Calculux is a software tool which can help lighting designers select and evaluate lighting systems. Speed, ease of use and versatility are features of the package from Philips Lighting, the world's leading supplier of lighting systems.

1.1 Philips - your partner in lighting

Philips Lighting, established over a century ago, has vast experience in helping customers to select the optimum solutions for their lighting applications, in terms of quality, performance and economy.

Our customer partnership philosophy means that we can support you from the planning, design and commissioning of projects, right through to realisation and aftersales support. This philosophy maximises cost-efficiency by ensuring the ability to choose the most suitable equipment for your application.

Philips Lighting Design and Application Centres situated throughout the world offer extensive consultancy, training and demonstration services. Our lighting specialists can recommend existing solutions or develop new tailor made solutions for your application. Because Philips Lighting is the leading supplier, you're assured of getting the best support available.

Calculux is part of that support. For consultants, wholesalers and installers wishing to develop lighting designs, it's the ideal tool; saving time and effort, providing the most advanced lighting solutions available and guaranteeing satisfied customers.

1.2 What Calculux does

Calculux is a very flexible system which offers lighting designers a wide range of options:

- You can use the package to simulate real lighting situations and analyse different lighting installations until you find the solutions which suits your technical as well as your financial and aesthetic requirements best.
- Calculux uses luminaires from an extensive Philips database and photometric data which is stored in the Philips Phillum external formats. Additionally other luminaire data formats can be imported (CIBSE/TM14, IES, EULUMDAT and LTLI).
- Simple menus, logical dialogue boxes and a step by step approach help you to find the most efficient and cost-effective solutions for your lighting applications.

1.3 What you can do with Calculux Road

- Specify and calculate Standard Road Lighting Schemes for which predefined calculations are set in a Profile. Profiles are lighting class and national recommendations dependent;
- Specify, within the Profile, the lighting requirements and save them to a file for use in future road projects;
- In the Profile, set the calculation Grid Method (which rules how the calculation points are put onto the road and the surroundings), based on Luminance or Illuminance calculations (according to CEN 13201).;
- Specify road Schemes, optimizing individual or multiple Schemes based on the installation parameters, to give the best installation specifications within the Profile requirements;
- Calculate a wide range of quality figures covering almost all existing national and international recommendations;
- Select luminaires from an extensive Philips database or from specially formatted files for luminaires from other suppliers;
- Perform lighting calculations on areas not directly related to the main road (e.g. on a footpath or the front of a house);
- Specify, separately from the main Scheme, additional rows of luminaires parallel to the main road;
- Specify maintenance factors;
- Compile reports displaying results in text and graphical formats. Display a summary of the Schemes, a detailed summary, the chosen calculation presentation formats of one specified Scheme and/or the results of the different Schemes;
- Predict financial implications including energy, investment, lamp and maintenance costs for different luminaire arrangements;
- Support multiple languages.

The logical steps used for project specification save you time and effort. The report facility gives you the opportunity to keep permanent records of the results.

1.4 Profile - Define which calculations to carry out together with the accompanying requirement criteria

Profile enables all the lighting quality figures, according to national or international recommendations, commonly used in roadlighting to be specified and calculated, with the option to save the profile requirements for re-use. The required lighting parameters and related calculation areas can be predefined in a requirement profile. In this profile it's also possible to define the limits for the quality figures. (A limit is expressed in terms of an operator and a limit value, as in: $TI < 15$.) The limits can be displayed in the Schemes Editor to see if the calculations fulfil the requirements. They must be used if optimization is selected.

A Profile consists of:

- Options;
- Requirements.

To set up Profile Options you select:

- The side of the road the users drive on (not needed for dual carriageways);
- The range of the limiting criteria (none, single or dual level). Optimization can only be carried out when a single or dual level requirements usage has been selected, with dual giving the choice of two levels of limiting criteria from which to select.


To set up Profile Requirements you select:

- The calculations required to be carried out together with any limits to set for the requirements levels;
- The Grid Method (which rules how the calculation points are put onto the road and the surroundings). The CEN-13201 Luminance and Illuminance grid are supported.

Calculux Road enables you to create any number of different requirement files and save them to disk for use in future road projects.

This facility allows for easy design of different road classes and has great benefits to the designer; e.g. in a case where you have been working on a motorway project. You've set the profile requirements (for a motorway) and saved them to a disk. At a later stage, when you will be working on a similar project, you'll be able to use the profile requirements set in one of the previous sessions. You'll only have to open the profile requirement file you saved in the previous project and all profile requirements are set up again.

Some of the profile requirements are subject to recommendation by the European Standard Norm CEN13201. This norm recognizes several different road lighting situations and has assigned a corresponding lighting class to each of them. In turn, each lighting class corresponds with a set of recommended requirements.

 See Appendix 2 (Requirements Profiles) for some examples.

Calculux supports the obtaining and filling in of these requirements in three different ways:

- If you know the relevant profile parameters and their values, you can fill them in yourself.
- If you know the appropriate lighting class, you can import the corresponding file with recommended requirements for that class. (The same holds for any custom file with requirements you saved in a previous project.)
- If you don't have this knowledge beforehand, you can determine the lighting class and its recommended requirements with the help of the Road Wizard program.



For more information, see the Help with Calculux Road.

1.5 Tailor make your road design

Calculux Road is designed for single and dual carriageways.

The carriageways are already predefined by the program in its set-up parameters. For instance, when a dual carriageway is selected, the out-lines of the carriageway are automatically generated together with the calculations and calculation method as set in the Profile.

1.6 Schemes Editor - Calculate, compare and optimize different Schemes

The Schemes Editor is the heart of Calculux Road and almost all general street lighting designs can be performed by it. You're able to calculate and compare different lighting designs (Schemes) at the same time.

The road is defined by setting the following parameters:

- Type of road (single or dual carriageway);
- Central reserve;
- Road width;
- Number of lanes;
- Road reflection table;
- Q0 of road reflection table.

Calculux Road supports the following standard installations for the luminaires allocation:

- Single sided left;
- Single sided right;
- Opposite;
- Staggered;
- Twin central;
- Twin central and opposite;
- Catenary.

The following installation parameters are used for the luminaires allocation, they are set in the Schemes Editor:


- Spacing;
- Height;
- Overhang;
- Tilt90;
- Luminaire Type.

1.7 Optimization

Optimization of your lighting installation is a major feature of Calculux Road. It enables the user to determine the best set of installation parameters while keeping within the limits of the quality figures. Calculux Road can carry out optimization on individual or multiple Schemes after:

- The road definition values (for one or more Schemes);
and
- The installation parameters;
and
- The design parameters have been entered into the Scheme Editor;
and
- The design parameters have been set up and enabled for optimization.

Having set the installation type, there are five installation parameters to set, listed in the previous paragraph in order of economical importance to the designer. To minimise costs a designer will want to have maximum Spacing, minimum Height, minimum Overhang, minimum Tilt90 and the most economical Luminaire Type. If the Spacing is fixed, the Height will become the primary concern and so on down the list.

-  Calculux cannot by itself determine how economical a Luminaire Type is, nor rank the selected Luminaire Types in any preference order. Instead, Calculux 'blindly assumes' that the Luminaire Types in your project are listed in descending preference order: the most economical on top, and so on down the list. During optimization, it will select the first (top-down encountered) Luminaire Type, that corresponds with the optimal set of values for the other installation parameters involved. So, to help Calculux select the optimal Luminaire Type, you yourself must beforehand place them in the right order. (You can do this in the dialog window Data > Project Luminaires...)

If you selected more than one Scheme, you can request Calculux Road to operate on the Schemes either:

- Individually, in which case the lighting design parameters per Scheme will be calculated irrespective of all other Schemes.
or
- Overall, in which case the lighting design parameters per Scheme will be the same as in all other Schemes (over the iteration parameters), but the requirements levels can be different per Scheme.

This is very useful for calculating:

- An installation which, e.g. meets wet and dry road surface requirements levels;
or
- A different requirement level value for before and after midnight.

1.8 Choose from a wide range of luminaires

Calculux is supplied with an extensive Philips database which includes the most advanced luminaires. For each luminaire you can view luminaire data, including the type of distributor, lamp type, output flux efficiency factors and power consumption. The light distribution can be shown in a Polar, Cartesian or Isocandela diagram, together with the luminaire quality figures.

Apart from the Philips database, the following other well known luminaire data formats from other suppliers can be used in Calculux:

- CIBSE/TM14;
- EULUMDAT;
- IES;
- LTLI.

The Photometric database is updated regularly (see www.lightingsoftware.philips.com).

1.9 Easy positioning of additional rows of luminaires parallel to the main installation

To increase the number of installation types available to the designer, Calculux allows the placing of additional rows of luminaires parallel to the main road. This feature is especially useful when there's a side road that runs close by and parallel to the main road. The effect the side road luminaires have on the main road can be taken in consideration.

1.10 Calculation Grids

A calculation grid can be in any situation and orientation (horizontal, vertical or sloping) the only restriction being that it has to be rectangular.

Preset Grids

In case an application field is used you don't have to define a calculation grid. Frequently used grids corresponding to the built in application fields can be automatically generated by setting a calculation grid default for each application field. Changing the position or the dimension of the application area will automatically update the calculation grid.

Automatically generated grids (Calculux Road only)

Calculation grids for the main road and kerb area are automatically generated by the schemes editor according to the road requirements and road definition given in the profile. For automatically generation of grids, Calculux supports the following grid methods:

- CEN Luminance;
- CEN Illuminance.

Calculux enables you also to define your own grids, or to change the specifications of existing grids.

1.11 Calculation possibilities

In Calculux Road calculations can be defined within a profile (used by the schemes editor) or selected by the user.

In the schemes editor, the following calculations (when selected) can automatically be performed on the main road and kerbs:

On the main road;

- Road Luminance, including the glare quality figures Threshold Increment and Glare Control Mark;
- Horizontal Illuminance;
- Vertical Illuminance;
- Semicylindrical Illuminance;
- Semispherical Illuminance.

On the kerbs:

- Average halfspherical illuminance;
- Minimum/average halfspherical illuminance;
- Surround ratios.

User defined calculations

The following calculations can be selected:

- Road Luminance, including the glare quality figures Threshold Increment and Glare Control Mark;
- Horizontal Illuminance;
- Vertical Illuminance in the four main directions,
- Illuminance in the direction of the observer;
- Semicylindrical Illuminance;
- Semispherical Illuminance;
- Veiling luminance.
- Uniformity on vertical planes.;
- Gradient calculations..

1.12 Save money by optimizing cost-effectiveness

Cost is a major consideration when specifying a lighting installation. Calculux provides a breakdown of the costs you can expect to incur with a particular installation, both in terms of initial investment and annual running costs. Thus it's possible to support you in the decision making process by comparing the cost-effectiveness of different lighting arrangements.

1.13 See your lighting design develop on screen

A special view menu is provided to enable you to monitor the development of your project on screen. A 3-D as well as a number of 2-D project overviews can be displayed on screen.

The view facility can also be used to study the calculated results in text and graphic format. Tables listing the calculated values are displayed. The view facility can also provide isotropic contours, mountain plots and graphic tables of the results.

1.14 Impress your customers with attractive reports

When you've finished a project you're able to generate attractive reports giving the results of the calculations. All you have to do is use the menu to select the elements which you wish to include in your report and they will be added automatically.

For example, you can incorporate:

- A table of contents;
- 2-D and 3-D project overviews;
- Summary;
- Luminaire information (including Polar or Cartesian diagram);
- Detailed information about the calculation results (in textual table, graphical presentation and/or Iso contour);
- Financial data.

It's also possible to add supplementary text. A convenient feature if you wish to comment on or draw conclusions from the results presented in the report.

1.15 Installation and operating platform

The Calculux application is supplied with the installation program and database.

The following target operating platform is recommended:

- CPU: Pentium 1G;
- RAM: 512 Mb;
- Hard disk: 100 Mb free disk space;
- Operating system: Windows 2000, Windows XP or later;
- Other: SVGA monitor (minimum 1024 x 768), mouse, Windows supported graphics printer or plotter.




Chapter 2

Getting Started



2 Getting Started

This chapter tells you how to install Calculux on your personal computer, what the resulting file structure looks like and how to set the environment directories and database settings.

-  For this and more information on the installation, refer to the Readme.doc file, which is stored in the Calculux directory.

2.1 Download program and database


To download the program and database:

- Go to www.lightingsoftware.philips.com.
- Under 'Choose your country', click the appropriate link. If your country is not in the list, click the **Others** link.
- Depending on the chosen country, a message may appear to redirect you to the Global Lighting Site. If so, click **OK**.
(You are redirected to the Tools & Downloads page.)
- Click the appropriate download link(s) to download the CalcuLux program.
- Save the CalcuLux program (zipfile) to Disk.
- Click the **CalcuLux Database** link to download the database.
- Save the CalcuLux Database (zipfile) to Disk.

2.2 Install the program

To install the program:

- To install Calculux correctly, please stop all other applications before starting the installation.
- Unzip the .zipfile while leaving the map structure intact.
- Double-click on **Setup.exe** to run it.
- Follow the instructions on screen and make the appropriate decisions:
 - The installation Wizard will suggest 'C:\Program Files\Calculux' as installation directory. In case you already have an older version of Calculux installed in this directory you want to maintain, select another directory for this newer version. (Old files may be overwritten during installation and downward compatibility is not guaranteed.)
 - Together with the program itself, some example project files, phillum files, R-table files and vignette files are included in the installation. All these files are the same for both Calculux Area and Calculux Road. In case you have one of these programs already installed and want to install the other one in the same directory (for instance 'C:\Program Files\Calculux'), the installation Wizard will detect that project files, phillum files, R-table files and vignette files of the same name are already present and ask if you want them to be overwritten. So, in case you have made any changes to these example files you want to maintain, answer this question with 'No'.

-  Project files (*.CAR/*.CRO) are upwards compatible. They can be used in the new releases. However, after saving, they cannot be used anymore in previous releases.

To uninstall the package:

- From the Windows Start menu, select Settings > Control Panel.
- Double click the Add/Remove Programs icon.
- Select **Calculux Area/Road**, click on the **Add/Remove** button and follow the instructions.

2.3 Install the database

To install the database:

- To install the Calculux database correctly, please stop all other applications before starting the installation.
- Unzip the .zipfile while leaving the map structure intact.
- Run **Setup.exe** and follow the instructions on screen.

2.4 Install other report languages

Calculux supports run-time selection of the report language.

To do so, each language requires an additional language file to be installed in the application folder of Calculux. All available report languages are installed automatically during installation. When additional languages must be installed, the required file (named CAR_*.RPT or CRO_*.RPT) must be copied into this folder (e.g. C:\Program Files\Calculux\Area or Road).

2.5 File Structure

During the installation procedure a number of directories will be created. The default directory structure, which should be created during the installation of the program and the database, is described below.

```
C: \PROGRAM FILES\CALCULUX
  \AREA (Calculux Area only)
  \ROAD (Calculux Road only)
  \ROADWIZARD
  \DB
  \IRRGRID
  \PHILLUM
  \PROJECT
  \VIGNETTE
  \RTABLE
  \REQUIRMT (Calculux Road only)
```

- In the AREA and ROAD directories, the program and its necessary files are stored.
- In the DB directory, the database is installed.
- In the PHILLUM directory, the individual photometric data files, not available in the database, (i.e. Phillum) are stored. The program is supplied with some example Phillum files.
- In the PROJECT directory, the projects can be stored. The program is supplied with some example project files.
- In the VIGNETTE directory, the files (Vignette files) containing the company names and addresses are stored. The program is supplied with some test vignettes.
- In the RTABLE directory the Road reflection tables are stored. The program is supplied with some Road reflection tables.
- In the REQUIRMT directory (only relevant for Calculux Road) all Profile Requirement files for the CEN-13201 classes are stored. These classes are used by the RoadWizard.

For more detailed information relating to each of the above directories, use the Readme icon.

2.6 Environment settings and preferences

When the program and database are installed successfully, you can start the application and use the Environment Options in the Option menu to set the environment directories and database settings.

The environment directories and database settings can be checked at any time.

You are now ready to start developing your first lighting project.

Chapter 3

Background Information



3 Background Information

This chapter describes in detail the background principles used in Calculux.

3.1 Project Info and Vignette file

3.1.1 Project Info

When you start a new project in Calculux, it can be beneficial to enter summary information. This can include remarks and statistics about the project, e.g. name, date and designer, as well as customer details.

3.1.2 Vignette file

Calculux enables you to include details about yourself and your company in your reports. The information will be printed on the cover page of the reports and can be used for reference at any time.

This provides the customer with contact details, should they need to consult you over the contents of the report.

If you create what is called a Vignette file you can save the information to a disk.


This eliminates the need to enter the same company information every time you open a new project. You can simply select the Vignette file to be included in your next project.

3.2 Road Definition

In Calculux Road, a road (generated by the Schemes Editor) contains one or two carriageways. A carriageway can:

- Contain up to six lanes.
- Have traffic flow in both directions:
 - Two directional traffic for a single carriageway.
 - One directional traffic for a dual carriageway.

If there are two carriageways (one for each direction of traffic), then they are separated by a central reserve.

 The central reserve can have a zero dimension.

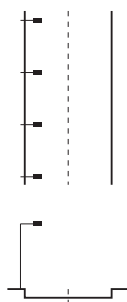
3.3 Lighting Installations

The Schemes Editor of Calculux Road allows the following Road lighting installations to be used:

- Single-Sided (left or right);
- Staggered;
- Opposite;
- Catenary;
- Twin central;
- Twin central and Opposite.

3.3.1 Single-Sided (left or right) Installation

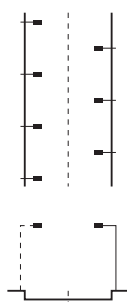
In this type of installation all the luminaires are located on one side of the road. It is used mainly when the width of the road is equal to or less than the mounting height of the luminaires. The luminance of the road surface on the luminaire side is inevitably higher than on the opposite side. This type of installation is normally used for a two-way traffic road consisting of one carriageway.



3.3.2 Staggered Installation

In a staggered installation the luminaires are located on either side of the road. It is used mainly when the width of the road is between 1 and 1.5 times the mounting height of the luminaires. Careful attention should be paid to the uniformity of the luminance on the road surface - alternate bright and dark patches can produce an unpleasant zigzag effect.

This type of installation is normally used for a two-way traffic road consisting of one carriageway.

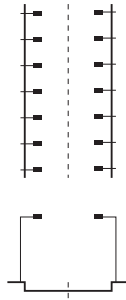


3.3.3 Opposite Installation

In this type of installation the luminaires located opposite to one another.

It is used mainly when the width of the road is greater than 1.5 times the mounting height of the luminaires.

An opposite installation is normally used for a two-way traffic road consisting of one carriageway.



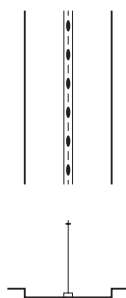
3.3.4 Catenary Installation

In this type of installation the luminaires, normally spaced 10 to 20 m apart, are suspended axially from longitudinal cables over the central reserve. The supporting columns are widely spaced (roughly 60 to 90 m).

The catenary system offers:

- Excellent visual guidance;
- Excellent uniformity;
- Less glare than with other systems (because the luminaires are viewed axially);
- Greater visibility, which is particularly noticeable in bad weather.

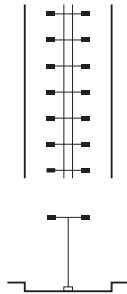
This type of installation is normally used for roads with dual-carriageways.



3.3.5 Twin central Installation

In a Twin Central Installation the luminaires are located above the central reservation only. Therefore, this type of installation can be considered as a single-sided installation for each individual carriageway.

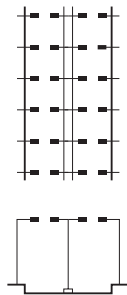
This type of installation is normally used for roads with dual-carriageways.



3.3.6 Twin Central and Opposite Installation

Twin brackets, located on the central reservation, are combined with the opposite installation. This can be considered as an opposite installation for each individual carriageway.

This type of installation is normally used for very wide roads with dual-carriageways.



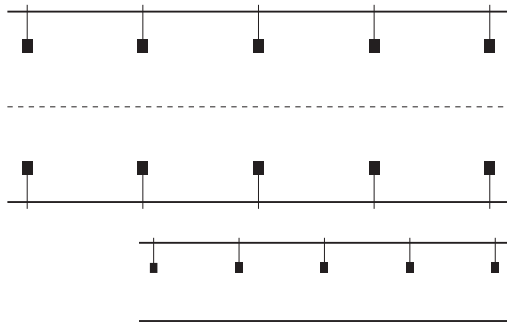
3.4 Advanced Lighting Installations


Calculux Road, which uses a lot of default settings, is used to compare different schemes.

As most roads are straight, Calculux Road is designed for calculations to be carried out on straight roads.

Calculux Road also enables rows of luminaires to be added to the ones generated by one of the standard installations.

However, to carry out calculations for road Junctions, high-masts or Curves, Calculux Area should be used.



-  All the calculations used in Road lighting can also be carried out in a general lighting program like Calculux Area.

3.5 Application Fields

3.5.1 General

In Calculux an application field is represented by a 2-Dimensional rectangular shape. Application fields can be used to graphically mark the area of interest for lighting calculations. Calculux includes a number of different applications.

To differentiate between the types, they contain zero or more predefined lines and/or markings that are associated with the different applications. In Calculux Road you can choose from:

- Single Carriageway;
- Dual Carriageway;
- General Field.

In Calculux, for each type of application field the default dimensions and grid settings can be entered. This allows local standards to be set, limiting the input requirements of the designer. Upon selection, Calculux automatically draws the application field using the default values.

For the calculations in Calculux Road, the following application fields will automatically be generated by the Schemes editor:

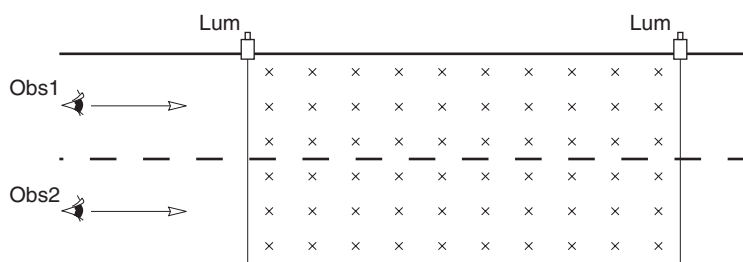
- A single or dual carriageway for the main road;
- A general field for the kerbs.

Single or Dual Carriageway

For a Single or Dual Carriageway, you need to specify the number of lanes and the grid method to be used. If the selected grid method is CEN Luminance, a Road Luminance calculation will automatically be performed. If the selected grid method is CEN Illuminance, an Illuminance calculation will automatically be performed.

For Road Luminance, observers will be placed automatically (depending on the number of lanes).

The following figure shows a Single Carriageway with two lanes and two observers. Both observers are placed in the middle of the lane.



General Field

The general application field is an empty rectangular field. It can be used when you wish to perform calculations for an application not included in the above list. A general field operates like any other application field. You can connect a grid to a general field, ensuring that any changes made to the field parameters automatically change the grid parameters.

Calculux also generates a grid and a surface illuminance calculation on this grid. You are free to change the dimensions, if necessary, to suit your personal design requirements.

3.5.2 Connections with calculation Grids

A calculation grid usually lies within an application field. Calculux enables you to connect a grid to an application field, ensuring that any changes made to the field parameters automatically change the grid parameters. You can set a calculation grid for each application field.

For an example demonstrating this feature see chapter 'Grids', section 'Grid Coupling'.


3.6 Luminaire Photometric Data

Calculux can retrieve luminaire photometric data from two different sources:

- A luminaire database;
- A specially formatted ASCII data file.

3.6.1 Luminaire Database

The luminaire database is supplied with Calculux and contains a wide range of luminaires from your supplier.

 A regularly updated version of the luminaire database can be downloaded on www.lightingsoftware.philips.com.

The luminaire database, of which you want to select your project luminaires, can be selected in the Select Database dialogue box.

When a database is selected, luminaire types for a particular application area can be selected in the Application Area dialogue box. For each luminaire, details about housing, light distributors, colour, lamps and luminous flux intensity are presented on screen in a logical, step-by-step way so that choosing a suitable luminaire for an application is easy.

The default luminaire database and directory in which the luminaire database is stored is set in the Database tab of the Environment Options dialogue box (Options menu). If you wish to extend the range of luminaires you can save more than one database in this directory.

If you have the Philips product selector for Dialux/Relux/Autodesk VIZ installed, then the connected database can also be used by Calculux.

(Default place: C:\Program Files\Philips Lighting\Luminaires\Philips.mdb)

3.6.2 ASCII data file

Calculux is supplied with an extensive Philips luminaire database.


New Philips luminaires that are not yet available in the database are sometimes supplied in specially formatted ASCII data file, the PHILips LUMinaires data format (PHILLUM).

Apart from the Philips database and the PHILLUM format, Calculux allows you to use photometric data from other suppliers.

The following other well known formats can be used in Calculux:

- CIBSE/TM14;
- EULUMDAT;
- IES;
- LTLI.

Luminaire files are stored in the default directory. You can set the location of the default directory in the Directories tab of the Environment Options dialogue box (Options menu).

-  The interpretation of the above luminaire formats can differ. You should pay attention when using them.

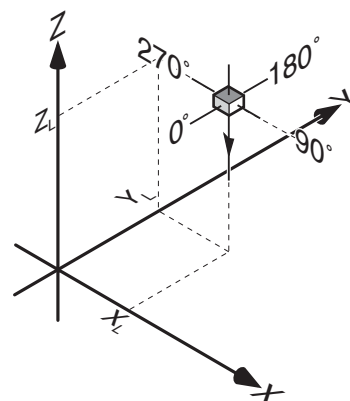
3.7 Luminaire Positioning and Orientation

3.7.1 Luminaire Positioning

XYZ-coordinates

To position a luminaire, Calculux requires the use of the (three dimensional) coordinate system XYZ. The $X_L Y_L Z_L$ coordinates position the centre of the luminaire in relation to the origin of the coordinate system.

The arrow in the following illustration indicates the centre of the light emitting area of the luminaire and represents the main axis of that particular luminaire.



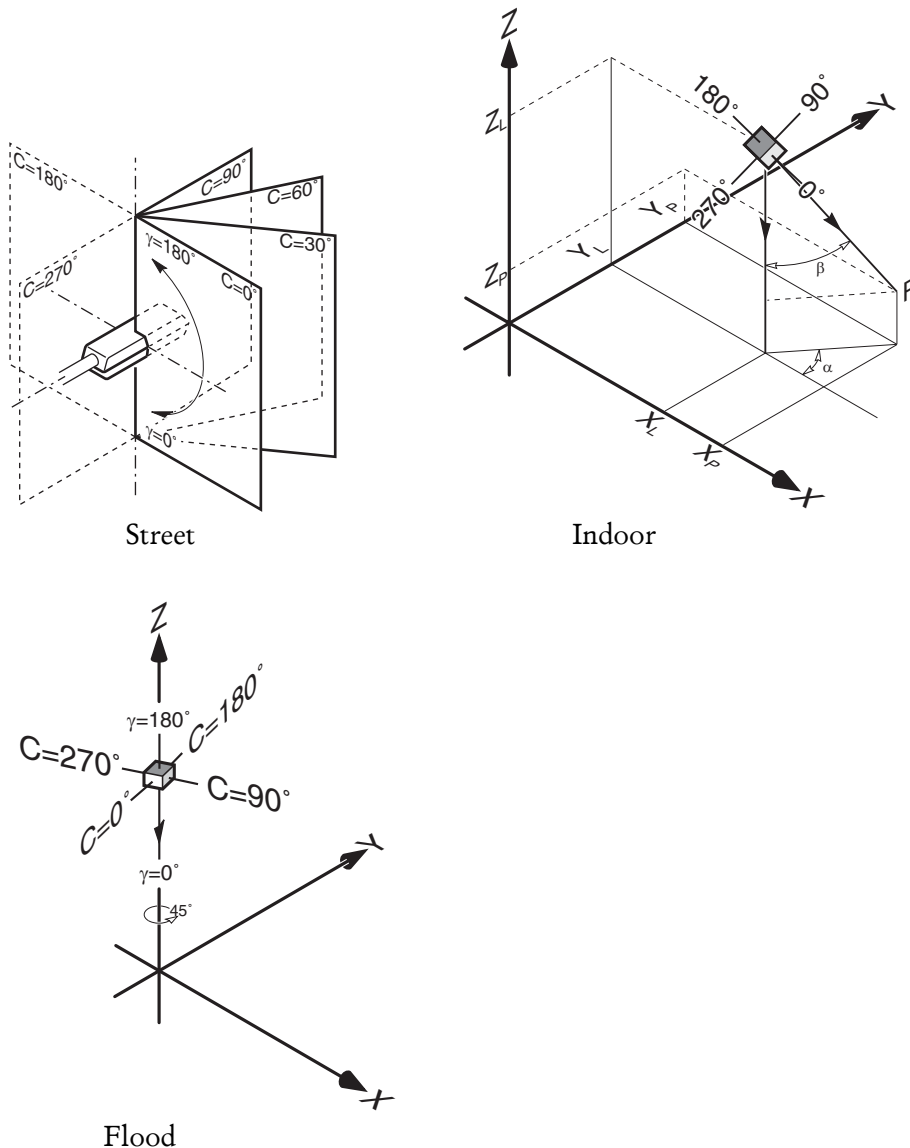
C- γ coordinate system

Each luminaire is given its own luminous intensity coordinate system, in order to provide information on its luminous flux distribution.

