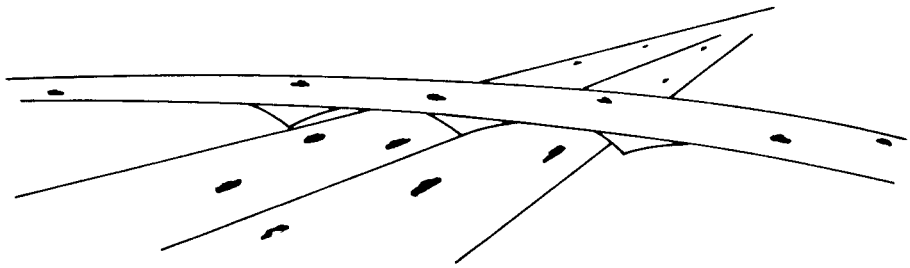

DEPARTMENTAL RESEARCH

Report Number SS21.1

NO-JOINT CAST-IN-PLACE CONCRETE PIPE

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

No-Joint Cast-In-Place Concrete Pipe

by

Texas State Department of
Highways and Public Transportation

District 4

Amarillo, Texas

Special Studies Report No. SS 21.1

March, 1977

CAST-IN-PLACE PIPE

In February of 1970 a contract was entered into between the Texas Highway Department and Gilvin-Terrill, Inc., of Amarillo, Texas, which included the reconstruction, widening and installation of a city financed storm sewer on U.S. Highway 60, through the City of Pampa. The unique thing about this contract was the inclusion of an alternate bid item covering "Pipe Sewer (Cast-in-Place)", which was the first time this item appeared in a Texas highway contract.

Much study and investigation was made by the District Design Engineer and the Resident Engineer before this item was presented to the District Engineer as an alternate bid item for the storm sewer construction.

When the District Engineer regained his composure, D-5 was contacted and various personnel in this Division were responsible for getting this item approved for inclusion in the construction plans.

The storm sewer was to be 100% financed by the City of Pampa, so the appropriate officials were contacted and they agreed to this type construction. An escrow check for $499,100 was obtained from them and the job was ready for letting.

The bids were opened and the successful bidder was Gilvin-Terrill, Inc. of Amarillo. This low bid included prices on the "Pipe Sewer (Cast-in-Place)" items and reflected a great savings for the City of Pampa. In March a refund was given to the City for $110,000 and when the project was completed another $3,522.18 was refunded. This reflected a savings to the City of 22.7%.

The first thing to arrive on the project was a special built ditch digger. (Fig. 1). This was a variable width digger (3-12 Ft.) with an attachment fitted to the bottom of the digger to give a round, smooth bottom in the trench. A different attachment was used for each size pipe to be placed. (Fig. 2).

Fig. 1

Fig. 2

The trenching was started on the east end where a double-barrel 60 inch pipe was constructed. (Fig. 3). One barrel was placed, backfilled and then the other barrel was placed. This double-barrel connected to a 72 inch at a manhole. (Fig. 4). Limited head room was the reason for the double-barrel 60 inch pipe.

Fig. 3

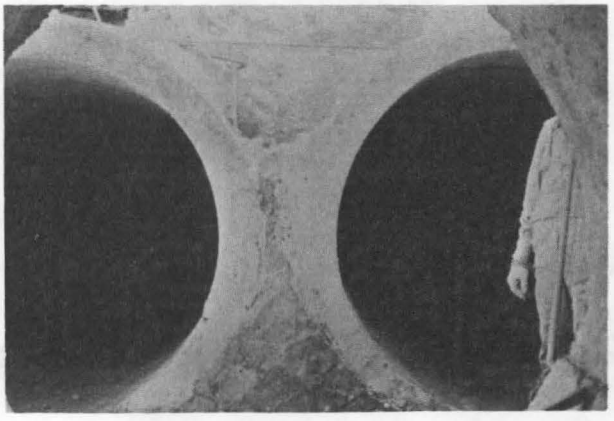

Fig. 4

The sizing on the pipe went as follows: A double-barrel 60 inch, to a 72 inch, to a 60 inch, to a 54 inch, to a 48 inch, to a 42 inch, to a 36 inch pipe. The 42 inch was the smallest size the "Cast-in-Place" type construction used.

There was a different pipe laying machine (Fig. 5) for each size pipe and these machines were set into the trench with a crane. (Fig. 6).

