

## Prestressed Storage Tanks

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# Agenda

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- DN Tanks overview
- Construction Procedures and Design for Prestressed Concrete Tanks
- Benefits of Prestressed Concrete Tanks
- Applications for Prestressed Concrete Tanks
- Inspection and Repair of other Types of Concrete Tanks – Concrete Tank Services



# DN Tanks

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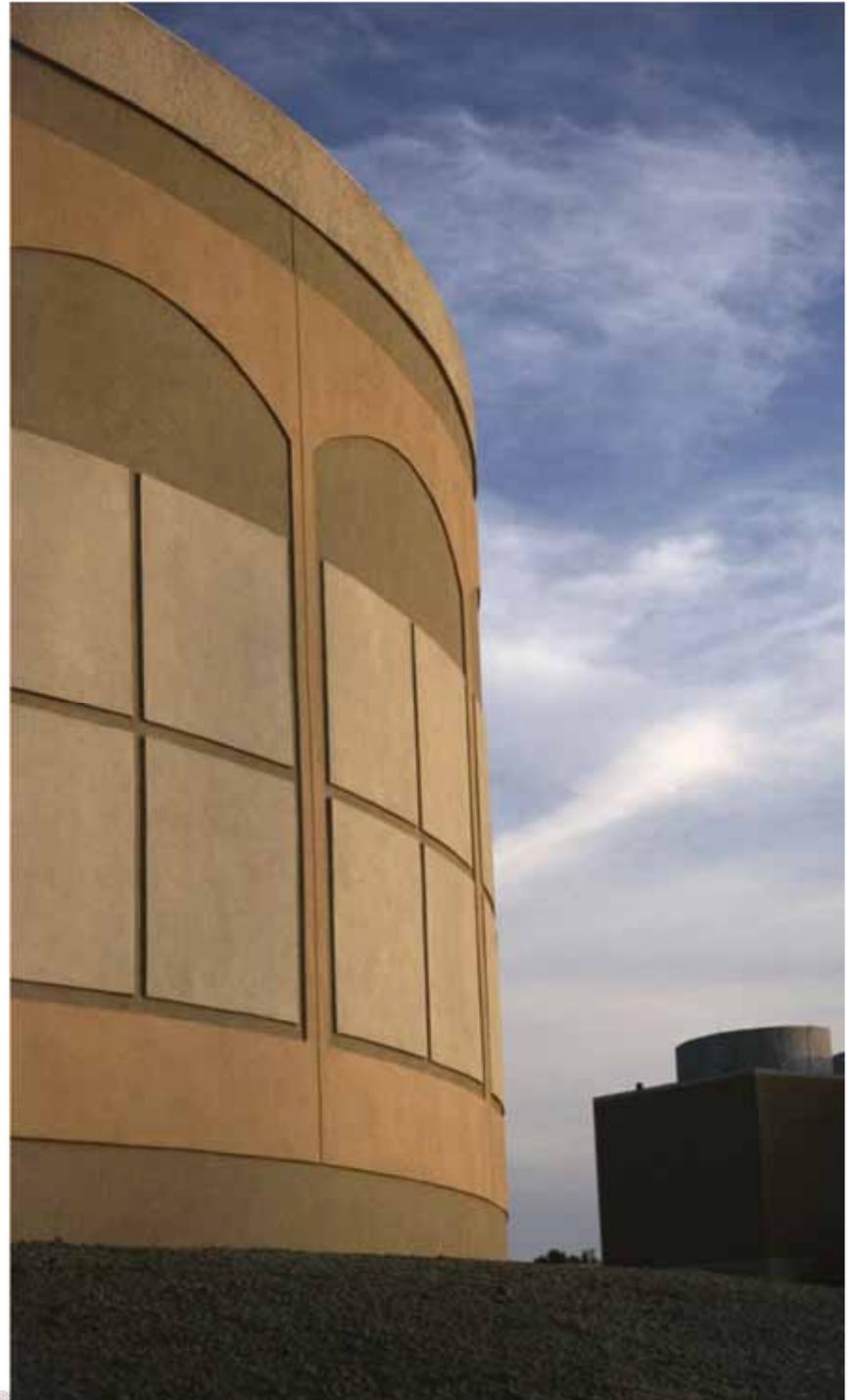
- Formed in 2011 from the merger of DYK and Natgun
- Design and construct prestressed concrete tanks
- The largest prestressed concrete tank manufacturer in the world
- 130 years of combined experience
- Over 2,500 completed tanks



# What we provide

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- The highest value tank
- Custom sizes from 40,000 gallons to 40,000,000 gallons and beyond
- Heights up to 85'
- Design and construction capabilities
- Currently constructing over 40 projects worldwide



# Designed to meet or exceed

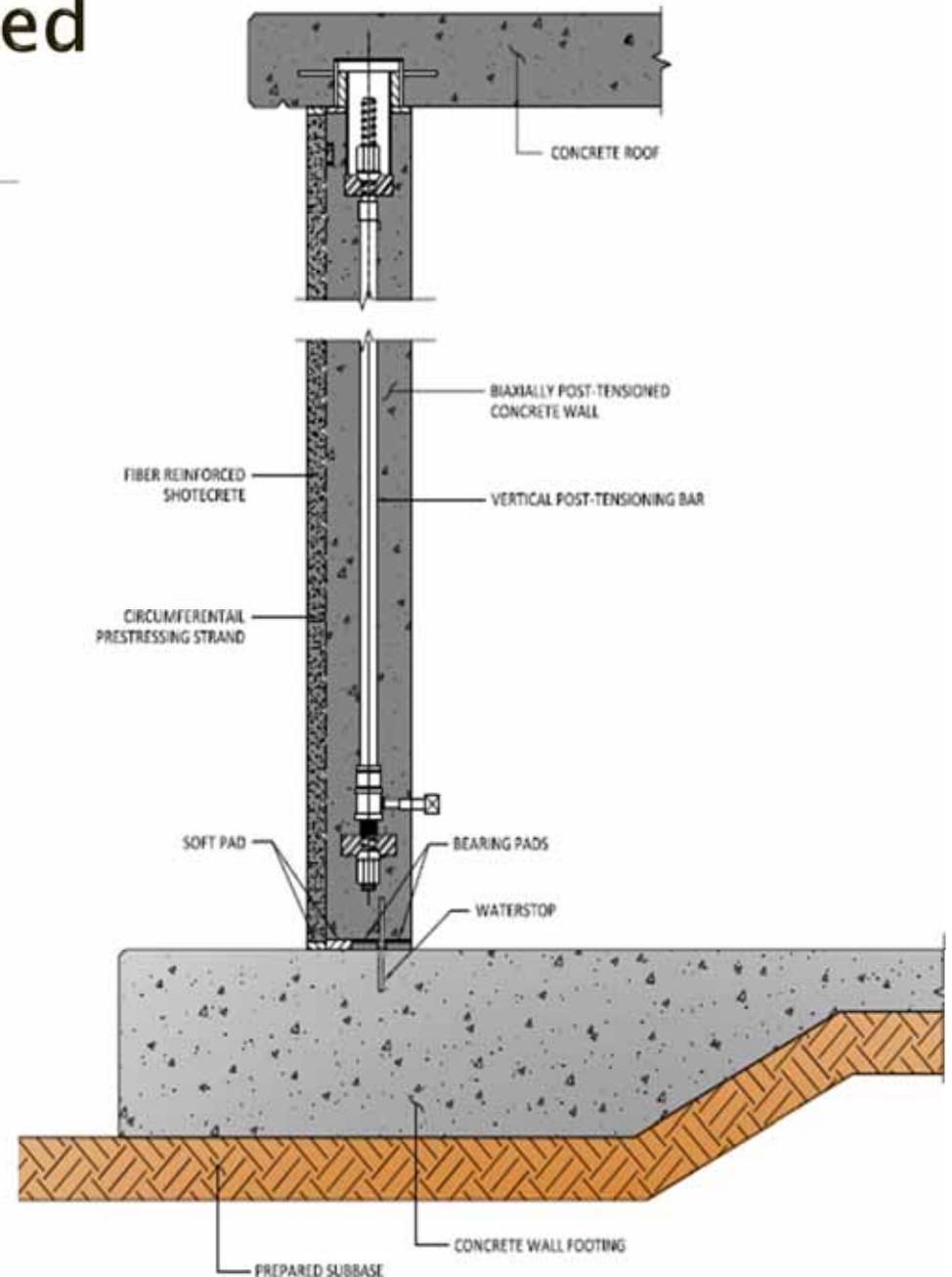
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- ACI 350 – Code Requirements for Environmental Engineering Concrete Structures
- ACI 350.3 – Seismic Design of Liquid-Containing Concrete Structures
- ASCE 7/IBC
- ACI 372R – Design and Construction of Circular Wire- and Strand-Wrapped Prestressed Concrete Structures
- AWWA D110 – Standard for Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks

