Dome Design Guide – Basic Considerations

Design Topics:

Why choose a dome shape?

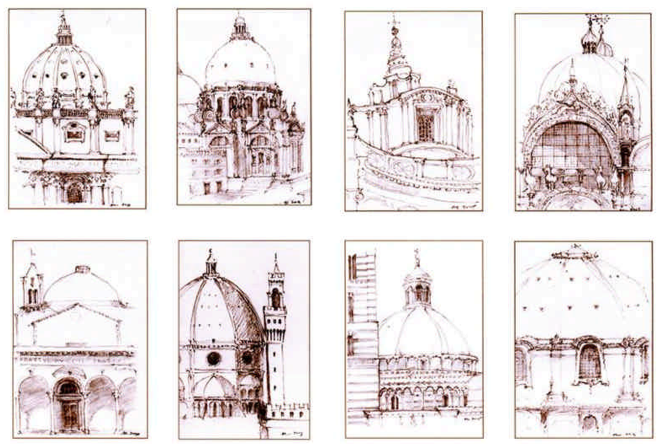
Clear-span; Safety; Visibility

What do you need to consider?

Support; Profile; Cladding

Putting it in place.

Construction



The dome shape has been around in architecture and design for hundreds of years. Most of the prominent architectural structures in the world have dome and vaulted shapes. The shape of the dome is based on spherical geometry and represents one of nature's performance elements: the shell. The dome '**shell**' behavior follows the idea of using curvature, a thin surface to establish **strength and stability**. The dome provides a structure with highly redundant strength and flexibility features. For instance, applying a local load to the surface results in a global response to distribute the load throughout the surface. This behavior allows for dome structures to lose portions of the structure and still remain stable and standing. The dome shape also provides abundant interior volume that is unencumbered by columns or restrictions. The dome shape supports itself from the periphery or edge of its surface boundary. The idea of column free spaces is often referred to as a **'clear-span'** strategy. This implies that dome shapes are best utilized in overhead applications, including roofs, skylights, atrium enclosures, and flexible use spaces. The opportunities that a 'clear-span' space provides are a highly adaptive program space, ambient/passive lighting for energy savings, and the use of natural day lighting. Skylights in the roof structure and fully glazed roof structures provide the designer and architect an opportunity to produce **healthy interior spaces** free from forced cubic confines established by traditional construction requirements.

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To introduce and integrate dome structures into a building or site plan, some considerations are made to best utilize the dome shape. There are several configuration types of dome structures; **geodesic, monolithic, radial, and triangulated**. Of primary concern are the support conditions and the impact to the superstructure of a building or space. As the dome is **edge supported**, there are a couple of options when supporting the perimeter. One is the use of a continuous ring-beam element from either steel or concrete that supports the entire perimeter. Also, the option exists for supporting the structure at regular discrete points around the perimeter. Both systems provide the option of having the dome structure with an internal support structure or an external support structure. This means that the dome can be self-restraining or be restrained from an external support structure. This is often described as having an internal 'tension ring' versus an external 'tension ring'. The choice is often up to the structural engineer for the primary structure as the decision often impacts their design directly.

The design choices that architects can make relate directly to the visual impact of the structure. One of the choices is that of profile, often expressed in **rise-to-span ratio**. This is a ratio that describes the overall rise (height) of the structure to the span at the base (support diameter). Rise-to-span ratios often begin at 0.10 (10% rise) and continue through 0.50 (hemisphere). Domes that exceed the hemisphere ratio are often described using a percentage of the sphere diameter (i.e. 5/8ths sphere). Specially engineered structures that fall below the 0.10 ratio are available and depend greatly on the span, support conditions, and environmental conditions (snow, wind, live load, etc.). **Profile geometry** greatly impacts the cost of the structure, the support structure requirements, the use of an internal tension ring, and the member depth. Discussing the profile options to address a variety of needs regarding the impact and aesthetic characteristics is key to achieving all the benefits a dome structure has to offer.

Other impacts to aesthetics include the **cladding** or dome surface skin. Domes have been constructed out of wood, steel, aluminum, concrete, stone, fiberglass, and PVC. Each structural system is often complemented by a system that understands the construction methods. Domes have been clad with glass, metal panels, fabric, wood paneling with a standing seam roof, composite metal panels and stone. Each cladding material provides a different texture to the finished surface. Some systems provide the appearance of a smooth surface, and others produce a faceted appearance. The effect of the skin depends upon the sightlines, distance from viewing points, and the proper use of lighting. Curvature and

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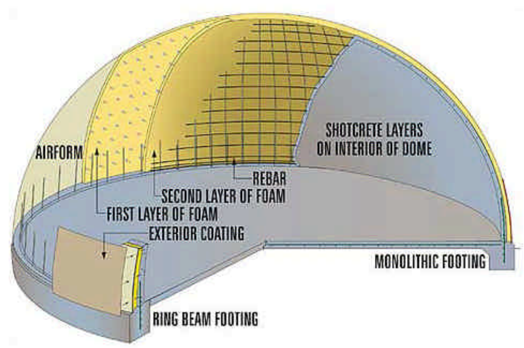
discretization of the surface structure are also important elements in achieving the desired aesthetic. An important element regarding domes is to remember that **curvature often equates to strength and stability**.



Once a dome design has been made, it is also necessary to understand the many methods for **constructing and installing** domes. As the dome is a stable structure when complete it is often possible to construct the structure on the ground and to lift the structure in to place. One advantage of this method is the ability to clad the structure close to the ground and save time. This is possible with aluminum, wood and steel structures. Typically, manlifts and cranes are used to lift materials up to roof structures to trades in glazing and roofing to perform their work after the structure is in place. Other options include in-place assembly (outside-in) and central tower construction (inside-out) that radiate from the tension ring and apex in concentric ring fashion. For domes constructed from pre-manufactured components, the tolerances and connections give the dome its final design shape without external staging or formwork. Domes that are constructed by using a form or rigging (often concrete and fiberglass) require additional considerations and often involve the dome springing from ground level as apposed to springing from a roofline. Dome structures that are field welded often require field measurements on a regular basis to confirm the appropriate profile. Field welding is often time intensive and costly depending upon the region where the structure is constructed. To save time in the field, it is often best to produce a design, take field measurements of the support structure and then make modifications at the support connections to accommodate any out-of-round conditions and construction tolerance. Many field conditions and configurations will often introduce their own challenges, so it's best to have an installer or consultant familiar with dome structures.

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