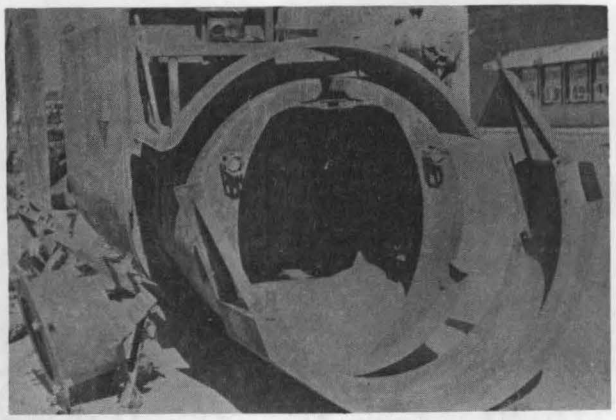

Fig. 5

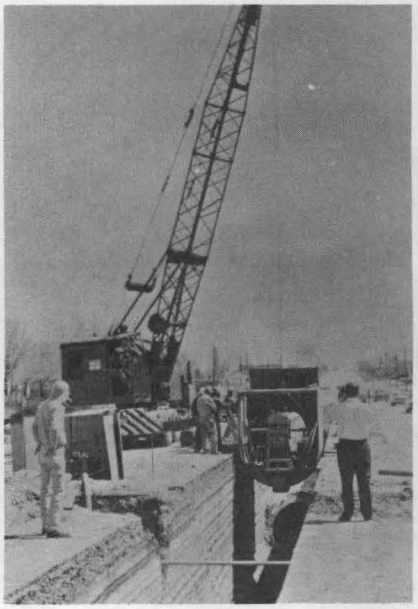

Fig. 6

The machine was charged with concrete as it moved along (Fig. 7) and forms were fed through the machine. These forms were made of aluminum (Fig. 8) and covered the upper 230° of the pipe.

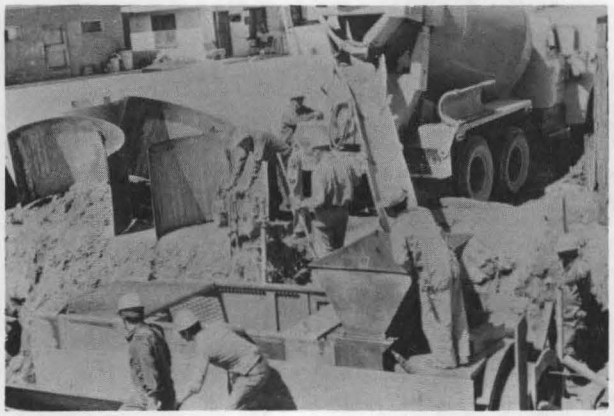

Fig. 7

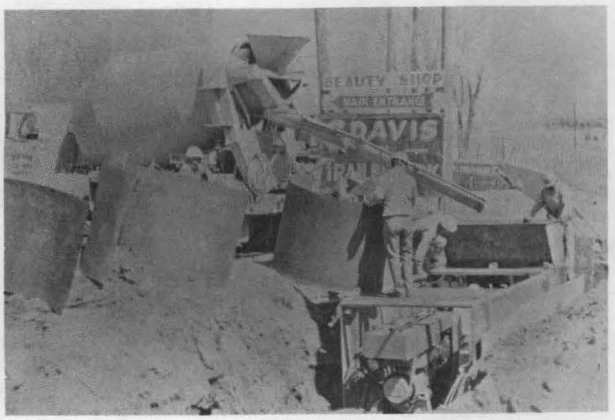

Fig. 8

placed as the machine moved along the trench.

If you wonder how the reinforcing steel was placed, your thoughts follow the same lines as those of the District Engineer. When he was told that there was no steel he rose about a foot out of his chair. Since the bedding is perfect and the pipe is not moved, reinforcing steel is not necessary. (Fig. 10).

