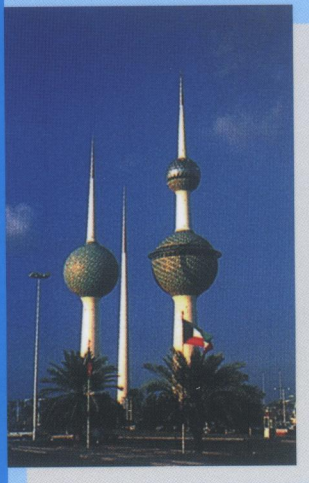


GUIDE TO PROPER CONCRETING PRACTICES PART - 1 MIXING AND CURING



ACI - Kuwait Chapter
P.O.Box : 12608 Shamiah 71657 KUWAIT
Tel. : 2448975 Ext. 312
Fax : 2428148
info@acikuwait.com

GUIDE TO PROPER CONCRETING PRACTICES

PART-1 MIXING AND CURING (ACI/KC 02-98)

This guide provides information on the mixing and curing of concrete under conditions applicable to Kuwait

Reported by:

Technical Sub-Committee 02 Members

A.W. Rumani and Moetaz M. El-Hawary
Task Force Officers

Suad Al Bahar F.M. Niederle Amgad Saad Amr Essam Adel Talba

Technical Committee Members

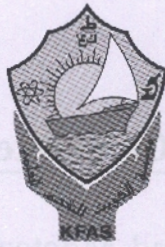
Ahmed Sherif Essawy and M. Naseerul Haque
Chairpersons

Abdel Hamid Darwish Hisham Abdel Fattah Naji Al-Mutairi Saad Al Hares
A.W. Rumani Moetaz M. El-Hawary

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1 General

1.1 Scope

The purpose of mixing concrete is to coat the surface of all aggregate particles with cement paste and to blend the ingredients into a uniform mass. This uniformity must be maintained throughout the processes of discharging and placing of the concrete. Curing is essential during the early stages of strength development to maintain the designed engineering qualities of the concrete and to assure its durability. Kuwait's climate is particularly hot and dry and this note covers the applicable mixing and curing procedures. It may be read in conjunction with the relevant ACI publications.

1.2 Objective

The purpose of this note is to provide guidance for the mixing and curing of concrete under Kuwait's particularly extreme conditions, such that the failure and rejection rate of concrete is minimized and additional expenses associated with costly repairs are avoided.

2 Concrete Materials

2.1 General

For all mixing regimes the concrete constituents should satisfy the engineering requirements and be protected from contamination and weather. Considerations are:

- Suitability for the required construction job.
- Handling and storage.
- Level of contamination.

2.2 Cement

It is important to obtain cement from reputable sources and pay special attention to its storage and handling on the construction site or concrete production plant. Cement temperatures can reach as high as 80° Celsius in summer. It is therefore essential to have it in shaded storage, or to keep it in silos for a few days to cool. Early ordering is therefore advised. Painting silos white is helpful to reflect the direct radiation from the sun.

The type of cement used in concrete production has an effect on its durability. Type I is often specified for superstructures and Type V for substructures. Type V cement, while giving resistance to sulphate attack, may not provide the same protection where chlorides and sulphates are present together. In that case, blended or Type II cement would be an overall better choice.

2.3 Concrete aggregates

Coarse aggregates and sand must be clean, i.e. free from contamination such as excessive dust, salts, oil spillage or potential alkali reactivity, to minimize the potential deterioration of concrete. With frequent handling there is a tendency for dust to accumulate in the coarse aggregate stockpile, so periodic cleaning is necessary. Aggregates should be shaded from direct sunlight.

