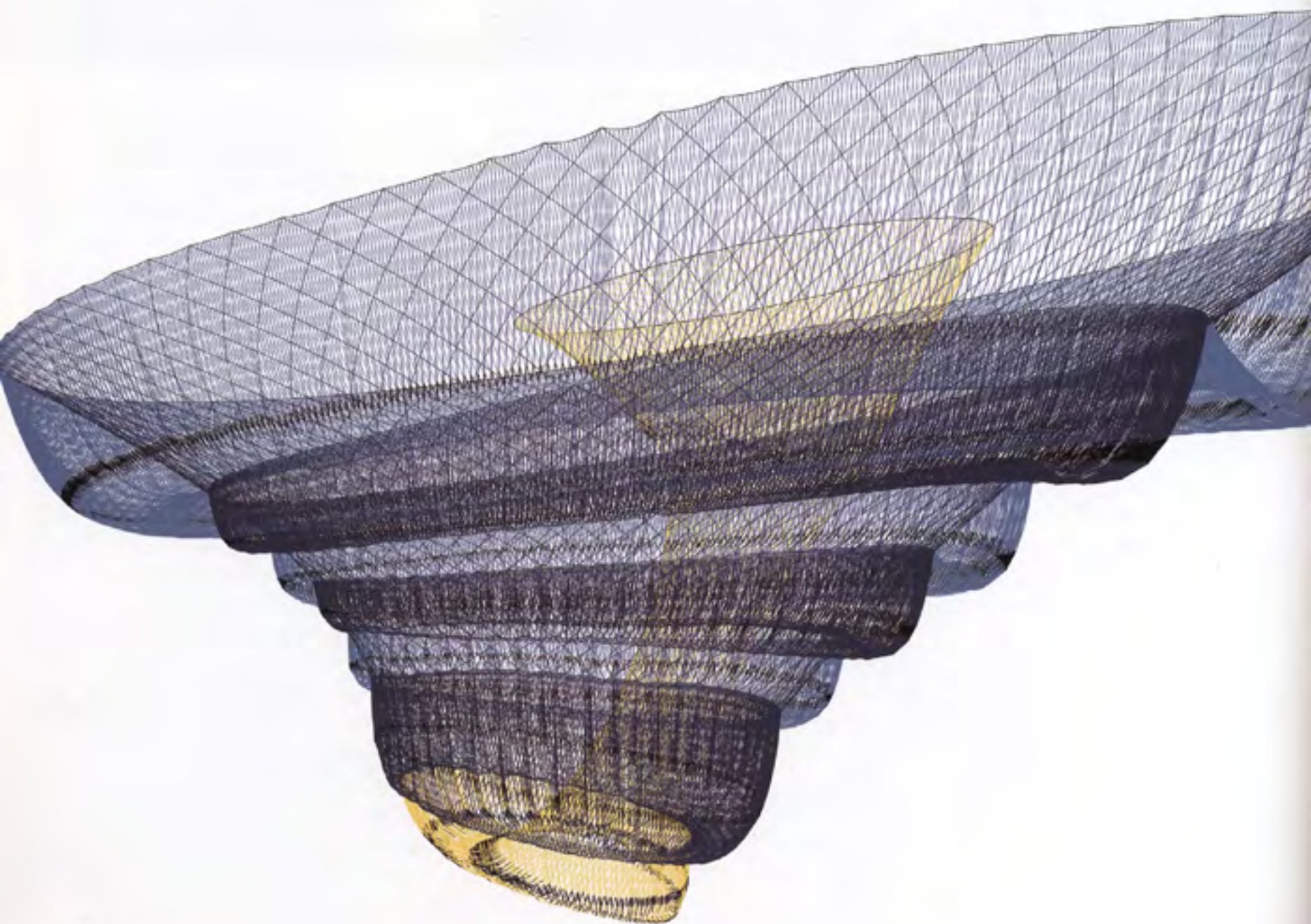


# *Her secret is patience and She Changes*

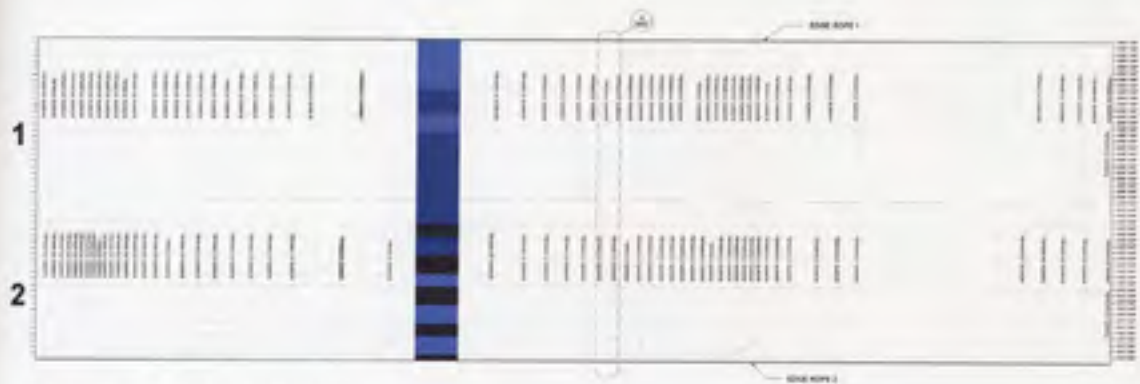
Phoenix, Arizona (2009) and Praça Cidade Salvador, Porto, Portugal (2005)

