

Guidance Note 6/17

Retrofitting LED luminaires on existing lighting columns

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1. INTRODUCTION

In the public lighting realm, there is a definitive move away from using High Intensity Discharge (HID) luminaires towards using Light Emitting Diode (LED) luminaires for their energy efficiency and reduced maintenance requirements. The LED luminaires are often being replaced on a one-for-one basis onto existing lighting columns, which is acceptable provided the appropriate checks are made on those lighting columns.

As part of the preparation for installation works, lighting engineers and contractors should consider specifically whether each existing lighting column is of suitable condition and strength to safely support the new luminaires.

This document sets out some brief guidance for public bodies and contractors on what information and design checks are required before proceeding with an LED installation on existing lighting columns. The focus of this guidance note is on structural assessment and it does not include advice on design requirements or any legal or other issues that may apply to the proposed works.

DISCLAIMER: Approval of the structural stability and integrity of lighting columns should only be carried out by qualified and competent structural or civil engineers who are familiar with the types of structures they are checking. The following information provides guidance to lighting engineers and contractors in how to assess whether a new LED luminaire can replace the existing HID luminaire safely and where more detailed analysis is likely to be required.

Under no circumstances can the information below be used to confirm suitability of specific columns or groups of lighting columns with any existing or proposed luminaire. The ILP accepts no liability for the use or misuse of this guidance in determining the suitability of any individual lighting column or group of lighting columns.

Lighting column inspection and design checks should also take account of all existing and/or occasional attachments such as, but not limited to, traffic signs, hanging baskets, seasonal decorations and Wi-Fi repeaters. In such instances, reference should be made to *ILP Professional Lighting Guide 06: Guidance on installation and maintenance of seasonal decorations and lighting column attachments*. PLG06 should therefore be used in conjunction with this guidance note.

This guidance note is not intended to include all the necessary provisions of a contract.

2. LUMINAIRE PARAMETER

The shapes and sizes of LED luminaires are as many and varied as they were for HID luminaires although quite different from each other. To define the luminaire's effect on the lighting column we define several parameters as set out below.

Simplified parameters

For HID luminaires which all have similar shape, control gear and optical compartments, it was common to define the weight and windage (or wind area) of the luminaire or of a typical luminaire for A-class roads and B-class roads that represented the majority of the HID luminaires manufactured. With LED luminaires, the weight and wind area has changed, with wind areas typically being smaller but with some luminaires having increased weight. Weight and wind area definitions are defined below.

Luminaire weight

Luminaire weight is the mass of the whole luminaire, including the luminaire body, spigot adaptors, lamps, control gear and switching controls (PECU, CMS etc.) where fitted. Where light shields may be provided, the weight of these should also be included.

Note: It's also useful to know where the centre of gravity of the luminaire is relative to the spigot entry point. This allows the luminaire

weight to be applied to the lighting column model at the correct position. If this value is not known, it is reasonable to assume this occurs at one third to one half of the luminaire length from the spigot entry point, depending on the luminaire construction, control gear position etc.

Luminaire windage

Windage is the silhouette area or Effective Projected Area (EPA) of the luminaire at the installed tilt, viewed horizontally from the most onerous direction.

Note: In addition to windage, it is also useful to have the effective centre of area defined as an offset from the luminaire spigot cap entry. The whole of the wind load is applied at the centre of area on the luminaire. Where not available, the centre of area may be assumed to occur at half the luminaire length from the spigot entry.

Windage is generally stated for use with a drag co-efficient of 1.0 which effectively ignores the shape of the luminaire and how the wind flows around it. See Fig. 1 below.

Typically for a road luminaire, the windage is largest when viewed side-on as if driving down the street; for a floodlight that’s tilted up and for some LED luminaires, it could be face on or diagonally and the column designer will need to know the lighting design details to determine the worst case windage. The

windage should include all control equipment and light shields on the luminaire (or that might be added to it in future unless additional checks are carried out at that time).

3. DETAILED PARAMETERS

While weight and windage remain useful to define a luminaire, manufacturers are increasingly making use of 3D modelling software to define more precise parameters which usually act to reduce the wind area stated in the luminaire datasheet.

