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Tying Construction Hoists and Mast Climbing Work Platforms to Supporting Structures

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Tying Construction Hoists and Mast Climbing Work Platforms to Supporting Structures

CPA Good Practice Guide

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Foreword

The construction industry relies on the use of construction hoists to move materials and people between levels on site. Hoists are an essential part of the construction process and can help ensure that the vertical transportation of both materials and people can be carried out efficiently and safely.

Hoists rely on both adequate ground bearing capacity to resist the loads imposed by the hoist base and support from an adjacent structure to prevent overturning. If either of these are inadequate there is a strong likelihood of the hoist collapsing, which provides the potential for death and serious injury to occur and indeed tragically, site workers have been killed in hoist accidents in the past. In addition to the terrible cost in human suffering, accidents have a financial cost. There is a very strong business case for improving safety performance.

The law relating to hoists is clear. There are requirements to ensure that hoists are installed safely to ensure they do not present a risk to users or others in the vicinity. The purpose of this guidance is to help those involved with design and installation of hoist bases and ties to achieve a better awareness of the processes involved and the good practice required to ensure that these activities are carried out effectively.

This guidance has been prepared to provide clarity about the practical elements of hoist base and tie design, and installation. The guidance is simple but comprehensive and easy to adopt. It represents good practice for hoists used in the construction industry and is equally applicable to all construction hoist installations across all industry sectors.

I thank those who have been involved in its preparation and commend the guidance to anyone who owns, supplies or controls the operation of construction hoists. Please read the publication and turn the advice into action.

Kevin Minton

Chief Executive
Construction Plant-hire Association

1.0 Introduction to Hoist Bases and Ties

1.1 *General*

All construction hoists and mast climbing work platforms (MCWPs) rely on their bases and ties for stability. This applies equally to all types and sizes of machine - passenger/goods, goods only, transport platforms and MCWPs - from the smallest to the largest.

In this document "hoist" is used as the generic term for construction hoists, transport platforms and mast climbing work platforms (MCWPs).

Recent changes to standards for both hoists and the construction fixings used to attach ties to supporting structures have resulted in confusion in the calculation of tie loads, the design of ties and the selection of fixings to attach those ties to structures. The increasing emphasis on the management of temporary works on construction projects requires that the design of hoist bases, ties and their fixings are recorded and subjected to checking.

A lack of understanding of the calculation of tie forces frequently results in excessive safety factors being applied, resulting in uneconomic tie designs requiring many fixings to attach them to the supporting structure. This has the effect of increasing costs and the difficulty of installing many fixings in one location, with the associated work at height issues.

Unfamiliarity with hoist tie and base design can provide difficulties for those carrying out temporary works checks, leading to misunderstandings and delays to programme. Hoist tie and base design should always be carried out by those with the necessary skills, knowledge, training and experience to undertake this work competently.

The aim of this document is to provide clear guidance on tie and base design, the selection and installation of fixings, and the presentation of temporary works information in a standard format.

Whilst this document is aimed specifically at tying construction hoists of all sizes to structures, the principles may be applied to Mast Climbing Work Platforms (MCWPs) and an example of an MCWP tie calculation is given in **Annex H.**

NOTE: *The examples used in this document reflect several different types and sizes of hoist and do not necessarily apply to all hoists*

1.2 *Hoist types and the forces acting on them*

Construction hoists, which may be for carrying both passengers and goods, transport platforms and mast climbing work platforms (MCWPs) are available in a large range of sizes as shown in **Table 1**.

Hoist	Transport Platform	Mast Climbing Work Platform
Usually with a single mast, up which the hoist carriage drives. Capacities range from 200kg for small goods only hoists to 3,200kg for large passenger-goods hoists. Payload is carried at relatively high speeds of between 24m/minute to 100m/minute	Single and twin masts with a platform fitted with a falling object protection guard. Can carry up to 7 people. The maximum speed is limited to not exceed 12m/min.	Available in both single and twin mast configurations with a long slender deck, up to 36m long on twin mast units. The deck is not enclosed and is situated close to the building so speeds are limited to not exceed 12m/minute.

Table 1 – Machine Types

As all hoists are modular and assembled from various components in various configurations it is essential that the manufacturer's instructions for the specific make, model and configuration of hoist are followed.

All hoists require a base or foundation which is capable of safely taking the loads imposed on it by the machine. The majority also require support from an adjacent structure, such as a building, to remain stable.

Figures 1, **2**, **3** and **4** show the forces that act on a typical passenger/goods hoist, goods only hoist, twin mast transport platform and twin mast MCWP. These are:

- The weight of the hoist cage, drive mechanism and mast;
- The weight of the load in the hoist cage;
- Wind blowing on the hoist cage and mast from any direction
- A vertical upwards force due to the cage striking the buffers on the base;

The first two produce two effects, firstly a vertical load which is applied to the hoist base and secondly an out of balance or turning effect which tries to overturn the hoist assembly. This is known as an overturning moment. The last effect, the wind, creates another overturning moment which may be added to or subtracted from the overturning moment due to the weight of hoist and load, depending on the direction of the wind.

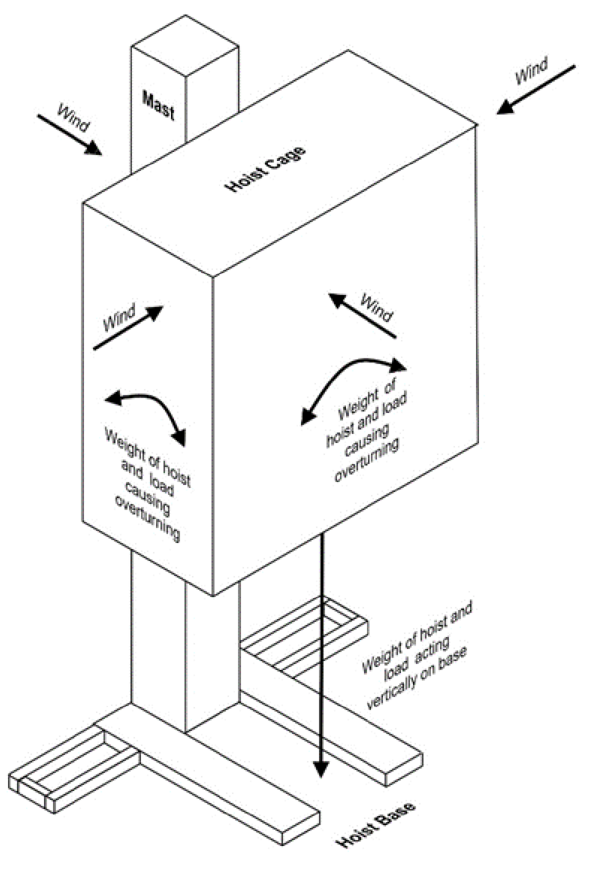


Figure 1 – Forces on A Typical Passenger/Goods Hoist

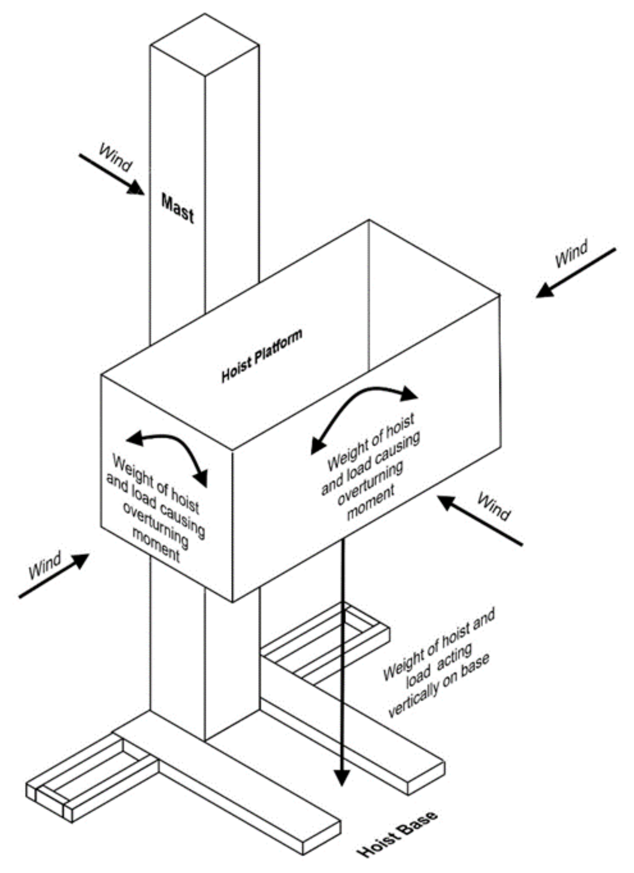


Figure 2 – Forces on A Typical Goods Only Hoist

1.3 *The hoist base*

The ground on which the hoist base is placed must be capable of supporting the hoist base without collapse or deflecting. On large hoists this may require installation of a concrete foundation to support the hoist base, whilst for a small hoist spreader plates to reduce the pressure on the ground may be sufficient. The base loads provided by the manufacturer should be used in assessing the adequacy of the ground to bear the loads imposed on it by the hoist. The assessment of ground bearing capacity is quite complex and the services of ~~an~~ engineer competent to assess the ground or supporting structure-should be sought. Most construction sites will have obtained a site investigation of the ground conditions which may be helpful in assessing the ground on which a hoist base is placed. The design of hoist bases is covered in Section **4.5** of this document.

Detailed guidance on ground conditions is given in the Plant Safety Group Publication *Ground Conditions for Construction Plant - Good Practice Guide.* Strategic Forum for Construction - Plant Safety Group (free download from www.cpa.uk.net)

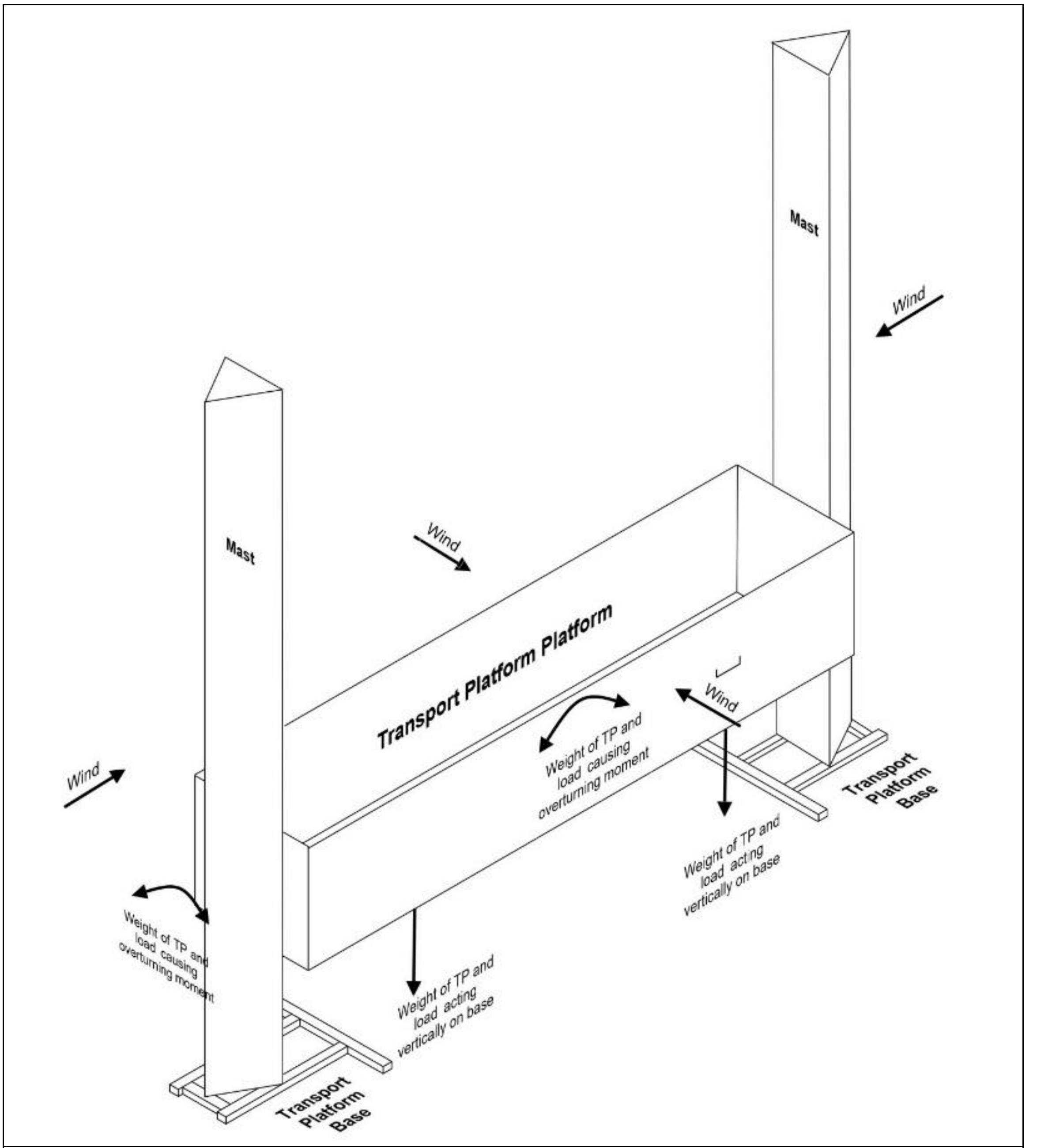


Figure 3 – Forces on A Typical Twin Mast Transport Platform

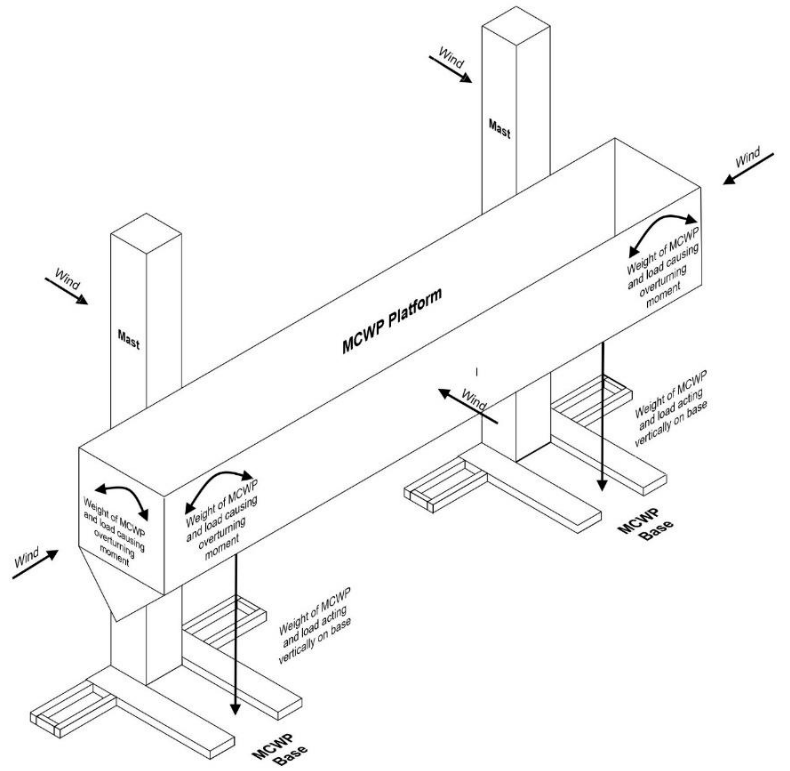


Figure 4 – Forces on A Typical Twin Mast MCWP

1.4 *Hoist ties*

Most hoists can only move a small distance up the mast before they become unstable and at risk of overturning. The manufacturer will specify in their instruction manual what this maximum freestanding height is. At this point the first supporting tie to the structure must be installed before additional mast sections are installed and the hoist cage platform is raised further up the mast. The design of ties is covered in Section **4.6** of this document with example calculations given in **Annex 1**.

Even with ties in place there is a maximum distance the hoist cage or platform can travel above the top tie before there is a risk of overloading the mast and ties with the consequent risk of collapse. This distance, often called “oversail” will be given in the manufacturer’s instructions for the particular model and configuration of hoist. An example for a 500kg goods only hoist is shown in **Table 2.**

Distance from base to first mast tie	Not exceeding 4 metres
Vertical distance between adjacent mast ties	Not exceeding 6 metres
Maximum mast height above the top tie when the hoist is in operation	3 metres
Maximum mast height above the top tie when the hoist is being erected.	5.5 metres

Table 2 – Maximum Tie Distances and Mast Oversail for a 500kg Goods Hoist

Hoist ties are typically steel tubes arranged in a triangular form to provide rigidity (see **Figure 5**). One end of a tube is attached to the hoist mast either directly or via a frame (see **Figure 6**). The other end of the tube is attached to the supporting structure which may include:

- A concrete slab (see **Figures 7 & 8**)

- Steelwork (see **Figure 9**)
- Masonry (see **Figure 10**)
- Scaffolding (see **Figure 11**).

Each of these presents particular challenges which are detailed in Section **5.0** of the guidance document

Sometimes standard ties cannot be use and special ties have to be designed. An example is shown in **Figure 12**.

The design of the fixing of ties to concrete slabs and masonry, including brickwork can be tricky and if a standard solution using a fixing manufacturer's software does not work the fixing manufacturer should be contacted for application specific advice. Alternatively, another fixing method should be considered.

1.5 *Factors of Safety*

It would obviously be unacceptable for a structure to fail as soon as it experienced the full load it was designed to carry. In order to prevent failure, the structure needs to be designed so that it has some extra load carrying capacity – in other words a *"margin of safety"***.** It should be noted that the presence of a safety margin does not mean that allowable (rated) loads can be exceeded - it is not spare capacity or overdesign that is available for intentional use.

Information about, for example, the size of the load, the forces involved, the strength of the material, the ground bearing capacity, etc may be provided in one of two ways:

- The characteristic load which is the load (force) applied by a hoist to a fixing, base material or structure

  NOTE: *This is sometimes known as an "unfactored load", "applied load" or "working load".*

- The design load which is the load derived from the characteristic load by application of a partial safety factor for the load

  NOTE*: This is sometimes known as a "factored load".*

It is essential that the user of this information clearly understands which approach has been adopted. If they have any reservations about the accuracy of the information or what factors (if any) have been applied they should seek clarification from the supplier or another authoritative source before proceeding with the design.

Therefore, when obtaining the loads and forces imposed on the supporting structure by a hoist it is vital to establish if these are factored or unfactored. If this is not established, additional factors may be applied to an already factored load, resulting in double application of safety factors and unnecessarily costly base support and tie fixings.
On the other hand, if safety factors are not applied to unfactored loads during base and tie designs, this may result in ground bearing failure and/or tie failure. It is essential that the designer is made aware of the status of loads and forces i.e. are they factored or unfactored.

Factored loads or capacities include a safety factor that the supplier has usually taken from a national or international code. It is also important for the designer to be sure that a factor already applied is suitable for the situation being assessed.

1.5.1 Global Safety Factors

Traditionally, loads used in the design process have been increased by a single global factor, taken from a design code or standard, which takes provides an adequate margin of safety.

1.5.2 Partial Safety Factors

A new approach introduced by the Eurocodes is the use of partial factors where loads are split into
three categories: permanent, variable and accidental and different factors are applied to each category. The magnitude of each factor reflects the probability of an unfavourable deviation from the characteristic value, inaccuracies in the calculation method and the consequences of failure. The outcome is a more accurate prediction of the performance of a structure (including ground) than the application of a single factor of safety.

More information on partial factors is given in **4.4**

1.6 *Selection of Fixings*

All hoist ties require fixing to the supporting structure and the various methods for doing this are detailed in **5.0.**

A significant number of hoist ties are attached using construction fixings such as mechanical and chemical anchors which are selected using software provided by the fixing manufacturer. When using such software, it is important to ensure that the unfactored input loads have been multiplied by the appropriate partial factor.

1.7 *Change Management*

It is essential that any changes to the design of hoist bases and ties are managed and communicated effectively

Many incidents occur because site conditions have changed, or the equipment or materials provided are not quite as expected. Immediately before a job starts the specified method should be checked to see if any aspect of the job has changed and the effect that these changes could have on the safety of the operation.

If any significant modifications to the plan are required these will need to be considered by the base and tie designer. The person responsible for the activity should amend the Method Statement and sign off any significant changes. Any changes should be explained to all those involved. (See also **5.1**)

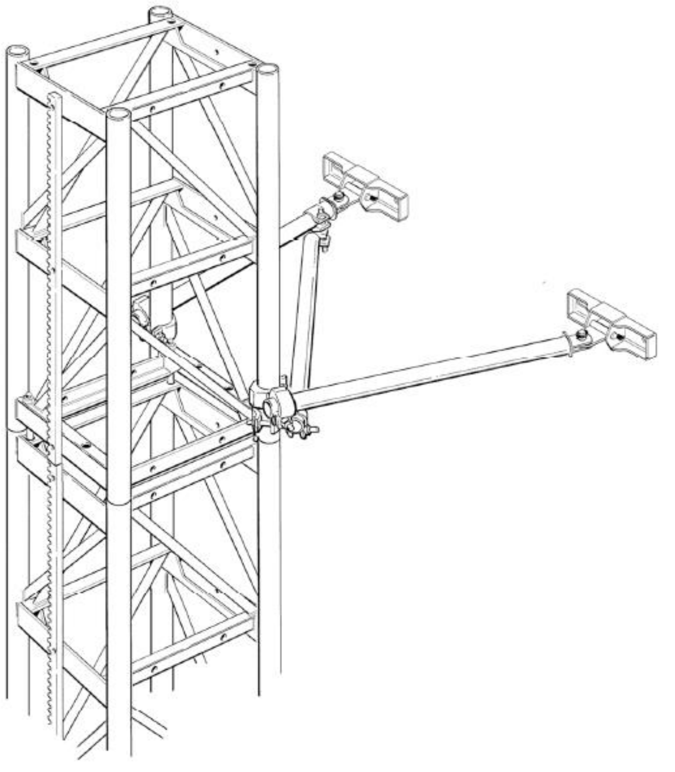


Figure 5 – Typical Three Tube Tie with Frame

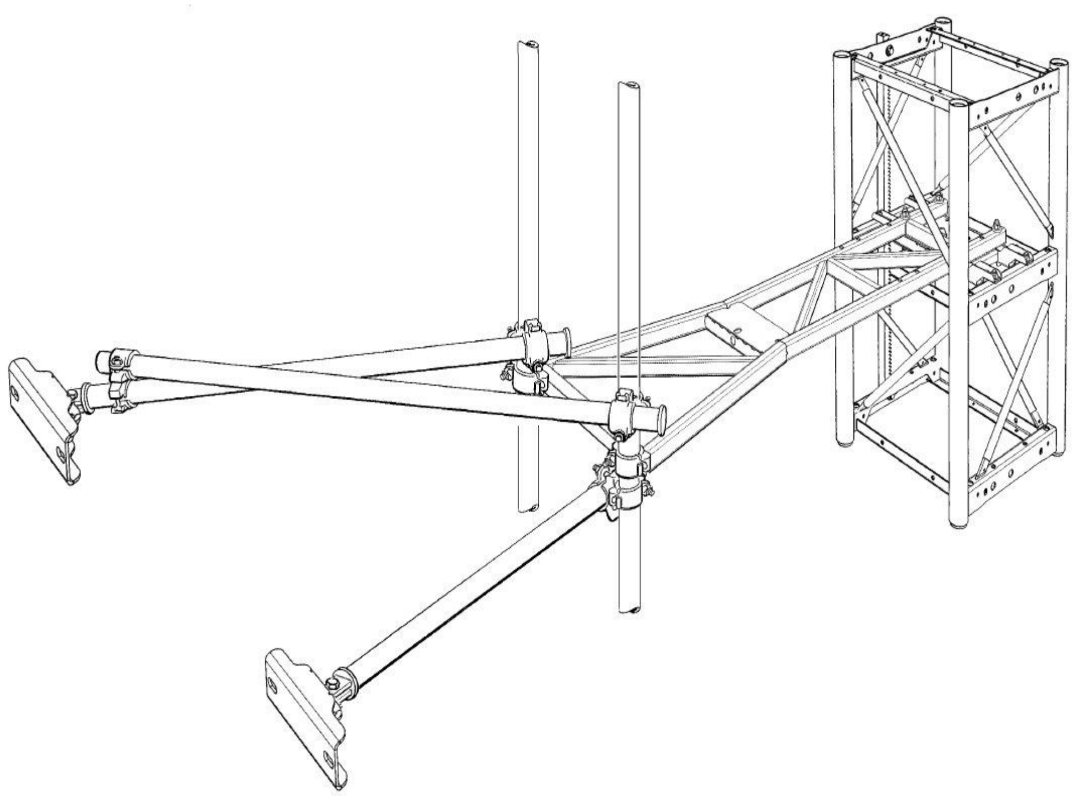


Figure 6 – Typical Three Tube Tie with Frame

Figure 7 – Tie to edge of Post Tensioned Concrete Slab

Figure 8 – Tie to Underside of Concrete Slab

Figure 9 – Tie to Steel Structure

Figure 10 – Tie to Brickwork

Figure 11 – Tie to Scaffolding

Figure 12 – Bespoke Tie

2.0 Definitions

action

load (force) applied by a hoist to a fixing, base material or structure

NOTE: *action is the term used in the Eurocodes for a load.*

appointed person: supplier

competent person appointed by the hoist supplier, who is responsible for supplying the hoist

appointed person: user

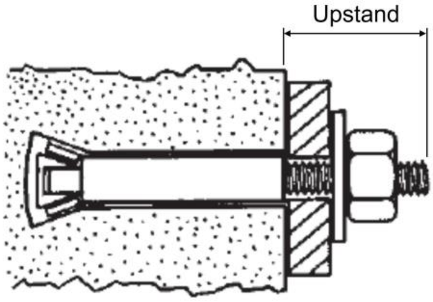
competent person appointed by the management of the user organization, who is responsible for liaising with the appointed person (supplier) and the safe use of the hoist

base material

material of a structure into which an anchor is installed

bolt/stud upstand

portion of stud thread between top surface of base material and the free end of the stud



competent person

person with the necessary skills and sufficient knowledge of the specific tasks to be undertaken and the risks which the work will entail, and with sufficient experience and ability to enable them to carry out their duties in relation to the project, to recognize their limitations, and to take appropriate action in order to prevent harm to those carrying out construction work, or those affected by the work

hoist

guided temporary lifting machine serving landing levels on sites of engineering and construction with a platform, cage or other load carrying device

hoist hirer

organisation hiring the hoist from the supplier

NOTE*: Often referred to as hoist user*

hoist supplier

organisation hiring the hoist to the hoist hirer

NOTE: *This may also be the hoist owner*

limit states

ultimate limit state (ULS)

the limit state at which a structure must not collapse when subjected to the peak design load for which it was designed.

serviceability limit state (SLS)

the limit state at which a structure functions effectively during normal use without exceeding limiting deflections or other limiting criteria

loads

characteristic load

load (force) applied by a hoist to a fixing, base material or structure

NOTE: *This is sometimes known as an "unfactored load", "applied load" or "working load".*

design load

load derived from the characteristic load by application of a partial safety factor for the load

NOTE*: This is sometimes known as a "factored load".*

mast climbing work platform (MCWP)

powered access system that provides moveable access for personnel working at height on structures, consisting of the following four assemblies or groups of parts:

a) at least one mast which is climbed by and which supports the work platform;

b) a work platform capable of supporting persons, equipment, tools and materials, etc., to a predetermined safe working load;

c) a base frame or a wheeled chassis supporting the mast structure; and

NOTE: *The chassis or base frame can provide stability for MCWPs up to a predetermined free-standing height, above which the mast(s) is tied to the building or other structure.*

d) mast tie assemblies

NOTE: *Mast tie assemblies are not necessarily required with mobile MCWPs.*

resistance

capacity of an anchorage to resist actions

allowable resistance

maximum working load derived from tests carried out on site when the proposed anchor is to be used in a base material approved by the manufacturer but for which there is no recommended resistance (load)

characteristic resistance

resistance derived as the 5% fractile of the mean ultimate resistance, determined from tests or by empirical calculation depending on mode of failure

NOTE*: This is based upon a 90% probability (confidence level) that 95% of anchors will exceed the characteristic resistance.*

design resistance

resistance derived from the characteristic resistance by the application of partial safety factors

mean ultimate resistance

average failure load determined in a series of tests

recommended resistance

maximum working load recommended by a manufacturer

NOTE: *This is sometimes referred to as "recommended load" or "permissible load". It is associated with the global safety factor approach, where it is derived from the characteristic action divided by a global safety factor.*

***temporary works co-ordinator* (TWC)**

competent person with responsibility for the co-ordination of all activities related to the temporary works

NOTE: *The appointment and responsibilities of a TWC is described in Clause **11** of BS 5975:2019*

***temporary works designer* (TWD)**

competent person with responsibility for the design of temporary works.

