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Holcim Concrete Pumping Handbook

Compiled by the OH&S Workgroup of Aggregates and Construction Materials (ACM) Committee in consultation with key Holcim Group Companies that provide a concrete pumping service and in conjunction with the OH&S function of Holcim Technology Ltd. Author: Spencer Sephton, ACM, Holcim Technology Ltd

Holcim Technology Ltd
Im Schachen
5113 Holderbank
Switzerland
www.holcim.com

This handbook was compiled for internal use only, in order to promote health and safety in concrete pumping services and may not be distributed outside Holcim. The information provided is intended to support and not substitute any Holcim Directives contained in the Holcim Policy Landscape. National laws and regulations where Holcim Group Companies operate must be adhered to at all times and take priority over the standards and guidance presented in the handbook where they represent a higher standard. This handbook is also not a substitute for operational procedures and training such as that provided by equipment manufacturers, particularly where this relates to specific pumping equipment and applications.

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Introduction

This handbook establishes Holcim Concrete Pumping minimum standards and best practice for the safe management of concrete pumping services. As such these minimum standards must be integrated into local Group Company OH&S management systems and are the expected minimum operating standards for Group Company as well as third party contractors carrying out pumping services on the Group Company's behalf. This handbook also communicates identified best practices which when implemented, will deliver high levels of operational safety in concrete pumping.

Group Company standards must by default be compliant with applicable country legislation, manufacturer operator manuals and pump specifications supplied by the pump and vehicle manufacturers. Where the Holcim Group and or a Group Company have agreements to abide by industry standards, these must also be incorporated.

This handbook is primarily designed to inform Group Company managers and supervisors tasked with the safe operational management of concrete pumping services.

Organisations safety performance typically evolves along the following broad categories, each representing challenging levels of maturity with time:

- Equipment and facilities
- Systems and processes
- Organisation and culture

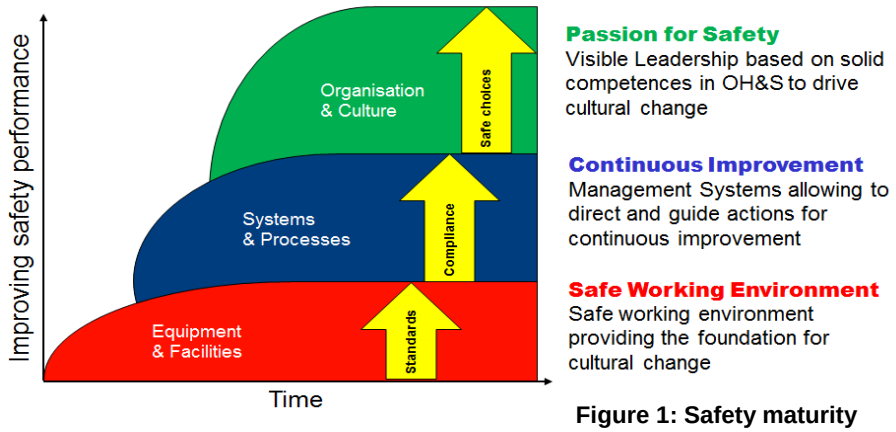


Figure 1: Safety maturity

Accountability, Responsibility and Authority

The Head of RMX for the Group Company shall be accountable for:

- Appointing a competent manager to be responsible for both direct and indirect concrete pumping services. Ideally this should be a dedicated function; however, for Group Companies with small scale pumping activities the responsibility may be included under other functions, but a responsible person shall be identified.

- Ensuring that the good practices contained in this handbook are integrated into their pumping processes, and or into contractual requirements with third party contractors where pumping is out-sourced. Supervisors, maintenance staff, operators, crew, order takers and other staff involved in any aspect of concrete pumping shall receive adequate and appropriate training on the minimum standards contained within this handbook.

- Annual internal auditing for compliance with the minimum standards in this handbook and, where non-compliance is identified, the timely and effective corrective action to

prevent a recurrence.

- Ensuring that the pump operator or if present, the pumping supervisor has the authority to suspend pumping operations if, in their reasonable opinion, their own safety or the safety of others that might be affected by pumping operations is significantly compromised and there is a real risk of significant harm or fatality.

The safety maturity journey typically starts with good standards for the workplace (equipment and facilities) which are then supported by the design of safe systems of work and compliance with those systems, processes and procedures. Ultimately, safety excellence is driven by a passion for safety that comes from visible leadership founded upon solid competencies and effective training.

As part of the Aggregates and other Construction Materials (ACM) business segment, concrete pumping plays an important role in the concrete delivery service. While pumping is a very efficient way of placing concrete, it is not without inherent risks. There are several business models for concrete pumping such as pumping that is:

- left entirely for the customer to arrange
- out-sourced to a third party contractor , thus managed indirectly by Holcim
- in-house and managed directly by Holcim

Where Holcim is directly, or indirectly responsible for pumping activities, the Group Company retains responsibility to ensure that both direct and indirect services are delivered safely as well as efficiently.

Under the mandate of the ACM Committee and in consultation with 10 key Group Companies which provide a concrete pumping service, minimum standards were developed and subsequently approved by the ACM Committee. Wherever a minimum standard is mandated in this handbook the word 'shall' is used e.g. 'The Group Company shall…' This indicates that the requirement must be met or exceeded. In addition, best practice examples have also been identified and are differentiated from minimum standards by use of the word 'should' e.g. 'The Group Company should…' This indicates that the requirement is recommended rather than mandatory. However, all Group Companies shall evaluate the adoption of the best practices and determine if it is reasonably practicable to implement them.

Group Companies shall identify all hazards and risks associated with directly managed pumping operations and design effective controls to eliminate hazards or mitigate the risks. For indirectly managed pumping operations, Group Companies shall ensure that third party contractors have equivalent systems and they should audit compliance with this requirement.

This handbook develops, improves upon and replaces the existing Holcim RMX Pumping Manual. It further incorporates significant findings of a literature review of publications from industry associations and governmental organizations. Where relevant, reference is made to mandatory OH&S corporate directives as shown in the red boxes adjacent to the minimum standards. The minimum standards in this handbook are intended to support corporate directives which take precedence at all times.

Safe Pumping Operations

The organizational aspects of a concrete pumping service are important to ensure that accountability, responsibility, levels of authority and specific role requirements are clearly communicated and understood by everyone involved in the planning and realization of good pumping services.

There are a number of interfaces with other functional roles such as sales, order taking, distribution, concrete technology, production and maintenance that directly or indirectly have a bearing on pumping safety. In a smaller pumping service, there is a risk that

pumping management could be a shared rather than a dedicated management function. There is also a likelihood that pumping may report lower down in the organisational hierarchy which could reduce management attention and thus increase the operating risks. Where concrete pumping is outsourced, it is particularly important to understand that Holcim remains responsible for managing the safety of the pumping service. The Contractor Safety Management directive is also applicable to outsourced pumping and the procurement aspects relating the contractual terms and conditions are particularly important.

A safe work place consisting of safe equipment and safe facilities is generally the most visible and tangible realization of the risk-based management of hazards. It also might appear to be logical to rely on the provision of guarding for moving parts of machinery and Personal Protective Equipment (PPE) for operators. However, while the provision of PPE is essential, it is the least effective control measure in the hierarchy of hazard control (refer to Figure 2 below) and shall always be the control of last resort having considered all other controls. The hierarchical sequence of controls should be evaluated and where reasonably practicable controls available should be implemented at each level finishing off with appropriate PPE.

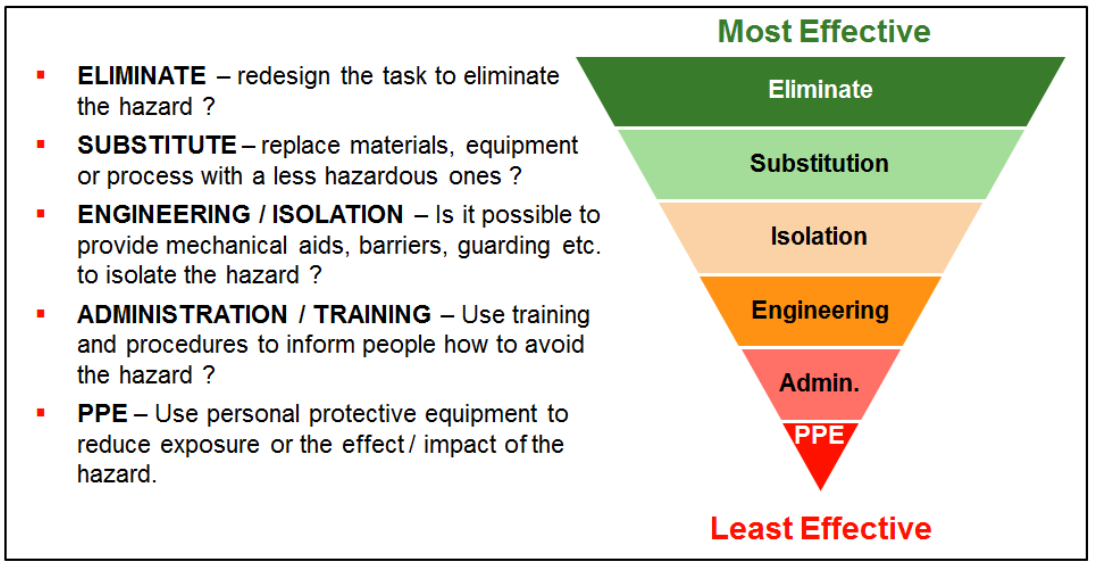


Figure 2: Hierarchy of controls

Hazard Profile for Pumping

The major hazards relating to equipment and facilities as identified in the hazard profile for concrete pumping shall be adequately controlled. However, hazard identification and risk assessments shall always be completed to ensure that all local conditions are considered.

Ensuring safety in pumping begins with the identification of hazards and managing risks.

- A **hazard** is something that has the potential to cause harm to persons or the environment, damage to property or other loss.
- The **risk** arising from a pumping activity is a combination of the potential consequence (harm etc.) and the likelihood that the consequence is realized.
- **Events** are **incidents** that either a) could have resulted in realization but did not due to one or more factors (also known as a 'near-miss') or, b) consequences were realized and are known as **accidents**.

A typical example of a major hazard profile for pumping has been presented in Table1 below. However this hazard profile will differ from one operation to another due to changes in workplace design, equipment, physical conditions, project types and locations as well as other local factors. Therefore, the Group Company shall identify a hazard profile for pumping applicable to their operating conditions. It is recommended that a hazard profile for pumping activities be grouped under the OSHA categories of:

- Safety Hazards
- Work & Organizational Hazards
- Chemical Hazards
- Physical Hazards
- Ergonomic Hazards
- Biological Hazards

Once the hazard profile for the local concrete pumping operation has been established, the hazards shall be mitigated using a risk based approach. The concrete pumping process has been divided into the following three categories which also reflects the recommended management priority for a safe pumping operation:

1. Organisation and culture
2. Systems and processes
3. Equipment and facilities

Table 1: Major hazard profile for concrete pumping

Equipment	Travel & Site establishment	Pumping (on the job site)	Maintenance
			
Safety Hazards Moving Machinery & parts Working at Heights Electricity Hot work (maintenance) Lifting & supporting loads Slips & trips Pressurized systems (hydraulic)	**Safety Hazards** Vehicles, traffic & pedestrians Site access (slopes & surface) Pump location (slope, space, edges) Electricity (power lines) Moving machinery & parts Slips & trips Pressurized systems (hydraulic & concrete pipe lines)	**Safety Hazards** Working at height (edges) Lifting & supporting loads Slips & trips (obstacles & surfaces) Pressurized systems (hydraulic & concrete pipe lines) Moving machinery Electricity (equipment & power cables) Sharp objects (ends of reinforcing)	**Safety Hazards** Working at height Lifting & supporting loads Slips & trips (obstacles) Pressurized systems Moving machinery Electricity Sharp objects Housekeeping Hot work (welding)
Work & Organizational Hazards Work hours	**Work & Organizational Hazards** Time pressure (work stress) Work pressure & intensity Fatigue	**Work & Organizational Hazards** Task pressure (fatigue) Multiple entities (roles & responsibilities)	**Work & Organizational Hazards** Task pressure (quality vs time) Irregular hours
Physical Hazards Noise Temperature	**Physical Hazards** High exposure (UV) Temperature extremes & wind	**Physical Hazards** Radiation(UV) Thermal stress (hot & cold) Noise (machinery)	**Physical Hazards** Thermal stress (hot & cold) Noise (machinery)
Chemical Hazards Cement & concrete (alkaline) Cleaning liquids (acid)	**Chemical Hazards** Cement & concrete (alkaline)	**Chemical Hazards** Cement & concrete (alkaline)	**Chemical Hazards** Cement & concrete (alkaline) Cleaning liquids (acid)
Ergonomic Hazards Musculoskeletal (driving, lifting, climbing)	**Ergonomic Hazards** Musculoskeletal (driving , standing & uneven surfaces)	**Ergonomic Hazards** Musculoskeletal (standing & uneven surfaces)	**Ergonomic Hazards** Musculoskeletal (standing & lifting)

Organization and Culture

A safe concrete pumping business consists of a safe workplace, solid processes and **competent people**. This section deals with organization and culture which forms the foundation of making safe choices in the workplace. Visible leadership and OH&S competencies drive cultural change and a proactive and safety conscious mind set.

1. Organisation and management

Organisational aspects are an important area of focus with regard to a safe pumping organisation. The chain of command and levels of authority need to be clear and the operation needs to be run by a competent manager who in turn needs to ensure the competence of supervisors, operators and maintenance functions. It is also important that when pumping is outsourced, the levels of competence is the same as if it was a Holcim own operation.

1.1. Competent person

The ACM Head shall appoint a competent person to manage own and/or third party pumping. A competent person is deemed to be a person who management ensures has skills and knowledge through a combination of training, qualification and experience to enable the person to correctly perform the task of managing a pumping operation or a third party pumping service.

Risk: Lack of leadership and clear lines of responsibility usually results in lower safety standards.
Holcim Minimum Standard: The ACM Head shall appoint a competent person to manage own and/or third party pumping.

1.2. Job descriptions

Pumping supervisors and operators shall have a clear understanding of their roles and responsibilities and the competences required to carry out their tasks in a manner that ensures the safety of their crew, construction workers and the public.

Risk: Lack of clear roles and responsibility awareness can have a negative impact on the execution of safety management.
Holcim Minimum Standard: Pumping supervisors and operators should have job descriptions that clearly set out roles and responsibilities.

1.3. Scheduling and recording of work hours

Concrete pumping is usually physically demanding and requires high levels of concentration. This can result in fatigue, leading to reduced alertness and a reduction in the ability to perform tasks effectively, especially during night time pumping. Recovery from fatigue is achieved by rest and it is therefore important to plan and record hours of both work and rest. Planning to ensure that rest breaks can be taken while allowing for continuity of pumping, particularly on long pours, is essential. Working hours are generally determined by national legislation which shall be complied with at all times.

Risk: Excessive fatigue could result in accidents.
Holcim Minimum Standard: Scheduling and recording of operator and crew working and rest hours shall be carried out and/or as required by country and local legislation.

1.4. Safety induction

Everyone on the pumping team shall receive concrete pumping specific safety induction before being allowed to participate in pumping activities. Refresher induction shall be repeated at lease annually and shall be placed on record.

Risk: Lack of awareness of procedures and of hazards specific to pumping increases the risk of safety incidents.
Holcim Minimum Standard: The manager responsible for pumping shall ensure that the pump crew have received and recorded concrete pumping specific safety induction before resuming duty with refresher induction carried out at least annually.

1.5. Authority not to begin pumping

Unsafe conditions occur on job sites from time to time. In such situations there is significant pressure placed on the pump operator by the customer or circumstances to proceed with pumping without fully resolving the conditions. These may relate to access to site, space restrictions, ground conditions, proximity to power lines and other conditions.

Where unsafe conditions are observed by the pump operator, he shall have the authority not to proceed without a satisfactory solution to manage the risk. In such an event the pump operator shall inform the job site contact person (contractor/customer point of contact) for a solution and/or immediately call his supervisor for further instruction.

Risk: Succumbing to pressure to pump where there are unsafe conditions could result in component failure or accidents.
Holcim Minimum Standard: The responsible person at the job site shall have the authority not to establish the pump or proceed with pumping where it is not safe to do so.

1.6. Performance management

Most Ready-mix functions impact on concrete pumping and cross functional performance management is recommended. Examples include the following:

- The order taking function can get an early indication of potential hazards from customers and is first point of contact with customers.
- The pump scheduler needs to allocate the appropriate pump and boom combination.
- The dispatcher needs to ensure a constant supply of concrete to the pump on the job site.
- The batcher needs to ensure that a consistent quality concrete is produced.
- The concrete technologist needs to balance a pump friendly mix design with the cost of concrete.
- The maintenance team need to ensure that the pump is maintained to high standards.

A safe and successful concrete pumping operation relies on teamwork from all the relevant functions. Dialog and KPIs are an effective performance management process.