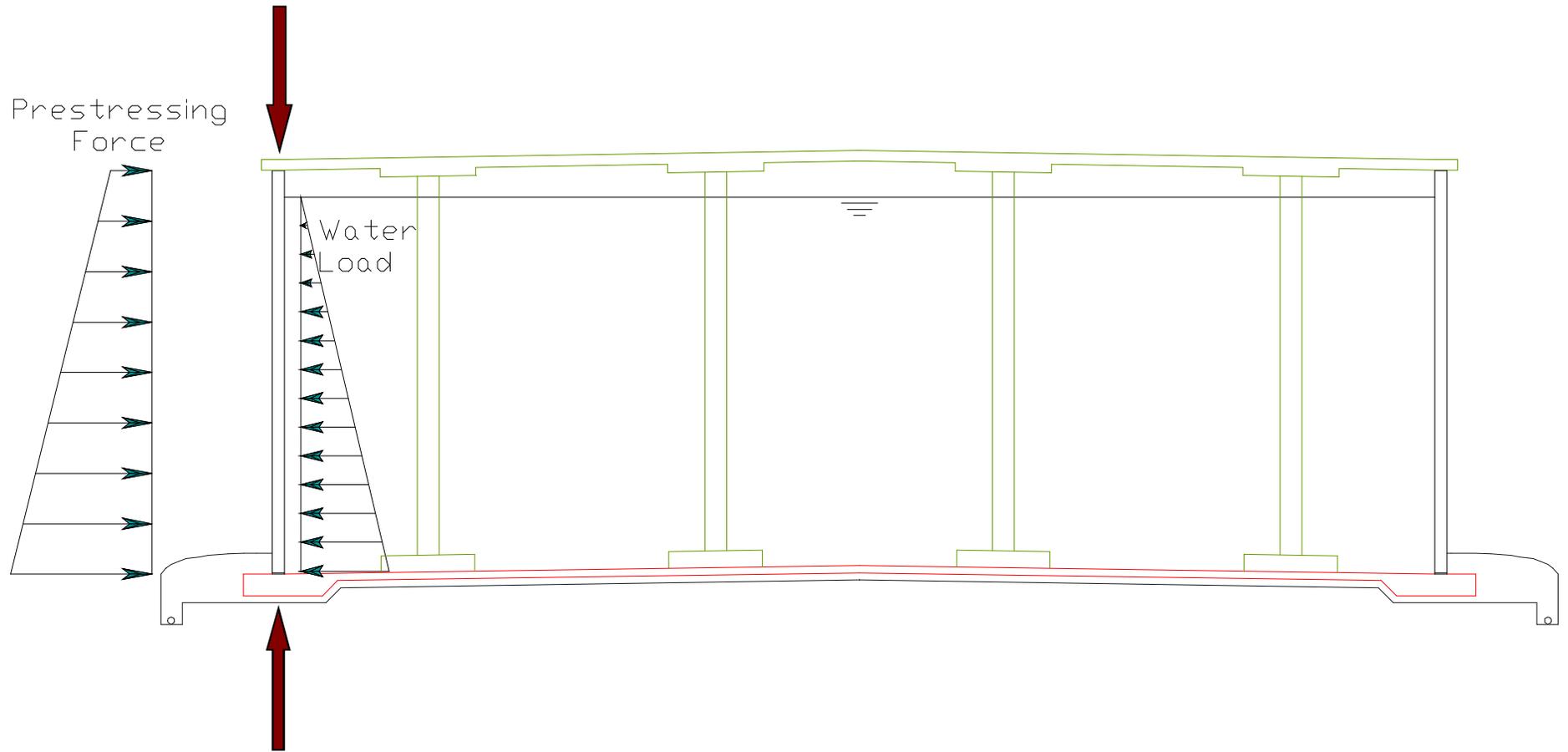


# AWWA D110 Prestressed Concrete Tanks

- Inner concrete core
- Horizontal prestressing providing compression:  
*Efficient use of Materials*
- Flexible floor-wall connection
- Secondary Assurance of Water-Tightness
  - *Vertical post tensioning*
  - *Embedded steel diaphragm*



# Prestressed Concrete Tank





# Construction Procedures

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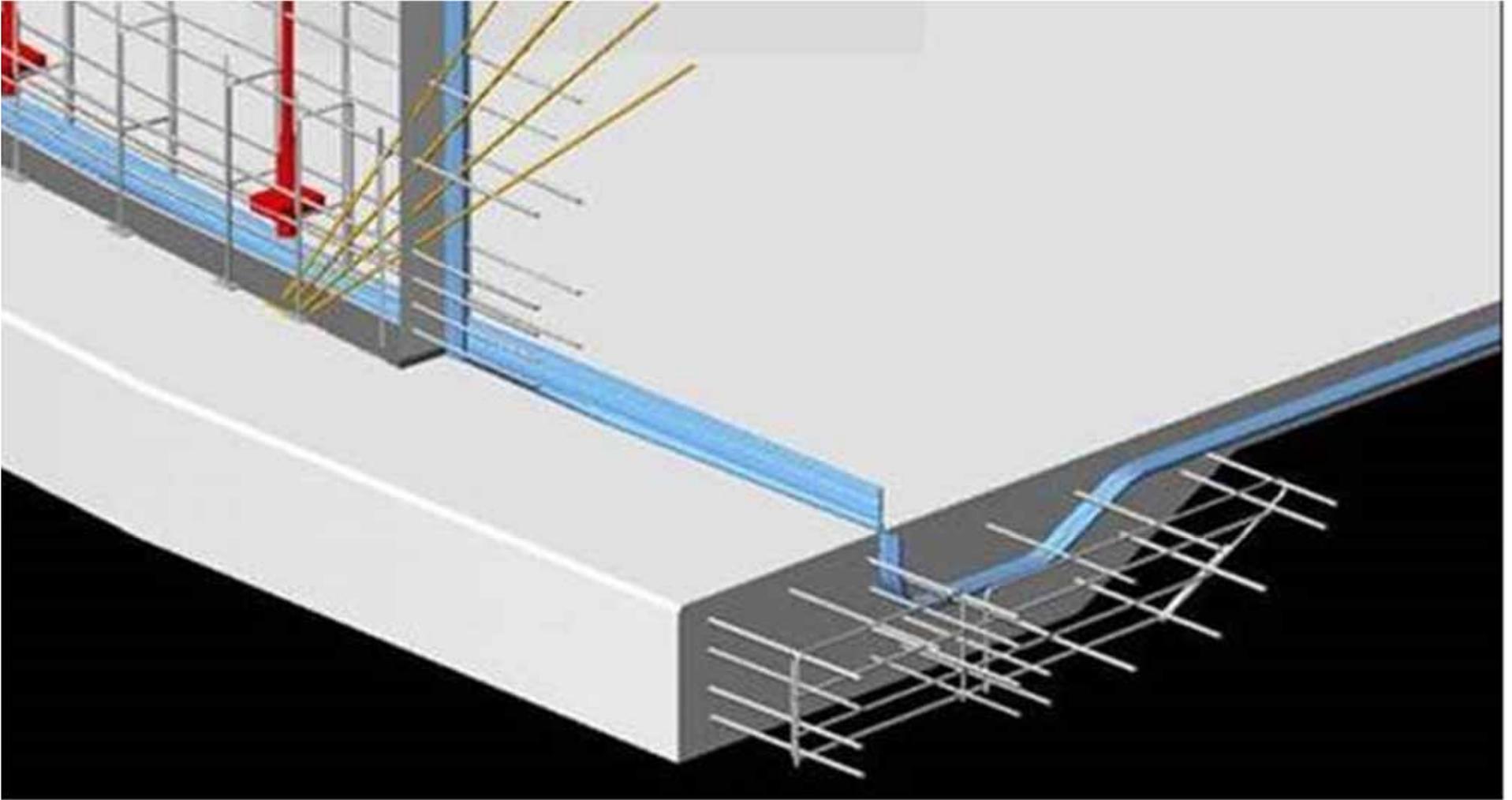
- Floor / Foundation
- Wall
- Roof
- Prestressing



