METROLINK

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A5.18 Construction Lighting

Contents

Abbreviations and Glossary

Term	Explanation
Control systems	Systems that control the switching and/or dimming of a lighting installation.
Directional lighting	Lighting designed to illuminate a task or surface predominately from one direction.
Disability glare	Glare produced directly or by reflection that impairs the visibility of objects without necessarily causing discomfort.
Discomfort glare	Direct glare that causes visual comfort.
Emergency lighting	Lighting provided for use when the main lighting installation fails.
General lighting	Lighting designed to illuminate the whole of an area uniformly, without provision for special lighting requirements.
Glare	A discomforting or disabling brightness which causes a loss in visibility as stray light scatters within the eyes. An example would be driving on a road and being temporarily blinded by oncoming headlights. Sensitivity to glare can vary widely.
Illuminance (lux)	The luminous flux density at a surface, i.e. the luminous flux incident per unit area. It is measured in lux = lumens/square metre.
Illumination	The process of lighting.
Indirect lighting	Lighting where most of the light reaches a surface, usually on a working plane, only after reflection off other surfaces.
Light clutter	An area where there are large groups of lights that may cause distraction or confusion. Clutter can be found in particular in parts of cities or on busy roads.
LEDs	Light emitting diodes.
Light trespass	Where light spills into areas in which it is unwanted. An example of this would be the light from an exterior site or streetlight entering a bedroom window and illuminating the interior.
Local lighting	Lighting designed to illuminate a particular small area which usually does not extend far beyond the task.
Localised lighting	Lighting designed to illuminate an interior and at the same time provide higher illuminances over particular areas or parts of an interior.
Luminaire	Light fitting which includes the components necessary for fixing and supporting the lamp, and for connecting it to the supply circuit. It also controls the distribution of light produced by a lamp or lamps.
Luminous flux (lumen)	The rate of flow of luminous energy at a given point from a light source. One lumen = 1 candela steradian (cd.sr).
Mounting height	The vertical distance between a luminaire and the working plane.

Term	Explanation
Reflectance	The ratio between the luminous flux reflected from a surface and the luminous flux falling on it.
Spacing/mounting height	The ratio between the distance from the luminaire centre to the height of the luminaire above a horizontal working plane.
Sky glow	This occurs from both natural and man-made sources of lighting which increase night sky brightness. Light can be emitted directly or reflected into the atmosphere to produce a luminous background. The ability to view the stars at night is hindered.
Visual field	The full extent of what can be seen by the visual system when looking in a given direction.
Working plane	The horizontal, vertical or inclined plane on which the task lies.
Over-illumination	The excessive use of lights.

1. Approach to Temporary Site Lighting

1.1 Preamble

Adequate temporary site lighting is necessary for the safety and productivity of the workers, and for the work to be executed properly. For construction sites to work effectively and safely, it is important that the site is well lit, either by natural or artificial lighting. This ensures that wherever people are working, they are able to do their work effectively and move around the site safely and efficiently.

Construction temporary site lighting can be arranged in different ways on site to allow for the most efficient use. Appropriate light levels on construction sites can help everyone working on the site itself, illuminate emergency exits and also enhance site security measures.

Lighting can be fixed to support poles, scaffolding, temporary structures e.g. hoardings and tower cranes, or it can be put on movable supports.

Avoiding hazards on a construction site is made much easier when potential hazards can be seen. This can be a particular issue during winter months but, with most major tunnel projects running 24 hours a day, providing adequate lighting is a key consideration all year round above and below ground level.

Every construction site must provide the following:

- Adequate power supply and distribution on site;
- Suitable and sufficient temporary lighting;
- Natural light, as far as is reasonably practical; and
- Suitable and efficient specific task and emergency lighting/routes where needed.

Temporary site lighting can be divided into three main types as follows:

- Site lighting for general working and/or task-specific working, e.g. roadworks, utility diversions, deep excavations, tunnelling works;
- Emergency back-up lighting; and
- Provision for security lighting (sometimes combined with CCTV).

Aside from risk of accidents owing to inadequate site lighting or illumination, poor lighting can have a detrimental effect on people's health and wellbeing, causing eye strain, migraines and headaches. As a consequence, efficiency and productivity on site can fall and staff may have to take time off through accidents, injuries and ill-health.

Temporary site lighting would be used internally for general movement and working on/within the site itself, externally for proper illumination of the works areas, site access/egress locations, storage and circulation areas, and can also be an effective form of deterrent for trespassers and site security.

There are a wide range of lamps and temporary lighting equipment available, from simple fixed tungsten filament lamps to low-energy mobile LED and energy-efficient prismatic lens technology lamps with dusk-to-dawn auto switching. Site lighting is generally run off mains electricity, where feasible, at a voltage of 230V, rather than using generators. However, technological advancements have led to low-energy and environmentally 'friendly' generators, which are perfectly suited for off-grid uses and powered by hydrogen fuel cells resulting in zero noise pollution, exhaust emissions, CO_2 emissions and risk of spillage contamination.

1.2 Key Reference and Legislation Information

The two main sources of guidance for lighting in the workplace are the Society for Light and Lighting's Code for Lighting (published by the Chartered Institution of Building Services Engineers-UK) and the Health and Safety Executive's Lighting at Work (UK) (HSG38). While the former covers all aspects of lighting, HSG38 is probably the most relevant for construction sites. It is important to note that there is very little construction-specific guidance available in Ireland or UK, hence why reference has been made to a variety of guidance and standards from Ireland, the UK and USA, which is deemed the most appropriate for use on MetroLink.

The focus of this Technical Note is to outline on-site temporary lighting requirements for external working only. Lighting of indoor or internal offices is not included in this Technical Note.

