

Chapter

Trends in Stadium and Arena Design

Todd L. Seidler and John J. Miller

34

This chapter will present an overview and analysis of certain recent trends and innovations in stadium and arena design. It is by no means a complete look at these unique sports facilities; many additional trends and innovations are covered in other parts of this book. This chapter will merely try to highlight certain significant trends and concepts that should not be overlooked.

Learning Objectives

After reading this chapter, the student should be able to

- understand the importance of using luxury suites, naming rights, and personal seating licenses for maximizing revenue from spectator facilities;
- identify the new arena design features intended to speed the change-over from one event to another;
- be familiar with the concept of the retractable roof stadium and understand its advantages;
- identify the three main types of fabric structures and list the advantages and disadvantages of each; and
- identify the advantages of wooden domes.

Funding Arenas and Stadiums

Building stadiums and arenas today can be tremendously expensive, often running into the hundreds of millions of dollars. Of major concern to the owners of these facilities is the concept of maximizing the revenue generating potential (See Chapter 7). One of the most significant trends in revenue generation and financing of stadiums and arenas is the selling or leasing of luxury suites, personal seating licenses, and the naming rights to the facility.

Luxury Suites

One of the most dynamic trends that developed in the design of spectator sports facilities is the inclusion of luxury suites in professional as well as intercollegiate arenas and stadiums. Additionally, suites are now found at rodeo arenas; PGA, LPGA and Senior PGA events; the Kentucky Derby; the U.S. Olympic track and field trials; and ATP Tour tournaments, among others. This popularity may be traced to luxury suites becoming a significant tactic to take full advantage of cash flow per seat in most stadium construction projects (Howard & Crompton, 1995). In 1997, Funk estimated that the 114 teams belonging to the four major leagues (Major League Baseball, the National Football League, the National Basketball Association, and the National Hockey League) realized nearly \$1 billion from luxury suite revenues.

This incredible increase in revenue can make a big difference in the profitability of an organization and can provide a huge competitive advantage over other organizations that do not have it. It also has become an essential part of the equation for financing a new facility. Thus, not only are luxury suites a design issue, but they are becoming of primary importance for any sports organization aspiring to maximize revenue.

Luxury suites are small, private rooms opening toward the court or field that are usually leased to individuals or companies who desire a semiprivate lounge area, typically large enough to accommodate 12 to 20 guests. Suites are normally leased on multiyear contracts and are often furnished and decorated by the tenant. The prevalence of these luxury suites is growing rapidly, primarily because they are such good revenue producers. Originally referred to as “skyboxes,” luxury suites have become a foremost feature of the majority of new stadiums and arenas constructed since the early 1990s (Heistand, 1999). The Houston Astrodome is generally recognized as being the pioneer facility to include luxury suites in sports venues in the late 1960s (Fischer & Ozanian, 1999). However, while the inclusion of luxury suites is an acceptable, almost mandatory, feature of a spectator sports facility today, its revenue potential did not become fully recognized for 20 years (Heistand, 1999).

The impetus for the luxury suite trend was the tremendous success of The Palace at Auburn Hills in Detroit and Joe Robbie Stadium, now referred to as Pro Player, in Miami (Howard & Crompton, 2004). The Palace at Auburn Hills is a good example of how important suites have become to the economics of this type of facility. The original plans called for 100 luxury suites to be built as part of the arena. About one-third of the way through construction, all 100 suites had already been leased. Some quick design changes by the architect produced an additional upper ring of 80 suites, which were also leased by the time The Palace opened. Total construction cost for The Palace was about \$70 million. The income from the lease of the suites alone was almost \$12 million per year, which allowed for an unheard of six-year payoff (Howard & Crompton, 2004).

As for the Miami Dolphins, they took in gross revenues of nearly \$20 million annually from the 216 luxury suites in their stadium. This amount equaled more than 50% of the entire team's 1990 gross revenues (Howard & Crompton, 2004).

The financial impact of luxury suites may be exemplified by the Dallas Cowboys who constructed 360 luxury suites which produced more than \$23 million annually in potential revenue in the early 1990s (Gorman & Calhoun, & Rozin, 1994). Then, later in the 1990s, they increased the number of luxury suites to 398 which grossed about \$29 million per year (Fischer & Ozanian, 1999). The Cleveland Browns' move to Baltimore was based on the assurance of a publicly funded stadium containing 108 luxury boxes that would be leased for between \$55,000 and \$200,000. As a result the Baltimore Ravens (formerly the Cleveland Browns) anticipated earning about \$11 million annually from suite leases at the brand new Raven Stadium.

Professional sports teams are not alone in reaping the benefits of luxury suite sales. Despite uncertain economic times and criticism from university circles, major colleges around the country are constructing sports facilities at a tremendously fast pace primarily due to luxury suite income potential. It has been estimated that universities will invest between \$800 million and \$1 billion for new athletic facilities in the five-year period between 1999 and 2005 (Garbarino & Johnson, 1999). For example, Auburn University incorporated 71 executive suites into the football stadium renovation. This allowed Auburn University to entirely balance the \$1-million-plus yearly debt created by the expansion. Once the facility construction debt is totally repaid, Auburn will realize an annual profit of close to \$1.8 million (Simers & Wharton, 1999). Other prominent university facilities that have used proceeds from luxury suites for construction cost repayment include the University of Oregon's Autzen Stadium, the University of Texas's Darrel K. Royal Memorial Stadium, the University of Michigan's "Big House," Virginia Tech's Lane Stadium, and Texas Tech's Jones/SBC Stadium. Luxury suites have become a significant design feature and not only make the construction of future arenas and stadiums more economically feasible, but are becoming a necessity for many sports organizations to remain financially competitive.

Naming Rights

As with luxury suites, selling the naming rights of sports facilities has gained recent importance in sports facility construction. Naming rights deals are agreements made between stadium owners and large corporations that permit the sponsor to connect a brand name or logo to a stadium for a given period of time. The first naming rights agreement occurred in 1971 when the New England Patriots agreed to have the Schaefer Brewing Company pay \$150,000 to rename Patriots Stadium, Schaefer Field. In 1973, the Buffalo Bills signed a 20-year agreement with a frozen food supplier, Rich Products, to rename War Memorial Stadium, Rich Stadium.

Between 1995 through 2000, the number and financial magnitude of sports facility naming rights grew dramatically. A primary reason for this escalation was due to the increased number of new sporting venues that were built in the late 1990s. For example, the period 1991 to 1995 had eight stadium or arena openings compared to a total of eight in the previous 15 year period between 1976 to 1990 (Waterman, 2002). In 1997, one third (41 of 113) of the sports stadiums or arenas used by teams in the NFL, NBA, NHL, or Major League Baseball had been named for corporations; however, by 2002, 80 of 121 teams were competing in sports venues that were named after large corporations (Waterman, 2002). According to a businessman who specializes in naming rights agreements there were three naming rights deals in professional sports totaling \$25 million in 1988 (Maher, 2003). Presently, there are 69 pro teams, with anticipated significant increase of intercollegiate teams, who have naming rights deals that total in excess of \$3.5 billion (Maher, 2003). Thus, this new strategy was implemented as a way of helping to ease the financial burden of stadium or arena construction.

On the next page are the names, naming rights sponsor, the name of the team, the average per year that the sponsor pays for the naming rights and the year the agreement will end for 69 professional teams associated with the four major leagues. The cost of naming rights for the professional teams listed on the next page ranges from \$620,000 per year (Alltel Stadium) to \$10 million per year (Reliant Stadium).