In general, the C- γ coordinate system is used. To create the required luminous flux distribution in your design you'll need to define a new orientation for the luminaire. This is done by rotating and/or tilting the luminaire in relation to its (local) coordinate system.

For indoor fluorescent luminaires the longitudinal axis of the lamp is called the $C=90^\circ/C=270^\circ$ axis. The lateral axis of the lamp (perpendicular to the longitudinal axis) is called the $C=0^\circ/C=180^\circ$ axis. For luminaires with an unusual shape, such as those used in outdoor applications, the mounting bracket is usually regarded as a reference which corresponds to the $C=270^\circ$ axis. The vertical axis of the lamp is normally called the $\gamma=0^\circ/\gamma=180^\circ$ axis.

The following illustrations display the C- γ coordinate system for the three main luminaire types, being street, indoor and floodlighting.



3.7.2 Luminaire Orientation

Rotating and Tilting Luminaires

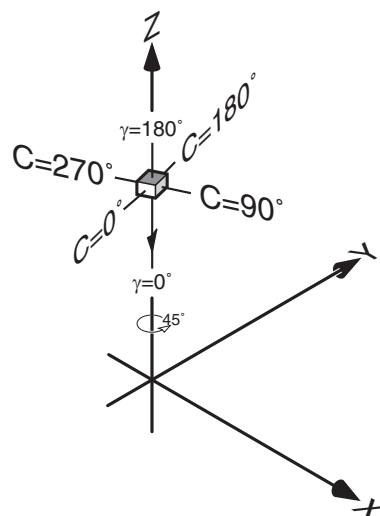
The positioning and orientation of the luminaires alongside the main road is controlled by the Schemes Editor. For additional rows of luminaires the position and orientation must be given by the user.

A luminaire is aimed (orientated) by defining fixed angles for Rot (around the vertical axis), Tilt90 (around the $C=0^\circ/C=180^\circ$ axis) and Tilt0 (around the $C=90^\circ/C=270^\circ$ axis).

Rotation (Rot)

If you wish to change the angle of rotation of the luminaire about its vertical axis, you need to enter a value in degrees for the variable 'Rot'. This value can be positive or negative.

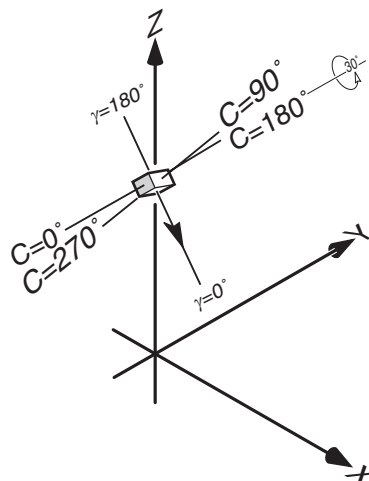
For example Rot = 45° :



Tilt90

If you wish to change the angle of rotation of a luminaire about its $C=0^\circ/C=180^\circ$ axis, you need to enter a value in degrees for the variable Tilt90. This value can be positive or negative.

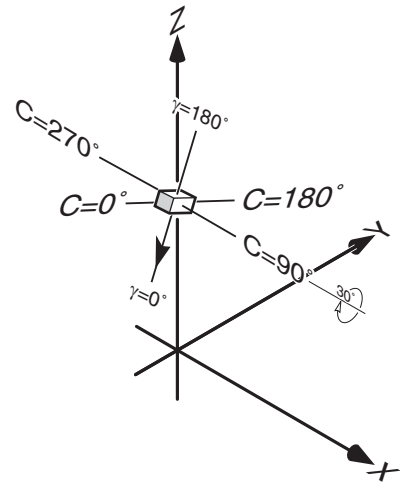
For example Tilt90 = 30° :



Tilt0

If you wish to change the angle of rotation of a luminaire about its $C=90^\circ/C=270^\circ$ axis, you need to enter a value in degrees for the variable Tilt0. This value can be positive or negative.

For example $\text{Tilt0} = 30^\circ$:



Luminaire orientation order

When specifying values for RBA aiming Calculux uses the following specification order:

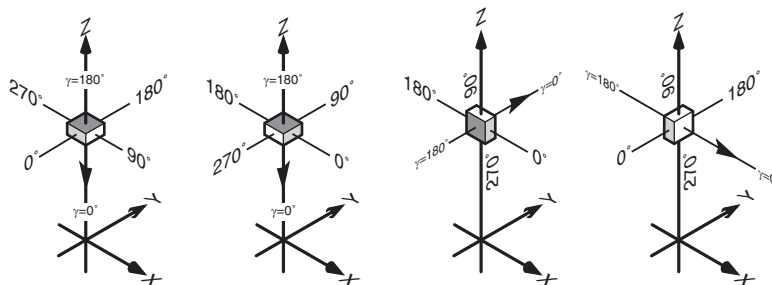
- Rot;
- Tilt90;
- Tilt0.

Extra attention must be paid, because the order in which the variables will be processed is of great influence on the resulting orientation.

For example if the following sequence of processing is executed for a luminaire:

- 90° rotation about the vertical axis (Rot = 90°);
- 90° rotation about the C = 0°/C = 180° axis (Tilt90 = 90°);
- 90° rotation about the C = 90°/C = 270° axis (Tilt0 = 90°).

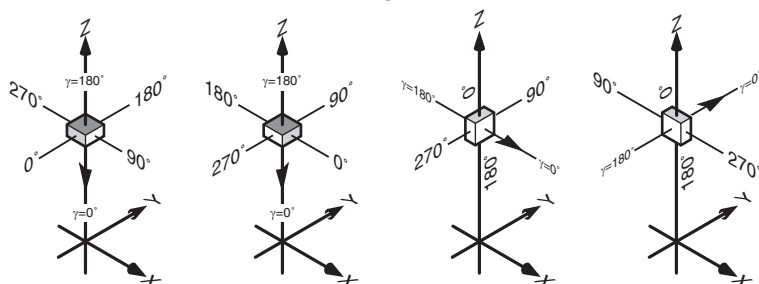
The result of the above order of processing gives the following orientation:



Consider this against the following order of processing:

- 90° rotation about the vertical axis (Rot = 90°);
- 90° rotation about the C = 90°/C = 270° axis (Tilt0 = 90°);
- 90° rotation about the C = 0°/C = 180° axis (Tilt90 = 90°).

This will result in the following orientation:



3.8 Luminaire Arrangements

3.8.1 General

In Calculux Road the rows of luminaires for the standard schemes are automatically generated by the Schemes editor. If required, it is also possible to add additional rows of luminaires (= Street Line arrangements) to the ones generated by the Schemes editor.

In general, for a Street Line arrangement the following luminaire attributes (if applicable) must be set:

- Project luminaire Type;
- Position of the arrangement;
- Orientation of the arrangement (Aiming).

To simplify the definition of the attributes, the arrangements dialogue box is split into two tab pages.

Arrangement Definition

In the Arrangement Definition tab you can define the name and position of the arrangement in relation to the XYZ coordinate system.

Where applicable you can set the orientation (= aiming) of the arrangement.

View

The View tab displays the luminaires in the arrangement graphically.

3.8.2 Street Line Arrangement

In a Street Line arrangement the luminaires are arranged in a line along a street.

Arrangement Definition

For the definition of a Street Line arrangement, the following parameters have to be set:

- Name of the arrangement;
- Position of the first luminaire in the Street Line;
- Number of luminaires in the Street Line;
- Spacing between the luminaires in Y-direction (in meters);
- Luminaire type to be used in the Street Line arrangement;
- Orientation of the luminaires in the arrangement.

Example:

The Street Line arrangement below has the following settings:

Position X, Y, Z = 1.0, 1.0, 5.0

Number of Luminaires = 3

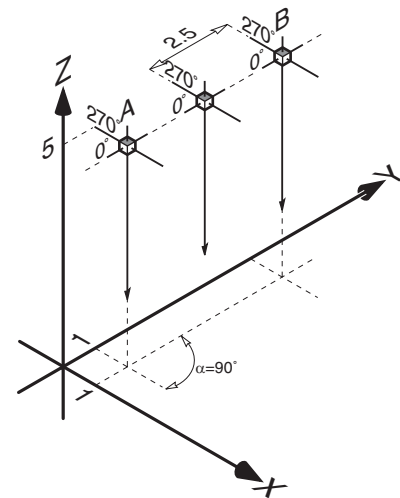
Spacing in Y-direction = 2.5 m

For the *luminaire orientation* the default settings are used:

Rot = 0°

Tilt90 = 0°

Tilt0 = 0°



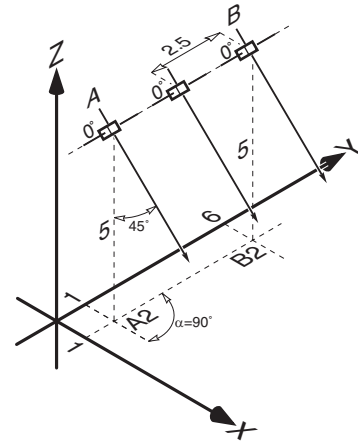
From the previous illustration, the luminaire orientation is now set to:

a) Rot = 0°

Tilt90 = 45° (rotation of 45° around $C = 0^\circ \dots C = 180^\circ$ axis)

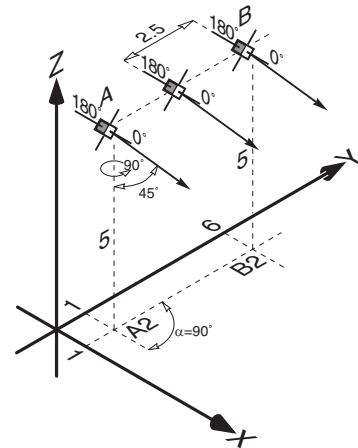
Tilt0 = 0°

Which results in the following arrangement:



- b) Rot = 90° (rotation of 90° around the vertical axis)
 Tilt90 = 45° (rotation of 45° around $C = 0^\circ \dots C = 180^\circ$ axis)
 Tilt0 = 0°

Which results in the following arrangement:



Luminaire Type

If a project contains two or more luminaire types, you need to select the required luminaire type. If afterwards a different luminaire type is needed, you can click on the down arrow in the Project Luminaire Type box and make your selection.

3.9 Grids

3.9.1 General

A grid is an area containing a specific number of points at which lighting calculations are carried out. A grid must always be rectangular in shape and can be in any plane in space (horizontal, vertical or sloping).

It is useful to think of a grid as an invisible surface to which a light meter can be attached. The amount of light measured by the light meter changes as it is moved to different points on the surface. It also changes if the light meter is moved from one side of the surface to another.

There are two types of calculation grids:

- Generated grids;
- User defined (Free added) grids.

3.9.2 Generated grids

These grids are generated by the program and are based on the requirements and grid method defined in the requirements profile and the road definition. Generated grids mostly cover a section of a carriageway (the area of interest) that is lying between two luminaires in a row, which are situated on *one* side of the road. When a staggered installation is used, the spacing for the main calculation grid is the distance between two luminaires on one side of the road.

Calculux Road allows you to choose between CEN Luminance and CEN ILLuminance grid: A maximum of five grids can be generated for each grid method:

- a) Main Road grid (this grid always covers one carriage way);
- b) Grids for surround ratio;
- c) Grid for average and minimum/average half-spherical right;
- d) Grid for average and minimum/average half-spherical left.

The width of the right and the left surround ratio grid is 10 meters (5 m being on the road and 5 meters being on the kerb).

If the carriageway is less than 5 meters then the width is the same as the carriageway.

If a road has two carriageways and the width of the central reservation is more than 10 meters, the surround ratio for one carriageway is calculated.

There are two kerb grids. One on the left and one on the right kerb of the carriageway.

The width of a kerb grid is 3.5 meters.

Details about the generated grids (like position, number of grid points) are derived from the selected grid method. They are described in the following sections.

CEN Luminance grid (see also EN 13201-2)**For the main road**

One grid is generated for the main road. It lies on the road (on the main area of interest), covering the spacing between two luminaires that are situated on the same side of the road. The grid for the Main Road always covers one carriageway.


Number of Calculation points in the lengthwise direction (N_l)

For a grid length (L) ≤ 30 meters, N_l is 10 points.

For a grid length (L) > 30 meters, N_l is the smallest integer giving

$D \leq 3$ meters.

D is the distance between calculation points in the lengthwise direction.

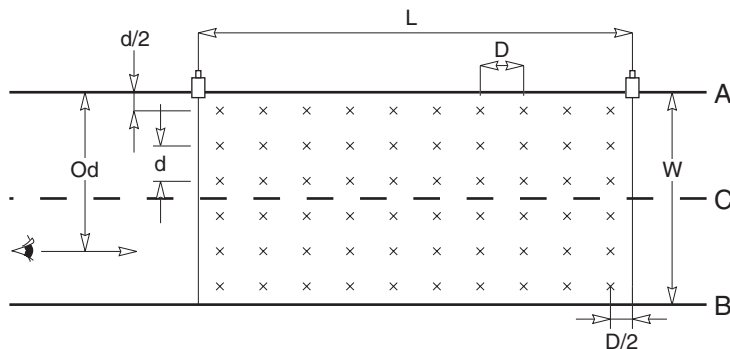
-  For all installations based on the CEN Luminance grid (Staggered installations included), the grid length L is the spacing between two luminaires on the *same* side of the road.

The first calculation point lies on the line that crosses the road and passes through the base of the first luminaire. The last calculation point lies one spacing before the line that crosses the road and passes through the base of the second luminaire that is situated on the same side of the road.


Number of Calculation points per lane in the crosswise direction (N_c)

There are always 3 calculation points per lane.

The first and last points are a half spacing from the edges of the lane.



The above figure illustrates the calculation points for the main grid, when using the CEN Luminance grid method.

-  In the Schemes Editor, the luminaire spacing is defined as the distance between two luminaires on *either* side of the road.

For the surround ratios

Two surround ratio grids can be generated. One for the left, and one for the right side of the road.

- ✂ For a dual carriageway with a central reserve > 10 meters, the surround ratio grid is generated as if the dual carriageway consists of one carriageway only. One grid is generated for the left side, and one for the right side of the *dual carriageway*.

Number of Calculation points in the lengthwise direction

The number and position of calculation points in the lengthwise direction is the same as defined for the *Main Road*.

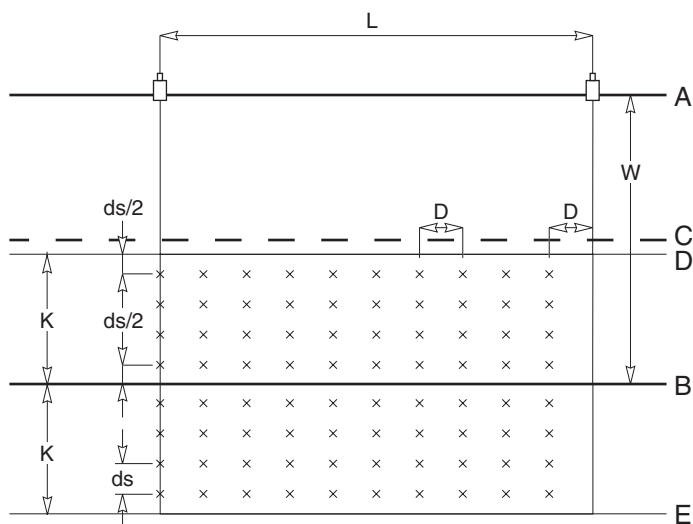
Number of Calculation points in the crosswise direction

For carriageways ≤ 9 meters, the number of calculation points is 6 (3 on the road and 3 on the kerb). The first point is positioned on the road at 2.5 times the crosswise spacing (ds) from the relevant edge.

For carriageways > 9 meters, the number of calculation points is 8. (4 on the road and 4 on the kerb). The first point is positioned on the road at 3.5 times the crosswise spacing (ds) from the relevant edge.

For carriageways > 10 meters, the crosswise spacing is 1.25 meter.

For carriageways ≤ 10 meters, the crosswise spacing is the width of the carriageway (W) divided by the number of calculation points.



The above figure illustrates the calculation points for the Surround Ratio calculation grid on the right side of the road (width carriageway > 9 meters), when using the CEN Luminance grid method.



- K stands for:
 - the width of the Surround Ratio calculation area on the road;
 - the width of the Surround Ratio calculation area on the kerbside.
- If the width of the carriage way is less than 10 meters, then K is half the width of the carriageway. Otherwise, K is 5 meters.
- The definition for the grid points is the same as for the CEN Illuminance grid.

For half spherical on kerbs

Two grids can be generated. One for the left, and one for the right side of the carriageway.

Number of Calculation points in the lengthwise direction

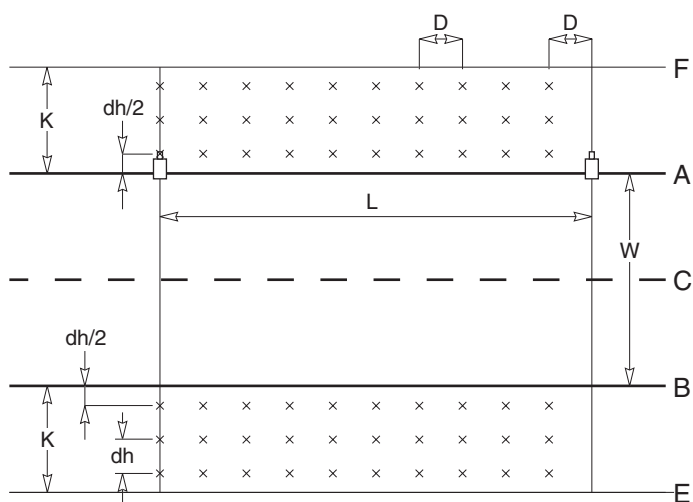
The number and position of calculation points in the lengthwise direction is the same as defined for the *Main Road*.

Number of Calculation points in the crosswise direction

There are 3 calculation points.

The first one is positioned at 0.583 meters from the relevant edge (kerbside).

The spacing between the calculation points is 1.167 meters.



The above figure illustrates the calculation points for the Half Spherical on Kerbs calculation grid on both sides of the carriageway, when using the CEN Luminance grid method.



- K (= 3.5 meters) is the width of the calculation area for calculating the half spherical illuminance on the kerbs.
- The definition for the grid points is the same as for the CEN Illuminance grid.

CEN Illuminance grid (see also EN 13201-2)**For the main road**

One grid is generated for the main road. It lies on the road (on the main area of interest), covering the spacing between two luminaires that are situated on the same side of the road. The grid for the Main Road always covers one carriageway.


Number of Calculation points in the lengthwise direction (N_l)

For a grid length (L) ≤ 30 meters, N_l is 10 points.

For a grid length (L) > 30 meters, N_l is the smallest integer giving

$D \leq 3$ meters.

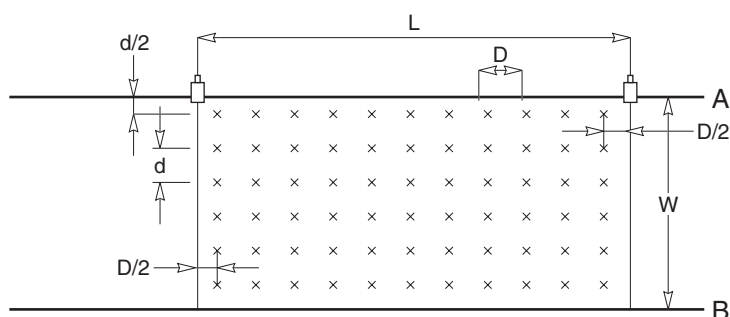
D is the distance between calculation points in the lengthwise direction.

-  For all installations based on the CEN Illuminance grid method (Staggered installations included), the grid length L is the spacing between two luminaires on the *same* side of the road.


The first calculation point lies on the line that crosses the road at a half spacing from the base of the first luminaire. The last calculation point lies a half spacing before the line that crosses the road and passes through the base of the second luminaire that is situated on the same side of the road.

Number of Calculation points per lane in the crosswise direction (N_c)

For carriageways N_c is the smallest integer giving $d \leq 1.5$ meter, in which d is the distance between calculation points in the crosswise direction and $N_c \geq 3$. The first calculation point is a half spacing from the road edge.



The above figure illustrates the calculation points for the main grid, when using the CEN Illuminance grid method with a road width > 7.5 and ≤ 9.0 meters.

-  In the Schemes Editor, the *luminaire spacing* is defined as the distance between two luminaires on *either* side of the road.

For the surround ratios

Two surround ratio grids can be generated. One for the left, and one for the right side of the road.

- ✍ For a dual carriageway with a central reserve > 10 meters, the surround ratio grid is generated as if the dual carriageway consists of one carriageway only. One grid is generated for the left side, and one for the right side of the *dual carriageway*.

Number of Calculation points in the lengthwise direction

The number and position of calculation points in the lengthwise direction is the same as defined for the *Main Road*.

Number of Calculation points in the crosswise direction

For carriageways ≤ 9 meters, the number of calculation points is 6 (3 on the road and 3 on the kerb). The first point is positioned on the road at 2.5 times the crosswise spacing (ds) from the relevant edge.

For carriageways > 9 meters, the number of calculation points is 8. (4 on the road and 4 on the kerb). The first point is positioned on the road at 3.5 times the crosswise spacing (ds) from the relevant edge.

For carriageways > 10 meters, the crosswise spacing is 1.25 meter.

For carriageways ≤ 10 meters, the crosswise spacing is the width of the carriageway (W) divided by the number of calculation points.



- K stands for:
 - the width of the Surround Ratio calculation area on the road;
 - the width of the Surround Ratio calculation area on the kerbside.
- If the width of the carriage way is less then 10 meters, then K is half the width of the carriageway. Otherwise, K is 5 meters.

For half spherical on kerbs

Two grids can be generated. One for the left, and one for the right side of the carriageway.

Number of Calculation points in the lengthwise direction

The number and position of calculation points in the lengthwise direction is the same as defined for the *Main Road*.

Number of Calculation points in the crosswise direction

There are 3 calculation points.

The first one is positioned at 0.583 meters from the relevant edge (kerbside).

The spacing between the calculation points is 1.167 meters.

3.9.3 User defined (Free added) grids

Calculux enables you to define your own grids, or to change the specifications of existing grids.

Size and position of a grid: points A, B and C

A grid is defined by specifying the X, Y and Z coordinates of the three reference corners A, B and C. The 4th reference corner is calculated automatically because the grid is a rectangle. Usually point A is considered the bottom left corner of the grid, so when this is the case, the reference corners are as follows:

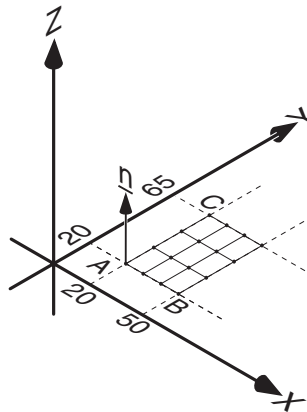
- A = The bottom left corner of the grid
- B = The bottom right corner of the grid
- C = The top left corner of the grid

The following rules apply to grids:

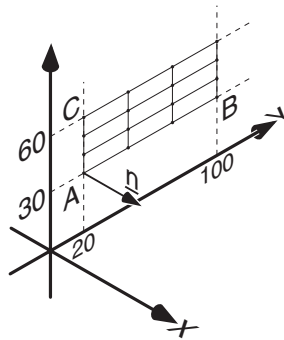
- a) The vectors (AB) and (AC) cannot be zero and must be perpendicular.
A small deviation from perpendicularity is allowed, Calculux will correct this automatically. This is especially useful when a person, using a system with limited accuracy, has to specify the corners of a grid with sides that are not parallel to the axis of the coordinate system.
- b) The reference corners A, B and C can not be on one line.

The following illustrations display a horizontal, vertical and sloping grid.

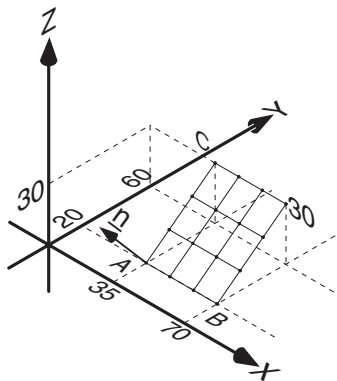
Horizontal grid



Vertical grid



Sloping grid



Calculation points in a grid

The number of calculation points you define in AB and AC direction is used to divide the grid into equal parts. These are the points at which the lighting calculations will be carried out. There is always a calculation point on each corner. For example, if you set both numbers of points in AB and AC direction to 4, the total number of grid points is $4 \times 4 = 16$, see figure below. The lighting calculations are performed at each of these points.

Distance between calculation grid points:

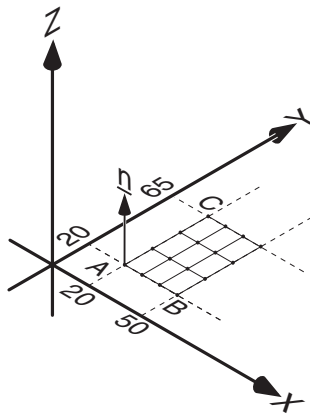
$$D = \frac{\text{Total length of vector}}{(\text{Nr. of grid points along vector}) - 1}$$

The number of divisions along (vector) AB and AC is the number of grid points along that vector - 1.

In the figure below, the distance between the calculation grid points in AB and AC direction is:

$$D_{AB} = \frac{30}{4 - 1} = 10$$

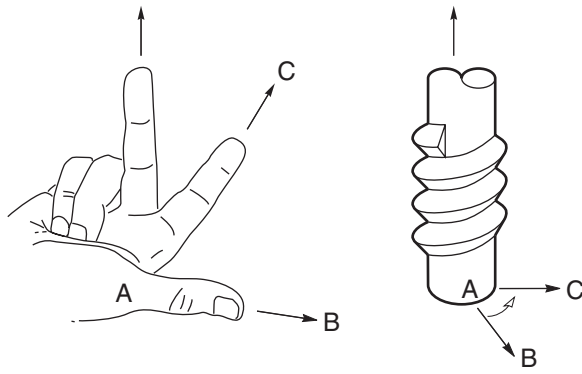
$$D_{AC} = \frac{45}{4 - 1} = 15$$



Default side

It is usually obvious on which side of the grid (it has two sides) the calculations are to be carried out. However, for some calculations, such as surface illuminance and luminance it is not always obvious and therefore becomes necessary to define the default side of the grid.

The default side of the grid is related to the orientation of A, B and C and is determined using the right hand rule. The direction of the arrow (the normal vector on the grid area) indicates the side of the grid which is the default. This is always the case unless it is specified otherwise.



