IN-LB	Inch-Pound Units
SI	International System of Units

Guide to Placing Concrete with Belt Conveyors

Reported by ACI Committee 304

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Always advancing

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This report includes a short history on the early development of conveyor belts for transporting and placing concrete; the design of conveyor systems in relation to the properties of the plastic concrete, the delivery rate, and the job specifications; as well as belt widths, speeds, and angles of inclination as they apply to specific site requirements. Also discussed are the three types of concrete conveyors (portable, feeder, and spreader types) and their particular applications; field practices in the selection, use, and maintenance of conveyors; and the economics of belt conveyor placement. The quality of the in-place concrete and inspection procedures are also stressed.

Keywords: belt conveyors; concrete construction; conveying; conveyors; economics; feeders; fresh concrete; inspection; maintenance; placing; quality control; workability.

CONTENTS

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CHAPTER 1—INTRODUCTION

1.1—General

Belt conveyors for handling normalweight concrete are special in that they transport plastic concrete, which is heavier than aggregate or other commonly conveyed materials. They transport plastic concrete from a supply source such as a truck mixer or a batching and mixing plant to the point of placement or to other equipment that is used to place the concrete. Concrete placement by belt conveyors should be a continuous operation. Maximum success for conveyor placing requires a constant supply of properly mixed concrete for charging the belt conveyor and a provision for moving the discharge point during placement so that the plastic concrete is deposited over the entire placement area without the need for rehandling or excessive vibration. Concrete belt conveyors are classified into three types: 1) portable or self-contained; 2) feeder or series; and 3) spreader—radial or side discharge.

1.2—History

The earliest recorded use of belt conveyors in North America was to handle grain. The first recorded use of belt conveyors to handle material heavier than grain did not come until the early 1890s when belt conveyors were installed at an ore processing plant in Edison, NJ (Rines 1920). The commercial introduction of antifriction bearings in idler rollers paved the way for the modern belt conveyor. In 1923, conveyors were first successfully used in handling coal (Conveyor Equipment Manufacturer Association 1997).

The first known successful use of concrete belt conveyors was in 1929 when a 600 ft (183 m) conveyor was used to place structural concrete for the East 238th Street Bridge, Bronx County, NY. The concrete mixture (1:2:4) contained 3/4 in. (19 mm) nominal maximum-size aggregate (NMSA).

Between 1935 and 1944, belt conveyors were used to transport concrete between the mixing plant and a central distribution point where the concrete was loaded into buckets for placement. These projects used from 320 to 432 lb/yd^3 (190 to 256 kg/m^3) of cement and 4 to 6 in. (100 to 150 mm) NMSA. Segregation of the largest aggregate at the transfer points and hoppers gave considerable trouble and various baffles, chutes, and hoppers were developed to reduce segregation to a minimum (Tennessee Valley Authority 2013). From 1941 to 1950, concrete belt conveyors were used successfully to place concrete on seven different dam projects (Malcolm and Young 1950).

1.3—Concrete conveyor development

The almost universal availability of ready mixed concrete for building projects in the United States in the early 1950s created a demand for equipment to bridge the gap between the area accessible to the truck mixer and the location where the concrete was to be placed. The first commercially available portable concrete belt conveyors were marketed in the late 1950s (Cope 1963).

The transporting or feeder conveyor was developed in 1962 (Oury 1963) and the first spreading belt conveyor was a side-discharge unit used in 1963 to place the deck concrete for the elevated East 46th Avenue Freeway in Denver, CO. Radial spreaders were developed shortly thereafter.

Modification and improvement of these conveyors have been rapid and significant. Early belt conveyors were limited to capacities of 30 to 40 yd^3/h (23 to 31 m^3/h). Today, placement rates of 120 yd^3/h (92 m^3/h) on 16 in. (406 mm) wide belts and 300 yd^3/h (230 m^3/h) on 24 in. (610 mm) belts make concrete belt conveyors applicable to massive concrete placements as well as to building construction.

Concrete belt conveyors are an excellent method for moving concrete from the batch plant to the lift surface on roller-compacted concrete (RCC) projects because they eliminate tracking mud onto the lift surface and damage from turning haul vehicles. All concrete conveyors require charge and discharge hoppers, belt wipers, and proper combinations of belt support idlers and belt speed to prevent segregation of the concrete. Any normalweight or lightweight aggregate concrete that can be discharged by a truck mixer can be placed by a concrete belt conveyor. In addition, concrete containing 3 and 6 in. (75 and 150 mm) coarse aggregate has been transported successfully on 16 and 24 in. (406 and 610 mm) wide belt conveyors, respectively (Cope 1972b). Belt conveyors were used successfully on Upper Stillwater, Elk Creek, and Middle Fork dams (Hansen 1991).

CHAPTER 2—DEFINITIONS

Please refer to the latest version of ACI Concrete Terminology for a comprehensive list of definitions.

CHAPTER 3—DESIGN CONSIDERATIONS

3.1—General requirements

Not all belt conveyors can successfully place concrete. Concrete conveyors should be designed specifically for concrete transport (Illingworth 1972). Concrete conveyors running at the correct belt speed and with properly functioning charging hoppers, transfer devices, and belt wipers have only a minor effect on the strength, slump, or air content of the concrete that they carry (Panarese 1972; Saucier 1974). Successful layout of concrete belt conveyors for specific job applications depends on an understanding of the interaction of the many variables involved, such as slump, placement rate, site location, travel paths required, aggregate size, and others too numerous to mention. Most unsuccessful attempts to place concrete with belt conveyors can be traced directly to a failure to incorporate in the design the capability of meeting the following handling and placing requirements:

a) All components of the conveyor should be sized to accommodate the weight of concrete, especially the drive unit, support frame, and belt support idlers. Normalweight concrete is approximately 50 percent heavier than commonly conveyed materials such as aggregates.

b) The conveyor itself, or at least the concrete discharge mechanism, should be capable of movement over the entire placement area without significantly interrupting or delaying concrete placement. This is because the concrete needs to be distributed uniformly over the entire placement area. When placement in lifts is required for proper consolidation of the concrete, the discharge mechanism need for movement is greatly increased to allow access for vibration.

c) Concrete belt conveyors should be able to stop, hold the concrete on the belt, and restart the fully loaded belt. This is because placement cannot progress faster than the concrete can be spread and consolidated. This is especially important when conveyors place concrete in wall and column forms because it is difficult to control filling of the form by varying only the rate of charging of concrete onto the conveyor.

d) Concrete belt conveyors should be designed to operate dependably under capacity loads without mechanical failures. Once placement begins, it should continue without interruptions that could result in cold joints. Reliability and dependability cannot be achieved simply by making components larger and heavier because this conflicts with the requirements of mobility over the placement area. To meet the requirements of mobility and dependability, the booms of most concrete belt conveyors are constructed of steel trusses or aluminum extrusions. Lightweight belt support idlers and drive components are used wherever possible.

3.2—Concrete ribbon parameters

The characteristics of the ribbon of concrete on a conveyor belt are determined by the angle of surcharge of the concrete, the required minimum edge distance, and the load cross section.