Notes

Stadium Name	Sponsor	Home Teams	Avg. \$/Year	Expires
Air Canada Centre	Air Canada	Toronto Maple Leafs, Raptors	\$1.5 million	2019
Alltel Stadium	Alltel Corp.	Jacksonville Jaguars	\$620,000	2007
American Airlines Arena	American Airlines	Miami Heat	\$2.1 million	2019
American Airlines Center	American Airlines	Dallas Mavericks, Stars	\$6.5 million	2031
America West Arena	America West	Phoenix Suns, Coyotes, Mercury	\$866,667	2019
Arco Arena	Atlantic Richfield	Sacramento Kings, Monarchs	\$750,000	2007
Bank of America Stadium	Bank of America	Carolina Panthers	\$7 million	2024
Bank One Ballpark	Bank One	Arizona Diamondbacks	\$2.2 million	2028
Bell Centre	Bell Canada	Montreal Canadiens	N/A	N/A
Cinergy Field	Cinergy	Cincinnati Reds	\$1 million	2002
Citizens Bank Park	Citizens Bank	Philadelphia Phillies	\$2.3 million	2028
Comerica Park	Comerica	Detroit Tigers	\$2.2 million	2030
Compaq Center	Compaq Computer	Houston Rockets, Comets,	\$900,000	2003
Compaq Center at San Jose	Compaq Computer	San Jose Sharks	\$3.1 million	2016
Conseco Fieldhouse	Conseco	Indiana Pacers, Fever	\$2 million	2019
Continental Airlines Arena	Continental Airlines	New Jersey Nets, Devils	\$1.4 million	2011
Coors Field	Coors Brewing	Colorado Rockies	N/A	INDEFINITE
Corel Center	Corel	Ottawa Senators	\$878,142	2016
Delta Center	Delta Airlines	Utah Jazz, Starzz	\$1.3 million	2011
Edison International Field	Edison Intl.	Los Angeles Angels	\$2.5 million	2018
Edward Jones Dome	Edward Jones	St. Louis Rams	\$2.65 million	2013
FedEx Field	Federal Express	Washington Redskins	\$7.6 million	2025
FedEx Forum	Federal Express	Memphis Grizzlies	\$4.5 million	2023
Wachovia Center	Wachovia Bank	Philadelphia 76ers, Flyers	\$1.4 million	2023
Fleetcenter	Fleet Bank	Boston Celtics, Bruins	\$2 million	2010
Ford Field	Ford Motor Co.	Detroit Lions	\$1 million	2042
Gaylord Entertainment Center	Gaylord Entertainment	Nashville Predators	\$4 million	2018
General Motors Place	General Motors	Vancouver Canucks	\$844,366	2015
Gillette Stadium	Gillette	New England Patriots	N/A	2017
Great American Ball Park	Great American Insurance	Cincinnati Reds	\$2.5 million	2033
Gund Arena	Owners	Cleveland Cavs, Rockers	\$700,000	2014
Heinz Field	H.J. Heinz	Pittsburgh Steelers	\$2.9 million	2021
HSBC Arena	HSBC Bank	Buffalo Sabres	\$800,000	2026
Invesco Field at Mile High	Invesco Funds	Denver Broncos	\$6 million	2021
Jacobs Field	Richard Jacobs	Cleveland Indians	\$695,000	2014
KeyArena	Key Corp.	Seattle Supersonics, Storm	\$1 million	2010
Lincoln Financial Field	Lincoln Financial Group	Philadelphia Eagles	\$6.7 million	2022
M & T Bank Stadium	M & T Bank	Baltimore Ravens	\$5 million	2018
MCI Center	MCI	Wash. Wizards, Caps, Mystics	\$2.2 million	2017
Mellon Arena	Mellon Financial	Pittsburgh Penguins	\$1.8 million	2009
Miller Park	Miller Brewing	Milwaukee Brewers	\$2.1 million	2020
Minute Maid Park	Coca Cola	Houston Astros	\$6 million	2030
Nationwide Arena	Nationwide Insurance	Columbus BlueJackets	N/A	INDEFINITE
Network Associates Coliseum	Network Associates	Oakland A's	\$1.2 million	2003
Office Depot Center	Office Depot	Florida Panthers	\$1.4 million	2013
Pacific Bell Park	Pacific Telesis	San Francisco Giants	\$2.1 million	2024
Pengrowth Saddledome	Pengrowth Mgmt.	Calgary Flames	\$1 million	2016
Pepsi Center	PepsiCo	Denver Nuggets, Colorado Avalanche	\$3.4 million	2019
Phillips Arena	Royal Phillips Electronics	Atlanta Hawks, Thrashers	\$9.3 million	2019
PNC Park	PNC Bank	Pittsburgh Pirates	\$2 million	2020
Pro Player Stadium	Fruit of the Loom	Miami Dolphins, Florida Marlins	COMPANY BANKRUPT	N/A
Qualcomm Stadium	Qualcomm	San Diego Padres, Chargers	\$900,000	2017

continued

Stadium Name	Sponsor	Home Teams	Avg. \$/Year	Expires
Raymond James Stadium	Raymond James Financial	Tampa Bay Buccaneers	\$3.1 million	2026
RBC Center	RBC Centura Banks	Carolina Hurricanes	\$4 million	2022
RCA Dome	RCA	Indianapolis Colts	\$1 million	2004
Reliant Stadium	Reliant Energy	Houston Texans	\$10 million	2032
Rexall Place	Katz Group	Edmonton Oilers	N/A	2013
Safeco Field	Safeco Corp.	Seattle Mariners	\$2 million	2019
Savvis Center	Savvis Communications	St. Louis Blues	N/A	INDEFINITE
SBC Center	SBC Communications	San Antonio Spurs	\$2.1 million	2022
Staples Center	Staples	Los Angeles Lakers, Kings, Clippers, Sparks	\$5.8 million	2019
St. Pete Times Forum	St. Petersburg Times	Tampa Bay Lightning	\$2.1 million	2014
Target Center	Target	Minnesota Timberwolves, Lynx	\$1.3 million	2005
TD Waterhouse Centre	TD Waterhouse Group	Orlando Magic, Miracle	\$1.6 million	2003
Toyota Center	Toyota	Houston Rockets	N/A	N/A
Tropicana Field	Tropicana	Tampa Bay Devil Rays	\$1.5 million	2026
United Center	United Airlines	Chicago Blackhawks, Bulls	\$1.8 million	2014
U.S. Cellular Field	U.S. Cellular	Chicago White Sox	\$3.4 million	2025
Xcel Energy Center	Xcel Energy	Minnesota Wild	\$3 million	2024

Source: ESPN.com (Sports Business, 2004).

Three reasons have been identified as to why the Houston Texans were able to command \$10 million per year. First, for the next three decades, not only will Reliant Stadium be the home of the Texans, each of three other facilities at the complex will bear the Reliant name. Reliant Park, as the Astrodome complex was renamed, consists of Reliant Stadium, Reliant Astrodome, Reliant Arena (formerly the AstroArena), and Reliant Center, a 1.4 million-square-foot exhibition center. Secondly, the 69,500-seat, retractable-roof stadium also annually holds the Houston Livestock Show and Rodeo, which attracts two million visitors during its two weeks of operation. Third, the stadium recently hosted the 2004 Super Bowl and is expected to become a part of the Super Bowl rotation. These value-added aspects significantly played an important part in Reliant's motivation to invest a large amount of money for the naming rights. The \$10 million per year that Reliant Energy will pay breaks down in the following fashion: the Houston Texans NFL team will receive \$7.5 million (75%), the Houston Livestock Show and Rodeo approximately \$1.5 million (15%) and Harris County about \$1 million (10%) annually until the agreement expires in 2032. Thus, the naming rights for Reliant Stadium will benefit not only the Texans, but also the Rodeo and the county as well in paying off the arena.