According to HG38, the minimum recommended requirements and approach for temporary site lighting would:

- Allow people to notice hazards and assess risks;
- Provide enough light for the working environment and the task;
- Enable people to see properly and discriminate between colours (particularly important with safety warnings);
- Not cause glare, flicker or stroboscopic effects;
- Not create big differences in light within an area or between adjacent areas;
- Meet any special needs of individuals;
- Not pose a health and safety risk itself;
- Be positioned to allow safe maintenance, replacement and disposal; and
- Include, when necessary, suitable and safe emergency lighting.

The main sources of legislation from the Health and Safety Authority (Ireland) are:

1. Safety, Health and Welfare at Work (General Application) Regulations 2007 (S.I. No. 299 of 2007) – Part 2, Chapter 1(8) refers to natural and artificial lighting; and
2. Safety, Health and Welfare at Work (Construction) Regulations 2013 (S.I. No. 291 of 2013).

According to the Safety, Health and Welfare at (Work (General Application) Regulations 2007, the key legislative requirements state that it is the duty of the employer to ensure that:

'*(a) places of work receive, as far as possible, sufficient natural light and are equipped with artificial lighting adequate for the protection of the safety and health of the employer's employees,*
(b) lighting installations in rooms containing workstations and in passageways are placed in such a way that there is no risk of accident to the employer's employees as a result of the type of lighting fitted, and
(c) places of work in which the employer's employees are especially exposed to risks in the event of failure of artificial lighting are provided with emergency lighting of adequate intensity.'

Other useful and relevant reference documentation and industry good practice guidance is as follows, as very little construction-specific guidance is available in Ireland or the UK:

1. Code of Lighting, produced by Chartered Institution of Building Services Engineers-UK, on guidance on luminaire types, their standards and markings;
2. Guidelines for Work Zone Designers, produced by Federal Highway Administration (USA);

3. Lighting Guide 0: Introduction to light and lighting, produced by the Society of Light and Lighting;
4. NCHRP Report 498, Illumination Guidelines for Nighttime Highway Work, produced by National Cooperative Highway Research (USA); and
5. HSG38, Lighting at Work, produced by the Health and Safety Executive (UK).

1.3 Site Lighting Plan and Arrangement

1.3.1 Lighting Plan

It is important and recommended that a draft Site Lighting Plan be developed for construction of MetroLink, which the main civil works contractor would prepare and develop to produce a Construction Phase Lighting Plan prior to commencement of construction activities. This will establish and accomplish the following objectives:

- Provide a consistent and safe approach to site lighting;
- Provide the appropriate level of lighting that allows construction work to be completed safely and effectively;
- Provide the most appropriate type of lighting that minimises carbon footprint and is energy efficient;
- Adopt a proactive approach to reduce light pollution and trespass; and
- Improve the overall safety of the workers and travelling public.

The Site Lighting Plan will take into consideration the type of work activities to be undertaken, and therefore the associated level of lighting requirements. For example, for work operations involving excavation, the lighting intensity would be measured and monitored at the bottom of the trench or excavation and/or within the cut and cover and tunnelling works.

Once the Site Lighting Plan is implemented, field observations of the work zone lighting would be performed by driving and walking through the work zone. The field checks would ensure that site lighting in all areas is inspected, managed, and the lighting is appropriate for the work being undertaken.

Once the field check is complete and the work area has been reviewed, any necessary modifications or adjustments would be implemented, and the work zone plan or inspection report would show that deficiencies were identified and remediated.

1.3.2 Site Arrangement

Every part of the construction site that is in use will be well-lit.

It is common on construction sites for shadows to form, obscuring hazards e.g. construction plant and vehicle movements, blind spots and nails. To avoid any injuries, additional or strategically placed lighting around the construction site can help illuminate any areas and mitigate any risk.

Lighting would be arranged on site in a static formation, where lamps are fixed to support poles, masts or items of plant such as scaffolding, piling rigs and crawler cranes. This lighting would also be arranged locally, as and where work is progressing, by the use of moveable or portable supports (see Diagram 1.1, Diagram 1.2 and Diagram 1.6).

In general, walkways are often illuminated by bulkhead lamps on standard mains voltage. Bulkhead lamp bodies and diffusers can be manufactured from a variety of approved materials, e.g. acrylic, die-cast aluminium alloy, steel bodies together with a vandal-resistant translucent polycarbonate diffuser.

To illuminate general working areas, festoon (overhead) lighting can be suspended from support brackets at regular spacings. These are usually tungsten individual lamps connected by short cable runs, and both cable and

lamp holders must be appropriately weather-resistant. It is likely that the use of LED type lighting would be more prevalent on site. The use of lamps with LED light sources would greatly assist with energy efficiency targets and would also provide improved impact and weather resistance compared to traditional filament lamps.

Temporary site lighting must be arranged such that any visual intrusion and light spillage is avoided, and it should be frequently monitored for compliance as the main civil works progresses. This is particularly important near residential properties and busy roads where it may cause significant nuisance or distraction to road users, e.g. when working on or near the R132.

Where necessary, semi-permanent site lighting would be provided to all site boundaries/hoardings, temporary bridges, haul routes, site entrances and exits to ensure the safety of passing pedestrians and other road users.

1.3.3 Field Check the Lighting Plan

Once the Site Lighting Plan has been developed and implemented by the main works contractor, field observations of the work zone lighting would be performed by driving and walking through the site and inspecting the work zones. The field checks would be conducted from the vantage point of the worker and plant operator on site, and of road users (if works are happening on or near existing live carriageways), to ensure that glare and light spill are controlled and the lighting is safe for the work being undertaken.

Regular measurements would also be taken to verify that the necessary lighting levels are met in the general works access routes and areas, including in particular where works are undertaken adjacent to private or commercial properties, and during offline works e.g. temporary road diversions, utility works or road/junction crossings. It is envisaged that this would be undertaken jointly by the contractor and the client's site representative. The contractor would provide the client's site representative with a light meter.

