Winter-built Concrete

Winter concrete work on $3,000,000 sewage treatment plant at Worcester, Mass., during winter of 1922-1923.

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Placing Concrete in Cold Weather

1. The safest practice is to protect newly placed concrete as soon as possible, before it has time to freeze. There is no certainty that concrete that has been frozen even once will ever attain its full strength. Repeated freezing and thawing causes serious injury and may necessitate removal of the concrete. No freezing whatever should be permitted in concrete that will be subjected to abrasion, as in floors and pavements.
2. Heat the aggregates and mixing water so that the concrete when placed will have a temperature not lower than 65 degrees F.
3. Place the concrete in the forms immediately after mixing so that little heat will be lost.
4. Protect the concrete as soon as placed in order to retain the heat. Canvas covering, sheathing or a layer of clean straw will furnish sufficient protection for some work in mild weather. If the straw contains any manure, cover the concrete with a layer of tar paper, to prevent damage to the freshly placed concrete from acids in the manure. Where work can be inclosed, open coke stoves or salamanders may be used. In severe weather such protection and heating should be continued for at least five days.
5. The concrete must be strong enough to support all imposed loads before the forms are removed. Examine by pouring hot water on the concrete or by heating in some other way. Be sure the concrete has hardened, not merely frozen.
6. Concrete work can be placed as successfully in winter as in summer if the above rules are followed. Carelessness imposes its own penalties at all seasons of the year.

Winter-built Concrete

Economy of Winter Work

A DISTINCT advantage is often gained by carrying on structural concrete work in the winter months. Construction work begun in the late summer or early fall may safely be continued throughout the winter. Builders and prospective owners need not hesitate to start construction during this period regardless of weather conditions.

Keenan Hotel, Fort Wayne, Ind. The 14-story reinforced concrete structural frame was built in the winter of 1922-1923, at the rate of one story in less than one week. By keeping five stories inclosed at one time the newly placed concrete was kept warm for about four weeks.

Contractors have found that the cost of winter construction is from 3 to 10 per cent greater than the same work would cost in summer, but certain advantages of winter construction frequently offset a part or even all of the additional cost so that the net results may prove an actual saving in construction. The material for the work can often be supplied in winter to the best advantage. Labor is more abundant and efficient and the project can be manned with the best of the labor market. There is also the important additional advantage to the owner of having the building ready for occupancy at an earlier date, as explained more fully in the paragraphs immediately following.

Earlier Use of Structure

Frequently it is imperative to have a structure completed and ready for use at the earliest possible date. Schools, residences, apartment houses, office buildings and hotels are usually needed by a certain date. Earlier occupancy of such structures is of prime importance also from the investment standpoint.

Money provided for building construction earns nothing for the borrower until it is represented as an investment in a completed structure, either rented or occupied by the business for which it is intended. It is often penny-wise and pound-foolish to delay the construction of a needed concrete building because of cold weather, for the extra cost of con-

struction in winter would often be more than offset by the interest saved on the money provided for its construction. The bonus or royalty often paid for the completion of a building before a specified time is tangible evidence of the value placed upon early occupancy by large corporations.

Fundamentals of Cold Weather Concreting

In order to place concrete successfully in cold weather, it is necessary to follow the methods and observe the precautions outlined in this booklet. The fundamentals of these methods are easily comprehended by an understanding of the action of concrete in hardening.

Hardening of concrete is not a process of drying out, as some people suppose, but is a chemical reaction between the cement and the water used in the mixing. Two things are necessary for proper hardening —namely, warmth and moisture.

Low temperatures will retard the hardening of concrete, extreme cold will prevent it altogether. Since water is necessary for the chemical action of hardening, evaporation of the water used in mixing the concrete must be prevented. This is

Cold weather need not delay the construction of tall concrete buildings. Construction of the 18-story Hide & Leather Building, New York, an all-concrete building, was carried on during the winter of 1920-21.

often done by keeping the surface covered with wet sand, saw-dust or burlap. As the temperature is lowered and the moisture content is reduced, the gain in strength and the entire hardening process become much slower and practically cease when the temperature of the water used in mixing falls to the freezing point.

