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Electrical Safety at Construction Sites: An Exploratory Study of Temporary Power

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ABSTRACT

Electricity powers all types of equipment that are necessary to complete jobs on a construction site. However, hazard associated with distribution of electricity to these power outlets cannot be overlooked given the fatalities linked to the improper design, installation and use of temporary power at construction sites. Many of the accidents caused by electricity could have been avoided with extra care or better attention to detail from the electrical distribution side. In this paper, various techniques that can be used to create a safer and more efficient temporary electrical system for construction job sites are discussed. The paper also presents guidelines by which to build these systems, keeping in line with the principles of OSHA when it comes to safe working with electricity. A real example of electrical distribution is also analyzed and dissected to have a better understanding of hazards and safety related to the electrical distribution on the construction sites.

Keywords: Electrical safety, OSHA, Temporary power, Construction

1. INTRODUCTION

The reliance on temporary electricity has become more than ever before as more and more tools, equipments etc. with increasing complexity are being used in the construction sites. Electricity powers almost all types of equipments that are necessary to complete various jobs on construction work sites. For instance, electricity helps to power the tower cranes that are inevitably required for constructing tall buildings as well as to operate huge selection of power tools needed for a job. Electrical power is also needed for all onsite offices as well as the buck hoist to carry workers up the buildings. Hence electrical power is a much-needed asset in construction. However, there are multiple sources of hazards associated with the use of electricity at construction sites. Employee contact with electricity is responsible for approximately 18% of the fatalities observed in construction (OSHA). Prior research indicates that many of the accidents caused by electricity could have been avoided with extra care or better attention to detail from the electrical distribution side (Goetsch, 2003; Hinze, J., 1997). It has been reported that most of the fatalities associated with electrocution is the result of contact with the overhead power lines (Construction Safety Association, 2000).

There are many methods to choose from when selecting temporary power distribution for a construction site. It's really not that dissimilar from the installation of regular power systems or permanent power systems. The only difference is that one is removable and the other is not. In the ensuing sections, various techniques that can be used to create a safer and more efficient temporary electrical system for construction job sites is discussed. Other topics discussed are the guidelines that help to build these systems, OSHA recommendations and enforcements that should be followed when working safely with electricity. A real example of electrical distribution will also be analyzed and will be dissected to get a better understanding of hazards and safety related to the electrical distribution.

2. TEMPORARY POWER FOR CONSTRUCTION

2.1 ELECTRICAL POWER DISTRIBUTION TYPES

There are many different types of setups for electrical risers to distribute power onto a construction site. The power company gives the power from the power pole but it's the responsibility of the electrical contractor to distribute the power based on the needs of the client or general contractor. Some construction sites require special equipment, such as welding by using electricity or special conveying systems, and based on what the need is and how much is needed; the electrical riser is setup to meet these needs. In some cases, the electrical engineers or designers require specific types of distribution and specify this on plan or drawings before construction begins. However, in most cases, it's the electrical contractor's responsibility to design and build the electrical distribution based on the clients needs. The National Fire Protection Association (NFPA) governs the requirements of electrical work through their code NFPA 70 or better known as The National Electrical Code (NEC). This code is solely designed to govern all electrical installations and designs for any type of electrical work, including temporary power. This is where one needs to look for the requirement of a safe temporary distribution system.

There are many considerations and much planning ahead that must be taken when designing the electrical power distribution system for a construction site. Electrical contractors and general contractors must ask or explore some of the following questions:

- Where will the riser be located so as to minimize the interruption to the work flow?
- What will this location become in the future – parking lot, garden, sidewalk, etc.? (note that temporary electrical power will last for the duration of construction)
- Is this location convenient and safe for the distribution of circuits along the site?
- Where is the power pole in relation to the electrical riser?
- If the power wires are overhead, will there be traffic under the live lines? (note that there are height requirements in NEC)
- If the power wires are underground, will there be a conflict with building foundations or utilities?
- What type of power is needed for construction and where is it located from the power company?

These are some of the many questions contractors should ask themselves and their clients in order to have a safe electrical distribution along the entire construction site.

