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Eamonn Ryan

Concrete pumping plays an important role in the concrete delivery service. While pumping is a highly 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, managed indirectly by a cement manufacturer
- in-house and managed directly by a cement manufacturer

When it comes to construction projects, being efficient ensures one stays within the boundaries of budget and timeline. Specialised machines such as the concrete pump work to help maximise construction time.

Versatile concrete pumping services save valuable time and effort, allowing contractors to pour concrete in even the hardest-to-reach locations, such as up the side of a 200m high-rise building. The primary purpose of pumping concrete is to save time, money, and effort during a building project, whether small or large. Instead of hauling concrete to the required location, a pump and boom allow one to place concrete precisely where it's needed, no matter the terrain or obstacles along the way that would make reaching it by truck impossible.

They also cater for volume – pumping concrete with boom pumps is ideally suited to large construction projects, such as large industrial projects, tunnelling work or high-rise buildings, as well as inaccessible locations hundreds of metres or even kilometres away from the truck. They can also be used for grout, mortar, wet screeds, shotcrete, sludge, and foamed concrete. Line pumps are ideal for repairing underwater concrete, placing concrete in heavily reinforced sections, filling fabric forms, and building bond beams.

But there are also small line pumps for transporting smaller volumes of concrete, and which are ideal for smaller concrete construction projects like pools, sidewalks, ground slabs, low-rise construction, and slabs for single-family homes.

This handbook explores concrete pumping minimum standards and best practice for the safe management of concrete pumping services. These minimum standards provide a reference point that can be integrated into third party companies' OH&S management and training systems where such contractors are carrying out pumping services either on their own or a third party's behalf. This handbook also aims to communicate identified best practices which when implemented, will deliver high levels of operational safety in concrete pumping.

Such minimum standards and best practices must by default be compliant with applicable country legislation, manufacturer operator manuals and pump specifications supplied by the pump and vehicle manufacturers. This handbook is primarily designed to inform the managers and supervisors of contractors tasked with the safe operational management of concrete pumping services.

Organisational safety performance typically covers the following broad categories, each representing challenging levels of maturity with time:

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

PUMPING handbook

CONCRETE PLANS

Global trends
Carlo Garbini, Flowmaster

Authority, Responsibility and Accountability

Safety and training
AfriSam

Global trends in concrete pumping

By Eamonn Ryan

The future of concrete pumps lies in lightweight carbon fibre booms along with hybrid and electrification of the pumping system.

Carlo Garbini, managing director Flowmaster, giving a presentation on the future of concrete pumping at the dmg events Big 5 Construct Southern Africa expo says: "Commercial concrete pumping was started by my late father in 1969, when he started a company called Ital Service which was bought out in 1992 by a group that ultimately became Afrisam. We've been involved in concrete pumping for 53 years now. I've been running the company since 1986 and so have also been personally involved in the concrete pumping equipment industry a long time.

"We've done much pioneering work in the industry on new ways to pump concrete, and how to place concrete in a variety of sectors from special dam projects to mining, construction, and more. At the same time, we've also seen other technology and developments change the industry. There are exciting times ahead in this industry, and we've seen particularly in the last 10 years many changes relating to increasing the sophistication of electronics in concrete pumps. The reach of the placing booms of concrete pumps has become consistently longer. As a result, the market today wants bigger pumps and further each, though in South Africa there are certain limitations with the road legislation."

Flowmaster represents and sources equipment from the Italian company CIFA – a leading manufacturer of concrete machineries, shotcrete equipment, and batching plants. CIFA has a worldwide presence providing solutions for concrete related technological processes: mixing, distribution and pumping. It is the first manufacturer of truck mounted concrete pumps with placing boom in carbon fibre material and is also the only provider of plug-in hybrid concrete machinery with the Energya truck mixer series.

"CIFA is at the forefront of technology, a big company with a massive product range of concrete and construction equipment. Ten years ago they already started pioneering carbon fibre technology on concrete pumps. The boom, which is the way one places the concrete to give greater reach, has historically always been 36m as the accepted standard in South Africa and globally. Today you get much bigger pumps with reaches in the 50m to 80m categories, and even 100m for highly specialised purposes that are focused on certain industries and markets," says Garbini.

"In South Africa, a 40m boom pump on a six-by-four truck has become the new standard compared to what would have been the stand-

ard 36m on a six-by-four in the past, and it's road legal. We have had a 45m operating in Cape Town for the past 10 years with a carbon fibre boom," Garbini said at the presentation. "The carbon fibre parts of the boom are usually the last two sections of a what is a four or five-stage boom, saving more than one ton, which is a lot. The benefits of that are that you can go further for the same weight, and an extra five meters in reach on a construction site. Contractors get a much more versatile concrete pump on their site, and the efficiency and effectiveness of placing concrete becomes higher. If one has further reach one can do bigger jobs, and so the bigger machine keeps clients happier."

TECHNOLOGY SOURCED IN COLLABORATION WITH FORMULA ONE AND MOTO GP

"CIFA approached Italian racing teams and composite material manufacturers 10 years ago, recognising that the latter's carbon fibre technology could be used to make the concrete pumps lighter – and so formed a partnership. The pump booms lose quite a bit of weight as a result and become much more versatile. That was one of the big technological leaps," says Garbini. The chassis is getting more and more sophisticated now, to the point where concrete pumps in the future are going to be Artificial Intelligence (AI) operated. AI is going to play a major part now in the future of concrete pumps, alongside developments in 3D printing.

This technology was already around 10 to 15 years ago when CIFA approached Ducati and Ferrari overseas for their carbon fibre technology and decided to convert some of their equipment to modern technology by lightening everything and making longer booms that are lighter than steel.

The first three sections of the boom are made in steel and the last two in carbon fibre resulting in a 25% reduction in weight, are 20% stronger and give an extra 20% increase to the length of the boom.

"The boom has a five-year warranty - that's how confident CIFA is. This technology first came out in 2013 on the 45m, which has now become a 47m. We also have a 60m and 80m carbon fibre boom and continue to grow in length.

"Not only are they lightweight, but extremely rigid with no welding on the carbon fibre. It has been tested through 10 years of simulated work, meaning they test with accelerated fatigue on the machine. There's no rust, it utilises a lighter truck chassis, and requires a smaller stabilisation area," he told delegates.

"The electronics of the machine are nowadays highly sophisticated with lot of telemetry, which perform adjustments as it pumps such as optimising the fuel consumption. It keeps the pumping under control, gives the pressure reading and has a faults localisation feature so one knows exactly where a fault is, as well as a stabilisation function. This is perhaps the most important advance whereby one can control the setup of the machine. The computer does it all."

The telemetry also has a pumping unit management covering the RPM on the engine, the diesel use, the shut-off of the engine when not pumping, pressure of the hydraulics, and how many cubic meters per hour are being delivered. The system automatically ramps up and down by regulating the engine and the pumping hydraulics to give the best efficiency possible – which is important nowadays with high fuel prices and operating costs, noted Garbini.

"Ground stability of a concrete pump machine is perhaps the most critical part. When setting up a concrete pump, the point load on the outrigger, for example, when pumping and the 36m boom is full of concrete is going to be in the region of 17 tons. If there's soft ground present, the machine can easily fall over. The computer works out the outrigger position and the automatic stability control (ASC) which allows the boom to work only in the allowed area. This ASC is more efficient, giving 50% more working area than normal."

Concrete pumping has always been a fuel intense operation and CIFA now has a sophisticated system that controls the fuel delivery according to the concrete type. It ramps up according to the pressure limiter and how the pump is going to be worked. Garbini noted that as a result "all the training on pumping efficiency is redundant as its now being done by the machine".

HYBRID AND ELECTRIC CONCRETE PUMPS

"An interesting development in view of the current world energy crisis, is the electrification of concrete equipment. Just as we're seeing hybrids and electric-powered cars, CIFA has had a range for over 10 years of low carbon footprint electric equipment for construction. It keeps growing. It charges itself while driving through means of a kinetic energy recovery system (KERS)." This is an automotive system for recovering a moving vehicle's kinetic energy under braking. The recovered energy is stored in a reservoir (for example batteries) for later use.

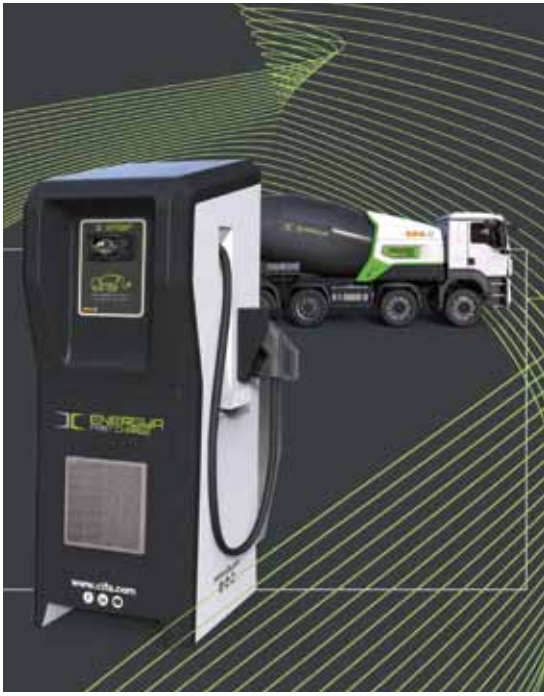
"A hybrid truck arrives on site, the engine is shut down and the batteries take over to offload the concrete. The KERS system, like in Formula One racers, recharges the batteries, and the batteries send energy back to the electric motors – in the case of a mixer it's being charged all the time by the brakes and by the drum which sends back current via a generator to the batteries.

"The pump runs off batteries when on site, with no fuel consumption on site, and most importantly a 27% reduction in overall diesel costs. There is also reduced wear and tear on the trucks' engine and gearbox as they are shut down and not running when on site -green technology on the go. This concept has been around for quite a long time from CIFA, but what is fairly recent is the hybrid electric con-

crete pump and truck mixer combination - the CIFA Magnum range with its truck mixer and placing boom on the same chassis. This is very popular in Europe for its low emissions and that will start filtering into South Africa just as it has with electric cars and hybrids," he noted.

"On the pumping side, we see the costs of fuel and cost of transport also becoming serious problems in all areas as a result of the energy crisis. In this regard, electrification could really change the industry in a short time to the extent that the actual pump itself will be electrified, as well as the mixer," delegates heard from Garbini.

Next in line is the fully electric Boom Concrete Pump - watch this space shortly, he said.



TRAINING

"We have one example of a carbon fibre machine in South Africa, and I see the electrification of concrete pumps as being a lot more beneficial to the industry. Africa is a bit sensitive to certain technologies as the local operating conditions are harsher than Europe. It needs highly specialised people to operate some of these technologies, and greater focus on operation and maintenance.

"For this reason I have developed a niche in training specialist pump operators leveraging my 40 year experience in the industry, inhouse and on site at construction companies using CIFA's training system. Training is very much manufacturer specific, and it's a specialised field that mostly only the manufacturers do and is typically part of the package when a pump is sold. There's a certain responsibility, obviously, involved in handling such equipment, and we have to certify operators and maintenance teams on how to work on this equipment and to certify the equipment," says Garbini.