Grid coupling

Calculux enables you to connect a grid to an application field, (a calculation grid usually lies within an application field) ensuring that any changes made to the field parameters automatically change the grid parameters. You can set a default calculation grid for each application field type in the application field defaults dialogue box. The following example demonstrates these principles:

General field:

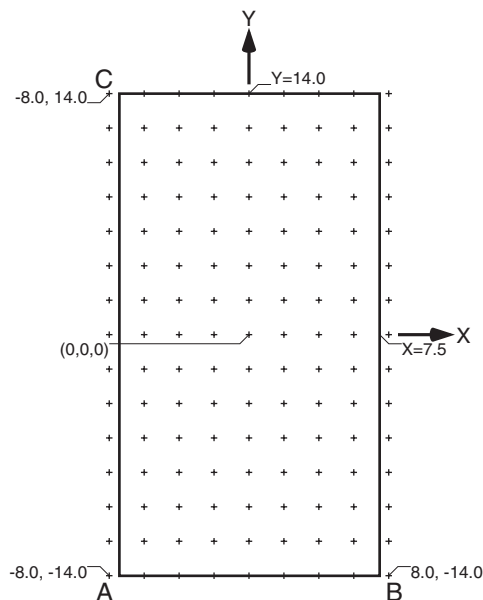
Width = 15 m
 Length = 28 m
 Centre position = (0.0, 0.0)

Calculation grid:

spacing AB = 2 meters
 spacing AC = 2 meters
 include Mid Point at Centre Width = yes
 include Mid Point at Centre Length = yes

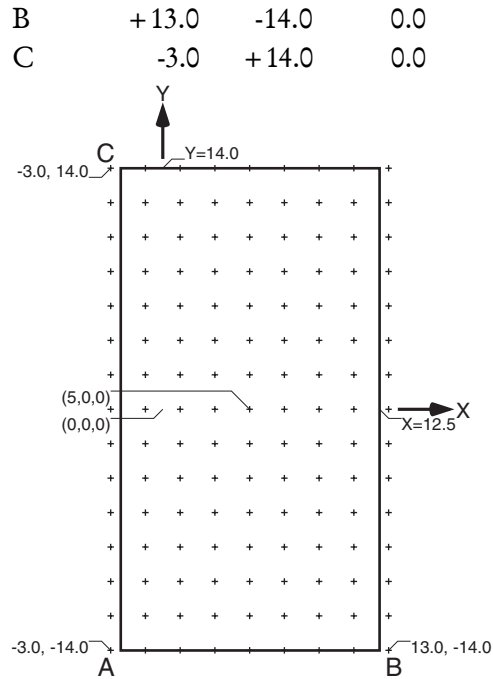
This will give the following grid reference corner coordinates, see figure below:

| | X | Y | Z |
|---|------|-------|-----|
| A | -8.0 | -14.0 | 0.0 |
| B | +8.0 | -14.0 | 0.0 |
| C | -8.0 | +14.0 | 0.0 |



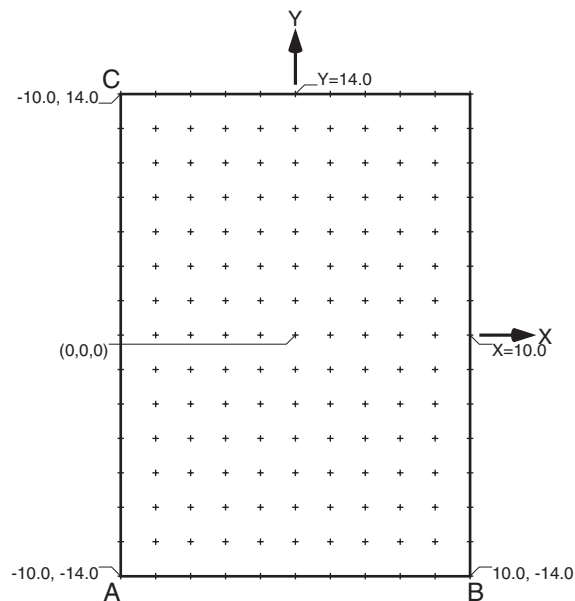
Now moving the centre position of the application field to (5, 0, 0) the grid parameters will automatically change to:

| | X | Y | Z |
|---|------|-------|-----|
| A | -3.0 | -14.0 | 0.0 |



If in the first example the application field width is changed to 20m, the new coordinates will be:

| | X | Y | Z |
|---|-------|-------|-----|
| A | -10.0 | -14.0 | 0.0 |
| B | +10.0 | -14.0 | 0.0 |
| C | -10.0 | +14.0 | 0.0 |



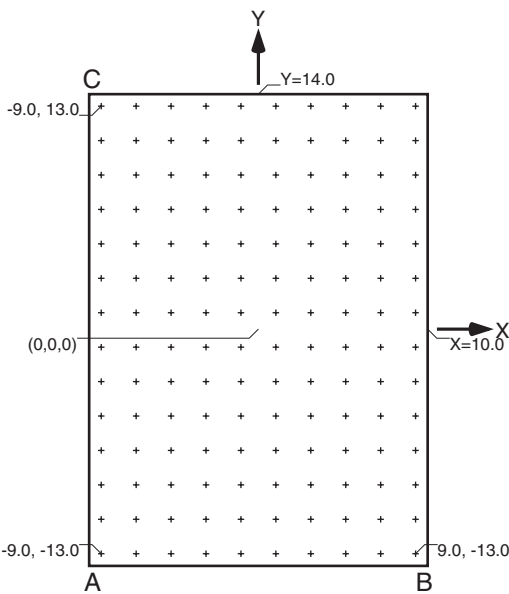
The grid corners can fall outside the application field due to the spacing leading rule, with the centre point of the dimension of the application field being included. See section 'Spacing leading' for a more detailed explanation.

To contain the grid inside the application field it is connected to, exclude
'Mid Point at Centre':

Mid Point at Centre Width = no
Mid Point at Centre Length = no

The grid corner coordinates will change to:

| | X | Y | Z |
|---|------|-------|-----|
| A | -9.0 | -13.0 | 0.0 |
| B | +9.0 | -13.0 | 0.0 |
| C | -9.0 | +13.0 | 0.0 |



This aspect of Calculux is very user-friendly: you'll begin to appreciate the benefits of grid coupling when you start building your own projects.

For connecting a grid to an application field the following grid point methods are possible:

No Rule

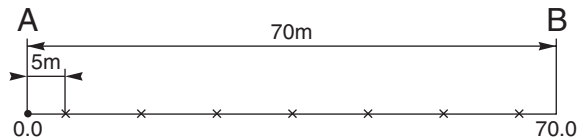
When a grid is connected to a application field with 'No Rule', there will be no relation between the definition of the grid and the definition of the field. The grid is defined by the corner points (A, B and C), the number of points in the AB and AC direction, and the direction of the normal vector.
The grid will remain at the same position when the application field is moved and will also be deleted if the application field is deleted.

Points Leading

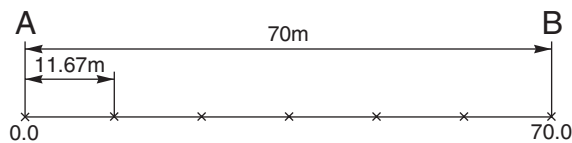
Along each dimension (i.e. length and width of the application field) the number of calculation grid points is defined. These points will be evenly spread over the surface of

the application field starting at the edge or at half spacing from the edge, depending on your selection. Once your selections have been made, Calculux calculates the positions of A, B and C displaying the grid in the view box.

In the following figure the number of calculation grid points along AB is 7, starting at half spacing from the edge. This gives a spacing of 10m. (between calculation points).



In the following figure the number of calculation grid points along AB is 7, starting at the edge (point A). This gives a spacing of 11.67m. (between calculation points).



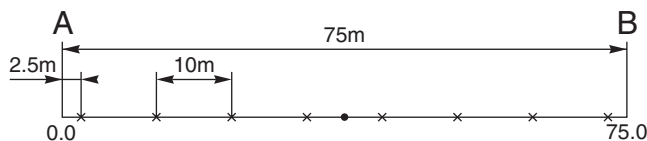
Spacing Leading

Along each dimension (i.e. length and width of the application field) the spacing of the calculation grid points is defined, together with the choice whether or not to include the centre of each dimension in the application field. Once your selections have been made, Calculux calculates the positions of A, B and C displaying the grid in the view box.

In the following figure the spacing between the calculation grid points along AB is 10m.

The centre point of the dimension of the application field is not included, giving:

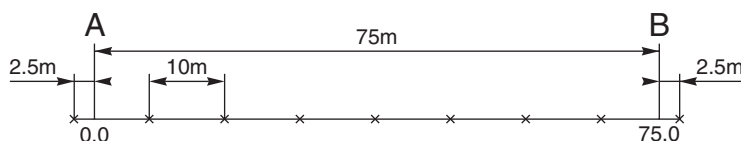
- The first point at $X = +2.5\text{m}$;
- The last point at $X = +72.5\text{m}$.



In the following figure the spacing between the calculation grid points along AB is 10m.

The centre point of the dimension of the application field is included, giving:

- The first point at $X = -2.5\text{m}$;
- The last point at $X = +77.5\text{m}$.



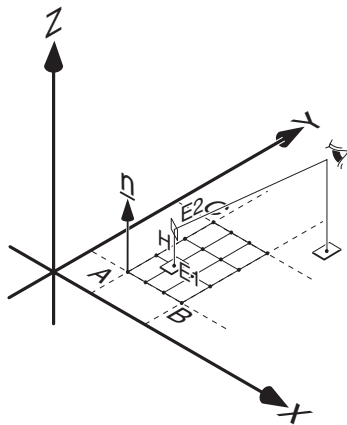
The distance between the application area and the border grid point is, at a maximum, half that of the spacing. In case spacing leading is used, the calculation grid can be larger than the application field to which it is connected. To include the grid within the field, switch between 'Mid Point at Centre' included 'Yes' or 'No'.

Normal vector of a grid

The normal vector is perpendicular to the plane of the grid and is defined by using the right-handed coordinate system.

Occasionally, illuminance in the direction of an observer as well as horizontal illuminance has to be calculated for a horizontal grid. In such a case the vertical illuminance towards an observer often has to be 1.5m.

This parameter refers to the vertical distance above each generated grid point. The calculations are carried out at the grid point positions with the 'Height above grid' parameter being added to the Z-coordinate (see figure below).



Irregular Grids (not always available; not in Calculux Road)

In addition to the rectangular grid described in the previous sections, Calculux also has the possibility to define irregular grids. An irregular grid is a set of points without any relation. Each point has its own x, y and z position.

Irregular grids can be very useful when local recommendation require calculations to be performed on points of a field that lay outside a rectangular arrangement.

For example, irregular grids can be used to comply with the French recommendations for the lighting of Tennis courts, where the grid points are not all at the same height.

To support the generation of irregular grids, it is also possible to define irregular grid points that lay on a rectangular or circular arrangement.

The figure below shows an example of an Athletic Track with its calculation points defined by irregular grids. Some points are on a rectangular arrangement, some are on a circular arrangement and some are given as individual points.



The definition of calculation points can be time consuming. For this reason it is possible to save the constructed irregular calculation grid for future usage.



- As an irregular grid is just a set of points it not possible to define the Isolux and Mountain plot output type.
- Only the textual and graphical tables are supported.
- The textual table is an X,Y,Z table with the calculated values.
- The graphical table is a projection of all the calculated values on the X-Y plane.

Irregular grid points allow you to perform tailor made calculations.

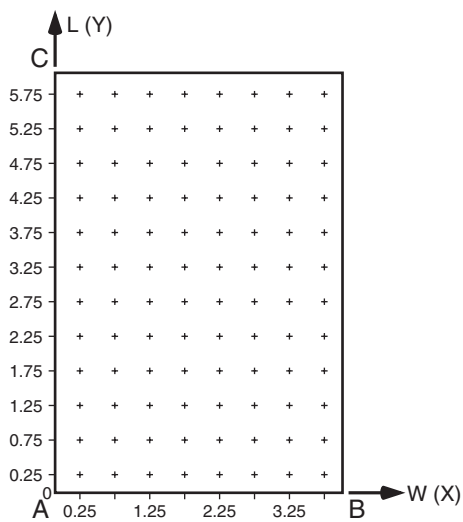
To avoid unnecessary long output lists or unreadable graphical tables, irregular grids must be applied with care. Also take care that values are not put on top of each other and that the output scale fits.

Presentation of results

When the results of lighting calculations are presented in a textual table, they have a particular format. The calculated results for point A always appear at the bottom left corner of the table, the results for point B at the bottom right corner and the results for C at the top left corner, for example:

| | | | |
|----|----------|----------|----------|
| A: | x = 0.25 | y = 0.25 | z = 0.00 |
| B: | x = 3.75 | y = 0.25 | z = 0.00 |
| C: | x = 0.25 | y = 5.75 | z = 0.00 |

If the number of points AB = 8 and AC = 12 and no output rotation is performed, this will give the following format:



L = Length

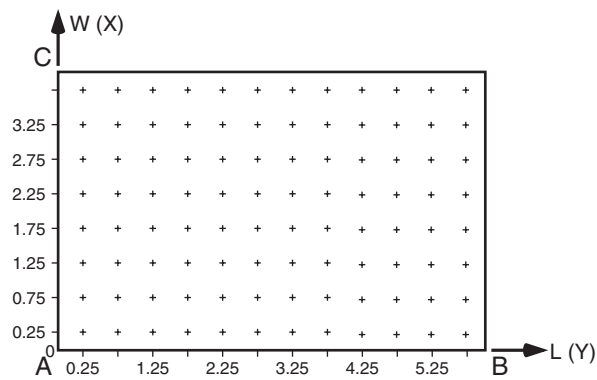
W = Width

The '+' represents the calculated result, (you can define points A, B and C to create any layout for the results you require).

A different presentation of the calculated results can be displayed by defining the coordinates of points A, B and C as follows:

| | | | |
|----|----------|----------|-----------|
| A: | x = 0.25 | y = 0.25 | z = 0.00; |
| B: | x = 0.25 | y = 5.75 | z = 0.00; |
| C: | x = 3.75 | y = 0.25 | z = 0.00. |

If the number of points $AB = 8$ and $AC = 12$ and no rotation is applied, this will give the following format:



L = Length

W = Width

3.10 Shapes

A shape is a surface area in the same plane as a grid. Shapes can be used to create a user-defined form on the rectangular grid which is excluded from the calculations. Virtually any kind of form can be created. Shapes are connected to a grid, therefore shapes can only be added after a grid is defined. If multiple shapes are defined for a grid, each shape has a unique name.

In Calculux, shapes can be set active or inactive.

Active and inactive shapes

Each shape can be set active or inactive individually. Only grid points not covered, or covered by inactive shapes will be used for calculation by Calculux.

The shapes on a grid cover a grid point if at least one active shape covers the grid point.

In Calculux shapes can be defined in two ways:

- Pre-defined shapes;
- User-defined shapes.

3.10.1 Pre-defined shapes

In Calculux, some application fields use a connected grid other than the standard rectangle. For these application fields a set of pre-defined shapes is used to create different application field outlines. If the size of the grid is changed, the position and size of the shapes is updated automatically. The user cannot change or delete these pre-defined shapes, but can duplicate or add a shape. A duplicated shape will be a user-defined shape. Each pre-defined shape can be set active or inactive.

3.10.2 User-defined shapes

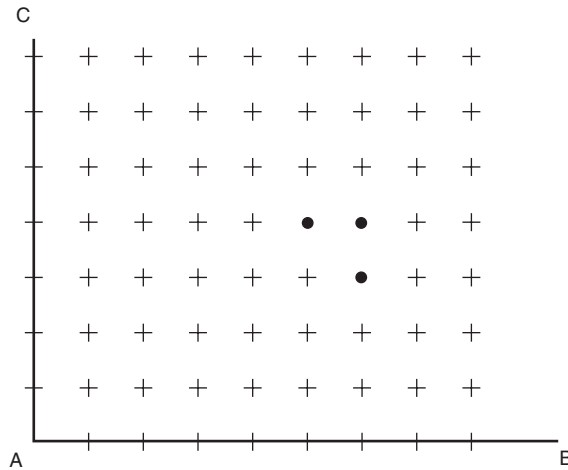
On all calculation grids the user can add shapes by specifying the required input parameters. The user can add, change, duplicate or delete shapes. A user-defined shape can be set active or inactive.

In Calculux, the following shape types can be defined by the user:

- Set of points;
- Rectangle;
- Free Grid (extension of polygonal shape);
- Closed polygon;
- Arc.

Set of points

The set of points shape can be used to cover individual grid points. This is especially useful when a few grid points at the edge of an application field or next to a generated shape must be excluded for calculation by Calculux. It only has effect when real grid positions are excluded. A point can be entered between grid points but will have no effect.



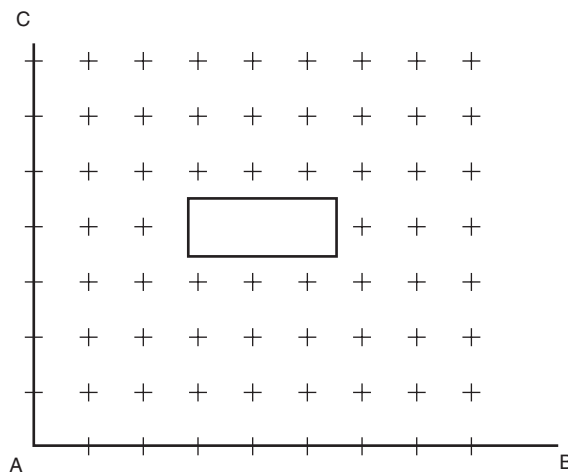
Coordinates can be entered using the dialogue box. However, coordinates which are exactly on a grid point can also be entered simply by mouse-clicking on the grid point in the view box.



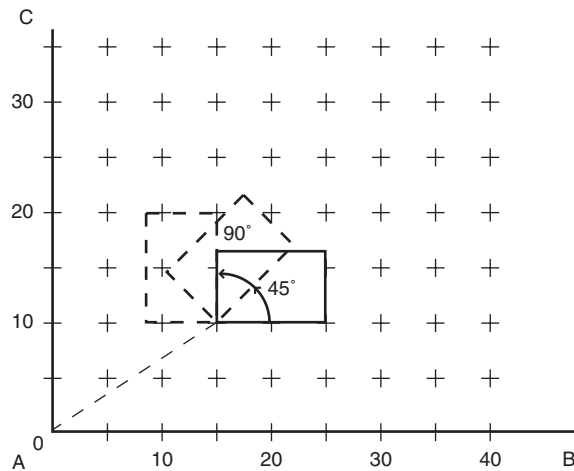
- Points within 5mm from a grid point are taken as that grid point.
- When the number of grid points is changed, it is possible that the selected points are no longer on a calculation point.

Rectangle

The rectangle shape can be used to create rectangular shapes. It is defined by its lower left corner position (relative to point A of the grid), width and length.



Furthermore, rotation around the starting point of the rectangle shape can be specified (see figure below).

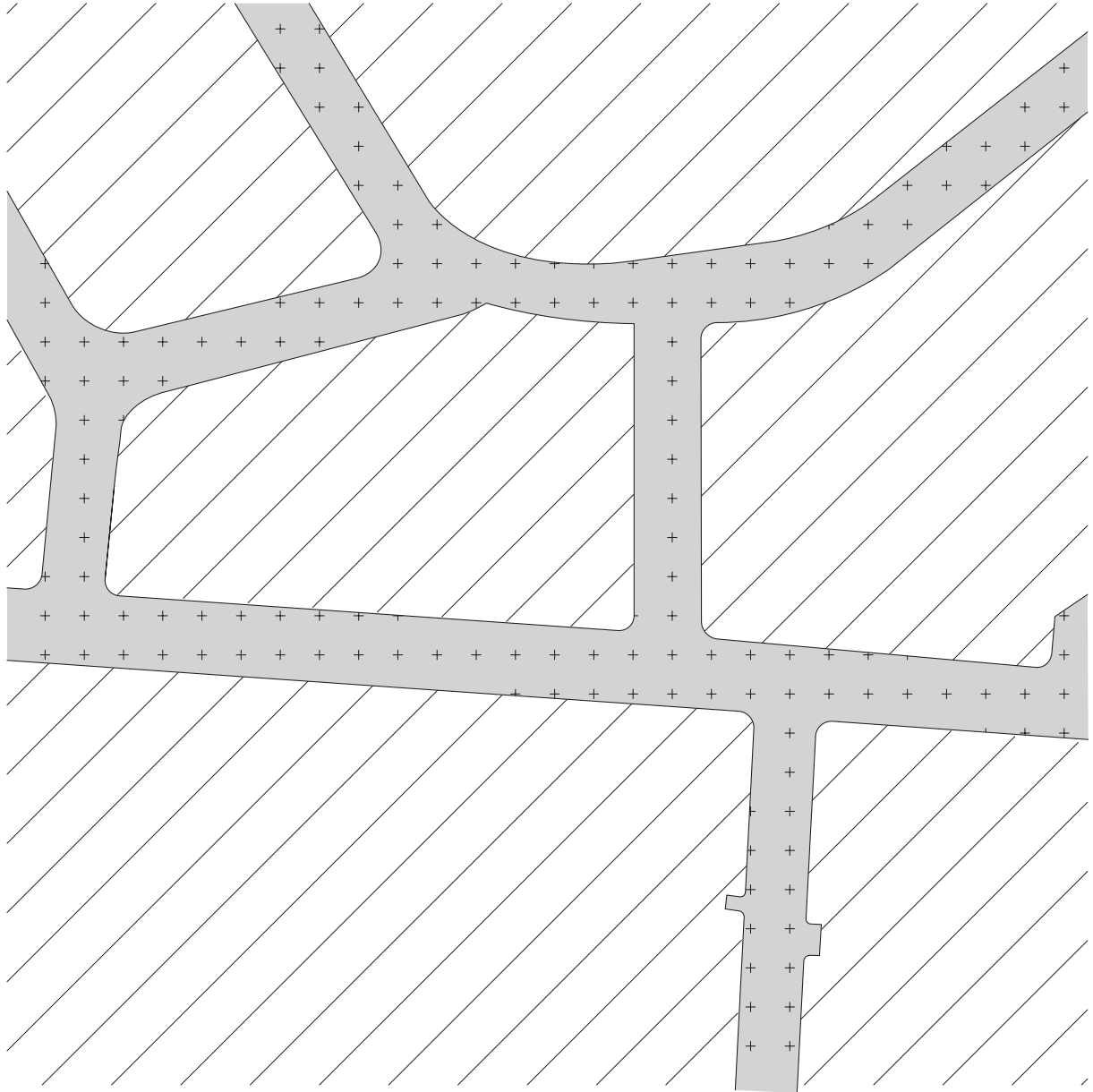


If the 'Change Proportionally' function is enabled, the position and size of the shape is changed proportionally with the size of the grid.

Free Grids (not always available; not in Calculux Road)

The free grids function is an extension of the polygonal grids. When defining a polygonal grid, the shapes function enables the possibility to create a form that excludes grid points from the calculation. Because both the grids and the shapes must be defined in a menu by entering the parameters, it is a time consuming and complex exercise.

The free grids function helps the user to define a grid form with some clicks of the mouse. Within the free grids function, the cutout function is used to define an area that excludes grid points from the calculation. This is also done with a few clicks of the mouse.



The example above shows the map of a residential area with its calculation points defined by free grids. The outlines of the roads are followed with the mouse to define the area. With the help of the cutout function, the 'island' in the middle is excluded from the calculation points, also just by following it with the mouse.

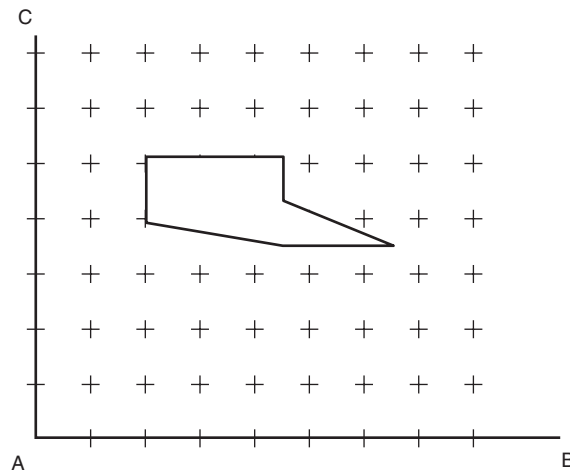
- ✎ After the free grid is changed with the rectangular grid function, the free grid is converted to a rectangular grid with shapes. From this point it is no longer possible to edit the free grid with the free grid function.

Polygon

The polygon shape can be used to create irregular shapes consisting of straight lines. At least three coordinates must be entered. The polygon is automatically closed by the program

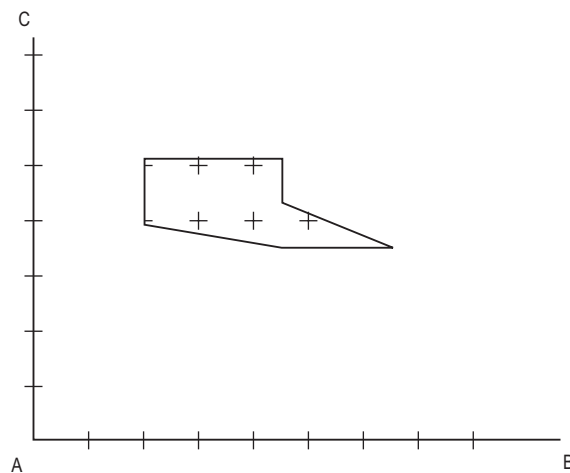
(first and last point are the same). All coordinates are relative to point A of the calculation grid. Lines within a polygon must not cross each other. Coordinates can be entered using the dialogue box. However, coordinates which are exactly on a grid point can also be entered simply by mouse-clicking on the grid point in the view box. Polygonal shapes can be set as inbound or outbound.

Inbound



The default setting for the polygon shape is inbound. In this case the area covered by the inbound of the shape will be excluded from the calculations.

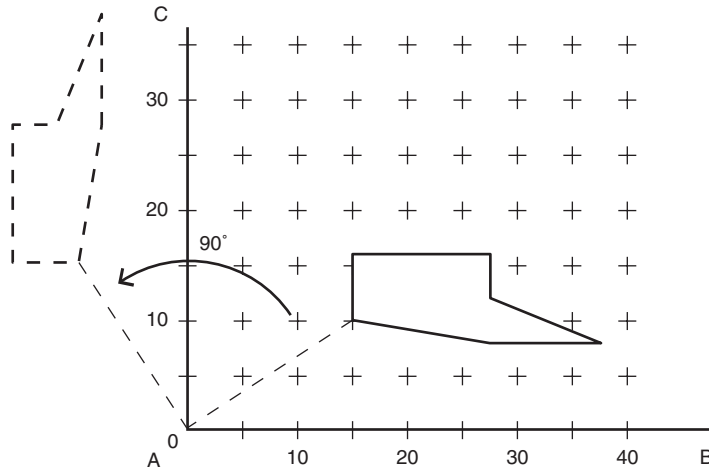
Outbound



Choose the Outbound Polygon option to create user-defined application fields that are polygonal shaped. The area covered by the outbound of the shape will be excluded from the calculations.

Rotation

If rotation is applied a polygonal shape is rotated around grid corner A (see figure below).

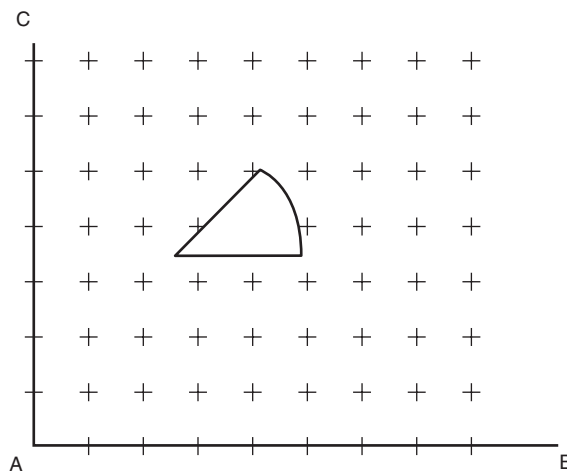


If the 'Change Proportionally' function is enabled, the position and size of the shape is changed proportionally with the size of the grid.

Arc

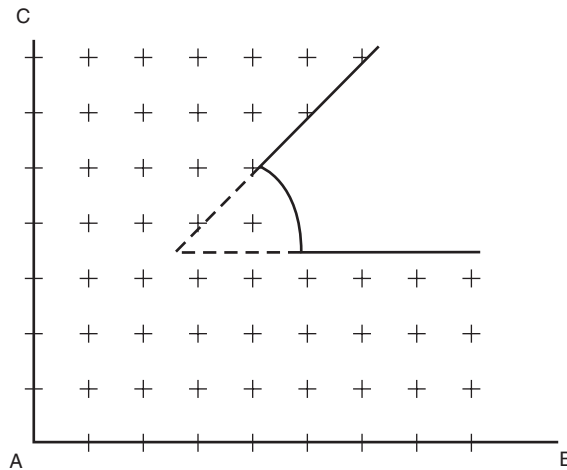
The Arc shape can be used to create circular shapes. The arc shape is defined by its starting position (relative to point A of the grid), radius and angle. The arc shape can be rotated around its starting position. Arc shape coordinates between grid points can only be entered using the dialogue box. The arc shape can be set as inbound or outbound.

