Spraying is among the more effective methods of curing concrete whenever a sufficient quantity of water at high pressure is available. In this view a city street pavement is being cured with water forced through spray nozzles located in the pipe extending down the center of the pavement. The chief objection to this method is its high cost.

Surveying the many...

Curing Methods and Materials

It would be difficult to overemphasize the importance of curing in concrete construction. On it hinges to a great extent concrete's watertightness, hardness, durability and strength. As a matter of fact, curing is the most important single factor in achieving high strengths. Essentially, curing is simply a means of assuring thorough hydration of the cement paste.

Studies have shown that the amount of water needed for cement hydration is always less than that needed to render a mix workable. Therefore, effective curing boils down to a matter of providing a moisture barrier to prevent evaporation of the mix water. The several methods of preventing dehydration of concrete vary appreciably in their efficiency and in the time when they can be employed. The following is a short survey of curing methods with a few comments on the characteristics of each type.

WATER

Most effective of all the known curing materials is water. Most effective, that is, in terms of preventing evaporation of the mix water. In actual practice, use of water by itself as a curing method poses a number of problems.

Two curing methods use water as their sole agents: fogging or spraying and ponding. In spraying, water is forced through horizontal pipes to various locations and out through nozzles which disperse it over the concrete surface. Fogging is essentially the same procedure with the exception that the nozzles produce a mist-like effect rather than a concentrated spray. In addition to their high cost, these methods are subject to several vagaries—water pressure, wind velocity, pipe leakage and nozzle clogging.

Earth dikes are set up around the perimeter of a slab in ponding and a pond of water is pumped over the concrete. Although highly efficient in preventing evaporation, ponding is messy and imposes a considerable load on structural slabs (those other than slab-on-ground).

Both of these methods require considerable quantities of water, need careful supervision and are applicable only to horizontal surfaces. Although they were once considerably in vogue (ponding especially found wide application), the rise in wages and materials costs have gradually rendered them less and...
The prime uses of ponding today are in farm construction and do-it-yourself projects.

**BURLAP**

Not too long ago the accepted standard for curing was ponding for primary use (before the concrete had hardened) and saturated burlap for secondary curing. The tarpaulins were positioned to cover the entire surface area and then sprayed with water and kept wet throughout the curing period.

For a while burlap was eclipsed by some of the then newly-developed methods—sprayed membranes, plastic sheets, paper, etc.—but in recent years it has made a strong bid for a comeback through a number of improvements. Treatments with plastics, aluminum and other materials have improved its handling qualities, even in cold weather; increased its light reflectance; curtailed rot; and greatly increased its fire resistance. When repeated use is important the new tarpaulins often prove of value.

**MEMBRANE COMPounds**

Membrane compounds have become popular curing aids due to their ease of application. When a concrete area is completely sprayed with one of these products it is effectively sealed and evaporation is greatly retarded. Membrane compounds are commonly available in three forms: clear, black and white.

Clear compounds are used on surfaces that must be architecturally attractive—exposed walls, ceilings, stairways and the like. Often a dye is added to help assure complete coverage of the concrete. This color fades within a few days leaving a transparent film.

Black compounds are manufactured with an asphaltic base. Because of their viscosity, dark color and freedom from pin holes, they provide an especially effective moisture barrier. This type is used in two-course basement floor slabs for waterproofing and is also effective on slabs that are to be covered with tile or linoleum. It has the disadvantage of a high heat absorption rate when compared with white compounds.

White compounds are especially useful in hot weather concreting since they reflect most of the heat rays, thereby reducing the concrete's temperature. This temperature reduction further minimizes evaporation and increases strengths. White compounds should be thoroughly mixed before spraying since the pigment used for coloring tends to settle out. Often a gray-colored compound is available for use where a natural concrete shade is desired or when the glare of a white surface would be objectionable.