NOTE: *The appointment and responsibilities of a TWD is described in Clause **8.4** of BS 5975:2019*

***temporary works design checker* (TWDC)**

competent person who evaluates the design to determine whether it conforms with the design brief and can be expected to provide a safe engineered solution

***temporary works supervisor* (TWS)**

competent person who is responsible to and assists the temporary works co-ordinator

NOTE: *The appointment and responsibilities of a TWS is described in Clause **12** of BS 5975:2019*

transport platform

temporarily-installed, guided powered platform with rack and pinion drive, which have an open platform and hold-to-run controls operated by authorized, trained operators on the platform, used for transporting authorised passengers and materials vertically, at limited speed, with a minimum safety offset distance and serving fixed levels on a building or structure for construction related activities including renovation and maintenance.

3.0 Responsibilities

Where construction hoists are installed on site a number of parties are involved, all of whom have specific responsibilities. This section identifies those parties and sets out their individual responsibilities.

3.1 *CDM responsibilities*

The Construction (Design and Management) Regulations 2015 (CDM 2015) cover the management of health, safety and welfare when carrying out construction projects. CDM sets out the responsibilities of all parties involved in the construction process. The roles with relevance to the provision of hoists and the design of bases and ties are as follows:

3.1.1 OEM Designer

The Original Equipment Manufacturer's designer is responsible for the design of the construction equipment together with any OEM bracketry and equipment used to support, anchor or tie the hoist to the permanent or temporary works. This person represents the hoist manufacturer and usually provides bespoke calculations for specific design cases. The OEM rarely releases design information or calculations that are commercially sensitive, as the machinery is supplied under the Machinery Directive and is CE marked, so is safe to use within the requirements laid out in the operations manual. The designer does, however, have a duty to supply all the necessary information (base and tie loads etc.) to enable the user to install the hoist safely.

3.1.2 Principal Contractor

It is the Principal Contractor's (PC)/Client's responsibility to ensure that capacity of the ground is assessed for adequacy of the applied loads. The hoist manufacturer/supplier is not responsible for making this assessment as they are not in possession of the necessary information relating to the site, nor do they have the relevant expertise to make an adequate assessment. The hoist's location is selected by the PC. The PC should also inform the hoist supplier of the location and nature of any buried services in the vicinity of the hoist and ensure that they will not be damaged due to the position of the hoist.

Although the design of the tie and any anchor bolts is generally carried out by the hoist supplier, the Client/Principal Contractor must assess whether the permanent or temporary works can accept this load without there being any deterioration to the structure. This may be a complex interface, for example anchor plates fixed onto a masonry wall. In this case the anchor plates will be assessed by the hoist/anchor plate manufacturer, the tie bolts will be designed by the hoist supplier, but the capacity of the wall will be assessed by the Principal Contractor/Client. Depending on the type of anchor used this may then be verified in practice by tests on the anchors (see **5.9**).

3.1.3 Designer (Hoist supplier)

The hoist supplier's designer is required to provide information to the hoist hirer, in particular their Temporary Works Co-ordinator (TWC), to allow the hirer to use the hoist safely. For example, the hoist supplier should:

- Select the correct assembly of parts to configure the hoist to meet the OEM designer's requirements;
- Provide information to the TWC to allow the hoist's tie load's effect on the supporting structure to be considered;
- Provide information to the TWC to allow the hoist's base load's effect on the supporting foundation to be considered;
- Outline any relevant residual risks that will affect the stability or safe use of the hoist in the particular environment for its proposed application.

The hoist supplier's designer is not usually qualified to undertake the assessment of ground conditions and building strength. Consequently, they should supply the loads at the interface with the foundation/tie bracket/wall. Under Regulation 8 of CDM 2015, designers must only work within their capability and can only be appointed to do what they are competent to do.

3.1.4 Temporary Works Co-ordinator (TWC)

The TWC employed by the hiring organisation (hirer) who is probably, but may not be, the Principal Contractor, is required to review the information received from the hoist supplier. The TWC should ensure that an adequate assessment of the building/foundation which supports the hoist (including the ties) is capable of doing so without collapsing or deteriorating over time. The TWC need not undertake the checks themselves but must ensure that a competent person undertakes a suitable assessment.

3.1.5 Temporary Works Designer (TWD) and Temporary Works Design Checker (TWDC)

TWDs should liaise with the PC's TWC, or assistant TWC where appropriate, to agree the category of temporary works design check.

Designers and TWDCs should confirm that the design details and outline methodologies are accurately translated into the design output, and that the design conforms to appropriate engineering principles. This includes any assumed construction methods, sequences, temporary works requirements, and loads to be either imposed on or supported by the permanent works. Where the method of construction is different from that envisaged by the designer of the permanent works, there should be an assessment of the permanent works.

Designers and TWDCs should confirm that the design output adequately describes the design in a design check certificate (see **3.3**).

3.1.6 Principal Designer

The Principal Designer employed by the Client may need to advise the TWC about the effect of the applied hoist loads on the permanent works, whether this is an existing building or a new structure. They will need to take into account any temporary conditions such as alterations, openings or early concrete age. They should also advise the TWC/hoist supplier of any relevant information that will assist with the siting, installation, use, maintenance and dismantling of the hoist. The Principal Designer is required to cooperate and provide sufficient information to allow the TWC to confirm the hoist can be tied and supported as proposed by the Hoist Supplier (Regulations 8, 9 and 10 apply).

NOTE: The Principal Designer may delegate the assessment to the Principal Contractor's temporary works designer (TWD).

3.2 *Hoist Supplier and User*

The user organization, which is the body that procures the hoist for use on the site, has primary responsibility for the management of the erection, modification and dismantling, and for the thorough examination, operation and maintenance, of the hoist.

NOTE: *This includes the provision of safe access for personnel carrying out installation, maintenance and dismantling of the hoist.*

The safe erection, modification and dismantling of hoists should be planned and carried out in co-ordination with a specialist hoist supplier, using their knowledge and experience, alongside the user organization's knowledge of the site and intended use of the hoist.

It is essential that the hoist supplier and the hoist user (hirer) liaise effectively to ensure that the correct hoist is selected and that it is installed, used, maintained and dismantled safely. Both parties should appoint an "appointed person" to take responsibility for the hoist installation and use. The responsibilities of the appointed person (supplier) and appointed person (user) are set out in Clause **6** of BS 7212:2016.

3.3 *Design Checking*

The checking of hoist tie and base designs should be carried out in accordance with Clause **13.7** of BS 5975:2019. Design checks should be undertaken in accordance with one of the categories given in Table 2 of BS 5975, which is reproduced below. The categories relate to the level of independence of the design check and are not related to the classification of risk associated with implementation stated in Clause **6.1.3** and listed in Table 1 of BS 5975.

NOTE: *Implementation risk in temporary works is classified as very low, low, medium or high. This is used to establish the management level required, not the design check category.*

The responsibility for ensuring that a design is checked to the appropriate category rests with the Principal Designer, taking account of any hoist user requirements. Where there are split design responsibilities, for example where the hoist supplier designs the ties and the hoist user designs the attachment to the supporting structure, the parties should agree on the category of the checks required and who will carry them out. It is essential that the design checker has the necessary competence to undertake the check, for example the hoist supplier's designer would not have the necessary competence to undertake either the assessment of the supporting structure's ability to absorb the loads imposed by the ties or the checking of that assessment. This equally applies to the assessment of ground below a hoist base.

On completion of the design and design check, a certificate should be issued for all categories, confirming that the design complies with the requirements of the design brief, the standards/technical literature used and the constraints or loading conditions imposed. The certificate should identify the drawings/sketches, specification and any methodology that are part of the design and it should be signed by the designer and design checker. The package of information issued to the TWC should include this certificate.

Category	Scope	Comment	Independence of checker	Checker
0	Restricted to standard solutions only, to ensure the site conditions do not conflict with the scope or limitations of the chosen standard solution. These may include standard trench boxes.	This applies to the use of standard solutions and **not** the original design, which will require both structural calculation and checking to category 1, 2 or 3, as appropriate.	Because this is a site issue, the check may be carried out by another member of the site or design team.	Can be Hoist supplier
1	For simple designs. These may include formwork; falsework (where top restraint is not assumed); needling and propping to brickwork openings in single storey construction.	Such designs would be undertaken using simple methods of analysis and be in accordance with the relevant standards, supplier's technical literature or other reference publications.	The check may be carried out by another member of the design team.	Can be Hoist supplier
2	On more complex or involved designs. Designs for excavations, for foundations, for structural steelwork connections, for reinforced concrete. Designs where stability is obtained by restraint at the top of the temporary works (e.g. top restrained falsework.)	Category 2 checks would include designs where a considerable degree of interpretation of loading or soils' information is required before the design of the foundation or excavation support or slope.	The check should be carried out by an individual not involved in the design and not consulted by the designer.	Must be Hirer or Third Party
3	For complex or innovative designs, which result in complex sequences of moving and/or construction of either the temporary works or permanent works. It also includes basement excavations and tunnels	These designs include unusual designs or where significant departures from standards, novel methods of analysis or considerable exercise of engineering judgement are involved.	The check should be carried out by another organization and should include an overall check to assure co-ordination of the whole design	Must be Hirer or Third Party

Table 3 – Categories of Design Check (derived from BS 5795)

4.0 Base and Tie Loads – Calculation methods, standards and assumptions

4.1 *Introduction*

Hoists, including transport platforms, and Mast Climbing Work Platforms (MCWPs) are only safe to use when they have an adequate foundation and when their stability has been considered in both the in and out of service states. It is essential that attention is given to the design of the foundation and the ties. **Table 4** below highlights the various issues with, and differences between, hoists and MCWPs.

Structural Element	Hoist	Transport Platform	Mast Climbing Work Platform
Machine Description	Usually with a single mast, which the hoist carriage drives up and down. Payload is carried at relatively high speeds of between 24m/minute to 100m/minute	Single and twin masts with a platform fitted with a falling object protection guard. Can carry up to 7 people. The maximum speed is limited to a maximum of 12m/min.	Available in both single and twin mast configurations with a long slender deck, up to 36m long, on twin mast units. The deck is not enclosed and is situated close to the building so speeds are limited to a maximum of 12m/minute.
Base	Machines with a rated capacity of 1000kg and above are, usually bolted down to a concrete slab or steel plate. May have large uplift forces and overturning moments	Machines with a rated capacity of 1000kg and above are usually bolted down to a concrete slab or steel plate. May have large uplift forces and overturning moments	The base is typically free on the ground with only local ground improvement. See **Figure 13**
First tie level	Usually 1.56m to 15m ***NOTE:*** *Temporary ties may be required during erection/dismantle*	Usually 3m to 9m, dependent on mast type ***NOTE:*** *Temporary ties may be required during erection/dismantle*	Usually at around 3m ***NOTE:*** *Temporary ties may be required during erection/dismantle*
Ties	Tie forces generated may be high, requiring large cross section tie members and bespoke brackets with high capacity anchors as specified by the hoist manufacturer or tie designer ***NOTE:*** *twin mast machines may have lower tie loads*	Tie forces generated may be high, requiring large cross section tie members and bespoke brackets with high capacity anchors as specified by the hoist manufacturer or tie designer ***NOTE:*** *twin mast machines may have lower tie loads*	Tie forces are generally less than for a hoist of similar capacity, due to the MCWP orientation and proximity to the face of the structure. In certain circumstances it may be possible to tie using standard scaffold components, although may still use a proprietary bracket. See **4.6.1**
Cantilever mast above a tie	This is the amount of free mast above the top tie which may vary from zero to 15m, depending on the hoist type, capacity and manufacturer. The hoist may travel on this mast section.	Limited ability to work above the top tie	Limited ability to work above the top tie

Table 4 – Hoist, Transport Platforms and MCWP Differences

It is very unusual to have hoists, transport platforms and MCWPs installed without a tie. If untied equipment is required, then particular attention must be given to the base, as it is the sole means of providing resistance to overturning.

4.2 *Base and Tie Loads*

The hoist manufacturer should supply the owner of the hoist with loading information as required by the relevant standard, such as Clause **7.1.2.7** of BS EN 12159:2012, *Builders hoists for person and materials with vertically guided cages*. These loads are given for various load cases including:

- When the hoist is freestanding, i.e. during erection / dismantle just prior to the installation of the first tie.
- When the hoist is tied and operational (in service)
- When the hoist is tied and out-of-service with the carriage parked at an agreed location, usually at the ground level.

The loads and forces action on various types of hoist are shown in **1.2**

4.3 *Wind Loads*

BS EN 12159:2012, *Builders hoists for person and materials with vertically guided cages* specifies that out-of-service loads should be calculated using minimum design wind pressures derived from the wind regions set out in the European Storm wind Map in Annex A of EN 12159. This map places southern central England in Region C, the rest of England and Wales in Region D and Scotland and Northern Ireland in Region E, resulting in loads that are significantly higher than continental Europe. The European Storm wind Map covers terrain of all heights whilst **Annex G (TIN 302)** shows a UK specific out-of-service wind region map showing wind regions for land under 200m above sea level which covers the majority of areas of the UK where construction hoists are used. This shows that England and Wales fall into Region C, whilst Scotland and Northern Ireland fall into Region D, resulting in a significant reduction in loads due to out-of-service wind.

Consideration should be given to requesting zone specific wind loads for the hoist location to ensure that the calculated base and tie loads are not unnecessarily conservative.

4.4 *Partial Factors Applied to Unfactored Loads*

When undertaking calculations for the foundations and ties, it is important to apply partial factors to the unfactored working loads supplied by the hoist manufacturer. **Table 5** shows the factors to be used, together with the source reference. Typically, all actions (loads) are considered as variable as there are assumptions made by the hoist manufacturer:

- the hoist is carrying a variable load;
- the load can be placed anywhere in the hoist cage;
- for allowances in the hoist loads e.g. how much load is actually being applied at the landings due to landing self-weight / materials handling.
- the hoist carriage is moving and subject to wind loads,

As such the whole hoist load is considered as a variable action, even though a proportion of the load is comprised of the known self-weight of the hoist. The example calculations make this assumption and a factor of 1.5 is applied to all the actions (loads).

Forces supplied by the hoist manufacturer are generally unfactored, however this is not always the case and should be checked before starting to design the attachment of the hoist to the supporting structure. The presence (or not) of partial safety factors being applied to the loads shall be indicated on the Word hoist tie template (see **Annex E**) (free download from https://www.cpa.uk.net/construction-hoist-interest-group/) .

The forces that are applied to the mast by the hoist carriage and any wind pressures are transferred to the building via system of ties and anchor bracket (see **1.4**). The values of these forces can be calculated, allowing the designer to calculate the tension/compression in connecting members such as tie tubes. Such tubes can be assessed for their structural capacity. This will include buckling loads as tubes are usually slender tension ties /

compression struts. It is not uncommon to have tube forces of 40 to 70kN (unfactored/Serviceability Limit State value).

Limit state	Permanent actions (G_k)	Variable actions (Q_k)	Reference
Equilibrium (EQU)	$\gamma_G = 1.1$ (0.9 when favourable)	$\gamma_Q = 1.1$ (0 when favourable)	NA to BS EN 1990
Strength at ULS	$\gamma_G = 1.35$ (1.0 when favourable)	$\gamma_Q = 1.5$ (0 when favourable)	BS EN 1990 Exp (6.10) & Table A1.2(B)NA to BS EN 1990
Serviceability	$\gamma_G = 1.0$	$\gamma_Q = 1.0$	BS EN 1990 Table A1.4
Accidental	$\gamma_G = 1.0$	$\gamma_Q = 1.0$	BS EN 1990 Exp (6.11a) & Table A1.3 NA to BS EN 1990 Figure 4.1 Partial factors on actions to BS EN 1990

Table 5 – Partial Load Factors

NOTE: *Some fixing manufacturers use a partial safety factor for actions γ = 1.4 which is taken from Clause A.2.2 of BS 8539:2012, Code of practice for the selection and installation of post-installed anchors in concrete and masonry.*

The recommendation of this guidance document is to use a partial factor of γ = 1.5 as this is a commonly used factor in temporary works and most actions (loads) associated with hoists are variable. The exception to this where the actions of the hoist ties and the resistance of the supporting structure are accurately known, in which case the use of γ = 1.4 may be appropriate.

The clamp fitting at the mast/hoist framework must have a sufficient slip resistance for the applied tube load. The addition of extra 'slip' fittings or supplementary couplers is not often practical or desirable. Requirements for supplementary couplers can be found in BS EN 74-1 and NASC TG14 (see **Annex I**), consequently it can prove difficult to tie larger hoists to traditional tube and fitting scaffold or other temporary works. The typical axial load imposed by a large Passenger/Goods hoist is 70kN, whereas the slip resistance of a Class A right angled coupler is 6.1kN and a Class B right angle or swivel coupler is 9.1kN.

When tying a hoist to scaffold is being considered, the practicability of this will depend on size of hoist. It is essential that the hoist supplier is advised of the intention to tie to scaffold by the hirer at the earliest opportunity, so that they can supply the tie forces to the hirer for consideration by the scaffold designer.

4.5 *Base Design.*

Hoists and MCWPs require an adequate foundation. This foundation may not be on original ground, but instead could be, for example: on a new slab, a pavement, a haul road or over a brick arch, steel grillage, scaffold gantry or suspended slab. The assessment of the suitability of the bearing surface can be a complex task, especially where the hoist affects (surcharges) a party-wall or comes under the scrutiny of interested third parties such as Network Rail. The loads provided by the hoist manufacturer are used to assess the adequacy of the supporting medium.

4.5.1 <u>Freestanding height before the first tie is installed</u>

Hoists are particularly vulnerable to overturning just prior to the first tie being installed. One of the cases considered when calculating bearing pressure should therefore be at the maximum freestanding height, but without the tie fitted. The calculation should allow for:

- The erection/dismantle wind speed;
- An allowance for the weight and position of hoist erectors, tools, mast sections, tie tubes;
- In-service rated load and limiting wind speed if the hoist is to be taken into service in the freestanding condition.

NOTE: *the manufacturers should be consulted to ensure that the worst case loads are considered in the design.*

The following operational factors over which the hoist manufacturer has no control must be considered in the design:

- The correct amount of mast to allow the tie to be installed;
- The correct weight of supporting foundation to anchor the hoist down;
- The adequacy of the supporting medium for the applied load;
- The hoist being correctly positioned on the foundation;
- The hoist being correctly anchored to the foundation.

These assumptions need to be communicated to the designer and the erection team so that they work within the design criteria. This is particularly relevant to MCWPs and hoists on narrow mast sections (for example 450mm and less) as these types of mast will usually require a low height tie which may be temporarily installed until a higher tie is installed. MCWPs, for example, are unlikely to have anchors for the ground bearing frame and consequently require the low level tie to prevent them overturning. Where low height ties are required, they must be assessed and re-installed, if required, during the dismantling operation (see **4.4**). Overturning accidents have occurred where this low height tie has been omitted on erection or has not been re-installed before dismantling.

Case Study – MCWP Overturn Due to Uneven Loading

A MCWP with unequal length decks installed on a balcony, was being dismantled and the mast sections placed on the longer left-hand wing as they were removed from the mast. When the last tie was removed the base machine overturned to the left, falling from the balcony to ground level. Sadly, both erectors suffered fatal injuries.

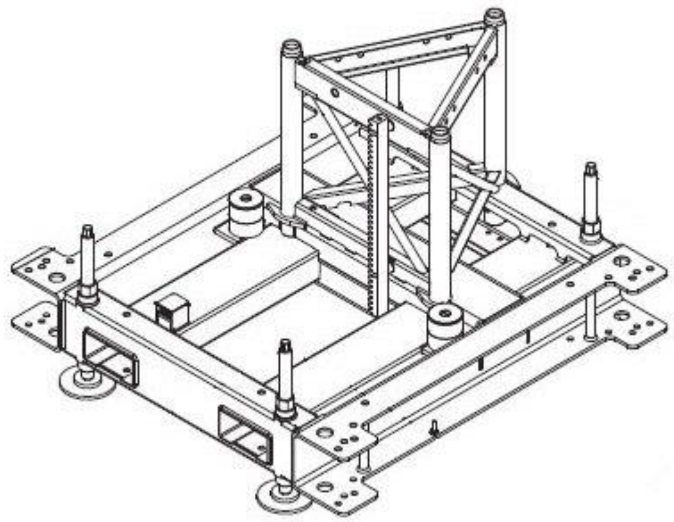


Figure 13 – Typical MCWP Base Frame (without holding down anchors)

4.5.2 Base frame fixings

It is essential that the foundation and tie anchor bolts have adequate strength to keep the hoist attached to the supporting structure (see **4.5** and **5.0**).

Some hoist suppliers will use the manufacturer's own cast-in anchor or foundation frame see (**Figure 14**). Others may use a suitable anchor into concrete. Frames and/or anchors must be adequate for the loads anticipated, as must the base material into which they are fixed. For example, a mass concrete base is unlikely to cope with significant tension generated under the mast of certain large capacity hoists. In certain circumstances a hoist with a large distance to the first tie may generate tensions of 90kN in each of the holding down bolts. A competent engineer should assess the anchors as the following elements are fundamental to the stability of the tie system. The following list is particularly relevant to anchoring the hoist into a hoist foundation slab, a similar list is provided later for hoist ties:

- Anchor base material strength (e.g. concrete grade and actual strength/condition) / setting in frame capacity;
- Capacity of structural steelwork or steel foundation plate;
- Insitu reinforced concrete (RC) or precast;
- Size and proximity of reinforcement which is required to ensure that the concrete does not crack when tension and shear forces are applied to the concrete. In some cases, excessive cover to concrete will be unacceptable where anchors are being used. Where this is critical, surveillance to ensure the correct positioning of reinforcement may be required;

Case Study – Resin Anchor Failure

Some concrete slabs weighing 8 tonnes were being lifted using a 4 leg chain sling attached to lifting eyes screwed into resin fixed inserts. During a trial lift the inserts failed when the load was about 500mm above the ground. The slab fell to the ground, shock loading the crane and causing the chain slings to whip.

The investigation into the failure showed that there was lack of resin bonding the insert to the concrete, which indicates that the hole may not have been cleaned correctly and that at installation of the insert wasn't rotated to allow the resin to mix with the thread of the insert.

- Presence of cast in items and post tensioning tendons – these will require clearance distances and / or the ability to drill an anchor in;

  NOTE: *Particular care is required on refurbishment work as accurate information on the location of such items may not be available*
- Depth of reinforcement;
- Base frame thickness and hole diameter;
- Bolt/stud upstand;
- Slab thickness;
- Edge distances;
- Anchor bolt diameter;
- Anchor spacing;
- Adequacy of the structure/medium beneath the foundation – for example the allowable bearing capacity of the soil beneath the hoist;

  NOTE: *It is the Principle Contractor's (PC) / Client's responsibility to ensure that capacity of the ground is assessed for adequacy of the applied loads. The hoist manufacturer / supplier is not required to make this assessment as they are not in possession of the information related to the site nor do they have the relevant expertise to assess this adequately. The hoist's location is selected by the PC. Likewise, the PC must communicate information regarding any buried services in the vicinity of the hoist and ensure that they will not be damaged due to the position of the hoist.*
- Is there a need for back propping beneath any supporting slabs? Care must be exercised when positioning props. Are they located under the mast and the emergency buffers? Do the props bear onto a foundation of adequate strength?
- Presence of underground services.

