

Secugrid®
Combigrid®

Project name
Gardens by the Bay
in Singapore





Greener Dreams Come to Life: Gardens by the Bay

Singapore is one of the most densely populated places in the world. Green space on this tightly developed island comes at a premium, but it has become the mission of this Asian city-state to transform itself into a truly green, world city. The impressive Gardens by the Bay installation is the result: a 101ha spread of botanical gardens, forestry, walking trails and waterway views in the heart of Singapore. It's built on land reclaimed from the sea, and geosynthetics from Naue have played a major role in bringing this garden vision to life.

Three major gardens are housed within the overall Gardens by the Bay development: Bay South Garden, Bay East Garden and Bay Central Garden. They form something of a ring around the bustling business district and its adjacent gambling meccas, providing a stunning refuge for the citizens. It's also flipped conventional urban planning on its head. Singapore is located only 1° of latitude from the equator; yet, showcase greenhouses – not something normally needed or sought at this latitude – are central to Gardens by the Bay. In fact, they've been designed to keep plants cooler, thus enabling multiple ecosystems, from arid to verdant, to be experienced in the city centre.

It's a statement on climate change and understanding how all people and the ecosystems they live in are connected.

But while an architect can conceive of transforming a “garden city” into a “city in a garden”, it takes engineering to make the most innovative and defining dreams a reality.

Reinforcing the vision

BBG Bauberatung Geokunststoffe GmbH & Co. KG was involved in the project in close cooperation with Green Cosmos Marketing Pte Ltd, Naue's local partner in Singapore. BBG was asked to design retaining walls that could be both “green walls” and provide a high factor of safety and long-term support for retaining structures. These walls would be essential to enabling connections between the different levels of the garden and supporting the adjacent major pedestrian walkways.

The engineering solution needed to match visual aesthetics of the garden.

They proposed a series of geogrid-reinforced earth walls that would be constructed using a wrap-around facing. Temporary formworks would allow this construction to happen efficiently and safely within the space constraints posed by the local and planned elevation changes. This approach would also minimise the amount of land needing to be disturbed during construction as well as minimise the amount of heavy equipment needed on site for construction.

The design was approved and the subsequent geogrid-reinforced structures were constructed with inclinations from 45° to a maximum 70° and at heights up to 7m. These were not typical geogrid-reinforced walls, however. True to the architectural and landscaping vision of the project, the construction and engineering had to incorporate a significant number of atypical details into the project “Green Walls”. For example, gargoyles, cascades, balconies and viewing decks, and



Fig. 1: Wall under construction



Fig. 2: Completed wall section



Fig. 3: Vegetated wall at “Supertree Grove”



Fig. 4: Gargoyle with lion head integrated into reinforced earth wall facing

concrete footings for bridges and artistic “aerial roots” needed to be incorporated.

In other parts of the garden, vertical geogrid-reinforced earth structures were constructed to function as “earth pressure absorbers” behind concrete retaining walls. This solution limited the horizontal pressure onto the concrete walls, thus improving their integrity and design life.

The largest of the gardens (Bay South Garden) includes the geogrid-reinforced “Green Walls” that were opened to the public in late June 2012 after approximately 5 years of planning and construction.

In total, Gardens by the Bay has used roughly 300,000m² of Secugrid® and Combigrd® reinforcement products with ultimate tensile strengths varying, depending on the reinforcement conditions and needs, from 80kN/m to 400kN/m.

The world in a garden

The two “cooling” botanical gardens designed by Wilkinson Eyre Architects are among the largest climate-controlled glass-houses in the world. Their special zones feature eco-systems not native to Singapore, such as the cool-dry Mediterranean climate found in the “Flower Dome” and the semi-arid subtropical climate of South Africa, Spain and Italy. A “Cloud Forest” replicates the cool-moist climate of high elevation areas, such as in South America.

Steel “Supertrees” are ranging in heights from 25 to 50m. The Gardens landscape enables upwardly sweeping vegetation and provides some very creative heat venting for the botanical gardens and energy systems on site. Furthermore, housed at the top of these supertrees are solar panels helping provide energy to light up the trees at night. A walkway links two of the trees 30 meters above ground.

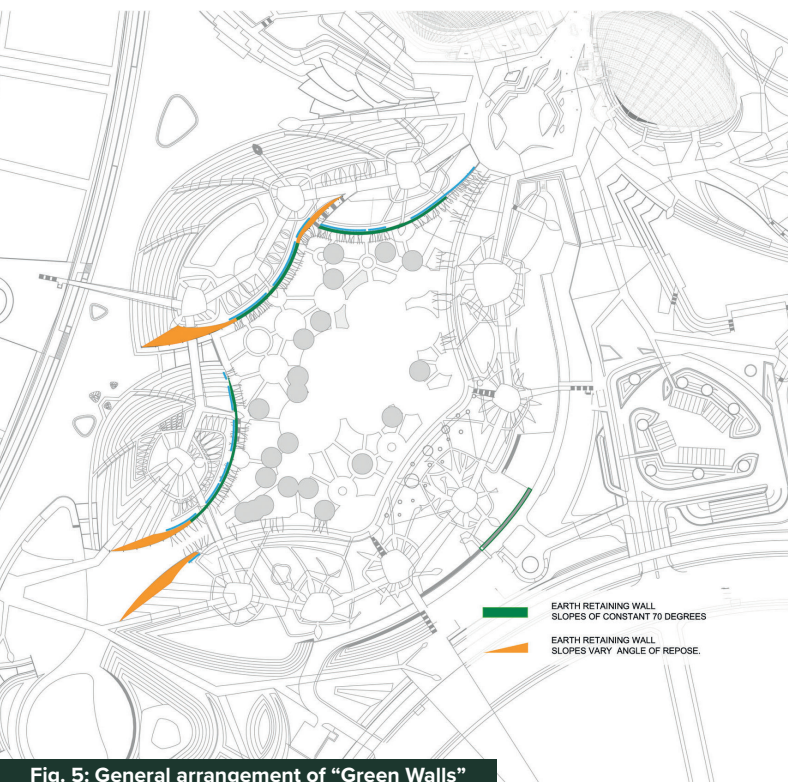


Fig. 5: General arrangement of “Green Walls”

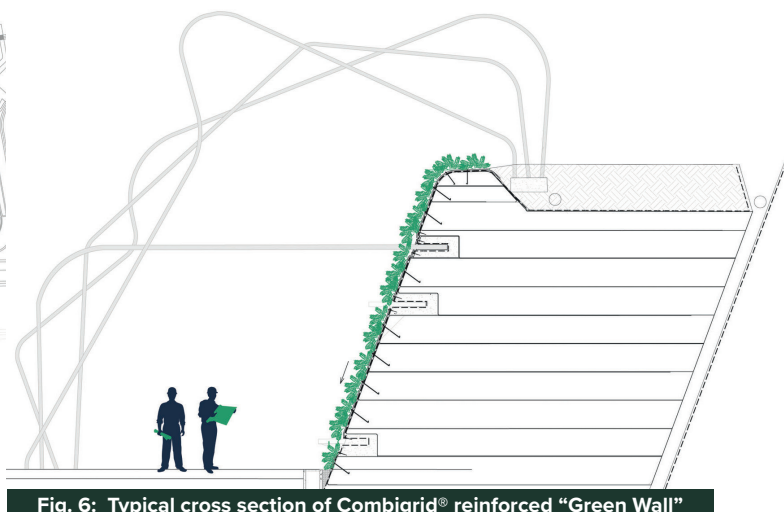


Fig. 6: Typical cross section of Combigrd® reinforced “Green Wall”