Stretto di Messina

Concessionaria per la progettazione, realizzazione e gestione del collegamento stabile tra la Sicilia e il Continente Organismo di Diritto Pubblico
(Legge n° 1158 del 17 dicembre 1971, modificata dal D.Lgs. n°114 del 24 aprile 2003)

EurolinK

PONTE SULLO STRETTO DI MESSINA

PROGETTO DEFINITIVO

EUROLINK S.C.p.A.

IMPREGILO S.p.A. (MANDATARIA)
SOCIETÀ ITALIANA PER CONDOTTE D'ACQUA S.p.A. (MANDANTE)
COOPERATIVA MURATORI E CEMENTISTI - C.M.C. DI RAVENNA SOC. COOP. A.R.L. (MANDANTE)
SACYR S.A.U. (MANDANTE)
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A.C.I. S.C.P.A. - CONSORZIO STABILE (MANDANTE)

IL PROGETTISTA	IL CONTRAENTE GENERALE	STRETTO DI MESSINA	STRETTO DI MESSINA
COWI Ing. E.M. Veje Dott. Ing. E. Pagani Ordine Ingegneri Milano n° 15408 EurolinK	Project Manager (Ing. P.P. Marcheselli)	Direttore Generale e RUP Validazione (Ing. G. Fiammenghi)	Amministratore Delegato (Dott. P. Ciucci)

Unità Funzionale	OPERA DI ATTRAVERSAMENTO	PI0078_F0
Tipo di sistema	IMPIANTI TECNOLOGICI	
Raggruppamento di opere/attività	ELETTRICI	
Opera - tratto d'opera - parte d'opera	Lighting	
Titolo del documento	Lighting Systems Calculation report	

CODICE: C G 1 0 0 0 P 4 R D P I T E 2 S I 0 0 0 0 0 0 0 1 F0

REV	DATA	DESCRIZIONE	REDATTO	VERIFICATO	APPROVATO
F0	20/06/2011	EMISSIONE FINALE	JASJ	CFA	ABR/JCA

NOME DEL FILE: PI0078_F0.doc

INDICE

1 Introduction

The Calculation Report gives an overview of the results of the design calculations witch has been carried out for the Progetto Definitivo.

All calculations are carried out in DiaLux

2 Lighting systems

The following lighting systems are calculated in this report

- Road Light
- Sevice lane light
- Internal light in bridge
- Internal light in tower
- Internal light in anchore block
- Architectural Lighting

2.1 Road lighting

This part to refer to drawing CG1000-P3ADPIT-E2SI000000-01 and CG1000-P1ADPIT-E2SI000000-01

Road light is placed on the cross girder every 30 meter along th bridge. Two luminaires will be installed on each pole.

Mainteance factor 0.8

Tender drawing B.6-001, detail 1 showes two lamps in one luminaire, due to that, this kind of luminarie is not available anymore, therefore two lumrinaries will be placed on each pole to fulfill the reqriment of two lamps

2.1.1.1 Requirements

Required luminance values for road lighting will be the same as the rest of the highway. Luminance class will be ME2 arcording to UNI EN 13201-2

Class	Luminance of the road surface of the carriageway for the dry road surface condition			Disability glare	Lighting of surroundings
	$\bar{L}$ in cd/m² [minimum maintained]	U_o [minimum]	U_l [minimum]	TI in %[a] [maximum]	SR[2b] [minimum]
ME1	2,0	0,4	0,7	10	0,5
ME2	1,5	0,4	0,7	10	0,5
ME3a	1,0	0,4	0,7	15	0,5
ME3b	1,0	0,4	0,6	15	0,5
ME3c	1,0	0,4	0,5	15	0,5
ME4a	0,75	0,4	0,6	15	0,5
ME4b	0,75	0,4	0,5	15	0,5
ME5	0,5	0,35	0,4	15	0,5
ME6	0,3	0,35	0,4	15	no requirement

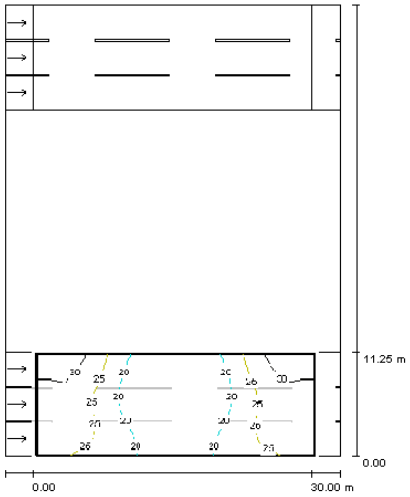
[a] An increase of 5 percentage points in *TI* can be permitted where low luminance light sources are used. (see note 6)
[b] This criterion can be applied only where there are no traffic areas with their own requirements adjacent to the carriageway.

Tabel from *ME-series of lighting classes (UNI EN 13201-2:2004)*

2.1.2 Calculation of Luminance

The calculation is carried out in DiaLux, maintenance factor 0,8

Messina / Road 1 / Results overview



Maintenance factor: 0.80

Grid: 10 x 9 Points
Accompanying Street Elements: Road 1.
tarmac: C2, q0: 0.070
Selected Lighting Class: ME2

(All lighting performance requirements are met.)

	L_{av} [cd/m²]	U0	Ul	Tl [%]	SR
Calculated values:	1.5	0.6	0.8	10	0.8
Required values according to class:	≥ 1.5	≥ 0.4	≥ 0.7	≤ 10	≥ 0.5
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

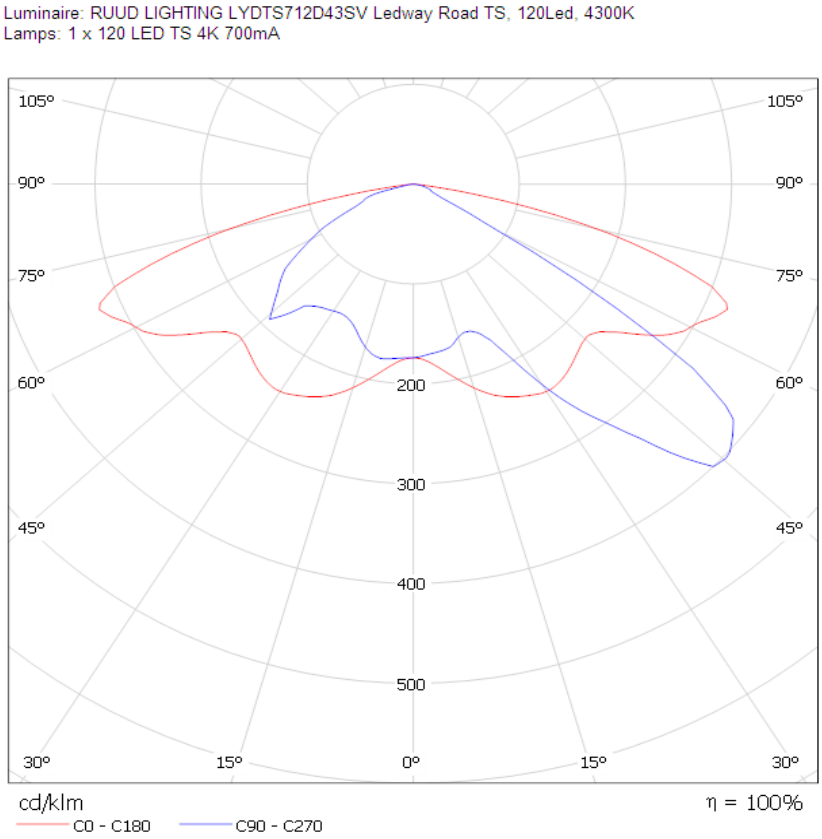
Assigned viewer (3 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	Tl [%]
1	Betragter 1	(-60.000, 1.875, 1.500)	1.6	0.6	0.8	6
2	Betragter 2	(-60.000, 5.625, 1.500)	1.6	0.6	0.8	8
3	Betragter 3	(-60.000, 9.375, 1.500)	1.5	0.6	0.9	10

Calculation fulfil the the requriment of lighting class ME2.

2.1.2.1 Road Luminaire

The road light will be supplied from QMT switchboard.
On each pole is mounted two luminaires equipt with 120 LED. Power 100% 240 W
LDC (Polar)



2.1.2.2 Control of Road Light

Refer to CG1000-P3ADPIT-E2SI000000-01
The Power-Line Comunication system (PLC) is a technology for transmitting data via an electrical network

The fittings are used as dimmable electronic drivers to which are added a control module called

Control Box. (CB) The module has the task of communicating directly with the driver, both to receive information regarding status and operation thereof, and to regulate the drivers feed current and, therefore, the luminous flux intensity of the luminaire

All apparatus may be controlled through a central Collecting Unit (CU) for collecting data on the functioning of the driver and send the Control Box the dimmer value operating the driver. The system is programmed by proprietary software that permits the creation of various dimmer profiles.
The CU makes available the following information:
The power supply status (ON/OFF).
2. Network voltage.
3. Dimming Level.
4. Absorbed current
5. Power consumption.
6. Power factor (cos φ).Setting profile.