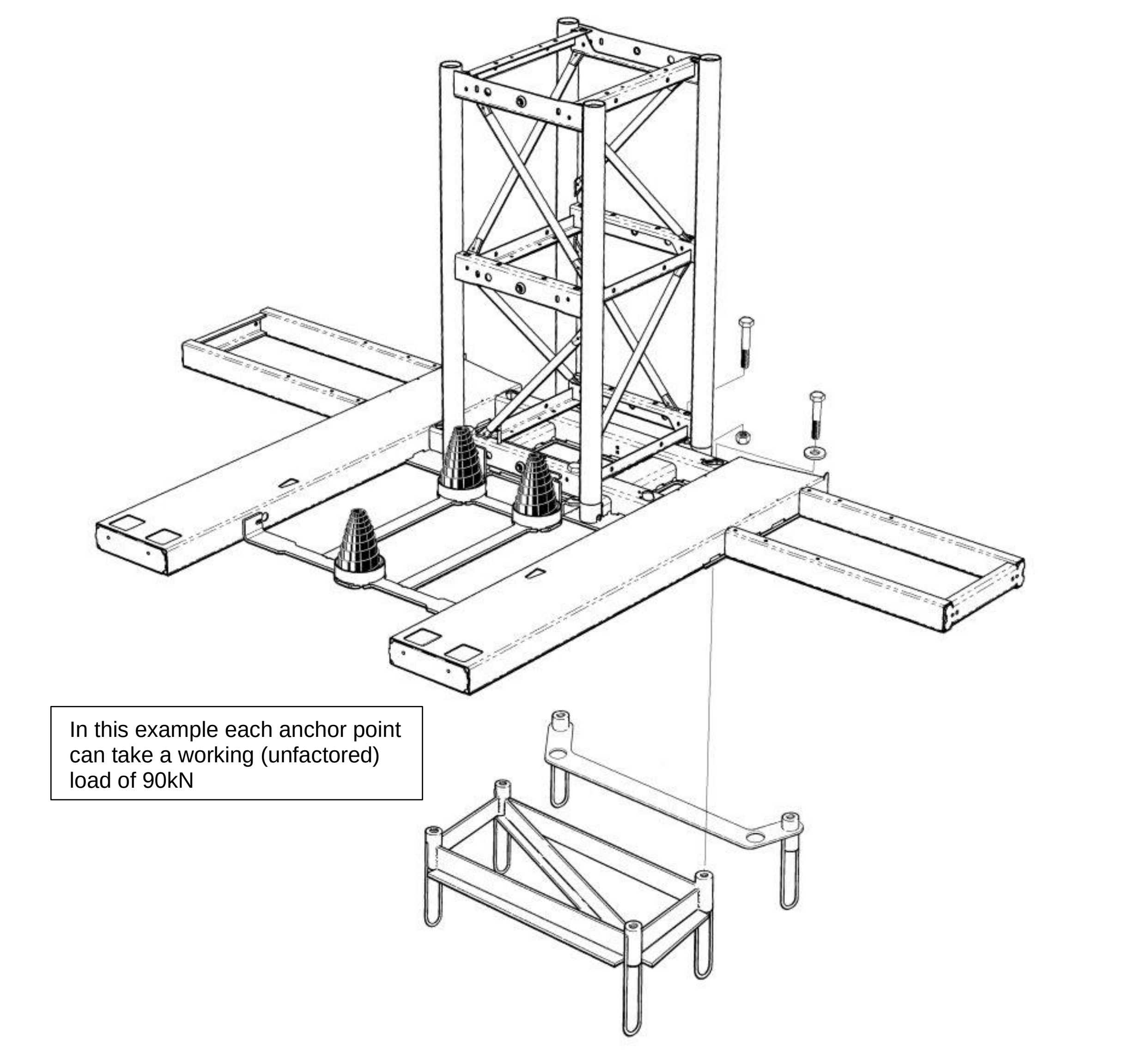


Figure 14 – Example of a Foundation Frame

Annex B shows an example of how to calculate bolt tensions based on a typical manufacturer's base loading information and shows the significant difference in bolt forces at the base frame anchor of a freestanding hoist and a tied hoist. Many hoist suppliers reduce the height to the first tie in order to minimise the anchor loads and the size of the foundation slab required.

Annex B also shows a typical order of magnitude for a smaller machine with a different bolting arrangement.

It is necessary to confirm with the manufacturer that the bolt loads can be carried by any proprietary / manufacturer's base frame. This is especially true where an old style "setting in frame" is used with a modern, large payload machine.

4.5.3 Ground assessment

If the base is located on the ground, the long-term effect of the hoist on the strata beneath it should be assessed. Soils may deteriorate over time at different rates, softening, allowing the hoist to settle and causing the base to lean. Similarly, if the soil can be washed out (scour), the base could become unstable. Any concrete or structural steel bases (e.g. base plates) providing support to the hoist must be designed and checked to the relevant design standards for the stated hoist loads.

NOTE: *Blinding may be required to the formation in order to provide a firm and level bearing surface and prevent degradation over time.*

Detailed guidance on ground conditions is given in *Ground Conditions for Construction Plant - Good Practice Guide.* Strategic Forum for Construction - Plant Safety Group (free download from www.cpa.uk.net)

The hoist supplier must ensure that base loads are provided for the specific hoist configuration that is going to be installed. Typical standard load cases will be available from the hoist manufacturer in the manual. The in-service, out-of-service and erection/dismantle load cases should be evaluated, appreciating that these loads may be applied to different parts of the hoist foundation. These specific load cases are not always provided by the hoist manufacturer or shown in their manual and may need to be requested. It is essential that the hoist hirer and user do not vary the installation and erection strategy as this could vary the base and tie loads from the manufacturer's data (see **1.7** on change management). A standard Word template for requesting and recording loads from the hoist manufacturer is shown in **Annex E** (free download from https://www.cpa.uk.net/construction-hoist-interest-group/) and an example of a completed template is shown in **Annex F**.

The mass of the supporting foundation should be considered in the base design. This mass provides the resistance to overturning and an adequate factor safety should be applied. The magnitude of the safety factor will depend on the designer's confidence in the loads provided by the manufacturer. A minimum factor safety of 1.67 (calculated from partial safety factors of 1.5/0.9) against overturning is recommended.

NOTE: *this value is taken from CIRIA C761 (see **Annex I**)*

In order to check the foundation, the loads must be used to calculate the peak pressure at the foundation edge. Vertical pipes are ignored in the sample calculation in **Annex C** as they reduce eccentricity of the hoist loads onto the foundation. In reality, vertical-pipes (which support the gates on passenger/goods machines) will need adequate support beneath them too as these can have significant load passing through them to the foundation. Some hoist installations also do not require vertical gate support tubes. In the example in **Annex C**, two alternative bases are being compared. The first is a base supporting a hoist just prior to its first tie being installed. The second is showing the base loads when two ties have been installed. A similar outcome is expected with only one tie installed. In this example, the hoist is located on a steel baseplate which is being used as the foundation; weighing 4.6 tonne, with a length of 4.0m and a width of 2.89m. The plate sits on the bearing structure which must be able to accept the loads with respect of bearing strength and stiffness.

Care should be taken when considering safety factors:

- Calculations of pressures applied to the ground would usually be unfactored (see **Table 6**);
- Calculations where load is applied to a structure would attract standard partial safety factors or dead/live load factors related to limit state assessments (see **Table 5**);
- For calculating the factor of safety for overturning systems dead loads should have a safety factor of 0.9 as these are considered as beneficial/restoring.

The calculation in **Annex C** shows factored forces and moments as if applied to a structure.

The calculations refer to a chart in **Annex D** which indicates a factor used to assess the edge pressures based on x and y axis eccentricity. The source of this reference is given.

The base calculations in the annexes show that a hoist exerts a higher bearing pressure along both the long and short foundation sides than when the average pressure is considered. The actual increase is dependent upon applied moments, applied loads and base geometry. When considering the effect of overturning on the foundation, the edge pressures are very much higher than average pressures. Average pressure calculations underestimate the applied loads significantly.

A competent temporary works engineer must review the various calculated pressures against the strength and stiffness of the bearing surface (see **3.1**). Materials that cannot tolerate the high edge loads may fail structurally or may settle over time. This may be significant if the hoist foundation is located on a weak structure.

4.6 *Tie Design*

Construction hoists are tied for several reasons:

1. To avoid overstressing the mast;
2. To transfer the loads from the hoist to the supporting structure;
3. To restrict the amount of free cantilever of mast. Excessive mast cantilever would allow the assembly to fail should the hoist carriage climb too high;
4. To restrict the amount of sway on a passenger hoist cage, for passenger comfort and considerations such as the correct operation of gate interlocks;
5. To prevent overturning.

The design of the ties is therefore crucial in ensuring the integrity of the hoist installation.

Tie loading information is provided by the manufacturer in the format detailed in this document. This information should be communicated by the hoist supplier to the hirer so that they can assess the effect of the loads on the structure that is being used to support the hoist.

NOTE: *Although the design of the tie and any anchor bolts is generally carried out by the hoist supplier, the Client / Principal Contractor must assess whether the permanent works can accept this load without there being any deterioration to the structure. This may be a complex interface, for example anchor plates onto a masonry wall: the anchor plates will be assessed by the hoist / anchor plate manufacturer, the tie bolts will be designed by the hoist supplier, but the capacity of the wall will be assessed by the Principal Contractor / Client. This is then verified in practice by tests on the anchors (see* ***5.7****).*

Usually just maximum values of loads are supplied, however, on occasions additional details, such as whether the loads are in and out of service, are given. Exceptionally, loads are given when the hoist is freestanding, i.e. during erection/dismantle just prior to the installation of the first tie.

4.6.1 <u>Variations in manufacture's tie loading information</u>

A review of calculations provided by several hoist manufacturer's, for a single size of hoist: a 2000kg capacity passenger/good hoist with a 1.5m x 3.2m cage, shows that some elements are fundamentally different. For example, different manufacturers have their x and y axis in different orientations. If this is not taken into account, the analysis of loads and selection of fixings will not reflect the actual loads applied, leading to potential failure. It is helpful if loads are presented in a graphical form, making the labelling and direction of the axis clear.

All the manufacturers who kindly took part in the review gave answers to the same questions, but the interpretation of their results needed care. Typically, the manufacturers give values that were of the same order of magnitude. For example, in service loads at the mast centreline were in the range 10.5 to 13.5kN for Rx values and 0.1 to 1.9kN for Ry. Out of service loads at the mast centreline varied from 9kN to 15.6kN for Rx and 7.7kN to 15.6kN for Ry. All manufacturers supplied unfactored loads i.e. characteristic loads.

EN 12158 and EN 12159 require the manufacturer to supply the tie loading information at the point at which tie tubes apply the load to the structure.

Hoist manufacturers may also supply the loads as acting at the centre line of the mast in the x and y axes, together with a torsional or twisting action which is due to the effect of the carriage on the mast due to wind and payload. Sometimes manufacturers will give the loads at the pin connection to a wall bracket or even the bolt loads where the bracket connects to the wall. This needs to be appreciated by the hoist supplier and explained to the hirer of the hoist so that the appropriate fixings can be selected, and the supporting structure checked for adequacy. Where brackets have slotted and/or oversized holes this may have an effect on the capacity of the anchor and the ability of the bracket to distribute the load between the fixings. In certain circumstances welded washers, grouting or other appropriate measures may be required.

It is the hoist hirer's (user's) responsibility to ensure that they adequately understand the effect of the applied load onto the structure that they are responsible for. Their assessment should include but may not be limited to the following:

- Anchor bracket bearing on the structure;
- Anchor tension / compression to the structure;
- Local bending, shear and bearing stresses;
- Local bursting stresses under any anchor post-tension;
- Strength and stiffness of the supporting structure;
- Local cast-in items such as post tensioning ducts, cladding support brackets/ panels;
- Actual achieved in-situ strength (not design strength). Variables in construction such as concrete quality, compaction and amount and location of reinforcing (see **5.2.4**);
- Actual achieved construction thickness, as opposed to design thickness, as variations in construction may result in a slab or panel which is thinner or thicker that that considered in the design. This may have implications for fixing strength and or ease of installation;
- Coordination of the tie and anchor with other temporary and permanent works;
- Coordination of the hoist installation, modification and dismantle with the latest version of the construction design;
- Insitu reinforced concrete or precast;
- Ties in masonry are particularly challenging as the ability of masonry to accept tension and tolerate bending is very low compared to reinforced concrete;
- Size and proximity of reinforcement – required to ensure the concrete does not crack when tension and shear forces are applied. In some cases, excessive cover to concrete will be unacceptable where anchors are being used. Where this is critical, confirmation of the correct positioning of reinforcement may be required;
- Diameter and depth of reinforcement;
- Slab thickness;
- Edge distances;
- Anchor bolt diameter;
- Anchor spacing.

There are many different types of hoist tie (See **Figures 5** to **12** for examples). The principles outlined below assist when considering alternative tie designs. Specific special case tie calculations may be requested from the hoist manufacturer. They may however, charge for this service.

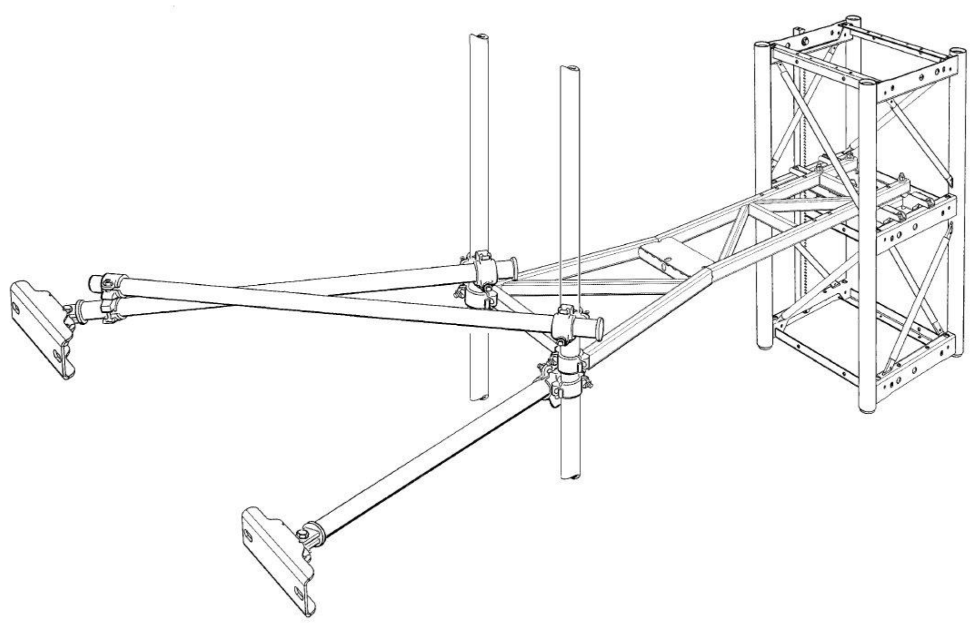


Figure 15 - Typical Tie Configuration

4.6.2 Example of manufacturer's tie force information

The example shown in **Figure 16** and **Table 6** is for a hoist with 4No. tie levels. The values of Rx and Ry are values for the forces/actions on the centreline of the mast. The values of P1 etc are the actions applied at the wall anchor brackets.

NOTE: *These in-service loads may not be the highest loads*

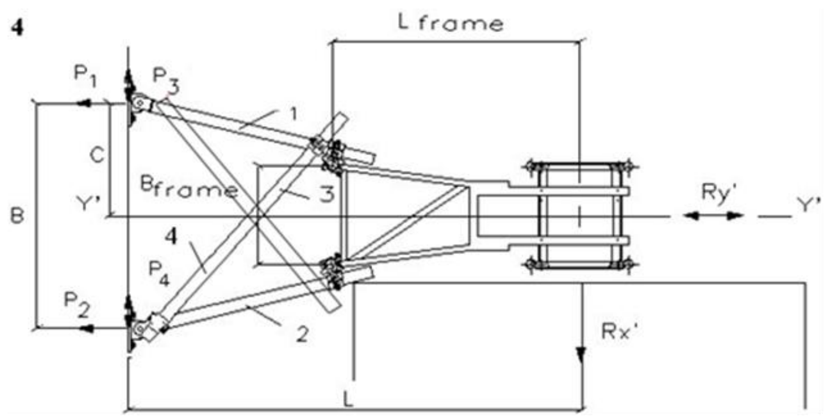


Figure 16 – Example Tie Layout

Tie No.	Level (m)	Forces at Mast Centre (N)		Forces at Tie Brackets (N)				Bolt Forces at Tie Brackets (N)			
		Rx'	Ry'	P1	P2	P3	P4	P1b	P1s	P2b	P2s
1	+15.73	13912	96	28512	-28416	6984	6928	17612	3492	0	3464
2	+27.73	12108	-77	24734	-24811	6031	6077	15266	3016	0	3038
3	+39.73	11934	-77	24378	24455	5944	5990	15046	2972	0	2995
4	+51.73	14528	71	29760	-29689	7285	7243	18380	3642	0	3622

NOTE: *The above forces are one load case from several design cases supplied by the manufacturer. These do not represent the worst case loads possible for this machine. They are also for a single cage machine rather than for a twin. The bolt loads P2b in the stated case is zero because of a particular load case where the wind is causing this bracket to be in compression, hence there are no bolt tension loads.*

NOTE:

- *a) Rx' and Ry' can be positive or negative*
- *b) The hoist is standing at the bottom landing when out-of-service*
- *c) Pb are bolt tensile forces*
- *d) Ps are bolt shear forces*
- *e) P1b and P1s are the maximum bolt forces at the wall bracket at P1*
- *f) P2b and P2s are the maximum bolt forces at the wall bracket at P2*

Table 6 – Example Tie Force Information for Single Hoist

A series of example calculations are found in **Annex A**. These calculations demonstrate how to:

- Calculate the tube forces in a single sway brace;
- Calculate the tube forces in a double sway brace;
- Calculate the anchor forces in a bracket;
- Consider the slip load in a fitting attached to the tie tubes.

The assessment and selection of fixing anchors is described in general terms only.

Two examples of the calculation are given. In the example above, with the double sway brace, this means that wall bracket P1/P3 is rotating around wall bracket P2/P4 if the load is in a positive Rx direction and vice versa (see **Figure 17**). Given the double sway brace the two bolts in the upper bracket would have identical bolt loads and vice versa. This is because the addition of the double sway brace makes the system rigid. Designers have the option to assess bolt loads in this simplified way or to base the assessment on individual bolt loads given loads applied at the hoist tie bracket pin. This latter option will give a conservative (higher) load in the bracket as it assumes a local fulcrum on the edge of the tie bracket rather than rotation about the other tie bracket.

Furthermore, where the two brackets are equally spaced around the centre line of the hoist mast, the two brackets will have identical loads.

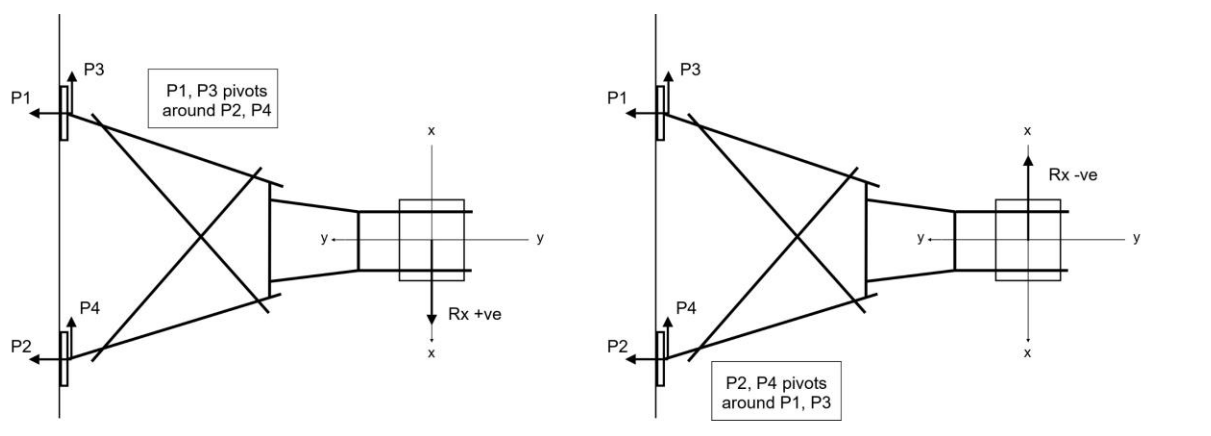


Figure 17 – Mirroring of Tie Loads

4.6.3 Variation of tie loads with increased mast height and number of ties

When building a hoist in stages, it is important to consider that the tie loads will vary with the addition of extra mast and ties. A typical example for single cage hoist is shown in **Figure 18**.

Tie Level	Worst in-service tie load (kN)
4	17.8
3	13.2
2	15.9
1	17.3

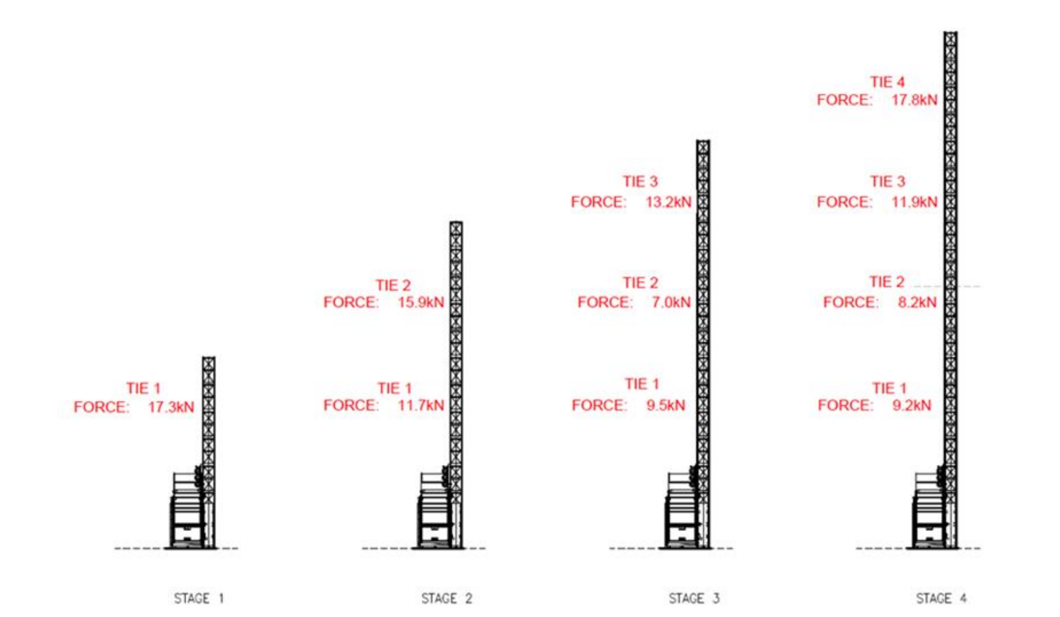


Figure 18. – Example of the Variation of Tie Forces at Different Stage of Erection

Normally, all ties would be designed for the worst tie for a particular hoist location, having reviewed all the stages of erection. **Figure 18** shows that:

- Generally, the highest tie force is experienced at the top tie because of the hoist on the cantilever of mast above the tie. This can occur at any stage, so care must be taken when assessing the worst case loading for tie design;
- If a second tie is close to the top tie, this will cause an increase in the tie forces in the system by virtue of the lever arm principle that is present;
- Alterations to tie centres and cantilevers on site can have an adverse effect on the magnitude of any tie forces calculated (see **4.6**);
- Where tie forces are high it may be necessary to add extra ties or remove existing ties in order to reduce the tie forces, however, care should be taken to ensure tie spacings are approximately equal otherwise anchor forces may increase. The hoist manufacturer should always be consulted in such cases.

5.0 Selection of Fixings to the Supporting Structure – including installation and testing

When choosing a fixing for a specific tying application, it is important to have accurate information on the installation location so that the correct choice of fixing can be made. Factors that should be considered include:

a) The base material to which the tie will be fixed including:

- i) Steelwork;
- ii) Concrete slab (core wall);
- iii) Brickwork, natural hard stone;
- iv) Timber framed structure;
- v) Scaffolding and other temporary structures.

b) Site requirements including:

- i) Accessibility, including safe access to the fixing locations;
- ii) Installation process including no drilling (post fix) and pre-cast inserts
- iii) Weight restrictions;
- iv) Location of the tie bracket;
- v) Special anchor requirement (e.g. Stainless steel, flush finish etc.);
- vi) Required lifetime of fixing;
- vii) Fixing removal after dismantling.

c) Environmental issues including:

- i) Temperature range during installation;
- ii) Temperature range during lifetime of anchor;
- iii) Water exposure;
- iv) Potentially corrosive elements.

d) Reusability

- i) Permanent
- ii) Temporary

e) The loads to be resisted by the fixings.

Fixing methods include:

- Post installed anchors (see **5.2.5**)
- Cast-in sockets and channels (see **5.2.6** and **5.2.8**)
- Through clamping (see **5.2.7**)
- Welding or bolting to steelwork (see **5.4**)

It is essential that where proprietary fixings are used the manufacturer’s instructions for selection and installation are adhered to.

Additional guidance on the selection of fixings is given in:

- BS 8539:2012, *Code of practice for the selection and installation of post-installed anchors in concrete and masonry.*
- *Guidance Note on Anchor Selection* produced by the Construction Fixings Association (see **Annex I**)

5.1 *Change Management*

Change management procedures need to be applied if the fixings need to be varied in any way. Reasons for needing to monitor change include:

- Change of hoist / type;
- Change of tie location height / spacing;
- Alteration of the tie load;
- Alteration of the tie bracket location;
- Availability of the specified anchor;
- Discovery of different anchor installation conditions e.g. condition of substrate, edge distances, type of substrate.

It is not appropriate to require the anchor installer to verify the adequacy of the anchors in the new situation. The variation needs to be communicated back to the original anchor specifier for verification or performance checks.

Consideration of alternative anchors needs to reflect not only the ultimate resistances but also the safety margins, edge distances and spacing along with other factors.

5.2 *Tying into concrete*

Concrete is the material into which most structural connections are made, for which most anchors are designed, and performance is most frequently quoted.

Anchor performance is most commonly quoted for C20/25 concrete which has a mean compressive strength of 25 N/mm^2. Some manufacturers also quote tensile performance in stronger grades or allow the calculation of increased allowable tensile loads within certain limits. Exceptionally strong concrete, i.e. > 60 N/mm^2, may inhibit the expansion of some expanding anchors and the manufacturer's advice should be sought to check for suitability. The same criteria apply to in-situ and pre-cast concrete; the slimmer sections and higher strengths of pre-cast units may require a different anchor choice.

5.2.1 Site details required for tying into concrete

When tying into concrete the following details are required:

- Type of slab;
- Type of concrete;
- Type of reinforcement (edge);
- Layout of existing inserts (cast in channels and sockets);
- Type of tie bracket;
- Orientation of bracket to the geometry of concrete e.g. a bracket on a slab edge or a core wall;
- Site preferred anchor (manufacturer).

5.2.2 Cracked/uncracked concrete

It is essential to determine when selecting an anchor if it is to be installed in cracked or uncracked concrete, as not all anchors have been tested and approved for use in cracked concrete.

It is acknowledged that concrete may be cracked for a variety of reasons, primarily the loading of the structure, (cracked concrete in tension zones, uncracked in compression zones) and reinforcement helps limit crack widths and restrict crack propagation. Although there is no evidence to hand in the UK of anchor failures being caused by cracked concrete, the "ETAG" (Guideline for European Technical Approval of Metal anchors for use in concrete) allows for the approval of anchors for use in both cracked or uncracked concrete or for use only in uncracked concrete. Anchors are now available, using both traditional and new design concepts, which function well in cracked concrete. Such anchors have undergone specific testing to determine the difference in their performance between cracked and uncracked concrete. The results of this testing are reflected in the resistance of the chosen anchor.

As well as the new "Undercut" anchors, both expansion and resin bonded anchors are available with approval for use in cracked concrete. Expansion anchors may, with care, be considered for such applications by locating the expansion point in the compression zone. Some expansion anchors can be installed in both cracked and uncracked concrete as they are self compensating. The anchor manufacturer’s advice should always be sought before installation.

