ILO CONSTRUCTION OS&H

A free, comprehensive, international, digital training package in occupational safety and health for the construction industry

THEME SUMMARY 11: VERTICAL MOVMENT

(Photo: Richard Neale. St David's 2, Cardiff, UK)

Summary of content	
1.	Preface
2.	Common hazards with vertical movement
3.	Cranes
4.	Hoists
5.	Vertical distribution of concrete
6.	Falls of materials
7.	Relevant elements of the Knowledge Base

1 PREFACE

This Theme Summary describes the processes of moving materials, components, plant, equipment, people and all other items that have to be moved vertically within a construction site. The design, maintenance and inspection of the plant and equipment in these processes are described in the Theme Summary 10: "General plant and equipment".

This Theme Summary follows the relevant structure and content of the "ILO Code of Practice: Safety & health in construction" (the "Code"). The following passage is taken from this Code:

1.1. Objective

1.1.1. The objective of this code is to provide practical guidance on a legal, administrative, technical and educational framework for safety and health in construction with a view to:

> *(a) preventing accidents and diseases and harmful effects on the health of workers arising from employment in construction;*
>
> *(b) ensuring appropriate design and implementation of construction projects;*
>
> *(c) providing means of analysing from the point of view of safety, health and working conditions, construction processes, activities, technologies and operations, and of taking appropriate measures of planning, control and enforcement.*

1.1.2. This code also provides guidance in the implementation of the provisions of the Safety and Health in Construction Convention, 1988 (No. 167), and the Safety and Health in Construction Recommendation, 1988 (No. 175)."

Other passages from this Code are included in this Theme Summary, and they are shown in the same format as above.

This Theme Summary also includes extracts from the ILO's "Safety, health and welfare on construction sites: A training manual" ("The Manual"). Further details of The Manual and the Code are given in Section 7 below: "Relevant elements of the Knowledge Base".

This Theme Summary follows the sections shown in the table above.

2 COMMON HAZARDS WITH VERTICAL MOVEMENT

Moving materials, components and items of plant and equipment vertically should create no hazards for anyone on a construction project. Many of the hazards that do arise have the following causes:

- Poor mechanical design (breaks in use, not powerful enough, components fracture or malfunction)
- Poor functional design (not properly designed for the stated purpose)
- Incorrectly erected or installed
- Poor workplace design
- Signalling systems (manual, mechanical, electronic) malfunction
- Misuse (not used as designed)
- Used in the wrong circumstances (e.g. ground collapses under a crane)
- Loads insecurely attached
- Release of pressure (concrete pumps)
- Poor maintenance (breaks or emits noxious gases)

These cause the following hazards:

- Falling machinery or parts of machinery
- Falling loads
- Crushing due to impact of moving or toppling plant and equipment
- Impact from release of pressure (e.g. concrete exploding from concrete pump hose failure)
- Falling from plant and equipment
- Falls caused by swinging loads, plant and equipment
- Limbs or bodies caught in machinery
- Electrocution
- Physiological damage through vibration
- Poor ergonomics
- Physiological and psychological damage through repetitive work
- Stress caused by poor environment (noise, heat, poor ventilation, chemicals, noxious gases)

These are, of course, just some of the main hazards; there are many more which are specific to particular projects.

3 CRANES

Before a crane is used on site, management should consider all the factors that could affect its safe use, such as:

- The weight, size and type of load it will have to lift

- The maximum reach or radius required of it; restrictions on use such as overhead power lines, the state of the site and the type of ground