Single sized coarse aggregates are recommended to minimize handling problems. To achieve the desired grading, blending of a minimum of two single sizes is usually adequate. A maximum size of 14mm aggregates will be adequate for placing in areas of congested reinforcement or thin sections. Natural sand must

be washed. Sand should be tested frequently for the presence of sulphates and chlorides. These cause deterioration in concrete and corrosion in reinforcing steel, particularly in combination

2.4 Water

Water used in mixing concrete must be of drinking quality. Excess water must not be added to the mix to overcome dryness of concrete during placement. The excess may cause cracking and an increase in permeability, affecting durability. Instead, chemical admixtures may be used. In summer, water temperature should be maintained below 10°C by the use of chillers or ice. Ideally, 4°C is the maximum for large-scale production.

2.5 Admixtures

Concrete in general and particularly ready-mixed concrete should be designed with plasticiser or superplasticiser and retarder. These retard the set and increase the workability, both of which can be achieved without the deleterious effects of excess water.

3 Mixing procedures

3.1 General

In Kuwait, methods of concrete production at construction sites vary from hand mixing by shovels to plant-mixing by tilted rotary mixers.

There are no general rules on the order of feeding the ingredients into large mixers. Generally, a small amount of water should be fed first followed by all solid materials fed simultaneously and if possible the greater amount of water should be fed at the same time, then the

remainder of the water is added after the solids. However, when dry mix is used it is necessary to feed some water first to allow its surface to become sufficiently wet. When dealing with partial cement replacement materials, such as Ground Granulated Blast Furnace Slag, Micro-silica or Pulverised Fuel Ash, (Fly Ash) trials will be needed to ascertain the best charging order of materials and mix characteristics.

Mixing can normally be classified into three methods, hand mixing, site mixing and central plant ready mixing.

3.2 Hand mixing

Hand mixing should not normally be allowed. In present times portable mechanical mixers are very economic and readily available.

3.3 Site mixing

Only weigh batching should be permitted and volume batching should be used only if unavoidable. Portable weigh scales for site purposes are available at very reasonable cost, to proportion the aggregates. The ingredients can then be mixed in a portable mixer and should be used without delay.

3.4 Ready mixed concrete

Concrete can be batched and mixed at a central plant and delivered to the site as ready-mixed concrete in purpose-designed transit mixer trucks. This mixing can be sub-divided into two categories, dry mix & wet mix. It is recommended that readymix concrete batch plants should be automatic and equipped to provide printed batch weights. They should be regularly calibrated and examined for wear and lack of cleanliness.

Mixing paddles should be replaced when worn, and manufacturers tolerances observed.

The condition of the transit mixer, including the mixer drum and water flow meter, is of primary importance to ensure homogeneous material. Regular inspections are needed to avoid the build up of hardened concrete in the mixer and ensure that there is no leakage of water into the drum during traveling and that the drum speed is in accordance with the manufacturers recommendations. The quality of concrete depends on the equipment efficiency:

3.4.1 Dry mix

Here, the coarse aggregate, wet sand and cement are batched into the transit mixer at the central plant and mixing is done immediately prior to the placement of concrete. Water, and admixtures, are added at the point of discharge. Some extra cement will be needed for a dry batched mix. A limiting time within which the concrete should have the water added and be placed must be agreed upon on the basis of site trials. This may well differ from season to season.

3.4.2 Wet mix

In this case, all the materials, including water and chemical admixtures, are mixed in a pan mixer or transit mixer, and ready-to-use concrete is delivered to site. The mix should be designed to produce slumps at the plant higher than the target at site to allow for slump loss during transit. Depending on the dosage of retarder, placement time can be extended to suit site conditions, without compromising the concrete quality.

3.5 Mixing Time

On site, there is a tendency to mix concrete as rapidly as possible to maximize output and save fuel. It is important to know what is the minimum mixing time necessary to produce concrete uniform in composition and, as a result, of satisfactory strength and durability. This time varies with the type of mixer and the optimum speed of rotation recommended by the manufacturer. It is usually the number of mixer revolutions, which is important. Time of mixing and uniformity of the mix are interdependent.