Once the field check is complete and the work area has been reviewed, any necessary modifications or adjustments would be agreed and implemented, and the work zone plan or inspection report would show that deficiencies were identified and remediated. As with any modification or adjustment to a plan that puts the work zone in greater compliance with standards and policies, complete and thorough records must be maintained.

1.4 Lighting Levels

There are generally three main levels of lighting or classification of illumination for a range of work zone considerations.

Level 1: All work operations areas; Level 1 illuminance is important in areas where the work crews are in motion, moving from spot to spot. This level of illuminance is appropriate for tasks requiring low accuracy, involving slow-moving equipment, and where there are large objects to be seen. It is recommended that Level 1 illuminance maintains a minimum of 40lux.

Level 2: Level 2 illuminance is recommended for areas on or around construction equipment to provide a safer environment for the workers operating the equipment, allowing them to perform tasks that require a moderate level of accuracy. It is recommended that Level 2 illuminance maintains a minimum of 80lux.

Level 3: Level 3 illuminance is appropriate for those tasks that require a greater level of visual awareness or for tasks with a higher level of complexity, either within or external to the site. It is recommended that Level 3 illuminance maintains a minimum of 160lux.

The recommended illuminance and lighting levels, based on available guidance, information and established good practice, is indicated in Table 1.1.

Table 1.1: Recommended Illuminance Levels for Worker Task Areas

Level 1: General Construction Min: 40lx Target: 55–110lx Max: 270lx*	Level 2: Specialised Activities Min: 80lx Target: 110–160lx Max: 380lx*	Level 3: Precision Operations Min: 160lx Target: 220–320lx Max: 480lx*
- Site surveying & measurement - Access ways - Excavation & materials handling - Embankment fill & compaction - Tunnels/portals/cut & cover - Asphalt paving/rolling - Subgrade construction - Concrete placement - Pavement sweeping/cleaning - Site clearance, landscaping - Bricklaying and other trades - Stockpile lighting - Batching plants/workshops - Locations where workers are on foot, are in close proximity to slow-moving equipment and objects to be seen are relatively large	- Installation of barriers - Pavement milling/removal - Demolition - Drainage works, culverts, storm sewers - Construction of bridge decks & other concrete structures - Waterproofing and sealing - Base course grading/profiling - Surface treatment - Asphalt paving/surfacing - Concrete paving - Footpath construction - Guard rails/fencing installation	- Traffic signage/management - Road markings - Pavement repair, joint filling - Finishing works - Painting & decorating - Site offices

Note: Relevant construction activities extracted and summarised from a number of sources listed in Section 2.
*Maximum illuminance assumed measured in conditions of full darkness and subject to further limits of glare control.

1.5 Site Lighting Positioning

After establishing the correct level of lighting, the next factors to consider are where the site lighting, i.e. temporary fixed or mobile light towers, would be placed and how its fixtures are positioned.

The ground on which any temporary site lighting equipment is placed is vital to the unit's stability including other factors such as weather, wind exposure and risk of collision.

When settling on a location, the structure or surface must be flat, firm and not cause obstruction, as a portable light tower could potentially fall over if placed adjacent to/on weak or an uneven grade.

Overhead obstructions, such as power lines and trees, may also inhibit the use of towers in a particular location. Since a tower can be deployed as high as 10m, the unit must be clear of anything above the ground that may damage the tower and subsequently risk the security of workers and others around the site either during installation or when in use.

The positioning of the tower's fixtures is the next safety factor to address. HSE Guidance Note GS6 Avoiding Danger from Overhead Power Lines should be followed when positioning lighting towers near or below high-voltage power lines. If light towers are not positioned correctly, the direction the light shines from the fixtures may reduce or impair visibility for site operatives or passing road users. Positioning of site lighting must find the right balance between creating the best possible or fit for purpose lighting scenario for the site as well as protecting the residents, drivers and the general public from unnecessary light pollution and distractions.

It is likely that the contractor on MetroLink will have a good choice of positions, angles, and directions in which light fixtures can be designed and strategically positioned. The most important factor is that site lighting is arranged to light up the job site safely, but not blind or obstruct workers, pedestrians, cyclists, motorists or traffic, nor impact environmentally sensitive areas, e.g. bats roosts and watercourses.

The prerequisite for site lighting during temporary road diversions or where the works cross a live road is to place the light towers in such a manner that they shine away from oncoming traffic, as this positioning creates optimum visibility for drivers travelling through the construction area. In addition, tilting the fixtures down 20 degrees increases the efficiency of the light tower by focusing the light on the worksite and lessening the amount reflected skyward.

Another important technique places the light towers on each side of the site so that they face each other, directing light towards the ground and construction activity. This helps reduce shadows and eliminate dark areas, which increases construction site visibility and safety for workers as well as reducing light pollution, glare, light spill or any other interference, e.g. residential properties, vehicular or aviation traffic, as illustrated in Diagram 1.4.

While advances site lighting technology have made a significant difference, some portable light towers may still produce a small amount of glare, which risks compromising the safety of both road users and construction crews. However, glare can be easily corrected by angling the light fixtures down while employing lighting visors or screening, which attaches to each fixture to prevent light from travelling in an undesired direction. In addition, mirrored visors can reflect light back to the ground to increase its intensity on the site whilst decreasing the possibility of potential distraction by light and luminaires while increasing the effectiveness of the sight lighting itself.

To light general working areas, overhead lighting can also be positioned and suspended from completed works to illuminate spaces effectively and as works are constructed. Diagram 1.4 shows how site lighting within, for example, a retained structure can be accommodated. This ensures workers can complete projects safely and efficiently, without damaging their eyes or becoming susceptible to injury. Lighting general working areas is especially important during out-of-hours activities when there is no more natural light.

1.6 Types of Lighting Options in Construction

Once the work activities have been identified, it would be necessary to determine the type of lighting source to use. Based on the planned work activities by the main works contractor and whether the work is mobile, stationary or long duration, a lighting source using fixed, portable, machine-mounted or other form of site lighting would be chosen.