The age of concrete is important as this has a great effect on strength. For example, the strength at 1 day is 20% to 40% of the 28 day strength and at 2.5 days old, it is 40% to 60% of the 28 day strength. The strength should be verified by the crushing of sample cubes where ties are being inserted into immature concrete.

5.2.3 Reinforcement

Reinforcement in concrete can take up the tension generated in the concrete. Calculation packages for anchors do not, however, take this into account but use information on reinforcement to calculate the shell spalling effect. Consequently, reinforcement does not improve anchor performance and while theoretically it may allow setting closer to edges, this is difficult to assess and is best ignored. Performance is usually quoted for unreinforced concrete. If rebar, which may not be cut, is hit during drilling, the aborted hole should be filled with a strong, non-shrink grout and the new hole spaced at least the depth of the aborted hole away. Additional holes designed into brackets will help cater for this common eventuality. It is essential that the position of rebar should be considered at the design stage.

5.2.4 Construction variables

Construction of concrete elements to which a hoist tie is attached may be subject to several variables which may affect the “as-built” strength of the supporting structure. If this is below the design strength, the ability of the structure to resist loads from the tie may well be affected.

These variables include:

- Concrete quality;
- Compaction;
- Quantity, size and location of rebar;
- Incorrect shuttering dimensions.

5.2.5 Post installed drilled anchors

These anchors are inserted into a hole drilled in the base material and are of two types:

Mechanical anchors

Mechanical anchors work in two ways:

- Expansion of the sleeve surrounding the bolt (see **Figure 19.**), to transfer load to the base material through friction. Expansion of the sleeve is either displacement or torque controlled.
- Segments on the outer part of the anchor being forced over a cone on the inner part and keying into an undercut in the base material to transfer the load (see **Figure 20.**).

Bonded anchors

Bonded anchors are bonded to the wall of the hole in the base material using a two part resin grout which transfers the load from the anchor stud to the wall of the hole in the base material (see **Figure 21.**). An example of a typical tie using a bonded anchor to a slab edge is shown in **Figure 22**.

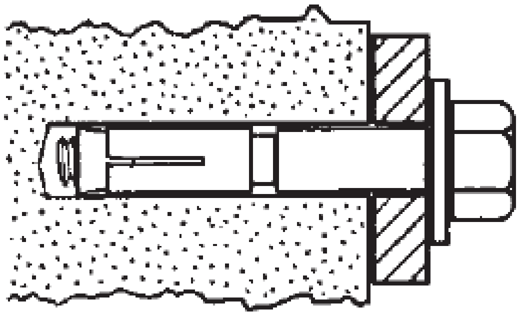


Figure 19. – Example of an Expansion Anchor

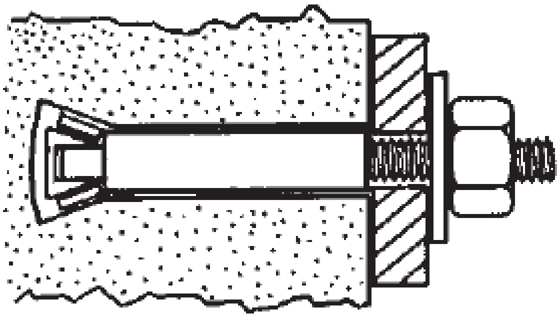


Figure 20. – Example of an Undercut Anchor

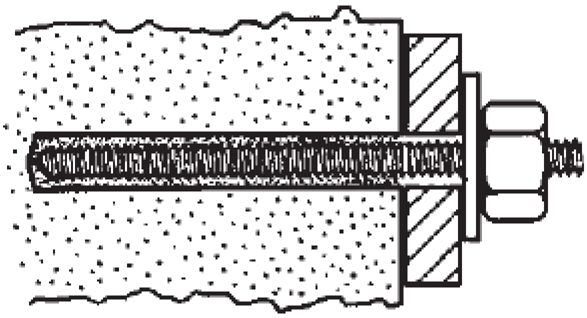


Figure 21. - Example of a Bonded Anchor

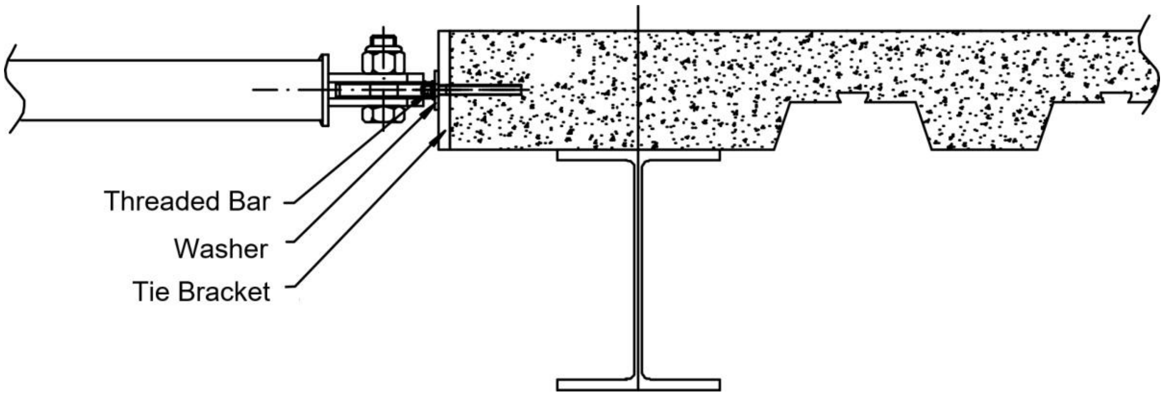


Figure 22. – Typical Tie with a Bonded Anchor to Concrete Slab Edge

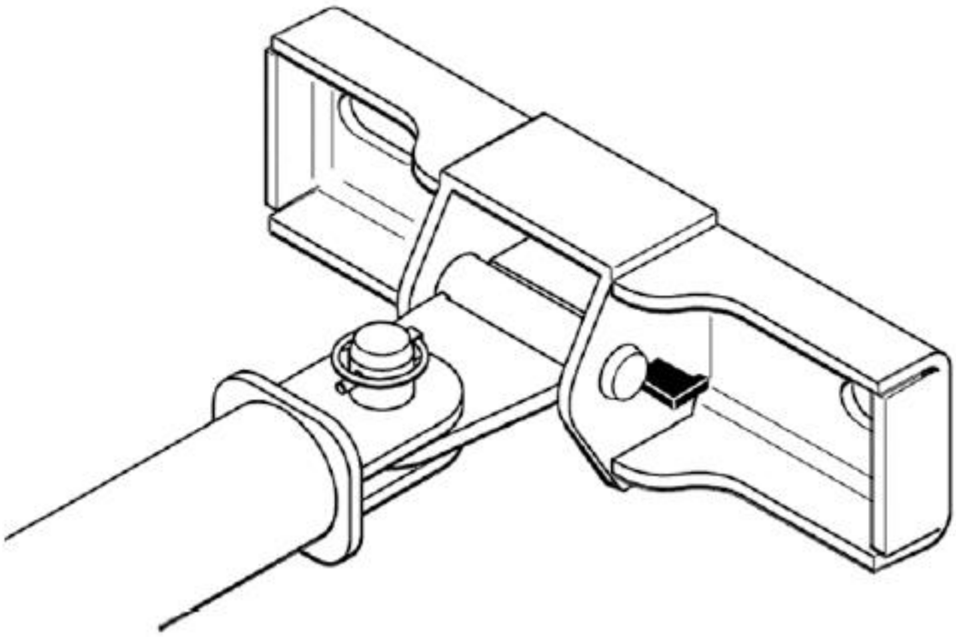


Figure 23. – Typical Tie Wall Bracket

When selecting drilled anchors, it is essential that the anchor manufacture's information is used for selection of an appropriate anchor and its subsequent installation. Most anchor manufacturers provide software to assist with selection.

5.2.6 Cast-in sockets

Cast-in sockets are a means of attaching ties to precast panels. They consist of a threaded socket machined from solid bar with a cross hole at the inner end for either an integral cross pin or rebar. The socket is inserted to the formwork before casting and provided a permanent means of fixing (see **Figure 24.**). These can be used also in traditional RC slabs in order to avoid drilling by the hoist installer. It is important that the sockets are set at the correct centres to line up with the holes in the tie adaptor plates. The use of a setting in frame or jig will help ensure their correct placement.

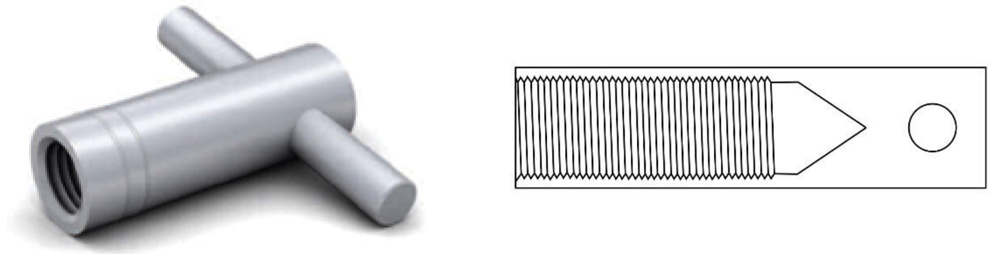


Figure 24. – Example of a Cast-in Socket

5.2.7 Through clamping

Through clamping involves passing a threaded rod through a hole drilled in a concrete wall or slab with a tie bracket on one side and a plate or channels on the other to spread the load and transfer it into the structure. The threaded bar is then pre-tensioned to ensure that the fixing is secure (see **Figure 25.**). The advantage of this method is that it provides a secure fixing of high capacity whilst the disadvantage is that access is required to both sides of the wall or floor slab.

Care needs to be given to the effect of the over-sized hole needed to accommodate the bar. This allows movement of the anchor in the annulus and bending stresses to be developed in the anchor, which could lead to failure. Close tolerance holes in both the wall and tie brackets through which the threaded bar passes are preferred. Where this is not possible it will be necessary to grout up the holes.

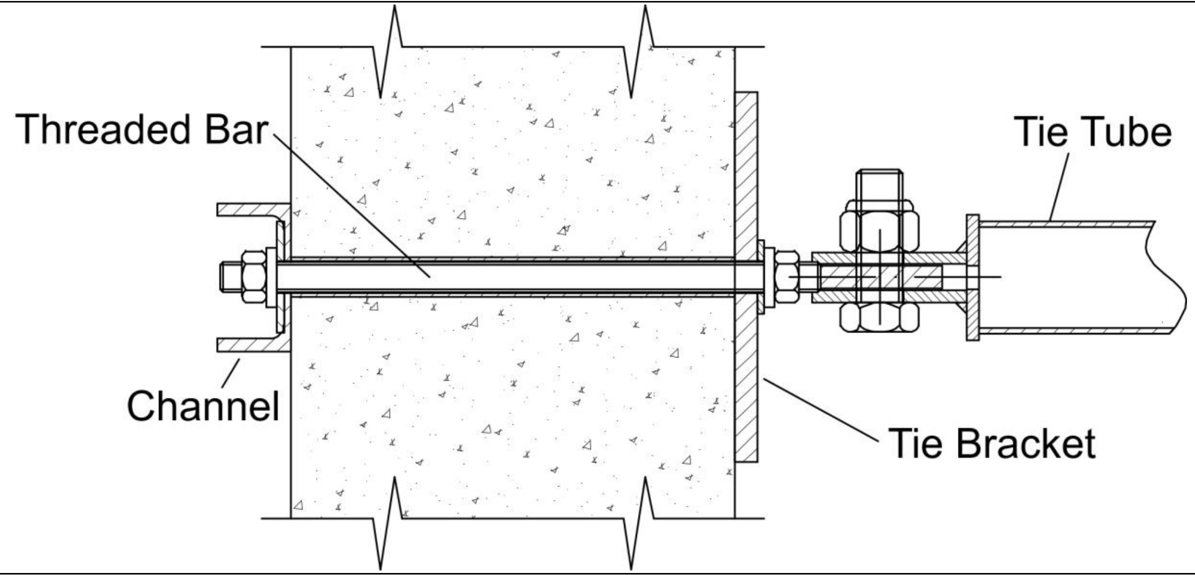


Figure 25. – Example of Through Clamping

5.2.8 Cast-in channels

Cast-in channels are a range of hot or cold rolled steel profiles designed to provide secure fixing into concrete. The channels are bonded to the concrete by adjustable bolt anchors attached to the back of the channel. The load is transferred to the channels by matching T-head bolts (see **Figure 26.**).

The advantages of channel fixings are:

- No drilling on site – eliminating power tools, vibration, dust and noise;
- Rapid fixing without damage to the concrete;
- Adjustable and adaptable;
- Small edge distance dimension;
- Fixtures are removable and new fixing can be made;
- Suitable for dynamic loads;
- Good resistance to corrosion;
- Suitable for prestressed structural elements – no restriction for cracked and non-cracked concrete;
- Suitable for Metal Deck type of slab.

The disadvantages are:

- Requires planning in advance, in the early stages of the project;
- Susceptible to human error for example where the channel not cast in or is in the wrong location;

- Not the best solution to transfer loads parallel to channel (longitudinal – shearing loads) although this can be overcome to some extent by using a toothed channel with an appropriate T bolt.

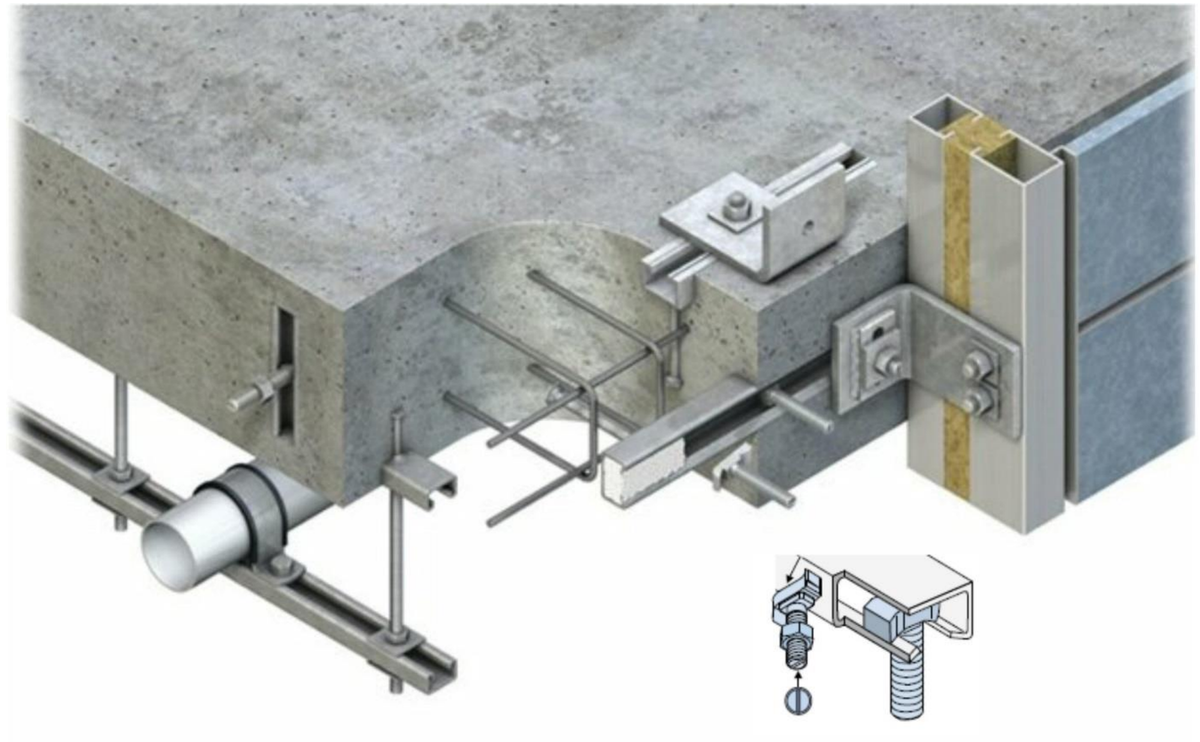


Figure 26. – Example of a Channel Fixing System

Tie brackets can be attached to either one or two channels as shown in **Figures 27** and **28** Using two channels doubles the capacity of the fixing.

5.3 *Tying to masonry (brickwork, blockwork and stonework)*

A structural engineer should always be consulted when fixing a hoist to masonry. Applying horizontal shear forces in a perpendicular direction to walls can be dangerous.

5.3.1 Brickwork

Brickwork is probably the most awkward material to fix into. Strengths vary from 5 - 70N/mm^2, mortar may be weak or non-existent in parts of the joints, bricks may be solid or have frogs or perforations which may not be filled with mortar.

When tying into brickwork the following details are required before selecting a fixing method:

- Type of brick;
- Pattern of wall (size of single brick and grout between them) total thickness of wall;
- Confirmation in writing from the PC that the wall can be drilled, this is of particular importance for listed buildings;
- Strength of brick to be confirmed (ultimate pull test required prior to installation) or site to confirm that the wall will withstand imposed load;
- The requirement for pull proof tests on the fixing.

Advice should always be sought from the fixing manufacturer and the structure designer.

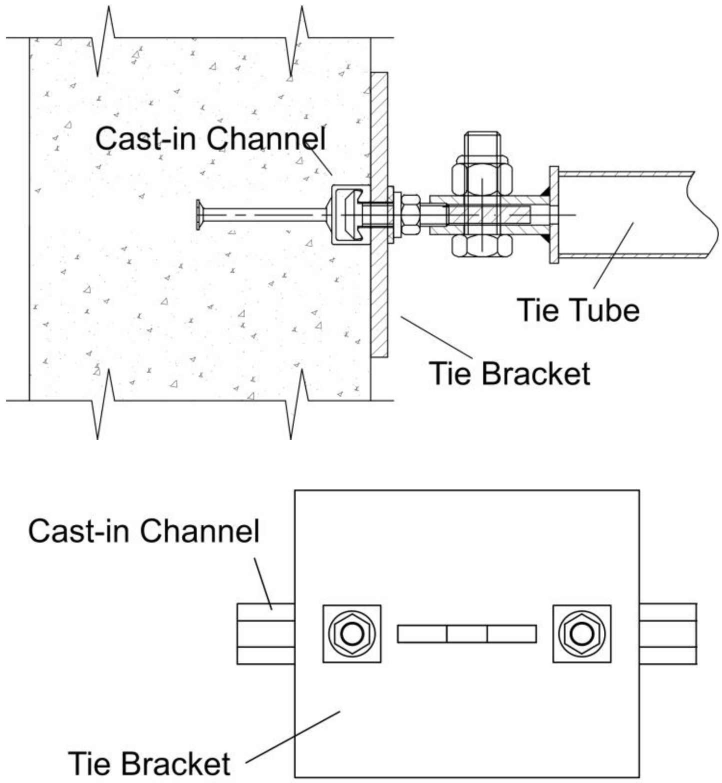


Figure 27. – Example of a Tie Fixing to a Single Channel

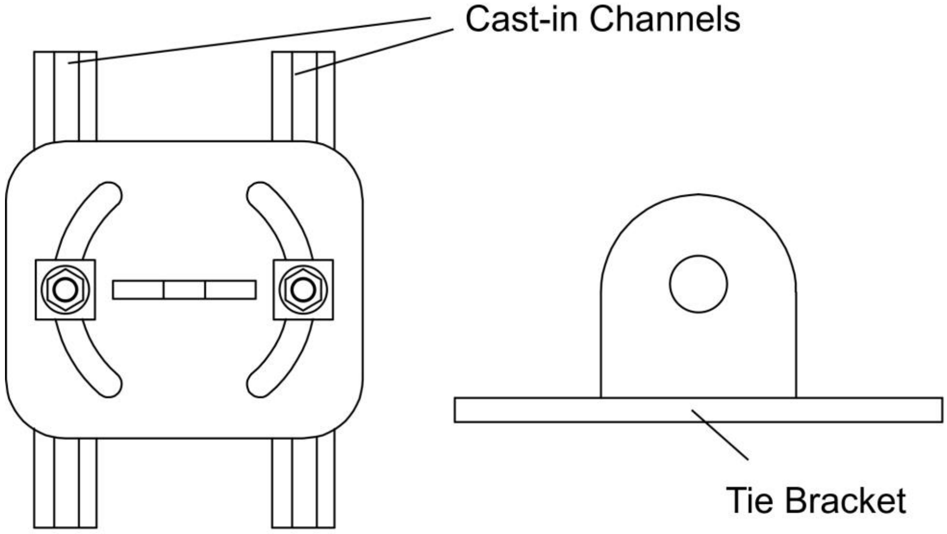


Figure 28. – Example of a Tie Fixing to Two Channels

Bonded anchors (see **Figures 21 and 29**) are particularly suitable as they exert no expansion stresses and will fill small voids, while injection resin systems have accessories available for controlling resin in frogs, poorly filled joints and perforations. The most appropriate metal anchors are thin-walled sleeve anchors which exert low expansion stresses and are less likely to crack weak bricks than anchors with thick expanders. They can also work well in perforated bricks. Shield anchors up to medium sizes work well in reasonably strong brickwork with good mortar joints.

Fixing locations for expansion anchors should be designed on the horizontal brick centre line (to avoid frogs) away from ends of bricks, at least a brick length from the wall edge and well below the top of an unrestrained wall. Anchors should not be located in joints. Failure modes for anchors in brickwork are shown in **Table 7.**

Figure 29. – Example of Bonded Anchors in Hollow Bricks

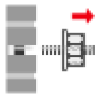
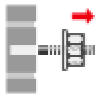
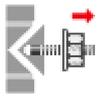
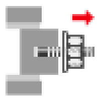
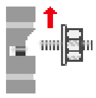
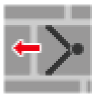
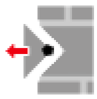
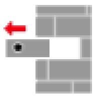
Load Direction	Failure Mode	
Tensile	Failure of the anchor material	
	Anchor pull out	
	Brick break out	
	Pull out of one brick	
Shear	Failure of the anchor material	
	Local brick failure	
	Brick edge failure	
	Pushing out of one brick	

Table 7 – Failure Modes of Anchors in Brickwork

Ties can also be fixed to brickwork using the through clamping method (see **5.1.6**). An example detail is shown in **Figure 30**.

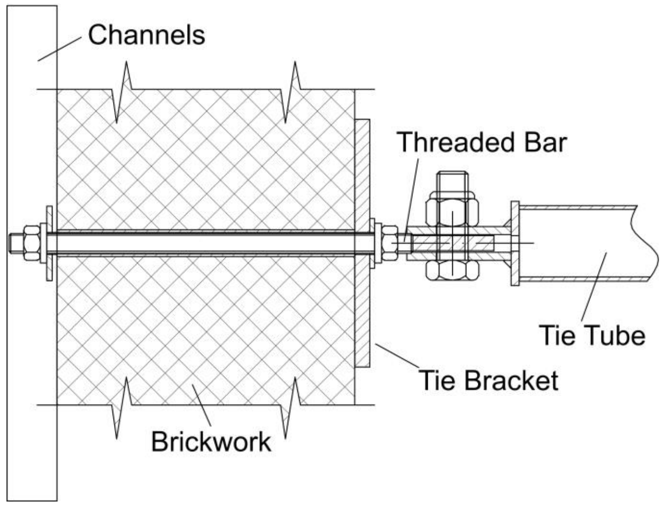


Figure 30. – Example of Through Clamping Method in Brickwork

5.3.2 Blockwork

Block work can include the lowest strength solid substrate!

Few metal expansion anchors work satisfactorily in "thermal" blocks. Thin walled sleeve anchors may be considered for solid blocks when the compressive strength of the blocks is known to be above $10N/mm^2$. Metal anchors specially developed for aerated concrete work well, as do injection resin systems for which accessories are available for hollow blocks. In weak base materials the manufacturer's recommended torque for installation in concrete may need to be reduced due to a weaker bond. Similar guidelines for positioning fixings apply as for bricks.

5.3.3 Stonework (masonry)

Tying to stonework requires a similar approach to brickwork. The strength of stones is as variable as bricks (from weak sandstone to granite). An added complication is the variation in shapes and sizes within the same wall and the possibility of rubble infill within "solid" stone walls. Anchor suitability and location guidelines are generally as for brickwork.

Additional guidance is given in *Guidance Note on Tying into Brickwork and Blockwork* published by the Construction Fixing Association (see **Annex I**)

5.4 *Tying into steelwork*

Tying into steelwork can be achieved using a permanently welded attachment point (see **Figure 31**) or with a temporary fixing. Where proprietary temporary fixings are used the system manufacturer should be consulted to ensure that the application is suitable.

Examples of temporary fixing to steelwork are:

- Bolted
  - Through bolt and nut – if access to the back of steel work is available (see **Figure 32**);
  - Blind bolt – if access to back of steel (tie into box section) is not available;
- Lindapter type of fixing – not suitable for high shear loads (see **Figure 33**);
- Sandwich tie (see **Figure 34**);

In all cases, local stresses must be considered, for example: lateral buckling of the beam, flange or web plus any local overstressing in thin webs. The tie designer should state the maximum movement that the steelwork is permitted to move laterally to restrain the hoist.

When tying into steelwork the following details are required:

- Type of steelwork;
- Permitted deflection under load;
- Dimensions;
- Coating of steelwork;
- Is a permit to drill or weld (hot works permit) required?
- Location of tie bracket.