Figure 1 shows the electrical riser assembled and used on the construction site for a project consisting of twenty-three proposed warehouses. This project has been taken as a case study for this research and will be discussed in detail in the next section. Note that all construction sites are different and unique and distribution system will therefore differ from one site to the other. Once the amount of power required is determined, one needs to select what are called the over current protection devices. These are devices such as breakers or fuses that provide protection in case of a short circuit anywhere in the distribution. In Figure 1, the over current protection is for 100A and is together with the panel board. Figure 2 shows an example of a typical panel board. The power from the power pole enters through the meter and is distributed through this over current protection device, which is the main breaker located at top of the panel board. The power is then distributed throughout the branch circuit breakers, which are located in the middle.

In case of Figure 1, the over current protection is provided in the form of a main breaker, other times they can be fuses as well. The over current protection must be sized according to NEC section 240, which deals with over current protection devices. The over current protection, whether it is in the form of a breaker or fuse box must be of rating NEMA 3R. This simply means that it must be rain proof and be able to withstand the weather elements. When electricity comes in contact with water, it becomes a major hazard and anyone who comes in contact with the wet area can be electrocuted. The panel board and over current protection must be sealed from elements to avoid any energizing of the surrounding areas.

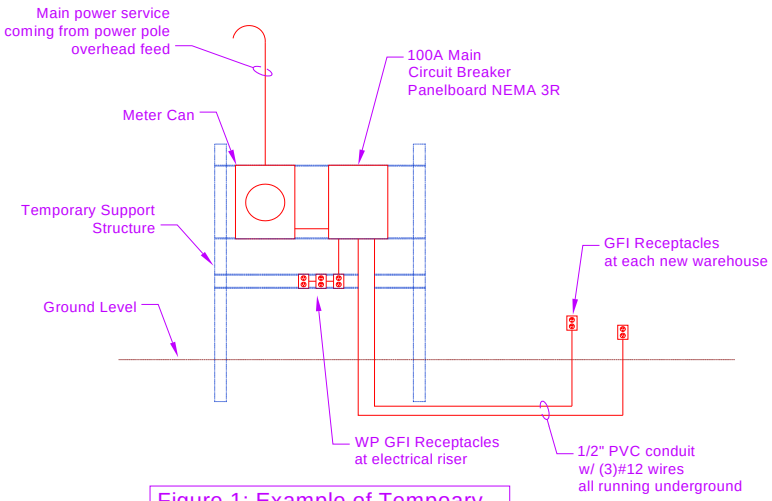

Figure 1: Example of Tempoary Electrical Riser and distribution of Case Study

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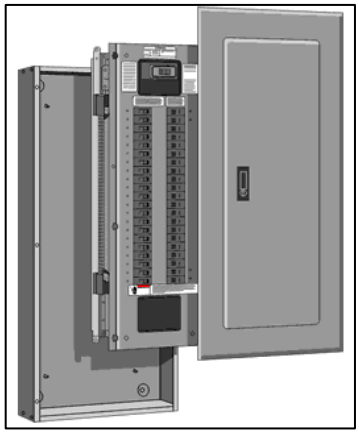

Figure 2: A Typical Panel Board

Grounding of the entire distribution structure must also be done properly. When the riser is grounded, in case of a short circuit anywhere along the line, it provides equipment and human safety. Grounding is very important not only for the electrical riser but also for all construction equipments operated by electrical power. Proper grounding of equipment, extension cords, receptacles, and anything else that uses electricity must be inspected.

Once the riser is setup, now the question becomes how to distribute the power safely throughout the construction site with it neither being a hazard nor an obstruction to construction workers. Branch circuits are the means for power distribution from the panel board to the site or location where needed. Branch circuits, like a tree, extend out from the trunk (panel board) outwards towards their locations for power. There are many different ways to distribute power throughout a construction site. Again the questions come down to what type of a site it is and

what type of work will normally be performed. If it is just a residential home, then just mounting a simple temporary riser with extension cords will suffice. Extension cords usually go up to one hundred to two hundred feet in length. Since the electricity need for the construction of a house is neither too much nor too far from the electrical riser, extension cords are often sufficient to distribute the power. Extension cords must be grounded and not spliced at any location. They must be inspected every time they are used and must not be used if they have become severely damaged, as seen in Figure 3(c). "Extension cord sets used with portable electric tools and appliances shall be of three-wire type and shall be designed for hard or extra hard usage" (29CFR 1926 OSHA). Figure 3(a) is an example of the proper type of extension cord that should be used on a construction site. As required by OSHA, it has the three wires and is grounded. Figure 3(b) is a type of extension cord that should never be used on or near a construction site. This type of cord is for house use and should never be used where a ground is required.