"There are prerequisites: the operator has to have been in the industry a certain number of years and acquired a certain amount of knowledge and experience, as it's a rather specialised piece of equipment. You can't just let anybody operate it. Concrete pump manufacturers are the ones which develop the training materials and all the courses and the training at their academies.

"It's not that easy to take an operator of one brand of equipment and switch them to another, without recertification and retraining to bridge the differences. There are risks involved in operating the machine incorrectly. It's not a generic type of training that allows one to operate all the machines, it's machine specific to operate whichever equipment type is on the certificate," he says.

In conclusion, Garbini expects we will shortly be experiencing the full benefits of the latest technology in carbon fibre and electrification of concrete pumps, as well as the latest training on operator and maintenance skills. This will ultimately make concrete pumping much more sophisticated and efficient to both the concrete pump owner, and contractor alike. ■

Authority, Responsibility and Accountability

Key responsibilities for the company director are:

- The appointment of a competent manager responsible for both direct and indirect concrete pumping services. This should ideally be a dedicated function, though in the case of a contractor with small scale pumping activities the responsibility may be included within other functions, but a responsible person should be identified.
- To ensure that the good practices such as those contained in this handbook – but also manufacturer operator manuals and pump specifications supplied by the pump and vehicle manufacturers - 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 must receive adequate and appropriate training on the such minimum standards.
- Perform annual internal auditing to check on compliance with the appropriate minimum standards and, where non-compliance is identified, the timely and effective corrective action to prevent a recurrence.
- To ensure that the pump operator or, when 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 harm or fatality.

The safety requirements typically start with good standards for the workplace equipment and facilities, supported by the design of safe systems of work and compliance with those systems, processes and procedures. Safety excellence is driven by a desire for safety and administered by visible leadership founded upon solid competencies and effective training.

Where a cement manufacturer or contractor is directly, or indirectly responsible for pumping activities, that company retains responsibility to ensure that both direct and indirect services are delivered safely as well as efficiently.

Where applicable country legislation, manufacturer operator manuals and pump specifications exist such requirements must be met or exceeded. But where best practices have been identified they are differentiated from minimum standards by use of the word ‘should’ as such requirements are recommended rather than mandatory. All concrete pumping operators should evaluate the adoption of the best practices and determine if it is reasonably practicable to implement them.

Operators should 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, managing company should ensure that third party contractors have equivalent systems and they should audit compliance with this requirement.

This handbook incorporates significant findings of a literature review of publications from industry associations and governmental organisations, as well as commentary from leading companies involved in concrete pumping.

SAFE PUMPING OPERATIONS AND HAZARD PROFILE

Organisational aspects of concrete pumping services are equally important in ensuring that accountability, responsibility, levels of authority and specific role requirements are clearly communicated and understood by everyone involved in the planning and realisation of optimum pumping services.

There are a number of interfaces have a bearing on pumping safety with other functional roles. These may include: sales, order taking, distribution, concrete technology, production and maintenance that directly or indirectly. This means that in a smaller pumping operation, there is the risk that pumping management becomes a shared rather than a dedicated management function.

There is also the potential that pumping may report lower down in the organisational hierarchy which could reduce management focus thereby increasing operating risks. Where concrete pumping is outsourced, it is particularly important to understand that the project owner remains responsible for managing the safety of the pumping service. Contractor safety management directives of the cement manufacturer remain applicable to outsourced pumping.

A safe workplace consists of safe equipment and safe facilities, generally being the most visible and tangible realisation of the risk-based management of hazards. It is 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 which consists of the following:

- **Eliminate:** redesign a task so as to eliminate the hazard
- **Substitution:** replace hazardous equipment, materials or processes with less hazardous alternatives
- **Engineering/isolation:** question the potential to provide mechanical aids, guarding or barriers to isolate the hazard
- **Training/administration:** Training and procedures are useful tools in informing people of how to avoid particular hazards
- **PPE:** The use of PPE is the bottom of the hierarchy, but reduces exposure of the impact of a hazard

Therefore, PPE shall always be the control of last resort having considered all other options in the hierarchical sequence of controls. These should each be evaluated and where reasonably practicable controls available should be implemented at each level finishing off with appropriate PPE.

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

Ensuring safety in pumping begins with a site assessment to identify hazards and manage risks. A hazard is defined as something that has the potential to cause harm to persons or the environment, damage to property or other loss. The risks arising from pumping activities are a combination of the potential harm multiplied by the likelihood that the consequence is realised. An 'event' is defined as an incident that either i) could have resulted in realisation but did not due to one or more factors, or a 'near-miss'; or, ii) consequences were realised and are known as accidents. ■

Concrete pumping by far outweighs the traditional method of placing concrete

By Eamonn Ryan

Here's everything you need to know about concrete pumping and why you should skip the wheelbarrow.

When it comes to construction projects, being efficient ensures one stays within the boundaries of budget and timeline. Specialised machines such as the concrete pump works to help maximise construction time.

Versatile concrete pumping services save valuable time and effort, allowing contractors to pour concrete in even the hardest-to-reach locations, such as up the side of a 200m high-rise building.

The primary purpose of pumping concrete is to save time, money, and effort during a building project, whether small or large. Instead of hauling concrete to the required location, a pump and boom allow one to place concrete precisely where it's needed, no matter the terrain or obstacles along the way that would make reaching it by truck impossible.

They also cater for volume – pumping concrete with boom pumps is ideally suited to large construction projects, such as large industrial projects, tunnelling work or high-rise buildings, as well as inaccessible locations hundreds of metres or kilometres away from the truck. They can also be used for grout, mortar, wet screeds, shotcrete, sludge, and foamed concrete. Line pumps are ideal for repairing underwater concrete, placing concrete in heavily reinforced

sections, filling fabric forms, and building bond beams.

But there are also small line pumps for transporting smaller volumes of concrete, and which are ideal for smaller concrete construction projects like pools, sidewalks, ground slabs, low-rise construction, and slabs for single-family homes.

TYPES OF CONCRETE PUMPS

- **Boom Pump:** A boom pump uses a remote-controlled robotic arm (boom). The unit is attached to a truck or semi-trailer to place large volumes of concrete with accuracy. The truck typically remains in one place for the entire pour as ready-mix concrete trucks unload directly into the pump's hopper. This hopper has an auger which churns the concrete to keep it liquid. It has a mesh grate to prevent large rocks or chunks from clogging the pump. A stationary centralised location for the truck within the job site facilitates a more efficient traffic flow.
- **Line or static pump:** A line pump (also known as a static pump) is a trailer-or truck-mounted concrete pump that uses a series of steel or rubber hoses to direct and place concrete wherever it needs to go. The ready-mix trucks will also unload the concrete directly into the pump's hopper.

Both types of pumps use twin cylinder hydraulics. One piston draws the liquid concrete from a hopper and into a cylinder while at the same time, the other piston pushes concrete out into the discharge pipes.

By switching over each time the pistons reach the end of the cylinders, the valves determine which piston is open to the concrete hopper and which is open to the discharge pipes. This valve mechanism permits each cylinder to alternate between drawing concrete and pushing concrete, pumping higher volumes of concrete and saving time.

In order for a concrete pump to function, the concrete mix must be suitable for pumping as 'pumpable concrete'. It must have enough water for the mix to move easily through the pump and hoses or risk clogging the pump lines.

NINE BENEFITS OF CONCRETE PUMPING:

- **Concrete pumping is a quicker, easier method to complete a project for better quality placement of concrete:** Concrete pumps can pump large volumes of concrete as quickly as a truck mixer can discharge the concrete. Many pumps can pump 30m3 to 100m^3/hour of concrete. This quick, precise placement method ensures a quality pour. The setup time for concrete pumps is also fast – arriving on site and pumping concrete within the hour.
- **Concrete pumping can lower labour costs:** Concrete placement with pumps requires fewer workers to distribute the concrete. A single operator or operator and assistant can accurately place the concrete using the boom or hose instead of relying on multiple workers to move back and forth to do the same job and the continuous flow of the concrete ensures no time is wasted. This increases productivity and means projects can be completed on time and within budget. This makes concrete pumping a cost-effective placement method for concrete projects large and small. Say goodbye to wheelbarrows and consider a concrete pumping service or purchasing a pump to save time, costs, and energy on your next concrete project.
- **It reduces site congestion as there are less construction workers:** Using a concrete pump and pipeline is an incredibly accurate method of pouring ready-mix concrete. It can be directed to the exact location that requires concrete, resulting in a precise pour. It is clean, as the concrete pump pipeline is exactly set up so to pass directly from the pump to the site. The pipeline is cleaned of excess slurry and concrete before it is unclipped and carried back to the pump

vehicle, meaning there is little chance of spillage or dropped concrete on site.

- **With its wider reach, contractors can get concrete to inaccessible places:** The hose or boom of concrete pumps can place concrete precisely in hard-to-reach areas, such the top of high-rise buildings, enclosed buildings, over fences, and down steep slopes. How far can a concrete pump truck reach? The vertical reach of a boom pump is 42m, and its horizontal reach 38m. Even longer booms exist.
- **Pumping of concrete is done before the concrete starts to set, improving concrete strength:** This can guarantee a more accurate result. There should be fewer stoppages, delays and in general it will result in a more even and polished finish. Overall, concrete pumping is a more convenient method that a traditional mix and pour method of transferring concrete.

- **Pipelines go wherever you want them to go:** Concrete pumps can be used on a wide range of building sites – from large-scale commercial developments to small residential properties. When used alongside volumetric mixers, they can be scaled up or down to suit the individual requirements of a project. Where a high volume of concrete is required to be delivered within a short time, multiple pumps can meet the demand. For lower-volumes projects, the volumetric mixer batches precisely the amount of concrete you need (which reduces waste), and the pump can pour this just as efficiently as it would for higher volumes. It is a flexible and affordable solution that can be easily tailored to suit a project's unique needs. Several pumps can pour simultaneously for larger projects how fast the concrete can be poured is an important aspect of any construction job. Using a concrete pumping method means that concrete can be poured at a much faster rate than other pouring methods. With faster placement, the project can move quickly and this will help you stay within your project deadlines.
- **It is effective and economical for various sized projects, including residential and commercial**
- **Concrete pumping has a large application, including foundations, slabs, columns, bridges and dams**

DOWNSIDES OF CONCRETE PUMPING

There are downsides to concrete pumping, though many of them are preventable and fixable. For instance, there is always the possibility of a concrete pump breaking down, a major headache when there is a queue of ready-mix concrete trucks delivering concrete. Most of the time the breakdown is resolved within a few minutes.

Then there is always the risk of injury to construction workers and damage to property. Concrete pumps are heavy machinery and as a result, there is always the chance of things going seriously awry. Fortunately all concrete pump operators are highly trained. No person is allowed to drive or operate a concrete pump without proof of operator training. All crew members working on concrete pumps are also trained in general health and safety.