The drive to make designs more and more efficient has led to the more technically accurate introduction of the aerodynamic terms used by engineers. These better define the effects of the shape of the luminaire on the resulting loads. Detailed definitions are provided below;

Effective Projected Area (EPA)

EPA is very much equivalent to the windage being the horizontally projected 2D silhouette area of a 3D shape.

The difference between the EPA and windage is that EPA should be defined with two additional parameters that indicate the drag and the lift components of load in the horizontal and vertical directions, respectively. This means the luminaire profile is more accurately represented as shown in the Fig. 2 (on the following page).

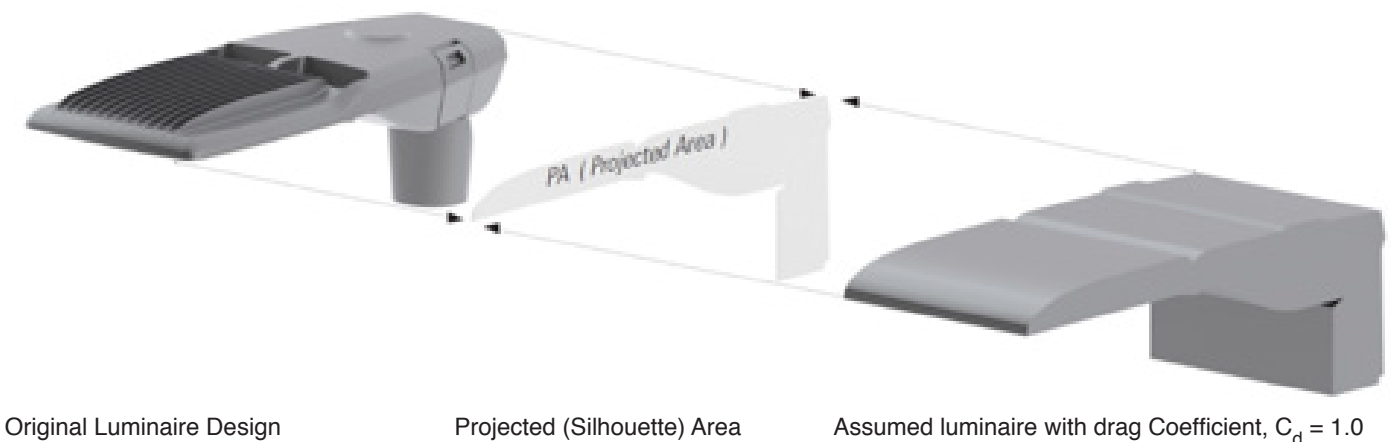


Fig. 1 – Assumed luminaire shape when specifying windage

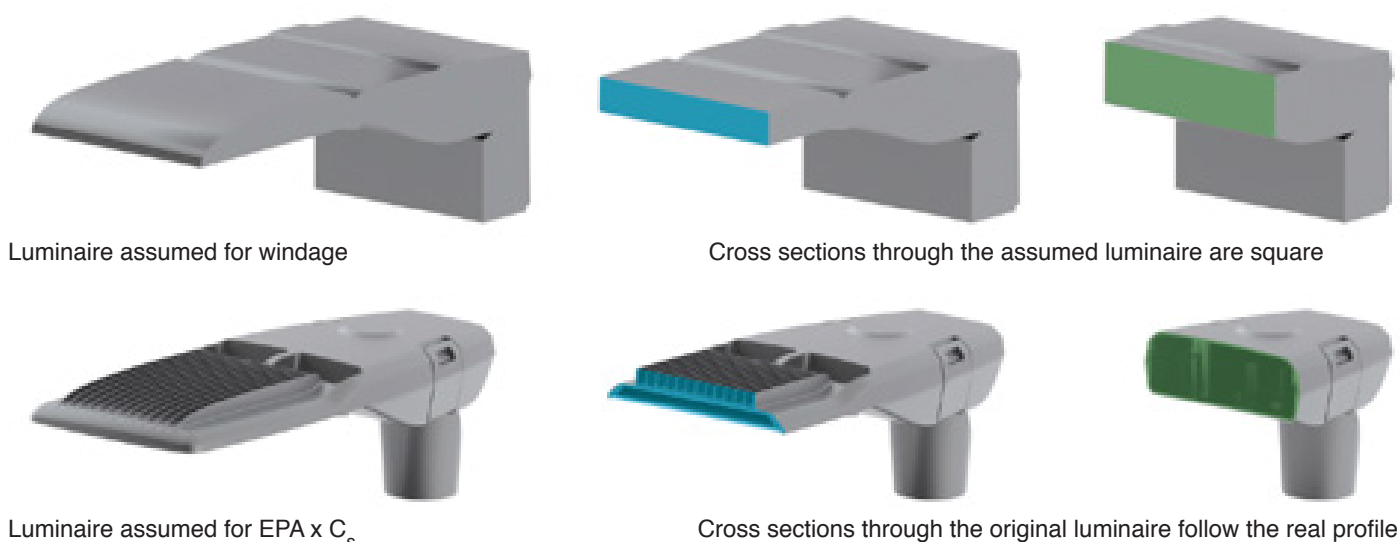


Fig. 2 – Comparison of assumed shape when specifying windage or EPA x C_s

There is usually some variation in the tilt (or floodlight elevation) angle at which the luminaire is installed on the column and in determining the EPA (and the drag and lift coefficients) it is recommended that the most onerous values are used based on tilt of the luminaire into any position between $+10^\circ$ and -10° from the horizontal plane.

Where the installation of a luminaire on a bracket arm is not fully secured on site, it is possible for the luminaire to rotate around the spigot increasing the EPA. For example, a 30° rotation out of the horizontal plane can increase the EPA of the luminaire by around five times. This will mean significantly higher loads are applied to the lighting column and bracket. A risk-based approach to this hazard would generally lead to the design allowing for a larger EPA, perhaps sufficient rotation