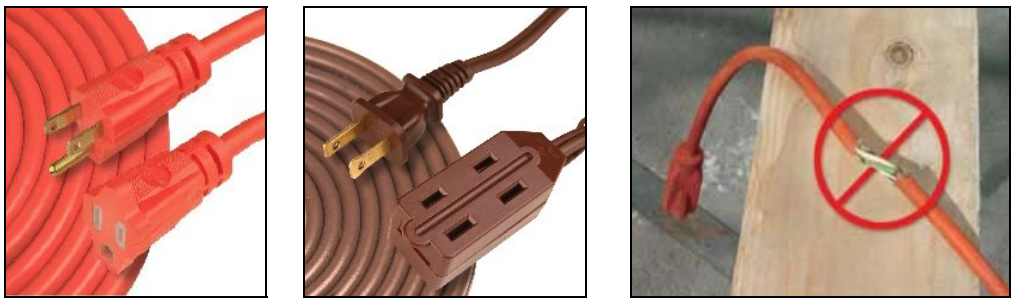

Figure 3: Extension Cords - (a) Proper Type, (b) Improper Type, (c) Damaged Cord

As mentioned in reference to Figure 1, the panel board for a simple house must also be of type NEMA 3R. The receptacles, which are where the extension cords will be plugged into, must be GFCI (Ground-fault circuit interrupter) to protect the worker or user from any shock if a short circuit occurs in the line. The GFCI must also be covered by a waterproof cover to protect from rain and exterior elements.

When there is demand for more electrical power than that required for constructing a simple residential building, such as a high-rise building or as in the case of the study project – a group of warehouses, the electrical riser as shown in Figure 1 and the distribution becomes a little more complex and extra care must be given to avoid any accidents. There could be a number of branch circuits and each one must be run according to the code to protect the workers and surroundings. In some large projects, there could also be more than one panel boards for different areas of the project. For example, in a high-rise, there could be a main service riser located in the bottom and a panel board located at every five floors. This helps avoiding a lot of smaller branch circuits running from the ground into the building. Extension cords must still follow OSHA specifications and must be inspected and protected from damage. For projects of this size, the distribution of power though branch circuits is very similar to that of a permanent electrical system of the building. They both follow basically the same rules as prescribed in NEC and must be installed with just the same amount of care to provide a safe work environment. Everything from the wires being sized properly according to NEC table 310.16 to the correct amount of wires to fit a conduit based on NEC annex C. This is a job that should be left to the professional electrical contractor and should always be done according to code. If the procedures are followed according to the code, then there should be a safe environment from the electrical feeder to the point of termination on the construction site. At the point of termination of the branch circuits, it's up to the workers to create a safe work environment.

There are various ways to distribute the branch circuits from the panel board throughout the construction site. When using any of the following methods, they should be done according to code and with appropriate care to avoid any damages.

Running branch circuit wires in conduit is one safe and effective way to distribute power. Conduit is easy to assemble and when not used underground, can be removed after construction is complete and used somewhere else. Conduit also provides protection to the wires inside the conduit. Note that these wires must be free from

crack or splices as well. Conduit protects the wires from any damage they could encounter. However, the conduit must be placed in locations to avoid any water or damage from equipment. Usually in a high-rise building, they can be attached to a column and keep adding to that same conduit as the building keeps growing. Once the building has reached its final height then the entire assembly is dismantled and reused somewhere else. One safety hazard that occurs in buildings that are under construction is standing water. As a building is rising, the roof structure has not been built. When it rains the water trickles down from floor to floor and sits there until it is either dried up or moved away. Many workers don't realize the dangers involved with using extension cords or improper distribution of power to do their work when there is water around. Using proper care along with safe extension cords that have been checked and are in good conditions will help to make the job safer.