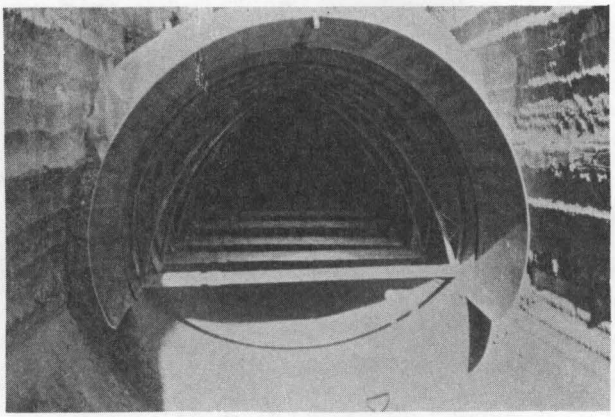

Fig. 9

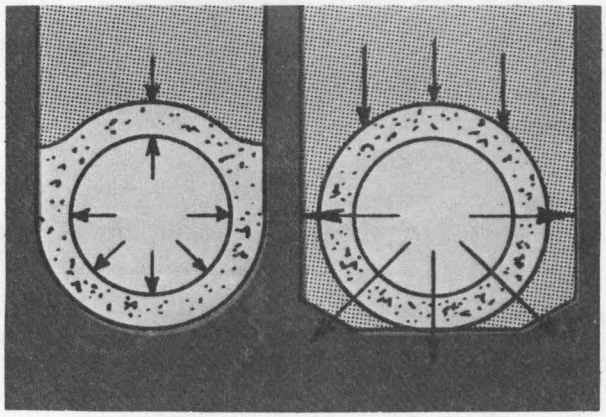

Fig. 10

The beautiful part about this project was the backfilling of the completed pipe. As the trench was excavated ahead, the dirt on the belt was sprinkled as it was excavated, brought up to optimum moisture, then loaded into a dump truck, hauled back to the completed pipe, dumped and dozed into lifts and compacted. (Fig. 11). The compaction was accomplished with vibrating rollers and a dozer was used to keep the backfill to uniform lifts. (Fig. 12). This backfilling was performed on pipe from eighteen to twenty-four hours old. This kept the area adjacent to the ditch free of piles of dirt and allowed one half the street to remain open to local and through traffic.

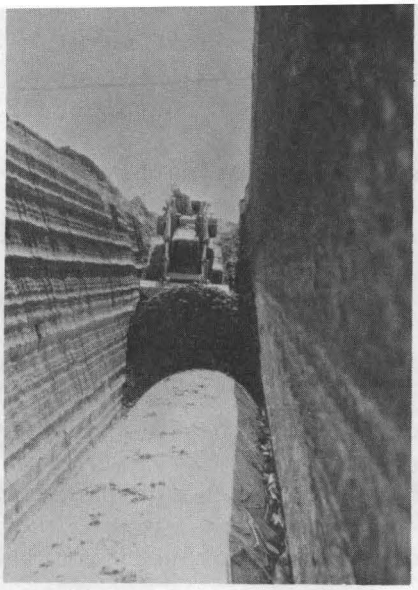

Fig. 11

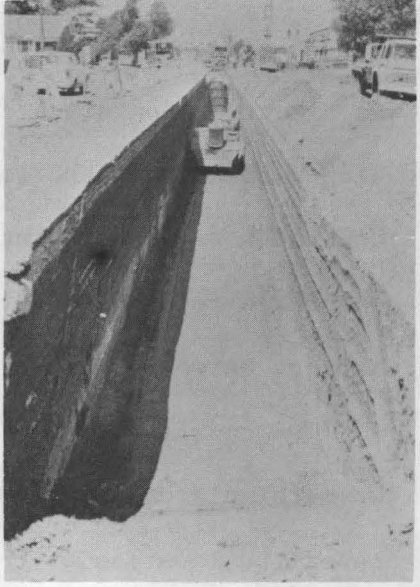

Fig. 12

The concrete mix design was a little unusual in that it contained a one inch maximum size coarse aggregate, a seventy-nine coarse aggregate factor, a water reducing agent, six sacks per cubic yard of high early strength cement, and had from one to two inch slump. (Fig. 13). This mix gave a compressive strength of from 2000 to 2400 PSI in eighteen to twenty-four hours. Cylinders were made every day and broken the next morning since the backfilling was limited to a 2000 PSI minimum cylinder strength. No problems were encountered concerning the strength limitations for back-filling.