3.2.1 *Angle of surcharge*—Each plastic concrete mixture has its own angle of repose. This is the angle that the surface of a normal, freely formed pile makes to the horizontal. The angle of repose for 2 to 6 in. (50 to 150 mm) slump concrete will usually range from 20 to 30 degrees. The angle of surcharge is the angle to the horizontal that the surface of the same concrete assumes while it is being carried on a moving (horizontal) belt conveyor. The angle of surcharge for most concrete falls in a range from 0 to 10 degrees (Conveyor Equipment Manufacturer Association 1997). A lower angle of surcharge results in a shallower ribbon of concrete. The angle of surcharge is influenced by slump/slump flow, aggregate characteristics, and mixture proportions, meaning that the ability of the concrete to flow by its own weight (rheology) properties will also affect the angle of surcharge. Such properties include:

a) Size and shape of the aggregate

b) Surface texture of the coarse aggregate

c) Ratio of fine aggregate to coarse aggregate (*FA*/*CA*)

d) Ratio of aggregate to cementitious materials (*a*/*cm*)

e) Ratio of water to cementitious materials (*w*/*cm*)

f) Additives such as fly ash, slag, metakaolin, and others, which affect cohesiveness

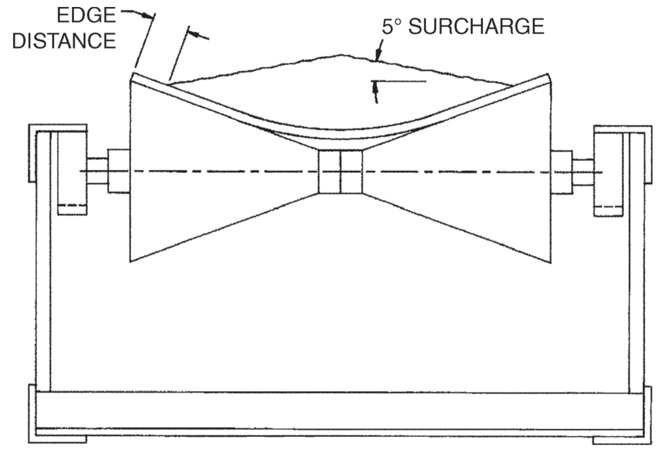

Fig. 3.2.1—Belt cross-sectional area.

g) Chemical admixtures that effect concrete properties

The angle of surcharge of plastic concrete is influenced by all its components. Small aggregates; water; and smooth, rounded, and uniform size aggregate tend to reduce the angle of surcharge. Irregular, rough aggregate; cement; and additives that make the mixture more cohesive or reduce the water requirement tend to increase the angle of surcharge. The angle of surcharge determines the cross section of the concrete ribbon that can be efficiently carried on the belt. It is also an indication of the maximum angle of incline or decline at which concrete can be handled by a belt conveyor. Angle of incline and angle of decline refer to the angle to the horizontal formed by the load-carrying belt of the conveyer.

The many variables that influence the angle of surcharge of concrete make it difficult to predict the maximum permissible angle of incline or decline. A good rule of thumb is that a concrete belt conveyor can operate with less than a 10 percent loss of cross-sectional area (refer to Fig. 3.2.1) at an angle of 20 to 25 degrees when equipped with a smooth belt and up to an angle of 30 to 35 degrees when the belt is equipped with small straight corrugations or ribs on the load-carrying surface (Conveyor Equipment Manufacturer Association 1997). Concrete has been successfully conveyed at greater angles of incline or decline with close control of factors that affect the angle of surcharge.

As the belt passes successively over each belt-supporting idler, the concrete on the belt is disturbed. This tends to work pieces of coarse aggregate to the surface of the concrete and to flatten the concrete ribbon. This is the primary reason that the angle of surcharge is less than the angle of repose. A proper combination of belt tension, belt speed, and idler spacing is necessary to prevent objectionable segregation (3.5.7). Belt speeds of 300 to 600 ft/min (92 to 183 m/min) with 3 ft (0.9 m) idler spacing and belt speed of 600 ft/min (183 m/min) on idlers spaced approximately 5 ft (1.5 m) apart have been used successfully on many projects.

3.2.2 *Minimum edge distance*—Concrete cannot be carried across the entire face of a belt. The ribbon of concrete should be centered on the belt with equal widths of clear belt or edge distance between it and each edge of the belt. The following equation is used to determine minimum edge distance: minimum edge distance, in. = 0.05 belt width + 0.9 in. (= 0.05

belt width + 23 mm)—that is, for a 16 in. belt, minimum edge distance is (0.05 × 16 in. + 0.9 in.) = 1.7 in. (40 mm).

Failure to observe the minimum edge distance requirement will result in excessive spilling and loss of large aggregate off the edge of the belt.

All concrete belt conveyors use idlers that trough or cup the belt, enabling it to carry a deeper ribbon of concrete than would be possible on a flat belt. The head pulley is usually slightly crowned to provide belt alignment or training (3.5.3). Because the belt flattens as it goes over the head pulley, the ribbon of concrete tends to flow toward the belt edges in the area between the last belt support idler and the head pulley. The loss of edge distance in this area and in the area where concrete is charged on the belt will establish the maximum load cross section of any given concrete mixture that can be handled by a given concrete belt conveyor.

3.2.3 *Load cross section*—The nominal cross section of the ribbon of concrete on a belt conveyor is measured in a vertical plane. All capacity calculations are based on this cross-sectional area and the belt speed.

As the angle of the belt (either incline or decline) is increased, the ribbon of concrete on the belt becomes shallower. This reduction in ribbon size increases the tendency for larger pieces of coarse aggregate to break loose from the ribbon of concrete and roll away. The size, shape, and surface characteristics of the coarse aggregate have an important effect on this tendency. As the angle of incline is increased, the tendency of the concrete to flow or slide back reduces the belt capacity for a given belt speed. The maximum angle at which a given concrete can be conveyed is determined when one of these factors identified in 3.2.1 becomes objectionable.

3.3—Belt charging

As concrete is loaded on a belt conveyor, any difference between its velocity in the direction of belt travel and the speed of the belt should be equalized by acceleration or deceleration of the concrete, which results in turbulence. Properly designed charging hoppers use this turbulence to produce a remixing of the concrete as it flows onto the belt. The turbulence should not be severe and result in concrete is spillage off the edges of the belt or a loss of individual pieces of coarse aggregate. Concrete with a low angle of surcharge accelerates to belt speed quicker and easier than concrete with a higher angle of surcharge.

A concrete belt conveyor should be equipped with a charging hopper that levels out surges of concrete flow and delivers a uniform ribbon of concrete onto the belt with proper edge distance. An alternative is a metering belt (Illingworth 1972) (4.2).

The wider belt can accept more concrete from a charging hopper without spilling and its speed is adjusted to charge the conveyor system at its maximum capacity. A metering belt conveyor is used as the first unit in a system of conveyors to achieve a higher capacity than could be achieved by feeding concrete directly to the conveyor system from a charging hopper. It is a conveyor with a belt that is wider and travels slower than those used in the rest of the system.

3.4—Belt discharge

Plastic concrete is traveling at the same speed as the belt when it is discharged from a belt conveyor. Plastic concrete would leave the belt as a cohesive mass except that the inertia and impetus of the larger pieces of coarse aggregate tend to separate from the stream and some mortar will cling to the belt. The energy contained in the concrete mass should be dissipated or redirected by a discharge hopper to prevent segregation. The turbulence created by this dissipation of energy produces a remixing action in properly designed hoppers. As the angle of incline or decline of a concrete belt conveyor is changed, the angle of the discharge hopper with respect to the horizontal is also changed. While most discharge hoppers function properly if slightly tilted, they may plug and delay operation.

Each end-discharge concrete belt conveyor should be equipped with a belt wiper or scraper to limit mortar loss (Panarese 1972). The wiper or scraper should be positioned so that the mortar is directed into the discharge hopper for remixing. Belt wipers depend on moisture in the concrete for lubrication and cooling. Dry belts should not be operated unless the belt wipers are removed.

Properly designed discharge hoppers, chutes, drop-chutes, or "elephant trunks" will eliminate concrete segregation problems at transfer and discharge locations. Job conditions frequently limit the size of such accessories, so numerous designs have been developed through trial and error that produce satisfactory results with the specific concrete mixture being placed. ACI 304 and The U.S. Bureau of Reclamation (1988) provide for a 24 in. (610 mm) minimum length drop-chute or elephant trunk. This length has been found to produce acceptable results in most cases; however, this should not preclude the use of other designs that demonstrate satisfactory performance under job conditions (6.2).

