

The Denver Coliseum: A Brief Historical Context



Photograph © Scott D. Murdock, 2010

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Historical Significance

The history of the Denver Coliseum is tied to the history of the National Western Stock Show, a livestock event that started in 1906 (initially called the Denver Fat Stock and Feeder Show¹) and takes place each January.² The Stock Show has become such an ingrained Denver tradition that local television weather forecasters refer to the bitter cold temperatures in January as “stock show weather.” The Stock Show reflects the importance of cattle and other livestock to Denver’s history and economy; in 1900, the large Livestock Exchange in the “cow town” of Denver handled not just cattle (over 200,000) but also over 300,000 sheep, more than 100,000 hogs, and over 22,000 horses.³

For the first few years, the Stock Show was held under large tents, but in 1909 the National Amphitheater – featuring 6,000 seats – opened and hosted the show. By the late 1940s a larger facility was needed. Denver voters approved a \$1.5 million bond in 1947, and livestock interests including the National Western Stock Show and the Denver Union Stock Yard Company contributed another \$750,000. The Colorado and Southern Railroad donated the land for what was then being called a “Municipal Coliseum.”⁴ The City of Denver contributed another \$500,000 for the effort.⁵

Groundbreaking for the Coliseum took place on September 16, 1949, and the dedication was held on January 10, 1952.⁶ (The construction period was lengthened by a strike during the

¹ City and County of Denver, “Denver’s ‘Salute to the Soil’ Dedication of the Denver Coliseum.” Dedication brochure. (January 10, 1952).

² National Western Stock Show, “History of the National Western Stock Show.” Accessed July 2, 2016. <http://www.nationalwestern.com/about/history/>.

³ Ibid.

⁴ Ibid.

⁵ Anton Tedesko, “Thin-shell arch selected for Denver Coliseum.” *Civil Engineering* 24, no. 7 (July 1954): 46.

⁶ City and County of Denver, “Denver’s ‘Salute to the Soil’ Dedication of the Denver Coliseum.”

summer of 1950⁷) The dedication program tells us “The coliseum... will be the scene of athletic events—hockey, basketball, boxing, track meets; national and regional conventions, civic meetings, merchandise and trade shows, dances, public ice skating, and spectacular road shows.” The program also mentions “the comfortable seats [8,006 permanent and 3,560 temporary] permit unobstructed vision from any part of the Coliseum.”⁸ Original seats are shown at figure 1. The unobstructed vision—thanks to a lack of interior columns—is a benefit of the unusual, and at the time state of the art, thin-shell concrete arch design (figure 2).

