Fuller's Fantastic Geodesic Dome

This lesson was created as a supplement to the *Fuller's Fantastic Geodesic Dome* program at the National Building Museum. It is designed to be used in your classroom independently, or as an activity before or after a school program at the Museum. For more information about and to register for the National Building Museum's school programs, visit http://www.nbm.org/schools-educators/school-visit/.

The *Fuller's Fantastic Geodesic Dome* program teaches fifth through ninth grade students about principles of engineering and design. Through studying geodesic domes, students are exposed to an innovative solution to the ongoing challenge of creating structures—how to maximize space while creating a strong, cost-effective, people-friendly structure. By studying the geodesic dome and its construction, students learn about materials, structures, and forces present in all buildings.

National Building Museum

Created by an act of Congress in 1980, the National Building Museum explores, celebrates, and illuminates achievements in architecture, design, engineering, construction, and planning. Since opening its doors in 1985, the Museum has become a vital forum for exchanging ideas and information about such topical issues as managing suburban growth, designing and building sustainable communities, and revitalizing urban centers. A private, nonprofit institution, the Museum creates and presents engaging exhibitions and education programs, including innovative curricula for school children.

Over the past two decades, the Museum has created and refined an extensive array of youth programming. Each year, approximately 50,000 young people and their families participate in hands-on learning experiences at the Museum: 2-hour-long school programs for grades K–9; major daylong festivals; drop-in family workshops; programs helping Cub and Girl Scouts earn activity badges; and three innovative outreach programs, lasting between 30 and 60 hours, for secondary school students. The Museum's youth programming has won the Washington, D.C., Mayor's Arts Award for Outstanding Contributions to Arts Education and garnered recognition from the National Endowment for the Arts.

NATIONAL BUILDING MUSEUM
NATIONAL BUILDING MUSEUM
401 F Street, NW Washington, DC 20001
202.272.2448/www.NBM.org
Red Line Metro, Judiciary Square

Introduction to Domes

Basic Engineering Principles

A dome is defined as a large hemispherical roof or ceiling. Although many different types of domes exist, all domes share certain advantages, whether or not they are geodesic. Their compound-curved shape is inherently strong, giving a self-supporting clear span with no columns as supports. Domes are resource and energy-efficient because, of all possible shapes, a sphere contains the most volume with the least surface. A dome typically has a circular footprint. A circle encloses the most area within its perimeter. Thus, for a given amount of material, a dome encloses more floor area and interior volume than any other shape.

A dome's design is dependent upon many factors, including:

- needed area and span, or distance between supports;
- budget and building schedule;
- architect's and /or client's aesthetic preferences;
- forces, such as compression and tension, acting on the structure; and
- building materials.

Area and Span

The architect must consider the area to be covered by the dome and the needs of the structure in terms of space and uses. Span is the length of a structural element between supports. The materials used will impact how long the span can be and the budget along with the building schedule will also influence the span.

Forces of Compression and Tension

A force is a push or a pull on an object. Built structures, such as domes and buildings, rely on unseen forces that hold them together and enable them to support additional weights, or loads. In every structure, two invisible forces are at work: compression and tension. Compression is the act of being pushed or pressed together. Tension is the act of being stretched or pulled apart.

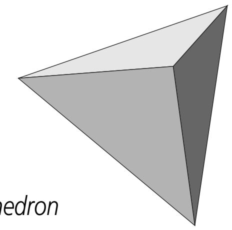
Materials

Engineers must consider the properties of building materials when making choices for any structure. When considering building materials for domes, engineers take into account the cost, proposed use of the dome, location, aesthetics, and durability.

Space-Framing

Space-framing (a network of triangular supports) is often used in dome construction. The most important element of a space frame is the triangle, which is also the strongest form used in architecture. Different types of geometric shapes (or polyhedra) are used in space framing. One common form is the tetrahedron—a four faced triangular shape, or a kind of pyramid with four faces and six struts. Six identical struts can form two triangles. But, when they are arranged synergistically, the same six struts make a tetrahedron of four triangles.