Most manufacturers of these materials recommend that they be applied at a rate of approximately one gallon per 200 square feet per coat and that two coats be used. Even using two coats they are impressively low cost. Membrane compounds can be applied with hand or power sprays or by automatic self-powered sprayers on large projects. Some trouble was experienced in the early history of these compounds with caking of the material and subsequent clogging of the lines and spray nozzles. Since then, however, dispersing agents have been developed that have largely ended this complication.

**PAPER**

A number of waterproof papers have come on the market in the last decade and found wide use. One of their important advantages is that they do not require periodic additions of water; they assure proper hydration by furnishing a moisture barrier, thereby preventing evaporation. Since water is continuously available, curing proceeds uniformly and the danger of improper curing from a breakdown in water supply is eliminated.

Waterproof curing papers also make it simple to check on the progress of curing and the condition of the slab. This is especially true if sand is used to anchor the paper edges. Manufacturers recommend that their paper overlap several inches where sheets butt and be secured with sand, nonstaining mastic, glue, or masking or pressure-sensitive tape. Wood planks should be used where areas are to be subject to heavy traffic. Curing papers also offer some protection against damage from frost, direct sun, traf-
A number of reinforced waterproof papers are now on the market for curing concrete and are finding increased acceptance. Their function is to provide a moisture barrier which prevents the evaporation of the water in the concrete. This method eliminates the always serious danger of an interruption in water supply.

A valuable addition to the list of curing materials has been plastic sheeting. These lightweight, effective moisture barriers are flexible tools in securing high-quality con-
crete. Although higher in first cost than most curing papers, they are easy to fit over even complex shapes. In highway work, no cutting is required on curved pavements. In addition, these sheets weigh as little as 20 pounds for enough material to cover 1,000 square feet of concrete.

Plastic sheeting is non-absorbent. It therefore resists rotting and mildew and the weight is constant dry or wet. It can be easily rolled up for reuse after controlled curing is completed; over twenty reuses have been reported with these materials. Plastic sheets need not be idle between curing applications, either. They find wide use for such jobs as protection for lumber and other materials affected by weather, for glazing windows, for walling temporary storage buildings and, when backed by paper, for lining wooden forms to achieve an especially smooth concrete surface.

Widths up to 32 feet are available in plastic sheeting. Even the largest sizes require little manpower to handle thanks to their lightweight and nonabsorptive characteristics. The durability of this material depends to a great extent upon its thickness. Sheets are manufactured in thicknesses ranging upwards from four mils (.004 inch). A white pigment is usually added to render these sheets more effective in keeping concrete temperatures low.

ODDS AND ENDS

Over the years a considerable amount of improvising has been done in connection with the curing of concrete. Many improvisations have fallen by the wayside as being impractical or ineffective, some have been replaced by more efficient methods, and others are relegated to use only under unusual circumstances.

Wet earth and sand were found to be expensive in manpower and messy in use. Straw and hay, although some times used for small farm projects, have proven mediocre curing materials; other products have largely replaced them in this field. Cotton mats have largely dropped from the picture due to problems of bulk, weight, expense and water absorption. Wet sawdust, in addition to its drawbacks in handling and clean-up, occasionally retarded hardening of the concrete through the action of sugar in the sap. Even electronics has made a bid in this field. Experiments in Japan with electrical curing in cold weather through the use of electrodes in the concrete have shown that this might be an effective method for certain conditions.

Our discussion has centered around methods and materials. Naturally, there are a number of other variables which influence the success of curing. These include subgrade composition and condition, concrete temperature, cement types, length of controlled curing and thermal shock. Also job conditions must be carefully considered when choosing a curing method. For example, in resurfacing work, a curing material which offers a great deal of thermal insulation as well as moisture retention would be highly desirable to prevent differential thermal movement of the base slab and the topping layer.

Enlightened practices and modern materials have reduced to three days the curing period which consumed 28 days in the “good old days.” Improvements in ease of use and efficiency; together with reductions in costs are a continuing job for both materials manufacturers and concrete contractors. As new ideas come to the fore CONCRETE CONSTRUCTION will report them promptly.