Janet Echelman

By Janet Echelman



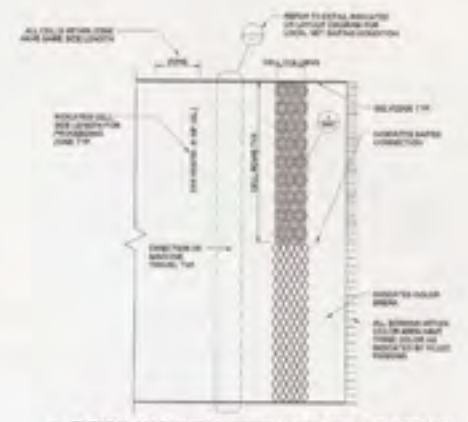




3 SCULPTURAL NET 1 FABRICATION LAYOUT



4 SCULPTURAL NET 2 FABRICATION LAYOUT



1 TYPICAL MACHINE KNOTTED NET LAYOUT DIAGRAM



2 CELL DETAIL

The intention has been to create sculptures in cities that interact with people in the course of their daily lives. Monumental, netted sculptural environments are animated by an ever-changing 'wind choreography', making the intricate patterns formed by this natural flow of air suddenly visible to the human eye as they are projected as shadow drawings on the ground below. The last decade has been spent developing a method for creating public sculptures that uses a rigid steel-armature system combined with flexible volumetric forms made of knotted high-tech fibre. The inspiration for these flexible membrane sculptures came from the design of life forms, in which a skeleton is draped with a skin to create a three-dimensional form. This was influenced by the study of evolutionary biology at Harvard University, and research into the ways surface area was maximised in a group of one-cell-thick life forms from the Precambrian era. For each project, the site, its geography, its physical, cultural and political history are researched, paying close attention to local materials, and how people have developed ways of working with such materials over the centuries.

A collaboration with Buro Happold Consulting Engineers, *Her secret is patience* for the Phoenix Civic Space, due for completion this year, transforms two city blocks in the centre of downtown Phoenix into a new civic icon in the sky. During the day, the sculpture uses sunlight to project the patterns of the Arizona Desert wind on to the paths of pedestrians. At night it is illuminated, and gradually changes colour throughout the seasons.

2005 saw the completion (with Eduardo Souto de Moura and Speranza Architects) of a voluminous net sculpture on the coast of Portugal. *She Changes* is a hollow form, 100 metres (328 feet) in diameter, that is suspended above a three-lane highway roundabout and moves in the wind. The sculpture has become the official symbol of the city. When interviewed, local people give different interpretations of the work: from the fishing nets, ships and masts of the country's maritime history and the red-and-white striped smokestacks of the area's industrial past, to Portuguese lace, sea creatures and ripples in water.

**Her secret is patience**

above: Knotting details from traditional lace-making were employed to achieve scalar jumps from nets of one cell size to those with a smaller cell size. The baiting twine, shown in detail drawings 1, 2 and 4 overleaf is knotted by hand after machine fabrication of the adjacent net sections. The variation in net sizes along the vertical axis of the net panel allowed the artist to vary the opacity of the finished sculpture.

opposite: The overall form of the sculpture comprises seven sculptural net sections and an internal structural net. Gravity and wind loads are transferred through the net sections to the internal structure and then to a supporting steel armature. Virtual form-finding was performed on reduced-resolution models to verify the hanging shapes under dead load and to calculate reactions at the supporting structure. This 'dynamic relaxation' locates the minimal-stress shape for a given configuration of net, bar and node elements.





**Her secret is patience**

above: The Phoenix Civic Space sculpture makes visible to the human eye the patterns of the Arizona Desert winds. During the day, sunlight projects patterned shadow drawings on to the paths of pedestrians. The large, three-dimensional, multilayered form was created by combining hand and machine knotting. At night, the sculpture is illuminated, and the colour of the light changes throughout the seasons with an inverse relationship to temperature. In winter, the colours become hot reds and fuchsia, and in summer cool greens and blues.