By being completely inclosed with canvas the concrete bridge over the Little Goose River in Sheridan County, Wyo., was completed during the severe cold weather of the winter of 1919 and 1920, and thereby permitted the opening of an important highway to spring traffic.

There is no certainty that newly placed concrete that has been frozen even once, and has then been thawed out and protected from further freezing until final hardening has taken place, will ever attain its full strength. The only safe practice is to protect freshly placed concrete as soon as possible, before it has time to freeze. If alternate freezing and thawing occur several times, the concrete will be seriously injured and may have to be removed. Concrete that will be subjected to abrasion, as in floors and pavements, should under no circumstances be allowed to freeze at all. The exact period that may be allowed to elapse between placing concrete and subjecting it to freezing temperature cannot be definitely stated because of the influence of unknown variations in temperatures and other conditions. Experience shows that this period should never be less than 48 hours, and if the outside temperature averages below freezing, 3 to 5 days should be allowed.

Bridge constructed in Waterloo, Iowa, during winter of 1921. No difficulty was experienced in this method of protection. Arch ring and hand rail are protected by the use of manure.

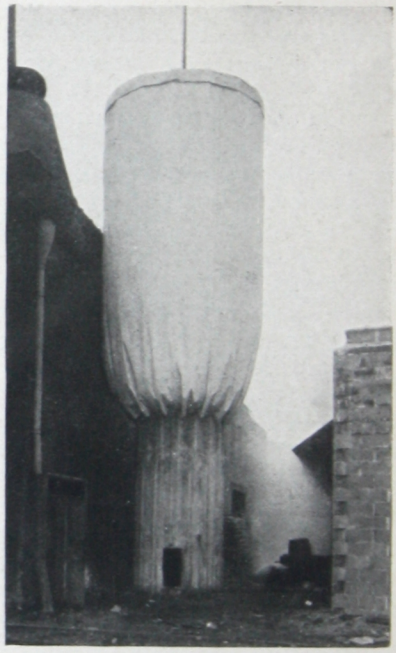
Methods for Winter Work

Heating Materials

Since warmth and moisture are required for the proper hardening of concrete, cold weather work should be planned with those necessities in view. Both the mixing water and the aggregates should be heated. The cement forms but a small portion of the concrete and need not be heated, but it is well to keep it in a warm place for a few hours before it is used.

The nearer the temperature of the water is to the boiling point the better will be the results because it will take longer to dissipate the heat and cool the mixture. There are several types of water heaters that can be used, but the most common method of heating is to pass steam into the water tank. The concrete should be mixed with the least amount of water practicable to produce a workable, plastic mixture. An excess of water must be carefully avoided.

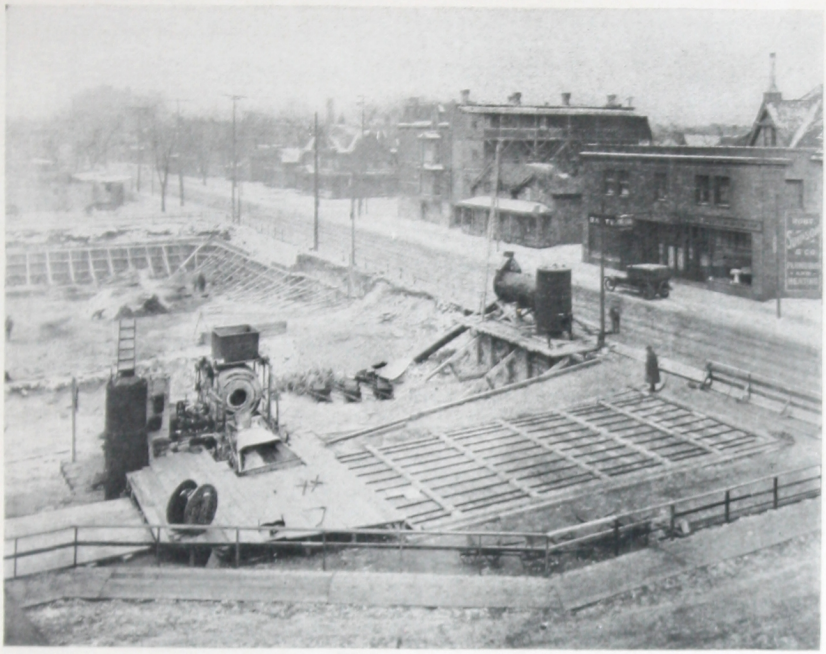
Many methods are used for heating aggregates. A simple method is to use a length of iron pipe, an old boiler, or any metal cylinder over which the sand, broken stone, or pebbles can be piled, and in which a fire can be built. Care must be taken to heat the fine and coarse aggregates separately in order to avoid pre-mixing them in wrong proportions. As this method entails rehandling the aggregate, and as the aggregates nearest the heater may be affected by excessive heat, the use of steam pipes is generally preferred.