so that it was obvious that the luminaire was incorrectly mounted during normal scouting operations or to a member of the public due to inadequate lighting performance. The allowed level will depend on the type inspection and maintenance plan used to cover the lighting installation.

Drag coefficient or Shape Factor, C_s

Drag coefficient represents the amount of resistance created by the luminaire as the wind flows around it. The lower the drag

coefficient, the lower the loads applied to the luminaire by the wind.

Luminaire drag coefficients can be determined in one of two ways. Either the finished luminaire can be installed in a wind tunnel and the drag force on the luminaire measured or a 3D CAD model of the luminaire can be analysed using computational fluid dynamics (CFD) software.

When modelling to determine the drag coefficient, sharp edged bodies are usually insensitive to wind speed but curved surfaces such as cylinders and domes are sensitive to parameters including wind speed, surface roughness and turbulence characteristics, known as Reynolds number effects, and these require special consideration as different results would be obtained for slow wind speeds versus higher wind speeds. The test wind speed should be chosen to be representative of the flow conditions expected at the design wind speed for the lighting column.

For irregular objects like luminaires, the drag coefficient may be defined for a specific luminaire orientation and wind direction and so may be stated as C_{sx} , C_{sy} being the drag coefficients along the x or y horizontal axes (z axis is usually defined as the vertical axis and so isn't relevant to drag coefficients).

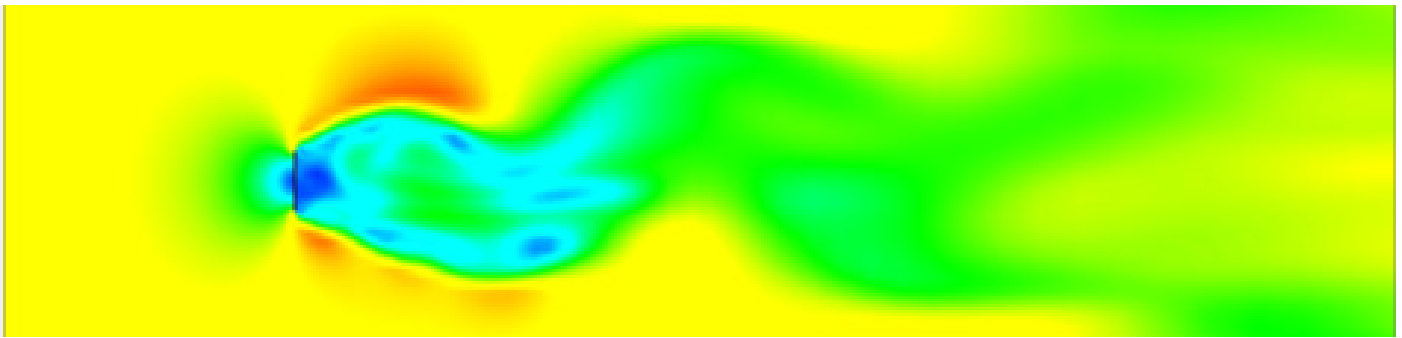


Fig. 3 – 1.0x0.3m sign plate, face on to the wind at 40m/s wind speed, $C_d = 1.33$

