PART V. CONCRETING SITE PRACTICES

HANDLING & PLACING

CEMENT CONCRETE & AGGREGATES AUSTRALIA

The main aim in handling and placing concrete is to distribute it from the point of delivery on a construction site to its final location as smoothly and efficiently as site conditions will allow – while at the same time maintaining it in a condition where it is both workable and free from segregation. This section describes methods, plant and equipment which may be used to handle and place concrete in a variety of circumstances.

CONTENTS

1. INTRODUCTION

Concrete is most commonly delivered to construction sites in a transit-mixer. Even on those projects where the concrete is batched and mixed on site in a dedicated plant (e.g. large highway projects), it will often be most convenient to move the concrete from the mixing plant to the point of placement in these vehicles. They have several advantages, including (a) they can transport workable concrete over quite long distances, and (b) they permit some adjustment to be made to the workability of concrete, immediately prior to discharge, by the addition of controlled amounts of water while still allowing some remixing of the concrete. AS 1379 *'Specification and supply of concrete'* sets out the conditions under which this may be done.

The handling of concrete on site effectively commences when the concrete is discharged from the truck (or from any other device used to transport it from the batching or mixing plant). The aim in handling concrete will always be to move it to the point of final placement as quickly and as efficiently as the site conditions allow without significantly affecting the plastic properties of the concrete.

A variety of methods, plant and equipment are available for this purpose. In choosing a distribution method, it should be the most appropriate method for use on that site. Care should then be taken to plan concrete handling on the site so that, once concreting operations commence, they proceed smoothly and without delay. Special care should be taken to ensure that the capacity of handling equipment is sufficient to (a) maintain placing operations at their planned rate and (b) match supply capability.

2. PRELIMINARY CONSIDERATIONS

2.1 WORKABILITY

The required concrete workability will normally be determined by the nature of the building element or project in which it is to be placed. For example, concrete to be placed in thin or narrow forms needs to be quite workable if it is to be placed and compacted satisfactorily. On the other hand, concrete to be placed in massive sections may have quite low workability. Consequently, the method chosen to distribute the concrete from the point of delivery to the point of placement in these two situations may be quite different in terms of delivery capacity and delivery process.

The equipment chosen must be able to maintain the concrete in the required workability condition. High temperatures and high winds can cause concrete to lose workability while being transported to, and moved around, the site – high temperatures by accelerating the rate at which the concrete stiffens and high winds by causing it to lose moisture and dry out. It is generally necessary for processes used to handle concrete on site to keep the concrete 'cool' and to prevent it from drying out. (For further information on this aspect see Section 18 *'Hot- and Cold-Weather Concreting'*.)

Corrective measures for losses of workability in excess of those anticipated depend on why such losses occurred. With a slight workability reduction, remixing may be enough to restore workability. In high temperature environments or in cases of long transport distances, the use of retarders may be appropriate. Similarly, slump retention admixtures may need to be considered in the basic mix design. The use of water addition on site to restore slump is problematic, particularly if it is uncontrolled. While this is the simplest approach, and the one often favoured by pump operators and/or placers, it can have significant impacts on concrete strength and durability and may lead to issues with excessive drying shrinkage – not to mention potentially exceeding maximum W/C ratios that may have been specified.
*(**NOTE**: Coloured concretes, where coloured oxides have been used, are particularly sensitive to slump loss. Extra water additions in these cases not only affect general concrete performance, but also affect colour consistency.)*

2.2 SEGREGATION

Segregation in concrete is the separation of the coarse aggregate from the mortar. This typically results in the hardened concrete being non-uniform and with weak/porous or honeycombed areas, and an increased likelihood that strength and durability requirements will not be achieved.

To avoid segregation during transport, the concrete should be cohesive and thoroughly mixed. As far as practicable, jolting and vibration of the concrete while distributing it around the site should be minimised and the concrete should be discharged vertically and in a controlled manner into its final position in the forms, or into the distributing equipment.

With flowing (Super Workable) concretes becoming more common, this creates an even greater risk of segregation. Attention to appropriate concrete mix design and good control of admixture use will lower the risk of segregation with these high-workability mixes.

3 PLANNING

3.1 SITE ACCESS

Access to the site by trucks delivering the concrete, either to the distribution equipment or to the point of placement, is an important factor in avoiding delays and interruptions to placing activities.

In planning access to the site, important considerations are:

- Ground conditions, e.g. Its ability to support loaded trucks;
- Headroom and ground clearances – particularly around power lines;
- Availability of adequate turning circles;
- Access to discharge chutes by distribution equipment;
- Holding area for trucks awaiting discharge;
- Suitable site ingress and egress.

Typical dimensions of typical concrete trucks are shown in **Figure 12.1**.

A prime consideration in planning access to the site is to avoid the delays caused by delivery trucks having to manoeuvre whilst on site, particularly when a continuous flow of concrete is required.