The connecting of triangles in this way provides a structural system that is strong and uses minimal amount of materials, all of which are interchangeable.



tetrahedron

Geodesic Domes

The aspects outlined about domes apply to all except the flattest domes, no matter what their structural system. Using space framing principles, geodesic domes have a major advantage over other domes: they are the strongest per pound of material employed. According to Webster's Dictionary, geodesic is defined as the "shortest line between two points that lies in a given surface." Further investigation revealed that the icosahedron (20 sided polyhedron or shape), with its 20 identical equilateral triangles, was the key. It didn't take R. Buckmister Fuller ("Bucky"), inventor of the geodesic dome, long to understand that a sphere made up of an icosahedral array of great circular geodesic lines represented the most efficient way to enclose space.

Positive Features of Geodesic Domes

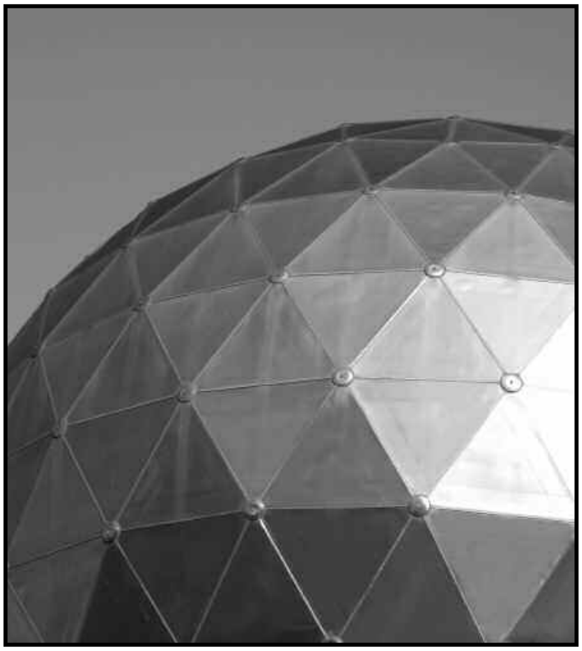
Nearly all advantages to geodesic domes are related to their efficiency.

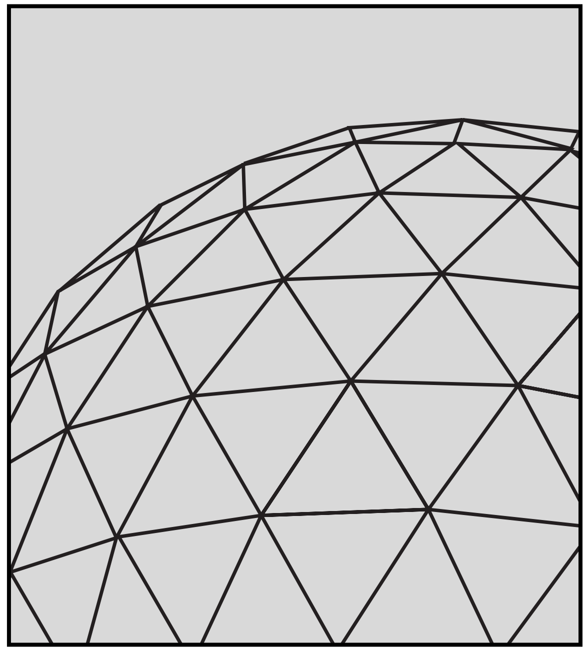
Geodesic domes are:

- The strongest structures per pound of material employed.
- Inherently strong and light; their curved form creates a span with no need for additional support (such as columns) and equally distributes stress throughout the structure.
- Resource- and energy-efficient because of all possible shapes, a sphere contains the most volume with the least surface area.
- Streamlined spherical forms let wind slide smoothly over their surface, thus helping to maintain a constant interior temperature with less need for heating and cooling systems.
- Structures that allow air to easily circulate, reducing heating and cooling costs.
- Easy to manufacture and construct due to interchangeable parts.

Negative Features of Geodesic Domes

- Do not fit certain lot shapes, particularly traditional rectangular city blocks.
- Do not gracefully accept additions.
- Difficult to enlarge by adding a second story.
- Often look identical to each other.
- Quickly distribute sound, smells, heat, cold, smoke, and fire because of their efficient circulation.
- Difficult to divide into separate spaces (such as rooms of a house or office).
- As its exterior becomes warm or cold with changes in weather, a dome's materials expand and shrink causing gaps where water can leak into the structure.


geodesic dome


geodesic dome outline drawing


geodesic dome photograph and outline drawing combined