There is no benefit in mixing concrete for longer than recommended, assuming the plant is in good order. An absolute maximum of one and a half minutes is usual for a plant mixer; since longer mixing causes aggregate attrition, higher mix temperature and earlier loss of workability. For a transit mixer, the situation is different and a minimum of five minutes at mixing speed is required to achieve the necessary 70 revolutions.

3.6 Mixing Conditions

Mixers, water tanks, and cement silos should be painted with white insulating paint and be in first class working order. Truck mixers drums should also be painted white, covered in wet burlap or hessian and kept in shade before dispatch, if possible. There are special problems involved in concreting in hot weather, such as high temperature of concrete and increased rate of evaporation from the fresh mix. Details can be found in ACI 305R. Higher temperature of fresh concrete results in more rapid hydration leading to accelerated set and lower concrete strength.

Rapid evaporation may cause plastic shrinkage cracking and crazing. Remedial measures can be taken to overcome these problems by lowering the temperature of the mix ingredients. For instance, fresh cement may be allowed to cool, aggregates can be shaded, ice can be used instead of some of the mixing water but should be completely melted before mixing is finished. All materials and mixing machinery must be protected from heat and direct sunlight and the temperature of concrete delivered at site, should be as low as possible. An upper limit of 30°C is desirable but cannot be achieved by readymix suppliers in Kuwait during the summer months without the addition of ice to the mix and 32°C is the commonly specified upper limit.

In shade, where the air temperature is in excess of 40°C, concrete deterioration can be anticipated and the above mentioned maximum concrete temperature should be observed, although in the case of non-structural mixes below ground level, a practical increase of about 2°C may be allowed. From May to September, it is practical to carry out concreting works at night. Local concrete plants are not equipped for the addition of flaked ice or of the additional cooling by liquid nitrogen which may be required for special projects, but any cooling of the concrete at the mixing stage is desirable.

Slumps at delivery should be from 10 cm to 14 cm. Designing for 15 cm slump avoids the risk of retempering on site. Moderate range water reducing admixtures available nowadays at very economical cost could be utilised.

4 Curing

4.1 General

For good durable concrete, its curing in a suitable environment during the early stages of hardening must follow the placing of an appropriate mix. Curing is the name given to procedures used to keep concrete humid as long as possible, and consists of control of temperature and of the moisture movement from and into concrete. The purpose of curing is to keep concrete saturated as much as possible, until the originally water-filled space in the fresh cement paste has been filled to a desired extent by the products of hydration of cement.

The evaporation rate of water from concrete soon after placing depends on its temperature, the temperature and relative humidity of the surrounding air and on the wind speed. It cannot be overemphasised that the quality of concrete depends on the length of time it is cured and attention to this will minimize the costs of crack repair and surface unsoundness. Intermittent or partial curing will prevent the concrete from developing its full durability.

A separate item for payment in respect of curing work should be included in BOQ. Non-compliance should lead to deductions and remedial works to encourage proper curing practices.

4.2 Methods of Curing

It is essential to maintain the moist environment so that curing must be continuous. There are two systems of achieving this:

(1) Frequent application of drinking

water through ponding, sprays or saturated cover material.

- (2) Prevention of excessive loss of water by mean of plastic or membrane-forming curing compounds.

A continuous supply of water is preferred to sealing compounds, which are not 100% efficient.

It is not often appreciated that for large surfaces of concrete, to prevent crazing of the surface, loss of water must be prevented even prior to setting, especially in dry weather. Fog spraying during the finishing operation provides an excellent start to curing for flat surfaces. This helps to maintain the moisture in the concrete since finishing is not usually completed until the initial set, and full curing not instituted until after the finishing. Once the concrete has set, wet curing can be maintained by keeping the concrete in contact with a source of water.

Actual procedures of curing vary widely depending on the conditions of the site and the size, shape and position of the member to be cured. Wind is responsible for a great deal of the water loss and the erection of windshields prior to placing can greatly assist in the avoidance of loss of moisture and the resulting cracking. Spraying or ponding, or covering the concrete with wet burlap is the preferred method of curing. Even wet sand can be used.