# Construction Procedures

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Floor / Foundation



Standard Floor/ Footing

Spread footing  
Membrane floor slab



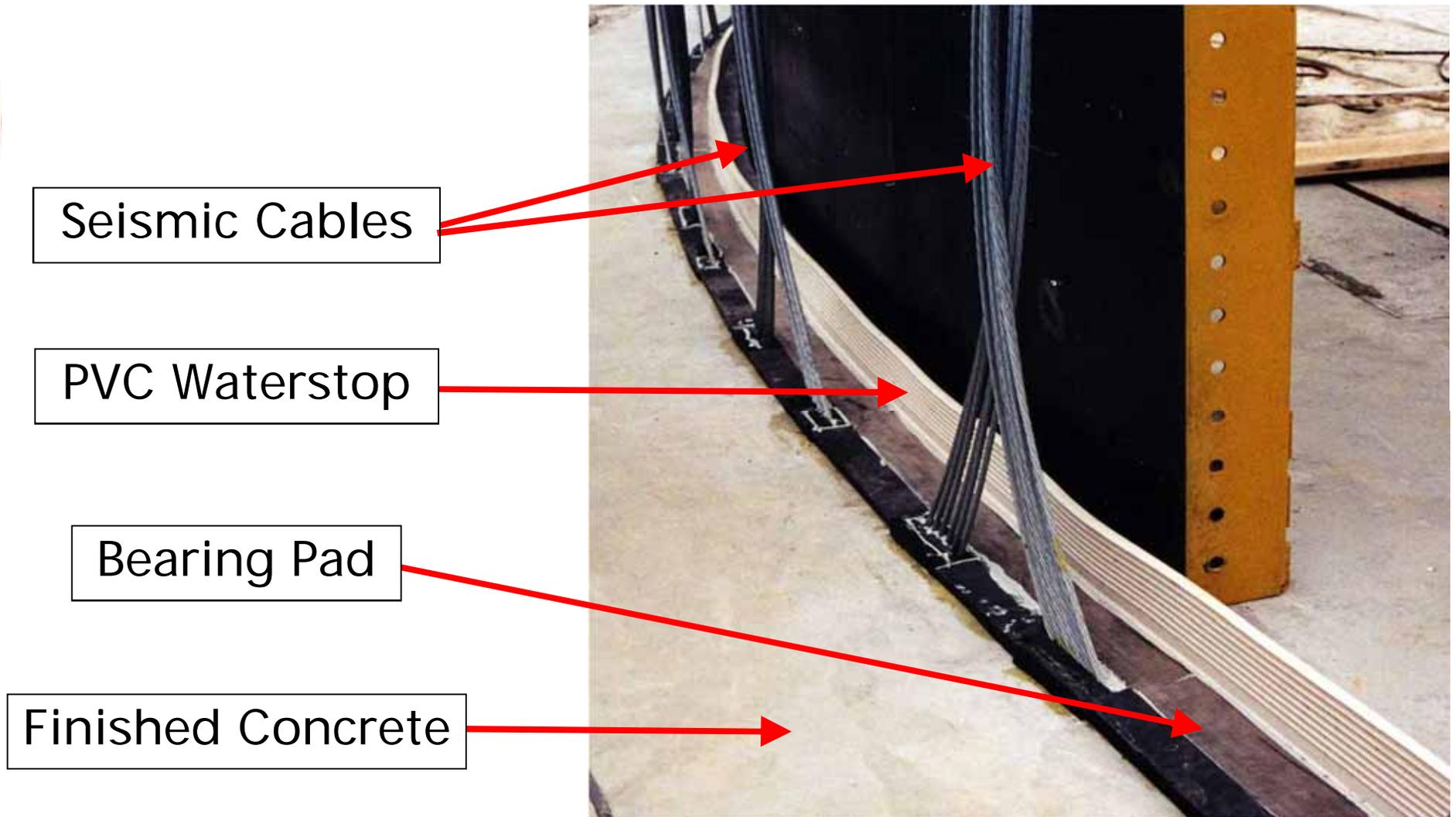
Floor construction

Monolithic Floor



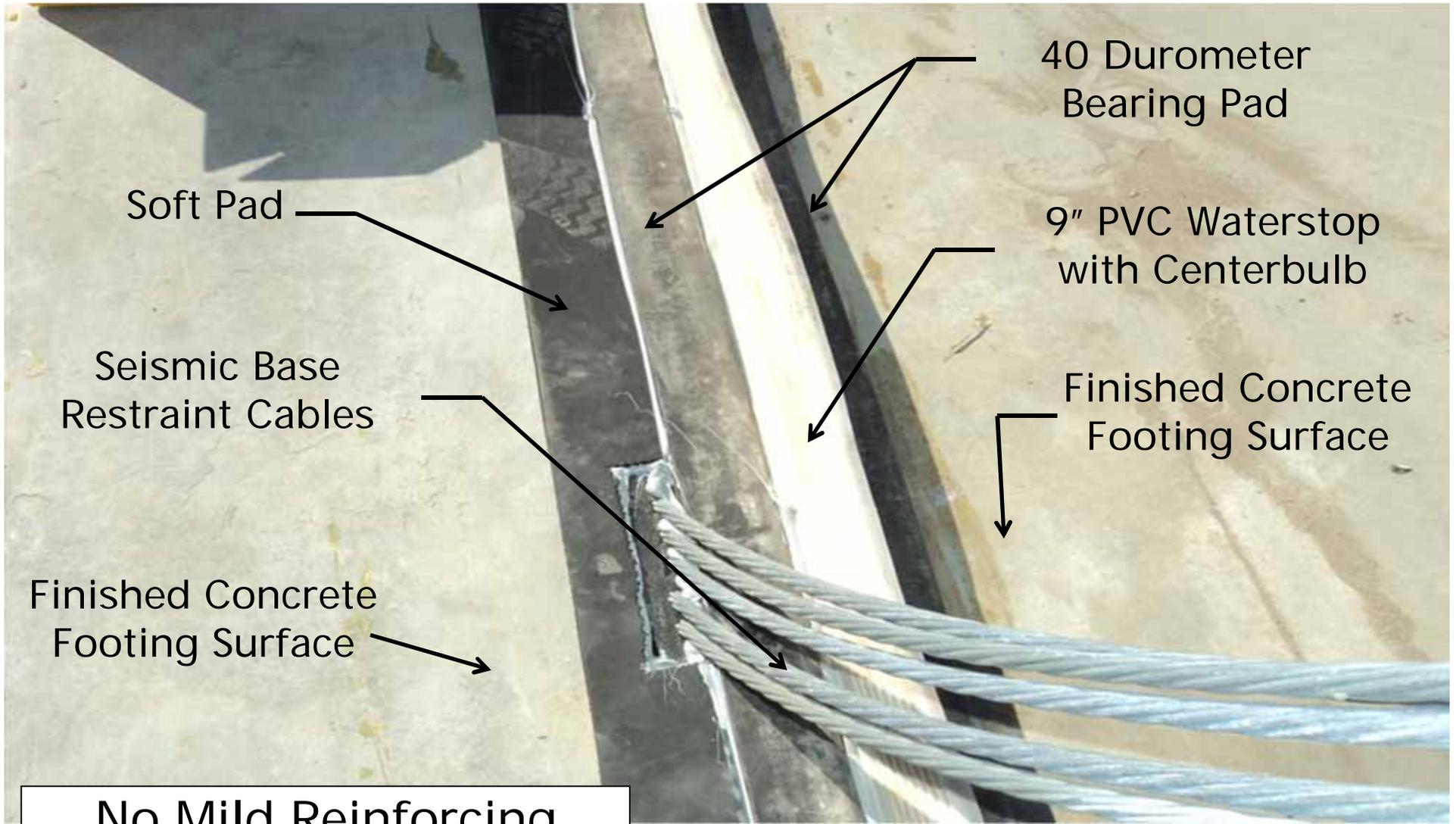
Floor construction

Multiple Floor Sections



Floor to Wall Connection

Anchored flexible base



Soft Pad

Seismic Base  
Restraint Cables

Finished Concrete  
Footing Surface

40 Durometer  
Bearing Pad

9" PVC Waterstop  
with Centerbulb

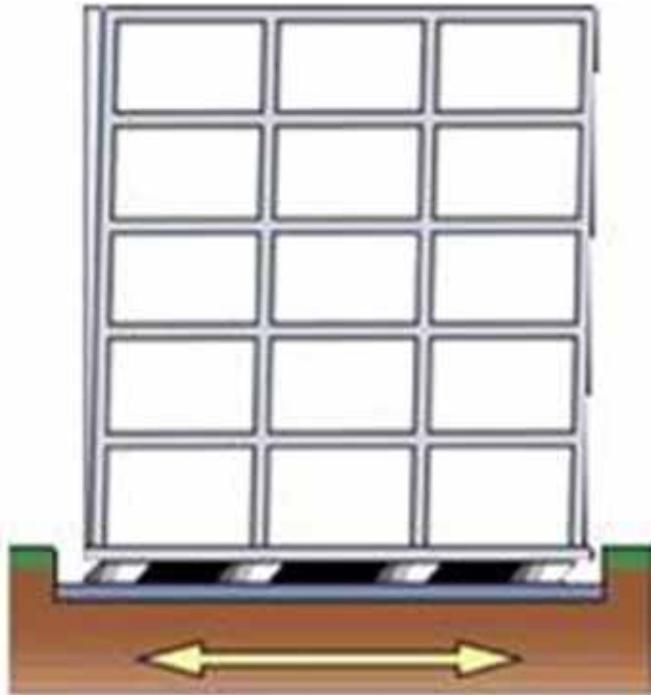
Finished Concrete  
Footing Surface

No Mild Reinforcing

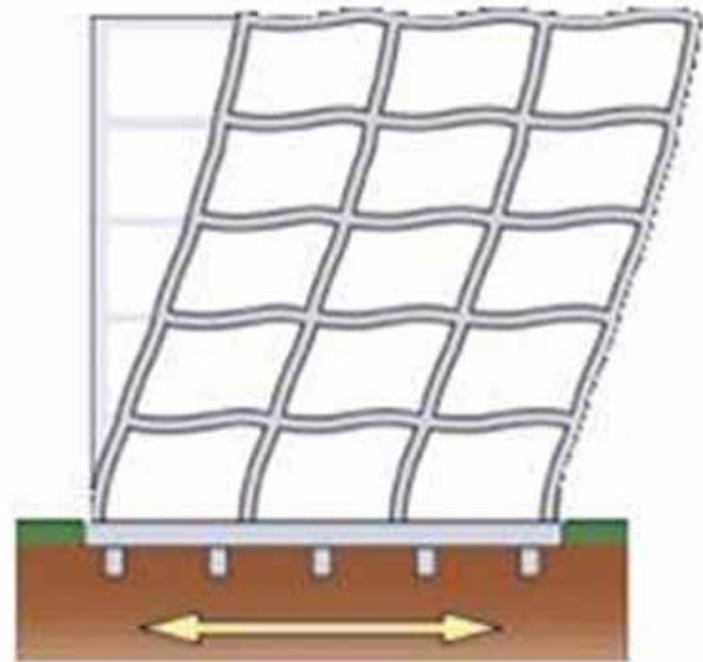
Floor to Wall Connection

Anchored flexible base

# Seismic Design & Operation Loads



Seismically Isolated - Flexible



Not Isolated - Rigid





Los Angeles, California  
January 1994, Northridge  
6.8M



# Construction Procedures

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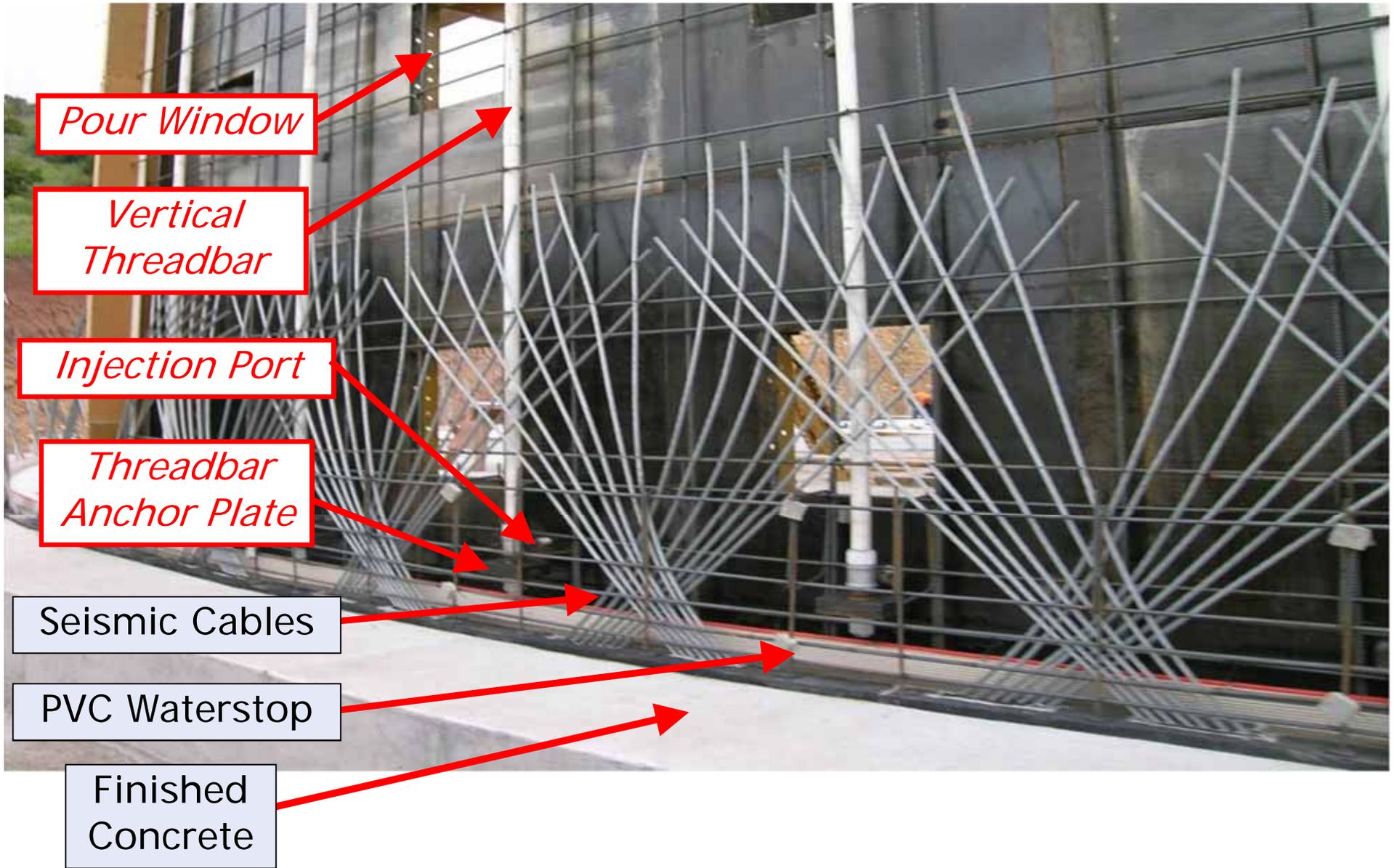
Tank Wall