Construction of this concrete chimney was not interrupted by cold weather. The canvas envelope protected the work completely and the interior was kept warm by a salamander located in the base of the chimney.

Steam heating is a more expensive method and requires a steam boiler, but on large jobs this method is usually advantageous because the steam may also be used for other purposes. A practical method is to use a perforated steam pipe with a pointed end which can be worked into the piles of aggregates. To reduce loss of heat the piles of aggregates should be covered with tarpaulins.

If the materials are heated as above outlined, and the concrete is deposited immediately after mix-

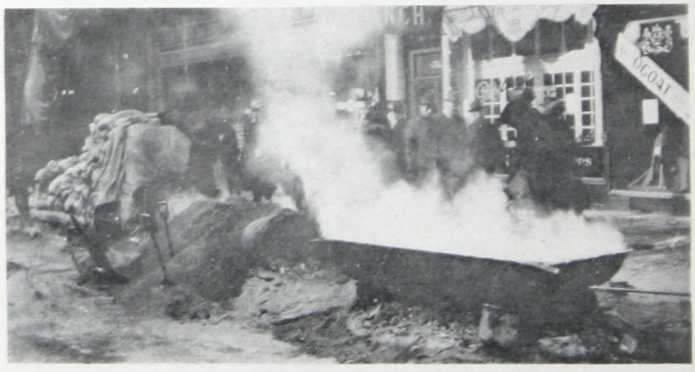


Special pipe grillage for heating aggregates installed by Thompson Starrett Co. The picture at the top of the page shows the complete installation of pipes, boiler and mixer. Note steam boiler has been removed from mixer frame and used to heat water in tank on top of mixer; electric motor substituted for former steam motive power. Loaded trucks of sand and gravel were dumped directly on to this platform. As soon as covered to a depth of 3 feet, steam is turned on continuously day and night. The lower picture shows a close-up of the arrangement of the pipe. Grillage drips for condensation are shown on the left hand side. This installation produced an aggregate with a temperature of approximately 70 degrees at all times.

Successful Methods for Concrete

A Coke-burning hot water heater is very convenient for heating water close to the mixer.

Repairing street car pavement at a busy corner in Chicago, sand and gravel being heated in a metal culvert and water in a flat tank.



Method of heating water for concrete work shown in picture above.

Salamanders unde forms and be furnish heat for shly placed co maintain stant temperat