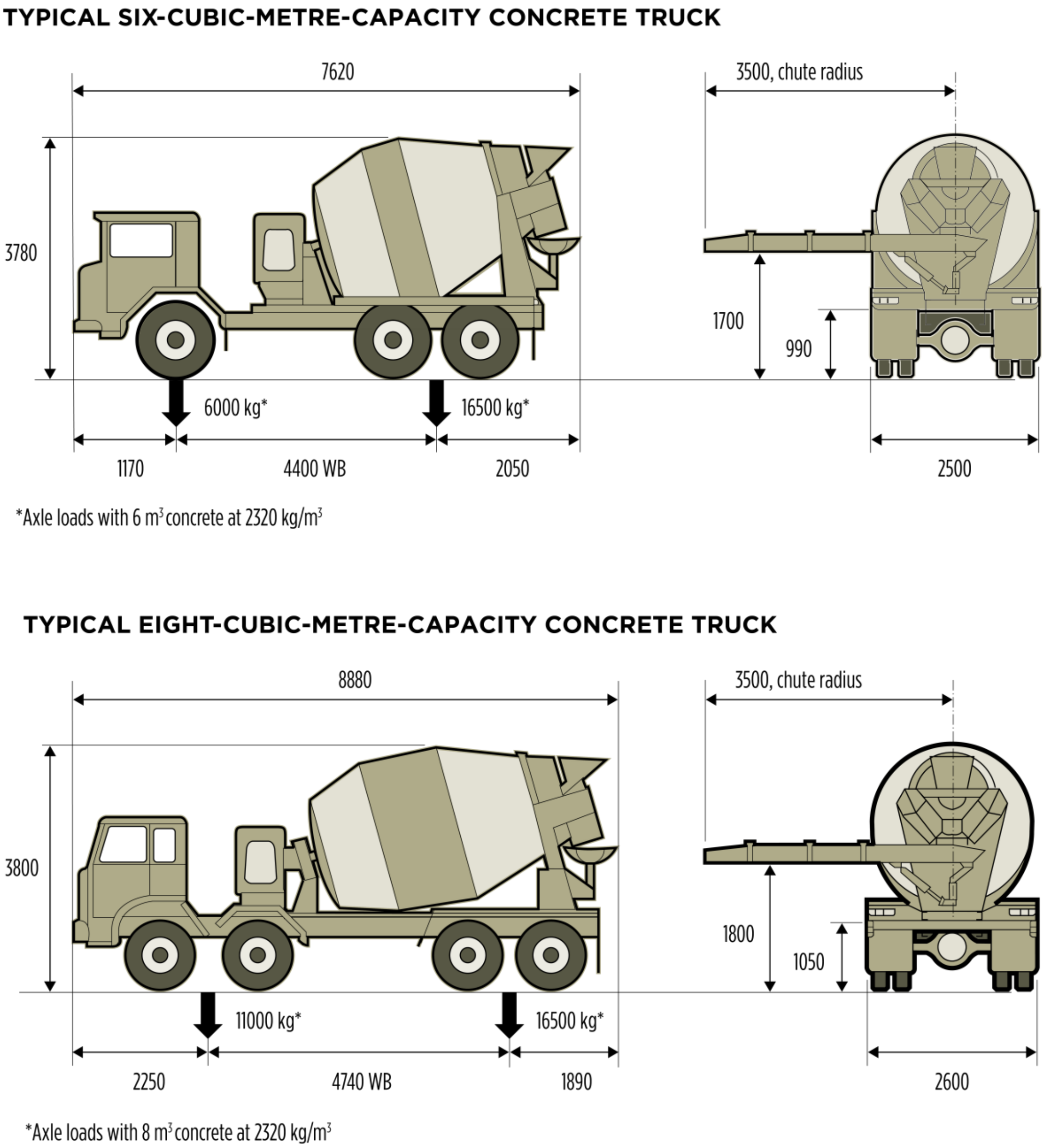

Figure 12.1 – Typical 6-m^3 and 8-m^3 Transit Mixers (all dimensions are in millimetres)

3.2 DELIVERY RATE

The delivery rate which can be achieved on a site is determined, in part, by the access to the site, i.e. the rate at which the delivery trucks can move on and off the site (**Figure 12.2**). More often, however, it is determined by the rate at which the concrete can be placed. The ideal rate will be where the work proceeds smoothly and the formation of unplanned construction joints (including cold joints) does not occur. Too high a rate is also problematic. The rate should not be so high that concrete cannot be adequately compacted and/or finished, e.g. in thin walls and columns.

One of the primary concerns involved in organising the delivery of concrete to a project site is safety. Truck movements increase the risks of safety incidents. To reduce these risks, certain measures need to be taken, including (1) designated zones for vehicle movement, (2) use of spotters when trucks are reversing onto (say) a concrete pump, (3) ensuring a minimum 600 mm spacing is observed between trucks delivering concrete at a pump, and (4) safe areas for testers to operate in when sampling loads of concrete.

Figure 12.2 – Access to the Site (and particularly the ease with which delivery vehicles can move on and off it) has a Significant Influence on the Overall Concrete Supply Rate[12.1]

4 DISTRIBUTION METHODS

4.1 GENERAL

The methods for distributing concrete on site range from simple (e.g. barrows) to sophisticated (e.g. pumps). Whatever the method chosen, it should be capable of moving the concrete uniformly, without delay, and at a rate appropriate to the method of placing.

