PRECAUTIONS WHEN CONCRETING IN COLD WEATHER

Environmental factors encountered in cold weather can adversely affect concrete properties. It is vital that all parties including concrete producers, specifiers, contractors, and site operatives fully understand these factors and the high risk of permanent damage to fresh and hardened concrete performance. All activities must be carefully planned with suitable precautionary measures taken in such conditions.

Temperature considerations

There are three aspects relating to temperature which must all be considered when concreting in cold weather. Any one or combination of these conditions can easily lead to permanent impairment of the concrete quality.

1. **Ambient air temperature.** As a general guide, when ambient temperatures are below 5°C on a falling thermometer or 3°C on a rising thermometer, there is a risk of damage to concrete. Higher ambient temperatures where there is a wind chill effect are also a risk
2. **Ground or surface temperatures.** Concrete should never be placed against frozen ground or other surfaces or substrates
3. **Concrete temperature.** For compliance with I.S. EN 206, fresh concrete must be delivered at a minimum of 5°C

Considering the three primary risk factors above relating to temperature, it is essential that concrete is protected from temperature drops and the potential of freezing until sufficient strength has developed. As a general guide, the temperature of the concrete itself needs to be continuously maintained at a minimum of 5°C for at least 48 hours and until the compressive strength has exceeded 5 N/mm^2. While concrete may be placed during the day in suitable conditions, adverse overnight conditions after concrete placement is often overlooked.

Potential impacts of cold weather on concrete

- Freezing of water within fresh concrete can result in catastrophic failure of the concrete
- Freezing of the concrete after initial stiffening but before sufficient strength has developed may also cause varying levels of damage ranging from surface damage or scaling to full structural failure
- Milder damage from cold weather impacts may not be immediately evident, but can result in irrecoverable decreased compressive strength and reduced durability of the resultant concrete element
- Early strength development of concrete is a function of the hydration of cement with water which generates heat. This reaction and subsequent strength development can be significantly slowed by colder temperatures

Measures to minimize risks

Concreting operations need to be carefully planned and executed when cold weather conditions occur to prevent permanent damage to the concrete. There are a number of practical measures which can be implemented which include:

Concrete mix considerations

There are several measures which can be taken with the concrete mix used which will aid with slightly quicker strength development. None of these will entirely remove the risk of cold weather damage and must be considered alongside site operational controls below.

- Increasing the strength class or cement content of the concrete mix
- Reduction in the use of cement replacements by agreement (minimize GGBS & PFA usage)
- Using a lower workability mix will result in quicker initial setting time
- Accelerating admixtures can be added to concrete; however, this will only result in concrete setting quicker. The concrete is still at the same risk of cold weather damage after setting. **Accelerators should be specified and used by exception with upmost caution** as the rapid setting may not lend itself to site placement and finishing operations without detailed and careful resourcing and planning
- Hot water for concrete batching is generally not a practice due to high relative cost and the infrequency of this requirement in Ireland

Site operations

- Consider placing concrete outside of expected low temperature conditions. Critical work should be postponed and carried out in ideal environmental conditions
- Plan and communicate delivery and demand carefully. Concrete should be batched, discharged, placed and finished without delay
- Appropriate curing and protection of the fresh concrete from heat loss must put in place as quickly as possible
- Wet curing techniques with water should never be used in cold weather
- Frost blankets and insulated form work should be used to protect concrete in cold weather conditions. In some cases where cold weather conditions are relatively mild, conventional timber formwork left in place for longer may provide adequate protection
- Remembering that cold weather conditions will result in slower strength development, frost blankets, insulated formwork and conventional formwork used as protection should be left in place for an extended. At least 48 hours after placement until sufficient strength has developed or ideally longer.
- Do not add water to concrete onsite. This exacerbates the risk. Where required order a concrete mix of suitable workability for the task
- For flatwork, i.e. slabs and floors, where possible the placement of concrete should be done after roofing and erection of walls. Frost blankets or other methods of surface protection may still be required
- The protection of concrete from extremes of temperature, shock and vibration is an integral part of concrete curing activities. All concrete projects must have a site operations specific planned curing procedure in accordance with EN 13670 clause 8.5

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PRECAUTIONS WHEN CONCRETING IN WARM WEATHER

Environmental factors encountered in warm weather can adversely affect concrete properties. It is vital that all parties including concrete producers, specifiers, contractors and operatives fully understand these factors and the high potential for negative impacts on fresh and hardened concrete performance. Concreting operations must be carefully planned with suitable precautionary measures taken in such conditions.

What is warm weather?

Warm weather for the purposes of concreting operations can be defined as when one or more of the following conditions exist. These conditions can easily lead to permanent impairment of the concrete quality through an accelerated rate of moisture loss and cement hydration:

- High ambient temperature
- High concrete temperature
- Low relative humidity
- High solar radiation
- Wind velocity

There is no specific temperature which would be considered an action point for warm weather concrete. Ambient temperatures up to about 20°C should not on their own cause significant problems. Ambient temperatures of 20°C and above with lower humidity and drying winds present a high risk to long term concrete quality. Lower ambient temperatures on dry days with a strong breeze also prevent a high risk.