Reactive and proactive KPIs should be implemented as part of the performance management process for the concrete pump team and also for the cross functional teams.

Risk: Lack of performance monitoring to support continuous improvement.
Holcim Best Practice: Reactive and proactive KPIs should be utilized and recorded as part of the performance management process.

2. Training and certification

Concrete pumping is a specialized activity with significant risks of exposure to specific hazards. In order to develop the required levels of competence, the concrete pumping team shall receive the necessary training to safely carry out their tasks. Competency is achieved through effective training under supervision. Operators should be assessed for theoretical knowledge as well as their ability to operate the equipment to the required level. They also need to possess the required national vehicle licence for the category of vehicle involved.

2.1. Training topics for pumping

Training for the pump crew needs to be a combination of theoretical training and practical on the job training under the guidance of a competent trainer covering a variety of topics that relate to safe pumping.

Risk: Operators and crew carrying out tasks for which they don't have adequate knowledge or experience, increasing the potential for an accident.
Holcim Minimum Standard: The concrete pumping team shall receive adequate training relative to their roles and at least cover the topics listed in the table below.

Table 2: Training topics for pumping

- Pumping specific safety induction.
- Operation of the truck & pump and operating parameters.
- Basic risk assessment for on-site establishment.
- Daily start up checks.
- Applicable training in FPE 3: Vehicle, Traffic and Pedestrian Safety
- Applicable Road Safety Program (RSP) training.
- FPE 4: Electrical safety.
- FPE1: Working at heights.
- Basic concrete technology relating to the pumping of concrete.
- Safe handling of discharge hoses & pipe lines.
- Competence in building pipelines (particularly vertical pipe lines).
- Pump and pipe clean out as well as care and safe stowage of equipment.
- The safe clearing of a blockage in the pipe line.
- Environmental awareness relating to the impact of pumping.

2.2. Toolbox talks

The regular and routine use of toolbox talks also serves the purpose of on the job training that will heighten safety awareness of the pump crew on selected topics. Toolbox talks also improve communication and safety at the pumping workplace and should be

included in the daily routines of the pump team. In addition to a safety topic, the talk should include updates on site issues, changes in routines, communication of accidents and key learning and awareness of changing site hazards. An example of a toolbox talk is included in Appendix H.

Risk: Lack of regular and routine training results in lower safety focus and awareness.
Holcim Best Practice: Toolbox talks should become part of a daily routine at the start of each pump job and can be conducted by a supervisor or pump operator.

2.3. Certification of pump operators

Operators should be certified as being competent to carry out concrete pumping without direct supervision. Operators should have certificates available for inspection at all times and best practice is to carry a certification card and have a "certified pump operator" patch or badge visible on their clothing.

Risk: Inability to prove competence can result in delays and has the potential for insufficiently trained operators resulting in the potential for accidents.
Holcim Best Practice: Certified operators should have certificates available for inspection at all times as well as a certification card, patch or badge.

Systems and Processes

A safe concrete pumping business consists of a safe workplace, **solid processes** and competent people. While the previous section dealt with organisation and culture, this section deals with solid processes, via minimum standards and also recommended best practice. Systems and processes form the foundation of compliance.

This aspect allows for sustainable continuous improvement by systems and processes that direct and guide actions in a systematic manner. This requires various forms of documentation. At best, a quality management system such as ISO 9000 would provide a suitable structure for the processes.

3. Risk Management

Due to the nature of pumping activities, there are a number of hazards that need to be identified in order to best mitigate the risks. While a number of these hazards are in common with other Holcim operations, the processes and activities associated with these risks need to be identified at the various stages of the operation. The minimum standards in this section are aimed at mitigating the risks presented by more significant hazards prevalent in concrete pumping.

3.1. Risk assessment

The challenges on a construction site vary from one job site to another requiring a basic risk assessment for each site to identify the hazards and their potential impact. Hazards of high significance highlighted by past incidents include vehicle and traffic movements, working at heights and working in the proximity of power lines. This makes it important for a basic risk assessment to be carried out by a competent person at each site where a pump is to be established for the first time. The risk assessment would identify the risk presented by any site specific hazards to be added to the pre-start-up check.

Risk: Lack of awareness of site specific hazards leads to accidents.
Holcim Minimum Standard: A risk assessment shall be carried out by a competent person for every site where a pump is to be established for the first time.

3.2. Pre-departure check

In order to ensure proper planning for the concrete pump job, the operator shall plan and carry out a check in accordance with established Group Company procedures, making use of templates to establish that all the preparation, equipment, material, route planning and administration is in place. Deviations need to be recorded and forwarded to the operator's supervisor or maintenance function for resolution.

Risk: Lack of systematic planning resulting in disruption or discontinuity in service which would place the pumping team under undue pressure, resulting in a accident.
Holcim Minimum Standard: The operator shall carry out a pre-departure check including a recorded checklist, record deviations and inform his supervisor or maintenance function to ensure that deviations are resolved.

3.3. Hazard identification at order taking

Potential hazards should be covered as a part of routine order taking involving concrete pumping and any potential hazard should be recorded on documentation that is visible to the supervisor and pump operator. The hazard should receive particular attention in the risk assessment for the first pump establishment on the site and subsequent observations and toolbox talks.

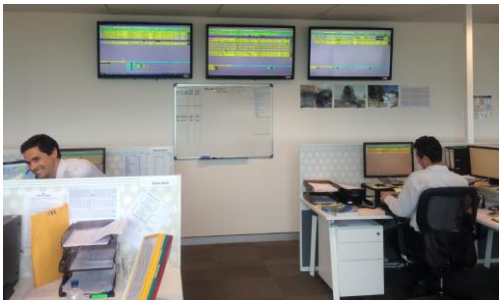


Figure 3: Hazard identification at order taking

Risk: Unexpected and or uncontrolled hazards arising from pumping activities resulting in injuries.
Holcim Best Practice: Potential hazards relating to pumping should be established as a part of routine order taking and communicated to the concrete pumping team.

3.4. Operator or supervisor site check

Before establishing the pump on site, the supervisor or pump operator should be familiar with the risk assessment for the site. They should walk the relevant area on the job site and follow up with a toolbox talk. This should include making contact with the responsible person on site for the concrete placement and also involve aspects such as:

- Location and building of pipe lines
- Access to the structure/working at height
- Edge protection (or lack of) and openings when working at height
- Stability of working platform (scaffolding and formwork)
- Handling of the discharge hose
- Exclusion and danger zones
- Communication between the operator, drivers and placing team leader

Clean-up options for the pump on the job site. **Risk:** Lack of planning could result in injury due to unsafe conditions at the workplace.
Holcim Best Practice: Before establishing the pump, the supervisor or pump operator should walk the job site, make contact with the responsible person for the concrete placement and should conduct a toolbox talk with his team where applicable.

3.5. Safety observation tours

In order to keep in touch with the conditions on site as well as the challenges facing the pump operators, managers and supervisors should conduct safety observation tours (SOT) and record observations of good practices and opportunities for improvement. This should include discussions with the responsible person for concrete placement on site and the pump operator as they are best placed to understand the potential risks involved. The observations should also include a basic assessment of the quality of scaffolding and support work to the formwork on the job site. Lack of cross-bracing, over extended jack screws and eccentric support loads on scaffolding that could lead to

Figure 4: Example of good scaffolding with access stairs and edge protection all round

instability and potential collapse of a concrete deck during placing and put the lives of the pump operator and crew at risk. The SOTs should form part of the pump managers OH&S KPIs.

Risk: lack of routine monitoring could result in lack of awareness of unsafe working conditions on site.
Holcim Best Practice: Managers and supervisors should conduct site observation tours (SOT) and record observations of good practices and opportunities for improvement.

3.6. Resolution of unsafe site conditions

Where a risk assessment or site observation has assessed that it is unsafe to proceed with work, a manager or competent supervisor shall stop the pumping operation, assess the situation and resolve the problem by implementing safe interim controls to reduce the risk to an acceptable level, or escalate the issue to their line manager for further instruction.

Risk: Identified hazards and risks are not controlled, resulting in ad-hoc and unsafe operating conditions.
Holcim Best Practice: Where work has been assessed to be unsafe, a competent manager or supervisor shall take control of the situation and determine a suitable outcome.

4 Operational and maintenance procedures

The following section deals with operational and maintenance procedures necessary for a safe pumping operation.

4.1 Contractor management

It is common for Holcim to outsource pumping to a third party concrete pumping service. Where this service is under Holcim direction and offered to Holcim customers, the Holcim Contractor Safety Management directive (CSM) applies. In principle the same OH&S rules that apply to our own employees, must also apply to third party contractors. Note that the Group Company CEO is the responsible person for ensuring adequate resources are provided for the implementation and ongoing management of the CSM Directive. As a minimum this requires that person/s are formally appointed to each function to be performed under the Directive. The category of concrete pumping can be considered to be Category 4, Contractors with moderate to high potential risk exposure.

Risk: Poor control over contractors can result in injuries and damage to property as well as harm to the Holcim brand.	Ref FPE 3: Vehicle, Traffic & Pedestrian Safety, CSM and RSP
Holcim Minimum Standard: Third party concrete pumping services shall be managed in accordance with the Contractor Safety Management directive, FPE3: Vehicle, Traffic & Pedestrian Safety as well as the Road Safety Program (RSP).	

4.2 Maintenance procedure

Maintenance of the equipment shall be completed to an high standard carried out as per manufacturers specifications and conducted by competent technicians within a planned maintenance schedule designed in consultation with the equipment supplier for the vehicle, pump and boom.

Risk: Pump equipment and component failure resulting in accidents or pipeline blockages placing pressure on the crew due to delays to effect repairs.
Holcim Minimum Standard: A maintenance procedure and schedule shall be established in conjunction with the equipment supplier.

4.3 Pump pre start-up check sheet

An operator pre start-up check sheet is common for the operation of most key items of equipment. This is particularly important for a concrete pump to ensure that items that require attention are scheduled for maintenance or repairs.

Risk: Lack of attention to items that require maintenance or repair leading to pump component failure or pipeline blockage.
Holcim Minimum Standard: The operator shall carry out a pre start-up check making use of a standard check sheet, record deviations and forward to his supervisor and/or maintenance function for the scheduling of repairs.

4.4 Compliance with vehicle and traffic safety

Vehicle, traffic and pedestrian hazards are responsible for the highest number of incidents and fatalities at Holcim. Concrete pumps typically travel through built up areas and are vehicles that are permanently carrying a full load consisting of the pump and boom. The vehicles are usually close to the limits of height width and axle mass distribution. The rear overhang of the boom is a further area of risk to other road users. Vehicles that tow pump trailers also require care to ensure control under braking. The drivers of these vehicles require high levels of competence and need to be alert at all times. The pumping operation needs to be managed in accordance with the Fatality Prevention Element (FPE3): Vehicle, Traffic and Pedestrian Safety as well as the Road Safety Program (RSP) that deals specifically with the risks presented by vehicles and traffic. The requirements of these directives apply equally to the management of outsourced pumping services.

Risk: Travel to and from the pumping sites involve significant risk of traffic accidents.	Ref FPE 3: Vehicle, Traffic & Pedestrian Safety, CSM and RSP
Holcim Minimum Standard: The pumping operation shall comply with the requirements of FPE 3: Vehicle, Traffic & Pedestrian Safety and the Road Safety Program (RSP).	

4.5 Certification of vehicles, pumps and booms

Besides the legal vehicle registration and licensing requirements, there should be an internal procedure to certify vehicles, pumps and booms to ensure that they meet the requirements as specified at the time of the purchase or subcontract enquiry, resulting in a certified declaration of conformity before entering service. This should include the carrying capacity of the vehicle, the weight of the pump and boom, the weight distribution of the vehicle for each axle and the vehicle dimensions. This also provides important information to the pump operator for where there are road weight and height restrictions.

Risk: The risk that a pump vehicle combination does not meet manufacturers or legislated specifications resulting in component failure on the road or on the job site.
Holcim Best Practice: There should be a procedure to certify vehicles, pumps and booms to ensure that they meet the specified requirements before entering service.

4.6 Operating parameters

When operating the pump, the operator should be aware of the operating parameters of the pump and boom. This would include pump hydraulic pressure and temperature as well as engine revolutions and temperature. Further information would be the pump reach and output. This information should be easily available to the operator on the job site. All information should be as per the manufacturer's specification and should be included in the Group Company standard operating procedures and training material.

Risk: Lack of monitoring of compliance with manufacturers operating standards could result in component failure resulting in an accident.
Holcim Best Practice: Operating parameters should be established in accordance with the manufacturer's specifications and be readily available to the operator

4.7 Boom inspection

Figure 5: Magnetic particle technique

Figure 6: Dye penetration technique

Due to the pulsating action of the concrete pump, the placement boom is subject to dynamic loads which results in the potential for metal fatigue or components being stressed beyond their design limits over time. The boom can be further stressed due to the way it is operated and connected to pipelines to extend the effective reach of the pump. Other than visual inspection, magnetic particle and dye penetration techniques are more effective at showing up cracks in critical areas of the boom. The CPMA (Concrete Pump Manufacturers Association: USA) recommends an annual inspection of pumps less than 5 years old, every 6 months for pumps between 5 and 10 years old and thereafter every 500 operating hours. Manufacturers' requirements for boom maintenance in particular must be strictly adhered to. All inspections should be done by competent persons with a proven track record in the use of advanced inspection techniques. The protocols of the Design Safety and Construction Quality Program (DSCQP) directive are also recommended for boom maintenance. Refer to case studies in Appendix K and "bath tub" reliability concept.

Risk: Structural or mechanical failure of concrete placement boom.
Holcim Best Practice: In addition to routine maintenance, an annual boom inspection should be carried out and the boom certified as fit for service by a competent service provider and as specified by the manufacturer.

4.8 Visual pipe inspection

There are many factors involved in pipeline management for concrete pumping, such as the grade of steel, wall thickness, wear patterns along the length of a pipe, abrasiveness of the aggregates, effectiveness of the concrete mix design etc. Bends and reducers are particularly susceptible to wear and need to be more closely and individually inspected. Pipes operate under pressure and can cause injury and damage to property should they rupture. As a result, a visual inspection of pipes, reducers, hoses and bends shall be carried out by a competent person at least monthly.

Risk: Unexpected pipe failure resulting in pressure and projectile related injury.	Pressure vessels (no FPE)
Holcim Minimum Standard: A visual inspection of pipes shall be carried out monthly by a competent person.	

4.9 Pipe specifications

The pipe parameters such as grade of steel, maximum pressure, wall thickness, minimum wall thickness and expected life should be established and form a part of the purchasing decision and design of maintenance procedures such as pipe wall thickness testing. Specifications should also be included in the pumping safety operating procedures and training material. The type or grade of pipe should be visibly displayed on the pipe, preferably indelibly marked to resist obscuring by contamination.

Risk: Uncertain pipe specification could result in pipe rupture or premature wearing and failure.
Holcim Best Practice: The pipe specifications should be established and form part of the maintenance procedure and training material.

4.10 Pipe thickness

In conjunction with the pipe specifications, there should be a system for routine measurement of pipe thickness by using ultrasonic testing or physical callipers as way of identifying which pipes are nearing the end of their life cycle. Different pressure class and composition of pipe relating to grade of steel would have a different wall thickness and as a result a different minimum thickness which should be established in conjunction with the pipe manufacturer or supplier. As a result, these differences need to be visible to the pumping crew and different class of pipes stored separately and systematically in the yard to facilitate use and measurement.

The wear rate for pipes is higher around the joins and the bottom section of pipes for horizontal lines. As a result pipe thickness checks should focus on the ends of pipes and there should be a practical and visible system for managing the end of cycle use. For example, pipes that are nearing their minimum wall thickness can be painted orange at their ends indicating one more cycle. Pipes with less than the required minimum wall thickness should be immediately removed from service. Horizontal

pipes that wear more around the bottom segment should have an orientation mark and should be given a quarter rotation to extend their useful life.

Risk: Lack of systematic pipe measurement will result in lack of awareness of minimum pipe thickness resulting in the rupture of pipes under pressure.
Holcim Best Practice: A quarterly measurement system should be established for the different types and grade of pipes, including, minimum wall thickness and pipes that have less than the minimum specified wall thickness should be removed from service immediately.

4.11 Concrete mix design

Concrete rheology has a major influence on pump pressure and hence the pressure exerted on concrete and hydraulic pipes. Besides meeting customer specifications, concrete also needs to be specifically designed for pumping in order to minimise pump pressure. In addition to concrete consistency, particular attention needs to be paid to aggregate particle shape and grading.

Risk: Incorrect concrete specification could result in blockages and thus injuries.
Holcim Minimum Standard: Concrete for pumping shall be specifically designed for ease of pumping and to minimize pump pressure.

4.12 Concrete quality assurance

An effective concrete pump mix needs to be accurately and consistently batched and managed via a concrete testing and recording regime. Concrete consistency testing such as the slump test is one of the most common tests and is particularly relevant for concrete pumping.

