Learning Text

Part 7

Production, Delivery and Storage of Mortar

Contents

	Page
Introduction	4
Types of plant	4
Fixed production plant	4
Plants for the production of lime: sand mortar and wet retarded ready-to-use mortar	4
Plants for the production of bulk dry mortar	7
Plants for the production of bagged dry mortar	8
Site batching and mixing	8
Mixer types	9
Fixed plant mixers	9
Pan mixers	9
Twin shaft “compulsory” mixers	9
Drum mixers	9
Continuous mixers	10
Truck mixing	10
Mobile mixing plant	10
Mobile storage and mixing plant, (dry mortar)	10
Mobile plant (compartmentalised silos)	11
Compartmentalised silo mixers	11
Transport of silos	11
Transport of wet ready mixed mortars	11
Agitators	12
Multi compartment delivery trucks	12
Single screw tippers	12
Flat bed delivery vehicles	13
Site storage	13
Silos	13
Tubs	13
Dry bags	13
Wet bags	13
Bulk wet storage	13
Stockpiles	14

On site care and mixing of factory made mortars 14

Dry silo mortars 14
Compartmentalised (multi compartment) silos 14
Dry bagged mortars 14
Ready mixed retarded wet mortars 14
Ready mixed lime: fine aggregate (sand) for mortar 15

Coloured mortars 15

Dry powder pigment 15
Granular pigment 15
Liquid pigment 15

Health and Safety 16

Glossary of Terms 17

Bibliography 19

Self-Assessment Questions 20

Answers to Self-Assessment Questions 21

Health and Safety

All mortar mixtures, both wet and dry, are abrasive and alkaline. When working with wet mortar, waterproof or other suitable protective clothing should be worn.

Guidance on the use of these materials can be found in Data Sheet No 20.

Production, Delivery and Storage of Mortar

Introduction

This learning text considers the topic of mortar production, both solely at a mortar production plant, and when mortar is factory batched and then transported to the site for final mixing. A glossary of terms analogy and a bibliography are included. The final section of the learning text is self-assessment questions and answers.

The major types of factory made mortar are covered as follows:

- Ready mixed lime: fine aggregate (sand) mortar
- Wet ready mixed mortar, (wet ready-to-use mortar)
- Dry ready mixed mortar delivered in silos, (dry ready-to-use mortar)
- Semi dry multi compartment mortar delivered in silos
- Dry ready mixed mortar in bags, (also known as dry ready-to-use)

Within the categories listed above there are further sub divisions and other mortar types but all share the major properties of factory made mortars in that they have consistent quality assured properties and conform to the requirements of all relevant British and European standards.

Production and mixing using a transit or truck mixer is also covered, as is storage on site.

Types of plant

There are many types of mortar production plant but for convenience this learning text considers two overall categories, fixed plant, where the mortar plant or factory is in a permanent location, often a quarry or industrial site, and mobile plant, where the mortar is mixed either in the delivery vehicle or on site. In the latter case, as for example in the case of dry silo mortars, although the final water addition is gauged and mixed on site the raw materials are accurately batched and proportioned and batched at the fixed plant or factory prior to despatch.

Fixed production plant

Fixed mortar plants may be designed for the production either of wet mortar or dry mortar. These two plant types share many features but those for dry mortar production are more sophisticated and complex. Some produce only dry mortars for bulk delivery, others only bagged dry mortars but some are able to produce both products, with most modern dry mortar plants having basic similarities, whether they are designed primarily for the production of bulk mortar to be delivered in silos or for mortar to be delivered in bags.

Plants for the production of lime: sand mortar and wet retarded ready-to-use mortar

Historically within the UK, Ireland and much of mainland Europe, the most commonly occurring fixed mortar plants have been those that are designed for the manufacture of lime: fine aggregate (sand) mortar. In the 1970's however, wet retarded ready-to-use mortar evolved and some of these plants became multi purpose, producing both products. Whilst still numerically greater in plant numbers, the production of mortars containing some or all of the final water requirement is declining while that of dry readymixed mortar is increasing.