The CB and CU dialogue through a proprietary protocol by exploiting the FSK - Standard (Frequency Shift Key) transmission at 110 kHz, Band B (EN 50065-1), at a speed of 2400Bps.
The single Control Unit may control up to 380 Control Box, permit monitoring of up to 13,000 scheduled events, and creation of up to 5 dimming profiles.
There are no limits on the maximum distance between the control box and the device or between devices; the only limitation regards the first device, which must never be more than 600, from the controlbox (and therefore from the Control Unit).
In the event that the CB is used without obtaining the CU, the driver will be set to operate at maximum output (the same occurs if communication fails due to a problem during the "on" stage).
The CU may be consulted or programmed with an ethernet, GSM or serial (RS485) connection.
Each control box mus thave a CU, and it is important (although not fundamental) that it be an electronic control box.

Normal

Two luminaires on each pole one is on and on is off or both are dimmed 50%. In case of failure in one of the luminare the other luminaire can be turn on or increased to 100% and luminance class of the road can be maintained and the defect luminare can be change or repaired.

Road Accident

In case of an accident the second luminare on the pole can be turned on or both can increase to 100% in the area of the accident to increase the safty for the people on the road.

3 Service lane light

Refer to Drawing CG1000-P1ADPIT-E2SI000000-01

Service lane light is placed 3,75 m center to center anlong the bridge on both sides of the bridge.

3.1.1 Requriments

EN 12464-2 Lighting of work places, outdoor work places

5.3 Lighting requirements for areas, tasks and activities

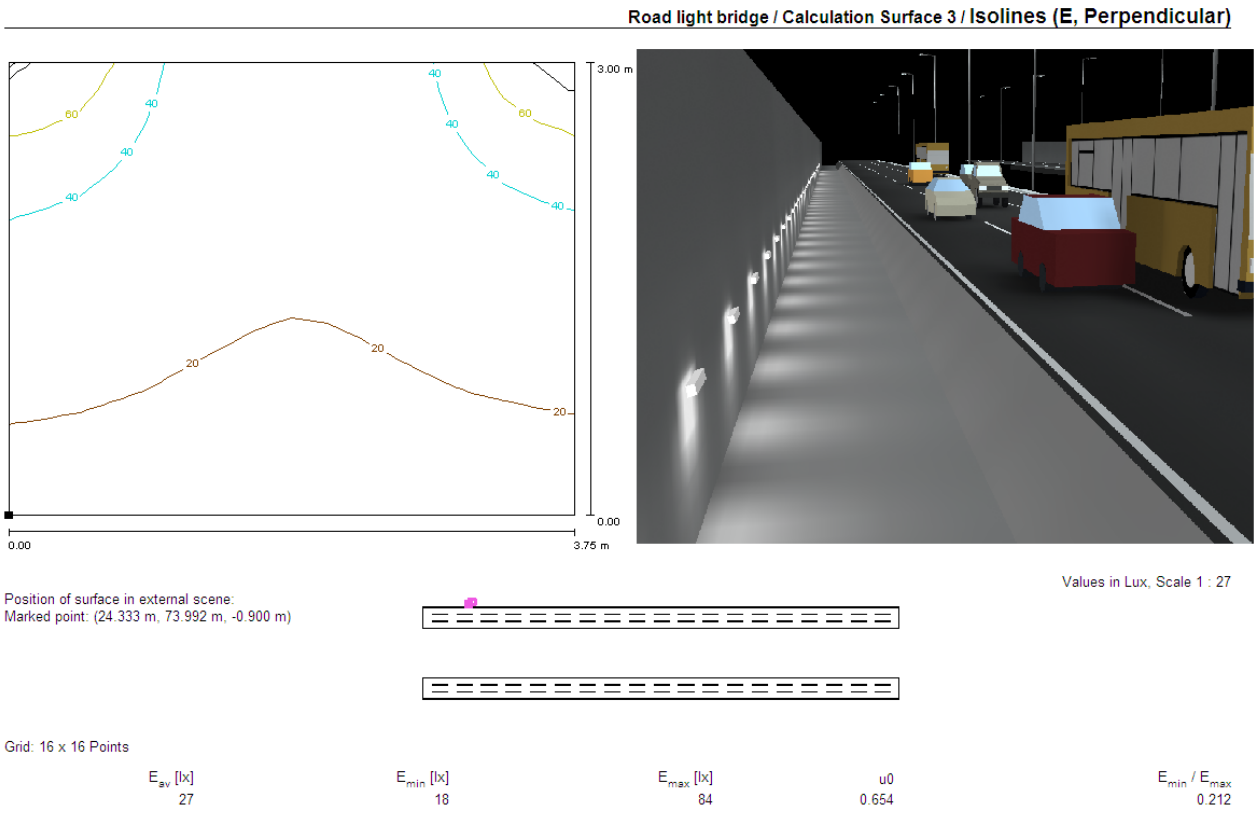
Table 5.1 — General circulation areas at outdoor work places

Ref. no.	Type of area, task or activity	$\bar{E}_m$ lx	U_o –	GR_L –	R_a –	Remarks
5.1.1	Walkways exclusively for pedestrians	5	0,25	50	20	
5.1.2	Traffic areas for slowly moving vehicles (max. 10 km/h), e.g. bicycles, trucks and excavators	10	0,40	50	20	
5.1.3	Regular vehicle traffic (max. 40 km/h)	20	0,40	45	20	At shipyards and in docks, GR_L may be 50
5.1.4	Pedestrian passages, vehicle turning, loading and unloading points	50	0,40	50	20	

Table from EN 12464-2

Requriment for service lane 5.1.3

3.1.2 Calculation



3.1.3 Luminires for the service road

Service lane light wil be supplied from FM A and B switchbords, every third luminare will be supplied from the UPS.

Luminare is equipped with LED T8 tube 9 W.

3.1.4 Control of service lane light

The light will be switched on from land, when it is required for maintaince work or repaire.

4 Internal light bridge

Refer to drawing CG1000-P1ADPIT-E2SI000000-03 and CG1000-P3ADPIT-E2SI000000-02.
There is internal light in the two road girders, one train girder and the cross girder.
For road and train girders will luminares be placed every 3,75 m along the bridge.

The calculation is carried out in DiaLux with a maintenance Factor 0.75.

4.1 Luminaires used for internal lighting

Internal lighting is supplied from FM A and B switchboards and the UPS. There has to occure three failures before everything in an area is totally dark.

Luminares will be equipped with LED T8 tube 9 W, 18 W and 36 W.

4.1.1 Requriments

Road girder will only be used when inspection has to be carried out, and the staff will use carriage to be transported and as an emergency escape route. The particular interior (area) task or activity is not listed. Similar area is man-sized underfloor tunnels, cellars etc.

EN 12464-1 Lighting of work places, indoor work places

Column 2 lists those **interiors (areas), tasks or activities**, for which specific requirements are given. If the particular interior (area), task or activity is not listed, the values given for a similar, comparable situation should be adopted.

2.8	Foundries and metal casting				
Ref. no.	**Type of interior, task or activity**	**$\bar{E}_m$** lx	**UGR_L** -	**R_a** -	**Remarks**
2.8.1	Man-size underfloor tunnels, cellars, etc.	50	-	20	Safety colours shall be recognisable.

4.1.2 Emergency light

Emergency light is supplied from centralised UPS instead of batteries local in the luminaires.
This will reduce the cost of maintaince, when there is no batteries ther has to be changed

4.1.2.1 Requriment

EN 1838 Emergency lighting:

4.2 Escape route lighting

4.2.1 For escape routes up to 2 m in width, the horizontal illuminances on the floor along the centre line of an escape route shall be not less than 1 lx and the central band consisting of not less than half of the width of the route shall be illuminated to a minimum of 50 % of that value.

NOTE 1: Wider escape routes can be treated as a number of 2 m wide strips or be provided with open area (anti-panic) lighting.

NOTE 2: Countries requiring different lighting levels are given in annex B.

4.2.2 The ratio of the maximum to the minimum illuminance shall not be greater than 40:1 along the centre line of the escape route.

Italy[2])

For cinemas, theatres and similar locations the minimum illuminance level measured at 1 m above the floor shall be 5 lx in proximity to the stairs and Exit doors. A minimum illuminance of 2 lx is required along escape routes. Where defined illuminance levels are required by law, they shall not be considered as design values but actual measured values including reflectance and available when emergency lighting is required.