***TYPE I***



**TYPE III**



*Pour Window*

*Vertical Threadbar*

*Injection Port*

*Threadbar Anchor Plate*

Seismic Cables

PVC Waterstop

Finished Concrete

## Wall Construction

Cast-in-place  
Vertically Post-tensioned



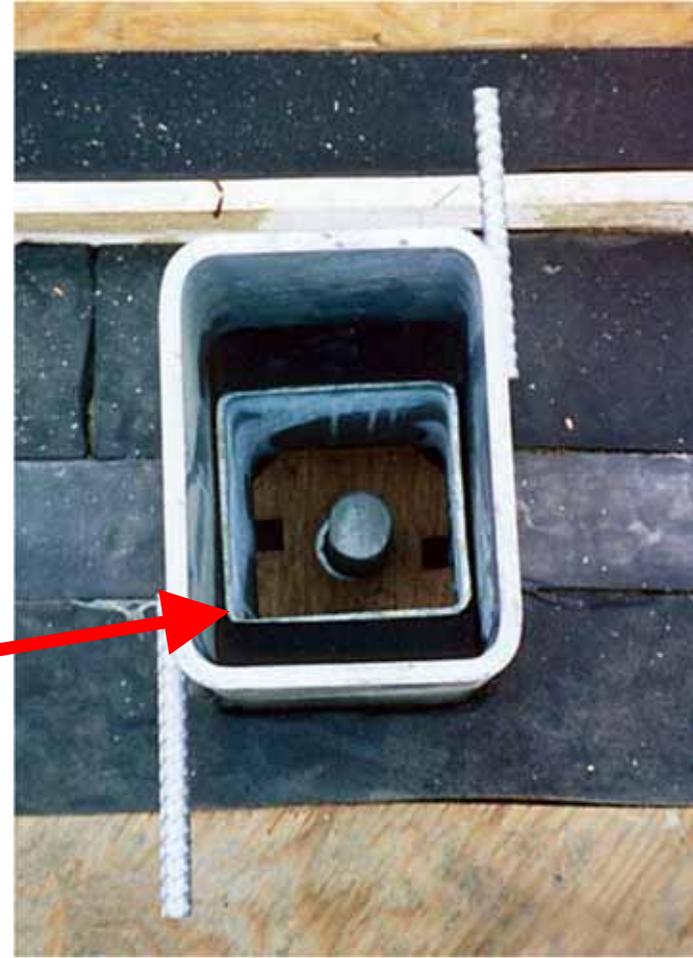
Steel Curtain

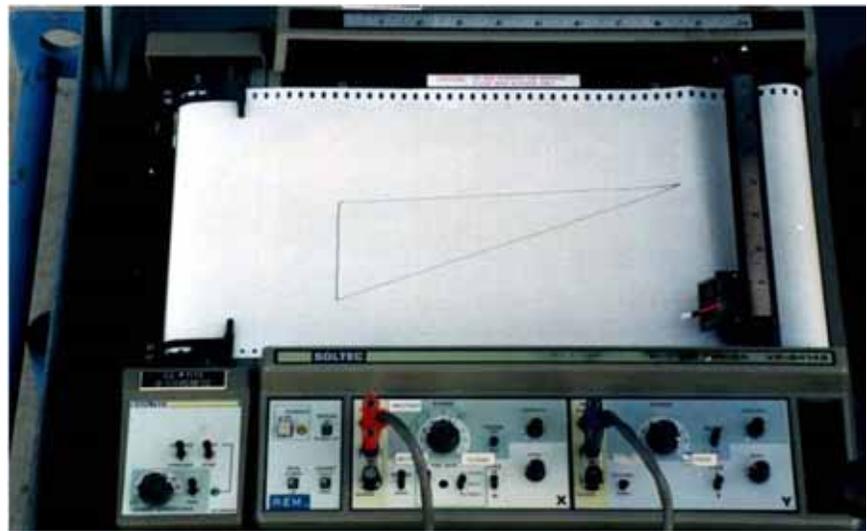


Wall Construction

Wall Form and Pour

# Roof/Wall Connection & Post Tensioning





Vertical Post-Tensioning

# Vertical Post-Tensioning



Epoxy grout  
following Post-  
Tensioning



**TYPE I**



***TYPE III***



## Wall Construction

Precast  
Embedded Diaphragm



Precast Panel Beds



Panels In Place



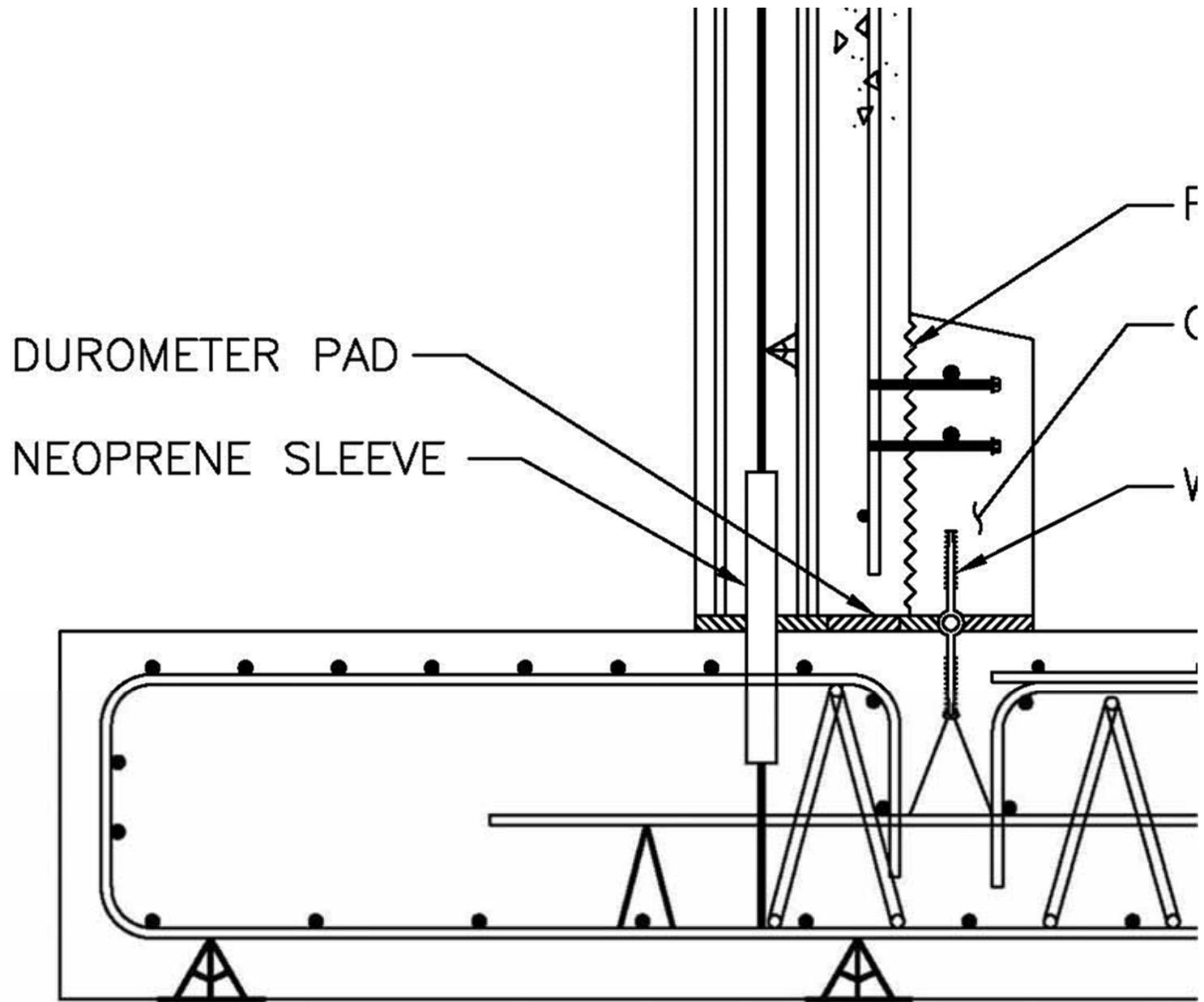
Wall Slot  
Plate



Wall Slot  
In Place



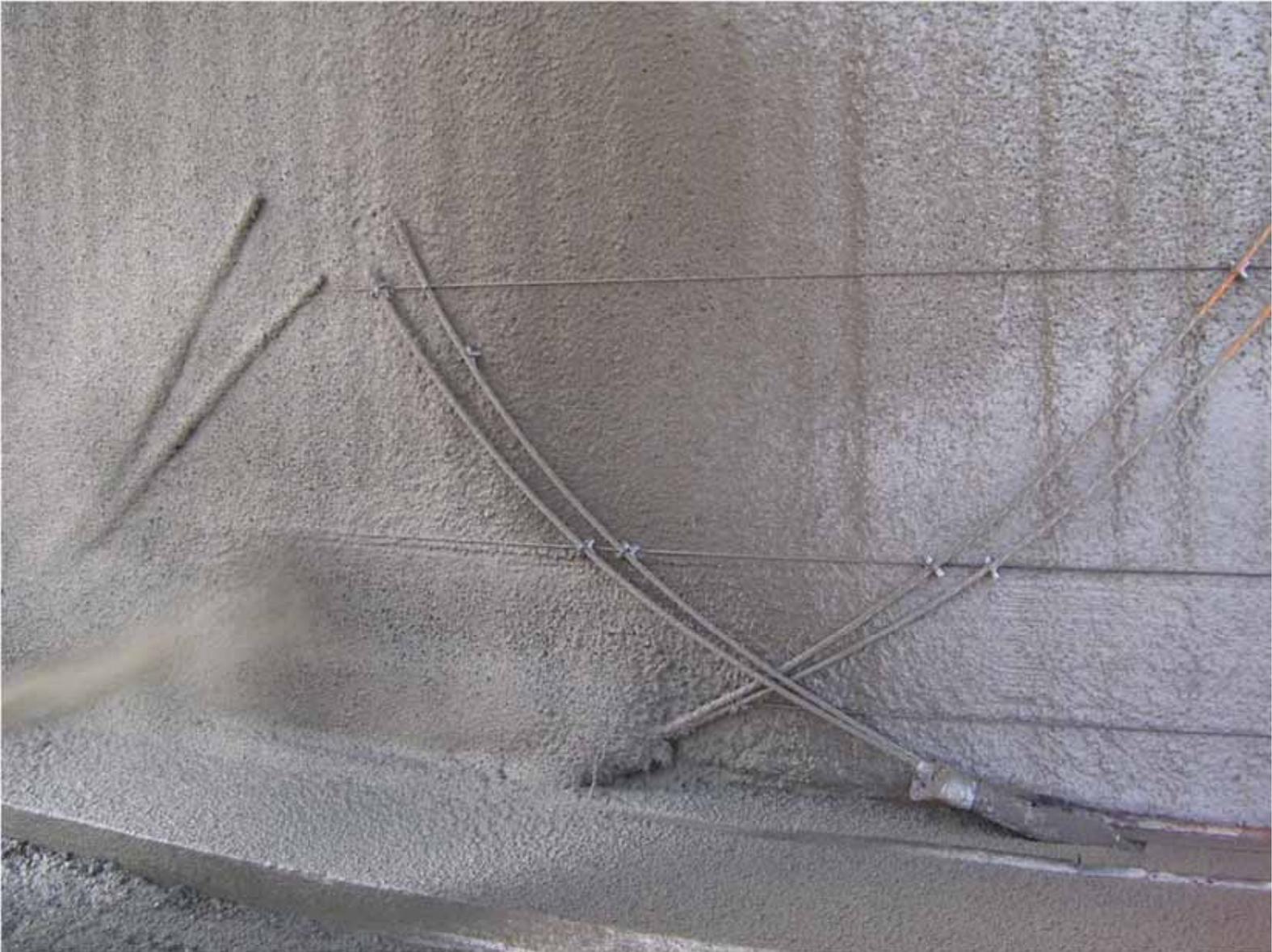
Interior  
Formwork



Internal Waterstop Cove



Initial Shotcrete Base Coat



Seismic Base Restraint Cables



# Construction Procedures

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## Roof Construction



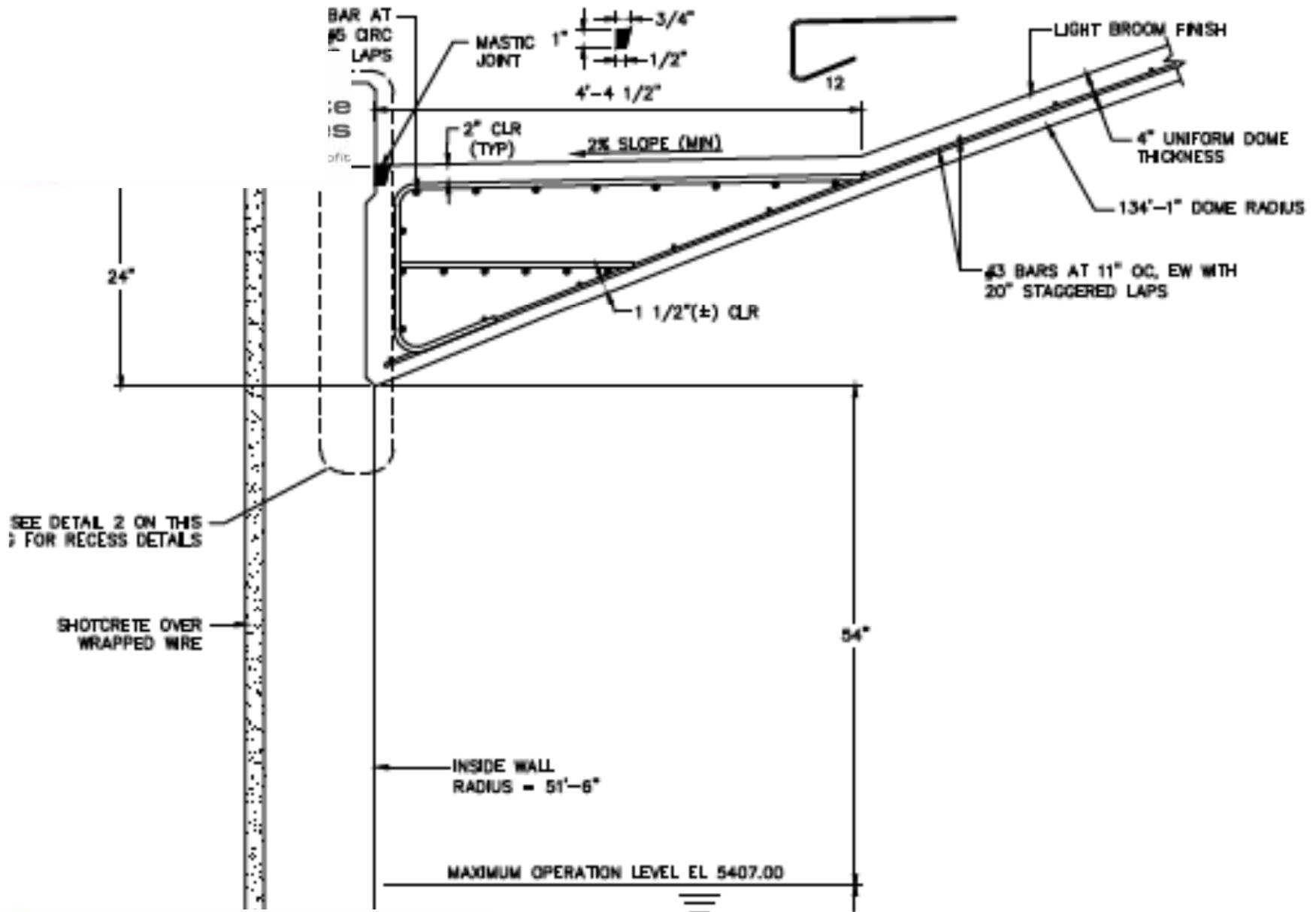