3.5—Belt conveyor design principles

3.5.1 *Belt materials*—Recent improvements in conveyor belt carcass material and construction have greatly reduced the restrictions on capacity that were made necessary by conveyor belt limitations in the past. Substitution of stronger synthetic materials such as nylon for cotton fabric have made it possible to use higher horsepower drives and to increase capacity by deep troughing or cupping of the belt. New cover compounds have extreme resistance to abrasion from the concrete and the belt wipers. The synthetic materials have also eliminated the mildew problems that had been associated with conveyor belts exposed to weather and moisture. Concrete conveyor belts should be flexible because they operate at high speeds over relatively small-diameter head and tail pulleys.

3.5.2 *Belt splicing*—Almost all conveyor belting is made in long lengths and is cut to fit the conveyor on which it is installed. The ends of the belt should be spliced to make the belt endless. Two types of splices are used: mechanical (clips that hold ends together), and vulcanized (adhesive splice). Each splice type has advantages and disadvantages (Conveyor Equipment Manufacturer Association 1997).

3.5.2.1 *Mechanically fastened splice*—This type of splice has the advantages of quick, easy installation with simple hand tools, low cost, and the capability of permitting shortening of the belt by resplicing whenever belt stretch approaches the limit of take-up provided on the conveyor. It has disadvantages of reduced strength at the splice and a surface that should be ground or filed smooth so it would not damage belt wipers.

3.5.2.2 *Vulcanized splice*—This type of splice has the advantages of higher strength, longer life (although normally these splices will not last for the life of the belt), and smoother belt surface. It has the disadvantages of difficult, slow, and expensive installation requiring special equipment.

3.5.3 *Belt training*—Most concrete belt conveyors are moved frequently, and it is improbable that the supporting structure and belt idlers will always be level in the plane at a right angle to the centerline of the belt. Whenever a belt conveyor is not level, gravity will cause the belt to drift to the low side. With longer conveyors, this problem is more severe. Slight shifting of the belt on the supporting idlers will change the cross section of the concrete on the belt and may result in concrete spillage or in damaging the belt by rubbing it against the supporting structure. This should not be tolerated, and provisions should be made to train the belt in the proper path when the conveyor is not level. Belt training is usually accomplished with specially designed belt support idlers or with guide rollers that contact the belt edge (Fig. 3.2.1).

3.5.4 *Belt width*—The most important single factor in determining load cross section is belt width. A concrete belt conveyor should have a width adequate to carry the desired cross section with an edge clearance adequate to prevent spilling. Occasionally, the belt width should be increased beyond that required for a desired capacity to handle the specified nominal maximum-size aggregate (NMSA). As a rule, belts should be at least 24 in. (610 mm) wide for 6 in. (150 mm) NMSA and 16 in. (406 m) wide for 3 in. (75 mm) NMSA.

A relatively small change in conveyor belt width greatly increases capacity. Increasing belt width from 16 to 24 in. (406 to 610 mm) more than doubles the capacity of the conveyor system at the same belt speed.

The cross section of the concrete on the belt determines the live load that should be carried by the supporting structure. The usual design approach is to use the maximum belt speed that is practical for the concrete mixtures to be placed and the smallest concrete cross section that will produce the desired capacity. This minimizes the conveyor support points on long conveyors.

3.5.5 *Theoretical capacity*—The equation for theoretical capacity is

$$yd^3/h = (0.0154)(A)(B)$$

$$m^3/h = (60)(A)(B)$$

where yd^3/h and m^3/h are volume of concrete per hour; A is cross-sectional area of concrete on belt, in inches (m^2); and B is speed of conveyor belt, in ft/min (m/min).

This equation is used to calculate the maximum placement rate assuming continuous charging of the conveyor. On a job, downtime of the conveyor results in averaging approximately 70 percent of theoretical capacity. Specific job conditions may dictate using a lower or higher efficiency rate (5.2).

Table 3.5.5—Concrete belt conveyor capacity

Rate of placing for continuous loading, yd^3/h							
	Belt speed, ft/min						
Belt size, in.	100	200	300	400	500	600	700
0-degree angle of surcharge							
16	23	46	69	92	115	138	161
18	30	61	91	122	152	182	212
20	36	73	110	146	182	219	255
22	43	86	128	171	214	256	299
24	49	98	147	196	244	294	342
5-degree angle of surcharge							
16	29	57	86	115	143	172	201
18	38	77	115	153	191	230	268
20	46	93	140	186	233	279	326
22	55	110	166	221	276	331	386
24	64	119	193	258	322	387	452
Rate of placing for continuous loading, m^3/h							
Belt size, mm	Belt speed, m/min						
	30	60	90	120	150	180	210
0-degree angle of surcharge							
410	17	35	52	69	87	104	121
460	23	46	68	92	114	137	160
510	27	55	83	110	137	165	192
560	32	65	96	129	161	193	225
610	37	74	111	148	184	221	257
5-degree angle of surcharge							
410	22	43	65	89	108	129	151
460	29	58	87	115	144	173	202
510	35	70	105	140	175	210	245
560	41	83	125	166	208	249	290
610	48	93	145	194	242	291	340

A convenient method of estimating concrete belt conveyor capacity is to use published conveyor capacity tables. These tables usually assume continuous horizontal operating conditions, average angle of surcharge, and a conventional three-roll idler configuration. An example of such is given in Table 3.5.5.

A capacity safety factor is desirable and can be obtained by selecting conveyor capacity in excess of job requirements (5.2). These tables are sufficiently conservative to cover average conditions and are usually accurate enough for most purposes (Goodyear Tire and Rubber Company 2012). The equation shows a direct proportion between capacity and belt speed so that capacities can be calculated for belt speeds not shown. Some tables are prepared on the basis of weight per hour instead of volume per hour. Conversions can be made if the weight of the material on which the chart is based is known—that is, 1 yd^3 (1 m^3) of concrete weighs approximately 2 tons (2400 kg), whereas 1 yd^3 (1 m^3) of gravel weighs only 1.33 tons (1600 kg). The factors that control the cross-sectional area of concrete on a belt (3.2.3) may also require adjustment of values from such tables.

3.5.6 *Belt speed*—It is desirable to keep the belt weight of concrete on the belt and the time it is exposed to ambient conditions to a minimum; therefore, concrete belt conveyors should run at optimum belt speed. As a rule, optimum belt speed is defined as the belt speed that will maintain the quality of the concrete and produce an acceptable level of placing capacity. Generally, this is in the range of 300 to 750 ft/min (92 to 229 m/min), depending on the type of concrete belt conveyor involved, the angle of surcharge of the concrete, and the angle of incline or decline of the conveyor.

3.5.7 *Belt idlers and belt tension*—The proper combination of idler spacing and belt tension allows concrete belt conveyors to stop and hold concrete on the belt without spillage. The stiffness of the belt is insignificant, so belt tension is relied on to minimize the belt sagging between idlers. Increasing idler spacing decreases the overall weight of the concrete conveyor, but increases the belt tension required for successful operation. Belt stretching is directly related to belt tension. Belt training becomes difficult if belt tension is excessive. Spilling of concrete off the edges of an apparently properly loaded belt usually indicates either inadequate belt tension or too-large idler spacing.

All conveyor manuals contain charts that facilitate the selection of proper idler spacing. In using these charts, keep in mind that density of concrete is approximately 150 lb/ft^3 (2400 kg/m^3).

The ability of the conveyor drive to transmit pull to the belt depends on the arc of contact of the belt on the driving pulley, and the friction coefficient between the belt and the driving pulley and on the slack side belt tension (Goodyear Tire and Rubber Company 2012). The diameter of the driving pulley is of little importance. The most commonly used belt driving pulleys are made from steel. These pulleys are usually lagged or covered with some form of rubber, fabric, or other material to increase the coefficient of friction between the belt and the driving pulley. Lagging also helps to reduce wear on the pulley face and to affect a self-cleaning action on the surface of the pulley.

Once the belt width, belt speed, and idler geometry have been established, concrete belt conveyor design follows established engineering principles presented in the Conveying Equipment Manufacturer Association (CEMA) book, *Belt Conveyors for Bulk Materials*. The design of successful charging, transfer, and discharge mechanisms is empirical and dependent on the ingenuity of the designer (Conveyor Equipment Manufacturer Association 1997).