While naming-rights deals have become commonplace in professional sports, the trend has recently been seen in intercollegiate athletics. For many years, universities named buildings after munificent donors and prominent alumni. At the time of this writing, about a dozen have sold naming rights to major corporations. For example, Comcast Corporation has a \$25 million, 25-year deal to have its name on the Terrapins' new arena in College Park at the University of Maryland (Weinberg, 2003). At Texas Tech University, SBC Communications is paying \$20 million over 20 years to have its name on Jones SBC Stadium and United Supermarkets has a \$10 million, 20-year naming rights deal for the United Spirit Arena, where the Texas Tech basketball teams play (Maher, 2003). The Ohio State University plays its basketball games at the Value City Arena, the result of a \$12.5 million naming-rights deal with a discount department store chain. While these institutions possess impressive naming rights agreements, the largest intercollegiate deal to date has been a \$40 million, 20-year deal for the Save Mart Center at Fresno State University. Most recently, the University of Memphis announced that the naming rights for the athletic director as well as the office of Memphis head basketball coach John Calipari had been sold for \$100,000 (Tiger Athletics, 2004). As a result, collegiate sports are going to "be the next frontier." The only concerns are which schools are going to be first and how much will they receive (Maher, 2003).

It has been estimated that 80% of new stadiums or arenas will be named after a corporation in the near future (Brenner, 1999). As the prices of sports venues increase new sources of income must be recognized and used to the maximum that the market will bear. Therefore, the importance of naming rights to raise revenue to pay for sports stadiums and arenas will undoubtedly continue, if not increase in the future.

Personal Seating Licenses (PSL's)

A third revenue trend that developed significantly in the 1990s was the concept of personal or permanent seating licenses (PSLs). Personal seating licenses are to individuals what luxury suites are to corporations (Yeomans, 2001). They have been primarily associated with new facility construction and are used to assist in financing plans (Irwin, Sutton, & McCarthy, 2002). PSLs have given athletic organi-

Notes

zations a tremendous benefit since they provide the opportunity to pre-sell seats in advance of the actual construction or renovation of the sports facility. This ensures that the organization responsible for the financing of the facility will not have to borrow as much (Irwin, Sutton, & McCarthy, 2002). Typically, PSLs allow the purchaser the right to buy season tickets in special seating areas such as club seats. Club seats are typically larger, more comfortable and have more leg room than regular seating. Also, they usually include special considerations such as a waitstaff who take orders and deliver food right to the seat and possibly access to certain restaurants or lounges.

First identified by the Dallas Cowboys in 1968, the concept of PSLs did not gain wide-spread recognition until the Carolina Panthers implemented a highly successful campaign in 1993. Using PSLs the Panthers were able to raise \$125 million prior to playing in the National Football League. By 2002, nearly 30 professional, intercollegiate, and racecar speedways had adopted the PSLs concept (Howard & Crompton, 2004). For example, the Chicago Bears were able to raise approximately \$60 million for 27,500 personal seating licenses to help pay for the recently completed renovation of Soldier Field. As stated earlier, other examples of the PSLs trend are not only limited to professional sports. The Ohio State University recently raised about \$20 million from the sale of licensed seating in its new basketball arena while Texas Motor Speedway sold 30,000 PSLs generate \$27.5 million of the \$110 million construction costs.

It is important to note that the trend of PSLs is not without controversy. Because some critics have accused sports organizations of holding ticket holders “hostage” by forcing them to pay large upfront fees, some sports organizations such as the Pittsburgh Steelers have changed the PSL acronym to SBL (stadium builder licenses). This strongly expresses to the ticketholder that the money raised through personal license sales is going directly to construction of the stadium rather than to owners’ pockets. Thus, whereas the corporate support and willingness to pay relative high prices for luxury suites and naming rights exists, the trend of PSLs, while an important component for paying for a sports facility, seems to be in an evolutionary, consumer-friendly stage.

Designing for Entertainment and Quick Changeover

The fundamental purpose and design of stadiums and arenas has changed radically in the last decade. These changes are so dramatic that many facilities have become obsolete, and even young ones 10 to 20 years old are facing the wrecking ball. The basic idea behind this change is that modern arenas and stadiums are no longer just places to watch an event, but are now designed to provide a total entertainment experience and optimally host as many different events as possible.

In order to maximize return on such a large investment as a stadium or arena, every effort must be made to ensure that the facility is able to accommodate as many events and different kinds of activities and generate as much revenue as possible. Recent trends include design features that allow a facility to change over from one event to another as quickly as possible. Whereas some older facilities would rely on 6 to 10 football games or 30 basketball games per year as their main source of revenue, some facilities now schedule from 250 to 600 events per year, including such varied activities as basketball, soccer, hockey, arena football, concerts, conventions, trade shows, rodeos, monster truck shows, and professional wrestling. It is not uncommon for older facilities to require up to a full day for a crew to change the setup from one event to another, whereas a well-designed facility can be transformed in a matter of hours. Not only can this provide significant cost savings in manpower, but also often means that more than one event can take place in the same day. Several aspects of design that allow a facility to accommodate a wide variety of events and also to quickly alter the setup for different events include:

- Versatile lighting and sound systems that are designed to adequately handle the wide variety of events.
- Heavy-duty lighting grids that can be lowered to the floor in order to enhance the placement of sound and lighting equipment for concerts.
- Loading ramps that allow semi-trucks to back all the way onto the floor. Even better, some facilities provide floor access for two or more trucks at a time so that one can be loading after a show while another is unloading for the next.
- Versatile, moveable sections of seats that can quickly change the configuration of a facility.
- Fixed, pre-wired camera positions that allow for quick and easy set-up for television broadcasts. Many new arenas are constructed with a full television production studio, which permits a television network to broadcast a game without bringing in their semi-trucks full of production equipment.
- Computerized curtain systems that can quickly change the layout and size of the facility.

Many sport organizations have made a shift in their fundamental mission and have gone from primarily trying to put a winning team on the court/field to providing a great family entertainment experience. This change in thinking has led to many design changes in the arenas and stadiums being constructed today. In general, this has caused a move toward more upscale facilities with greater service, entertainment and convenience for spectators. Some aspects of this trend include the following:

- Providing more restrooms, especially for women. In the past, many spectator facilities provided only enough restrooms to satisfy the local code requirements. This often resulted in long lines and frustration on the part of spectators. Many facilities are now being designed with more than twice as many restrooms as the minimum required. Since some events may draw a disproportionate number of men

or women, consideration should be given to designing some rest rooms that can serve either gender simply by changing the sign on the door. Family restrooms are also becoming common in new stadiums and arenas.

- Taking into consideration the requirements of customers with disabilities. With the advent of the Americans With Disabilities Act, full accommodation of the needs of people with disabilities is now federal law. Recent lawsuits have established new standards for the placement of handicapped seating. All wheelchair-accessible seats should now be located so that users can see over the heads of the spectators in front of them even when the spectators stand.
- Building larger concourse areas and adding separate concourses to serve different levels. Improved access and less crowding make these areas more attractive. Some concourse areas are being designed to resemble a mini-mall by offering many different choices of food, novelty items, and entertainment opportunities. Some concession areas are designed so that customers standing in line still have a direct view of the field while others place closed-circuit televisions so that patrons will not miss the action while spending their money. Opportunities for amusement are becoming more common. These include things such as batting cages, merry-go-rounds, museums, and many types of electronic games. Many facilities strive to provide the atmosphere of an amusement park.
- Improving pedestrian traffic flow into, out of, and within the facility. People do not enjoy standing in long lines. This can be accomplished by providing more entrances/exits, as well as wider and more stairways and escalators.

Innovations in Materials and Methods of Construction

Recent innovations in the methods of enclosing large areas without support pillars and posts that interfere with spectator sight lines are providing many more options for the construction of stadiums and arenas. Stadiums with retractable roofs, tension fabric structures, air-supported fabric structures, cable domes, and wooden domes are examples of building designs that have been successfully used to enclose large sports facilities.

Retractable Roof Stadiums

One of the biggest innovations in stadium design is the concept of having a stadium that is open to the elements when the weather is nice but can be quickly covered when needed. The first attempt at a retractable roof stadium was Olympic Stadium in Montreal, built for the 1976 Olympic Games. The original plan was to build a huge concrete mast next to the stadium that would support a fabric roof supported by steel cables. The roof was supposed to have the ability to be lifted off the stadium and suspended from the mast, thereby creating an open-air stadium (Holleman, 1996). The roof could then be lowered back on top of the stadium to enclose it again when desired.

