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Designing and detailing of scaffoldings

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ABSTRACT

Construction is a vast field. It involves so many processes, stages, materials, and tools. Scaffolding is a temporary or movable structure made of wooden planks and metal poles, used by workmen while building, repairing, or cleaning the building, bridges and all other manmade structures. It is also called 'staging' or 'scaffold'. Scaffolds are widely used on construction site to get access to heights and areas that would be otherwise difficult to get to or to reach. Scaffolding, also called scaffold or staging, is a temporary structure used to support a work crew and materials to aid in the construction, maintenance and repair of buildings, bridges and all other manmade structures. Scaffolding is also used in adapted forms for formwork and shoring, grandstand seating, concert stages, access/viewing towers, exhibition stands, ski ramps, half-pipes and art projects. The scaffold has to fulfil a diverse set of requirements: - the creation of safe and productive working areas providing access to working areas at higher levels - carrying area and/or point loads. Scaffolding work is erecting, altering or dismantling a temporary structure erected to support a platform and from which a person or object could fall more than 4 meters from the platform or the structure. Scaffolding work must be undertaken by a person holding the appropriate class of high-risk work license. This definition applies whenever the term 'scaffolding work' is used in this Guide.

Keywords— *Scaffolding, Fire and Safety, Safety management*

1. INTRODUCTION

1.1 Wooden and Bamboo Scaffolding

Although wooden scaffolding is used almost everywhere, there are regulations for how to build it. It is more common outside of North America and Europe. Pre-cut lumber was the most common type of scaffolding until steel, and the fabrication of materials became more affordable. Normally all wooden members, vertical and horizontal are tied with coconut coir rope at all joints. This has a low initial cost but short life. They are not suitable where duration for which scaffolding has to be kept is more or there comes monsoon in between as its strength entirely depends on coconut coir rope.

1.2 Tube and Clip Scaffolding

This scaffolding is one of the earliest types of steel scaffolding. It consists of two parts, including the tubes and clips, sometimes called 'couples'. It is very simple and one also popular because of its easiness in assembly and disassembly. To erect the scaffold, you have to connect tubes together to make long runs and then connect the verticals and horizontals together with clamps built specifically for these tubes. This system is very flexible as you can place the verticals tube wherever you need them. Where other types of scaffolding don't easily form or adjust to odd shapes, tube and clamp scaffolding can be adapted to round, straight, or irregular shapes. The steel in this type of scaffolding is specially designed to protect against corrosion and rust, which mean that it is a good choice for regions with harsh weather. There are specific requirements that scaffold companies and designers must fulfil. This has a long life but high initial cost.

1.3 Cup locks Systems Scaffolding

This type of scaffolding is generally made from galvanized steel. This scaffolding is popular for its capacity to support heavy loads. By using cup locks at every 500 mm to 1,000 mm, this type of scaffolding creates highly standardized systems that work well for scaffolding designs with repeated patterns. This is even costlier, but it is quite strong and safe.

2. LITERATURE REVIEW

2.1 Trestle Scaffolding

Fig. 1: Trestle Scaffolding

As the name suggests, this type of Scaffolding is supported on tripod type movable ladders. This type of Scaffolding is used primarily in indoors, like for repairs or painting works. The usage of Trestle Scaffolding is limited to indoors as the height in this Scaffolding is up to 5 meters only.

2.2 Steel Scaffolding

Fig. 2: Steel Scaffolding

Following its name, this Scaffolding is created using steel tubes set by couplers and it is easy to assemble as well as disintegrate. Steel Scaffolding comes with many benefits, thus has a higher cost but it does provide higher safety standards during construction. The structure provides strength, durability and is fire resistant. Despite the cost, it is one of the most popular Scaffolding today owing to its benefits. Steel Scaffolding is mainly used for outdoor construction and bigger structures.