[2]) The deviation from Italy is based on the following national regulations:

Decree of the Ministry of the Interior dtd. 1986-02-01 (Garages)
Decree of the Ministry of Transport dtd. 1988-01-11 (Underground)
Decree of the Ministry of the Interior dtd. 1992-08-26 (Schools)
Decree of the Ministry of the Interior dtd. 1994-04-09 (Hotels)
Decree of the Ministry of the Interior dtd. 1996-03-18 (Sport premises)
Decree of the Ministry of the Interior dtd. 1996-08-19 (Cinemas, theatres and public entertainment)

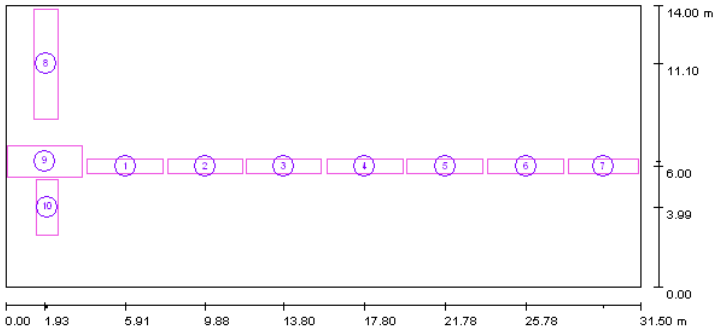
4.1.2.2 Requirement for work space

EN 12464-1 Lighting of work places, indoor work places 2.15.4

2.15	Power stations				
Ref. no.	Type of interior, task or activity	$\bar{E}_m$ lx	UGR_L -	R_a -	Remarks
2.15.1	Fuel supply plant	50	-	20	Safety colours shall be recognisable.
2.15.2	Boiler house	100	28	40	
2.15.3	Machine halls	200	25	80	For high-bay: see 4.6.2.
2.15.4	Side rooms, e.g. pump rooms, condenser rooms etc.; switchboards (inside buildings)	200	25	60	

4.2 Calculation road girder

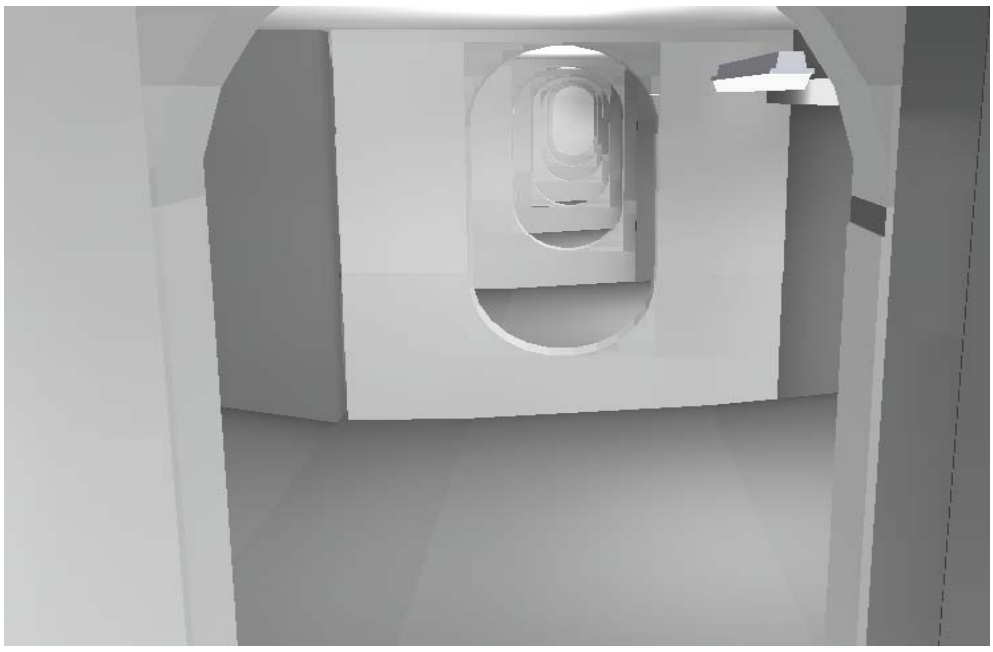
Messina / Calculation surfaces (results overview)



Scale 1 : 226

Calculation Surface List

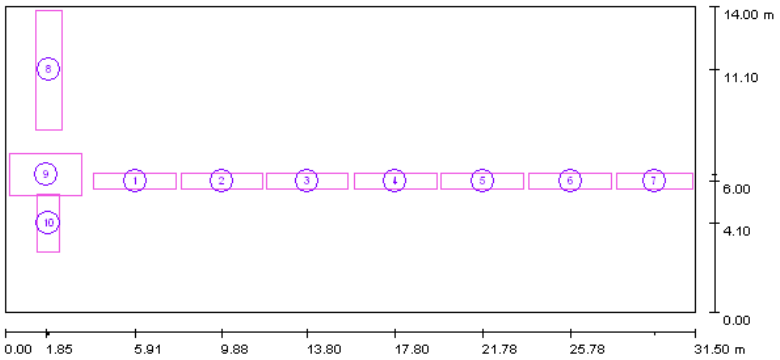
No.	Designation	Type	Grid	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1	Girder road	horizontal	32 x 8	79	35	140	0.437	0.247
2	Girder road	horizontal	32 x 8	81	38	141	0.469	0.268
3	Girder road	horizontal	32 x 8	80	39	140	0.481	0.276
4	Girder road	horizontal	32 x 8	80	37	142	0.461	0.259
5	Girder road	horizontal	32 x 8	80	36	142	0.452	0.254
6	Girder road	horizontal	32 x 8	80	36	143	0.451	0.254
7	Girder road	horizontal	32 x 8	82	42	139	0.507	0.299
8	Cross girder	horizontal	64 x 16	58	15	142	0.256	0.105
9	Cross girder	horizontal	32 x 16	62	29	103	0.477	0.285
10	Cross girder	horizontal	16 x 32	106	55	173	0.524	0.321



Fulfil requirement 4.2

4.2.1 Calculation road girder emergency

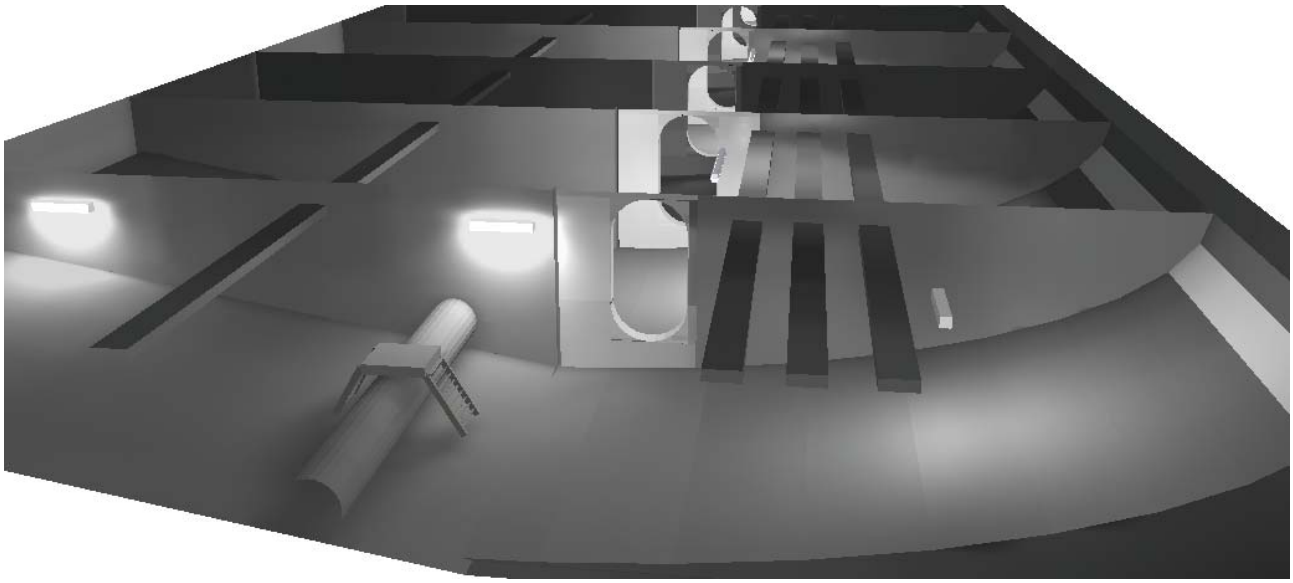
Messina / Calculation surfaces (results overview)



Scale 1 : 226

Calculation Surface List

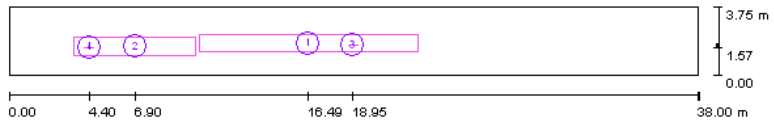
No.	Designation	Type	Grid	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1	Road girder	horizontal	32 x 8	76	32	138	0.428	0.235
2	Road girder	horizontal	32 x 8	5.81	2.86	11	0.493	0.268
3	Road girder	horizontal	32 x 8	75	34	138	0.458	0.250
4	Road girder	horizontal	16 x 4	5.06	2.51	9.16	0.497	0.274
5	Road girder	horizontal	32 x 8	75	33	139	0.445	0.239
6	Road girder	horizontal	32 x 8	5.79	2.82	12	0.487	0.240
7	Road girder	horizontal	32 x 8	78	41	135	0.520	0.301
8	Cross girder	horizontal	64 x 16	17	6.34	52	0.380	0.122
9	Cross girder	horizontal	32 x 32	27	15	72	0.549	0.205
10	Cross girder	horizontal	16 x 32	75	22	193	0.297	0.115