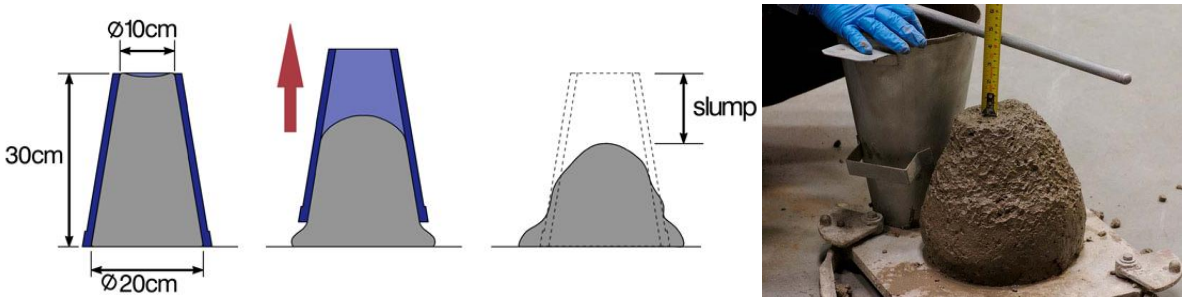


Figure 7: Concrete slump test

Risk: Lack of effective routine testing could result in inconsistent concrete delivery, increase in pump pressure and pipe blockage, leading to pipe failure and injuries from projectiles.
Holcim Minimum Standard: The product technical / concrete technology function shall put quality assurance in place and carry out quality control on pumped concrete.

4.13 Records

It is important to retain records relating to key concrete pumping activities as evidence of procedures having been carried out but also for proactive maintenance and decision making. For example, the choice of pipes should be on the basis of the volume of concrete pumped and wear rate records. Records would also be required should there be a need to investigation an incident such as a boom failure.

4.14 Risk management records

Records shall be retained as required by local legislation and integrated into the Group Company quality management system. Relevant records such as truck and pump maintenance, boom and pipe inspections shall be retained and be available at all times.

Risk: Lack of records results in limited learning from and defense of an incident.
Holcim Minimum Standard: Risk management records shall be retained and available for assessment and auditing.

4.15 Maintenance and repair records

Records shall be kept of repairs and maintenance for the lifetime of the equipment, including inspections carried out before the pump unit re-entered service. This is of particular importance for the maintenance of structural components such as booms where the risk of failure increases with time and use.

Risk: Lack of historic records results in lack of awareness of failure experience and potential for unreliable equipment in use.	FPE 3: Vehicle, Traffic & Pedestrian Safety
Holcim Minimum Standard: Maintenance and repair records shall be kept for the life time of the vehicle pump and boom as is applicable.	

4.16 Relevant certificates

Regulatory certificates and licencing shall be available on request as a proof of the vehicles compliance to the relevant legislative requirements.

Risk: Interruption of service due to lack of availability of certification.	FPE 3: Vehicle, Traffic & Pedestrian Safety
Holcim Minimum Standard: Relevant certificates or certified copies shall be retained in the vehicle and be visible and available for inspection at all times.	

Equipment and Facilities

A safe concrete pumping business consists of a safe workplace, solid processes and competent people. While the previous sections dealt with organisation and culture as well as systems and processes, this section deals with equipment and facilities fundamental to a safe working environment. In terms of the evolution of safety maturity, equipment and facilities are actions usually implemented ahead of organisation, systems and process activities. This is likely as a result of safety of equipment and facilities being more tangible and visible. However, while this section is generally not as effective in terms of the hierarchy of controls, it represents the foundation for continuous improvement, compliance and cultural change

5 Concrete Pumping Equipment

This section focuses on hazards relating to pumping equipment rather than the tasks related to the pumping activity. Moving and rotating pumping machinery are some of the major hazards that must be controlled in concrete pumping. In addition to the hazards related to trucks on the road, a truck mounted concrete pump has outriggers and a boom that unfolds in various configurations and rotates about its mounting point. The pump and pipes operate at high pressure to enable the concrete to be pumped through the pipeline. The pumping process and dynamic loads imposed on the boom and other components result in the potential for serious injury and even fatalities to operators and associated work teams.

The pump is usually in close proximity to Ready-mix truck drivers, construction workers and members of the public. As a result, operators shall be certified to be competent in the control of their equipment, including the use of remote controls and in the associated safety controls required to ensure safety in the operation of pumping equipment.

5.1 Mobile pump

Most concrete pumps are mounted on a standard truck chassis and the weight imposed by the pump is usually close to the maximum carrying capacity of the vehicle. The choice of vehicle shall comply with the Gross Vehicle Mass (GVM or in some states, the Gross Vehicle Weight rating GVWR) and maximum allowable axle loads stipulated by the applicable legislation. The specification of the truck including the mounted pump and boom shall comply with applicable road traffic and vehicle legislation. The legality of all vehicles shall be verified before first being put into service, especially where they have been imported or are pre-used.

The declaration of conformity shall be a requirement of the conditions of purchase or where the vehicle is not new or belongs to a third party, shall be obtained from a competent service provider before the vehicle is put into service. The associated risks could include brake failure, steering failure, suspension failure, tire failure, impact from protruding equipment, pipe and boom failure.

Planned inspections and preventative maintenance are important for the safe operation of mobile pumps and should be carried out at the intervals and using the methods as recommended by the manufacturer. An example of advanced inspection methods is crack detection using the die penetration or magnetic particle tests associated with the age of the pump and volume of concrete pumped or hours worked. The competent service provider should be the pump equipment supplier (or suppliers approved agent or service provider) and should be a Holcim vendor. The boom inspection should include all structural aspects of the boom, including its mounting point, hinges and hydraulic ram connection points.

Figure 8: Truck mounted concrete pump

Risk: Traffic collision or component failure as a result of operating a vehicle beyond design capabilities.	FPE 3: Vehicle, Traffic & Pedestrian Safety
Holcim Minimum Standard: Mobile pumps shall be certified via a declaration of conformity issued by a competent person before entering service validating that the vehicle complies with the manufacturer's specifications and all applicable legislation.	

5.2 Concrete hopper

Figure 9: Hopper grate & vibrator

The concrete receiving hopper has moving parts that agitate and guide the concrete into the two pump cylinders. Hopper grates (recommended max 70mm spacing and min 150mm above moving parts) act as a machine guard but also prevent large pieces of material from entering the concrete pump. The interlock must ensure that any opening of the grate for whatever reason would result in the pump machinery stopping and being isolated to prevent injury from contact with moving parts.

Risk: Entanglement in rotating parts	FPE 3: Vehicle, Traffic & Pedestrian Safety
Holcim Minimum Standard: A hopper grate shall be in place over the receiving hopper at all times during operation and shall be interlocked with an emergency cut out that isolates the hopper energy when opened.	

5.3 Moving parts and openings

Piston action concrete pumps are fitted with various configurations of valve systems such as the Putzmeister S-valve. These valves have a guillotine like action when alternating between piston chambers. While pumping concrete, these valves are not accessible. However, when the discharge elbow is hinged open for cleaning or maintenance, the valves are within reach and present an extreme hazard when activated, particularly the earlier gate valve systems. The insertion of any article or reaching into the pipe is prohibited. For cleaning of the pump after

Figure 10: Putzmeister S-Valve cutaway

use, manufacturer's recommendations need to be followed rigorously, including the retrieval of the sponge-ball. Due to the routine nature of this activity, there should be a documented safe operating procedure for pump cleaning.

Risk: Amputation of fingers, hand or forearm.	FPE 5: Machine Guarding
Holcim Minimum Standard: No one shall reach into any openings in the pump, the pump valves, or pipelines under any circumstances, including during cleaning.	

5.4 Emergency shut-down

In the event that something goes wrong such as a concrete pipe or hydraulic pipe burst, it is important for the pump to be shut down fast. The emergency stop needs to be visible and reachable at all times.

Risk: Injury or damage due to not being able to stop pumping.	FPE 5: Machine Guarding
Holcim Minimum Standard: The pump shall be equipped with an emergency shut-down easily accessible by the operator or RMX driver.	

5.5 Trailer pump

It is important to ensure that trailer pumps are road legal and are fitted with suitable tow bars, an effective braking system and road legal trailer lights. Tow bars, air or electronically activated braking and or lighting systems need to be compatible and matched with the tow vehicle. A double safety chain is required between the trailer and tow vehicle and the chains should be cross over each other when connected.

Figure 11: Trailer pump

Risk: Traffic accident caused by an un-roadworthy trailer mounted concrete pump that does not have an effective breaking and/or lighting system.	FPE 3: Vehicle, Traffic & Pedestrian Safety
Holcim Minimum Standard: Trailer type pumps shall be certified to be road legal, fitted with a suitable tow bar and effective braking systems, safety chains and shall be certified for being towed before entering service.	

5.6 Tow vehicle for a trailer pump

Trailer pumps could weigh between 2000 kg and 11000 kg with high pressure pumps in the 4000kg to 11000kg range. It is important to ensure that the tow vehicle used has sufficient towing capacity such as GVM, stability, power, traction and braking, suitable for the trailer it is towing, particularly for on road use. It is also important to ensure that the tow vehicle has a braking and lighting system that is compatible with the trailer pump, such as air or electrically activated systems. The tow vehicle and pump combination shall be certified to be road legal with the appropriate tow speed limitation which should be visible on the vehicle and trailer.

Risk: Traffic accident due to a tow truck that is not adequately specified or matched to tow a specific trailer pump.	FPE 3: Vehicle, Traffic & Pedestrian Safety
Holcim Minimum Standard: The tow truck capability shall be adequate for towing specific trailer pumps and shall be fitted with a suitable tow hitch and braking system, all in accordance with the vehicle manufacturer's specification and shall be certified before entering service as suitable to tow a trailer pump of a given mass and shall also comply with national and local legislation.	

5.7 Pipelines

Various grades of steel and designs of pipes are manufactured for concrete pumping. For high pressure applications, particularly vertical pipelines, it is important to ensure that the pipes are designed for the pressures involved. For maintenance purposes, the minimum thickness for pipes will depend on the type of pipe (single or double skin), grade of steel, pipe diameter and maximum pumping pressure of the pump. The wear rate of the pipe is also higher near the ends of pipes, the bottom segment of a horizontal pipe as well as being far higher at the outside of pipe bends. Due to these variables, it is not feasible to provide a standard minimum pipe wall thickness and these need to be determined in conjunction with the pipe supplier for the type of pipe and application.

Location	Deck pipe
Type	Twin wall induction hardened
Inside diameter	117mm
Outside diameter	132.6mm
Wall thickness	7.8mm
Maximum working pressure	1,233 psi (85 bar)

Figure 12: Pipe parameters for Putzmeister SK Series pipes

Risk: Burst pipes due to incorrect selection of pipes.	Pressure vessels (no FPE)
Holcim Minimum Standard: The pipes used shall be as per the class specified by the pump manufacturer and as a minimum match the maximum pressure of the pump.	

5.8 Supplementary PPE

Additional PPE shall be supplied to the pump crew based on local risk assessments and the need for further risk control measures. Examples include non-slip soles for safety boots for icy underfoot conditions. A further example would be safety harnesses and restraints where there is no edge protection on job sites and where access cannot be avoided by the operator or crew. While this measure may be the least effective on the hierarchy of controls, it nevertheless has the potential to save lives.

Figure 13: Comprehensive PPE

Risk: Injury or increased severity of injury due to inadequate specific PPE.	Holcim Cardinal Rule
Holcim Minimum Standard: Additional PPE shall be supplied as determined by risk assessments and safety observations	

5.9 Operating information

Key information relating to the vehicle, pump and boom, should be available at all times. For example there may be weight and height restrictions on certain routes. When scheduling and operating the pump it is also important to know the maximum reach, output and operating pump pressure parameters. The illustrations below are examples of what is available on manufacturer's web sites.

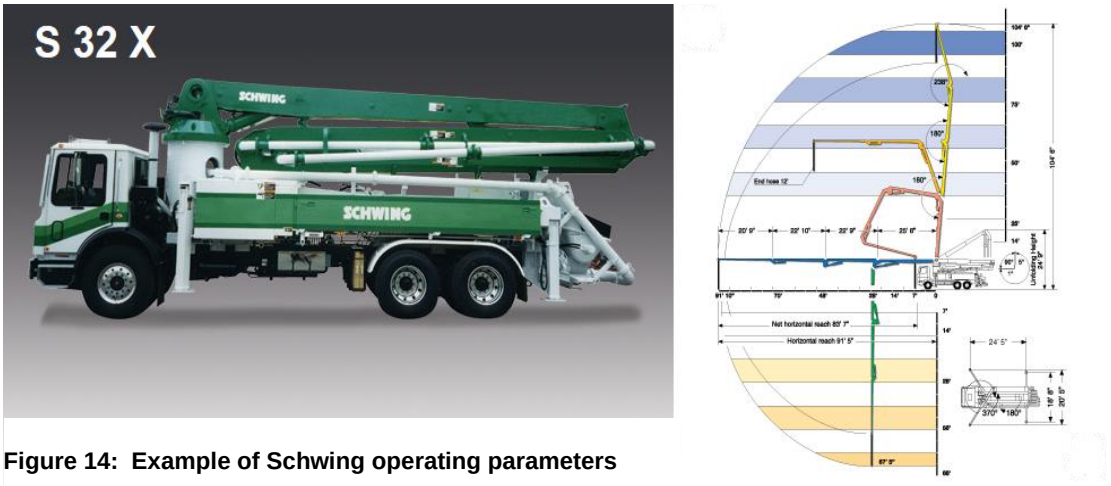


Figure 14: Example of Schwing operating parameters

Risk: Lack of access to key information resulting in scheduling and operating a pump with incomplete knowledge with the risk of component failure or damage to property.
Holcim Best Practice: Mobile pumps should be plated with relevant details including height when folded for traveling, vehicle mass data, manufacturer, year of manufacture, serial number, type or model, pipe diameter, max design working pressure and maximum reach.

6 Site Establishment

While the concrete pumping equipment does not change much from day to day, setting up on a job site presents a number of hazards and every situation is different, presenting a variety of different challenges. It is important that the pump is set up in good time well in advance of the arrival of the concrete to ensure that everything is in good order and final checks are done to avoid undue pressure on the pump crew.

6.1 Pre-job site inspection

A pre-job site inspection should be carried out making use of templates as a check list to establish that all the preparation, contact persons, equipment, material and administration is in place. The inspection should evaluate access to the job site as well as the space required to properly establish the pump with fully extended outriggers. Deviations and exceptions need to be recorded and forwarded to the operator's supervisor or managers for resolution.

Risk: Collision with pedestrians, equipment or structures or over-toppling of the pump due to poor site access and establishment conditions.
Holcim Best Practice: A pre-job site inspection check should be carried out to ensure that the pump has safe access to the job site with sufficient space to establish and operate the pump.

6.2 Securing the boom and outriggers

While traveling to site or repositioning the pump on site, the boom must be fully folded and secured in the transport mode. Outriggers must also be fully retracted and secured.

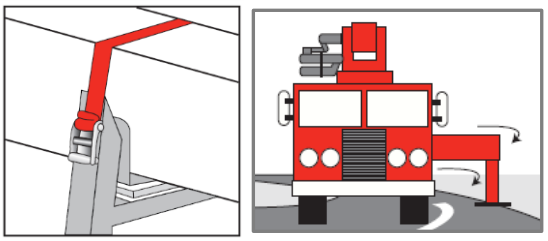


Figure 15: Securing of booms and outrigger

Risk: Pump roll-over or striking an object due to the pump being moved without the boom secured and outriggers moving outwards on cornering, endangering oncoming vehicles.	FPE 3: Vehicle, Traffic & Pedestrian Safety
Holcim Minimum Standard: The boom and outriggers shall always be in the folded or transport mode when traveling or when the pump is moved to a new position.	

6.3 Vehicle and pump access

When accessing or getting down from a pump, the same “3 point rule” applies as when the cab of the vehicle is accessed. As is the case with RMX and tipper trucks, slips and trips are significant causes of injury and lost time in pumping operations.

Where heights being accessed exceed 1.8m, the requirements of FPE 1: Working at heights applies.

Figure 16: Three-point contact for access & egress

Risk: Falling from the vehicle during access or egress.	FPE 3: Vehicle, Traffic & Pedestrian Safety
Holcim Minimum Standard: The 3 point rule shall be used when climbing onto and off pumps and vehicles.	

6.4 Wind

It is important to have an awareness of the weather conditions for the day when establishing on site. Concrete mobile pumps can have a vertical reach of 17 meters to 70 meters. The limits to operating in wind needs to be known for each pump as per the manufacturer’s recommendations.

Risk: The collapse or over-toppling of a boom due to excessive wind.	FPE 9: Lifting & supporting loads
Holcim Minimum Standard: No pumping shall take place in winds exceeding 80 km/hr or as specified by the manufacturer.	

