
reFolding Muqarnas: A Case Study

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This project uses folded surface as a mechanism to make a historically non-structural system, Muqarnas, into one that combines surface and structure. The resulting forms are structurally optimized while operating as skin, aperture, circulation core, etc. In recent years, ornament has captured the attention of artists, architects, scientists and literati alike, as the site of ideas that span disciplinary boundaries and are operative in constructing culture. This research begins with a study of traditional methods of pattern generation and construction techniques still practiced by artisans. Traditionally, Muqarnas has been used as a way to negotiate between two disparate geometries, that of a rectilinear base and a curvilinear top, i.e. dome, vault, half dome, etc. (Lur'zādah, 1979) It consists of an often-elaborate geometric pattern, which is then translated vertically to span between the two geometries. This translation happens by way of utilizing pre-determined 'units' - or Girih - that are within the lexicon of Muqarnas styles, depending on period and region (Lur'zādah, 1979). The structural and geometric logics of Muqarnas are tested through digital and physical modeling. Using computational techniques, two-dimensional patterns incorporating "girih" tiles are generated, and translated into three-dimensional constructs.

The system is adapted geometrically, materially and structurally to create a viewing platform in the San Francisco Bay Area. A peri-style hall emerges, drawing on the structural grid of the existing pier while responding to program

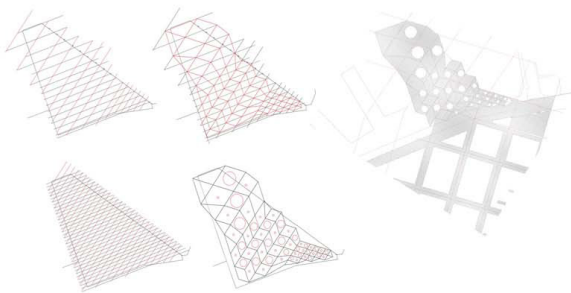
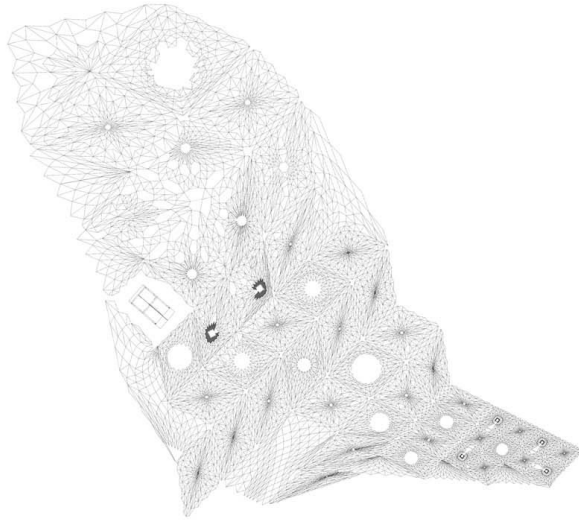
and urban grid as well as the slope and depth of the ground below the surface of water. As the bay slopes away from the shore, the piers become farther apart from one another while becoming deeper and wider. While the bays operate within a variable repetitive grid, creating smaller apertures, furniture and circulation cores, the symmetrical geometry gives way to an unfolding that translates to stairs, ramps and canopies where needed.

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This project utilizes folding surfaces as a mechanism to make a historically non-structural system, Muqarnas, into one that combines surface and structure. The resulting forms are structurally optimized, while operating as sites, apertures, circulation cores, etc. In recent years, research has explored the application of artists, architects, scientists and the liberal arts, as the site of ideas that span the boundaries of disciplines and are an integral part of constructing culture. The research presented here starts with a study of the traditional methods of pattern generation/topography and traditional construction techniques that are still practiced by artisans. The structural and geometric logic of Muqarnas are tested through digital and physical modeling. Using computational techniques, two-dimensional patterns incorporating 'girly' lines are generated and two-dimensional patterns are translated into three-dimensional constructs in a parametric environment.

The system is adapted geometrically, materially and structurally to create a viewing platform in the San Francisco bay area. A peil-style hull emerges drawing on the structural grid of the existing pier, while responding to program and urban grid, as well as the slope and shape of the ground below the surface of water. As the bay slopes away from the shore, the piers become farther apart from each other, while becoming deeper and wider. Within the bays create within a variable repetitive grid, creating smaller apertures, bays and circulation cores, the geometrical geometry gives way to an unfolding which translates to stairs, ramps and canopies where needed.

Simultaneously developed in Persia and North Africa, and widely distributed by Islamic builders and artisans, Muqarnas is an ornamental device often used at the base of a wall—dome or niche—to transition between the geometries of base and vault. Similar to the procedure, Muqarnas is used to negotiate between two disparate geometries—that of a cylindrical base and a curvilinear vault. It is based on a complex, often multi-scalar, and two-dimensional geometric pattern, projected vertically, creating a dome or wall-like, three-dimensional construct whose structural and formal integrity is attributed to the differentiated tessellation of two geometries. The determined 'girly' or 'girly' varied in style, depending on period and region, constitute the Muqarnas in an apertic arrangement. For centuries, artisans have used complex methods for generating and fabricating these three-dimensional structural ornaments that adorn courtyards mosques in a region influenced by Islam and its corresponding philosophy.

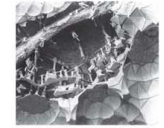
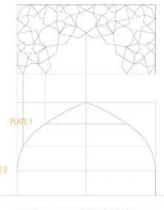
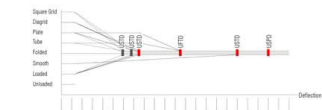


Structuring Element



Keeping the weight and tributary area of the structure constant, variables such as geometry, material and degree of folding were tested to measure the system's deflection under its own weight. The data was then used to optimize the structure. In the optimization diagrams below, the darker color indicates areas where structural contribution of the material is minimal to the system. These areas were used to introduce apertures in the system.

Mapping Deflection & Structural Optimization



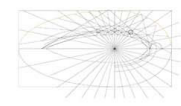
View of Muqarnas under construction field



Muqarnas - Applied



Muqarnas - Compound Curve



Muqarnas - Elliptical Curve