Now that the distribution and access of power to workers have been discussed, the next step to discuss is the safe operation of equipment and power tools. Power tools must be inspected and checked prior to every use for any defects. One item that workers often overlook is the cords of the power tools. The extension cords must be free from cracks or splices, but so must the cords for power tools. These too must be inspected prior to every use. It's also not safe to operate power tools near or on water. It is a bad combination to use power tools while standing in water. Many accidents or problems can be avoided with proper care and use of electric power tools. It is also important to make sure the tool has a ground. The extension cord needs to be grounded so that the tool is grounded as well.

2.2 TEMPORARY SERVICE POLE

Upon request Florida Power and Light (FPL) or any other Utilities Companies will install a service drop to the service pole located within 65 feet of an existing power pole. A typical arrangement for this is as shown in Figure 4.

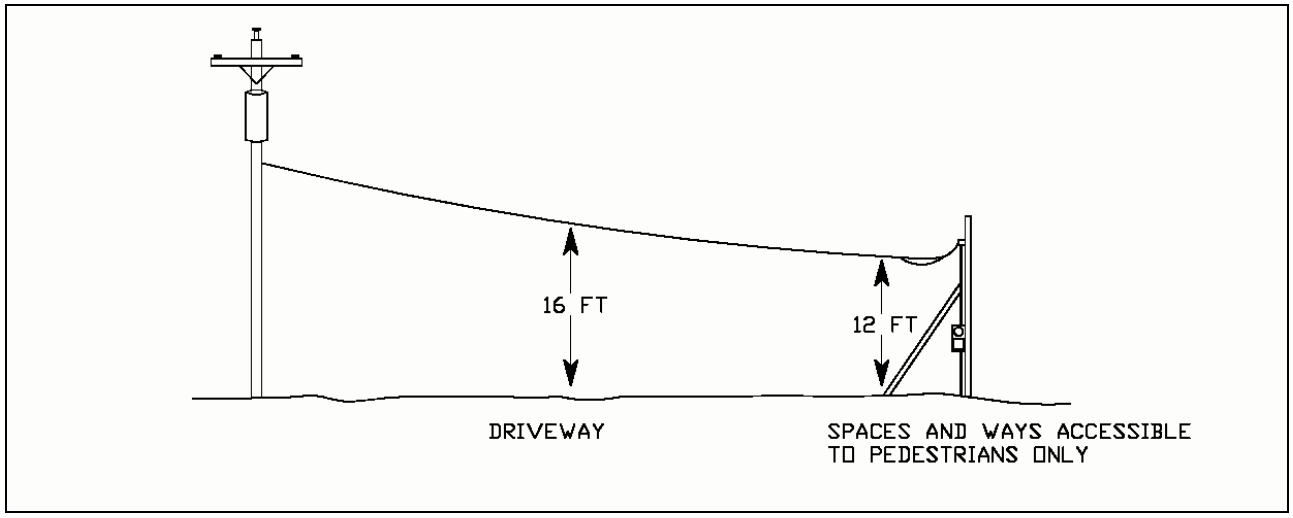

Figure 4: Temporary/Construction Service Pole from Overhead System

2.3 MOUNTING STRUCTURES

In the case of the project where the electrical riser shown in Figure 1 was used, it proved to be very efficient and convenient. As seen in Figure 1, the meter and panel board were mounted on a structure support that was strong enough for any type of weather. The strength of the structure used to support the electrical riser is very important. A simple piece of plywood with some nails will not be sufficient and might catch on fire or get blown over by a strong wind.

Figure 5: Temporary Power Distribution Setups

Figure 5 shows another typical structure setup for temporary power distribution. This is typically seen for the construction of many single-family homes as the temporary electrical riser. It should be a vertical piece of 2 inch x 8 inch plank standing vertical and buried into the ground. At least three pieces of 2 inch x 4 inch woods should be placed as shown to add further stability to the riser. The support legs should also be secured to the ground with rods or other means. This kind of typical structure has proven to be very safe and efficient for projects where the need for electrical power is very small.