Fulfil requirement 4.1.2.1

4.3 Calculation train girder

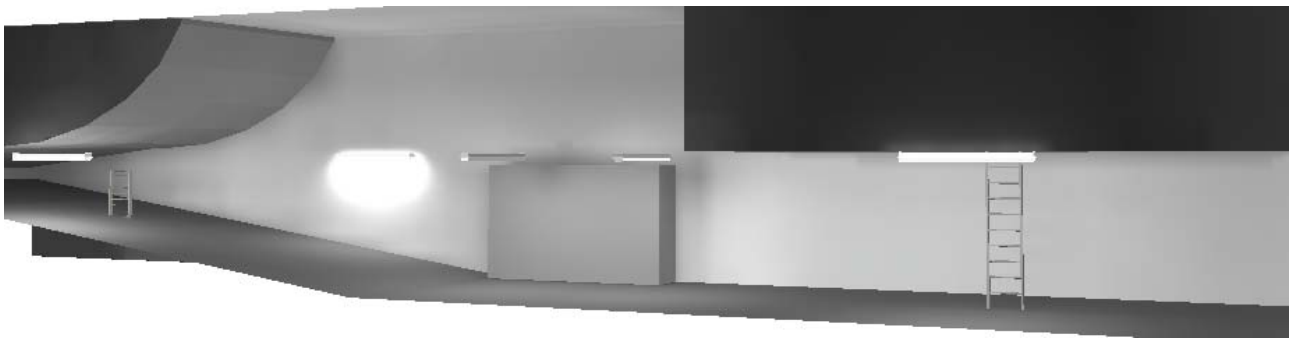
Messina Bridge / Calculation surfaces (results overview)



Scale 1 : 272

Calculation Surface List

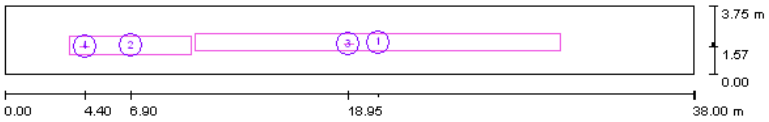
No.	Designation	Type	Grid	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1	Cross girder	horizontal	64 x 8	80	38	139	0.477	0.275
2	Cross girder	horizontal	128 x 64	89	24	184	0.265	0.128
3	Ladder under Train girder	perpendicular	4 x 8	148	125	165	0.847	0.760
4	Ladder under road girder	perpendicular	4 x 8	135	126	145	0.931	0.870



Fulfil the requirements 4.2

4.3.1 Calculation train girder emergency

Messina Bridge / Calculation surfaces (results overview)



Scale 1 : 272

Calculation Surface List

No.	Designation	Type	Grid	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1	Cross girder	horizontal	128 x 8	22	3.21	121	0.145	0.027
2	Cross girder	horizontal	128 x 64	29	5.56	102	0.192	0.055
3	Ladder under Train girder	perpendicular	8 x 16	139	112	159	0.808	0.702
4	Ladder under road girder	perpendicular	4 x 8	131	120	140	0.920	0.857

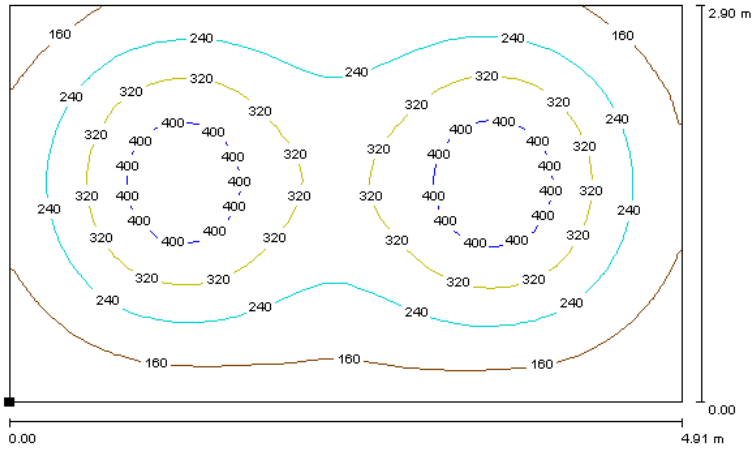
Fulfil requirement 4.1.2.1

4.3.2 Work space in from of FM switchboard

FM switchboard is placed in cross girder

4.3.2.1 Calculation in front of FM switchboard

Messina Bridge / Task Area 2 / Infront of Switchboard / Isolines (E)



Values in Lux, Scale 1 : 36

Position of surface in room:
Marked point: (22.600 m, 0.600 m, 0.750 m)

Grid: 32 x 32 Points

	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
Infront of Switchboard	258	83	464	0.322	0.179

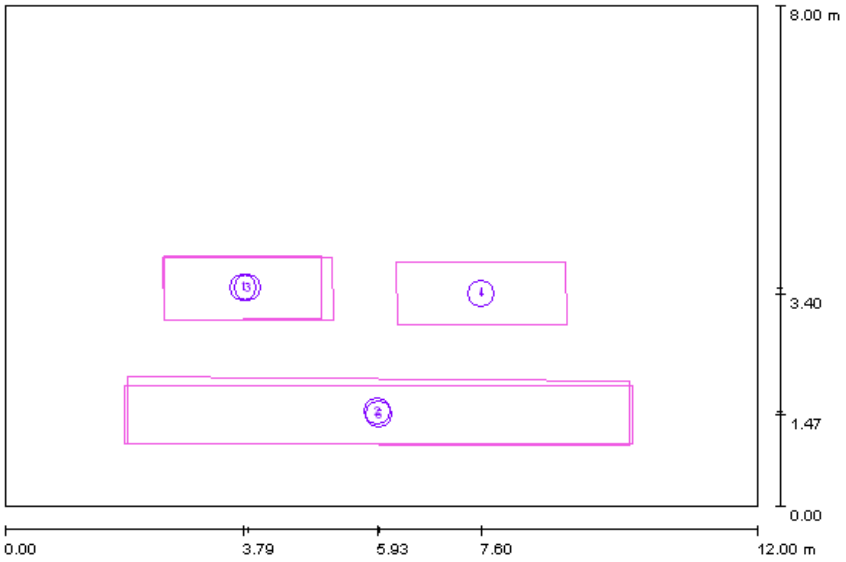
Fulfil requirements 4.1.2.2

5 Internal lighting Tower

Refer drawing CG1000-P1ADPIT-E2SI000000-04

Staircase is an escape route, the maintenance staff will use the escalator when they have inspect switchboards. the same requirements as 4.2.

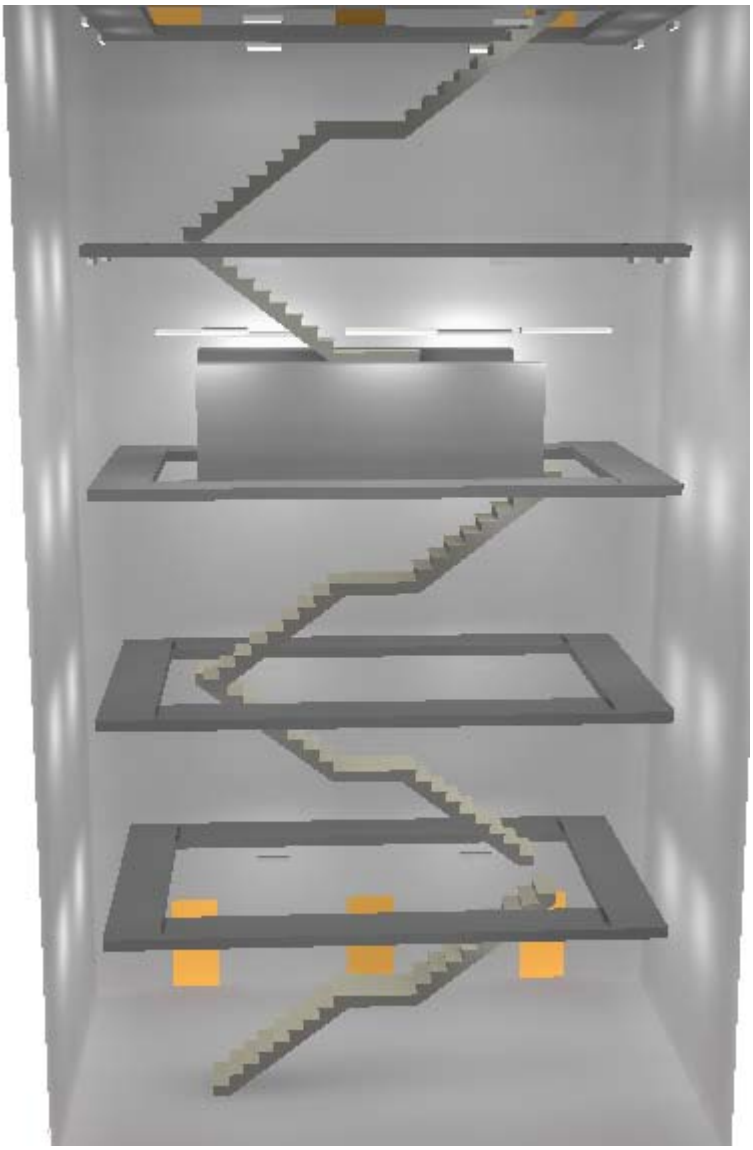
5.1 Calculation staircase



Scale 1 : 92

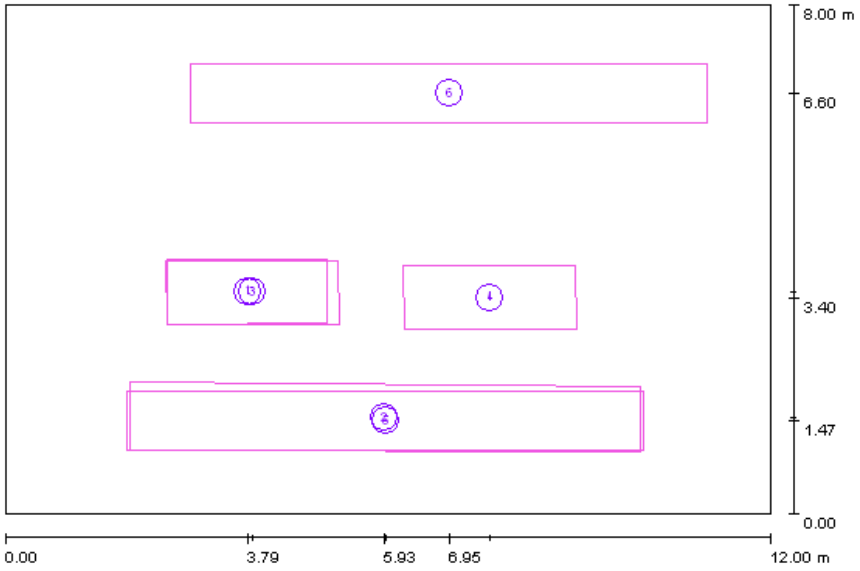
Calculation Surface List

No.	Designation	Type	Grid	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1	Staircase	horizontal	16 x 8	76	73	80	0.952	0.907
2	Walkway	horizontal	32 x 4	75	65	83	0.865	0.783
3	Stair	horizontal	16 x 8	81	71	88	0.882	0.806
4	Stair	horizontal	128 x 64	79	64	121	0.813	0.530
5	Front of Switchgear FM	horizontal	32 x 4	212	172	240	0.811	0.719