Mortars containing water are therefore either semi-dry, requiring the addition of cement and some water on site, or wet ready-to-use, where the material requires no further additions or mixing on the building site. The plants in which these wet mortars are manufactured are now generally similar to or even based on a normal ready mixed concrete plant with a number of components common to the production of both concrete and mortar.

There is at least one or more commonly, two or more silos, to contain the binder or binders. For ready-to-use mortars these will typically consist of Portland cement, almost certainly supplemented by an additional material such as fly ash, (formerly known as pulverized fuel ash), or ground granulated blastfurnace slag. There may also be a silo for hydrated lime. For further details of these materials please refer to MIA Learning Text Part 2 on cementitious materials.

In the case of older plant used solely for the production of lime: fine aggregate (sand) mortar there may be just a lime silo. However, some of these plants, as well as many newer ones, also now produce retarded floor screeding mortars which contain cement and in which case they will require at least one further binder silo.

Finally, with respect to silos and binders, a small number of modern plants also have a silo for hydraulic lime, but as this material begins to set in the presence of water and is not manufactured in retarded form, its use is confined to dry mortar plants.

The binders will generally be stored in separate free-standing silos but in some designs one large silo is split or sub-divided vertically to form a number of self contained compartments. This use of a sub-divided silo is quite acceptable in theory but in practice ensuring that the two binder types remain separate can be a problem if the integrity of the divider or its fixing is compromised and the view is often taken that individual silos are preferable.

The silos will be equipped with fill pipes to enable the bulk tanker carrying the binder delivery to link its discharge pipe to the silo. The discharge process is, often referred to as “blowing” the binder, into the silo. Because large volumes of air are involved in this process, which have to be dispersed or vented, it is necessary to provide a vent to the atmosphere. As the air that needs to be vented is dust laden, it has to be cleaned of powdery material prior to release and it is therefore passed through a filter system first. These filters contain cloth, fabric or similar, often in the form of bags. The dust-laden air is forced through them, with the dust being trapped in the fabric and the air passing through the fine holes.

Because the filters rapidly become clogged, it was common practice to mount them on a frame that could be shaken, in order to remove the dust that was filling the mesh and clogging the filter. A typical filter housing would be positioned on top of the silo so that the excess material shaken out fell back into the main body of the silo. Alternative designs, with the filter at the bottom of the plant had the benefit of allowing easier access for cleaning and maintenance but the disadvantage that the recovered material still had to be returned to the silo.

Modern designs of filter often use jets of air rather than mechanical shaking to clean the mesh, which has the advantage of relative mechanical simplicity and reliability. These

systems are known as reverse air jet filters, as the jets of air that clean the filter medium and blow the binder in the reverse direction to that when filling and hence back into the storage silo.

A pressure relief valve is also fitted to all silos. Although silos are not designed to be pressure vessels, and should never be used as such, the incorporation of a pressure relief valve is a safety measure in the event of excess pressure developing. Pressure relief valves used to be retained in the closed position by means of a large spring on the inside of the cap but these have been found to stick and jam in some cases and some mortar manufacturers favour valve designs that rely on a simple counterweight, sometimes adjustable, pressing down on the valve cap for closure. These are simple and generally require little attention.

It is recommended that the silo entry pipes are clearly labelled with their contents and that entry is locked off by a lockable hatch, padlock or similar, with the keys being kept in the personal possession of the plant manager, and only operated by him rather than any third party. It is important to observe appropriate health and safety precautions when blowing bulk binders into storage silos and it is recommended that the publications on safe delivery of cement (see bibliography) be obtained and read in conjunction with this Learning Text.

The silos are equipped with access hatches and ladders for complete operation and are invariably fitted with fill level indicators in order to show when they are full during the discharge process, thus enabling the tanker operative to cease discharge. Again, these are available in different designs, with some relying on mechanical impeding of rotation of a small rotor, others on an electrical property. Whatever type is installed care is required in selecting the level at which they operate, having in mind the requirement to allow a margin of safety whilst discharge is stopped.