Finally, during busy periods it is not always easy to find an available concrete pump. Therefore, advance planning is essential if a contractor wants one, especially before holiday periods. ■

Concrete pumping by far outweighs the traditional method of placing concrete

By Eamonn Ryan

A safe concrete pumping operation is one with a plan. It consists of a secure workplace, proven processes and well trained people. These are achieved through processes, minimum standards and recommended best practices. Systems and processes within a concrete plan form the foundation of compliance.

Planning permits sustainable continuous improvement by systems and processes that direct and guide actions in a systematic manner and requires thorough documentation. At best, a quality management system such as ISO 9000 would provide a suitable structure for the processes.

RISK ASSESSMENT AND MANAGEMENT

Considering the nature of pumping activities, there are a number of hazards that need to be identified so as to best mitigate their risks. Some of these hazards are common to other site operations, so the processes and activities associated with these risks are not unknown but still need to be identified at the various stages of the operation. Minimum standards need to be in place to mitigate the risks presented by the more significant hazards prevalent in concrete pumping, and we suggest some herein.

The challenges on each construction site are unique – varying from one job site to another and therefore requiring a basic risk assessment for each site to identify the hazards and their potential impact. Typically most significant hazards are informed from past incidents, and would include vehicle and traffic movements, working at heights and working in the proximity of power lines. A basic risk assessment carried out by a competent person at each site where a pump is to be established for the first time will

reveal the exact nature of these hazards. The risk assessment aims to identify individual risks presented by any site-specific hazards which can be added to the pre-start-up check.

Lack of awareness of site-specific hazards leads to accidents, and the minimum standard should therefore be that a risk assessment be carried out by a competent person for every site where a pump is to be established for the first time.

PRELIMINARY SITE CHECK

To ensure a proper concrete plan for each pump job, the operator shall plan and carry out a check in accordance with established OH&S minimum 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.

A lack of systematic planning can result in disruption or discontinuity in service which would place the pumping team under undue pressure, possibly resulting in an accident. The minimum standard would consequently be for

the operator to carry out a pre-departure checklist recording deviations and inform the supervisor or maintenance function to ensure that deviations are resolved.

The concrete plan should be structured to uncover potential hazards involving concrete pumping as well as any other potential hazards and record them on documentation that is readily available and visible to the supervisor and pump operator. Each hazard should receive particular attention in the risk assessment for the first pump establishment on the site and subsequent observations and toolbox talks.

Risks include unexpected and/or uncontrolled hazards arising from pumping activities resulting in injuries, and the best practice is for potential hazards relating to pumping to be established as a part of routine order taking and communicated to the concrete pumping team.

Before establishing the pump on site, the supervisor or pump operator should thereafter be familiar with the risk assessment for the site. The individual should walk around the relevant areas of the job site and follow up with a talk to staff and the responsible person on site for the concrete placement and cover aspects such as:

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

Regarding clean-up options for the pump on the job site, the risk exists that a lack of planning could result in injury due to unsafe conditions at the workplace. In this instance, best practice suggests that 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 technical talk with his team where applicable.

SAFETY OBSERVATION WALKABOUTS

To remain familiar with conditions on site as well as challenges facing the pump operators, the supervisor or manager should conduct safety observation walkabouts to record their observations both of good practices and of any opportunities for improvement. A tour would include discussions with the responsible person for concrete placement on site and the pump operator, they being best placed to understand the potential risks involved.

Such observations should include a basic check of the quality of scaffolding and support work of the formwork throughout the job site. Such risks include a lack of cross-bracing, overextended jack screws and irregular support loads on scaffolding that could lead to instability and potential collapse of a concrete deck during placement – thereby putting the lives of the pump operator and site crew at risk.

As a lack of routine monitoring could result in lack of awareness of unsafe working conditions on site, best practice suggests that supervisors or managers conduct site observation walkabouts and record their observations of good practices and opportunities for improvement.

Wherever a risk assessment or site observation has evaluated that it is unsafe to proceed with pumping work, the competent supervisor should cease pumping operations, further assess the situation and immediately resolve the problem by implementing safe interim controls. This aims to reduce the risk to an acceptable level, or to escalate the issue to the line manager for further instruction.

Identified hazards and risks that are not controlled, result in isolated and unsafe operating conditions, and best practice suggests that where work has been assessed to be unsafe, a competent manager or supervisor shall take control of the situation and determine a suitable outcome. ■

Operational and maintenance procedures

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

It is common for manufacturers to outsource pumping to a third party concrete pumping service. Where this service is under the manufacturer's direction and offered to their own customers, it is common that the manufacturer's Contractor Safety Management rules apply. In principle the same OH&S rules that apply to its own employees would also apply to third party contractors.

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

Pump equipment and component failure may result in accidents or pipeline blockages placing pressure on the crew due to delays to effect repairs. Consequently, minimum standards of a cement or equipment manufacturer requires that a maintenance procedure and schedule shall be established in conjunction with the equipment supplier.

- **Checklist for pump pre start-up:** An operator pre start-up checklist is common for the operation of most key items of equipment. This is particularly important for a concrete pump so as to ensure that any items requiring attention are in fact scheduled for maintenance or repairs. The risk exists that a lack of attention to items that require maintenance or repair leading to pump component failure or pipeline blockage. A typical minimum standard would cover an operator carrying 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.

- **Compliance with traffic and vehicle safety standards:** Pedestrian, vehicle and traffic hazards are responsible for the largest number of incidents and fatalities on construction sites. Concrete pumps are typically required to travel through urban areas carrying a full load consisting of pump and boom. These vehicles are invariably close to their limits of height, width and axle mass distribution. The rear overhang of the boom is an area of risk to other road users. Vehicles that tow pump trailers must also take adequate care to ensure control under braking. The drivers of such vehicles must attain high levels of competence and to be alert at all times. The pumping operation needs to be managed in accordance with manufacturer directives for fatality prevention; pedestrian, vehicle and traffic safety; as well as a road safety programme dealing specifically with the risks presented by vehicles and traffic. The requirements of these directives apply equally to the management of outsourced pumping services.
- **Certification of vehicles, booms and pumps:** Notwithstanding legal vehicle registration and licensing requirements, contractors should implement 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, 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 any road height and weight restrictions. The risk exists that a pump vehicle combination does not meet manufacturers or legislated specifications resulting in component failure on the road or on the job site. Best practice suggests there should be a procedure to certify vehicles, pumps and booms to ensure that they meet the specified requirements before entering service.
- **Inspecting the boom:** The throbbing action of a concrete pump subjects the boom to dynamic pressure which results in the potential for metal fatigue or component stress beyond their design limits over time. A boom can be subject to additional stress from the manner in which it is operated or connected to pipelines in a bid to extend the effective reach of the pump. Apart from visual inspection, magnetic particle and dye penetration techniques are other effective means of identifying cracks in critical areas of the boom. In the US, for instance, the Concrete Pump Manufacturers Association recommends an annual inspection of pumps less than five years old, and thereafter every six months for pumps up to 10 years old followed by 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 best practice to address the risk of structural or mechanical failure of concrete placement boom, is that of 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.
- **Operating factors:** While operating a pump, an operator should be aware of the operating parameters of the boom and pump. These include engine revolutions and temperature; pump hydraulic pressure and temperature; as well as pump reach and output. This information should be easily accessible to the operator on site. All information should be according to the manufacturer's specification and should be included in the company's standard operating procedures and training material. A

risk exists that inadequate monitoring of compliance with manufacturers operating standards could result in component failure resulting in an accident. Best practice lies in establishing operating parameters in accordance with the manufacturer's specifications and be readily available to the operator

- **Visual pipe inspections:** There are a number of factors involved in pipeline management for concrete pumping, including wall thickness, wear patterns along the length of a pipe, abrasiveness of the aggregates, the grade of steel, and effectiveness of the concrete mix design. Reducers and bends are especially susceptible to wear and tear, and consequently need to be more closely and individually inspected. Pipes operate under great pressure and can cause injury to people and damage to property should they rupture. As a result, a visual inspection of pipes, reducers, hoses and bends should be carried out by a competent person at least monthly. The risk of an unexpected pipe failure resulting in pressure and projectile related injury, can be alleviated by regular inspections of pipes carried out monthly by a competent person.
- **Specifications of pipes:** Part of the concrete plan should include establishing pipe parameters such as grade of steel, maximum pressure, wall thickness, minimum wall thickness and expected life. These parameters form a part of the purchasing decision and design of maintenance procedures such as pipe wall thickness testing. These specifications should 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. Uncertain pipe specification could result in pipe rupture or premature wearing and failure, and best practice is for the pipe specifications to be established and form part of the maintenance procedure and training material.
- **Thickness of pipes:** Alongside the above, pipe specifications should include a system for the routine measurement of pipe thickness. This can be accomplished by using ultrasonic testing or physical callipers to identify 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 marked at their ends to indicate so. 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. Lack of systematic pipe measurement will result in lack of awareness of minimum pipe thickness resulting in the rupture of pipes under pressure. This is best addressed through a quarterly measuring system of 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.
- **Concrete mix design:** Concrete mix design plays a major influence on pump pressure and hence the pressure exerted on concrete and hydraulic pipes. Besides meeting cus-

tomer specifications, concrete also needs to be specifically designed for pumping so as to minimise pump pressure for concrete consistency, with particular attention paid to aggregate particle shape and grading. Incorrect concrete specification could result in blockages and thus injuries, with the minimum standard being for concrete for pumping being specifically designed for ease of pumping and to minimise pump pressure.

- **Slump test:** 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. 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. The minimum standard requires the concrete technology function shall put quality assurance in place and carry out quality control on pumped concrete.
- **Record keeping:** It is important to maintain a system of filing records relating to key concrete pumping activities. These are evidence of procedures having been carried out and of adequate maintenance and decision making. Records must be retained as required by local legislation and integrated into a quality management system. Relevant records such as truck and pump maintenance, boom and pipe inspections shall be retained and be available at all times. Poor record keeping leads to limited learning from and defence against an incident. A contractor's minimum standard must be that risk management records shall be retained and available for assessment and auditing. 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.
- **Relevant certificates:** Regulatory certificates and licencing shall be available on request as a proof of the vehicles' compliance to the relevant legislative requirements. These exists the risk of interruption of service due to lack of availability of certification. The minimum standard should be that relevant certificates or certified copies shall be retained in the vehicle and be visible and available for inspection at all times. ■

Pre-job checklist for concrete pumping

(Use this checklist to manage general details, top-line mix notes, and safety accreditations.)

Project: ..... Date:.....

Location:.....

Directions: .....

