Temporary Works Toolkit

Part 18: Introduction to site hoarding

The Temporary Works Toolkit is a series of articles aimed primarily at assisting the permanent works designer with temporary works issues. Buildability – sometimes referred to now as 'construction method engineering' – is not a new concept and one always recognised as vital to the realisation of one's ideas; it ought to be at the forefront of an engineer's mind.

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Introduction

Site hoarding is a temporary structure erected around the perimeter of construction sites to prevent any unauthorised person gaining access[1]. In this way, site hoardings ensure the health and safety of the general public and enable a site to fulfil its obligations.

Hoarding can be erected using a modular system or be a bespoke installation. It can be made using a wide range of materials, such as steel, timber or plywood, which may be re-useable or disposed of after use. Hoarding can incorporate barriers, gates and viewing windows, and may be used to display warning and information signs.

This article provides an introduction to the design of conventional timber hoardings using plywood sheets.

Regulations

Site hoarding requirements for building construction sites are set out in various regulations and guidelines. In the UK, the Health and Safety at Work etc. Act 1974 (HSWA)[2] stipulates that all employers and the self-employed must take reasonably practical steps to ensure the health and safety of the general public. Section 3 of the HSWA states that the business must be conducted without putting members of the public at risk.

Regulation 18(2) of the Construction (Design and Management) Regulations 2015 (CDM 2015)[3] requires that the perimeter of a construction site either be identified by suitable signs or be fenced off.

Health and Safety Executive publication HSG151 *Protecting the public*[4] advises that a risk assessment should be conducted to decide how the perimeters will be defined, what type of hoarding will be needed to protect the public and where it should be placed. Factors will include: the nature and type of the construction work; how heavily populated the area is; who will need to visit the site during the work; whether the site may attract children; and the site characteristics.

It is a responsibility of the principal contractor to maintain site security. The task of constructing (and designing) the hoarding can be assigned to the client, the principal contractor or a subcontractor, but under CDM 2015, responsibility for protecting the site lies with the principal contractor.

Understanding the structure

Types of hoarding

Hoarding is commonly made of timber, i.e. plywood sheets fixed to timber rails which are attached to softwood posts. However,

Figure 1 Example of conventional post-in-hole hoarding, prior to application of plywood

Figure 2
Example of kentledge hoarding seen from site side

hoarding can also be made of steel panels supported by steel or concrete posts. There are generally two types of foundation used: conventional post-in-hole; and above-ground foundation blocks/kentledge.

Conventional post-in-hole hoarding is very similar to domestic-style fencing (Figure 1). The normal construction method involves posts being placed in pre-excavated holes at suitable centres; while each post is held in position, concrete is placed around it. Typical hole sizes are 300–400mm wide and 800–900mm deep.

A bolted foundation has posts bolted to the base. Care is necessary in the selection of corrosion-resistant bolt assemblies to ensure the design service life is achieved.

A post-in-kentledge foundation has a post that is attached to a block which is placed above ground (Figure 2). The blocks are verified for sliding and overturning against the prevailing site conditions.

Mechanics

Site hoardings are frequently substantial structures. Generally, they are 2.4m in height, although they can be over 3m. Hoardings are designed to remain structurally robust for the duration of the works. Wind actions and a notional load are the key loads for the hoarding to resist, as stipulated by Temporary Works Forum (TWf) guidance[1] (Figure 3). Vertical posts act as cantilevers from the ground or foundation. The foundation blocks resist lateral forces through their self-weight and by friction to prevent sliding.

Wind load varies along the length of the hoarding and increases significantly near corners and free ends, as described in BS EN 1991-1-4:2005 (Eurocode 1)[5]. The location of hoarding will also affect the flow of wind around it. For example, the wind on a freestanding hoarding will pass over it and create both pressure and suction forces on the hoarding, whereas when hoarding is erected in front of a large building, the wind is effectively stalled by the building. In the latter case, the wind will cause either pressure or suction depending on the direction of the wind. In all cases, the wind will accelerate near the edges of hoardings and buildings.

Notional loading due to a crowd can be significant. Therefore, if the hoarding is located in a retail area where foot traffic is onerous, then crowd loading should be considered.

Design guidance

The TWf has published *Hoardings – A guide to good practice*[1] to provide assistance in the design of timber hoardings in the temporary works industry.

There are several initial considerations when tackling the design of site hoardings that should be clearly outlined in a client's design brief. The engineer must know the precise site location, the expected duration of use, the required height, kentledge requirements, possibly ground conditions, and spatial constraints if they are applicable. All these items determine the design of the hoarding in terms of material, fixings and kentledge size.

