4-19.1 General

Freshly placed concrete must be protected until it develops sufficient strength to open it to service. The three objectives are listed below:

- Maintain adequate moisture throughout the concrete mass to support hydration, especially at the exposed surfaces.
- Prevent freezing of the concrete throughout the concrete mass, especially at the exposed surfaces.
- Protect the concrete from damage caused by mechanical loading, thermal-induced stress, or moisture-induced stresses.

These three objectives address with the final goal of obtaining opening strength as prescribed in standard spec 415.3.17.

4-19.2 Curing

Curing is the maintenance of a satisfactory moisture content and temperature throughout the concrete mass to support hydration until the concrete has developed sufficient strength to open it to service. Concrete develops strength due to hydration, a chemical reaction that occurs when Portland cement is combined with water. Concrete does not harden as it dries; quite the contrary, if freshly placed concrete dries out, hydration ceases and the concrete quits gaining strength. Optimum durability is achieved as the concrete approaches full hydration. Proper curing is critical for the development of strong, durable, high quality concrete.

Curing should begin as soon as the free water "sheen" has disappeared from the surface. Paving operations should be slowed or suspended when the contractor's curing operation falls behind.

Spray-on impervious membrane materials and impervious sheeting materials must seal in the moisture required for hydration and prevent rapid drying of exposed surfaces. Except during cold weather, these materials must be colored white to reflect radiant heat that could cause surface overheating and impose thermal stress on the concrete. In cold weather, black or clear sheeting materials may be used.

Three principal types of curing compounds are currently specified for use on WisDOT work:

- Poly-alpha-methylstyrene (PAM) curing compound (Standard spec 415.2.4)
- Linseed oil based curing compound (Standard spec 415.2.4)
- ASTM C309 water based wax curing compound (Standard spec 501.2.9)

Each of these types of curing compound has different performance characteristics, and is appropriate to be used in different applications. Linseed oil or PAM may be used in all applications except for pavement that will be overlain under the contract use curing compound conforming to Standard spec 501.2.9.

PAM curing compound has very good water retention characteristics. For WisDOT work the principal use for PAM is concrete pavement on rural highways and on expressways and high performance concrete (HPC) in urban areas as well.

Linseed oil based curing compound provides excellent resistance to concrete scaling due to salt application over the first winter that the concrete is in service. This is very important in the urban environment where appearance is very important due to a high level of public presence and “sidewalk inspection”. For WisDOT work the principal uses for linseed cure are in urban areas for concrete pavement, appurtenant items and associated ancillary items in the right of way exposed to de-icing salt.

Traditional wax curing compound provides adequate water retention for miscellaneous ancillary items, and allow better bonding to items that will be covered up in service. In the concrete pavement area, the principal use for the traditional wax cure is for concrete base and concrete base patching, both items that will be covered up in service. The wax cure wears off faster, and is more easily removed, allowing better bond of the concrete base to the final pavement layer placed on top of it. A concern is that use of PAM or linseed cure would be more likely to cause debonding of the overlay from the concrete base.

A word of caution when using linseed oil cures: Linseed oil cures can take significantly longer to set up and lose their tackiness and tracking tendency more than PAM or wax cures, especially during cool weather. When working with linseed cures, it is especially important to wait until all bleed water has evaporated from the concrete surface before applying the cure. If you do a touch test on the concrete surface and feel any moistness on your finger, it is too soon to cure. Applying linseed cure too early can significantly make problems worse with

slow set and tracking of the cure.

4-19.3 Thermal Protection

Freshly placed concrete must be protected from thermal stresses until it has developed sufficient tensile strength to resist thermal cracking. Covering should be considered, even in warm weather, when nightfall or approaching storms may lead to rapidly falling temperatures that might cause surface damage.

Standard spec 415.3.15 prescribes specific measures that must be taken to protect concrete from freezing. This protection is not required unless the predicted or actual air temperature on the project falls below 28 F for the following reasons:

- The temperature of the concrete at the point of placement is well above freezing as prescribed in standard spec 415.3.15.
- The fresh concrete has a high thermal mass and thus loses its initial heat relatively slowly.
- The hydration reaction produces considerable heat.

The contractor is responsible for frozen or frost damaged concrete. If this damage is not identified before the concrete achieves the opening criteria prescribed in standard spec 415.3.17, the department can still recover the costs of repair or replacement of the defective concrete under the standard specification provisions of standard spec 107.16, No Waiver of Legal Rights.

4-19.4 Equivalent Curing Days

The contractor should provide compressive strength information as prescribed in standard spec 415.3.17 whenever practical. The use of the equivalent curing day minimum curing period is intended as a default option where the contractor fails to provide valid strength data.

The department is obligated to allow the contractor to open concrete pavements and appurtenant construction to service when 3,000 psi compressive strength is achieved. The contractor is responsible for providing accurate and reliable compressive strength results. If the contractor fails to provide this strength information the engineer will unilaterally decide when the concrete can be opened to service.

Standard spec 415.3.17 uses the concept of equivalent curing days to adjust the time recommended for opening to service when no reliable compressive strength information is available. The specification does not require opening after the specified period. The engineer will adjust the minimum curing period based on their assessment of the average daily air temperature on the project. The engineer is empowered to extend these periods as necessary to be assured that 3000 psi has been achieved. If the contractor disagrees with the engineer's determination they should submit actual compressive strength data for the concrete in question.