Staircase in tower

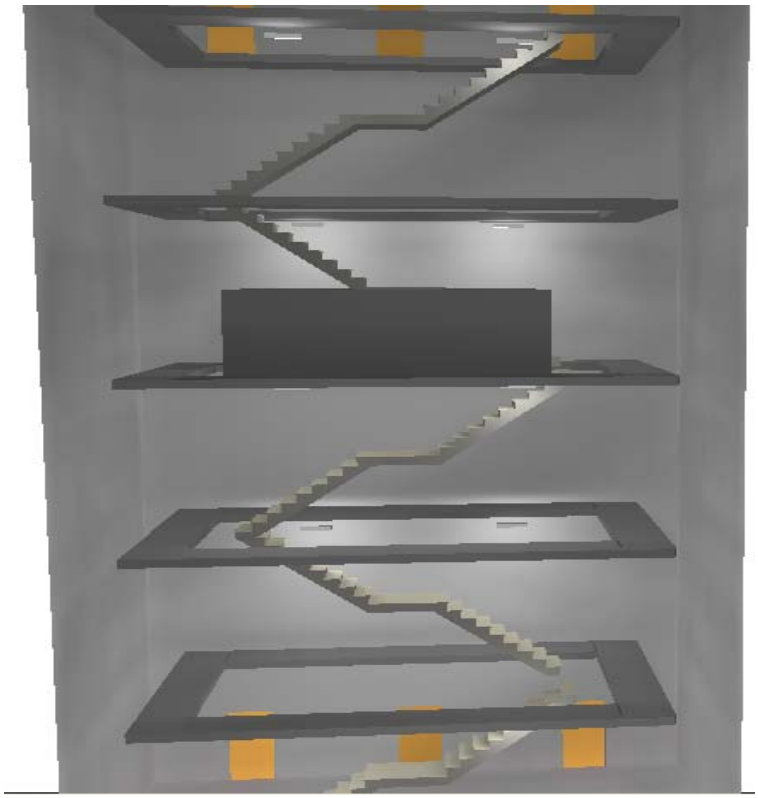
5.1.1 Calculation emergency lighting staircase



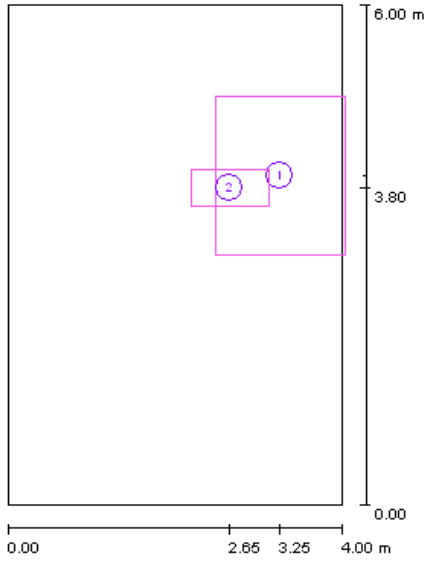
Scale 1 : 92

Calculation Surface List

No.	Designation	Type	Grid	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1	Staircase	horizontal	16 x 8	18	12	26	0.643	0.459
2	Walkway	horizontal	32 x 4	12	8.91	15	0.769	0.590
3	Stair	horizontal	16 x 8	25	18	33	0.722	0.564
4	Stair	horizontal	128 x 64	27	10	75	0.376	0.134
5	Front of Switchgear FM	horizontal	32 x 4	5.52	4.53	8.50	0.820	0.532
6	Walkway	horizontal	32 x 4	10	8.51	12	0.849	0.713



5.2 Calculation ladder



Scale 1 : 69

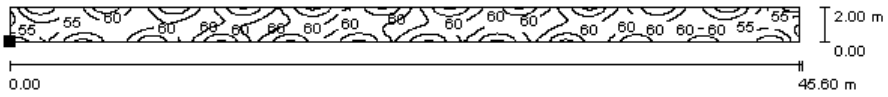
Calculation Surface List

No.	Designation	Type	Grid	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1	floor	horizontal	32 x 32	56	33	73	0.593	0.454
2	Ladder	horizontal	16 x 32	177	47	421	0.265	0.111

5.2.1 Emergency lighting ladder

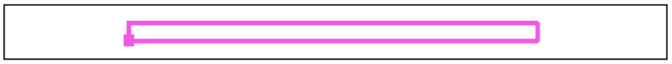
All light are Emergency lights.

5.3 Calculation Cross beam



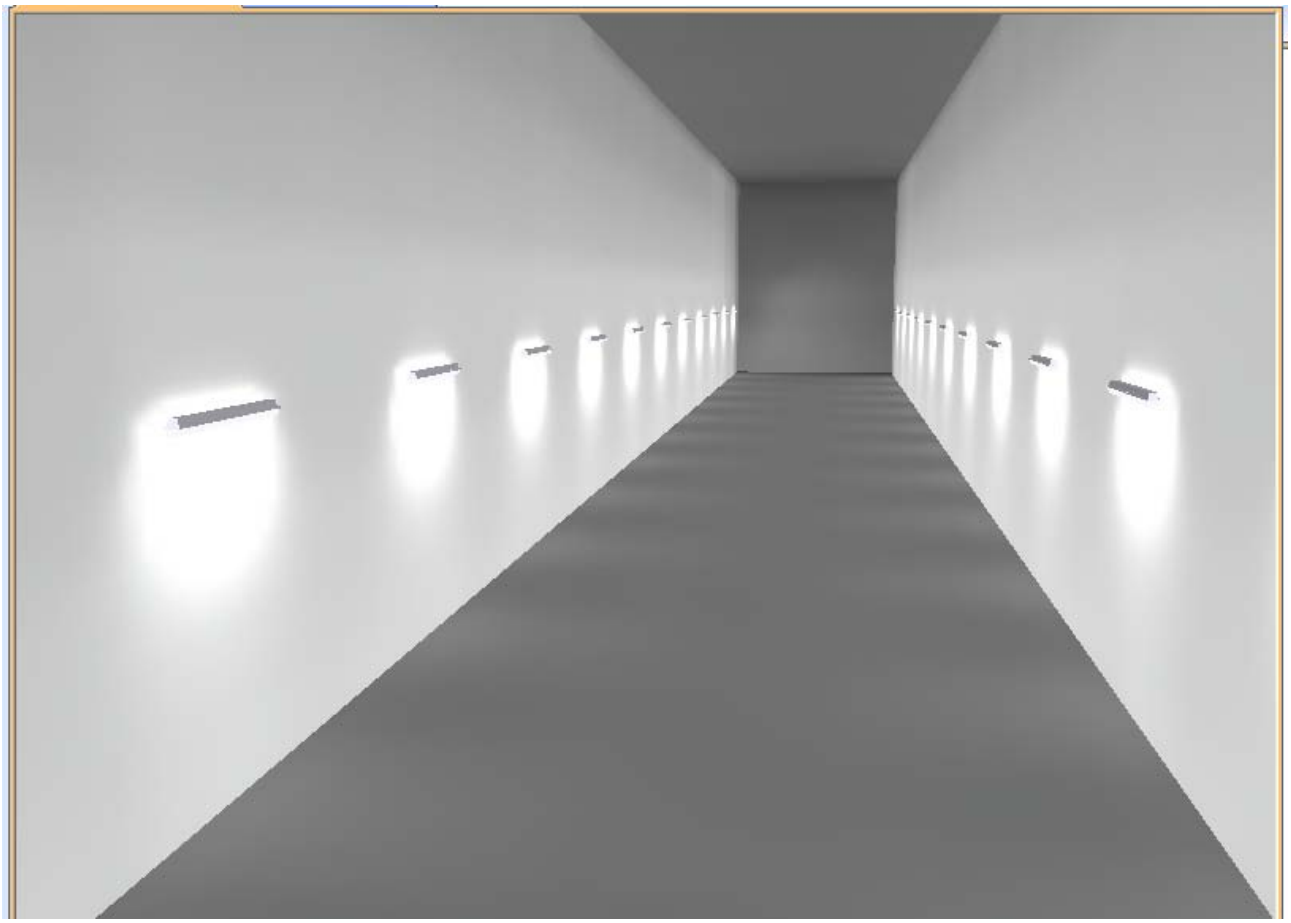
Values in Lux, Scale 1 : 327

Position of surface in room:
Marked point: (14.000 m, 2.000 m, 0.850 m)

