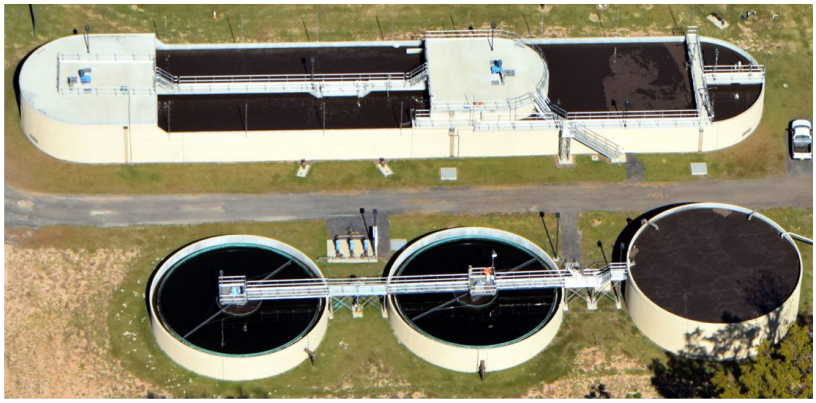
PRESTRESSED CONCRETE TANKS

DESIGN & CONSTRUCTION EXCELLENCE SINCE 1953



CROM®

INTRODUCTION

CROM® is a specialist in the design and construction of prestressed concrete tanks. With over 65 years of experience, our continued success is driven by our self-performing skilled team with zero division of responsibility for our clients. CROM is built on a foundation of core values that is committed to safety, professional integrity, and high quality execution.

CROM has designed and built over 4,200 concrete tanks since 1953, with capacities ranging from 25,000 to over 30,000,000 gallons. The success of CROM is based on our understanding of all phases of design, construction, and management required to produce a tank that is leak-free with life expectancies in excess of 50 years. CROM tanks are designed to AWWA D110 and ACI 372 standards. As a founding member of both design committees, CROM remains a "leader in the industry".

PRINCIPALS

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HISTORY OF PRESTRESSED CONCRETE TANKS

Circular prestressed concrete tanks have been in various stages of development and perfection for decades. Early systems called for the use of cast-in-place concrete in the core wall of the tank and steel rods with turnbuckles as the prestressing elements. Although theoretically this approach to circumferentially prestressed concrete tanks was sound, deficiencies in placement of concrete together with insufficient residual compression in the core wall brought about modifications and improvements.

The matter was fully understood in the 1930's when J.M. Crom, Sr. began the development of what was later to become the composite system of tank wall construction; using a steel shell cylinder with shotcrete encasement for the core wall, and high strength wire for the prestressing elements.

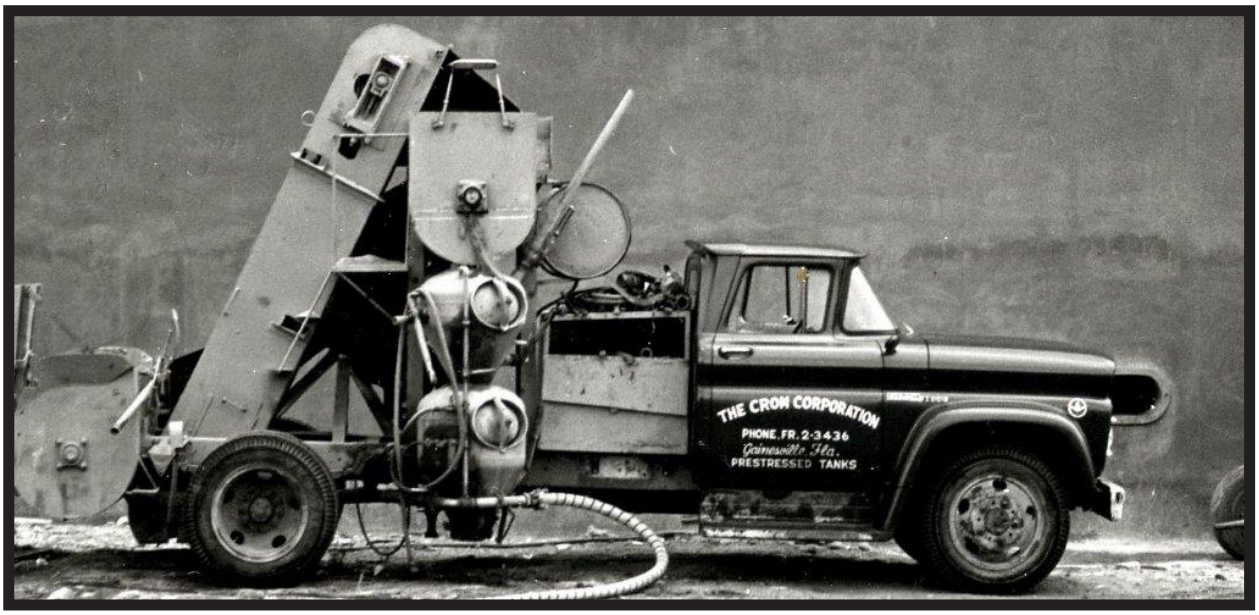
In the early 1950's, J.M. Crom, Sr. and three associates, Ted Crom, Jack Crom, Jr., and Frank Bertie, established The Crom Corporation, with headquarters in Gainesville, Florida, for the prime purpose of perfecting the design and construction techniques for tanks with composite walls.