## Roof Options



Column supported flat slab roof



Column supported flat slab roof



Dome detailing





Finished Dome

# Benefits of Roof Options

## *Flat Slab*

- Dual land use
- Slightly Lower overall height
- Easily utilizes flexible connection between wall and roof
- More economical at larger diameters

## *Concrete Dome*

- No internal obstructions for easier cleaning
- Accommodates more differential settlement
- More economical at smaller diameters





# Construction Procedures

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Abrasive Blasting / Prestressing / Shotcrete

# Prestressing

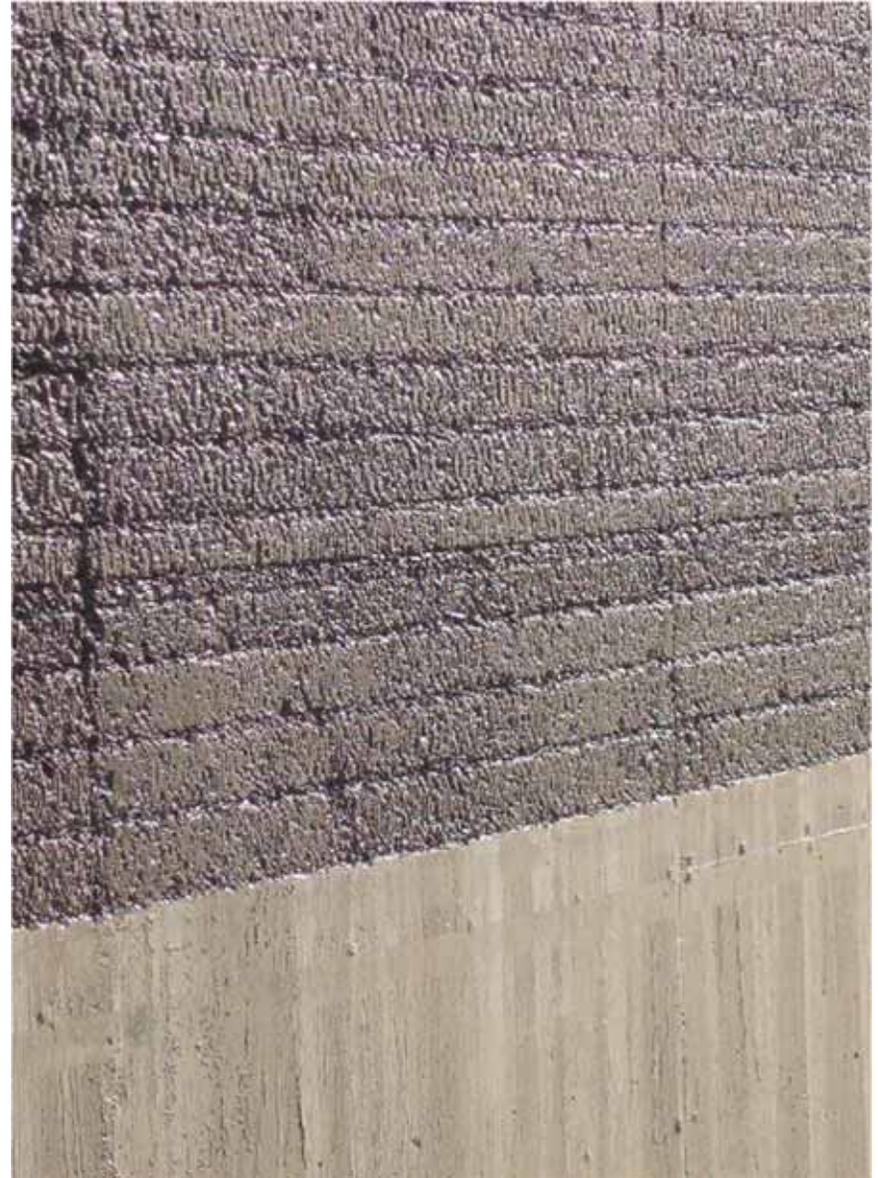
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Abrasive / Water Blasting  
Tank wrapping (Strand & Wire)  
Shotcrete covercoat



# Strand Circumferential Prestressing





Abrasive Blasting / Water Blasting (Type I)

# Strand Circumferential Prestressing



240 ksi, 7-wire,  
galvanized strand





Wire Circumferential Prestressing (Type III)