The main types of temporary site lighting equipment and systems used on construction sites today are outlined below.

1.6.1 Portable Light Towers

Lighting towers are the most commonly used form of construction lighting equipment, as they provide quality illumination for a large area. They are typically equipped with a generator, a retractable mast, and anywhere from two to six lighting fixtures attached at the top of the mast structure. The masts can reach up to 9m and be rotated 360 degrees, allowing for maximum versatility and efficient light coverage.

Light towers would generally be provided as a primary means of illumination and would provide Level 1 illumination throughout the construction site. They may be supplemented as required by lighting fixtures mounted on construction equipment to provide Level 2 or Level 3 illumination where required.

Light towers would be sturdy and free-standing without the aid of guy wires or bracing and would be capable of being moved as necessary to keep pace with construction operations. Light towers would be positioned to minimise the risk of being impacted by construction equipment or, if used on an existing roadway, by construction traffic or equipment.

To prevent glare, these lighting systems would not be aimed toward traffic, but instead be aimed downward at the work and rotated outward no greater than 30 degrees from straight down unless the light has been designed specifically to prevent glare.

Portable light towers are lights that tend to stay in one place, but usually these can also move along with the construction site.

Recently, these towers have been reinvented in the form of solar and hydrogen fuel cell type portable light towers. Not only do solar light towers not require generators, but they make it possible to move light sources quickly. These solar-powered portable lights offer up to 36 hours of continuous use and keep gasoline fumes out of the workplace.

Diagram 1.1 shows an example of the latest hydrogen fuel type generator, which is clean, virtually silent (45dB at 5m distance) and can be remotely operated. It is currently in use on the Crossrail project and would be ideal for future use in urban or cityscape environments such as MetroLink.

Diagram 1.1: Typical Mobile Light Towers (Hydrogen Fuel type, Source: Taylor Construction Plant)

1.6.2 Balloon Lighting

Originally developed for the film industry, balloon lights area specialty luminaires and typically used on construction sites as equipment-mounted lighting or in stationary locations for specific night-time activities, e.g. road or utility diversions. These types of lights are particularly useful in roadworks locations, where workers and equipment need to be clearly visible. The lights have fabric covers that are inflated with helium or air and can be mounted on stands, tripods or mobile towers.

Light balloons really compare to large area lights such as light towers without producing the glare and shadows known from light towers. In addition, balloon lights can be used in practically any situation as they are portable, and the light is soft and diffused; comparable to daylight on an overcast day. Diagram 1.2 and Diagram 1.3 illustrate typical efficient use of balloon temporary site lighting.

It is likely that this system would be deployed for temporary/permanent works where construction is expected to be of short duration, e.g. up to 6 months.

Diagram 1.2: Balloon Site Lighting – Task Specific

Diagram 1.3: Balloon Site Lighting – General Linear Working

1.6.3 General Site Lighting

This would consist of any permanent roadway type lighting fixture mounted on temporary poles and hard wired to an electrical system.

This type of system would normally be prepared by a lighting design professional. Diagram 1.4 indicates a typical use of this type of temporary site lighting arrangement for MetroLink. This would be subject to a robust Site Lighting Plan and installation methodology provided by the main works contractor, which would eliminate the impact of

light pollution, e.g. direct glare, light trespass or light spill, particularly in construction areas where risk of public nuisance is high.

It is likely that this system would be deployed for temporary or permanent works where construction is expected to be of a long duration, e.g. six to 12 months or more.

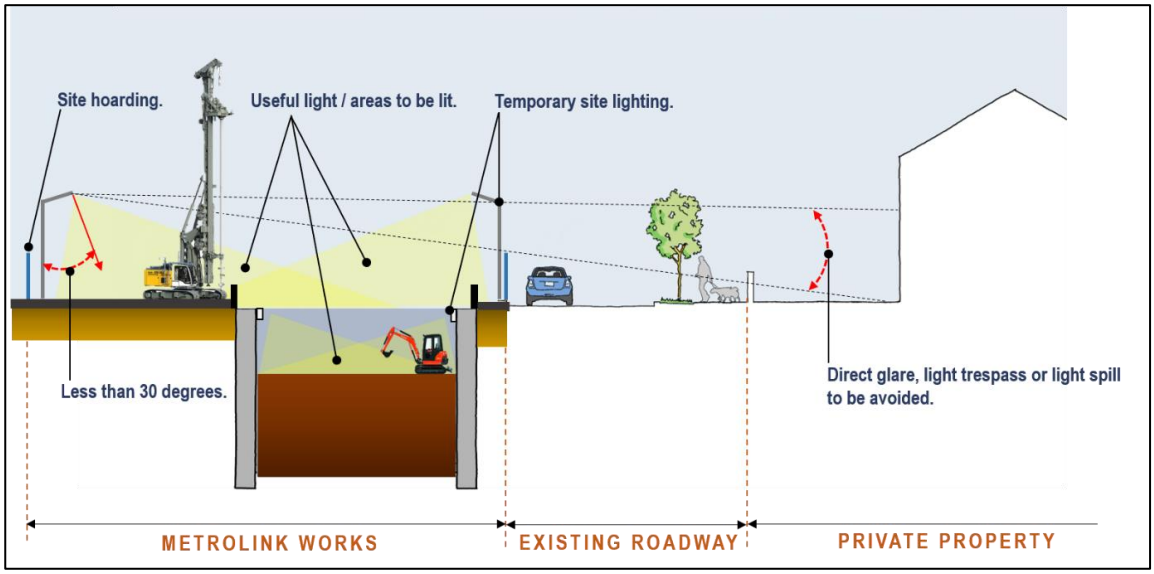

Diagram 1.4: Typical Site Lighting – MetroLink

This type of equipment, rather than being only temporary construction lighting, serves as a semi-permanent or long-term fixture on a work site. These lighting fixtures are generally composed of LED type luminaires mounted on high-mast poles, which provides excellent lighting for construction workers.