3. CASE STUDY

Figure 1 shows the temporary power riser needed for the construction of twenty-three warehouses in the Doral area, Miami. The electrical power need was basically for small hand power tools. The major problem was how to get the power to where it was needed on such a largely spread out site. It was inefficient to provide more than one riser: it would be too costly and there was only one place to draw power from. A decision was made to build the structure as close to the power pole to avoid any traffic of trucks or cranes in between the pole and riser. The structure proved to be strong enough to withstand the element.

As mentioned earlier, since the construction site was spread to a large area, and since it was inefficient to provide many risers all over the job site it was decided that the most convenient and safest way to get branch circuits to the areas where work was going to be done was to run the conduit with wire underground. With coordination between the electrical contractor and the foundations contractor, the conduit was laid at the same time the footings were being prepared. The conduit was unharmed and the method proved to be a success. Since there was minimum or no underground activity once the foundation was completed, underground distribution of service wire to different ware house units under construction would minimize the length of the flexible cord. This was particularly done to ensure that the electrocution hazard in the site was minimal. One conduit was taken to each of the proposed warehouse units and at the end was provided with a GFCI receptacle. This way all the units had their own temporary power outlet and no single outlet was more than one hundred feet away. Also, by running the branch circuits underground, they were safe from any damage during construction. Once the construction was done, the conduit was cut and capped and let underground. All receptacle devices used either at every warehouse unit or on the electrical riser were GFCI as required. All electrical distribution equipment was also NEMA 3R and could withstand all the exterior elements.

4. BRIEF DESCRIPTION OF THE NEC AND OSHA

The National Electrical Code is produced by NFPA, National Fire Protection Association. It is number seventy of a series of codes produced by the association. It applies to all types of work related to electrical applications. When working on any electrical job, whether it is changing a safety switch or panel board or an engineering design application, the National Electric Code applies and governs all such type of work. NEC covers all aspects

of design, distribution, new construction, proper installation of electrical devices, and all that has to do with electrical work. Article 590 is the part of the code that regulates and serves as a guide for temporary power either on construction site or for temporary power at other events.

The 29CFR 1926 OSHA regulations also have a section for electrical safety. This is Subpart K. Many topics such as grounding, GFCI, equipment, over current protection, and wiring design and protection are covered by this part. Properly following Subpart K and the NEC should have all the answers and regulations to have a safe electrical working environment at the construction sites.

5. DISCUSSION AND CONCLUSIONS

Temporary facility distribution for construction sites has been a popular topic for research in construction. Different techniques, like genetic algorithm, ant colony optimization techniques have been used for site lay out planning. Temporary power distribution, which is an important element of all construction sites needs to be optimally located without interrupting the work flow in the construction site. Moreover, the arrangements to distribute power to the electrical appliance used in the site should be given utmost care as electrocution is one of the major fatalities encountered in the construction sites. Although the code gives a detailed standards and specifications for the electrical contractors to comply, it is only with the due diligence of the contractor working on the site that a safe site can be maintained.

When properly done and analyzed, there should be no problem or hazards encountered during construction related to temporary electrical distribution. In order to design and assemble an electrical riser, the NEC and OSHA should be explored to see what applies to that particular construction site. Also, it is very important to look and think ahead. Many problems and hazards could be avoided just by looking ahead. A lot of the responsibility for an electrically safe work environment is in the worker's hands. The workers and supervisors must take extra time, care and effort to check all extension cords and power tools in order to assure a safe work environment for the workers. Simple observations such as standing water where the extension cord will be used could help to avoid a problem. Some construction projects last for a few years, and like electrical equipment in buildings, the temporary electrical distribution systems for construction need maintenance and attention during the construction of a project. The distribution system could be exposed to various damages from chemicals, concrete and other operations that are taking place in the construction sites. These are situations that could potentially cause a hazard if not attended immediately. Through constant supervision, many problems can be avoided and work at construction site can be much safer as far as electrical hazards are concerned.

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