3.5.8 *Belt enclosures*—Operating conditions for concrete belt conveyors require the use of watertight or waterproof electrical components, sealed bearings, and closed hydraulic circuits. Consequently, there is no equipment-related reason to protect the conveyors from weather and environmental conditions.

There is rarely a need to enclose or protect the concrete on portable conveyors or on other types of conveyors up to 200 to 300 ft (60 to 90 m) long. The concrete is conveyed at high speed and is exposed to ambient conditions for only a short time. During construction of the Castatic Power Plant in Southern California, concrete was conveyed a greater distance. On a bright sunny day with 90°F (32°C) ambient temperature and no protection for concrete on the belts, the temperature of the plastic concrete increased only 3 to 4°F (2°C) when it was conveyed 700 ft (213 m) (Cope 1972a). The time required to move concrete the full length of the conveyor system was approximately 1 minute.

For construction of Stage II of Melvin Price Locks and Dam on the Mississippi River, a system of 20 in. (510 mm) belt conveyors transported concrete from the batch plant across a bridge to the lock area and down the cofferdam the length of the lock. The conveyor system transported concrete up to 2900 ft (880 m) at rates of up to 300 yd^3/h (230 m^3/h). At the longest reach, concrete was on the belts for only 4 or 5 minutes and air content varied from 1.5 to 2 percent and slump loss range was from 1 to 1.5 in. (25 to 38 mm). During summer placement, concrete that left the batch plant at 60°F (15°C) experienced a total temperature gain of less than 5°F (2.8°C) with at least 4°F (2.2°C) of this rate attributable to hydration of the concrete. During cold weather, the concrete experienced little or no temperature loss (Cope 1990).

Experiments that simulated transporting concrete up to 6000 ft (1800 m) with conveyors were conducted at the U.S. Army Engineer Waterways Experiment Station (Saucier 1974). They established that there was no change in the temperature of the concrete due to conveying. When the concrete temperature was higher than the air temperature, the concrete temperature tended to decrease; when concrete temperature was lower than the air temperature, it tended to increase. The rate of increase or decrease was dependent on the initial difference in temperature.

These experiments confirmed earlier work that indicated that elapsed time (that is, time after water was added to the mixture) had a significant effect on the measured slump of the concrete (Wilson and Stowe 1971). Under relatively severe drying conditions (that is, temperatures above 70°F [21°C], relative humidity below 50 percent, and wind velocity greater than 10 mph [16 km/h]), the slump loss attributable to conveying concrete 1500 ft (450 m) was approximately 0.5 in. (13 mm). Concrete conveyed over 3000 ft (900 m) experienced a more pronounced slump loss of approximately 2 in. (50 mm). Strength tests indicated a definite increase in strength corresponding to the decrease in slump. The loss of entrained air was less than 0.5 percent of concrete originally containing approximately 5 percent air (Saucier 1974).

If extreme ambient conditions are anticipated when conveyor systems longer than 1500 ft (450 m) are to be used, some form of enclosure may be necessary to maintain the workability of the concrete or to protect it from freezing. Enclosures mounted on the conveyor increase the dead load, which should be supported by the conveyor structure and may require adjustments in structural design. Self-supporting enclosures increase the capital investment required for a conveyor system and are generally practical only on stationary conveyor applications.

3.6—Concrete mixture proportioning for conveying

All structural concrete can be handled satisfactorily by a concrete belt conveyor. Extremes of slump, either below 1 in. (25 mm) or above 7 in. (178 mm), tend to reduce the placing capacity of a belt conveyor significantly. Low-slump concrete does not flow onto the belt as quickly as concrete with a higher slump. High-slump concrete will not exceed a water profile or zero angle of surcharge on the belt. The rollback tendencies of NMSA in excess of 4 in. (100 mm) greatly reduce the permissible angle of incline or decline. Maximum placing efficiency and capacity with belt conveyors can be obtained with a plastic concrete mixture with the slump controlled within the range of 2 to 4 in. (50 to 100 mm). Belt speed becomes more critical when the slump is outside this ideal range. Generally, lower slumps require slower-moving belts, whereas higher slumps require faster-moving belts (Panarese 1972).

3.7—Specifications

To assure satisfactory performance of a concrete belt conveyor, all factors treated in the preceding paragraphs should be incorporated into the design of the conveyor. No single factor is of such overriding importance that it alone would produce satisfactory or unsatisfactory operation.

Although frequently blamed for causing segregation of concrete, conveyor belt speed, head pulley diameter, and belt tension are seldom a main cause (Oury 1970). It is recommended that specifications relating to concrete belt conveyors call for the desired end result for the concrete in place rather than specific details of conveyor design. The recommended field practice contained in Chapter 5 may be incorporated into job specifications where applicable.

CHAPTER 4—TYPES OF CONVEYORS AND FUNCTIONS

4.1—General

Different project requirements have resulted in the development of portable, feeder, and spreading conveyors for concrete placement. Each type may be used alone or combined with others to form a conveyor system.

4.2—Portable conveyors

Short-lift or short-reach concrete placing applications require the use of a portable belt conveyor. This type of equipment may differ from manufacturer to manufacturer, but all portable conveyors have certain basic characteristics. The most important characteristic is that each unit is self-contained and can be readily moved about the project. Each unit should carry its own power supply because no equipment can be considered truly portable if it is dependent on a stationary power source. Belt widths of 16 or 18 in. (406 or 460 mm) are most common. The weight and mobility tradeoff of the portable belt conveyor restricts its overall length to approximately 60 ft (18 m). This, in turn, establishes the maximum discharge height at approximately 35 ft (11 m). The maximum discharge height is determined by the maximum angle of incline at which concrete can be handled efficiently on the belt (3.2.3).

Portable belt conveyors are generally powered with diesel or gasoline engines and use hydraulic drive systems to power the load-carrying belt. Hydraulic drive systems have a high horsepower-to-weight ratio and the ability to start and stop capacity loads without danger of mechanical problems. These conveyors are equipped with a boom-elevating mechanism and can be self-propelled and have power steering.

Portable belt conveyors (Fig. 4.2) place more concrete each day than all other types of conveyors combined because most ready mixed concrete placements that require intermediate handling fall within their lift and reach capabilities.

A self-propelled 56 ft (17 m) overall length belt conveyor with 30 hp (22 kW) engine and power steering can place at a rate as high as 100 yd^3/h (76.5 m^3/h). The discharge of the concrete from a portable belt conveyor is either by a chute that swings through an arc of 360 degrees or by a drop chute or elephant trunk for below-grade or deep-form applications.

Because setup costs for portable belt conveyors are nominal, they can be used for placements, such as columns, where only a small volume of concrete is involved. On large projects, several portable conveyors may be used to handle separate, widely spaced placements at the same time, or they may be combined to obtain high capacity for large placements.

4.3—Feeder conveyors

Long-reach concrete placing applications require the use of transporting or feeder-type belt conveyors (Fig. 4.3a) that operate in series with end discharge transfer points.

The primary design criterion is to have a system of multiple conveyors that operate together in an integrated system and automatically prevent overloading of any individual unit or transfer point. Because the use of such a system involves an appreciable setup time, this type of belt conveyor is normally used only for large volume placements. To simplify the problems of control and coordination, feeder belt conveyors are normally powered with alternating current electric motors so that the load-carrying belt speed will be controlled by the power supply. The electrical system for feeder belt conveyors should meet several critical requirements. Because motors are 5 hp (3.7 kW) or larger and the distances covered are long, three-phase power at higher voltages is recommended. Controls and cables should meet the normal electrical code requirements and be safe for use in a wet environment. The motors should be protected against both overload conditions and low-voltage conditions by following local electrical codes pertaining to cable lengths for cables required for use. In long-reach conveying systems, it is important that the conveyors automatically start in sequence, with the discharge conveyor starting first and successive conveyors back to the charging point starting at intervals. It is not desirable for all the electric motors to be started simultaneously under load because starting current is much higher than running current. Feeder conveyors are frequently used in areas where the only power available comes from portable generators, and this feature permits the use of smaller generators. In addition to the electrical considerations, sequence starting is required by the nature of concrete conveying. The concrete-carrying belts cannot handle surges, so it is important that the system operators ensure that each flight or unit of the system is operating at the proper belt speed before concrete is discharged onto

Fig. 4.2—Portable conveyor application.

the belt. This avoids spilling of concrete and plugging of transfer points.