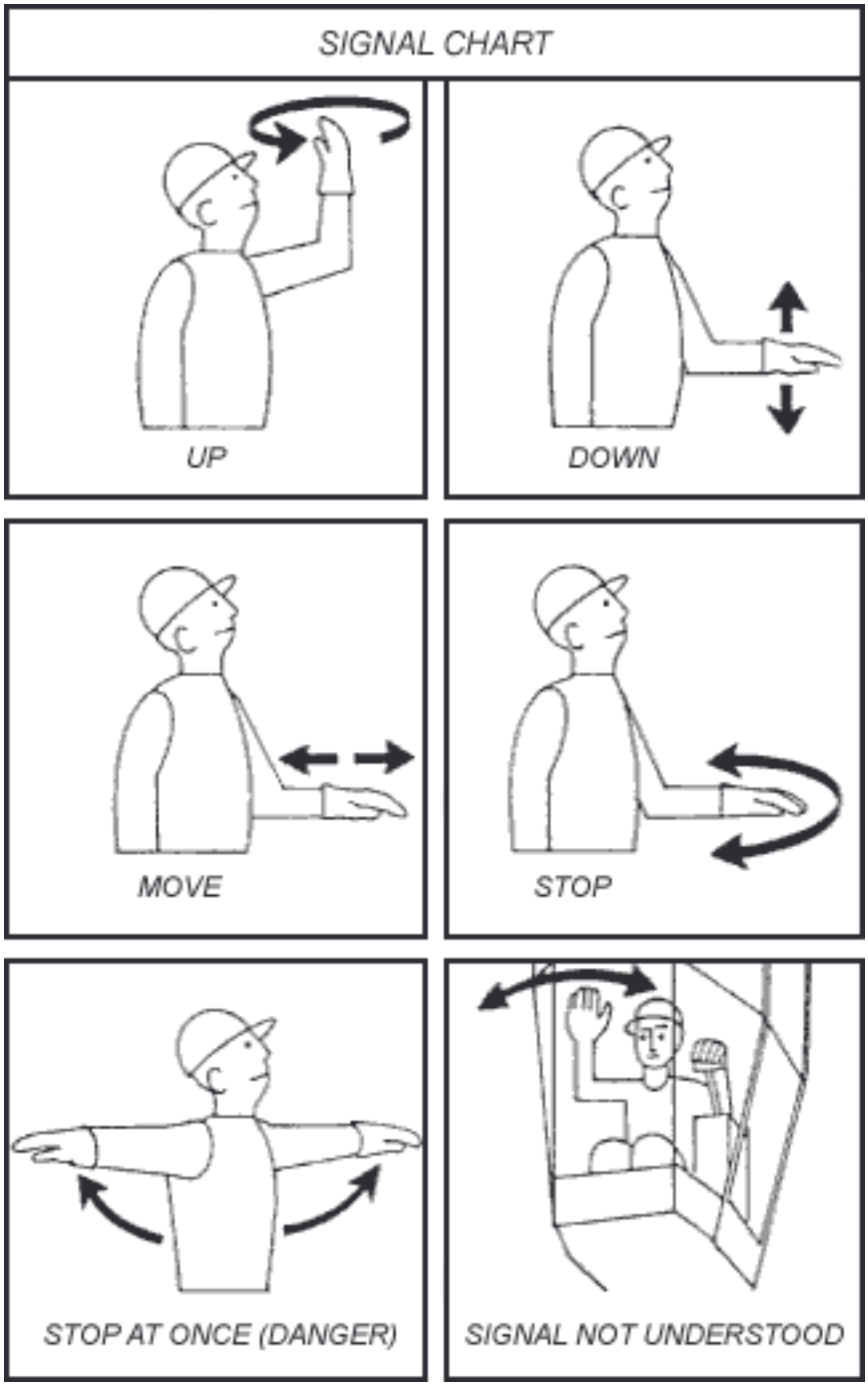
- Crane operators and signallers must be over the age of 18, and trained and sufficiently experienced.

Erection

Skilled workers under the immediate direction of a competent and experienced supervisor should do both the erection and dismantling of cranes. The manufacturers' instructions should be closely followed.

Signalling

There should always be a signaller, or a signalling system such as a telephone, if the crane operator cannot see the load throughout the lift. Hand signals should be clear and distinct, and should follow a recognized code or system.



Safe load indicators

All jib cranes should have an automatic safe load indicator which alerts the operator, just before the safe load is reached and warns both the operator and others nearby if the safe load is exceeded.