4.2 CHUTES

On most sites, the transit-mixer chute is the initial means of delivering concrete on site – either to another method of distribution or direct into its final position (**Figure 12.3**). 'Off the chute' delivery is ideal for elements such as strip footings, house floor slabs, road pavements and low retaining walls, provided:

- Truck access to within chute radius is available;
- The element is below truck tray level;
- Free-fall of concrete does not exceed two metres in height.

Chutes can also be a useful means of distributing concrete from a higher to a lower level. In such applications, care must be taken that the chute has sufficient slope for the concrete to flow freely. A minimum slope between 1:2 and 1:1 is often suggested. With long chutes, those which slope steeply, or where the free-fall of the concrete exceeds two metres, additional controls should be provided (**Figure 12.4**).

Figure 12.3 – Delivery from a Transit mixer Chute is the Quickest, Most Convenient and Economical Method of Distribution

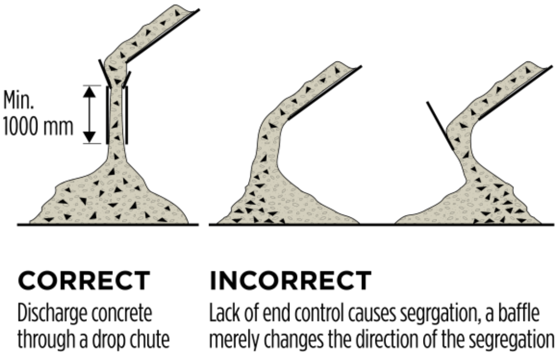

Figure 12.4 – Discharging from Long Chutes (i.e. – longer than standard transit mixer chutes)

4.3 BARROWS

Barrows and small handcarts/buggies are an appropriate means of moving concrete on small sites or where only small quantities of concrete have to be placed (**Figures 12.5** and **12.6**). These methods are labour intensive and have largely been replaced by more-efficient methods. Other limitations are that:

- Only a low placing rate of about 1-1.5 m^3/h can be achieved;
- The travel distance is limited to about 50 m for continuous work.

When used, care should be taken to provide near level, smooth runways and access ways to avoid jolting which may promote segregation of the concrete.

Figure 12.5 – Barrows, despite their limitations, are the Most Suitable Distribution Means on Small Projects[12.2]

Figure 12.6- Small Handcarts and Buddies (of about 100-litre capacity) have been largely superseded by more Efficient Methods

4.4 CRANE AND BUCKET

The use of a crane and bucket or skip or 'kibble' are appropriate means of handling concrete on sites where adequate crane time is available, other access is limited and/or a concrete mix which is difficult to pump is required. Buckets or skips of 1-2 m^3 capacity are most commonly used (**Figure 12.7**). There are 'lay-down' varieties that may be filled readily from a truck-mixer. Normally, they have hand-operated discharge gates which permit sufficient control of location and discharge (**Figure 12.8**).

On large mass concrete projects, buckets of up to 6 m^3 capacity may be employed with the discharge gates operated by compressed air. In discharging buckets and skips, care must be taken that formwork and reinforcement are not damaged by the impact of the concrete. High impact forces and an increased risk of segregation are possible consequences if the concrete is discharged from a height of more than about two metres.

Figure 12.7 – Crane Buckets and 'Kibbles' are easily filled from Transit Mixers[12.3]

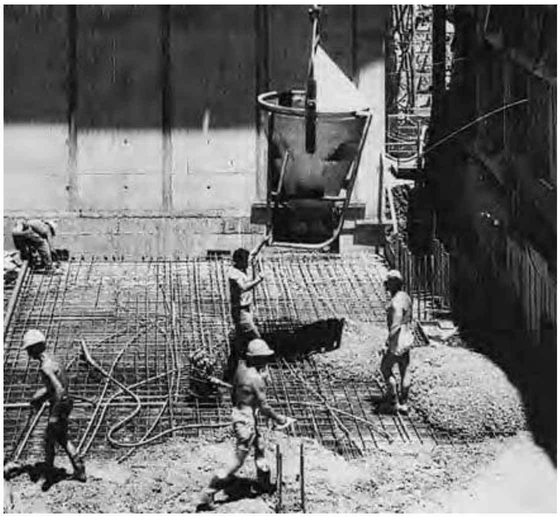

Figure 12.8 – Hand-operated Gates on Crane Buckets give control over Concrete Discharge

The placing rate is dependent on the bucket capacity and the height and distance from the pick-up point. For example, about 13 m^3/h could be placed on a tenth-floor level using a 1 m^3 bucket, while about 20 m^3/h could be placed using a 2 m^3 bucket. On a fifth-floor level, the placing rates would only be about 10% higher.

4.5 TREMIE CONCRETE

Tremie concrete refers to the delivery of suitable concrete from a hopper and through a long pipe – most often used for placing concrete underwater or at depth in concrete piles. The concrete is initially unloaded into an above-ground hopper and from there it flows through the vertical pipe down to the required depth. As concrete flows from the bottom of the pipe, more concrete is added to the hopper so that a continuous feed is established. As the concrete flows from the bottom of the tremie the pipe is gradually lifted while ensuring that the end of the tremie tube remains within the body of the concrete being placed, usually to a depth of about 1 metre. The concrete around the end of the tremie effectively seals the pipe and, in the case of placing concrete under water, prevents the water washing paste from the concrete being delivered. It is necessary for the concrete to have appropriate flow capability for this method to work properly (**Figure 12.9**). Further discussion on tremie concrete is provided in Part VI, Section 21 of this Guide.