Feeder belt conveyors are operated over an easily installed rail or track that allows the feeder train to be extended or retracted without interrupting concrete placement. Development of the track system made it possible to use heavier units in the feeder train; 30 and 40 ft (9 and 12 m) units are most common. On long-reach applications such as bridge decks, units up to 85 ft (26 m) are used. Longer conveyors provide a lower equipment cost per foot (meter) of reach, but they may increase cost for transportation to the project and setup time.

Selection of the proper length equipment for a specific project is determined by the relative importance of these

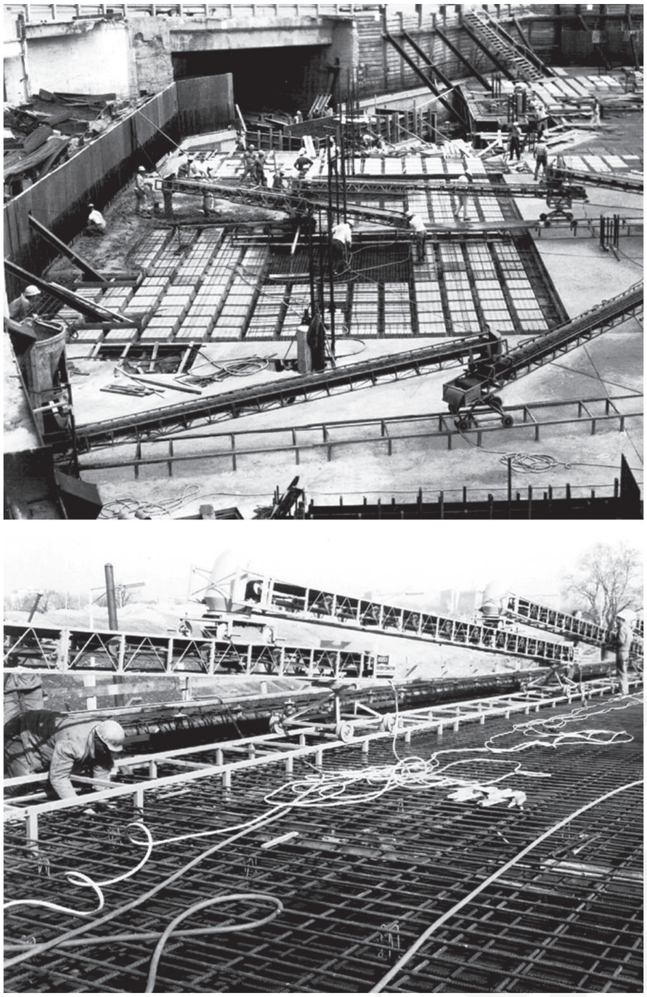

Fig. 4.3a—Feeder conveyors.

different factors. Most feeder conveyors use 16 in. (406 mm) wide belts traveling at relatively high speeds, in excess of 500 ft/min (153 m/min). Such a feeder train has a capacity for concrete placement of up to 120 yd^3/h (92 m^3/h).

Generally, feeder belt conveyor trains are completely set up before concrete placing begins. Individual units can be moved on the track to extend or retract the train without interrupting concrete placing.

On large projects, relatively permanent feeder belt conveyor installations can be established. Under these conditions, much longer conveyor units may be used. From 1969 to 1971, a total of 186,000 yd^3 (142,000 m^3) of concrete was placed in the spillway, stilling basin, and power plant at Dworshak Dam using such a conveyor system (U.S. Army Corps of Engineers 1972). A 659 ft (201 m) long, 18 in. (460 mm) wide feeder belt conveyor traveling at 710 ft/min (216 m/min) moved concrete down a 30-degree slope to the placement area (Fig. 4.3b).

Concrete mixtures having maximum-size aggregates up to 3 in. (75 mm) were used. The problems of segregation, sliding, and piling of material were effectively eliminated on the conveyor system that was fed by a metering belt conveyor. At the Dworshak Dam installation, the metering belt was 30 in. (760 mm) wide and traveled at 125 ft/min (38

Fig. 4.3b—Feeder belt conveyor 659 ft (200 m) on Dworshal Dam spillway operating down 30-degree slope.

m/min). With communications between the operators at the discharge and charging points and a concrete feed hopper with a manually operated gate, this system provided a uniform ribbon of concrete to the placement area. Additional feeder conveyors in the train occasionally operated at angles of incline up to 35 degrees with belt speeds of 1000 ft/min (305 m/min) with 1.5 in. (38 mm) nominal maximum-size aggregate (NMSA) concrete.

Because feeder belt conveyors move a large volume of concrete, the spreading of the concrete at the discharge end of the train requires specific attention. Usually, feeder conveyors discharge into equipment especially designed for spreading concrete.

4.4—Spreading conveyors

4.4.1 *Radial spreaders*—Radial spreaders (Fig. 4.4.1a) are mounted in the placing area on a cantilevered support that swings the discharge end through an arc. It also has some provision for extending and retracting the placing conveyor a substantial distance. Cantilevered radial spreaders normally rely on outrigger legs supported by the forms or the base on which the concrete is being cast to resist the overturning moment created by the loaded belt. The simplest and least expensive models of this type are operated manually and are not more than 30 ft (9 m) long. If the cantilevered support can swing the conveyor through an arc of 180 degrees, placement widths up to 60 ft (18 m) can be achieved. Swinging through an arc much greater than 120 degrees, however, becomes quite inefficient because this requires moving the entire radial spreader unit frequently.

Powered radial spreaders that can raise or lower and extend or retract the conveyor boom under power increase the efficiency of radial spreading substantially. Adding these power and reach features, however, increases the total weight of the radial spreader, which in turn increases the difficulty and expense both of installation before placement begins and movement during placement.

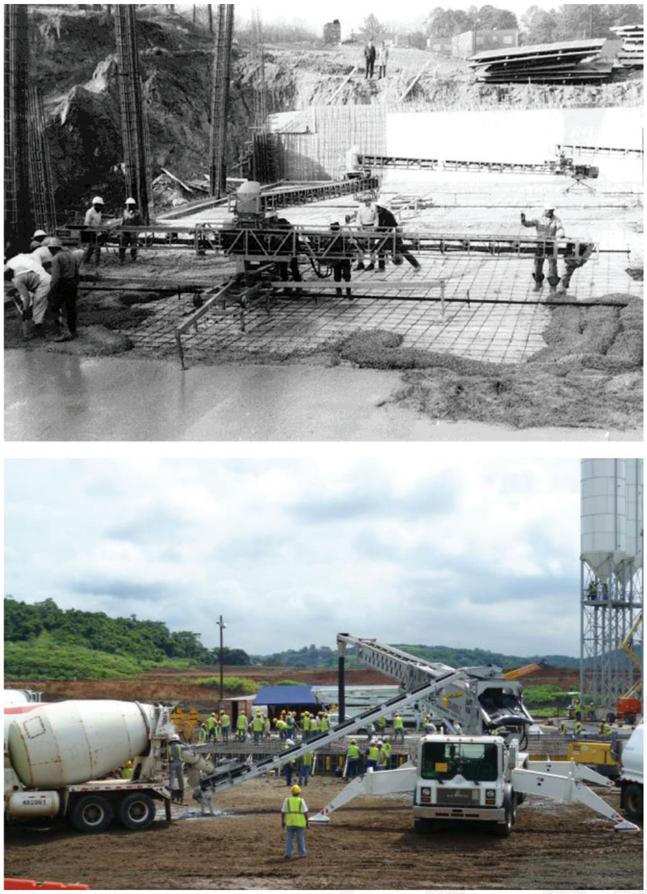

Fig. 4.4.1a—Radial spreading.