Inbound



The default setting for the arc shape is inbound for creating segments up to a full circle. The area covered by the inbound of the shape will be excluded from the calculations.

Outbound



Choose the Outbound Arc option to create rounded corners or edges on user-defined application fields. The area covered by the outbound arc shape will be excluded from the calculations.

3.10.3 Symmetry

Symmetry is an optional specification that can be used to simplify individual shape entry when one or more shapes have a symmetrical orientation and/or position. If applied, the shape is duplicated on the opposite side of a line parallel to the AB axis or the AC axis, or it is duplicated to all quadrants. The user can specify the symmetry type (AB, AC, AB-AC or none) and the AB and AC origin (relative to point A of the grid).

3.11 Observers

An observer is a location to be used as an observer's reference point. A television camera is often placed at such a point.

Using a person as an observer enables you to calculate the veiling luminance he experiences upon his eyes. For Road lighting luminance, the observer is the driver of the car. The veiling luminance is the basis upon which the glare calculations are based. If included in the project, you must specify the xyz coordinates of each observer's position.



- The location of the referred observer is not allowed to coincide with any calculation grid point, on the grid upon which it is being used.
- For veiling luminance and glare calculations, the angle between the vector from the observer to any grid point, and the vector from the observer to any luminaire belonging to this calculation, must always be greater than 1.5 degrees.
- For semi-cylindrical illuminance calculations towards an observer, the location of the observer's reference point must not be above or below any grid point in the calculation grid.
- For veiling luminance calculations, only the location of the observer is a calculation point.

Road luminance calculations

For Road luminance calculations an observer is often positioned in the middle of each traffic lane, facing the direction of the traffic flow. In some situations Calculux automatically places default observers.



For road luminance calculations towards an observer, the angle between the vector from the observer to any grid point of the referenced grid, and its projection on the referenced grid plane, must be between 0.5 and 1.5 degrees. If this is not true, the road reflection table is not applicable.

3.12 AutoCAD Import and Export

Calculux Area allows you to import and export AutoCAD .DXF or .DWG files.

3.12.1 Import

The import function enables you to use an existing AutoCAD drawing as "underlay" in a Calculux project. During import the AutoCAD drawing entities are converted to the basic drawing entities of Calculux (Line, Rectangle, Arc or Text). The AutoCAD drawing is stored in Calculux as a single layer drawing. Editing in Calculux is not possible.

Observe that during import, much of the complexity and detail of the original multi-layered AutoCAD drawing is left out in the flattened, single layer result drawing. Nevertheless, the larger and more complex the import file, the more memory space and processing time the import will require. Therefore:

- Make sure to strip your original drawing from any details and layers which are not relevant for the lighting design.
- Simplify your drawings, as much as possible, to only the relevant two-dimensional line fragments.
- Also, make sure to do this *before* you start the import. As one of the import settings, you can still exclude layers to participate in the result. But they will be processed anyway, thereby extending the processing time.

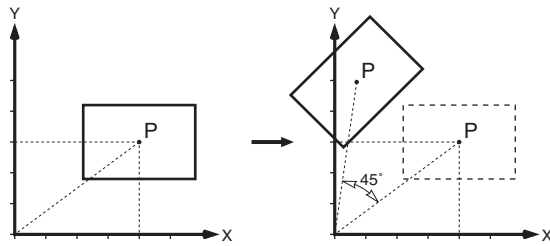
To inspect the AutoCAD drawing, please use world co-ordinates and realise that the Calculux world is from $X = \pm 9999$ to $Y = \pm 9999$.

In Calculux the following AutoCAD DWG-DXF import properties can be set/selected:

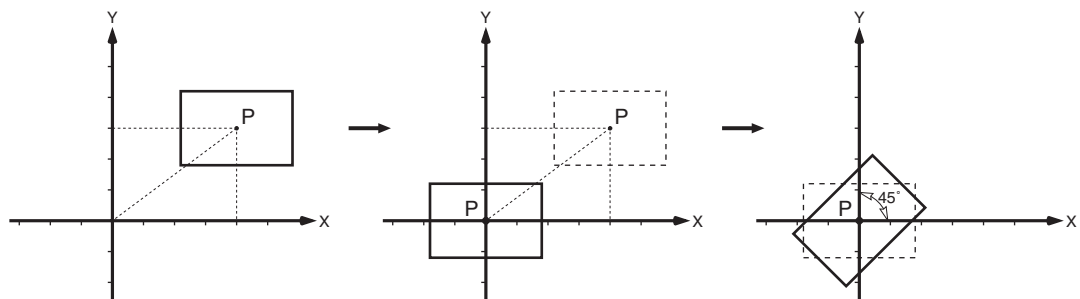
- Layers includes/excludes layers;
- Unit unit used for the drawing;
- Scale (%) scaling of the drawing;
- Rotation the angle of rotation (counter-clockwise) of the drawing around the centre point (0,0,0) of the XYZ co-ordinate system;
- Translation moves the XY position of the drawing in relation to centre point of the XYZ co-ordinate system.

Attention must be paid when rotating a drawing, because the position of the drawing in relation to the centre point (0,0,0) of the XYZ co-ordinate system has great influence on the resulting drawing position.

For example, if a rectangular graph with centre point $P = (4,3)$ is rotated 45° . This will give:



The following example shows the same drawing, but now also translation is applied $(-4,-3)$ when the drawing is rotated 45° . The result of the translation and rotation will be:



3.12.2 Export

The export function enables you to include Calculux calculations in an AutoCAD drawing (.DXF or .DWG format). During export graphical output (lighting installation, aiming arrows, isolux, graphical table and mountain plot) is converted in to an AutoCAD drawing format (.DWG or .DXF). Each graphical output is saved in a separate layer.

For example, assuming your customer has supplied you with an AutoCAD drawing of a sports complex with football fields and some tennis courts. With Calculux you can do the lighting design, then export the lighting design and calculation results as an AutoCAD drawing and import them in the original AutoCAD drawing. The unchanged original AutoCAD drawing, including the lighting design, can then be returned to your customer.

In Calculux the following export properties can be set/selected:

- **Graphs to include** selects which graphical output of your lighting design is included in the AutoCAD drawing;
- **Translation** moves the XY position of the graph in relation to centre point of the XYZ co-ordinate system;
- **Rotation** the angle of rotation (counter-clockwise) of the graph around the centre point (0,0,0) of the XYZ co-ordinate system;
- **Export Format** selects the format of the export file (.DWG or .DXF);


- Version the version of AutoCAD the export file is compatible with (ACAD 10, ACAD 12, etc.).
- ✍ The the export file always contains the graphs of the whole installation, so no separate Luminaires per switching mode.

3.13 Drawings

A drawing is a 2-dimensional shape which you can add to your lighting design. A drawing may be a rectangle, arc, line or text. For example, you can place a drawing outside an application field to illustrate your design (e.g. to represent a nearby construction).

Be aware that if you move the centre coordinates of an application field, the drawing you've added will not move. Drawings appear on screen and in your printed reports if selected, but do not affect your calculations or scaling.

The name and dimensions must be entered before a drawing can be included in a project. The exception is the text option. For this drawing, entering the name, the XYZ coordinates of where the centre of the text should be and the actual text is all that is required.

-  A drawing does not affect the scaling of project overviews, calculation result views and the results of calculations.

3.14 Light-technical Calculations

Two types of calculations can be carried out in Calculux Road:

- Automatic calculations;
- User defined Calculations.

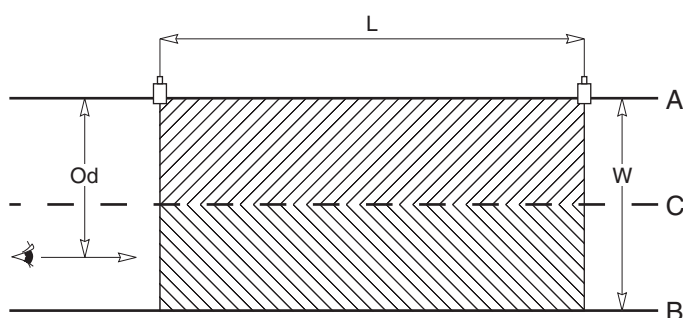
3.14.1 Automatic Calculations

Automatic calculations are directly controlled by the Schemes Editor and are always carried out on one carriageway. The calculation can be performed on the following three different areas, relating to the carriageway:

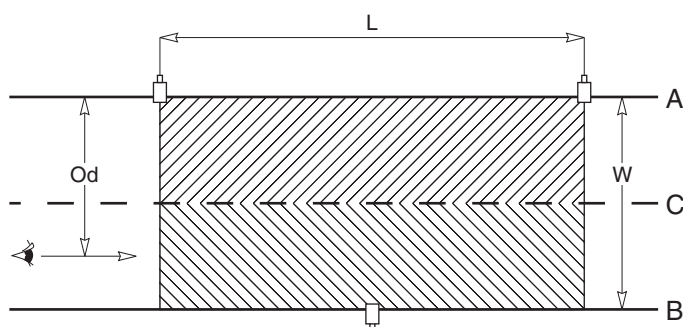
- Main area;
- Surround ratio area (left and right);
- Kerb area (left and right).

Main area

This is defined as the area of a carriageway that lies between two luminaries (on the *same* side or *either* side of the road). The illustrations below show the possible main areas (dependent on the Grid used).




(General main area in pre-defined grid).



(Main area in pre-defined grid; *Staggered installation*).

On these main areas, the following main luminance and/or illuminance calculations can be performed:

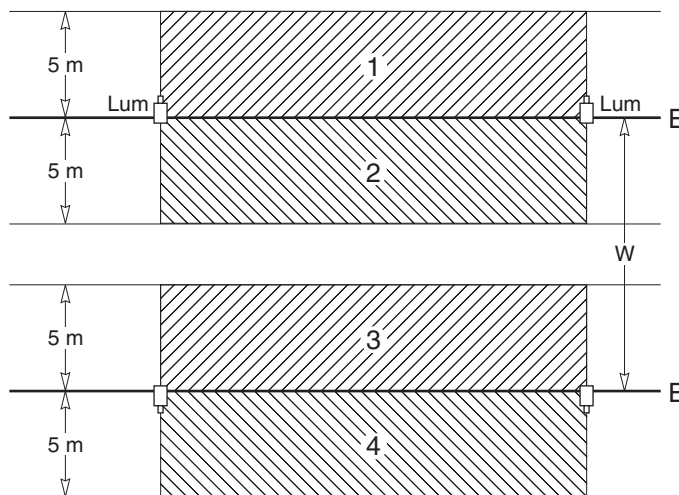
- Plane illuminance (Horizontal and Vertical).
- Semi Cylindrical illuminance.
- Semi Spherical illuminance.
- Glare.
- Road Luminance.

 Horizontal and Vertical illuminance are special types of Plane illuminance.

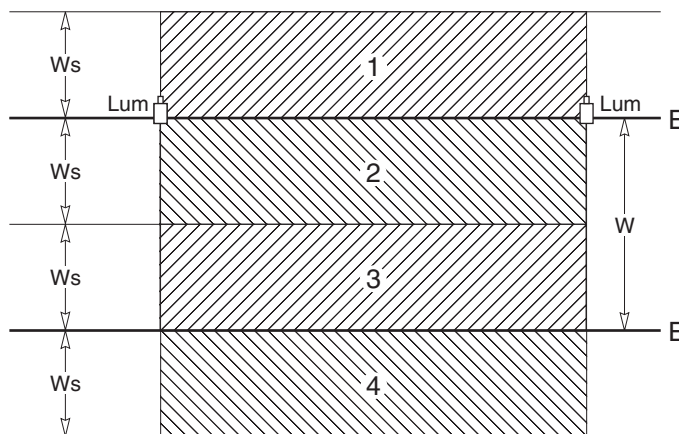
Surround ratio area

The Surround ratio is the average horizontal illuminance on two longitudinal strips each adjacent to the two edges of the carriageway, and lying off the carriageway, divided by the average horizontal illuminance on two longitudinal strips each adjacent to the two edges of the carriageway but lying on the carriageway.

The width of all four strips is the same. If the width of the carriageway is ≥ 10 meters, each strip is 5 meters (see figure).



For carriageways < 10 meters, the width (W_s) of each strip is half the width of the carriageway.



For dual carriageways (separation < 10 meters), both carriageways together are treated as a single carriageway.

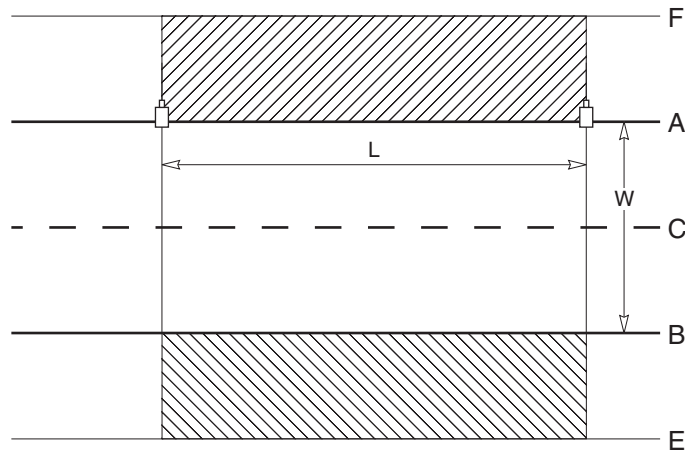
The Surround ratio is calculated using the following formula:

$$\text{Surround ratio} = \frac{\text{Average illuminance of strip 1} + \text{Average illuminance of strip 4}}{\text{Average illuminance of strip 2} + \text{Average illuminance of strip 3}}$$

Kerb area

For some Scandinavian countries (in particular cases), the Average and Minimum/Average hemispherical illuminance for the kerbs, acting as surround areas (see figure below), have to be calculated. For this reason, a kerb is defined on each side of the carriageway.

The width of each kerb is 3.5 meters, with the calculations being carried out on these kerbs.



3.14.2 User defined Calculations

Calculux Road supports the following user defined calculation type:

- Plane Illuminance;
- Semi Cylindrical Illuminance;
- Semi Spherical Illuminance;
- Gradient Calculations;
- Illuminance Uniformity on vertical planes;
- Road Luminance;
- Veiling Luminance;
- Glare Rating;

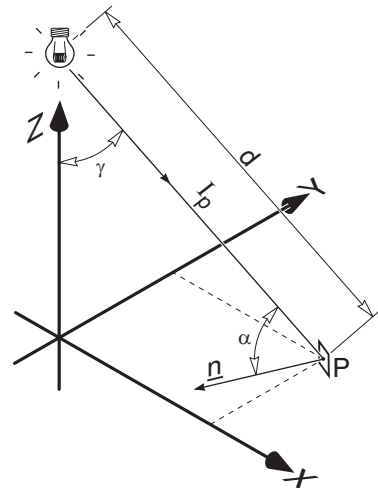
3.14.3 Plane Illuminance

This is the ratio of the luminous flux incident on an infinitely small flat surface to the area of that surface.

The surface can have any orientation. The orientation is defined by the normal vector on the surface.

The plane illuminance (from one light source) at point P on the calculation grid is given by:

$$E_p = \frac{I_p}{d^2} \cos \alpha$$



Variables:

E_p

Meaning:

plane illuminance at point P (lx);

I_p

luminous intensity from the light source in the direction of point P (cd);

d

distance from the source to point P (m);

α

angle between the normal \underline{n} and the light incidence (deg).

This formula assumes that the luminaire is a point source. For fluorescent luminaires, of which the distance between the luminaire and the point P is short in comparison with the dimensions of the luminaire, the above formula is not valid. Calculux has a built-in feature (luminaire splitup) which overcomes this problem. When the luminaire splitup feature is activated, the luminaire is considered to be made up of a number of smaller luminaires with the same light distribution but proportionally smaller lumen output.

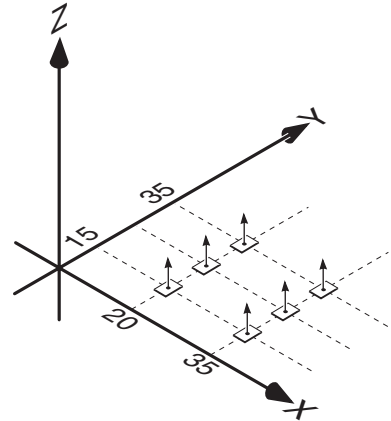
The following types of surface orientation information relating to each point on the grid are recognised by Calculux.

- a) The surface orientation of each point on the grid can be in one of the main directions of the XYZ coordinate system:

Hor +Z

Horizontal +Z grid point.

The surfaces in the grid points, used in the calculation, are orientated towards the positive Z direction.

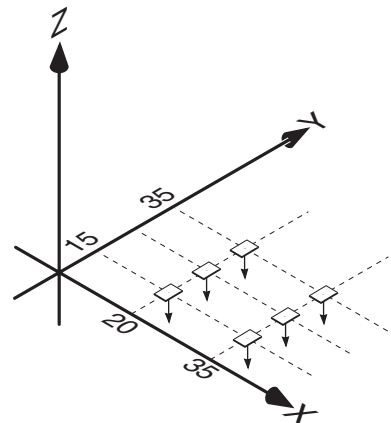


The surfaces are infinitely small planes (one in each grid point) on which the light calculations will be performed.

Hor -Z

Horizontal -Z grid point.

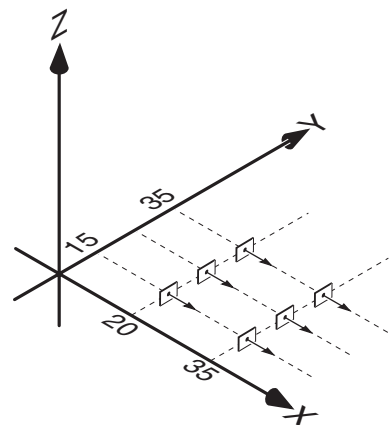
The surfaces in the grid points, used in the calculation, are orientated towards the negative Z direction.



Vert +X

Vertical +X grid point.

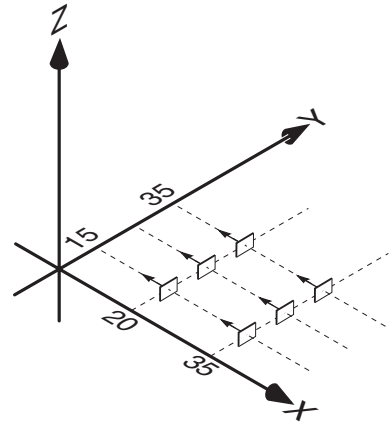
The surfaces in the grid points, used in the calculation, are orientated towards the positive X direction.



Vert -X

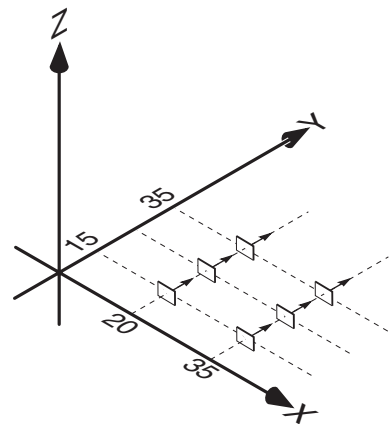
Vertical -X grid point.

The surfaces in the grid points, used in the calculation, are orientated towards the negative X direction.

**Vert +Y**

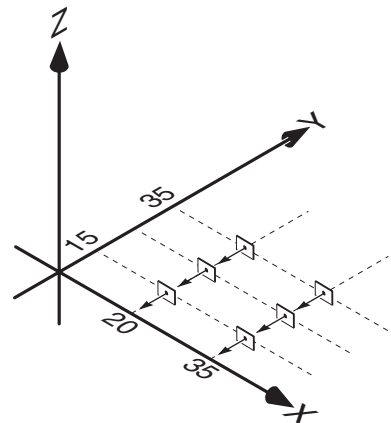
Vertical +Y grid point.

The surfaces in the grid points, used in the calculation, are orientated towards the positive Y direction.

**Vert -Y**

Vertical -Y grid point.

The surfaces in the grid points, used in the calculation, are orientated towards the negative Y direction.

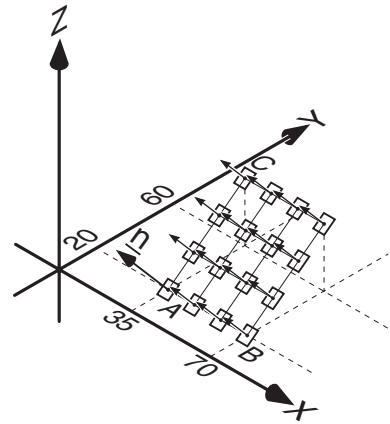


- b) The surface orientation is parallel to the plane that passes through the grid points. This enables the illuminance to be calculated on two sides of the plane through the grid points:

Surface +N

Surface +N grid point.

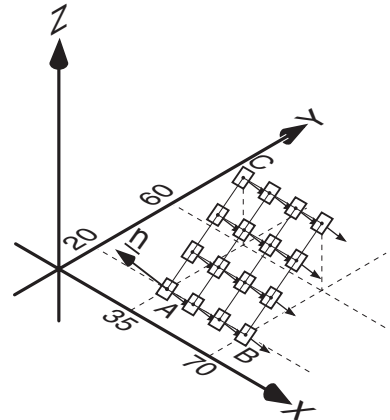
The surfaces in the grid points, used in the calculation, are orientated parallel to the plane which passes through the grid points in positive N direction.



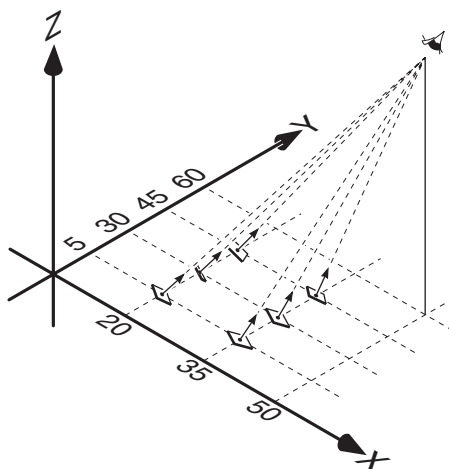
Surface -N

Surface -N grid point.

The surfaces in the grid points, used in the calculation, are orientated parallel to the plane which passes through the grid points in negative N direction.



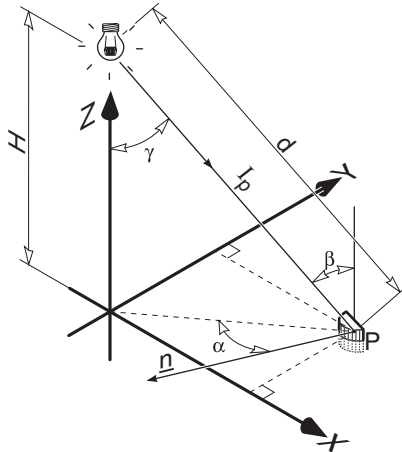
- c) The surface orientation is in the direction of an observer. The normal vector of the surfaces, used in the calculation is orientated towards the observer. In each grid point, the orientation of the surface is different.



3.14.4 Semi Cylindrical Illuminance

This is the ratio of the luminous flux incident on a rounded part of an infinitely small semi cylinder to the area of the rounded part of that semi cylinder.

The base of the semi cylinder always remains parallel to the XY plane. The rounded surface of the semi cylinder, however, can have any orientation.



The semi cylindrical illuminance (from a single light source) at point P on the calculation grid is given by:

$$E_{sc} = \frac{I_p}{\pi d^2} (1 + \cos \alpha) \sin \beta$$

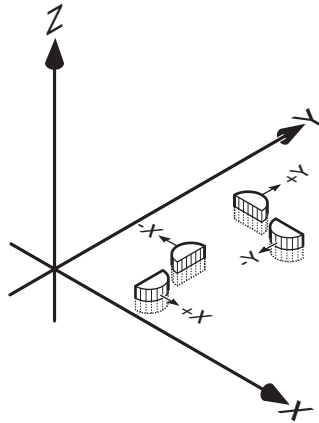
Variables:

Meaning:

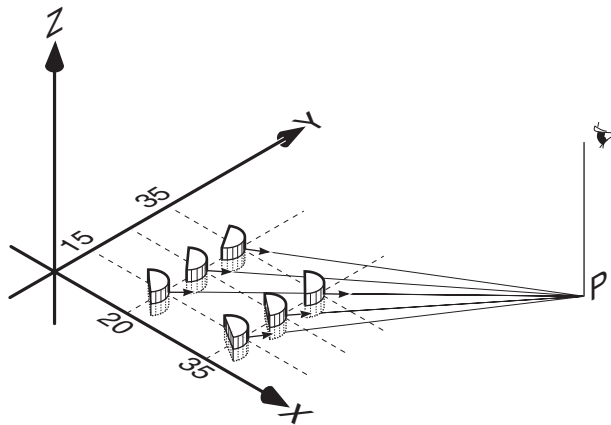
| | |
|----------|--|
| E_{sc} | semi cylindrical illuminance at point P (lx); |
| I_p | luminous intensity of the source in the direction of point P (cd); |
| α | angle between the direction of the projected light incidence and normal \underline{n} (= direction of observation) (deg); |
| β | angle between the direction of light incidence and the normal on the flat part of the semi cylinder (deg); |
| d | distance between the light source and point P (m). |

The following orientation information of the rounded surface is recognised by Calculux:

- The surface orientation of the infinitely small cylindrical surfaces is in one of the main directions of the XYZ coordinate system:
 - Vertical +X;
 - Vertical -X;
 - Vertical +Y;
 - Vertical -Y.



- ✎ The base of each semi cylinder, and thus normal \underline{n} (\rightarrow), is always parallel to the XY plane.
- b) The surface orientation of the infinitely small cylindrical surfaces is in the direction of an observer.

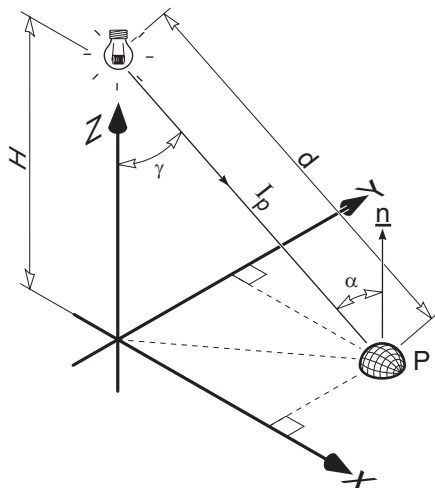


- ✎ As the base of the semi cylinder is always parallel to the XY plane only the X and Y coordinates of the observer need to be specified.

3.14.5 Semi Spherical Illuminance

This is the ratio of the luminous flux incident on an infinitely small semi sphere to the area of that semi sphere.

The semi sphere can have any orientation. The orientation is defined by the normal vector on the surface.



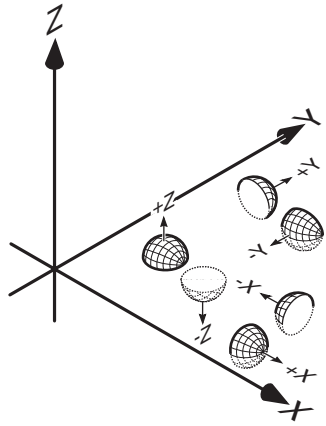
The semi spherical illuminance (from a singular light source) at point P on the calculation grid is given by:

$$E_{\text{sph}} = \frac{I_p}{4d^2} (1 + \cos\alpha)$$

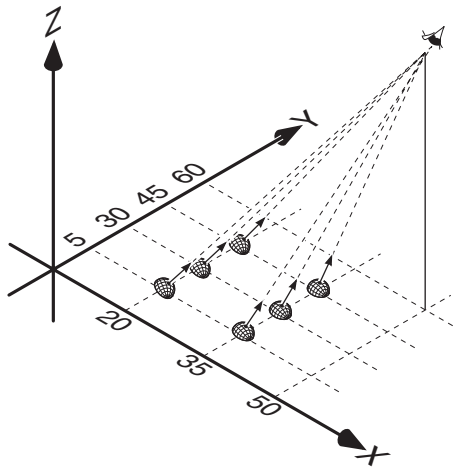
| Variables: | Meaning: |
|------------------|--|
| E_{sph} | semi spherical illuminance at point P (Lx); |
| I_p | luminous intensity of the source in the direction of the point P (cd); |
| α | angle between the direction of light incidence and the normal \underline{n} (deg); |
| d | distance between the light source and the point P (m). |

The following orientation information for the semi sphere is recognised by Calculux:

- a) Surface orientation of the semi sphere in one of the main directions of the XYZ coordinate system:
- Vertical +X;
 - Vertical -X;
 - Vertical +Y;
 - Vertical -Y;
 - Horizontal +Z;
 - Horizontal -Z.