Diagram 1.5 indicates two types of high mast light or luminaires that are typically used for general working. The luminaire heads can be rotated, or visors added to ensure the correct level of lighting is provided, including mitigating against risk of light pollution as shown in Diagram 1.4 above.

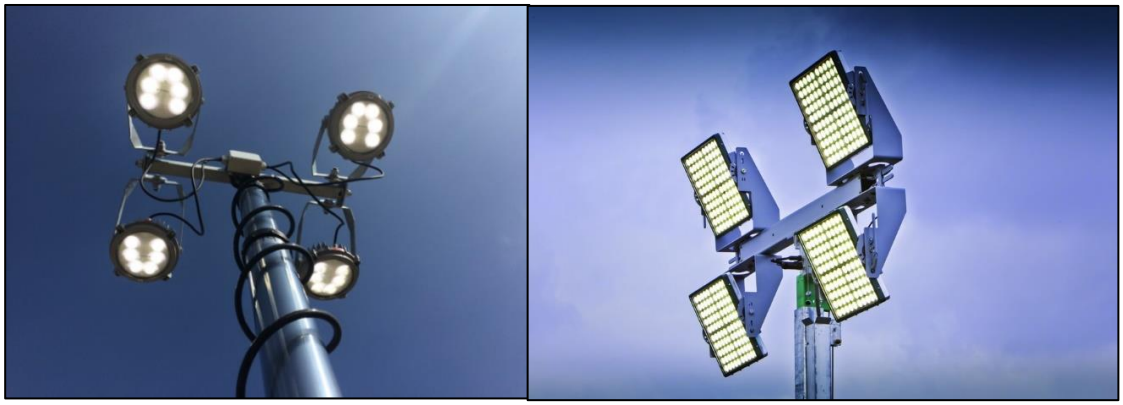

Diagram 1.5:Typical Mast Head Luminaires

1.6.4 Construction Equipment – Mounted Lights

Headlights installed on most equipment do not normally provide adequate lighting for most worksite operations and glare would also occur when facing any oncoming traffic. As shown in Diagram 1.6, some types of lighting luminaires can be mounted directly on construction equipment. As the lights move with the equipment, this can reduce the effort required to set up area lighting. Another advantage is that the lights can be powered by the construction equipment's electrical system, which is increasingly more practical with the use of energy efficient lamp technologies such as LEDs.

Diagram 1.6: Typical Equipment-Mounted Site Lighting

The construction industry uses a combination of permanent and portable lights to provide adequate visibility to work areas, and these four types of lighting systems are the main types that are used.

1.6.5 Tunnel Temporary Lighting

When new construction begins on a cut and cover structure or tunnel, safe and dependable lighting is always a challenge. Weather conditions, the availability of natural light, or even the availability of power can be dramatic factors in determining whether or not a job site has adequate lighting.

In principle, the requirements pertaining to site lighting in BS 6164 would be followed.

As tunnels go deeper and farther away from power sources, the ability to light the work area safely is extremely challenging. The limits of string lights can cause problems, as the length of the string lights increases deeper into a tunnel and so results in power accessibility issues. These issues are generally overcome by the positioning of 11kv/400V substations throughout the tunnels, spaced at 1km intervals, to cover the requirements of tunnel lighting and other power requirements, e.g. conveyors, communications, intermediate transformers, power sockets, pumps and general power usage.

It is likely that a two-string temporary tunnel LED lighting system would be the preferred option for high output illumination. BS 6164 states that lighting levels for tunnelling should be at least 30lux, below a light fitting. Lux

levels of between 15lx and 30lx would likely be maintained at the mid-points between each of the light fittings, which may allow light fittings to be spaced further apart.

It is likely that a site lighting scheme would be used to provide the required lighting lux based on 110V circuits with 10m spacing between fittings. These could be staggered so there would be at least a 40W LED light fitting equal or approved type at say every 5m, as illustrated in Diagram 1.7. A temporary tunnel LED lighting system usually comprises industrial grade LED work lamps with protective guards fixed to the tunnel lining/wall as tunnelling works progresses, as shown in Diagram 1.8. The daisy chain operation allows multiple stringers to be connected together for maximum work site illumination during tunnelling works, while at the same time aiding in servicing, storage and transport of the temporary tunnel light system.

These LED lamps are suitable for wet areas, resistant to damage from impacts and vibrations, and consume less energy than standard lamps. Machined aluminium housings, cast aluminium guard, tempered glass lamp globe and abrasion-resistant cord make this a durable unit that resists damage from chemicals, abrasions, vibrations and impacts. LED lamps provide more and better-quality illumination than 100-watt incandescent string lights without the high heat and fragile glass construction of traditional lamps.