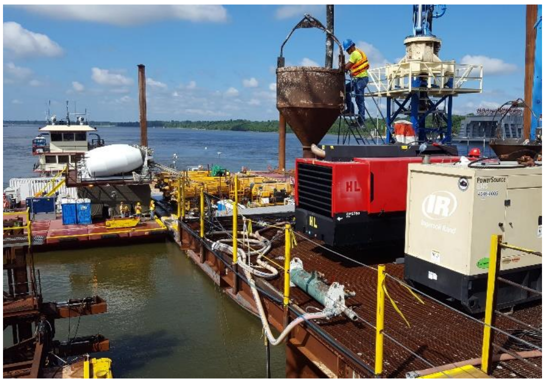

Figure 12.9 – Tremie Pipe being filled from Above-ground Hopper[12.4]

4.6 PUMPS AND PIPELINES

General – Concrete pumps and pipelines are perhaps the most widely used of all methods of distributing concrete on construction sites (**Figure 12.10**) in Australia today. The ready availability of mobile pumps, and their relative reliability, make them an efficient and economical means of transporting concrete, even on quite small sites.

A wide rage of pump types are available, generally trailer- or truck-mounted, although fixed installations are not uncommon where the pump has to be in frequent operation (**Figure 12.11**) or where it is used over longer periods of time.

Figure 12.10 – Concrete Distribution by Pump (from a discharge point in street where permitted) is the Most Common Method

Figure 12.11 – Fixed Pumps generally have the Highest Pumping Capacity and are the usual Choice for Major Projects[12.5]

Usually, however, concrete pumps are mobile and are often fitted with an articulated boom which enables the unit to deliver concrete over a radius of 30 m or more (**Figure 12.12**). Such units require little set-up and are especially versatile in the range of applications they can handle. They may also be coupled to fixed pipelines for delivering concrete over greater distances, say 60 m vertically and up to 300 m horizontally. For greater distances, more powerful pumps are required.

Figure 12.12 – Mobile Concrete Pumps are quick to Set up and Versatile in their Range of Applications[12.6]

In tall city buildings, concrete has been pumped to heights of 200 m or more and on large flat sites, for horizontal distances of up to 1,000 m. Such installations require quite rigidly fixed pipelines to withstand the considerable pressures involved. In these situations, 'piston pumps' are generally the pump of choice.

While the main focus on concrete pump capability is on high delivery rates, there are situations where reliable delivery at low rates is required, e.g. for delivering block fill. In these situations, a 'squeeze' or 'peristaltic' pump type, which can deliver reliably at rates as low as 1 m^3/hr, can be used.

The advantages of using pumps include:

- High output;
- Versatility and flexibility (they can distribute concrete both vertically and horizontally and require little space);
- Continuous distribution;
- Short set-up time;
- Low labour requirement.

It should, however, be noted that:

- Concrete mix designs need to appropriate, particularly for tall buildings or for long transfer distances;
- Some pump mixes may give increased concrete drying shrinkage;
- High slump concrete mixes may have a susceptibility to segregate when pumping;
- Downhill pumping is difficult and will require a more cohesive concrete mix design to prevent segregation.

Pump Selection – The rate of delivery which can be achieved will depend on the type of pump and its power; the distances to be pumped horizontally and vertically; the number of bends; and the type of concrete mix. Smaller pumps may deliver up to 10 m^3/h and high-performance units deliver up to 80 m^3/h. However, this rate can be compromised in practice because of the need to move and reposition pipelines.

The selection of a suitable pump will depend on the maximum required output and pumping pressure. The output required is a function of the placing rate and the actual time the pump will be operating. Thus, if an overall placing rate of 30 m^3/h is required but the pump will be in use for only 45 minutes in each hour, the required output will be (30 × 60/45) = 40 m^3/h.

The required pumping pressure will depend on the:

- Required output as determined above;
- Pipeline diameter (often controlled by the maximum aggregate size);
- Total equivalent length of the pipeline (actual horizontal length plus an equivalent horizontal length for vertical pipe distances, bends and any reducer piping or hydraulic placing boom that may be used);
- Plastic properties of the concrete (often expressed as its slump).

From this information the required pumping pressure can be determined from a nomograph such as that shown in (**Figure 12.13**).