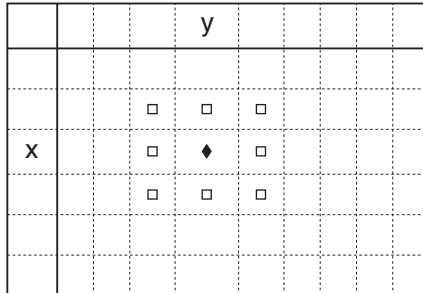
- b) The surface orientation of the infinitely small spherical surfaces is in the direction of an observer. In this case, all semi spheres within the calculation grid will have their normal vector in the direction of the observer.



3.14.6 Gradient Calculations (not always available)

Gradient calculations give an insight in the change of illuminance values on an area of interest (the grid). For each grid point the illuminance is compared with the illuminance of the adjacent grid points. The gradient in a grid point X is defined as the maximum of

$|E_{ij} - E_{xy}| / E_{xy}$ for the eight surrounding points of grid point X (see figure below).



The gradient is given by:

$$U = \text{MAX}_{-1 \leq i \leq 1, -1 \leq j \leq 1, (i,j) \neq (0,0)} \frac{|(E_{x+i, y+j} - E_{x,y}) * (d_{\text{step}} / d((x,y), (x+i, y+j)))|}{E_{xy}} * 100\%$$

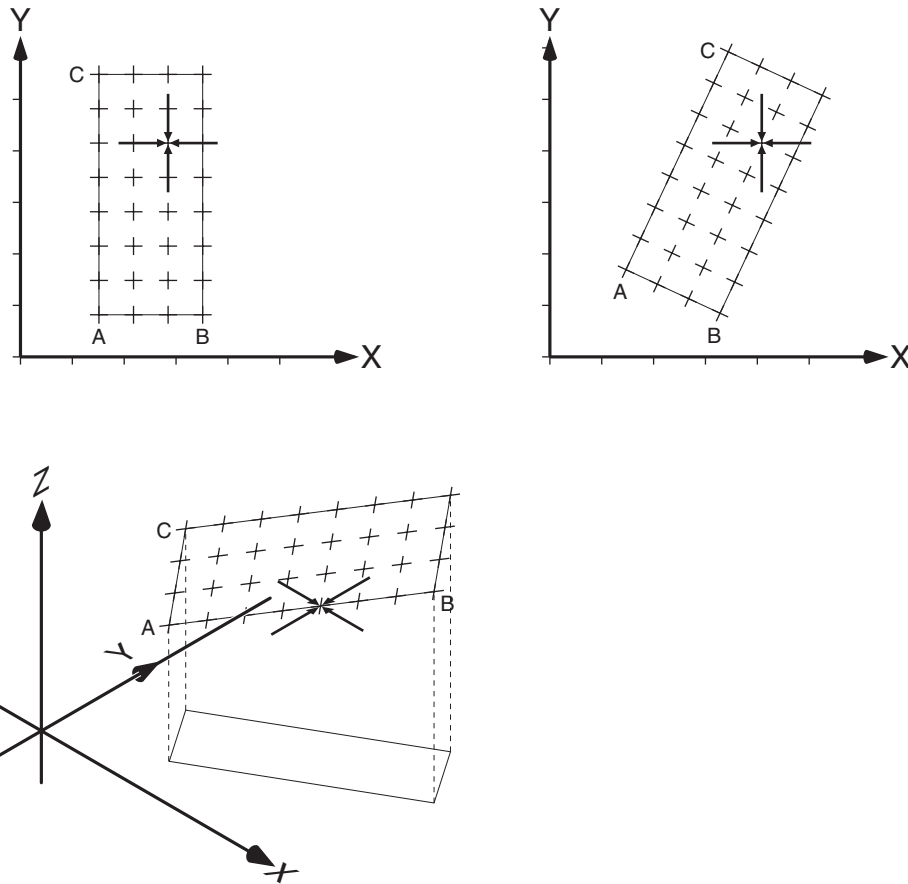
d is the distance between point (x,y) and $(x+i, y+i)$.



- The gradient is connected to an illuminance calculation (plane, semi spherical or semi cylindrical). The values will only be presented in a textual or graphical table. If no textual or graphical table is included for the connected calculation, no output will be generated.
- The step-size for which the gradient is calculated can be defined in the input. A threshold value can be defined. All values below the threshold will not be presented.

3.14.7 Illuminance uniformity on vertical planes

The Illuminance uniformity on vertical planes calculated in each grid point in a grid. The vertical illuminance is calculated in four directions, all parallel to the original co-ordinate axes and perpendicular to the Z-axis (see the figures below).



The uniformity in each point is given by:

$$U = \frac{E_{\text{vertical min}}}{E_{\text{vertical max}}}$$

Variables:

$E_{\text{vertical min}}$

$E_{\text{vertical max}}$

$E_{-x}, E_{+x}, E_{-y}, E_{+y}$

Meaning:

minimum ($E_{-x}, E_{+x}, E_{-y}, E_{+y}$);

maximum ($E_{-x}, E_{+x}, E_{-y}, E_{+y}$);

the illuminances measured from the four directions perpendicular to the Z-axis.

3.14.8 Luminance

In Calculux it is possible to calculate the luminance of a plane through the grid points, assuming that the plane reflects light in a perfectly random way (diffuse reflection) with reflection factor ρ .

The luminance is given by the formula:

$$L_p = \rho \frac{E_p}{\pi}$$

| Variables: | Meaning: |
|------------|---|
| L_p | luminance in point p; |
| E_p | plane illuminance at point p; |
| ρ | reflection factor of the plane through the grid points; |
| π | 3.141593. |

3.14.9 Road Luminance

In order to calculate the surface luminance of a road surface, the reflective properties of the surface must be known.

Luminance Coefficient

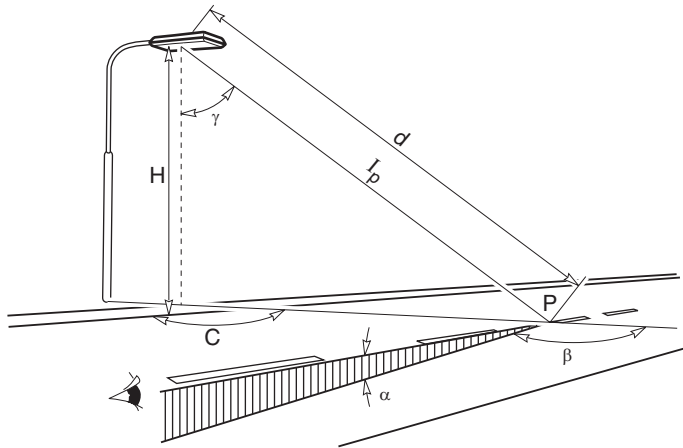
The reflective properties of a surface can be indicated by means of luminance coefficient q . This coefficient is defined as the ratio of the luminance at a point to the horizontal illuminance at the same point (as obtained from a single luminaire):

$$q = \frac{L}{E_h} \quad \text{and} \quad L = q * E_h$$

| Variables: | Meaning: |
|------------|---|
| q | luminance coefficient; |
| L | luminances at a point P (cd/m ²); |
| E_h | horizontal illuminance at point P (Lx). |

The luminance coefficient depends on the position of the observer and the light source relative to the point on the road surface under consideration.

This relation can be described by the angles illustrated in the following figure:



$$q = q(\alpha, \beta, \gamma)$$

To a car driver the area in front of a car (60-160 m ahead) is very important. In this area α only varies between 0.5 and 1.5 degrees. Measurements have shown that, within this α -range, the α -dependency of q can be neglected.

Road Reflection Table

The luminance coefficient of a road surface thus depends on the values of the angles β and γ . The reflection properties of a surface can therefore be specified in a table in which, for each relevant β and γ combination, the q value is given.

Calculux contains a number of Road reflection tables (which are included in the Appendix of this binder).

However, additional tables can be added, provided they have the correct format.

3.14.10 Glare

Glare is the condition of vision in which there is a reduction in the ability to see details or objects due to an unsuitable distribution or range of luminance, or to extreme contrasts.

Glare can occur in one of two possible forms:

- Disability glare glare that impairs the vision;
- Discomfort glare glare that induces a feeling of discomfort.

For outdoor sports and area lighting situations a measure for *disability glare* is 'Glare Rating'. In road lighting applications it is the 'Relative Threshold Increment'. For both, an important measure is the 'Veiling Luminance'.

For road Lighting another measure for *discomfort glare* is the 'Glare Control Mark (G)'.

The above measures are described in the following sections.

Veiling Luminance

Veiling luminance is the loss of visibility performance as a result of glare. The light from glare sources scattered in the direction of the retina will cause a bright veil to be superimposed on the sharp image of the scene in front of the observer.

Veiling Luminance can be caused by the luminaires as well as by the environment.

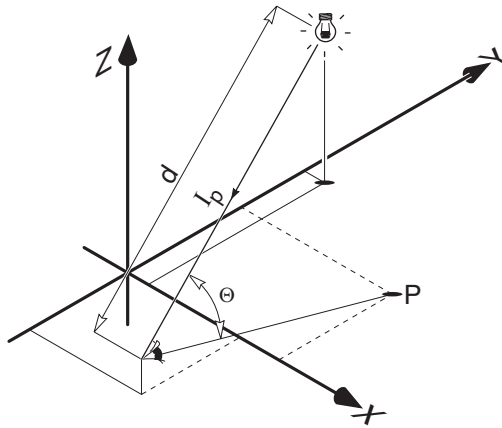
The equivalent veiling luminance L_{vl} (the light produced by the luminaires which is directly incident on the eye) is defined by the following formula:


$$L_{vl} = k \sum_{i=1}^n \frac{E_{eye,i}}{\Theta_i^2}$$

| Variables: | Meaning: |
|-------------|---|
| L_{vl} | equivalent veiling luminance (cd/m ²); |
| $E_{eye,i}$ | illuminance on the observer's eye (in a plane perpendicular to the line of sight) caused by the glare source (L_x); |
| Θ_i | angle between the viewing direction and light incidence of the glare source on the eye (deg); |
| k | age factor (for calculation purposes set to 10); |
| n | total number of light sources. |

For veiling luminance calculations, Θ_i must be more than 1.5 degrees. If this angle is less than 1.5 degrees, the veiling luminance calculations are not valid. Also luminaires with

$\Theta_i > 60$ degrees are not taken into account.



-  For veiling luminance calculations, only the observer location is a calculation point.


Relative Threshold Increment (TI)

This is the measure for the amount of disability glare in a road lighting installation. TI (Threshold Increment) expressed as a percentage is calculated, using the following formula:

$$TI = \frac{(65 * MF^{0.8} * L_{vl})}{L_{av}^{0.8}} \quad \text{for } L_{av} \leq 5$$

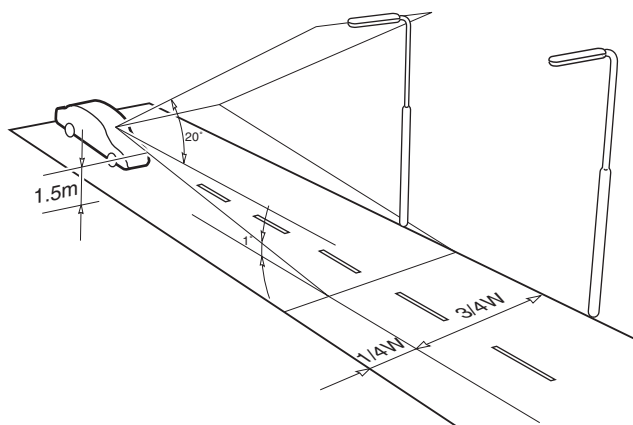
$$TI = \frac{(95 * MF^{1.05} * L_{vl})}{L_{av}^{1.05}} \quad \text{for } L_{av} > 5$$

| Variables: | Meaning: |
|------------|--|
| L_{vl} | equivalent veiling luminance produced directly by the luminaires. (The value is calculated under 'new' conditions); |
| L_{av} | average maintained road luminance; |
| MF | general maintenance factor used to calculate the average luminance. |

 TI is a quality figure of a Road Lighting installation.

Since the position of the driver (observer) relative to the luminaires of the road lighting installation is changing continuously, the Threshold Increment will vary. When the value of the variation is not too high, the variation itself will cause no disturbance. It is therefore sufficient to specify a top limit for the Threshold Increment.

The longitudinal position of the observer at which the Threshold Increment will be a maximum, is dependent upon the screening angle of the vehicle's roof.



This angle has been standardised by the CEN (for the purpose of glare evaluation in road lighting design) at 20 degrees above the horizontal. The TI is only calculated for luminaires within this limit.

The TI calculation is repeated with the observer moved forwards in increments that are same in number and distance as the longitudinal spacing of the grid points. Each line of luminaires (parallel to the road) is extended to 500 meter in front of the observer. For each luminaire in the (extended)line, that is in front of the observer and contributes more than 2% of the sum of all previous ones in that line, the contribution is taken into account. Individual luminaires are also taken in to account.

The lower the level of Threshold Increment, the better the visibility. The following scale provides an insight into the practical meaning of differences in Threshold Increment.

| Threshold Increment (%) | Assessment |
|-------------------------|------------|
| > 20 | Bad |
| 10 | Moderate |
| < 10 | Good |

Calculux Road only:

In Calculux Road the initial position of the observer for TI is automatically calculated by the Schemes editor. The observer is placed on the street in such way that the first luminaire is seen under a screening angle of 20 degrees.

Calculux Area only:

In Calculux Area the initial position of the observer for TI is the same as for the Road Luminance.

Glare Control Mark (G)

Glare Control Mark is a measure of discomfort glare in Road Lighting designs. It is calculated from certain luminaire and installation characteristics. The higher the value of G, the less will be the glare, resulting in a higher visual comfort for the road user.

The Glare Control Mark is given by the formula:

$$G = SLI + 0.97 * \log(L_{av}) + 4.41 * \log(h'') - 1.46 * \log(p)$$

Variables:

SLI

L_{av}

h''

p

Meaning:

specific luminaire index;;

average maintained road luminance;

luminaire height minus eye height;

number of luminaires per kilometer.

The SLI is a luminaire characteristic and is given by:

$$SLI = 13.84 + 3.31 \log I_{80} + 1.3 \left(\log \left(\frac{I_{80}}{I_{88}} \right) \right) * 0.5 - 0.08 \log \left(\frac{I_{80}}{I_{88}} \right) + 1.29 \log F + C$$

Variables:

I_{80}

Meaning:

luminous intensity at an elevation angle of 80 degrees in the $C=0$ plane of the luminaire. This is the new value, so no maintenance factors are taken into account;

I_{80}/I_{88}

ratio of the luminous intensity at an elevation angle of 80 degrees and 88 degrees in the $C=0$ plane;

F

flushed area of the luminaire (m^2);

C

colour factor (dependent on the lamp type).



Calculux will only calculate the Glare Control Mark if the following conditions are met:


- Road Luminance is the selected calculation type.
- Luminaires are placed in straight and continuous rows (≥ 300 meters), all with the same spacing and height above the road. Per row, the orientation must be:
 - \Rightarrow The same for all luminaires in that row.
 - \Rightarrow Perpendicular to the road axis (The $C=90^\circ..C=270^\circ$ plane of the luminaire is perpendicular to the road surface). No luminaire tilt in the $C=0^\circ..C=180^\circ$ plane is allowed.
- Only one luminaire type is used.
- If more than one row of luminaires is used the luminaires must be symmetric around the $C=90^\circ..C=270^\circ$ plane. The maximum number of rows possible is 2.
- $0.3 \leq L_{av} \leq 7$
- $5 \leq h'' \leq 20$
- $20 \leq p \leq 100$
- $SLI > 0$

The following restrictions apply to the calculation of SLI:

- $50 \leq I_{80} \leq 7000$
- $1 \leq I_{80}/I_{88} \leq 50$
- $0.007 \leq F \leq 0.4$

Typical values of G are shown in the following table:

| G | Assessment |
|-----|------------|
| < 3 | Bad |
| 5 | Moderate |
| > 7 | Good |

 The Glare Control Mark is not used very much any more.

3.14.11 Quality Figures

Calculux allows you to show the quality figures of the calculations. Depending on the settings of the Quality Figure tab (see Calculation menu, Presentation...) the following quality figures can be displayed:

Average value calculation

The average value for a grid is worked out by adding the calculated values of each point and dividing it by the number of grid points (grid dimensions; AB, AC).

$$\text{Average} = \frac{\sum \text{calculated values for all individual points}}{(\text{Points AB}) * (\text{Points AC})}$$

Minimum

This is the minimum calculated value.

Maximum

This is the maximum calculated value.

Minimum/maximum

This is the minimum calculated value divided by the maximum calculated value.

Minimum/average

This is the minimum calculated value divided by the average calculated value.

3.15 Report Setup


A very useful feature of Calculux is the report facility. When you have completed a lighting project you can create attractive reports to present the results of the calculations to your customers. By means of the Report Setup you can simply specify the layout of the report and components you wish to include.

For example, you can include, a table of contents, 2-D and 3-D project overviews, a summary, luminaire information (including Polar or Cartesian diagram) and/or financial data.

For detailed information about your calculation results you can include the following presentation formats:

- Textual Table;
- Graphical Table;
- Iso Contour;
- Filled Iso Contour;
- Mountain Plot.

You can also include a summary of your findings and recommendations about the best lighting solutions. If you wish, you can produce reports in several languages.

 The order of the calculation results can be altered (see Calculation Presentations dialogue box). However, the order of the presentation formats is governed by Calculux and cannot be altered.

Calculux enables you also to print a report in portrait or landscape format with the 2D result views rotated 90°. This option (Report menu, Print Setup, Layout tab) can be very useful. For instance, when a report which has to be printed in portrait format contains a landscape formatted 2D result view which looks relatively small. By selecting 'Rotate presentation for Portrait Printing', the 2D result views will be rotated 90°. Because of the rotation the view can be enlarged.

3.16 Cost Calculations

An important factor in any lighting project is the financial cost. Calculux allows you to calculate the expected total investment and annual costs per km for a particular luminaire or luminaire combination.

As calculations are carried out per kilometre (km) road length, no calculations can be performed when additional rows of luminaires are added to the ones generated by the Schemes Editor.

3.16.1 Total Investment

The Total Investment per km is the cost of the luminaires and lamps used in the lighting project. plus the installation costs per km. The Total Investment costs are calculated according to the following formula:

$$\text{Total_Investment(INV)} = (\text{NT} * (\text{LPR} + (\text{LAPR} * \text{NL}))) + \text{INSTC}$$

| Variables: | Meaning: |
|------------|---|
| INSTC: | Installation costs per km; |
| LAPR: | Lamp price for the particular luminaire type; |
| LPR: | Price of the particular luminaire type; |
| NL: | Number of lamps for the particular luminaire; |
| NT: | Number of luminaires of the particular type; |
| INV | Total investment costs per km. |

The installation costs per km (INSTC) consist of three elements:

- Pole costs per km.
- Pole installation cost per km.
- Cabling costs per km.



- Except for a Twin Central installation, each row of luminaires is using a separate cable.
- For a Twin Central installation, only one cable is used.
- Except for a Twin Central installation, each luminaire has one pole (this also applies to a Catenary installation where the cost calculation model assumes one pole for each luminaire). For a Twin Central installation, the two luminaires are on one pole.

3.16.2 Annual costs

The total annual costs per km are calculated according to the following formula:

$$\text{Total Annual Cost} = \text{EN} + \text{AI} + \text{LC} + \text{MC}$$

| Variables: | Meaning: |
|-------------------|---|
| EN: | Energy costs per year; |
| AI: | Annual investments costs for the particular luminaire type; |
| LC: | Lamp replacement costs per year; |
| MC: | Maintenance costs per year. |

The formulas for these costs are:

$$\text{EN} = \frac{\text{KWHPR}}{1000} * \{((\text{NT} * \text{LWATT})) * \text{BRNH}\}$$

$$\text{AI} = \text{AF} * \{\text{NT} * (\text{LPR} + \text{INSTC})\}$$

$$\text{AF} = \frac{\text{R}/100}{1 - \{1/[1 + \text{R}/100]\}^{**\text{N}}}$$

$$\text{LC} = \frac{\{\text{NT} * \text{NL} * \text{LAPR}\}}{\text{RP}}$$

$$\text{MC} = \frac{\{\text{NT} * \text{MCL}\}}{\text{RP}}$$

| Variables: | Meaning: |
|-------------------|---|
| AF | the annuity factor; |
| BRNH | the burning hours per year of the switching mode; |
| INSTC | the installation cost per km; |
| KWHPR | the kilowatt-hour price; |
| LAPR | the lamp price for a particular luminaire type; |
| LPR | the price per luminaire for a particular luminaire type; |
| LWATT | the total watts per luminaire for a particular luminaire type; |
| MCL | the maintenance cost per luminaire for a particular luminaire type; |
| N | the amortization period (years); |
| NT | the number of luminaires of a particular type; |
| NL | the number of lamps per luminaire for a particular luminaire type; |
| R | the interest rate (%); |
| RP | the relamping period (years) for a particular luminaire type. |

3.17 Maintenance Factor/New Value Factor

The Maintenance Factor is the ratio of the average illuminance on the plane under investigation after a specified period of use of the lighting installation, to the average illuminance obtained under the same conditions for a new installation. It is always equal or less than 1 and is used as a multiplier for calculations, based on luminaire light distribution tables.

In some countries the **New Value Factor** (or Inverse Maintenance Factor) is used. Calculux allows you to use new value factors instead of maintenance factors. The 'Inverse Maintenance Factor' is always more than or equal to 1.

The following maintenance factors are specified:

- General Project Maintenance Factor;
- Luminaire Type Maintenance Factor;
- Lamp Maintenance Factor.

3.17.1 General Project Maintenance Factor

This maintenance factor takes into account a general factor with which all calculation results are multiplied. It acts as a safeguarding factor and must reflect the overall conditions of the installation. The value of the 'Project Maintenance Factor' is always equal or less than 1.

3.17.2 Luminaire Type Maintenance Factor

This maintenance factor takes into account the reduction of light output caused by dirt deposited on or in a luminaire. The rate at which the dirt is deposited depends on the construction of the luminaire and the extent of what dirt is present in the environment.

The value of the 'Luminaire Type Maintenance Factor' is always equal or less than 1.

3.17.3 Lamp Maintenance Factor

The Lamp Maintenance Factor value is always equal or less than 1 and consists of two elements:

- a) Lamp Survival Factor;
- b) Lamp Lumen Depreciation Factor.

a) Lamp Survival Factor

This maintenance factor takes into account the percentage of the lamp failures during a specific number of operation hours. It is only applicable when a group replacement is to be carried out. The 'Lamp Survival Factor' is based on the assumptions about the switching cycle, supply voltage and control gear.

b) Lamp Lumen Depreciation Factor.

This maintenance factor takes into account the fact that the luminous output of all lamps decreases with use.



Appendix 1

Road Reflection Tables



Road Reflection TABLES

R-Tables are tables which give the Reflection Characteristics of the roads. They are needed to calculate the Road luminance.

The following R-tables are supplied with the Calculux package:



All R-table files are in ASCII format. If new R-tables are added they must have the extension RTB.

| File name | Name in User Interface | S1 | Q0 |
|------------|------------------------|--------|-------|
| RTAB1.RTB | Concrete CIE C1 | 0.244 | 0.100 |
| RTAB2.RTB | Asphalt CIE C2 | 0.967 | 0.070 |
| RTAB3.RTB | Asphalt CIE R3 | 1.109 | 0.070 |
| RTAB4.RTB | Asphalt (dark) CIE R4 | 1.549 | 0.080 |
| RTAB5.RTB | Wetsurface W1 | 3.152 | 0.110 |
| RTAB6.RTB | Wetsurface W2 | 5.722 | 0.150 |
| RTAB7.RTB | Wetsurface W3 | 8.633 | 0.200 |
| RTAB8.RTB | Wetsurface W4 | 10.842 | 0.250 |
| RTAB9.RTB | CIE CLASS R1 | 0.247 | 0.100 |
| RTAB10.RTB | Concrete CIE R2 | 0.582 | 0.070 |
| RTAB11.RTB | N1 very diffuse | 0.180 | 0.100 |
| RTAB12.RTB | N2 concrete | 0.409 | 0.070 |
| RTAB13.RTB | N3 asphalt | 0.881 | 0.070 |
| RTAB14.RTB | N4 glossy asphalt | 1.607 | 0.080 |
| RTAB15.RTB | ZOAB (Dutch Porous) | 0.689 | 0.100 |
| RTAB16.RTB | Porous Asphalt (UK) | 0.582 | 0.050 |

Tables 1-14 are according to the following CIE publications:

- Publication Nr. 66 1984
Road Surfaces and Lighting
Joint technical report CIE/PIARC
- Publication Nr. 47 1979
Road Lighting for Wet conditions

Table 15 is measured by the KEMA for the Dutch Road Authorities (Rijkswaterstaat). The table represents the properties of dry Porous Asphalt.

Table 16 is recommended by the UK Highways Agency when Porous Asphalt is to be used. The reflection properties are the same as Concrete CIE R2, the only difference is the Q0 value which is 0.05.



It might be that in your Calculux version not all tables are supplied, or that additional tables are supplied. Tables which are not needed can be deleted so they will not show up in the different dialogues.

For more details contact the supplier of your package.