The safe load indicator is an aid to safe crane operation, but does not guarantee it. For example, it does not take into account the effect of wind or soft ground conditions.

If you are lifting a load that you know or believe to be close to the safe working load, do not proceed immediately to a full lift. Rather raise the load a short distance and stop to check the stability of the crane before continuing with the lift. Remember that if a load

is allowed to swing or is lowered rapidly, the radius of the jib may be increased unintentionally by flexing of the jib. Some indicators operate also as an overload cut-out.

Never bypass the indicator in order to lift an overload.

Never drag a load with a crane because the friction may cause the safe load to be exceeded.

Site inspection and maintenance

Cranes are subject to wear and tear which may not be easily detected; for example, bolts and similar parts may be subject to metal fatigue. Cranes should be tested and examined by a competent person before they are used on a construction site, and subsequently inspected at regular intervals in accordance with government requirements. The manufacturer's recommended programmes of operator checks and maintenance should be followed and any damage or defect should be reported to the supervisor. Never use a crane if you think it is unsafe.

Particularly susceptible components are wire ropes, brakes and safety devices. The constant contact of wire ropes with the sheaves on the jib accelerates wear. Brakes are in constant use and need to be checked, adjusted or renewed regularly. Safe load indicators and other safety devices such as overload cut-outs and limit switches are often susceptible to breakdown under site conditions and are sometimes deliberately disconnected.

Overloading

Overloading, causing vital parts to be stressed beyond rated capacities, can easily occur when neither the operator nor the supervisor is able to estimate the weight of material to be lifted, which is likely in the case of odd-shaped items.

An operator who is not properly trained may then lower a load at too high a speed so that when the brake is abruptly applied the jib snaps.

All cranes should be marked with their safe working load which must not be exceeded during the use of the crane. In the case of cranes with a derricking jib; that is, with a variable operating radius, the safe working load should be shown for every increment of radius of the jib. Winches and pulley blocks should be similarly marked.

Points to remember

If you cannot see the load all the time, you need a signaller

Beware of exceeding the safe working load when trying to free a stuck load

Mobile cranes

There is a huge range of mobile cranes available, but in terms of their safe use they all give rise to similar hazards.

(Photo: Robert Carr, http://myconstructionphotos.smugmug.com)

A mobile crane works on the basis of balancing overturning forces so it is potentially unstable and is liable to overturn if used on un-compacted ground or on a slope. Remember that rain can soften the ground, and sites which are not level impose strains on the crane which may lead to unintentional overloading.

The training of a crane operator should provide an understanding of the advantages and limitations of outrigger settings and an awareness of the dangers of failing to use them.

Lifting is made more difficult or hazardous by the wind. Make sure that there is adequate clearance for the crane's jib or boom and counterweight from traffic and fixed structures such as buildings, and that no part of the crane or the crane load will be closer than 4m to live overhead power lines.

It is not good practice to travel with a load but if this has to be done it must be controlled very carefully. If the movement is up-hill the load will become closer to the crane body, which increases the risk of impact. If the crane is to travel downhill, the effective radius may be increased, so making the effective load heavier.

Excellent advice on the safety of mobile cranes is provided by The California State Compensation Insurance Fund, at http://www.statefundca.com/safety/safetymeeting/.

"Mobile cranes are responsible for the most accidents, injuries, and fatalities of all of the crane types. Be aware of the hazards if you operate or work around mobile cranes. Get proper training on crane operation and load preparation and securing. Wear hard hats, safety boots, and high visibility clothing when operating or working around cranes.

Falling loads from mobile cranes pose a severe hazard to operators and nearby workers. Never exceed the load capacity of the mobile crane. If you are unsure about the load size and weight, calculate the weight to ensure that it meets your crane's capacity. Load indicating devices, called load moment devices, can prevent an accidental overload. Properly secure the loads that you will be lifting. Inspect all slings, chains, and hooks that will be used to lift and secure the load.