The limitations of reach and weight of radial spreading units have been largely overcome through the use of two- or three-section telescoping conveyors mounted on tracks or the telescoping boom of a hydraulic crane (Fig. 4.4.1b). Models are available that have the ability to reach through a radius of up to 65 ft (20 m) on small units and 125 ft (38 m) on the largest units. The largest units are able to reach 75 ft (23 m) vertically with the boom at a 30-degree angle of incline. Such units are rated to place up to 240 yd^3/h (185 m^3/h).

Radial spreaders have the advantages of relatively quick setup time and the capability of reaching past obstructions. They also create a minimum obstruction or congestion in the placement area itself. One disadvantage of radial spreaders is the loss of efficiency in rectangular placements where the radius requirement is established by the center to the corner reach requirement of the placement. For wide placements, the most efficient method of equipment use and the best placement pattern for finishing with mechanical equipment are achieved by side-discharge conveyors or straight-line spreaders (Cope 1972a).

4.4.2 *Side-discharge conveyors*—Side-discharge conveyors (Fig. 4.4.2a and 4.4.2b) span completely across the placement area. By discharging concrete over the side of the belt with a traveling plow or diverter, they place a straight ribbon of concrete that is ideal for mechanical finishing. Because truck mixers cannot chute concrete efficiently more than 10 to 12 ft (3 to 4 m), many side-discharge conveyors 24 to 32 ft (7 to 10 m) long are used to spread concrete for decks, warehouse floors, airport ramps, streets, and other flat slab work. Side-discharge conveyors that span up to 100 ft (30 m) are used for large projects such as bridge decks, canal slope

Fig. 4.4.1b—Cranes suspending conveyors to reach difficult access points.

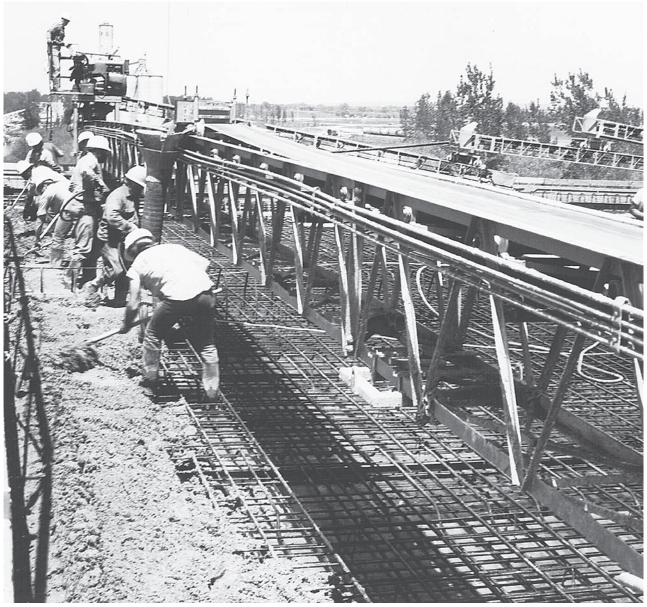

Fig. 4.4.2a—Side-discharge conveyor spreading concrete on bridge deck.

Fig. 4.4.2b—Side-discharge conveyor spreading concrete for slope placements.

paving, dams, and spillways. They also span across excavations to place all the concrete into below-grade work such as foundations, drainage structures, and sewage treatment plants. Side-discharge conveyors normally operate horizontally, so the belt can be loaded heavily. Those equipped with 16 in. (406 mm) wide belts have a capacity of approximately 100 yd^3/h (75 m^3/h), 20 in. (508 mm) wide belt capacity is 200 yd^3/h (153 m^3/h), and 24 in. (610 mm) wide belt capacity is approximately 300 yd^3/h (229 m^3/h). The simplest side-discharge conveyor applications are fed directly from the chutes of truck mixers. Where access is limited, portable or feeder conveyors can be used to bring concrete to the side-discharge conveyor. The use of side-discharge conveyors to spread and place concrete can lower placing costs even where pumps or cranes are also needed to reach the placement area.

Side-discharge conveyors have been used with one end fixed at the center of large circular foundations to permit uniform placement along the radius with the outboard end riding on the perimeter formwork. A 140 ft (42.7 m) diameter silo foundation with a significant center crown requiring 1400 yd^3 (426 m) was placed in 8 hours with this arrangement (Paranese 1972).

A crane using a bucket to bring concrete to the relatively stationary and usually visible hopper of a side-discharge conveyor is significantly more efficient than the same crane swinging blind to place concrete for an elevated slab. The side-discharge conveyor permits a smaller crane to be used in elevating the concrete because the crane can operate with a smaller radius than would be involved in actually placing the concrete in the slab. Side-discharge conveyors have made pumps more practical for wide slabs or decks by eliminating the labor needed to constantly move the discharge end of the pipeline back and forth in front of the commonly used straight-line finishing equipment.

The diverter that removes concrete from the belt and discharges it over the side of the conveyor uses a wiper blade to remove the concrete from the belt. The operation and adjustment of the wiper blade is more critical than on an end-discharge conveyor because it does not have the force of gravity helping to remove the grout and very fine material from the belt. Provisions should be made for adjusting the belt wiper or scraper on side-discharge conveyors while concrete is being placed. Some wear on the wiping strip is normal and a small amount of grout may be carried past the diverter. The grout lost from the concrete mixture in this manner will be end-discharged off the conveyor belt and care should be taken that this material does not form grout puddles in the concrete placement or splatter on previously placed work.

4.5—Conveyor combinations

Concrete belt conveyors are classified according to the function that they perform most successfully. Each type of conveyor has some limited ability to reach, lift, carry, or spread. On complex or large projects, economics will normally favor using each type of machine for the function it performs best. As long as belt speeds and widths are compatible, it is practical to combine equipment and use portable conveyors to reach to either side-discharge or feeder conveyors and for feeder conveyors to charge radial spreading or side-discharge conveyors (Fig. 4.5a and 4.5b).

Feeder belt conveyors were once limited to applications involving horizontal reach only. It is now practical, however, to use such conveyors on elevating or descending applications as well. When horizontal and inclined or declined conveyors are used together, the units that are not horizontal will control the total capacity of the system (3.2.3).

4.6—Special belt conveyors

Conveyors up to 40 ft (12 m) long mounted on truck mixers are used to place concrete. They have hydraulically articulated sectional booms that fold to comply with highway height and length restrictions. These conveyors swing through a wide arc around the rear of the truck mixer and can elevate concrete up to 23 ft (7 m) at the rate of 100 yd^3/h (75 m^3/h). (Refer to Fig. 4.6 and "Superior Concrete Gears Up for Burgeoning Area Growth" [1988].)

Short conveyors mounted to receive the discharge of large concrete buckets or hoppers are used in some precast or

Fig. 4.5a—Portable conveyor supplying side-discharge concrete on elevated slab.

Fig. 4.5b—Feeder conveyors supplying side-discharge conveyor on bridge deck.

prestressed plants. Other such plants use portable conveyors and high-volume plants have used permanently installed feeder and side-discharge conveyor systems to place concrete in the forms. Belt conveyors are used on concrete paving projects. They are part of a machine that receives concrete from a dump truck and conveys it through a 170-degree, 25 ft (7.6 m) radius to place concrete ahead of the paving machine. This practice stops delivery trucks from leaving road mud from wet haul roads in the area where concrete is placed reducing the potential to contaminate the placed concrete.

Conveyors are also used in tunnel work to elevate concrete to the receiving hoppers of concrete pumps. While these machines do not fall completely into any of the three types of conveyors described previously, they do operate within the limits and conditions that apply generally to all concrete belt conveyors.