2.3 Patented Scaffolding

Fig. 3: Patented Scaffolding

This type of Scaffolding is also made using steel however; these are readymade Scaffoldings and are fitted with special couplings and frames etc. The readymade Scaffoldings are available in the market and are ready to use once bought. When using the Patented Scaffolding, the working platform is set on the brackets; these brackets can be adjusted to the required level.

2.4 Suspended Scaffolding

Fig. 4: Suspended Scaffolding

Suspended Scaffolding is used for a variety of repair works as well as painting. Mainly used in painting as the platform is adjustable to desired length multiple times. Suspended Scaffolding is created using rope or chains tied to the platform for the construction worker, which is then hanged from the roof with the height adjusted at the desired level.

2.5 Cantilever Scaffolding

Fig. 5: Cantilever Scaffolding

Also known as, Single Frame Scaffolding, Cantilever Scaffolding has limited usage and requires various checks before the installation. In this Scaffolding system, the standards are supported by a chain of needles that are pulled out from the holes in the wall. There is another type of Cantilever Scaffolding, in which instead of all the needles are supported inside the floors through the double frame Scaffolding. One needs to be very careful and follow all the required steps when installing the Cantilever Scaffolding. Given below are the scenarios in which this type of Scaffolding is recommended:

- The top section of the wall is under construction
- The ground is unable to support the standards
- The ground is close to the wall and free from traffic

2.6 Single Scaffolding

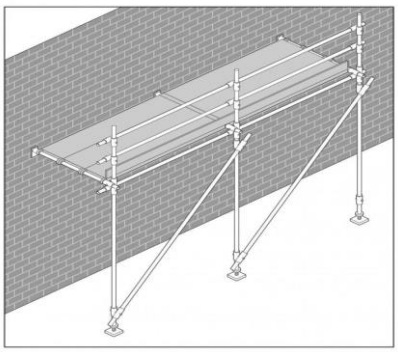

Fig. 6: Single Scaffolding

One of the basic and oldest methods used in Construction, Single scaffolding is mainly used for brick masonry. This type of Scaffolding includes standards, putlogs, ledgers, which links to the wall at a distance of 1.2 meters approximately. In addition, Ledgers join the standards at a vertical distance of 1.2 to 1.5 meters while the distance between the standards is 2 to 2.5 meters. Putlogs fixed at a distance of 1.2 to 1.5 meters but extracted from a gap in the wall at the end of the ledger. All these technical calculations when followed by book keep the structure sturdy and offer desired support.

2.7 Double Scaffolding

Fig. 7: Double Scaffolding

Double Scaffolding also knew as the Independent Scaffolding, is the type of Scaffolding that is used mainly for the stone masonry job. It is very difficult to make holes in the stone walls for supporting the putlogs, hence two scaffoldings together create a sturdy structure for construction work. While the first row is 20 to 30 cm away from the wall, the second one is erected 1 meter far from the first row. With the support of both frames then putlogs are positioned. Additional steps are taken to make the structure firmer by adding cross braces and rakers.

2.8 Kwikstage Scaffolding

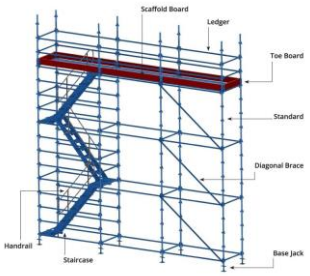

Fig. 8: Kwikstage Scaffolding

The last but not the least in the list is the Kwikstage Scaffolding system. This Scaffolding is contrived from hardwearing galvanized steel and is admired for its easy installation. Effortless to assemble as well as disintegrate, it is used for both big and small construction works. Kwikstage Scaffolding can easily replace regular scaffold system and provide a safer and strong platform to work. Created using a durable and safe interlocking system, the patented Kwikstage modular system is customizable to any desired height.