6.5 Setting up near power lines

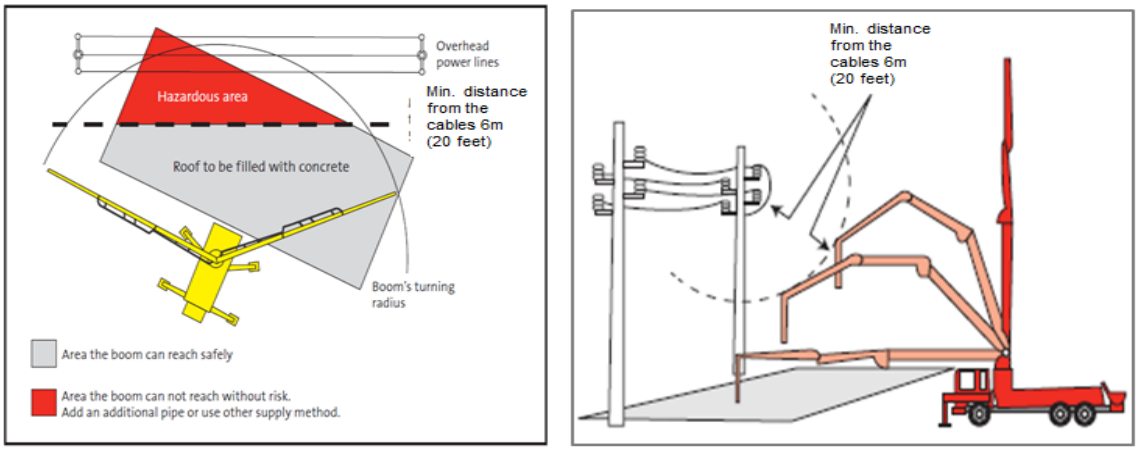


Figure 17: Power line exclusion areas

Pumping establishment regularly involves setting up in the proximity of power lines. Electricity is a major hazard as a result of the action of unfolding the boom from transport mode or moving the boom during pumping. There is the potential for electric current to pass down the boom through a person to the ground. Note that the boom does not need to be in direct contact with the power lines for such a possibility. When setting up near power lines, national legislation and regulations apply. The person in charge of the site needs to be consulted and where lines are de-energised, there needs to be evidence to this effect. Where lines are live a minimum clearance distance needs to be established relative to the voltage of the power line and this becomes the “exclusion zone”.

Many countries have different network voltages and also have regulations that require different exclusion zones, most of them are freely available to download via the internet. Below is an example of the UK requirements set by the organization that controls the power network there.

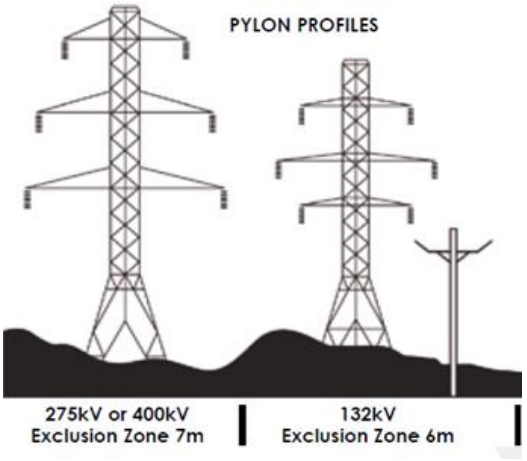


Figure 18: Example of UK power line exclusion zones

Risk: Receiving a life threatening electrical shock by making contact with the pump where the boom encroaches on the exclusion zone of a power line.	FPE 4 Electrical Safety
Holcim Minimum Standard: The pump shall not operate within 6 m of a power line and within 15m of a 350kV line or as required by relevant national legislation and regulations.	

6.6 Use of a spotter near power lines

Due to multidirectional movements of the pump boom and the need to concentrate on the delivery point, a concrete pump operator may lose perspective of the position of the boom relative to powerlines. A further difficulty would be judgement of depth of field based on the position of the pump operator. It is unlikely that a pump operator can accurately judge the boom proximity to the exclusion zone, therefore where there is a risk that the pump boom could enter the exclusion zone, a safety observer should to be designated to alert the pump operator. The pump also should to be effectively earthed as a precaution when working near power lines.

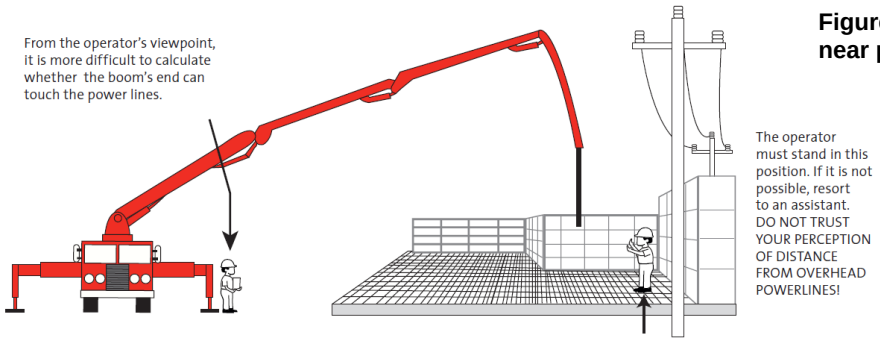
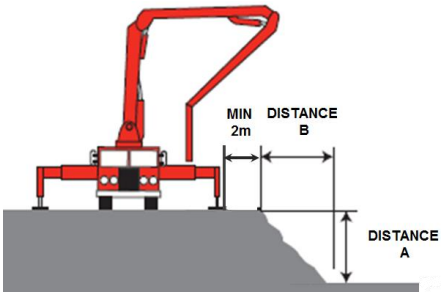


Figure 19: Use of a spotter near power lines

Risk: Life threatening electrical shock by making contact with the pump when a boom unintentionally enters an exclusion zone of a power line
Holcim Best Practice: A dedicated spotter should be used to observe safe working distance and should be in direct contact with the operator. Alternatively, a warning device can be fitted to a boom to alert the pump operator when encroaching on an exclusion zone.

6.7 Pump outrigger position

Trenches and embankments are a common feature of construction sites and usually occur between the pump position and discharge point.



Distance B must be greater than A (unsupported embankments & trenches) and the outrigger pad must be 2 meters from an unsupported edge

Figure 20: Safe operating distances near embankments

Risk: Pump roll-over due to lack of support or collapse of a trench or embankment.	FPE 8: Digging & excavation
Holcim Minimum Standard: The pump outrigger support shall be located further than one meter from the toe of an embankment or base of a trench for every one meter height or depth (one-to-one rule) and the outrigger pad must be 2m from an unsupported edge.	

6.8 Outrigger pads and blocks

Undisturbed ground or ground disturbed on construction sites for the installation of services are unlikely to have sufficient bearing pressure to support the outrigger pads that are supplied with the pump. Additional timber blocks or beams placed under the sole pads help to further distribute the load applied through the outriggers. The length of the timber beams depends on the type of ground support. They also prevent local damage to pavement surfaces. Refer to Appendix L for a guide to the length of timber blocks for dufferent ground conditions.

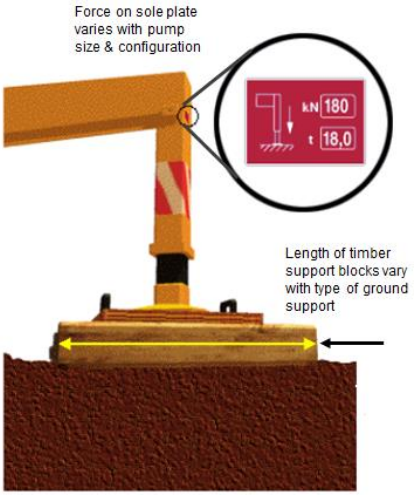


Figure 21: Sole plate & timber blocks

Risk: Pump roll-over due to lack of ground support to an out rigger pad.	FPE 8: Digging & excavation
Holcim Minimum Standard: Sole plates shall be used under stabilizer pads to spread the load on the ground.	

Raising and levelling of the pump

Once the pump has been safely positioned, it needs to be raised to a position that allows for a stable working platform. The pump action introduces harmonic loads which will be aggravated by the pumps tyres if the pump is not raised and stabilised by the outriggers, leading to metal fatigue and potentially failure of boom components and collapse of the boom.

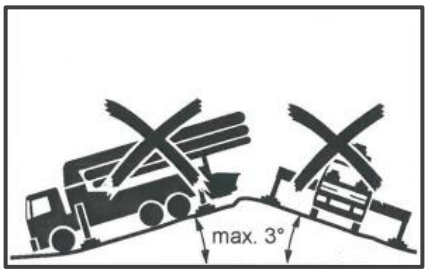


Figure 22: Levelling of the pump

Risk: Roll-over or boom failure due to the pump not operating from a level or stable platform.	FPE 9: Lifting & supporting of loads
Holcim Minimum Standard: The pump shall be raised to a level within 3 degrees of horizontal and stabilized to prevent any movement influenced by the tires or in compliance with the manufacturer's specifications.	

6.9 Attaching pipes to the end of a boom

Ideally a pump should be selected with sufficient reach to deliver concrete to the required position. This may not always be possible resulting in the addition of further pipes to the end of the boom. Where the reach of a pump needs to be extended, there needs to be a section of flexible hose between the boom and the pipe line. The weight of the pipeline needs to be supported independently of the boom. Examples of such support could be in the form of trestles. Note that this type of flexible hose has a metal collar at both ends and must not be used on its own hanging from the end of a boom as it can represent an additional hazard. There should also only be one section of flexible hose hanging from the end of a boom.

Risk: Failure of the boom or failure of the scaffolding.	FPE 9: Lifting & supporting of loads
Holcim Minimum Standard: No rigid pipeline shall be directly attached to the end of the boom without a section of flexible hose in-between.	

6.10 Pipeline safety cable

Where a discharge or placing hose is attached to the end of a boom, this hose shall also be secured with a safety chain/cable. Flexible hoses are frequently added and removed from boom pipelines. In the event that the hose is not properly secured it may result in the hose falling from considerable height. A safety Chain/cable would prevent the hose from falling should it become detached from the boom pipe line.

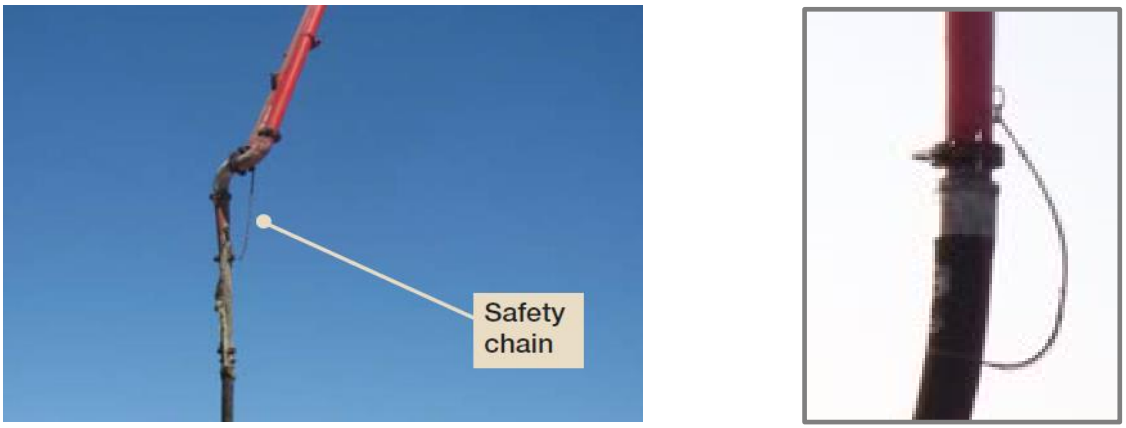


Figure 23: Discharge hose safety cable/chain

Risk: The discharge hose becomes detached while being suspended from the pump, becoming a large and heavy falling object.	FPE 9: Lifting & supporting of loads
Holcim Minimum Standard: Each attachment to the boom pipe line shall be secured with a safety chain/cable attached to the boom.	

6.11 Snap clamps

Snap clamps are used to build steel pipelines and while the clamps speed up the process, it is possible for them snap open under pressure.

Figure 24: Snap clamps with safety pins

Risk: Clamps snapping open under pressure.	Pressure vessels (no FPE)
Holcim Minimum Standard: Snap clamps shall be fitted with safety pins and no clamps shall be released while the pipeline is under pressure.	

6.12 Rubber seals

Clamps for joining steel pipes are designed to work with rubber seals. If different seals are used or other materials in the place of seals, there is a likelihood of concrete paste leaking from the join. This will result in the concrete being less pumpable, leading to increasing pump pressure and potential blockage of the pipeline.

Besides using the rubber seals specifically designed for the clamp,

Figure 25: Rubber seals

seals need to be cleaned immediately after each use to prevent concrete build up and difficulties in building the next pipeline.

Risk: Leaking pipelines at joins and bursting of the pipeline under pressure.	Pressure vessels (no FPE)
Holcim Minimum Standard: All clamps shall be fitted with the rubber seals provided for the specific clamp type and as specified for the purpose by the manufacturer.	

Lifting and fixing of pipes

Particular care needs to be taken in the carrying, lifting and fixing of pipes to a structure, for which there shall be a safe work procedure. Where pipelines are attached to a building, the pipe line attachment should be designed, detailed and signed off by a professional engineer. Particular care should be taken when accessing a structure via staircases or temporary platforms without adequate edge protection.

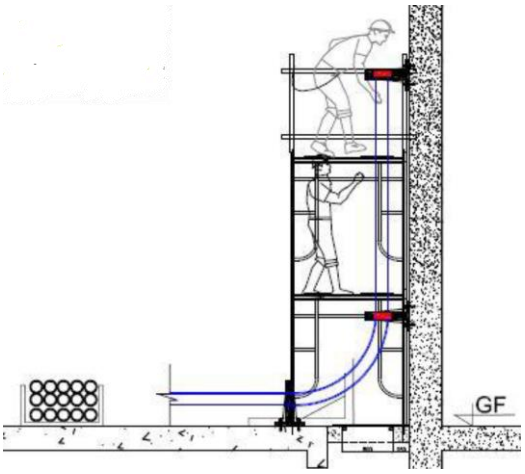


Figure 26: Pipeline support brackets

Risk: Pipeline failure due to pipes not being properly carried, lifted, supported and secured, resulting in falling objects from height.	FPE 9: Lifting & supporting of loads
Holcim Minimum Standard: All pipes shall be carried and lifted in accordance with a work procedure and fixed to a structure in accordance with the design and detailing signed off by a professional engineer.	

6.13 Thrust block

Due to the high pressure produced while pumping, vertical pipelines need to be effectively supported where they change direction. Where the pipe bend cannot be secured in position, a thrust block cast from concrete is an effective way to secure the base elbow of a vertical concrete pipe line.

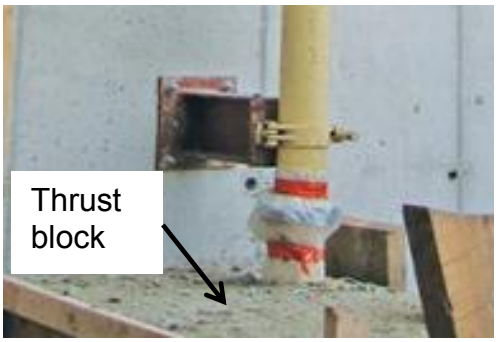


Figure 27: Thrust block

Risk: Failure of pipelines at bends due to thrust created by pumping pressure.	Pressure vessels (no FPE)
Holcim Minimum Standard: A vertical pipeline of more than 25m shall be secured at the base elbow with a thrust block at the base of the pipeline.	

6.14 Inspection of tools

Any interruption to concrete pumping can have a significant knock on effect. For example there is potential for air to enter the delivery pipe which could result in a whipping action upon resumption of pumping. Delays are also likely to affect subsequent

planning for deliveries of concrete. Having the tools necessary to keep the pump operational and in good condition contributes to a safe operation.

Particular attention should be paid to tools and materials used for effective clean-up of the pipe line and pump after the completion of a pump job to ensure that pumping services are not delayed at the next job.

Risk: Unserviceable equipment delays the start of a pumping operation and results in added pressure of work leading to mistakes.
Holcim Best Practice: All tools should be inspected on a weekly basis and be maintained and replaced if defective.

6.15 Building a pipeline

Longer pipelines require adequate time to build and secure. Where the pipeline is of significant length or where the site conditions are not straight forward, it is recommended that the pipe line is established well ahead of the pump establishment.

Risk: Inadequate time to build a pipe line which increases the possibility of mistakes, blockage and failure of the pipeline.
Holcim Best Practice: A pipe line of longer than 30m should have a dedicated vehicle to transport the pipes and a competent linesman and labour to build the pipe line.

6.16 Supporting pipe lines

Both vertical and horizontal pipelines need to be properly supported at regular intervals and must adhere to manufacturer's requirements. For horizontal lines, the support may be in the form of trestles while vertical lines need to be firmly bracketed onto the structure.

Risk: Failure of pipelines that are not secured to resist pumping forces, resulting in potential injury from projectiles and falling objects.
Holcim Best Practice: Horizontal and vertical pipe lines should be supported every 3 m.