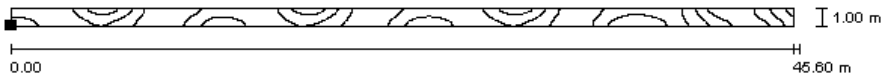


Grid: 128 x 128 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
61	49	72	0.803	0.675

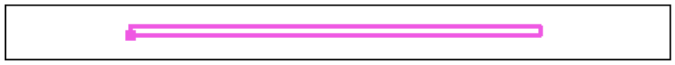


5.3.1 Emergency cross beam



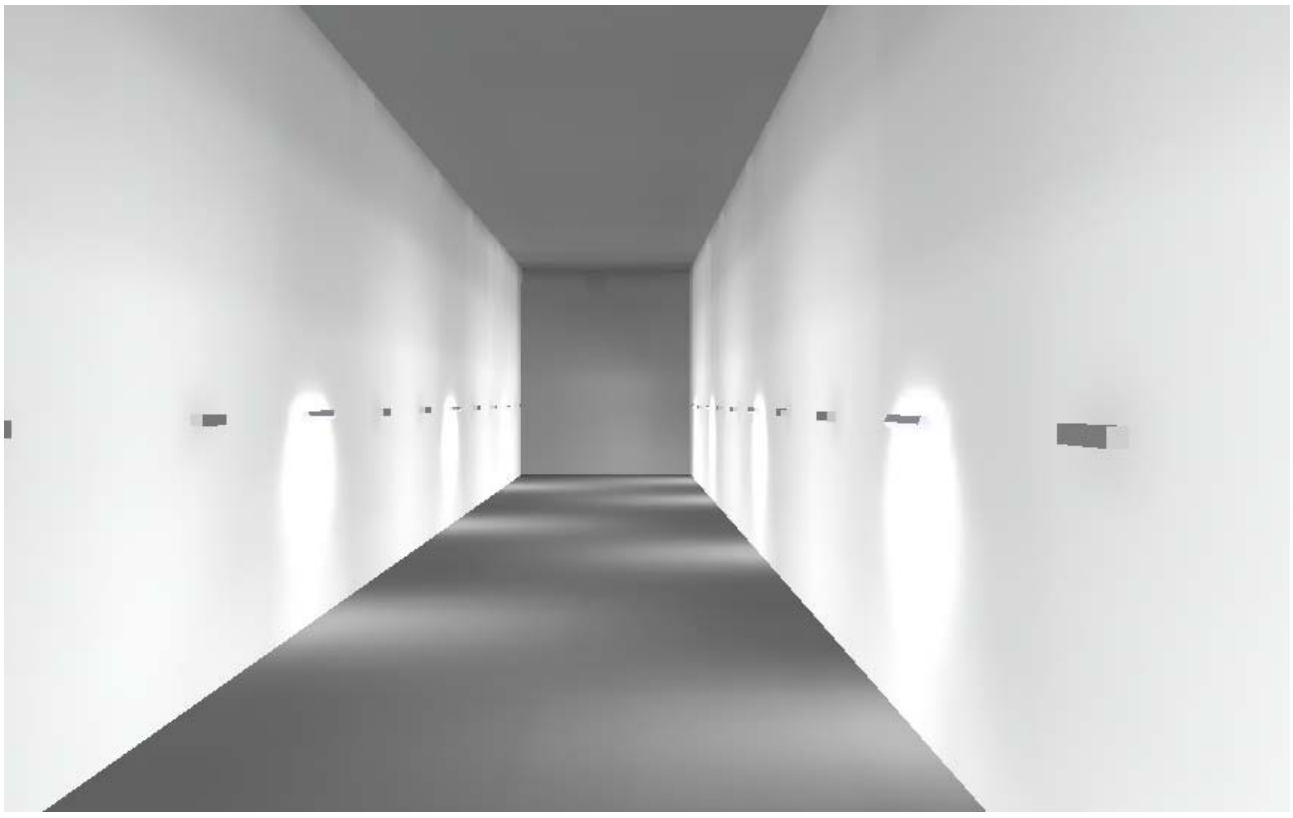
Values in Lux, Scale 1 : 327

Position of surface in room:
Marked point: (14.000 m, 2.650 m, 0.000 m)



Grid: 128 x 128 Points

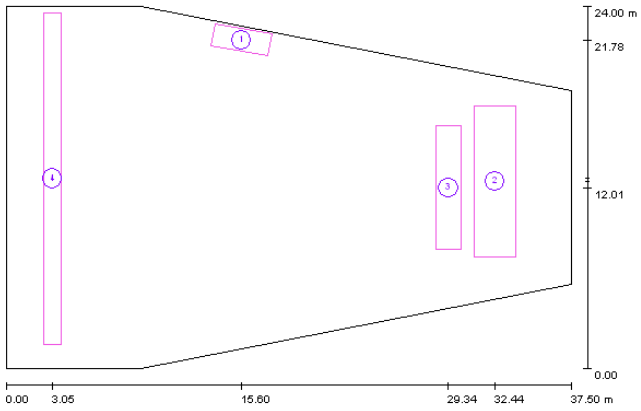
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
25	16	40	0.663	0.407



5.4 Anchor block

Refer document CG1000-P1ADPIT-E2SI000000-05

5.4.1 Calculation anchor block



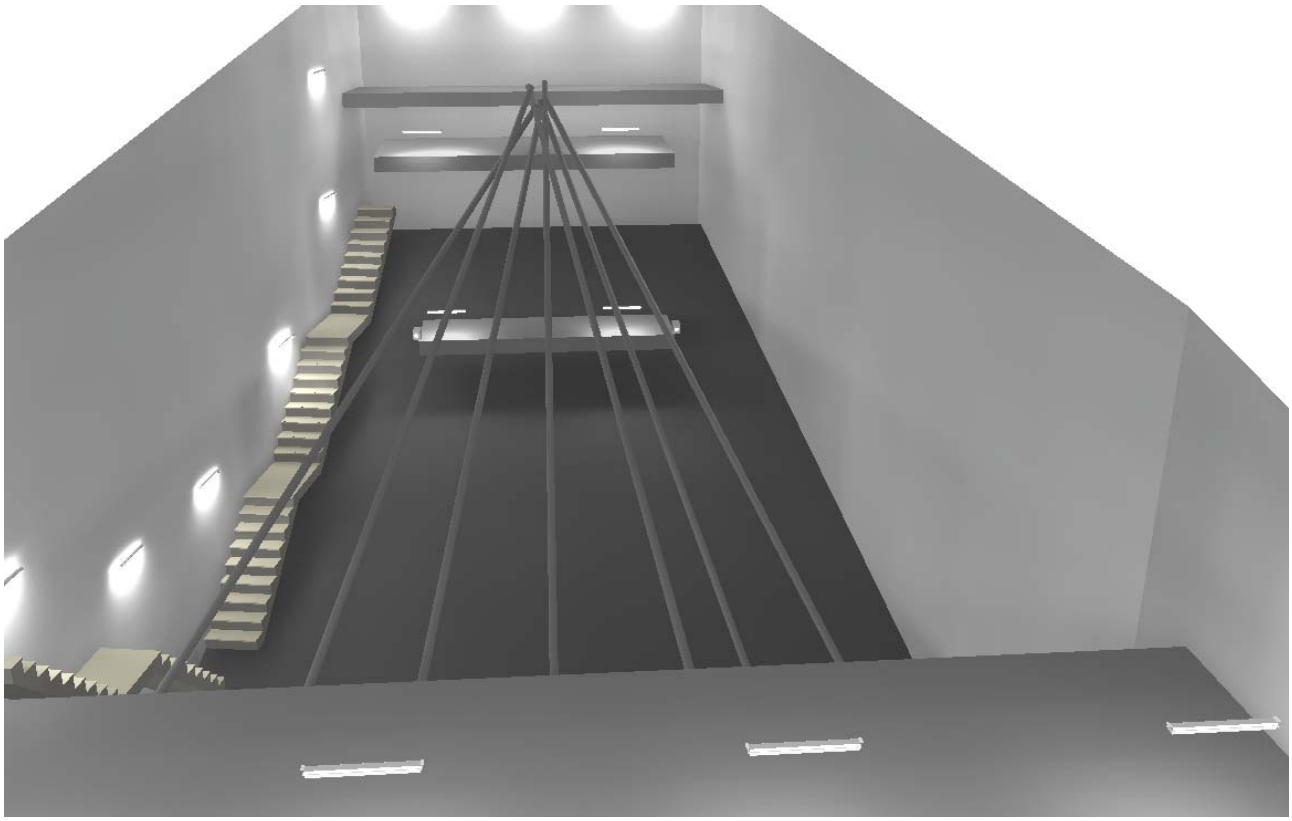
Scale 1 : 274

Calculation Surface List

No.	Designation	Type	Grid	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1	Anchor block, Staires	horizontal	32 x 16	58	39	85	0.671	0.459
2	Platform	horizontal	32 x 128	78	40	347	0.508	0.115
3	Platform	horizontal	16 x 64	58	25	246	0.431	0.101
4	Platform	horizontal	8 x 128	50	35	74	0.708	0.473

Summary of Results

Type	Quantity	Average [lx]	Min [lx]	Max [lx]	u0	E_{min} / E_{max}
horizontal	4	63	25	347	0.40	0.07



Anchore block

6 Architectural lighting

Refer to drawing CG1000-P1ADPIT-E2SI000000-02 and CG1000-P1ADPIT-E2SI000000-09

By the architectural lighting of the bridge over the Messina strait we want to tell the story about this impressive landmark after sunset. The architectural lighting shall contribute to the visual perception of the bridge structures after dark. And with movement in the light the bridge will be drawn up in the dark every evening.