Rotate, raise, and lower the crane boom slowly. Avoid sudden stops or accelerations that could jar the load. When rotating the load, you can use taglines or guidelines to control the arc and swing. Try to avoid lifting loads over workers or over the cab of the crane. If this type of lifting is necessary, use safety hooks or other approved devices. If two cranes are required to lift a load, a qualified person should be in charge of planning and directing the lift.

Cranes can accidentally come in contact with electrical lines. Before you start work, survey the site for potential electric hazards. Consider all lines energized unless they are certified by the owner/operator and visibly grounded at the site. Always maintain the required clearances from electrical lines and sources.

Tip-overs and instability are another mobile crane hazard. Soft or unlevel ground can cause a crane to tip. Use outriggers to stabilize the crane when the ground surface or the load requires it. Never operate a crane if the load or slope lifts the wheels off the ground. For stability when traveling, keep the boom steady in the direction of the movement. Boomstops should be used if there is a danger of the boom falling backward.

Workers near mobile cranes can get run over if they do not pay attention or if the operator loses sight of them. Operators should use an audible warning and operating signal device to notify workers of movement. Workers should stay out of the way of the

load, the crane wheels, and outrigger wheels. If the operator has a limited view, a qualified signals person should direct and communicate the operations. Never ride a load on a crane. Always lash or secure empty hooks when moving the crane so they do not swing.

Lack of training is the leading cause of accidents. Certification as a crane operator is required unless you are operating a mobile crane with a boom length of less than 25 feet or a maximum rated load capacity of less than 15,000 pounds."

Fixed cranes

By far the most common fixed crane nowadays is the tower crane, so only this type of fixed crane will be considered in **Construction OS&H**.

Tower cranes are very sophisticated items of plant and there is a wide range of types and sizes available.

(Photo: Richard Neale. Project site in Dar es Salaam)

The photo shows a type of crane commonly in use worldwide

An example of an incident:

"Eurolift (Tower Cranes) Ltd of Aldershot, Hampshire has been fined £50,000 plus £1,000 costs at Chichester Crown Court for breaches of health and safety legislation following the collapse of the tower crane in Worthing that killed two people.

Gary Miles, 37, and Steven Boatman, 45, both from Reading, Berkshire, died when the 36m crane collapsed at Durrington High School in Worthing on 11 February 2005. The accident happened when an unsupervised colleague mistakenly loosened the bolts of the crane they were working on.

Judge William Wood said he believed the breach was serious enough to attract a fine in the region of £100,000 to £200,000. However taking into account the current financial state of the company he imposed a fine of £50,000 and ordered it to pay costs of £1,000."

[http://www.contractjournal.com/Articles/2009/06/19/68976/50000-fine-for-tower-crane-collapse-that-killed-two.html]

(130 words so 'fair use)

Use of cranes

To prevent overturning, a tower crane must either be anchored to the ground or securely counterweighted or ballasted. If the crane is rail mounted, remember that the rail tracks cannot be used as an anchor.

Ballast material may be moved so a diagram of the counterweight or ballast should be fixed to the crane, and the ballast should be checked against this whenever the crane is erected, and after bad weather.

Equipment such as slings and chains used with the crane must not clutter access-ways or ladders and must be well clear of any machinery in which it may become entangled.

Loads must be lifted vertically, as any out-of-vertical lifting may result in crane collapse.

Crane manufacturers specify the maximum wind speed at which tower cranes may be safely used.

Loads having a large surface area should not be lifted in windy conditions.

The crane must be positioned to ensure that the crane jib or boom is free to wind-vane (rotate through 360° degrees) around the tower, so that there are no horizontal wind forces on it when it is not in use.

When the crane is not in use, the hook should be raised to its highest position; the crane should be allowed to wind-vane and the power should be turned off.

When more than one tower crane is used on a site, care must be taken when designing the site layout to ensure that collisions between booms, loads or lifting ropes are avoided. If physical separation cannot be arranged, effective electronic warning devices have to be used.

Tower cranes should not be used for magnet, or demolition ball service, piling operations or other duties which could impose excessive loadings on the crane structure.