1. Contacts					
Who	**Name**	**Phone**	**Mobile**	**Fax**	**E-Mail**
C. Contractor					
Plant(s)					
Pump Contractor					

2. General Conditions				
Start Time	**Pump:**	**am/pm**	**Concrete:**	**am/pm**
Placement Location	• Slabs	• Walls	• Footings	Other
Placement Rate (m^3/hr.)		Volume (m^3)		
Type of Pump	• Regular	• Z-Boom	• Telescoping	• Trailer
Size of Pump (m)		Pipeline dia, mm		
Pumping Distance (m)	Vertical		Horizontal	
Slump/Air Spec	• Point of Discharge		• Point of Placement	
Testing	• Point of Discharge		• Point of Placement	
Priming Agent	• Grout		• Slick Pack	

3. Concrete Mixture (see Concrete Mix Submission form)		
Class of Concrete	CSA A23.1	Mix ID
Strength MPa	28 day	Other
Ordered Slump (mm)	Air Range %	
Special Requirements		

4. Pump		
Pump Equipment Safety Certified	Yes	No
Pump Operator ACPA Certified	Yes	No

Safety and training on pumps are one and the same

By Eamonn Ryan

The length of the ground area or height of construction that the concrete must be pumped are key factors that go into choosing the right concrete pump and boom for a particular job, says Russell Wearne, Regional Manager Ready Mix Business Unit – AfriSam.

Russell Wearne

In the same vein, the condition of the terrain and accoutrements are the factors to be considered-when it comes to the all-important health and safety considerations when pumping concrete.

For these reasons, Afrisam will send out a technical consultant ahead of pump time to observe where the pump will stand and determine the length of the pump boom that is required. Afrisam has 36m and 42m pumps, the booms of which lift up and are angled towards where the concrete is to be pumped. They can typically reach every part of the site where casting is taking place.

"Where the area to be cast extends beyond our maximum range of 42m we would have to re-establish the pump in a different location of the site so as to cover the additional area it couldn't reach. Boom pumps are mostly used on an area at ground level," says Wearne.

When it comes to tall buildings, Afrisam also has a range of static or boom-less pumps which have a pipe connected to the pump's discharge point which is mounted to the sides of the building when pumping long distances. This is especially useful up the sides of buildings so the pipework can be built upwards as the building progresses.

Afrisam provides pumping services to contractors using primarily Putzmeister branded pumps, for the reason that Wearne says, "it is the most common and reliable pump in South Africa".

To ensure that reliability, Afrisam does regular scheduled maintenance of its pumps. "We do pre-start inspections each morning when the construction crew arrive on site, an inspection which includes the safety and efficiency of the pump, as well as a pre-run of the pump. There is a set checklist for this – given it is a large piece of equipment – which ensures the pump remains in good operating condition. The pipes used are changed at determined intervals in order to minimise failures on site, and we record the wear on delivery pipes every month against cubic metres pumped," explains Wearne.

"The pumps are serviced and maintained using our own internal SAP planned maintenance process. All our equipment is documented on the SAP Maintenance system which generates an automatic notification to our mechanics to do a service on a particular piece of equipment.

"Preventative maintenance is a lifestyle for us because a pump cannot be allowed to breakdown on site. You cannot afford that to happen when a crew is busy pouring a concrete deck or other large surface area for a customer. For this reason, the pre-start up inspection would include taking note of anything observed by the operator the day before," adds Wearne.

"Nonetheless, it still happens that a pump can breakdown on site – that is the nature of a machine. What we normally do is have a similar pump on standby if one is available. Alternatively, we have outsource arrangements in each area which we tap into when overbooked or have a breakdown."

SAFETY IS CENTRAL TO SETTING UP JOBSITE PUMPING

Safety is a key aspect of all Afrisam's operations, and especially in pumping, says Wearne.

For instance, safety is a central component of the pre-start checklist. Afrisam has an OHS official that goes out the day before a pump to inspect the site and agree with the client exactly where the pump is going to be established. At that location, all safety measures are put in place to ensure it is not close to working people, not going to influence traffic and is in general set up in an environment conducive to both Afrisam's crew and the contractor's safety with good accessibility from the trucks.

This process is done according to a checklist, which Wearne explains covers factors such as:

- Is the terrain stable? If it is unstable the client would have to be advised to move it to a more stable, flat section of the site. Unstable ground could result in the pump going off balance, which in turn affects the pumping.
- Is the location accessible to the pump and the delivery trucks? The delivery trucks are top-heavy when delivering concrete and need terrain that is not uneven or muddy, as the truck could get stuck or even topple over.
- Are there any overhead electrical lines? These could be a risk to the boom as it extends.
- Are there any services such as sewer lines, stormwater drains? These are inspected to ensure they receive no damage.
- Is there any scaffolding? On the sides of buildings there may be scaffolding with workers on, and these could get bumped by the boom.
- How is the traffic flow?

"Operating the pumps are our pump operators and pump assistants, and a team leader who provides them with in-house training. The latter are themselves trained directly by Putzmeister when we buy a pump and truck on how to operate them.

"Training on the pump operation and health and safety, tends to be one and the same they are so interoperable. "At the beginning of every year we hold a safety induction wherein we go through all the safety aspects, our safety policies and procedures. Each month we have a safety meeting, and then each day we also have a safety meeting on site wherein the pump operator and assistant will review any incidents that

happened the previous day and discuss how they could have been avoided," says Wearne

'PUMPABLE' CONCRETE

"Because the concrete is being pumped through a fairly thin pipe, it must be workable and flowable – but still maintain its strength. If it is too dry it won't pump. We have a technical department which comes up with a mix design which accommodates various concrete requirements, one of which is concrete that needs to be pumped. We have various concrete applications where a certain slump is required, and in the case of a pumpable concrete mix it requires a 125mm slump in order for it to be conducive to pumping," he adds.

"The sole purpose of pumping is because the ready-mix truck cannot reach that point of discharge, for instance in the case of a high-rise building, and the process makes no difference to the ultimate quality of the concrete in the building. The only difference is that the water: cement ratio is adjusted in order to be able to supply that slump," concludes Wearne. ■

FACTORS WHICH INFLUENCE THE CONCRETE SLUMP TEST:

- Material properties like chemistry, fineness, particle size distribution, moisture content and temperature of cementitious materials. Size, texture, combined grading, cleanliness and moisture content of the aggregates
- Chemical admixtures dosage, type, combination, interaction, sequence of addition and its effectiveness
- Air content of concrete
- Concrete batching, mixing and transporting methods and equipment
- Temperature of the concrete
- Sampling of concrete, slump-testing technique and the condition of test equipment
- The amount of free water in the concrete, and
- Time since mixing of concrete at the time of testing

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PUMPING handbook

PUMP SOLUTIONS

Spare parts and tools

Choosing the right pump
Putzmeister

Boom vs static pump
PPC Materials

Spare parts and tools

By Eamonn Ryan

- **Inspection of tools:** Any interruption to concrete pumping can have a significant financial impact. 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 pipeline and pump after the completion of a pump job to ensure that pumping services are not delayed at the next job. Unserviceable equipment delays the start of a pumping operation and results in added pressure of work leading to mistakes. The best practice is for all tools to be inspected on a weekly basis and be maintained and replaced if defective.
- **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. The risk is of clamps snapping open under pressure. The minimum standard is therefore for snap clamps to be fitted with safety pins and no clamps shall be released while the pipeline is under pressure.
- **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, seals need to be cleaned immediately after each use to prevent concrete build up and difficulties in building the next pipeline. There exists a risk of pipelines leaking at the joins and bursting of the pipeline under pressure. The minimum standard is that all clamps shall be fitted with 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 pipeline 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. Pipeline failure is a risk due to pipes not being properly carried, lifted, supported and secured, resulting in falling objects from height. The minimum standard is that all pipes shall be carried and lifted in supporting of loads accordance with a work procedure and fixed to a structure in accordance with the design and detailing signed off by a professional engineer.
- **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 pipeline. A risk is the failure of pipelines at bends due to thrust created by pumping pressure. The minimum standard should be for a vertical pipeline of more than 25m to be secured at the base elbow with a thrust block at the base of the pipeline.

- **Building a pipeline:** Longer pipelines require adequate time to build and secure. Where the pipeline is of a significant length or where the site conditions are not straight forward, it is recommended that the pipeline is established well ahead of the pump establishment. There lies a risk that inadequate time is provided to build a pipeline increases the possibility of mistakes, blockage and failure of the pipeline. The best practice is for a pipeline of longer than 30m to have a dedicated vehicle to transport the pipes and a competent linesman and labour to build the pipeline.
- **Supporting pipelines:** 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. The risk of failure of pipelines that are not secured to resist pumping forces can result in potential injury from projectiles and falling objects. The best practice is for horizontal and vertical pipelines to be supported every three metres.
- **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. Any stoppage or breakdown while pumping a significant vertical pipeline or the need to empty a pipeline could result in concrete under the pressure of gravity with the associated risk of opening the pipeline to discharge the concrete. The best practice is that a pipeline of more than 30m has a shut-off or switching valve. ■

What when a contractor has no experience in pumping concrete

By Eamonn Ryan

In that instance, what are the factors that go into choosing the right concrete pump for a particular job?

Democratic Republic of Congo

"We come across many customers who have never been in the business and approach us the first time they do a high-rise building and consequently are for the first time doing concrete pumping – especially in other countries in Africa. They're used to doing two-, three- or four-story buildings and now have to do something much larger at 200m or 250m high. Africa doesn't yet have much experience with large buildings," says Putzmeister sub-Saharan Africa head Rudy Myburgh.

"You'd be surprised how often this happens on a weekly basis. That's where we come in – to assist them on what equipment to use based on the various factors. We are focused on equipment supply but also get involved in advising on the right machine for the job. We had one instance where we proposed the right machine for a task, the contractor ignored our advice and rather selected a cheaper machine, only for them to realise at 70% of the height that their machine was not up to the task, and the supplier representative was 'suddenly' unable to speak anything other than Chinese. Their site had to stand idle for six weeks while we ordered the correct machine, which being specialist was not readily available.

"When it's a specialised job it's necessary to look at the full spectrum of factors of the site and task in order to guide the client to the correct machinery. These factors include what concrete is being used; how far, high or fast they are going to pump; are there any additives


KwaZulu-Natal, South Africa

in the concrete? We direct the client to the right solution, and in the process also educate them."

The viability of purchasing such equipment depends on the size of the development company, or in the case of a single project the size of that job. "There are jobs of such magnitude that they will take three or four years to complete, and this alone warrants the purchase price.

Myburgh emphasises that there is still a tendency by contractors to buy purely on price rather than the full range of factors. "There is quite a lot of science behind erecting a high-rise building. You have to have the right concrete and you have to have the right machine to get it to the correct place. If you want to save on construction time you have to use a placing boom to place the concrete at the site or a machine that climbs the building as it rises, as we did with the Discovery building in Sandton.

"You have to look at the pressures in the pipelines, and whether the steel pipeline is sufficient to pump the concrete from the truck to the discharge point. These are normally only rated up to 85 Mpa and the thinner it gets the less pressure it can handle. If the pipe is too thin and it explodes – it is like a grenade," says Myburgh.

RISKS AND INSURANCE

There's a lot of responsibility that goes into operating a concrete pump, and yet people can operate these machines without a formal license.

"There is a range of things that can go wrong: there are power lines overhead; if it is not stable it can topple over at a cost of several millions of rands in damages, as well as risk to human life. That's just from the boom, never mind the loss involved in the damage to the building and property being worked on. Insurance companies simply pay out without checking the professionalism of the operation. Putzmeister prides itself that it trains the operators when it sells a machine – but someone can buy a used machine that does not come with any training.

