Today's Composite Elevated Storage Tanks

Presented at the 2002 AWWA Conference & Exposition - New Orleans, LA

Stephen W. Meier, P.E., S.E.
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Abstract: Over the last two decades, composite tanks for water storage—tanks with a steel tank storage container atop a reinforced concrete pedestal—have gained popularity. The challenge for tank owners, engineers, and designers has been that no widely recognized standards were in place to provide guidance for the construction of these types of tanks.

AWWA Standard Committee D170 is working to fill that those gaps and provide a comprehensive standard that will supply tank owners and specifiers with the tools needed to design, specify, build, and maintain these structures. It will also aid the tank owner in better determining the type—steel, concrete, composite—tank that will best serve their water system needs now and in the years to come.

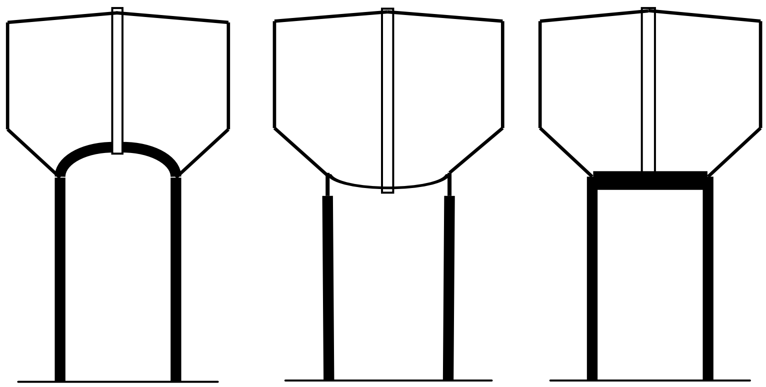
This paper reviews the development of the composite tank and includes a state-of-the-art look at what concepts are being built today, the status of the standards process, how composite tanks differ from the AWWA D100 tanks, and how to properly specify a composite elevated tank. Mr. Meier chairs the AWWA Steel Elevated Tanks, Standpipes & Reservoirs Committee and has been a member of the AWWA Composite Tank standard committee since its inception. In addition, he is a member of the ACI 371R Committee; the American Concrete Institute recommended practice for the design of the pedestal.

What is a Composite Elevated Tank?

A composite elevated water tank is comprised of a welded *steel tank* for watertight containment, a single pedestal *concrete support structure*, a foundation, and accessories. These tanks are also sometimes referred to as "concrete pedestal elevated tanks." The steel tank provides a proven, watertight container derived from the AWWA D100 Standard for welded steel tanks which has demonstrated superior performance through decades of use by the water industry. The reinforced concrete support column provides a cost effective, structurally robust pedestal with minimal maintenance.

The basic configurations of the composite elevated storage tanks built in the US and Canada over the last 25 years is shown in Figure 1.

Figure 1 - Common Composite Tank



Style A - Domed Concrete Floor with Liner | **Style B - Suspended Steel** | **Style C - Concrete Slab with Liner**

The most common composite tank is the domed concrete floor with a carbon steel liner (Style A). The advantages and disadvantages of each style are shown in Table A.

Table A – Advantages and Disadvantages of the Styles

Style	Advantages	Disadvantages
A - Dome	• Balance of forces at tank-to-pedestal intersection • Scalable to large capacity tanks • Reduced dead storage (i.e. water quality)	• Special formwork • Intersection with steel tank more complex • Liner fitting/grouting dome shape • Underside of liner inaccessible for coating similar to a ground storage tank • Additions or modifications to tank bottom are difficult
B – Suspended Bottom	• Bottom is accessible for coatings and addition or modification	• Tolerances at top of pedestal critical for skirt support • Skirt-to-cone intersection design • More dead storage • Condensation on bottom may require a condensate ceiling for interior uses
C - Slab	• Simple forming • Liner is not formed (similar to flat bottom tank on slab)	• Limited to smaller capacity tanks • Bending tension stresses cause cracking in lower face of slab • Bending moments in top of pedestal • Underside of liner inaccessible for coating similar to a ground storage tank • Additions or modifications to tank bottom are difficult

History
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Figure 2 - 1985 to1990 New Composite Tank Construction (map point plots)

Figure 3 – 1978 to 1998 New Composite Tank Construction

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In all, over 450 composite tanks have been constructed since 1978 even though there is no AWWA or other recognized national standard for this structure. Most of these tanks were constructed according to manufacturer's proprietary designs and job-specific engineer's specifications. In 1992, AWWA and others recognized the need for a standard and began the development process that is still ongoing today. The following are highlights of the past standard related activities:

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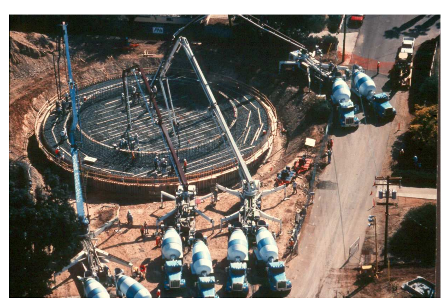
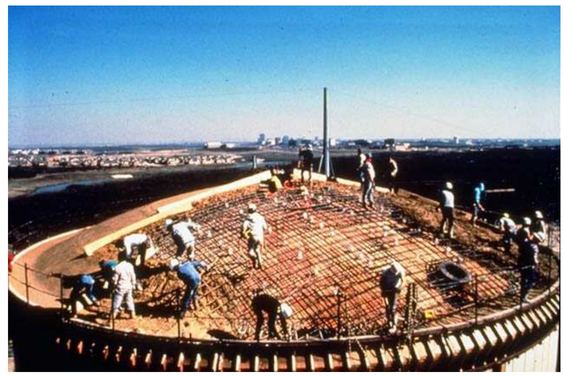


Step 2: Pedestal Wall Construction

From the footing, the wall forms are erected and the process of building the wall begins. Form systems are usually proprietary to the tank constructor. The forms typically have strips fastened to the formwork that create rustications in the concrete that hide construction joints and give a pleasing panel-like appearance. Regardless of the formwork details, care should be taken to ensure wall tolerances on thickness and plumbness are met.   Additional reinforcement near openings, block outs for the wall openings and embedment installation should be monitored. The concrete mix, placement and vibration should be implemented in such a way to achieve good consolidation and minimal surface defects (fins, bugholes, etc) and shading.

Step 3: Tank Erection – In Place

Photo courtesy of Landmark Structures, Inc



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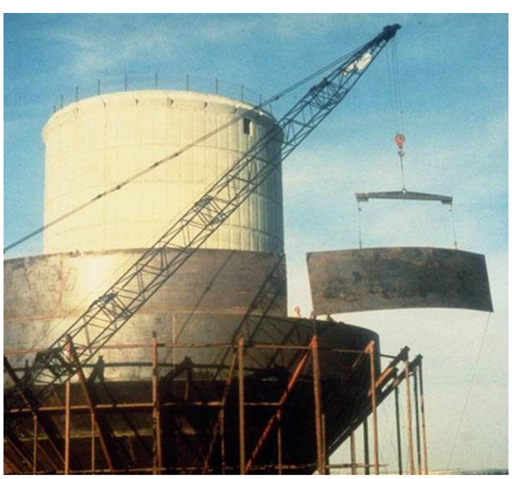
One popular method of construction is to construct the steel tank in-place similar to that used in welded steel elevated tanks. After the pedestal and dome are erected, the subassemblies of the tank sections are lifted and fit into position. Welding, radiographic and tolerance examinations, and coating work are also done in final position.



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Lifting frames and hydraulic cable jacks are supported on the top of the pedestal /dome and used to hoist the tank into final position. When the tank reaches the final position, the tank is pinned in place with proprietary locking systems until the final concrete placement can be made to permanently lock the tank and tower together.

Photos Courtesy of Caldwell Tanks, Inc

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After tank is secured to the pedestal the lifting equipment is removed and the tank roof and any internals are installed. The floor liner is installed and, if required, the space between the liner and dome is grouted. The remainder of accessories, roof handrails and communication antennas (if required) are installed. Coatings are applied to roof and remaining tank components.

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If specified, the interior of the pedestal can be finished for a variety of uses – storage, office space, training areas and other imaginative uses. If the tank is used for communication antennas, the interior may be sub-divided to provide space for the communication carriers. The interior space also provides a convenient space for controls and valves for the tank. One word of caution, storage of explosive or flammable material is not recommended.

Typically a 1.5 million gallon tank can be completed in approximately 1 year from the issuance of the notice to proceed.

Specifying a Composite Tank
Since no national or AWWA standard exists as yet, specifying a new composite tank is more demanding than a tank type with an AWWA Standard. In the US, the tank builders often perform detail engineering for several of the components based on their proprietary designs, fabrication techniques and erection methods. Therefore, each tank builder has unique design characteristics for their product. Over the past decade, through the development efforts of writing the AWWA Standard for the composite tanks, the major tank builders have reached consensus on some of the design requirements, but areas of disagreement remain.

While detailing a complete specification is beyond the scope of this paper, there are several areas that a specifier should be aware of in preparing the project documents that are different than the typical AWWA welded steel elevated tank. As constructed today, composite elevated tanks and AWWA D100-96 welded steel tanks are not equivalent tanks, even though both serve the intended function.

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- Pedestal
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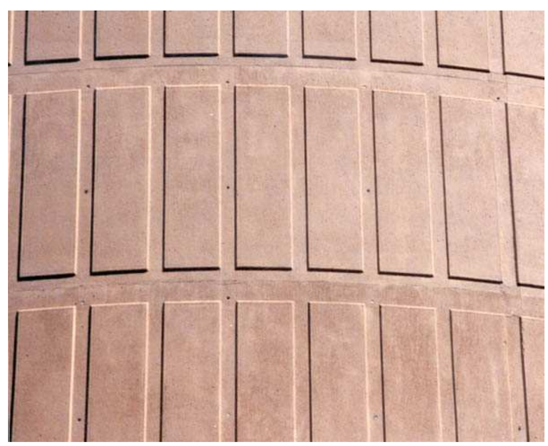

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  - Openings – Limiting the number and size of openings in the pedestal is recommended, especially in regions where high lateral loads may be encountered. A 10 to 12 ft wide equipment door and a 30 inch personnel door are usually included in the standard design. For larger tank pedestals, a second equipment door can be provided if it is spaced around the perimeter from the other openings.