Table A1 RTAB1.RTB

Name = Concrete CIE C1

Q0 = 0.100 s1=0.244

| Beta | 0.0 | 2.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
|------------|------|------|------|------|-------|-------|-------|-------|-------|-------|
| Tan(Gamma) | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 | 150.0 | 165.0 | 180.0 |
| 0.0 | 7700 | 7700 | 7700 | 7700 | 7700 | 7700 | 7700 | 7700 | 7700 | 7700 |
| | 7700 | 7700 | 7700 | 7700 | 7700 | 7700 | 7700 | 7700 | 7700 | 7700 |
| 0.2 | 7100 | 7080 | 7030 | 7100 | 7120 | 7100 | 7080 | 7080 | 7070 | 7040 |
| | 7020 | 7080 | 6980 | 7020 | 7040 | 7140 | 7080 | 7240 | 7190 | 7230 |
| 0.5 | 5860 | 5820 | 5870 | 5810 | 5810 | 5760 | 5700 | 5670 | 5640 | 5560 |
| | 5480 | 5410 | 5310 | 5440 | 5460 | 5620 | 5660 | 5870 | 5810 | 5890 |
| 0.8 | 4680 | 4670 | 4650 | 4550 | 4570 | 4460 | 4300 | 4200 | 4100 | 3990 |
| | 3890 | 3830 | 3730 | 3840 | 3910 | 4120 | 4190 | 4370 | 4380 | 4450 |
| 1.0 | 3780 | 3720 | 3730 | 3630 | 3470 | 3310 | 3140 | 2990 | 2850 | 2730 |
| | 2630 | 2600 | 2500 | 2650 | 2780 | 2950 | 3050 | 3180 | 3230 | 3290 |
| 1.2 | 3080 | 3040 | 3050 | 2850 | 2700 | 2440 | 2180 | 2030 | 1930 | 1850 |
| | 1790 | 1730 | 1730 | 1830 | 1940 | 2070 | 2240 | 2370 | 2380 | 2450 |
| 1.5 | 2580 | 2540 | 2510 | 2290 | 2030 | 1780 | 1570 | 1430 | 1340 | 1280 |
| | 1240 | 1200 | 1200 | 1320 | 1400 | 1550 | 1630 | 1770 | 1790 | 1840 |
| 1.8 | 2170 | 2140 | 2050 | 1820 | 1530 | 1290 | 1100 | 1000 | 950 | 900 |
| | 870 | 840 | 880 | 980 | 1030 | 1160 | 1230 | 1340 | 1370 | 1380 |
| 2.0 | 1880 | 1810 | 1740 | 1420 | 1160 | 950 | 800 | 730 | 690 | 640 |
| | 620 | 640 | 640 | 720 | 780 | 880 | 950 | 1050 | 1080 | 1090 |
| 2.5 | 1450 | 1360 | 1210 | 900 | 660 | 530 | 460 | 410 | 390 | 370 |
| | 360 | 360 | 390 | 440 | 500 | 550 | 600 | 660 | 690 | 710 |
| 3.0 | 1180 | 1080 | 870 | 570 | 410 | 320 | 280 | 260 | 250 | 230 |
| | 220 | 230 | 250 | 280 | 310 | 370 | 410 | 450 | 470 | 510 |
| 3.5 | 970 | 870 | 640 | 390 | 260 | 200 | 180 | 170 | 160 | 150 |
| | 150 | 160 | 170 | 190 | 230 | 270 | 300 | 330 | 350 | 370 |
| 4.0 | 800 | 690 | 500 | 290 | 170 | 140 | 130 | 120 | 110 | 110 |
| | 110 | 110 | 130 | 150 | 170 | 190 | 220 | 260 | 270 | 290 |
| 4.5 | 700 | 580 | 370 | 210 | 130 | 100 | 90 | 80 | 80 | 80 |
| | 80 | 90 | 100 | 120 | 140 | 160 | 170 | 200 | 210 | 220 |
| 5.0 | 600 | 510 | 290 | 150 | 90 | 70 | 70 | 60 | 60 | 60 |
| | 60 | 70 | 70 | 90 | 100 | 120 | 140 | 170 | 170 | 180 |
| 5.5 | 520 | 410 | 230 | 120 | 70 | 60 | 60 | 60 | 50 | 40 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6.0 | 480 | 360 | 190 | 80 | 60 | 50 | 50 | 50 | 50 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6.5 | 440 | 320 | 170 | 70 | 60 | 50 | 50 | 50 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7.0 | 410 | 280 | 140 | 60 | 50 | 40 | 40 | 40 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7.5 | 370 | 260 | 120 | 60 | 40 | 30 | 30 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8.0 | 340 | 230 | 110 | 50 | 40 | 30 | 30 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8.5 | 320 | 210 | 90 | 50 | 40 | 30 | 30 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9.0 | 290 | 190 | 80 | 40 | 30 | 30 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9.5 | 270 | 170 | 70 | 40 | 30 | 30 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10.0 | 260 | 160 | 60 | 30 | 30 | 30 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10.5 | 250 | 160 | 60 | 30 | 20 | 10 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11.0 | 230 | 150 | 60 | 30 | 20 | 10 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11.5 | 220 | 140 | 60 | 30 | 20 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12.0 | 210 | 140 | 50 | 30 | 20 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table A2 RTAB2.RTB

Name = Asphalt CIE C2

Q0 = 0.070 s1=0.967

| Beta | 0.0 | 2.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
|------------|------|------|------|------|-------|-------|-------|-------|-------|-------|
| Tan(Gamma) | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 | 150.0 | 165.0 | 180.0 |
| 0.0 | 4700 | 4700 | 4700 | 4700 | 4700 | 4700 | 4700 | 4700 | 4700 | 4700 |
| 0.2 | 4700 | 4700 | 4700 | 4700 | 4700 | 4700 | 4700 | 4700 | 4700 | 4700 |
| 0.5 | 5171 | 5114 | 5300 | 5200 | 5300 | 5271 | 5171 | 5100 | 5014 | 4986 |
| 0.8 | 4971 | 4857 | 4686 | 4457 | 4271 | 4200 | 4257 | 4114 | 4171 | 4014 |
| 1.0 | 5414 | 5257 | 5357 | 5329 | 5243 | 5129 | 5000 | 4857 | 4686 | 4529 |
| 1.2 | 4371 | 4000 | 3800 | 3557 | 3386 | 3386 | 3300 | 3300 | 3243 | 3357 |
| 1.5 | 5429 | 5357 | 5400 | 5214 | 5014 | 4771 | 4500 | 4214 | 3929 | 3657 |
| 1.8 | 3414 | 3114 | 2829 | 2543 | 2500 | 2514 | 2514 | 2414 | 2500 | 2514 |
| 2.0 | 5314 | 5357 | 5314 | 5057 | 4500 | 3957 | 3471 | 3157 | 2929 | 2743 |
| 2.5 | 2586 | 2171 | 1914 | 1857 | 1786 | 1771 | 1786 | 1843 | 1829 | 1829 |
| 3.0 | 5357 | 5329 | 5029 | 4543 | 3786 | 3157 | 2700 | 2371 | 2143 | 1943 |
| 3.5 | 1786 | 1529 | 1300 | 1329 | 1300 | 1300 | 1257 | 1343 | 1386 | 1386 |
| 4.0 | 5057 | 5029 | 4800 | 3871 | 3043 | 2429 | 2000 | 1729 | 1557 | 1386 |
| 4.5 | 1243 | 1086 | 957 | 929 | 943 | 943 | 957 | 971 | 1014 | 1014 |
| 5.0 | 4757 | 4671 | 4314 | 3171 | 2371 | 1843 | 1486 | 1286 | 1071 | 971 |
| 5.5 | 900 | 757 | 729 | 700 | 700 | 671 | 743 | 729 | 757 | 771 |
| 6.0 | 4543 | 4429 | 3800 | 2571 | 1729 | 1286 | 1071 | 886 | 771 | 714 |
| 6.5 | 686 | 571 | 571 | 543 | 543 | 543 | 586 | 586 | 614 | 643 |
| 7.0 | 3829 | 3743 | 2929 | 1700 | 1029 | 714 | 586 | 514 | 471 | 414 |
| 7.5 | 371 | 357 | 329 | 343 | 357 | 343 | 371 | 386 | 414 | 400 |
| 8.0 | 3243 | 3100 | 2100 | 1057 | 600 | 414 | 357 | 329 | 300 | 271 |
| 8.5 | 257 | 229 | 229 | 243 | 257 | 243 | 271 | 300 | 300 | 329 |
| 9.0 | 2771 | 2400 | 1514 | 671 | 429 | 314 | 243 | 200 | 186 | 171 |
| 9.5 | 171 | 157 | 143 | 157 | 171 | 186 | 214 | 200 | 214 | 200 |
| 10.0 | 2400 | 1943 | 1086 | 486 | 271 | 200 | 186 | 157 | 143 | 143 |
| 10.5 | 143 | 114 | 114 | 129 | 143 | 129 | 157 | 171 | 157 | 186 |
| 11.0 | 2014 | 1586 | 771 | 300 | 200 | 157 | 129 | 114 | 114 | 114 |
| 11.5 | 114 | 100 | 100 | 114 | 114 | 114 | 114 | 143 | 143 | 157 |
| 12.0 | 1800 | 1286 | 614 | 243 | 143 | 114 | 114 | 100 | 86 | 86 |
| 12.5 | 100 | 86 | 100 | 86 | 86 | 100 | 114 | 114 | 114 | 129 |
| 13.0 | 1529 | 1129 | 457 | 171 | 114 | 100 | 100 | 100 | 86 | 71 |
| 13.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14.0 | 1343 | 929 | 371 | 143 | 100 | 86 | 86 | 86 | 71 | 0 |
| 14.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15.0 | 1229 | 800 | 300 | 114 | 100 | 86 | 71 | 71 | 0 | 0 |
| 15.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16.0 | 1114 | 714 | 243 | 100 | 71 | 71 | 71 | 71 | 0 | 0 |
| 16.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17.0 | 1000 | 586 | 200 | 100 | 57 | 43 | 57 | 0 | 0 | 0 |
| 17.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18.0 | 900 | 529 | 157 | 71 | 57 | 57 | 57 | 0 | 0 | 0 |
| 18.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19.0 | 857 | 529 | 143 | 71 | 57 | 57 | 57 | 0 | 0 | 0 |
| 19.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20.0 | 800 | 457 | 129 | 71 | 57 | 43 | 0 | 0 | 0 | 0 |
| 20.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21.0 | 757 | 400 | 129 | 57 | 57 | 57 | 0 | 0 | 0 | 0 |
| 21.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22.0 | 743 | 386 | 100 | 71 | 57 | 43 | 0 | 0 | 0 | 0 |
| 22.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23.0 | 643 | 329 | 100 | 57 | 43 | 43 | 0 | 0 | 0 | 0 |
| 23.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24.0 | 614 | 314 | 100 | 43 | 43 | 43 | 0 | 0 | 0 | 0 |
| 24.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25.0 | 757 | 314 | 100 | 43 | 43 | 0 | 0 | 0 | 0 | 0 |
| 25.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26.0 | 600 | 286 | 100 | 57 | 43 | 0 | 0 | 0 | 0 | 0 |
| 26.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table A3 RTAB3.RTB

Name = Asphalt CIE R3

Q0 = 0.070 S1 = 1.109

| Beta | 0.0 | 2.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
|------------|------|------|------|------|-------|-------|-------|-------|-------|-------|
| Tan(Gamma) | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 | 150.0 | 165.0 | 180.0 |
| 0.0 | 4200 | 4200 | 4200 | 4200 | 4200 | 4200 | 4200 | 4200 | 4200 | 4200 |
| 0.2 | 4657 | 4657 | 4585 | 4585 | 4528 | 4457 | 4400 | 4400 | 4328 | 4257 |
| 0.5 | 4914 | 4914 | 4842 | 4842 | 4657 | 4528 | 4400 | 4257 | 4128 | 3942 |
| 0.8 | 5100 | 5042 | 5042 | 4842 | 4585 | 4328 | 4071 | 3814 | 3485 | 3171 |
| 1.0 | 5171 | 5171 | 5028 | 4657 | 3942 | 3557 | 3228 | 2914 | 2585 | 2257 |
| 1.2 | 5100 | 5100 | 4971 | 4257 | 3485 | 2971 | 2514 | 2200 | 1942 | 1685 |
| 1.5 | 5042 | 4971 | 4657 | 3814 | 3100 | 2514 | 2071 | 1671 | 1428 | 1228 |
| 1.8 | 4842 | 4785 | 4328 | 3300 | 2457 | 1814 | 1485 | 1271 | 1128 | 1000 |
| 2.0 | 4657 | 4585 | 4000 | 2714 | 1942 | 1428 | 1171 | 1014 | 885 | 771 |
| 2.5 | 4128 | 4000 | 3171 | 1814 | 1228 | 928 | 771 | 628 | 542 | 485 |
| 3.0 | 3614 | 3357 | 2328 | 1214 | 757 | 542 | 442 | 357 | 328 | 285 |
| 3.5 | 3100 | 2771 | 1742 | 857 | 500 | 357 | 314 | 271 | 228 | 214 |
| 4.0 | 2714 | 2328 | 1285 | 614 | 371 | 285 | 228 | 200 | 171 | 142 |
| 4.5 | 2328 | 1942 | 1042 | 442 | 285 | 214 | 171 | 142 | 128 | 114 |
| 5.0 | 2071 | 1557 | 857 | 342 | 228 | 171 | 128 | 114 | 114 | 100 |
| 5.5 | 1814 | 1342 | 671 | 257 | 200 | 142 | 114 | 100 | 85 | 85 |
| 6.0 | 1614 | 1100 | 514 | 214 | 157 | 128 | 114 | 100 | 71 | 0 |
| 6.5 | 1485 | 971 | 428 | 157 | 114 | 85 | 71 | 57 | 0 | 0 |
| 7.0 | 1357 | 857 | 342 | 128 | 100 | 71 | 57 | 42 | 0 | 0 |
| 7.5 | 1242 | 757 | 300 | 100 | 71 | 57 | 57 | 0 | 0 | 0 |
| 8.0 | 1185 | 671 | 242 | 85 | 57 | 57 | 42 | 0 | 0 | 0 |
| 8.5 | 1114 | 600 | 214 | 71 | 57 | 42 | 42 | 0 | 0 | 0 |
| 9.0 | 1042 | 542 | 171 | 57 | 42 | 28 | 0 | 0 | 0 | 0 |
| 9.5 | 985 | 485 | 142 | 57 | 57 | 28 | 0 | 0 | 0 | 0 |
| 10.0 | 928 | 457 | 128 | 42 | 28 | 28 | 0 | 0 | 0 | 0 |
| 10.5 | 885 | 414 | 114 | 42 | 28 | 28 | 0 | 0 | 0 | 0 |
| 11.0 | 842 | 371 | 100 | 42 | 28 | 28 | 0 | 0 | 0 | 0 |
| 11.5 | 800 | 342 | 85 | 28 | 28 | 0 | 0 | 0 | 0 | 0 |
| 12.0 | 757 | 314 | 85 | 28 | 28 | 0 | 0 | 0 | 0 | 0 |

Table A4 RTAB4.RTB

Name = Asphalt (dark) CIE R4

Q0 = 0.080

S1 = 1.549

| Beta | 0.0 | 2.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
|------------|------|------|------|------|-------|-------|-------|-------|-------|-------|
| Tan(Gamma) | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 | 150.0 | 165.0 | 180.0 |
| 0.0 | 3300 | 3300 | 3300 | 3300 | 3300 | 3300 | 3300 | 3300 | 3300 | 3300 |
| 0.2 | 3712 | 3962 | 3962 | 3962 | 3962 | 3875 | 3800 | 3625 | 3550 | 3462 |
| 0.5 | 4125 | 4287 | 4287 | 4287 | 4125 | 3875 | 3712 | 3550 | 3462 | 3300 |
| 0.8 | 4700 | 4787 | 4625 | 4375 | 4125 | 3800 | 3462 | 3137 | 2887 | 2637 |
| 1.0 | 4950 | 4950 | 4950 | 4125 | 3625 | 3137 | 2725 | 2475 | 2312 | 2062 |
| 1.2 | 5037 | 5112 | 4625 | 3875 | 3137 | 2637 | 2225 | 1900 | 1650 | 1437 |
| 1.5 | 5112 | 4950 | 4450 | 3550 | 2725 | 2150 | 1737 | 1437 | 1250 | 1100 |
| 1.8 | 5112 | 4950 | 4287 | 3137 | 2225 | 1737 | 1350 | 1100 | 937 | 825 |
| 2.0 | 5112 | 4787 | 3962 | 2800 | 1812 | 1325 | 1075 | 887 | 737 | 662 |
| 2.5 | 4950 | 4450 | 3300 | 1900 | 1250 | 912 | 687 | 562 | 462 | 400 |
| 3.0 | 4625 | 3800 | 2637 | 1187 | 787 | 550 | 375 | 312 | 262 | 212 |
| 3.5 | 4287 | 3387 | 2062 | 787 | 500 | 325 | 237 | 187 | 162 | 150 |
| 4.0 | 3962 | 2975 | 1650 | 562 | 300 | 200 | 162 | 137 | 125 | 112 |
| 4.5 | 3712 | 2637 | 1325 | 412 | 212 | 137 | 112 | 100 | 87 | 87 |
| 5.0 | 3462 | 2312 | 987 | 300 | 162 | 100 | 87 | 75 | 75 | 62 |
| 5.5 | 3212 | 2012 | 737 | 237 | 125 | 87 | 75 | 62 | 62 | 50 |
| 6.0 | 3050 | 1750 | 575 | 162 | 100 | 75 | 62 | 50 | 50 | 0 |
| 6.5 | 2887 | 1525 | 462 | 137 | 75 | 62 | 50 | 37 | 0 | 0 |
| 7.0 | 2725 | 1325 | 400 | 112 | 62 | 50 | 37 | 37 | 0 | 0 |
| 7.5 | 2562 | 1175 | 325 | 100 | 50 | 37 | 37 | 0 | 0 | 0 |
| 8.0 | 2412 | 1025 | 275 | 75 | 50 | 37 | 25 | 0 | 0 | 0 |
| 8.5 | 2300 | 925 | 237 | 62 | 37 | 37 | 25 | 0 | 0 | 0 |
| 9.0 | 2175 | 825 | 200 | 62 | 37 | 25 | 0 | 0 | 0 | 0 |
| 9.5 | 2112 | 737 | 162 | 50 | 37 | 25 | 0 | 0 | 0 | 0 |
| 10.0 | 2050 | 662 | 150 | 50 | 25 | 25 | 0 | 0 | 0 | 0 |
| 10.5 | 1975 | 612 | 137 | 37 | 25 | 25 | 0 | 0 | 0 | 0 |
| 11.0 | 1912 | 562 | 125 | 37 | 25 | 25 | 0 | 0 | 0 | 0 |
| 11.5 | 1862 | 512 | 100 | 37 | 25 | 0 | 0 | 0 | 0 | 0 |
| 12.0 | 1812 | 462 | 100 | 37 | 25 | 0 | 0 | 0 | 0 | 0 |

Table A5 RTAB5.RTB

Name = Wet surface W1

Q0 = 0.110 S1=3.152

| Beta | 0.0 | 2.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
|------------|-------|-------|------|------|-------|-------|-------|-------|-------|-------|
| Tan(Gamma) | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 | 150.0 | 165.0 | 180.0 |
| 0.0 | 3456 | 3456 | 3456 | 3456 | 3456 | 3456 | 3456 | 3456 | 3456 | 3456 |
| 0.2 | 3456 | 3456 | 3456 | 3456 | 3456 | 3456 | 3456 | 3456 | 3456 | 3456 |
| 0.5 | 3736 | 3736 | 3736 | 3728 | 3710 | 3666 | 3622 | 3587 | 3552 | 3491 |
| 0.8 | 3429 | 3307 | 3184 | 3114 | 3079 | 3070 | 3052 | 3070 | 3070 | 3087 |
| 1.0 | 4394 | 4377 | 4333 | 4219 | 4026 | 3815 | 3614 | 3412 | 3219 | 3035 |
| 1.2 | 2859 | 2561 | 2386 | 2333 | 2315 | 2368 | 2394 | 2447 | 2473 | 2491 |
| 1.5 | 5683 | 5622 | 5455 | 5052 | 4491 | 3894 | 3377 | 2973 | 2614 | 2342 |
| 1.8 | 2096 | 1737 | 1605 | 1605 | 1640 | 1710 | 1754 | 1833 | 1859 | 1894 |
| 2.0 | 7306 | 7175 | 6780 | 5710 | 4587 | 3605 | 2833 | 2298 | 1859 | 1605 |
| 2.5 | 1386 | 1123 | 1061 | 1088 | 1140 | 1210 | 1272 | 1333 | 1368 | 1395 |
| 3.0 | 8823 | 8560 | 7736 | 5929 | 4245 | 3008 | 2123 | 1640 | 1272 | 1061 |
| 3.5 | 895 | 737 | 710 | 746 | 798 | 860 | 921 | 982 | 1009 | 1026 |
| 4.0 | 9981 | 9508 | 8157 | 5561 | 3526 | 2324 | 1535 | 1131 | 833 | 693 |
| 4.5 | 579 | 491 | 491 | 526 | 570 | 631 | 675 | 728 | 754 | 772 |
| 5.0 | 10683 | 10008 | 8201 | 4859 | 2780 | 1702 | 1044 | 763 | 553 | 465 |
| 5.5 | 395 | 342 | 342 | 386 | 421 | 465 | 509 | 553 | 570 | 588 |
| 6.0 | 10893 | 10025 | 7692 | 4035 | 2131 | 1245 | 728 | 526 | 377 | 325 |
| 6.5 | 272 | 246 | 254 | 281 | 316 | 360 | 395 | 421 | 447 | 465 |
| 7.0 | 10385 | 9139 | 6104 | 2570 | 1210 | 658 | 360 | 263 | 193 | 167 |
| 7.5 | 149 | 140 | 149 | 175 | 193 | 228 | 246 | 272 | 298 | 307 |
| 8.0 | 9271 | 7683 | 4324 | 1561 | 649 | 351 | 193 | 149 | 114 | 96 |
| 8.5 | 88 | 88 | 96 | 114 | 132 | 149 | 167 | 193 | 202 | 210 |
| 9.0 | 8017 | 6227 | 2982 | 921 | 360 | 202 | 114 | 88 | 70 | 61 |
| 9.5 | 61 | 61 | 70 | 79 | 96 | 105 | 123 | 140 | 149 | 158 |
| 10.0 | 6754 | 4806 | 2017 | 570 | 193 | 114 | 70 | 61 | 53 | 44 |
| 10.5 | 44 | 44 | 53 | 61 | 70 | 79 | 96 | 105 | 114 | 114 |
| 11.0 | 5499 | 3605 | 1368 | 351 | 123 | 79 | 53 | 44 | 35 | 35 |
| 11.5 | 35 | 35 | 35 | 44 | 53 | 61 | 70 | 79 | 88 | 96 |
| 12.0 | 4456 | 2763 | 956 | 228 | 79 | 53 | 35 | 35 | 26 | 26 |
| 12.5 | 26 | 26 | 35 | 35 | 44 | 53 | 61 | 61 | 70 | 79 |
| 13.0 | 3631 | 2105 | 658 | 149 | 53 | 44 | 35 | 26 | 26 | 18 |
| 13.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14.0 | 2956 | 1640 | 474 | 105 | 44 | 35 | 26 | 18 | 18 | 0 |
| 14.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15.0 | 2438 | 1298 | 342 | 79 | 35 | 26 | 18 | 18 | 0 | 0 |
| 15.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16.0 | 2052 | 1044 | 272 | 61 | 26 | 18 | 18 | 18 | 0 | 0 |
| 16.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17.0 | 1745 | 860 | 210 | 53 | 26 | 18 | 18 | 0 | 0 | 0 |
| 17.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18.0 | 1491 | 702 | 167 | 35 | 26 | 18 | 18 | 0 | 0 | 0 |
| 18.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19.0 | 1272 | 579 | 132 | 35 | 18 | 18 | 18 | 0 | 0 | 0 |
| 19.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20.0 | 1105 | 491 | 114 | 26 | 18 | 18 | 0 | 0 | 0 | 0 |
| 20.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21.0 | 974 | 421 | 96 | 26 | 18 | 18 | 0 | 0 | 0 | 0 |
| 21.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22.0 | 860 | 368 | 79 | 18 | 18 | 9 | 0 | 0 | 0 | 0 |
| 22.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23.0 | 763 | 325 | 61 | 18 | 18 | 9 | 0 | 0 | 0 | 0 |
| 23.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24.0 | 684 | 298 | 61 | 18 | 18 | 9 | 0 | 0 | 0 | 0 |
| 24.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25.0 | 623 | 263 | 53 | 18 | 18 | 0 | 0 | 0 | 0 | 0 |
| 25.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26.0 | 570 | 246 | 44 | 18 | 9 | 0 | 0 | 0 | 0 | 0 |
| 26.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table A6 RTAB6.RTB

Name = Wet surface W2

Q0 = 0.150 S1=5.722

| Beta | 0.0 | 2.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
|------------|-------|-------|------|------|-------|-------|-------|-------|-------|-------|
| Tan(Gamma) | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 | 150.0 | 165.0 | 180.0 |
| 0.0 | 2273 | 2273 | 2273 | 2273 | 2273 | 2273 | 2273 | 2273 | 2273 | 2273 |
| 0.2 | 2273 | 2273 | 2273 | 2273 | 2273 | 2273 | 2273 | 2273 | 2273 | 2273 |
| 0.5 | 2439 | 2433 | 2433 | 2413 | 2406 | 2373 | 2346 | 2320 | 2293 | 2260 |
| 0.8 | 2220 | 2140 | 2060 | 2034 | 2007 | 2021 | 2027 | 2047 | 2040 | 2047 |
| 1.0 | 2891 | 2871 | 2838 | 2772 | 2665 | 2519 | 2379 | 2233 | 2094 | 1987 |
| 1.2 | 1881 | 1682 | 1549 | 1542 | 1549 | 1582 | 1602 | 1642 | 1648 | 1668 |
| 1.5 | 4127 | 4108 | 3995 | 3649 | 3184 | 2718 | 2313 | 1994 | 1715 | 1529 |
| 1.8 | 1363 | 1137 | 1070 | 1077 | 1097 | 1143 | 1176 | 1230 | 1243 | 1263 |
| 2.0 | 5995 | 5989 | 5636 | 4699 | 3589 | 2645 | 1947 | 1529 | 1196 | 1017 |
| 2.5 | 864 | 731 | 711 | 738 | 764 | 811 | 844 | 891 | 911 | 931 |
| 3.0 | 8295 | 8149 | 7378 | 5244 | 3529 | 2273 | 1462 | 1057 | 764 | 651 |
| 3.5 | 552 | 479 | 472 | 505 | 532 | 572 | 605 | 651 | 665 | 678 |
| 4.0 | 10342 | 9943 | 8361 | 5231 | 2951 | 1715 | 990 | 705 | 498 | 425 |
| 4.5 | 359 | 319 | 326 | 352 | 379 | 419 | 445 | 479 | 492 | 512 |
| 5.0 | 11950 | 11226 | 8793 | 4633 | 2340 | 1263 | 678 | 472 | 326 | 279 |
| 5.5 | 239 | 226 | 233 | 259 | 279 | 306 | 332 | 359 | 372 | 385 |
| 6.0 | 13007 | 11911 | 8547 | 3835 | 1728 | 877 | 445 | 312 | 226 | 193 |
| 6.5 | 173 | 160 | 173 | 186 | 206 | 239 | 253 | 279 | 292 | 299 |
| 7.0 | 13758 | 11711 | 7211 | 2499 | 851 | 432 | 219 | 160 | 120 | 106 |
| 7.5 | 93 | 93 | 100 | 113 | 126 | 146 | 160 | 179 | 186 | 193 |
| 8.0 | 13313 | 10568 | 5357 | 1436 | 432 | 213 | 106 | 86 | 66 | 60 |
| 8.5 | 60 | 60 | 66 | 73 | 86 | 100 | 106 | 120 | 126 | 133 |
| 9.0 | 12077 | 8906 | 3755 | 831 | 226 | 120 | 60 | 47 | 40 | 33 |
| 9.5 | 33 | 40 | 40 | 53 | 60 | 73 | 80 | 86 | 93 | 100 |
| 10.0 | 10482 | 7225 | 2546 | 472 | 133 | 73 | 40 | 33 | 27 | 27 |
| 10.5 | 27 | 27 | 33 | 40 | 40 | 53 | 60 | 66 | 73 | 73 |
| 11.0 | 8753 | 5583 | 1615 | 266 | 80 | 47 | 27 | 20 | 20 | 20 |
| 11.5 | 20 | 20 | 27 | 27 | 33 | 40 | 47 | 53 | 60 | 60 |
| 12.0 | 7198 | 4287 | 1070 | 166 | 53 | 33 | 20 | 20 | 13 | 13 |
| 12.5 | 13 | 20 | 20 | 20 | 27 | 33 | 33 | 40 | 47 | 47 |
| 13.0 | 5889 | 3250 | 731 | 106 | 33 | 27 | 20 | 13 | 13 | 7 |
| 13.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14.0 | 4898 | 2539 | 512 | 73 | 27 | 20 | 13 | 13 | 13 | 0 |
| 14.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15.0 | 4101 | 2001 | 366 | 53 | 20 | 13 | 13 | 13 | 0 | 0 |
| 15.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16.0 | 3423 | 1589 | 266 | 40 | 20 | 13 | 13 | 7 | 0 | 0 |
| 16.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17.0 | 2871 | 1269 | 206 | 27 | 13 | 13 | 13 | 0 | 0 | 0 |
| 17.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18.0 | 2439 | 1030 | 160 | 27 | 13 | 13 | 7 | 0 | 0 | 0 |
| 18.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19.0 | 2074 | 831 | 120 | 20 | 13 | 7 | 7 | 0 | 0 | 0 |
| 19.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20.0 | 1775 | 685 | 93 | 20 | 13 | 7 | 0 | 0 | 0 | 0 |
| 20.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21.0 | 1529 | 578 | 73 | 13 | 7 | 7 | 0 | 0 | 0 | 0 |
| 21.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22.0 | 1316 | 485 | 66 | 13 | 7 | 7 | 0 | 0 | 0 | 0 |
| 22.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23.0 | 1150 | 419 | 53 | 13 | 7 | 7 | 0 | 0 | 0 | 0 |
| 23.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24.0 | 1017 | 366 | 47 | 13 | 7 | 7 | 0 | 0 | 0 | 0 |
| 24.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25.0 | 904 | 326 | 40 | 7 | 7 | 0 | 0 | 0 | 0 | 0 |
| 25.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26.0 | 818 | 292 | 33 | 7 | 7 | 0 | 0 | 0 | 0 | 0 |
| 26.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table A7 RTAB7.RTB