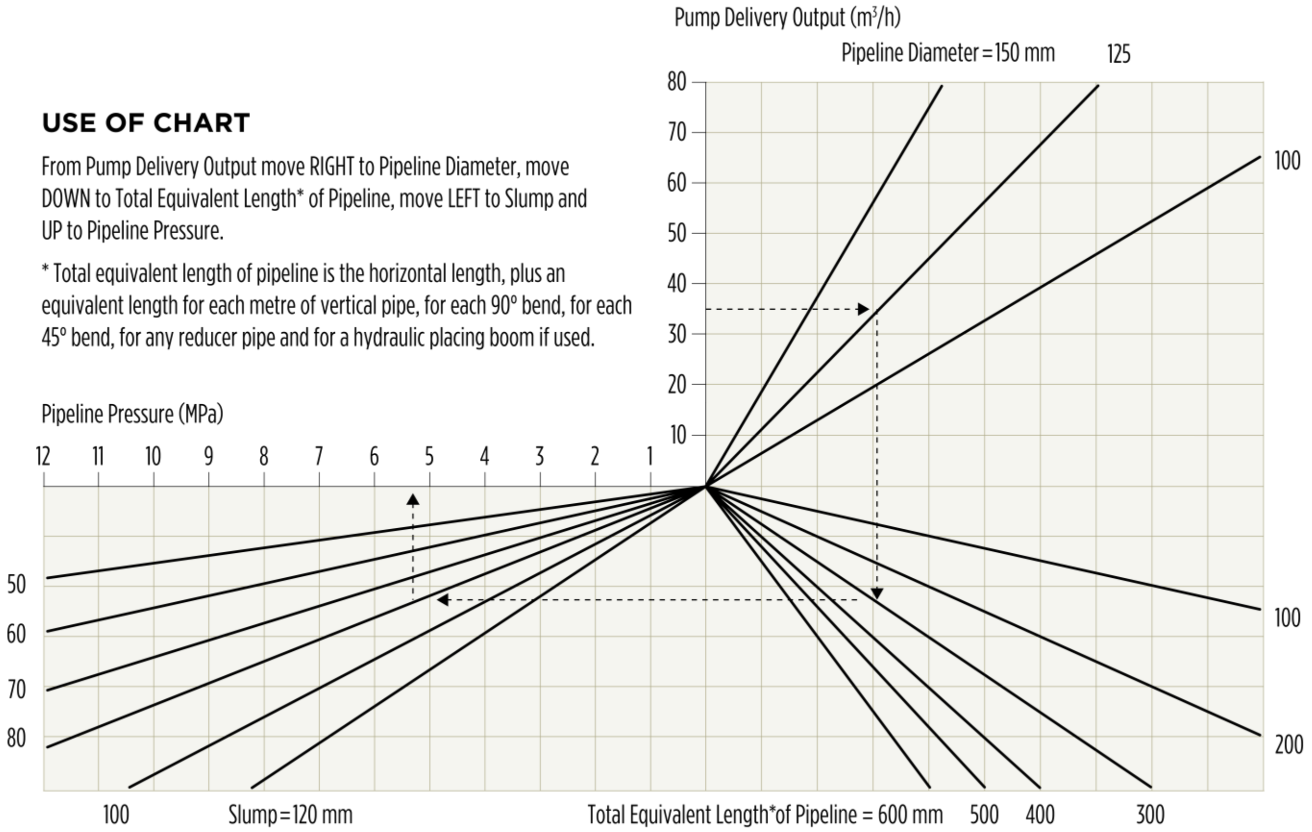

Figure 12.13 – Nomograph for Determining the Required Pumping Pressure

The pumping power required can be calculated from the equation:

Power (kW) = Output (m^3/h) × Pressure (MPa)/2.5 …..**Eq.12.1**

The design of a successful pumping operation requires an experienced operator. Of paramount importance is preplanning and, in particular, close liaison between the placing contractor, the pump operator and the concrete supplier.

Pumping Operations – Before pumping commences, the pump and pipelines must be lubricated by coating the internal surfaces with a cement-based slurry, pumped through the pipes at the rate of about 2.5 litres of slurry per metre of pipeline. After pumping is completed, the pipelines must be cleaned out as soon as possible as any paste residue will lead to increased pipe friction and may eventually cause blockages.

Pipelines should be adequately supported and fixed in position since quite substantial forces (thrusts) can be generated as the concrete is forced through the lines. Joints should be watertight as loss of paste from the mix can lead to blockages. The wall thickness of the pipe should be adequate for the pressures that will be experienced. Pipelines should also be readily accessible for maintenance and cleaning should a blockage occur.

Once commenced, concrete pumping should be continuous to avoid blockages in the pipeline. If concrete is to be discharged directly into the forms or on-grade in flatwork, sufficient manpower and equipment to compact and finish the concrete must be available. It is very important that the rate of pumping matches the rate of placing and finishing.

While 'pumpable' concrete mixes are now readily available, it is still required that the concrete supplier be notified 'of the intended method of placement' (see Clause 1.5.3.2(d) of AS 1379). Not all concrete mixes can be pumped successfully. For example, mixes required to have very low shrinkage characteristics may be difficult to pump because of limitations on the fines content of the mix. Similarly, 'pumpable' mixes may not be the best suited to very high standards of off-form finish. Low slump concretes are generally not easily pumpable.

5. PLACING

5.1 GENERAL

As is the case when handling concrete, certain fundamental considerations govern placing techniques. First and perhaps foremost is the need to avoid segregation (separation of the paste and aggregate materials) of the concrete caused by using improper techniques. Second is the need to ensure thorough compaction of the concrete. Whilst compaction requirements are discussed in more detail in Section 13 *'Compaction'*, the manner in which concrete is placed can have a significant influence on its ability to compact under vibration.