Silos may also be equipped with low level indicators to show when they require filling, and some are even completely suspended on load cells so that the gross weights are constantly shown and may be monitored.

The binder passes from the silo, into a weigh hopper, or in a minority of designs onto a continuous belt weigher, and then into the mixer of fixed mixing plants, or the back of the truck in the case of truck or transit mixing plants. Occasionally, as in the case of a compartmentalised silo, of the type originally produced by a company known as Megamix, the cement will fill one section of the silo, for delivery to site. These systems are discussed later in this text.

The other major part of the plant is that used for storing and weighing the second key mix component, the fine aggregate (sand). This may be kept at or below ground level in bins or hoppers, or in conveyor fed overhead bins at the top of the plant. The use of overhead bins results in the ability to discharge the fine aggregate (sand) simply into the weigh hopper or truck by opening a gate and relying on gravity, whereas with ground storage the aggregate is conveyed directly up into the mixer, although with the former the material also has to be initially taken to the top of the plant. Ground storage is simpler but generally requires constant mobile plant availability in order to keep the in-ground bins charged.

Admixtures are used in all factory made mortars. These are stored in 25 or 205 litre drums, 1 or 2 tonne polybins or in purpose made steel or plastic tanks or silos. Admixture container

tanks should be bunded, that is with spillage protection provided by a double skin, walled enclosure or similar, and many modern storage tanks are designed with built-in integral bunds. Liquid admixtures should also be protected from freezing and for this reason their storage vessels are often situated within clad parts of the plant.

Pigments are invariably finely divided iron oxides, and may be added as dry powders, either from silos, small bags, or via feeder/powder conveyor systems. Where silos or feeders are used automation is possible. Alternatively, they may be suspended in water and pumped into the batch as liquids, this method leads to easy automation but needs care, and probably re-cycling or stirring/agitating systems to avoid settlement and segregation. Many liquid pigments incorporate glycols during winter periods to prevent freezing and at the levels used are not deleterious to the final mortars. The use of powders in granulated form makes them easier to handle, with less dust and contamination of staff and working environment. Pigments are discussed in a later section of this learning text and in Part 4 of the Learning Text series.

Water is dispensed into the plant via water meters or other measuring devices, which may be either mechanical or electronic. Where plants use recycled water, which is an increasingly environmentally driven trend, mechanical meters may need more frequent maintenance.

Plants for the production of bulk dry mortar

Dry mortar is also ready-to-use, with the exception of the mixing water, which is added on the construction site. Production of this material utilises similar plant to that for wet mortar although the units are invariably much more sophisticated. They generally incorporate a fine aggregate (sand) drier, although this not essential if the fine aggregate (sand) feedstock has been pre-dried.

Plant design for dry mortars must carefully consider the need for cleaning between batches and the avoidance of cross contamination. Design must also address dust control, with initial minimisation and perhaps vacuum extraction requiring consideration. The risk of segregation must also be considered, particularly where materials and mixes are being transported within the plant.

Where fine aggregate (sand) driers are used these tended historically to be simple rotary driers of the type used in the coated roadstone industry. In recent years more fuel efficient fluidised bed driers, which are very well insulated against heat loss and dust have been increasingly used.

Although for dry mortar it is possible to use a pan mixer of the type used in plants for wet mortar production, it is usual to use a mixer that has clamshell gates, (gates that pivot from a horizontal axis longitudinal to the long axis of the mixer and open outwards). These are usually a large size so that when they open fully, effectively the whole lower section of the mixer opens outwards and downwards. This ensures that every time they are opened the complete mix is discharged, with no residual risk of cross contamination of a fresh batch. Alternatively, air pulse mixers of the type widely used in the pharmaceutical mixing industry have been used successfully for the production of dry mortars.

Most dry mortar plants also contain provision for the storage of a number of alternative

binders, as well as a greater number of admixtures than would be the case for a wet mortar plant.

Plants for the production of bagged dry mortar

Historically, some bagged dry mortar production was from small, simple plants not greatly different from some wet ready mixed mortar plants, with the production being largely uncomplicated basic mixes. Now however, most dry bagged mortars are as sophisticated as the bulk materials and are often produced at the same plants, which are designed with provision for final discharge into either a bagging plant or bulk silos.