4.7—Truck-mounted conveyors

Concrete placements with belt conveyors took a large leap forward when telescopic belts were mounted to trucks, providing reaches of 80 to 120 ft (25 to 40 m) as commonly available sizes. Special order equipment can reach out to 200 ft (60 m). The telescopic belt conveyors have framework that allows the truck-mounted conveyor to meet the dimensional requirements to travel on public roads without special permits. Setup time for the conveyors can be as little as 10 minutes, depending on the jobsite conditions.

Commercial availability of the truck-mounted conveyors with reaches that allow complete placements without multiple conveyor resets occurred in the mid-1980s and gained ground in 1990s. The Panama Canal Expansion used truck-mounted conveyors to place concrete for the third set of locks. They arrived on site in 2010 and the project used six 130 ft (40 m) units and one 200 ft (60 m) unit (Putzmeister 2011).

The truck-mounted telescopic belt conveyor typically carries its own feed conveyor (Fig. 4.7). The feed conveyor can be placed as needed to feed the main conveyor that is

Fig. 4.6—Mixer-mounted conveyor.

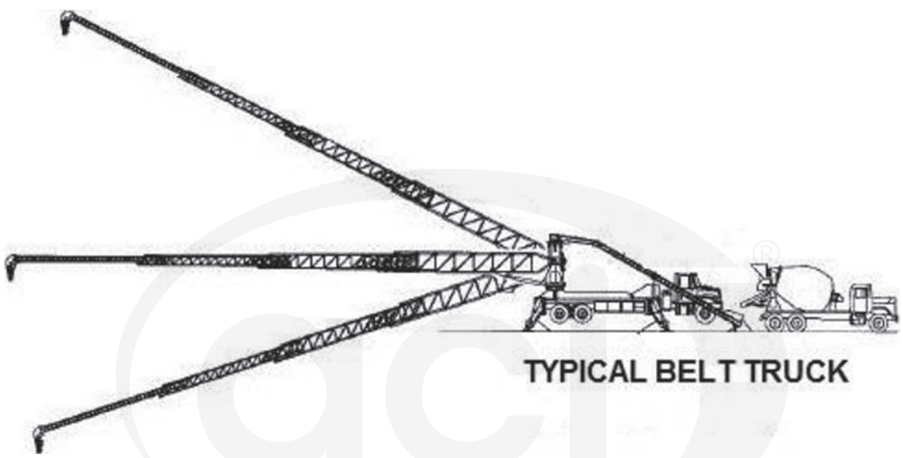

Fig. 4.7—Drawing of telescopic belt truck.

mounted on the truck. The telescopic conveyors have unique take-up systems that thread the conveyor belt, allowing a single belt to be used. Truck belts normally use vulcanized splices to allow for the best use of belt scrapers and idler wear. Care should be taken to clean the telescopic conveyors at the end of placements to stop concrete buildup on frame members that will interact with each other to retract and travel. The units can have remote controls allowing the operator the ability to move the belt into position quickly and keep up the position changes required for efficient concrete placement.

Each jobsite has obstacles that should be considered when locating the conveyer truck and this should be determined on a site-by-site basis. It is common to place conveyors to reach the point farthest from the truck for initial concrete placement and then work back toward the truck.

This does not preclude the operator from assessing the jobsite for hazards that should be avoided to properly use the equipment. Overhead power lines should also be taken into consideration when placing the unit on the jobsite. Avoid placing the conveyor unit next to unsecured excavations that may settle when the conveyor is fully loaded with concrete.

4.8—Economics of conveyor placement

In the final analysis, the suitability of any type of conveyor for a particular project will be largely determined by what it costs to use the equipment and the capital investment it represents. The cost of using conveyors is generally divided into two classifications: 1) operation or placement; and 2) setup and maintenance.

The makers of concrete conveyor systems claim savings in the operation cost resulting from continuous placing of concrete with such equipment compared to using a crane and bucket method (Day 1973). Conveyor setup costs tend to be independent of the volume of concrete to be placed. They are determined largely by the type of conveyor involved and the distance over which concrete should be transported. For example, use of feeder conveyors for concrete placements with a significant reach and volume of concrete and without restrictions on the rate of placement generally produces lower combined costs than can be achieved with any other type of placing equipment (Fisher 1968). Heavy mat foundations are excellent conveyor applications because they require placement of large volumes of concrete without cold joints.

Maintenance cost is predominantly the expense of keeping the conveying equipment clean and free of accumulated concrete. Replacement of the wearing material used for belt wiping is required regularly. The need to resplice the belt and make other equipment adjustments is determined primarily by the length of time the equipment has been in service. Replacement of the flashing and rubber liners at transfer points varies depending on both the volume and abrasiveness of the concrete placed.

Another advantage of conveyor placement was demonstrated at the Castaic Power Plant Project in California where conveyors delivered concrete to seemingly inaccessible places at rates exceeding 200 yd^3/h (150 m^3/h) and at a cost far less than that of a crane and bucket. The high placing rates allowed doubling the size of individual placements with a resulting reduction in form costs ("Conveyors Cut Concreting Cost" 1971). Any concrete placing system that decreases total job completion time will result in substantial savings in interest on construction loans. Revenues from the completed facility are then available to the owner sooner.

Conveyors made expressly for handling concrete are relatively inexpensive and may eliminate the need for other more expensive equipment such as cranes (Panarese 1972). The capital investment required for a concrete conveyor is determined by the desired placement capacity and the distance over which it should operate. A large project may justify the equipment investment necessary to convey concrete by belt from the batch plant to all parts of the project. If there is a roadway, mixer trucks or other hauling units are usually the most economical method of transporting concrete from the batch plant to a point reasonably near the placement area. Because it is usually easy to incorporate supports for conveyors in conjunction with formwork, or to provide temporary conveyor supports in the placement area, the distance a conveyor should span is usually kept under 100 ft (30 m) and cantilever reach requirements are usually limited to under 40 ft (12 m).

Even where job requirements other than concrete placement require the availability of a crane, conveyors to place the concrete are frequently justified. Placing the concrete with conveyors may allow the use of a smaller-lifting-capacity crane. The greater availability of the crane for other purposes combined with the concrete placement capacity of conveyors may allow faster completion of the project.

CHAPTER 5—FIELD PRACTICE

5.1—Selection of conveyors

The design and operating principles already presented should be supplemented by a few proven general rules of field practice for complete success in concrete conveying. Because concrete construction projects are relatively short in duration compared to the life expectancy of a concrete belt conveyor, it is generally not practical to custom design belt conveyors for each project or application. Normal practice is to select standard commercially available equipment that has adequate placing and reach capability, and to organize and plan its use to meet the general construction sequences required to properly perform the work. Modular design of most equipment makes it possible to lengthen or shorten feeder trains and side-discharge conveyors so that single units can be adapted to many different jobs.

5.2—Actual capacity

The actual field placing capacity of a concrete conveyor will rarely equal the capacity calculated from the equation in 3.5.5. This is primarily due to the inevitable delays that occur in batching, mixing, and transporting concrete to the belt conveyor at the placement area. Other delays involve consolidation and finishing of the concrete and moving of the conveyor. The magnitude of these delays will vary from project to project and from day to day on the same project.

A belt conveyor cannot place a surge of concrete in excess of design capacity because excess concrete placed on the belt will usually be spilled off the sides. Even if the angle of surcharge of the concrete is such that the belt will accept additional material, there is the possibility that it will plug the transfer or discharge hoppers and cause delay instead of saving time.

In addition to the concrete delivery and placing delays, placing capacity will be reduced by factors that decrease the cross section of the concrete ribbon as outlined in 3.2.3 relating to vertical angle of incline; nominal maximum size and shape of the coarse aggregate; and the slump, cement content, and angle of surcharge of the concrete.

As the angle of incline of concrete belt conveyors is increased, difficulty is usually encountered with rollback of large aggregate before the angle of surcharge of the concrete becomes a problem. In addition, rollback problems are more severe with smooth, rounded aggregate than with rough, irregular shapes.