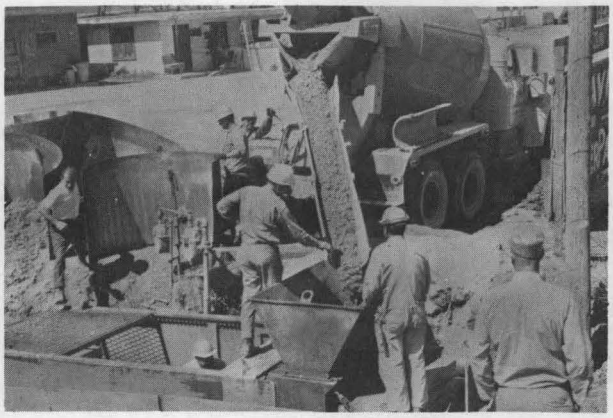

Fig. 13

Fig. 14

It was noted that when the forms were removed the next morning there was a contraction crack completely around the inside of the pipe, (Fig. 14) which varied in width from one sixteenth inch to approximately three sixteenths inch and were about twenty-two feet apart. For a short period of time the cement was reduced to five sacks per cubic yard and it was noted that the distance between these cracks increased to about fifty feet.

The construction of manholes was unique in that they were formed with two metal plate forms, one inside and one outside. When the pipe machine passed the location of the manhole, the concrete was removed from the top of a pipe and a templet was set to grade. The templet was round and formed a circle which protruded about two inches. Inside this protrusion one-half inch dowles were set twelve inches apart. The next day the metal forms were set on the inside and outside of this protrusion and were filled with concrete. In a short time the outside plates, where the laterals were to enter, were removed and the still plastic concrete was removed. (Fig. 15). The next day the rest of the forms were removed and backfilling was completed.

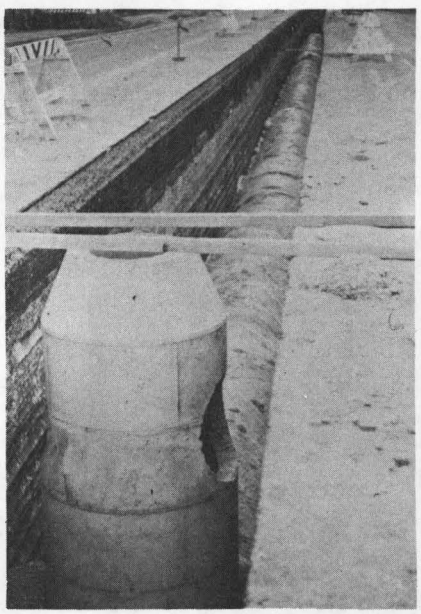

Fig. 15

An inspection was made in December of 1976 and there was very little change from the day it was completed. A hairline crack, barely perceptible, had appeared along the top and bottom of the pipe. There was no evidence of any seepage having taken place at any of the cracks.

The storm sewer portion of this project lasted three months and the Cast-in-Place pipe was a very satisfactory method of construction. One half the street remained open for traffic, there were no piles of dirt along the trench, the inconvenience to the adjacent property owners was not prolonged, the City saved money, and a new method of construction was proven.

The features that make no-joint pipe more economical to build include the simplified method of trench construction and the reduced excavation quantities. Because the design of the pipe without reinforcing steel requires that the excavation be made in a stable material, no-joint pipe construction lends itself very well to soil conditions over most of District 4. However, in areas where the soil is either too plastic or too sandy to maintain a vertical face after excavation, or where the P.I. of the soil is high and subject to movement, the selection of this type of construction would not be economically feasible.

Since this project's satisfactory completion, no-joint pipe has been included as an alternate on other projects in District 4. Interest in its use has been shown by several contractors on these other projects. Although no-joint pipe was not the lowest bid alternate on any other project, we still feel that an indirect benefit was received because of the increased competition for other types of storm sewer construction.

The Pampa project included the following quantities of no-joint pipe:

4,332.5' L.F. of 72" Pipe
1,747 ' L.F. of 60" Pipe
804 ' L.F. of 54" Pipe
850 ' L.F. of 48" Pipe
995.5' L.F. of 42" Pipe

Excavation depths ranged from 7' to 18' and all pipe was placed within the roadway limits. For this type of construction excavation is not paid for directly but is considered as part of the cost per foot of the pipe.

The engineering drawings that were included on the Pampa storm sewer project are shown in Figure 16. The specifications for the storm sewer were prepared with the help of D-5 personnel. This specification is also included with this report.