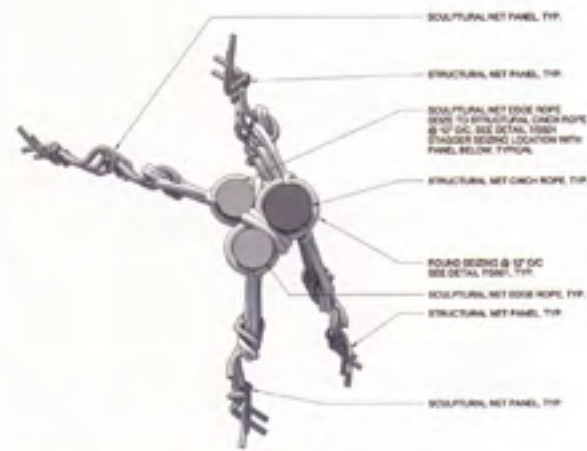


1 STRUCTURAL NET CINCH ROPE CONNECTION DETAIL  
SCALE: 1/8"



2 TEXTILE ROPE NET CONNECTION DETAIL  
SCALE: 1/8"

right: Custom knot types were developed to avoid the problems of fatigue experienced in previous tests. A series of edge connection details were designed to ensure structural redundancy in the event of local failure of a net panel. The knotting techniques were also designed to facilitate ease of installation of the net panels. The knots were virtually tested with modelling software to understand how they would behave under stress. Edge ropes were digitally designed with UV-resistant jackets that prevented breakdown of the material due to the intense desert sun in Arizona.



3 CINCH ROPE CONNECTION DETAIL  
SCALE: 1/8"



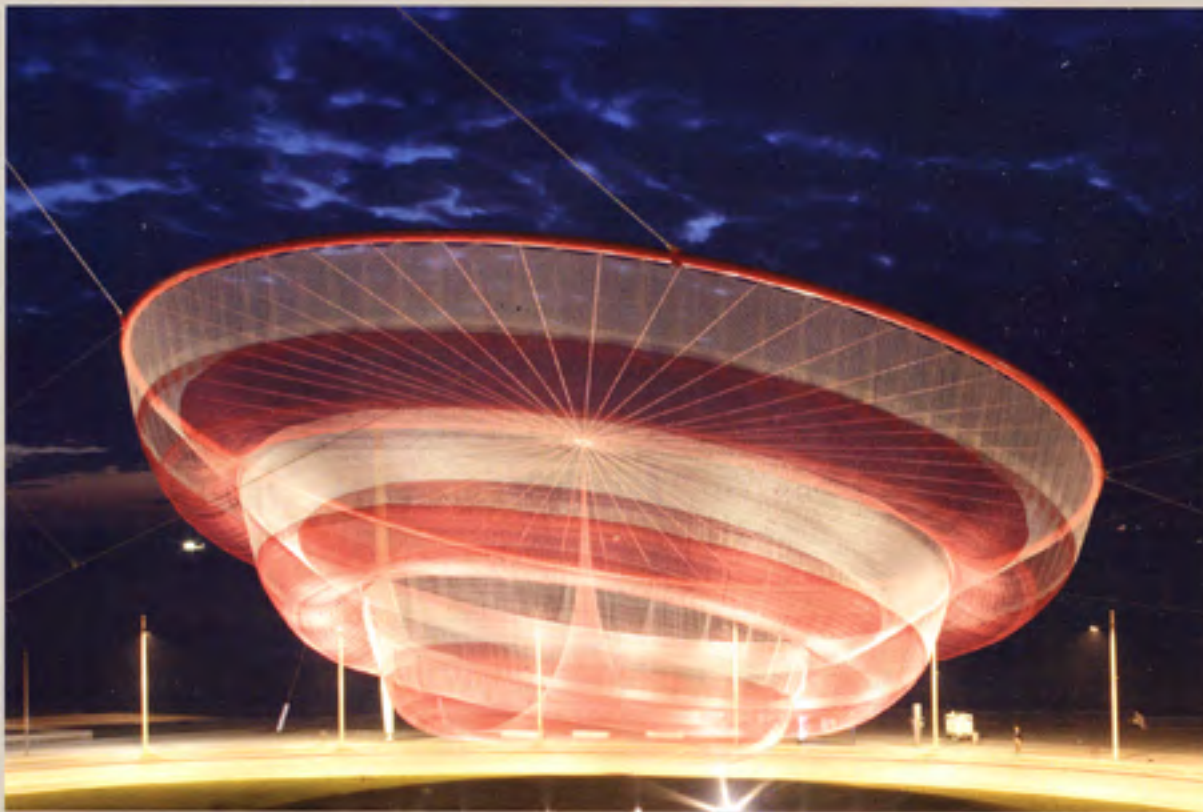
4 TEXTILE ROPE NET CONNECTION ALTERNATE DETAIL  
SCALE: 1/8"





### *She Changes*

Using colour and material methods to invoke memories of the site's historic past as a fishing and industrial centre, *She Changes* is a three-dimensional, multilayered net that floats over the area's waterfront plaza. This \$1.6 million work, a collaboration with Eduardo Souta de Moura and Speranza Architects, and consulting engineers AFA Associates and Peter Heppel Associates, is credited as the first permanent, monumental public sculpture to use an entirely soft and flexible set of membranes that move fluidly in the wind. This casts cinematic shadows over the ground below. At night the sculpture is illuminated, becoming a beacon along the Portuguese coast.



The net is made up of 36 individual mesh sections in different densities, hand-joined along all sides to create the sculpture's multilayered form. The material used is GORE Tenara® architectural fibre, a 100 per cent UV-resistant, colourfast fabric made of PTFE (polytetrafluoroethylene), which is more commonly known as the non-stick cooking surface Teflon®. **D**

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