3. MATERIALS USED IN SCAFFOLDING

There are various materials used in scaffolding:

(a) It depends on the local availability of materials and their cost. Before the use of metal tubes as scaffolding, in the early 1900s wooden branches or bamboo was widely used as a method of scaffold construction and are still used. In India wooden materials are easily available at a lower cost. Therefore, in India bamboo and wooden poles are used as scaffolding materials. Tubular scaffolding of steel or aluminum has largely replaced wooden scaffolding on most large construction projects. Tubular scaffolding can easily be erected in any height, shape, or length, with better safety.

(b) Depending on where you're working in the world, different types of scaffolding systems will be seen in a different country.

(c) In some countries of Northern Europe, labour is very expensive. Thus, aluminum scaffolding is becoming more common. Most of the scaffolding has to be manually lifted to be put in place, and aluminum is lighter than steel, and lighter scaffolding means that the scaffold can be built, reducing labour cost too.

(d) In some countries, aluminium is expensive and labour is affordable, so wooden poles and bamboos are very common. Bamboo is more commonly used in Asia where it's favoured for, flexibility, strength and eco-friendliness. Hong Kong is a well-known city that uses bamboo scaffolding even for skyscrapers. Highly-skilled designers and technicians are required for the design and construct through multiple stories with bamboo.

4. SAFETY TIPS FOR SCAFFOLDINGS AND SCAFFOLDING WORKS

4.1 A person conducting a business or undertaking

Duties: A person conducting a business or undertaking has the primary duty to ensure, so far as is reasonably practicable, workers and other people are not exposed to health and safety risks arising from the business or undertaking. This duty requires the person to manage risks by eliminating health and safety risks so far as is reasonably practicable, and if it is not reasonably practicable to eliminate the risks, by minimising those risks so far as is reasonably practicable. It also includes ensuring so far as is reasonably practicable the: „ provision and maintenance of safe scaffolding and scaffolds „ safe erection, alteration, dismantling and use of scaffolds, and „ safe use, handling, storage and transport of scaffolding. The WHS Regulations include specific duties for a person conducting a business or undertaking with management or control of scaffolding plant, powered mobile plant and plant that lifts or suspends loads.

4.2 Designers, manufacturers, suppliers and importers

Duties: Designers, manufacturers, importers and suppliers of scaffolding or scaffolds must ensure, so far as is reasonably practicable, the plant or structure they design, manufacture, import or supply is without risks to health and safety. This duty includes carrying out analysis, testing or an examination and providing specific information about the plant. The information must, so far as is reasonably practicable, be passed on from the designer through to the manufacturer and supplier to the end user.

4.3 People installing, constructing or commissioning plant or structures

Duties: People installing, constructing or commissioning scaffolding or scaffolds must ensure, so far as is reasonably practicable, all workplace activity relating to the plant or structure including its decommissioning or dismantling is without risks to health or safety. In this Guide, the scaffolding contractor is the person responsible for installing, constructing and commissioning scaffolds.

4.4 Officers

Duties: Officers, such as company directors, have a duty to exercise due diligence to ensure the business or undertaking complies with the WHS Act and Regulations. This includes taking reasonable steps to ensure the business or undertaking has and uses appropriate resources and processes to eliminate or minimize risks from the plant.

4.5 Workers and others

Duties: Workers and other people at the workplace must take reasonable care for their own health and safety, co-operate with reasonable policies, procedures and instructions and not adversely affect other people's health and safety.

5. MANAGEMENT OF RISKS ASSOCIATED WITH SCAFFOLDINGS

Use the following steps to ensure, so far as is reasonably practicable, that workers and other people are not exposed to health and safety risks.

(a) Find out what could cause harm. The following can help you identify potential hazards: „ Observe the workplace to identify areas where scaffolds are used or scaffolding work is performed and where there is interaction with vehicles, pedestrians and fixed structures. „ Look at the environment in which the scaffold is to be used including checking ground conditions. „ Identify the major functional requirements of the scaffold-like the maximum live and dead loads and access requirements. „ Inspect the scaffolding before and after use. „ Ask your workers about any problems they encounter or anticipate at your workplace when constructing or interacting with scaffolds and scaffolding work–consider operation, inspection, maintenance, repair, transport and storage requirements. „ Inspect the erected scaffold. „ Review your incident and injury records including near misses.