4 HOISTS

(Photo: Richard Neale. St David's 2, Cardiff, UK)

Goods hoists

The goods, or platform, hoist used to raise materials and equipment vertically to successive levels as construction proceeds is probably the most widely used item of mechanical handling equipment. It consists of a platform which is driven either from a rope winch or by a rack and pinion with the motor and gearbox mounted on the platform

The principal hazards are of falling down the hoistway from a landing on the platform, being struck by the platform or other moving parts, and being hit by materials falling down the hoistway.

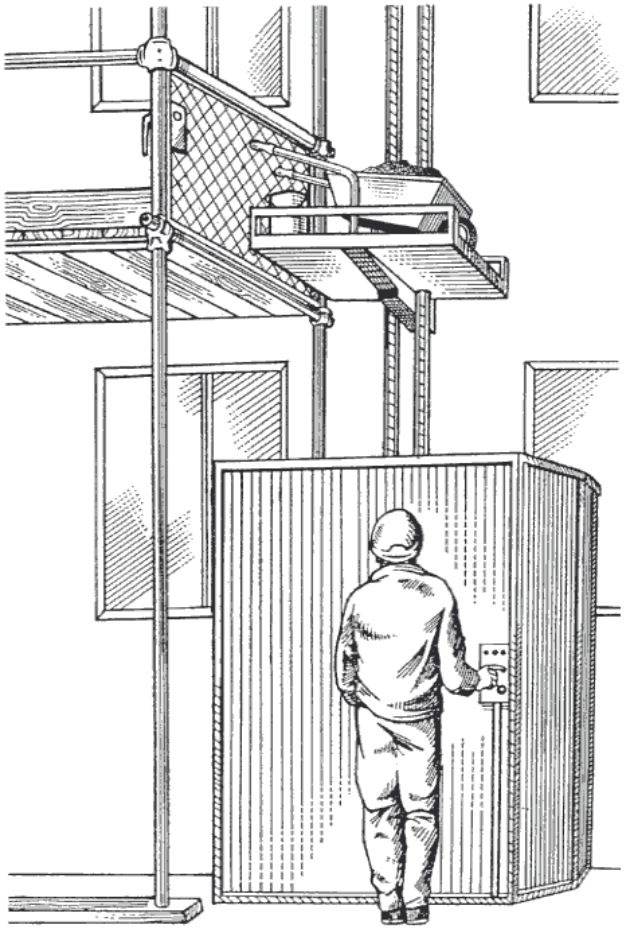
Passenger hoists

Lifts for the carriage of persons need to be especially constructed and installed for the purpose, with such features as mechanical and electrical interlocking devices on the cage and landing gates. They must be fully enclosed.

Enclosure

A substantial enclosure should be erected at ground level around the hoist-way to a height of at least 2m. It should have suitable gates giving access to the platform. The remainder of the hoist-way should be enclosed (e.g. with wire mesh) throughout its height sufficiently to contain falling material within the enclosure.

Gates should be fitted at every landing level where access to the platform is needed, and the gates must be closed except during loading and unloading at that level.



The diagram above shows the cage of a passenger hoist entering the access enclosure at ground level.

Safety devices

An overrun device should be fitted just above the highest platform position required, or near the top of the mast. An arrestor device should be fitted to support the platform, fully loaded, in the event of failure of the hoist rope or driving gear. There should be at least three turns of rope on the winch-drum when the platform is in its lowest position.

Operation

To prevent the hoist operator, who should be trained and aged at least 18 years old, from moving the platform while someone is trying to load or unload materials, the controls need to be set up so that the hoist can be operated from one position only. From this position the operator can see all landing levels clearly. If this is not possible, a signalling system must be used during loading and unloading.

There should be overhead protection for the operator if, as is usually the case, he or she is at ground level.

Loads

The platform should be clearly marked with its safe working load and the platform should not be overloaded. Barrows should not be overfilled, and their wheels should be chocked or secured so that they cannot move about on the hoist platform while it is moving. Loose bricks or other materials should never be carried on an open hoist platform. No one should be allowed to ride on the platform and there should be a notice on the platform forbidding riding.