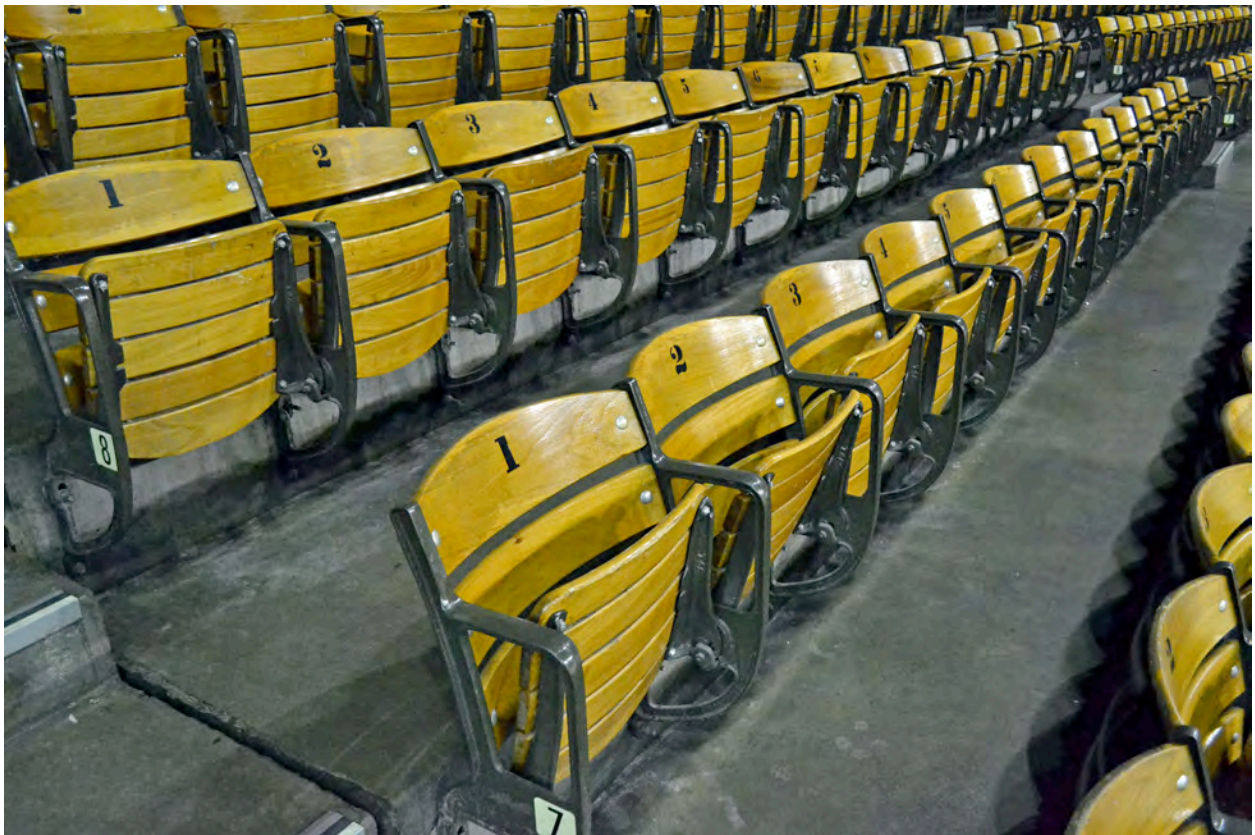


Figure 1. Denver Coliseum. Interior view showing original seats. Photograph © Scott D. Murdock, 2016.

⁷ Tedesko, “Thin-shell arch selected,” 50.

⁸ City and County of Denver, “Denver’s ‘Salute to the Soil’ Dedication of the Denver Coliseum.”



Figure 2. Denver Coliseum. Interior view showing unobstructed view. Photograph © Scott D. Murdock, 2016.

Architectural Significance

The Coliseum is Denver's largest single span, thin-shell concrete structure. It is the work of an engineer considered a master in the field of thin-shell concrete design, Anton Tedesko.⁹ Tedesko, born in Germany and raised in Austria, received a Diploma in Structural Engineering in 1926. After working for a few years both in Europe and the United States, in 1930 he joined the firm of Dyckerhoff and Widmann (D&W) in Germany. Two years later, Tedesko moved to the United States as a representative of D&W to the firm of Roberts and Schaefer (R&S) in Chicago. His role was to promote the use in the United States of D&W's patented thin-shell concrete structural design, known as the Z-D (for Zeiss-Dywidag) system. Tedesko's first major foray into concrete thin-shell design in the US was the Hayden Planetarium, in New York (since demolished and replaced). It was completed in 1934, at which time D&W was no longer

⁹ Thomas E. Boothby, M. Kevin Parfitt and Mark Ketchum, "Milo S. Ketchum and Thin-Shell Structures in Colorado." *APT Bulletin* 43, no. 1 (2012): 41, accessed June 7, 2016. <http://www.jstor.org/stable/41548693>.

interested in the US market, so to continue his work in the US Tedesko joined the firm of R&S in that year. Although his early credibility was enhanced by the authorized use of the Z-D patent, Tedesko was an innovator. He developed new forms and types of concrete shells, rather than just using what had been developed in Germany.¹⁰ His next major accomplishment was the Hershey Arena, Pennsylvania, with a 222-foot arch span.¹¹ Still in use today, when completed in 1936 it was “the longest-span concrete thin-shell barrel roof structure in the world.”¹²