(b) Assess the risk. In many cases, the risks and related control measures will be well known. In other cases, you may need to carry out a risk assessment to identify the likelihood of somebody being harmed by the hazard and how serious the harm could be. A risk assessment can help you determine what action you should take to control the risk and how urgently the action needs to be taken.

(c) Take action to control the risk. The work health and safety laws require a business or undertaking do all that is reasonably practicable to eliminate or minimise risks. The ways of controlling risks are ranked from the highest level of protection and reliability to the lowest. This ranking is known as the hierarchy of risk control. You must work through this hierarchy to manage risks. The first thing to consider is whether hazards can be completely removed from the workplace. For example, risks can be eliminated by carrying out work at ground level or on completed floors of a building. If it is not reasonably practicable to completely eliminate the risk then consider the following options in the order they appear below to minimize risks, so far as is reasonably practicable: „ substitute the hazard for something safer e.g. using mechanical aids like cranes, hoists, pallet jacks or trolleys to move equipment and materials wherever possible instead of manually lifting scaffolding „ isolate the hazard from people e.g. install concrete barriers to separate pedestrians and powered mobile plant from scaffolds to minimize the risk of collision, and „ use engineering controls e.g. provide toeboards, perimeter containment sheeting or overhead protective structures to prevent objects falling hitting workers or other people below the work area. If after implementing the above control measures a risk still remains, consider the following controls in the order below to minimise the remaining risk, so far as is reasonably practicable: „ use administrative controls e.g. storing scaffolding as close as practical to the work area to minimize the distance over which loads are manually moved, and „ use personal protective equipment (PPE) e.g. hard hats, protective hand and footwear and high visibility vests. A combination of the controls set out above may be used if a single control is not enough to minimize the risks. #1 Identify hazards #2 Assess risks #3 Control risks 4 JULY 2014 General Guide For Scaffolds And Scaffolding Work You need to consider all possible control measures and make a decision about which are reasonably practicable for your workplace. Deciding what is reasonably practicable includes the availability and suitability of control measures, with a preference for using substitution, isolation or engineering controls to minimize risks before using administrative controls or PPE. Cost may also be relevant, but you can only consider this after all other factors have been taken into account.

(d) Check your control measures regularly to ensure they are working as planned. Control measures need to be regularly reviewed to make sure they remain effective, taking into consideration any changes, the nature and duration of work and that the system is working as planned.

6. METHODOLOGY

A primary objective of scaffold planning and design is to prevent scaffold collapse before, during and after placement of the scaffold. The collapse of a scaffold can cause death or significant injury to workers or passers-by and damage to structures.

(a) Choosing a scaffold: Managing the risks associated with scaffolds and scaffolding work begins when you first start making decisions about how scaffolds are going to be used at a workplace and what type of scaffold will be best and safest for the job.

(b) Designing the scaffold: The first step in controlling the identified risks should be at the design stage where the focus is on eliminating risks through good design of: „ scaffolding—the Act classifies these individual components as “plant”

(c) Work systems and processes for the safe erection, alteration and dismantling of the scaffold.

(d) The scaffolding plant: Scaffolding designers have a duty to design scaffolding that is safe to manufacture, assemble and use for the purpose it was designed for. They design the scaffolding system. The scaffolding may be purchased, hired in or supplied, for example by a scaffolding contractor.

(e) The scaffold structure: The scaffold designer will be responsible for selecting the appropriate scaffolding and preparing a scaffold design for the job. They design the scaffold installation. The scaffold designer should consider:

- The intended use of the scaffold hazards and risks for people who erect, dismantle, use or are near the scaffold,
- The foundations including ground conditions,
- The load-bearing capacity of the surface where the scaffold is to be erected or the suspension systems for hung or suspended scaffolds,
- Dead loads e.g. resulting from the size and weight of the scaffold,
- Live loads e.g. workers, plant and material on the scaffold „
- Environmental loads e.g. wind loads, bracing, tying and anchors—where anchors will be placed on the supporting structure and types of anchors to be used,
- Supporting structures,
- Edge protection,
- Protection against falls and falling objects,
- Containment sheeting, and
- Safe entry and exit.

