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A CASE STUDY ON THE USE OF LED TEMPORARY CONSTRUCTION LIGHTING SYSTEM

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Abstract: Adequate lighting is a necessity on construction sites not just for work completion, but also for the work quality, worker safety, and project productivity. This paper discusses the problems associated with traditional temporary lighting on construction sites and presents a case study on using LED temporary construction lighting as a potential solution. Various studies have shown that the traditional methods of providing temporary lighting are inadequate due to their non-compliance with OSHA requirements; visual discomfort; constant maintenance; and impacts to productivity, safety and health. On the other hand, studies have shown that using LED as a source of temporary construction lighting provides benefits over the traditional lighting system, even though such uses are still rare within the industry. Using LED for temporary construction lighting, however, is subject to the high initial materials cost and other drawbacks. To this end, the objective of the research is to provide a deeper understanding of LED temporary construction lighting and ascertain its benefits and limitations through a case study. The study involves the University of Washington's Bothell Science and Academic Building Project. The study involves interviews with both the lighting system vendor and onsite project personnel; survey questionnaire distributed to the field workers; and cost analysis of the LED temporary lighting system. The case study concluded that the benefits of using LED temporary construction lighting outweighed its limitations, but the individual cost savings may belong to different parties and may not necessarily be passed on to the owner depending on the contractual arrangements.

1 BACKGROUND

Adequate lighting is important on the construction site not just for work completion, but also for the work quality, worker safety and productivity of the workers. Whilst construction sites can be lit by natural lighting, temporary lighting is usually required to supplement the natural lighting especially for enclosed work areas, during early/late work hours, and around evacuation egress. Often, a general contractor would place the duty of providing and maintaining temporary general lighting (and temporary power) under its electrical contractor's scope of works and include it as part of the electrical bid package. Whilst task lighting has always been the responsibility of individual subcontractors, the scope of temporary general lighting has always been ambiguous with the level of illumination required not being clearly defined in the contract provisions.

Various studies have shown that the traditional methods of providing temporary lighting are inadequate. *Non-compliance* with the regulatory illumination standards during daylight hours was found (Smith and

Azhar, 2007) and only very high wattage light sources (e.g. 400 W metal halides) spaced at an appropriate distance could achieve the illumination standards (Smith, 2008). However, high wattage light sources are very bright, creating glares, shadows, and *visual discomfort*. The traditional method of temporary lighting also creates *safety* concerns. It is not uncommon that the lamps would burn out from overloaded source of energy, expose workers to high voltage wires, or become tripping hazards because of the extension cords and wires attached. Based on field observations and experiences, workers' *productivity* tends to be negatively impacted with the use of traditional methods of temporary lighting. The traditional method requires constant moving of the lamps, resulting in the lamps being dropped, broken, or smashed easily. Oftentimes workers are required to replace the damaged lamps, or to locate, move and set-up task lighting due to the insufficient illumination of the general temporary lighting. The last area of concern is *worker health*. When light bulbs break, workers cleaning up the broken bulbs might be exposed to the escaping Mercury vapor or UV rays commonly seen in compact fluorescent lights.

Due to the problems associated with the traditional method of providing temporary lighting, the Capital Project Office at the University of Washington (UW) deployed the use of low voltage temporary LED lighting system to replace traditional temporary lighting on the UW Bothell Phase 3 ("UWB P3") – Bothell Science and Academic Building project. This is the first west coast installation of low-voltage LED temporary construction lighting system in the U.S. Construction for the 74,000 square foot UWB P3 building consists of four levels and one basement and was delivered using the GC/CM (General Contractor / Construction Manager) and EC/CM (Electrical Contractor / Construction Manager) approach to have the general contractor and electrical contractor on board early. While studies have shown that there are benefits of using low voltage LED lighting system over the traditional methods to provide temporary lighting, there are limitations as well with the most significant one being the high initial system cost. To this end, this paper: (1) introduces the case study background, (2) describes how the LED lighting system was deployed in the studied project UWB P3, (3) discusses data collected through interviews, survey questionnaires, and cost estimates, and (4) presents findings and concluding remarks. It should be noted that as most of the data collected are of qualitative nature, the case study discussion and results although were produced following a scientific procedure are still subject to human bias.

2 DEPLOYMENT OF THE LOW VOLTAGE TEMPORARY LED LIGHTING SYSTEM AT UWB P3

The FLEX SLS lighting system by Clear-Vu Lighting was deployed at UWB P3 to provide temporary construction lighting to all corridors and stairwells, as well as individual rooms where necessary. A typical setup comprises of 450-watt power systems, LED modules with 10' whips, a T connector and low voltage (24V) cables. As this system made use of low voltage, the temporary lighting power cables and drivers could be designed to be embedded within the concrete slab, with only the whips and LED light fixtures dropped and exposed below the ceiling deck. Installation of the temporary LED construction lighting system at UWB P3 was undertaken in a three-stage process, including pre-construction estimate, planning for the lighting and controller setups, and the physical installation.