Based on the client's requirements, the

Figure 3
Design loads applied to typical hoarding (point of rotation of embedded post as per TWf guide[1])

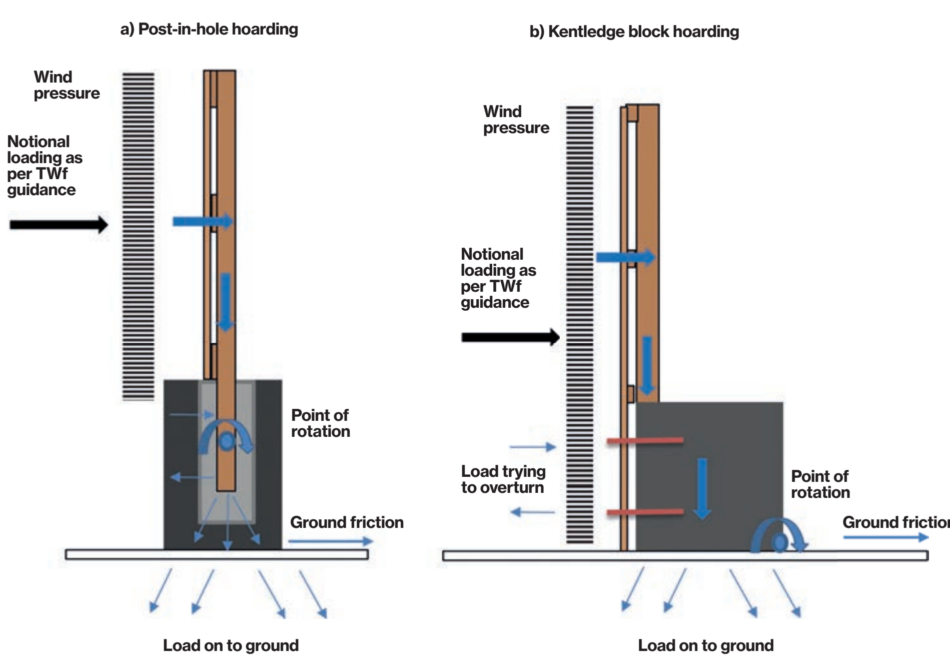

TABLE 1: LOAD COMBINATION FACTORS FOR WIND LOAD AND NOTIONAL LOADS FROM PUBLIC SIDE AND SITE SIDE[1]

Direction		From public side			From site side	
	Load case	Maximum wind	Minimum lateral load	Crowd	Maximum wind	Minimum lateral load
No crowd	LC9	1.0	0.7	N/A		
	LC10	0.5	1.0	N/A		
	LC11				1.0	0.7
	LC12				0.5	1.0
With crowd	LC13	1.0	–	0.7		
	LC14	0.5	–	1.0		
	LC15				1.0	0.7
	LC16				0.5	1.0

Notes
1) Partial safety factor for variable actions, not included – see Section 4.6.3 of TWf guide[1]
2) Where accidental load is a considered combination of load, refer to BS EN 1990
3) Load combinations from passing trains need separate consideration

design loads applied to the hoarding must be determined. For a typical hoarding, the TWf guide stipulates that the hoarding must be able to resist wind loads (based on site location) and, in addition, a line load of 0.74kN/m at a height of 1.2m. The wind forces are calculated using BS EN 1991-1-4:2005[5].

One key issue to highlight in the derivation of the wind forces is the use of the probability factor, c_{prob}. For general cases, c_{prob} is equal to 1.0 (which is equivalent to a mean return period of 50 years)[6]. However, the TWf guide[1] specifies that a factor of 0.83 may be applicable for hoardings, as there is a smaller chance of them being exposed to peak wind. This is applicable for hoardings with a design life of up to two years, but can be increased to 1.0 for any intended duration longer than this.

Another key issue is the net pressure coefficients for the design wind pressure. A hoarding is a freestanding structure and cl. 7.4.1 of BS EN 1991-1-4:2005[5] provides the necessary guidance to determine the variation of net pressure coefficients along the length of the hoarding. The coefficients are dependent on the ratio of the effective length of the hoarding over its length, and whether it has return or no return corners. Wind pressure on Zone B is used to design the hoarding for the general case, while Zone A is used for the design of the fixings, as stipulated by the TWf guide[1].