Where necessary, improved scaffold stability may be achieved by:

- Tying the scaffold to a supporting structure
- Guying to a supporting structure
- Increasing the dead load by securely attaching counterweights near the base, and „
- Adding bays to increase the base dimension.

Scaffolds should be designed by a competent person, for example, a person holding a relevant scaffolding high-risk work license. The system of work: Systems of work should be clear but flexible to meet changing circumstances as the work progresses. The system of work should provide for the assessment and control of any new risks arising from proposed changes to the work before they are implemented. A documented safe system of work is administrative control. For scaffolding work this could include consideration of:

- Worker competency and licensing requirements
- Consultation and coordination of the work with others
- Access and exit
- Exclusion zones
- permit-to-work systems
- fall arrest systems
- Inspection and maintenance
- Emergency arrangements, and
- Changes to the work arrangements.

7. FORMULATION OF PLAN IN ORDER FOR AN EFFICIENT ERECTION OF SCAFFOLDING

7.1 Scaffolding plan

Where required, a Safety Management will set out the work method to safely erect, use and dismantle a scaffold. Where an SWMS is not required a scaffolding plan will help identify ways to protect people who are:

- Erecting, using, maintaining, altering and dismantling the scaffold, and
- Near the scaffold or scaffolding work e.g. other workers and members of the public.

For more complex scaffolds a scaffolding plan should be prepared by a competent person. In preparing a scaffolding plan the person should consult with a range of other people relevant to the work and workplace, for example:

- The scaffold designer e.g. to discuss the design loads and the capability of the structure to support extra loadings
- The scaffolding contractor or builder—this may be the person conducting a business or undertaking or a principal contractor—e.g. to assess where underground drains or pits and underground services are located. The work should be planned to avoid excavating service trenches under, through or adjacent to scaffolds
- workers, work health and safety committees and health and safety representatives regarding erecting, maintaining, altering and dismantling the scaffold
- other competent people familiar with similar structures e.g. an engineer or a person holding an intermediate or advanced scaffolding high risk work license, and
- The electricity supply authority if the scaffold is being erected near overhead electric lines.
- The scaffolding plan should include a site layout plan and detail the elevations and sections of the scaffold. It should be kept at the workplace if reasonably practicable, or be readily accessible near the scaffold should it be required. The scaffolding plan should address:
- Basis of design
- Type of scaffold
- Foundations including ground conditions

7.2 Inspection and maintenance

A person with management or control of a scaffold at a workplace has a responsibility to ensure a scaffold is inspected and maintained so it is safe to use. This includes inspections at hand-over and post-handover and after scaffold repairs, modifications or additions. For a registered plant like prefabricated scaffolding, a record of all commissioning and decommissioning, inspection, maintenance, alterations and dismantling must be kept.

8. PROCEDURE FOR ERECTING AND DISMANTLING OF SCAFFOLDING

The sequence of work should be planned and followed for each type of scaffold to be constructed. The sequence of work should include consideration of the following unless you have developed an alternative process that provides an equivalent or higher level of work health and safety. Erecting a scaffold safely:

- Erecting a scaffold safely will include preparing the foundations for the scaffold, installing sole boards and base plates where required, and erecting the scaffold including for adequate access and work platforms that minimize the risk to those doing the scaffolding work and people who will use the scaffold.
- Foundations: Scaffold foundations should be designed and constructed to carry and distribute the full weight of the scaffold including both dead and live loads.
- Ground conditions, the effects of the weather—particularly wind and rain—and live loads should be considered when designing and preparing the scaffold foundation.