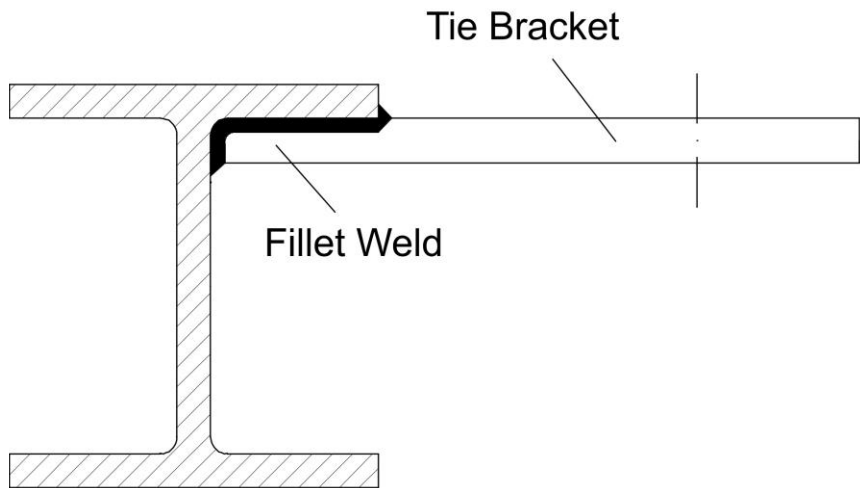


Figure 31. – Typical Welded Fixing Detail

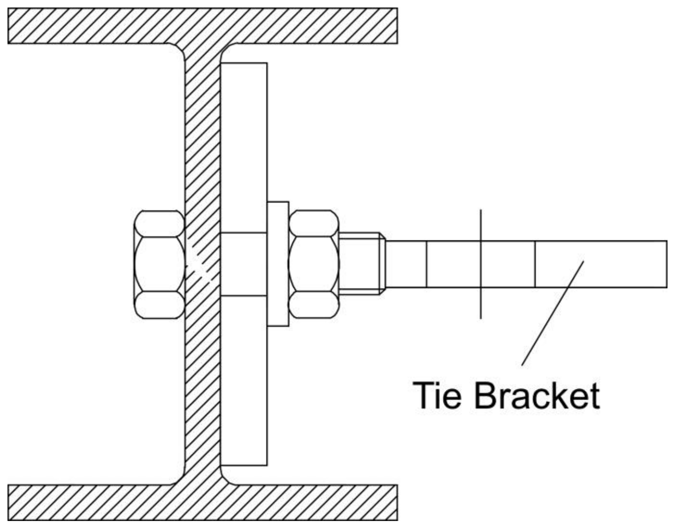


Figure 32. – Typical Bolted Fixing Detail

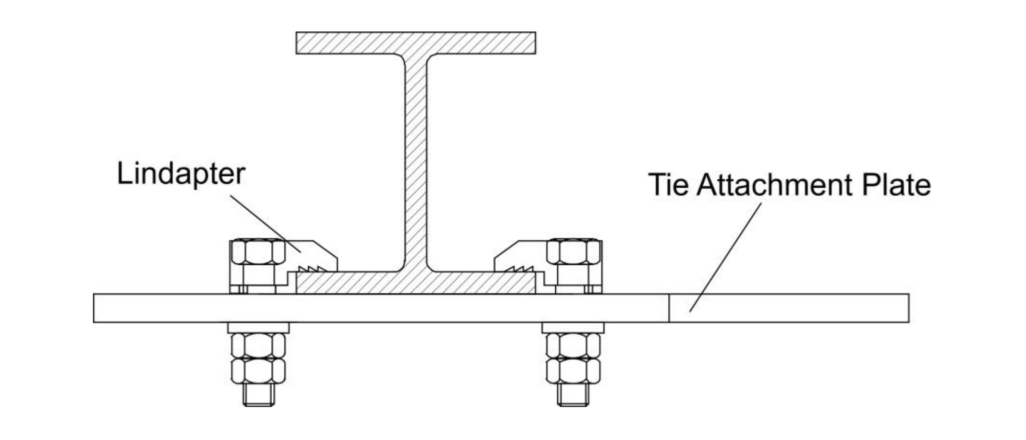


Figure 33. – Typical Lindapter Fixing Detail

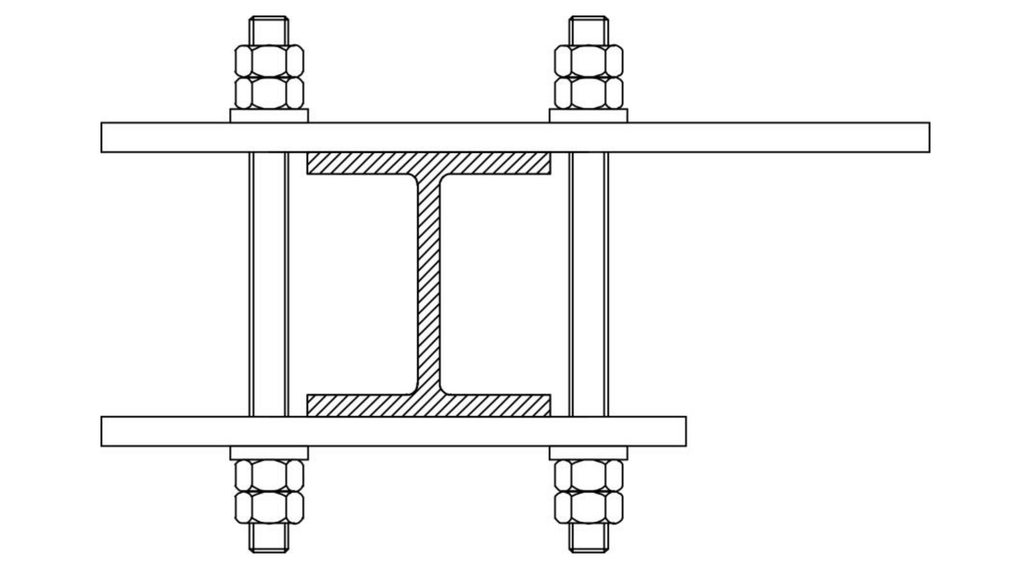


Figure 34 - Example of a "Sandwich" Tie Fixing

5.5 Anchor installation

When anchors fail in service it is generally due to poor installation. This is often due to incorrect embedment length and with resin anchors, lack of hole cleanliness.

The design performance of an anchor can only be realised if correct installation procedures are followed. In extreme cases poor installation may reduce the safety margin to the extent that the fixing fails either during installation or while in service.

Correct installation will be achieved by following the manufacturer's instructions and ensuring that installers are trained in the installation method for the specific type of fixing being used. Installers should be adequately supervised during the installation process and should use the correct installation equipment (see **5.6**)

The temperature of the air and substrate will also have an effect on resin curing time. This can affect the speed of hoist installation if the hoist erectors have to wait a long time for the anchor resin to set before torqueing is possible.

5.5.1 <u>Safe access</u>

The installation of tie anchors on hoists inevitably involves work at height. Part of the planning process for carrying out such work should involve the provision of safe access during the installation process. This is normally the responsibility of the hoist user.

Where access is not possible from the hoist or other structure e.g. slipform rig, then a MEWP may be required. This may require the hiring organisation to provide a competent operator if the hoist erectors do not have the relevant competencies to operate it. An operation such as this will also require a rescue plan.

Further guidance on this is given in the CPA *Best Practice Guide on Work at Height on Construction Hoists* (see **Annex I**)

5.5.2 Pre-installation checks

Before starting installation, the following checks should be carried out:

- Fixings to be used are to the required specification;
- Equipment needed for the installation, including hole cleaning, is available and is to the manufacturer's specification. (Special setting tools are not usually interchangeable between makes, even if the fixing involved is of a similar type and the same size.);
- Drilling machines and cables are in a safe condition or batteries are fully charged;
- Any special conditions are complied with. For example, for bonded anchors allowable installation temperature range and hole condition, wet, damp or dry and dust free);
- Ensure that appropriate PPE is available and worn including:
    - Eye protection;
    - Dust protection;
    - Ear protection;
    - Gloves (gloves to BS EN 374 should be worn when handling resins).

5.6 *Installers*

Personnel carrying out the installation of fixings should have received training in the installation of the specific type of fixing being used. They should be competent to carry out the installation and should be effectively supervised.

As the installation of drilled anchors involves the use of drilling machines, attention should be paid to the risk of Hand Arm Vibration Syndrome (HAVS). Advice on measures to prevent or mitigate HAVS can be found on the HSE website at http://www.hse.gov.uk/vibration/hav/index.htm

5.7 *Supervision and certification of anchor installation*

The hoist installation supervisor should monitor every stage of the fixing installation and, once all aspects of the installation have been completed and any proof tests satisfactorily carried out, should certify that the specified anchors have been correctly installed in accordance with the manufacturer’s instructions and in the specified locations so that they can be put into service. A form for this purpose, CFA Form 8539/03 Installation Certificate, is available from the CFA website (http://www.the-cfa.co.uk/publications-and-downloads/cfa-8539-forms/).

If, at any stage, the supervisor has any concerns regarding the suitability of the fixings, the placing of further units should not proceed and the fixings in question should be made safe until the concerns have been addressed to the satisfaction of the fixing designer/specifier.

5.8 *Basic installation procedures*

The following steps are common to all drilled anchors:

- Drill hole to correct diameter and depth
- Clean hole thoroughly

- Use correct setting equipment and procedure
- Tighten to correct torque

Additional guidance on the installation of anchors is given in *Guidance Note on Anchor Selection* produced by the Construction Fixings Association (see **Annex I**)

5.9 *On-site testing of anchors*

The testing of anchors on site might be required at two stages of a hoist installation:

- Before the installation of anchors, in order to ensure that the proposed anchors are suitable for use in the base material concerned and to determine the allowable resistance; or
- After installation, when a sample of all anchors may be proof tested to validate the quality of installation.

The effectiveness of anchors not only depends on the design of the selected anchor, but also on the capacity of the substrate into which the anchor is installed. Consequently, testing of the installed anchor may be required to establish the integrity of the substrate by proof loading the anchor once it is embedded and set with a torque value. This is very important as the hoist installer needs to prove that the design assessment will actually work in the installed condition. It is important that the reaction from the jack or bridge does not enhance the anchor capacity by reacting against any failure cone.

Testing may, however, prove difficult for reasons which include:

- Standard testing equipment may not fit over the anchor bracket;
- Gaining access to the ties can be challenging and may require provision of a MEWP to gain access to the brackets once installed.
- In extreme cases access the use of a man-riding basket suspended from a crane may be required

Additional means of access introduces additional rescue requirements which must be reflected in the planning of the operation. In order to avoid this, it may be prudent to consider undertaking a representative test elsewhere on an area of identical substrate where access is easier.

NOTE: *The Construction Fixings Association states that tests are not needed if anchors are specified with a European Technical Approval and have been designed (selected) and installed fully in accordance with the requirements of the ETA*

Requirements for testing are set out in:

- BS 8539:2012, *Code of Practice for the selection and installation of post-installed anchors in concrete and masonry*
- *Guidance Note on the Procedure for Site Testing Construction Fixings*, produced by the Construction Fixings Association (see **Annex I**)

5.10 Inspection

All fixings of the ties to the supporting structure should be inspected, both during installation and after testing (if required). The inspection should include:

- That the installation is in accordance with the design and/or manufacturer's instructions
- Observation of:
  - Rotation;
  - Movement;

- Deformation;
- Cracking;
- Other damage;

The inspection findings should be recorded in writing and any notification of defects given to the fixing designer/specifier so that appropriate action can be taken.

Tie fixing inspection should form part of the thorough examination of the hoist installation both before the hoist is taken into service and periodically. Requirements for the thorough examination of hoists are given in Clause **12** of BS 7212:2016, *Code of practice for the safe use of construction hoists* (see **Annex I**).

Annex A – Example Tie Calculations

A.1 Resolution of tie forces at the wall plates from loads at the mast centre

A typical selection of mast centreline forces are shown in **Table A1 for a twin cage passenger / goods machine**. Only a small selection of the possible load cases are given and the user must consider all of the load cases in order to determine the worst one when designing the tie system. The loads at the centre of the mast will obviously be identical between the single and twin sway brace options. The forces vary in the sway braces, the tie brackets and the wall anchors between the twin and single sway brace options.

Some hoists will also have a torsion that is applied at the mast centreline. This too will affect the tie forces. Some manufacturers will apply a torsion of M_{cz} value at the tie location.

	Mast centreline forces	
Tie number and level	**Force R_x (kN)**	**Force R_y (kN)**
Hoist in-service, wind x-x		
Tie 1 at 15.7m above base	16.9	0.1
Tie 2 at 27.7m above base	15.5	0.1
Hoist in-service, wind diagonal		
Tie 1 at 15.7m above base	14.6	6.8
Tie 2 at 27.7m above base	13.2	6.9
Hoist out-of-service, wind diagonal		
Tie 1 at 15.7m	6.2	6.6
Tie 2 at 27.7m	7.5	7.4

Table A1 – Typical Mast Centreline Loads (single mast, twin carriage hoist)

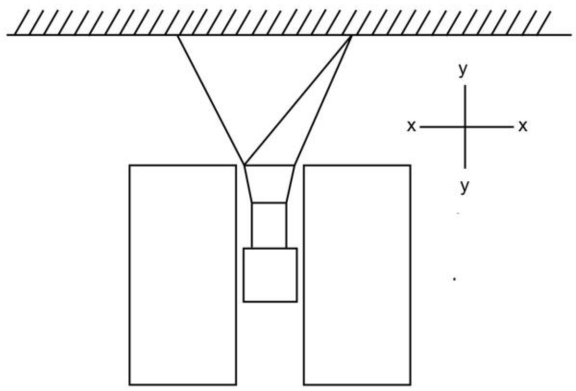


Figure A1 - Wind Axis

From **Table A1**, two possible in-service load cases should be considered:

- In service, wind parallel to x-x giving Rx = 16.9kN and Ry = 0kN

- In service, wind diagonal giving Rx = 14.6kN and Ry = 6.8kN

The out of service case, Rx = 7.5kN and Ry = 7.4kN, should also be checked, as this may be a worse case.

In **Table A1**, the lower tie does give the highest loads, although it would be advisable to check all levels for tie forces. If there was a large cantilever of mast above the top tie, the top tie will probably have the larger value. Consider also the case where the hoist has only one tie and is in erection mode for the installation of the second tie. Furthermore, some hirers ask for a hoist to be operational with a large mast cantilever above the single tie. This can generate very large tie forces. This load case should also be checked.

The calculations in this appendix demonstrate how to calculate the loads at any given point from the mast centreline to either a tie tube pin / bracket or an intersection with the wall. The equations allow forces to be calculated in the tie tubes as well as the forces at corresponding clamp fittings

This appendix follows two calculations: single sway brace and twin sway brace. Some manufacturers may apply a torsion in order to allow for wind rotating the hoist / horizontal loading forces applied to the carriage floor. These are ignored herein but can be applied by adding the moment value into the calculations below when assessing the reactions.

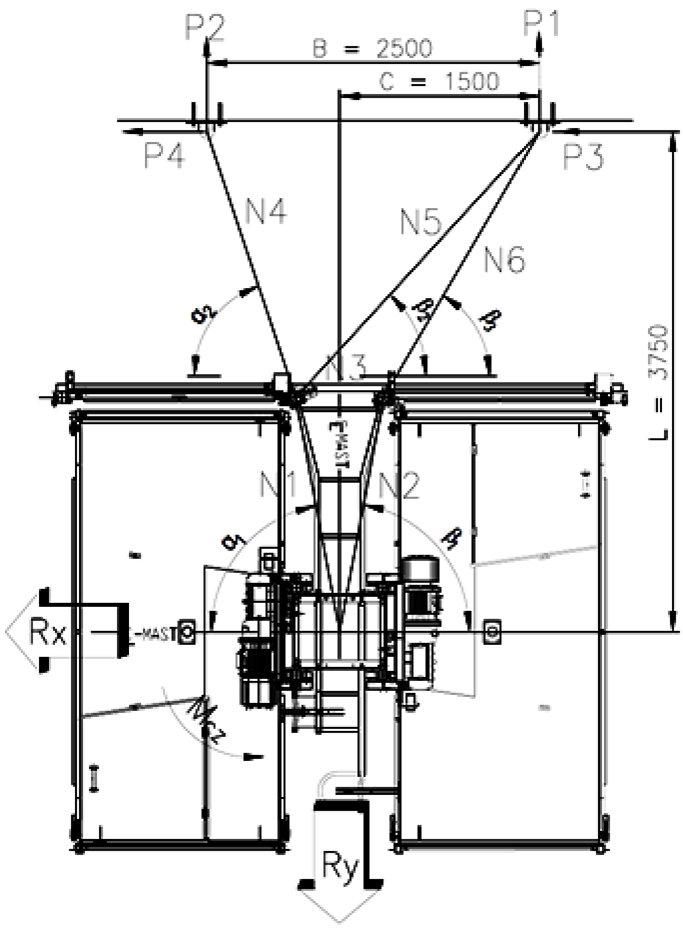


Figure A2 – Tie Fixing Reaction Example – Single Sway Brace

A.2 Reaction equations for single or double sway brace

Taking moments about P2 gives $(Rx.L) + Ry(B - C) + Mcz = P1.B$

This makes the reaction $P1 = \dfrac{(3.75Rx + Ry(2.5 - 1.5) + Mcz)}{2.5}$

Or $P1 = 1.5Rx + 0.4Ry + \dfrac{Mcz}{2.5}$

Taking moments about P1 gives $(P2.B) + (RxL) = (Ry.C) + Mcz$

Or $2.5P2 + 3.75Rx = 1.5Ry + Mcz$

Therefore $P2 = 0.6Ry - 1.5Rx + \dfrac{Mcz}{2.5}$

Torsion at tie locations can be added simply by placing them into the equations above in the Mcz value.

It should be noted that the force calculations in the tie tubes require the creation of a force in the pipe support frame between the mast and the vertical-pipes: N1 and N2, at approx. angles $\alpha 1$ and $\beta 1$

Using the figures from **Table A1** and the reaction equations, the reactions in **Table A2** and **Table A3** can be calculated. The forces are taken to apply in either direction, consequently a force can be either negative or positive, tension or compression, especially where a twin hoist is considered.

From this assessment above, it is possible to see that the worst tension/compression perpendicular to the wall is 25.2 kN (unfactored). However, the horizontal load will introduce a shear into the wall fixings, so this load case should be considered.

The shear is sometimes assessed as being shared equally between the brackets, so 14.6kN (unfactored) would be applied to the anchor calculation. However, the actual value can be calculated if the angle to the wall bracket is known and the forces are ‘triangulated’. This is demonstrated in a worked example below.

In summary, the most heavily loaded bracket in this design check case is P1 in load case 1. It has a tension (and compression) on the bracket of 24.6kN and a shear force (in both directions) of a proportion of 14.4kN. The bracket and fixings should be capable of resisting this force combination.

Tie number and level	Force Rx (kN)	Force Ry (kN)
Hoist In service, wind x-x		
	16.9	0.0
P1 = 1.5Rx + 0.4Ry		P1 = 25.4 kN
P2 = 0.6Ry - 1.5Rx		P2 = -25.4 kN
Hoist In service, wind diagonal		
	14.6	6.8
P1=1.5Rx + 0.4Ry		P1 = 24.62kN
P2=+0.6Ry -1.5Rx		P2 =-17.82kN
Hoist out of service, wind diagonal		
	7.5	7.4
P1=1.5Rx + 0.4Ry		P1 = 14.2kN
P2=+0.6Ry -1.5Rx		P2 = -6.8kN
		Check sum of P1 + P2 = Ry

Table A2 – Tie Reactions Normal to the Wall

NOTE: *The Mcz mast torsion value is ignored in this example.*

The included angle between the single tube and the wall is 68 degrees. The gives a horizontal component of the force as:

$$\tan\theta = \frac{vertical\ force\ component}{horizontal\ force\ component}$$

$$\tan 68 = \frac{24.6}{horizontal\ shear\ component}$$

∴ Ra (shear) = 10.0kN.

The sum of the horizontal forces should resolve to balance the external force. ∴ Rx =14.4N

Hence the horizontal force component at P4 (shear) = 14.4 – 10.0 = 4.4 kN.

Table A3 – Tie Reactions Parallel to the Wall

It is possible to see that the worst pull out and compression forces applied to the wall / bracket are 25.4kN. However, there are also horizontal forces applied also. These vary according to whether there is a single or double sway brace.

All of the load cases should be checked to assess that their individual combinations do not provide the worst case tie bracket or tie tube loadings. Only the ‘hoist in service, wind x-x’ case is considered in the examples below.

A.3 Example calculation of the reactions and tie tube loads for a single sway brace tie.

Considering the single tie brace option (from **Figure A2** above where:

$\alpha_2 = 72°$ $\beta_2 = 48°$ & $\beta_3 = 60°$ with $\alpha_1 = \beta_1 = 79°$

<u>To calculate N4 tube load, then:</u>

Sum of forces at a point add up to zero, so considering bracket P2 in figure 8,

then $P2 = N4.\sin\alpha_2$

Resolving for N4 $N4 = \frac{P2}{\sin\alpha_2}$

$$N4 = \frac{25}{\sin 72^\circ}$$

$$N4 = 26.3\text{kN axial load in the tube}$$

Resolving N4 for horizontal component gives the shear on the bracket

$$P4 = N4.\cos\alpha_2$$

$$P4 = 26.3\cos 72^\circ$$

$$P4 = 8.1\text{kN (bracket 2 shear)}$$

To calculate N5 tube load, then:

$$N2 \text{ (mainframe force)} = \frac{R_y + R_x.\tan\alpha_1}{\tan\alpha_1.\cos\beta_1 + \sin\beta_1}$$

$$N2 = \frac{0 + 16.9\tan 79^\circ}{\tan 79^\circ.\cos 79^\circ + \sin 79^\circ}$$

$$N2 = \frac{86.942}{1.963} = 44.3kN$$

$$N1 = \frac{Rx - N2.\cos\beta_1}{\cos\alpha_1}$$

$$N1 = \frac{16.9 - 44.3.\cos 79^\circ}{\cos 79^\circ} = \frac{16.9 - 8.45}{0.191} = 44.3\text{kN}$$

Vertical and horizontal components of N1 (N1V) and (N1H)

$$N1V = N1.\sin\alpha_1$$

$$N1V = 44.3\sin 79^\circ = 43.5\text{kN}$$

$$N1H = N1.\cos\alpha_1$$

$$N1H = 44.3\cos 79^\circ = 8.5\text{kN}$$

To calculate N3 tube load

$$N3 = \frac{N2\sin\beta_1.\cos\beta_3}{\sin\beta_3 - N2\cos\beta_1}$$

$$N3 = \frac{44.3\sin 79^\circ.\cos 60^\circ}{\sin 60^\circ - 44.3\cos 79^\circ}$$

$$N3 = 25.1\text{kN} - 8.45\text{kN} = 16.6\text{kN}$$

To calculate N5 tube load

$$N5 = \frac{\frac{N1V.\cos\alpha_2}{\sin\alpha_2} + N3 - N1H}{(\cos\beta_2 + \frac{\sin\beta_2}{\sin\alpha_2})\cos\alpha_2}$$

$$N5 = \frac{\frac{43.4\cos 72°}{\sin 72°} + 16.6 - 8.43}{(\cos 48° + \frac{\sin 48°}{\sin 72°})\cos 72°}$$

$$N5 = \frac{14.1 + 16.6 - 8.43}{0.6691 = 0.2414} = 24.8\text{kN (tension)}$$

To calculate N6 tube load, then:

$N6V = N2V$ (vertical components of the forces at that node joint)

$$N6\sin\beta_3 = N2\sin\beta_1$$

$$N6\sin 60° = N2\sin 79°$$

$$N6 = \frac{44.3\sin 79°}{\sin 60°} = 50.2\text{kN}$$

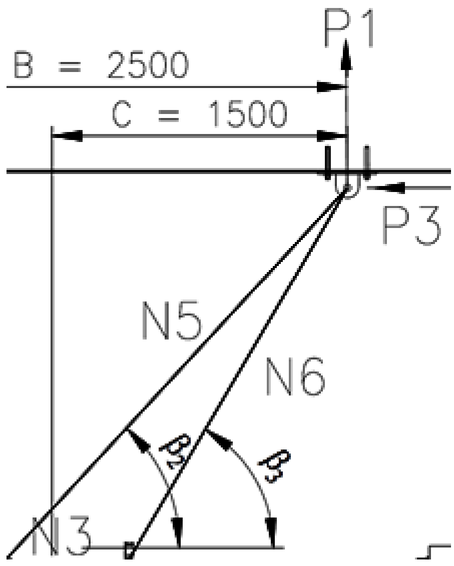
To calculate P3 bracket shear force, then:

$$\Sigma H = 0$$

$$P3 = N5\cos\beta_2 + N6\cos\beta_3$$

$$P3 = -24.8\cos 48° + 50.2\cos 60°$$

$$P3 = 8.5\text{kN (bracket shear)}$$



In summary, the bracket loads have been calculated as Bracket 1 at 25.4 tension and 8.5kN in shear. Bracket 2 at 25.4kN and 8.1kN shear. The slight imbalance is in the rounding errors in the shear loads.

The ULS bracket loads and those of the axial forces in the tie tubes below use a partial safety factor γ_Q as 1.5

In the nomenclature of the Eurocodes, these would be expressed as below:

Bracket	Serviceability Limit State		Ultimate Limit State	
1	$R_{x,k}$= -8.5kN	$R_{y.k}$=-25.4kN	$R_{x1,Ed}$=-12.75kN	$R_{y1.Ed}$=-38.1kN
2	$R_{x,k}$=8.1kN	$R_{y.k}$=25.4kN	$R_{x2,Ed}$= 12.15kN	$R_{y2.Ed}$= 38.1kN

Tie tube loads are:

Tie Tube	Serviceability Limit State	Ultimate Limit State
N4	$N_{k,4}$ = 26.4kN	$N_{Ed,4}$ = 39.6kN
N5	$N_{k,5}$ = -24.8kN	$N_{Ed,5}$ = -37.2kN
N6	$N_{k,6}$ = 50.2kN	$N_{Ed,6}$ = 75.3kN

A.4 Example calculation of the reactions and tie tube loads for a twin sway brace tie.

The above calculation has been undertaken for a single sway brace, the calculation below will use the same mast centreline loads but with the addition of the second sway brace in order to assess the effect on the tie tube leg loads and the tie bracket loads.

In this case, the tie system is considered as rigid, thus the bolt group or cast-in fixings used to secure the wall bracket to the supporting structure can be assessed as rotating around the point where the line of force intersects with the concrete face of the other bracket. It should be noted that line of force is likely to not be on the centreline of the other bracket. The resulting bracket load can then be divided by two to calculate the bolt forces.