Drag coefficient is dependent on the geometry of the object around which the wind is flowing. For example, the drag coefficient on a flat rectangular sign face with the wind hitting the face of the sign will give a drag coefficient of 1.3 to 1.8 depending on the sign plate dimensions, see Fig. 3 above.

For a drag coefficient greater than 1.0, the total wind loads on the object will be greater than that obtained by just assuming the windage with a drag coefficient of 1.0.

A CFD model output for an LED luminaire (side-on to the wind) is given in Fig. 4. This shows a drag coefficient of 0.68 which is lower than 1.0. This means that the wind loads applied to the lighting column in the horizontal direction are lower than would be obtained by just using the windage and a drag coefficient of 1.0. This reduction in applied horizontal load is the reason that manufacturers are increasingly stating the luminaire area as the EPA including C_{sx} .

As described above, the drag coefficient only defines the horizontal component of the wind load on the luminaire and a second coefficient is defined to represent the vertical components of drag.

Lift coefficient, C_L

In the same way that the drag coefficient represents the component of the total wind load that acts on the luminaire in the horizontal direction, the lift coefficient represents the vertical component of the wind load on the luminaire.

Care needs to be taken in calculating the resulting vertical loads on the luminaire as the lift coefficient is the vertical component relating to the wind horizontally onto the luminaire and so the lift coefficient is multiplied by the EPA not by the plan area of the luminaire.

Note that the lift coefficient could result in loads in either a vertical-up or a vertical-down direction depending on the shape of the luminaire. In the column and bracket design calculations, any upward or downward lift force from the luminaire shall be applied to the bracket in the downwards direction in addition to the luminaire weight.

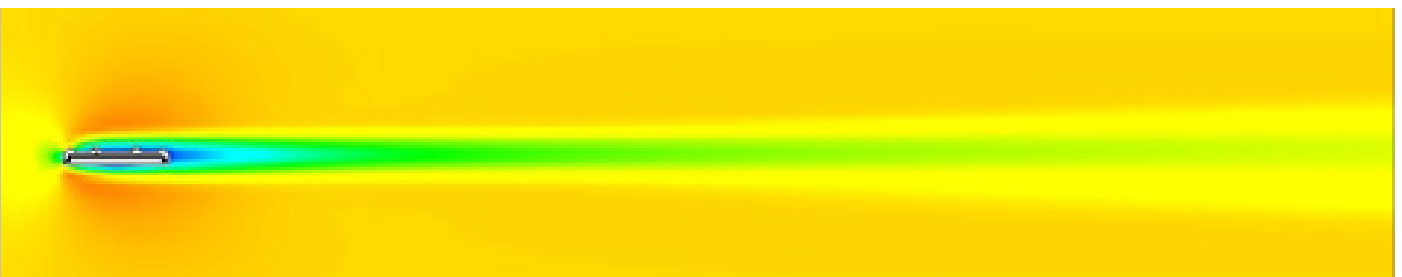


Fig. 4 - CFD model showing the luminaire under test at 40 m/s wind speed, $C_d = 0.68$

4. DESIGN CONSIDERATIONS

Combining luminaire parameters

If a manufacturer chooses to provide the Effective Projected Area with the drag coefficient rather than the simple windage, then strictly they should provide the lift coefficient too. This enables the magnitude and direction of the lift and drag forces to be combined to accurately represent the full magnitude and direction of the wind load on the luminaire.

Non-standard wind conditions

During the structural design of lighting columns, the engineer makes assumptions about the geometry of the column and luminaire and the wind direction, and the impacts of these should be carefully considered.

The wind is assumed to only blow horizontally when considering the stability of a lighting column. Vertical loads may be generated by the shape of the luminaire or structure but the wind is not considered to blow from above or below it. In practice, vertical wind flows may occur around steep slopes or adjacent to buildings and forests, as the wind rises or dips around these obstacles.