The architectural lighting design consists of three different lighting elements. Light on the structure, the vertical, the horizontal and the plane surface.The rhythm of light, the light seen as you move relative to the bridge. The movement of light, the way the light is switched on, is an event in the movement.

Different aspects of perception have been considered when designing the architectural lighting. The following three aspects have been considered as relevant:

1. From a distance the bridge is seen as a whole, as an “icon”
2. From the shore, when arriving at the bridge, it is seen in a perspective view, details of the bridge are seen more clearly, not the total picture.
3. When driving across the bridge, in movement.


8 am


1 pm


6 pm

The movement of the light
During the day the movement of the sun will create different shadow patterns on the structures. The sunlight and the shadow on the structure reveal details and tell the story about the bridge.


Cold white

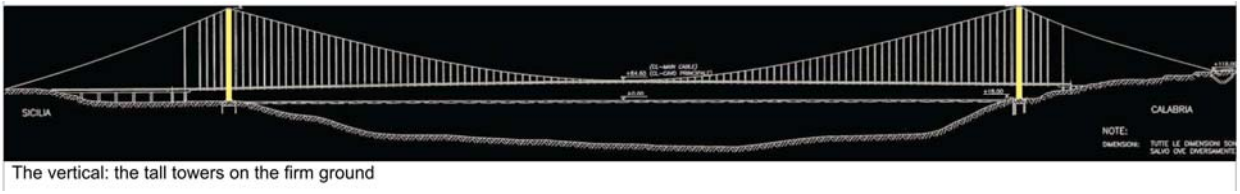

Neutral white


Warm white

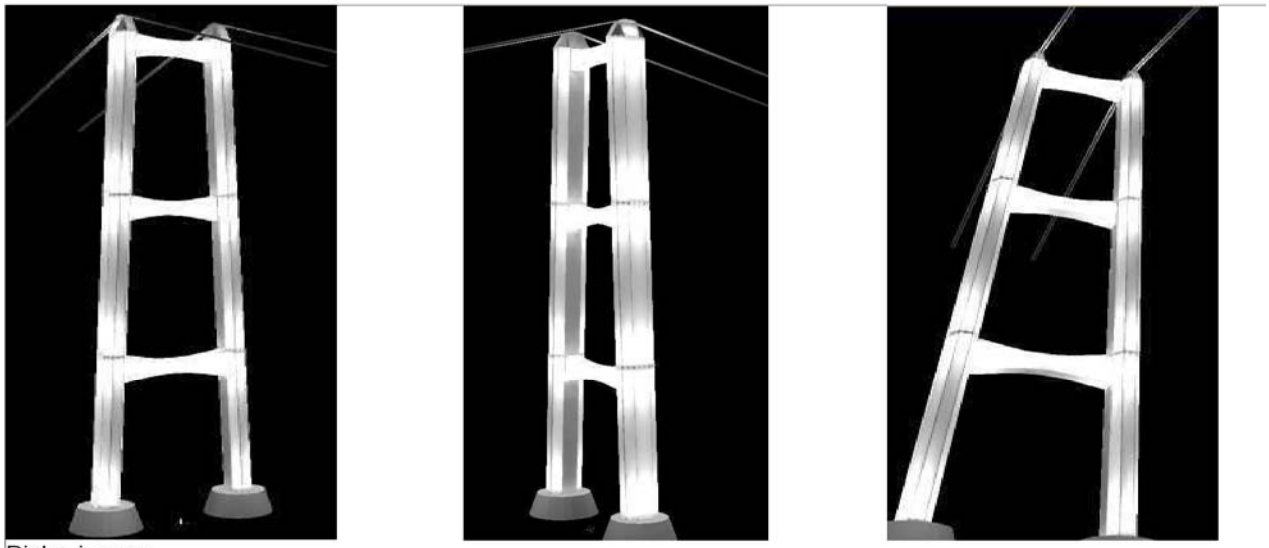
The colour of the light:

The idea is to illuminate the bridge with white light in different hues of colour temperature, referencing the changing colours of the daylight.
The light on the towers and cross beams are warm white, the cross beams cool white and the light on the main cables and the hangers neutral white.
Neutral whiteCold white Warm white

6.1 Towers



The vertical: the tall towers on the firm ground


Dialux images

Vertical: The towers and their cross beams.

The towers are illuminated on seven out of the eight surfaces of each tower leg. The luminaires are placed in 5 levels: at ground level and coinciding with the cross beams. The top of cone of the tower legs are illuminated as well. Cross beams are illuminated from luminaires placed on the tower leg and directed against the cross beam. The luminance is highest close to the tower legs and fades towards the centre, to emphasise the shape of the cross beam.

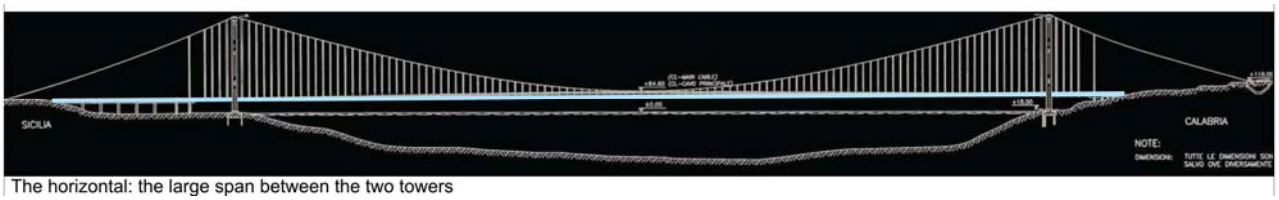
6.1.1 Luminaires for towers

Luminaires for towers: iW Reach Powercore, Philips

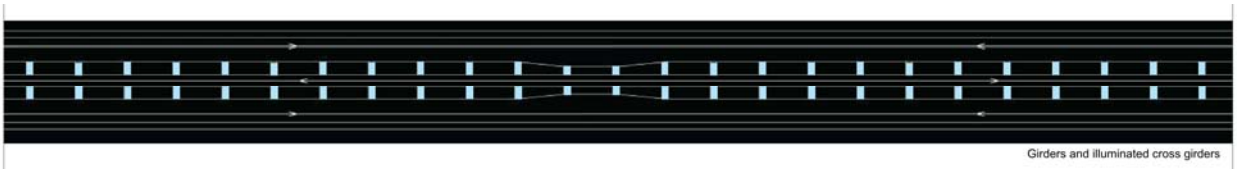
Luminaires for the top of the tower legs: eW Graze Powercore, Philips

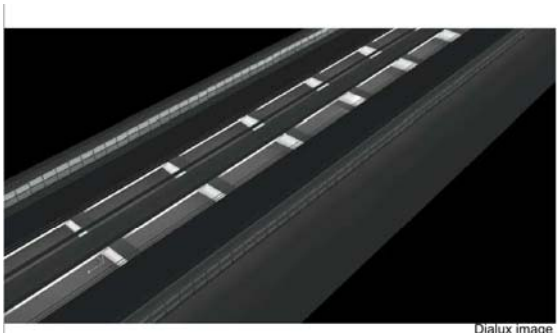
Luminaires for cross beams: iW Reach Powercore, Philips

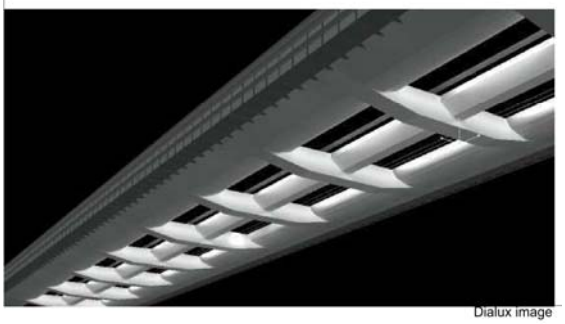
6.2 Cross girder



The horizontal: the large span between the two towers


Girders and illuminated cross girders


Dialux image

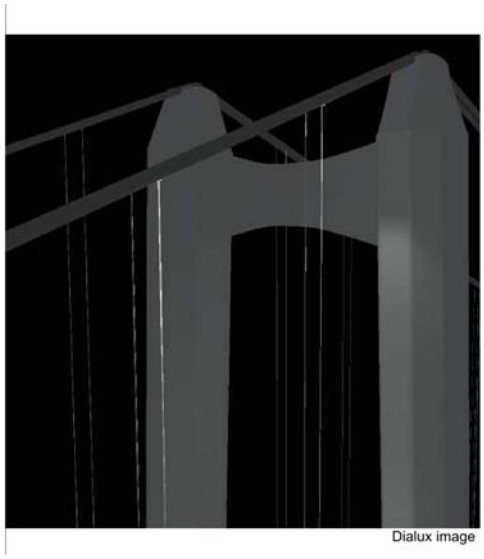

Dialux image

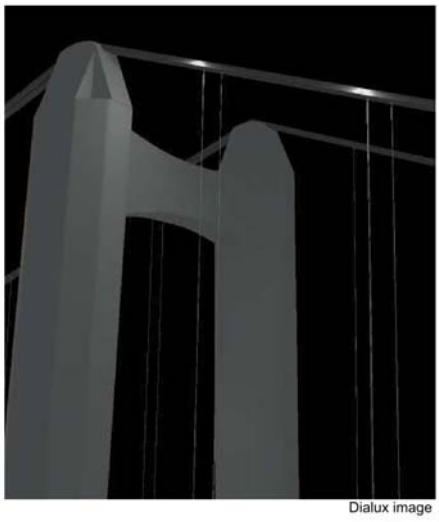
Horizontal: The cross girders across the bridge deck. Each cross girder is illuminated by luminaires placed on the adjacent cross girders. By illuminating the cross girders and hangers the rhythm of the structure will be emphasized. When moving around on the bridge or below or above the bridge, the perception of its huge construction will be amplifi ed by the feeling of the “rhythm” after dark.