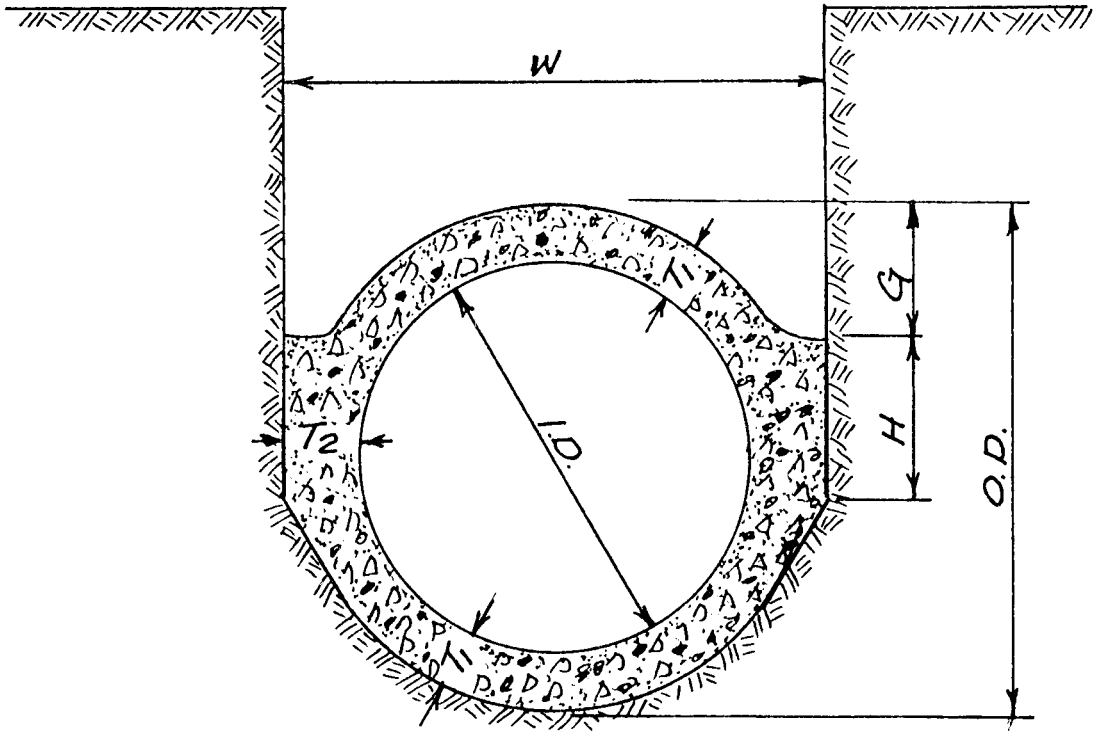

Table of Dimensions for No-Joint Concrete Pipe

I.D.	T_1	T_2	W	G	H	O.D
18"	2½"	3¼"	2'-0½"	6"	8"	1'-11"
24"	3"	3¾"	2'-7½"	8"	10"	2'-6"
30"	3½"	3¾"	3'-1½"	10"	12"	3'-1"
36"	4"	4¼"	3'-8½"	12"	1'-2"	3'-8"
42"	4½"	4¾"	4'-3½"	1'-2"	1'-6"	4'-3"
48"	5"	6½"	5'-1"	1'-3"	1'-10"	4'-10"
54"	5½"	7½"	5'-9"	1'-4½"	2'-0"	5'-5"
60"	6"	8"	6'-4"	1'-7"	2'-0"	6'-0"
72"	7"	8½"	7'-5"	1'-10"	2'-6"	7'-2"

TYPICAL SECTION
No-Joint Concrete Pipe
Cast in Place
(Non-Reinforced)

Figure 16

TEXAS HIGHWAY DEPARTMENT

SPECIAL SPECIFICATION

ITEM 4106

CAST-IN-PLACE CONCRETE SEWER PIPE (NONREINFORCED)

1. DESCRIPTION: This item shall cover machine cast-in-place monolithic nonreinforced concrete pipe, which shall consist of Portland cement concrete placed in a prepared trench at such locations and grades shown on the plans and intended to be used for the conveyance of storm water.

2. MATERIALS: The cast-in-place pipe shall be constructed of Class "C" concrete. The concrete shall meet the requirements of Item 421, "Concrete for Structures", and Special Provision thereto, except as otherwise noted herein or on the plans. Type III Portland Cement shall be used.

Job control will be by Flexural (beam) Strength. The allowable strength, in order to proceed with backfilling operations will be the equivalent of 2000 psi compressive strength. This factor will be reached by the method of preparing and testing trial batches utilizing the materials selected, tested and designated for use in construction of the pipeline.