As discussed previously, where there is a risk that the luminaire can accidentally rotate on the spigot axis, a 30° rotation would result in an EPA increasing by perhaps five times. Where applicable, using a risk-based approach to this case seems sensible.

The allowable angle of luminaire rotation can need to be defined for the lighting column and bracket with consideration of the inspection and maintenance regimes in place to identify and correct this defect on site.

Where luminaire rotation around the spigot axis can occur, the Effective Projected Area, drag coefficient and lift coefficient should be assessed for the most onerous wind direction relative to the luminaire.

As a shortcut method to achieve this, the windage of the luminaire (with $C_{sx}=1.0$) can be assumed to be 1/4 of the plan area of the luminaire equivalent to approximately 15° of rotation around the spigot axis. Luminaires rotated above this angle will have a significant adverse effect on light pollution and glare and should be corrected.

Summary of luminaire parameters for design

Given the above, the luminaire parameters required for the design checks on the lighting columns are:

- i. Luminaire Weight
- ii. Offset between luminaire *centre of gravity* and spigot cap entry
- iii. Effective Projected Area or windage
- iv. Offset between luminaire centre of area and spigot cap entry and optionally:
- v. Where EPA is provided, the drag coefficient, C_s and lift coefficient, C_L

Using this information, the designer can calculate the wind loads and dead loads on the lighting column resulting from adding a new luminaire.

5. LIGHTING COLUMN CONDITION SURVEYS

Lighting columns are inspected and maintained in accordance with *ILP Technical Report No. 22 Managing a Vital Asset*¹. This requires that the column condition is recorded during visits and should highlight any visible impact damage, corrosion, weld cracking etc. which would indicate the column needed replacing or repairing.

Before installing the new LED luminaires, each lighting column should be subject to both a ground based visual inspection and, if required, appropriate Non-Destructive Testing in accordance with TR22 to identify any defects, for example, corrosion or cracking to the swage, door cut-out or in the root section; or any impact damage or vandalism.

¹ At the time of writing this document was starting to be reviewed with a new version expected in late 2018

Where defects are identified, the implications of these should be assessed and where necessary, either remedial works or column replacement carried out.

During the surveys, it is useful to collect other information about the lighting column that may be required for the information of the installing contractor.

For example, the presence, type and diameter of the brackets and luminaire spigot which will be needed to select the correct diameter side entry or post top luminaire spigot cap.

6. LIGHTING COLUMN DESIGN CHECKS

The design process

Lighting columns are designed to BS EN 40 and this standard sets out the calculation process for the wind loads, based on the location, terrain category and site altitude. It also defines the calculation method to determine the strength of the lighting column at its critical sections: the ground level; bottom or top of the door cut-out; swage position; bracket connection; etc.

Manufacturers and consultants typically produce calculation models of the lighting columns in accordance with these standards to determine whether the forces in the column (shear forces, bending moments and torsion moments) generated by the dead and wind loads exceed the structural capacities of the lighting column in shear, bending and torsion, allowing for the relevant partial safety factors on the loads and materials.

When designing new columns, the designer can set the required lighting column parameters such as column height, bracket projection, and luminaire type, and then can choose and vary the material (steel or aluminium grade etc), base and shaft tube diameters and thicknesses to enable the column to pass the structural design checks.

Where an existing column will have other attachments including signs, flower baskets, seasonal decorations, CCTV cameras, or telecommunication antenna mounted at any time of the year, these individual attachments should be listed and included in the design. The design input parameters required for the additional attachments are as follows: description, wind area, weight, height to centre of area, offset between centre of area and column centreline.

Conservative luminaire parameters

Where the existing luminaire is of greater EPA and greater weight than the new LED luminaire, then in all cases the loads on the column will be reduced, regardless of material, column type, location etc. Therefore, provided that the asset owner is satisfied that the lighting columns were originally designed to carry the existing HID luminaire, then it is acceptable to determine by inspection that the columns will also be acceptable with the new LED luminaire.

An exception to this is where columns have been designed with old luminaires specified with an EPA and C_{sx} value rather than a windage. This was the case for some Philips MA series LPS luminaires for example. In these cases, more analysis by a competent engineer will be required to assess the suitability of the column for any new luminaire.