5.2 AVOIDING SEGREGATION

The most important rules for avoiding segregation during the placing of concrete, in any element, are:

- Concrete should be placed vertically and from as near as possible to its final position;
- Concrete should not be made to flow into position. Where concrete must be moved it should be shovelled into position.

Other techniques for avoiding segregation during placing depend on the type of element being constructed and on the type of distribution equipment being used.

For flatwork and slabs incorporating ribs and beams (i.e. shallow forms) the techniques shown in (**Figure 12.14**) should be adopted. For walls and columns (i.e. deep, narrow forms), problems occur when the concrete is dropped from too great a height and ricochets off the reinforcement and form-faces, resulting in segregation. The means of avoiding this risk vary with the type of distribution equipment being used (**Figure 12.15**).

5.3 AIDING COMPACTION

To aid proper compaction of the concrete, care should be taken to place concrete in layers which are of a suitable depth for the compaction equipment being used. Layers that are too deep make it virtually impossible to adequately compact the concrete to full depth, with the risk of leaving entrapped air that creates voids and prevents the concrete from achieving its potential or required strength and durability performance.

The two main types of compaction equipment are (1) immersion (poker) vibrators (**Figures 12.16** and **12.17**), and (2) vibrating-beam screeds (**Figure 12.18**). The effective radius of action of an immersion vibrator depends on its operating frequency and amplitude as well as the diameter of the vibrator shaft. The common sizes found in normal concrete construction work have a radius of action between 200 mm and 350 mm. This means, in practice, concrete should be placed in uniform layers ranging from 250 mm to 400 mm, depending on the vibrator being used. To ensure each layer is properly merged together, the vibrator should penetrate about 150 mm into the lower layer of previously compacted concrete (**Figure 12.19**).

The effective depth of compaction of vibrating-beam screeds depends on the beam weight, its amplitude, its frequency and the forward speed. For the commonly available range of surface vibrators, the maximum effective depth is 200 mm.

*(**NOTE**: For slabs between 150 mm and 200 mm thick, immersion vibrators should be used adjacent to all construction joints and edges to supplement the vibrating screed in these areas.) For slabs greater than 200 mm thick, immersion vibrators should be employed to compact the concrete and the vibrating-beam screed used to finish it (**Figure 12.19**).)*