Shotcrete encasement



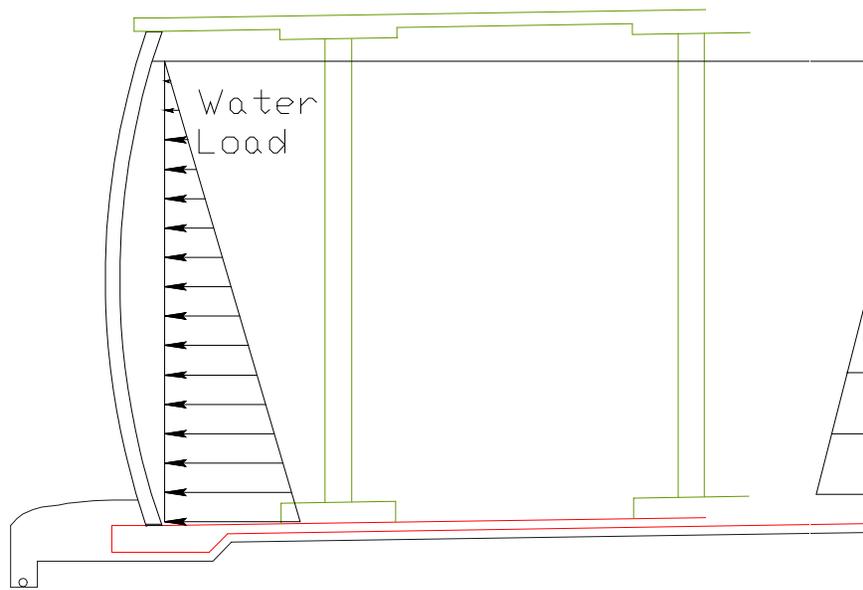


# Why Prestress a Concrete Tank?

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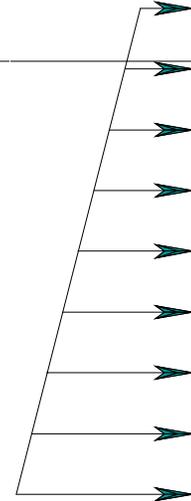


# CAST-IN-PLACE CONCRTE TANK (Conventional)

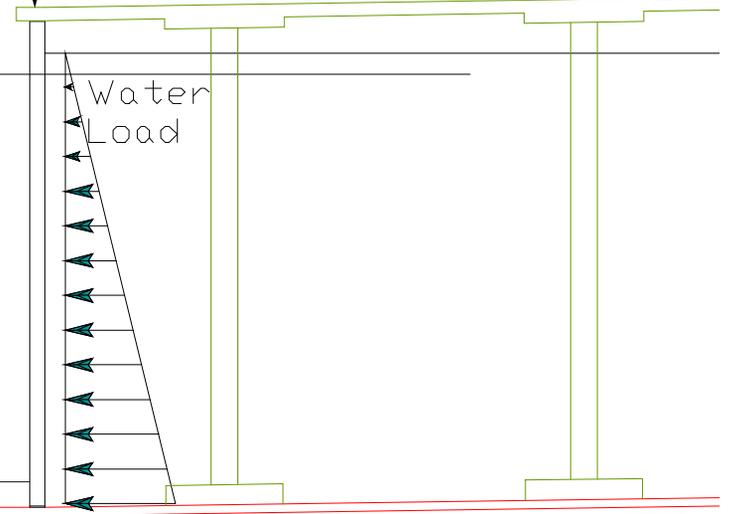


# PRESTRESSED CONCRETE TANK

Prestressing  
Force



Water  
Load



.. INCREASED DUCTILITY  
HIGH QUALITY  
COST EFFICIENT



When to use a Prestressed Concrete Tank?

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***ALWAYS.....!***



## Large Tanks

33.0 MG, 40.0 MG,  
and (2) 7.5 MG Reservoirs  
San Marcos, CA



## Small Tanks

200,000 Gallon Reservoir  
Sausalito, CA



## Small Tanks in Remote Locations

125,000 Gallon Reservoir  
Outside El Paso, TX



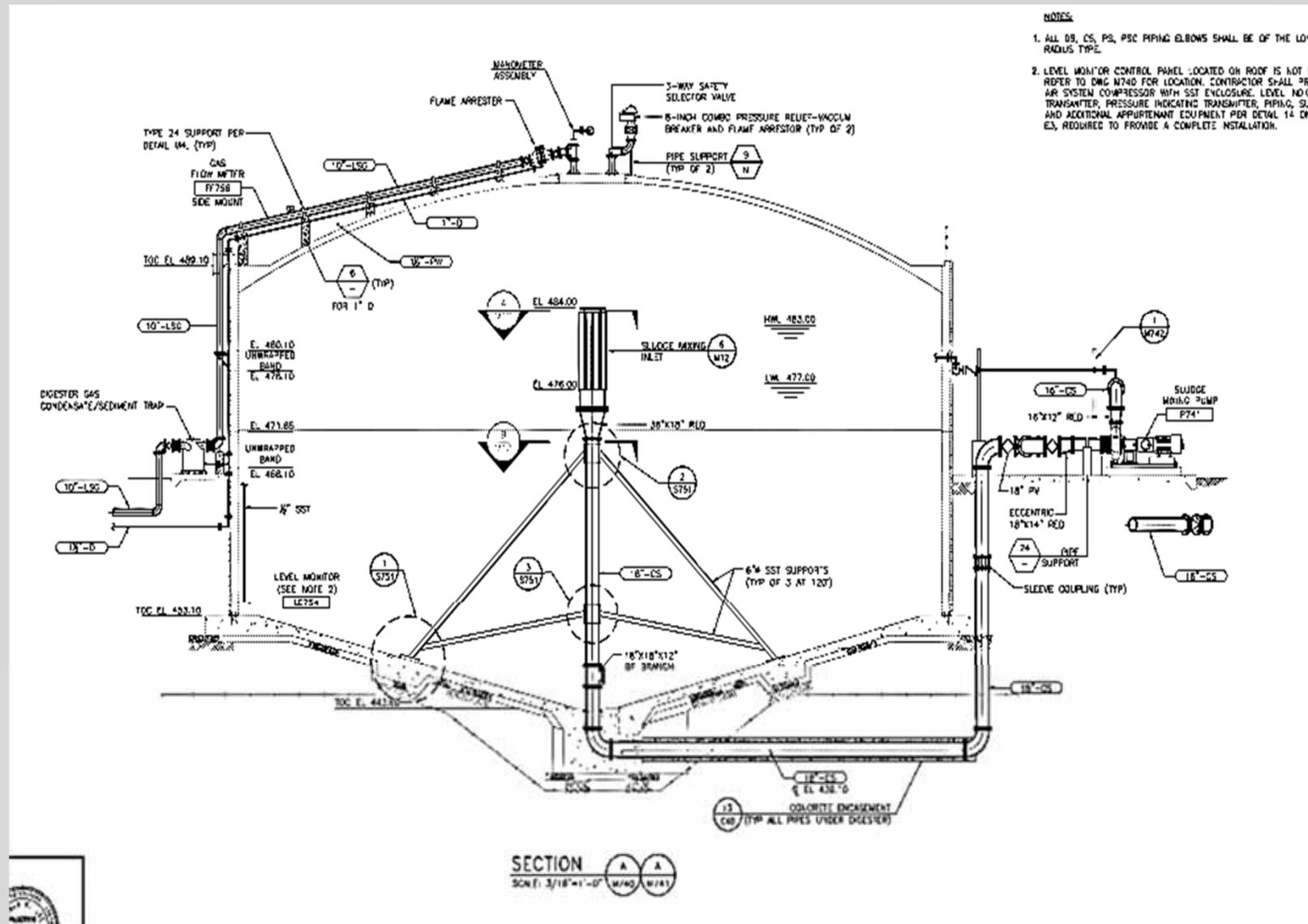
**Buried or Backfilled /  
Multi-Use**

(2) 5.0 MG Reservoirs  
El Segundo, CA



## Wastewater Storage

(23) 4.0 MG Reservoirs  
Carson, CA



Wastewater Storage

"Modified Egg Digester"