This check is particularly powerful where an asset owner has had a consistent and controlled lighting column procurement specification. Columns supplied under and compliant with such a specification can all be deemed to have this specified luminaire size as its minimum capacity and therefore the LED luminaire weight and windage can be compared to the lighting column specification values to carry out the logical check. This is helpful particularly where the specification includes for a larger heavier luminaire but much smaller luminaires have been installed on site.

The logical check on the luminaire parameters does not remove the need to carry out the lighting column condition survey to check for damage or deterioration. Fundamentally a column that passes the BS EN 40 design checks could still fail due to being damaged or in poor condition.

Non-conservative luminaire parameters

Where the LED luminaire weight OR the LED luminaire EPA is greater than the existing luminaire values, the column must be subject to a design check in accordance with BS EN 40.

The complication with checking existing columns is that while the column height, bracket projection and luminaire may be known, its often the case that the existing column diameters, thicknesses, material grades and attachment details are not known.

Without this missing information, it's not possible to assess the suitability of the existing lighting column stock for use with the new luminaires.

However, since there is a need to visually inspect each lighting column as part of the condition survey, it is possible to take the critical dimensions of the lighting column and attachment parameters, enabling the design checks to be carried out.

The design input information which cannot be collected by site inspection is the material grade and for steel columns this will need to be assessed by a competent engineer based on the age, type and manufacturer or the column. However, these parameters will remain assumptions unless evidence of the correct values is provided.

Once all relevant design input information has been collected for each affected column, the design calculation checks can be carried out in accordance with BS EN 40 and each column accepted or rejected based on the results.

Outline findings from calculations show that the HID luminaires for columns 8m and above typically had a greater windage but lower or equivalent weight and these are often, although not always, acceptable as a large reduction in windage will tend to offset a small increase in weight, except on the longer projection brackets.

For road luminaires on columns under 8m height, the picture is not as clear. There are several very lightweight luminaires used which are equivalent to or lighter than the replacement LED luminaires. Where asset owner knowledge cannot establish a minimum luminaire weight and windage in the lighting column procurement specification, more of these the columns will need to be assessed using the design checks method.

Fatigue checks

The BS EN 40 design checks do not cover fatigue, however, the Highways England specification for lighting columns requires that road lighting columns of 9m or greater nominal height are checked for fatigue to BD 94/07.

Typically, where the luminaire weight increases, the allowable fatigue stress range increases (due to the reduced natural frequency). However, for a given windage, an increase in weight will increase the applied fatigue stress and may be unconservative.

If brackets are removed and the luminaire is installed post top, or if bracket projections are reduced, this is likely to decrease the allowable stress range. However, typically, the applied fatigue stress will reduce faster than the allowable stress range, and so fatigue conditions would become less onerous with reducing bracket projection.

It is recommended that a study of the effects of fatigue is carried out using the typical lighting column construction and dimensions, and the existing HID and proposed LED

luminaires including any changes to bracket projection lengths before any specific conclusions are drawn on whether the fatigue needs to be considered in detail for every calculation or can be deemed conservative.

Large scale luminaire replacement projects

For large scale replacement projects, there may be financial limitations restricting the possibility of individually checking each column. However, an alternative approach based on the collating all similar columns together into batches would allow design checks to be carried out by batches. Conservative design input parameters should be used where there is variance of a parameter across the batch.

Columns failing the design checks

Once the columns have had a design check, there will be a group of columns which pass the checks and can have the LED luminaires added. However, there may also be a group of columns that while in acceptable condition, don't pass the design checks. For these, an approach is required to reduce the loads on the column such that the column can then pass the design checks. This is most easily achieved by removing additional attachments, but may also require a strategy of cutting back the bracket projection to a length that allows the lighting column to pass the design checks.

Future proofing columns and brackets

Where very small wind area LED luminaires are specified, it would be sensible to specify a minimum luminaire wind area (and weight) for the design inputs of new columns to ensure that there is sufficient capacity to enable a different slightly larger luminaire to be installed if required in future. It is recommended that new columns allow for a luminaire of at least 0.12m² wind area as a minimum for columns up to 6m and 0.15m² for columns over 8m. Minimum luminaire weights can be determined by an assessment

of luminaire types that may be used on the network for the relevant column height. Remember to allow additional weight and wind area where it is likely that baffles will need to be installed.