In areas of buildings packed close together, the wind force at the hoarding level will be very small in comparison with the wind passing above it – this has the effect of applying negative wind pressure to hoardings. Cl. 4.3.5 of BS EN 1991-1-4 2005[5] stipulates that the designer can take this effect into account, by elevating the height of the wind force by a distance, h_{dis}. In the case of hoardings, it is important for the designer to note the complex nature of the wind forces acting on a hoarding, in the context of the surrounding buildings and potential obstacles for wind at the site location.

"THE PLYWOOD SPANS BETWEEN THE RAILS, AND THE DESIGN BENDING MOMENT AND SHEAR FORCE ARE CALCULATED BASED ON THE WIND AND NOTIONAL FORCES"

As in the Eurocodes, partial safety factors are applied to the design pressure. Since both the wind loads and the notional loads are considered as variable actions, a factor of 1.5 is to be utilised. Since both loads are applied simultaneously, the Eurocodes provide reduction factors to account for this. These are summarised in Table 2 of the TWf guide[1] (reproduced here as Table 1).

In the element design of a timber hoarding, the first step is to determine the adequacy of the plywood material. The plywood spans between the rails, and the design bending moment and shear force are calculated based on the wind and notional forces. In addition, the TWf guide[1] recommends a panel robustness check of 1.5kN/m² on the face material only to ensure strength of the material; however, this is not to be applied in conjunction with the wind and notional loads. The Concrete Society's *Formwork guide*[7] provides permissible resistances of plywood sheet material; therefore, the plywood can be verified against serviceability limit state (SLS) loading. These permissible resistances of plywood sheets are derived from BS 5268-2[8].

Timber rails are commonly used in industry, spanning between the posts, and are subjected to an equivalent line load to be resisted in bending and shear. Timber resistances can be calculated using the equations provided in BS EN 1995-1-1:2004 (Eurocode 5)[9]. On site, a timber grade of C16 is common, but C24 grade can be selected.

Timber posts are designed in a similar way to the rails by calculating the design moment and shear force and verifying these against the timber resistances. It is important to note that a post may cantilever from its base, as in the case of an embedded post hoarding; however, for a kentledge block hoarding, the post bends about the top of the kentledge block or top restraint/anchor point dependent on wind direction.

The adequacy in overturning of the hoarding structure is critical and its mechanism for resistance to overturning is determined by its ballast provisions. For the overturning verification, the factor of safety against overturning should be greater than 1.2[1]. Kentledge blocks also require verification against sliding based solely on their frictional resistance, with the TWf guide stipulating a minimum factor of safety against sliding of 2[1].

In the case of embedded posts, the verification is dependent on the ground conditions and how much passive resistance can be generated behind the concrete foundation. The lever arm of the post is also increased as the fulcrum point is located inside the concrete foundation. The method recommended by the TWf is based on a method initiated for the design of lamp posts. In designs, 50mm cover of the timber post to the bottom of the foundation is encouraged, to prevent any potential rotting of the post due to water ingress.

Finally, the timber fixings of the hoarding require verification, and the Institution of Structural Engineers (IStructE) *Manual for the design of timber building structures*[10] provides guidance on the resistances of different timber nails and screws depending on their diameter, length, thickness of timber member, etc. In the case of hoardings, fixings must be designed for the wind case in Zone A, and not Zone B. The timber screws fix the plywood face material to the rails, and in the condition where the wind load blows in from the site side, the screws will be subject to a pull-out force. In addition, for the case of the ballast box hoarding where the diagonal member is secured to a back post, lateral screws are also required. Therefore, the IStructE manual also provides resistances for screws being laterally loaded.

Access gates are a common feature of all construction sites. In some instances, clients request a cover to be applied to the gate. Since the gate now attracts wind load, a verification of the kentledge requirements is needed to determine its resistance to overturning. Gates typically consist of steel hollow sections and the edge posts are welded to a base plate. Therefore, once the pertinent wind loads and notional loads have been determined, one can calculate the amount of kentledge to be provided on the base plate. An additional check on its capacity to slide is also important (through friction); however, on some sites where gates are placed on concrete slabs, one can anchor the baseplate to the slab with chemical fixings.

Conclusions

In conclusion, site location, expected design life and existing site conditions are all important considerations in the design of hoardings, and guidance is provided to undertake structural verifications. Hoardings should not to be overlooked as an engineering structure, as their design serves to ensure the health and safety of the general public and passers-by. Well-designed hoardings also make the site less intrusive and more aesthetically pleasing.

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