Catenary Arches

- Catenary Arches
- Compression Thrust Lines
- Ideal Compression Arches
- Compression Shells
- Masonry Arches and Vaults

Catenary Shapes

The shape of the catenary depends on the loading. Simon Stevin showed this vector analysis and experimentally in 1585 with a weighted cord.

Because the cord has no resistance to bending, it hangs in pure tension. The reverse shape (flipped over) will be in compression only.

Tension only shapes

Compression only shapes
Catenary Shapes

The shape of the catenary depends on the loading. Because the cord has no resistance to bending, it hangs in pure tension. The reverse shape (flipped over) will be in compression only.

Selfweight loading produces a funicular curve. Uniformly applied load (e.g. horizontal PLF load) results in a parabolic curve.

Catenary Shapes

The shape of the catenary also depends on the length of the cord. For any given load and span there are an array of solutions based on the amount of sag.

The greater the sag the less horizontal force will be present at the reaction. The same is true for pure compression arches.
Methods to Determine
Ideal Compression Arches

Method 1: FBDs to find forces and dimensions

1. Choose loading
2. Set 3 points (reactions + sag)
3. Solve reactions
4. Calculate funicular shape (as a cable)
5. Invert the shape

Method 2: Moment Diagram for Even Supports

1. Choose loading
2. Draw moment diagram
3. Scale
Methods to Determine
Ideal Compression Arches

Method 3: Physical model

1. Choose loading
2. Hang catenary
3. Scale
4. Invert the shape

Compression Arches

Ideal Compression Shell or Arch
- All members in compression
- No flexure
- Encloses the catenary line

Pont du Gard
Nîmes, France

Giovanni Poleni (1683-1761)
repairs to St. Peter’s dome, 1748

Simon Stevin (1548-1620)
Compression Arches

'Ideal' catenary shape

Shape with moments

Compression Arches

Ideal Compression arch
• All members in compression
• No flexure
• Encloses the catenary line

Tensile Net to Compression Shell
• All members in tension
• No flexure

Frei Otto
Compression Shells
Grid shells based on catenary nets

Frei Otto, Grid Shells (IL Series) TA 663 .G58 1974
Compression Shells
German Pavilion Expo'67 – Frei Otto
Compression Shells
Grid Shell design

Masonry Arches
Corbeled arches and vaults

Figure 1.21 Tomb of Agamemnon (c. 1325 B.C.).

Corbeled arch in wall, Tiryns, Greece (c. 600 B.C.).

Ostia
Masonry Arches

Ostia, Italy

Pont du Gard
Nîmes, France

Figure 1—Masonry Arch Forms
Masonry Arches

Thrust lines

Institute for Lightweight Structures (IL)

Gothic Masonry

Gothic vaults
- Amiens
- 1220-1225

Additional vertical load
Oblique thrust from roof

The effect of an additional load at the top of the wall is to reduce the eccentricity of the thrust line.
Catenary Masonry
Catalonian

- Antonio Gaudi 1852 - 1926
- Catalan Art Nouveau
- Park Guell
Catenary Masonry
Catalonian
- Antonio Gaudi 1852 - 1926
- Catalanian Art Nouveau
- Crypt at Colonia Guell

Catenary Masonry
Catalonian
- Antonio Gaudi 1852 - 1926
- Catalanian Art Nouveau
- Casa Mila
Catenary Masonry
Catalonian
• Antonio Gaudi 1852 - 1926
• Catalanian Art Nouveau
• La Sagrada Familia