7. LIGHTING COLUMN APPROVAL PROCESS

Outline process

The outline process required should be structured to ensure that the engineering principles are used to determine the outcomes for groups of similar structures, based on similar new LED luminaire parameters and with specific exclusions.

- a. Clean/update the Asset Database to ensure correct information is held on existing lighting columns.
- b. Identify column material, height, dimensions, bracket arrangements, luminaire types, other approved attachments etc. to define what the current equipment installed on site is.
- c. Complete visual inspection of every column being altered for deterioration and damage. Confirm details in Asset Database and collect missing information.
- d. Complete NDT where necessary to assess deterioration in columns.
- e. Replace (or plan to replace) any severely damaged or deteriorated columns ensuring these are designed to take the proposed new luminaire and any existing attachments required whether present on the column or not (remember seasonal decorations and hanging baskets may not always be present during the visual inspection but will need to be included in the design). Record the column material type, material grade and tube section thicknesses in the Asset Database for future reference.
- f. From the Asset Database, identify the existing luminaire types installed across the columns affected by the retrofit works. Determine the manufacturer's weight and EPA for the luminaires

- g. Identify all the columns to be replaced on the Asset Database.
- h. Identify the make and model of the new LED luminaire to be installed and obtain the accurate weight and EPA from the manufacturer's datasheets.
- i. At this point a logical test can be used to compare the required retrofit luminaire weight and EPA with the new LED luminaire weight and EPA. Each existing luminaire and new luminaire pairing will need to be compared.
- j. For columns that fail the logical check, design checks shall be carried out on columns to determine if they support the new higher loads.
- k. Where the column design checks fail, load reduction strategies including additional attachment removal and bracket shortening can be used to reduced loads to an acceptable level.
- l. Where columns failing the design checks have no attachments or brackets or where these cannot be removed or brackets shortened, it is likely that the column will need to be replaced before the new luminaire is installed. Record the column material type, material grade and tube section thicknesses in the Asset Database for future reference.

Lighting column materials

The majority of lighting columns in the UK are either steel or aluminium and the above process works for these column types.

Other construction materials commonly used include cast iron, concrete, fibre reinforced polymer composite (FRPC) and less frequently engineered wood. These columns are all based on composite materials, combining concrete with steel or glass with resin. As a result, they have more complex calculation methods or require verification by testing to determine their suitability. In this case, it is much more difficult to establish approval due to the lack of design information or calculation methodology.

For concrete lighting columns, it is reasonable to assume these are strong enough to carry an LED luminaire provided that they are in good condition which can be established by a visual check. Any defects (see TR22 for a full list of common defects) will act to reduce the column strength and the column should be replaced before installing the LED luminaire.

For damage or corrosion to the bracket connection it is acceptable to remove the original concrete bracket and replace this with a sleeve over galvanised steel bracket before proceeding with the luminaire installation.

Where any significant defects are identified, including cracking, spalling or corrosion staining on a concrete column, the column should be replaced before the new luminaires are installed.

For cast iron, FRPC and engineered wood columns, it is recommended to contact the original equipment manufacturer and ask them to carry out a design check with the new luminaire parameters to establish if the existing lighting columns are suitable for the new LED luminaires.

8. FURTHER INFORMATION

For further information on lighting columns please contact the Lighting Column Technical Forum via their website www.lctf.org.uk

Acknowledgements

David Lodge CU Phosco Lighting

Glossary

Luminaire weight: the mass of the whole luminaire, including the luminaire body, spigot adaptors, lamps, control gear and switching controls (PECU, CMS etc.) where fitted.

Luminaire windage: the profile area or silhouette area of the luminaire at the installed tilt, viewed horizontally from the most onerous direction and with a drag coefficient of 1.0.

Effective Projected Area (EPA): the area created by projecting the outline of a 3D shape horizontally onto a 2D surface combined with its drag and lift coefficients.

Drag coefficient: the horizontal component of the resistance to the wind pressure of

a luminaire representing how blocky or aerodynamic the luminaire is. Drag coefficient is combined with the wind pressure and EPA to give the horizontal component of the wind load on the luminaire.

Lift coefficient: the vertical component of the resistance to the wind pressure of a luminaire which is combined with the wind pressure and EPA to give a vertical component of wind load on the luminaire.

LPS – Low Pressure Sodium

NDT – Non-Destructive Testing