Since then, J.M. Crom's successors have continued the tradition of excellence initiated by the company's founders and achieved the goal through the selection of more advanced construction materials, sophisticated design, and robust construction procedures.

In the due course of time, the features in the composite wall design using diaphragm, shotcrete, and high strength wire were incorporated into the American Water Works Association Standard-D110 "Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks" and designated as a "Type II Core Wall - Shotcrete with a Steel Diaphragm."

Key Elements of the Type II Prestressed Composite Wall System:

- Continuous steel shell diaphragm for a watertight core wall.
- Shotcrete with high cementitious content and low water/cement ratio for greater corrosion inhibition, impermeability, and higher strength than conventional concrete.
- High-strength single-wire prestressing to provide a higher factor of safety, durability, and the necessary residual compression.



PRESTRESSED CONCRETE TANK DESIGN
AWWA-D110 TYPE II
COMPOSITE WALL

BENEFITS OF A CROM TANK:

- Guaranteed watertightness
- Structural integrity
- Greatest economy
- Pleasing appearance

WATERTIGHTNESS

Watertightness of the AWWA-D110 Prestressed Concrete Tank with Type II Composite Wall is made possible by combined performance of a steel shell diaphragm, shotcrete encasement, epoxy injection, and wire prestressing.

The steel shell extends continuously the full height of the tank wall, thus precluding by positive means any through-wall leakage. The diaphragm has no horizontal joints. The vertical joints which connect the steel shell panels are sealed by epoxy injection after the diaphragm is encased inside and outside with shotcrete. The diaphragm is also epoxy sealed into a slot in the floor or waterstop. The complete system creates a continuous water barrier of impermeable materials. The corrugations in the steel cylinder, running in a vertical direction, provide a mechanical bond between the diaphragm and the shotcrete encasement. Mild steel reinforcement is included to resist bending moments, shrinkage, and temperature stresses. Circumferential prestressing assures permanent ring compression in the tank core wall.

STRUCTURAL INTEGRITY

CROM designs its structures under the supervision of professional engineers; trains and certifies its key employees; selects and uses the best available construction materials; and adheres rigidly to high standards of quality construction.

ECONOMY

Economy is a natural by-product of the AWWA D110 Type II Prestressed Concrete Design with Type II Wall – lesser quantities of materials and labor are utilized than is possible under conventional reinforced concrete design.