The coarse aggregate grading for pipe diameters 48 inches or less shall conform to that of Aggregate Grade No. 3 for one inch maximum size aggregate under Item 421. For pipe diameters over 48 inches, Coarse Aggregate Grade No. 2 for 1½ inch maximum size aggregate shall be used.

No concrete having a slump in excess of 2" will be permitted for use in pipes with diameters of 48 inches and over. For pipes with diameters less than 48 inches, no concrete having a slump in excess of 3" will be permitted for use.

At the option of the Contractor, sections of precast reinforced concrete pipe (Class III) may be substituted for cast-in-place concrete pipe. Pipe and installation shall conform to the requirements of Item 465, "Pipe Sewers". Backfill shall be in accordance with Item 401, "Excavation and Backfill for Sewers".

3. PIPE MAKING EQUIPMENT: The pipe shall be constructed with equipment specially designed for constructing cast-in-place monolithic concrete pipe. The equipment shall be acceptable to the Engineer and the Contractor may be required to furnish evidence of successful operation in other work of the equipment he proposes to use. Equipment not suitable to produce the quality of work required for the pipeline will not be permitted to operate on the project.

4. DIMENSIONS AND TOLERANCES: The design shell thickness shall be as specified in Table 1.

TABLE 1

Internal Diameter (Inches)	Shell Thickness (Inches)
18	2½
24	3
30	3½
36	4
42	4½
48	5
54	5½
60	6
66	6½
72	7
84	8
96	9
108	10
120	11

The shell thickness at any point shall not be less than that specified above by more than ½ inch.

Variation in the internal diameter shall not exceed plus or minus 3 percent. The maximum allowable deviation from the true grade of the design invert of the pipe shall not exceed ½ inch either side of true grade. Where deviation from true grade occurs, true grade shall be reestablished at a maximum departure of one-eighth inch per foot.

5. EXCAVATION AND BACKFILL: Excavation shall be in accordance with Item 401, "Excavation and Backfill for Sewers", except as modified herein. The trench shall be excavated in the lines and grades shown on the plans, or as directed by the Engineer. The width of the trench shall only be sufficient to accommodate travel of the pipe machine. The bottom of the trench shall be shaped to the nominal outside circumference of the pipe. Excavation shall be performed from the outlet to the inlet. If the trench is over-excavated for the bottom 210 degrees of the pipe the excess area shall be filled with concrete. If rock is encountered, it will be removed at least 6 inches below the bottom of the pipe and the trench refilled with material sufficiently compacted to allow operation of the machine and provide a smooth firm surface.

Quality of backfill material will be in accordance with Item 401.2(8). No backfill other than permitted for curing purposes shall be placed until the line has been insepcted and approved by the Engineer. The trench may be completely backfilled after the pipe has been in place at least 24 hours and concrete strength requirements have been reached. Light traffic, axle load less than 6,000 pounds, may be routed over the pipe after backfill has been completed for twenty-four (24) hours. Unrestricted traffic may be permitted over the pipe after the backfill has been in place for forty-eight (48) hours.

All backfill material shall be mechanically compacted to the extent necessary to provide not less than 96 percent of the density as determined in accordance with Test Method Tex-114-E. Field density determinations will be made in accordance with approved methods.

6. CONSTRUCTION: All surfaces against which concrete is to be placed shall be free from standing water, mud, and debris. Absorptive surfaces against which concrete is to be placed shall be moistened thoroughly so that moisture will not be drawn from the freshly placed concrete.

The concrete shall be placed in one operation around the full circumference of the pipe by means of a traveling form. The forms used shall be of sufficient strength to withstand vibrating or tamping the concrete and to permit workmen to walk on the forms without causing springing or bulging at any point.

As the traveling form moves forward, forms shall be placed inside the newly formed pipe to support a minimum of 230 degrees of the upper portion of the pipe.

The concrete shall be vibrated, rammed, tamped or worked with suitable appliances until the concrete has been consolidated to the maximum practicable density, free of rock pockets, and closes snugly against all surfaces of forms and provides a bond between the pipe shell and supporting earth.

When placing operations cease for any reason, the end of the pipe shall be left rough with a slope of approximately 45 degrees. The ends of the pipeline shall be covered with canvas or other suitable cover material to prevent excessive loss of moisture from the interior of the pipe already placed.