Site batching and mixing

Within the UK and Ireland it is rare to see anything other than a free-fall drum mixer on a site. (These are so called because as the drum rotates in a vertical plane, material is carried to the top by the blades and the body, where it then falls to the bottom, to be carried back up to the top and so on in a continuous process). In North America, however, forced action mixers are widely used, as they are in continental Europe. Free-fall mixers are far from ideal. They are sensitive to the order in which materials are charged into them and in some situations cement or other fines can adhere to the mixer, effectively changing the cement content. Once material has adhered in this way it is difficult to remove and ill judged removal attempts made by banging the outside of the drum with a shovel, for example often causing distortion of the drum with the result that even more material tends to build up when the mixer is next used.

Free-fall mixers are also unsuited to the production of materials of low consistence such as semi-dry lime: fine aggregate (sand) mortars.

Primarily for the purpose of floor screed production, mixers with a horizontal shaft and attached mixing arms and blades are sometimes used on site and designs of this general type are usually excellent for the purpose of mixing mortar, although little used at present.

Historically, mortar mills were used for the mixing of lime mortars, and some are still in existence today, generally in smaller builders merchants. These mills consist of a vertical shaft, which rotates a large arm or frame in a circular motion in the horizontal plane. Two large wheels are attached to the perimeter and as the assembly rotates, these wheels roll around the perimeter of the mixer floor and both crush and mix the mortar. This is an efficient action and as well as mixing the constituents it ensures that any lumps or larger particles are broken up. These mixers were originally used when lime was slaked on site, or in a builders or merchants yard, in conditions that were far removed from those of modern mortar factories, but they coped well and had the valuable ability to crush any oversize or related contamination. Although hardly used today in the developed world, expensive, heavy and bulky and unsuited to a high throughput, these mixers can produce an excellent product.

Whatever the mixer type, if it is used on site to mix mortar from its separate binder and fine aggregate (sand) constituents it is desirable that the capacity is calculated so that full bags of cement may be used. This is because weigh batching facilities are rarely in place on site and splitting bags of cement or other binders is not accurate. If a mixer is sized to produce the desired mix proportions by using one bag of cement, followed by sufficient fine aggregate

(sand): lime mix to fill the mixer volume, then there is a higher probability of achieving the correct mix proportions, together with reasonable batch-to-batch consistency.

Mixer types

Mixers may be broadly categorised as two types, those that are in fixed locations, usually quarries or industrial sites, and those that are able to travel by road to the construction site where they are required. Each of these types is considered below.

Fixed plant mixers

There are a number of different mixer types that are designed for use in fixed mortar plants and these have varying features and applicability's. They are discussed in the remainder of this section.

Pan mixers

These are probably the most used type. They have a vertical shaft, which carries horizontal arms, tipped with blades that rotate in the horizontal plane. In general they are simple and easy to maintain and relatively easy to clean, although unless they are perfectly adjusted they usually fail to discharge every trace of material when emptied, which can lead to cross contamination of batches.

In one form of pan mixer, the whole assembly rests on wheels or rollers and rotates. This has the potential to produce a good mixing action but is complex and may be difficult to maintain.

Twin shaft "compulsory" mixers

These mixers have two parallel contra-rotating shafts equipped with arms and blades and are used quite widely. They are robust, and with externally mounted motors and gearboxes appear easy to maintain which is probably one reason why they were used fairly widely. However, they are not easy to keep clean and may not always discharge fully. They were originally designed for mixing coal slurries and do not mix as efficiently as pan mixers or purpose made mortar mixers. They also suffer from the disadvantage that maintaining the large gates and apertures well so that there is no water leakage can be difficult, if not impossible.

Drum mixers

These are a similar shape, and operate in a similar way, to the well-known free-fall site mixers. They have the great advantage of simplicity, and are available in very large batch sizes, but are probably better suited to the production of concrete as opposed to mortar, However, as they have not been widely used for mortar production to date it is possible that further experience would result in their greater utilisation. Experience shows that they do appear to suffer from the disadvantage of producing balling when used for semi dry mixes.