Testing and examination

Every hoist should be tested and examined after installation, and checks made on the arrester and overrun devices. Weekly recorded checks should be made by a competent person.

(Photo: Richard Neale. Construction project in Gaza)

The photo above shows a hoist by a public road. There is no enclosure at all, which is extremely dangerous. Note that the lifting cable is very close to overhead power lines. This hoist is on the side of a road, so the lack of an enclosure is a hazard for the public as well as those who work on the project site.

5 VERTICAL DISTRIBUTION OF CONCRETE

The main means of transporting concrete vertically are by means of a crane and skip or by concrete pumps. Cranes (which use 'skips' or 'concrete buckets') have been explained in Section 3 above, so this section is mainly about concrete pumps.

(Photo: Robert Carr, http://myconstructionphotos.smugmug.com)

Concrete pump providing concrete in a deep excavation

(Photo: Richard Neale. Project site in Dar es Salaam)

A static pump installed on the project on a long-term basis

7.9.13. Scaffolding carrying a pipe for pumped concrete should be strong enough to support the pipe when filled and all the workers who may be on the scaffold at the same time, with a safety factor of at least 4.

Examples of incidents ('accidents)

This is a good example, from: WorkCover New South Wales: Concrete Placing Pumps. Safety Alert No 4024, 22 November 1994
http://www.cfmeu-construction-nsw.com/pdf/saconcreteplacingpumps.pdf

"Two serious accidents, one fatal, in Sydney in June 1994 involving concrete placing boom pumps, highlighted the need to follow the safety recommendations in the WorkCover Authority's Codes of Practice on Pumping Concrete and Construction and Testing of Concrete Pumps.

The first accident occurred when a boom pump operator stood on the hopper grate of his machine and his leg slipped through the grate. His leg became entangled in the auger of the pump and his left leg was severed below the knee.

Investigation revealed the hopper grate bars at each end of the grate were wider than the 70mm recommended by WorkCover Codes of Practice.

WorkCover recommends that all pump operators should:

- *Never stand on the hopper grate of concrete placing pumps.*
- *Always ensure the grate complies with the recommendations of the WorkCover Authority.*
- *Always ensure that grates are in good condition and not unduly worn or damaged.*

The second accident involved the collapse of the boom of a concrete placing boom pump, which hit the pump line operator on the head and inflicted fatal injuries.

Investigation revealed that a failure of the pedestal-to-hydraulic ram connection caused the boom to collapse.

Recommendations

- *A regular and thorough maintenance program be undertaken by pump owners and operators in accordance with WorkCover's codes of practice.*
- *Operators and concreters should avoid standing or working under the elevated boom as much as possible.*
- *When working on a construction site, workers should always remember to wear head protection."*

(250 words, so 'fair use')

Despite the specialised nature of concrete pumping, basic safe operation can be achieved by applying the general processes and procedures of **Construction OS&H**: for example, working with the pumping specialist to identify hazards, develop a safe working method, and briefing everyone involved carefully.

Some of the main special features of concrete pumps that give rise to hazards are:

- Mobile pumps are large vehicles and need care when driven to and from the site and manoeuvring into position.

- Mobile pumps are subject to the same types of forces as mobile cranes and so must be sited in the same way.

- All mobile pumps work with high pressures, so the pump itself and all pipes and hoses must be carefully maintained, positioned and held securely in place.

- Concrete for pumping is poured into a hopper and drawn forward by powerful pumping mechanisms. This hopper must be covered by a strong and well-fixed grill to prevent any part of a human body getting into it.

- Emptying and cleaning the pipeline can cause explosive pressures if not done carefully.

- There must be safe workplaces for those using the pump, including safe means of access and egress.

- Handling the discharge pipe can give rise to strong forces so can cause muscular and impact injuries.