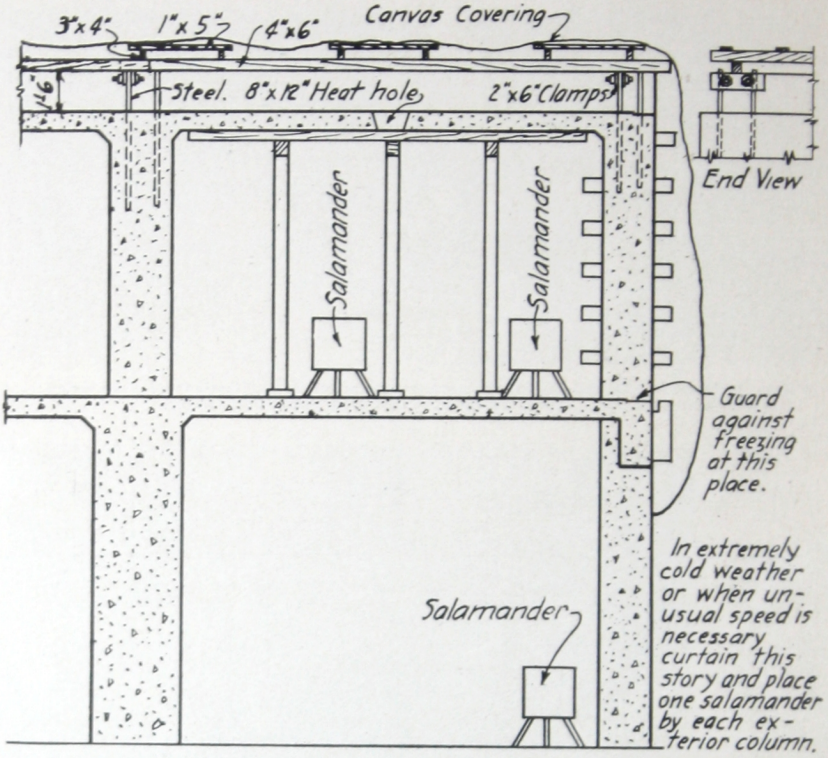
Concrete Work in Cold Weather

An oil-burning heater projected into the mouth of the mixer heats the materials sufficiently to keep the concrete from freezing, providing other precautions are used after placing in the forms.

Steam jets placed in aggregate pile to keep the material from freezing. Frozen lumps may also be thawed out by the use of these jets.

s and behind canvas placed concrete and temperature.

Another method of heating materials by the use of a coal fire in a discarded hot water boiler, seen in the lower left hand corner.



Cross-section of building under construction during winter weather and showing the placing of salamanders and canvas covering.

ing, its temperature when placed in the forms will be around 80 degrees F. and if care is taken to prevent too rapid loss of this contained heat, the concrete will harden properly. The early stages of hardening may be even more rapid than under ordinary conditions.

Heating the Forms

The forms must be free from snow, ice and frost, and should also, if possible, be reasonably warm, especially in the case of metal forms, which will absorb heat from the concrete rapidly. Live steam is an effective agent for cleaning ice and snow from the forms, and warming them. It should be used just before the concrete is placed.

Protection and Supplying Heat While Hardening

A rapid loss of contained heat must be prevented. Protect the concrete while hardening so as to maintain the warm, moist condition essential for the rapid development of strength. There are many

methods of doing this: the most common is an enclosure of canvas or tarpaulins. In mild weather this alone may be sufficient, but when the temperature drops below the freezing point, some means should be provided for heating the enclosure. Steam escaping from perforated steam pipes around the concrete will give the best results, because the steam saturates the air and prevents evaporation of moisture from the concrete.

This 48-apartment building in Milwaukee was completed in time for spring occupancy because the work on the reinforced concrete structural frame was continued without interruption through January, 1923.

Coke salamanders or stoves are often used when steam is not available to supply warmth to the enclosure, but large pans of water should be placed over them in order to provide as much moisture in the air as possible. Care should be taken not to have these stoves or salamanders so close to the concrete as to dry it out in spots. An even temperature of at least 60 degrees F. should be maintained at all times in all parts of the enclosure. To maintain this temperature within a properly housed enclosure during cold weather, with good coke properly handled, one salamander will be required for every 300 to 500 square feet of floor area.

The most common practice is to build inclosures of tarpaulins, overlapped so as to prevent rapid escape of heat, about two stories being inclosed at one time. Undoubtedly a better method was the one followed in the winter of 1922-1923 in the construction of the Keenan Hotel, a 14-story reinforced concrete building in Fort Wayne, Ind. As shown in the illustration on page 3, five stories were inclosed at one time. This prolonged the length of time during which freshly placed concrete was kept warm and resulted in complete hardening before the protection was removed.