By 1940, Tedesko (still with R&S, and advancing through the ranks of management) was designing structures for the US military, specifically warehouses and aircraft hangars. The military valued his thin-shell concrete designs because they used a minimum of strategic materials. In the later 1940s, Tedesko designed the two largest barrel shell buildings in the world: Massive aircraft hangars with 340-foot arch spans, one at Ellsworth Air Force Base, South Dakota, and the other at Loring Air Force Base, Maine. The structural improvements Tedesko developed through his work on these hangars were incorporated into the design of the Denver Coliseum, “which in many ways was an updated version of his earlier Hershey Arena.”¹³

The original drawings for the Coliseum show the name as “Denver Municipal Stadium”¹⁴ although it was known as Denver Coliseum by the time of the building’s dedication.¹⁵ The thin-shell arch has a clear span width of 254 feet, and the length of the arch roof is 336 feet. The firm of R&S is credited, although Roland L. Linder, Consulting Architect, Denver, has top billing in

¹⁰ Richard G. Weingardt, “Anton Tedesko: Father of Thin-Shell Concrete Construction in America.” *STRUCTURE Magazine* (April 2007): 69, accessed June 9, 2016. <http://www.structuremag.org/wp-content/uploads/2014/09/D-GreatAchievements-Weingardt-Apr07-online-version1.pdf>.

¹¹ American Society of Civil Engineers, “Anton Tedesko.” 1, accessed June 9, 2016. <http://www.asce.org/templates/person-bio-detail.aspx?id=11219>.

¹² Weingardt, “Anton Tedesko: Father of Thin-Shell Concrete Construction in America,” 70.

¹³ Ibid.

¹⁴ Roberts and Schaefer Co, “Denver Municipal Stadium, Contract 4809,” drawing no. A-2, July 1, 1949.

¹⁵ City and County of Denver, “Denver’s ‘Salute to the Soil’ Dedication of the Denver Coliseum.”

the title block. Lorimer and Rose, and Associated Engineers and Architects, Chicago-New York, are also listed. As a R&S employee Tedesko's name is not printed separately on the title block, but his signature is there as the drawings' approver (figure 3).¹⁶



Figure 3. Title block, Roberts and Schaefer, Drawing no. A-2, Denver Municipal Stadium.

The “thin” part of the thin-shell name stems from the fact that the Coliseum’s arched roof surface, between the thick supporting ribs, is only four inches thick (at the crown) to five inches thick (at the springing line). The supporting arch ribs are 20 inches wide and 4.5 feet deep.¹⁷

Comparison of Denver-area Thin-shell Concrete Buildings

The Denver area has been home to several noteworthy thin-shell concrete structures, four engineered by Tedesko and three by his closest competitor in US thin-shell design, Denver native Milo Ketchum. These seven structures show a wide range of thin-shell technology and

¹⁶ Roberts and Schaefer, “Denver Municipal Stadium, Contract 4809,” drawing no. A-2.

¹⁷ Tedesko, “Thin-shell arch selected,” 47.

design ideas, as shown in Table 1. Tedesko's work in Denver spanned the period 1948 to 1958, with four structures of three different designs.

The Western Electric Warehouses featured a series of small spans, shallow circular barrels, connected to form a large useable interior space. This building is difficult to identify as a thin-shell design from ground level, as the roof parapet conceals the arches from most viewing angles (figure 4). The entry canopy to the May D&F store was a unique hyperbolic paraboloid shape. The unusual structure survived until the 1990s when the store was repurposed, and the paraboloid was demolished.¹⁸ A closer companion to the Coliseum is on Buckley Air Force Base in Denver's neighboring city of Aurora (figure 5). The Naval Reserve Hangar is a smaller building, with a clear span roughly 70 percent the size of the Coliseum's, but has a similar distinctive curved and ribbed roof. It uses buttresses with angled extensions that approximate the curve of the arch, gaining additional clear space inside the hangar. Ketchum's local thin-shell works were built during the period 1959 to 1962, and feature three distinct arch designs. The Ideal Basic Cement Company aircraft hangar features a barrel vault surface, but it is made into a diamond shape with the barrel vault span as the longest dimension (figure 6). The Fan Fair shopping center (demolished during December 2013-January 2014¹⁹) used four rows of nine translation shells²⁰, each domelike in appearance and approximately 57 feet square (Google Earth). The Wonder Bread bakery building uses an undulating shell—shaped much like corrugated fiberglass panels but on a larger scale. The corrugations run from front to back on the building, and the width of each undulation, peak-to-peak, appears to be 40 feet (Google Earth).