Continuous mixers

Once widely used for mortar production, these plants are now used much less.

They mix continuously as opposed to batch by batch and rely on continuous belt weighers attached to the fine aggregate (sand) feed conveyer. The plant takes a longer period of time to commission and will require further calibration on a routine basis. Raw material variability may also give rise to batching accuracy doubts.

Truck mixing

Not all wet plants contain integral mixers, some merely weigh the constituent materials and discharge them into a truck with a rotating drum mixer.

Mixing in this way has the potential to be effective for mortar mixes of high workability. For very workable mixes they can be ideal as the absence of a mixer means that there is no possibility of contamination arising from a failure to wash out the mixer after the preceding batch, a problematic process for busy plants because it can lead to the production of large amounts of liquid waste that are generally difficult to dispose of economically.

Although apparently similar externally, the internal design, construction and state of repair or wear varies greatly for different truck mixers. Well maintained drums with generous "T" bladed configurations mix very well, less well-designed drums with worn blades mix far less efficiently.

The inlet design and configuration is also important. Some inlet hoppers are small and/or poorly designed and several designs rely on the presence of aggregate in the concrete mixes, for which they were designed, to aid the passage of fine aggregate (sand) through the hopper and into the drum. In the absence of aggregate, when used for mortar, these designs can prove prone to blocking and overflowing whilst being charged.

Overall drum capacity is also an issue with truck mixing and the rated capacity of the unit for its primary design purpose of concrete production is unlikely to be achieved in the case of mortars of high workability.

Mobile mixing plant

Mobile plants are available where the truck chassis carries an arrangement that is perhaps similar to a very small scale fixed mortar or concrete plant. They carry fine aggregate (sand) in one hopper or compartment, cement in another and have a water tank. There are screws to move each of the raw materials and a mixing chamber so that the precise amount of material required at one time may be batched and discharged for use. The disadvantages of these machines are their cost and complexity and relatively limited capacity.

Mobile storage and mixing plant (dry mortar)

Ready mixed dry mortar that is delivered to site and stored in silos is mixed with the required amount of water, as and when needed, by means of an integral mixer positioned at the bottom of the silo. Because the throughput time through these mixers is very low, in the order of only a few seconds, the design of the mixer screw and chamber is critical. These mixers perform very effectively in practice and the dry mortars require careful mix design to take

account of the reduced mixing energy input during the brief mixing process.

Mobile plant (compartmentalised silos)

These silos store the fine aggregate (sand) in one compartment and the cement in another, with, in a minority of cases, lime or indeed any other binder in the third compartment in the case of three compartment machines. The mixing requirement in this instance is therefore more complex, as there is a need to simultaneously feed all of the materials into the mixer. Clearly, any interruption or change in the flow of one or other has to be avoided by careful design and consideration of their flow properties. They are designed to handle damp fine aggregate (sand), with a constraint placed on the maximum moisture content, but this may prove difficult to comply with and if exceeded may result in material sticking, with the potential for inaccurate batching.

The problem of sticking of the fine aggregate (sand) may also occur when dry screened or very fine materials are used. Various mechanical modifications and enhancements have been made in an attempt to control sticking and regularise flow, and silos have been fitted with vibrators and agitators, but no solution has yet been found that is perfectly adequate.

Below freezing temperatures may also cause problems when these occur for protracted periods of time with the potential for fine aggregate (sand) to freeze in the silo overnight.

Compartmentalised silo mixers

Most of these silo mixers work on the basis of volumetric batching, with the constituents being fed into the mixer at controlled rates. This concept may be adequate so long as the material flow properties are satisfactory, but variability in this area, caused for instance by the freezing conditions or excessive moisture content issues discussed above, may be an issue.

These issues may be overcome to some extent by the compartmentalised silo systems that utilise weight batching, but these are more complex and expensive and little used for that reason.