Safety is the biggest and most important element that is often overlooked. Our operators go through a vigorous training course and are re-certified every two years. The importance of this OEM-provided training is as important as getting a license for a motorcycle, car or truck. If an operator does not know what he is doing or his training is on a machine other than the one he is working on accidents can happen at heavy financial cost to the concrete pumping company or contractor, or even the loss of life.

"I am at the moment approaching the SABS that there should be a SANS standard stipulating that operators of concrete pumps should only be certified by the OEMs. As it stands now, there are certain companies that make up their own certificates that are not worth the paper they're printed on. The insurers thereafter do not look at this element but take the certification at face

value - as it is not part of their protocol to verify certification..

"This is a project we're working on currently, to get SANS approval of an accreditation process, and thereafter to approach the insurers. The analogy is that if a driver doesn't have a driver's license and makes an accident, the insurer would not pay out – so why do they do so with a far more dangerous concrete pump and boom?

"There are more and more unprofessional contractors around today, and so this has become an important issue. We see this when insurance companies ask us to appraise one of them."

Honeydew, South Africa

CHOOSING THE RIGHT PUMP

Myburgh expands on the process: The correct concrete pump for the job greatly depends on the type of project and time frame of the job. On high rise and bigger project buildings a combination of stationary concrete pumps and truck mounted boom pumps are used due to the vastness and height of the building site. Putzmeister locally sells up to a 47m reach (BSF 47) truck mounted boom pump due to road axle weight restrictions. As a building progresses and gets taller it grows beyond the reach of any truck mounted boom pump and this is where the stationary pump comes in to its own. He says that with many famous projects in Sandton and Cape Town, Putzmeister was involved from the onset in getting the correct Putzmeister concrete pumps and placing equipment.

"With a stationary pump on site the concrete is fed using ready mix or site batched concrete that pumps the material many meters up vertically via a 5.5" steel pipe line with the correct safety and operating pressure rating. The correct concrete pump for the project will be dependent on how high, far and fast it needs to pump. There are many other factors to also consider over and above the latter for example what the slump and Mpa of the concrete is, what the climatic conditions are, how many bends and clamps are in the pipeline to only name a few. At the end of the pipeline the concrete can be placed using our hydraulically operated MX placing booms or our smaller manual rotating distribution placer like the RV 12 Lift.

"Our range of pumps is vast and depends on the project and site conditions. We have our BSA range of stationary concrete pumps that will pump anything from small residential projects at 0.5m³/hour to the Leonardo tower in Sandton and beyond.

"When considering our BSF range of truck mounted concrete boom pumps our international range covers anything from 20m to 70m reach boom but locally in South Africa we focus on what is legally permissible for road axle weights and so we offer anything from our BSF 20m to the 47m reach pumps here," he says.

MAINTENANCE ISSUES RELATING TO ON-SITE PUMPING

Myburgh emphasises that maintenance issues should not arise on site and if an issue does

Mosselbaai, South Africa

arise it is mostly due to incomplete maintenance. "When purchasing a pump, as it is a considerable investment not only in the machine but in the business, you would always want to complete daily checks, to ensure that all boom inspections are completed in the correct time period and most importantly that operators are adequately trained. A rigorous cleaning regime will also ensure that your pump is always performing at its best as it will assist in avoiding pipe blockages. You should always pump good quality concrete suitable for the rig," he explains.

SETTING UP THE PUMP

There are many critical factors to setting up a concrete pump at a job site. "Proper planning of the entire scope of the concrete pumping project, including the location of the pump on the work site, delivery line layout, concrete placing schedule, and concrete supply will result in better ROI (return on investment) and less downtime for customers. The concrete pump should be as close to the placement area as possible. Concrete delivery lines should have easy access to the concrete pump. Delivery lines from the concrete pump to the placement area should be comprised of rigid pipes and contain a as limited a number of sharp bends or corners as possible. For large placement areas, alternate delivery lines should be laid for efficient connection when required, and standby power/concrete pumping equipment should be readily available to replace/ exchange, should a breakdown or blockage occur to prevent any further downtime or loss of material or of any kind."

PUMPABLE CONCRETE

Pumpable concrete mixture / proportions of pumpable mixtures are about the same as those to be placed by other methods, apart from the fact that more emphasis is placed on the fine aggregates content in the concrete mixture.

"Concretes which are pumped must be cohesive and mixed well. Pressure exerted by the pump can force concrete/ mortar away from coarser aggregates resulting in blockages in the line if the mixture is not proportioned/measured or weighed out properly.

"The cement content will generally be higher for pumped mixtures than those of mixtures placed by conventional methods. The higher the fine aggregate content the higher the requirement is for water in the mixture, which in turn will require a higher cement content.

Ochicoto, Namibia

"Extra cement should however not be used to correct pumping issues resulting from poor grade aggregates. It is preferable to correct deficiencies in concrete mix by blending in additional fine aggregates rather than by adding more cement to the mixture.

"There is a safety checklist usually issued by the company SHEQ officer. Putzmeister has a referral in the manual to the safety file by the internal safety procedures of each individual company should be used in conjunction with Putzmeister as well as the Chassis OEM standards."

Myburgh lists some of the safety measures:

- Proper PPE
- Proper running tests prior to pump initiation
- All requirements must be met as pointed above in critical setup schedule

"These safety measures are in place not only to ensure safety but also the optimum working performance output of the Putzmeister machine, thereby ensuring that both operator and machine perform at optimal 'health' level," says Myburgh. ■

On site experience is key with pumpable concrete

By Eamonn Ryan

With a previous background in the readymix industry, and with 16 to 20 pump jobs each day, the pumpability of concrete is something Gideon Wolvaardt, manager at E & G Concrete Pumps, is passionate about – he deals with it every minute.

"The newer, more advanced concrete mix designs are much different to the old traditional way of mixing concrete – the manufacturers reduce the cementitious material as much as possible to save money, through highly advanced admixtures which reduce the amount of water required. Those admixtures are extremely volatile. A little water can affect the entire load one way or another – as little as 10ℓ on a truck load can either make it too dry or too wet. There is a small window that you have to work with.

"A pump mix has to be 110 to 120 slump. Less than that and the pump struggles to pump it. Higher and its strength gets compromised and it can segregate. With many of these admixtures, and 10ℓ more water than it should have, it can completely segregate and become impossible to pump. With admixtures, it has become impossible to judge the slump by eye and not each load is individually tested – only every fifth or sixth load is checked with a slump cone because it's time consuming.

"Due to the admixtures, you might estimate by eye a 120 slump whereas by test it's 150. One can no longer distinguish, unless one actually does the physical slump test. The effect of this is that a pump operator might think a load is too dry and add water, compounding a problem when the load was in fact too wet.

"At the plant, the slump is normally set a little bit wetter at 140 to compensate for it drying out while being transported to site. On a hot day, the mix may reach the site with a 100 slump, so you might need to add a bit of water. However, in the event of a cold day or some other factors, the concrete might not reach 120 slump and an inexperienced pump operator thinks it's too dry because it struggles to pump – and again adds water worsening the problem.

"It is a challenge we deal with every day. The plant is trying to get the most economic mix for the client because tenders are won and lost on that factor. They put in as little cementitious material as possible, because it is the most expensive component, but this is what lubricates the rest of the mix," says Wolvaardt.

Where the issue becomes controversial, he says, is when it leads to the load being sent back to the plant and a dispute arising as to where the fault lies. It has to be handled in a diplomatic manner, he suggests, "because the minute you say to a concrete supplier their concrete is not pumpable, they will argue otherwise".

"In the event of a load being rejected by the operator, there are a number of options available. The worst of all options is to force it through the pump, because of the risk of a blockage and putting strain on the pump. This is a major safety risk. In this case the first accusation tends to be that the pump is at fault, when in fact the issue is most likely the pumpability of the concrete.

"The correct way to respond is to first determine the slump of that concrete. I would suggest every pump carries a slump cone to do an immediate slump test. If it falls within 110 to 135 slump, it should be most likely pumpable. If it falls outside that range, the operator should ask permission from the owner and concrete supplier to make adjustments to the batch, usually only 10ℓ or 15ℓ, or add some admixture without adding water does the trick. These are usually small adjustments required, and great care should be taken, but all too often the operator will simply put a hosepipe in without measuring and then there's too much water added," says Wolvaardt.

"The other option is to send it back to the plant, but that upsets everybody, because it's a delay for everybody and a cost for the plant. Preferably it should be resolved on site, if possible. The need to dry it out on site – which is the case very often – is slightly more tricky would involve adding cement.

"It is important to get permission before making adjustments, in which case the contractor can still keep the guarantee on that concrete by adding a specified amount of water or cement. Then the volume of water needs to be properly measured in a 20ℓ bucket. It thereafter takes five to ten minutes to mix everything thoroughly. Overseas they have flow meters on every readymix truck so one can measure how much water is added, but in South Africa this is not done.

"Another challenge with pumpable concrete is where the blades in the mixer become worn out, in which case they don't thoroughly mix. This can result in lumpy cement which doesn't offer the required adhesion and lubrication. To determine the cause of segregation is not easy – it could be one or several of many possible factors, such as too much or too little water, the blades or the pump.

E & G Concrete Pumping provides the entire service to contractors: the pumping, sale of new equipment and spare parts and rents out concrete pumps. "We've got a fleet of 16 concrete pumps, including 48m all the way down to 20m.

"Operating a pump is in fact extremely simple - like playing Playstation – but what's more important is understanding concrete and being able to manage difficulties as they arise with the concrete. The biggest challenge comes when one gets a blockage. It is vital to have an experienced person in charge of discharging the concrete into the hopper, to see what goes into the pump, so that one can react as soon as a problem occurs" says Wolvaardt. ■

Boom vs static pumps

By Eamonn Ryan

Due to the level of specialisation required for pumping concrete, PPC has made a strategic decision not to own any pumps and to rather maintain a pool of approved pumping contractors to deliver its concrete on site when pumping is required. "In South Africa roughly 30% of our concrete is pumped, with the rest being either straight discharge or by crane," says PPC Materials executive, Dave Miles.

On the central question of why to pump at all, Miles explains: "There are a number of reasons but the biggest one is time saving. Pumping is a lot faster than a crane. You can put the concrete exactly where you want to. Therefore, from the contractor's point of view, a pump saves a significant amount of time compared to using a crane. Taking into account the fast-track nature of most projects these days the pump has become indispensable on any construction site.

Dave Miles

"In addition, from a ready-mix point of view one gets faster turnaround on the trucks when they go to a pump. One can send a truck to a pump and ten minutes later it's empty on its way back to the plant for another load. If one had to do that same load with a crane, the truck could be on site for an hour and a half to two hours. This results in better utilisation of the ready-mix producers assets.

"The customer gets a one stop shop with us whereby on their behalf we deal directly with the pumping contractors. This is something we found to be a much more effective operating business model and allows us to focus on producing high quality concrete. The brand of pump is the contractor's concern, while customer relations remains our concern – as far as they are concerned they are always dealing with PPC, and we are answerable for the job quality," adds Miles.