6.2.1 Luminaires for cross girder

Luminaires for cross girders: eW Graze Powercore, Philips

6.3 Hangers and main cable





MAIN CABLE

The lighting of the main cables is proposed as point lights. A luminaire will be mounted above each hanger. The luminaires have omnidirectional light distribution, to be seen from many viewing angles.

Luminaires for main cables: Airfi eld lighting luminaire, LER, O.C.E.M.

HANGERS

The plane surfaces: The illumination of the hangers is provided by very narrow spotlights placed at the main cables and grazing downwards along the hangers. Downwards grazing is chosen to avoid light pollution.No luminaires or cables shall be placed on the hangers as they would jeopardize their dynamic stability.

Luminaries for hangers: to be determined. LED luminaires with the required combination of high lumen output and narrow light distribution has presently not been identifi ed, but is expected to be available at the time of procurement.

Luminaires, light sources and lighting control

Luminaires:

Calculation of the necessary light flux and luminance distribution, for deciding how the different lighting tasks can be realized, requires the use of specific digital light distribution files from specific brands and manufacturers of luminaires.

The proposed luminaires, which have been used in the software simulations of the lighting, may be replaced by similar luminaires from other manufacturers. During the time from this design to the actual procurement, a number of new luminaires will have been developed, that may even solve the illumination task better and for less power consumption than the presented solution,

which is necessarily based on existing luminaires. The present proposal is based on theoretical calculations. It is strongly recommended that full scale tests of the light distribution be carried out for all the luminaire types.

Light sources:

This design proposal includes work with a dynamic illumination. The LED lamps are particularly suitable for this because they do not require a warming up period such as the other possible relevant metal vapour lamps.LED lamps have a long technical lifetime which is advantageous for the maintenance of the lighting installation. The technical development of the LED lamps is presently very fast. At the time of procurement the effi ciency (lumen per watt) of the LED lamps are expected to be much better, i.e. the LED lamps will require considerably less energy than the corresponding traditional metal vapour lamps.

Lighting control:

All luminaires or groups of luminaires shall have individual control of intensity and colour temperature, by individual or group addressing by for example the USITT DMX 512 standard digital communication protocol. The changes in the lighting pattern and switching modes can be programmed into several scenarios that may be controlled from a pc, possibly with overall control and fault monitoring from the CMS.

6.4 Luminaries used for Architectural lighting

Luminaire description: lighting on the towers and cross beams

Name:	iW Reach Powercore
Manufacturer:	Philips
IP rating:	IP 65
Lamp type:	LED
Wattage:	250 W
Colour/beam:	Warm White / 8°

Luminaire description: lighting on the tower top and cross girders

Name:	eW Graze Powercore
Manufacturer:	Philips
IP rating:	IP 65
Lamp type:	LED
Wattage:	60 W
Colour/beam:	Warm white - tower top / 10 x 60° Cold white - cross girders / 10 x 60°

Luminaire description: lighting on the hangers

Name:	To be determined
Manufacturer:	
IP rating:	
Lamp Type:	LED
Wattage:	
Colour/Beam:	Neutral white / < 3°

Luminaire description: lighting on the main cables

Name:	LER
Manufacturer:	O.C.E.M.
IP rating:	IP 65
Lamp Type:	LED
Wattage:	90 W
Colour/Beam:	Neutral white

6.5 Lighting pollution from road and architectural lighting

The lighting pollution on the water surface caused by architectural lighting and road lighting has been calculated for the whole bridge showing isolines at horizontal sea level and horizontal deck level. Appendix 1. We have designed the lighting systems in order to minimize spill of light and cause unnecessary light pollution. As a result of the design the light pollution on the sea waters will not exceed 3-4 lux. There is no clear standard defining maximum acceptable light pollution, but an off-shore standard addresses this issue.

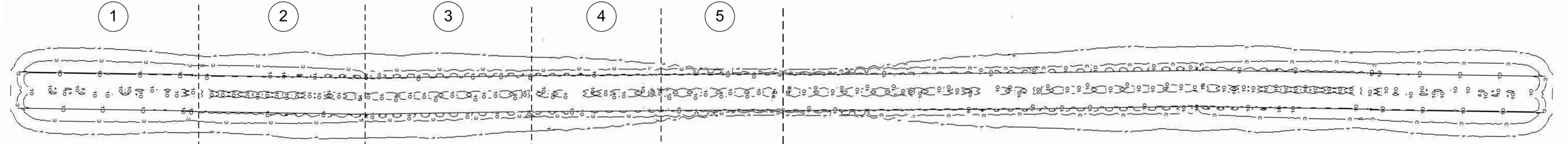
EN 12464-2 regarding light on the sea surface.

Table 5.8 — Off-shore gas and oil structures

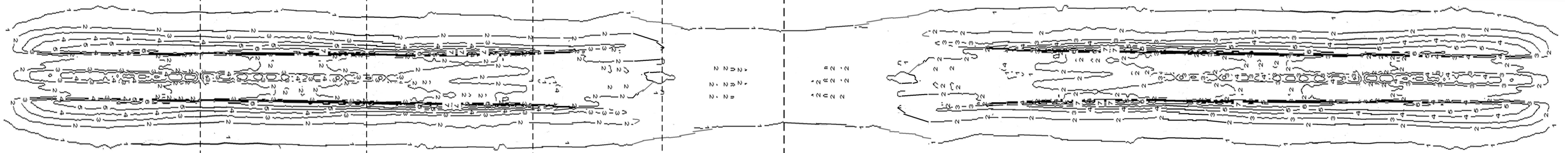
Ref. no.	Type of area, task or activity	$\bar{E}_m$ lx	U_o –	GR_L –	R_a –	Remarks
5.8.1	Sea surface below the rig	30	0,25	50	20	

When compared with this EN 12464-2 standard the light pollution under the bridge will be significally lower that specified in this standard. Furthermore, the lighting systems are prepared for remote control of lighting level which may contribute to decrease of lighting pollution in periods with low traffic intensity on the bridge.

Horizontal deck level



Horizontal Sea Level



1

No.	Designation	Type	Grid	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1	Calculation surface 1- horizontal sea level	horizontal	128 x 128	2.43	0.45	6.40	0.185	0.070
2	calculation surface 1- vertical sea level	vertical, 0.0°	128 x 128	0.43	0.02	1.59	0.048	0.013
3	Calculation surface 1- horizontal deck level	horizontal	128 x 128	7.43	0.28	42	0.038	0.007

2

Calculation Surface List

No.	Designation	Type	Grid	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1	Calculation surface 1- horizontal sea level	horizontal	128 x 128	2.23	0.47	7.79	0.210	0.060
2	calculation surface 1- vertical sea level	vertical, 0.0°	128 x 128	0.43	0.02	1.51	0.047	0.013
3	Calculation surface 1- horizontal deck level	horizontal	128 x 128	7.26	0.28	51	0.039	0.005

3

Calculation Surface List

No.	Designation	Type	Grid	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1	Calculation surface 1- horizontal sea level	horizontal	128 x 128	2.01	0.47	8.64	0.236	0.055
2	calculation surface 1- vertical sea level	vertical, 0.0°	128 x 128	0.44	0.02	1.77	0.034	0.009
3	Calculation surface 1- horizontal deck level	horizontal	128 x 128	8.09	0.08	111	0.010	0.001

4

Calculation Surface List

No.	Designation	Type	Grid	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1	Calculation surface 1- horizontal sea level	horizontal	128 x 128	1.33	0.28	4.92	0.210	0.057
2	calculation surface 1- vertical sea level	vertical, 0.0°	128 x 128	0.33	0.01	1.46	0.018	0.004
3	Calculation surface 1- horizontal deck level	horizontal	128 x 128	6.28	0.00	626	0.000	0.000

5

Calculation Surface List

No.	Designation	Type	Grid	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1	Calculation surface 1- horizontal sea level	horizontal	128 x 128	1.02	0.22	2.07	0.218	0.107
2	calculation surface 1- vertical sea level	vertical, 0.0°	128 x 128	0.27	0.01	1.06	0.023	0.006
3	Calculation surface 1- horizontal deck level	horizontal	128 x 128	6.05	0.00	1519	0.000	0.000