The design never has worked correctly, but this ambitious idea eventually led to the successful designs we are seeing today. It is estimated that adding a retractable roof to the design of a new stadium will increase the cost between \$40 and \$90 million.

Some examples of retractable roof stadiums are:

- SkyDome—Located in Toronto, Ontario, SkyDome was the first stadium to have a fully retractable roof. Opened in 1989, SkyDome can completely open or close the entire steel-trussed roof in 20 minutes. This is accomplished by three movable roof sections, two of which slide and another that rotates. The stadium seats 50,600 for baseball, 53,000 for football, and has different seating arrangements for concerts ranging from 10,000 to 70,000. It also contains 161 luxury suites, a 348-room hotel and health club, full broadcast facilities, underground parking, and a 110-foot-by-33-foot state-of-the-art video screen.



Photo courtesy of Ellerbe Becket

Toronto Skydome.

Original estimates of the cost for SkyDome were \$184 million (Canadian) but it ended up costing about \$585 million. Typically, the roof only has to be closed for about four or five games a season due to inclement weather (Gordon, 1990).

Notes

- Bank One Ballpark (BOB)—Opened for the 1998 season, BOB is the home of the Arizona Diamondbacks. Located in downtown Phoenix, it was the first retractable-roof stadium to be built since SkyDome. This air-conditioned, retractable-roof stadium is designed primarily for baseball and seats 48,500. It has a natural grass field and was built for a cost of \$349 million with 68% coming from public financing. With a total of 69 private suites, 6 party suites and 5,592 club seats, there is something for everybody, including 350 bleacher seats that are sold for \$1 per game. As with many of the new stadiums, it is more than just a



Photo courtesy of Ellerve Becket

Bank One Ballpark.

- place to watch a ballgame. BOB contains two micro-breweries and two 10,000-square-foot beer gardens, a mini hall of fame fashioned after Cooperstown, a 4,000-square-foot team store, 110 picnic tables, 212 concession stands, and a swimming pool just beyond the outfield fence.
- Seattle Safeco Field—Opened in 1999, Safeco Field's retractable roof allows fans to stay dry during the rainy days of the season. While the retractable roof covers the entire ballpark, it does not enclose it, thus giving the stadium an open air feel. When opened, the roof sits above and behind the right field seats. There are many amenities at Safeco Field. There are three panels that glide on 128 steel wheels powered by almost 100 ten-horsepower electric motors. When fully extended, the roof encompasses almost nine acres in size and weighs 22 million pounds, yet, at the push of a button can close or open in 10 to 20 minutes depending on wind and other weather conditions. For protection against lightning the roof is self-grounded and is planned to hold up under six or seven feet of snow as well as winds of up to 70 miles per hour.
- Minute Maid Field—Originally named Enron Field, it was completed in time for the 2000 baseball season. In 2001, Enron declared bankruptcy and the naming rights were sold to the Minute Maid Company for an estimated \$170 million for 28 years. Built for a relatively inexpensive \$248 million, it seats approximately 42,000 and has a fully retractable steel roof. The roof covers 6.25 acres when closed and is made up of three moveable sections that can be opened in less than 20 minutes. The moving roof panels contain over 5,000 tons of steel as well as an acre of glass to allow for spectacular views even when the roof is closed. Also, the roof has been designed to withstand hurricane force winds. Special amenities within the stadium include a kid's play area, batting cages, more than 60 private suites and 4,850 club seats, a café, retail space, and even a 65,000-pound, full-size locomotive that moves along an 800-foot section of track after game highlights. The new stadiums are meant to provide a quality entertainment experience, not just a place to watch a game.
- Milwaukee Miller Park—Miller Park, which opened in 2001, possesses many unique features, the most obvious one being the retractable roof. The 12,000 ton, seven panel roof has a unique fan shape design. The moveable roof panels pivot from a point behind home plate and go along a semicircular track beam with 60-horsepower engines. The roof can open or close in 10 minutes and sits 175 feet above second base. Miller Park has no air-conditioning, but an air-circulation system keeps the ballpark comfortable when the roof is closed. The roof is able to withstand snow drifts of up to 12 feet.
- Reliant Stadium—The new 1.9-million-square-foot facility opened in August 2002 as the NFL's first retractable roof venue. It is also home to the largest rodeo in the world, the Houston Livestock Show and Rodeo and was built at a cost of \$417 million. The roof is composed of two translucent Teflon-coated fiberglass fabric panels, which separate at the 50-yard line, slide on tracks, and rest over each end zone. It can open or close in just 7 to 10 minutes, depending on wind conditions. The super-trusses used to support the retractable roof transport system are 84 feet tall and 12 feet wide and weigh 3,750 tons (equivalent to the weight of more than 1,000 cars). The retractable panels move in opposite directions, similar to the Arizona Diamondbacks' Bank One Ballpark's roof but unlike the two moving panels at Houston's Minute Maid and Seattle's Safeco Field, which travel in the same direction. Miller Park in Milwaukee also has two moving panels, but they retract in a fan-shaped pattern. Even though Reliant Stadium's roof weighs an estimated 2,000 tons, high winds can create havoc. To counteract this, operable clamps hold the roof in place stabilize it.
- Arizona Cardinals Stadium—Construction of the Cardinals' stadium began in July 2003. Originally expected to be completed in time for the 2005 NFL season, it is now anticipated that the stadium will

open in August 2006 at a cost of \$355 million. Once completed, the facility will become the second NFL stadium to have a retractable roof. The roof will consist of two large panels that retract to uncover the entire playing field and has been designed to provide a balance of sun on the field and shade in the seats. An additional innovation will be a natural grass field contained on a moveable, 12-million-pound tray 234 feet wide by 400 feet long. The entire field will roll outside of the facility where the grass will absorb sunlight and receive nourishment, maintenance, and grooming. The facility will seat up to 73,000 with 7,000 club seats and 88 luxury suites.

Other professional teams that have stadium plans that will include a retractable roof are the Dallas Cowboys, New Orleans Saints, New York Jets, Minnesota Vikings, Minnesota Twins, New York Yankees, and the New York Mets. As of the time of this writing, several other teams are planning or considering construction of retractable-roof stadiums. It appears that the retractable-roof stadium is now coming into its own and we will probably see many new examples in the coming years.

Going “Green”

Another significant innovation of stadium and arena design will be the use of renewable and sustainable materials. The 2000 Summer Olympic Games in Sydney, Australia, exemplified the essence of going green on a global scene for sports facilities. Solar power was used for street lighting, water heating, and air conditioning. Bathing and kitchen water were treated on-site for reuse on gardens and for washing vehicles. Buildings facing north allowed for warmth in winter and cooling in summer, and there was a ban on environmentally harmful gases in insulation, refrigeration, and air-conditioning units. The 2004 Summer Olympics in Athens, Greece, followed the lead of the Sydney Games as many of the sports venues were made from materials that can be recycled after use. Additional concerns for the 2004 Summer Games that needed to be addressed by implementing green tactics was the potential of damaging the ancient ruins surrounding the sites. By incorporating ecologically friendly sports designs, the likelihood of excessive pollution protected the invaluable, historical monuments of Greece.

In regard to North American teams following “green” facility design, the new New York Jets stadium may be referred to as a truly “green” building in the truest sense of the term. The stadium will feature renewable technologies such as wind turbines, photo-voltaic panels to generate electricity, and collector tubes that may be integrated into the facade for solar heating of domestic hot water. Other advanced technologies make certain that water conservation and recovery and ultra low energy-use systems will be included. Through these innovations the Jets intend to become the leader in developing the New York Sports & Convention Center allowing the opportunity to host big-time events ranging from the Super Bowl to World Cup soccer matches to the 2012 Olympic Games.