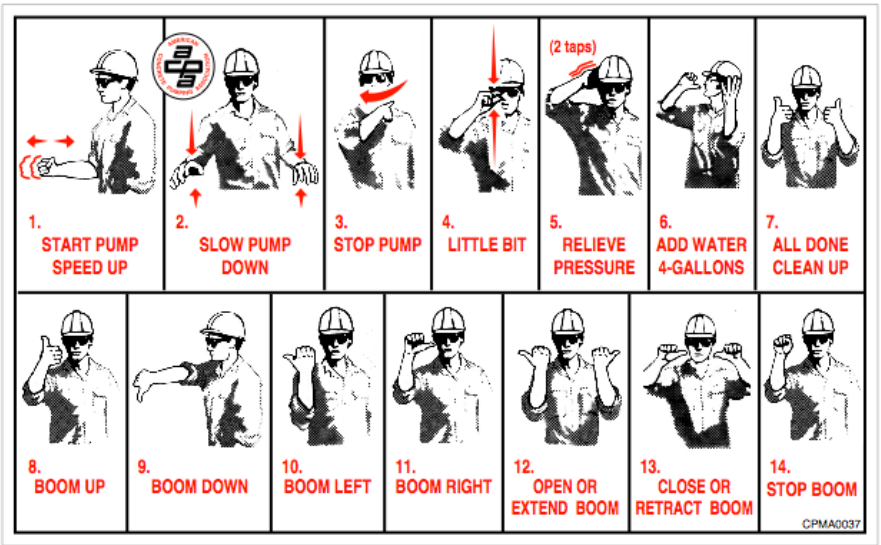
- Concrete is a corrosive substance to human skin, so good PPE must be provided.

- It is often the case that the pump operator cannot see the end of the pumping hose, so a banks-man is required.

The photo below shows a good example of the way in which concrete pumps can be used to place concrete in inaccessible places, and also illustrates how pump operators sometimes have to operate completely out of sight of the placing team.

(Photo by Richard Neale. St David's 2, Cardiff, UK)

Signalling should be as shown below.



(Source: http://www.concretepumpers.com/pdfs/Pumping_Checklist_FINAL.pdf
The ILO is grateful to ACPA for permission to use this graphic.)

6 FALLS OF MATERIALS

Working at height obviously creates the potential hazard of falling materials, tools and equipment. Every effort must be made to prevent these incidents, primarily by:

- Planning all activities carefully
- Keeping all plant and equipment in a condition that is safe to use
- Installing all plant and equipment securely
- Making sure that loads are attached properly and that no part of the load can become detached
- Keeping all working platforms tidy, so reducing the likelihood of loose tools and material being dislodged and falling
- Providing properly designed safety nets or solid ‘fans’ to catch anything that does fall

The photo below shows a building that has been carefully sheeted to prevent falling objects landing in the street, and also a solid fan to catch falling objects. [The sheeting also improves working conditions in bad weather.]

(Photo: Richard Neale. Old Town, Geneva)

7 RELEVANT ELEMENTS OF THE KNOWLEDGE BASE

Title	ILO Code of Practice: Safety & health in construction
Type of source	Code of practice, 174 pages
Publication or other source details	ILO Publications http://www.ilo.org/global/Publications
Date & ISBN/ISSN	1992. 92-2-107104-9
Summary of contents	*"It goes a long way in mapping out the agenda for health and safety professionals in this most dangerous and populous industry."* Content: 1. General provisions 2. General duties 3. Safety of workplaces 4. Scaffolds and ladders 5. Lifting appliances and gear 6. Transport, earth-moving and materials-handling equipment 7. Plant, machinery, equipment and hand tools 8. Work at heights including roof work 9. Excavations, shafts, earthworks, underground works and tunnels 10. Cofferdams and caissons and work in compressed air 11. Structural frames, formwork and concrete work 12. Pile-driving 13. Work over water 14. Demolition 15. Electricity 16. Explosives 17. Health hazards, first aid and occupational health services 18. Personal protective equipment and protective clothing 19. Welfare
Comments on relevance	This Code of Practice is fundamental to this training package. It has influenced the structure and informed the content.
Other information	Downloaded as “ILO Code of Practice”