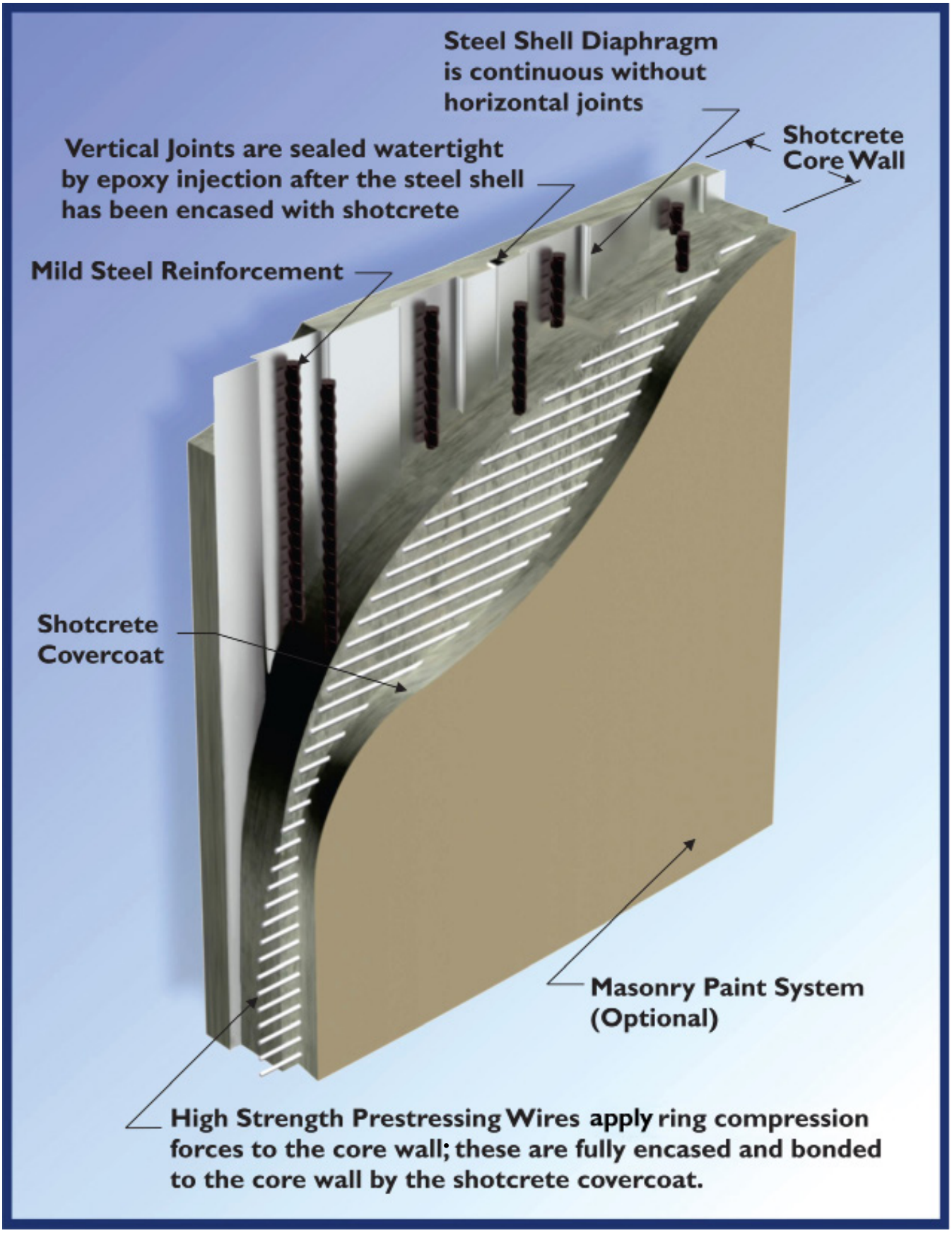
Of greater significance is the quality of *permanence* inherent in the construction materials used. Shotcrete is a durable, high-strength building material whose long life with minimum maintenance is universally recognized.

Under most operating conditions, interior surfaces of the tank do not require painting. This is a major cost benefit. Exposed exterior surfaces are usually painted for beautification.

APPEARANCE

The soft texture of the shotcrete finish assures lasting beauty with minimum care and the low silhouette dome roof, pleasing in line and shape, completes the structure's architectural appeal.

PRESTRESSED CONCRETE WALL
AWWA-D110 TYPE II
COMPOSITE WALL DESIGN



COMPLETE TANK CONSTRUCTION

CROM provides a complete tank construction service. The company prefers no division of responsibility with respect to the tank structure itself. As a consequence, tanks are built *totally* by CROM, including wall footings, floor slab, circular wall, dome roof, and other such appointments as are required for the structure. By avoiding a division of responsibility, the consulting engineer and the owner can proceed with confidence that the tank will be built expertly and the responsibility for its performance will be clearly shouldered by CROM.

1 The floor of the prestressed tank is a heavily reinforced membrane concrete slab. This view illustrates placement of floor concrete, reinforced with mild steel bars; a strong foundation.