"The most important thing when selecting a pump is to first establish where the concrete must be placed, whether the job is at ground level or a high rise. When many people think of a concrete pump, they automatically think of a boom pump because it looks impressive. However, a boom pump is not always the best solution. If it's high up, then a boom pump generally gets utilised more than a static pump. Yet

if you take for example, the Burj Khalifa in Dubai, the tallest building in the world, it was built with a batch of static pumps, not with boom pumps. That building is 800m high and no boom pump can reach that high. Furthermore, the majority of static pumps can operate at higher pressures allowing them to pump concrete further distances than a boom pump.

"With Burj Khalifa, the contractor mounted permanent pipes onto the structure and pumped absolutely everything on the entire project as the quickest solution, using some extremely specialised pumps because of the height that they had to pump. Using a crane would have been too slow and not cost effective," says Miles.

"In the case of a long-term project such as a high rise, it makes better sense to utilise a static pump and just add pipes as the building rises. However, at the moment few if any real high rises are being constructed in South Africa, and if one looks at the rate at which concrete is placed, the boom pump does make more sense for its convenience. One can do one floor at a time, taking it off site between floors to do other jobs and periodically returning. This practice does reduce the operating costs for the contractor as he does not incur the full cost of the pump when it is not in operation. He only pays when he needs it making the cost a totally variable one.

"Every pump has a different performance level: just because a pump has a long boom of 46m or more doesn't mean it pumps faster. Generally, static pumps are used where there is a requirement for flows over long distances. They tend to run at higher pressures, thereby pumping further or higher. Many of the 46m booms have a theoretical pumping capacity of 60m^3 an hour, and in reality only achieve around 40m^3 – which at 100 tons an hour is still a lot of concrete. But a static pump can push up to 120m^3 an hour, which no boom currently available in South Africa will achieve.

"In the case of a boom pump, ground conditions are critical as the pump and boom create a massive counterweight load with the booms jutting out 46m. They require well compacted substrates and must be level. If one places a boom pump on a 10 degree slope it may fall over. Access is critical and should preferably be sufficient to allow two ready-mix trucks in at a time. This is a point that is often overlooked by the contractor and one ends up with a underutilised pump as a lot of time is spent moving ready-mix trucks around.

"With a static pump, ground conditions and site conditions aren't as critical because there's not a huge load being applied to the ground. This means the pump can be placed out of the way as long as trucks can have easy access," he says.

CONCRETE PUMPS ARE HIGH ON MAINTENANCE

Miles adds: "Hydraulic pumps are extremely expensive, in the region of R250 000 a pump – making maintenance crucial. One is taking a highly aggressive material in concrete and pushing it through a mechanical operation. The biggest maintenance issues in all pumps are hydraulic – the seals and pistons are critical to keeping the concrete out of the hydraulic pumps, or it can quickly damage them.

"If there are delays on site, the concrete can set in that pump, which is expensive to fix. Therefore when pumping, the contractor has to ensure a smooth supply of concrete from the supplier. It is important to maintain the seals and cleanliness of oils which lubricate the more expensive parts. If a pump is not cleaned thoroughly every single day, it will be damaged. This is simply general maintenance, nothing highly complex and if done regularly, a pump will last a long time.

"When choosing a pump contractor, we therefore investigate their service, the condition of their pumps, their maintenance process, and whether those pumps are reliable – because those factors are a reflection on us as the contractor deals with PPC and not the pumping contractor. Boom pumps have to be stress tested annually, which we verify. It is also important they carry a variety of boom pumps, from the 46m down, as well as static pumps," he says.

PUMPABLE CONCRETE

Miles explains: "The mix of our standard concrete placed by a truck, crane or straight discharge, has a higher stone content, and tend to be slightly drier with a slump in the region of 75mm to 90mm. There's a lot more physical compaction required on the mix on the job site.

"The mix for pumping aims at reducing the abrasion or friction of the concrete on the machinery. It will therefore have a slightly lower content of stone and slightly more sand, probably in the region of about 100 - 150kg/m^3, to achieve more paste in the mix. It looks fluffier or more cohesive and also has a slightly higher slump. Its slump will be in the region of between 100 and 150mm, so it is easier to pump. As far as maintaining that slump from plant to site, we use admixtures for workability retention - but there is not a great difference in the end product.

"The two main differences between the two concretes types lie in its workability and its stone content. When it comes to laying out a slab it doesn't make any significant difference which concrete is used in the performance of that slab as long as the engineer has taken the differences into account with their slab design," says Miles. "The main difference that the engineer will need to take into account is that the pumped concrete will have slightly more shrinkage because there is a slightly higher water content and a higher paste content. The engineers take that into account in the steel design in the bigger spans, but on the majority of deck slabs in any building there is no difference in performance strength-wise." Where a contractor has specialised performance criteria for the end product PPC's technical team will assist the contractor and engineer by designing bespoke mixes that meets the performance criteria of the structure.

The worker in charge of the pump hopper

has the role of checking if anything goes wrong - and ideally should be able to fix it. "He's not just your normal driver. He has to have a fair understanding of mechanical operation, safety operations and working conditions as well as a certain amount of concrete technology training. To operate a boom pump, in many cases the operator is situated on the ground and cannot actually see the end of the pump 20m or 30m up on top of a deck. Communication between the operator and the team on the deck is critical in these instances.

"The pump operator has the final say as to whether they're going to pump the concrete or not. Because he doesn't want to damage his machine, he's not going to push the wrong concrete through. If it's not of the correct consistency, the operator has the right to reject a load. That's an agreement we have with all our subcontractors."

Furthermore if the slump of the concrete is out of specification the operator may reject the load as it is an indication that the quality might not be to PPC's high standards. "In that event, the batch would be analysed to check what was physically put into the mix by our technical team. After analysis of the mix by the technical team and they feel adjustments can be made to the mix on site then if the operator can make adjustments to that mix and still be within specification parameters, he would do so. If he cannot make adjustments, the truck would normally be returned to the plant and diverted to another site where the concrete can be used at a much lower strength mix. In the worst-case scenario, it would be dumped – though that rarely occurs," he says.

HEALTH AND SAFETY

Miles identifies three primary risks with concrete pumping on a construction site.

- "The first risk is invisible: operators work with tremendous pressures in the hydraulic system and in the actual delivery line of the concrete. If a pumped concrete pipe bursts and somebody is standing next to it, those pressures can kill. Therefore the condition of all fittings has to be verified on each pour - which is actual fact done. The hydraulic oil is also under a huge amount of pressure at about 320 bar and if that pipe bursts the oils coming out are as sharp as a knife at those pressures. This represents a hidden safety risk because you can't see pressure."
- The second risk is more visible – the danger of the overhead boom failing. "If the hydraulics fail the boom can fall. They are inspected annually for stress fractures, and that's why we insist on our pumping contractors getting yearly certificates to show that those booms have been stress tested. It is part of the construction safety code. One also has to inspect the substrata on which the boom is located, for any weakness.
- "Thirdly, when pumping there are trucks moving about constantly around the pump that the operator needs to be conscious of as they might not be visible to the truck driver," explains Miles.

Taking all of this into account, although pumping concrete has certain elements of risk Miles says it is here to stay in the construction industry. Not only do they save the contractor money but they also enable the client to get a quality structure in reduced time. ■

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Checklist for concrete pumping

(Use this checklist to manage contact details, general site conditions, safety and equipment conditions and special concrete mixture notes.)

Project: .....

Location:.....

1. Contacts					
Who	**Name**	**Phone**	**Mobile**	**Fax**	**E-Mail**
C. Contractor					
RMC Supplier					
Pump Contractor					

2. General Conditions				
Start Time	**Pump:**	**am/pm**	**Concrete:**	**am/pm**
Placement Location	• Slabs	• Walls	• Footings	Other
Placement Rate (m^3/hr.)		Volume (m^3)		
Type of Pump	• Regular	• Z-Boom	• Telescoping	• Trailer
Size of Pump (m)		Pipeline dia, mm		
Pumping Distance (m)	Vertical		Horizontal	
Slump/Air Spec	• Point of Discharge		• Point of Placement	
Testing	• Point of Discharge		• Point of Placement	
Priming Agent	• Grout		• Slick Pack	

3. Concrete Mixture				
Strength (MPa)	28 days:		Other	
Max Size of Aggregate (mm)	(no larger than 1/3 pipeline diameter)			
Density (kg/m^3)		Lightweight	Yes	No
Slump (mm)		Air (%)		
Water Reducer	Regular	MRWR	HRWR	
Fibres	Yes	No		
Special Requirements				
Set Time Requirements (hr.)	Initial:		Final:	
Water Addition	Yes	No		
Permitted				

4. Jobsite/Safety			
Wash Out Area	Yes	No	Location:

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PUMPING
handbook

CONCRETE SOLUTIONS

Admixtures' role
CHRYSO

What to use and what to avoid

Pumping concrete operation plan

Admixtures have become ubiquitous as they drive down cost while increasing productivity.

Admixtures' role in and pumping concrete

By Eamonn Ryan

Virtually no concrete is pumped today without one or more admixtures added to the concrete batch either immediately before or during mixing concrete. Admixtures have become ubiquitous as they drive down cost while increasing productivity – most particularly their ability to improve concrete quality, manageability, acceleration, or retardation of setting time. In the case of pumped concrete admixtures improve its viscosity to allow it to be pumped.

The main purpose of using superplasticisers is to produce flowing concrete with a high slump to be used in heavily reinforced structures and in placements where adequate consolidation by vibration cannot be readily achieved. The other major application is in the production of high-strength concrete.

Patrick Flannigan, technical manager at CHRYSO Southern Africa, says: "Of course water is the cheapest additive to concrete as a plasticiser – but it has its limitations when it comes to strength. Today, when it comes to pumped concrete, contractors tend to go for one of the newer generation long chain polymers, called superplasticisers which give them workability and water retention while remaining still cohesive, so one can more easily pump the concrete.

"Dependent on the material to be used, mix designers try avoid natural sands such as river sands and filler sands – in order to reduce their carbon footprint, and CO_2 emissions – which would normally be used in a mix and which gives the pastiness to the concrete.

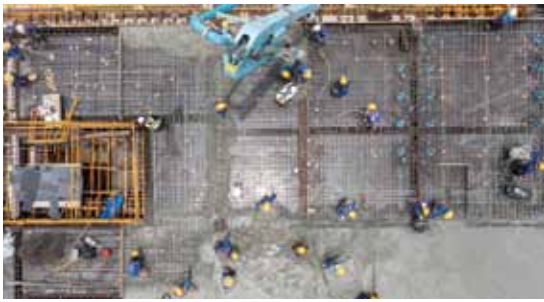
"Where concrete lacks that pastiness, contractors use pumping aids, whether it be a viscosity modifier or something similar to help keep the concrete together so it can pump without segregating. The mix for pump concrete contains less stone than conventional concrete, due to the need for lubrication. Pumping-aids lubricate the pipes and ensure the concrete pumps smoothly while ensuring the concrete in the pump doesn't segregate," explains Flannigan.