8.1 Sole boards and base plates

Sole boards and base plates should evenly distribute the load from the scaffold to the supporting surface to provide scaffold stability. A sole board distributes the load from a load-bearing member to a supporting surface and is intended for use underneath base plates

Both sole boards and base plates may be required for use on less stable surfaces, for example, soil, gravel, or fill. The size of the sole board will vary depending on the supporting surface. They can be placed under a single standard or multiple standards. Where necessary a competent person should determine the bearing capacity of the ground or other supporting structure.

Sole boards and base plates should be level. Adjustable bases can be used on uneven surfaces for modular scaffold systems to give a level base lift. No part of the base plate or adjustable base should protrude over the side of the sole board to ensure the loads are carried evenly on the sole board. Needles and spurs should be considered where ground conditions are very unstable.

8.2 Scaffold Erection

The following safe work practices should be used when erecting a scaffold:

- Develop and follow a methodical work sequence—e.g. in an SWMS or scaffolding plan.
- Scaffold fittings and other connections should be securely tightened where required. Fittings should be in accordance with the manufacturer's or designer's specifications and the scaffolding plan.
- Scaffolding including all bracing and ties, guy ropes or buttresses should be installed as the scaffold is erected.
- Consider using specifically designed loading platforms or back propping to prevent overloading the building floor or the scaffold. „
- Get a certification from a competent person before erecting scaffold on awnings.
- Check live loads arising from the work of erecting or dismantling the scaffold are within the specification for the final design the number of workers on the scaffold at any one time may need to be limited.
- Work from a full deck of planks whenever possible.
- Do not overload scaffold bays with scaffolding awaiting installation.
- Do not climb on guardrails to gain extra height. „ Do not climb on outside of scaffold.
- Implement measures to control the risk of a fall if the internal gap, the gap between the inner edge of the length of the platform and the face of the building or structure immediately beside the platform.

8.3 Tying and anchoring

Tie methods and spacing should be in accordance with the manufacturer, designer or supplier instructions. Consult the scaffold designer, manufacturer, supplier or an engineer if it is not practical to position the ties in accordance with the instructions.
Control measures for tying scaffold include:

Using more ties if:

- The scaffold is sheeted or netted due to increased wind loadings, it is used as a loading platform for materials or equipment, and lifting appliances or rubbish chutes are attached.
- Regularly inspecting scaffold ties to check they are not modified or altered by unauthorized people e.g. finishing trades who may loosen, relocate or remove ties to gain access to walls and openings.
- Not attaching extra loads to the scaffold e.g. signs and perimeter containment screens, without first consulting a competent person like the scaffold design engineer or the supplier.
- Using cast-in anchors or through bolts that pass through a wall in preference to expansion or chemical anchors for securing scaffold ties because of possible failure due to faulty tensioning or chemical adhesion.
- Deformation-controlled anchors, thread cutting anchors and insert type anchors should not be used.
- All drill-in expansion anchors should be installed using a torque wrench set to the required torque unless the anchor has an in-built torque indicator.

Documented verification should be kept on site stating:

- The anchor setting torque
- Install date
- Location and name of the competent person installing the anchors.
- Ties should not obstruct access along with the working and access platforms.
- Ties should interconnect with both the inner and outer scaffold standards unless otherwise specified by an engineer to increase the rigidity of the scaffold.
- Ties from the scaffold to structure should be designed to be non-pivoting and fully secured to ensure they cannot be loosened.

9. CONCLUSION AND RESULT

A person with management or control of a scaffold at a workplace must prevent unauthorized access to the scaffold while the scaffold is incomplete or unattended. This applies to suspended, cantilevered, spur or hung scaffolds, as well as any scaffold from which a person or thing could fall more than 4 meters.

Entry to scaffold areas should be restricted to those carrying out the scaffolding work while the scaffold is being erected, altered, repaired or dismantled. Control measures, for example, barriers and warning signs, should be used to prevent unauthorized access when the scaffold is left unattended.

Fig. 9: Output results

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