A more substantial form of protection is the complete wooden inclosure shown in our illustration of the Robertson-Cataract Electric Company building on page 12. The Majestic Building in Milwaukee,

as the illustration on page 13 shows, was built under a complete inclosure of tarpaulins supported on frame-work. Complete inclosures necessarily cost more than temporary ones that protect only a few stories at a time. Their great advantage, however, consists in the fact that they protect the workmen of all trades and speed up the work from beginning to end. Furthermore, when once built they require no shifting.

The complete inclosure idea was followed in the construction of the three-span reinforced concrete arch bridge over the Little Goose River, in Wyoming, illustrated on page 5. A large tent covered the entire

The Robertson-Cataract Electric Company's building in Buffalo was built in winter under summer temperature conditions. Complete inclosures, while costing more than temporary, movable ones, have the advantage of providing protection from the beginning to the completion of the work, for the workmen of all trades.

bridge site and permitted construction during severe winter weather when the stream was solidly frozen over. The cold weather, in fact, eliminated trouble from running water and actually speeded up the progress of the work. Fires were kept going in stoves with smoke outlets extending through the top of the tent. During the placing of concrete a heavy snow storm, followed by severe cold that lasted several days, tested the effectiveness of the tent. The protection proved equal to the emergency.

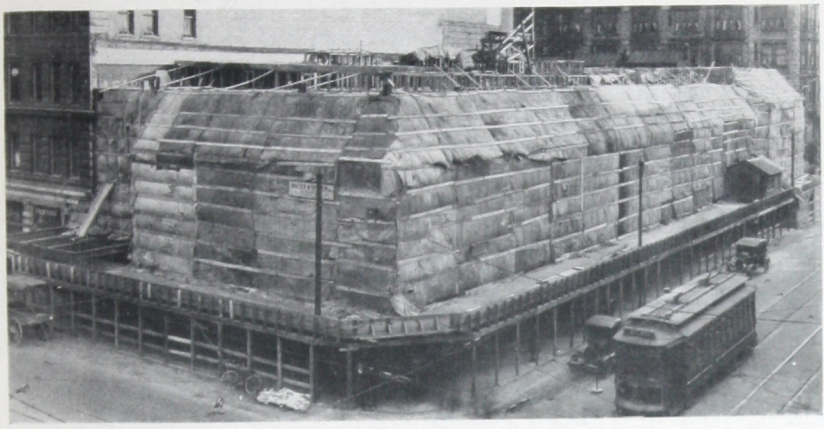
For retaining walls and similar structures a light roofing paper envelope placed outside the forms with steam pipes at the bottom has proved satisfactory.

Protective Coverings

When it is warm during the day with a temperature drop close to the freezing point at night, floors, pavements and foundations are often protected by covering with straw, hay or other material with satisfactory

results, but such covering should not be relied upon during protracted low temperatures.

Even though the outdoor temperature may not drop to freezing, protection is necessary to prevent the concrete from losing the heat



The addition to the Majestic Building, in Milwaukee, was built under a complete inclosure, providing protection to the workmen of all trades as long as the cold weather lasted. This view was taken in February, **1922**.

introduced by heating the materials, and insure proper hardening. At low temperatures the heat developed by the chemical reaction of the cement and water is too small to be safely relied upon except in large masses underground. Even in those cases the materials should be heated and the surface protected.

Thin structural members and floors have such a large surface area in proportion to their size that the heat within the concrete is dissipated rapidly, and therefore protection must be provided. Recent inspection of several concrete floors placed during the winter of 1922-1923 disclosed the fact that the top surface was inadequately protected after being placed. On one floor in particular it is known that the top surface was placed during cold weather and no protection whatever was provided. It was permitted to freeze almost immediately after it was placed, and it is probable that it froze and thawed several times before it hardened. The result was an unsatisfactory wearing course which in many places must be removed and replaced. Work of this kind should be protected with canvas, supported slightly above the surface, and with live steam forced under the canvas. The steam has the excellent characteristic of providing both heat and moisture, both essential in obtaining the best results in the hardening of concrete.

Use of Salt or Calcium Chloride

The practice of adding "anti-freezing" compounds such as sodium chloride (common salt) or calcium chloride solutions to the concrete

mixture is not generally recommended. Under no circumstances should they be depended upon to prevent freezing below 22 degrees Fahr., and they should never be considered substitutes for protection and heating.