6.17 Shut off valve

The installation of a shut off or switching valve allows for further options and contingencies on larger projects. This would allow for the switching between pumps without emptying a pipeline and would also allow for the discharge of concrete from a vertical pipeline into a receiving hopper or ready-mix truck.

Figure 28: Shut-off valve

Risk: Any stoppage or breakdown while pumping a significant vertical pipeline or the need to empty a pipeline would result in concrete under the pressure of gravity with the associated risk of opening the pipeline to discharge the concrete.
Holcim Best Practice:. A pipeline of more than 30m should have a shut-off or switching valve.

7 Concrete Pumping

Once established, the pumping process should become a lot more controlled and repetitive. Consistency and continuity of supply as well as quality of concrete become key to a successful and stress free pump job. However, there are specific areas of risk, such as ready mix trucks backing up to the pump hopper, the area around the boom and the area around the discharge hose, particularly when working at height. A particular problem regarding working at height is the extent of edge protection provided and safety relating to the stability of the support to the formwork. While these aspects fall outside of the scope of the pumping service, the pump crew needs to have some basic knowledge in order to raise the alarm should they not feel safe. A further activity that requires attention is the clean-up process.

7.1 Pump remote control

To take advantage of a better viewing point, it is common to use a remote control or radio remote control for concrete pumping. Where this is the case the controls on the pump need to be effectively isolated. The remote control shall be on the person of the pump operator. Should it become necessary to put the remote control down, the emergency shut-down must be activated and the remote control shall be locked up to ensure that it is not otherwise activated.

Figure 29: Schwing remote control unit with emergency shut-down button

Risk: The remote control being compromised by the pump mounted controls or unintended action on the remote control, resulting in unexpected and uncontrolled movement of the boom.	Cardinal rule: Isolation and lock-out
Holcim Minimum Standard: When using the remote control of a concrete pump, other controls shall be isolated and the remote control shall not be left unattended by the operator without being isolated.	

7.2 Boom danger zone

The area under the boom is a high risk area due to the continuous adjustment of the boom, an error in the control of the boom and even sudden boom collapse due to component or hydraulic failure.

While it may seem obvious to stay away from the area immediately under the boom, this is the area where concrete needs to be compacted and finished off, often under some time pressure. There are generally too many workers in the area under the boom.

Figure 30: Typical work area showing too many workers in the danger zone

Risk: Sudden and unexpected movement of the boom or hose impacting with the pump crew or construction personnel, particularly the placing crew.	FPE 9: Lifting & supporting of loads
Holcim Minimum Standard: All persons shall stay away from the area directly under the boom.	

7.3 Delivery hose danger zone

The rubber delivery hose usually hangs in a vertical position from the end of a mobile pump boom. In the event that air is sucked into the concrete pump, the resulting compression can result in a whipping action when exiting the delivery hose. Under no circumstances shall a hose fitted with a metal collar (rubber connecting hose) be used as a discharge hose.

Figure 31: Delivery hose danger zone

Risk Whipping action by the delivery hose causing an impact with the pumping or placing crew. This can result in severe injuries which can be fatal if the rubber hose has a metal collar.	FPE 9: Lifting & supporting of loads
Holcim Minimum Standard: All unauthorised persons shall stay away from an area around the delivery hose equivalent in diameter to twice the length of the hose.	

7.4 Unsighted discharge point

Under certain circumstances, the pump operator will not have visibility of the concrete discharge point. It is also important that the signaller and pump operator have radio contact or at least a clear understanding of signals to be used to direct the positioning of the discharge point.

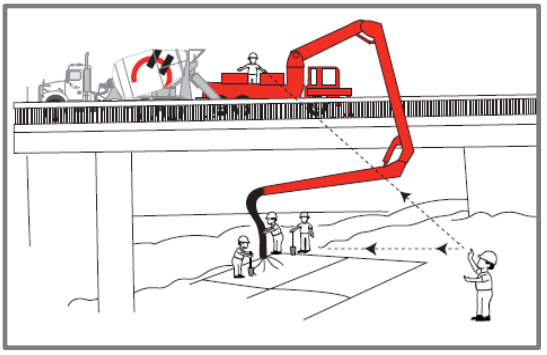


Figure 32: Unsighted discharge point

Risk: Unsafe movement of the boom due to no line of sight between the pump operator and discharge point, putting workers at risk.	FPE 9 Lifting & supporting of loads
Holcim Minimum Standard: One signaler shall be designated when the pump operator does not have visibility of the discharge point.	

7.5 Misuse of the boom

The concrete boom has been purpose built for the pumping of concrete only. The weight of the boom has also been designed to optimized the reach of the boom. It is tempting for an operator to assist the pumping crew in lifting and moving a pipeline attached to a mobile pump as pumping progresses. Any lifting action for which the pump is not designed shall be avoided at all times, as it not only risks failure, but also weakens the boom, contributing to boom failure at a later stage.

Risk: Failure of the boom due to lifting or slewing actions for which the boom was not designed.	FPE 9 Lifting & supporting of loads
Holcim Minimum Standard: The boom shall never be used to lift or otherwise move objects. This includes any concrete pipeline that may be attached to the boom pipeline via a flexible hose.	

7.6 Resting the boom on an object

The boom is designed to be self-supporting. Resting the boom on any object will result in forces being applied to the boom that was not allowed for in the design of the boom. Dynamic loads during pumping would further aggravate the problem and also put the support work or structure at risk.

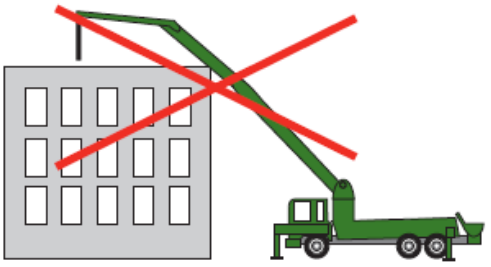


Figure 33: No resting of boom on structures

Risk: Boom failure or failure of support work or part of a structure.	FPE 9 Lifting & supporting of loads
Holcim Minimum Standard: The boom shall not rest on any structure or object.	

7.7 Pump cleaning

It is essential to clean pipelines immediately after pumping before slurry from the concrete sets in the pipes and becomes hard. Manufacturer's instructions need to be followed at all times. Various cleaning devices are provided by manufacturers such as sponges, rubber cleaning plugs or "pigs", adaptors and sponge baskets. Particular care should be taken in retrieving cleaning devices from the pipeline at which time the engine and pump must be switched off and in the emergency shut-down mode. Mobile pumps should also never travel with concrete in the pipe as the segregation of concrete in the pipe will lead to blockage even after a short distance of travel.

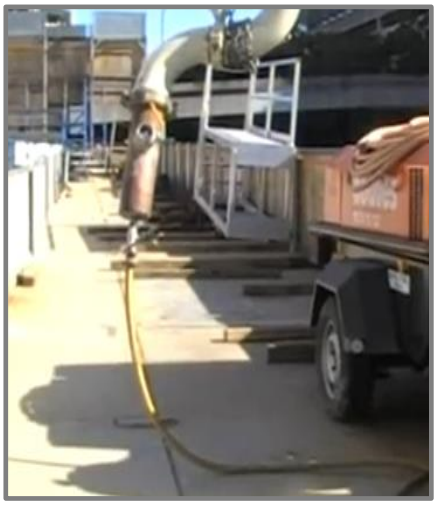
Figure 34: Sponge ball and a selection of Putzmeister cleaning devices

Risk: Impact from uncontrolled discharge of concrete or sponge ball, or pipe not properly cleaned leading to blockage when next used.	Pressure vessels (no FPE)
Holcim Minimum Standard: Unless otherwise specified by the manufacturer, pipe lines shall only be cleaned out with the sponge ball (or equivalent) using the reverse pumping method immediately after completion of pumping.	

7.8 Pipeline cleaning using water or compressed air

For long pipelines, it may be necessary to use water or compressed air to clean out pipelines. This is a highly specialised activity that requires special attention due to the pressures involved and the potential for concrete and cleaning devices to be ejected under pressure.

Where the use of water or compressed air is required to clean out pipe lines, this should only be carried out using the required equipment by competent people specifically trained for this method. Equipment includes an air compressor of the specified capacity, air to concrete pipeline adaptors, valves and a sponge ball catching basket where required. A standard operating procedure shall be drawn up incorporating manufacturer's specifications and shall be followed at all times.



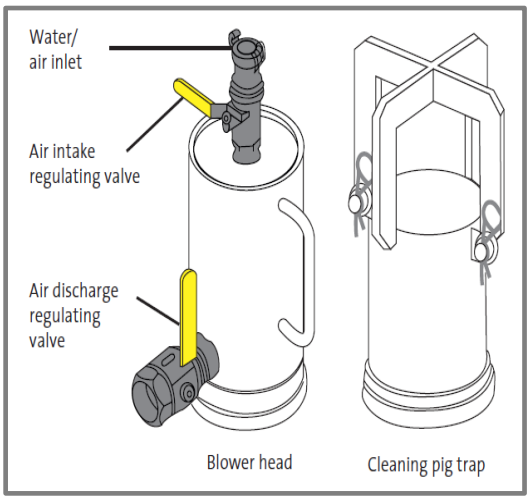


Figure 35: Pipeline cleaning with compressed air

Risk: Burst pipeline or expelled projectiles (concrete, attachments or cleaning device).	Pressure vessels (no FPE)
Holcim Minimum Standard be used by persons specifically trained in the use of these methods. The pipe line shall be fitted with a washout adaptor and valves as well as a ball catcher where compressed air is used.	

7.9 Pipeline blockages

Blockages in the concrete pipelines do occasionally happen and must be promptly but safely dealt with to avoid the consequence of concrete setting in the pipeline. A blockage is the result of a combination of a number of failures in the process and is a sure indication that all is not fully under control. Due to the added pressure that the stoppage causes to personnel on the job site and further queuing of mixer trucks, the situation can compound itself and increase the likelihood of a hazardous event. As a result, the blockage needs to be removed by a competent person. The despatch office needs to be notified immediately to hold further deliveries and reschedule deliveries for when the blockage has been cleared. It is also important for the root cause to be established and steps taken to avoid the situation repeating itself.

Figure 36: Never open a pipeline that is under pressure

Risk: Pressure build up in the pipeline when trying to clear a blockage, with the increased risk of the pipe bursting or a hydraulic hose bursting on the pump releasing hot hydraulic oil.	Pressure vessels (no FPE)
Holcim Minimum Standard: Blockages shall only be removed by persons specifically trained to do so and all pressure in the pipeline shall first be released by reversing the pump action.	

7.10 Addition of water to the concrete

Adding water to the concrete at the delivery point must be avoided. The addition of water to concrete not only reduces the concrete strength but could lead to concrete segregation which could lead to a blockage in the pipe line. Concrete consistency changes with time, particularly in transit, commonly referred to as slump loss. This is normally anticipated and allowed for in the concrete mix design. However should the properties be sub-optimal for pumping, the consistency should not be altered through the addition of water. Where there is a risk of slump loss due to distance travelled or elevated temperatures, it is recommended that admixtures are on hand and are added with the customer's knowledge and under the direction of a competent concrete technologist. In any event, the concrete technologist should be notified when there is a greater than expected change in the property of concrete at the delivery point. It is good practice to do a slump test on each truck load of concrete to be pumped and it is also a requirement of the specification for many projects.

Figure 37: No adding water to concrete

Risk: Potential blockage and burst pipe line due to the addition of water to the concrete mix.	Pressure vessels (no FPE)
Holcim Minimum Standard: No water shall be added to the concrete at the job site via the readymix truck or the concrete pump.	

7.11 Safe working loads

A concrete pump should be operated well within its working loads or "green zone". Safe working loads include limits of hydraulic pressure and temperature. Length, height and bends in concrete pump pipe lines as well as concrete properties can all have a significant impact on pump pressure and pump operating temperatures. Elevated hydraulic temperature results in reduced hydraulic oil viscosity and increases the likelihood of hydraulic failure.

Risk: Lack of safe working loads awareness could result in component and hydraulic failure.
Holcim Minimum Standard: Safe working loads shall be established as per the manufacturer's specifications and clearly marked on the pump and pump certification.

7.12 Pump operator line-of-sight

The pump operator should position himself so that he has visibility of the concrete discharge hopper as well as the discharge point of the delivery hose. Where this is not possible, the operator should have effective communication with a designated single point of contact at the concrete delivery point. This should at least include established hand signals and should include radio contact.

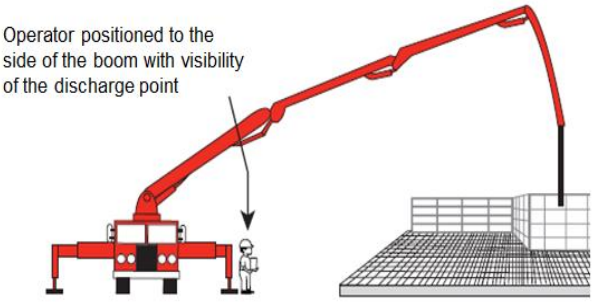


Figure 38: Correct operator location

Risk: Lack of line of sight with the concrete discharge points in recognized danger zones could result in injuries to workers or impact between objects.
Holcim Best Practice: The pump operator should have visibility of the concrete discharge into the pump hopper as well as the discharge point of the concrete delivery hose.

7.13 Danger zone around the pump

The area around the pump is dangerous due to the trucks backing up to the pump hopper and the positioning of the discharge chute. No one should be in the area between a truck and a pump, particularly when backing up. Anyone guiding the truck back should be off to the side of the truck and visible to the driver at all times. It is important that no un-authorised persons should be in this area other than persons competent in carrying out planned and routine tasks. A distance of 600mm or more should be maintained between all vehicles and the pump.

Figure 39: Unsafe position

Risk: Potential for crush injuries caused by vehicles or mobile equipment collision.
Holcim Best Practice: No un-authorized persons should be within 2m of the pump without making contact with and being under the direct supervision of the concrete pump operator.

7.14 Pump hopper concrete level

Should the concrete level in the pump hopper become too low, there is the potential for air to be sucked into the concrete pump. This can lead to air in the pipe becoming compressed and discharge with explosive force on exiting the flexible hose resulting in a dangerous whipping action. At start up and when air is ingested into the pump, all persons must be clear of the exclusion zone which is twice the length of the flexible discharge or placing hose.

Risk: Air entering the pump could result in pipe whipping of the discharge hose resulting in injury.
Holcim Best Practice: The level of concrete in the receiving hopper should never be allowed to get to a point where there is a risk of sucking air into the pump.

Conclusion

This concrete pumping safety handbook was drawn up in response to hazardous incidents experienced in concrete pumping, to assist pumping managers and share learning experiences in Holcim and thus contribute to the overall goal of "Zero harm to people". The handbook is not intended as a manual for pump operators as this is best carried out by specialists and under the supervision of experienced operators with support, training and material from pump manufacturers. The information contained in this guide can also not cover all eventualities and every Group Company will have a varying degree of technical, logistic and climatic challenges that need to be managed in a dynamic fashion. However because of the high impact and severity of the incidents prevalent in concrete pumping, it is important to conform to the minimum standards contained in this handbook.

The outsourcing of concrete pumping to a third party is often under estimated in terms of managerial control and commitment required and as a result, needs to be the focus of special attention. The matter is further complicated where construction site workers are involved with the pumping activity or working in close proximity to the pump crew. It is clear that Holcim cannot outsource its responsibility to OH&S and third party safety needs to be managed to the same high standards as Holcim own operations.

The work in compiling this handbook was mandated by the ACM Committee and developed by the OH&S Work Group representing the Holcim regions with input from the main concrete pumping operations. In the application of the minimum standards and best practice contained in this handbook, it must be clear that corporate mandates, national and local legislation and regulations take precedence.

The contents of the handbook are for Holcim use only and not for use outside of Holcim. The handbook is not to be copied, shared or used for commercial purposes.

Further useful information is appended such as a reference to online information, glossary of terminology, templates and operational information.

Appendix A: Reference to online information

Reference to corporate FPEs and Group Company safety procedures and policies is essential when developing operational pumping procedures.