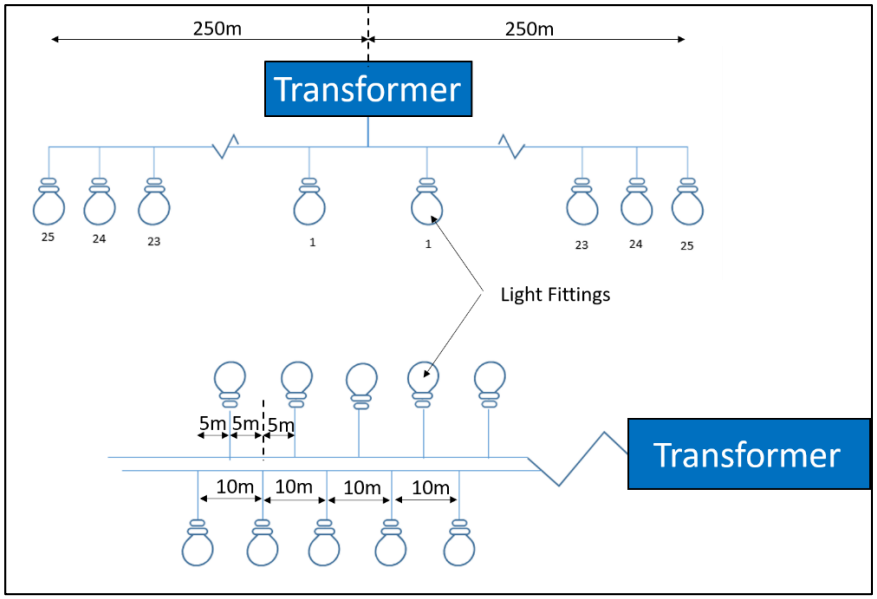

Diagram 1.7: Typical Tunnel Site Lighting Arrangements

The key requirement for temporary site lighting in tunnels is that a uniform level of illuminance is maintained throughout the tunnel to ensure adequate and safe levels of lighting and avoid visual irritation. In addition, these LED lamps are suitable to a tunnel working environment and are resistant to damage from impacts and vibrations and consume less energy and emit less heat than standard lamps. The choice of LED lamps also contributes to the management and reduction of heat-related stress and health risks for workers. With the low energy requirements of LED lamps, very long assembly units are now physically possible and conducive to the potentially volatile atmospheric conditions in tunnel construction.

Following the civils construction work of the tunnel, the fit-out work would require LED lighting at 5m spacing to provide sufficient lighting levels for these works. A double string of cabling with spacing between fittings of 10m on each string, staggered so that there is an LED light fitting every 5m would be considered.

In addition to the required back-up power supplies, pumps and ventilation systems and other hazard reducing devices like cut-out, earth leakage and isolating devices would also be considered. Emergency lighting would be provided and generally located on all access walkways as shown in Diagram 1.8 and Diagram 1.10.

Similarly, with general surface working the main hazard and risks that may result due to poor temporary site lighting are collisions, people being struck or run over by equipment, inability to assess ground and equipment conditions, and trips, slips, falls and fatigue. To mitigate this, it would be considered whether hard-wired site lighting needs to be provided at:

- Transformer installations;
- Workshops or service bays;
- Fuelling points, pump stations or sumps;
- Stores areas and meal rooms;
- Loading/unloading points;
- Shaft and tunnel intersections; and
- Plant rooms.

In addition, the following control measures would be implemented in respect of temporary site lighting in tunnels:

- Providing extra temporary lighting at the face area including lighting on the platforms of mobile plant/equipment;
- Lighting for detailed work, hazardous processes and where plant is being operated; and
- Emergency exit lighting to the surface and/or safe havens, including back-up lighting in case of power failure.

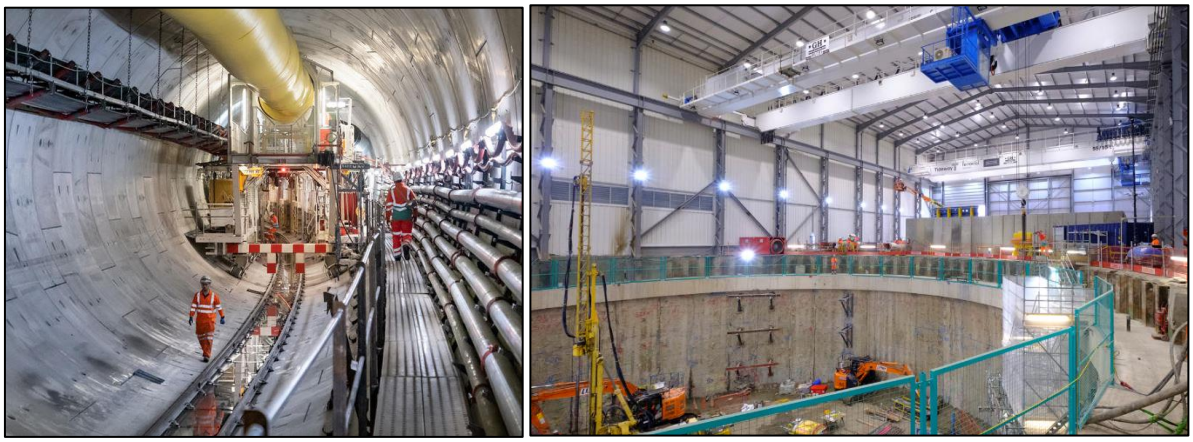

Diagram 1.8: Typical Tunnel Site Lighting

1.6.6 Building (Internal Use) Temporary Site Lighting

To light general internal working areas, overhead lighting can be suspended from the existing structure, e.g. constructed slabs, beams and walls, to illuminate spaces safely and effectively. This ensures workers can complete projects safely and efficiently, without damaging their eyes or becoming susceptible to injury. Lighting

general working areas is especially important out of hours when there is no natural light. Diagram 1.9 shows a typical example of good practice and efficient internal site lighting. This lighting would be positioned and arranged for a long duration and/or up to the time of the mechanical, electrical and plumbing Mechanical Electrical Plumbing (MEP) transition and installation works.

Diagram 1.9: Example of Well-Lit Internal Site Lighting

Other types used, which are portable and work off transformers, are typically installed on tripods or telescopic poles, with lighting guards to avoid glare and light spill, or free-standing LED lighting systems as indicated in Diagram 1.8.

In most or all of the above worksite scenarios, and given that the nature of construction on MetroLink is predominantly linear, a typical temporary lighting system using the configuration as shown in Diagram 1.10 would likely be used either fixed or mounted on the building element as indicated in Diagram 1.9. Free-standing or weighted-down telescopic lighting posts would also be used. It is feasible to connect 50 LED site lighting poles using a single 2kVA generator and achieve 500m illuminated distances as shown in Diagram 1.10.