The momentum and support provided by additional concrete feeding onto the belt from a charging hopper makes it possible to convey concrete at a higher angle of elevation without aggregate rollback. When conveying concrete at such an angle, care should be taken to assure a continuous supply of concrete in the charging hopper. If the concrete is coming from truck mixers, it is best to blend the last material discharged from one truck with the first material from the succeeding truck. This prevents a concentration of the larger aggregate in the last material discharged by the truck mixer from causing difficulty and makes it easier for the truck mixer operators to keep the charging hopper properly filled.

Nothing can be done to increase the rate at which a conveyor will carry concrete and delays are almost inevitable. Hourly production on an efficient project will average approximately 70 percent of the capacity of the belt conveyor. This adjustment of the theoretical capacity provides the safety factor that most jobs require for successful completion within scheduled times. Failure to distinguish between the short interval or momentary rate of placing and attainable production averages has been a persistent source of confusion when belt conveyors are evaluated for the placing of concrete.

5.3—Conveyor charging

Where ready mixed concrete can be charged directly from the truck mixer chute onto concrete belt conveyors, high capacities can be achieved by planning movement of the trucks to and from the charging hopper (Fig. 5.3).

The belt conveyor and truck delivery layout should be planned so that one truck can be backing in and preparing to discharge while a second truck is discharging. If conveyors are charged directly from a batch plant, a large surge hopper with an adjustable gate should be used to provide an uninterrupted flow of concrete to the belt conveyor.

Improper charging of conveyors will result in spilling concrete off the belt edges near the charging point of all conveyors, and at transfer points on feeder conveyor systems. It is good practice to install protective tarps or plastic sheeting as needed in these areas to avoid the necessity of interim cleanup of placement areas and embedded items.

5.4—Discharge control

As the placing progresses, fresh concrete should always be discharged onto or against concrete of plastic consistency that is already in place, so there is some melding of concrete through vibration and there is no opportunity for objectionable rock pockets to be formed. If the concrete does not flow readily, a vibrator should be available for operation continually where the concrete is dropping to prevent stacking and segregation of the large pieces of coarse aggregate. This vibration is intended to provide minor leveling action only and the vibrators should not be inserted within 2 ft (610 mm) of any leading (unconfined) edge of the concrete. The point of delivery should be moved frequently so the concrete does not have to be rehandled or moved laterally by vibration. Because belt conveyor placing rates are higher than can be achieved with crane and bucket placement, a larger number of vibrators may be required for consolidation of the concrete. Vibration at the delivery point and immediately behind the advancing edge of the concrete will cause the concrete to envelop reinforcing steel without significant separation.

Embedded items should be firmly supported or anchored so that they are not displaced by the flowing concrete. Special care should be taken in placing concrete through closely spaced, small-diameter reinforcing steel or wire mesh so concrete does not stack on top of these items and displace them. Slowing the rate of placement will usually reduce this problem.

Mass concrete should be placed in lifts or layers that allow access for the vibration equipment to reach areas of possible cold joints forming, depending on the effectiveness of the vibration equipment. Successive lifts should be stepped back so the full height of the placement is reached as soon as possible at one end or side. This practice limits the exposed concrete that should be kept plastic and reduces the risk of cold joints (refer to Fig. 3-1 of USACE EM 1110-2-2000 [U.S. Army Corps of Engineers 2000]).

5.5—Maintenance

Some conveyor maintenance may be necessary during concrete placement on large volume projects.

5.5.1 *Belt tension adjustment*—All conveyor belting will stretch to some degree during concrete placement. Because transferring power from the drive pulley to the belt depends on return belt tension, adequate belt tension should be maintained at all times while concrete is being placed. All concrete conveyors should have provisions for increasing belt tension in the event the drive pulley begins slipping inside the belt during concrete placement.

Fig. 5.3—One truck is preparing to discharge while the second truck is discharging.

5.5.2 *Belt wiper adjustment*—The belt wiper is in constant contact with the belt and abrasive concrete. The belt may travel many miles during a placement; thus, wear of the belt wiper is normal. The conveyors should have provisions to compensate or adjust for this wear so that efficient belt wiping is maintained during placement of concrete. Belt wipers should be replaced when they do not produce satisfactory belt cleaning.

5.5.3 *Equipment cleanup*—No equipment operates well or for a long time if it is not kept clean. This is especially true of belt conveyors. Any spilled concrete should be cleaned off the conveyor before it hardens. Extra care should be taken to keep the charging hopper, discharge hopper, belt wiper, and return idlers clean and free of concrete buildup. Buildup in these areas will almost immediately begin rubbing the belt, resulting in damage to and improper operation of the belt. Except for the belt, it is desirable to coat all parts of the conveyor with form oil to expedite cleanup. Generally, the conveyors themselves should be cleaned by lightly tapping the conveyor to loosen concrete, which is then removed by scraping or wire brushing (Panarese 1972). The belt will clean itself as it flexes over the head and tail pulleys. High-pressure water washing should not be done, as the stream of water may damage seals on the idler bearings.

CHAPTER 6—INSPECTION AND TESTING

6.1—Concrete inspection

The fact that concrete belt conveyors are an open system where almost all the concrete being placed can be visually inspected provides an excellent opportunity to exercise control of the concrete. The ribbon of concrete on the conveyor belt should be visually inspected at the start and frequently throughout the placement. The same concrete is visible at any point on the belt and, because the belts travel fast, the point of inspection is not critical.

After appropriate testing, coupled with regular visual inspection, shows that quality concrete is being delivered to the belt, the main emphasis of inspection should be on the proper discharging of concrete from the conveyors and consolidation of the concrete. Concrete discharged from a conveyor should not freefall far enough to cause segregation. Several authorities limit freefall to 10 ft (3 m). Care should be taken to see that the recommended field practices are followed.

6.2—Testing

Concrete belt conveyor systems should be tested under job conditions before any significant placement is attempted if there is any doubt about the ability of the system to successfully place the concrete. Handling of only a few cubic yards (cubic meters) of concrete over any belt conveyor system will validate the conveyor design and identify problem areas. If a system performs satisfactorily in such tests, it is safe to assume that the system will perform satisfactorily under job conditions.

Tests of the plastic concrete and samples for strength determination taken at the discharge from the mixing or transporting equipment and at the concrete belt conveyor discharge point should provide adequate assurance of satisfactory operation under any condition. The quality of concrete being placed in the structure can only be measured at the point of placement in the structure. Once a satisfactory correlation between samples taken at the point of placement and at the discharging point of the mixer has been established, sampling at the most convenient point should be satisfactory, provided placing conditions remain unchanged. All parties should agree on the point of sampling and testing protocols prior to project or placements starting.

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- Spring and fall conventions to facilitate the work of its committees.
- Educational seminars that disseminate reliable information on concrete.
- Certification programs for personnel employed within the concrete industry.
- Student programs such as scholarships, internships, and competitions.
- Sponsoring and co-sponsoring international conferences and symposia.
- Formal coordination with several international concrete related societies.
- Periodicals: the ACI Structural Journal, Materials Journal, and Concrete International.

Benefits of membership include a subscription to Concrete International and to an ACI Journal. ACI members receive discounts of up to 40% on all ACI products and services, including documents, seminars and convention registration fees.

As a member of ACI, you join thousands of practitioners and professionals worldwide who share a commitment to maintain the highest industry standards for concrete technology, construction, and practices. In addition, ACI chapters provide opportunities for interaction of professionals and practitioners at a local level to discuss and share concrete knowledge and fellowship.

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The American Concrete Institute (ACI) is a leading authority and resource worldwide for the development and distribution of consensus-based standards and technical resources, educational programs, and certifications for individuals and organizations involved in concrete design, construction, and materials, who share a commitment to pursuing the best use of concrete.

Individuals interested in the activities of ACI are encouraged to explore the ACI website for membership opportunities, committee activities, and a wide variety of concrete resources. As a volunteer member-driven organization, ACI invites partnerships and welcomes all concrete professionals who wish to be part of a respected, connected, social group that provides an opportunity for professional growth, networking and enjoyment.

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