¹⁸ Boothby, Parfitt and Ketchum, "Milo S. Ketchum and Thin-Shell Structures in Colorado," 41.

¹⁹ Aurora, Colorado Historical Society, "Fan Fair Lost December 2013." <http://www.ahs.co.org/endangered-places/fan-fair/>

²⁰ Boothby, Parfitt and Ketchum, "Milo S. Ketchum and Thin-Shell Structures in Colorado," 40.

Table 1. Comparison of Denver-area Thin-Shell Concrete Buildings

Structure / Engineer / Date	Type of span	Dimensions of clear span (feet)	
		Width	Length
Western Electric Warehouses / Tedesko / 1948	Shallow circular barrel ^a	50	50
Denver Naval Reserve Hangar / Tedesko / 1951	Barrel vault ^b	136	240
Denver Coliseum / Tedesko / 1952	Barrel vault	254	336
May D&F Canopy / Tedesko / 1958 (demolished)	Hyperbolic paraboloid	112	132
Ideal Basic Cement Co. Hangar / Ketchum / 1959	Barrel vault	160	unk
Fan Fair Store / Ketchum / 1960 (demolished)	Translation shell ^c	57	57
Rainbow Bread Bakery / Ketchum / 1962	Undulating shell ^d	40	varies

Source: Eric M. Hines and David P. Billington. "Anton Tedesko and the Introduction of Thin Shell Concrete Roofs in the United States," *Journal of Structural Engineering* (November 2004) 130, no 11: 1640, table 1. Boothby, Parfitt and Ketchum. "Milo S. Ketchum and Thin-Shell Structures in Colorado," 40, table 1; Karen J. Weitze. *Cold War Infrastructure for Strategic Air Command: The Bomber Mission* (Langley Air Force Base, VA: United States Air Force, Air Combat Command, 1999, 32; Roberts and Schaefer Co. with Ninth Naval District Public Works Division. "N.A.R.T. Hangar & Leantos," job no. 5103, drawing no. 486605; Tedesko, *Thin-shell arch selected*, 47; Wolfenbarger. *Ideal Basic Cement Company Corporate Hangar*; Aurora, Colorado Historical Society. "Fan Fair Lost December 2013."

^a 56 shell units arranged in 7 rows of 8.

^b Angled buttresses increase useable width at the lower level of the hangar, up to 150 feet.

^c 36 shell units arranged in 4 rows of 9; dimensions estimated.

^d Width of undulations estimated.

Both Tedesko and Ketchum, as specialized structural engineers, usually partnered with architectural firms on their projects. As mentioned above, for the Denver Coliseum R&S had the overall design and supervision responsibilities, and architects Roland L. Linder, Denver, and Lorimer & Rose, New York, were consultants to the effort.²¹ For the May D&F entry canopy, Tedesko paired with architect I.M. Pei.²² Ketchum teamed with architect William Muchow on Fan Fair Discount City,²³ and with the architectural firm of Fisher, Fisher and Davis for the Ideal Basic Cement Company corporate hangar.²⁴ Specific architects remain unverified for the Western Electric Warehouses, Naval Reserve Hangar, and Rainbow Bread Bakery.

²¹ Tedesko, "Thin-shell arch selected," 50.