2 Steel shell diaphragm is erected on a system of formwork especially designed for this purpose. Steel shell extends continuously the full height of the tank to insure watertightness. To avoid joint sealing problems, no horizontal splices are allowed in the diaphragm. Vertical joints in the steel shell are sealed watertight by epoxy injection.*

3 Exterior encasement of the steel shell is accomplished with shotcrete, which is pneumatically placed concrete. The core wall of the tank is built up to its full thickness by applying successive layers of shotcrete.

4 The wall formwork has been removed and the inside face of the diaphragm is now encased with shotcrete. To insure good workmanship, all shotcrete nozzlemen are certified by the American Concrete Institute.

5 Vertical reinforcing bars are placed to design requirements and will later be encased in shotcrete. Once this encasement is complete, the tank wall is ready for epoxy injection of the vertical joints in the encased diaphragm.*

6 Dome roof construction is undertaken with the aid of a system of forms made to the accurate curvature of the dome shell. Ordinarily, the dome has a rise from springline to apex of 1/10th the diameter of the tank.

*U.S. Patent No. 5,150,551

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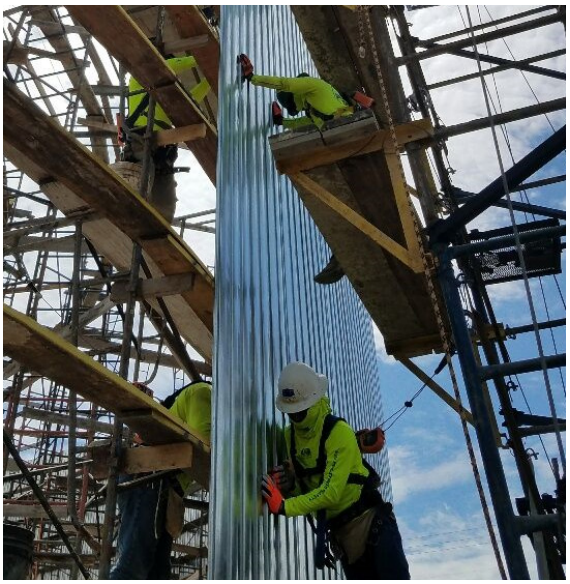

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EXPERT WORKMANSHIP

A hallmark of doing business with CROM is the high standard of quality workmanship required of its field crews. The company over a period of many years has thoroughly trained field construction personnel, totaling more than 300 people, who have become experts in tank construction. Unlike work in other fields, construction of tanks for water service is critical in that leakage cannot be tolerated.

By constant control of its field operations, CROM is able to guarantee the highest quality of workmanship in terms of watertightness, appearance, and dimensional accuracy of its structures. Because the company specializes in one area of construction, the high risk often associated with tank construction is overcome.

Inspection of tanks built as early as 1953 indicates that these vessels have endured the test of time and arduous service.

7 Once the roof formwork is completed with an overlay of sheathing, reinforcement is placed.

8 The free-span dome roof is constructed of cast-in-place concrete. This view shows dome concrete being placed.

9 Both the core wall and the free-span dome roof are circumferentially prestressed using high-strength steel wire wrapped around the tank in a continuous helix. Wall prestressing is designed to carry the tank's hydraulic load, while dome ring prestressing resists the horizontal forces of roof live and dead loads.

10 To avoid over-stressing or under-stressing of the tank, the tension in the wire is accurately measured to within 2% accuracy by the use of a direct-reading electronic digital stressometer.

11 In order to afford complete protection for the prestressing elements, a shotcrete covercoat is placed over the wire, permanently bonding the wire to the tank wall. Whenever two or more layers of prestressing steel are required, a flash coat of shotcrete separates the layers. Once the covercoat has been finished, the tank is structurally complete.

12 Final stage of construction involves the assembly of accessories and painting of the exterior surfaces for decorative purposes.

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TYPICAL INSTALLATIONS

Water supply systems, wastewater treatment plants, and industrial installations create corrosive environments with varying degrees of severity. These facilities derive great benefits from the permanent and low maintenance nature of prestressed concrete tanks.

Over 4,200 tanks have been built by CROM ranging in capacity from 25,000 to over 30,000,000 gallons. These tanks are employed in applications virtually without limit.

WATER RESERVOIRS

Prestressed concrete reservoirs are usually built with free-span dome roofs of concrete construction. Accessories, including ventilator, hatch cover, liquid level indicator, and interior ladder, are of fiberglass construction and the exterior ladders are fabricated aluminum. All accessories use stainless steel fasteners throughout. These features insure freedom from maintenance issues The typical projects illustrated here exemplify the functional beauty of reservoirs built by the CROM system.