Transport of silos

Silos of dry ready mixed mortar are delivered to site on specialist vehicles, some of which have a dual or multi-functional role and are also able to carry other materials and objects, such as waste skips, when not hauling mortar silos.

When dry mortars are delivered in silos the silos are not usually full because the gross weight would then be in excess of statutory legislation, but the silos are subsequently filled on site by blowing in refill material from a tanker.

Transport of wet ready mixed mortars

There are many types of vehicle for use purely in delivery, as opposed to mixing and delivery of mortars, and the most widely used of these are discussed below.

Agitators

Agitators of exactly the same type used for concrete delivery may be used for mortar, although if it is proposed to use the same vehicle for both purposes care must be taken to ensure that the drum is washed out properly after carriage of concrete and prior to usage for mortar.

Utilisation of the full truck rated truck capacity can be an issue with agitators as many sites will not wish to take as much as a full load. This need not be problematic, as a "milk run" can be established with the delivery vehicle travelling from one site to another until the load is completely discharged, but clearly discharge on site must only be made into accurately calibrated vessels in order to comply with relevant Weights and Measures legislation.

It may also be the case that adjacent sites require mortar of different workability, if for example one site is laying dense units of low suction, the next lightweight units with much higher suction. If this is the case to such an extent that one delivery requires additional water and mixing from the truck's own tank, then the delivery route will need to be planned in the appropriate order.

Some agitators incorporate a small mixer at the discharge chute which allows pigmented mixes to be produced individually on a site by site basis, thus enabling one vehicle load of standard mortar to be delivered to several sites with a different coloured mix for each, in accordance with the individual customer requirements.

Multi compartment delivery trucks

There have been a number of specially designed mortar delivery trucks, with several compartments, varying in number from two to four. These allow the delivery of mixes of different mix designs and/or workability's on one vehicle. Some of these are designed as de-mountable units, so that the delivery truck may be used as an ordinary tipper vehicle when desired by removing the mortar mixing/delivering modules. Some designs allow agitation en route, with others this is not possible.

Although all of these innovations appear to be beneficial, in reality, due to their low production numbers they are usually found to be costly both in terms of initial purchase and thereafter in running costs.

Single screw tippers

Some tipper bodies have been modified by the addition of a transverse screw to the rear of the vehicle, thus providing a rear discharge to one side, powered by a hydraulic power take off from the vehicle engine. These are robust and enable the vehicle to revert to its ordinary use as a tipper when provided with a simple removable cover plate, but are unable to agitate the mortar en route, which can lead to segregation issues.

Flat bed delivery vehicles

Mortar can be discharged from a plant into vessels that are then delivered to site by Hyab or similar light crane offload vehicle. This method of delivery has the advantage of simplicity and lack of capital investment, and is robust, but offloading is slow and tedious. In addition, segregation cannot be taken account of as it can in a vehicle that is able to re-mix en route.

Site storage

Storage of mortars on site may utilise a variety of plant, as discussed further in this section.

Silos

On-site, storage of ready mixed dry mortars is carried out in silos of various sizes. Commonly used silo sizes are from 18 to 22m^3, which hold between 27 and 33 tonnes. Various smaller sizes are also available, which are available in sizes as small as 6m^3, with a capacity of 9 tonnes. These smaller silos may be delivered by crane offload vehicle, with two per vehicle allowing a delivery vehicle to visit two sites.

Twin compartment and multi compartment silos also allow storage on site but care must be taken at low temperatures that the wet fine aggregate (sand) does not freeze.

Tubs

Wet retarded ready mixed mortars may be stored on site in a variety of ways but small tubs, with capacities of 0.2, 0.25, 0.3 or 0.33 m^3 are generally used. Some of these may be transported by crane but they are not all suitable for this application. Great care must be taken if this is contemplated to follow all relevant Health and Safety guidelines, to ensure that the particular skip is designed for craneage, that it does not need any special slings, grabs or related devices and that only properly trained personnel are involved.

Dry bags

Ready mixed dry mortar is produced in 25kg bags and where these are stored on site it is essential that they are covered, in a dry environment.