²² Boothby, Parfitt and Ketchum, "Milo S. Ketchum and Thin-Shell Structures in Colorado," 40.

²³ Ibid., 42.

²⁴ Deon Wolfenbarger, *Ideal Basic Cement Company Corporate Hangar: Colorado State Register of Historic Properties Nomination Form*. Denver, CO: Colorado Historical Society, November 21, 2005: 4, accessed July 10, 2016. <http://www.historycolorado.org/sites/default/files/files/OAHP/NRSR/SDV9446.pdf>.



Figure 4. General Electric Warehouses. View of west façade showing arched roof surface and reinforcing ribs. Photograph © Scott D. Murdock, 2016.



Figure 5. Naval Reserve Hangar, Buckley Field, ca. 1950. United States Air Force photograph from author's collection.



Figure 6. Ideal Cement Company corporate hangar. Photograph © Scott D. Murdock, 2016.

Comparison of Selected Tedesko Thin-shell Spans Nationwide

Tedesko's thin-shell portfolio included various types and sizes of arches; he engineered at least 60 thin-shell concrete arch structures in his career.²⁵ For a nationwide comparison with the Coliseum, other short barrel vaulted arch structures are shown in Table 2. The Denver Coliseum has a wider span than the early Hershey Arena or the Naval Reserve Hangar, but is considerably narrower than the giant Loring Air Force Base (figure 7) and Ellsworth Air Force Base (figures 8 and 9) aircraft hangars. Length is not as difficult to achieve as width with this type of structure, as the supporting framework used to construct each section of arch is merely repositioned to add successive sections. The requirements of the structure, and the available land, dictate the length.

²⁵ Weingardt, "Anton Tedesko: Father of Thin-Shell Concrete Construction in America," 69.

Table 2. Comparison of selected Tedesko thin-shell spans nationwide

Structure	Type of span	Dimensions of clear span (feet)	
		Width	Length
Hershey Arena / 1936	Short barrel vaulted arch	222	362
Ellsworth / Loring hangars / 1948	Short barrel vaulted arch	340	300
Naval Reserve hangar / 1951 ^a	Short barrel vaulted arch	136	240
Denver Coliseum / 1952	Short barrel vaulted arch	254	336

Source: Data from Eric M. Hines and David P. Billington. "Anton Tedesko and the Introduction of Thin Shell Concrete Roofs in the United States," *Journal of Structural Engineering* (November 2004) 130, no 11: 1640, table 1; Weitze. *Cold War Infrastructure for Strategic Air Command: The Bomber Mission*, 32; Roberts and Schaefer Co. "N.A.R.T. Hangar & Leantos," job no. 5103, drawing no. 486605; Tedesko, *Thin-shell arch selected*, 47.

^a Also constructed in five other US locations, and one in Cuba.



Figure 7. Loring Air Force Base. Thin-shell concrete hangar, exterior. Photograph © Scott D. Murdock, 2004.



Figure 8. Ellsworth Air Force Base. Thin-shell concrete hangar, exterior. Photograph © Scott D. Murdock, 2010.



Figure 9. Ellsworth Air Force Base. Thin-shell concrete hangar, interior. Photograph © Scott D. Murdock, 2001.

Present Condition

Externally, the building is little changed from 1952. An addition to the east façade, ca. 2001, houses the box office with external customer windows, replacing original ticket booths that could only be accessed after entering the facility (figure 10).



Figure 10. Denver Coliseum. Box office addition on east façade. Photograph © Scott D. Murdock, 2016.

Six roof ventilators were added ca. 1992 (date estimated based on review of images on the Historic Aerials web site). On the west façade, an addition known as the “annex” was built at an undetermined date (probably in the 1970s, based on a review of online USGS topographic maps), connecting the Coliseum to a large storage building known as the “barn.” The “barn” appears to have been built at about the same time as the Coliseum (figure 11).