WATER TANKS WITH AERATORS

Reinforced plastic, widely known as fiberglass, is ideally suited for applications in water, wastewater, and industrial plants, where corrosion is a serious consideration. One such application is the aeration of water for removal of hydrogen sulphide using a natural draft tray aerator.

Since aeration and storage of water are often complementary operations, installations which combine CROM fiberglass aerators and prestressed concrete tanks are both attractive and efficient.

Because of the release of hydrogen sulphide gases during the aeration process, the non-submerged interior concrete surfaces of these tanks may be subject to corrosive attack, and should be protected. This is often accomplished by poly-lining or coating the concrete surfaces above the high water line, or by exhaust fans, or by submerging the free-board surfaces (wall and roof) so as to achieve a self-washing effect.* Periodic inspections should be made to evaluate the condition of these tanks.

*U.S. Patent No. 5,129,413

TANKS WITH ARCHITECTURAL TREATMENT

Utility, low maintenance costs, watertightness, and beauty are all attributes of prestressed concrete tanks built by CROM.

Because of their proximity to sensitive residential or downtown neighborhoods, some installations demand superlative appearance. In these situations, prestressed concrete tanks with architectural treatment are ideal.

TANKS FOR WASTEWATER TREATMENT

Vessels required in wastewater treatment plants include equalization, tanks sludge digesters, effluent storage tanks, clarifiers, aeration tanks, SBR tanks, and package treatment tanks. Each of these provides an ideal application for the prestressed concrete design, which permits economical construction. Installations depicted on these pages are representative of the superior structures built by CROM.

TANKS FOR REUSE WATER

Storage of reuse wastewater is a good application for prestressed concrete tanks. These tanks may be located at the treatment plant facility, or at point of use, such as golf courses or agricultural lands, where the treated water is used for irrigation purposes. Typical of such installations are the tanks pictured here: watertight, attractive, and permanent.

TANKS FOR INDUSTRIAL APPLICATIONS

The problem of maintenance is particularly severe in many industrial installations. The corrosive atmosphere in chemical plants and paper mills require great care in the selection of construction materials and techniques that will not be susceptible to deterioration.

Prestressed concrete vessels built with composite walls have performed well as mill water treatment tanks and reservoirs, chemical processing basins, and pulp storage chests lined with tile or fiberglass.

Industrial plants build effluent water treatment facilities to combat stream pollution. As part of these installations, effluent treatment tanks are ideally built by the CROM system.

TANKS FOR THERMAL ENERGY STORAGE

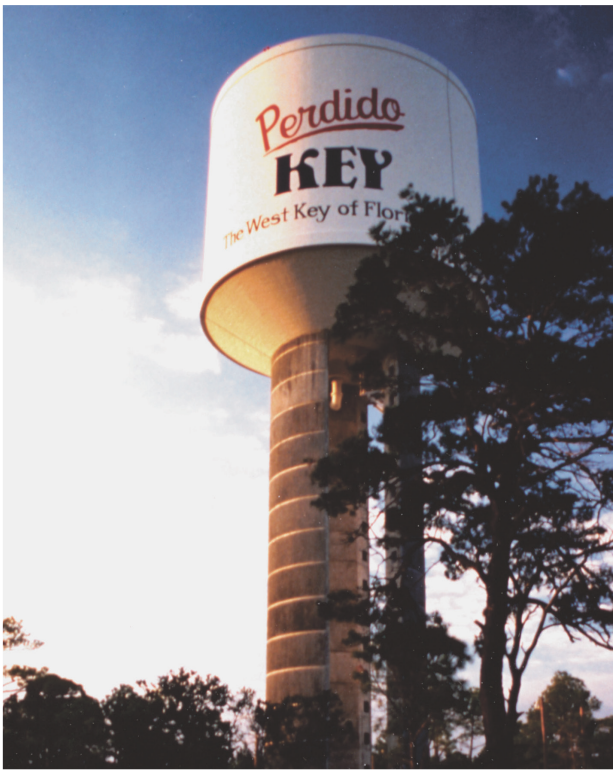
Thermal energy storage (TES) is a process whereby electric power costs for cooling can be shifted from high demand to low demand periods. This is accomplished by storing stratified or chilled water during times of low cost/low power demand and using it later at the time of peak demand.