Patrick Flannigan, technical manager at CHRYSO Southern Africa.

OPERATOR EXPERIENCE COUNTS

"Experienced pump operators know the ideal pump pressure for their equipment rather than just using a visual assessment of the slump. It's not necessarily a wetter mix that's going to pump easily. Therefore it's better to select someone as a pump operator who is either a technical person or a technical supervisor, as that knowledge enables them to determine the pumpability of the mix. Otherwise, if it's wet it might look like its segregating – it looks stony – even though there might be enough paste in it. One can immediately see what the mix is like from the pump pressure if it's too wet to pump. Even if an experienced pump operator can visually see the slump of the concrete, I don't think they should make a call on it," says Flannigan.

In the event of the slump being inadequate, he says rather than simply adding water there can be added to the concrete a 'slump-rescue pack' which contains one of the long chain polymer derivatives to increase the slump, without changing the water cement ratio. "Consequently, it won't have any negative effect when it comes to early or late strengths. Why contractors tend to steer away from this quick-fix is that once their operators see the ease of pumping they will want to use it continuously – and it does add to the cost of the concrete. One can see its advantage immediately in the pump pressure as soon as the pack is put in – it gives a soft icing-like consistency to the concrete.



The main purpose of using superplasticisers is to produce flowing concrete with a high slump.

For pump concrete one needs filler sand and an admixture can compensate for the lack of sand to give it flow.

"A superplasticiser gives a nice pump pressure and depending on the distance to be pumped the admixture maintains slump retention for quite some time with no build-up in the pipeline," he adds.

Although the slump-rescue pack comes at a cost and could not be used for every load unless budgeted for, Flannigan says there are certain situations where it is a cost benefit: "For

Admixtures improve concrete quality, manageability and acceleration or retardation of setting time.

A superplasticiser gives a nice pump pressure maintains slump retention for quite some time.

instance when a team is on site, and there may be labour issues whereby they cannot change shutters, or a pump breaks down or there's a row of trucks backed up, then the product will be well worthwhile as it can save the concrete and still enable it to be used without sending back or dumping a six-cube truck."

WHAT ADMIXTURE TO USE AND WHAT TO AVOID

He cautions that some admixtures should be avoided in pumping concrete. One is an air entrainer in which entrained air bubbles act as a physical buffer against the cracking caused by the stresses due to water volume augmentation. "One should not permit that compression effect in the pump. They call it the 'concertina effect' as it pushes the air out but doesn't move the concrete, thereby blocking the pump.

"Accelerators too tend to be avoided over long-distance pours. In that case, and in high rises, an open time retarder can be used in conjunction with normal plasticisers and super-plasticisers – but it is not recommended to be used on its own. What admixture is used will be determined in the lab that develops the mix design.

"A mix design typically aims to lower the volume of cementitious material and coarse aggregate, reducing the stone size with more water for a more flowable mix. However, by reducing the stone content to create space, one actually increases the likelihood of shrinkage and cracks. The only way to overcome that risk is by using a superplasticiser. You can get away with a plasticiser but most contractors prefer a superplasticiser for its water reduction ability and which in turn provides extra flow without using too much water or too much cementitious materials like fly ash, slagment or something similar.

"If anybody is not using admixture they are throwing away money because it's biggest benefit lies in lowering cost. There is the added benefit of reducing one's carbon footprint, as

Research and development in admixtures is heavily focused on greener cement and concrete products.

well as producing a more durable concrete. The only way you can reduce that is by using an admixture," he explains.

R&D IN ADMIXTURES

"Research and development (R&D) in admixtures is heavily focused on 'greener' cement and concrete products. This trend is accentuated by a global shortage of decent natural sands – though this is not yet prevalent in Africa. For pump concrete one needs filler sand and an admixture can compensate for the lack of sand to give it flow. All the R&D under way at the moment is to do with sustainability: clinker reduction, less CO_2 emissions by using more extenders, fly-ash, slagment, limestone and the like. These all reduce costs by reducing cement content by up to 50% in the case of slagment and 30% in the case of fly-ash. This is particularly important for developers wanting their buildings to gain green accreditation."

Flannigan notes that historically, when it comes to long chain polymers the older generation superplasticisers were made from by-products from the paper industry and elsewhere. "The newer generation polymers are bespoke products for a specific purpose or a specific aggregate so that it all works together seamlessly.

"This means when contractors come on site for a certain project they will be able to do that project using locally sourced material. They will not have to transport or truck materials in from far away to meet their demands. The admixtures can help control issues like clay content and bad gradings whether from lack of fines or excess of fines. R&D developments in admixtures are making their job a lot easier," suggests Flannigan. ■

Pumping concrete operation plan

(Use this checklist to sign off plans and track all revisions and copies.)

Project Name: .....

Contract No:.....

Document Reference No:	Document Status	Tick Applicable Box
		Draft
		Live
Contacts	**Name:**	**Signature:**
Pumping Operation Manager		
Batching Plant Manager		
Project Manager		
Pump Supervisor / Site Manager		
Health & Safety Manager		

Issued to: (name & company)		
Response required by (date):	Plan Approved/Agreed by:	
Plan Approved/Agreed Status: *(Indicate by circling relevant option)*	**Yes** *(Accepted, ready for implementation.)*	**No** *(Rejected, must be amended & resubmitted.)*

Revision Records				
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2				
3				
4				
5				

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PUMPING handbook

TRAINING AND CERTIFICATION

Occupational training

Akane

Pumping maintenance

Foxcrete

Training, health and safety

Occupational training is today inseparable from health and safety

By Eamonn Ryan

All concrete pump operators require intensive training as their function is vital to the completion of a project. In order to pump concrete to where it is required, the concrete truck has to become stationary, and given that concrete starts to harden immediately the concrete has to be delivered to location without delay.

All training on concrete pumps is specific to a particular brand. Each course has a SAQA unit standard, and Akane Training Academy adapts its training for each brand to blend together the requirements of the specific machine and their varying tonnages and those of the unit standard in order to train the users of that machine, explains Jackie Ross, Akane general manager.

Jackie Ross

The rationale for training is that if an incident occurs on site, the department of labour can shut down the site, and will investigate what training the company has provided to workers. Companies that permit a worker to operate equipment they're unqualified to use can get fined up to a million rand or have the owner/director imprisoned – as it is manslaughter. Training therefore protects both the worker and the employer. Occupational training is consequently almost inseparable from health and safety issues.

"For instance, concrete has chemicals in it requiring personal protective equipment (PPE) so training involves not just the technical aspects of laying concrete but the correct PPE they need to use. It is integral to operational training.

"The unit standard and credits all stay the same, the training is simply adjusted to include the specifics of how to use that particular machine, the controls of which would differ from one machine to another. You can add to a unit standard but cannot take away from it. Sometimes the pump operator function is separate to that of the vehicle driver and on occasion it is one and the same person. In that instance the driver of the ready-mix truck would require both a driver's license and a pump operator's license."

Learners typically come from building contractors involved in a project that they have just won a tender on. "The contractor would have to produce a safety file which would include proof of all the training that workers have undergone. That training would cover a wide range of topics such as Working at Heights if they climb up scaffolding, Firefighting, First Aid through to all the occupation training that relates to concrete

and construction, and the to operate the on-site equipment," says Ross.

NOVICES AND REFRESHERS

"To train a novice to become a licensed concrete pump operator takes five days, and as with all training that involves vehicles and equipment it expires after two years and has to be renewed with a refresher course, including an eye test and medical certificate – given that workers age. This is important because the workers may not use the equipment regularly, but perhaps only every three or six months when their firm wins a specific type of contract. We do find that people coming for their refresher have not seen that equipment for two years and have forgotten how it functions," says Ross.

Furthermore, they have to do the refresher within 90 days of the expiry of the two-year license period or either redo the full five-day course as a novice, or a RPL (Recognition of Prior Learning) three-day course.

"We buy the specific SAQA training books and materials from the Transport Seta (TETA) which covers the sector of driven machinery. This is to enable us to be accredited to do the training and get moderated and also audited by TETA to check our training system and materials. This is important because there are many unaccredited or even fly-by-night training programmes on the market using out of date manuals which are not updated to the new regulations and unit standards. These operators get business by being cheaper, and they are cheaper through not being accredited or appropriate.

"In every case, we deliver the training at the client's premises or on site wherever it is in the country, as this enables us to show them how to operate the machine they will actually be using in situ. We do not run a traditional college whereby learners come to our classrooms except in some cases where clients have small numbers of learners, and it becomes more cost effective in that instance than sending our trainer to their premises. On driven machinery we are only permitted to train four at a time and the training needs to take place where the machinery is."

Drivers of concrete mixers for instance are limited to the tonnage size of their vehicle and cannot drive a larger tonnage mixer because they function differently.

A further complication is that mines are big employers and are governed by a separate set of rules in the Mines Act, and much of the training Akane does on concrete pumping takes place on mines. In this instance, it is a combination of the unit standard, the operating manual for the equipment and is also site specific to the mine, incorporating their site procedures.

"The Occupational Health and Safety Act is actually written 'with blood', developed from all the workplace safety incidents that have occurred over the years. When someone has died on site, it makes regulators think about how to avoid such incidents, and this is how the Act has been crafted over time. This has resulted in regulations having a zero tolerance towards safety – it always comes first. It never used to be like that, and has only evolved since 2009, which is when I became involved in training. Safety was always important, but zero tolerance was not," explains Ross. Today, there are much fewer workplace incidents.

Being trained – at least through RPL – also enhances individual worker's career prospects. Ross explains that they often find someone who has been doing a certain job for ten years without any formal qualification. Through their three-day RPL courses that person gets a formal qualification which makes them more marketable – as opposed to having to prove they can do the job each time they get employed.

TRAIL OF ACCOUNTABILITY

Ross explains the trail of accountability: Under section 16.1 of the OHS the director is accountable for health, safety and training and can be imprisoned for certain breaches. The director in turn commonly delegates that accountability under section 16.2 to a manager who is required to ensure all workers are appropriately trained. The training provider in turn is also accountable, says Ross, and if there is an incident the training provider will also be investigated.

"For this reason it is imperative we keep our records in excellent order documenting that the training was done according to regulations, with IDs, eye tests, driver's license and more - and that we are accredited."

Often, says Ross, she is called in by a client which is ignorant of even what training they require, and it is her job to inform them of their legal obligations in respect of training and OHS. "For example, a Working at Heights need is itself quite vast, there are many different types of courses. It is similar to consulting. To answer their need I require a full understanding of what the project entails and what exact work they will be doing, or I might suggest the wrong training – and that invokes my accountability. This becomes an issue for companies that undercut on the tender simply in order to win it, don't do the appropriate needs-based research and thereafter suggest inappropriate courses. The client might not know what to ask and are not getting advised appropriately.