TES/Aesthetics

3.0 MG TES Tank  
Orlando, FL

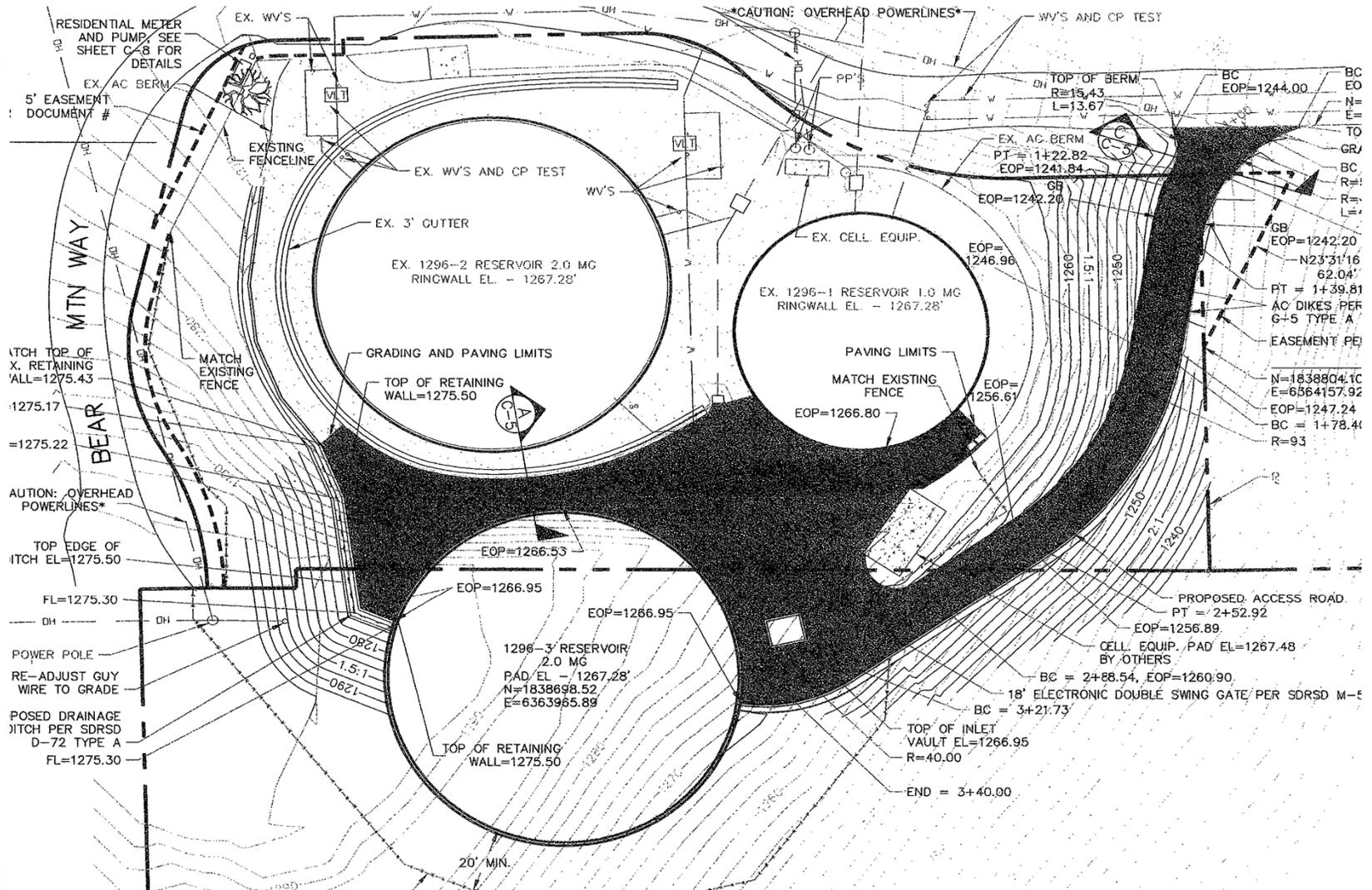


Save on Site Work  
Costs

2.0 MG Reservoir  
Jamul, CA



# PSC Tank Site Layout





2.0 MG Reservoir  
Jamul, CA

# Benefits of a DN Tank over Welded Steel

- Con's
  - *Prestressed Concrete Tanks Slightly Greater Initial Cost*
- Pro's
  - *Leak Free Design*
  - *Steel Tanks must be taken out-of-service for repainting (Steel Needs Redundancy) – Concrete Does Not*
  - *Steel limited to at grade installation. Concrete construction allows at grade construction, partial backfill, or complete burial*
  - *Resistance to Gun Fire*





## **BUILT TO WITHSTAND DRIVE-BY SHOOTINGS**

This 350,000-gallon Natgun water tank is sited next to a road in a remote area frequented by hunters. The owner and engineer were concerned about accidental or deliberate vandalism and wanted a tank that was both maintenance-free and puncture-proof.

# Benefits of a DN Tank over Welded Steel

- Pro's
  - *Reduced Freeboard*
    - *Steel – AWWA D100 – Freeboard = Sloshing Height*
    - *PSC – AWWA D110 – Freeboard = Designed case by case*
    - *2.0 MG Tank on Peninsula – Sloshing height 12'*
      - *Steel Tank = 12' Freeboard*
      - *Prestressed Concrete Tank = 5' Freeboard*
- **Eliminate High Maintenance Costs!**



# Welded Steel Tanks Must Be Maintained to Prevent Structural Defects



# ed Steel Maintenance Costs

- Lakeside, CA – 2.25 MG - \$411,677.00
- Capitola, CA– 1.2 MG - \$360,472.00
- **Spring Valley, CA - 1.0 MG - \$259,200.00**
- Spring Valley, CA – 2.0 MG - \$359,300.00
- Los Altos Hills, CA - 0.8 MG - \$252,400.00



# 1.0 MG Tank Maintenance Project

ITEM No.	DESCRIPTION	ENGINEER'S ESTIMATE				WEST COAST INDUSTRIAL COATINGS, INC.	
		QTY	UNITS	Unit Price	Total Price	1/8	
						Unit Price	Total Price
<b>CIP P2490 - 1296-1 RESERVOIR INTERIOR/EXTERIOR COATING AND UPGRADES</b>							
1	Mobilization, Demobilization, Insurance and Bonds	1	LS	\$15,000	\$15,000	\$15,000	\$15,000
2	Interior Surfaces	1	LS	\$125,000	\$125,000	\$110,000	\$110,000
3	Exterior Surfaces	1	LS	\$150,000	\$150,000	\$77,000	\$77,000
4	Sacrificial Anodes	11	EA	\$400	\$4,400	\$1,500	\$16,500
5	Exterior Ladder	1	LS	\$5,000	\$5,000	\$12,500	\$12,500
6	Roof Vent, Anchor Chairs and Bolts	1	LS	\$6,100	\$6,100	\$9,500	\$9,500
7	Tank Penetrations/Miscellaneous Structural Modifications	1	LS	\$25,000	\$25,000	\$30,700	\$30,700
<b>CIP P2492 - 1296-2 RESERVOIR INTERIOR/EXTERIOR COATING AND UPGRADES</b>							
8	Mobilization, Demobilization, Insurance and Bonds	1	LS	\$15,000	\$15,000	\$6,350	\$6,350
9	Interior Surfaces	1	LS	\$200,000	\$200,000	\$189,000	\$189,000
10	Exterior Surfaces	1	LS	\$250,000	\$250,000	\$120,250	\$120,250
11	Sacrificial Anodes	13	EA	\$400	\$5,200	\$1,423	\$18,500
12	Roof Vent, Anchor Chairs and Bolts	1	LS	\$6,100	\$6,100	\$9,500	\$9,500
13	Tank Penetrations/Miscellaneous Structural Modifications	1	LS	\$19,000	\$19,000	\$26,200	\$26,200
<b>ALLOWANCE ITEMS</b>							
14	Structural Modification Allowance	1	LS	\$25,000	\$25,000	\$25,000	\$25,000
15	Cell Vendor Appurtenances Allowance	1	LS	\$25,000	\$25,000	\$25,000	\$25,000
<b>TOTAL SUBMITTED BID</b>						<b>\$875,800</b>	<b>\$690,000</b>

## Tank Dimensions

Tank Diameter =	75.0	FT.
Side Water Depth =	31.0	FT.
Tank Capacity =	1.02	MG

## Tank Surfaces

Top of Floor =	4416	SF
Interior Wall =	7301	SF
Interior Dome =	4697	SF
Total Interior =	16414	SF
Maintenance Cost Interior =	\$157,200.00	LS
Maintenance Cost Interior =	\$ 9.58	Per SF
Exterior Wall =	7301	SF
Exterior Dome =	4697	SF
Total Exterior =	11998	SF
Maintenance Cost Exterior =	\$ 92,000.00	LS
Maintenance Cost Exterior =	\$ 7.67	Per SF

Average of bids results for maintaining welded steel tanks from the past few years.

*Cumulative Average from bids yields a Unit Cost for Maintenance of \$7.50 per SF*



# Welded Steel Tank Maintenance Costs

<b>Tank Dimensions</b>					
Tank Diameter =	83.0	FT.			
Side Water Depth =	25.00	FT.			
<b>Usable Tank Capacity (1.5% Sloped Floor)=</b>	<b>1.00</b>	<b>MG</b>			
<b>Welded Steel Tank Specific</b>					
Assumed Freeboard =	7	FT.			
<b>Total Steel Tank Volume =</b>	<b>1.28</b>	<b>MG</b>			
Assumed Steel Tank Cost =	\$ 800,000.00	DOLLARS			
<b>Prestressed Concrete Tank Specific</b>					
Assumed Freeboard =	3	FT.			
<b>Total Prestressed Concrete Tank Volume =</b>	<b>1.12</b>	<b>MG</b>			
Assumed Prestressed Concrete Tank Cost =	\$ 1,150,000.00	DOLLARS			

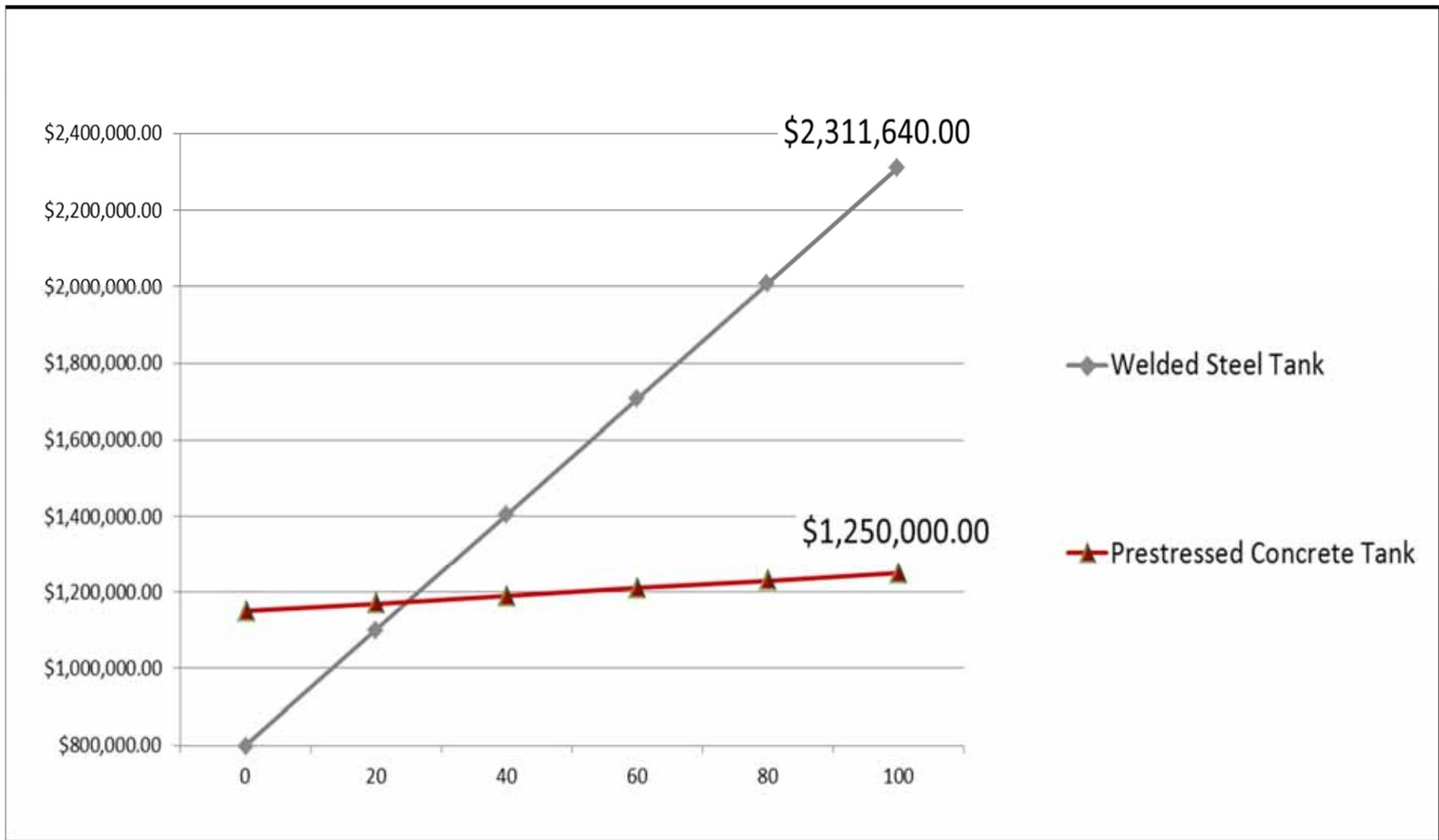
## Welded Steel Tank Maintenance Costs

Return Period	Maintenance Scheduled	Sq Ft	Unit Price	Total Price
20	Blast exterior and re-application of coating	14,092	\$7.50	\$105,690.00
20	Blast interior and re-application of coating	19,500	\$7.50	\$146,250.00
20	Engineering Design Cost (Estimate 10%)			\$25,194.00
20	Construction Management / Inspection Cost (Estimate 10%)			\$25,194.00
<b>TOTAL MAINTENANCE COST PER 20 YEAR RETURN PERIOD</b>				<b>\$302,328.00</b>