Bags should also be used in rotation and care taken to comply with the usage dates printed on each bag.

Wet bags

Wet bagged ready mixed mortars are produced in small amounts, primarily for the DIY and related small user markets. The bags are closed by heat sealing or similar and should remain closed until the cessation of mortar working life, generally about 7 days after manufacture.

Bulk wet storage

Various bins and hoppers have been used to store wet retarded ready mixed mortar on site. These have included many designs, with capacities typically of from 0.5 to 2m^3, provided with a gate or similar for discharge into a wheelbarrow or similar. The aim of all has been to provide a means of storing material after discharge from the delivery vehicle, with a

convenient way of discharging small amounts as and when required.

None of these storage methods has succeeded in being widely adopted however, they tend to suffer from fragility and/or excessive weight and complication and to require careful moving around the site, using large mobile plant, in order to re-position them at convenient usage points.

Stockpiles

Stocks of ready mixed lime: fine aggregate (sand) for mortar should be stored on a clean, hard, level surface, for example a concrete slab or similar, and preferably sheeted to protect the material from extremes of sun and rain. If the surface few centimetres harden due to carbonation, they may be discarded and the remainder used in the normal manner.

On-site care and mixing of factory made mortars

The requirement for mixing on site varies according to the type of factory made mortar under consideration and the different procedures appropriate to differing mortar types are discussed in the remainder of this section. Regardless of type, all dry cementitious mortars should be used within the dates indicated as a function of the maximum cement storage times. These dates will be indicated on the silo or bag.

Dry silo mortars

These require no extra equipment on site as the mixers are provided as an integral part of the silo machinery. The mortars cannot freeze, as they do not contain any water, but in extremes of cold weather the water inlet and any water storage facility may need some protection.

Compartmentalised (multi compartment) silos

As one of the compartments in these pieces of equipment contains wet fine aggregate (sand), freezing is a possibility. Electrical tracer wiring has been used to warm vulnerable parts but is unlikely to prove cost effective and often fails to be reinstated after maintenance or repair.

Dry bagged mortars

Storage of these mortars should be in a dry place, off the ground. Shrink-wrapped palletised bags provide a good method of storage if kept inside a structure. Care should be taken to use in rotation, according to date of delivery/production.

Ready mixed retarded wet mortars

These materials should be used within the period of time encompassed by their manufacturer's stated length of retardation time. Stored quality is improved if the mortar in the bins is covered with a layer of plastic or similar and this is provided by many manufacturers. In hot weather and in the absence of plastic, a thin layer of water will suffice.

If water is lost due to evaporation, which may occur to uncovered tubs, particularly in hot weather, it is permissible to replace this and to remix by hand with a shovel. It is not advised

to mechanically remix, or to add any further water than that lost by evaporation.

If freezing occurs, this will generally only affect the top few centimetres of material, and this may be discarded and the material remaining underneath used as normal.

Ready mixed lime: fine aggregate (sand) for mortar

This material may be stored for a protracted period of time, certainly for several months at least, so long as it is properly protected by covering with an impermeable sheet of plastic or similar. Smoothing down the surface with a shovel prior to covering will ensure that the storage life is maximised, by reducing the surface area available to potentially carbonate. When mixing for use, it should be gauged with cement, preferably by weight but if not using a volumetric measure. Gauging by the shovel-full is not recommended as it is unlikely to be accurate.

Coloured mortars

Many factory made mortars are coloured. Where a coloured mortar is specified it is preferable to ensure the use of factory made mortar in order to obtain a consistent result.

Although some alternatives exist, it is usual to use iron oxide based pigments, as these are stable and non-fading. Alternatives, in particular those based on carbon in the case of black and some blended browns, may well lack colour stability and are likely to lose their colour over time. Correctly chosen pigments may be handled efficiently by mechanical means, and have the potential to produce coloured mortars that do not fade in service.

Dry powdered pigment

Pigments may be added to the mixer as powders, granules or liquids. These are the same in terms of their active ingredients, but represent different ways of handling the pigment. The basic powders are very fine and are therefore dusty and difficult to handle whilst maintaining a clean working environment.