The Irish National Annex to EN 206 requires that the temperature of fresh concrete does not exceed 30°C unless the user specifies otherwise.

Potential impacts of warm weather on concrete

With fresh concrete the main issues which may arise are:

- Increased water demand which reduces the water-cement ratio
- Increased rate of slump loss leading to requests to add water to the concrete onsite
- Accelerated setting which may create issues with handling, placing, compacting and finishing the concrete
- Unpredictability with setting time in such conditions and experience of concrete operatives with such factors can lead to unsatisfactory finished concrete elements
- Increased risk of cold joints
- Potential difficulties maintaining specified air content in air entrained concrete mixes
- Very high potential for plastic shrinkage cracking, particularly on flatwork

Issues which may arise with hardened concrete in such conditions generally cannot be rectified:

- Permanent loss of compressive strength
- Increased potential for drying shrinkage
- Higher potential for thermal cracking either due to cooling of the overall structure, temperature differential or thermal shock due to high differential from daytime to nighttime temperatures
- Decreased permeability, durability and water-tightness where applicable
- Surface scaling, laitance or delamination due to rapid moisture loss from the surface

Measures to minimize risks

Concreting operations need to be carefully planned and executed when warm weather conditions occur to prevent permanent damage to the concrete. There are a number of practical measures which can be implemented which include:

- Consider placing concrete outside peak temperature times. Critical work should be postponed and carried out in ideal environmental conditions
- Plan and communicate delivery and demand carefully. Concrete should not be sitting in trucks agitating where it will lose workability
- Do not add water to concrete onsite. Where required order a concrete mix with suitably increased workability
- Discharge, place, compact and finish concrete without delay. The permitted 2-hour maximum delivery period will not be a suitable measure of usability in these conditions
- For flatwork, where possible the placement of concrete should be done after roofing and erection of walls to minimize solar gain and drying winds.
- When discharged directly onto sub-base materials this should be dampened to avoid loss of water from the concrete
- Protect the concrete from rapid moisture loss during any delay between placing and finishing operations
- Cure the concrete immediately and fully. Curing must continue for at least several days after placement of concrete. A planned curing

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Hydraulically Bound Coarse Graded Aggregate (Porous no fines concrete mix)

Production Standard	IS EN 14227-1
Material Composition	Hydraulically Bound Coarse Graded Aggregate is a mixture of a coarse aggregate (usually 20mm nominal size), cement, and water.
Typical Compressive Strength	Class C5/6 in accordance with IS EN 14227-1 Table 2 Line 4.
Typical Use / Application	Porous concrete is used where free drainage of water is required, eg pervious concrete hard-standings and as a stiffening transfer layer in Concrete Block Permeable Pavements which are to receive heavier traffic loads. The lack of sand (fines) in the mixture allows the material to act as a transfer drainage layer, whereby the open graded matrix of the material allows for 20-30% voids within the compacted volume of the material.

Workability & Water Demand

Freshly mixed porous concrete does not behave as a viscous fluid like a normal concrete mix, but as a conglomerate of mortar coated coarse aggregates. Its workability in conventional concrete terms has no relevance as its placeability is little affected by the quantity of water it contains. The water demand for porous concrete is that required to produce an even coating of viscous mortar over the coarse aggregate surface.

Being open textured, fresh porous concrete loses water rapidly to the atmosphere. In consequence it needs to be placed and compacted as soon as possible after mixing. The porous concrete mixture must be maintained in a suitably damp condition at all times and must never be allowed to dry out during placement, installation and curing. Visually the material should be adequately moistened so that the coarse aggregates in the mixture begin to glisten. After discharge from the truck it will be necessary to have a supply of water available which can be used to gently spray over the surface of the material, it. Alternatively a roller with a water spray bar may be suitable to keep the material damp. On warm or dry days it may be necessary to dampen down the sub base material on which the porous concrete is to be placed to prevent the sub base excessively drying out the porous concrete mixture.

Conventional site rules prohibiting the addition of water to ready mixed concrete may need to be disregarded to ensure that the material is maintained adequately moist at all times.

Installation Methodology

The porous concrete should be placed and compacted as soon as possible, it may be levelled by hand or machine. Compaction should be with a roller using no vibration. Four to five passes of the roller should be adequate. Care must be taken not to excessively compact the material thus inadvertently reducing permeability, or to cause crushing of the aggregate within the mixture. The material must be maintained damp as described above at all times during compaction.

Precautionary Measures

Care must be taken for 24-48 hours after placing the porous concrete mixture to prevent the material from drying out too quickly. On warm or dry days it may be required to regularly spray a mist of water on the surface periodically to maintain the moisture of the concrete during curing, or alternatively polythene sheeting may be used to prevent moisture loss. The porous concrete surface must also be protected from heavy rain during the first 48 hours after placing. No construction traffic should be allowed upon the porous concrete surface and care must be taken to ensure it is kept clean and free of any detritus and contaminants.

Disclaimer

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