Formed by the Washington D.C.-based U.S. Green Building Council (USGBC), the original standards for green design were mainly developed for privately built commercial buildings. However the Leadership in Energy and Environmental Design (LEED) standards are gradually gaining the awareness of city officials due to their potential energy and environmental saving costs. Five states, Washington, Oregon, Pennsylvania, New York, and Maryland, have introduced building programs that encourage LEED certification for state buildings. Additionally, cities of sporting note (Seattle; Portland, OR; and Austin, TX) require new public buildings to obtain LEED certification. Thus, individuals in charge of planning and/or construction of public sports and recreation facilities should be conscious of the rising attractiveness of a national voluntary movement to apply stringent “green building” standards to new construction and major renovation projects.

While approximately 40 projects in the United States have gotten one of the four levels of certification offered by the building council, more than 600 additional building projects, of which 150 were municipal building projects, have indicated their intent to apply for certification by the end of last year (Hammel, 2003). However, one of the primary concerns regarding whether to incorporate LEED standards into new building construction has been cost. Energy-efficient lighting systems have a greater initial cost but often lead to significant benefits due to reduced energy consumption. Among additional significant secondary savings available in a number of communities are tax credits for the construction of buildings that are environmentally responsible. Rebate programs have also been established in some communities; in the Seattle School District, each school gets back about 90% of its energy savings to purchase needed equipment and supplies (McCarron, 2001). Another example is the recent construction of a sports and recreation facility in Boulder, Colorado. The city of Boulder anticipates being able to recover much of the initial costs through an expected 37% annual reduction in energy costs (Hammel, 2003). Additionally, the significant cost of such items as solar panels were estimated to be recouped within 12 years (Hammel, 2003).

Through the adoption of LEED standards, a sports facility may recover much of the initial cost of the building without sacrificing sustainability. A well-designed building can decrease energy usage, increase indoor air quality, and utilize open areas better. When one considers the operating cost savings over the lifetime of a sports facility, the additional up-front cost is relatively insignificant. It is apparent, given the status of our environment that green design of sports facilities is and will continue to be an innovative trend.

Notes

Trends in Indoor Playing Surfaces

Due to the increase of retractable roofs or domed stadiums there needed to be playing surfaces that required either no or minimal amounts of sunlight. At first artificial turf fields were categorized as nothing more than carpets, often laid on hard, concrete bases. These surfaces presented a sports participant extensive opportunity for injury. Often, players would suffer injuries, sometimes career-ending ones such as Michael Irvin, as a result of being slammed to the ground. In other situations the footing was too good, thereby creating the potential for ankle, knee, and groin injuries when an athlete's shoe became planted in the carpet. The danger of friction burns when players slid on the carpet with bare limbs posed an additional risk of infection if these abrasions were not treated properly.

In response to these potentially unsafe situations, innovative indoor playing surfaces have evolved to the point that players actually prefer to play on some types of artificial surfaces. Approximately 40 Division I-A schools use synthetic turf on their playing fields, according to the NCAA. The majority of colleges still play on natural grass, but the percentage of artificial fields is the highest since 1997. In fact, a 2003 NCAA report showed baseball players experienced nearly identical injury rates on synthetic and natural surfaces. The following information will highlight the improvements of playing surfaces for retractable and/or domed stadiums.

New Breed of Synthetic Turf

The last decade has seen a tremendous improvement in the design and manufacture of synthetic turfs. Many of the old concerns about higher injury rates have been alleviated. The new designs are much softer to fall on and do not produce the friction burns of the previous designs. Most participants report that conditions are more similar to those found on good natural grass fields. The new turfs are typically filled with ground-rubber particles and sometimes with sand.

Recently the National Football League Player's Association conducted a survey of playing fields. The FieldTurf surface at Seattle Stadium finished as the third most popular playing surface in the NFL (Waterman, 2003). Additionally, the new FieldTurf playing surface at the Detroit Lions Ford Field ranked as the 11th most popular playing surface (Waterman, 2003). This despite the fact that only 9 of the 32 NFL teams had the opportunity to play on it. It is important to note that both of these fields were rated ahead of many natural grass fields and that no other artificial turf field rated higher than 20th. An added feature of FieldTurf is its ability to be installed for football, markings and all, in eight hours or less. The markings can be removed in the equivalent time frame as well. Therefore, it is also entirely possible that a field conversion from football to another sport may be accomplished in even less than eight hours. This would allow a stadium to stage a soccer game or tennis matches on it one day and a football game the next without the problem of tearing up the playing field that often exists on natural grass (Waterman, 2003).

Examples of professional football teams that have recently installed FieldTurf at their game or practice facilities are the Atlanta Falcons, St. Louis Rams, Kansas City Chiefs, Houston Texans, New England Patriots, Cleveland Browns, Green Bay Packers, Seattle Seahawks, Detroit Lions, Pittsburgh Steelers, New York Giants, and New York Jets. Additionally, the Florida Marlins have, of late, elected to install FieldTurf for their fields. It has becoming evident that the FieldTurf system is becoming the preferred design choice for the National Football League and major league baseball.

Removable Natural Grass

Another turf-related option that has become a facility design issue in sports stadiums is removable natural grass. This innovative concept was first used in the Silverdome for the 1994 World Cup Soccer Tournament. A hybrid grass was developed at Michigan State University that was designed to thrive in the low levels of sunlight that could enter through the fabric roof of the Silverdome. A system of nearly 2000 interlocking pallets was computer designed and built to provide the regulation soccer field. The pallets were set up in the parking lot where the grass received plenty of sunlight. Just prior to the first game, they were hauled by trucks and forklifts into the stadium and assembled. The process took two days to complete. The field was a success and got very good reviews. Unfortunately, it was too large an undertaking to make it feasible to move in and out of the stadium on a regular basis, so the Detroit Lions continued to play on their Astroturf field.

The idea of using a removable natural grass field was also hotly debated during the construction of Reliant Stadium, since the field would accommodate both professional football and rodeo. A palletized

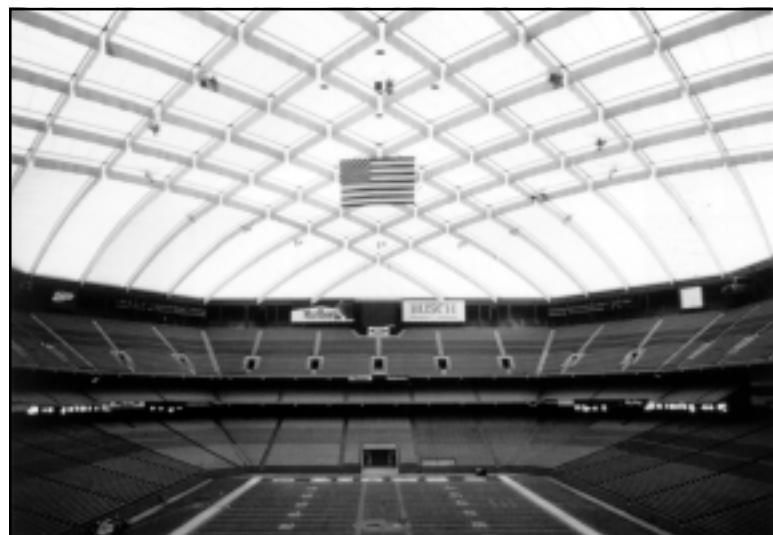


Photo by Todd Scidler

Pontiac Silverdome.

natural turf field was seen as the solution. It integrates portable turf units of eight feet by eight feet, including a metal drainage base. The units incorporate a growing medium that is reinforced with Reflex mesh elements (small pieces of nylon mesh) that increase field stability, aids in water and air management, and provides a forgiving (non-hard) surface for the athletes (Thompson, 2001). The turf was designed so that any unit can be replaced without affecting the unit next to it (Valentine, 2003). They can be easily replaced so as to resist extreme wear as well as the effects of extended time in shade. The field is completely removed to an outside nursery once a year while the stadium hosts the Houston Livestock Show and Rodeo. While only Reliant Stadium possesses this turf, at the time of this writing, it is quite likely that this trend will continue in the future, given the propensity for multiple-use sports facilities.