There is no need to resolve the local bolt / anchor forces by taking moments about the corner/fulcrum of the local anchor bracket. This is because the individual brackets are part of a rigid system so will not be able to locally rotate if the system is locked rigidly.

$$N2 = \frac{Ry + Rx \tan\alpha_1}{\cos\beta_1 . \tan\alpha_1 + \sin\beta_1}$$

$$N2 = \frac{0 + 16.9 \tan 79°}{\cos 79° . \tan 79° + \sin 79°}$$

$$N2 = \frac{86.94}{0.9816 + 0.9816} = 44.2\text{kN}$$

$$N1 = \frac{Rx - N2 . \cos\beta_1}{\cos\alpha_1}$$

$$N1 = \frac{16.9 - 44.28 \cos 79°}{\cos 79°} = \frac{16.9 - 8.45}{0.191} = 44.3\text{kN}$$

Given the double tie tube / bracing from each vertical pipe, the value of N3 will tend to zero and all the load will pass into the tie legs.

$$N6 = \frac{-N1(\cos\alpha_1 . \tan\alpha_2 - \sin\alpha_1)}{\cos\beta_2 . \tan\alpha_2 + \sin\beta_2}$$

$$N6 = \frac{-44.3(\cos 79° . \tan 72° - \sin 79°)}{\cos 48° . \tan 72° + \sin 48°}$$

$$N6 = \frac{-44.3 \text{ x} - 0.394}{2.803} = 6.2\text{kN}$$

$$N4 = \frac{N1 . \cos\alpha_1 + N6 . \cos\beta_2}{\cos\alpha_2}$$

$$N4 = \frac{44.3 \cos 79° + 6.2 \cos 48°}{\cos 72°}$$

$$N4 = \frac{12.60}{0.309} = 40.8\text{kN}$$

$$N5 = \frac{N2(\sin\beta_1 - \cos\beta_1 . \tan\beta_3)}{\sin\alpha_3 + \cos\alpha_3 . \tan\beta_3}$$

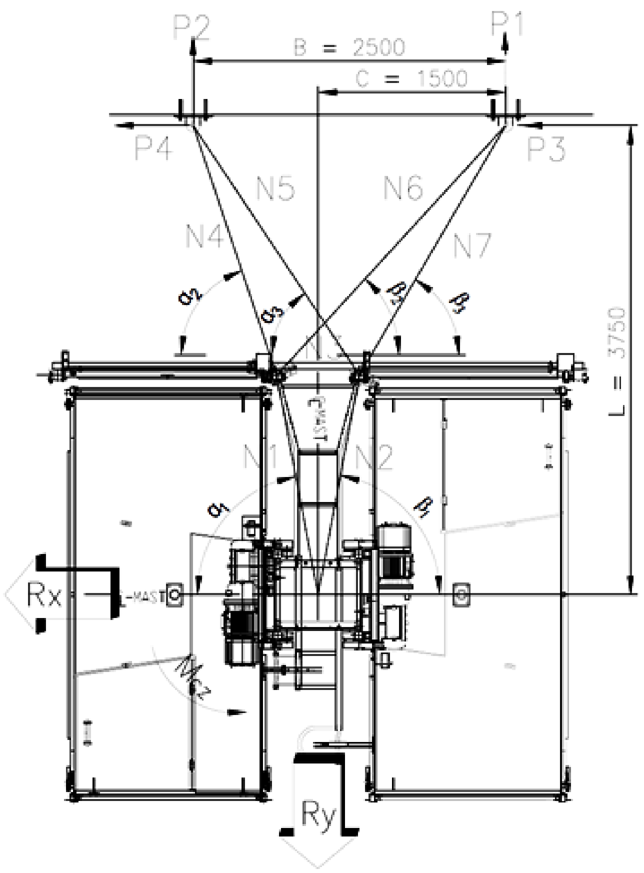
$$N5 = \frac{44.28(\sin 79° - \cos 79°.\tan 60°}{\sin 56° + \cos 56°.\tan 60°}$$

$$N5 = \frac{44.28 \text{ x } 0.6511}{1.798} = 16.0\text{kN}$$

$$N7 = \frac{N2.\cos\beta_1 + N5.\cos\alpha_3}{\cos\beta_3}$$

$$N7 = \frac{44.28\cos 79° + 16\cos 56°}{\cos 60°}$$

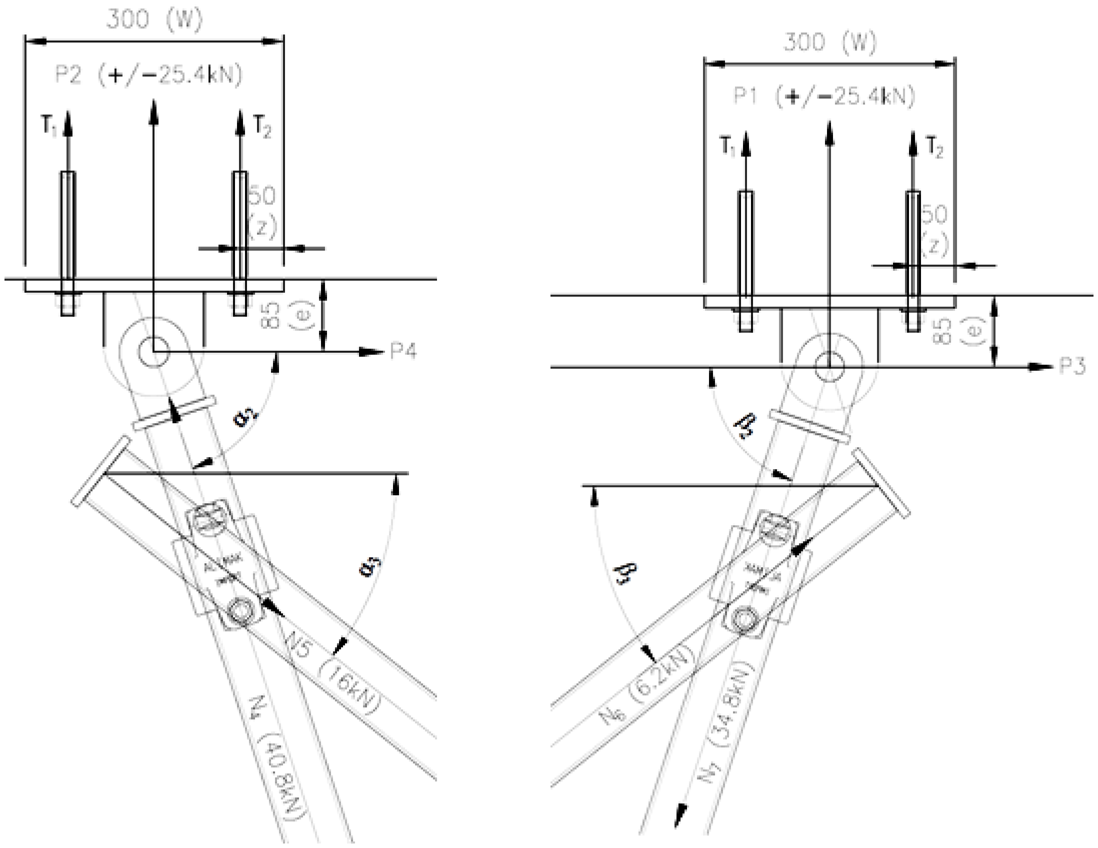
$$N7 = \frac{17.396}{0.5} = 34.8\text{kN}$$



Considering the twin sway brace option where:

α2= 72°, α3= 56°, β2= 48° & β3=60° with α1= β1= 79°

Figure A3 – Tie Fixing Reaction Example – Twin Sway Brace



Considering the twin sway brace option where:
$\alpha 2 = 72°$, $\alpha 3 = 56°$, $\beta 2 = 48°$ & $\beta 3 = 60°$ with $\alpha 1 = \beta 1 = 79°$:

Figure A4 – Tie Bracket Reaction (shear) Example – Twin Sway Brace

Bracket 1 (P3) bracket shear force: $\Sigma H = 0$

$$P3 = N7\cos\beta_3 - N6\cos\beta_2$$

$$P3 = 34.8\cos 60° - 6.2\cos 48° = 13.3\text{kN}$$

Bracket 2 (P4) bracket shear force: $\Sigma H = 0$

$$P4 = N4\cos\alpha_2 - N5\cos\alpha_3$$

$$P4 = 40.8\cos 72° - 16\cos 56 = 3.66\text{kN}$$

Check: does P3 + P4 = Rx? Yes: 13.3+3.66 = 16.96kN comparable to 16.9kN

In summary, the bracket loads for the twin sway brace option have been calculated as Bracket 1 at 25.4 tension and 13.3kN in shear. Bracket 2 at 25.4kN and 3.7kN shear. The slight imbalance is in the rounding errors / accuracy of measuring the angles in the shear loads.

The ULS bracket loads and those of the axial forces in the tie tubes below use a partial safety factor γ_Q as 1.5

In the nomenclature of the Eurocodes, these would be expressed as below:

Bracket	Serviceability Limit State		Ultimate Limit State	
1	$R_{x,k}$= -13.3kN	$R_{y.k}$= - 25.4kN	$R_{x1,Ed}$= - 20.0kN	$R_{y1.Ed}$= - 38.1kN
2	$R_{x,k}$= - 3.7kN	$R_{y.k}$= 25.4kN	$R_{x2,Ed}$= - 5.6kN	$R_{y2.Ed}$= 38.1kN

Tie tube loads are:

Tie Tube	Serviceability Limit State	Ultimate Limit State
N4	$N_{k,4}$ = 40.8kN	$N_{Ed,4}$ = 61.2kN
N5	$N_{k,5}$ = -16kN	$N_{Ed,5}$ = -24kN
N6	$N_{k,6}$ = 6.2kN	$N_{Ed,6}$ = 9.3kN
N7	$N_{k,7}$ = -34.8kN	$N_{Ed,6}$ = -52.2kN

Based on the above information, it is possible to design the tie tubes / fittings and also to calculate the loads in the anchor bolts.

A.5 Consideration of loads in the tubes and fittings

It can be seen from the worked examples above, that adding the second sway brace reduces the high tube load in the single sway brace option. This reduces the compression (buckling) load and will help where the slip load in the tube is compared to the slip resistance in the connection fitting.

The hoist manufacturer's tie tube attachment / fitting should be checked against the applied loads in the bracing tubes. In the single sway brace example, the fitting must resist 50kN (characteristic / working load) compared to 40kN in the twin sway brace option. This is particularly relevant where the loads are at the slip capacity of the clips. Comparing these loads to the image in **Figure A5** below, the slip capacity is 72kN, so the tie system works. It is possible to see that a traditional class B scaffold fitting which has a slip capacity of 9.1kN will not be sufficient. Care must be taking if substituting the original equipment manufacturer's fittings for alternatives. Ensure that suitable and comparative test results are provided for the alternative before considering the substitution.

Braking load	129 kN
Slip force	90 kN
Allowable force	**72 kN**
SF	1.8

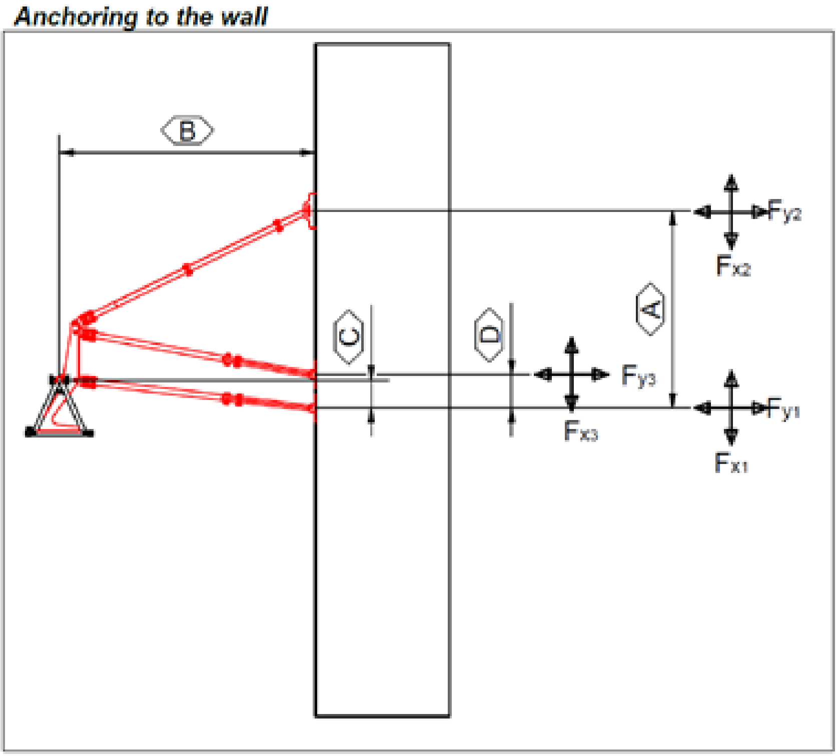
Figure A5 – Example fitting and capacity when checking tie tube connections

The loads vary in direction, so typically a +/- value is applied to the figures to cope with all eventualities of wind and load placement.

Summary bracket load for the fixing assessment would be +/-25kN and +/-14.0kN. These values should now be used to select the fixings / anchor system required to attach the hoist ties to the structure.

When using a standard anchor design package, the chosen anchor may be shown as not able to take the required load. In this case consult the anchor supplier who may be able to offer a bespoke solution. Care should be taken determine whether the loads are factored or unfactored. Hoist manufacturers generally supply loads that are unfactored. In terms of anchor design, these values are described as “characteristic” or “unfactored”.

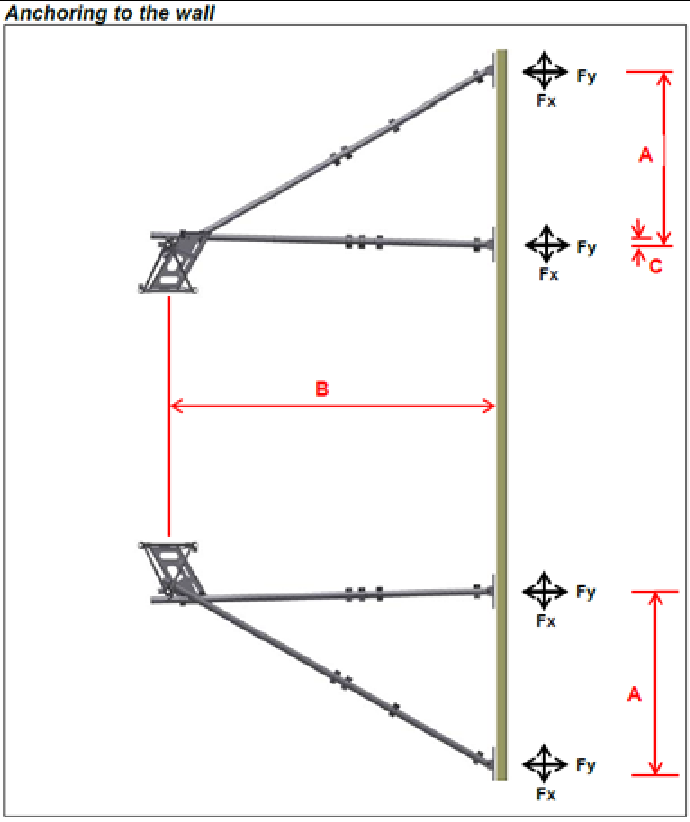
The tie forces shown in this example are for a large single mast heavy duty hoist. **Figures A6** and **Figure A7** show examples of typical tie forces for smaller single and twin mast hoists.



Platform "C" (1.4 m x 3.2 m)				Table for max. wall distance (B_{max})			
Vertical anchoring distance				9 m			
Load capacity				max. 1000 kg			
Horizontal anchoring distance, external				**A** = 2.50 m			
Distance circular mast tube to wall				**B** = 2.25 m			
Distance circular mast tube to inner wall tie				**C** = 0.25 m			
Horizontal anchoring distance, internal				**D** = 0.30 m			
Specifications in accordance with EN 12158-1: 2000				Upper anchoring for mast projection **4.5 m**		All anchor points without mast projection	
Wind speed	**Wind load / dynamic pressure**	**Wind region**		**Fx1**	**Fy1**	**Fx1**	**Fy1**
202.5 km/h	1977 N/m²	A - E		1.9 kN	16.9 kN	1.5 kN	13.9 kN
				Fx2	**Fy2**	**Fx2**	**Fy2**
202.5 km/h	1977 N/m²	A - E		8.1 kN	10.3 kN	6.8 kN	8.5 kN
				Fx3	**Fy3**	**Fx3**	**Fy3**
202.5 km/h	1977 N/m²	A - E		1.7 kN	11.5 kN	1.5 kN	10.4 kN

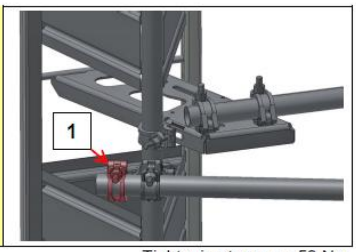
Figure A6 – Typical Tie Forces for a Lightweight Single Mast Hoist

Anchoring to the wall



Assembly in front of a wall							
Platform C, D, E, ED							
Load capacity				max. 2000 kg			
Vertical anchoring distance				10 m			
Horizontal anchoring distance, external				**A** = 1.2 m			
Distance circular mast tube to wall				**B** = 1.6 m			
Distance circular mast tube to inner wall anchoring				**C** = 0.28 m (platform **without** assembly bridge)			
Specifications according to EN 12158-1: 2000				Upper anchoring for mast projection 6m		All anchor points without mast projection	
Wind speed	Wind load / dynamic pressure	Wind region		Fx	Fy	Fx	Fy
135 km/h	879 N/m²	A / B		3.1 kN	6.2 kN	2.6 kN	4.5 kN
158 km/h	1196 N/m²	C		3.1 kN	6.2 kN	2.7 kN	4.6 kN
180 km/h	1562 N/m²	D		3.5 kN	6.2 kN	3.5 kN	6.1 kN
203 km/h	1977 N/m²	E		*4.4 kN	*7.7 kN	*4.4 kN	*7.7 kN

☞ **For tie forces identified with ∗, an additional clamp (1) must be installed on the bracing tube.**



Tightening torque = 50 Nm

Figure A7 – Typical Tie Forces for a Lightweight Twin Mast Hoist

A.6 Example calculation of the anchor bolt loads given loads at an eccentric tie tube pin.

Once the load is known at the pin or connection point of the tie bracket, then the forces can be resolved to provide the individual anchor loads. The anchor loads must now be calculated to allow for the type and size of bracket. The example that follows is using the values of pin load for the single sway brace example.

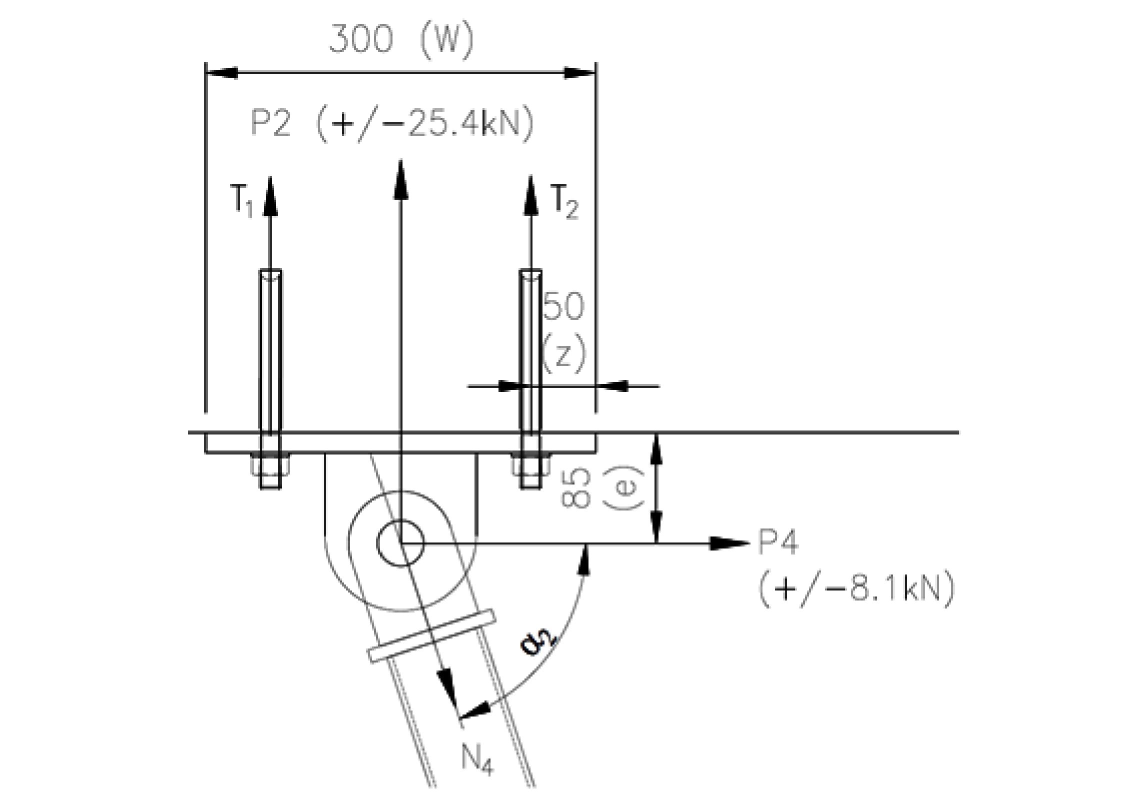


Figure A8 – Tie Bracket & Resin Anchor Example

The formulae to calculate the bolt loads is shown below and assumes a stiff bracket. It also shows the partial factor applied to the characteristic bracket loads that were calculated in the earlier section.

$$T1 = \frac{P2.\gamma_Q(0.5W - z) + (P4.\gamma_Q.e)}{W - 2z}$$

$$T1 = \frac{25.4 \text{ x } 1.5(01.15 - 0.05) + 8.1 \text{ x } 1.5 \text{ x } 0.085}{0.3 - 0.1}$$

$$T1 = \frac{3.81 + 1.083}{0.2} = 24.47\text{kN}$$

$$T2 = P2.\gamma_Q - T1$$

$$T2 = 25.4 \text{ x } 1.5 - 24.47 = 13.7\text{kN}$$

The shear applied to the bolts will be identical = $8.1\text{kN x } \frac{1.5}{2} = 6\text{kN}$

The worst-case bolt loads to be used for the design of the anchors is therefore:

tension load (ULS) N_{Sd} = 25kN and shear V_{Sd}= 6kN.

Anchor Solution(s)

RESIN OPTION: Hilti HIT- HY200-A with HIT-Z M16 anchor rod. Injection mortar with 96 mm embedment, M16, Hot dip galvanized, Hammer drilling installation per ETA 11/0493

EXPANDING ANCHOR OPTION: Hilti HST3 M16 with 85mm effective embedment but with suitable annular gap filling solution. Hammer drilling installation per ETA 11/0493

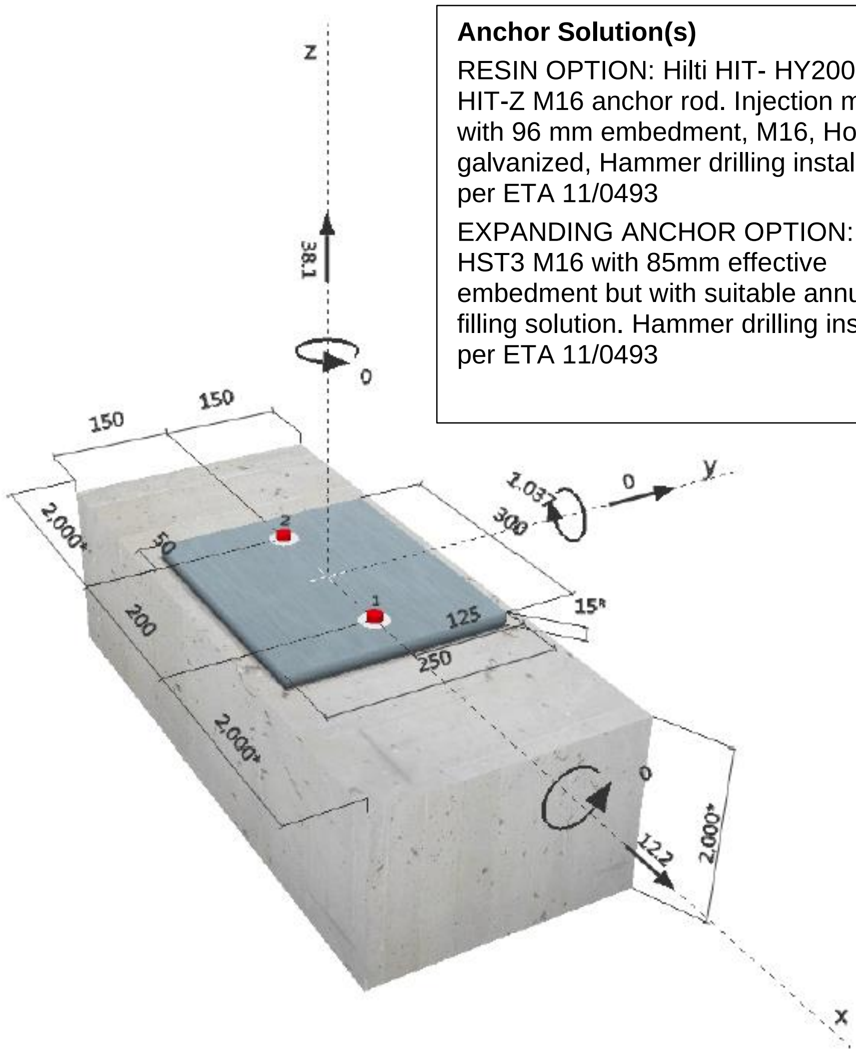


Figure A9 - Hilti Profis Model of Tie Bracket Attachment

NOTE**:** *The values for the applied loads are shown with partial factors applied. The stand-off / eccentricity of the bracket/tie pin is modelled as a moment about the y-axis in the example above. The previous manual calculation also allows for this stand-off*

The method above results in a M16 anchor. An expanding anchor result or resin anchor option are both shown above.

As mentioned previously, there are two possible methods of calculation of the tie in a twin sway brace solution:

1. Consider the load applied at the pin on and the anchor bracket (as already demonstrated above;
2. Take moments about the centre of force in the other bracket (assuming a rigid tie system).

In option two, the tension load per anchor would be the bracket reaction divided by two, however, the forces should be calculated at the line of force intersection with the tie bracket / slab edge interface

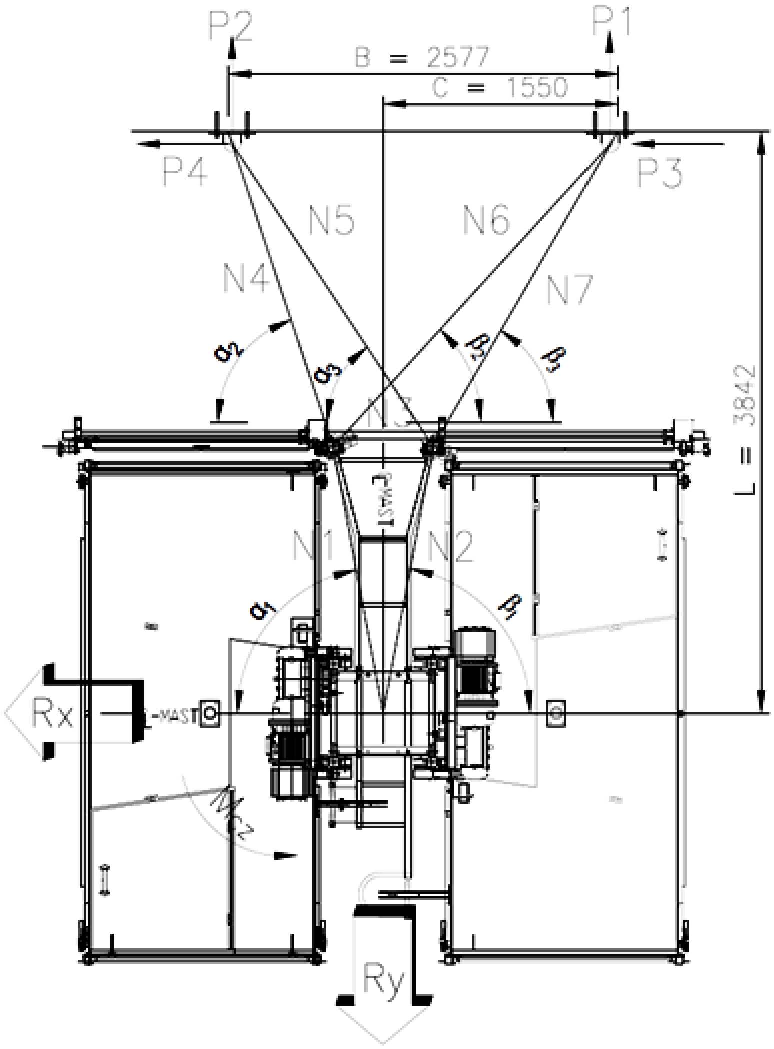


Figure A10 - Double Sway Brace – anchor load simplified method

Taking moments about P2 gives $P1.B = (Rx.L) + Ry(B - C) + Mcz$

This makes the reaction $$P1 = \frac{3.824Rx + Ry(2.577 - 1.55) + Mcz}{2.577}$$

Or $$P1 = \frac{1.49Rx + 0.399Ry + Mcz}{2.5}$$

Taking moments about P1 gives $P2.B + Rx.L = Ry.C + Mcz$

Or $2.577P2 + 3.842Rx = 1.55Ry + Mcz$

Therefore $$P2 = 0.601Ry - 1.49Rx + \frac{Mcz}{2.577}$$

So $P1 = 1.49 \text{ x } 16.9 + 0.399 \text{ x } 0 = 25.2\text{kN}$

$P2 = 0.601 \text{ x } 0 - 1.49 \text{ x } 16.9 = -25.2\text{kN}$

Applying the partial safety factor 1.5 and dividing by two in order to calculate the actual bolt tension, the value = 18.9kN (ULS). This value is less than the calculated 24.9kN when considering local forces in the bracket and is due to the assumption of a rigid system.