Granular pigment

Granulation, achieved either by the use of small amounts of polymer, or by freeze drying or similar processing of slurries, produces much larger particles that are easier to handle mechanically and are also much cleaner to use.

Liquid pigment

Powered pigments may also be slurrified, to produce liquids that may be handled within the plant by pumping. Liquid pigments are very well suited to automated batching procedures but care must be taken during periods of cold weather that they do not freeze.

Health and Safety

Production, Delivery and Storage of Mortar

Production and delivery of mortar involves personnel coming into contact with moving machinery and vehicles, it is essential that company safe working practices are fully adhered to.

Glossary of Terms

Continuous mixer	-	A mixer that discharges its contents in a continuous flow.
Drum type mortar mixer	-	Batch mixer, with a drum fitted with a series of blades that rotates about a horizontal or inclined axis.
Fluidised bed dryer	-	A fluidised bed dryer is an item of equipment where solid particles are made to behave as a fluid by having pressurized gas forced through them. The materials are transported easily across the bed, achieving a high rate of heat exchange without overheating.
Forced action mixer	-	A mixer where the material is physically pushed around by blades.
Free fall mixer	-	A mixer where blades inside the drum lift the materials to the top of the drum, from where they fall or cascade under gravity promoting mixing.
Gauge	-	The process of measuring or adding constituent materials.
High level indicator		A device to measure and indicate the full point in a silo.
Mortar mixer	-	Machine that combines the constituents to produce mortar.
Pan mixer	-	A mixer that has a horizontal pan revolving about a vertical axis.
Pigment.	-	A substance, generally in the form of fine particles, which is practically insoluble in the application medium and for which the sole purpose is to colour cement- and/or lime based- building materials. An alternative definition is: Material used for imparting various colours to a mortar mix.

Pressure relief valve	-	A valve attached to a silo that monitors the pressure whilst it is filling, an audio and/or visual alarm is activated if the safe working pressure or volume in the silo is exceeded. Some systems incorporate an automatic shut off valve to the silo inlet.
Silo	-	A cylindrical structure for storing bulk material.
Tilting drum mixer	-	Drum type mortar mixer that discharges its contents by tilting the drum.
Tub.		A container usually made of plastic, to hold mortar on site.

Bibliography

BS 6100-9: 2007	Building and civil engineering- Vocabulary- Part 9: Work with concrete and plaster.
British Cement Association	Customer site safety: Bulk Delivery: 2005 (available for free down load from the BCA website)
British Cement Association	Customer site safety: Bagged Delivery: 2005 (available for free down load from the BCA website)
Mortar Industries Association	Data Sheets: Nos: 1-8 No: 9 No: 20
Mortar Industries Association	Learning Text: Parts 1, 2, 3 & 4.

Self-Assessment Questions

1	What is the function of a filter within a silo system?
2	What is a reverse air jet filter and what are its advantages?
3	What is a high level indicator?
4	What is a clamshell gated mixer and what are its advantages?
5	Where can guidance be found on cement deliveries and safety?
6	What is a bund?
7	What type of product should fall fall mixers not be used for?
8	What are the advantages of granulated pigments?
9	What is the disadvantage of a mechanical water meter?
10	Name three advantages of a fluidised bed drier.

Answers to Self-Assessment Questions

1	To remove particles of dust (material) prior to the air being vented to the atmosphere.
2	A filter where the cleaning is carried out by jets of air directed in an opposite direction to that of filling. It has less moving parts and is therefore more reliable than mechanical alternatives.
3	A device to visually and/or audibly indicate when a silo is full.
4	A mixer with two gates that move apart and open like a clamshell, it enables complete emptying of the mixer without the need to wash out.
5	British Cement Association publications.
6	A wall or other protective barrier to control any spillage or leakage.
7	Products with a low level of consistence (workability)
8	They are cleaner, with less dusting.
9	It may become blocked if used with recycled water unless regular maintenance is undertaken.
10	They produce less dust, a lower exit temperature and are more fuel efficient.