## Prestressed Concrete Tank Maintenance Costs

Return Period	Maintenance Scheduled	LS	Unit Price	Total Price
20	Powerwashing, Routine Maintenance, and Inspection	LS	\$20,000.00	\$20,000.00
<b>TOTAL MAINTENANCE COST PER 20 YEAR RETURN PERIOD</b>				<b>\$20,000.00</b>

# Welded Steel Tank Maintenance Costs



# Benefits of a DN Tank over Welded Steel

## ▶ Local Involvement

- *Concrete Suppliers*
- *Lumber*
- *Local Labor*
- *Rentals*
- *Ice Cream Shop*





**All Around You!**



8 MG Graham Reservoir, Mountain View, CA



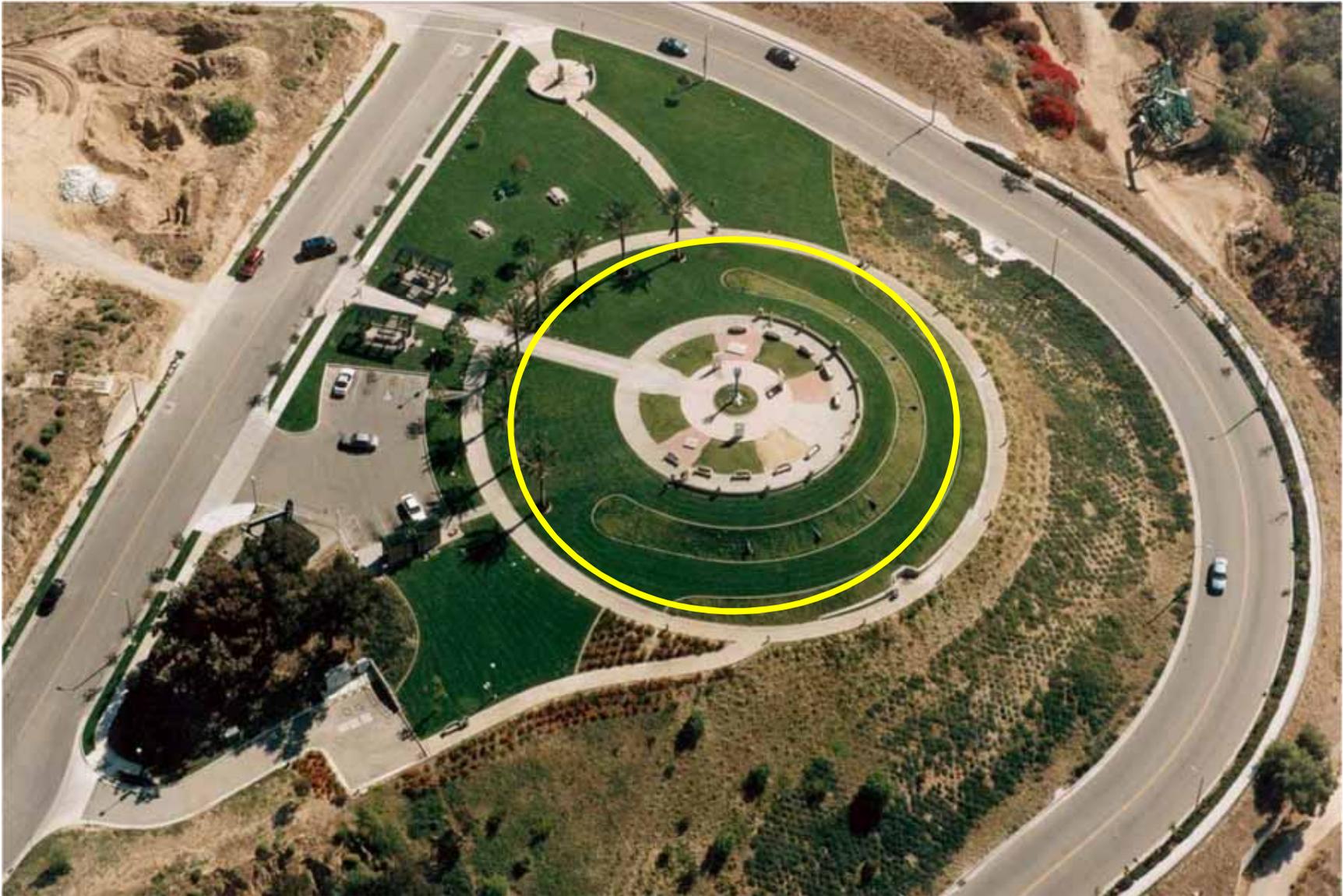
0.5 MG Reservoir, Laconia, NH



2 MG Reservoir, Anaheim, CA



1.1 MG Reservoir, Naval Hospital, San Diego, CA



1.2 MG Reservoir, Signal Hill, CA



o.6 MG Reservoir, Overland Park, KS



10 MG Reservoir, Los Angeles, CA



**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit

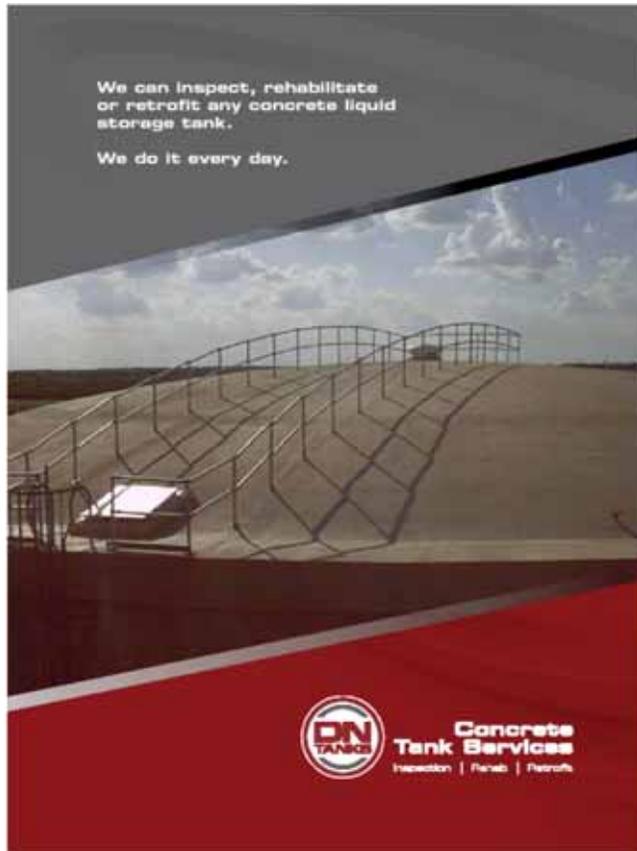
# CONCRETE TANK SERVICES





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit

# Who Is DN Tanks CTS



## *DN Tanks Concrete Tank Services Division*

- Division of DN Tanks
- Works Nationwide
- Performs inspection, rehabilitation, retrofit, and seismic upgrades of all types of concrete tanks

# Repairs and Inspections

- ▶ Water Districts asked for our help, even on tanks that we did not build.
  - Response to State Requirements for Periodic Inspection
  - Response to New State Mandated Regulations
  - Response to Aging Infrastructure
  - Seismic upgrades





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit

# Repairs and Inspections

- ▶ Response to Change in Tank Needs



# Repairs and Inspections

- ▶ Increased Security Needs





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit

# Inspection





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit

# Rehabilitation - Cleaning





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit

# Rehabilitation - Repairs





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit

# Rehabilitation - Repairs





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit

# Rehabilitation - Repairs





**Concrete  
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# Rehabilitation - Repairs





**Concrete  
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# Rehabilitation - Repairs





**Concrete  
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# Rehabilitation - Repairs





**Concrete  
Tank Services**  
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# Rehabilitation - Repairs





**Concrete  
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# Rehabilitation – Repair





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit

# Rehabilitation – Repair





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit

# Rehabilitation – Repair



# Retrofit – Seismic Upgrade

*Location: SF Bay, CA*  
*Problem: Seismic Retrofit*



Forming of new machine footing and seismic cable system application



Seismic cable attached to wall before automated shotcrete application



**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit

# Retrofit – Water Quality





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit

# Retrofit – Water Quality





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit

# Retrofit – Water Quality





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit

# Retrofit – Water Quality





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit

# Retrofit – *Safety/Security/Access Upgrades*





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit

# Retrofit – *Safety/Security/Access Upgrades*





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit

# Retrofit – *Safety/Security/Access Upgrades*





**Concrete  
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Inspection | Rehab | Retrofit

# Retrofit – *Safety/Security/Access Upgrades*





**Concrete  
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Inspection | Rehab | Retrofit

# Retrofit – *Safety/Security/Access Upgrades*





**Concrete  
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Inspection | Rehab | Retrofit

# Retrofit – *Safety/Security/Access Upgrades*





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit





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Inspection | Rehab | Retrofit





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit





**Concrete  
Tank Services**  
Inspection | Rehab | Retrofit



# Recap

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- DN Tanks overview
- Construction Procedures and Design for Prestressed Concrete Tanks
- Benefits of Prestressed Concrete Tanks / Applications
- Modifying or Retrofitting Existing Concrete Water Storage tanks





Think Value



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