In the new Arizona Cardinals stadium, the natural grass field will be contained on a movable, 12-million-pound tray that will be 234 feet wide by 400 feet long. The first field of its kind in North America, the entire tray will move from the parking lot into the stadium in about 45 minutes. The tray will rest on tracks and will roll out on steel wheel sets powered by small electric motors. When not needed for games, the field will move out of the stadium so the grass will be able to absorb more sunlight.

Fabric Structures

A fairly recent development in the area of physical education, recreation, and athletic facilities is the concept of fabric structures. The fabric used most commonly is a Teflon®-coated fiberglass material. The fiberglass fabric is, pound for pound, stronger than steel and is also less expensive. It can be designed to allow either a large or very little amount of natural light to penetrate. The fabric can withstand temperatures of 1,300° to 1,500° F and is not adversely affected by cold or the ultraviolet rays of the sun. Fabric structures offer a number of potential advantages and disadvantages when compared with standard construction.

Advantages

- Lower initial cost—Initial costs are usually lower than with conventional construction. Several factors contribute to this, the primary one being weight. A fabric roof is 1/30 the weight of a conventional steel-truss roof. This reduced weight means that the walls, footings, and foundations are not required to be nearly as strong as in a conventional building.
- Less construction time—The amount of construction time is directly related to the initial cost of the structure. The total time necessary to build a fabric structure is usually less than for a conventional roof.
- Natural lighting—Since the fiberglass fabric material that is used is translucent, it results in a large amount of interior natural lighting. Without using artificial lights during the day, the light intensity inside can vary anywhere from 100 to 1,000 foot-candles, depending on weather conditions, design, and choice of fabric. The interior light is considered to be of high quality, because it is nonglare and shadow-free.
- Possibly lower energy costs—In some climates or regions, energy costs may be substantially reduced by the fabric's translucency. The large amount of natural light may reduce or eliminate the need for artificial light during the daytime. This may also reduce the need for air-conditioning required to overcome the heat generated by the artificial lights.
- Less maintenance—The nonstick characteristics of Teflon® allow the fabric to be washed clean each time it rains.
- Full utilization of space—Depending on the fabric structure's configuration and support, the area that can be enclosed is almost limitless.

Disadvantages

- Life span—The fabric envelope in use today has a life expectancy of up to 25 years, with longer-life materials being tested. All other items such as the foundation, flooring, and mechanical equipment have the life span of a conventional building.
- Poor thermal insulation—In cold climates there may be an increase in energy cost when compared with conventional construction due to lower insulating properties of the fabric roof. The insulating value of a typical fabric roof is about R-2 but can be increased substantially (see Lindsay Park Sports Centre). The cost of heating is a significant factor and should be evaluated against that for a conventional building over time. During winter months when the heat is required to melt the snow or to cause it to slide off, a safe level of temperature will have to be maintained at all times, which has an impact on heating costs. If the bubble is not to be heated during inactive hours, it will have to be supervised constantly for the dangers of unexpected snowfall. In the summertime the heat gain of the air-supported structure may pose a cooling problem.
- Acoustic problems—The curved shape of the air-supported structure produces a peculiar acoustic environment. This large reflective surface magnifies crowd noise and can create undesirable noise conditions.
- Restriction due to wind—In winds of hurricane velocity, many codes require that the fabric structure be evacuated.

Notes

There are three basic types of fabric structures in use: 1) tension structures, 2) air-supported structures, and 3) cable domes. Tension structures are made by stretching the fabric between rigid supports and/or steel cables. Air supported structures are sealed buildings that, through the use of fans, maintain a positive internal air pressure that supports the roof. These structures are actually inflated like a balloon and must maintain the positive air pressure to remain inflated. Cable domes are the newest type of fabric structure. The cable dome is actually a modified tension structure that uses a complex network of cables and supports to suspend and hold up the fabric roof.

Tension Structures

Some projects lend themselves more naturally to tension structures than to air-supported structures or cable domes. Some of the conditions in which tension structures may be more favorable are as follows:

- Free and open access from the sides is desirable or required.
- A unique design or aesthetics are of importance.
- The facility will be largely unattended or not monitored.
- Possible deflation of an air structure would constitute a severe operational or safety problem.
- A retrofit to an existing building or structure such as a swimming pool or an outdoor stadium is desired.

Some examples of tension structures are:

- Knott Athletic, Recreation & Convocation Center—Located at Mount Saint Mary's College in Emmitsburg, Maryland, the Knott Center is a unique combination of standard construction and a fabric tension structure. Completed in 1987, most of the facility is built with standard brick construction, with the tension-structure field house connected onto one side of the building. The fabric roof covers 30,000 square feet of activity space including a multiple court setup and a 10-lap-per-mile running track. Rising to a height of 40 feet, the double-layered roof allows for almost exclusive use of natural light during the day. Also included within the facility are four racquetball courts, locker rooms, and a 25-yard pool.
- Lindsay Park—The Lindsay Park Sports Centre in Calgary, Alberta, Canada, houses a 50-meter pool, a diving pool, a fully equipped 30,000-square-foot gymnasium, and a 200-meter running track. The roof is unique in that it was designed with insulation that is rated at R-16. This compares with a typical fabric roof that has about an R-2 rating. Despite the great improvement in insulating qualities, the fabric roof is still translucent enough to allow for an interior illumination of about 200 foot-candles. This facility was completed in 1983.
- McClain Athletic Training Facility—Completed in 1988, this field house is located at the University of Wisconsin at Madison. Due to site restrictions, this \$9.5 million facility contains a 90-yard football field instead of a full-size



Photo courtesy of Bohlin Cywinski & Jackson
Photo by Matt Wargo

Knott Center—exterior.



Photo courtesy of Bohlin Cywinski & Jackson
Photo by Matt Wargo

Knott Center—interior.

field. Most of the field is covered by a 42,000-square-foot fabric-tension roof that admits up to 750 foot-candles of natural light into the structure. When comparing the fabric roof to standard construction, it is estimated that the increased cost for heating and the reduced cost for artificial lighting result in an overall saving of about \$21,000 per year. Below the synthetic turf field lies a full 64,320-square-foot basement that contains locker rooms for football, track, and coaches; weight room; training facilities; and therapy pool. The therapy pool is 15 feet by 40 feet and goes from 4 to 7 feet in depth. Also included in the facility are an auditorium, six meeting rooms, and a film room.

Air-Supported Structures

There are two basic types of air-supported structures: 1) large permanent structures and 2) smaller, more portable structures.

Air-supported fabric roofs are held up by a positive air pressure within a totally enclosed building. These facilities are actually inflated with positive air pressure that is produced by a group of large fans. In conventional buildings, the foundation, walls, and internal columns must support a roof weight of between 10 and 40 pounds per square foot. In air-supported structures, a roof weight of about 1 pound per square foot is transmitted directly to the ground by the increased air pressure. This increased pressure of about 4 or 5 pounds per square foot greater than ambient pressure is usually unnoticed by the building's occupants. Some of the instances when an air-supported structure may be preferable to a tension structure or standard construction are:

- When column-free spans of greater than 150 feet are desired.
- When large, column-free spans are desired at a cost that is greatly reduced compared to conventional structures. In fact, cost per unit area usually decreases as the size of the span increases.
- When a low silhouette is desired.