Name = Wet surface W3

Q0 = 0.200 S1=8.633

| Beta | 0.0 | 2.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
|------------|-------|-------|------|------|-------|-------|-------|-------|-------|-------|
| Tan(Gamma) | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 | 150.0 | 165.0 | 180.0 |
| 0.0 | 1576 | 1576 | 1576 | 1576 | 1576 | 1576 | 1576 | 1576 | 1576 | 1576 |
| 0.2 | 1576 | 1576 | 1576 | 1576 | 1576 | 1576 | 1576 | 1576 | 1576 | 1576 |
| 0.5 | 1658 | 1663 | 1658 | 1653 | 1643 | 1622 | 1602 | 1587 | 1566 | 1551 |
| 0.8 | 1530 | 1485 | 1449 | 1439 | 1428 | 1439 | 1434 | 1444 | 1444 | 1449 |
| 1.0 | 2046 | 2051 | 2025 | 1959 | 1888 | 1755 | 1632 | 1530 | 1434 | 1357 |
| 1.2 | 1280 | 1153 | 1107 | 1107 | 1107 | 1133 | 1143 | 1173 | 1173 | 1184 |
| 1.5 | 3183 | 3173 | 3051 | 2729 | 2362 | 1964 | 1638 | 1367 | 1143 | 1020 |
| 1.8 | 913 | 801 | 770 | 781 | 796 | 826 | 847 | 877 | 888 | 903 |
| 2.0 | 5071 | 4979 | 4714 | 3836 | 2780 | 1918 | 1326 | 1025 | 791 | 679 |
| 2.5 | 582 | 520 | 515 | 536 | 556 | 587 | 607 | 638 | 648 | 658 |
| 3.0 | 7525 | 7336 | 6489 | 4596 | 2734 | 1612 | 949 | 679 | 490 | 423 |
| 3.5 | 372 | 347 | 347 | 372 | 388 | 418 | 434 | 464 | 474 | 485 |
| 4.0 | 9871 | 9387 | 7805 | 4561 | 2255 | 1153 | 587 | 418 | 301 | 265 |
| 4.5 | 240 | 235 | 240 | 260 | 281 | 301 | 316 | 342 | 352 | 362 |
| 5.0 | 11938 | 11402 | 8525 | 4035 | 1673 | 801 | 383 | 270 | 194 | 179 |
| 5.5 | 158 | 163 | 173 | 189 | 204 | 224 | 235 | 255 | 265 | 270 |
| 6.0 | 13606 | 12427 | 8520 | 3362 | 1158 | 520 | 235 | 173 | 133 | 122 |
| 6.5 | 117 | 117 | 128 | 138 | 153 | 168 | 184 | 199 | 204 | 214 |
| 7.0 | 15550 | 13075 | 7035 | 1990 | 556 | 245 | 107 | 87 | 71 | 71 |
| 7.5 | 66 | 71 | 77 | 82 | 92 | 102 | 117 | 128 | 133 | 138 |
| 8.0 | 15708 | 12152 | 5285 | 1122 | 265 | 117 | 51 | 51 | 46 | 46 |
| 8.5 | 41 | 46 | 46 | 56 | 61 | 71 | 77 | 87 | 92 | 97 |
| 9.0 | 14830 | 10382 | 3699 | 592 | 143 | 71 | 36 | 31 | 26 | 31 |
| 9.5 | 31 | 31 | 31 | 41 | 46 | 51 | 56 | 61 | 66 | 71 |
| 10.0 | 13458 | 8606 | 2510 | 332 | 71 | 41 | 26 | 20 | 20 | 20 |
| 10.5 | 20 | 20 | 26 | 31 | 31 | 36 | 41 | 46 | 51 | 51 |
| 11.0 | 11535 | 6821 | 1597 | 184 | 46 | 31 | 20 | 15 | 15 | 15 |
| 11.5 | 15 | 15 | 20 | 20 | 26 | 31 | 31 | 36 | 41 | 41 |
| 12.0 | 9805 | 5270 | 1036 | 112 | 31 | 20 | 15 | 10 | 10 | 10 |
| 12.5 | 10 | 10 | 15 | 15 | 20 | 20 | 26 | 31 | 31 | 36 |
| 13.0 | 8076 | 4040 | 673 | 71 | 20 | 15 | 15 | 10 | 10 | 10 |
| 13.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14.0 | 6709 | 3209 | 469 | 51 | 15 | 15 | 10 | 10 | 10 | 0 |
| 14.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15.0 | 5612 | 2571 | 337 | 36 | 15 | 10 | 10 | 10 | 0 | 0 |
| 15.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16.0 | 4785 | 2076 | 245 | 31 | 10 | 10 | 10 | 10 | 0 | 0 |
| 16.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17.0 | 4071 | 1663 | 184 | 20 | 10 | 10 | 10 | 0 | 0 | 0 |
| 17.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18.0 | 3479 | 1357 | 143 | 20 | 10 | 10 | 10 | 0 | 0 | 0 |
| 18.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19.0 | 2969 | 1102 | 107 | 15 | 10 | 10 | 10 | 0 | 0 | 0 |
| 19.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20.0 | 2551 | 898 | 87 | 15 | 10 | 10 | 0 | 0 | 0 | 0 |
| 20.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21.0 | 2183 | 750 | 66 | 10 | 5 | 5 | 0 | 0 | 0 | 0 |
| 21.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22.0 | 1888 | 633 | 56 | 10 | 5 | 5 | 0 | 0 | 0 | 0 |
| 22.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23.0 | 1648 | 541 | 51 | 10 | 5 | 5 | 0 | 0 | 0 | 0 |
| 23.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24.0 | 1449 | 464 | 41 | 10 | 5 | 5 | 0 | 0 | 0 | 0 |
| 24.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25.0 | 1280 | 413 | 36 | 10 | 5 | 0 | 0 | 0 | 0 | 0 |
| 25.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26.0 | 1153 | 367 | 31 | 10 | 5 | 0 | 0 | 0 | 0 | 0 |
| 26.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table A8 RTAB8.RTB

Name = Wet surface W4

Q0 = 0.250 S1=10.842

| Beta | 0.0 | 2.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
|------------|-------|-------|------|------|-------|-------|-------|-------|-------|-------|
| Tan(Gamma) | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 | 150.0 | 165.0 | 180.0 |
| 0.0 | 1149 | 1149 | 1149 | 1149 | 1149 | 1149 | 1149 | 1149 | 1149 | 1149 |
| | 1149 | 1149 | 1149 | 1149 | 1149 | 1149 | 1149 | 1149 | 1149 | 1149 |
| 0.2 | 1117 | 1117 | 1117 | 1121 | 1129 | 1125 | 1117 | 1113 | 1113 | 1105 |
| | 1097 | 1085 | 1064 | 1060 | 1056 | 1069 | 1073 | 1077 | 1081 | 1081 |
| 0.5 | 1206 | 1218 | 1206 | 1170 | 1154 | 1089 | 1028 | 988 | 947 | 915 |
| | 882 | 850 | 818 | 826 | 830 | 854 | 862 | 878 | 886 | 890 |
| 0.8 | 1777 | 1769 | 1769 | 1692 | 1429 | 1145 | 915 | 809 | 712 | 672 |
| | 631 | 587 | 575 | 587 | 599 | 619 | 635 | 656 | 668 | 676 |
| 1.0 | 3262 | 3193 | 2971 | 2339 | 1623 | 1077 | 712 | 583 | 474 | 437 |
| | 405 | 385 | 389 | 405 | 417 | 441 | 449 | 478 | 486 | 494 |
| 1.2 | 5545 | 5262 | 4327 | 2777 | 1457 | 830 | 474 | 376 | 300 | 279 |
| | 263 | 259 | 263 | 275 | 291 | 312 | 324 | 344 | 352 | 364 |
| 1.5 | 8103 | 7399 | 5379 | 2789 | 1137 | 583 | 295 | 243 | 198 | 186 |
| | 174 | 174 | 182 | 198 | 206 | 223 | 235 | 251 | 259 | 267 |
| 1.8 | 10523 | 9212 | 6144 | 2615 | 854 | 405 | 190 | 158 | 134 | 125 |
| | 121 | 121 | 125 | 142 | 150 | 166 | 174 | 190 | 194 | 202 |
| 2.0 | 12458 | 10799 | 6472 | 2117 | 652 | 279 | 121 | 109 | 97 | 89 |
| | 85 | 89 | 93 | 105 | 113 | 125 | 134 | 146 | 150 | 158 |
| 2.5 | 15785 | 12223 | 5525 | 1113 | 267 | 134 | 69 | 61 | 53 | 49 |
| | 49 | 53 | 53 | 65 | 69 | 77 | 85 | 93 | 97 | 101 |
| 3.0 | 16991 | 12045 | 4270 | 611 | 105 | 61 | 36 | 32 | 32 | 32 |
| | 32 | 32 | 36 | 40 | 45 | 53 | 57 | 65 | 69 | 73 |
| 3.5 | 17084 | 10969 | 2926 | 291 | 57 | 32 | 20 | 20 | 16 | 20 |
| | 24 | 24 | 24 | 28 | 32 | 36 | 40 | 49 | 49 | 53 |
| 4.0 | 16639 | 9621 | 2028 | 146 | 32 | 20 | 16 | 12 | 12 | 12 |
| | 16 | 16 | 16 | 20 | 24 | 28 | 32 | 36 | 36 | 40 |
| 4.5 | 15028 | 7852 | 1311 | 77 | 24 | 16 | 12 | 12 | 12 | 12 |
| | 12 | 12 | 12 | 16 | 20 | 24 | 24 | 28 | 28 | 32 |
| 5.0 | 13296 | 6306 | 765 | 49 | 16 | 12 | 8 | 8 | 8 | 8 |
| | 12 | 12 | 12 | 12 | 16 | 20 | 20 | 24 | 24 | 28 |
| 5.5 | 11495 | 4978 | 506 | 28 | 12 | 12 | 12 | 8 | 8 | 8 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6.0 | 10111 | 3910 | 304 | 20 | 12 | 12 | 12 | 8 | 8 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6.5 | 8949 | 3088 | 206 | 16 | 8 | 8 | 8 | 8 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7.0 | 7630 | 2424 | 142 | 16 | 8 | 8 | 8 | 8 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7.5 | 6601 | 1906 | 101 | 12 | 8 | 8 | 8 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8.0 | 5658 | 1506 | 81 | 12 | 8 | 8 | 8 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8.5 | 4812 | 1214 | 61 | 8 | 8 | 8 | 8 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9.0 | 4145 | 1008 | 49 | 8 | 8 | 8 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9.5 | 3606 | 850 | 40 | 8 | 4 | 4 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10.0 | 3173 | 712 | 32 | 8 | 4 | 4 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10.5 | 2777 | 611 | 28 | 8 | 4 | 4 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11.0 | 2424 | 530 | 24 | 8 | 4 | 4 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11.5 | 2153 | 465 | 20 | 8 | 4 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12.0 | 1939 | 417 | 20 | 8 | 4 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table A9 RTAB9.RTB

Name = CIE CLASS R1

Q0 = 0.100 S1=0.247

| Beta | 0.0 | 2.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
|------------|------|------|------|------|-------|-------|-------|-------|-------|-------|
| Tan(Gamma) | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 | 150.0 | 165.0 | 180.0 |
| 0.0 | 6550 | 6550 | 6550 | 6550 | 6550 | 6550 | 6550 | 6550 | 6550 | 6550 |
| 0.2 | 6190 | 6190 | 6190 | 6190 | 6100 | 6100 | 6100 | 6100 | 6100 | 6100 |
| 0.5 | 5390 | 5390 | 5390 | 5390 | 5390 | 5390 | 5210 | 5210 | 5210 | 5210 |
| 0.8 | 4310 | 4310 | 4310 | 4310 | 4310 | 4310 | 4310 | 4310 | 4310 | 4310 |
| 1.0 | 3950 | 3860 | 3710 | 3710 | 3710 | 3710 | 3710 | 3860 | 3950 | 3950 |
| 1.2 | 3410 | 3410 | 3410 | 3410 | 3230 | 3230 | 3050 | 2960 | 2870 | 2870 |
| 1.5 | 2780 | 2690 | 2690 | 2690 | 2690 | 2690 | 2690 | 2780 | 2780 | 2780 |
| 1.8 | 2690 | 2690 | 2690 | 2600 | 2510 | 2420 | 2240 | 2070 | 1980 | 1890 |
| 2.0 | 1890 | 1800 | 1800 | 1800 | 1800 | 1800 | 1890 | 1980 | 2070 | 2240 |
| 2.5 | 2240 | 2240 | 2240 | 2150 | 1980 | 1800 | 1710 | 1620 | 1530 | 1480 |
| 3.0 | 1440 | 1440 | 1390 | 1390 | 1390 | 1440 | 1480 | 1530 | 1620 | 1800 |
| 3.5 | 1890 | 1890 | 1890 | 1710 | 1530 | 1390 | 1300 | 1210 | 1170 | 1120 |
| 4.0 | 1080 | 1030 | 990 | 990 | 1030 | 1080 | 1120 | 1210 | 1300 | 1390 |
| 4.5 | 1620 | 1620 | 1570 | 1350 | 1170 | 1080 | 990 | 940 | 900 | 850 |
| 5.0 | 850 | 830 | 840 | 840 | 860 | 900 | 940 | 990 | 1030 | 1110 |
| 5.5 | 1210 | 1210 | 1170 | 950 | 790 | 660 | 600 | 570 | 540 | 520 |
| 6.0 | 510 | 500 | 510 | 520 | 540 | 580 | 610 | 650 | 690 | 750 |
| 6.5 | 940 | 940 | 860 | 660 | 490 | 410 | 380 | 360 | 340 | 330 |
| 7.0 | 320 | 310 | 310 | 330 | 350 | 380 | 400 | 430 | 470 | 510 |
| 7.5 | 810 | 800 | 660 | 460 | 330 | 280 | 250 | 230 | 220 | 220 |
| 8.0 | 210 | 210 | 220 | 220 | 240 | 270 | 290 | 310 | 340 | 380 |
| 8.5 | 710 | 690 | 550 | 320 | 230 | 200 | 180 | 160 | 150 | 140 |
| 9.0 | 140 | 140 | 150 | 170 | 190 | 200 | 220 | 230 | 250 | 270 |
| 9.5 | 630 | 590 | 430 | 240 | 170 | 140 | 130 | 120 | 120 | 110 |
| 10.0 | 110 | 110 | 120 | 130 | 140 | 140 | 160 | 170 | 190 | 210 |
| 10.5 | 570 | 520 | 360 | 190 | 140 | 120 | 100 | 90 | 90 | 90 |
| 11.0 | 90 | 90 | 90 | 100 | 110 | 130 | 140 | 150 | 160 | 160 |
| 11.5 | 510 | 470 | 310 | 150 | 110 | 90 | 80 | 80 | 80 | 80 |
| 12.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12.5 | 470 | 420 | 250 | 120 | 90 | 70 | 70 | 60 | 60 | 0 |
| 13.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13.5 | 430 | 380 | 220 | 100 | 70 | 60 | 50 | 50 | 0 | 0 |
| 14.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14.5 | 400 | 340 | 180 | 80 | 60 | 50 | 40 | 40 | 0 | 0 |
| 15.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15.5 | 370 | 310 | 150 | 70 | 50 | 40 | 40 | 0 | 0 | 0 |
| 16.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16.5 | 350 | 280 | 140 | 60 | 40 | 40 | 30 | 0 | 0 | 0 |
| 17.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17.5 | 330 | 250 | 120 | 50 | 40 | 30 | 30 | 0 | 0 | 0 |
| 18.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18.5 | 310 | 230 | 100 | 40 | 30 | 30 | 0 | 0 | 0 | 0 |
| 19.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19.5 | 300 | 220 | 90 | 40 | 30 | 30 | 0 | 0 | 0 | 0 |
| 20.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20.5 | 290 | 200 | 80 | 30 | 20 | 20 | 0 | 0 | 0 | 0 |
| 21.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21.5 | 280 | 180 | 70 | 30 | 20 | 20 | 0 | 0 | 0 | 0 |
| 22.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22.5 | 270 | 160 | 70 | 30 | 20 | 20 | 0 | 0 | 0 | 0 |
| 23.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23.5 | 260 | 150 | 60 | 20 | 20 | 0 | 0 | 0 | 0 | 0 |
| 24.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24.5 | 250 | 140 | 60 | 20 | 20 | 0 | 0 | 0 | 0 | 0 |
| 25.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table A10 RTAB10.RTB

Name = Concrete CIE R2

Q0 = 0.070 S1=0.582

| Beta | 0.0 | 2.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
|------------|------|------|------|------|-------|-------|-------|-------|-------|-------|
| Tan(Gamma) | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 | 150.0 | 165.0 | 180.0 |
| 0.0 | 5571 | 5571 | 5571 | 5571 | 5571 | 5571 | 5571 | 5571 | 5571 | 5571 |
| 0.2 | 5571 | 5571 | 5571 | 5571 | 5571 | 5571 | 5571 | 5571 | 5571 | 5571 |
| 0.5 | 5871 | 5871 | 5871 | 5871 | 5871 | 5871 | 5871 | 5871 | 5871 | 5871 |
| 0.8 | 5414 | 5257 | 5100 | 5100 | 4942 | 4942 | 4942 | 4785 | 4785 | 4785 |
| 1.0 | 5871 | 5871 | 5871 | 5871 | 5757 | 5757 | 5485 | 5414 | 5285 | 4942 |
| 1.2 | 4642 | 4328 | 4014 | 4014 | 3871 | 3871 | 3871 | 3714 | 3714 | 3714 |
| 1.5 | 5414 | 5414 | 5414 | 5257 | 5100 | 4942 | 4642 | 4328 | 4014 | 3714 |
| 1.8 | 3400 | 3085 | 2942 | 2942 | 2942 | 2942 | 2942 | 2942 | 2942 | 2942 |
| 2.0 | 4785 | 4785 | 4785 | 4642 | 4171 | 4157 | 3714 | 3400 | 3085 | 2785 |
| 2.5 | 2471 | 2171 | 2171 | 2171 | 2171 | 2171 | 2014 | 2014 | 2014 | 2014 |
| 3.0 | 4328 | 4328 | 4171 | 3871 | 3400 | 2942 | 2628 | 2171 | 1857 | 1700 |
| 3.5 | 1542 | 1428 | 1471 | 1514 | 1542 | 1542 | 1628 | 1628 | 1700 | 1700 |
| 4.0 | 3871 | 3871 | 3714 | 3242 | 2557 | 2171 | 2014 | 1700 | 1542 | 1328 |
| 4.5 | 1142 | 1085 | 1085 | 1142 | 1200 | 1242 | 1271 | 1300 | 1328 | 1357 |
| 5.0 | 3557 | 3400 | 3242 | 2785 | 2171 | 1771 | 1514 | 1300 | 1114 | 957 |
| 5.5 | 871 | 742 | 771 | 828 | 900 | 957 | 985 | 1014 | 1042 | 1057 |
| 6.0 | 3242 | 3085 | 2785 | 2171 | 1671 | 1357 | 1142 | 957 | 871 | 742 |
| 6.5 | 642 | 571 | 585 | 642 | 700 | 742 | 771 | 800 | 814 | 828 |
| 7.0 | 2785 | 2714 | 2085 | 1571 | 1057 | 828 | 685 | 571 | 500 | 428 |
| 7.5 | 385 | 342 | 371 | 400 | 428 | 471 | 500 | 542 | 571 | 585 |
| 8.0 | 2285 | 2214 | 1642 | 957 | 614 | 471 | 371 | 300 | 257 | 242 |
| 8.5 | 228 | 228 | 242 | 242 | 257 | 300 | 314 | 342 | 371 | 385 |
| 9.0 | 2085 | 1871 | 1242 | 585 | 357 | 257 | 214 | 185 | 171 | 157 |
| 9.5 | 157 | 157 | 157 | 157 | 171 | 200 | 214 | 242 | 257 | 300 |
| 10.0 | 1885 | 1614 | 957 | 385 | 214 | 171 | 142 | 128 | 128 | 114 |
| 10.5 | 114 | 114 | 114 | 128 | 142 | 157 | 171 | 185 | 214 | 242 |
| 11.0 | 1685 | 1357 | 714 | 285 | 171 | 128 | 100 | 100 | 85 | 85 |
| 11.5 | 85 | 85 | 85 | 85 | 100 | 114 | 142 | 171 | 185 | 200 |
| 12.0 | 1514 | 1157 | 542 | 200 | 114 | 85 | 71 | 71 | 71 | 71 |
| 12.5 | 71 | 57 | 71 | 71 | 85 | 100 | 128 | 142 | 142 | 157 |
| 13.0 | 1371 | 985 | 414 | 157 | 85 | 71 | 57 | 57 | 57 | 57 |
| 13.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14.0 | 1242 | 828 | 314 | 114 | 71 | 57 | 57 | 42 | 42 | 0 |
| 14.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15.0 | 1114 | 714 | 242 | 85 | 57 | 42 | 42 | 42 | 0 | 0 |
| 15.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16.0 | 1014 | 614 | 200 | 71 | 42 | 42 | 28 | 28 | 0 | 0 |
| 16.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17.0 | 957 | 542 | 171 | 57 | 42 | 28 | 28 | 0 | 0 | 0 |
| 17.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18.0 | 900 | 471 | 142 | 42 | 28 | 28 | 28 | 0 | 0 | 0 |
| 18.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19.0 | 828 | 400 | 128 | 42 | 28 | 28 | 28 | 0 | 0 | 0 |
| 19.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20.0 | 785 | 357 | 100 | 42 | 28 | 14 | 0 | 0 | 0 | 0 |
| 20.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21.0 | 742 | 328 | 100 | 28 | 28 | 14 | 0 | 0 | 0 | 0 |
| 21.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22.0 | 700 | 300 | 85 | 28 | 14 | 14 | 0 | 0 | 0 | 0 |
| 22.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23.0 | 671 | 257 | 71 | 28 | 14 | 14 | 0 | 0 | 0 | 0 |
| 23.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24.0 | 628 | 228 | 57 | 28 | 14 | 14 | 0 | 0 | 0 | 0 |
| 24.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25.0 | 600 | 200 | 57 | 28 | 14 | 0 | 0 | 0 | 0 | 0 |
| 25.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26.0 | 585 | 185 | 57 | 14 | 14 | 0 | 0 | 0 | 0 | 0 |
| 26.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table A11 RTAB11.RTB

Name = N1 very diffuse

Q0 = 0.100 S1=0.180

| Beta | 0.0 | 2.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
|------------|------|------|------|------|-------|-------|-------|-------|-------|-------|
| Tan(Gamma) | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 | 150.0 | 165.0 | 180.0 |
| 0.0 | 7680 | 7680 | 7680 | 7680 | 7680 | 7680 | 7680 | 7680 | 7680 | 7680 |
| 0.2 | 6940 | 6940 | 6940 | 6940 | 6940 | 6930 | 6930 | 6930 | 6930 | 6930 |
| 0.5 | 5570 | 5570 | 5570 | 5550 | 5540 | 5500 | 5460 | 5440 | 5440 | 5430 |
| 0.8 | 4240 | 4240 | 4240 | 4170 | 4150 | 4060 | 3970 | 3920 | 3880 | 3820 |
| 1.0 | 3780 | 3810 | 3880 | 4070 | 4250 | 4500 | 4690 | 4890 | 4970 | 5050 |
| 1.2 | 3230 | 3220 | 3210 | 3100 | 3020 | 2890 | 2780 | 2710 | 2660 | 2610 |
| 1.5 | 2570 | 2590 | 2660 | 2840 | 3030 | 3280 | 3460 | 3680 | 3750 | 3810 |
| 1.8 | 1730 | 1750 | 1830 | 2000 | 2160 | 2370 | 2540 | 2710 | 2790 | 2850 |
| 2.0 | 2020 | 1980 | 1930 | 1770 | 1600 | 1470 | 1350 | 1280 | 1240 | 1210 |
| 2.5 | 1190 | 1220 | 1290 | 1420 | 1570 | 1750 | 1890 | 2040 | 2120 | 2160 |
| 3.0 | 840 | 860 | 930 | 1040 | 1160 | 1310 | 1440 | 1550 | 1620 | 1660 |
| 3.5 | 610 | 630 | 690 | 780 | 880 | 1010 | 1110 | 1210 | 1270 | 1310 |
| 4.0 | 350 | 370 | 410 | 480 | 550 | 640 | 710 | 790 | 840 | 860 |
| 4.5 | 210 | 230 | 260 | 310 | 360 | 420 | 480 | 550 | 580 | 600 |
| 5.0 | 150 | 180 | 180 | 210 | 250 | 310 | 350 | 390 | 420 | 440 |
| 5.5 | 100 | 120 | 130 | 160 | 190 | 230 | 260 | 300 | 320 | 340 |
| 6.0 | 80 | 80 | 100 | 120 | 150 | 180 | 200 | 230 | 250 | 270 |
| 6.5 | 60 | 60 | 80 | 100 | 120 | 140 | 180 | 180 | 210 | 210 |
| 7.0 | 350 | 280 | 150 | 80 | 60 | 50 | 50 | 50 | 50 | 50 |
| 7.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8.0 | 310 | 250 | 130 | 70 | 50 | 40 | 40 | 40 | 40 | 0 |
| 8.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9.0 | 280 | 210 | 110 | 50 | 40 | 30 | 30 | 30 | 0 | 0 |
| 9.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10.0 | 250 | 190 | 90 | 50 | 30 | 30 | 30 | 30 | 0 | 0 |
| 10.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11.0 | 230 | 170 | 80 | 40 | 30 | 30 | 30 | 0 | 0 | 0 |
| 11.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12.0 | 210 | 150 | 70 | 40 | 30 | 20 | 20 | 0 | 0 | 0 |
| 12.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13.0 | 190 | 140 | 60 | 30 | 20 | 20 | 20 | 0 | 0 | 0 |
| 13.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14.0 | 180 | 130 | 50 | 30 | 20 | 20 | 0 | 0 | 0 | 0 |
| 14.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15.0 | 170 | 120 | 50 | 20 | 20 | 20 | 0 | 0 | 0 | 0 |
| 15.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16.0 | 160 | 110 | 40 | 20 | 20 | 20 | 0 | 0 | 0 | 0 |
| 16.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17.0 | 150 | 100 | 40 | 20 | 20 | 10 | 0 | 0 | 0 | 0 |
| 17.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18.0 | 150 | 90 | 40 | 20 | 20 | 10 | 0 | 0 | 0 | 0 |
| 18.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19.0 | 140 | 90 | 30 | 20 | 20 | 0 | 0 | 0 | 0 | 0 |
| 19.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20.0 | 140 | 80 | 30 | 20 | 20 | 0 | 0 | 0 | 0 | 0 |
| 20.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table A12 RTAB12.RTB