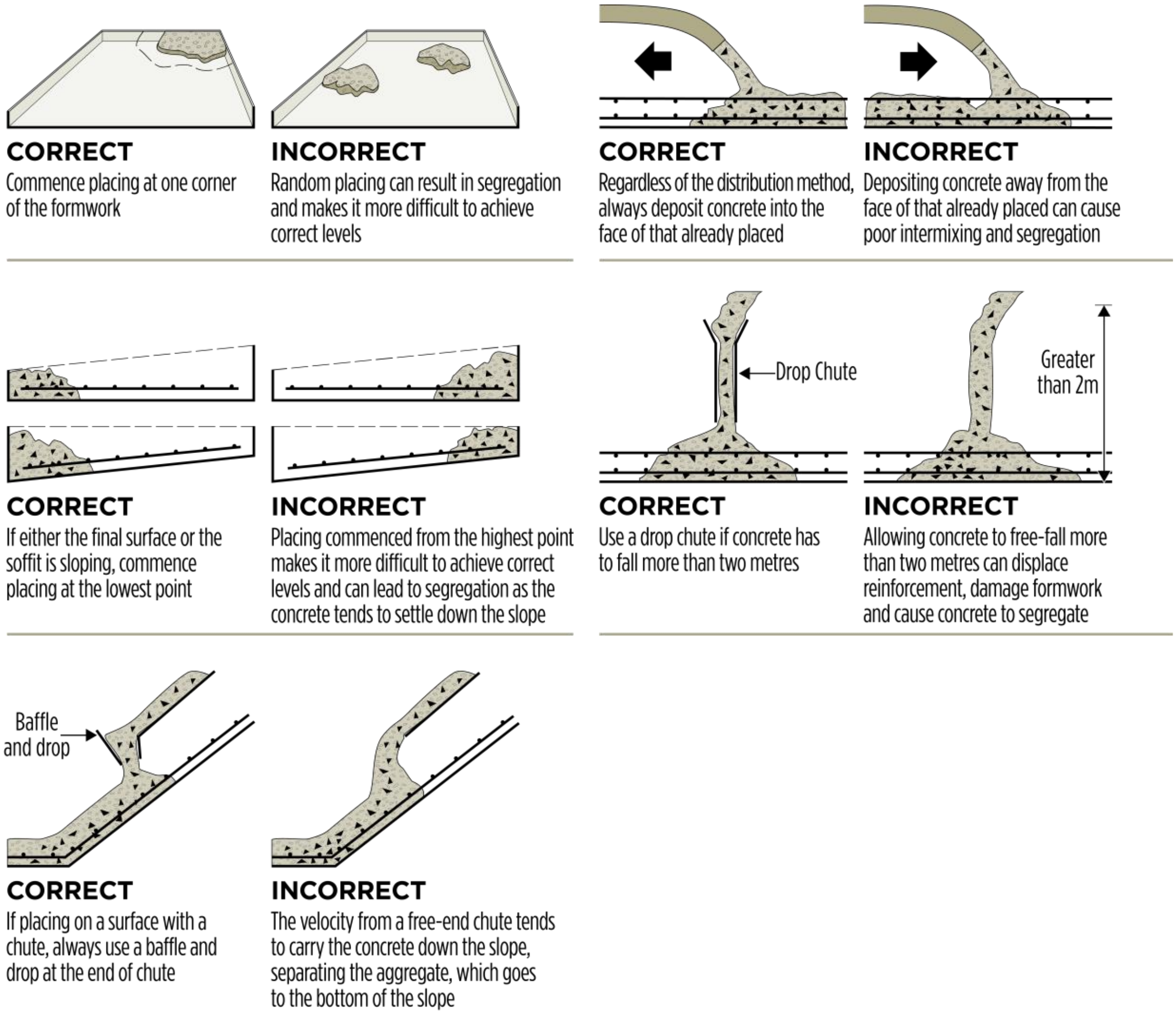

Figure 12.14 – Placing Techniques for Flatwork

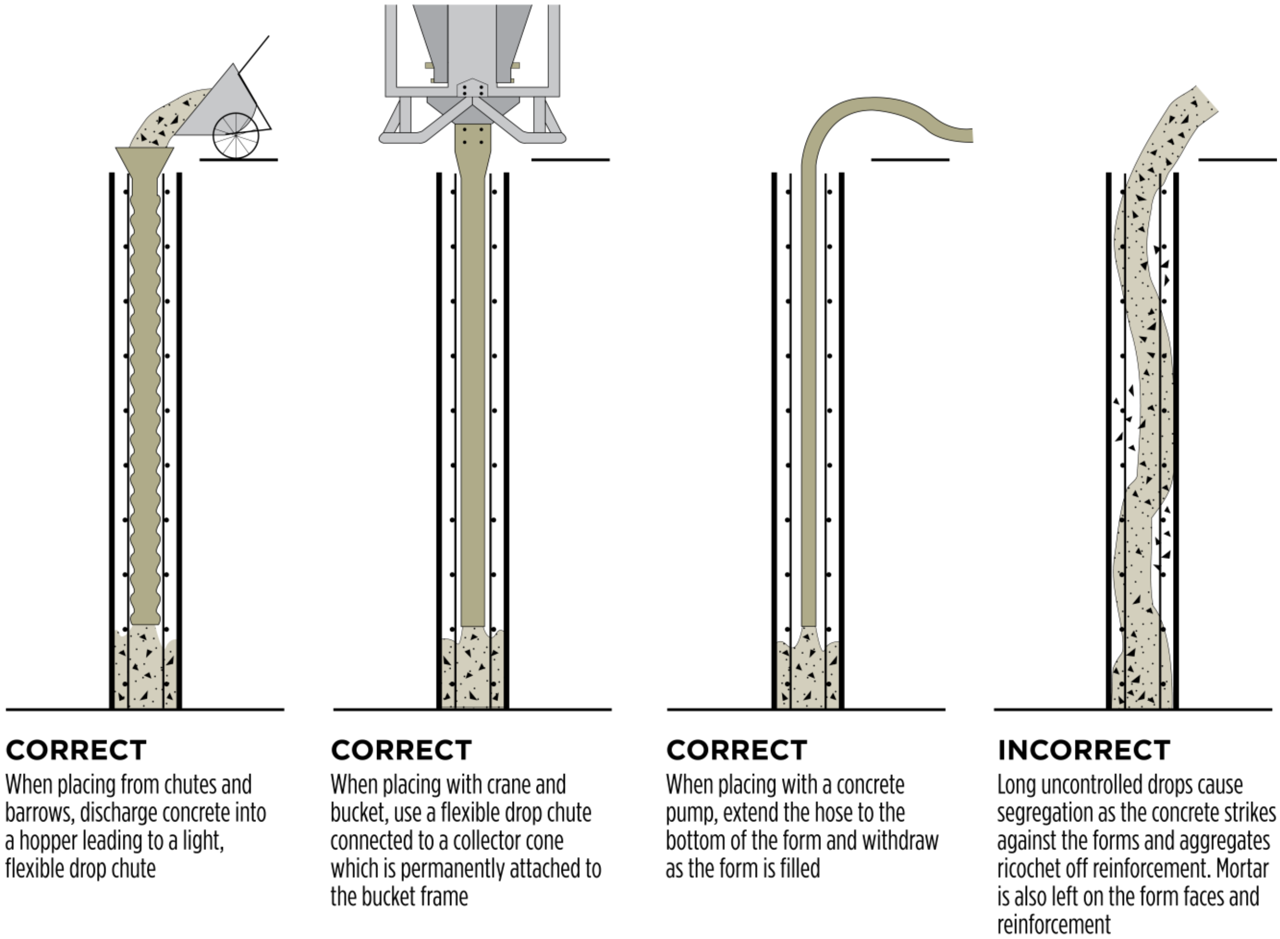

Figure 12.15 – Placing Techniques for Walls and Columns

Figure 12.16 – Action of Immersion Vibrator[12.7]

