

STRUCTURAL ENGINEERING

Engineered Urban Farm Grows atop Cardboard Tubes

What began as a desire to create an environmentally friendly “urban farm” in the courtyards of the P.S.1 Contemporary Art Center, in Queens, New York, has become a life-size experiment in materials and geometry, and visitors can explore it until the end of October. The farm is growing a variety of fruits and vegetables in interconnected cardboard tubes, some placed on the ground, others elevated on progressively longer cardboard columns. The structure rises in two directions to form a V in elevation, the two legs of the V having a total length of 135 ft (41 m) long.

Architects with WORK Architecture Company (WORKac) and engineers with Leslie E. Robertson, Associates (LERA), both of which are based in New York City, worked together closely to create the biodegradable structure out of tubes that are more typically used as formwork for concrete columns. The design team chose the tubes because they were

seen as being strong enough to support the elevated structure, durable enough to withstand constant contact with water, and safe enough to provide shade for the art center’s parties, which are attended by up to 5,000 people at a time. In addition to water from any storms that might occur, up to 800 gal (3,028 L) of water from a cistern will be added every night to the tubes that

contain the vegetation.

The structure is based on a single module—dubbed a daisy for its flowerlike appearance in plan—that is repeated 40 times. Each daisy is constructed from seven tubes: a 30 in. (762 mm) diameter center tube and six “petals,” two of them 34 in. (864 mm) in diameter and the other four 28 in. (711 mm) in diameter. “Those dimensions were selected not only for what

are formed by 3 ft (0.9 m) long tubes into which plywood disks have been inserted so that the tubes can be filled with lightweight engineered soil and plants.

Although the engineers developed a three-dimensional computer model to predict the stresses and deflections of the cardboard, it was not possible to accurately predict how much force it might take to tear bolts out of the



An interconnected cardboard tube structure located in the courtyards of the P.S.1 Contemporary Art Center, in Queens, New York, is supporting a biodegradable “urban farm” that is growing a variety of fruits and vegetables. The temporary structure can be explored by visitors until the end of October.

we felt was sound structural capacity, but also to make sure that there were no gaps between any two daisies,” says Matthew D. Melrose, P.E., an associate at LERA. “It’s a real study in geometry.” As constructed, half of the center tubes are 3 ft (0.9 m) tall, while the other half are as much as 28 ft tall (8.5 m) to serve as columns to support the V-shaped structure. The six petals of each daisy

cardboard. Therefore all of the bolted connections—between tubes and between modules of tubes—were reinforced with pieces of lumber 2 ft 8 in. (0.8 m) long, 4 in. (102 mm) wide, and 2 in. (51 mm) thick. Since the lateral strength of the structure comes from these fixed connections, it was crucial that each tube nestle as tightly as possible with its neighbors. For this