The original enclosed passageway connecting the Coliseum to the nearby stock show complex (located to the north) is extant, though no longer used for public pedestrian traffic. The historical setting was compromised by the construction of Interstate 70 in the 1960s; the elevated highway runs east-west and is situated mere feet from the north walls of the Coliseum, visually separating the building from the stock show facilities it was built to augment. However, the highway does provide motorists an up-close view of the roof shell and support ribs (fig 12).



Figure 11. Denver Coliseum (right) and “barn” (left). Connecting “annex” not visible. Photograph © Scott D. Murdock, 2010.



Figure 12. Denver Coliseum. Arch roof surface and supporting ribs as seen from Interstate 70, view to the south from eastbound lane. Photograph © Scott D. Murdock, 2010.

Internally, the Coliseum's general form and appearance have remained unchanged. The wooden seats are original, touted as being wider and more comfortable than plastic seats typically found in newer facilities. Minor functional upgrades have been made to restrooms, offices, and directional signage. The anteroom of one restroom was reduced in size at an unverified date to create a new exit in the northwest corner of the building. The underside of the concrete shell roof still has the original cork insulation, though some damage has occurred within reach of the uppermost seating rows (figure 13). Major structures, like the concrete arch buttresses that frame the north and south promenades, remain in their original condition (figure 14). The internal changes do not seriously detract from the historic feel of the building.

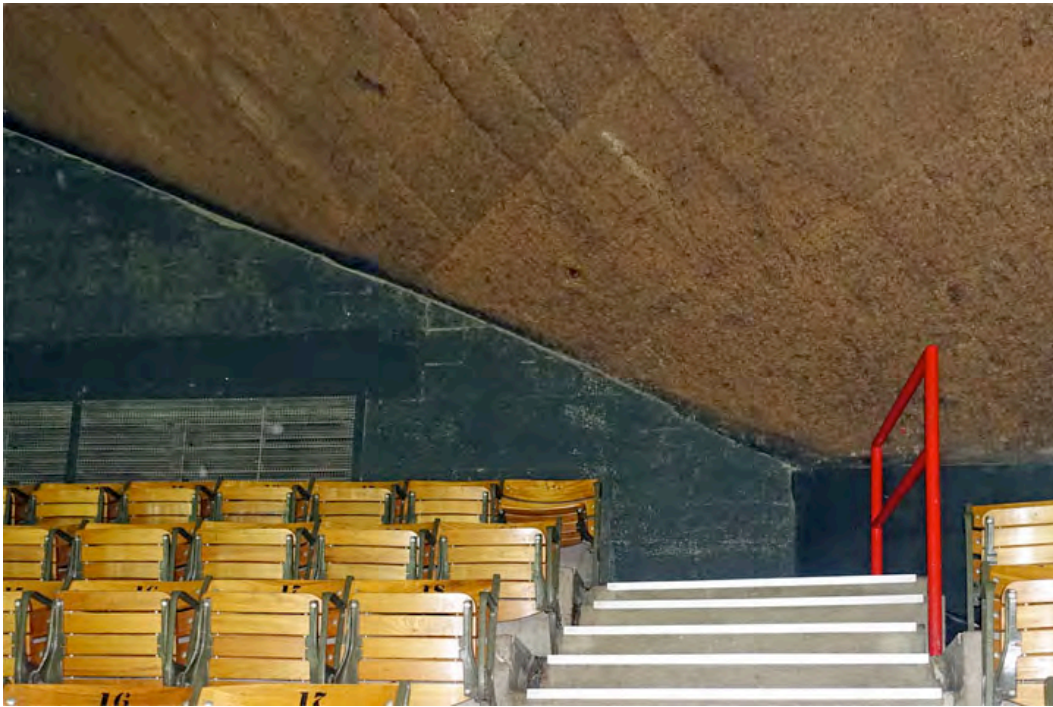


Figure 13. Denver Coliseum. Upper bleachers, intersection of arch roof structure with interior wall showing original cork insulation. Photograph © Scott D. Murdock, 2016.



Figure 14. Denver Coliseum. South promenade under concrete arch buttresses. Photograph © Scott D. Murdock, 2016.

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