Figure 12.17 – Immersion Vibrator in Use on Slab[12.8]

Figure 12.18 – Vibrating Screed in Use[12.9]

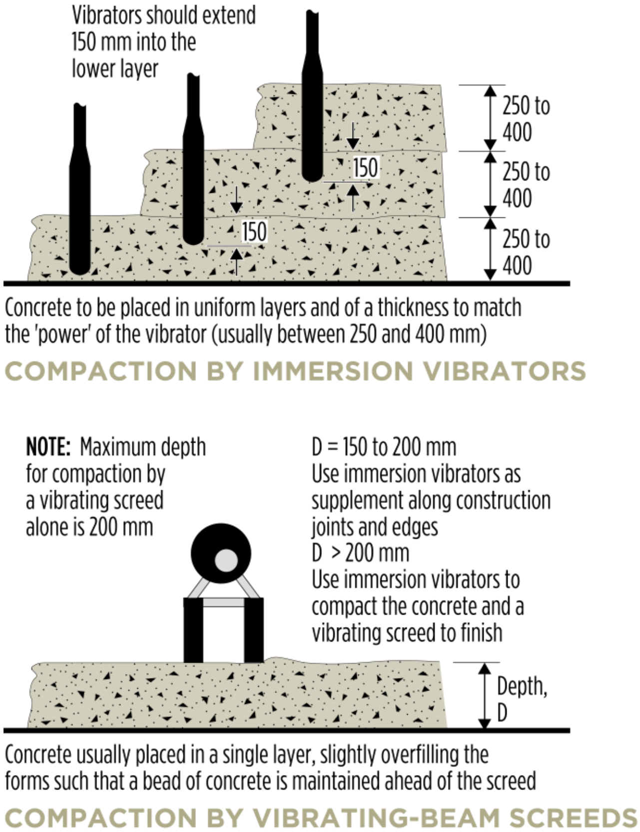

Figure 12.19 – The Depth of the Layers in which Concrete is placed Dictates the Requirements and Methods necessary to achieve Effective Compaction

6. SUMMARY

Method	Application	Comment
Chute	Where work is below the level of truck tray; Ideal for strip footings, house floor slabs, road pavements, low retaining walls, etc.	May be direct from transit mixer if work is within radius of its chute; Free fall of concrete should not exceed 2 m without additional end controls.
Barrows and hand carts	Suitable for small projects such as domestic construction.	Labour intensive; Low placing rate (typically 1-1.5 m^3/h); Maximum distance about 50 m for continuous work; Requires relatively level, smooth access.
Crane and bucket	Suitable for mass concrete structures and heavyweight concretes; Can be used when concrete is unsuitable for pumping.	Adequate crane time must be available; Limitations dependent on bucket size, crane capacity and reach.
Tremie	For placement of concrete under water or in deep piles.	The concrete needs to readily flow from the delivery hopper down the tremie pipe; The tremie pipe should remain about 1 metre below the surface of the concrete being placed to prevent paste being washed out of the mix.
Pumps and pipelines	Versatile and flexible – can distribute concrete both vertically and horizontally.	Require little space; High output; Continuous distribution; Short set-up time; Low labour requirement; Not suitable for all concretes; Possibility of increased concrete shrinkage; Downhill pumping is difficult.

7. RELEVANT AUSTRALIAN STANDARDS

1) AS 1379 – *The specification and supply of concrete*
2) AS 3600 – *Concrete structures*

End Notes:

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12.4 Photo adopted from *'Tremie concrete placement at Olmsted'* by LouisvilleUSACE, licensed under Attribution 2.0 Generic (CC BY 2.0), https://www.flickr.com/photos/louisvilleusace/28947270312

12.5 Photo adopted from *'Liebherr Stationary concrete pump THS 70 D-K. In the background: Liebherr Piling and drilling rig LRB 355 in Dornbirn (Vorarlberg, Austria)'*, by Asurnipal, licensed under the Creative Commons Attribution-Share Alike 4.0 International license, https://commons.wikimedia.org/wiki/File:Liebherr_THS_70_D-K_Raupenbetonpumpe_-01.jpg

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CCAA OFFICES

NATIONAL OFFICE (NSW)
Level 10
163 -175 O'Riordan Street
Mascot NSW 2020

POSTAL ADDRESS
PO Box 124
Mascot NSW 1460
Telephone: (02) 9667 8300

QUEENSLAND
Level 14, 300 Ann Street,
Brisbane QLD 4000
Telephone: (07) 3227 5200

VICTORIA
Suite 910/1 Queens Road
Melbourne VIC 3004
Telephone: (03) 9825 0200

WESTERN AUSTRALIA
45 Ventnor Avenue
West Perth WA 6005
Telephone: (08) 9389 4452

SOUTH AUSTRALIA
Level 30, Westpac House
91 King William Street
Adelaide SA 5000
Telephone: (02) 9667 8300

TASMANIA
PO Box 1441
Lindisfarne TAS 7015
Telephone: (03) 6491 2529

ONLINE DETAILS
www.ccaa.com.au
Email: info@ccaa.com.au