1. Holcim Group

Group (corporate) Policy and FPEs can be found on the intranet Hub via this link:

https://sites.google.com/a/holcim.com/cp-corporate-ohs/

2. Selection of pumping safety publication organizations:

2.1 American Concrete Pumping Association (ACPA)
606 Enterprise Drive
Lewis Center
Ohio 43035
http://www.concretepumpers.com

2.2 British Concrete Pumping Association (CPA)
Construction Plant Hire Association
27/28 Newbury Street
London EC1A 7HU
http://www.cpa.uk.net/british-concrete-pumping-group-bpcg/

2.3 Cement Concrete & Aggregates Australia (CCAA)
Level 10
163-175 O'Riordan Street
Mascot NSW 2020
http://www.ccaa.co.au

2.4 Worksafe Victoria, Australia
Victorian Work Cover Authority
24th Floor
222 Exhibition Street
Melbourne Victoria 3001
http://www.worksafe.vic.gov.au/construction

2.5 High Risk Licence Training
Licence to operate a concrete placing boom
Safe Work Resources (Australia)
Bendigo Media Centre
Lily Street, Bendigo
Victoria VIC 3550
http://www.safework.com.au/pdfsamples/CPCCLBM3001A.pdf

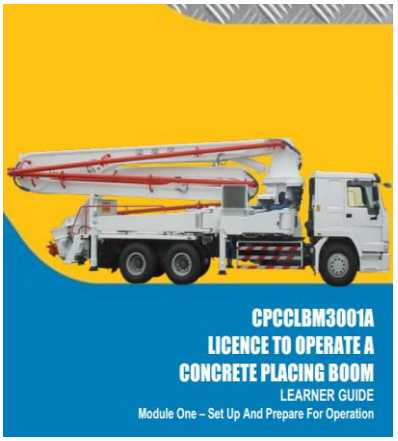


Figure A1 Licence to operate a concrete placing boom

2.6 Guideline for delivering to concrete pumps
Ready Mixed Concrete Association of Ontario
http://www.rmcao,org

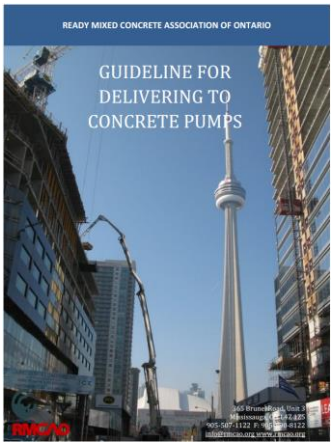


Figure A2: Guideline for RMX truck drivers

Appendix B: Glossary of pumping terms

(Source: Camford Concrete Pumps Ltd (Ref: http://www.camfaud.co.uk))

Agitator: A re-mixer in the hopper that keeps the concrete in a homogeneous state and feeds it towards the pumping cylinders.
Ball catcher: A device, fitted to the end of a concrete delivery pipeline when cleaning it with compressed air, designed to catch the sponge ball and prevent it from being fired across the site. Note: the ball catcher should be fitted to steel pipeline – all hoses must be removed before attaching the ball catcher.
Bend: A bent or cast steel pipe that allows a concrete delivery pipeline to deviate from a straight line. Bends are available in a number of different radii typically up to 1 metre. Different angle bends are used, the most common of which are 90 and 45 degrees.
Blockage: When the concrete blocks in the pipeline and cannot be pumped. The common causes of a blockage are 1. Insufficient grout used to grout up, 2. too thin a grout used to grout up and 3. the concrete mix is not suitable for pumping due to insufficient cement and / or fines and / or poorly graded aggregates.
Blown washout out adapter: A stub pipe with an air inlet port and an air vent port used to introduce compressed air into a concrete pumping pipeline to force a sponge ball through the line to clean it. The adapter should also include a stop to prevent the sponge ball being forced back under pressure and thus sealing the vent port.
Boom: The hydraulically controlled arm of a concrete pump used to distribute and place the concrete.
Mobile pumps: A truck mounted concrete pump with a hydraulic boom that is used to place the concrete. A mobile pump consists of three major components – 1. truck cab/chassis, 2. concrete pumping unit and 3. boom.
Clamp: A coupling that connects together two sections of pipeline and / or end placing hose.
Competent person: A person who the pump manager ensures has skills and knowledge through a combination of training, qualification and experience to enable the person to correctly perform the task required.
Concrete delivery pipe: A steel pipe used to deliver concrete. The length of a standard pipe is 3 meters. They have a flange at both ends to allow them to be coupled together using coupling sets.
Concrete pump: A piece of construction equipment designed to pump concrete from one position on a construction site to another. Concrete pumps can be categorized as stationary pumps or mobile pumps.
Concrete pump primer: A non cementitious material which is mixed with water and used to grout up the pump. Pump primers are often used instead of the more traditional cement grout – they are promoted as being better from a health and safety perspective as they are lighter and less dusty. Best practice suggests that the pump primer should be pumped to a suitable waste receptacle and not into the structure.
Coupling: The fitting that connects together two sections of pipeline and / or end placing hose.
Coupling set: The items needed to couple one pipe to another – typically a coupling, seal and safety pin.
End placing hose: A steel reinforced hose used to distribute concrete at the end of a boom or static line.
Gate valve: A type of shut off valve. There are two types of gate valves – manual and hydraulic.
Ground line: A term used for a concrete delivery pipeline that is laid on the ground / reinforcing steel.
Grout: A mix of cement and water pumped ahead of the concrete to line the pipeline. This grout lining forms a lubricating layer ahead of the first load of concrete ensuring that the concrete does not block in the line. Best practice suggests that the grout should be pumped to a suitable waste receptacle and not into the structure.
Hopper: The part of the pumping mechanism that receives the concrete from the ready mixed concrete truck and feeds it into the pumping mechanism.

Hose: A concrete delivery hose, used at the end of a boom or as part of a ground line.
Line Trailer pump: A mobile concrete pump without a boom – the concrete being pumped through a ground line.
Long radius bend: A large bend typically with a 1 meter radius.
Manual boom: A small stationary placing boom used to distribute and place concrete into a slab.
Mobile pump: A concrete pump that is mounted on a truck. The vast majority of mobile pumps are equipped with a placing boom to distribute and place the concrete. Mobile pumps without booms are called line pumps.
Outrigger pads: Pads that are placed under the foot of the outriggers to spread the load exerted by the pump onto the ground. Each pump comes equipped with outrigger pads but, if the ground is poor, additional timber blocks need to be used.
Outriggers: Support structures for the pump that are generally extended and lowered to give stability to the pump when using the boom. The outriggers should be deployed as per the manufacturer's guidelines. This usually means being fully extended but some pumps, those fitted with a boom interlock that limits the slew of the boom, can work the boom on one side of the pump and short rig on the other side.
Pig: A moulded rubber device used for cleaning out long pipelines especially when cleaning out with water.
Pipeline: A run of concrete delivery pipes, usually ending with an end placing hose, to distribute concrete from the pump to the structure being built.
Pipeline job: A contract where it is not possible to place directly from the end placing hose at the end of the boom. The concrete is placed via a ground line.
Placing hose: A steel reinforced hose used to distribute concrete at the end of a boom or stationary line.
Pump mix: A mix of concrete designed to be pumped. It generally has more cementitious material and more fines than a standard mix.
Radio remote control: A remote control device that does not require the control box to be connected via a cable.
Reducer: A pipe used to reduce from one size pipeline to another. The most common reducer is a 5-4 reducer that allows a reduction from 125mm to 100mm pipeline.
Remote control: A control for the pump and boom that can be operated away from the machine. Modern pumps are fitted with radio remote controls and a cable remote control for occasions when the radio remote control cannot be used.
Riser: A vertical pipeline built to pump concrete to a higher level.
Safety grille: A grille on the hopper that catches oversized material and prevents it from entering the pumping mechanism. It has an interlock that shuts off the pump when it is opened to prevent the possibility of the agitator or pump valve causing injury whilst the pump is being cleaned / being repaired.
Safety pin: A pin used to lock a coupling closed to stop it from springing open accidentally.
Seal: The part that is used in a coupling to seal the joint. It is important to use a seal in at every joint to prevent grout leaking at the joint.
Short-rig: Deploy the pump outriggers not fully extended. This must not be done except in accordance with the manufacturer's recommendations when deploying the boom interlock to limit the range of slew.
Shut off valve: A valve installed into a concrete delivery pipeline to prevent the concrete from flowing back under gravity in a vertical pipeline, mostly used to isolate the pump when washing out the pipeline.
Slew restrictor: A device that sets limits to the slewing angle of a boom thus preventing it from over-sailing an area of danger, for instance a railway line.
Spider boom: A manual boom; small stationary placing boom used to distribute and place concrete into a slab.
Sponge ball: A ball made from a rubber compound that is forced through a pipeline to clean it out. Sponge balls come in a variety of sizes and density of material (soft, medium and hard). The sponge ball selected will be slightly oversized to scour the pipeline clean.

Stationary pump: A concrete pump mounted on a skid or wheeled chassis, powered by a Diesel engine or electric motor. Stationary pumps are usually used on medium to long term contracts; they are set up in a pumping station and left in position the duration of the concreting program. Stationary pumps do not have booms but the pipeline from them can be connected to manual booms or stationary placing booms.

Stationary placing boom: A hydraulic placing boom used in conjunction with a stationary concrete pump to place concrete on a high rise building and occasionally on large civil engineering structures. They are usually mounted on a steel column and can be free standing or climbed through a building as it progresses. Stationary placing booms are popular on inner city sites where space and crane hook time is at a premium.

Trailer pump: A trailer pump is a stationary pump mounted on a wheeled trailer so that it can be moved about on site. Note that only the very smallest, lightest trailer pumps have trailers suitable to allow the pump to be towed to and from site.

Wash out/ blow out adapter: A stub pipe with an air inlet port and an air vent port used to introduce compressed air into a concrete pumping pipeline to force a sponge ball through the line to clean it. The adapter should also include a stop to prevent the sponge ball being forced back under pressure and thus sealing the vent port

Washout box: A box that is made to contain the waste from a concrete pump when it is washed out at the end of a pour. It is typically 4 pieces of scaffold board approximately 2m long, placed on their ends and nailed together then lined with polythene sheeting.

Figure B1: Mobile concrete pump

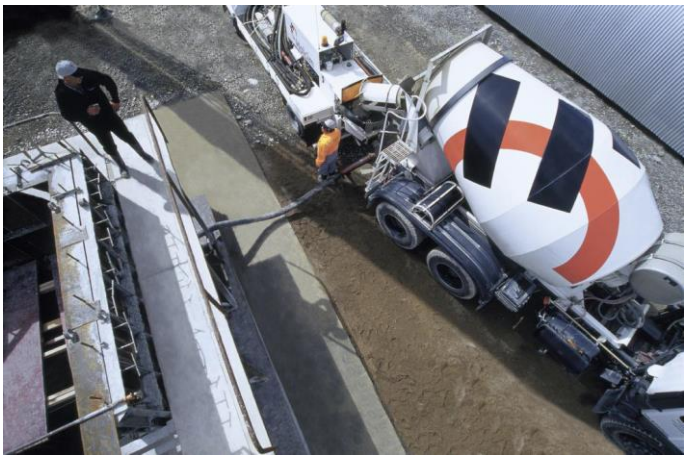
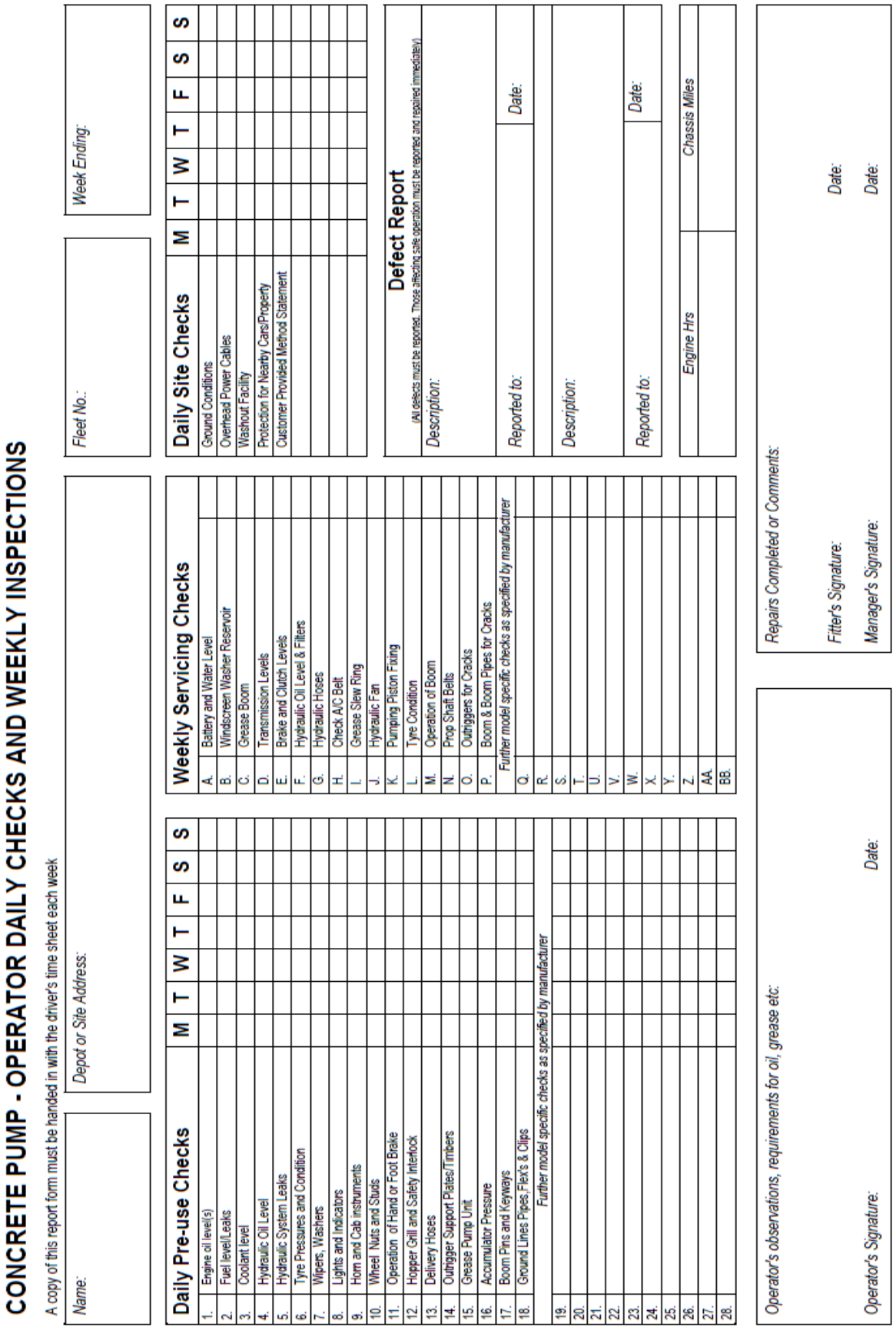


Figure B2: Truck mounted stationary pump (without a boom)

Appendix C: Example of Daily check & Weekly Inspection checklist

Source: Concrete Pumping Association, Good practice guide, Safe use of concrete pumps



CONCRETE PUMP - OPERATOR DAILY CHECKS AND WEEKLY INSPECTIONS

A copy of this report form must be handed in with the driver's time sheet each week

Name:

Depot or Site Address:

Fleet No.:

Week Ending:

Daily Pre-use Checks	M	T	W	T	F	S	S
1. Engine oil level's)							
2. Fuel level/Leaks							
3. Coolant level							
4. Hydraulic Oil Level							
5. Hydraulic System Leaks							
6. Tyre Pressures and Condition							
7. Wipers, Washers							
8. Lights and Indicators							
9. Horn and Cab instruments							
10. Wheel Nuts and Studs							
11. Operation of Hand or Foot Brake							
12. Hopper Grill and Safety Interlock							
13. Delivery Hoses							
14. Outrigger Support Plates/Timbers							
15. Grease Pump Unit							
16. Accumulator Pressure							
17. Boom Pins and Keyways							
18. Ground Lines Pipes, Flex's & Clips							
Further model specific checks as specified by manufacturer							
19.							
20.							
21.							
22.							
23.							
24.							
25.							
26.							
27.							
28.							

Weekly Servicing Checks	
A. Battery and Water Level	
B. Windscreen Washer Reservoir	
C. Grease Boom	
D. Transmission Levels	
E. Brake and Clutch Levels	
F. Hydraulic Oil Level & Filters	
G. Hydraulic Hoses	
H. Check A/C Belt	
I. Grease Slew Ring	
J. Hydraulic Fan	
K. Pumping Piston Fixing	
L. Tyre Condition	
M. Operation of Boom	
N. Prop Shaft Bellts	
O. Outriggers for Cracks	
P. Boom & Boom Pipes for Cracks	
Further model specific checks as specified by manufacturer	
Q.	
R.	
S.	
T.	
U.	
V.	
W.	
X.	
Y.	
Z.	
AA.	
BB.	