Prestressed concrete tanks built by CROM are particularly well suited for these applications.

- Prestressed concrete is the ideal material for chilled water/ice storage tank construction.
- Tanks may be partially or completely buried without concern for maintenance.
- Aesthetically pleasing insulation systems may be added economically.
- The free-span concrete dome can be designed to support the loads of internal piping or ice machines.
- Interior surfaces do not require costly coatings or maintenance.

UNIQUE INSTALLATIONS

In the interest of diversification, and in response to the demands of the market, CROM has designed and built some outstanding and unique structures. Pictured on this page are some of these projects.



CAPACITIES AND DIMENSIONS FOR CIRCULAR TANKS *

Inside Diameter in Feet	Capacity in Millions of U.S. Gallon															
	.1	.2	.25	.3	.4	.5	.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	7.5	10.0
30	18'11"															
35	13'11"	27'9"	34'9"	41'8"	55'8"	69'6"										
40	10'8"	21'3"	26'7"	31'11"	42'7"	53'2"										
45	8'5"	16'10"	21'1"	25'3"	33'8"	42'0"	63'1"									
50	6'10"	13'7"	17'1"	20'6"	27'3"	34'1"	51'2"	68'2"								
55		11'3"	14'1"	16'11"	22'6"	28'2"	42'3"	56'3"								
60		9'5"	11'10"	14'2"	18'11"	23'8"	35'5"	47'4"								
65			10'1"	12'1"	16'1"	20'2"	30'3"	40'4"	60'6"							
70				10'5"	13'11"	17'5"	26'1"	34'9"	52'2"	69'6"						
75					12'1"	15'2"	22'9"	30'4"	45'5"	60'7"						
80					10'8"	13'4"	19'11"	26'8"	39'11"	53'2"	66'6"					
85						11'9"	17'8"	23'7"	35'4"	47'2"	58'11"					
90						10'6"	15'9"	21'1"	31'7"	42'1"	52'7"	63'11"				
95							14'2"	18'10"	28'4"	37'9"	47'2"	56'7"				
100							12'9"	17'1"	25'7"	34'1"	42'7"	51'1"	68'1"			
105							11'7"	15'5"	23'2"	30'11"	38'7"	46'4"	61'10"			
110							10'7"	14'1"	21'1"	28'2"	35'2"	42'3"	56'3"			
115								12'10"	19'4"	25'9"	32'2"	38'7"	51'6"	64'5"		
120								11'10"	17'9"	23'8"	29'7"	35'6"	47'4"	59'2"		
125									16'4"	21'9"	27'3"	32'9"	43'8"	54'6"		
130									15'2"	20'2"	25'2"	30'3"	40'4"	50'5"		
135									14'1"	18'8"	23'4"	28'1"	37'5"	46'8"	70'0"	
140									13'1"	17'5"	21'9"	26'1"	34'9"	43'5"	65'2"	
145									12'2"	16'3"	20'3"	24'3"	32'5"	40'6"	60'9"	
150									11'5"	15'2"	18'11"	22'9"	30'4"	37'10"	56'9"	
155											17'9"	21'3"	28'4"	35'6"	53'2"	
160											16'8"	20'0"	26'7"	33'3"	49'10"	66'6"
165												18'10"	25'0"	31'3"	46'11"	62'7"
170												17'8"	23'7"	29'5"	44'2"	58'11"
175												16'8"	22'3"	27'9"	41'8"	55'7"
180												15'10"	21'1"	26'4"	39'5"	52'6"
185													19'11"	24'10"	37'4"	49'9"
190													18'11"	23'7"	35'4"	47'2"
195													17'11"	22'4"	33'7"	44'10"
200													17'1"	21'4"	31'11"	42'6"
205														20'3"	30'4"	40'6"
210															28'11"	38'8"

Water Depth in Feet and Inches to Nearest Inch

Quick Formula For Volume in U.S. Gallons: $V = 5.875\ D^2H$

Where: V = Volume in U.S. Gallons

D = Inside Diameter in Feet

H = Liquid Depth in Feet

CROM can build tanks to any specified dimensions. CROM has built domed tanks in excess of 285' ID. Maximum side wall depth should be 70' 0" or lower.

* Larger capacities are available and typical. Omitted here for chart clarity.

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TRUSTED
RESPECTED

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