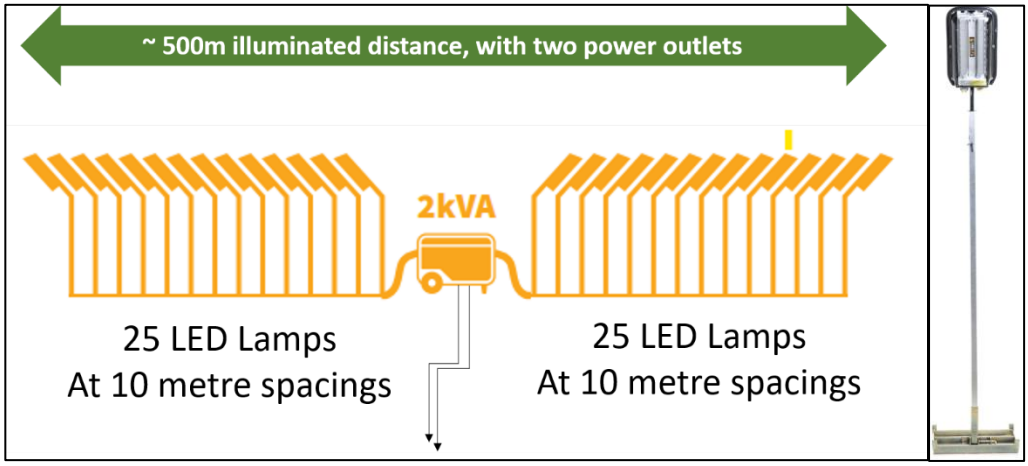

Diagram 1.10: Typical Site Lighting Arrangement (Source: Linklite, used by Irish Rail)

1.7 Emergency Lighting and Emergency Routes

To ensure the safety of everyone on site, it is important to provide emergency lighting for emergency escape routes. This ensures that, where workers quickly need to access or escape the site in an emergency, they do so where sufficient site lighting has been installed and provides safely lit areas. Where it is not possible to provide automatic lighting that comes on as soon as other lighting turns off, additional back-up emergency or battery-type lighting, including accessible torches, would be provided to ensure suitable lighting along pre-determined emergency routes.

When there is an emergency on the construction site, it is essential everyone can follow a well-lit escape route. It is important to ensure that, as part of developing the Site Lighting Plan, measures for emergency lighting are provided in all emergency routes, so that escape routes remain illuminated if the primary temporary site lighting fails. Emergency lighting does not need to be very bright; it only needs to be bright enough to illuminate emergency escape routes sufficiently.

Diagram 1.11 provides a typical example of good practice for provision of site lighting to emergency routes.

Diagram 1.11: Typical Site Lighting Arrangement (Source: Linklite, used by Irish Rail)

1.8 Light Pollution and Mitigation Measures

The main categories of light pollution are as follows:

- Glare: A discomforting or disabling brightness which causes a loss in visibility as stray light scatters within the eyes. An example would be driving on a road and being temporarily blinded by oncoming headlights. Sensitivity to glare can vary widely.
- Sky glow: This occurs from both natural and man-made sources of lighting which increase night sky brightness. Light can be emitted directly or reflected into the atmosphere to produce a luminous background. The ability to view the stars at night is hindered.
- Light trespass: Where light spills into areas in which it is unwanted. An example of this would be the light from an exterior streetlight entering a bedroom window and illuminating the interior.
- Light clutter: An area where there are large groups of lights that may cause distraction or confusion. Clutter can be found in particular in parts of cities or on busy roads.
- Over-illumination: The excessive use of lights, as indicated in Diagram 1.12 and Diagram 1.13.
- Environmental damage: e.g. light spill into foraging areas for photosensitive species such as bats, otters and voles.

Light pollution can be a particular problem on construction sites, where new or temporary lighting may be installed and large areas flood-lit, causing over-illumination and nuisance. Guidelines suggest that construction light nuisance can be reduced by screening, effective programming of work, directional lighting and using the correct type of lights.

Diagram 1.12: Example of Over-Illumination – Glare and Skyglow

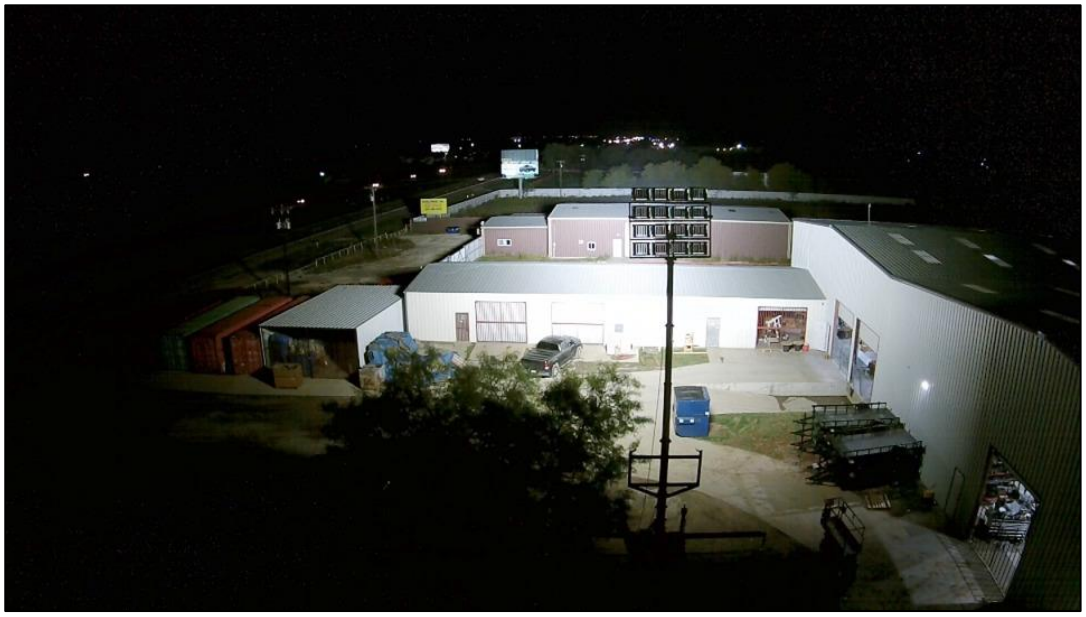

Diagram 1.13: Example of Over-Illumination – Light Trespass and Light Spill

2. Site-Specific Lighting

The lighting provided to light up each site would be designed by the contractor or their representative to suit the construction methodology and equipment used at that site/location. It would provide a safe working environment within the construction site, without blinding or obstructing traffic, pedestrian, cyclists nor impact environmentally sensitive areas around the site.