Calcium chloride in quantity not exceeding 4 per cent, by weight, of the mixing water is a better anti-freezing agent than common salt. It accelerates the hardening of concrete to some extent, while salt retards hardening. Salt has a tendency to corrode reinforcing steel, and may cause efflorescence, which is unsightly on exposed surfaces.

Even if anti-freezing solutions are used, the aggregates and mixing water should be heated to remove ice or frost.

Application of Load

Too early removal of forms is always to be guarded against even during construction in favorable weather, and great caution should be observed in placing loads upon cold weather concrete. Especially is this true of walls, roofs and floors above ground, which carry loads other than their own weight.

Before removing forms the concrete should be examined to see that it has properly hardened and not frozen. A reliable test is to apply heat to the surface by means of a blow torch or a jet of hot water or steam against it. Frozen concrete will be disclosed by softening as it thaws out, but if properly hardened, the concrete will be unaffected by the application of heat.

Bibliography of Cold Weather Concreting

Those wishing further and more detailed information on cold weather concreting are referred to the following recently published articles:

1. "Concreting Plant Designed for Cold Weather Work." Article by Richard P. Wallis in Engineering News-Record, June 7, 1923, pages 994-996. Describes special layout for cold weather concreting in the construction of a group of buildings in Cleveland, built during the winter of 1922 and 1923. Article outlines the principles of cold weather concreting.

2. "Cold Weather Concreting Methods and Equipment." Engineering News-Record, February 2, 1922, page 196. The article describes plant for heating materials, methods of placing canvas housing, erection of salamanders and fire-protection. The practice described is that followed by the Turner Construction Company, New York City. A similar article entitled "Practical Side of Cold Weather Concreting" is published in Engineering and Contracting, issue of January 25, 1922, page 83.

3. "Cold Weather Concreting in Construction of Hide and Leather Building," an 18-story reinforced concrete building in New York City. Described in Engineering and Contracting, July 26, 1922, page 79. See also illustration on page 4 of this booklet.

4. "Building Concrete Bridge in Cold Weather." Article by G. F. Scales, General Contractor, in Engineering News-Record, October 5, 1922, page 563, describes manure protection method used in building a six-span reinforced concrete arch bridge at Waterloo, Iowa. Heat from manure actually raised temperature of concrete during the first 72 hours.

5. "Concrete Bridge Construction in Winter." Article in Engineering and Contracting, December 28, 1921, pages 585-586, describes and illustrates work on two concrete bridges protected by the housing-in method and one bridge where heating of aggregates was the method used.

Practical Points for Cold Weather Work

From Instructions to Superintendents
By TURNER CONSTRUCTION COMPANY

1. **Aggregates are heated** to best advantage by 1½-inch steam pipes laid as a grill under the piles or by a 6-ft. length of perforated pipe insert, inserted into the pile.

2. **Water is heated** by running a 1½-inch steam pipe into the water barrel.

3. **A 50-horsepower boiler,** carrying 50 to 60 pounds of steam is required for a large job, but an 18 to 25-horsepower boiler is sufficient for jobs of not more than 5,000 square feet of floor area.

4. **One salamander** is usually sufficient for 300 square feet of floor area and a heat hole should be provided for each salamander. (See Page 10.)

5. **Columns** should be concreted the same as the floor and column tamping continued for an hour or more after the floor is concreted.

6. **Bases of exterior columns** are most difficult to protect and in extremely cold weather a salamander should be placed on two sides of exterior columns.

7. **For unusual speed or cold weather** or when monolithic walls are carried up, the lower floor should be curtained and salamanders placed at exterior columns.

8. **Apply fuel to salamanders frequently** and in small quantities to minimize smoke and provide uniform temperature.

9. **Water barrels** should be provided to extinguish fires and care taken to secure canvas against blowing against salamanders.

10. **A detailed temperature record** should be kept showing date, hour, outside temperature, temperature at bottoms of columns, underside of slab, under the canvas over the slab, temperature of concrete as deposited and, especially, temperature at bases of exterior columns on windward side of building.