Some examples of air-supported structures are:

- **Dedmon Center**—Located at Radford University in Radford, Virginia, the Dedmon Center was constructed for a cost of \$6,750,000 and opened in 1982. Encompassing 110,000 square feet, it has 5,000 temporary seats for basketball. Used for physical education, athletics, and recreation, the center provides five full basketball courts, weight room, pool, locker rooms, and offices.
- **Dakota Dome**—Located at the University of South Dakota in Vermillion, South Dakota, the Dakota Dome contains five basketball/volleyball courts, two tennis courts, an eight-lane 200 meter track, four racquetball courts, a six-lane 25-meter pool, locker rooms, classrooms, and the offices for the athletic department. The main floor is a synthetic surface that is used for most court activities and has an artificial turf football field that can be rolled out for football, soccer, and other field events. When the facility is set up for football, there is seating for 12,000 spectators. The entire facility was built for the bargain price of about \$51 per square foot in 1978.
- **Carrier Dome**—The Carrier Dome, located in Syracuse, New York, is the home of Syracuse University athletics. The stadium seats 50,000 for football and over 30,000 for basketball. Also a great bargain, total construction cost was \$27,715,000, which figures out to \$554 per seat. This is very inexpensive when compared to conventional covered stadiums. This facility was completed in 1980.
- **RCA Dome**—Originally called the Hoosier Dome, it first opened in 1984. The home of the Indianapolis Colts, the RCA Dome seats 57,890 for football and was built for a cost of \$77.5 million. The versatile facility has been host to many national and international events including the Pan American Games, the World Track & Field Championships, the World Gymnastic Championships and several NCAA Final Fours.
- **Steve Lacy Field House**—Milligan College, Milligan, Tennessee—1974.
- **Uni-Dome**—University of Northern Iowa, Cedar Falls, Iowa—1975.
- **Metrodome**—Minneapolis, Minnesota—1982.

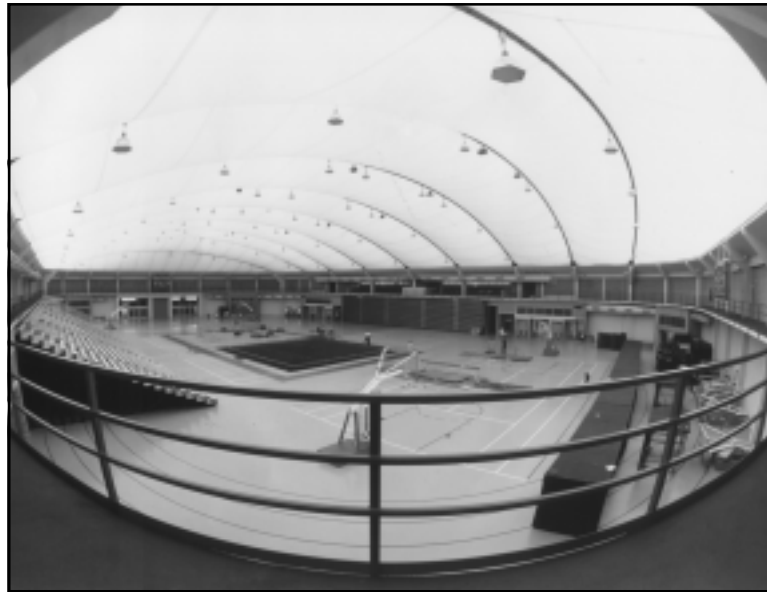


Photo courtesy of Sasaki Associates

Dedmon Center.

Notes

- B.C. Place Amphitheater—Vancouver, B.C., Canada—1983.
- Tokyo Dome—Tokyo, Japan—1988.

The primary disadvantage of air-supported structures is the need for the constant positive air pressure. Since this positive pressure is what supports the roof, if there is even a temporary loss of pressure, the fabric will hang down on the supporting cables. Although this alone should cause no damage to the facility, this is when the structural system is the most vulnerable. Even light winds, snow, or rain may cause extensive damage to a fabric roof in the deflated position. These facilities must be constantly monitored and all precautions must be taken to ensure that all systems are functioning properly. Since cable domes appear to have the same advantages as the large air-pressure structures but without many of the disadvantages, it is entirely possible that we have seen the last large air-supported structure that will ever be built (see Cable Domes on page 482).



Photo courtesy of Geiger Engineers

Metrodome.

Combining Air-Supported and Tension Roofs

Another development in the construction of fabric structures is the idea of combining both an air-supported roof and a tension roof in the same building. An example of this concept is the Stephen C. O'Connell Center. This physical education, recreation, and athletic complex is located at the University of Florida at Gainesville. This was the first structure to combine both air-supported and tension roofs in one building. The center or main arena is covered by a large air-inflated roof, while the outer areas of the building are the tension-covered spaces. The main arena has an indoor track and can seat 10,400 spectators for basketball. Located under the tension supported areas are a gymnastics area; dance studio; weight room; locker rooms; offices; and a 3,000-seat, 50-meter natatorium. Like most fabric structures, this facility was a bargain. The total construction cost was \$11,954,418, which comes out to about \$49 per square foot. This facility was completed in 1980.

The Sun Dome at the University of South Florida in Tampa is based on a very similar design. Following the same plans as the O'Connell Center, the Sun Dome initially was built with only the air-supported fabric roof main arena. It was not until several years later that the outer areas were enclosed by a tension roof and the building was completed.

Temporary Air-Supported Structures

This section will outline the merits of the smaller and more portable air structures. Air structures work well as environmental covers placed over existing recreational areas and, for many organizations, the 'bubble' is the answer to an increasing need for large covered activity areas at a nominal cost. Cost savings are in proportion to the size of the space to be covered. Spaces over 300 square feet usually bring a cost savings when compared to conventional roofing. Heat gain seems to present a more severe problem than heat loss and must be considered in warmer climates. There are numerous playing fields within communities and around schools and colleges that lend themselves easily to enclosure by a fabric air structure. Some of the additional advantages and disadvantages of using small air-supported structures are as follows:

- Speed of erection—Once in place, the actual erection of the structure usually takes only one or two days. However, additional time is required for the ground work, site services, foundation, anchorage, flooring, and installation of mechanical and electrical equipment needed in the initial installation. Only minimal field labor is needed.
- Ease of deflation, inflation, and repair—Deflation and inflation of the fabric bubble usually does not require skilled labor.
- Portability—When deflated and packed, the fabric envelope can be stored in a small space or easily transported elsewhere for storage or use. Depending on the size of the dome, deflation and packing usually require one or two days.
- Adaptability for temporary functions—For temporary use, the air-supported structure has definite physical and financial advantages over a conventional building.
- Long-span and high-ceiling features—Clear and unobstructed spaces are an inherent feature of the air-supported domes. Conventional long-span and high-ceiling structures are much more expensive.

- Integrated heating, ventilation, and air-pressure system—The integrated heating, ventilation, and air-pressure system is simple and less expensive than conventional systems. Lengthy duct work is not required.

Some examples of temporary air-supported structures are:

- Memorial Stadium—A portable inflatable fabric bubble is used to cover the entire football field at the University of Illinois in the winter. First erected in 1985, it was purchased for \$1.5 million. With an average inside winter temperature of 55 degrees, the field is used heavily by several departments across the campus. The concept of a portable dome over the game field adds extra use to a facility that would otherwise sit empty much of the year.
- University of Santa Clara—The swimming pool at the Thomas E. Leavey Center is covered by a portable air structure. It is removed for use as an outdoor pool in the summer months and then reinflated for the winter to transform the pool for indoor use.
- Numerous tennis centers, golf driving ranges, pools, and fitness centers.

Cable Domes

Cable domes are the most recent innovation in fabric structure technology. Through a complex system of cables and girders, very large spans can be inexpensively covered by a fabric roof without the need for columns or fans to maintain integrity. Engineers predict that the cable dome concept is feasible for spans of at least 1,000 feet. Cable domes incorporate most of the advantages and fewer of the disadvantages of fabric structures when compared to standard construction. Many experts in fabric roof technology believe that cable domes will replace the air-supported structure as the fabric roof design of choice for the future. There will probably not be any more large air structures built because of the inherent advantages of the cable dome. Some of these advantages are as follows:

- Huge, column-free spans can be covered.
- There is no need for expensive, energy-consuming fans.
- A passive system means there is no need for someone to constantly monitor the facility.
- The structure has an extremely low silhouette.