Ideally the set concrete surface should be covered with wet hessian (burlap) with a soaker hose and then covered with plastic sheet. On no account should the hessian be allowed to dry out. Dry hessian on concrete will act as a wick and draw more

moisture out of the concrete. Horizontal surfaces should be shaded from the sun. Curing water temperature should not be more than 10°C cooler than the concrete since the spraying of cold water on the surface of hot concrete can induce cracking from thermal shock.

For members of small surface/volume ratio, curing can be aided by oiling and wetting the forms before casting. The surface should be wetted after stripping the concrete and sprayed with water, covered with wet burlap and wrapped with polyethylene sheet or other suitable impermeable covering.

Curing membranes of various types are available. Some contain reflective material and all should biodegrade but the process of degradation takes a long time, even if exposed to direct sunlight.

4.3 The period of curing

For ordinary portland cement, a minimum of seven days is the usually specified period of curing. However, with slow-hardening cements a longer curing period is desirable. Temperature affects the length of required period of curing and controls the rate of progress of the hydration, affecting the development of the strength of concrete. During curing, concrete should be regularly checked for the absence of cracks and crazing. Cube strength could be used to assess the quality of curing by measuring the relative strength of the concrete using field-cured specimens compared with laboratory cured ones. Curing should continue throughout the specified period

and not stop when the 28-day cube strength is attained.

4.4 Table of curing methods

A table of suggested curing methods under different circumstances is attached.

5 References

- ACI Committee 305R-91, Hot Weather Concreting, American Concrete Institute, Detroit.
- ACI Committee 304R-85, Guide for measuring, Mixing, Transporting and Placing Concrete, American Concrete Institute, Detroit.
- ACI Committee 308-81(Revised 86), Standard Practice for Curing Concrete, American Concrete Institute, Detroit.
- A Guide for Concrete Practice in the Gulf Region, Bahrain Center for Studies and Research, 1994.
- Special Publication 31, The CIRIA Guide to Concrete Construction in the Gulf Region, Construction Industry Research and Information Association, London.

4.4 TABLE
GUIDE TO CURING IN-SITU CONCRETE*

CONCRETE ELEMENT	CURING MATERIAL	APPLICATION
1. One) Road and paved areas, aprons, open flat slabs. Two) Internal slabs.	Pigmented resin based curing compound with high efficiency rating. Wet Hessian & Polythene or other impervious sheeting material.	Apply immediately after finishing process has been completed. Protect with shading for the first few hours especially in hot sunshine and high drying winds. Take care to avoid wind tunnel effect under the sheeting.
2. One) Tops of beams, columns. Two) Top of trench fill, footings, bases	Wet Hessian & Polythene or other impervious sheeting material.	Apply immediately as soon as finishing process has been complete. Protect with shading for the first few hours, especially in hot sunshine & high drying winds.
3. Concrete columns beams, walls, etc. which are not to receive subsequent treatment: Cast in hot dry conditions.	Resin-based curing compound. Wet Hessian & Polythene or other impervious sheeting material. Formwork itself.	After formwork has been removed, spray water & apply the curing compound as soon as the surface is dry. Fix in close contact with surface immediately after formwork has been removed. Leave undisturbed for at least 4 days preferably 7 days.
4. Concrete columns, beams, walls, etc. where subsequent treatment is envisaged: Cast in temperate conditions.	Wet Hessian & Polythene or other impervious sheeting material. Formwork itself.	Fix in close contact with surface immediately formwork has been removed. Leave undisturbed for at least 4 days & preferably 7 days.
5. Large concrete section with a minimum thickness or depth exceeding 1 meter.	Top surface insulation. Delayed removal of formwork or replacement of formwork by insulating material.	Fix insulation clear of surface as soon as finishing process has been completed. Maintain for at least 7 days or until internal temperature gradient is minimized.

*Fog spraying during finishing states is recommended

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