The actions (loads) calculated for the above example are all characteristic (unfactored), unless stated otherwise. **Figure A11** helps to explain the reasons why partial safety factors are applied to these values.

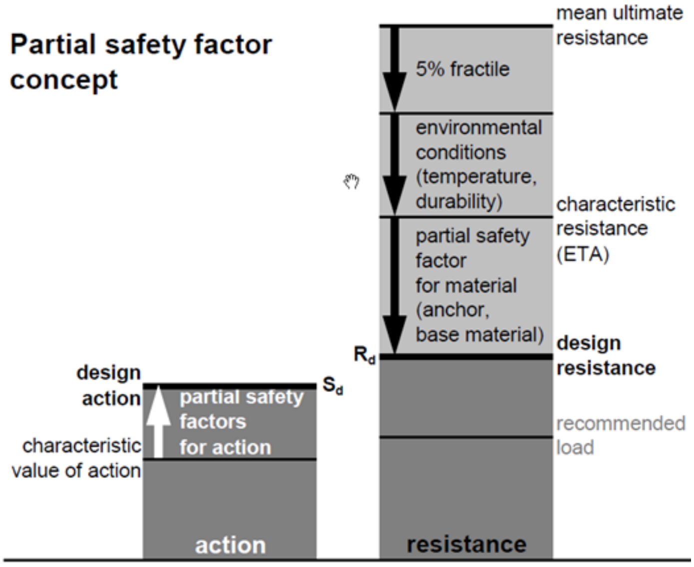
Safety concept

Depending on the application and the anchor type one of the following two concepts can be applied:

For anchors for use in concrete having an European Technical Approval (ETA) the partial safety factor concept according to the European Technical Approval Guidelines ETAG 001 or ETAG 020 shall be applied. It has to be shown, that the value of design actions does not exceed the value of the design resistance: $S_d \leq R_d$.

For the characteristic resistance given in the respective ETA, reduction factors due to e.g. freeze/thaw, service temperature, durability, creep behaviour and other environmental or application conditions are already considered.

In addition to the design resistance, in this manual recommended loads are given, using an overall partial safety factor for action γ = 1,4.



NOTE: *The Hilti partial safety factor for action γ = 1.4 is taken from Clause A.2.2 of BS 8539:2012, Code of practice for the selection and installation of post-installed anchors in concrete and masonry states:*

Values for γ_G and γ_Q are given in ETAG 001, Annex C [5] (and taken from BS EN 1990) as 1.35 and 1.5 respectively (see Annex E for a guide to which actions may be regarded as permanent and which variable). For the general case, and where the distinction between the permanent and variable actions is unknown or unclear, the partial safety factor for action may be taken as 1.4.

The recommendation of this guidance document is to use a partial factor of γ = 1.5 as this is a commonly used factor in temporary works and the majority of actions (loads) associated with hoists are variable.

Figure A11 – Safety Concept

The loads applied to the brackets and anchors are considered to be ‘non-static actions’. They are not shock or seismic loads, but are fatigue inducing. However due to the applied anchor torque and design methods outlined in the guidance, fatigue is not usually a problem on the typical short duration hoist projects. BS 8539:2012, *Code of Practice for the selection and installation of post-installed anchors in concrete and masonry* provides guidance on the process of selection and installation of the anchors.

Annex B – Construction Hoist Foundation Bolt Tension Calculation

The base loads supplied by the hoist manufacturer can be used to calculate the holding down bolt/anchor tension. The tension in the four bolts connecting the base frame to the support can be calculated using the following equation. **Figure B.1** shows a typical mast and bolt configuration and the loads in relation to the mast.

$$Bolt\ Tension\ [kN] = \frac{M_x}{2w} + ((d+l) \times \frac{M_y}{2d^2 + (l+d)^2})$$

Where:

M_x - Overturning moment around the x axis [kNm]
M_y - Overturning moment around the y axis [kNm]
w - Width between bolts [m]
l - Length between bolts [m]
d - Distance from bolt to edge of mast [m]

Example values:

$w = 0.96m$
$l = 0.38m$
$d = 0.135m$

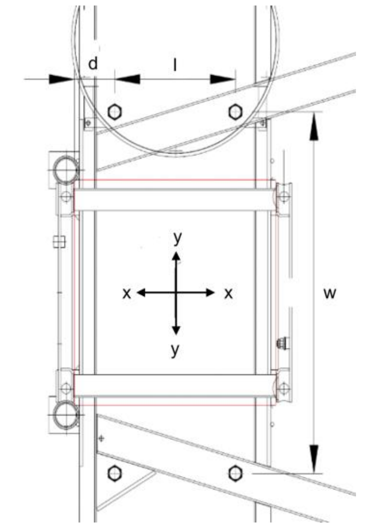


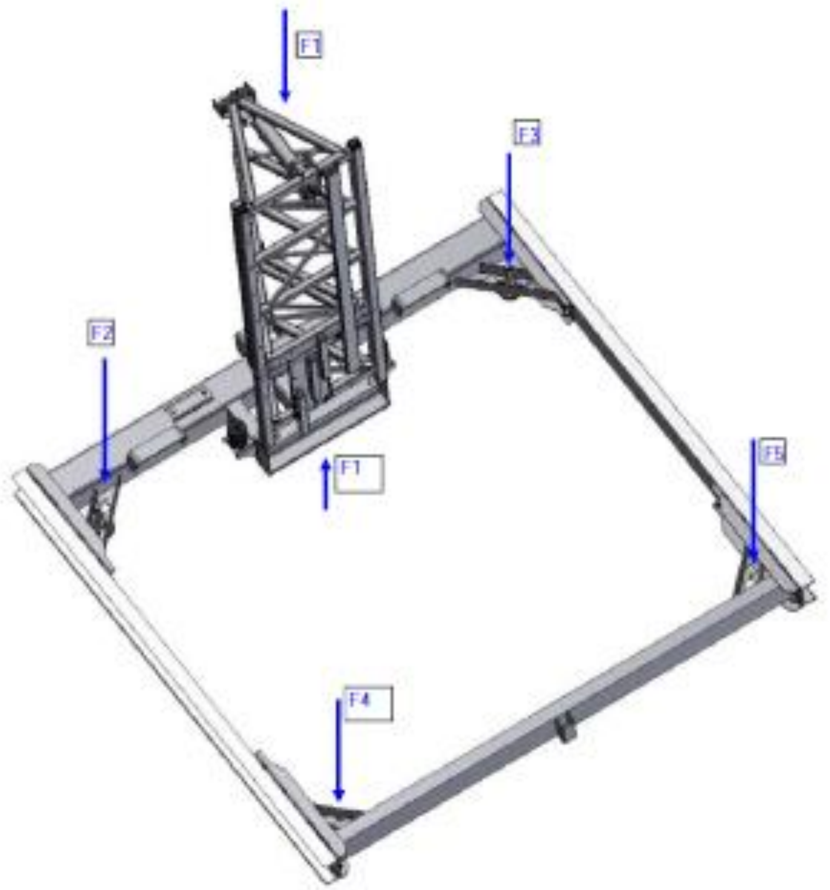
Figure B.1

	Hoist without ties	**Hoist with 2 ties**
M_x [kNm]	5.654	0.354
M_y [kNm]	150.326	53.374
Bolt Tension	$= \frac{5.654}{2 \text{ x } 0.96} + ((0.135 + 0.38) \text{ x } \frac{150.326}{2 \text{ x } 0.135^2 + (0.38 + 0.135)^2})$ $= 139.5\text{kN (unfactored)}$	$= \frac{0.354}{2 \text{ x } 0.96} + ((0.135 + 0.38) \text{ x } \frac{53.374}{2 \text{ x } 0.135^2 + (0.39 + 0.135)^2})$ $= 48.7\text{kN(unfactored)}$

This example shows the significant difference that can exist between the bolt forces at the base frame anchor of a freestanding hoist and the tied hoist.

Many hoist suppliers will reduce the height to the first tie in order to reduce the bolt anchor loads.

The following example shows a 1000kg capacity single mast transport platform erected to 15m and tied to the adjacent structure at 3m and 12m.



F_1 = 2226 kg (maximum force during erection up to first tie at 3m)

F_1 = 2953 kg (maximum force with hoist stationary - loading and unloading)

F_1 = 3383 kg (maximum force with hoist starting, running and stopping)

F_1 = 3580 kg (maximum force during operation of safety device)

F_2 = 354 kg (maximum jack loads)

F_3 = 354 kg (maximum holding down bolt force)

F_4 = 535 kg (maximum holding down bolt force)

F_5 = 535 kg (maximum holding down bolt force)

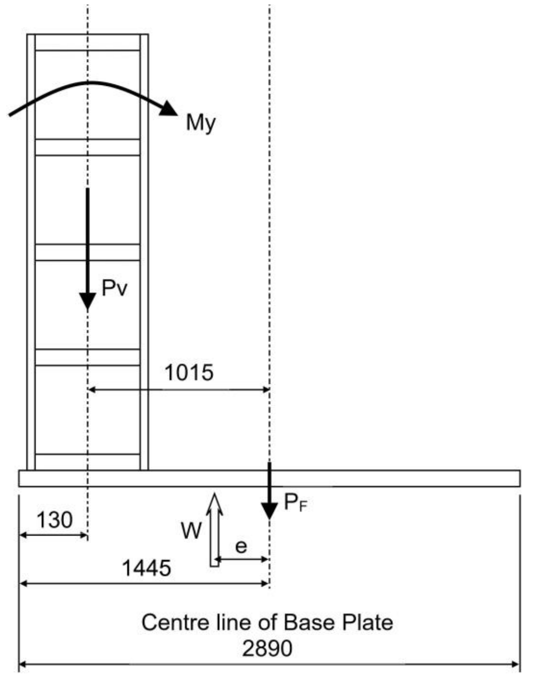
Figure B.2

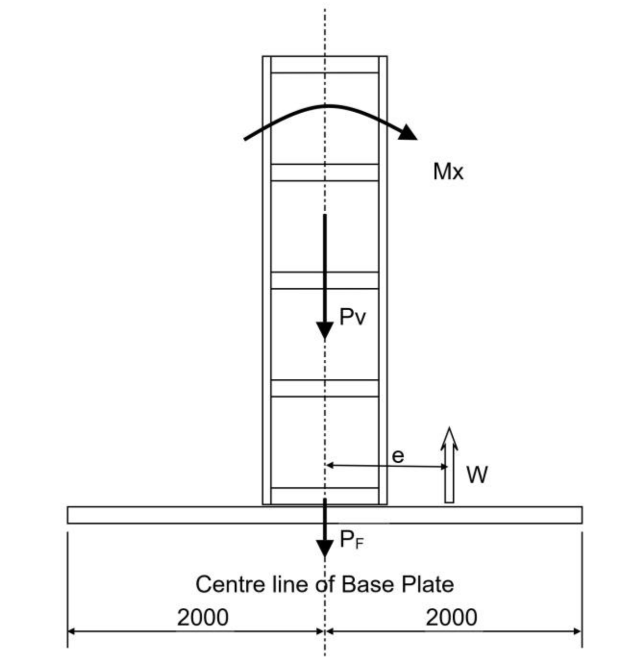
Annex C – Foundation Bearing Pressure Calculation Method

The following is a method of calculating the bearing pressures under a hoist foundation. Two example cases are considered. This method applies partial safety factors to the loads. No assessment is made as to the adequacy of the bearing medium beneath. This is the role of the Principal Contractor rather than the hoist supplier/installer.

NOTE: *The uplift value of force generated by a buffer strike has been ignored in the following calculations as this would have a relieving effect.*

The self-weight elements of the hoist and base plate are given are treated identically to the overturning forces in order to give a conservative bearing pressure





Hoist just prior to its first tie being installed. Moments about the x-axis (factored).	Hoist that has already been tied Moments about the y-axis (factored)
Figure C.1 – Case 1	**Figure C.2 – Case 2**

<table>
<tr><th colspan="2">CASE 1: Hoist with no ties, low height</th><th colspan="2">CASE 2: Hoist with 2 ties, taller than Case 1</th></tr>
<tr><td>VERTICAL</td><td>$Dead\ Load = 126 \times 1.6 = 202kN$
$Plate\ Load = 46 \times 1.6 = 74kN$</td><td>VERTICAL</td><td>$Dead\ Load = 182 \times 1.6 = 291kN$
$Plate\ Load = 46 \times 1.6 = 74kN$</td></tr>
<tr><td>HORIZONTAL</td><td>$M_x = 5.7 \times 1.6 = 9.1kNm$
$M_y = 150 \times 1.6 = 240kNm$</td><td>HORIZONTAL</td><td>$M_x = 0.35 \times 1.6 = 0.56kNm$
$M_y = 53.4 \times 1.6 = 85.4kNm$</td></tr>
<tr><td colspan="2">OT Moment x-x around base centre line
$M = 240 - 202 \times 1.015 = 34.97kNm$
$\frac{M}{w} = \frac{34.97}{202 + 74} = 0.127m = e$
$\frac{e}{b} = \frac{(0.127)}{2.89} = 0.044$</td><td colspan="2">OT Moment x-x around base centre line
$M = 85 - 291 \times 1.015 = -210.4kNm$
$\frac{M}{w} = \frac{-210.4}{291 + 74} = -0.576m = e$
$\frac{e}{b} = \frac{0.576}{2.89} = 0.199$
(note the minus sign means the eccentricity is on the opposite side of the centreline, which in this case means it is closer to the mast)</td></tr>
<tr><td colspan="2">OT moment y-y around the left hand end of the steel foundation plate
$M = 9.1 + 2 \times (202 + 74) = 561kNm$
$\frac{M}{w} = \frac{561}{202 + 74} = 2.03m$
$\frac{e}{a} = \frac{(2 - 2.03)}{4} = 0.008$

Using the table in Annex D and the values of e/a and e/b it is possible to derive a factor to adjust the average pressure for the effect of the overturning moment. In this example:
$^{e}/_{b} = 0.044\ and\ ^{e}/_{a} = 0.008$
$c = 1.35$
$Peak\ pressure = \frac{cw}{ab} = \frac{1.35 \times (202 + 74)}{2.89 \times 4} = 32kNm^{-2}$
This is the pressure experienced under the edge of the foundation plate. It is not a uniform pressure under the full width of the plate, which is a factor of 1.35 less.</td><td colspan="2">OT moment y-y around the left hand end of the steel foundation plate
$M = 0.56 + 2 \times (291 + 74) = 731kNm$
$\frac{M}{w} = \frac{731}{291 + 74} = 2.003m$
$\frac{e}{b} = \frac{2 - 2.003}{4} = 0.001$

Using the table in Annex D and the values of e/a and e/b it is possible to derive a factor to adjust the average pressure for the effect of the overturning moment. In this example:
$^{e}/_{b} = 0.001\ and\ ^{e}/_{a} = 0.199$
c = 2.35
$Peak\ pressure = \frac{cw}{ab} = \frac{2.35 \times (291 + 74)}{2.89 \times 4} = 74kNm^{-2}$
This is the pressure experienced under the edge of the foundation plate. It is not a uniform pressure under the full width of the plate, which is a factor of 2.35 less.</td></tr>
<tr><td colspan="2">$Average\ pressure = \frac{w}{ab} = \frac{202 + 74}{2.89 \times 4} = 23.9kNm^{-2}$</td><td colspan="2">$Average\ pressure = \frac{w}{ab} = \frac{291 + 74}{2.89 \times 4} = 31.6kNm^{-2}$</td></tr>
<tr><td colspan="4">NOTE: refer to Annex D for the chart used to convert the eccentricity to length ratios to the enhanced edge bearing factors needed to calculate the edge bearing pressure</td></tr>
</table>

Effect of a hoist striking the buffers

If considering the effect of the hoist striking the buffers, even in an untied case, where there would be an increased likelihood of overturning, the hoist would need to be very light before such a possibility were to arise. The following example shows the principle of a check:

Declared buffer load = 238kN shared between 3 buffers. 2 at 38%, 1 at 24%. There is also an 88kN uplift created by the effect of the buffer strike. This occurs in the mast.

Pb1, Pb2 combined = 238 x 0.76 = 181kN

Pb3 = 238 x 0.24 = 57kN

Taking moments about the plate centreline gives:

(88 x 1.015) – (181 x 0.565) + (57 x 0.185) = -150 x e

-2.4 = -150e

Giving e = 0.016m

In this case there is very little eccentricity and so uniform base loads give an acceptable allowance to allow for this.

In the case where calculated bearing pressures are negative a competent temporary works engineer should be consulted.

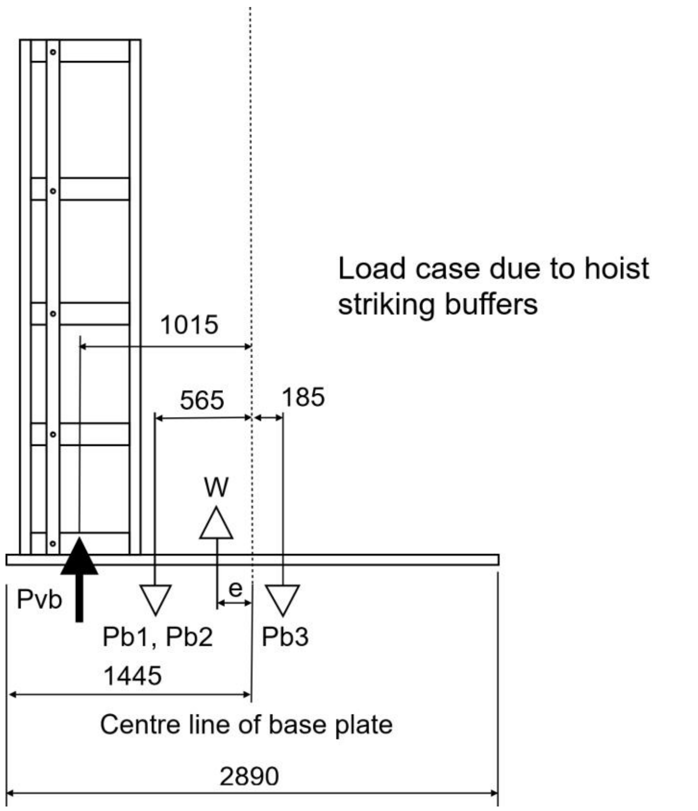


Figure C.3 – Buffer Strike Load Case

Annex D – Lines of Pressure at Intersection of Components of Forces

Below is a table from the Minutes of Proceedings of the Institution of Civil Engineers, Vol CLXV (1906) Paper No. 3592 by Frederick Karl Esling entitled *“A problem relating to railway-bridge piers of masonry or brickwork”*. It allows a foundation with a double eccentricity to be assessed for the peak edge pressures.

TABLE I.- LINES OF PRESSURE AT INTERSECTIONS OF COMPONENTS OF FORCES

Component = Breadth of Foundation multiplied by	e/b \ e/a	Component = Length of Foundation multiplied by																
		0	0.025	0.050	0.075	0.100	0.125	0.150	0.175	0.200	0.225	0.250	0.275	0.300	0.325	0.350	0.375	0.400
	0	1.00	1.15	1.30	1.45	1.60	1.75	1.90	2.05	2.22	2.43	2.67	2.96	3.33	3.87	4.44	5.33	6.67
	0.025	1.15	1.30	1.45	1.60	1.75	1.90	2.05	2.21	2.39	2.61	2.87	3.18	3.58	4.08	4.77	5.73	7.18
	0.050	1.30	1.45	1.60	1.75	1.90	2.05	2.21	2.38	2.58	2.81	3.09	3.43	3.87	4.41	5.16	6.17	7.73
	0.075	1.45	1.60	1.75	1.90	2.05	2.20	2.37	2.56	2.78	3.03	3.33	3.70	4.16	4.74	5.56	6.66	8.30
	0.100	1.60	1.75	1.90	2.05	2.20	2.37	2.56	2.76	2.99	3.27	3.60	3.99	4.48	5.14	5.99	7.16	9.00
	0.125	1.75	1.90	2.05	2.20	2.37	2.56	2.75	2.97	3.24	3.54	3.90	4.32	4.81	5.57	6.47	7.78	9.74
	0.150	1.90	2.05	2.21	2.37	2.56	2.75	2.96	3.22	3.51	3.84	4.22	4.66	5.28	6.03	7.04	8.45	10.60
	0.175	2.05	2.21	2.38	2.56	2.76	2.97	3.22	3.50	3.81	4.16	4.55	5.08	5.73	6.55	7.66	9.17	11.50
	0.200	2.22	2.39	2.58	2.78	2.99	3.24	3.51	3.81	4.13	4.50	4.97	5.54	6.24	7.12	8.33	9.98	-
	0.225	2.43	2.61	2.81	3.03	3.27	3.54	3.84	4.16	4.50	4.93	5.48	6.05	6.83	7.82	9.13	10.90	-
	0.250	2.67	2.87	3.09	3.33	3.60	3.90	4.22	4.55	4.97	5.48	6.00	6.67	7.50	8.57	10.00	12.00	-
	0.275	2.96	3.18	3.43	3.70	3.99	4.32	4.66	5.08	5.54	6.05	6.67	7.41	8.37	9.55	11.10	-	-
	0.300	3.33	3.58	3.87	4.16	4.48	4.81	5.28	5.73	6.24	6.83	7.50	8.37	9.37	10.80	-	-	-
	0.325	3.87	4.08	4.41	4.74	5.14	5.57	6.03	6.55	7.12	7.82	8.57	9.55	10.80	-	-	-	-
	0.350	4.44	4.77	5.16	5.56	5.99	6.47	7.04	7.66	8.33	9.13	10.00	11.10	-	-	-	-	-
	0.375	5.33	5.73	6.17	6.66	7.16	7.78	8.45	9.17	9.98	10.90	12.00	-	-	-	-	-	-
	0.400	6.67	7.18	7.73	8.30	9.00	9.74	10.60	11.50	-	-	-	-	-	-	-	-	-

The following general conclusions can be drawn from the table above:

A hoist exerts a higher bearing pressure along both the long and short foundation sides than when the average pressure is considered. The actual increase is dependent upon applied moments, applied loads and base geometry. When considering the effect of overturning on the foundation, the edge pressures are very much higher than average pressures. Average pressure calculations under-estimate the applied loads significantly. This may be significant if the hoist foundation is a weak structure, whereas ground may be able to cope with both values without any difficulty.

A competent temporary works engineer must review the various calculated pressures against the strength and stiffness of the bearing surface. Materials that cannot tolerate the high edge loads may fail structurally or may settle over time.

Annex E – Construction Hoist Temporary Works Template

NOTE: *This template can be downloaded as a Word form for on-screen completion from* https://www.cpa.uk.net/construction-hoist-interest-group/

Construction Hoist Temporary Works Report

This form to be submitted to assist the site appointed Temporary Works Coordinator in understanding the information supplied for a hoist installation and allow them to evaluate whether further information needed to make any necessary recommendations or approvals.

Note Shading = Temporary Works Responsibility

Reference:

Date:

Site Details:

Report Author:

Hoist Location:

Company:

Position:

Tel No.:

E-mail:

Hoist Information (OEM – Original Equipment Manufacturer)

Hoist Manufacturer:

Hoist Type:

Hoist Model:

Original OEM Specification: Yes ☐ No ☐

If Not Original OEM Specification Please Give Details:

Passenger & Goods ☐ Goods Only ☐ Transport Platform ☐ Twin ☐ Twin Combination ☐

Size: LxW:

Safe Working Load: Kg

No. of Landing Gates (e.g. G+4)

Are the calculations site specific?	Yes ☐	No ☐
Are the forces indicated taken from the manufacturer's manual?	Yes ☐	No ☐
Is the hoist installed in accordance with manufacturer's manual?	Yes ☐	No ☐
Is the hoist being erected/dismantled progressively?	Yes ☐	No ☐
Is Manufacturer's information supplied with this Report?	Yes ☐	No ☐
Are the hoist components all genuine manufacturer's parts e.g. Tie Brackets?	Yes ☐	No ☐

Any Further Comments:

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Base Information

Ground bearing pressure checked to withstand imposed loads by user: Yes ☐ No ☐
Site checked for presence of any services beneath hoist: Yes ☐ No ☐

Foundation Type:
Existing Ground ☐ Concrete ☐ Steel Plate ☐ Gantry ☐ Suspended Slab ☐ Scaffolding Base ☐ Other ☐
Hoist fixed at base: Yes ☐ / No ☐ Back-propping required? Yes ☐ / No ☐

Base Loads

Load Type: Installation ☐ In Service ☐

Free Standing Mast Yes ☐ No ☐ Mast Moment Mx ____ kNm Mast Moment My ____ kI

Mast Shear Rx ____ kN Mast Shear Ry ____ kI

Mast Height ____ Metres

Static load on base ____ kN Buffer Force ____ kN

Buffer Reaction ____ kN

Has a Safety Factor been included in the above forces? Yes ☐ / No ☐ Safety Factor ____ See drawing for buffer details ____

Base Fixing Method

Details of connection substrate (i.e. Slab thickness / Steel size / cracked / un-cracked etc): ____

Connection Method: Expanding Anchor ☐ Chemical Anchor ☐ Bolt Fixing ☐ Cast in Insert ☐ Welded ☐

Other? ☐ Please Specify: ____

Method used for Anchor Selection: Anchor Manufacturer's Software ☐ Anchor Manufacturer's Manual ☐ Data Sheet ☐

Details of fixing method included: Yes ☐ / No ☐ Have any additional safety factors been applied? Yes ☐ / No ☐

Design ☐ or Characteristic Load ☐

NOTE: *See drawing for fixing details* Factor applied? ____ (Or Resistance)? ____

Anchor Testing Required Yes ☐ / No ☐ Testing According to BS 8539 Or Other please specify: ____

Mast Tie Information

Calculations in accordance with: EN12159 ☐ EN12158 ☐ Wind Region...? Choose an item.