Some examples of cable domes are:

- Redbird Arena—Opened in 1991, Redbird Arena is on the campus of Illinois State University in Bloomington-Normal, Illinois. This multipurpose arena can seat 10,500 spectators for basketball, with the ability to provide an additional 1,500 seats on the floor for concerts or commencement. The lower sections of seats are portable bleachers that can be removed to provide 36,000 square feet of space on the main floor. Built for a cost of \$20 million, Redbird Arena was the first cable dome to be constructed on a college campus, but probably will not be the last.
- Tropicana Field—Tropicana Field is located in St. Petersburg, Florida, and was opened in 1990. This multipurpose stadium was designed primarily for baseball, yet with the flexibility to accommodate football, basketball, soc-



Photo by Todd Seidler

Redbird Arena.



Photo courtesy of HOK, INC.
Photo by George Cott

Tropicana Field.

Notes

cer, and tennis, as well as concerts and trade shows. In addition to 50 private suites, a variety of seating arrangements allow the facility to function as an 18,000-seat arena or a 43,000-seat stadium for baseball. The unique movable grandstands contain built-in concession stands and public toilets. The fabric roof is 688 feet in diameter and was constructed on a tilt of 60 degrees. This tilt is designed to allow more clearance for the trajectory of fly balls and allows the roof to reach a height of 225 feet in front of home plate. The cable truss roof system is capable of supporting 60 tons of lighting and sound equipment for concerts, yet weighs a mere six pounds per square foot. Tropicana Field was built for a cost of \$132 million and is the home of the Tampa Bay Devil Rays.

- **Georgia Dome**—Located in downtown Atlanta, Georgia, the Georgia Dome was completed in August 1992. This \$210 million structure was the site of both the Super Bowl and the Olympics in 1996. The Teflon-coated fabric roof covers 8.6 acres, weighs 68 tons, and incorporates 11.1 miles of steel support cables. This multipurpose facility seats 70,500 for football and is the home of the Atlanta Falcons. A total of 202 luxury suites are located on different levels around the stadium that range in price from \$20,000 to \$120,000 per year for a 10-year lease. During the planning process it was estimated that changing the design from an open-air stadium to a fabric-covered dome increased the cost of the project by only 20% or less.



Photo courtesy of Heery Architects & Engineers
Georgia Dome—exterior.

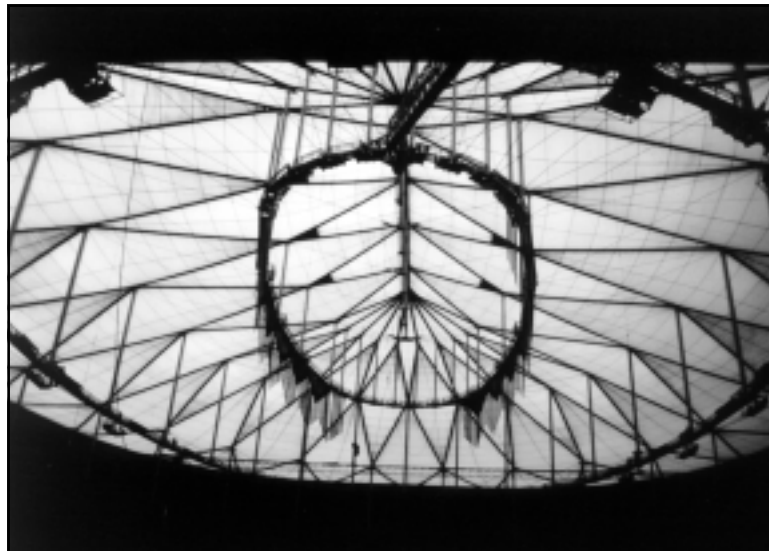


Photo by Todd Seidler
Georgia Dome—interior roof.

Wooden Domes

Another recent development in encapsulated spaces is the wooden dome. These spherical wooden structures have several advantages over conventional structures. Column-free spans of up to 800 feet are possible, and they are generally easier to build. There are several wooden dome structures around the country ranging from high school gymnasiums to very large stadiums. Some of the advantages of wooden domes when compared with standard construction may include

- efficient construction of huge column-free spans,
- lower initial cost when compared with conventional construction,
- less construction time,
- full utilization of space, and,
- good insulation and acoustical properties.

Some examples of wooden domes are:

- **Round Valley Ensphere**—Located in Eager, Arizona, this wooden dome is the only domed high school football stadium in the world. Opened in 1991, it was built for a total project cost of only \$11.5 million and is unique in many respects. The 113,000 square feet of unobstructed floor space provides a full-size synthetic turf football field with seating for 5,000; a six-lane, 200-meter, synthetic-surface running track with 100-meter straight away; seven combination basketball, volleyball, or tennis courts; and a softball field; as well as offices, training room, and four full locker rooms. The wooden roof is insulated to a value of R-28 and is very energy and acoustically efficient. One of the most interesting

features of the dome is that it contains a large skylight in the center of the roof. This skylight is made of clear Lexan and provides good illumination of the activity areas even on overcast days. At an elevation of over 7,000 feet, the Round Valley area experiences extremes in weather, including snow-packed winters. During these colder months, the skylight also acts as a solar collector, helping to make the Ensphere very energy efficient.

- **Walkup Skydome**—This laminated wood dome is located in Northern Arizona University in Flagstaff, Arizona. Opened in 1977, the Skydome is 502 feet across and covers 6.2 acres. It contains a full-size, roll-up, synthetic football/soccer field, a professional-size ice hockey rink, a 1/5-mile running track, a portable wood basketball court, and has seating for more than 15,000 people. The total construction cost was \$8.3 million, or about \$620 per seat.
- **Superior Dome**—Constructed on the campus of Northern Michigan University in Marquette, Michigan, this state-owned wooden dome was opened in the fall of 1991. With a diameter of 533 feet, the 14-story, \$21.8-million structure was envisioned in 1985 as an Olympic training center. It has a 200-meter track, a full-size football field and is



Photo courtesy of Rossman, Schneider, Gadberry & Shay

Round Valley Ensphere—exterior.



Photo courtesy of Rossman, Schneider, Gadberry & Shay

Round Valley Ensphere—interior.



Photo courtesy of TMP Associates, Inc.
Photo by Balthazer Korab, Ltd.

Superior Dome—exterior.

home to the NMU football team, with seating for 8,000 spectators. Designed to be constructed in phases as funding becomes available, the facility will eventually include an additional 5,000 seats; an ice rink for hockey, speed skating, and figure skating; locker rooms; sports medicine facilities; and public use areas.

Summary

The fundamental purpose and design of stadiums and arenas has changed dramatically in the last decade or so. These changes are so radical that many facilities built in the last 20 years have become obsolete. The basic idea behind these changes is that modern arenas and stadiums are no longer just places to watch an event but are now designed to provide a total entertain-

Notes



Photo courtesy of TMP Associates, Inc.
Photo by Balthazer Korab, Ltd.

Superior Dome—interior.

advantages include lower initial cost, less construction time, natural lighting, possible lower energy costs, less maintenance, and full utilization of space. The disadvantages may include shorter life span, poor thermal insulation, acoustical problems, and restrictions due to high winds.

The advantages of wooden domes include huge column-free spans, lower initial costs, less construction time, full utilization of space, and good insulation and acoustical properties.

The new modern facilities are designed to accommodate a wide variety of events and also to quickly alter the setup for different events. The planners included such things as versatile lighting and sound systems; heavy-duty, moveable lighting grids; moveable seating sections; loading ramps with main floor access; and fixed, pre-wired camera positions to improve the changeover efficiency of these facilities.

ment experience and maximize the generation of revenue for the owner.

The cost of operating professional sports teams has grown dramatically over the past two decades and shows no signs of slowing. Therefore, it is imperative that professional sports venues include a variety of income-generating aspects. Luxury suites, naming rights, and PSLs are among the many new streams of revenue for the cash-hungry professional franchises. These concepts cater to big-dollar clients and may guarantee bonds used in funding the new facilities.

The retractable roof concept was born in the 1970s. The main advantage is fan comfort and being able to play during inclement weather.

The three main types of fabric structure include tension, air-supported, and cable domes. The

Copyright of Facilities Planning for Health, Fitness, Physical Activity, Recreation & Sports is the property of Sagamore Publishing, LLC and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.