Daily Site Checks	M	T	W	T	F	S	S
Ground Conditions							
Overhead Power Cables							
Washout Facility							
Protection for Nearby Cars/Property							
Customer Provided Method Statement							

Defect Report

(All defects must be reported. Those affecting safe operation must be reported and repaired immediately)

Description:

Reported to: *Date:*

Description:

Reported to: *Date:*

Engine Hrs	*Chassis Miles*

Operator's observations, requirements for oil, grease etc:

Operator's Signature: *Date:*

Repairs Completed or Comments:

Fitter's Signature: *Date:*

Manager's Signature: *Date:*

Appendix D: Example of Site Delivery Check List

(Source: Published by the CCAA of which Holcim Australia is a member)

CCAA Concrete Pump Delivery Industry Guidelines

Appendix 3
Safe Site Delivery Checklist

Your Name: _____ Date: _____

Site Location: _____ Job #: _____

Docket #: _____ Truck #: _____ Time: _____

Take Five to Stay Alive

1. Stop, look, walk around
2. Think through the task
3. Identify hazards
4. Control and communicate
5. Do the job safely

Site Access	Y	N
Safe and legal entry to site eg clear visibility, traffic control, signage	☐	☐
Surface/grade of access safe eg loose material, steep, soft ground	☐	☐
Access clear and unobstructed eg trees, steel storage, width	☐	☐
Overhead clearance adequate eg powerlines, scaffolding, roofs	☐	☐
Pedestrian accesses defined and safe eg clear visibility, signage, barricades	☐	☐
Safe and legal exit from site eg clear visibility, traffic control, signage	☐	☐

Working Space	Y	N
Level ground provided eg potholes, rocks, loose materials	☐	☐
Fall protection provided eg barricades, open trenches, pits	☐	☐
Clear of sharp objects/protrusions eg uncapped star pickets/reo bar, trip hazards	☐	☐

Site Access	Y	N
Safe reversing eg spotter visible, clear access	☐	☐
Clear of overhead hazards eg power lines, workers above	☐	☐
Pump positioning safe eg clear working space to discharge	☐	☐
Grate in place on hopper	☐	☐
Hose joints have safety locks	☐	☐
Pump E-stop accessible	☐	☐
Two truck feed setup safe (if applicable)	☐	☐

General (if applicable)	Y	N
Adequate lighting provided	☐	☐
Vehicle wash down area eg chute and wheel wash area	☐	☐

List any other hazards you have identified that need to be rectified: _____

List any other hazards you have identified that need to be rectified: _____

If you don't feel safe to work on this site then stop.
Immediately communicate any issues or changes on site to plant staff.

CEMENT CONCRETE & AGGREGATES AUSTRALIA

Appendix E: Pipe wall thickness and hand signals

(Source: Worksafe Victoria Australia, Industry Standard, Concrete Pumping, 2004)

1. Pipe wall thickness

An example of determining minimum steel pipe wall thickness based on formula from Standards Australia AS4041 for 108mm & 133mm outside diameter pipes. The standard suggests the use of Grade 200 steel and 120 Bar thickness values where the grade and pressure are not known.

MINIMUM PIPE WALL THICKNESS [mm]

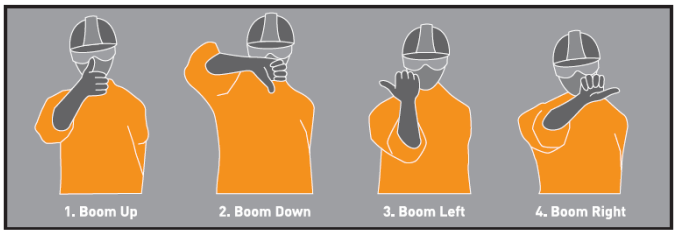
Maximum Pressure		Outside Diameter of Pipe					
kPa	Bar	Grade 200		Grade 250		Grade 350/ST-52	
		108mm	133mm	108mm	133mm	108mm	133mm
4,500	45	2.2	2.7	1.7	2.1	1.3	1.6
6,000	60	2.9	3.5	2.3	2.8	1.7	2.1
8,000	80	3.8	N/A	3.0	3.7	2.3	2.8
10,000	100	N/A	N/A	3.8	N/A	2.9	3.5
12,000	120	N/A	N/A	N/A	N/A	3.4	N/A

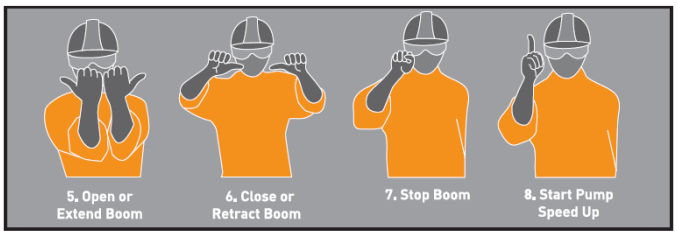
The above reference is provided as a guide only and similar tables should be drawn up using manufacturers specifications, known steel grades and maximum pump pressure.

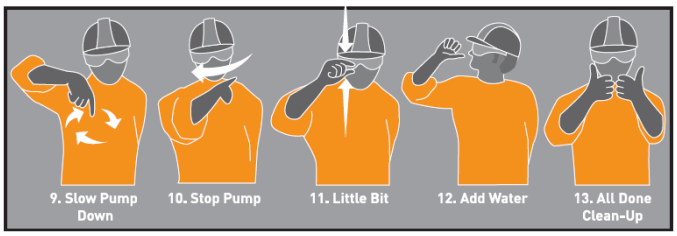
The standard recommends monthly testing for pipe wall thickness using ultrasonic testing.

2. Spotter hand signals

The use of standard hand signals should be used to ensure clear communication between the spotter and operator.







Appendix F: Continuous Flight Auguring (CFA)

One specialist application of concrete pumping is to form CFA bored piles. In this application a hollow stemmed auger is drilled into to ground and as the auger is withdrawn, concrete is pumped through the auger to fill the void created by the withdrawing auger. A steel reinforcement cage is then pushed into the fluid concrete to complete the reinforced concrete pile.

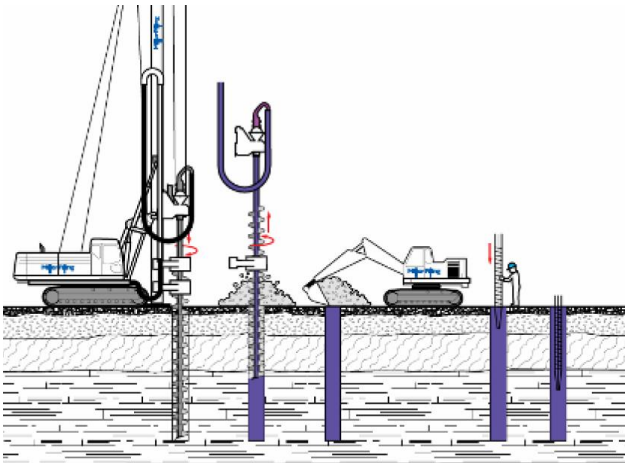


Figure F1 CFA work sequence

Specific Features of CFA concrete Pumping.

- A Static pump is normally used;
- As the piling rig is tracking to different pile positions, rubber ground hoses are normally used;
- To allow the auger to move up and down the rig mast, the rig will include a steel pipe up the side of the mast to a 180° bend termed the “elbow”. From this, there is a loop of rubber hose connecting to the “swan neck” on the rotary table atop of the auger assembly. This hose is termed the “loop hose” or “drop hose”. See Figure A1above;
- To ensure continuity of concrete supply between delivery loads, a site concrete agitator (similar to a ready-mixed concrete drum) is normally used. The concrete is placed into the agitator either by pumping or by direct discharge using an access ramp;
- As the rate of auger extraction must match the rate of concrete delivery, direct and continuous communication is necessary between the pump operator and the rig operator.

Site Planning

- During setting up the site, the pump should be located convenient to the site entrance yet generally centrally to the piling operations;
- The hoses to the rig should be routed so they will not be driven or tracked over. Where road crossings are necessary, hose bridges should be used or the hose buried in a shallow trench;
- The pump operators work area should normally be segregated from other site activities by fencing or other robust demarcation. Within this area, a safe and non-slip working environment is to be provided and maintained

Source: Concrete Pumping Association, Good Practice guide, Safe use of concrete pumping, 2004

Appendix G: Pipeline blockage clearance safety

This section contains an example of a procedure for the safe clearance of a pipeline blockage. Group Companies should develop their own documented procedure and ensure that all operators are adequately trained in it.

The three main causes of concrete pumping system blockages are :
1.1.3 Mix design deficiencies
1.1.4 Pipeline and joint deficiencies
1.1.5 Operating error or careless use of the discharge hose

To clear a pipeline blockage the follow procedure can be followed

- All line blockages must be treated as potential hazards that must be treated cautiously.
- After locating a blockage or rock jam by tapping on the steel pipes to detect a more solid sound, always ensure that the line is no longer under pressure before attempting to clear it. Reverse the pump briefly to reduce the pressure.
- After the pipeline has been depressurized, remove the joint coupling nearest to the jam.
- Never stand straddled over a horizontal line when opening a coupling; always stand to one side.
- Lift the line so that all the free-flowing concrete runs out.
- Bend the hose or tap on the pipeline in the area of the jam and shake out loose particles.
- After the line has been cleaned out, recouple the section and resume pumping.
- If the blockage is in the delivery hose, placing crews should stand clear of the hose until the blockage is cleared. The hose can whip around if the obstruction suddenly moves.
- Never use compressed air to clear a blockage. It’s unsafe and unnecessary. If a much higher pump pressure can’t move the blockage, air pressure can’t move it either. Any attempt to clear a blockage with air is extremely dangerous and have resulted in fatal injuries. Problems relieving the air pressure, residual air pockets, and additional blockages due to segregation can be created.

Appendix H: Example of OSHA Training Toolbox Talk

Personal Protective Equipment – Hard Hat Dos & Don'ts

ANSI-approved hard hats are designed to protect you from the impact of falling objects, and with some types, from accidental contact with electrical current. However, the way we take care for our hard hats can have a big impact (no pun intended) on how well it does its job. Here are a few DOs and DON'Ts regarding the use and care of your hard hat:

- DO CLEAN your hard hat as needed, using a mild soap and water solution or other solution recommended by the manufacturer.
- DO STORE your hard hat as recommended by the manufacturer, which means keeping it out of the direct sun (like on the back dash of your car) and out of areas with high heat (like in the car trunk) while you're off the job.
- DO INSPECT your hard hat shell and suspension for damage and deterioration every day before use, as well as after any event that may affect its integrity (such as being struck by a falling object or crushed).
- DO REPLACE your hard hat shell or suspension when it shows any signs of damage or deterioration.
- DO NOT PAINT your hard hat. Hard hat manufacturers typically forbid using paints because they can degrade the strength of the hard hat shell, making it easier to break.
- DO NOT USE SOLVENTS to clean your hard hat. Just like with paints, solvents can also degrade the strength of the hard hat shell.
- DO NOT ALTER OR MODIFY your hard hat. Drilling holes and/or inserting screws in your hard hat so you can add attachments (or for any other reason) can weaken the shell of your hard hat, and can also allow electrical current to pass through.
- DO NOT WEAR YOUR HARD HAT BACKWARDS unless specifically approved by the hard hat manufacturer and your employer.
- DO NOT WEAR A BALL CAP BENEATH YOUR HARD HAT. Doing so could interfere with the suspension and shell, which work together to reduce the force of an impact. Cold weather liners approved by the hard hat manufacturer are available.

Obviously, your hard hat won't protect you unless it's being worn. But to give you the maximum protection offered, they must also be worn in accordance with the manufacturer's recommendations for the particular brand and model in use, as well as in accordance with the policy of your employer. So please take care of your hard hat, so it can take care of you.

Any question or comment about the proper care and use of your hard hat?

Please be sure to sign-in on the training certification form.

OSHA SAFETY TRAINING CERTIFICATION FORM
Toolbox Topic Covered: Personal Protective Equipment – Hard Hat DOs and DON'Ts
Company Name: _____ Date: _____

Training led by: _____

PRINT NAME & SIGN (Participants)

_____

_____

Holcim OH&S

Toolbox Talk: Concrete delivery to a pump

When Holcim employees deliver concrete to a job site, the following is required to be provided for the driver prior to off-loading:

- The readymix truck driver shall comply with the Holcim cardinal rules.
- The readymix truck driver shall comply with the Holcim 5 “Road-2-safety” rules.
- Appropriate and complete PPE to be worn at all times (safety glasses, hard hat, ear protection, safety shoes, high visibility vest/clothing and rubber gloves.
- Instructions on the job site hazards communicated to readymix truck drivers.
- Access in and out of the job site with a safe level operating area for the readmix truck.
- Adequate lighting of the job site (especially during dawn, dusk and night periods).
- Signaler/spotter (traffic controller) should be provided and identified to the driver.
- Discharge area is to be communicated to the driver, if possible prior to delivery.
- Location of a proper wash out area must be designated and shown to the driver.
- The readymix truck must remain the legislated distance, required in the Construction Projects Regulation away from any overhead electrical wires.
- Worksite personnel are not to access the readymix truck ladder or truck.
- The readymix truck driver shall only perform tasks relating to concrete delivery and shall not handle any other equipment on site.
- A clear walkway around the truck shall be provided for all stationary work. This may result in only one truck at the discharge point at one time should space not permit.
- One (1) meter distance is suggested between trucks at all times.
- The pump truck boom shall never be moved over the concrete truck or driver and no closer than 6 metres or 20 feet from overhead electrical wires.
- A communication plan must be identified between the pump operator and readymix driver including the appropriate level of concrete to be maintained in the pump at all times, when to start and stop pouring and any other communications required.
- The readymix driver must be made aware of the emergency stop locations on the pump prior to discharging concrete.
- Concrete shall not be poured into the pump hopper until the pump operator has primed the pump to avoid plugging and back pressure projectile hazards.
- Unused concrete in the pump shall not be discharged back into the concrete mixer.
- Water shall not be added to the pump hopper via the readymix truck schute.
- Any question or comment about concrete delivery to a pump?

Please be sure to sign-in on the training certification form.

OSHA SAFETY TRAINING CERTIFICATION FORM
Toolbox Topic Covered: concrete delivery to a pump

Company Name: _____ Date: _____
Training led by: _____

PRINT NAME & SIGN (Participants)

Appendix I: Lifting of pipes

- Refer to FPE 9: Lifting and Supporting of loads
- Use mechanical means where possible (cranes and pulleys)
- Check the condition of ropes before use to ensure that not defective
- Check for overhead power lines or other obstacles
- Establish an isolated area and demarcate the area with safety cones or tape.
- No persons should be in the demarcated danger zone while the pipes are being lifted.
- Under no circumstances should anyone be standing under suspended loads
- Persons at higher levels (above 1.8m) must adhere to FPE1: Working at heights
- There must be effective communication between the pipe crew that are working at different levels
- For manual lifting of pipes, refer to the recommended slinging method in the illustration below.

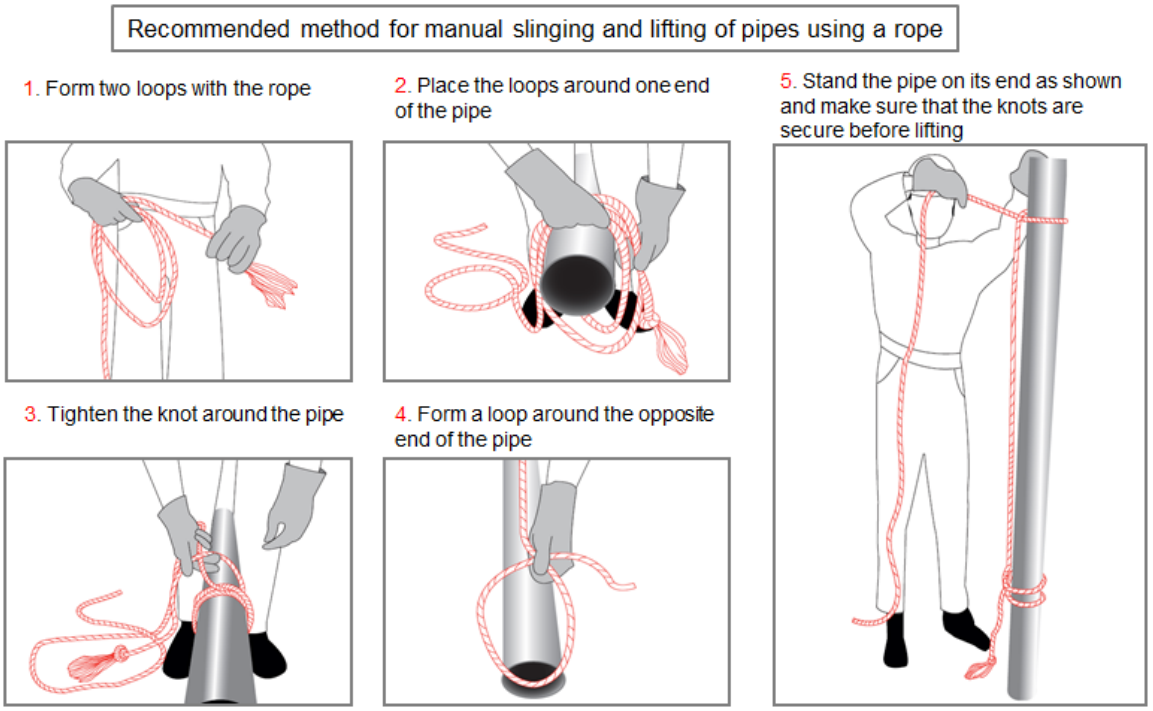


Figure I 1 Pipe slinging method using a rope

Appendix J: Holcim Policy Landscape

(Most applicable FPEs for concrete pumping in red).