Name = N2 concrete

Q0 = 0.070 S1=0.409

| Beta | 0.0 | 2.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
|------------|------|------|------|------|-------|-------|-------|-------|-------|-------|
| Tan(Gamma) | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 | 150.0 | 165.0 | 180.0 |
| 0.0 | 6771 | 6771 | 6771 | 6771 | 6771 | 6771 | 6771 | 6771 | 6771 | 6771 |
| 0.2 | 6771 | 6771 | 6771 | 6771 | 6771 | 6771 | 6771 | 6771 | 6771 | 6771 |
| 0.5 | 6743 | 6729 | 6729 | 6714 | 6714 | 6686 | 6657 | 6629 | 6614 | 6557 |
| 0.8 | 6429 | 6429 | 6329 | 6271 | 6235 | 6200 | 6200 | 6214 | 6229 | 6229 |
| 1.0 | 6100 | 6086 | 6086 | 6029 | 5971 | 5900 | 5829 | 5700 | 5571 | 5457 |
| 1.2 | 5357 | 5129 | 4957 | 4900 | 4871 | 4914 | 4971 | 5029 | 5043 | 5086 |
| 1.5 | 5343 | 5314 | 5286 | 5157 | 4986 | 4800 | 4586 | 4414 | 4243 | 4071 |
| 1.8 | 3929 | 3643 | 3500 | 3486 | 3500 | 3614 | 3657 | 3743 | 3786 | 3829 |
| 2.0 | 4657 | 4614 | 4557 | 4329 | 4057 | 3757 | 3471 | 3243 | 3043 | 2886 |
| 2.5 | 2757 | 2529 | 2429 | 2429 | 2486 | 2571 | 2657 | 2743 | 2800 | 2843 |
| 3.0 | 4057 | 4014 | 3929 | 3586 | 3200 | 2829 | 2514 | 2300 | 2129 | 1986 |
| 3.5 | 1886 | 1729 | 1671 | 1700 | 1757 | 1843 | 1929 | 2014 | 2071 | 2100 |
| 4.0 | 3557 | 3514 | 3357 | 2900 | 2457 | 2086 | 1814 | 1614 | 1486 | 1386 |
| 4.5 | 1314 | 1200 | 1186 | 1214 | 1271 | 1343 | 1414 | 1500 | 1543 | 1571 |
| 5.0 | 3129 | 3086 | 2871 | 2314 | 1843 | 1514 | 1300 | 1157 | 1043 | 971 |
| 5.5 | 914 | 857 | 843 | 886 | 929 | 1000 | 1057 | 1129 | 1171 | 1200 |
| 6.0 | 2771 | 2714 | 2443 | 1829 | 1386 | 1114 | 929 | 814 | 757 | 686 |
| 6.5 | 657 | 629 | 629 | 657 | 700 | 757 | 814 | 871 | 914 | 929 |
| 7.0 | 2243 | 2143 | 1771 | 1171 | 814 | 629 | 529 | 457 | 429 | 400 |
| 7.5 | 386 | 371 | 371 | 400 | 429 | 471 | 529 | 571 | 600 | 614 |
| 8.0 | 1857 | 1714 | 1286 | 743 | 500 | 371 | 314 | 271 | 257 | 243 |
| 8.5 | 243 | 229 | 243 | 257 | 286 | 314 | 343 | 386 | 400 | 414 |
| 9.0 | 1571 | 1400 | 929 | 486 | 314 | 229 | 200 | 186 | 171 | 157 |
| 9.5 | 157 | 157 | 157 | 171 | 200 | 229 | 257 | 271 | 300 | 300 |
| 10.0 | 1343 | 1143 | 686 | 329 | 214 | 157 | 129 | 129 | 114 | 114 |
| 10.5 | 114 | 114 | 114 | 129 | 143 | 171 | 186 | 214 | 229 | 229 |
| 11.0 | 1143 | 929 | 514 | 243 | 143 | 114 | 100 | 86 | 86 | 86 |
| 11.5 | 86 | 86 | 86 | 100 | 114 | 129 | 143 | 157 | 171 | 186 |
| 12.0 | 1000 | 786 | 400 | 171 | 114 | 86 | 71 | 71 | 57 | 57 |
| 12.5 | 57 | 57 | 71 | 71 | 86 | 100 | 114 | 129 | 143 | 143 |
| 13.0 | 871 | 657 | 314 | 129 | 86 | 57 | 57 | 43 | 43 | 43 |
| 13.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14.0 | 771 | 557 | 257 | 100 | 71 | 57 | 43 | 43 | 43 | 0 |
| 14.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15.0 | 686 | 486 | 200 | 86 | 57 | 43 | 29 | 29 | 0 | 0 |
| 15.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16.0 | 614 | 429 | 171 | 71 | 43 | 29 | 29 | 29 | 0 | 0 |
| 16.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17.0 | 557 | 386 | 143 | 57 | 29 | 29 | 29 | 0 | 0 | 0 |
| 17.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18.0 | 514 | 329 | 129 | 43 | 29 | 29 | 14 | 0 | 0 | 0 |
| 18.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19.0 | 471 | 300 | 100 | 43 | 29 | 14 | 14 | 0 | 0 | 0 |
| 19.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20.0 | 429 | 257 | 86 | 29 | 14 | 14 | 0 | 0 | 0 | 0 |
| 20.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21.0 | 400 | 243 | 71 | 29 | 14 | 14 | 0 | 0 | 0 | 0 |
| 21.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22.0 | 371 | 229 | 71 | 29 | 14 | 14 | 0 | 0 | 0 | 0 |
| 22.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23.0 | 357 | 200 | 57 | 14 | 14 | 0 | 0 | 0 | 0 | 0 |
| 23.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24.0 | 329 | 186 | 57 | 14 | 14 | 0 | 0 | 0 | 0 | 0 |
| 24.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25.0 | 314 | 171 | 43 | 14 | 14 | 0 | 0 | 0 | 0 | 0 |
| 25.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26.0 | 300 | 171 | 43 | 14 | 14 | 0 | 0 | 0 | 0 | 0 |
| 26.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table A13 RTAB13.RTB

Name = N3 asphalt

Q0 = 0.070 S1=0.881

| Beta | 0.0 | 2.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
|------------|------|------|------|------|-------|-------|-------|-------|-------|-------|
| Tan(Gamma) | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 | 150.0 | 165.0 | 180.0 |
| 0.0 | 5057 | 5057 | 5057 | 5057 | 5057 | 5057 | 5057 | 5057 | 5057 | 5057 |
| 0.2 | 5586 | 5586 | 5571 | 5557 | 5543 | 5500 | 5443 | 5400 | 5329 | 5271 |
| 0.5 | 5800 | 5771 | 5757 | 5671 | 5571 | 5414 | 5229 | 5071 | 4900 | 4714 |
| 0.8 | 4543 | 4157 | 3829 | 3657 | 3529 | 3457 | 3429 | 3429 | 3429 | 3429 |
| 1.0 | 5786 | 5757 | 5700 | 5486 | 5214 | 4886 | 4557 | 4257 | 3971 | 3714 |
| 1.2 | 3486 | 3043 | 2743 | 2600 | 2514 | 2500 | 2500 | 2514 | 2529 | 2529 |
| 1.5 | 5657 | 5600 | 5486 | 5100 | 4600 | 4100 | 3629 | 3257 | 2957 | 2700 |
| 1.8 | 2500 | 2100 | 1900 | 1800 | 1771 | 1757 | 1786 | 1814 | 1843 | 1857 |
| 2.0 | 5471 | 5343 | 5143 | 4529 | 3843 | 3243 | 2757 | 2400 | 2129 | 1914 |
| 2.5 | 1757 | 1471 | 1329 | 1271 | 1243 | 1271 | 1300 | 1343 | 1357 | 1371 |
| 3.0 | 5143 | 5014 | 4686 | 3857 | 3071 | 2457 | 2014 | 1700 | 1500 | 1343 |
| 3.5 | 1229 | 1029 | 943 | 900 | 900 | 914 | 957 | 986 | 1014 | 1029 |
| 4.0 | 4786 | 4643 | 4200 | 3200 | 2357 | 1814 | 1457 | 1229 | 1071 | 957 |
| 4.5 | 871 | 743 | 671 | 657 | 671 | 686 | 714 | 743 | 771 | 786 |
| 5.0 | 4457 | 4257 | 3700 | 2600 | 1800 | 1343 | 1071 | 900 | 800 | 714 |
| 5.5 | 643 | 543 | 500 | 500 | 500 | 529 | 543 | 571 | 600 | 614 |
| 6.0 | 3857 | 3571 | 2843 | 1714 | 1086 | 757 | 614 | 500 | 457 | 400 |
| 6.5 | 371 | 329 | 314 | 300 | 314 | 329 | 343 | 386 | 400 | 400 |
| 7.0 | 3329 | 2943 | 2114 | 1114 | 657 | 443 | 371 | 300 | 271 | 257 |
| 7.5 | 243 | 214 | 200 | 200 | 214 | 229 | 243 | 257 | 271 | 286 |
| 8.0 | 2886 | 2443 | 1557 | 729 | 414 | 286 | 243 | 200 | 186 | 171 |
| 8.5 | 157 | 143 | 143 | 143 | 157 | 157 | 171 | 186 | 200 | 214 |
| 9.0 | 2529 | 2029 | 1171 | 500 | 286 | 186 | 157 | 143 | 129 | 129 |
| 9.5 | 114 | 100 | 100 | 100 | 114 | 114 | 129 | 143 | 157 | 157 |
| 10.0 | 2214 | 1686 | 871 | 343 | 200 | 143 | 114 | 100 | 100 | 86 |
| 10.5 | 86 | 71 | 71 | 86 | 86 | 86 | 100 | 114 | 129 | 129 |
| 11.0 | 1957 | 1429 | 671 | 257 | 143 | 100 | 86 | 86 | 71 | 71 |
| 11.5 | 71 | 57 | 57 | 71 | 71 | 71 | 86 | 86 | 100 | 100 |
| 12.0 | 1729 | 1200 | 529 | 186 | 114 | 86 | 71 | 57 | 57 | 57 |
| 12.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13.0 | 1543 | 1029 | 414 | 157 | 86 | 71 | 57 | 57 | 57 | 0 |
| 13.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14.0 | 1386 | 886 | 343 | 129 | 71 | 57 | 57 | 43 | 0 | 0 |
| 14.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15.0 | 1271 | 786 | 286 | 100 | 57 | 43 | 43 | 29 | 0 | 0 |
| 15.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16.0 | 1157 | 700 | 243 | 86 | 57 | 43 | 43 | 0 | 0 | 0 |
| 16.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17.0 | 1057 | 614 | 214 | 71 | 43 | 29 | 29 | 0 | 0 | 0 |
| 17.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18.0 | 971 | 543 | 171 | 57 | 43 | 29 | 29 | 0 | 0 | 0 |
| 18.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19.0 | 900 | 486 | 157 | 57 | 29 | 29 | 0 | 0 | 0 | 0 |
| 19.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20.0 | 829 | 443 | 129 | 43 | 29 | 29 | 0 | 0 | 0 | 0 |
| 20.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21.0 | 771 | 400 | 114 | 43 | 29 | 29 | 0 | 0 | 0 | 0 |
| 21.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22.0 | 729 | 371 | 100 | 43 | 29 | 14 | 0 | 0 | 0 | 0 |
| 22.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23.0 | 686 | 343 | 86 | 29 | 29 | 14 | 0 | 0 | 0 | 0 |
| 23.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24.0 | 643 | 314 | 86 | 29 | 14 | 0 | 0 | 0 | 0 | 0 |
| 24.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25.0 | 614 | 300 | 71 | 29 | 14 | 0 | 0 | 0 | 0 | 0 |
| 25.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table A14 RTAB14.RTB

Name = N4 glossy asphalt

Q0 = 0.080 s1=01.607

| Beta | 0.0 | 2.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
|------------|------|------|------|------|-------|-------|-------|-------|-------|-------|
| Tan(Gamma) | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 | 150.0 | 165.0 | 180.0 |
| 0.0 | 3525 | 3525 | 3525 | 3525 | 3525 | 3525 | 3525 | 3525 | 3525 | 3525 |
| 0.2 | 4150 | 4150 | 4138 | 4100 | 4100 | 4050 | 3988 | 3938 | 3888 | 3788 |
| 0.5 | 4688 | 4675 | 4663 | 4588 | 4475 | 4313 | 4138 | 3975 | 3813 | 3588 |
| 0.8 | 5150 | 5138 | 5075 | 4850 | 4513 | 4213 | 3925 | 3550 | 3200 | 2938 |
| 1.0 | 5513 | 5475 | 5325 | 4813 | 4263 | 3675 | 3138 | 2750 | 2450 | 2175 |
| 1.2 | 5738 | 5663 | 5375 | 4563 | 3738 | 3038 | 2475 | 2100 | 1825 | 1600 |
| 1.5 | 5825 | 5700 | 5213 | 4075 | 3075 | 2363 | 1863 | 1525 | 1313 | 1150 |
| 1.8 | 5800 | 5613 | 4900 | 3550 | 2488 | 1825 | 1425 | 1150 | 988 | 863 |
| 2.0 | 5663 | 5388 | 4450 | 2925 | 1913 | 1350 | 1063 | 863 | 750 | 650 |
| 2.5 | 5313 | 4838 | 3538 | 1900 | 1163 | 800 | 625 | 513 | 450 | 388 |
| 3.0 | 4813 | 4163 | 2638 | 1225 | 713 | 475 | 375 | 313 | 275 | 238 |
| 3.5 | 4363 | 3575 | 1975 | 825 | 463 | 313 | 250 | 213 | 188 | 163 |
| 4.0 | 3950 | 3063 | 1463 | 588 | 338 | 225 | 175 | 150 | 138 | 125 |
| 4.5 | 3575 | 2588 | 1100 | 413 | 250 | 175 | 138 | 113 | 100 | 88 |
| 5.0 | 3250 | 2188 | 863 | 300 | 188 | 125 | 100 | 88 | 75 | 75 |
| 5.5 | 2963 | 1838 | 675 | 238 | 150 | 100 | 75 | 75 | 63 | 63 |
| 6.0 | 2713 | 2025 | 538 | 188 | 113 | 75 | 63 | 63 | 50 | 0 |
| 6.5 | 2475 | 1350 | 438 | 150 | 88 | 63 | 63 | 50 | 0 | 0 |
| 7.0 | 2300 | 1188 | 350 | 113 | 75 | 63 | 50 | 25 | 0 | 0 |
| 7.5 | 2113 | 1063 | 288 | 100 | 63 | 50 | 38 | 0 | 0 | 0 |
| 8.0 | 1975 | 938 | 250 | 88 | 50 | 38 | 38 | 0 | 0 | 0 |
| 8.5 | 1850 | 850 | 213 | 75 | 50 | 38 | 38 | 0 | 0 | 0 |
| 9.0 | 1725 | 763 | 175 | 63 | 38 | 25 | 0 | 0 | 0 | 0 |
| 9.5 | 1638 | 688 | 150 | 50 | 38 | 25 | 0 | 0 | 0 | 0 |
| 10.0 | 1575 | 625 | 138 | 50 | 25 | 25 | 0 | 0 | 0 | 0 |
| 10.5 | 1475 | 575 | 125 | 38 | 25 | 13 | 0 | 0 | 0 | 0 |
| 11.0 | 1375 | 525 | 100 | 38 | 25 | 13 | 0 | 0 | 0 | 0 |
| 11.5 | 1288 | 488 | 100 | 38 | 25 | 0 | 0 | 0 | 0 | 0 |
| 12.0 | 1225 | 450 | 88 | 25 | 25 | 0 | 0 | 0 | 0 | 0 |

Table A15 RTAB15.RTB

Name = Dutch DOT porous

Q0 = 0.100 s1=0.689

| Beta | 0.0 | 2.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
|------------|------|------|------|------|-------|-------|-------|-------|-------|-------|
| Tan(Gamma) | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 | 150.0 | 165.0 | 180.0 |
| 0.0 | 5300 | 5300 | 5300 | 5300 | 5300 | 5300 | 5300 | 5300 | 5300 | 5300 |
| 0.2 | 5550 | 5540 | 5590 | 5530 | 5480 | 5450 | 5420 | 5340 | 5260 | 5230 |
| 0.5 | 6020 | 5930 | 5540 | 5300 | 5160 | 5020 | 4890 | 4720 | 4560 | 4460 |
| 0.8 | 4380 | 4010 | 3760 | 3600 | 3510 | 3510 | 3480 | 3520 | 3430 | 3510 |
| 1.0 | 5010 | 4930 | 5020 | 4790 | 4610 | 4390 | 4140 | 3680 | 3590 | 3370 |
| 1.2 | 3190 | 2840 | 2690 | 2560 | 2490 | 2490 | 2540 | 2570 | 2570 | 2610 |
| 1.5 | 4680 | 4640 | 4630 | 4260 | 3870 | 3480 | 3120 | 2820 | 2580 | 2390 |
| 1.8 | 2240 | 1960 | 1800 | 1770 | 1740 | 1800 | 1790 | 1880 | 1860 | 1900 |
| 2.0 | 4420 | 4400 | 4180 | 3690 | 3160 | 2670 | 2260 | 1990 | 1800 | 1660 |
| 2.5 | 1550 | 1360 | 1260 | 1220 | 1210 | 1270 | 1310 | 1350 | 1390 | 1390 |
| 3.0 | 4140 | 4030 | 3760 | 3040 | 2490 | 1990 | 1600 | 1370 | 1240 | 1140 |
| 3.5 | 1080 | 930 | 890 | 880 | 900 | 930 | 970 | 1010 | 1050 | 1070 |
| 4.0 | 3950 | 3790 | 3380 | 2500 | 1880 | 1460 | 1170 | 980 | 880 | 810 |
| 4.5 | 760 | 660 | 660 | 640 | 650 | 710 | 720 | 750 | 750 | 810 |
| 5.0 | 3650 | 3560 | 2790 | 2010 | 1400 | 1050 | 830 | 710 | 640 | 580 |
| 5.5 | 540 | 480 | 490 | 470 | 500 | 520 | 550 | 590 | 630 | 620 |
| 6.0 | 3220 | 2940 | 2250 | 1230 | 810 | 580 | 470 | 390 | 350 | 320 |
| 6.5 | 310 | 280 | 270 | 290 | 300 | 310 | 340 | 380 | 390 | 400 |
| 7.0 | 2840 | 2440 | 1640 | 820 | 470 | 320 | 270 | 240 | 230 | 200 |
| 7.5 | 170 | 170 | 170 | 180 | 200 | 230 | 240 | 270 | 290 | 280 |
| 8.0 | 2470 | 2090 | 1230 | 510 | 300 | 210 | 170 | 150 | 150 | 130 |
| 8.5 | 120 | 110 | 120 | 120 | 140 | 150 | 180 | 200 | 200 | 210 |
| 9.0 | 2150 | 1730 | 900 | 340 | 200 | 130 | 110 | 100 | 100 | 90 |
| 9.5 | 90 | 80 | 80 | 90 | 100 | 110 | 130 | 140 | 150 | 160 |
| 10.0 | 1900 | 1450 | 670 | 230 | 140 | 100 | 90 | 70 | 60 | 60 |
| 10.5 | 60 | 60 | 60 | 70 | 70 | 90 | 100 | 110 | 120 | 120 |
| 11.0 | 1650 | 1190 | 500 | 170 | 90 | 60 | 60 | 50 | 50 | 50 |
| 11.5 | 50 | 40 | 50 | 50 | 60 | 70 | 80 | 90 | 90 | 100 |
| 12.0 | 1450 | 960 | 370 | 130 | 70 | 50 | 50 | 50 | 40 | 30 |
| 12.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13.0 | 1270 | 800 | 290 | 100 | 60 | 40 | 40 | 40 | 30 | 0 |
| 13.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14.0 | 1170 | 710 | 230 | 70 | 50 | 40 | 30 | 30 | 0 | 0 |
| 14.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15.0 | 1090 | 600 | 180 | 60 | 40 | 30 | 30 | 30 | 0 | 0 |
| 15.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16.0 | 980 | 520 | 170 | 50 | 30 | 20 | 20 | 0 | 0 | 0 |
| 16.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17.0 | 900 | 460 | 140 | 40 | 20 | 20 | 20 | 0 | 0 | 0 |
| 17.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18.0 | 830 | 420 | 110 | 30 | 20 | 20 | 20 | 0 | 0 | 0 |
| 18.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19.0 | 740 | 370 | 90 | 30 | 20 | 10 | 0 | 0 | 0 | 0 |
| 19.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20.0 | 710 | 320 | 80 | 30 | 10 | 10 | 0 | 0 | 0 | 0 |
| 20.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21.0 | 650 | 290 | 70 | 20 | 10 | 10 | 0 | 0 | 0 | 0 |
| 21.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22.0 | 620 | 270 | 60 | 20 | 10 | 0 | 0 | 0 | 0 | 0 |
| 22.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23.0 | 580 | 250 | 60 | 20 | 10 | 0 | 0 | 0 | 0 | 0 |
| 23.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24.0 | 540 | 230 | 50 | 20 | 10 | 0 | 0 | 0 | 0 | 0 |
| 24.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25.0 | 510 | 220 | 40 | 20 | 10 | 0 | 0 | 0 | 0 | 0 |
| 25.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table A16 RTAB16.RTB

Name = Porous Asphalt (UK)

Q0 = 0.050 S1=0.582

| Beta | 0.0 | 2.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
|------------|------|------|------|------|-------|-------|-------|-------|-------|-------|
| Tan(Gamma) | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 | 150.0 | 165.0 | 180.0 |
| 0.0 | 5571 | 5571 | 5571 | 5571 | 5571 | 5571 | 5571 | 5571 | 5571 | 5571 |
| 0.2 | 5871 | 5871 | 5871 | 5871 | 5871 | 5871 | 5871 | 5871 | 5871 | 5871 |
| 0.5 | 5414 | 5257 | 5100 | 5100 | 4942 | 4942 | 4942 | 4785 | 4785 | 4785 |
| 0.8 | 5871 | 5871 | 5871 | 5871 | 5757 | 5757 | 5485 | 5414 | 5285 | 4942 |
| 1.0 | 4642 | 4328 | 4014 | 4014 | 3871 | 3871 | 3871 | 3714 | 3714 | 3714 |
| 1.2 | 5414 | 5414 | 5414 | 5257 | 5100 | 4942 | 4642 | 4328 | 4014 | 3714 |
| 1.5 | 3400 | 3085 | 2942 | 2942 | 2942 | 2942 | 2942 | 2942 | 2942 | 2942 |
| 1.8 | 4785 | 4785 | 4785 | 4642 | 4171 | 4157 | 3714 | 3400 | 3085 | 2785 |
| 2.0 | 2471 | 2171 | 2171 | 2171 | 2171 | 2171 | 2014 | 2014 | 2014 | 2014 |
| 2.5 | 4328 | 4328 | 4171 | 3871 | 3400 | 2942 | 2628 | 2171 | 1857 | 1700 |
| 3.0 | 1542 | 1428 | 1471 | 1514 | 1542 | 1542 | 1628 | 1628 | 1700 | 1700 |
| 3.5 | 3871 | 3871 | 3714 | 3242 | 2557 | 2171 | 2014 | 1700 | 1542 | 1328 |
| 4.0 | 1142 | 1085 | 1085 | 1142 | 1200 | 1242 | 1271 | 1300 | 1328 | 1357 |
| 4.5 | 3557 | 3400 | 3242 | 2785 | 2171 | 1771 | 1514 | 1300 | 1114 | 957 |
| 5.0 | 871 | 742 | 771 | 828 | 900 | 957 | 985 | 1014 | 1042 | 1057 |
| 5.5 | 3242 | 3085 | 2785 | 2171 | 1671 | 1357 | 1142 | 957 | 871 | 742 |
| 6.0 | 642 | 571 | 585 | 642 | 700 | 742 | 771 | 800 | 814 | 828 |
| 6.5 | 2785 | 2714 | 2085 | 1571 | 1057 | 828 | 685 | 571 | 500 | 428 |
| 7.0 | 385 | 342 | 371 | 400 | 428 | 471 | 500 | 542 | 571 | 585 |
| 7.5 | 2285 | 2214 | 1642 | 957 | 614 | 471 | 371 | 300 | 257 | 242 |
| 8.0 | 228 | 228 | 242 | 242 | 257 | 300 | 314 | 342 | 371 | 385 |
| 8.5 | 2085 | 1871 | 1242 | 585 | 357 | 257 | 214 | 185 | 171 | 157 |
| 9.0 | 157 | 157 | 157 | 157 | 171 | 200 | 214 | 242 | 257 | 300 |
| 9.5 | 1885 | 1614 | 957 | 385 | 214 | 171 | 142 | 128 | 128 | 114 |
| 10.0 | 114 | 114 | 114 | 128 | 142 | 157 | 171 | 185 | 214 | 242 |
| 10.5 | 1685 | 1357 | 714 | 285 | 171 | 128 | 100 | 100 | 85 | 85 |
| 11.0 | 85 | 85 | 85 | 85 | 100 | 114 | 142 | 171 | 185 | 200 |
| 11.5 | 1514 | 1157 | 542 | 200 | 114 | 85 | 71 | 71 | 71 | 71 |
| 12.0 | 71 | 57 | 71 | 71 | 85 | 100 | 128 | 142 | 142 | 157 |
| 12.5 | 1371 | 985 | 414 | 157 | 85 | 71 | 57 | 57 | 57 | 57 |
| 13.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13.5 | 1242 | 828 | 314 | 114 | 71 | 57 | 57 | 42 | 42 | 0 |
| 14.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14.5 | 1114 | 714 | 242 | 85 | 57 | 42 | 42 | 42 | 0 | 0 |
| 15.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15.5 | 1014 | 614 | 200 | 71 | 42 | 42 | 28 | 28 | 0 | 0 |
| 16.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16.5 | 957 | 542 | 171 | 57 | 42 | 28 | 28 | 0 | 0 | 0 |
| 17.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17.5 | 900 | 471 | 142 | 42 | 28 | 28 | 28 | 0 | 0 | 0 |
| 18.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18.5 | 828 | 400 | 128 | 42 | 28 | 28 | 28 | 0 | 0 | 0 |
| 19.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19.5 | 785 | 357 | 100 | 42 | 28 | 14 | 0 | 0 | 0 | 0 |
| 20.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20.5 | 742 | 328 | 100 | 28 | 28 | 14 | 0 | 0 | 0 | 0 |
| 21.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21.5 | 700 | 300 | 85 | 28 | 14 | 14 | 0 | 0 | 0 | 0 |
| 22.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22.5 | 671 | 257 | 71 | 28 | 14 | 14 | 0 | 0 | 0 | 0 |
| 23.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23.5 | 628 | 228 | 57 | 28 | 14 | 14 | 0 | 0 | 0 | 0 |
| 24.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24.5 | 600 | 200 | 57 | 28 | 14 | 0 | 0 | 0 | 0 | 0 |
| 25.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25.5 | 585 | 185 | 57 | 14 | 14 | 0 | 0 | 0 | 0 | 0 |
| 26.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |




Appendix 2

Requirement Profiles




Requirements Profiles

Calculux Road comes with several standard requirement profiles. In the tables below, some example profiles are given: the profiles with the **CEN** and **CIE** lighting classes for Motor traffic for which Luminance is the main design criterion.

-  The requirements only contain one set of values, therefore the second level is not given.

| | Grid method | L_{ave} | U_0 | U_1 | TI | SR |
|---------|-------------|-------------|-------------|-------------|----------|------------|
| EN_ME1 | Luminance | ≥ 2.0 | ≥ 0.40 | ≥ 0.70 | < 10.0 | ≥ 0.5 |
| EN_ME2 | Luminance | ≥ 1.5 | ≥ 0.40 | ≥ 0.70 | < 10.0 | ≥ 0.5 |
| EN_ME3a | Luminance | ≥ 1.0 | ≥ 0.40 | ≥ 0.70 | < 15.0 | ≥ 0.5 |
| EN_ME3b | Luminance | ≥ 1.0 | ≥ 0.40 | ≥ 0.60 | < 15.0 | ≥ 0.5 |
| EN_ME3c | Luminance | ≥ 1.0 | ≥ 0.40 | ≥ 0.50 | < 15.0 | ≥ 0.5 |
| EN_ME4a | Luminance | ≥ 0.75 | ≥ 0.40 | ≥ 0.60 | < 15.0 | ≥ 0.5 |
| EN_ME4b | Luminance | ≥ 0.75 | ≥ 0.40 | ≥ 0.50 | < 15.0 | ≥ 0.5 |
| EN_ME5 | Luminance | ≥ 0.50 | ≥ 0.35 | ≥ 0.40 | < 15.0 | ≥ 0.5 |
| EN_ME6 | Luminance | ≥ 0.30 | ≥ 0.35 | ≥ 0.40 | < 15.0 | ≥ 0.5 |
| CIE_M1 | Luminance | ≥ 2.0 | ≥ 0.40 | ≥ 0.70 | < 10.0 | ≥ 0.5 |
| CIE_M2 | Luminance | ≥ 1.50 | ≥ 0.40 | ≥ 0.70 | < 10.0 | ≥ 0.5 |
| CIE_M3 | Luminance | ≥ 1.00 | ≥ 0.40 | ≥ 0.50 | < 10.0 | ≥ 0.5 |
| CIE_M4 | Luminance | ≥ 0.75 | ≥ 0.40 | n.a | < 15.0 | n.a |
| CIE_M5 | Luminance | ≥ 0.50 | ≥ 0.40 | n.a | < 15.0 | n.a. |

| File name | Description |
|-----------|------------------------------|
| EN_ME1 | European Lighting Class ME1 |
| EN_ME2 | European Lighting Class ME1 |
| EN_ME3a | European Lighting Class ME3a |
| EN_ME3b | European Lighting Class ME3b |
| EN_ME3c | European Lighting Class ME3c |
| EN_ME4a | European Lighting Class ME4a |
| EN_ME4b | European Lighting Class ME4b |
| EN_ME5 | European Lighting Class ME5 |
| EN_ME6 | European Lighting Class ME6 |
| CIE_M1 | CIE Lighting Class M1 |
| CIE_M2 | CIE Lighting Class M2 |
| CIE_M3 | CIE Lighting Class M3 |
| CIE_M4 | CIE Lighting Class M4 |
| CIE_M5 | CIE Lighting Class M5 |

-  It might be that in your version not all the above requirement (or other) files are given. Files which you do not need can be deleted.



Appendix 3

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