When starting pipe laying operation from a previously laid cast-in-place pipe or section of precast pipe, a construction joint shall be made by excavating a "bell" completely around the end of the existing pipe and constructing a concrete collar to extend at least one foot either side of the joint with a minimum thickness equal to that of the wall of the pipe. The end of the existing pipe shall be clean and damp before continuing pipe making operations. Cleaning construction joints shall consist of removing all laitance, loose or defective concrete, coatings, and any other deleterious materials.

All forms shall be clean and shall be placed at the trench side at the location of their proposed use for inspection by the Engineer. Forms which are defective in any way will not be used, and upon condemnation they shall be removed from the site of the work. The forms shall not vary more than ½ inch from the lower edge of a straightedge laid parallel to the centerline of the form, and shall be free of any holes larger than 5/8 inch in greatest dimension. The pipe machine shall be thoroughly clean and serviced prior to the pouring of concrete. Particular attention will be given to all parts of the machine with which concrete comes into contact.

Concrete chutes or trunks shall be provided to reach within 1 foot of the pipe machine hopper. The end of the chute or trunk shall discharge the concrete at the center of the hopper. Provisions shall be maintained to

minimize segregation of the concrete mix in all phases of the operation.

Delays in placing shall be handled as follows or as otherwise directed. The concrete hopper on the pipe laying machine shall be kept ½ full at all times, provided, however, that when placing operations cease or are delayed for any reason for more than 20 minutes, the pipe machine shall be pulled forward until all the concrete is exhausted and until the top troweling skirt is clear of the concrete. If the pipe laying operation proceeds within one hour of the time of the last placement, no further steps need be taken. However, if longer than one hour has elapsed, then a construction joint must be made as previously described. Leave the end of the pipe rough and at the natural slope when the machine is moved forward.

All junctions of pipe shall be provided for at the time the cast-in-place pipe is placed.

Inside forms shall be removed from the pipe not sooner than 4 hours nor longer than 24 hours after placement of the concrete. Care shall be taken when removing forms to prevent damage to the pipe. The inside of the pipe shall be carefully inspected for imperfections in placement, and any required repairs or smoothing shall be made immediately to provide a uniform interior surface. No wash, mortar or concrete shall be applied to a surface not properly moistened and cleaned. Visible cracks shall be brushed with cement paste or chipped out and pointed up with cement mortar. Any cracks that appear to go through the shell shall be grooved and filled with mortar. All construction operations and methods for providing a water tight pipeline shall be the responsiblity of the Contractor. Mortar shall consist of one part cement, two parts well graded sand passing 1/8 inch sieve. Wash shall consist of four parts cement, one part fireclay. The finished surface of the concrete pipe shall be substantially free of fractures, cracks and surface roughness.

7. CURING CONCRETE: Immediately after the concrete is placed the exposed surface of the concrete shall be cured by any one, or a combination of the following methods:

(a) As outlined in Item 420, Article 420.21.
(b) A six (6) inch layer of backfill material consisting of damp, fine earth may be placed over the pipe immediately after the concrete has hardened sufficiently to prevent injury to the pipe from backfill operations. Initial backfill shall be kept moist until covered with final backfill.
(c) Cover the top with a sheet of polyethelene film sealed with dirt along the edges.

During the curing period following the placement of the concrete, the ends of the pipeline and all other opening into the pipeline shall be covered with canvas or other suitable material, except at locations where work is actually in progress. The inside surface of the pipeline shall not be cured.

8. MEASUREMENT: The method of measurement shall conform to that prescribed in Item 465, "Pipe Sewers", Article 465.5 "Measurement".

9. PAYMENT: Payment for cast-in-place nonreinforced pipe sewers, measured as prescribed above, will be made at the unit price bid per linear foot for the various sizes of "Pipe Sewers (Cast-in-Place)" complete in place including all excavation and backfill necessary to place the cast-in-place pipe, and excavation and backfill for all appurtenances thereto such as manholes and inlets.

Such payment shall be full compensation for furnishing all concrete materials, precast reinforced concrete pipe used in place of cast-in-place pipe, excavation, backfill and for all other materials, tools, labor, equipment, and incidentals required to perform the applicable work prescribed herein.

Where the use of reinforced concrete pipe is required by the plans it shall be paid for in accordance with Item 465, "Pipe Sewers". When precast reinforced concrete pipe at the Contractor's option is used in a line of cast-in-place pipe the excavation for the pipe will be subsidiary.