Hoist tie forces supplied......are they: In Service Loads ☐ Out of Service Loads ☐ Both in and out of service ☐

Total mast height including oversail: ____ Metres Tie Intervals ☐ Elevations ☐ ____ Metres

Height to 1st mast Tie: ____ Metres Maximum oversail? ____ Metres

NOTE: *See drawing for tie plate wall mounting details*

Please sketch hoist tie arrangement:

BUILDING / STRUCTURE LINE

/ /

NOTE: *Refer to drawing for multiple tie layouts*

NOTE: *See drawing for hoist elevation details*

Please sketch hoist tie ELEVATIONS / INTERVALS :

FOUNDATION / STRUCTURE LINE

/ /

NOTE: *Refer to drawing for multiple tie layouts*

Tie Forces

Hoist fixed to: Building ☐ Scaffolding ☐ Other ☐ Please specify

Maximum Tie Point Rx kN Maximum Tie Point Ry kN

Maximum Tie Point McZ Nm ***NOTE: Not All Manufacturers will provide this information***

Distance from C/L of mast to connection point? Metres Distance between connection points? Metres

Maximum Tensile Load kN Maximum Shear Load kN

At Pin ☐ or ☐ At Fixing? At Pin ☐ or ☐ At Fixing?

Has a Safety Factor been included in the above forces? Yes ☐ / ☐ No Safety Factor applied:

Tie Fixing Method

Hoist ties into: Concrete ☐ Masonry ☐ Stone ☐ Steelwork ☐ Scaffolding ☐ Timber ☐

Other? ☐ Please Specify

Details of connection substrate (i.e. Slab thickness / Steel size / cracked / un-cracked etc):

Connection Method? Expanding Anchor ☐ Chemical Anchor ☐ Screw Fixing ☐ Cast in Insert ☐ Scaffold Fitting ☐

Standard Tie Plates? Lindapters ☐ Bolts ☐ Clamps ☐ Welded ☐

Other? ☐ Please Specify:

Method used for Anchor Selection: Anchor Manufacturer's Software ☐ Anchor Manufacturer's Manual ☐ Data Sheet ☐

Details of fixing method included: Yes ☐ / No ☐ Have any additional safety factors been applied Yes ☐/ No ☐ Design ☐ or Characteristic Load ☐

NOTE: *See drawing for fixing details* Factor applied? (Or Resistance)?

Anchor Testing Required Yes ☐ / No ☐ Testing According to BS 8539 Or Other please specify:

Appendix

List of Included documents for reference:

Annex F – Example of a Completed Template

Construction Hoist Temporary Works Report

This form to be submitted to assist the site appointed Temporary Works Coordinator in understanding the information supplied for a hoist installation and allow them to evaluate whether further information needed to make any necessary recommendations or approvals.

Note Shading = Temporary Works Responsibility

Reference:	Client	Date:	21st Aug 2018
Site Details:	Block A Long Street London	Report Author:	RPC
Hoist Location:	Betw een GL 1-2 Along GL A	Company:	GB Access
		Position:	Technical Services Manager
		Tel No.:	01832 272 408
		E-mail:	Bob.cox@gbaccess.co.uk

Hoist Information (OEM – Original Equipment Manufacturer)

Hoist Manufacturer:	Alimak Hek	Hoist Type:	Scando 650
Hoist Model:	I25/50 (650) XL	Original OEM Specification:	Yes ☒ No ☐

If Not Original OEM Specification Please Give Details:

Passenger & Goods ☒ Goods Only ☐ Transport Platform ☐ Twin ☒ Twin Combination ☐

Size: LxW	5 x 2m	Safe Working Load	2500 Kg
No. of Landing Gates (e.g. G+4)	10 landings = 20 Gates		

Are the calculations site specific?	Yes ☒	No ☐
Are the forces indicated taken from the manufacturer's manual?	Yes ☒	No ☐
Is the hoist installed in accordance with manufacturer's manual?	Yes ☒	No ☐
Is the hoist being erected/dismantled progressively?	Yes ☒	No ☐
Manufacturer's information supplied with this Report?	Yes ☒	No ☐
Are the hoist components all genuine manufacturer's parts e.g. Tie Brackets?	Yes ☒	No ☐

Any Further Comments:

N/A

Base Information

Ground bearing pressure checked to withstand imposed loads by user? Yes ☐ No ☐
Site checked for presence of any services beneath hoist? Yes ☐ No ☐

Foundation Type?
Existing Ground ☐ Concrete ☐ Steel Plate ☒ Gantry ☐ Suspended Slab ☐ Scaffolding Base ☐ Other ☐
Hoist fixed at base? Yes ☐ / No ☐ Back-propping required? Yes ☐ / No ☐

Base Loads

Mast Height: 45.240 Metres

Static load on base: ____ kN

Dynamic load on base: 302 kN

Buffer Force: 251 kN

Dynamic Factor applied: 1.34

Safety Factor: ____

Has a Safety Factor been included in the above forces? Yes ☐ / No ☐

See drawing for buffer details: ____

Mast Tie Information

Calculations in accordance with: EN12159 ☒ EN12158 ☐ Wind Region...? Region C

Hoist tie forces supplied......are they? In Service Loads ☐ Out of Service Loads ☐ Both in and out of service ☒

Total mast height including oversail? 45.240 Metres

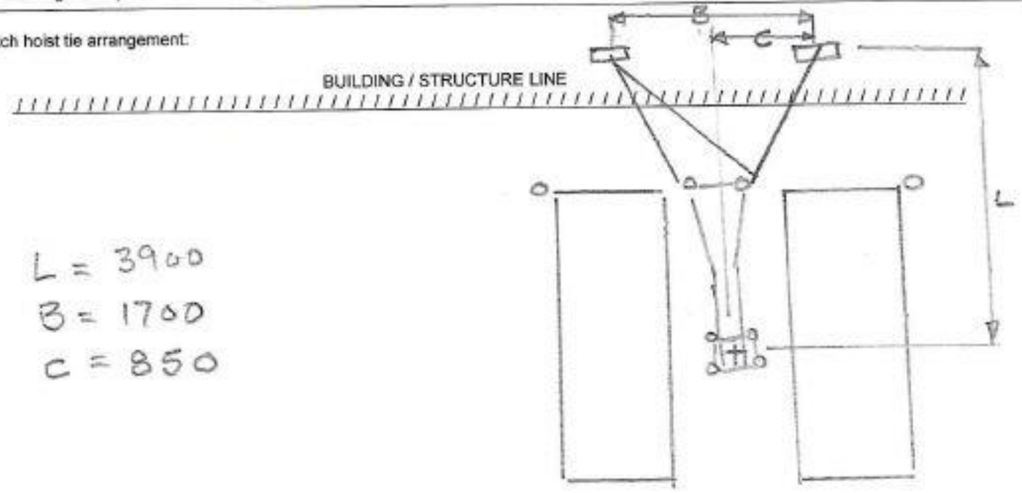
Tie Intervals ☐ Elevations ☒ 9.56, 20.73, 31.83, & 43.01 Metres

Height to 1st mast Tie? 9.56 Metres

Maximum oversail? 2.35 Metres

NOTE: *See drawing for tie plate wall mounting details*

Please sketch hoist tie arrangement:



NOTE: *Refer to drawing for multiple tie layouts*

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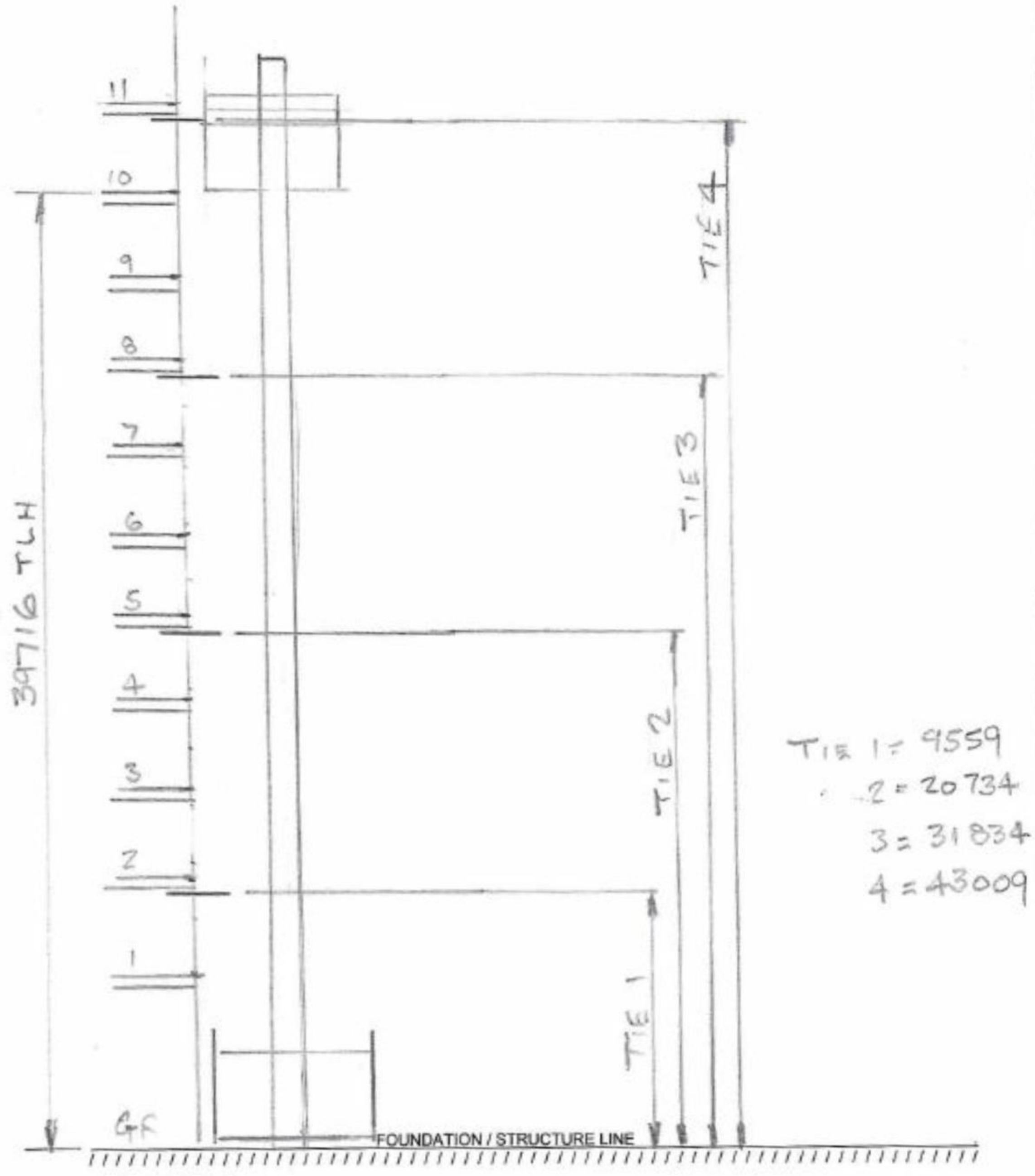
NOTE: *See drawing for hoist elevation details*

Please sketch hoist tie ELEVATIONS / INTERVALS :



NOTE: *Refer to drawing for multiple tie layouts*

Tie Forces

Hoist fixed to? Building ☒ Scaffolding ☐ Other ☐ Please specify: under side of slab

Distance from C/L of mast to connection point? 3900 Metres

Distance between connection points? 1700 Metres

Maximum Tensile Load: 38.894 kN — At Pin ☐ or ☒ At Fixing?

Maximum Shear Load: 38.835 kN — At Pin ☐ or ☒ At Fixing?

Has a Safety Factor been included in the above forces? Yes ☐ / ☒ No

Safety Factor applied:

Fixing Method

Hoist ties into? Concrete ☒ Masonry ☐ Stone ☐ Steelwork ☐ Scaffolding ☐ Timber ☐

Other? ☐ Please Specify

Details of connection substrate (i.e. Slab thickness / Steel size / cracked / un-cracked etc):

Connection Method? Expanding Anchor ☐ Chemical Anchor ☐ Screw Fixing ☐ Cast in Insert ☒ Scaffold Fitting ☐

Standard Tie Plates? Lindapters ☐ Bolts ☐ Clamps ☐ Welded ☐

Other? ☐ Please Specify:

Method used for Anchor Selection? Anchor Manufacturer's Software ☐ Anchor Manufacturer's Manual ☐ Data Sheet ☒

Details of fixing method included? Yes ☐ / No ☐

Have any additional safety factors been applied? Yes ☐ / No ☐

Design ☐ or Characteristic Load ☐

NOTE: See drawing for fixing details

Factor applied?

(Or Resistance)?

Anchor Testing Required Yes ☐ / No ☐

Testing According to BS 8539 Or Other please specify:

Appendix

List of Included documents for reference:

Alimak Hek Calculation Report L8457G
GB11993-1 to 5 Installation draw ings

Annex G -TIN 302 Construction Hoist Out-of-Service Wind Speeds

	Construction Plant-hire Association Construction Hoist Interest Group	
	Construction Hoist Technical Information Note	
TIN 302	**Construction Hoist Out-of-Service Wind Speeds**	

Introduction

When planning the installation of a construction hoist on a site the planning process must take into account both the in-service *and* the out-of-service wind speed on the hoist. The out-of-service wind speed will have an effect on both the structure, base and ties of the hoist and thus a bearing on the stability of the hoist. This Technical Information Note (TIN), which applies to all types of construction hoist, outlines the steps to be taken in assessing appropriate out-of-service wind speeds for construction hoists in the UK.

Legal Requirements

The requirement to ensure that an appropriate out-of-service wind speed is taken into account when configuring a construction hoist and designing the ties and base for a particular location is contained in several pieces of legislation:-

- Health and Safety at Work etc. Act 1974. - Sections 2 & 3
- Provision and Use of Work Equipment Regulations (PUWER) 1998 – Regulation 20
- Lifting Operations and Lifting Equipment Regulations (LOLER) 1998 – Regulation 4
- Management of Health and Safety at Work Regulations 1999 – Regulation 3
- Construction (Design and Management) Regulations 2015

Current Requirements

The majority of construction hoists supplied into the UK until recently were designed using the out-of-service wind load requirements of BS 4465:1989.

Construction hoists produced in the past few years have been designed to the European Harmonised Standard for construction hoists - EN 12159:2012. This standard specifies that construction hoists should be designed to take account of out-of-service wind pressures set out in Table 4 of EN 12159, which is reproduced below.

Height H of parts of hoist above ground level [m]	Wind Region							
	A/B		C		D		E	
	Wind Pressure [N/m²]	Wind Speed [m/s]	Wind Pressure [N/m²]	Wind Speed [m/s]	Wind Pressure [N/m²]	Wind Speed [m/s]	Wind Pressure [N/m²]	Wind Speed [m/s]
0<H≤10	544	30	741	34	968	39	1225	44
10<H≤20	627	32	853	37	1114	42	1410	48
20<H≤50	757	35	1031	41	1347	46	1704	52
50<H≤100	879	38	1196	44	1562	50	1977	56
100<H≤150	960	39	1306	46	1706	52	2159	59

Table 1 – Minimum Design Wind Pressure and Speed, based on Table 4 of EN 12159:2012

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The wind pressure varies for both the height of parts of the hoist above ground level and the geographical region in which the hoist will be erected. The geographical regions are set out in the European Storm Wind Map.

EN 13001-2:2014, *Crane safety. General design. Load actions,* encourages the use of detailed national wind maps or local meteorological with the European Storm Wind Map only being used in the absence of more precise data.

The UK National Annex to the Eurocode EN 1991-1-4:2005, *General actions - Wind actions*, was published in 2008 and contains a map of the UK showing the values of fundamental basic wind velocity vb.map before the altitude correction factor is applied. Taking these values and correcting for altitude, it has been possible to produce **Figure 1**, which shows that with the advantage of more precise information, England and Wales fall into Region C, whilst Scotland and Northern Ireland fall into Region D.

It is important to note that whilst this holds true for most areas up to 200m above sea level, higher or more exposed areas will require an individual assessment to be made.

A more detailed explanation of **Figure 1** is given in Annex 2 of CPA Tower Crane Technical Information Note TIN 027 which can be downloaded from the CPA's website at http://www.cpa.uk.net/tower-crane-interest-group-tcig-publications/

Construction Plant-hire Association Construction Hoist Interest Group
Construction Hoist Technical Information Note

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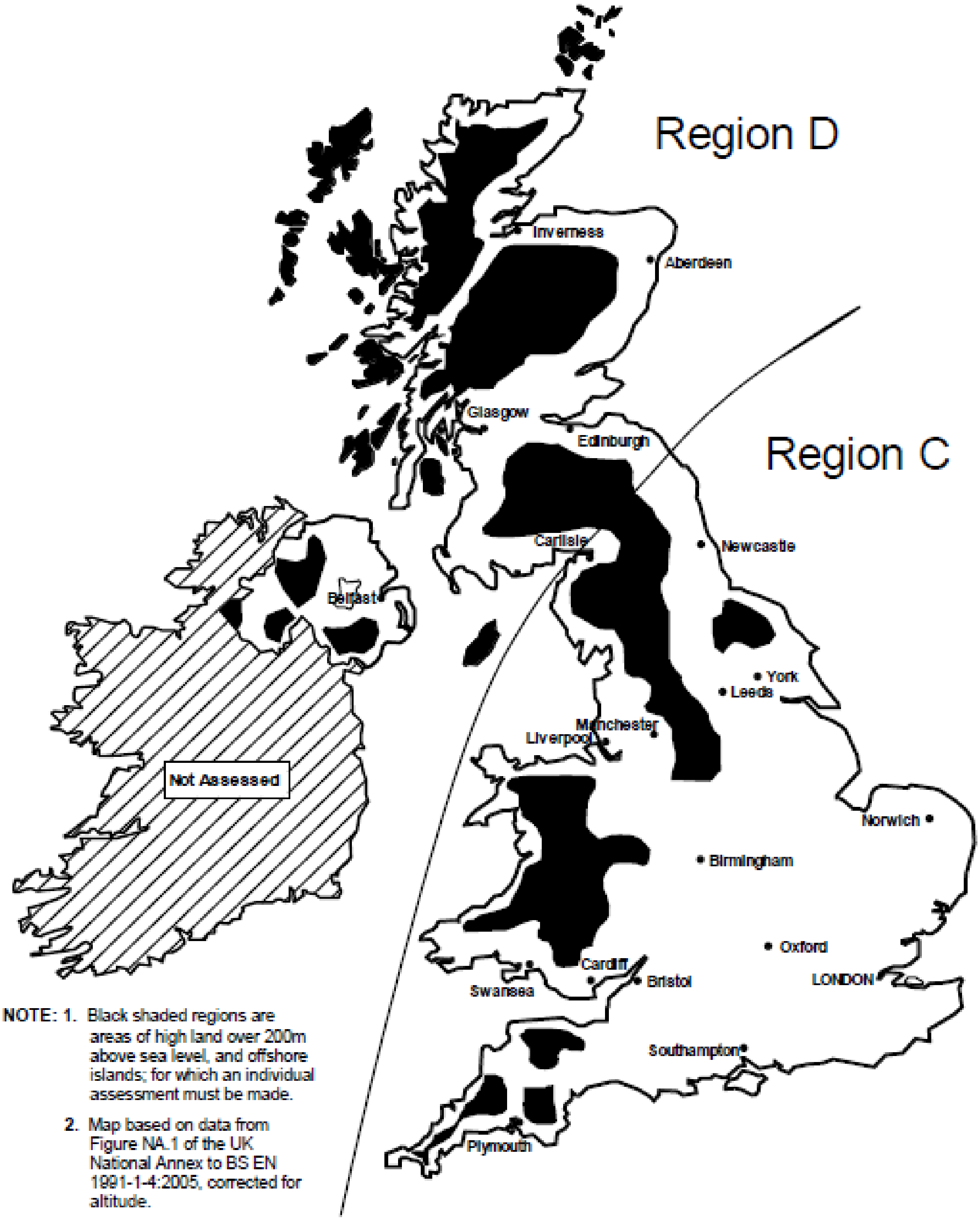

NOTE: 1. Black shaded regions are areas of high land over 200m above sea level, and offshore islands; for which an individual assessment must be made.

2. Map based on data from Figure NA.1 of the UK National Annex to BS EN 1991-1-4:2005, corrected for altitude.

Figure 1 - UK Out-of-Service Wind Region Map for Construction Hoists

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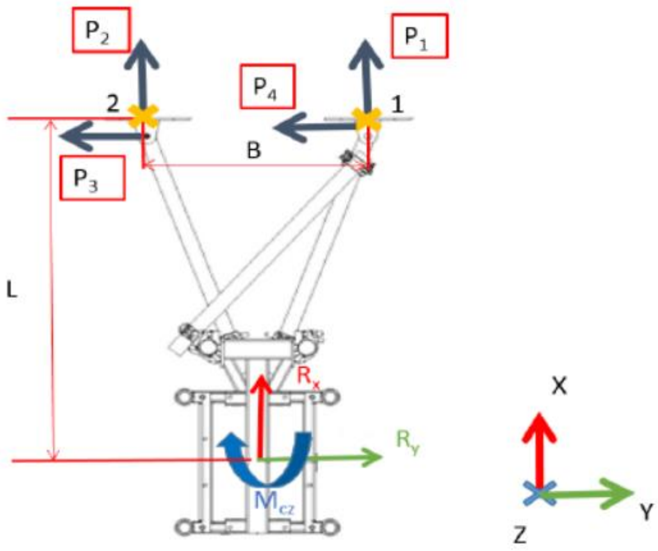
Annex H - Example of a tie design for a MCWP



Platform – Plf3					
Configuration	**Length**	**Payload**	**Extension**	**Tie in dimension**	
	m	**2300**	**2.6**	**L (m)**	**B (m)**
CCC-A-CCCCCC-A-CC	18.9	kg	m	0.75	0.55

Tie Intervals						Ground Force	Tie-in force		Manufacturer's Double (check) coupler?
Base to 1st (m)	**1st to 2nd (m)**	**2nd to 3rd (m)**	**3rd to 4th (m)**	**4th to 5th (m)**	**Overhang (m)**		**Max (P_1, P_2)**	**Max (P_3, P_4)**	
						kN	**kN**	**kN**	
10.4	8.9	8.8		N/A	4.5	67.3	25.6	9.0	Yes

NOTE: *Standard scaffold fittings will not be suitable for these forces*

This example indicates that MCWPs may have tie forces that are similar to those of a construction hoist.

Annex I - Bibliography

Legislation

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Provision and Use of Work Equipment Regulations 1998 (PUWER).

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L22 Safe use of work equipment, HSE Books.

The Management of Health and Safety at Work Regulations 1999 as amended (MHSWR).

Work at Height Regulations 2005 (WAHR).

The Supply of Machinery (Safety) Regulations 2008 (SM(S)R).

The Construction (Design and Management) Regulations 2015 (CDM).

Standards

BS 5975:2019, *Code of practice for temporary works procedures and the permissible stress design of falsework*

BS 7212:2016, *Code of practice for the safe use of construction hoists*

BS 8539:2012, *Code of practice for the selection and installation of post-installed anchors in concrete and masonry*

BS 5975:2019, *Code of practice for temporary works procedures and the permissible stress design of falsework*

BS EN 74-1:2005, *Couplers, spigot pins and baseplates for use in falsework and scaffolds. Couplers for tubes. Requirements and test procedures*

BS EN 1990:2002+A1:2005, *Eurocode. Basis of structural design*

NA to BS EN 1990:2002+A1:2005, *UK National Annex for Eurocode. Basis of structural design*

BS EN 1992-4:2018, *Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete*

NA to BS EN 1992-4:2018, *UK National Annex to Eurocode 2: Design of concrete structures. Design of fastenings for use in concrete*

BS EN 12158-1:2000 + A1:2010, *Builders hoists for goods. Hoists with accessible platforms*

BS EN 12159:2012, *Builders hoists for goods and materials with vertically guided cages*

Other Guidance

Work at Height on Construction Hoists – Best Practice Guide. Construction Plant-hire Association (free download from www.cpa.uk.net)

Ground Conditions for Construction Plant - Good Practice Guide. Strategic Forum for Construction - Plant Safety Group (free download from www.cpa.uk.net)

Guidance on Anchor Selection, Construction Fixings Association (free download from https://www.the-cfa.co.uk/publications-and-downloads/guidance-notes/).

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TG14:03 Supplementary Couplers and Check Couplers, National Association of Scaffolding Contractors (priced publication from https://www.nasc.org.uk/shop/)

Useful Websites

Build UK (formally UKCG)	www.builduk.org
Construction Fixings Association	www.the-cfa.co.uk/
Construction Plant-hire Association	www.cpa.uk.net
CITB	www.citb.co.uk
Health and Safety Executive	www.hse.gov.uk
Home Builders Federation	www.hbf.co.uk
Lifting Equipment Engineers Association	www.leea.co.uk
Safety Assessment Federation	www.safed.co.uk
Strategic Forum for Construction	www.strategicforum.org.uk
Temporary Works Forum	www.twforum.org.uk/home

Annex J - Working Group Membership

Name	Employer	Representing
K Archbold-Laming	Southern Hoists Limited	CPA Construction Hoist Interest Group
K Bah	Hilti (Gt. Britain) Ltd	Fixing Manufacturer
G Beentjes	Hoist-It Limited	CPA Construction Hoist Interest Group
N Bland	GB Access (A Plant)	CPA Construction Hoist Interest Group
A Bolton	Alimak Group	CPA Construction Hoist Interest Group
M Broad	Sir Robert McAlpine	Temporary Works Forum
R Cox	GB Access (A Plant)	CPA Construction Hoist Interest Group
L Foster	Southern Hoists Limited	CPA Construction Hoist Interest Group
C Hook	Sir Robert McAlpine	CPA Construction Hoist Interest Group
J Humphrey	Alimak Group	CPA Construction Hoist Interest Group
J Muir	Construction Fixings Association	Construction Fixings Association
S Prower	Steve Prower Temporary Works Limited	Temporary Works Forum
T P Watson	Construction Plant-hire Association	CPA Construction Hoist Interest Group
K Witecki	Hoist-It Limited	CPA Construction Hoist Interest Group

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