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Acknowledgements
The author is grateful to the following individuals for their assistance with the photographs and information presented in this paper: Greg Larson, P.E., Chicago Bridge and Iron Company, Clive, IA; Eric Lamon, Landmark Structures, Inc., Keller, TX; Rusty Spangler, Caldwell Tanks, Inc, Louisville, KY

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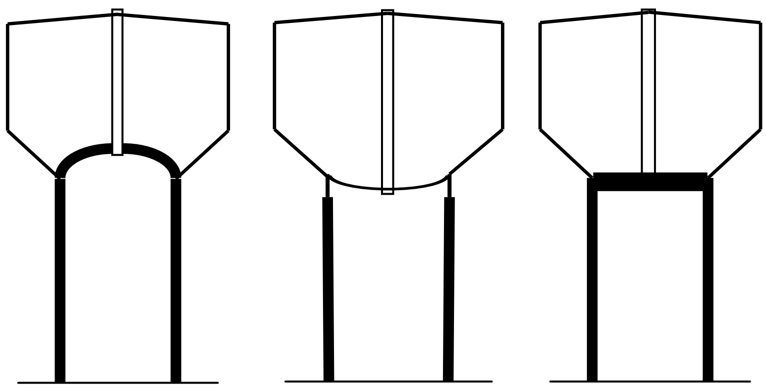

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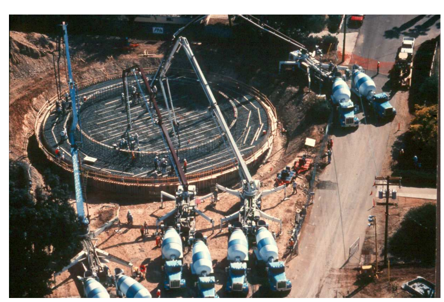

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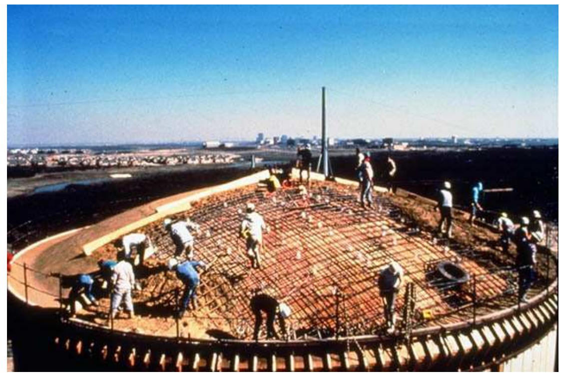

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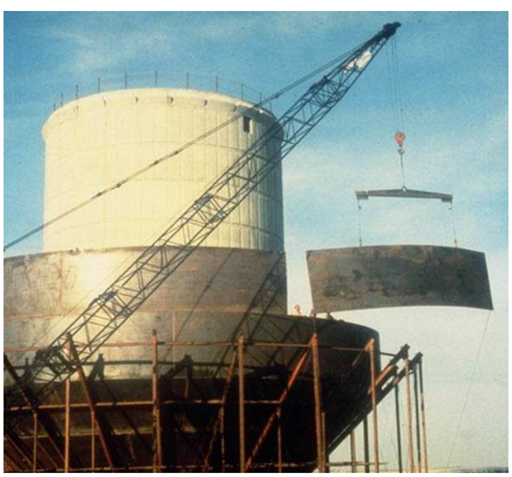

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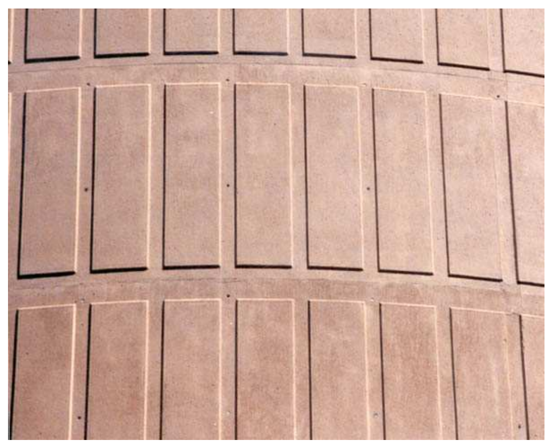

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The composite elevated water storage tank has continued to evolve and grow into an increasingly vital part of the storage tank options for the US and Canadian water industry. Even thought composite tanks have been in service a little more than 20 tears and there is limited experience with maintenance of these tanks, it appears that composite tanks will be the tank of choice for many water systems in the coming years.

Acknowledgements
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