"We do a fair bit of training outside South Africa's borders especially in Mozambique, DRC and Malawi, and to a lesser extent in Swaziland and Botswana. Because their OHS regulations are often weak we train them according to the South African OHS legislation." These countries tend to be far behind the curve when it comes to OHS and Ross says it is only South African companies in such countries that follow regulations and train their workers, because even abroad South African companies have to follow South African regulations. They would get their local contract companies to follow suit, says Ross. ■

36m Nduna

Foxcrete finds a niche in pump maintenance

Foxcrete Concrete Pumping has built up a fleet of concrete boom pumps ranging from 32 to 43 meters since its establishment in 2007. It has a number of Zoomlion, CIFA and Sany concrete pumps, both static and with booms.

Erika du Plessis, Foxcrete general manager, explains that the company provides a concrete pumping service to contractors and occasionally assists other companies in the maintenance of their equipment.

In 2008, Chinese group Zoomlion Heavy Industry took over CIFA, which produces concrete machinery (truck mixers, truck pumps, truck mixer pumps). Development and manufacturing are shared by both.

"The choice of pump for a project depends on what type of job it is, the space on site and other physical details. If it's a bigger slab, we'll send a 43-meter boom for its longer reach, and if that's not long enough we can add additional pipes to the pipeline. For smaller jobs or where there's limited space, we usually send our smaller pumps, particularly in housing estates, shopping malls or warehousing. Apart from the boom, a pump needs at least 10 by nine meters of establishment space for its outriggers, and enough space for the ready mixed concrete trucks to reach the hopper area for concrete discharge.

"In selecting the appropriate pump for a job, we first do a site inspection and a risk assessment to determine safety, which pump will reach the discharge area, and if there's enough establishment space. This assessment includes the stability of the site and structure; safe access to the discharge area; whether props for slabs are secure; building materials that pose safety hazards; disturbed soil or anything on site which can cause a pump to collapse or fall over. Other things we look out for are overhead obstructions like high voltage cables or trees that can impede the boom or cause damage," explains Du Plessis.

The establishment area for a pump must be within three degrees for a pump to be estab-

lished safely. "A pump has a level-indicator that informs an operator if the ground incline is more than the three degrees. Most concrete pump models have a safety feature that if it's not within the three-degree limit, the pump won't function." Working within these parameters and following other critical establishment rules regarding the setting of the outriggers, the likelihood of a pump falling over will be low.

The variations between different concrete pumps are not that significant, with the real difference being in the length of the boom, boom type and outrigger design. "There are different boom types which affect the amount of space required for the boom to open: there are roll-and-fold booms, which unfurl and require more space; Z-boom types which open like a scissors requiring less space and a m-boom type which is a combination of the two. The Z-boom is suitable for pumping slabs in warehouses for example, where it can manoeuvre under roofs and in small spaces. Where a longer reach is required, one commonly attaches extra pipes to the boom to achieve a longer reach, having lain the boom flat on the slab. This works well, though it's considerable manual labour as a three-meter pipe weighs about 45kg, which also raises health and safety concerns regarding workers.

MAINTENANCE OF THE PUMP AND BOOM

Maintenance is one of the biggest challenges in the pumping sector. Du Plessis says that pre-

43m Ndlovu

ventative maintenance of the concrete pump is constant and imperative as the equipment experiences repetitive wear and tear with stones and sand being pushed through the system.

"It's also under constant hydraulic pressure while working, so it's something we keep an eye on all the time. Maintenance requires checking for weak points in the pipeline. When a pipe wears too thin, working under so much pressure, it can explode with concrete flying everywhere. One must regularly check the thickness of the pipes, for which there are thickness testers. A pipe has a relatively predictable lifespan before replacement, that is if it hasn't been compromised in any other way and manufacturers' pipe rotation guidelines were followed - a double wall pipe can pump 60 000 to 80 000 cubic metres, a single wall from 30 000 to 40 000, at which point they must be replaced.

"We use checklists that cover the pump's grease, hydraulic liquids, checking hydraulic lines, hoses, fittings and wear parts to name a few. The pump shakes and vibrates while working, so the electrical wiring could disconnect if not regularly checked," she adds.

Du Plessis explains that given the complexity of pumping it is more common for a contractor to sub-contract this task to a company like Foxcrete than to purchase its own pump and perform it in-house.

"A pump is a highly specialised piece of equipment and is high in maintenance. Due to the cost involved and limited support available, we had to develop the expertise and systems to conduct the maintenance of our pumps ourselves."

TRAINING, HEALTH AND SAFETY

Another major discipline in the industry is operator competency. Besides general health and safety training, such as working at height, Du Plessis explains that Foxcrete does operator training themselves as they identified this as being a big gap. "The existing training, even from the OEMs, wasn't comprehensive enough. I've developed the training programme myself, both the theory and practical elements."

"I imported a training programme, researched international pumping standards, and adapted it to local conditions. It had been a problem in the industry where operators can operate concrete pumps reasonably well but lacked the necessary knowledge and skills in the health, safety and environmental domain. As health and safety compliance in the construction industry is quite low and concrete pumping is a high-risk operation, it is imperative for us that our operators are competent in all facets of pumping," she adds. ■

Health and safety issues concerning concrete pumping on site

By Chris Coetzee – director of OHS Savvy Consulting, HSE Member of IOPSA and Technical Member of SAIOSH.

When we look at any OHS Legislation in South Africa, we must always determine how to best implement the laws and regulations to the specific scope of work we are performing. As always section 8 of the OHS Act states that an "Employer shall provide and maintain, as far as is reasonably practicable, a working environment that is safe and without risk to the health of his employees".

Chris Coetzee

This is inclusive of any occupation or scope of works. Thus, for concrete pumping on a site, this work must take place within an environment that is safe and without risk to the health of employees.

According to the Construction Regulations of 2014, concrete casting can only be done once authorisation has been given in writing by a competent person as stated in CR12(3)(a)

We can thus see the need to have competence and assigned responsibility to specific persons when working with any concrete casting on a site.

Again, we go back to the OHS Act and find that in section 8(2)(b) employers are responsible for "taking such steps as may be reasonably practicable to eliminate or mitigate any hazard or potential hazard to the safety or health of employees, before resorting to personal protective equipment".

All work conducted must be subjected to a proper, documented risk assessment compiled by a competent person who has knowledge of the scope of work being performed. The risk assessment will also support the design of Safe Working Procedures for the tasks to be performed. From these documents and methodologies of work, we can design a bespoke inspection form for the site. Using a template, we can add or remove items that are necessary to the specific site conditions and scope of works so as to provide a site-specific set of standards to be adhered to be all employees.

A person performing the inspecting must take into consideration certain fundamental items such as:

- The area where the concrete pump will be positioned with outriggers extended, must be demarcated and barricaded.
- The safety of public to be considered and where applicable, a flagman posted.
- The pump and delivery pipes to be connected and secured correctly.
- Sufficient space to allow delivery trucks to stop and que for delivery of premix.
- Preventative measures taken to prevent concrete spill on the road service or into the stormwater system.
- The area where the concrete bucket is filled directly from delivery truck, must be barricaded.
- All the principles applicable to crane operations e.g. safe connections, lifting and banksman duties are valid and needed to be applied during this operation.
- A concrete bag to be installed around bucket outlet to prevent dripping spillage during transit of the concrete.
- All safety whistles and signs applied; the bucket may not be moved over a public road of walkway.
- The supervisor for the concrete pour must ensure that the bucket is empty, and the safety cover is inserted over the opening before returning it for refilling.
- Ensure that the concrete bucket is cleaned daily after concrete pour to prevent concrete to set in or on the bucket to prevent it from falling when accidently dislodged.

As with many other materials, there are potential risks involved in handling or working with cement or mixes made using cement.

The composition of cement is such that when dry cement is exposed to water a chemical reaction called hydration takes place, releasing a very strongly alkaline (and caustic) fluid. This can cause alkali burns and safety measures should be observed. Appropriate precautions are advised to prevent tissue damage when handling fresh mixes containing water and cement. Cement dust, dusts from handling aggregates and from cutting concrete are easily inhaled.

PROLONGED OR REGULAR EXPOSURE TO THESE DUSTS SHOULD BE AVOIDED

Cement is a complex combination of compounds that includes minute quantities of trace elements. Although South African cements typically contain less than two parts per million of Hexavalent Chrome (widely regarded as a safe level), it may serve as an aggravating factor in cases of exposure to alkaline fluids. There have been some reports of allergic dermatitis after exposure to these fluids.

When fresh concrete or its bleed water comes into contact with human skin, the alkalis react with the oils and fats in the skin as well as the proteins in the skin itself causing tissue damage. Other organic tissue (e.g. mucous membrane) can also be attacked by strong alkalines leading to burns that can sometimes be severe, and users should try to avoid all unnecessary contact with these fluids.

Where such contact is unavoidable, suitable precautions should be taken.

Roughness and dryness of the hands after working with concrete is a typical consequence of loss of these oils and fats. More prolonged exposure could result in irritant dermatitis. It is possible that the effects of trace elements may aggravate the condition and lead to an allergic dermatitis. To safeguard against accidental exposure, appropriate protective equipment is strongly recommended.

- Impermeable gauntlet type rubber gloves and high length rubber boots should be worn to prevent direct contact with skin
- Trousers should overlap the boots rather than be tucked into them
- Hydrophobic alkali-resistant barrier creams should be applied to hands and any areas of skin likely to be in contact with fresh concrete

ORDINARY BARRIER CREAMS ARE LIKELY TO BE INADEQUATE

These precautions may be ineffective if the skin itself is not clean and free of concrete residue. Even a tiny trace of cement dust remaining in contact with wet skin will raise the pH significantly. Regularly wash (at least daily) protective clothing and keep it clean and free of concrete and wash any areas that have been accidentally splashed with wet concrete as soon as possible with large quantities of clean water.

Ensure that normal and protective clothing does not become soaked with wet concrete or concrete fluids as this could result in exposure over an extended period, resulting in tissue damage.

Cement is an abrasive fine powder, and when handled, some dust may become suspended in the air in the working area. Users should avoid inhaling cement dust as this may cause irritation of the nose and throat. Cement dust may also cause irritation of the eyes. This will occur because of the chemical reaction of the suspended dust with the moist mucous membranes. Airborne cement dust

should be kept to a minimum to avoid these problems. Should this be impractical, then the use of goggles and dust masks are strongly recommended.

Many of the aggregates used in concrete have high silica contents. The fine silica dusts created when crushing or handling these aggregates could cause lung problems, and precautions should be observed to avoid breathing in such dusts.

Dust from demolishing or cutting hardened concrete may contain un hydrated cement and could cause respiratory problems as outlined above. In addition, if the coarse or fine aggregate used in making the concrete contains crystalline silica, then inhalation of these fine silica particles could expose workers to the risk of developing silicosis. A concerted effort should be made to avoid generating such dusts. If this is not possible, the use of suitable respiratory protective equipment is recommended.

Site workers should also not kneel on fresh concrete during placing, compacting, and finishing operations. If kneeling is unavoidable, thick waterproof kneepads should be worn with a kneeling board to prevent the pads sinking into the fresh concrete. In severe cases of alkali burns, a medical practitioner should be consulted as soon as possible. ■


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