- OH&S Pyramid
- Contractor safety management (CSM)
- Design Safety and Construction Quality program (DSCQP)
- Cardinal rules

Holcim OH&S Cardinal Rules

1. Do not override or interfere with any safety provision nor allow anyone else to override or interfere with them.
2. Personal Protective Equipment (PPE) rules applicable to a given task must be adhered to at all times.
3. Isolation and lock-out procedures must always be followed.
4. No person may work if under the influence of alcohol or drugs.
5. All injuries and incidents must be reported.

Cardinal Rules to be applied without compromise and zero tolerance as of 1.1.2007

- Fatality Prevention Elements (FPE)

Holcim Fatality Prevention Elements (FPE)			
1	Vehicle, Traffic & Pedestrian Safety	8	Digging & excavating
2	Working at heights	9	Lifting & supporting loads
3	Isolation & lockout	10	Working near water
4	Electrical safety	11	Rail safety
5	Machine guarding	12	Quarry slopes & stockpiles
6	Confined space entry	13	Exposure to hot material, surfaces & gasses*
7	Hot work (Ignition sources)	*	To be developed

- Road Safety Program (RSP)

All Companies to establish the 5 'Road-2-Safety' Rules

1. Look out for vulnerable road users, and care for yourself
2. Obey traffic and loading laws, and drive at a safe speed
3. Maintain your vehicle, and properly restrain your load
4. Do not drive under the influence of alcohol or drugs
5. Report all injuries and accidents

Appendix K: Pumping incidents case studies

(Where MS refers to minimum standard and BP refers to best practice)

Alerts and Critical incidents are part of the Holcim OH&S Cardinal Rules, namely #5: Report all injuries and accidents. The purpose is to learn and share information so that these incidents are not repeated. The following case studies in a summarised form and the full version can be made available via the Group Company safety Co-ordinator. The approach taken here is to highlight mitigation of risks based on material from the handbook, rather than establish the root cause of the incidents or establish what measures where in place.

1. Critical Incident: A third party employee had his right hand amputated due to crushing while cleaning a concrete pump.

What happened: In August 2013, a third party concrete pump operator had completed a pump job and proceeded to clean the pump by sucking back a sponge ball towards the pump hopper. On opening the inspection lid the sponge ball had moved beyond this point towards the pump hopper. The operator opened the lid and placed his hand in the pipe in order to retrieve the ball and put the pump into the pump mode. Concrete was projected down the pipe crushing his hand on the edge of the opening and catapulting the operator backwards.

Figure K1: Picture from the incident

Figure K2: Picture from a Putzmeister brochure

Mitigation of risk from the pumping manual:

- # 1.1 Competent person to manage a third party pumping service as though it was a Holcim own operation (MS).
- Holcim Cardinal Rules: Isolation and lockout procedures must always be followed (Holcim policy landscape).
- OH&S Pyramid: Safe work procedures (and others).
- # 2.1 Training: Pump and pipe clean out (BP).
- # 2.2 Toolbox talks: Develop one for pump clean out for specific pumps (BP).
- # 2.3 Certification of pump operators (BP).
- # 4.1 Contractor management and Contractor Safety Management (MS)
- # 6.3 Moving parts and openings: No one shall reach into any openings in the pump.
- # 8.7 Pump cleaning: Retrieving devices from the pipe line (MS). This is a key mitigation of risk in this case. There should be a safe operating procedure taking into account the operating manual or supplier's specification for this routine task.

In figure K2 above, the inspection opening lid has a pin designed to be inverted and to prevent the sponge ball from being sucked into the valve system on cleaning. With the pump isolated, the elbow can be hinged open and the ball safely retrieved.

2. Fatality alert**:** A construction worker was killed when the boom of a concrete pump failed.

In November 2014, a Holcim concrete boom pump was in the process of pumping the first load of concrete to the second floor slab of a building. The second stage of the boom failed killing the hose man who was holding the hose and standing underneath the boom. The pump was part of an acquisition and had been in operation for 27 years.

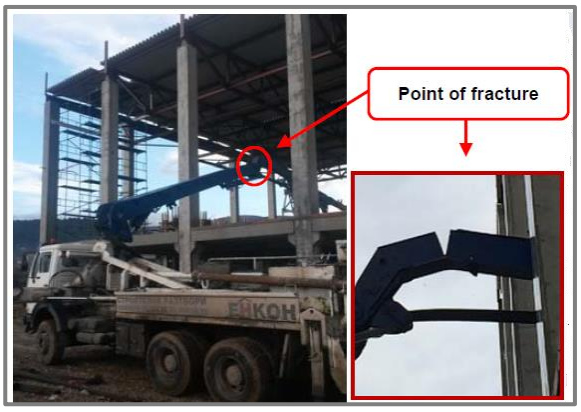


Figure K3: Pictures from the incident

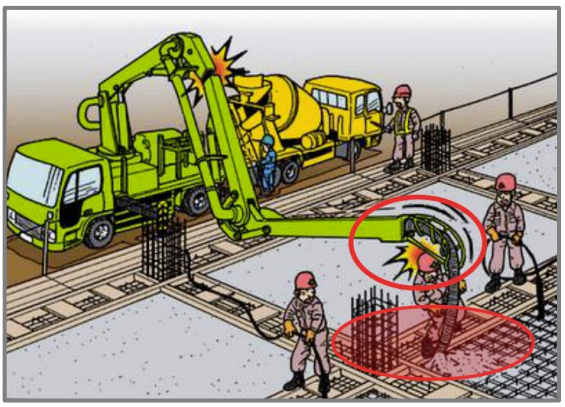


Fig K4: Illustration of a boom failure and danger zone directly below a boom

Mitigation of risk from the pumping manual:

- # 1.1 Competent person to manage a Holcim pumping service (MS).
- # 1.4 Safety induction: Pump specific which would take into account the output of a risk assessment and the danger zone under a pump (MS)
- # 2.2 Toolbox talks: Develop one for danger zones and concrete placing (BP).
- # 2.1 Training: Basic risk assessment for on-site establishment (BP).
- # 4.2 Maintenance procedure: To be established for pump and boom in conjunction with the supplier (MS).
- # 4.5 Certification of vehicles pumps and booms (BP). Certification of pumps before entering service, particularly given the age of the pump.
- # 4.7 Boom inspection (BP). Recommended every 500hrs for booms over 10 years old.
- # 5.1 Risk management records (MS), including boom inspections.
- # 5.2 Maintenance and repair records (MS). For the life time of the vehicle for decision making but also in defense of incidents.
- # 8.2 Boom danger zone (MS). All persons shall stay away from the area directly under the boom. Key risk mitigation relevant to this incident.
- # 8.3 Delivery hose danger zone (MS). All unauthorised persons to stay away from the area around the delivery hose. In this case if the hose man who worked for the contractor was authorised, he would also need to be competent (trained, experienced with a pumping specific induction). This area requires specific management attention as a person who is not an employee and likely to be a contractors employee or sub-contractor is in direct contact with Holcim equipment.

Notes on reliability maintenance with reference to the bath tub curve:

Application of to the Design Safety and Construction Quality Program (DSCQP) is recommended as it deals specifically with the monitoring and failure of steel structures. In terms of reliability engineering theory, wear out failure can be anticipated in concrete boom pumps and hence the recommendation for more intensive monitoring after 5 and particularly 10 years. These periods cannot be considered fixed as the extent of fatigue would be more a function of hours worked or concrete volume pumped (best practice) than time. A particular warning sign would also relate to lack of service history where a pump was not a new unit and hence had an unknown history. According to the DSCQP assessment procedure, the boom in this case would have fallen into category IV: Intensified monitoring and even a decision to scrap the boom.

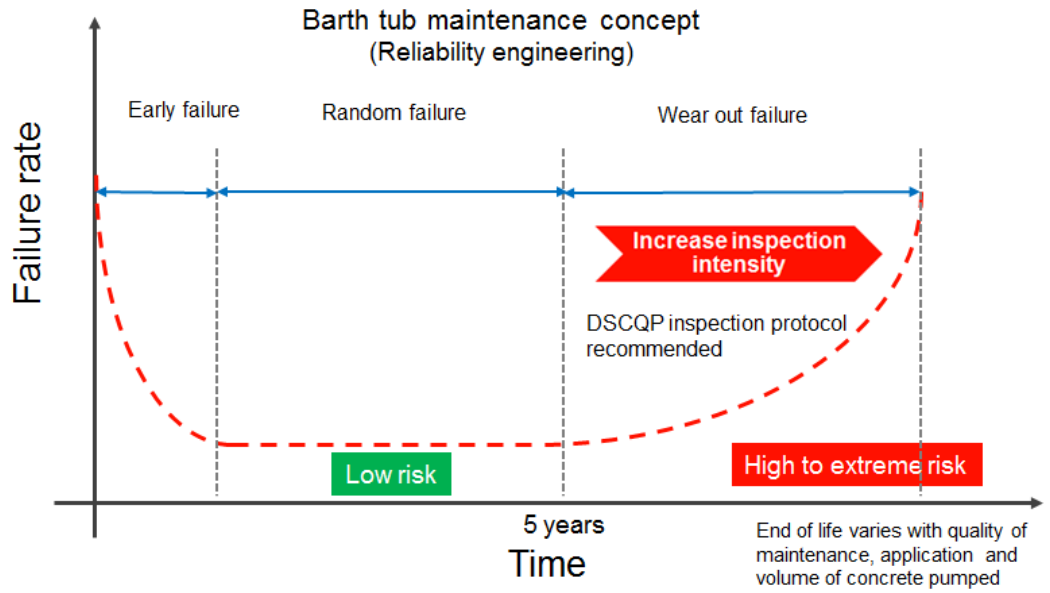


Figure K5: Bath tub reliability curve

3. Fatality alert**:** A concrete pump assistant died after falling 12 meters from the 4th floor of a building.

In June 2013 a pump assistant of a third party pumping service fell 12 meters through an opening (1.5m wide) on the 4th floor of a building. The concrete was being pumped from a stationary / trailer pump and pipeline attached to the building. As observed by a Holcim site supervisor, 1 of the 4 pump pipeline crew was wearing PPE for working at heights and there was no edge protection on the 4th floor, including the opening. The deceased stumbled backwards and fell through the opening in the deck and later died from head injuries after being evacuated to hospital.

Notes: Working at heights has been shown to be one of the most prevalent hazards and has resulted in a number of fatalities in concrete pumping crews. By its nature, a deck before concrete has been poured has numerous trip hazards presented by the reinforcing. In some cases there is no or limited edge protection. Unfinished or temporary stair cases also present a hazard which is exacerbated by the carrying or lifting of pipes. A further issue which is challenging to assess is the stability of scaffolding that supports decks with the potential for the deck to collapse during pumping resulting in a cascading collapse of the completed decks below.

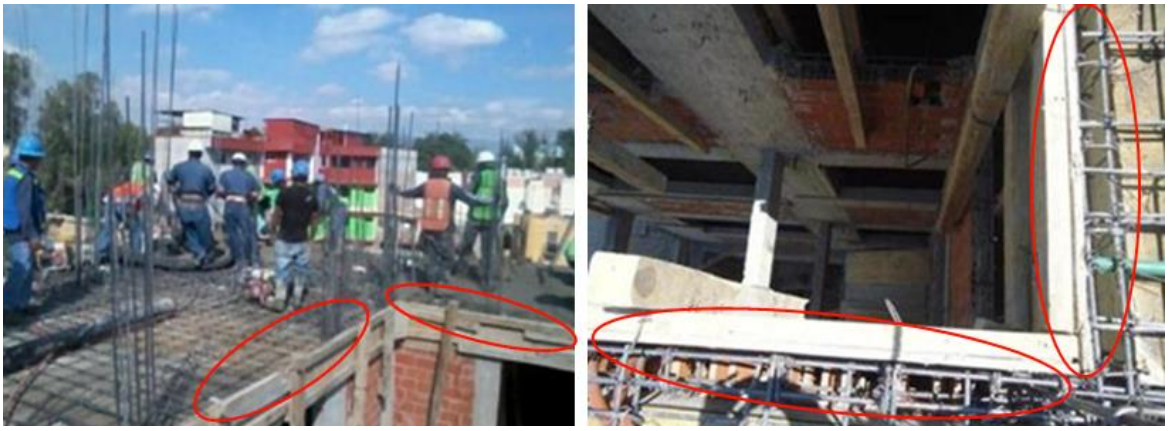


Figure K6: Site pictures showing lack of edge protection, working at height PPE and underfoot obstacles presenting a tripping hazard.

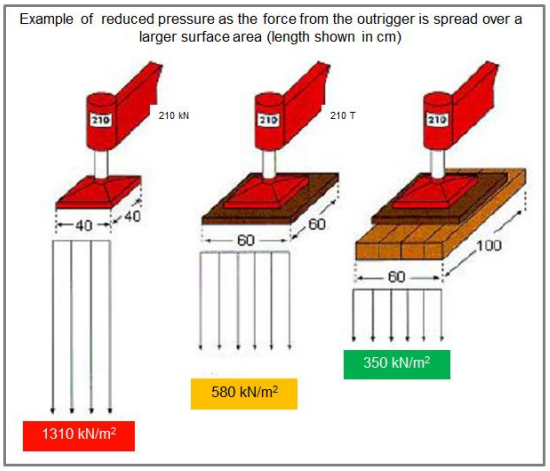
Mitigation of risk from the pumping manual:

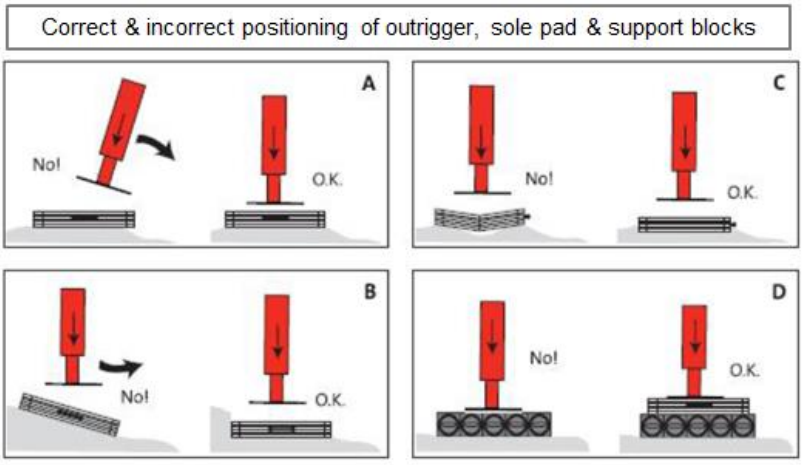
- # 1.1 Competent person to manage a third party pumping service as though it was a Holcim own operation (MS).
- # 1.4 Safety induction: Pump specific which would take into account requirements for working at height. (MS)
- # 1.5 Authority not to begin pumping where it is not safe to do so.
- # 2.1 Training: FPE 1: Working at heights (BP).
- # 2.2 Toolbox talks for working at height (BP).
- # 2.3 Certification of pump operators (BP).
- # 3.1 Risk assessment, particularly for working at heights (MS)
- # 3.1 Pre-departure check including PPE for working at heights (MS).
- # 3.3 Hazard identification at order taking, will there be a need to work at heights over 1.8 meters (BP).
- # 3.4 Operator or supervisor site check before establishing a pump (BP).
- # 3.5 Safety observation tour would identify that there was no edge protection (BP).
- # 3.6 Resolution of unsafe conditions, particularly lack of edge protection (BP).
- # 4.1 Contractor management (MS).
- # 5.2 Risk management records: Competent persons, working at height training and risk assessments , safety observations and actions, pre-departure check, contractor management (T&C of contract) etc
- # 6.8 Supplementary PPE for working at height (MS).
- # 7.1 Pre-job site inspection (BP).
- # 8.3 Deliver hose danger zone (MS).

Appendix L: Guide for timber support blocks

Where the ground support is assessed to be inadequate for the load applied to each outrigger sole plate and sole pad, additional timber blocks can be added to spread the load. Note that the load will vary with the reach and size of the pump.

From the known values of permissible ground pressure [kN / m^2] and support force [kN], the necessary support surface can be determined from the table below. The table gives the timber lengths in addition to the 60 cm x 60 cm support plates. (Source: Holcim Switzerland pumping manual)





Example of table todetermine additional support for different ground or surface conditions

Support loads in kN (see support legs)		50	75	100	125	150	175	200	225	250	275	300	325	350	375	400
Permissible surface pressure	kN/m²	Timber block length in cm														
Natural ground	100	71	84	112	138	166										
Asphalt (min. 20 cm thick)	200			84	104	126	147	166								
Hardcore (compacted)	250				84	89	117	132	150	166						
Clay (firm)	300					84	96	112	126	138	154	166				
Mixed stone (firm)	350						84	96	106	120	132	144	153	166		
Stratified pebbles (firm)	400							84	94	104	115	126	135	147	156	166
	500								74	84	91	98	109	117	126	132
	750												73	77	84	89
Stone (fractured, weathered)	1000															

Supporting ground is not suited for support

With PUTZMEISTER support blocks without additional timber blocks

With PUTZMEISTER

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