During the *pre-construction estimate*, the electrical contractor estimated that 285 LED light fixtures would be needed based on the site conditions and layout, considering that each LED module's coverage is roughly 17 ft by 17 ft. During *lighting and controller setup planning*, layout of the MEP was examined to determine possible locations that did not run across known MEP services. Locations of the walls that reached all the way to the bottom of the concrete deck were also taken into consideration, as they would block any light source once the walls were erected. Due to the capacity of the drivers, the number of LED fixtures connected to each driver was limited and therefore impacted routing of the cables, the number of drivers required to be installed per floor, and the number of circuits required to be run per floor. Upon confirmation of the locations of the fixtures and drivers, approximate measurements of their distances from gridlines were taken to aid the physical installation. During the *physical installation*, based on the approximate dimensions from the gridlines, the forms had to be drilled through so that the inserts could be placed within the concrete deck for both the fixtures and the whip. Coordination with ironworkers was necessary as the cables were installed concurrently with the reinforcement bars. During concrete pour, the electrical contractor would station a "pour watch" to ensure that the cables do not get damaged or pulled back into the slab during the pour. After the concrete has cured, upon stripping of the formwork, the LED fixtures were installed on the floor slab and energized immediately to provide temporary lighting for that floor. Figure 1 illustrates how a LED fixture was deployed below a ceiling deck at UWB P3.

Figure 1: Temporary LED lighting fixture dropped and exposed below ceiling deck (courtesy of Nelson Electric)

3 DATA COLLECTION

To verify the benefits and limitations of using the LED fixtures as construction temporary lighting at UWB P3, data were collected via various approaches to triangulate common themes. Site interviews providing qualitative data were conducted with the project management staff from the UW CPO, general contractor, and electrical contractor. The interview data can be summarized into six themes as described in Table 1.

Table 1: Themes from the interview data

Theme	Description
Immediate use of temporary lighting	The temporary lighting system could be energized immediately upon the stripping of the formwork, way before MEP rough-ins
Light reflection off drywall	Drywalls would reflect the LED light and brighten up surrounding spaces as the internal partitions being erected
Workers drilling into embedded cables	Workers drilling through the slab for their works would accidentally drilled through the embedded cables
Upward lighting requirement	The LED lights were generally hung faced downwards but upward lighting is required for HVAC works
Duration of use of temporary lighting	Due to the ease of light fixture removal, the temporary lighting could be used until permanent lighting was turned on
Contractual requirement	Temporary lighting as “means and methods”, up to the general contractor’s discretion

A survey was administered to solicit worker input on the lighting requirements specific to their tasks and on how the LED lighting fixtures compared to the traditional methods. Based on the 19 responses received, in overall, the workers appeared to have had a more positive experience with LED lighting as compared to the traditional lighting, consistent with the interview results. Based on the ratings of both systems (on a scale of 1 to 5), the average rating of LED lighting's attributes (e.g. visual comfort) ranged from 3.5 to 4.0 as compared to an average rating of 2.4 to 3.2 for traditional lighting's attributes. Particularly, plumbers were in more agreement in their ratings than other trades. The electricians, on the other hand, had mixed reviews as to whether working in LED lighting was a more positive experience than traditional lighting.

Estimated cost data were obtained (see Table 2) to compare the costs of providing a temporary metal halides lighting system and a temporary LED lighting system to meet the OSHA 5 foot candle requirements for UWB P3. As the electrical contractor had never tracked these cost categories for temporary metal halides lighting systems used in the past, estimates from a different electrical contractor, Clear-Vu, and NECA Manual of Labor Units were also consulted to provide a basis of comparison and to establish a range of possible costs.

Table 2: Summary of total cost comparison between LED and metal halides systems

Categories	LED	Metal Halides
Materials	$53,953	$40,990
Installation	$30,915	$26,757
Maintenance	$3,324	$26,985
Removal	$3,836	$10,228
Energy	$3,442	$24,527
Total	**$95,470**	**$129,488**

4 STUDY FINDINGS AND CONCLUSION

Use of the temporary LED lighting system does provide better illumination and minimizes the other identified problems of safety (less hazards), productivity (less maintenance required), and health (less risk of mercury and UV exposure). In addition, the case study revealed that use of the temporary LED lighting system allowed immediate use of temporary lighting on site as it could be energized upon the stripping of the formwork, allowing the building to be fully lit up at least one to two months earlier than it would have been in a traditional temporary lighting setting. However, it was also revealed that the temporary LED lighting system required additional pre-construction planning; more time and labor was required for installation, including additional works such as coordination with iron workers. These resulted in higher installation costs. Whilst the cost comparison showed that the temporary LED lighting system had lower overall costs, it is pertinent to note that the individual cost savings may belong to different parties and may not necessarily be passed on to the owner depending on the contractual arrangements. Verticality of a trade's work space and the trade's type of tasks also seemed to potentially influence the workers' experience with LED lighting system.

References

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