The lighting towers and equipment would be designed and positioned to illuminate within the working area only and with minimum impact on surrounding receptors.

Potential receptors around each site have been summarised in Table 2.1.

Table 2.1: Potential Lighting Receptors around each Construction Site

	Construction Site	Surrounding Receptors	Potential Environmentally Sensitive Receptors?
1	Park and Ride Facility and Estuary Station	R132, Ennis Lane	Yes
2	Seatown Station	R132 and the roundabout, Seatown Road, Residential buildings to the west of R132	Yes
3	Swords Central Station	R132, Residential buildings to the west of R132, Residential buildings to the north-east of the station	Yes
4	Fosterstown Station	R132, Boroimhe Willows, Residential buildings to the west of R132	Yes
5	R132 route	L2305 Road, Premier Inn Hotel to the east of R132, Nevinstown Lane, Residential building to the south of Nevinstown Lane, Residential buildings both sides of R132	Yes
6	Dublin Airport North Portal	Naul Road and a residential area to the south, R132 (Dublin Road) to the east	Yes
7	Dublin Airport Station	Dublin Airport buildings and roads around the site	No
8	Dublin Airport South Portal	Dublin Airport and aeroplanes, Old Airport Road	Yes
9	Dardistown Station	R108 to the west, Old Airport Road to the north and M50 to the south	Yes
10	Dardistown Depot	R108 to the west, Old Airport Road to the north and M50 to the south	Yes
11	Central surface inc. M50	M50 all directions	Yes
12	Northwood Station	R108, Northwood Avenue, St Margaret's Road, R104 (Balbutcher Lane, Carton Way, Residential buildings to the south of R104, Residential buildings to the east of R108	Yes
13	Northwood Portal	R108, Northwood Avenue, St Margaret's Road, R104 (Balbutcher Lane, Carton Way, Residential buildings to the south of R104, Residential buildings to the east of R108	Yes
14	Ballymun Station	Balbutcher Lane, Sillogue Road, Residential buildings to the south of Sillogue Road, Shangan Road, Hotel and residential building to the north of Shangan Road	No
15	Collins Avenue Station	Albert College Court residential area and surrounding buildings, Albert College Ct street, Ballymun Road, Residential building to the west of Ballymun Road, Residential building to the north-east of the station	No
16	Albert College Park Shaft	Ballymun Road, Residential building to the west of Ballymun Road, Hampstead Avenue, Residential building to the south of Hampstead Avenue, Residential buildings to the east and north of Albert College Park	Yes

	Construction Site	Surrounding Receptors	Potential Environmentally Sensitive Receptors?
17	Griffith Park Station	St Mobhi Road (R108), Residential buildings to the west of R108, St Mobhi Drive, Residential buildings and the church to the south of St Mobhi Drive, Whitehall College of Further Education to the east of station	Yes
18	Glasnevin Station	R108, Residential building both sides of R108, Royal Canal Way, Phibsborough Road, Railways	Yes
19	Mater Station	Berkeley Street, Residential buildings to the west of Berkeley Street, Eccles Street, Sarsfield Street, O'Connell Avenue, Geraldine Street, St Joseph's Church, Residential buildings in Eccles Street, Mater Misericordiae University Hospital	No
20	O'Connell Street Station	O'Connell Street Upper, Moore Lane, Parnell Street, Henry Street, O'Rahilly Parade Street, Residential buildings to the east of O'Connell Street Upper, Residential buildings around Henry Street, Residential buildings around Moore Lane and O'Rahilly Parade, Hotel to the west of Moore Lane	No
21	Tara Station	Railway, Poolbeg Street, Townsend Street, R802, Dublin Fire Brigade HQ, Residential and commercial buildings around Townsend Street, Residential and commercial buildings around Poolbeg Street and R802	No
22	St Stephen's Green Station	R138, Birds and other species in the St Stephen's Green Park, Residential and commercial buildings to the east of R138, R110	Yes
23	Charlemont Station	Railway, Dartmouth Road, Residential buildings to the east of station, Residential buildings to the west of station and railway, Residential buildings to the south of Dartmouth Road, R111	Yes

3. Conclusions

Protecting the construction workers and general public will be a top priority. Bad or inefficient lighting can be detrimental on construction sites, causing accidents, fatigue and danger for those working with heavy or even light-duty machinery and equipment.

A high-level assessment of receptors has been summarised in Section 2, but more detailed and local assessment should be carried out by the Environmental Team. The contractor will design the lighting to meet the environmental requirements.

To ensure the light levels on construction sites are appropriate, the good practice use of light or lux meters to measure and check actual lighting levels on site would be adopted. This would ensure that light pollution is mitigated and workers are fully protected while they work, and so less susceptible to injury. The key issue is to always ensure sufficient, safe and acceptable lighting is implemented at all times during surface and tunnelling works without causing significant nuisance or risk of injury to the general public at large and site operatives.

Emergency lighting is also required to ensure that, in an emergency or power interruption, construction workers are able to move to a place of safety quickly and with the ability to identify potential hazards such as debris in their path.